PRELIMINARY/FINAL DRAINAGE REPORT

FOR

JUDGE ORR ROAD RV PARK & STORAGE DEVELOPMENT

Prepared For:
Prairie Stone, LLC
9476 Dakota Dunes Lane
Peyton, CO 80831-4138

Prepared By:
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3520 Austin Bluffs Parkway
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719.266-5212

ADP Project No.160301
May 1, 2019

PCD Project #PPR-16-040

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ENGINEER'S STATEMENT:
The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports, and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

_____
Michael A. Bartusek, P.E. #23329

DEVELOPER'S STATEMENT:
I, the Developer, have read and will comply with all of the requirements specified in this drainage report and plan.

By: _____
Andrea Minnich

Title: President

Address: Prairie Stone, LLC
9476 Dakota Dunes Lane
Peyton, CO 80831-4138

Filed in accordance the El Paso County Land Development Code, Drainage Criteria Manual Volumes 1 and 2, and the Engineering Criteria Manual, as amended.

_____ _____
Jennifer Irvine, County Engineer/ECM Administrator Date

Conditions:

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GENERAL

The Judge Orr Road RV Park & Storage project consists of 35.0 acres located along Judge Orr Road just east of US 24 and approximately two miles northeast of Falcon, Colorado. The project is located within the previously approved Meadowlake Commons Master Plan area. The site is further described as being located in central El Paso County within the Southwest Quarter of Section 33, Township 12 South, Range 64 West of the 6th Principal Meridian, El Paso County, Colorado.

The proposed development lies within the Haegler Ranch Drainage Basin Planning Study area, prepared by URS Corporation in 2007. It is also included in the Meadowlake Commons MDDP, prepared by Springs Engineering in 2008. For this report, the existing flows for this project utilize the findings of the Meadowlake Commons MDDP.

SOILS

The Soil Conservation Service (NRCS) soil survey for El Paso County has identified the soil type in this study area as follows:

Map Symbol No.	Soil Name	Hydrologic Soil Group
19	Columbine Gravelly Sandy Loam	A

FLOODPLAIN STATEMENT

A small portion of the site is located within a Zone A floodplain as determined by FEMA on the Flood Insurance Rate Map (FIRM) Panel 08041C0575G, dated December 7, 2018.

METHOD OF COMPUTATION

The methodology used for this report is in accordance with the *City/County Drainage Criteria Manual*. The Rational Method for computation of runoff was used for local basin design.

$$Q = cia$$

Where	Q	=	Maximum rate of runoff in cubic feet per second
	c	=	Runoff coefficient representing drainage area characteristics
	i	=	Average rainfall intensity, in inches per hour, for the duration required for the runoff to become established
	a	=	Drainage basin size in acres

The overall drainage for the area including off-site flows was calculated using the US Army Corp of Engineers Hydrologic Engineering Center – Hydrologic Modeling System, Version 3.1.0 (HEC-HMS). The Soil Conservation Service (SCS) (since renamed National Resources Conservation Service - NRCS) curve number method was selected for calculating the runoff volumes from the drainage basins per the DCM. Runoff rates for the five-year minor storm and 100-year major design storm were calculated.

Times of concentration were estimated using the SCS procedures described in the DCM based upon the hydrologic soil type, the natural conditions found in the basins and the runoff curve numbers (CN) chart from Table 5-4 of the DCM.

The 100-year, 24-hour storm precipitation selected from the NOAA isopluvial map in Figure 5-4e from the DCM was 4.6 inches. The ten-year, 24-hour storm precipitation selected from the rainfall depth-duration relationship chart in Figure 5-6 from the DCM was 3.1 inches. The five-year, 24-hour storm precipitation was derived from Figure 5-6 of the *City/County Drainage Criteria Manual*. The calculated rainfall amount was 2.6 inches. These numbers, along with SCS information, were used as input.

WATER QUALITY/DETENTION CONCEPTS

In accordance with current NPDES requirements, stormwater quality BMPs will be incorporated into the development of this project. Water quality facilities will be included in all proposed full spectrum detention facilities.

EXISTING DRAINAGE CONDITIONS

The existing site is only minimally developed with some gravel roads and two existing structures. The site is covered with Rangeland grasses and generally drains to the southeast at an average slope of three percent. An existing channel and a Zone A floodplain exist within the far northeastern corner of the project area. An existing, broad swale bisects the site and travels through an abandoned stock pond prior to exiting the site. All flows from Judge Orr Road are intercepted by a roadside ditch which continues past the site to the east.

There are currently two culvert crossings running under US 24. One crossing is a 24-inch CMP culvert located approximately 1,000 feet northeast of the US 24/Judge Orr Road intersection. This pipe is estimated to accommodate flows of 12.9 cfs for the five-year storm and 54.1 cfs for the 100-year storm. The second crossing consists of twin 54-inch CMP culverts. These pipes are located approximately 2,900 ft northeast of the intersection. The twin culverts carry offsite flows of 44.2 cfs for the five-year storm and 192.7 cfs for the 100-year storm and enter the project in the northeast corner, enter the existing channel located in the far northeast corner of the site and cross the property north of the project site.

The existing area located northwest of the parcel is designated as Sub-Basin OS1. This sub-basin drains existing pasture land and produces flows of 3.3 cfs for the 5-year storm and 15.2 cfs for the 100-year storm. These flows are intercepted by an existing ditch which carries the flows south along the property line to a low point from Sub-Basin OS2.

Sub-Basin OS2 drains the area just west of the parcel. This area is currently vacant and produces flows of 4.0 cfs and 28.0 cfs respectively. These flows combine with the flows from Sub-Basin OS1 at DP1 for total flows of 6.4 cfs for the 5-year storm and 39.0 cfs for the 100-year storm. These flows travel east through a broad swale located in Sub-Basin A2 and into an existing stock pond within Sub-Basin A2

Sub-Basin A1 drains the northeastern portion of the site. It is currently vacant and covered with rangeland grasses. This sub-basin produces flows of 2.2 cfs for the 5-year storm and 16.5 cfs for the 100-year storm. These flows leave the site in a southeasterly direction approximately 600 ft north of the main channel. These flows eventually join the main channel about 500 ft east of the site.

Sub-Basin A2 drains the major portion of the site and contains the stock pond and farm residence. The site also contains an existing stock pond which has been breached and is covered with rangeland grasses. This sub-basin produces flows of 3.1 cfs and 24.0 cfs respectively. These flows combine with the flows from DP1 at DP2 to produce total flows of 7.9 cfs for the 5-

year storm and 52.1 cfs for the 100-year storm. These flows leave the site in the southeast area of the site.

Sub-Basin OS3 drains an area west of SH24 and drains to the east into Sub-Basin OS4 through a 24" CMP. This area is currently zoned A-35 and is primarily open range. This sub-basin produces flows of 17.8 cfs and 62.0 cfs respectively.

Sub-Basin OS4 drains an area west of the parcel. The area is vacant and covered with rangeland grasses. It slopes to the southeast and flows east along Judge Orr Road. It produces flows of 8.2 cfs and 36.7 cfs respectively. These flows combine with the flows from OS3 at DP3 to produce flows of 24.8 cfs for the 5-year storm and 94.8 cfs for the 100-year storm.

Sub-Basin A3 drains the southern area of the site and is mostly vacant with a barn and some gravel drives located in the western portion of the site. It produces flows of 1.1 cfs and 5.3 cfs respectively and drains into the roadside ditch. OS5 drains the area between the property line and the center line of Judge Orr Road. This area produces flows of 1.3 and 3.3 respectively, and combines with the flows from A3 at DP4 within the Judge Orr roadside ditch to produce total flows of 2.0 cfs for the 5-year storm and 7.6 cfs for the 100-year storm. These flows combine with the flows from DP3 at DP4 to produce total flows of 23.3 cfs for the 5-year storm and 89.0 cfs for the 100-year storm within the roadside ditch. These flows leave the site in a northeasterly direction and join with the main channel about 300 ft east of the property. These flows eventually combine with the flows from DP2 and Sub-Basin A1 at DP6 to produce total flows in the main channel of 33.3 cfs for the 5-year storm and 156.2 cfs for the 100-year storm.

Sub-Basin B drains a small portion of the site in the northern corner. It produces flows of 0.2 cfs for the 5-year storm and 1.6 cfs for the 100-year storm.

The estimated runoff amounts produced for the project under existing conditions are shown in Table 1 below.

TABLE 1 – EXISTING CONDITIONS

Sub-Basin	Q_5CFS	Q_{100} CFS
OS1	3.3	15.3
OS2	4.0	28.0
OS3	17.8	62.0
OS4	8.2	36.7
OS5	1.3	3.3
A1	2.2	16.5
A2	3.1	24.0
A3	1.1	5.3
B	0.2	1.6
DP1 (OS1 + OS2)	6.4	39.0
DP2 (DP1 + A2)	7.9	52.1
DP3 (OS3 + OS4)	24.8	94.8
DP4 (DP3+OS5 + A3)	23.3	89.0
DP5 (DP2 + DP4 + A1)	33.3	156.2

DEVELOPED DRAINAGE CONDITIONS

The development of the site will include an RV storage area in the northern portion of the site with RV pads located in the southern portion of the site. The northern area will be covered by 4 inches of loose gravel. The southern area will have 120 gravel RV pad sites with asphalt roads connecting the sites and vegetated areas between the pads.

Flows amounts from the area west of SH 24 will remain the same as delineated in the existing conditions portion of the report. Currently these flows travel east in a swale toward the RV development. In the future these flows will be intercepted by a storm sewer and routed directly into the Judge Orr Road ditch as delineated on the Developed Conditions Map.

Existing historic flows from the property to the west will be transported through the site by way of a 30" HDPE storm sewer. The proposed 30" HDPE storm sewer will be located near the west property line to facilitate the connection from a future detention facility once the property to the west has been developed. The overflow spillway will also be directed to the 30" storm sewer along the west property line. This design has been coordinated with the current property owner, as has the proposed swale within the west property. OS1 and OS2 will flow down the existing swale on the west property and into a 4' wide swale which outlets at the same location as detention Pond 2. In the future a new detention pond will replace the swale and will tie directly into the 30" private HDPE storm sewer, with the portion of the storm sewer which will run under the future Right of Way constructed with RCP. This storm sewer will direct the flows around the RV storage site and outlet onto the adjacent property to the east adjacent to the Pond 2 outlet and will be maintained by the owner of the west property. The storm sewer will be placed within a drainage easement in the future when the property is platted. A conceptual 4.6 acre foot pond (Pond 1) was calculated for the future neighborhood commercial site with an estimated outflow of 0.1 cfs for the 5-year storm and 50.7 cfs for the 100-year storm, however the current flows are 6.4 cfs and 39.0 cfs respectively.

Sub-Basin A1 will drain the northern part of the site. This area will be used for RV storage and will be covered by 4 inches of loose gravel. This area will produce flows of 12.3 cfs and 26.0 cfs for the five- and 100-year storms. A 12" berm will keep the flows within the sub-basin. The flows will travel along the berm, cross the drive in a concrete pan and flow into a ditch which will take the flows into Pond 2.

Sub-Basin A2 drains the area between the west property line and the RV storage and will contain the future public road. It will produce flows of 5.8 cfs and 12.2 cfs respectively and will flow into Sub-Basin A4.

Sub-basin A3 drains the central area of the site between the gravel parking area to the north and the storm sewer to the south. Flows from this RV park area will sheet flow toward a proposed swale. It will produce of 6.5 cfs and 17.3 cfs respectively. These flows will be intercepted by a Type C inlet and an 18" private HDPE storm sewer and transported into Pond 2.

Sub-Basin A4 drains the western and southern part of the developed parcel. This area will be developed as an RV park with private streets and gravel parking areas for RV's. The RV Park area will have asphalt roads with natural grass areas between the parking pads. Flows will travel to the southeast and be intercepted by a main road and transported into the detention basin. It will produce flows of 12.4 cfs and 31.7 cfs respectively. These flows will combine with the flows from Sub-Basin A2 to produce total flows into the detention basin at DP2 of 15.9 cfs and 38.9 cfs respectively. The total flows into Pond 2 at DP3 will be 30.2 cfs and 37.5 cfs for the

five- and 100-year storms. The proposed 2.67 AF detention basin will release these flows through an outlet structure with a 36 inch RCP pipe at a rate of 1.0 cfs for the 5-year storm and 37.7 cfs for the 100-year storm.

