

# Chapter 6: Detention

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## 1.0 Overview

As stated in 2016 UDFCD Manual, “detention facilities are used to manage stormwater quantity by attenuating peak flows during major storm events. They can also be designed to enhance stormwater quality by incorporating design components to promote sedimentation, infiltration, and biological uptake. This Chapter provides guidance for the analysis and design of detention facilities that are implemented independently or in combination with stormwater quality facilities.”

Detention facilities represent a significant portion of open space within both public and private developments in the City. The City encourages site planning that allows for multipurpose, attractive detention facilities that are safe and maintainable while also meeting the release rate requirements as stipulated by the hydrology of the site and applicable law.

This Chapter presents information that is specific to the City of Fort Collins and may be a significant deviation from the information presented in the UDFCD Manuals. Utilizing UDFCD methodologies for detention calculations may not be accepted by FCU.

### 1.1 Master Plan Requirements

Detention of stormwater runoff is required, as directed by individual Master Drainage Plan(s). A hydrologic routing analysis is also required. In basins where a Master Drainage Plan does not exist or has not been approved, the City will require stormwater detention in accordance with the criteria set forth in this Manual as well as when such stormwater detention is deemed necessary to protect irrigation ditches, reservoirs and other facilities, and downstream properties.

#### **TYPICAL RELEASE RATES:**

ALLOWABLE RELEASE RATES DURING THE 100-YEAR STORM EVENT ARE LIMITED TO THE 2-YEAR HISTORIC RELEASE RATE, OR LESS, AS SPECIFICALLY PRESCRIBED IN THE APPLICABLE MASTER DRAINAGE PLAN.

Onsite detention is required for all development projects. The required minimum detention volume and maximum release rate(s) for the developed condition 100-year recurrence interval storm must be determined in accordance with the conditions and regulations established in the appropriate Master Drainage Plan(s) for that area of the City, for the development and in accordance with the criteria set forth in this Manual.

## 1.2 Drain Time Criteria

All detention facilities constructed after August 5, 2015, including Alternative Detention Facilities (as discussed in Section 4.0 of this Chapter), must meet the requirements of “stormwater detention and infiltration facilities” under CRS §37-92-602(8) which was enacted through Senate Bill 15-212. This statute was signed into law in May 2015 and became effective on August 5, 2015. It provides certain legal protections for detention facilities in Colorado if they meet the statute’s criteria. The statute’s criteria for such facilities are summarized here for convenience purposes only and the statute, as it may be interpreted by Colorado courts, controls in the event of any discrepancies between the statute and this Manual.

All detention facilities must:

- 1) Be solely operated for stormwater management;
- 2) Be owned and operated by a governmental entity or is subject to oversight by a governmental entity;
- 3) Continuously releases or infiltrates at least 97% of all runoff from a rainfall event that is less than or equal to the 5-year storm within 72 hours after the end of the event;
- 4) Continuously releases or infiltrates at least 99% of the runoff from a rainfall event that is greater than the 5-year storm within 120 hours after the end of the event; and
- 5) Operates passively and does not provide active water treatment processes for the stormwater.

The water detained or released by detention facilities:

- 1) Shall not be used for any purpose, including, without limitation, by substitution or exchange, by the entity that owns, operates, or has oversight over the facility or that entity's assignees, and is available for diversion in priority after release or infiltration; and

**FOR DETENTION FACILITIES  
CONSTRUCTED AFTER AUGUST 5,  
2015, THE DESIGN ENGINEER IS  
REQUIRED TO PROVIDE THE  
FOLLOWING:**

1. DOWNLOAD AND FILL OUT THE STORMWATER DETENTION AND INFILTRATION DESIGN DATA SHEET THAT SHOWS THAT THE DETENTION FACILITY IS MEETING DRAIN TIME REQUIREMENTS.
2. PROVIDE NOTICE, PURSUANT TO CRS §37-92-602(8)(D) ON THE STATEWIDE NOTIFICATION PORTAL WEBSITE PRIOR TO CITY ACCEPTANCE OF THE “OVERALL SITE AND DRAINAGE CERTIFICATION”. THE “OVERALL SITE AND DRAINAGE CERTIFICATION” CHECKLIST INCLUDES DIRECTIONS FOR WHAT THE CITY WILL REQUIRE TO BE UPLOADED TO THE WEBSITE.

- 2) Shall not be released for the subsequent diversion or storage by the person that owns, operates, or has oversight over the facility or that entity's assignees.

References:

[Colorado Senate Bill 15-212:](#)

[UDFCD Memo regarding New Colorado Revised Statute \(CRS\) §37-92-602 \(8\):](#)

[Colorado Division of Water Resources Administrative Statement Regarding the Management of Stormwater Detention Facilities and Post-Wildland Fire Facilities in Colorado:](#)

<http://water.state.co.us/DWRIPub/Documents/DWR%20Storm%20Water%20Statement.pdf>

### 1.3 Site Planning for Drainage Systems

Stormwater drainage infrastructure, such as channels, storm sewers, and detention facilities provide conveyance, water quality treatment and flood control for controlled release rates. When space requirements are considered, the provision for adequate drainage becomes a competing use for space. Therefore, adequate provision must be made in the site plan for drainage space requirements. This may entail the dedication of adequate right-of-way or easements during the development review process, in order to minimize potential conflict with other land uses.

The City requires that all drainage facilities be designed in a manner that provides a gravity-driven positive outfall into a natural drainage way such as a river or creek, or a component of or a tributary to the public storm drainage infrastructure system. Positive outfall in this context refers to the provision that all sites must be designed to drain with a gravity system to the public infrastructure system or

**PLANNING FOR DRAINAGE:**

- ALLOW ADEQUATE SPACE FOR DRAINAGE FACILITIES
- EASEMENT DEDICATION MAY BE NECESSARY
- SEPARATE LEGAL TRACT REQUIRED FOR DRAINAGE FACILITIES SERVING MORE THAN 3 RESIDENTIAL LOTS
- GRAVITY OUTFALL IS ALWAYS REQUIRED

natural drainage way(s). Outfall to a sump, drywell or “bubbler” is not considered a positive, gravity-driven system and is not typically allowed for any major storm conveyance systems.

