



# FINAL DRAINAGE REPORT

**FALCON MEADOWS AT BENT GRASS  
FILING NO. 1**

El Paso County, Colorado

**PCD-ENGINEERING REVIEW COMMENTS  
IN BLUE BOXES WITH BLUE TEXT**

PREPARED FOR:  
**Challenger Communities  
8605 Explorer Dr., Suite 250  
Colorado Springs, CO 80920**

PREPARED BY:  
**Galloway & Company, Inc.  
1155 Kelly Johnson Blvd., Suite 305  
Colorado Springs, CO 80920**

DATE:  
**March 2021**

Engineering Review

06/22/2021 8:11:42 AM

*dsdrice*

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**EPC Planning & Community  
Development Department**

Add text:  
PCD Filing No.:  
SF-21-020

Text added



## I. Purpose

The intent of the developer is to develop the residential portion of the Bent Grass Subdivision. The purpose of this Final Drainage Report is to identify on and offsite drainage patterns, locate and identify tributary or downstream drainage features and facilities that impact the site, and to identify which types of drainage facilities will be needed and where they will be located. This report will remain in general compliance with the MDDP, which is being submitted concurrently with this report, for the site prepared by Galloway & Company.

## II. General Description

The Falcon Meadows at Bent Grass Subdivision consists of 217.8 acres within the Bent Grass development. It is located south of the existing West Tributary of the Falcon Basin. The project is a subdivision of 71 lots, located in the Falcon area of El Paso County, Colorado, East ¼ and Southwest ¼ of Section 1, Township 13S, Range 65W of the Sixth Principal Meridian, County of El Paso, State of Colorado. The subject property is located to the south of The Meadows Filing No. 3; west of Bent Grass Residential Filing No. 1; north of Latigo Business Center Filing No 1, undeveloped property, and the Mountain View Electric Association; and east of The Meadows Filing No. 2. A Vicinity Map is included in Appendix A.

A Planned Unit Development Plan Amendment was approved for the site, PUD-14-002, approved in July 2014. The site consists of approximately 103.4 acres and includes 309 dwelling units.

The existing soil types within the proposed site as determined by the NRCS Web Soil Survey for El Paso County Area consist of Columbine gravelly sandy loam, Blakeland-Fluvaquentic Haplaquolls, and Blakeland loamy sand. All soils are defined as having a hydrologic soil group of A. See the soils map included in Appendix A.

## III. Previous Reports

The proposed site has been in the past. The following is a composite list of the existing reports pertaining to this site analysis.

1. *Falcon Drainage Basin Planning Study*, by Matrix Design Group, September 2015.
2. *Master Development Drainage Plan – Bent Grass Residential Subdivision*, by Galloway & Company, February 2021 (In Review).
3. *Master Development Drainage Plan and Preliminary Drainage Plan – Bent Grass Subdivision*, by Kiowa Engineering Corporation, December 2006.
4. *Final Drainage Report for Bent Grass Residential (Filing No. 1)*, by Classic Consulting Engineers & Surveyors, LLC, August 2014.
5. *Final Drainage Report Addendum for Bent Grass Residential (Filing No. 1)*, by Classic Consulting Engineers & Surveyors, LLC, August 2015.
6. *Master Development Drainage Plan for The Ranch*, by Classic Consulting Engineers & Surveyors, LLC, November 2018.
7. *Falcon Highlands Master Development Drainage Plan & Preliminary Drainage Report & Final Drainage Report for Filing 1*, by URS, January 2005.
8. *Final Drainage Report and Erosion Control Plan – Latigo Business Center Filing No. 1 A Re-subdivision of a Portion of Latigo Business and Research Center Filing No. 1*, by Kiowa Engineering Corporation, November 2004.

9. *Final Drainage Letter Report for Lot 1, Latigo Business Center Filing No. 1*, by Colorado Design Concepts, April 2005.
10. *Final Drainage and Erosion Control for The Meadows Filing Three Subdivision*, by LADD Engineering, July 2000.
11. *Final Drainage Report Bent Grass Residential Subdivision, Filing No. 2*, Galloway & Company, March 2020.
12. *Preliminary Drainage Report Falcon Meadows at Bent Grass*, by Galloway & Company, February 2021.

#### IV. Drainage Criteria

Hydrology calculations were performed using the City of Colorado Springs/El Paso County Drainage Criteria Manual, as revised in November 1991 and October 1994 with County adopted Chapter 6 and Section 3.2.1 of Chapter 13 of the City of Colorado Springs/El Paso County Drainage Criteria Manual as revised in May 2014 and the El Paso County Engineering Criteria Manual (ECM) as revised in July 2019.