Sub-Basin A5 drains the western and southernmost area of the site. This area contains a proposed cinder trail and 75 ft future Judge Orr Road right-of-way. This area will produce flows of 0.4 cfs and 2.9 cfs respectively. OS5 drains the area between the property line and the centerline of Judge Orr Road. This area produces flows of 1.0 cfs and 2.6 cfs respectively and combines with the flows from A5 and DP5 at DP6 to produce total flows in this area of 18.3 cfs for the 5-year storm and 62.8 cfs for the 100-year storm. These flows will combine with the detained flows at DP7 to produce total flows of 19.3 cfs for the 5-year storm and 138.2 cfs for the 100-year storm.

Sub-Basin B in the northeastern portion of the site will contain a landscaped area and produce flows of 0.2 cfs for the 5-year storm and 1.6 cfs for the 100-year storm.

Table 2 shows the estimated runoff which will be produced for the project under developed conditions.

TABLE 2 – PHASE I DEVELOPED CONDITIONS		
Sub-Basin	**Q_5CFS**	**Q_{100} CFS**
OS1	3.3	15.3
OS2	7.2	54.9
OS3	17.8	62.0
OS4	3.7	10.1
OS5	1.0	2.6
A1	12.3	26.0
A2A	5.7	12.0
A2B	2.4	4.8
A3	6.9	18.0
A4	11.8	30.0
A5	0.4	2.9
B	0.2	1.6
DP1 (OS1+OS2)	9.7	66.4
DPD1 (Existing DP1)	6.4	39.0
DP2 (A2A+A3)	11.2	27.1
DP3 (DP2+A1+A4)	29.6	70.0
DPD2 (Detained DP2)	0.5	39.1
DP4(DPD2+DPD1)	6.5	71.8
DP5 (OS3+OS4 Existing)	24.8	94.8
DP6 (A2B+A5+OS5+DP5)	22.8	87.5
DP7 (DP5+DP6)	28.9	154.7

WATER QUALITY

The water quality basin for this project is incorporated with the detention basin for this project and is designed with current NPDES requirements as provided by the El Paso County Drainage Criteria Manual as amended for an EDB. The required water quality capture volume is 0.470

AC-FT. The basin will be constructed with a 2.5-foot permanent micro-pool and a forebay. Design forms for this basin can be found in Appendix B. The design summary is below.

TABLE 3 –WATER QUALITY DESIGN SUMMARY				
Location	Depth	Size (CF)	Depth (FT)	Size (IN)
Pond 2	2.84	20,470	0,1.76,3.51	1.94,1.94,1.94

DETENTION

Developed flows from this project will be reduced to historic levels by using a privately owned and maintained detention facility. The *UDFCD Design for Full Spectrum Detention Basins* is used for the basin. Since a neighborhood commercial development is proposed for the property to the west, a conceptual detention basin, Pond 1, was designed for the area and routed around the site. The site detention for the RV project was routed through Pond 2 with the flows from Ponds 1 & 2 combined at the outlet structure for Pond 2.

TABLE 4 DETENTION BASIN DETAILS				
Location	Size (AF)	Pipe Outlet	Outlet Structure	Riprap Weir Width
2	2.532	36"	Typical Outlet Structure OS-2	40'

Flows from the detention basins drain into a broad grasses swale. The swale is located within an existing pasture area with an existing slope of approximately 1.7%. It has an average bottom width of 8 ft. with 8:1 side slopes. The detention basin outflow of 33.7 cfs plus the future Pond 1 flows of 50.7 cfs will only produce a flow depth of 1.2 ft. and a velocity of 4.1 fps. Once the Judge Orr ditch flows combine with the detained flows, the 154.7 cfs, approximately 300 ft. east of the project, will produce a flow depth of 1.6 ft and a velocity of 4.80 fps. These flows are below the existing condition flows and the existing grassed swale is hydraulically adequate with a Froude number at 0.85. There are no downstream manmade drainage systems in the area to tie into.

Should a 20 ft. breach occur in the detention embankment, the outflow would be approximately 199.5 cfs and would produce an initial wave of approximately 1.7 ft., a velocity of 5.1 fps and a Froude number at 0.86. This wave would dissipate within the 850 ft. prior to flows crossing Judge Orr Road. No structures exist prior to this crossing.

PRIVATE DRAINAGE FACILITIES

Item	Unit	Quantity	Unit Cost	Total Cost
30" HDPE FES	EA	1	$650	$650.00
18" HDPE FES	EA	1	$500	$500.00
36" RCP FES	EA	1	$1000	$1,000.00
24" RCP FES	EA	2	$750	$1,500.00
30" HDPE	LF	1607	$75	$120,525.00
24" HDPE	LF	120	$69	$8,280.00
38" x 24" RCEP	LF	570	$94	$53,580.00
24" RCP	LF	250	$84	$21,000.00
Concrete HDWL	EA	4	$2,500	$10,000.00
Type C Inlet	EA	1	$3,270	$3,275.00
Storm MH Type II	EA	4	$4,575	$18,300.00
Riprap	CY	380	$98	$37,240.00

Detention Outlet Structure	EA	1	$8,000	$8,000.00
Emergency Spillway	EA	1	$2,500	$2,500.00
			Sub-Total	$286,350.00
			15% Contingency & Engineering	$ 42,952.50
			TOTAL	**$329,302.50**

DRAINAGE BASIN FEES

The entire project lies within the Haegler Ranch Drainage Basin. However, the parcel is not being platted at this time, so no fees are due. In the future when this site is platted the drainage and bridge fees will be determined based on the percent of imperviousness of the platted subdivision.

CONCLUSION

The proposed development and subsequent lot developments follow the "Four Step Process" as mandated by the EPA as follows:

Step 1: Employ runoff reduction practices

Runoff has been reduced by disconnecting impervious areas where possible, eliminating "unnecessary" impervious areas and encouraging infiltration into suitable soils.

- Impervious areas have been directed to earth swales to encourage infiltration.
- Gravel will be used throughout the site to reduce the impervious of the areas.

Step 2: Stabilize drainageways

All drainageways, ditches and channels have been stabilized by the following methods:

- Tributaries have been left in their relatively natural state where possible.
- New drainageways and swales have been stabilized with either riprap or erosion control fabric depending on the erosion potential.

New roadside ditches have been designed to be stable and handle the design capacity.

Step 3: Provide water quality capture volume (WQCV)

The proposed development will disturb approximately **30** acres, a WQCV of **0.470** ac-ft will be provided.

Step 4: Consider need for industrial and commercial BMP's.

The site is being developed as an RV Park with minimal impervious area therefore no industrial or commercial BMP's are required.

REFERENCES

1. City of Colorado Springs and El Paso County (1994). ***Drainage Criteria Manual Volume 1*** (DCM).

2. City of Colorado Springs and El Paso County (1994). ***Drainage Criteria Manual Volume II*** (DCM).

3. Soil Survey of El Paso County Area, Colorado by USDA, NRCS.

4. ***El Paso County (January 2006) Engineering Criteria Manual.***

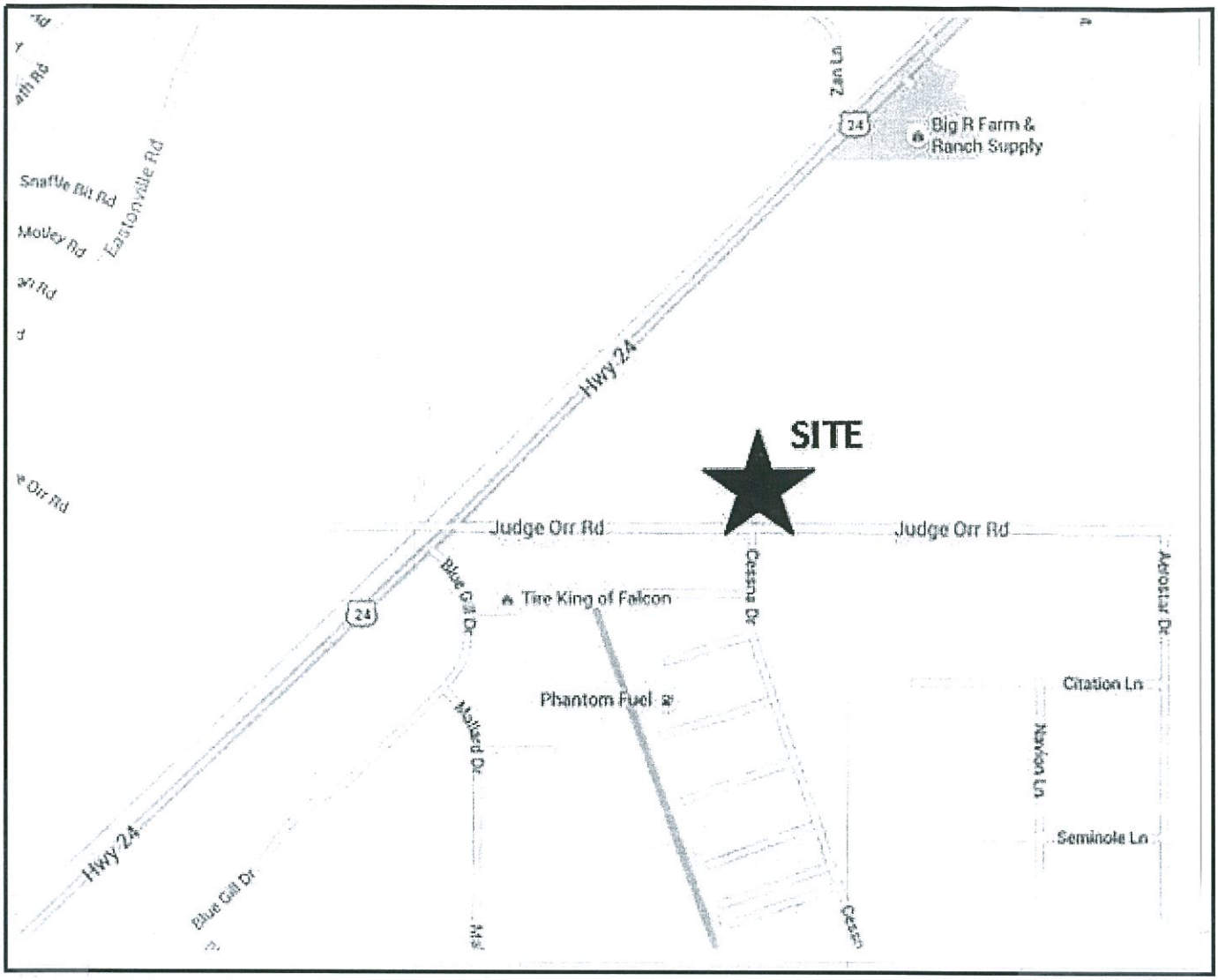
5. Urban Drainage and Flood Control District (June 2011). ***Urban Storm Drainage Criteria Manual, Volume 1-3***.

6. Meadowlake Commons MDDP by Springs Engineering, dated July, 2008.

7. Heagler DBPS by URS Corporation dated July, 2007.

APPENDIX A

MAPS



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VICINITY MAP

N.T.S.