Urban development is not permitted immediately downstream of existing or proposed emergency spillways or in areas that may act as spillways for canals, dams, or embankments impounding stormwater.

Stormwater detention is required when a development is proposed and there is an increase in impervious area greater than 1000 square feet. For project sites located within the Old Town

**DETENTION THRESHOLDS:**

- >1000 SQUARE FEET OF ADDED IMPERVIOUSNESS
- >5000 SQUARE FEET OF ADDED IMPERVIOUSNESS IN OLD TOWN BASIN
- PARKING LOT DETENTION ALLOWED (QUANTITY DETENTION ONLY) UP TO 12" MAXIMUM DEPTH

Master Drainage Basin, onsite detention is required when there is an increase in impervious area greater than 5000 square feet. Detention requirements are based on the newly added impervious areas only and previously existing impervious surface area is allowed to release runoff from the site at an undetained rate.

Parking lot detention for water quantity is allowed as long as it is not deeper than twelve inches (12"). See Section 4.2 of this Chapter for more information.

In designing drainage systems, the City requires that no undue burden be placed on the owners of single family lots by the placement of large storm drainage conveyance or detention facilities on their property. In order to prevent or minimize such occurrences, all storm drainage channels, pipes, and water quality or detention facilities serving more than three (3) properties must be located within tracts dedicated as drainage easements to the City.

**1.3.1 Utilizing Regional Facilities**

Onsite detention requirements may be deemed met where there are existing regional conveyance and/or detention facilities that have been sized with the capacity to accommodate flows from the fully-developed basin that includes the subject site. Typically, areas with regional detention are identified within one of the Master Drainage Plans and pertinent system information is provided to the site applicant by FCU staff. If applicable, when utilizing public facilities, any requirements for cost sharing or reimbursement to the City must be met.

**SECONDARY USES IN DETENTION BASINS:**

THE MS4 PERMIT SHOULD BE REVIEWED FOR COMPLIANCE ANY TIME SECONDARY USES ARE PROPOSED FOR DETENTION BASIN AREAS.

**1.4 Multi-Purpose Uses**

Detention basins can be designed to both meet the engineering requirements and provide an attractive diverse space. A detention basin can serve as a multi-use area, wildlife habitat, picturesque scene, entry experience or educational opportunity while maintaining the necessary functions of stormwater

## 2.0 Water Quantity Detention

detention and water quality improvement. Stormwater facilities should be considered an opportunity for aesthetic interest and natural integration rather than solely necessary features of a development.

For detention basins that are intended to serve as multipurpose areas, any active recreation or gathering areas may need to be placed in areas where the frequency of stormwater inundation is minimized. Likewise, secondary uses that would create added sediment loading or pollutants in the detention basin should not be planned unless a high level of maintenance will be provided. Examples of secondary uses that may add sediment or pollutant loads are dog parks and community gardens.

[Reference: CDPS General Permit Stormwater Discharges Associated with Municipal Separate Storm Sewer Systems \(MS4s\)](#)

## 1.5 Offsite Flows

If there are offsite tributary areas that contribute runoff to a project site, the total tributary area must be accounted for in the design of the drainage systems by routing the runoff generated by that offsite area safely through the site. Offsite flows do not need to be detained and released at historic rates.

## 1.6 Prohibited Detention Systems

- 1) Detention basin that is located within, under or on the roof of a building is prohibited.
- 2) On-stream stormwater detention is prohibited. Off-stream detention is the only stormwater detention method allowed for development sites in the City of Fort Collins. An off-stream detention facility collects and treats runoff from the proposed development site before entering the drainage way.
- 3) Detention that does not have a positive outfall or a system that outfalls to a drywell or sump.

## 2.0 Water Quantity Detention

### 2.1 Hydrologic Design Methods and Criteria

There are two detention basin sizing methodologies approved by FCU: the Rational Formula-based “Modified Federal Aviation Administration (FAA) Procedure” and the Stormwater Management Model (SWMM). In general, the chosen methodology should follow the basin size limitations listed in **Table 2.1-1**. The City is the determining authority with respect to the appropriate methodology to use under uncertain circumstances.

**Table 2.1-1: Detention Calculation Method**

Project Size *	Detention Calculation Method
< 5 acres	Modified FAA Required
5-20 acres	Modified FAA or SWMM Accepted
≥20 acres	SWMM Required

\*Project Size must include any offsite runoff that is tributary to the subject site

Note about the UDFCD Manual: Because of the Master Drainage Plans detention requirements, the City does not allow for detention basins to be designed with the “full-spectrum detention” method that is described in the UDFCD Manual.

## 2.2 SWMM

For project sites equal to or greater than 20 acres, the use of a Stormwater Management Model (SWMM) is required.

If there are upstream detention facilities within the watershed that contribute and route runoff into the site being designed, hydrograph routing methods must be employed to allow for the upstream facilities to be included in the overall SWMM model.

Reference: The theory and methodology for reservoir routing is not covered in this Manual as this subject is well described in many hydrology reference books.

## 2.3 Modified FAA Procedure

The Modified FAA Procedure (1966) detention sizing method as modified by Guo (1999a), provides a reasonable estimate of volume requirements for detention facilities. This method provides sizing for one level of peak control only and not for multi-stage control facilities.