The drainage calculations were based on the criteria manual Figure 6-5 and IDF equations to determine the intensity and are listed in Table 1 below.

**Table 1 - Precipitation Data**

Return Period	One Hour Depth (in.)	Intensity (in/hr)
5-year	1.50	5.17
100-year	2.52	8.68

The rational method was used to calculate peak flows as the tributary areas are less than 100 acres. The rational method has been proven to be accurate for basins of this size and is based on the following formula:

$$Q = CIA$$

Where:

- Q = Peak Discharge (cfs)
- C = Runoff Coefficient
- I = Runoff intensity (inches/hour)
- A = Drainage area (acres)

The runoff coefficients are calculated based on land use, percent imperviousness, and design storm for each basin, as shown in the drainage criteria manual (Table 6-6). Composite percent impervious and C values were calculated using the residential, streets, roofs, and lawns coefficients found in Table 6-6 of the manual.

The 100-year event was used as the major storm event for pipes and inlets. The 5-year event was used as the minor event.

For the preliminary design of the channels HEC-RAS version 5.0.3 was utilized. The model was prepared to evaluate velocity, Froude number, and channel depth. Additionally, the model was utilized to size the culverts under Bent Grass Meadows Parkway. A Manning's n value of 0.045 was utilized for the channel

which is appropriate for a bunch type native grass that is anticipated within the full channel section. The channels were designed to have a maximum depth of 5' per foot. The maximum velocity of 5 ft/s with a maximum Froude number of 0.6. Drains with a maximum velocity of 5 ft/s will be lined with riprap. **This has been revised.**

The UD-Detention spreadsheet was utilized for sizing the water quality orifices on the proposed water quality portion of the regional detention pond. This spreadsheet was also utilized for the design of the proposed on-site water quality ponds, Pond (North) and Pond (South).

HEC-HMS was utilized to analyze the hydrology of the overall basin and verify that no changes in release rates have occurred to the regional detention pond with it's addition of water quality.

UD-Inlet was utilized to calculate both the street capacities and the inlet capacities.

StormCAD was utilized to size the storm sewer systems.

## V. Existing Drainage Conditions

The site is contained fully within one major drainage basin. The site does border the Middle Falcon Tributary along the eastern side. The site generally drains from north to south with an average slope of 2% outside of the channel. The rational method was used to analyze the individual basins within the site because their size permits it. Excerpts from the DBPS are included in Appendix A. **To be cross-checked against PDR**

In addition to the DBPS, The Ranch MDDP to the north and west of the site has revisited their existing conditions as well as existing conditions from the site directly to the north of them. Several detention ponds have been created within the Paint Brush Hills Subdivision which revise the offsite flow entering the site within the major drainageway. This is taken into account with The Ranch MDDP. While The Ranch is still in design stage, they are proposing detention ponds within their site to release at historic rates. This will revise the flow rates in their designed section of the channel to below the rates that are identified within the DBPS. A HEC-HMS model was updated and submitted with the Master Development Drainage Plan (MDDP), which was submitted in February 2021 for review.

Per the DBPS the site lies within the basins, WT200, WT210, and WT220. These basins connect to channel reaches RWT202, RWT204, and RWT210. Both the RWT204 and RWT210 sections of channel currently exist and appear as a drainageway when visiting the site. Reach RWT202 appears to be a shallow overland flow through the project site. It is nearly unrecognizable through the site from a visual standpoint.

The existing channels have been visually inspected via a site walk and all appear in really good condition. There are no signs of scour within the bottoms of the channel. There are small areas that are incised or sloughing at the top of bank of the channel. These areas are less than 12" in height.

A historic basin map has been prepared for this site to analyze the existing basins as well as the offsite basins contributing to the site. The historic map is included in Appendix E and basins are described below.

**Basin EX-1** (1.19 AC,  $Q_5 = 0.4$  cfs,  $Q_{100} = 2.5$  cfs): is associated with the northeastern portion of the proposed site east of the existing channel. The basin is currently undeveloped. Runoff from the basin generally flows to the southwest, into Basin EX-2 at **DP 4**.

provide water quality for the basin. Flows will then be routed East by Existing Swale – F until out-falling into RWT210.