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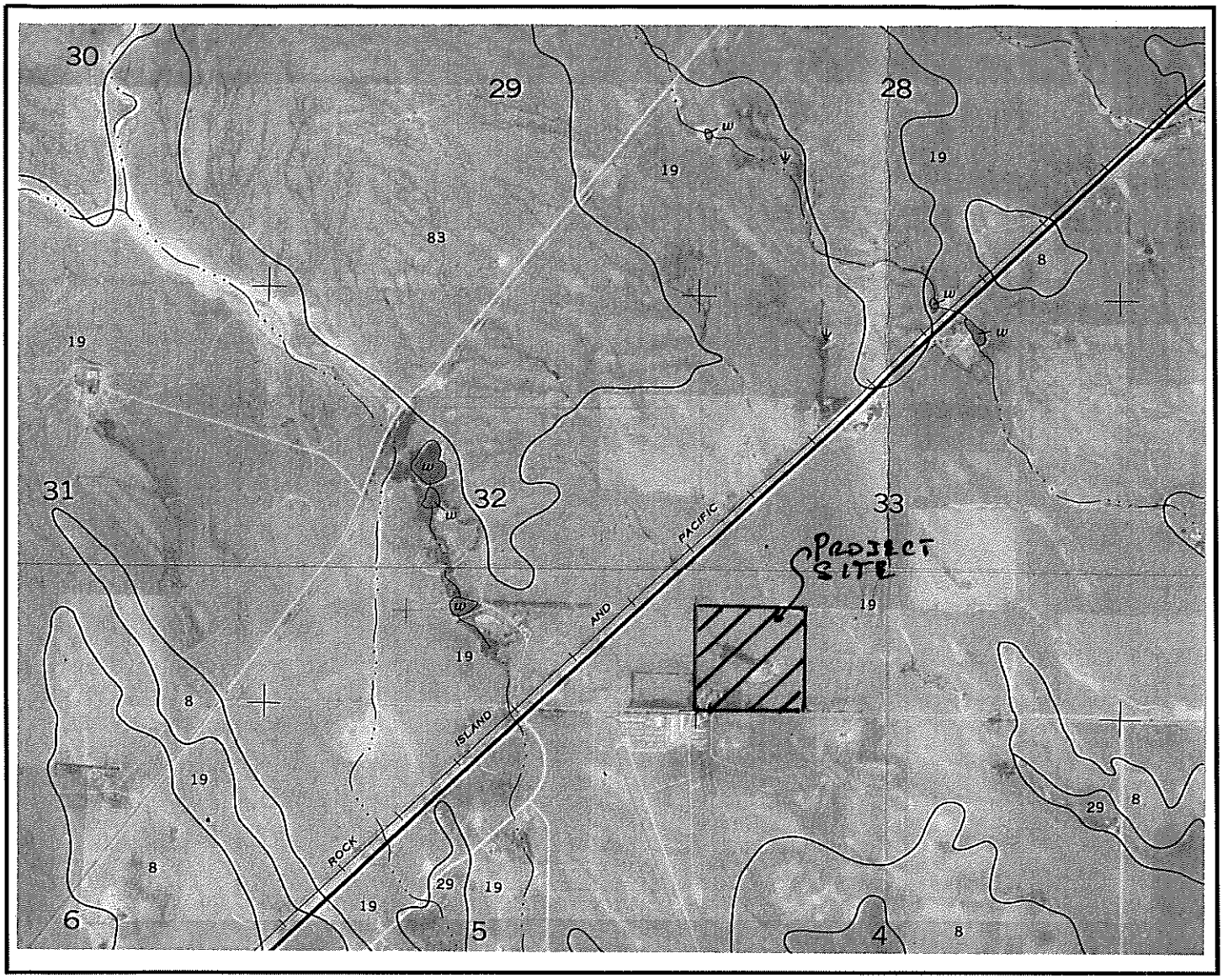

SOILS MAP

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National Flood Hazard Layer FIRMette

FEMA

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Area of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN — Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 — Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represe an authoritative property location.

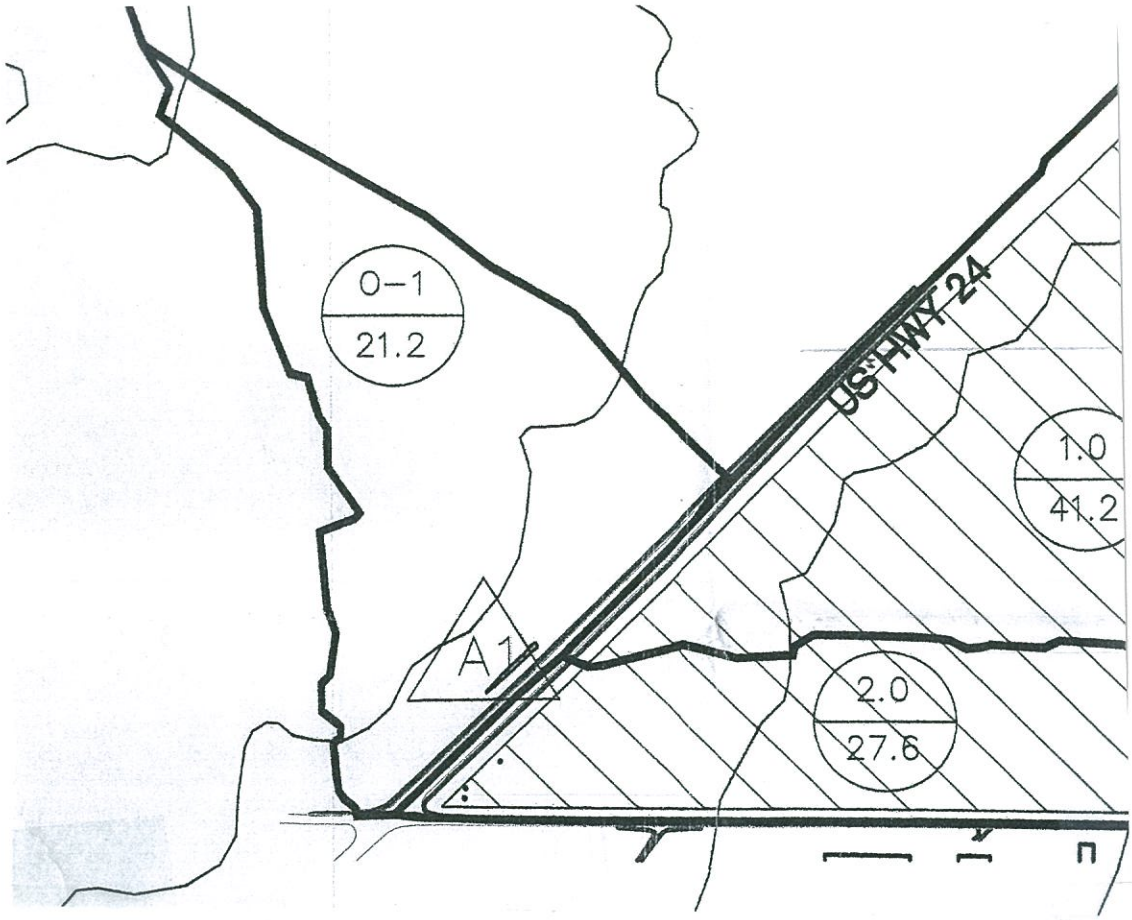
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/1/2019 at 4:13:20 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX B

DESIGN CALCULATIONS



NOTE: SUBBASIN O-1* RENAMED AS SUBBASIN OS3 IN THIS REPORT

* **FROM MEADOWLAKE COMMONS MDDP BY SPRINGS ENGINEERING, DATED JULY 2008**

OFFSITE DRAINAGE MAP

SCALE: 1" = 500'

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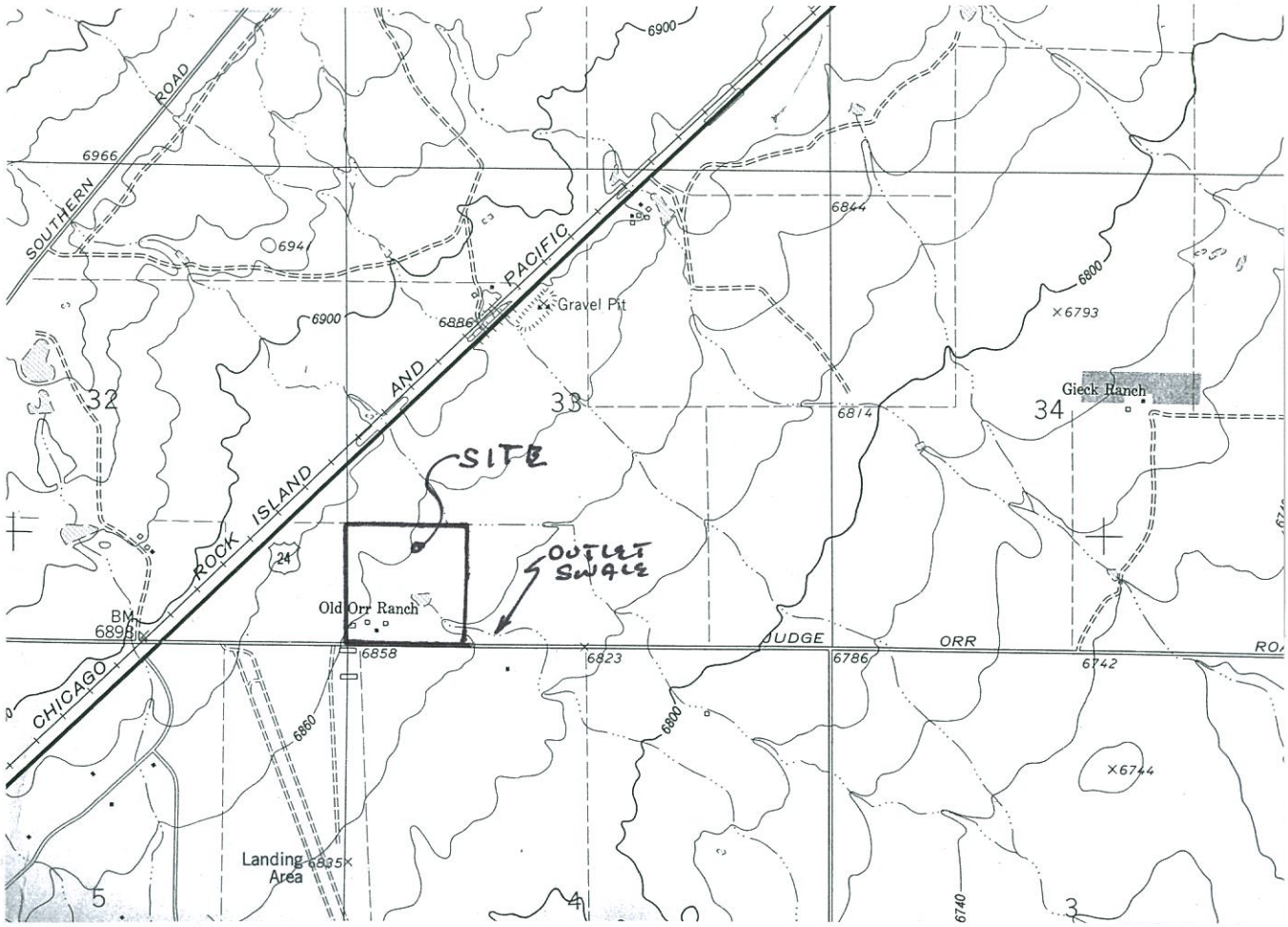

OFFSITE DRAINAGE MAP

SCALE; 1'=2000'

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JUDGE ORR ROAD RV PARK & STORAGE DEVELOPMENT

C FACTOR CALCULATION SHEET

RUNOFF COEFICIENT

TYPE A/B SOILS

LAND USE	5 YR	100 YR	IMPERV. %
UNDEV	0.08	0.35	0
LOOSE GRAVEL	0.59	0.7	80
GRAVEL ROADS	0.59	0.7	80
GRAVEL RV PARKING PAD	0.59	0.7	80
PAVED ROADS/BUILDINGS	0.9	0.96	100

Historic Conditions

AREA DESIG.	TOTAL AREA (acre)	SURFACE CONDITION AREAS: GRASSED SURFACE	LOOSE GRAVEL	GRAVEL ROADS	BUILDINGS OR PAVED ROADS	CALCULATED C: 5 YR	100 YR
A1	11.75	11.75	0.00	0.00	0.00	**0.08**	**0.35**
A2	20.75	20.60	0.00	0.10	0.05	**0.08**	**0.35**
A3	4.36	3.91	0.00	0.35	0.10	**0.14**	**0.39**
	36.86	36.26	0.00	0.45	0.15	0.09	0.36
% Impervious		0%	80%	80%	100%		
Imp x A		0	0	0.36	0.15		
Total I x A	0.51						
Total Imp	0.51/36.86 = 1.4%						
B	0.87	0.87	0.00	0.00	0.00	**0.08**	**0.35**
OS1	7.81	7.19	0.00	0.00	0.62	**0.15**	**0.40**
OS2	36.41	35.96	0.00	0.00	0.45	**0.09**	**0.36**
OS3	27.21	From Heagler DBPS				**0.30**	**0.60**
OS4	13.73	12.37	0.00	0.00	1.36	**0.16**	**0.41**
OS5	0.71	0.42	0.00	0.00	0.29	**0.41**	**0.60**