The input required for this Modified FAA volume calculation procedure includes:

- A = area of the catchment tributary to the detention facility (acres)
- C = runoff coefficient
- Q<sub>out</sub> = allowable maximum release rate from the detention facility (cfs)
- T<sub>c</sub> = time of concentration for the tributary catchment (minutes)
- I = rainfall intensity (inches/hour) at the site taken from Chapter 4: Hydrology Standards, for the relevant return frequency storms

The calculations are best set up in a tabular (spreadsheet) form with each 5-minute increment in duration being entered in rows and the following variables being entered, or calculated, in each column:

- 1) Storm Duration Time, T (minutes), up to 120 minutes



## 2.0 Water Quantity Detention

- 2) Rainfall Intensity, I (inches per hour)
- 3) Inflow volume,  $V_i$  (cubic feet), calculated as the cumulative volume at the given storm duration using the equation:

$$V_i = CIA (60T) \quad \text{Equation 6-1}$$

- 4) Calculated outflow volume,  $V_o$ , (cubic feet), given the maximum allowable release rate,  $Q_{out}$  (cfs), over the duration T:

$$V_o = Q_{out} (60 T) \quad \text{Equation 6-2}$$

- 5) Required detention volume,  $V_s$  (cubic feet), calculated using the equation:

$$V_s = V_i - V_o \quad \text{Equation 6-3}$$

The value of  $V_s$  increases with time, reaches a maximum value, and then starts to decrease. The maximum value of  $V_s$  is the required detention volume for the detention facility.

[Note about UDFCD Manual:](#) Please note that the UDFCD excel-based spreadsheets are not allowed to be used to calculate required detention volumes because they utilize Denver region rainfall data. The Design Engineer will be required to establish their own spreadsheet for calculating basin volume requirements based on the Modified FAA Procedure documented above using Fort Collins IDF curves.

## 2.4 Detention Basin Volume

### 2.4.1 Stage-Storage

A relationship between the water surface elevation and detention basin volume, commonly referred to as a “stage-storage” curve, needs to be developed. This relationship, in conjunction with the “stage-discharge” relationship will provide the required detention volume. An initial detention basin design must be created and a “stage-storage” curve developed that corresponds to the design.

The available detention volume shall be based on the following formula:

$$V = \frac{D}{3} (A + B + \sqrt{AB}) \quad \text{Equation 6-4}$$

Where  $V$  = Volume between two contours,  $\text{ft}^3$

$D$  = Depth between contours, feet

$A$  = Area of bottom contour,  $\text{ft}^2$

$B$  = Area of top contour,  $\text{ft}^2$

[Note about UDFCD Manual: The UD-Detention\\_v2.35 excel-based spreadsheet, Basin tab](#) may be allowed to aid in calculating the provided basin capacity and “stage-storage” curve.

## 2.5 Alternative to Quantity Detention (“Beat the Peak”)

For development sites that are adjacent to major drainage or water ways, the **“Beat the Peak”** procedure described in this Section allows for Design Engineers to analyze the timing of a hydrograph from the development site relative to the hydrograph on a nearby drainage or water way. If the development site hydrograph can be shown to “beat the peak” under the methodology described below on the nearby drainage or water way, then the development site may be allowed to eliminate stormwater detention on the site.

[Reference:](#) The review and approval of a “beat the peak” analysis will need to follow the variance procedure as outlined in Chapter 2: Development Submittal Requirements Section 8.0.

Included here is a step-by-step procedure for this analysis:

- 1) Existing Condition hydrologic model – Update to include the proposed development without the required detention. Existing Condition model is available from FCU staff upon request.

The model should then be checked to ensure that:

- 1) Downstream discharges,
- 2) Basin volumes, and
- 3) Basin water surface elevations do not increase as a result of the proposed development

- 2) Master Plan – Selected Plan Condition hydrologic model – Update to include the proposed development without the required detention. Selected Plan Condition model is available from FCU staff upon request.

The model should be checked to ensure that:

- 4) Downstream discharges,
- 5) Basin volumes, and
- 6) Basin water surface elevations do not increase as a result of the proposed development.

- 3) If the development meets all 6 of the no-impact criteria for the Existing and the Selected Plan condition models, and all other related requirements are met, then a written

## 3.0 Detention Basin Components

variance request may be submitted for the “no detention” scenario and is still subject to staff review and approval.

- 4) If the development fails to meet any of the 6 listed criteria, then the detention requirements and allowable release rates based on the pertinent Master Drainage Plan will be enforced.

In regards to this design procedure:

- The City is the determining authority on whether a site is considered “adjacent to major drainage or water ways”. Generally speaking, “adjacent” means directly next to the water way or a parcel that is contiguous to the water way. Parcels separated from the water way by other parcels or public rights-of-way are not considered “adjacent” for this purpose.
- The City reserves the right to request additional analyses, including hydraulic analyses to assess the effects of any revised discharges.
- The City reserves the right to deny the request to eliminate onsite detention even if the “beat the peak” analysis shows no impact.
- Water quality provisions (refer to Chapter 6: Water Quality) will still be a requirement of the site design and will not be waived as a result of these analyses.
- Adequate conveyance of the 100-year storm from the site to the drainage or water way must be provided if no detention is provided at the site.
- FCU will retain and maintain an updated version of the Existing Condition and the Selected Plan Condition hydrologic models to track the cumulative effect of any and all allowed “no-detention” projects. The Design Engineer must submit the updated models for City files.

## 3.0 Detention Basin Components

[Reference](#): [Detention basin layout, geometrical requirements and grading criteria are provided in Chapter 8: Grading of this Manual.](#)

### 3.1 Forebay

Pre-treatment in the form of a forebay is a feature that can, but is not required, to be included in detention basins for the purpose of removing trash and large sediment from stormwater instead of allowing the sediment to be deposited throughout the detention basin. Forebays are to be located at storm pipe outlets or other concentrated points of inflow into the detention basin. They are typically constructed with a concrete bottom or other hard surface bottom to allow for easy maintenance and sediment removal and include a berm or curb around the perimeter with a notched outlet.

## 3.0 Detention Basin Components

The inclusion of forebays into detention basins is encouraged if the Design Engineer believes they are necessary. However, FCU does not require forebays and does not consider these to be an applicable LID technique.

[Reference](#): UDFCD Manual provides design parameters for forebays. Design Engineers may utilize this or other design guides if including forebays within detention basins.

### 3.2 Spillway

An emergency spillway shall be designed to safely convey the 100-year overtopping discharge for the entire area tributary to the detention facility, assuming a fully-developed condition in the tributary area and a fully-clogged outlet works condition.

When a detention facility falls under the jurisdiction of the Colorado Division of Water Resources, a.k.a. Office of the State Engineer (SEO), the spillway's design storm is prescribed by the SEO and the spillway embankment and/or detention basin are considered "jurisdictional".