**Basin I-1** (0.31 AC, Q5 = 1.0 cfs, Q100 = 2.1 cfs): a basin that is associated with Latigo Business Center Filing No. 1 lot 1. It encompasses a portion of Bent Grass Meadows Parkway South of the existing (2) 10' & (2) 15' CDOT Type R Inlets on Bent Grass Meadows Drive, near the south property line. There are a set of on-grade inlets (20' on the east side, 15' on the west side), which will intercept this flow. Inlets will then release flows to the east into an existing drainage swale. Based on the Latigo Business Park drainage report by Kiowa Engineering, inlets were designed for flows of 9.9 and 21.2 cfs from this basin. The development of the Bent Grass site has reduced the flows entering the Latigo Business Park site, ensuring the existing storm system will continue to function adequately.

**Basin C-8** (0.42 AC, Q5 = 0.2 cfs, Q100 = 1.0 cfs): a basin that is in the South-central area of the site adjacent to RWT204 and RWT 210. It encompasses the rears of single-family residential Type B lots. Runoff will sheet flow West directly into RWT204 and RWT210.

**Design Point CC** is the location in channel reach RWT210, where flows exit the Bent Grass Site, including the offsite flows from RWT202, RWT204 and WT200. The minor flows are 302.4 cfs and the major flows are 1336.7 cfs.

## VI. Four Step Process

Revise the "Four-Step Process" for selecting structural BMPs per ECM Section I.7.2 BMP Selection (ie: switch #2 and #3. And revise #4).

The Four Step Process is used to minimize the adverse impacts of urbanization and is a vital component of developing a balanced, sustainable project. Below identifies the approach to the four-step process:

### 1. Employ Runoff Reduction Practices

The proposed development uses Low Impact source. Rather than creating point discharges is routed through pervious areas to promote practical.

Order of #2 & #3 has been switched and #4 has been revised.

ice runoff at the various areas, runoff are used where

### 2. Implement BMPs That Provide a Water Quality Capture Volume with Slow Release

This step utilizes formalized water quality capture volume to slow the release of runoff from the site. The EURV volume will release in 72 hours, while the WQCV will release in no less than 40 hours. On-site water quality control volume detention ponds will provide water quality treatment prior to the runoff being released into the channel.

### 3. Stabilize Drainageways

This step implements stabilization to channels to accommodate developed flows while protecting infrastructure and controlling sediment loading from erosion in the drainageways. Erosion protection in the form of riprap pads at all outfall points to the channel to prevent scouring of the channel from point discharges. A HEC-RAS model has been created and used to evaluate the stability of the existing channels. It has been determined that given that the channel is stable in its current state and the proposed velocities and Froude numbers are similar to those in the existing channel, no improvements will be made to the channel at this time. This will be further discussed later in this report.

#### 4. Implement Site Specific and Other Source Control BMPs

Source control BMPs for homeowners include the use of garages as the primary area where pollutants can be stored. The single-family detached homes provide garages which can act as storage areas. The proposed development does not include outdoor storage or the potential for introduction of contaminants to the Counties' MS4, thus no targeted source control BMPs are necessary. The biggest source control BMP is public education which can be found on the City of Colorado Springs website and discuss topics such as: pet waste, car washing, lawn care, fall leaves, and snow melt and deicer.

To be cross-checked against PDR when available

### VII. Proposed Drainage Conditions

According to the DBPS, there are two channels that run through the site. As was discussed within the Existing Conditions portion of the report both the RWT202 and RWT204 run through the site. With Bent Grass Filing No. 2, the RWT202 channel was rerouted to run along the north line, prior to combining flows with the existing RWT204 channel. The proposed development will drain to the RWT204 channel, which becomes RWT210 further south in the site. As Bent Grass Filing No. 2 development is in the process of being approved, (2) 16' x 6' concrete box culverts for RWT204 will be constructed. **Noted.**

Within the Bent Grass MDDP, currently under review, and the FDR for Bent Grass Filing No. 2, Pond SR-3, from the Falcon DBPS, was removed and replaced with 4 water quality ponds throughout the Bent Grass Development. 2 ponds were approved with the Bent Grass Filing No. 2, 1 is proposed with this portion of the development, and the fourth pond will be designed in a future filing.

The site will provide WQCV Detention Ponds to provide water quality treatment prior to discharging the runoff directly into the West Tributary channel RWT204/RWT210. There are 3 total basins, within the proposed development, which are not routed to any of the WQ facilities. Basin A-2 (0.86 acres) releases directly into channel RWT204. Basins B-1 (4.32 acres) & B-2 (1.17 acres), although larger than 1 acre, do not count towards the allowable area of 1 acre or less to be released from a site, untreated, as these basins represent the channel reaches RWT204/210, and are described as undeveloped land remaining undeveloped.