Developed Conditions							
	TOTAL	SURFACE CONDITION AREAS				CALCULATED C	
AREA	AREA	GRASSED	LOOSE	GRAVEL	PAVED	5	100
		SURFACE	GRAVEL	RV	ROADS		
DESIG.	(acre)			PARKING		YR	YR
A1	8.30	0.61	7.69	0.00	0.00	**0.55**	**0.67**
A2A	2.58	0.86	0.00	0.00	1.72	**0.63**	**0.76**
A3	6.85	3.88	0.00	1.15	1.82	**0.38**	**0.57**
A4	11.92	9.18	0.00	1.49	1.25	**0.23**	**0.46**
Total @Pond	29.65	14.53	7.69	2.64	4.79	**0.39**	**0.57**
A2B	0.70	0.16	0.00	0.00	0.54	**0.71**	**0.82**
A5	1.80	1.72	0.00	0.00	0.08	**0.08**	**0.38**
% Impervious		0%	80%	80%	100%		
Imp x A		0	6.15	2.11	4.79		
Total I x A	13.05						
Total Imp	13.05/29.65 = 44.0%						
B	0.87	0.87	0.00	0.00	0.00	**0.08**	**0.35**
OS1	7.81	7.19	0.00	0.00	0.62	**0.15**	**0.40**
OS2	42.70	19.20	0.00	0.00	23.50	**0.53**	**0.69**
OS3	27.21	From Heagler DBPS				**0.30**	**0.60**
OS4	4.18	2.82	0.00	0.00	1.36	**0.35**	**0.55**
OS5	0.70	0.42	0.00	0.00	0.28	**0.41**	**0.59**
Pond 1							
% Impervious							
	TOTAL	GRASSED	NEIGHBORHOOD				
	AREA	SURFACE	COMMERCIAL				
OS1	7.81	7.81					
OS2	42.70	1.65	41.05				
	50.51	9.46	41.05				
% Impervious		0%	70%				
Imp x A		0	28.74				
Total I x A	28.74						
Total Imp	28.74/50.51 = 56.9%						

JUDGE ORR ROAD RV PARK & STORAGE DEVELOPMENT

PROJ. #160301

DRAINAGE CALCULATION SHEET

file:judge orr rv1 dr

04/25/19

							Initial Tci			Travel Time								length	vel.		
AREA	AREA	C5	C100	C5 X A	C100 X A		Slope	ti		Slope	V	Tt	TC	I5	I100	Q5	Q100	L	V	^t	AREA
DESIG.	(acre)	(5 yr)	(100 yr)			L (ft)	(%)	(min)	L (ft)	(%)	(fps)	(min)	(min)	(in/hr	(in/hr	(cfs)	(cfs)	(feet)	(fps)	(min)	DESIG.
EXISTING CONDITIONS																					
A1	11.75	0.08	0.35	0.94	4.11	200	2.00	21.46	1150	1.90	2.10	9.13	30.59	2.29	4.00	2.15	16.47				A1
OS1	7.81	0.15	0.40	1.17	3.12	150	2.00	17.31	600	1.18	2.35	4.26	21.56	2.80	4.89	3.28	15.27	450	4.50	1.67	OS1
OS2	22.10	0.09	0.36	1.99	7.96	150	2.00	18.40	1400	1.20	1.20	19.44	37.85	2.01	3.52	4.00	27.97				OS2
DP1	29.91			3.16	11.08								37.85	2.01	3.52	6.36	38.95	1250	2.10	9.92	DP1
A2	17.47	0.08	0.35	1.40	6.11	250	3.20	20.55	1400	1.90	2.10	11.11	31.66	2.25	3.92	3.14	23.98				A2
DP2	47.38			4.56	17.19								47.77	1.73	3.03	7.91	52.10				DP2
OS3	27.21	0.30	0.60	8.16	16.33	250	2.00	18.82	1570	2.90	1.80	14.54	33.35	2.18	3.80	17.76	62.04	1800	4.00	7.50	OS3
OS4	25.14	0.16	0.41	4.02	10.31	250	2.00	22.11	1800	1.00	2.00	15.00	37.11	2.04	3.56	8.20	36.68				OS4
DP3	52.35			12.19	26.63								37.11	2.04	3.56	24.83	94.79	1050	2.25	7.78	DP3
A3	2.80	0.14	0.39	0.39	1.09	100	2.00	14.28	1050	1.23	2.25	7.78	22.06	2.76	4.83	1.08	5.27				A3
OS5	0.82	0.41	0.60	0.34	0.49	10	2.00	3.25	1050	1.23	2.25	7.78	11.02	3.89	6.79	1.31	3.34				OS5
DP4	55.97			12.91	28.22								44.89	1.81	3.15	23.32	89.02				DP4
DP5	115.10			18.41	49.52								44.89	1.81	3.15	33.25	156.23				DP5
B	0.87	0.08	0.35	0.07	0.30	80	2.00	13.57	650	1.30	2.30	4.71	18.28	3.05	5.34	0.21	1.62				B
DEVELOPED CONDITIONS																					
OS1	7.81	0.15	0.40	1.17	3.12	150	2.00	17.31	600	1.18	2.35	4.26	21.56	2.80	4.89	3.28	15.27	450	4.50	1.67	OS1
OS2	22.10	0.09	0.36	1.99	7.96	150	2.00	18.40	1400	1.20	1.20	19.44	37.85	2.01	3.52	4.00	27.97				OS2
DP1	29.91			3.16	11.08								37.85	2.01	3.52	6.36	38.95	1594	10.00	2.66	DP1
A1	8.30	0.56	0.68	4.65	5.64	100	2.00	8.03	1150	1.50	1.20	15.97	24.01	2.64	4.61	12.26	26.00	650	1.20	9.03	A1
A2A	2.58	0.63	0.76	1.63	1.96	35	2.00	4.14	700	1.50	1.20	9.72	13.86	3.50	6.12	5.69	12.00	675	1.20	9.38	A2A
A3	6.85	0.38	0.57	2.60	3.90	100	2.00	10.71	950	1.50	1.20	13.19	23.91	2.64	4.62	6.88	18.03				A3
DP2	9.43			4.23	5.87								23.91	2.64	4.62	11.18	27.08	230	1.20	3.19	DP2
A4	11.92	0.39	0.57	4.65	6.79	100	2.00	10.56	1100	1.50	1.20	15.28	25.84	2.53	4.42	11.76	30.02				A4
DP3	29.65			13.53	18.30								33.03	2.19	3.82	29.60	69.97	150	5.00	0.50	DP3
DPD2	29.65			0.23	10.24	*Adjusted C Factor for Detention Basin							33.03	2.19	3.82	0.50	39.10				DPD2
DP4	59.56			3.39	21.32								40.50	1.93	3.37	6.54	71.81				DP4
OS3	27.21	0.30	0.60	8.16	16.33	250	2.00	18.82	1570	2.90	1.80	14.54	33.35	2.18	3.80	17.76	62.04	1800	4.00	7.50	OS3
OS4	25.14	0.16	0.41	4.02	10.31	250	2.00	22.11	1800	1.00	2.00	15.00	37.11	2.04	3.56	8.20	36.68				OS4
DP5	52.35			12.19	26.63								37.11	2.04	3.56	24.83	94.79	1050	2.25	7.78	DP5

A2B	0.69	0.71	0.82	0.49	0.57	35	2.00	3.43	200	1.50	1.20	2.78	6.21	4.84	8.46	2.37	4.79	110	1.20	1.53	A2B
A5	1.80	0.08	0.38	0.14	0.68	180	2.00	20.36	1050	1.23	2.25	7.78	28.14	2.41	4.21	0.35	2.88				A5
OS5	0.70	0.41	0.59	0.29	0.42	10	2.00	3.26	1300	1.23	2.25	9.63	12.89	3.62	6.33	1.04	2.63				OS5
DP6	55.54			12.62	27.73								44.89	1.81	3.15	22.78	87.49				DP6
DP7	115.10			16.00	49.05								44.89	1.81	3.15	28.90	154.73				DP7
B	0.87	0.08	0.35	0.07	0.30	80	2.00	13.57	650	1.30	2.30	4.71	18.28	3.05	5.34	0.21	1.62				B
	* C Factor Adjusted to Model Flows from Detention Model into Rational Method Design																				

DITCH CAPACITY CALCULATION SHEET

Swale Location	Q5 cfs	Q100 cfs	S %	B ft	n	Z	D ft	d100 ft	V fps	Froude #	Riprap Size ft	Riprap Size in
Swale A	6.4	39.0	1.00	4.00	0.035	3:1	3.00	1.30	3.70	0.71		
Swale B	3.0	10.0	1.00	0.00	0.035	3:1	1.50	1.10	2.75	0.65		
Swale C	12.3	26.0	1.40	0.00	0.035	3:1, 1%	1.00	0.50	2.00	0.71		
Swale D	12.3	26.0	1.50	0.00	0.035	3:1	2.00	1.50	4.10	0.84		
Swale E	11.1	27.1	1.40	0.00	0.035	15:1	1.00	0.80	2.75	0.76		
Swale F	11.8	30.0	1.50	0.00	0.015	56:1	0.25	0.3*	3.10	1.52	asphalt road	
								*d5				
Judge Orr Rd												
Ditch G	24.8	94.8	1.60	4.00	0.035	3:1/4:1	2.00	1.70	5.50	0.94		
Ditch H	22.8	87.5	1.60	4.00	0.035	3:1/4:1	2.50	1.70	5.40	0.93		
Spillwy K	24.6*	73.0*	5.00	40.00	0.040	3:1	2.00	0.40	4.40	1.25	0.20	Use 12"
	*Undetained Flows from UD-Det											
Spillway												
Swale L	31.0*	112.0*	0.30	10.00	0.040	3:1	3.00	1.90	2.50	0.37	0.38	Use 12"
	*Undetained Flows from UD-Det+ Storm Sewer Flows											
Exist Swale At												
E PL Line	6.9*	78.1*	1.70	8.00	0.040	8:1	6.00	1.20	4.00	0.81		
	*Detained Flows + Storm Sewer Flows											
*Swale 300'												
E of PL	28.9	154.7	1.70	8.00	0.040	8:1	6.00	1.60	4.80	0.85		
	*From Spreadsheet											
*Det Breach												
Flow	---	199.5	1.70	8.00	0.040	8:1	6.00	1.80	5.10	0.86		

*Flows from the development travel within a natural swale covered with rangeland grasses. No downstream manmade facilities exist.

STORM SEWER HYDRAULIC GRADELINE CALCULATION SHEET

Location	Pipe Size	Slope %	Q5	Q100	Pipe Cap	Critical d	Invert	
DPD1	30"	1.3	0.1	50.7	54.5	2.3	6855.5	Future Pond Flows
A2A	24"	0.4	5.7	12.0	15.4	1.24	6856.0	
DP2	24"	5.7	11.2	27.1	58.1	1.82	6842.1	
DP5	(3)38"x24"	1.0	24.8	94.8	44	1.36	6855.4	
DP6	(3)38"x24"	1.0	22.8	87.5	44	1.36	6841.6	

FOREBAY CALCULATIONS

Total for Basin

2% OF WQV

0.02 X 0.470 = 0.0094 AF = 409 CF

Total Flows at Forebays = 83.1 CFS (Without Time of Concentration Adjustment)

At Swale D-D

Flow at Swale D-D = 26.0 CFS

Forebay Size = (26.0/83.1)x409 = 128 CF

FOREBAY NOTCH CALCULATIONS

0.02 OF 100YR FLOW

0.02 X 26 = 0.52 CFS

W =Q/(D^1.5XC)

W=0.52/(1X3.0)=0.17 FT

At DP2

Flow at DP2 = 27.1 CFS

Forebay Size = (27.1/83.8)x409 = 133 CF

0.02 OF 100YR FLOW

0.02 X 27.1 = 0.54 CFS

W =Q/(D^1.5XC)

W=0.54/(1X3.0)=0.18 FT

At Sub-Basin A4

Flow at Sub-Basin A4 = 30.0 CFS

Forebay Size = (30.0/83.1)x409 = 148 CF

0.02 OF 100YR FLOW

0.02 X 30.0 = 0.60 CFS

W =Q/(D^1.5XC)

W=0.60/(1X3.0)=0.20 FT

PROJECT: Judge Orr Rd @ Pond
Culvert At DP1

STATION: _____

SHEET _____ OF _____

CULVERT DESIGN FORM

DESIGNER / DATE: MAB / 2/7/19

REVIEWER / DATE: _____ / _____

HYDROLOGICAL DATA

SEE ADD'L HITS.