If the detention facility is not a "jurisdictional" structure, the size of the spillway design storm must be based upon analysis of the risk and consequences of a facility failure. Generally, embankments should be fortified against and/or have spillways that, at a minimum, are capable of conveying the total peak 100-year storm discharge from a fully developed total tributary catchment. In addition, detailed analysis of downstream hazards must be performed and may indicate that the embankment protection and/or spillway design needs to be sized for events much larger than the 100-year design storm.

Flow over a horizontal spillway can be calculated using the following equation for a horizontal broad-crested weir:

$$Q = C_{BCW} LH^{1.5} \quad \text{Equation 6-5}$$

Where: Q = Discharge, cfs

$C_{BCW}$  = Broad-crested weir coefficient, dimensionless (ranges from 2.6 to 3.0)

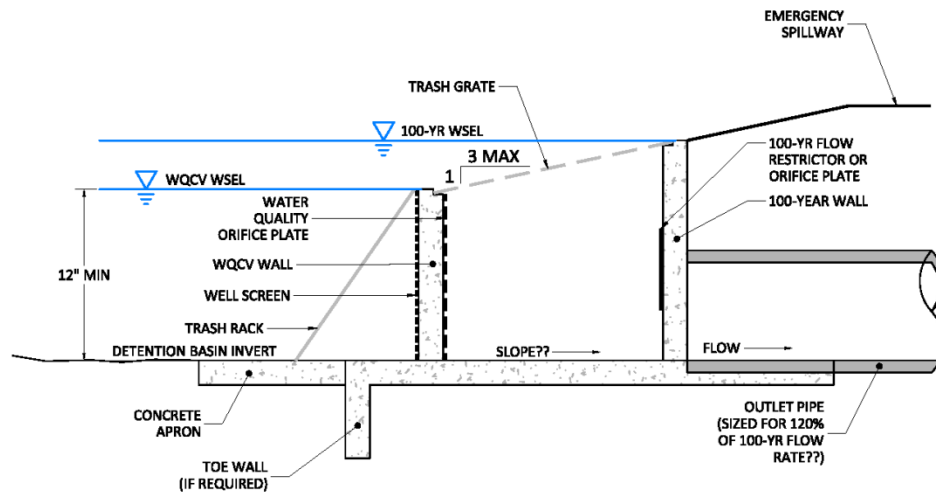
L = Length of weir, ft

H = Head above weir crest, ft

### 3.3 Outlet Works

Included below is a typical configuration for an extended detention outlet structure. **Figure 3.3-1** includes the general features and layout of the basic components of a typical outlet structure. This figure is not a construction detail. The Design Engineer will be required to refer to the City construction details for additional design requirements for final design of an outlet structure.

Figure 3.3-1. Extended Detention Outlet Structure



### 3.3.1 Quantity Detention Orifice Plate

As with the entire facility, the outlet works for detention facilities shall be designed to meet Colorado Revised Statute §37-92-602 (8) drain time requirements. These requirements are discussed in more detail in Section 1.2 of this Chapter.

With drain time requirements in mind, the outlet works for an extended detention basin shall be designed to release the WQCV over a 40-hour period.

Quantity detention is released through a low-flow outlet structure. The minimum outlet pipe size for use in detention facilities is 15-inch diameter (or equivalent) when located in a public right-of-way. Orifice plates may be utilized to reduce flows from the minimum pipe sizes. The outlet flow capacity shall be estimated using the orifice equation shown below:

$$Q = C_o A \sqrt{2gh} \tag{Equation 6-6}$$

- Where: Q = Discharge, cfs
- C<sub>o</sub> = Orifice coefficient, dimensionless
- A = Cross-sectional area of orifice, ft<sup>2</sup>
- g = Gravitational constant (32.2 ft/sec<sup>2</sup>)
- h = Effective head, ft

If the outlet from the detention basin is under free outfall, the effective head is measured from the centroid of the orifice to the upstream water surface elevation. If the downstream jet or orifice is

## 3.0 Detention Basin Components

submerged, then the effective head is the difference in elevation between the upstream and downstream water surfaces.

For square-edged, uniform orifice entrance conditions, a discharge coefficient of 0.61 should be used. For rough-edged orifice entrance conditions, a discharge coefficient of 0.4 should be used.

### 3.3.2 Water Quality Orifice Plate

The Water Quality Capture Volume (WQCV) is released through a low-flow perforated orifice plate. The perforations can be determined using the following equation:

$$a = \frac{WQCV}{0.013D_{WQ}^2 + 0.22D_{WQ}^{-0.10}} \quad \text{Equation 6-7}$$