As mentioned previously, the site is proposed to be single family residential. The site is designed to provide a large lot buffer between the existing large lots to the north and west of the site and the proposed site. Beyond this buffer the majority of the site is smaller approximately 1/8 acre lots.

**Basin OS-1** (32.28 AC, Q5 = 15.1 cfs, Q100 = 65.1 cfs) is associated with The Meadows Filing No. 3 lots 14, 15, 16, and 17. Runoff from this basin sheet flows to the northern property line of the site and then flows, via an existing drainage swale, into the existing channel reach RWT204 from the Falcon DBPS at **DP 21**.

**Basin OS-4** (4.46 AC, Q5 = 5.6 cfs, Q100 = 14.0 cfs) is associated with The Bent Grass Residential Filing No. 2, lots 152-160, lots 163-168, Tract D, and portions of Thedford Court & Willmore Drive. Runoff from this basin flows via curb & gutter south on Thedford Court then continues flowing west along the northern curb & gutter along Willmore Drive before discharging into Basin A-1 at **DP 2**.

The inlets located within Bent Grass Meadows Drive (DP-8, DP-24 and DP-25) were all designed under the FDR for Bent Grass Residential Filing No. 2. The inlets were "rechecked" based on updated flows reaching each of these design points. The analysis of these inlets is included in Appendix C.

Final drainage reports for future filings will include details concerning inlet location, street capacity, storm sewer sizing, outlet protection items.

Revised to note that the only on-site basin is B-2 and Basins A-1 and B-1 are offsite.

### IX. Proposed Water Quality

Two Water Quality Capture Volume Detention Ponds will be provided for the Falcon Meadows site. One future pond will be provided for the area north of Bent Grass Meadows Drive, one proposed pond will be provided for the area to the. All ponds are private. These detention ponds will only provide water quality. The EURV and 100-year volumes will be conveyed via the emergency overflow weir, which will be lined. The water quality volume release will be controlled with an orifice plate that will release in 40 hours. The future north water quality pond will release into RWT204 and the south will release into RWT210. Once the area north of Bent Grass Meadows Drive develops, final design of the north pond and it's components will be provided.

offsite

There are three basins which are not provided with on-site water quality, as stated previously. Basin A-2 is 0.86 acres and will release future residential flows from the back lots to channel reach RWT204. Basins B-1 and B-2 (combined area of 5.39 acres) represents the area of the West Tributary Channel (RWT204/RWT210) for the Falcon Basin as it traverses the project site. As these areas are undeveloped, will remain undeveloped, and release onto undeveloped land (continuation of channel reach RWT210), they do not "count" towards the 1 acre of area being able to be released untreated from the site.

Total area which will not be treated via on-site facilities is less than 1.0 acre, as required.

### X. Channel and Swales

Address only this final plat or clarify which ponds and areas are in different filings

#### Swales

There are 5 swales associated with the proposed development, 1 existing (Swale E), 1 future (Swale F), and 3 future (Swale A, C and D). The swales have been designed to meet the 10 Appendix C contains the analysis of these facilities. Swale E was designed in the FDR Residential Filing No. 2. Flows were analyzed based on the existing swale configuration determined that the swale will continue to function per design criteria.

Has been revised to note that only the south pond is proposed and north pond is future and final design calculations will be included in corresponding FDR

Swale F is located along the south boundary of the site and will convey flows to the east towards a proposed WQCV pond. The swale will be a trapezoidal ditch with a bottom width of 6', minimum depth of 4.0' and 4:1 side slopes. Longitudinal slope will be 1.0%, generating a flow depth of 1.16' and a velocity of 4.24 fps.

Swales A, C and D are all part of the Falcon Meadows future development and final design of these facilities will be done with the corresponding FDR's. Preliminary design of the swales have been included in the appendix.

Refer to Appendix C for channel design calculations.

Noted that Swales A & D are future & calculations will be included in a future filing FDR

only include the facilities for this FDR

## Channel

With the proposed development of Falcon Meadows at Bent Grass Filing No. 1, there is no encroachment into the existing channel reaches RWT204/RWT210. It is intended to leave the channel in its existing condition, until development occurs adjacent to the channel. Reach RWT204 does not lie within the FEMA 100-year floodplain. This development will define the 100-year floodplain into Tract H. Future development will reroute RWT204 into this tract.