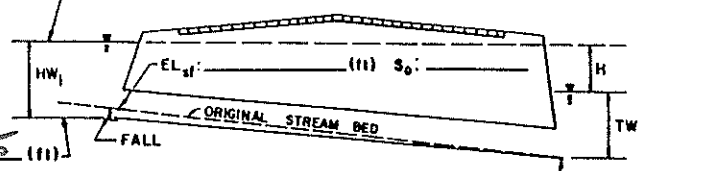
- ☐ METHOD: RATIONAL
- ☐ DRAINAGE AREA: 29.91 ☐ STREAM SLOPE: 1%
- ☐ CHANNEL SHAPE: TRAP
- ☐ ROUTING: _____ ☐ OTHER: _____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
100	39.0 (EXIST)	

EL_{hd}: _____ (ft)

ROADWAY ELEVATION: 6861.0 (ft)



EL_i 6855.5 (ft)

EL_o: _____ (ft)

$S = S_o - FALL / L_a$

S = _____

L_a = _____

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_hi (4)	OUTLET CONTROL TW (5)	d_c	(d_c+D)/2	h_o (6)	k_e	H (7)	EL_ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
HDPE 30" w/FES	39.0	39.0	1.48	3.70		59.2								61.75		

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[(1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

PIPE INLET DESIGNED FOR EXIST. COND. PIPE WILL BE CONNECTED IN THE FUTURE TO AN EXTENDED DETENTION BASIN

CULVERT BARREL SELECTED:

SIZE: _____

SHAPE: _____

MATERIAL: _____

ENTRANCE: _____

HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date
OCT. 1987

Figure
9-44

REFERENCE: Federal Highway Administration, Hydraulic Design of Highway Culverts; Hydraulic Design Series No. 5 1985

9-72

PROJECT: JUDGE ORR RD RV PARK
BASIN A2A PIPE

STATION: _____

SHEET _____ OF _____

CULVERT DESIGN FORM

DESIGNER / DATE: MAB / 4/30/19

REVIEWER / DATE: _____ / _____

HYDROLOGICAL DATA

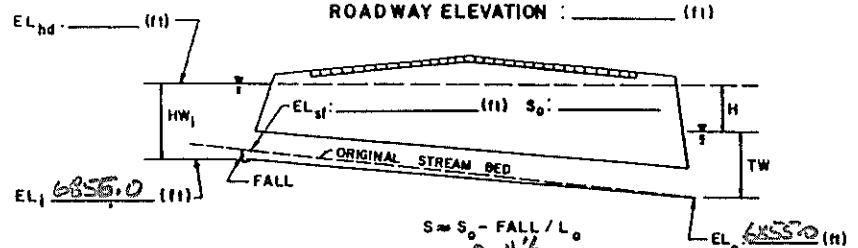
SEE ADD'L SHTS.

- ☐ METHOD: RATIONAL
- ☐ DRAINAGE AREA: 2.58 ☐ STREAM SLOPE: 1.3%
- ☐ CHANNEL SHAPE: 'V' SHAPE SWALE
- ☐ ROUTING: _____ ☐ OTHER: _____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
5	5.7	0.5
10	12.10	0.6

ROADWAY ELEVATION: _____ (ft)



$S = S_o - FALL / L_a$

$S = 0.4\%$

$L_a = 250$

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_hi (4)	OUTLET CONTROL TW (5)	d_c	(d_c+D)/2	h_o (6)	k_e	H (7)	EL_ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
24" RCP W/FES	12.10	12.10	0.9	1.8		57.8										
	5.7	5.7	0.57	1.14		57.14										

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: _____

SHAPE: _____

MATERIAL: _____

ENTRANCE: _____

HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date
OCT. 1987

Figure
9-44

REFERENCE: Federal Highway Administration, Hydraulic Design of Highway Culverts; Hydraulic Design Series No. 5 1985

REFERENCE : Federal Highway Administration, Hydraulic Design of Highway Culverts ; Hydraulic Design Series No. 5 1985

9-72

PROJECT: JUDGE ORR RD RV PARK
WEST CULVERT - RANGE FLOWER

STATION: _____

SHEET _____ OF _____

CULVERT DESIGN FORM

DESIGNER / DATE: MAC / 4/30/19

REVIEWER / DATE: _____ / _____

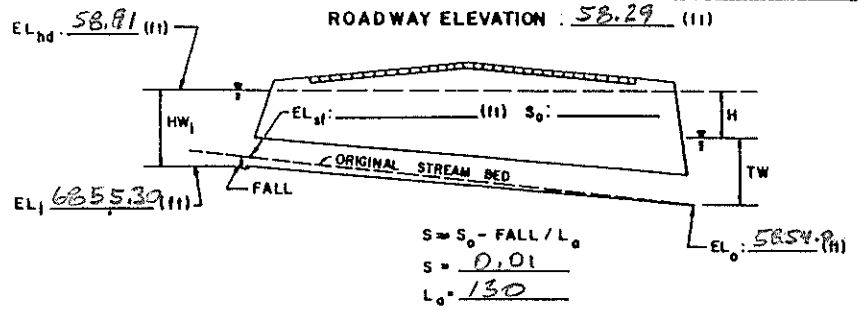
HYDROLOGICAL DATA

SEE ADD'L SHTS.

- ☐ METHOD: RATIONAL
- ☐ DRAINAGE AREA: 52.4 ☐ STREAM SLOPE: 1.6%
- ☐ CHANNEL SHAPE: TRAP.
- ☐ ROUTING: _____ ☐ OTHER: _____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
5	24.8	0.9
100	94.8	1.7



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_hi (4)	OUTLET CONTROL TW (5)	d_c	(d_c+D)/2	h_o (6)	k_e	H (7)	EL_ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
RCEP-(2)36"X24" W/HDWL	94.8	31.6	1.22	2.44		58.74	1.7	1.6	1.4	1.95	0.2	3.15	57.15	58.74		
" "	24.8	8.3	0.55	1.10		56.4	0.9	0.9	0.9	0.3	0.2	1.20	55.2	56.4		

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW /D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) EL_{hi} = HW_i + EL_i (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS :

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION :

CULVERT BARREL SELECTED :

SIZE: _____

SHAPE: _____

MATERIAL: _____

ENTRANCE: _____

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Drainage Criteria Manual

Date
OCT. 1987

Figure
9-44

PROJECT: Judge Orr Rd RV Park
EAST CULVERT - FIRE ACCESS

STATION: _____

SHEET _____ OF _____

CULVERT DESIGN FORM

DESIGNER / DATE: M Ahl / 4/30/16

REVIEWER / DATE: _____ / _____

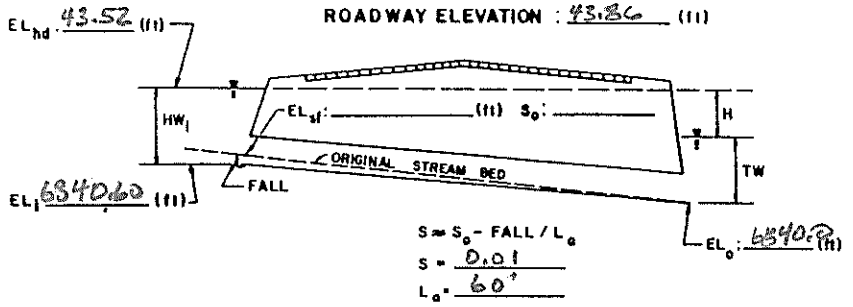
HYDROLOGICAL DATA

SEE ADD'L SHTS.

- ☐ METHOD: RATIONAL
- ☐ DRAINAGE AREA: _____ ☐ STREAM SLOPE: 1.6%
- ☐ CHANNEL SHAPE: TRAP
- ☐ ROUTING: _____ ☐ OTHER: _____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
5	22.8	0.9
100	87.5	1.7



CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	INLET CONTROL HW_i	INLET CONTROL FALL (3)	INLET CONTROL EL_hi (4)	OUTLET CONTROL TW (5)	OUTLET CONTROL d_c	OUTLET CONTROL (d_c+D)/2	OUTLET CONTROL h_o (6)	OUTLET CONTROL k_e	OUTLET CONTROL H (7)	OUTLET CONTROL EL_ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
RCBP-(2) 3'X2' w/HDWL	87.5	29.2	1.15	2.30		42.9	1.7	1.6	1.4	1.28	0.2	2.98	42.98	42.98		
	22.8	7.6	0.52	1.04		41.64	0.9	0.9	0.9	0.3	0.2	1.20	41.20	41.64		

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT BARREL SELECTED:

SIZE: _____

SHAPE: _____

MATERIAL: _____

ENTRANCE: _____

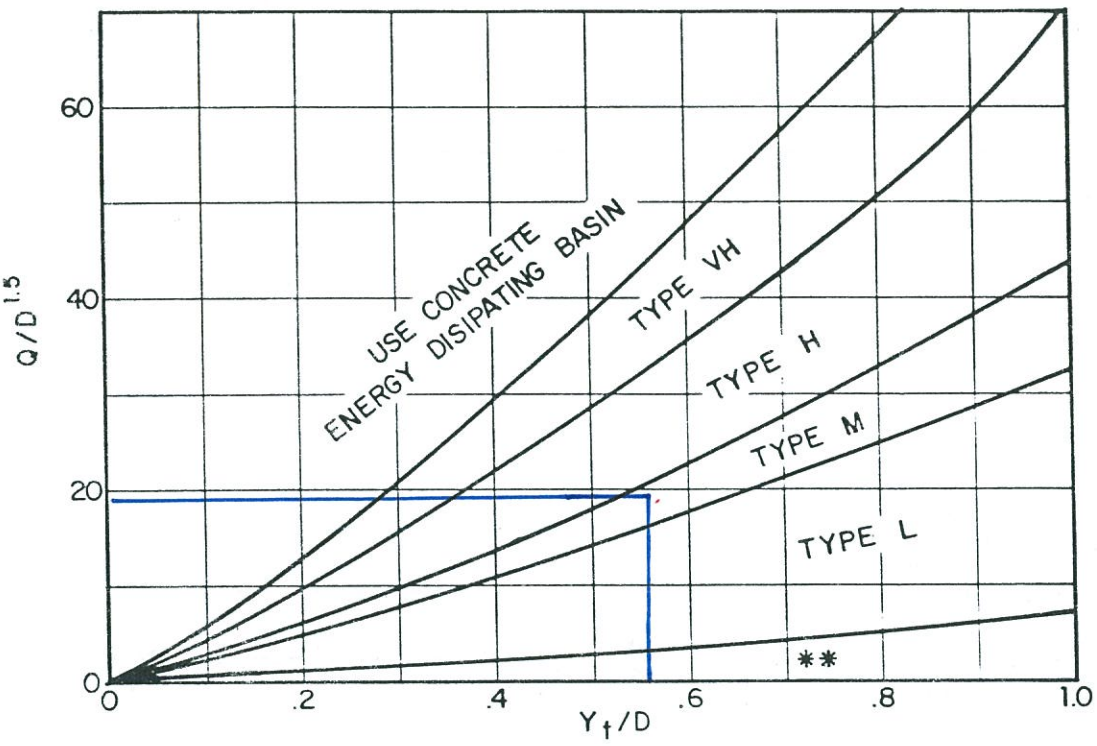
HDR Infrastructure, Inc.
A Centerra Company

The City of Colorado Springs / El Paso County
Drainage Criteria Manual

Date: OCT. 1987

Figure: 9-44

REFERENCE: Federal Highway Administration, Hydraulic Design of Highway Culverts; Hydraulic Design Series No. 5 1985



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

FOR POND 2 OUTLET PIPE

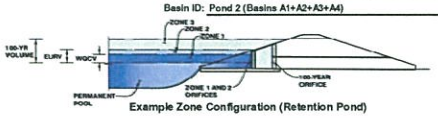
FIGURE 5-7. RIPRAP EROSION PROTECTION AT CIRCULAR CONDUIT OUTLET.