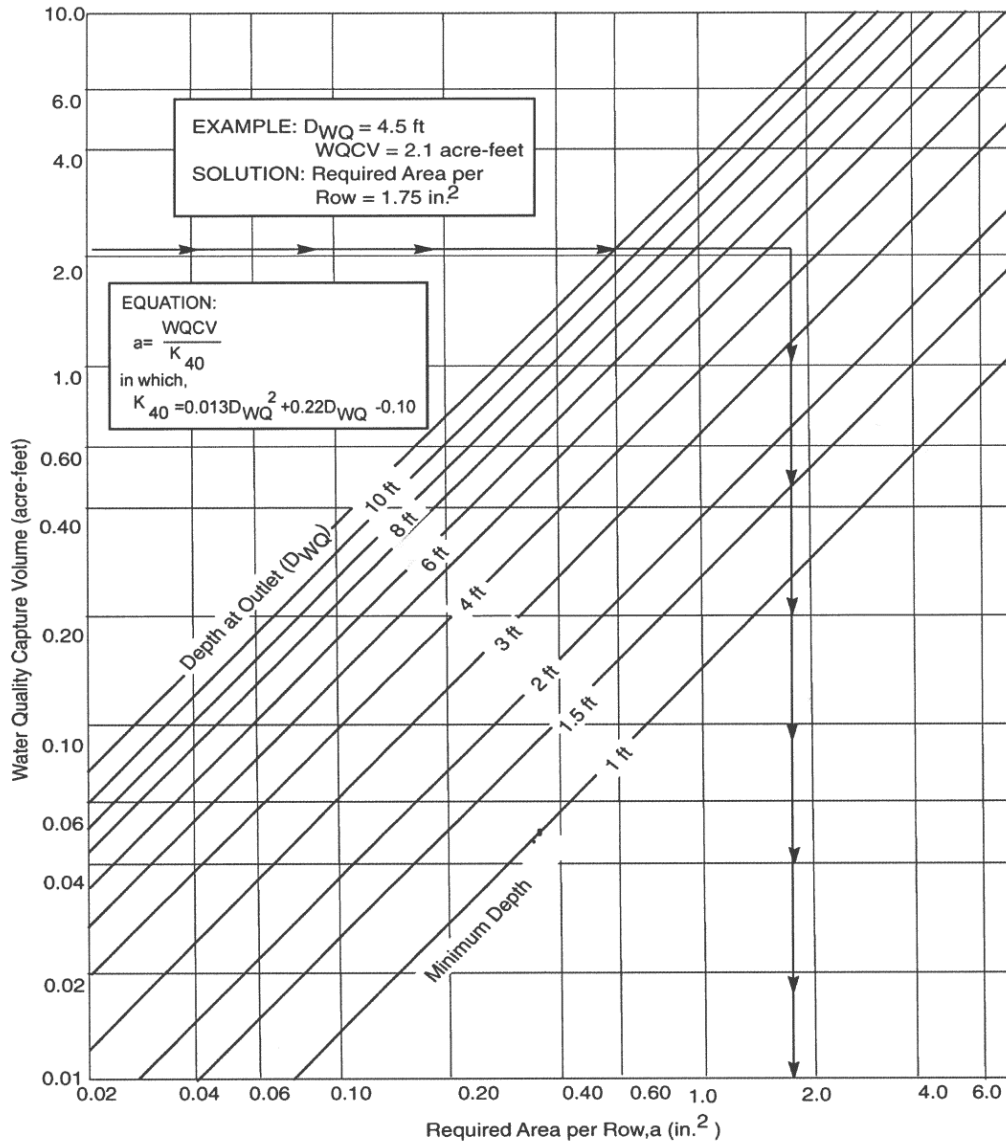
Where: a = Area per row of orifices (spaced on 4" centers), in<sup>2</sup>

WQCV = Water quality capture volume, acre-feet

D<sub>WQ</sub> = Depth of WQCV, ft

The water quality orifice plate perforations may also be found using **Figure EDB-3** (UDFCD, 6/2002) shown below.

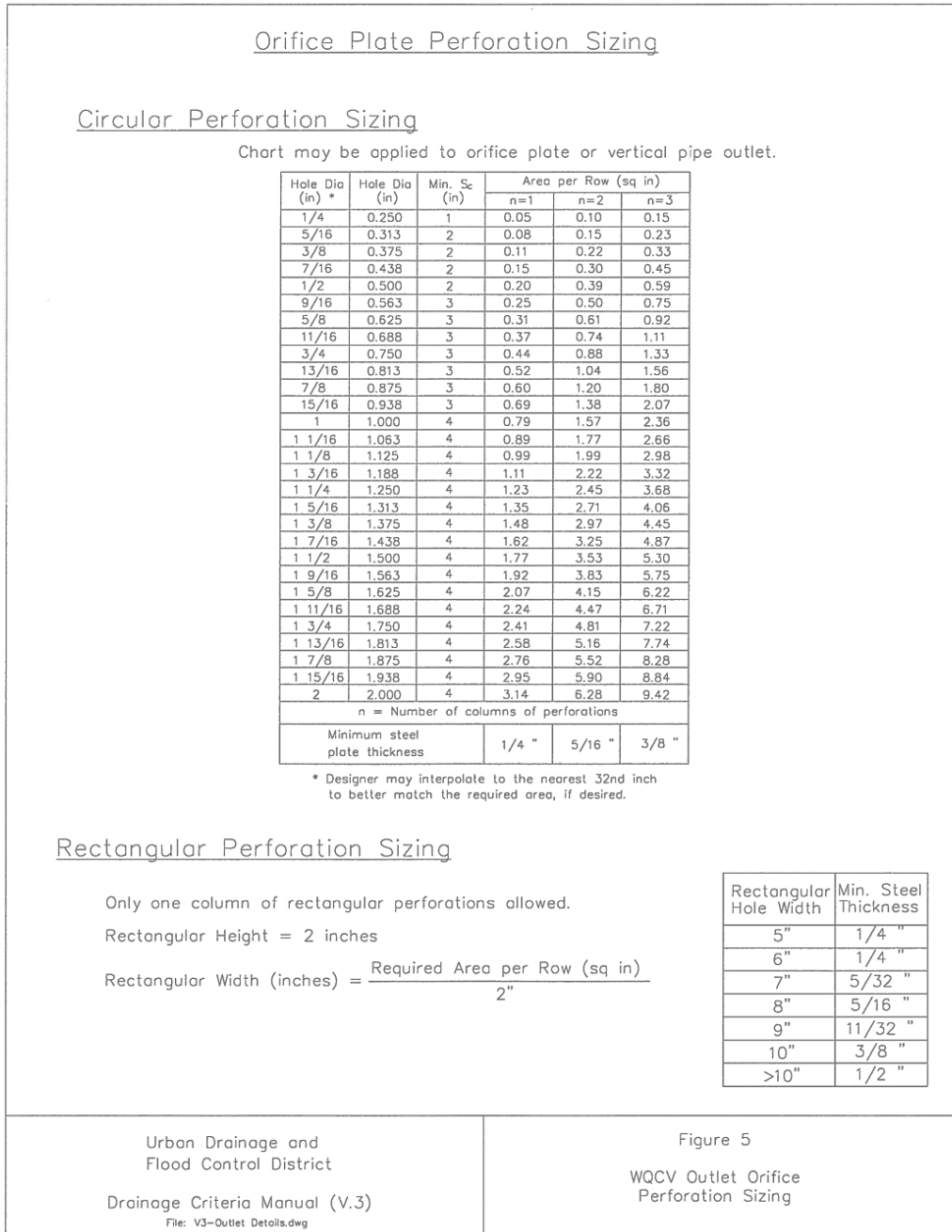
3.0 Detention Basin Components



**Figure EDB-3—Water Quality Outlet Sizing: Extended Detention Basin (Dry)  
 With 40-hour Drain Time for Capture Volume**

3.0 Detention Basin Components

The perforation pattern on the orifice plate (i.e. number of columns and exact hole diameter) can be found utilizing **Figure 5** (UDFCD, 12/2004) and **Table 6a-1** (UDFCD, 12/2004) shown below.