The future channel design, which will realign the facility with future development, has been analyzed with HEC-RAS and shown to be stable with increased flows.

Riprap protection will be provided at the south pond outfall from the site into the channel to prevent scouring from the point discharge.

Noted.

The MDDP identifies the use of check structures for the RWT210 channel downstream of the site. Again, due to the existing stability of the channel and the minor increase in flows, velocities and Froude numbers have only slightly changed, but channel remains stable.

See comment letter.

## XI. Maintenance

The future channels are to be private facilities, along with the water quality ponds, which will be maintained by the Bent Grass Metropolitan District. After completion of construction and upon the Board of County Commissioners acceptance, all public drainage facilities within easements and public Right-of-Way will be owned and maintained by El Paso County. No channel improvements are proposed with this Filing, as all proposed development will remain 50' or more from the existing floodplain. When development begins to occur adjacent to the floodplain, channel improvements and maintenance will be addressed with the concurrent FDR's.

## XII. Wetlands Mitigation

No wetlands are located on site.

This plat includes the floodplain and needs to design the onsite channel

## XIII. Floodplain Statement

A portion of the project site lies within Zone AE Special Flood Hazard Area as defined by the FIRM Map number 08041C0553G effective December 7, 2018. A copy of the FIRM Panel is included in Appendix A.

Preliminary design of channel has been included in appendix. Report notes that a channel design report and Final construction drawings are current under development and will be submitted under it's own separate cover. Channel design package will be the next design package submitted.

is only the RWT210 and RWT204 portions of the 02 is unmapped since it is the larger contributor PREFD and a no rise certificate will be required for FEMA which show that the FEMA discharges are Bent Grass Meadows Parkway was sized per tion will be provided under a separate report, filings.

## XIV. Drainage/Bridge Fees and Credits/Reimbursements

The site lies within the Falcon Drainage Basin. The DBPS was approved in 2013 and has drainage and bridge fees associated with the basin.

The project site has a total area of 21.28 acres. The tracts account for a total of 8.4 acres. Tract areas will pay fees when they are platted with future filings. This leaves a total area of 12.88 acres to assess fees for Falcon Meadows at Bent Grass Filing No. 1.

The percent impervious for the subdivision has been calculated with this report to be approximately 31.7 percent.

21 Ac.?

12.88 acres x 31.7% = 4.08 Impervious Acres

Updated per area shown on plat

The following calculations are based on an interpolated drainage/bridge fees:

**Drainage Fees**

\$31,885 x 4.08 Imp. Acres = \$130,090.80

**Bridge Fees**

\$4,380 x 4.08 Imp. Acres = \$17,870.40

Costs need to be documented in the MDDP, PDR and specific to this filing in this FDR

Per discussions with El Paso County the fees will be offset by the cost of regional improvements.

Below is a cost estimate for the improvements proposed with this filing.

Item	Quantity	Unit	Unit Cost	Cost
Storm Drain Improvements (Public)				
10' CDOT Type R Inlet (Public)	2	EA	\$ 8,000.00	\$ 16,000.00
15' CDOT Type R Inlet (Public)	2	EA	\$ 9,800.00	\$ 19,600.00
CDOT Type D Area Inlet (Public)	1	EA	\$ 7,900.00	\$ 7,900.00
7' Manhole - Type II (Public)	6	EA	\$ 4,500.00	\$ 27,000.00
8' Manhole - Type II (Public)	1	EA	\$ 5,000.00	\$ 5,000.00
18" RCP Storm Drain (Public)	15	LF	\$ 60.00	\$ 900.00
24" RCP Storm Drain (Public)	50	LF	\$ 70.00	\$ 3,500.00
30" RCP Storm Drain (Public)	48	LF	\$ 95.00	\$ 4,560.00
42" RCP Storm Drain (Public)	321	LF	\$ 160.00	\$ 51,360.00
48" RCP Storm Drain (Public)	483	LF	\$ 190.00	\$ 91,770.00
30" FES	1	EA	\$ 1,500.00	\$ 1,500.00
48" FES	1	EA	\$ 2,500.00	\$ 2,500.00
<b>Subtotal</b>				<b>\$ 231,590.00</b>
WQCV Detention Ponds (Private)				
Pond (South)	1	EA	\$ 80,000.00	\$ 80,000.00
<b>Subtotal</b>				<b>\$ 80,000.00</b>
Total				\$ 311,590.00
Contingency			10%	\$ 31,159.00
<b>Grand Total</b>				<b>\$ 342,749.00</b>

**FALCON DRAINAGE BASIN PLANNING STUDY**  
**SELECTED PLAN REPORT**  
**FINAL - SEPTEMBER 2015**

Prepared for:



El Paso County Public Services Department  
3275 Akers Drive  
Colorado Springs, CO 80922

Prepared By:



Matrix Design Group  
2435 Research Parkway, Suite 300  
Colorado Springs, CO 80920

Matrix Project No. 10.122.003

Included copies of revised sheets from MDDP on routing and basin changes. Will include final version once MDDP is approved.