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: Judge Orr Road RV Park and Storage

Basin ID: Pond 2 (Basins A1+A2+A3+A4)



Example Zone Configuration (Retention Pond)

Required Volume Calculation

Selected BMP Type =	EDB	
Watershed Area =	29.65	acres
Watershed Length =	1,600	ft
Watershed Slope =	0.018	ft/ft
Watershed Imperviousness =	44.00%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	100.0%	percent
Percentage Hydrologic Soil Groups C/D =	0.0%	percent
Desired WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Denver - Capitol Building	
Water Quality Capture Volume (WQCV) =	0.470	acre-feet
Excess Urban Runoff Volume (EURV) =	1.380	acre-feet
2-yr Runoff Volume (P1 = 1.19 in.) =	1.099	acre-feet
5-yr Runoff Volume (P1 = 1.5 in.) =	1.517	acre-feet
10-yr Runoff Volume (P1 = 1.75 in.) =	2.109	acre-feet
25-yr Runoff Volume (P1 = 2 in.) =	3.067	acre-feet
50-yr Runoff Volume (P1 = 2.25 in.) =	3.720	acre-feet
100-yr Runoff Volume (P1 = 2.52 in.) =	4.576	acre-feet
500-yr Runoff Volume (P1 = 3.01 in.) =	6.054	acre-feet
Approximate 2-yr Detention Volume =	1.028	acre-feet
Approximate 5-yr Detention Volume =	1.424	acre-feet
Approximate 10-yr Detention Volume =	1.927	acre-feet
Approximate 25-yr Detention Volume =	2.133	acre-feet
Approximate 50-yr Detention Volume =	2.235	acre-feet
Approximate 100-yr Detention Volume =	2.532	acre-feet

Optional User Override 1-hr Precipitation

1.19	inches
1.50	inches
1.75	inches
2.00	inches
2.25	inches
2.52	inches
3.01	inches

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.470	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.910	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	1.152	acre-feet
Total Detention Basin Volume =	2.532	acre-feet
Initial Surcharge Volume (ISV) =	user	ft^3
Initial Surcharge Depth (ISD) =	user	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	user	ft
Slope of Trickle Channel (S_{TC}) =	user	ft/ft
Slopes of Main Basin Sides (S_{main}) =	user	H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =	user	

Initial Surcharge Area (A_{SV}) =	user	ft^2
Surcharge Volume Length (L_{SV}) =	user	ft
Surcharge Volume Width (W_{SV}) =	user	ft
Depth of Basin Floor (H_{FLOOR}) =	user	ft
Length of Basin Floor (L_{FLOOR}) =	user	ft
Width of Basin Floor (W_{FLOOR}) =	user	ft
Area of Basin Floor (A_{FLOOR}) =	user	ft^2
Volume of Basin Floor (V_{FLOOR}) =	user	ft^3
Depth of Main Basin (H_{MAIN}) =	user	ft
Length of Main Basin (L_{MAIN}) =	user	ft
Width of Main Basin (W_{MAIN}) =	user	ft
Area of Main Basin (A_{MAIN}) =	user	ft^2
Volume of Main Basin (V_{MAIN}) =	user	ft^3
Calculated Total Basin Volume (V_{total}) =	user	acre-feet

Depth Increment = 0.1 ft

Stage - Storage Description	Stage (ft)	Optional Override Stage (ft)	Length (ft)	Width (ft)	Area (ft^2)	Optional Override Area (ft^2)	Area (acre)	Volume (ft^3)	Volume (ac-ft)
Top of Micropool	--	0.00	--	--	--	30	0.001		
	--	0.33	--	--	--	638	0.015	104	0.002
	--	0.40	--	--	--	1,327	0.030	166	0.004
	--	0.50	--	--	--	2,016	0.046	326	0.007
	--	0.60	--	--	--	2,705	0.062	555	0.013
	--	0.70	--	--	--	3,394	0.078	853	0.020
	--	0.80	--	--	--	4,082	0.094	1,220	0.028
	--	0.90	--	--	--	4,771	0.110	1,656	0.038
	--	1.00	--	--	--	5,460	0.125	2,161	0.050
	--	1.10	--	--	--	6,149	0.141	2,734	0.063
	--	1.20	--	--	--	6,838	0.157	3,377	0.078
	--	1.30	--	--	--	7,526	0.173	4,088	0.094
	--	1.40	--	--	--	7,945	0.182	4,857	0.112
	--	1.50	--	--	--	8,364	0.192	5,669	0.130
	--	1.60	--	--	--	8,783	0.202	6,522	0.150
	--	1.70	--	--	--	9,202	0.211	7,417	0.170
	--	1.80	--	--	--	9,621	0.221	8,354	0.192
	--	1.90	--	--	--	10,040	0.230	9,333	0.214
	--	2.00	--	--	--	10,459	0.240	10,353	0.238
	--	2.10	--	--	--	10,878	0.250	11,525	0.265
	--	2.20	--	--	--	11,297	0.259	12,633	0.290
	--	2.30	--	--	--	11,716	0.269	13,784	0.316
	--	2.40	--	--	--	11,978	0.275	14,969	0.344
	--	2.50	--	--	--	12,241	0.281	16,180	0.371
	--	2.60	--	--	--	12,503	0.287	17,417	0.400
	--	2.70	--	--	--	12,766	0.293	18,680	0.429
	--	2.80	--	--	--	13,028	0.299	19,970	0.458
	--	2.90	--	--	--	13,291	0.305	21,286	0.489
	--	3.00	--	--	--	13,553	0.311	22,628	0.519
	--	3.10	--	--	--	13,816	0.317	23,997	0.551
	--	3.20	--	--	--	14,078	0.323	25,391	0.583
	--	3.30	--	--	--	14,341	0.329	26,812	0.616
	--	3.40	--	--	--	14,603	0.335	28,259	0.649
	--	3.50	--	--	--	14,866	0.341	29,733	0.683
	--	3.60	--	--	--	15,128	0.347	31,233	0.717
	--	3.70	--	--	--	15,391	0.353	32,759	0.752
	--	3.80	--	--	--	15,653	0.359	34,311	0.788
	--	3.90	--	--	--	15,916	0.365	35,889	0.824
	--	4.00	--	--	--	16,178	0.371	37,494	0.861
	--	4.10	--	--	--	16,441	0.377	39,125	0.898
	--	4.20	--	--	--	16,703	0.383	40,782	0.936
	--	4.30	--	--	--	16,966	0.389	42,466	0.975
	--	4.40	--	--	--	17,228	0.396	44,175	1.014
	--	4.50	--	--	--	17,491	0.402	45,911	1.054
	--	4.60	--	--	--	17,753	0.408	47,673	1.094
	--	4.70	--	--	--	18,016	0.414	49,462	1.135
	--	4.80	--	--	--	18,278	0.420	51,277	1.177
	--	4.90	--	--	--	18,541	0.426	53,117	1.219
	--	5.00	--	--	--	18,803	0.432	54,985	1.262
	--	5.10	--	--	--	19,066	0.438	56,878	1.306
	--	5.20	--	--	--	19,328	0.444	58,798	1.350
	--	5.30	--	--	--	19,591	0.450	60,744	1.394
	--	5.40	--	--	--	19,853	0.456	62,716	1.440
	--	5.50	--	--	--	20,116	0.462	64,714	1.486
	--	5.60	--	--	--	20,378	0.468	66,739	1.532
	--	5.70	--	--	--	20,641	0.474	68,790	1.579
	--	5.80	--	--	--	20,903	0.480	70,867	1.627
	--	5.90	--	--	--	21,166	0.486	72,971	1.675
	--	6.00	--	--	--	21,428	0.492	75,100	1.724
	--	6.10	--	--	--	21,691	0.498	77,256	1.774
	--	6.20	--	--	--	21,953	0.504	79,439	1.824
	--	6.30	--	--	--	22,216	0.510	81,647	1.874
	--	6.40	--	--	--	22,511	0.517	83,883	1.926
	--	6.50	--	--	--	22,806	0.524	86,149	1.978
	--	6.60	--	--	--	23,101	0.530	88,445	2.030
	--	6.70	--	--	--	23,396	0.537	90,769	2.084
	--	6.80	--	--	--	23,691	0.544	93,124	2.138
	--	6.90	--	--	--	23,986	0.551	95,508	2.193
	--	7.00	--	--	--	24,281	0.557	97,921	2.248
	--	7.10	--	--	--	24,576	0.564	100,364	2.304
	--	7.20	--	--	--	24,871	0.571	102,836	2.361
	--	7.30	--	--	--	25,166	0.578	105,338	2.418
	--	7.40	--	--	--	25,461	0.585	107,869	2.476
	--	7.50	--	--	--	25,757	0.591	110,430	2.535
	--	7.60	--	--	--	26,052	0.598	113,021	2.595
	--	7.70	--	--	--	26,347	0.605	115,641	2.655
	--	7.80	--	--	--	26,642	0.612	118,290	2.716
	--	7.90	--	--	--	26,937	0.618	120,969	2.777
	--	8.00	--	--	--	27,232	0.625	123,678	2.839
	--	8.10	--	--	--	27,527	0.632	126,415	2.902
	--	8.20	--	--	--	27,822	0.639	129,183	2.966
	--	8.30	--	--	--	28,117	0.645	131,980	3.030
	--	8.40	--	--	--	28,421	0.652	134,807	3.095
	--	8.50	--	--	--	28,726	0.659	137,664	3.160
	--	8.60	--	--	--	29,030	0.666	140,552	3.227
	--	8.70	--	--	--	29,335	0.673	143,470	3.294
	--	8.80	--	--	--	29,639	0.680	146,419	3.361
	--	8.90	--	--	--	29,944	0.687	149,398	3.430
	--	9.00	--	--	--	30,248	0.694	152,408	3.499
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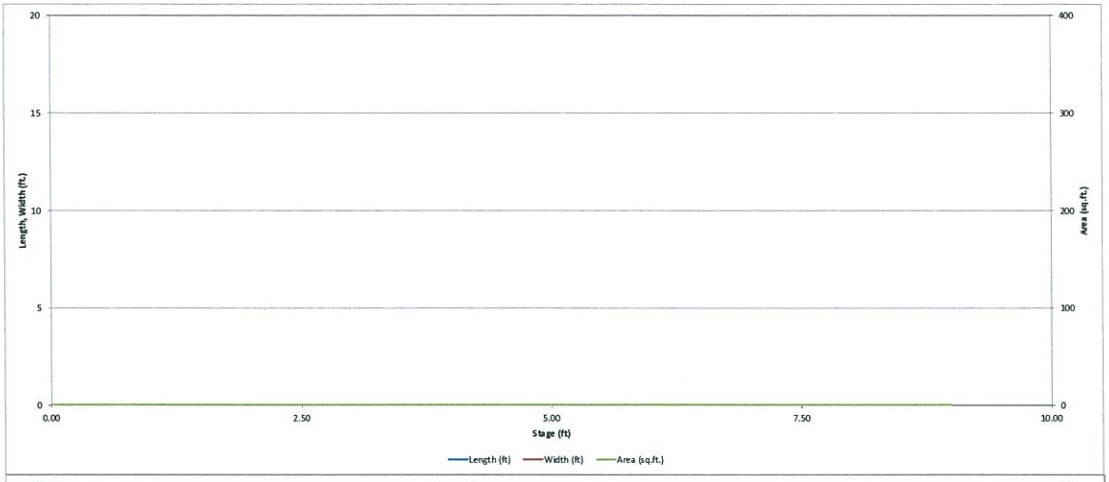
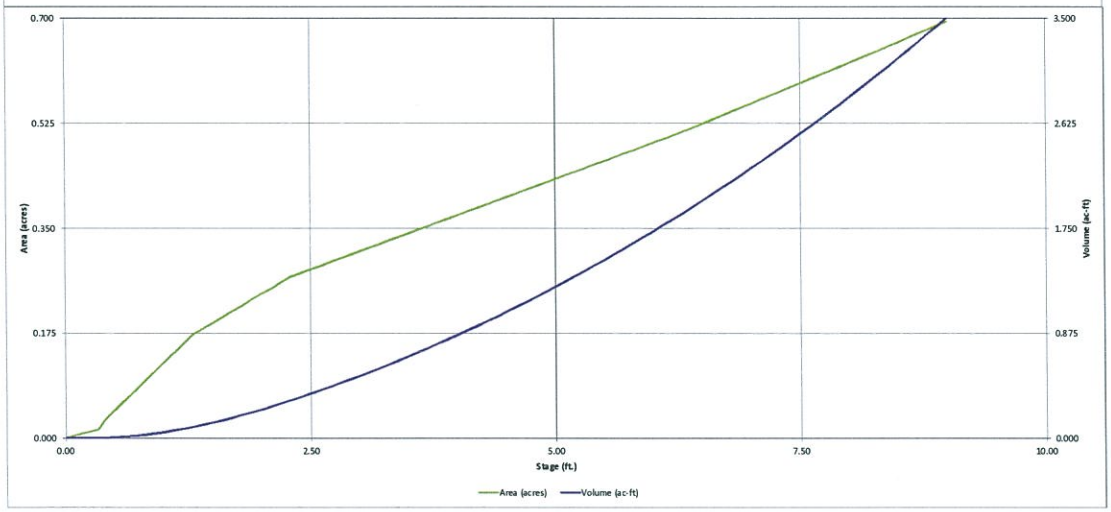
DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)