**Figure 5—WQCV Outlets Orifice Perforation Sizing.**



3.0 Detention Basin Components

**Table 6a-1—Standardized WQCV Outlet Design Using Circular Openings**  
(2" diameter maximum)

Minimum Width ( $W_{opening}$ ) of Opening for a Well-Screen Type Trash Rack.

Requires a minimum water depth below the lowest perforation of 2'-4".

See Figure 6-a for Explanation of Terms.

Maximum Dia. of Circular Opening (inches)	Width of Trash Rack Opening ( $W_{conc.}$ ) Per Column of Holes as a Function of Water Depth H Below Lowest Perforation					Maximum Number of Columns
	H=2.0'	H=3.0'	H=4.0'	H=5.0'	H=6.0'	
≤ 0.25	3 in.	3 in.	3 in.	3 in.	3 in.	14
≤ 0.50	3 in.	3 in.	3 in.	3 in.	3 in.	14
≤ 0.75	3 in.	6 in.	6 in.	6 in.	6 in.	7
≤ 1.00	6 in.	9 in.	9 in.	9 in.	9 in.	4
≤ 1.25	9 in.	12 in.	12 in.	12 in.	15 in.	2
≤ 1.50	12 in.	15 in.	18 in.	18 in.	18 in.	2
≤ 1.75	18 in.	21 in.	21 in.	24 in.	24 in.	1
≤ 2.00	21 in.	24 in.	27 in.	30 in.	30 in.	1

**Table 6a-2—Standardized WQCV Outlet Design Using Circular Openings**  
(2" diameter maximum).

US Filter™ Stainless Steel Well-Screen<sup>1</sup> (or equal) Trash Rack Design Specifications.

Max. Width of Opening	Screen #93 VEE Wire Slot Opening	Support Rod Type	Support Rod, On-Center, Spacing	Total Screen Thickness	Carbon Steel Frame Type
9"	0.139	#156 VEE	¾"	0.31'	¾"x1.0" flat bar
18"	0.139	TE .074"x.50"	1"	0.655	¾" x 1.0 angle
24"	0.139	TE .074"x.75"	1"	1.03"	1.0" x 1½" angle
27"	0.139	TE .074"x.75"	1"	1.03"	1.0" x 1½" angle
30"	0.139	TE .074"x1.0"	1"	1.155"	1 ¼"x 1½" angle
36"	0.139	TE .074"x1.0"	1"	1.155"	1 ¼"x 1½" angle
42"	0.139	TE .105"x1.0"	1"	1.155"	1 ¼"x 1½" angle

<sup>1</sup> US Filter, St. Paul, Minnesota, USA

Reference: Information presented above for the Water Quality Orifice Plate calculations and the well screen design specifications are from the UDFCD Manual Volume 3, Revision dates 6/2002 and 12/2004.