Provide marked up sheets from the MDDP and PDR when approved

# Existing Computations

Not verified with this review

Noted.



## PIPE OUTFALL RIPRAP SIZING CALCULATIONS

Subdivision: Bent Grass  
 Location: CO, Colorado Springs

Project Name: Bent Grass Filing No. 3  
 Project No.: CLH000018  
 Calculated By: TJE  
 Checked By: CMD  
 Date: 2/10/21

Storm Drain System				
	Pond Outfall			
Q100 (cfs)	48.1			
D or H (in)	30			
W (ft)				
Slope (%)	0.50			
Yn (in)	27.00			
Yt (ft)	Unknown			If "Unknown" Yt/D=0.4
Yt/D, Yt/H	0.40	#DIV/0!	#DIV/0!	
Supercritical	Yes	Yes	Yes	Based on Froud Number >/< 1
Q/D <sup>2.5</sup> , Q/WH <sup>1.5</sup>	4.87	#DIV/0!	#DIV/0!	
Q/D <sup>1.5</sup> , Q/WH <sup>0.5</sup>				
Da, Ha (in) *	28.50	0.00	0.00	Da=0.5(D+Yn), Ha=0.5(H+Yn)
Q/Da <sup>1.5</sup> , Q/WHa <sup>0.5</sup> *	13.14	#DIV/0!	#DIV/0!	
d50 (in), Required	11.37	#DIV/0!	#DIV/0!	
Required Riprap Size	M	#DIV/0!	#DIV/0!	
<b>Use Riprap Size</b>	<b>M</b>	<b>M</b>	<b>VH</b>	Found using Figure 9-38 (USDCEM)
d50 (in)	12	12	24	
1/(2 tan θ)	2.50		6.80	Found using Figure 9-35/9-36 (USDCEM)
Erosive Soils	Yes			
At	8.75	0.00	0.00	At=Q/5.5
L	15.6	#DIV/0!	#DIV/0!	L=(1/(2 tan θ))(At/Yt - D)
Min L	7.5	0.0	0.0	Min L=3D or 3H
Max L	25.0	0.0	0.0	Max L=10D or 10H
Length (ft)	16.0	#DIV/0!	#DIV/0!	
Bottom Width (ft)	7.5	0.0	0.0	Width=3D (Minimum)
Riprap Depth (in)	24	24	48	Depth=2(d50)
Type II Base Depth (in)	6	6	8	
Cutoff Wall	Yes	Yes	Yes	
Cutoff Wall Depth (ft)	3.0	3.0	4.7	Depth of Riprap and Base
Cutoff Wall Width (ft)	5.3	#N/A	#N/A	

Outlet protection has been added to plans.

Note: No Type II Base to be used if Soil Riprap is specified within the plans

\* For use when the flow in the culvert is supercritical (and less than full).  
 \*\* This is a temporary minor storm culvert and the riprap has been sized for minor storm flows

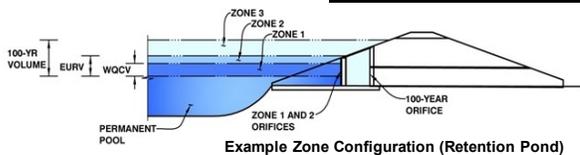
Show on CDs

# DETENTION BASIN OUTLET STRUCTURE DESIGN

*MHFD-Detention, Version 4.03 (May 2020)*

**Project: Falcon Meadows at Bent Grass**

**Basin ID: WQCV Pond - South**



	Estimated Stage (ft)	Estimated Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	3.41	0.894	Orifice Plate
Zone 2			
Zone 3			
<b>Total (all zones)</b>		<b>0.894</b>	

**User Input: Orifice at Underdrain Outlet (typically used to drain WQCV in a Filtration BMP)**

Underdrain Orifice Invert Depth =  ft (distance below the filtration media surface)  
 Underdrain Orifice Diameter =  inches