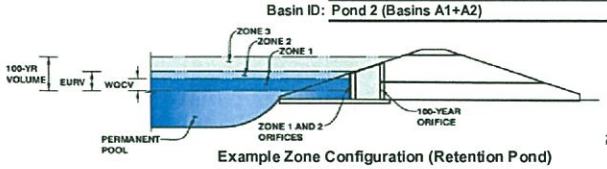


Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Project: Judge Orr Road RV Park and Storage

Basin ID: Pond 2 (Basins A1+A2)



Example Zone Configuration (Retention Pond)

	Stage (ft)	Zone Volume (ac-ft)	Outlet Type
Zone 1 (WQCV)	2.84	0.470	Orifice Plate
Zone 2 (EURV)	5.27	0.910	Orifice Plate
Zone 3 (100-year)	7.50	1.152	Weir&Pipe (Restrict)
		2.532	Total

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

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

Calculated Parameters for Underdrain

Underdrain Orifice Area =	N/A	ft^2
Underdrain Orifice Centroid =	N/A	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)

Invert of Lowest Orifice =	0.00	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Orifice Plate =	5.96	ft (relative to basin bottom at Stage = 0 ft)
Orifice Plate: Orifice Vertical Spacing =	23.80	inches
Orifice Plate: Orifice Area per Row =	2.92	sq. inches (diameter = 1-15/16 inches)

Calculated Parameters for Plate

WQ Orifice Area per Row =	2.028E-02	ft^2
Elliptical Half-Width =	N/A	feet
Elliptical Slot Centroid =	N/A	feet
Elliptical Slot Area =	N/A	ft^2

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	1.99	3.97					
Orifice Area (sq. inches)	2.92	2.92	2.92					

	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)

	Not Selected	Not Selected	
Invert of Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Depth at top of Zone using Vertical Orifice =	N/A	N/A	ft (relative to basin bottom at Stage = 0 ft)
Vertical Orifice Diameter =	N/A	N/A	inches

Calculated Parameters for Vertical Orifice

	Not Selected	Not Selected	
Vertical Orifice Area =	N/A	N/A	ft^2
Vertical Orifice Centroid =	N/A	N/A	feet

User Input: Overflow Weir (Dropbox) and Grate (Flat or Sloped)

	Zone 3 Weir	Not Selected	
Overflow Weir Front Edge Height, Ho =	5.95	N/A	ft (relative to basin bottom at Stage = 0 ft)
Overflow Weir Front Edge Length =	5.00	N/A	feet
Overflow Weir Slope =	4.00	N/A	H:V (enter zero for flat grate)
Horiz. Length of Weir Sides =	5.00	N/A	feet
Overflow Grate Open Area % =	70%	N/A	%, grate open area/total area
Debris Clogging % =	50%	N/A	%

Calculated Parameters for Overflow Weir

	Zone 3 Weir	Not Selected	
Height of Grate Upper Edge, H_t =	7.20	N/A	feet
Over Flow Weir Slope Length =	5.15	N/A	feet
Grate Open Area / 100-yr Orifice Area =	6.83	N/A	should be ≥ 4
Overflow Grate Open Area w/o Debris =	18.04	N/A	ft^2
Overflow Grate Open Area w/ Debris =	9.02	N/A	ft^2

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

	Zone 3 Restrictor	Not Selected	
Depth to Invert of Outlet Pipe =	0.00	N/A	ft (distance below basin bottom at Stage = 0 ft)
Outlet Pipe Diameter =	36.00	N/A	inches
Restrictor Plate Height Above Pipe Invert =	14.40		inches

Calculated Parameters for Outlet Pipe w/ Flow Restriction Plate

	Zone 3 Restrictor	Not Selected	
Outlet Orifice Area =	2.64	N/A	ft^2
Outlet Orifice Centroid =	0.70	N/A	feet
Half-Central Angle of Restrictor Plate on Pipe =	1.37	N/A	radians

User Input: Emergency Spillway (Rectangular or Trapezoidal)

Spillway Invert Stage=	7.50	ft (relative to basin bottom at Stage = 0 ft)
Spillway Crest Length =	40.00	feet
Spillway End Slopes =	3.00	H:V
Freeboard above Max Water Surface =	1.00	feet

Calculated Parameters for Spillway

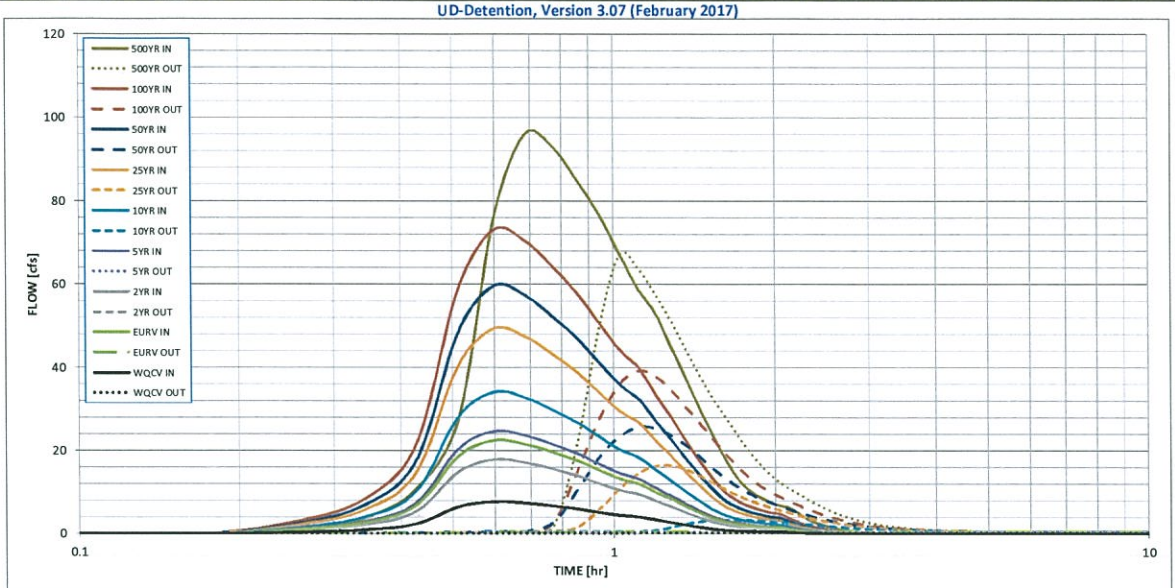
Spillway Design Flow Depth=	0.69	feet
Stage at Top of Freeboard =	9.19	feet
Basin Area at Top of Freeboard =	0.69	acres