## 3.0 Detention Basin Components

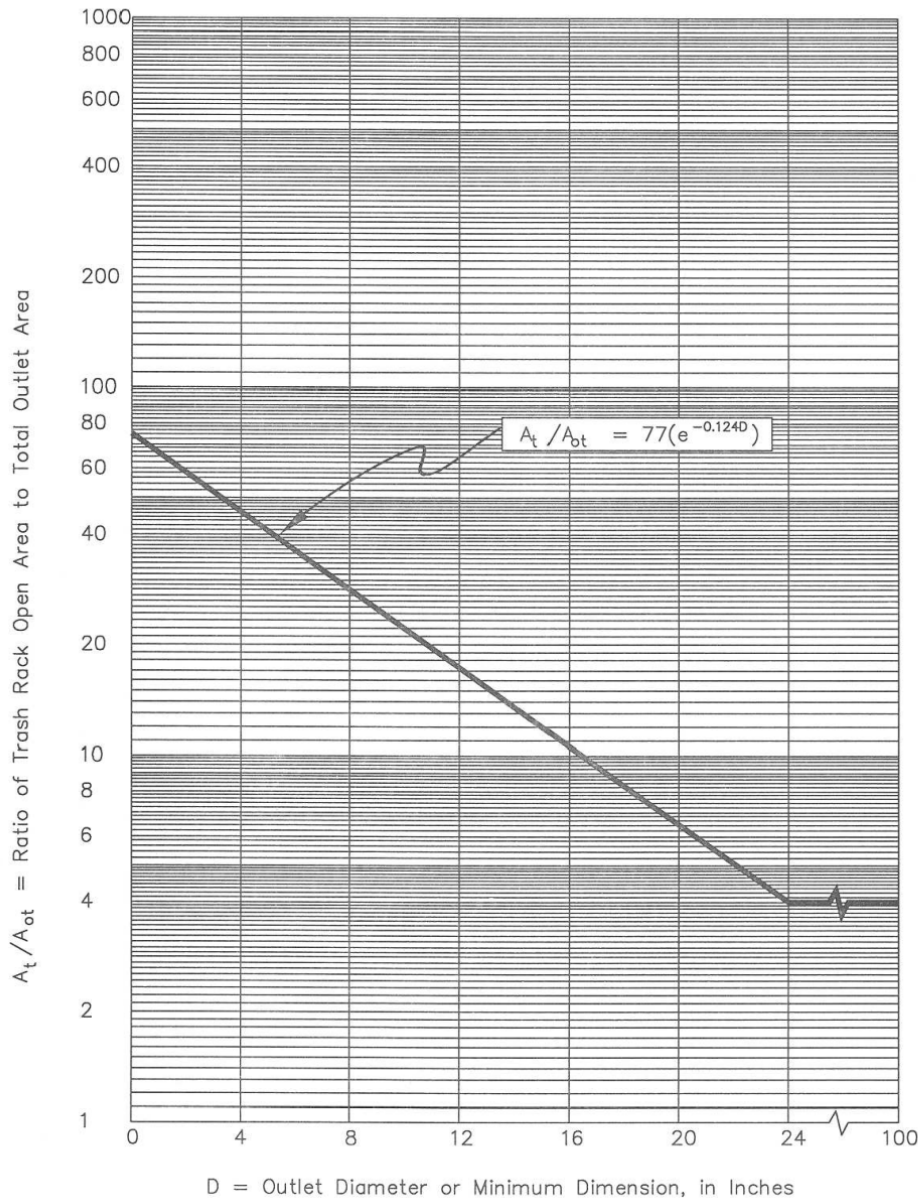
**3.3.3 Trash Racks**

Trash racks are required to be installed as part of outlet structures (at the upstream end of piping systems) to help address safety concerns and provide some ease in maintenance. Trash racks must be of sufficient size such that they do not interfere with the hydraulic capacity of the outlet structure. Trash racks typically consist of either a bar grate, a closed-mesh grate, or an open grate. Examples are shown in the figure below.

Bar grates and closed-mesh grates are appropriate for horizontal or sloping surfaces, while open grates are only appropriate for vertical surfaces. Closed-mesh grates are typically more appropriate for pedestrian or high traffic areas but require more maintenance because these catch smaller debris.

Trash racks are not allowed to be installed at the downstream end of piping systems. These may trap people or debris, impede flows, hinder maintenance or fail to prevent access to the pipe. On the other hand, desirable conditions can be achieved through careful design and positioning of the pipe outlet as well as through careful landscape placement for screening.

The figure below indicates the required minimum trash rack open area based on outlet size.



[Reference:](#) Information included here for trash racks is from the 2016 and 2011 UDFCD Manual, Storage Chapters.

### 3.4 Maintenance

To reduce maintenance and avoid operational problems, outlet structures must be designed with no moving parts other than the trash rack (i.e. use only pipes, orifices, and weirs). Manually and/or electrically operated gates shall be avoided. To reduce maintenance, outlets should be designed with openings as large as possible, compatible with the depth-discharge relationships desired and with water

## 4.0 Alternative Detention Facilities

quality, safety, and aesthetic objectives in mind. One way of doing this is to use a larger outlet pipe and to construct orifice(s) in the headwall to reduce outflow rates. Outlets should be robustly designed to lessen the chances of damage from debris or vandalism. Avoid the use of thin steel plates as sharp-crested weirs to help prevent potential accidents, especially with children. Trash racks must protect all outlets.

All detention systems shall satisfy the following design and operating criteria:

- 1) Standard Operating Procedures (SOPs) that detail the operation and maintenance of the proposed drainage system are included as a part of every Development Agreement for every project site. A final copy of the approved Development Agreement and SOPs must be kept onsite by the party responsible for facility maintenance and referenced as often as required for proper maintenance.
- 2) If the City deems that the detention system is not being maintained in accordance with the SOPs specified in the Development Agreement, the system owner will be sent written notice by FCU to conduct corrective measures within 30 days. The City will conduct a follow-up inspection after 30 days and if corrective measures have not been addressed then FCU shall have the right to enter the property for proper maintenance of the system. FCU may then charge the owner time and material costs incurred by FCU to take corrective action and maintain the system.

## 4.0 Alternative Detention Facilities

### 4.1 Underground Detention Facilities

#### 4.1.1 Policy

Underground detention has been formally allowed by City Council in January 2016 pursuant to Ordinance No. 006, 2016.

[Reference: The underground detention ordinance, Ordinance No. 006, 2016, can be found on the City of Fort Collins website.](#)

The use of structural underground detention will be allowed as long as the system can demonstrate a gravity outfall for stormwater release and is made accessible for proper long-term maintenance and functionality and meets the requirements of this Manual. If an underground detention system is proposed, a system owner must seek approval of such a system through the development review process, where the underground system may be approved upon a determination that the requirements of this section are satisfied and that no adverse impacts are expected to result from the proposed system.

## 4.0 Alternative Detention Facilities

**4.1.2 Design Criteria for All Underground Detention Systems**

The purpose of this subsection is to set forth technical criteria to be utilized for the use of underground stormwater detention as a permanent structural control measure to meet water quality and/or stormwater runoff detention requirements.

Any proposed underground stormwater detention system, including gravel reservoirs in porous interlocking concrete pavement (PICP) systems and chambers or pipes, shall satisfy the following design and operating criteria:

- 1) Runoff must flow through a pre-treatment facility (e.g. water quality chamber) before it enters the underground detention system
- 2) A gravity outfall is required at the invert of the underground detention system.
- 3) Inspection ports are required to be installed as a part of the system for inspection and maintenance purposes.
- 4) Groundwater level must be documented to be at least two foot (2') below reservoir bottom during the high groundwater period of the calendar year.
- 5) Underdrain pipes are required. The underdrain pipe shall be at least four inches (4") in diameter. Underdrain cleanouts are required at all changes in direction. If the minimum underdrain size results in a release rate larger than allowed under these criteria, a restrictor plate in a manhole must be added at the point of outflow.
- 6) Other utilities such as water mains, sewer mains or dry utilities are not allowed to be located within or below the extents of the underground detention system.
- 7) Potential lateral movement of contained stormwater outside the limits of the detention chamber must be controlled, accounted and designed for in a manner that ensures the structural integrity of adjacent structures and infrastructure.
- 8) Drainage easements are required for all underground detention facilities. This includes the entire detention basin area and all appurtenances necessary for the outfall.
- 9) Standard Operating Procedures (SOPs) that detail the operation and maintenance of the proposed drainage system are included as a part of every Development Agreement for every project site. A final copy of the approved Development Agreement and SOPs must be kept onsite by the party responsible for facility maintenance and referenced as often as required for proper maintenance.
- 10) If the City deems that the underground detention system is not being maintained in accordance with the SOPs specified in the Development Agreement, the system owner will be sent written notice by FCU to conduct corrective measures within 30 days. The City will conduct a follow-up inspection after 30 days and if corrective

## 4.0 Alternative Detention Facilities

measures have not been addressed then FCU shall have the right to enter the property for proper maintenance of the system. FCU may then charge the owner time and material costs incurred by FCU to take corrective action and maintain the system.