**Calculated Parameters for Underdrain**

Underdrain Orifice Area =  ft<sup>2</sup>  
 Underdrain Orifice Centroid =  feet

**User Input: Orifice Plate with one or more orifices or Elliptical Slot Weir (typically used to drain WQCV and/or EURV in a sedimentation BMP)**

**Calculated Parameters for Plate**

Invert of Lowest Orifice = <input type="text"/> 0.00	ft (relative to basin bottom at Stage = 0 ft)	WQ Orifice Area per Row = <input type="text"/> 1.979E-02	ft <sup>2</sup>
Depth at top of Zone using Orifice Plate = <input type="text"/> 3.41	ft (relative to basin bottom at Stage = 0 ft)	Elliptical Half-Width = <input type="text"/> N/A	feet
Orifice Plate: Orifice Vertical Spacing = <input type="text"/> N/A	inches	Elliptical Slot Centroid = <input type="text"/> N/A	feet
Orifice Plate: Orifice Area per Row = <input type="text"/> 2.85	sq. inches (diameter = 1-7/8 inches)	Elliptical Slot Area = <input type="text"/> N/A	ft <sup>2</sup>

**User Input: Stage and Total Area of Each Orifice Row (numbered from lowest to highest)**

	Row 1 (required)	Row 2 (optional)	Row 3 (optional)	Row 4 (optional)	Row 5 (optional)	Row 6 (optional)	Row 7 (optional)	Row 8 (optional)
Stage of Orifice Centroid (ft)	0.00	1.14	2.27					
Orifice Area (sq. inches)	2.85	2.85	2.85					

	Row 9 (optional)	Row 10 (optional)	Row 11 (optional)	Row 12 (optional)	Row 13 (optional)	Row 14 (optional)	Row 15 (optional)	Row 16 (optional)
Stage of Orifice Centroid (ft)								
Orifice Area (sq. inches)								

**User Input: Vertical Orifice (Circular or Rectangular)**

**Calculated Parameters for Vertical Orifice**

Invert of Vertical Orifice = <input type="text"/> Not Selected	<input type="text"/> Not Selected	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Area = <input type="text"/> Not Selected	ft <sup>2</sup>
Depth at top of Zone using Vertical Orifice = <input type="text"/>	<input type="text"/>	ft (relative to basin bottom at Stage = 0 ft)	Vertical Orifice Centroid = <input type="text"/>	feet
Vertical Orifice Diameter = <input type="text"/>	<input type="text"/>	inches		

**User Input: Overflow Weir (Dropbox with Flat or Sloped Gate and Outlet Pipe OR Rectangular/Trapezoidal Weir (and No Outlet Pipe))**

**Calculated Parameters for Overflow Weir**

Overflow Weir Front Edge Height, Ho = <input type="text"/> 3.50	ft (relative to basin bottom at Stage = 0 ft)	Height of Gate Upper Edge, H <sub>g</sub> = <input type="text"/> 3.50	feet
Overflow Weir Front Edge Length = <input type="text"/> 6.00	feet	Overflow Weir Slope Length = <input type="text"/> 3.00	feet
Overflow Weir Gate Slope = <input type="text"/> 0.00	H:V	Grate Open Area / 100-yr Orifice Area = <input type="text"/> 2.93	
Horiz. Length of Weir Sides = <input type="text"/> 3.00	feet	Overflow Grate Open Area w/o Debris = <input type="text"/> 14.40	ft <sup>2</sup>
Overflow Grate Open Area % = <input type="text"/> 80%	% , grate open area/total area	Overflow Grate Open Area w/ Debris = <input type="text"/> 7.20	ft <sup>2</sup>
Debris Clogging % = <input type="text"/> 50%	%		

**User Input: Outlet Pipe w/ Flow Restriction Plate (Circular Orifice, Restrictor Plate, or Rectangular Orifice)**

**Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate**

Depth to Invert of Outlet Pipe = <input type="text"/> 2.50	ft (distance below basin bottom at Stage = 0 ft)	Outlet Orifice Area = <input type="text"/> 4.91	ft <sup>2</sup>
Circular Orifice Diameter = <input type="text"/> 30.00	inches	Outlet Orifice Centroid = <input type="text"/> 1.25	feet
		Half-Central Angle of Restrictor Plate on Pipe = <input type="text"/> N/A	radians