**4.1.3 Additional Design Criteria for Detention in Permeable Pavers Void Spaces**

The following additional design and operating criteria are for detention reservoirs located in gravel void spaces of Porous Interlocking Concrete Pavement (PICP) (permeable pavement) systems. In addition to the criteria set forth in the “All Systems” section above, the following additional criteria apply to any PICP system with a gravel layer void space.

- 1) The maximum allowable detention volume within the subsurface void spaces is up to a maximum of 1 acre-foot, with the maximum allowable assumption of 30% void space.
- 2) Additional detention volume is allowed within chambers or pipes.
- 3) A PICP parking lot surface must be designed with a minimum 0.5% slope.
- 4) An overflow inlet must be included as part of the overall design in the event that the PICP system fails and to ensure that stormwater enters the detention system.
- 5) Aggregates used for subbase material must assume a maximum of 30% void space for available detention volume in order to account for potential sedimentation. (Note that construction specifications for permeable pavers shall be referenced during design and construction of paver areas. Construction specifications are not included in this Manual.)

**4.1.4 Additional Design Criteria for Detention in Underground Chambers or Pipes**

The following additional criteria apply to any detention system using underground chambers and/or pipes.

- 1) All chambers or pipes must be placed with a minimum slope of 0.2%.
- 2) Maintenance access must be provided, at a minimum, at the point of inflow and point of outflow from the system. The accesses must be such that they would allow human access to inspect the functionality of the system. Confined space entry must be considered into the design and maintenance responsibilities outlined within the SOPs and/or Development Agreement.
- 3) All pipes or chambers must be vacuum truck accessible through manholes.
- 4) An underdrain system is required for open bottom chambers.
- 5) The minimum pipe size allowed for detention in pipes is fifteen inches (15”).

## 4.0 Alternative Detention Facilities

- 6) The structural system capacity must be designed to support AASHTO HS20 (fire truck) loading, as well as anticipated lifetime AASHTO 18,000 lb. equivalent single axle loads (ESALs).

## 4.2 Detention Basins in Parking Areas

The maximum permissible detention basin depth within parking areas is 12 inches (12"). For commercial properties only, an exception may be granted by FCU for ponding depths of up to 18 inches (18"), if the percentage of spaces with ponding depths of greater than 12 inches is less than 25% of the total parking spaces provided.

In all circumstances, twelve inches (12") of freeboard must be provided between the high water elevation and the minimum opening elevations of adjacent buildings.

Signage will be required for parking areas that include stormwater detention to alert the public that stormwater ponding within the parking areas may occur. Format and information included in the signage must be included in the Utility Plans and approved by FCU.

The water quality component of extended detention basins is not allowed within the extents of the parking lot area. The water quality portion of the detention basin must be located on vegetated areas only and will not be allowed to encroach onto paved areas.

## 4.3 Spill Control for Gas Stations and Vehicle Maintenance Facilities

Spill control structures are required for all new and redeveloping gas stations and vehicle maintenance facilities. In addition to emergency spill response procedures, such as the use of absorbent booms, structural spill controls must be used to protect all areas downstream of the site including roadways, drainage channels, storm sewer systems, wetlands, creeks and tributaries from petroleum products and other pollutants that are stored and handled at gas stations and vehicle maintenance facilities.

The spill control structure can be a below-grade concrete vault and should be placed in a location on the site that allows for spills to be directed toward it. Low flows, both pollutant spills and runoff from small storms, should be able to be directed into the control structure. Larger storm flows may be directed into the control structure but more likely will overtop a curb or bypass the spill structure and runoff toward the site detention basin.

The spill control structure or vault must have a minimum capacity of 150 gallons. The vault should be covered for safety although ventilation should be provided to allow for evaporation between storms.



#### 4.4 Pumped Detention Basins

Permanent retention or pumped detention basins are not allowed to serve as permanent water quantity or quality control measures for any development within the City or its GMA. Pumped detention basins are sometimes necessary as a temporary measure to hold water until a permanent, gravity outfall is available. FCU may approve such temporary pumped detention basin in a Development Agreement or other written agreement, as an interim solution, until a permanent outfall is built. Approval of pumped detention facilities will be based upon a known improvement that will allow for a gravity outfall to be constructed and the known improvement must be understood to be installed within 5 years. This required timeframe and related terms and conditions must be included in the Development Agreement for the development. If approved, these basins must be designed to meet the requirements of CRS §37-92-602(8).

When temporary use of a pumped detention basin is proposed as a solution, design requirements are as follows:

- 1) Basin is sized to capture, at a minimum, the runoff equal to two times the 2-hour, 100-year storm plus one foot of freeboard.
- 2) The facility must be situated and designed so that when it overtops, no human-occupied or critical structures (e.g., electrical vaults, homes, etc.) will be flooded, and no catastrophic failure at the facility (e.g., loss of dam embankment) will occur.
- 3) When a trickle outflow can be accepted downstream or a small conduit can be built, it shall be provided and sized in accordance with the locally approved release rates, and be capable of emptying the full volume pursuant to the requirements of CRS §37-92-602(8).
- 4) All pumped detention ponds must be built with a redundant pumping system and with a concrete hard surface at the bottom of the structure that is capable of evacuating the full volume pursuant to the requirements of CRS §37-92-602(8).
- 5) Pumping systems must include complete design of the pumps, sump pit or pump housing.
- 6) All pumped detention basins must be built and operated in accordance with all applicable State and Federal laws, including but not limited to CRS §37-92-602(8) regarding drain time requirements.