**With updates, gate velocity has reduced.**

Gate Velocity = <input type="text"/> .90	ft (relative to basin bottom at Stage = 0 ft)
Gate Velocity = <input type="text"/> 4.00	feet
Gate Velocity = <input type="text"/> .00	H:V
Gate Velocity = <input type="text"/> .00	feet

**Calculated Parameters for Spillway**

Spillway Design Flow Depth = <input type="text"/> 0.93	feet
Stage at Top of Freeboard = <input type="text"/> 5.83	feet
Basin Area at Top of Freeboard = <input type="text"/> 0.85	acres
Basin Volume at Top of Freeboard = <input type="text"/> 2.65	acre-ft

**Routed Hydrograph Results**

*The user can override the default CUHP hydrographs and runoff volumes by entering new values in the Inflow Hydrographs table (Columns W through AF).*

	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
Design Storm Return Period	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.68
One-Hour Rainfall Depth (in)	N/A	N/A	1.19	1.50	1.75	2.00	2.25	2.52	3.68
CUHP Runoff Volume (acre-ft)	0.894	2.004	1.567	2.147	2.629	3.791	4.879	6.331	12.443
Inflow Hydrograph Volume (acre-ft)	N/A	N/A	1.567	2.147	2.629	3.791	4.879	6.331	12.443
CUHP Predevelopment Peak Q (cfs)	N/A	N/A	0.4	0.8	1.1	10.3	20.6	34.2	89.1
OPTIONAL Override Predevelopment Peak Q (cfs)	N/A	N/A							
Predevelopment Unit Peak Flow, q (cfs/acre)	N/A	N/A	0.01	0.01	0.02	0.15	0.30	0.50	1.30
Peak Inflow Q (cfs)	N/A	N/A	15.0	20.9	25.8	41.8	55.7	73.1	143.3
Peak Outflow Q (cfs)	0.4	56.4	5.8	10.8	15.2	29.3	39.5	51.8	129.5
Ratio Peak Outflow to Predevelopment Q	N/A	N/A	N/A	13.6	13.7	2.9	1.9	1.5	1.5
Structure Controlling Flow	Plate	Spillway	Overflow Weir 1	Spillway	Spillway				
Max Velocity through Gate 1 (fps)	N/A	3.85	0.36	0.7	1.0	2.0	2.7	3.5	4.3
Max Velocity through Gate 2 (fps)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to Drain 97% of Inflow Volume (hours)	38	38	42	41	40	37	35	33	23
Time to Drain 99% of Inflow Volume (hours)	40	42	45	44	44	43	42	41	37
Maximum Ponding Depth (ft)	3.41	5.30	3.74	3.88	3.98	4.25	4.52	4.97	5.78
Area at Maximum Ponding Depth (acres)	0.56	0.82	0.59	0.61	0.62	0.67	0.73	0.80	0.85
Maximum Volume Stored (acre-ft)	0.897	2.210	1.087	1.165	1.227	1.402	1.598	1.935	2.611

**Consider safety railing for outlet structure design.**

Directional labels are ok, but please also include A, B, C naming convention shown on plans for clarity. (typical comment for next 2 pages).

SOUTH POND - NORTH FOREBAY CALCULATIONS

1) WQCV (inches) =  $a(.911^3 - 1.191^2 + .781)$   
I = impervious percentage =  
a = Coefficient corresponding to WQCV drain time =

62%  
1 (40 hours)

WQCV (inches) = 0.24 inches

Names for forebay call-outs have been updated to correspond to plan set

2) WQCV (ac-ft) = (WQCV (inches))/12 x A  
Area = tributary area = 1.69 acres

WQCV (ac-ft) = 0.03  
WQCV (cubic feet) = 1,493

3) Forebay Volume

Per Table EDB-4, Section T-5 of USDCM Volume 3 - Forebay Volume = 2% of WQCV and be 12" max depth since watershed between 1 and 2 impervious acres

Forebay Volume = 2% of WQCV = 30 cubic feet  
with pond depth at 0.5', Forebay Area = 59.7 sq-ft (minimum)

4) Forebay Discharge

Per Table EDB-4, Section T-5 of USDCM Volume 3 - Forebay Discharge = 2% of 100-yr Flow into pond

Q100 = 8.1 cfs  
Forebay discharge = 0.16 cfs

Calculation has been provided

Per comment on GEC Plans, provide calcs that show well screen or bar grate open area is sufficient.

## Pond (North) Calculations

Delete if not part of this filing

Report has been updated to note that this is a future pond and analysis for size & volume has only been provided. The sheet call out has been updated to also show this is a future pond.