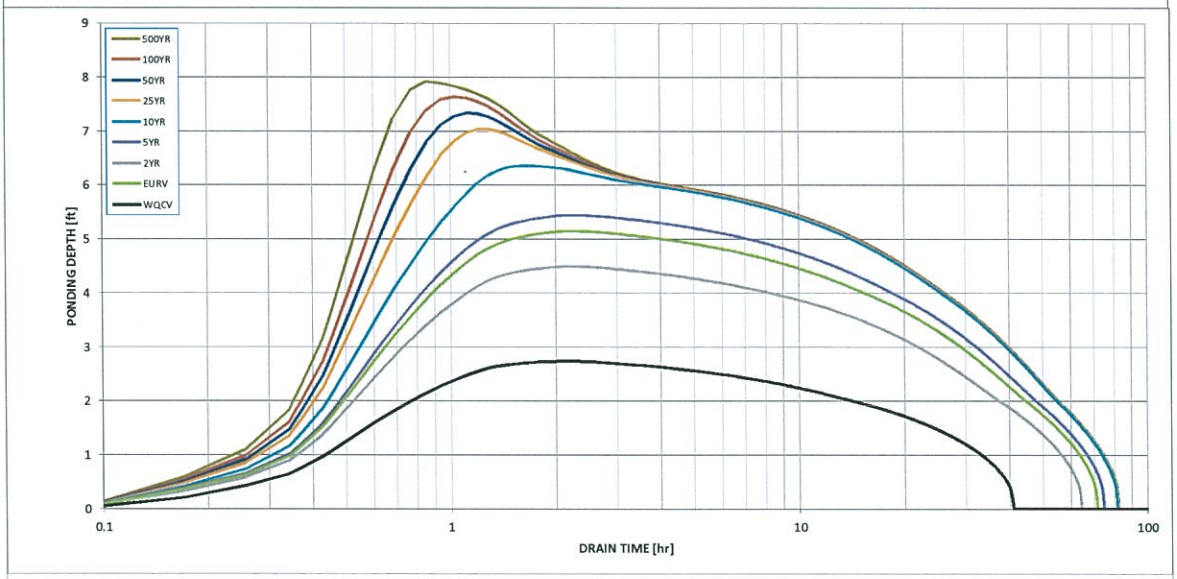
Routed Hydrograph Results

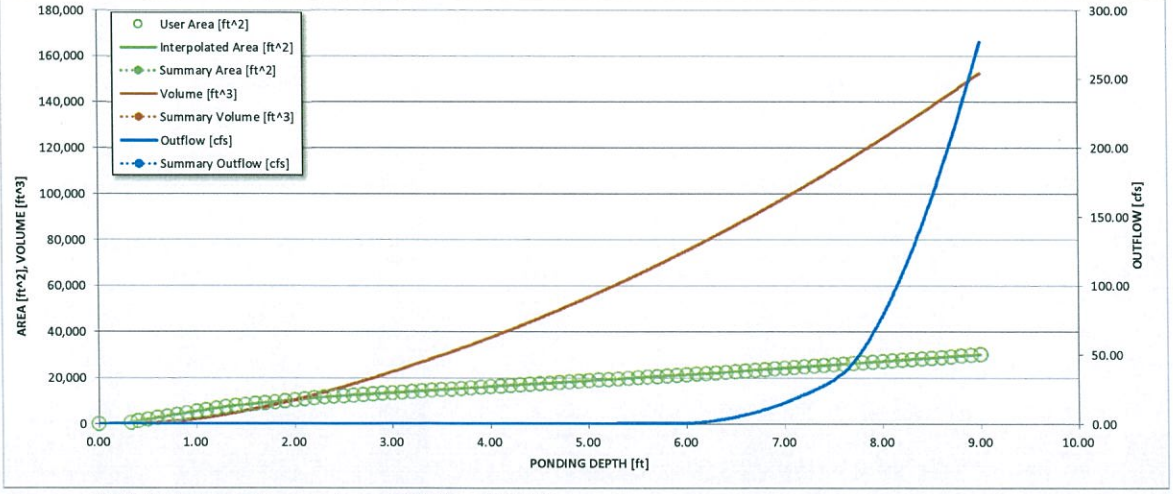
Design Storm Return Period =	WQCV	EURV	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year	500 Year
One-Hour Rainfall Depth (in) =	0.53	1.07	1.19	1.50	1.75	2.00	2.25	2.52	3.01
Calculated Runoff Volume (acre-ft) =	0.470	1.380	1.099	1.517	2.109	3.067	3.720	4.576	6.054
OPTIONAL Override Runoff Volume (acre-ft) =									
Inflow Hydrograph Volume (acre-ft) =	0.476	1.400	1.114	1.538	2.137	3.109	3.770	4.638	6.136
Predevelopment Unit Peak Flow, q (cfs/acre) =	0.00	0.00	0.01	0.02	0.20	0.65	0.91	1.22	1.73
Predevelopment Peak Q (cfs) =	0.0	0.0	0.4	0.6	5.9	19.4	26.8	36.1	51.2
Peak Inflow Q (cfs) =	7.7	22.4	17.9	24.6	34.0	49.3	59.6	73.0	95.9
Peak Outflow Q (cfs) =	0.2	0.5	0.4	0.5	3.3	16.3	25.6	39.1	67.0
Ratio Peak Outflow to Predevelopment Q =	N/A	N/A	N/A	0.9	0.6	0.8	1.0	1.1	1.3
Structure Controlling Flow =	Plate	Plate	Plate	Plate	Overflow Grate 1	Overflow Grate 1	Overflow Grate 1	Spillway	Spillway
Max Velocity through Grate 1 (fps) =	N/A	N/A	N/A	N/A	0.1	0.9	1.4	1.8	1.9
Max Velocity through Grate 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	65	59	68	72	69	67	65	60
Time to Drain 99% of Inflow Volume (hours) =	40	69	62	72	78	77	76	75	73
Maximum Ponding Depth (ft) =	2.74	5.14	4.49	5.44	6.35	7.03	7.33	7.63	7.92
Area at Maximum Ponding Depth (acres) =	0.29	0.44	0.40	0.46	0.51	0.56	0.58	0.60	0.62
Maximum Volume Stored (acre-ft) =	0.438	1.323	1.050	1.453	1.900	2.259	2.430	2.607	2.783

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)







S-A-V-D Chart Axis Override	X-axis	Left Y-Axis	Right Y-Axis
minimum bound			
maximum bound			

Detention Basin Outlet Structure Design

Outflow Hydrograph Workbook Filename:

Storm Inflow Hydrographs **UD-Detention, Version 3.07 (February 2017)**

The user can override the calculated inflow hydrographs from this workbook with inflow hydrographs developed in a separate program.

User-Defined	SOURCE	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK	WORKBOOK
Time Interval	TIME	WQCV [cfs]	EURV [cfs]	2 Year [cfs]	5 Year [cfs]	10 Year [cfs]	25 Year [cfs]	50 Year [cfs]	100 Year [cfs]	500 Year [cfs]
5.14 min	0:00:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0:05:08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrograph	0:10:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Constant	0:15:25	0.34	0.97	0.78	1.07	1.46	2.08	2.49	3.00	3.82
0.986	0:20:34	0.93	2.65	2.12	2.90	3.99	5.74	6.90	8.38	10.83
	0:25:42	2.38	6.80	5.44	7.45	10.26	14.73	17.71	21.51	27.81
	0:30:50	6.53	18.67	14.96	20.45	28.15	40.42	48.57	58.95	76.18
	0:35:59	7.72	22.41	17.89	24.59	34.04	49.25	59.55	72.96	95.90
	0:41:07	7.36	21.43	17.10	23.52	32.60	47.25	57.22	70.31	92.93
	0:46:16	6.70	19.51	15.57	21.41	29.67	43.00	52.07	64.08	84.90
	0:51:24	5.98	17.49	13.94	19.20	26.65	38.69	46.90	57.74	76.54
	0:56:32	5.15	15.17	12.07	16.67	23.18	33.76	40.99	50.54	67.14
	1:01:41	4.49	13.19	10.50	14.48	20.15	29.42	35.77	44.14	58.70
	1:06:49	4.07	11.96	9.52	13.13	18.26	26.61	32.31	39.82	52.84
	1:11:58	3.35	9.94	7.90	10.93	15.23	22.25	27.06	33.41	44.49
	1:17:06	2.72	8.17	6.48	8.99	12.57	18.40	22.40	27.70	36.94
	1:22:14	2.09	6.37	5.03	7.02	9.86	14.52	17.72	21.98	29.44
	1:27:23	1.55	4.82	3.79	5.32	7.52	11.16	13.67	17.00	22.85
	1:32:31	1.12	3.51	2.75	3.89	5.54	8.28	10.19	12.72	17.18
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	1:42:48	0.72	2.20	1.73	2.42	3.42	5.04	6.16	7.65	10.24
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	1:53:05	0.54	1.63	1.28	1.79	2.52	3.70	4.52	5.59	7.46
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	2:03:22	0.45	1.34	1.06	1.48	2.07	3.04	3.70	4.58	6.09
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	2:18:47	0.18	0.53	0.42	0.58	0.82	1.21	1.47	1.83	2.46
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	2:34:12	0.07	0.20	0.16	0.22	0.31	0.47	0.58	0.72	0.97
	2:39:20	0.05	0.15	0.11	0.16	0.23	0.34	0.42	0.52	0.70
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	2:49:37	0.02	0.06	0.05	0.07	0.10	0.15	0.19	0.24	0.32
	2:54:46	0.01	0.03	0.02	0.04	0.05	0.08	0.11	0.14	0.19
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	3:05:02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03
	3:10:11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:15:19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:20:28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:25:36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:30:44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:35:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:41:01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3:46:10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	4:27:17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	6:04:56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6:10:05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Detention Basin Outlet Structure Design

UD-Detention, Version 3.07 (February 2017)

Summary Stage-Area-Volume-Discharge Relationships

The user can create a summary S-A-V-D by entering the desired stage increments and the remainder of the table will populate automatically.

The user should graphically compare the summary S-A-V-D table to the full S-A-V-D table in the chart to confirm it captures all key transition points.

Stage - Storage Description	Stage [ft]	Area [ft^2]	Area [acres]	Volume [ft^3]	Volume [ac-ft]	Total Outflow [cfs]

For best results, include the stages of all grade slope changes (e.g. ISV and Floor) from the S-A-V table on Sheet 'Basin'.

Also include the inverts of all outlets (e.g. vertical orifice, overflow grate, and spillway, where applicable).

APPENDIX C

DETENTION POND

GEOTECHNICAL RECOMMENDATIONS

July 25, 2018

ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
FAX (719) 531-5238

William Guman & Associates, Ltd.
731 North Weber Street, Suite 10
Colorado Springs, Colorado 80903

Attn: Bill Guman

Re: Detention Pond
Judge Orr RV Park and Storage
PCD File No. PPR-18-040
El Paso County, Colorado

Dear Mr. Guman:

The detention pond referenced above will be constructed within the Judge Orr RV Park and Storage property at the southeastern corner of the proposed facility, north of the intersection of Judge Orr Road and Cessna Drive. Two soil investigations have been conducted on the property in the vicinity of the detention pond; a Soil, Geology, Geologic Hazard, and Wastewater Study dated December 12, 2016, revised July 25, 2018, Job No. 160533 and a Tactile Test Pit Observation & Septic Design Letter dated August 16, 2017, Job No. 160533. The findings and development recommendations are reported under separate covers. This letter should be used in conjunction with our Soil, Geology, Geologic Hazard, and Wastewater Study and Tactile Test Pit Observation & Septic Design Letter. This document provides recommendations for constructing a detention pond based on our investigations, laboratory testing, and requirements specified in the El Paso County Engineering Criteria Manual and the El Paso County Drainage Criteria Manual.

The soils in the vicinity of the pond were recovered from test pits and a profile hole prepared nearby. The location of the test boring/pits and the test boring/pit logs are included in the Soil, Geology, Geologic Hazard, and Wastewater Study and Tactile Test Pit Observation & Septic Design Letter. The soils recovered north of the pond were described as fine to coarse grained clayey sand loam, fine to coarse grained sand loam, and sandy clay loam to depths of 8 to 10 feet. The soils south and west of the pond were described as fine to coarse grained clayey sand loam, fine to coarse grained sand loam, and sandy clay loam to depths of 5.5 to 6 feet with underlying sandy claystone. A test boring drilled west of the pond to a depth of 20-feet encountered clayey sand to a 9-foot depth overlying very clayey sandstone. Groundwater was not encountered in the test pits and encountered at a depth of 17-feet in the test boring.

Grading Plans were not finalized, however discussions pertaining to the pond indicate that the pond embankments will be less than 10-feet with significant cuts likely. Based on the existing site topography, cuts of 6 to 9 feet are likely exposing the underlying sandstone and claystone on the western and southern portions of the pond. Laboratory testing on a sample of sandstone obtained from the test boring determined the soil to contain between approximately 9 and 98 percent of the materials passing a No. 200 sieve (SC and CL) and the bedrock to contain 46.3 percent on one sample.

The detention pond design parameters and geometry shall conform to the requirements specified in the El Paso County Engineering Criteria Manual and the El Paso County Drainage Criteria Manual. Sandstone/Claystone will likely be exposed in the southern portion of the supporting the pond embankment based on the soil investigations referenced herein. The undisturbed sandstone/claystone will provide a soil bearing capacity of 3,500 psf, and soil mitigation will likely not be required. The embankment foundation shall be fully exposed and observed by personnel of Entech to determine mitigation requirements, if any, prior to constructing the embankment. Overexcavation of expansive material may be required for the outlet works which should be field determined. Groundwater is not expected at the proposed excavated depth depending on the time of year the pond is constructed. Seasonally perched groundwater is known to exist in the area and dewatering in conjunction with soil stabilization will likely be required if groundwater is encountered during construction.

The embankment soils shall be compacted to a minimum of 95 percent of the soils maximum dry density as determined by ASTM D-1557 at ±2 percent of the soils optimum moisture content. Periodic observation and density testing will be performed during construction. Based on the suggested compaction efforts for the embankment soils and the expected foundation soils, it is likely that embankment settlement will be less than 3 percent of the embankment height.

We trust this letter has provided you with the information required to construct the proposed detention pond. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Stan C. Culp, P.E.
Senior Engineer

COLORADO REGISTERED STANLEY CLARE CULP 36723 7/25/18 PROFESSIONAL ENGINEER

Reviewed By:

Joseph C. Goede, Jr., P.E.
President

SCC/sc
Entech Job No. 181205
F:\AA projects\2018\181205\180205 dp

APPENDIX D

DESIGN CHARTS

Table 6-6. Runoff Coefficients for Rational Method
(Source: UDFCD 2001)

Land Use or Surface Characteristics	Percent Impervious	Runoff Coefficients											
		2-year		5-year		10-year		25-year		50-year		100-year	
		HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D	HSG A&B	HSG C&D
Business													
Commercial Areas	95	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.87	0.87	0.88	0.88	0.89
Neighborhood Areas	70	0.45	0.49	0.49	0.53	0.53	0.57	0.58	0.62	0.60	0.65	0.62	0.68
Residential													
1/8 Acre or less	65	0.41	0.45	0.45	0.49	0.49	0.54	0.54	0.59	0.57	0.62	0.59	0.65
1/4 Acre	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
1/3 Acre	30	0.18	0.22	0.25	0.30	0.32	0.38	0.39	0.47	0.43	0.52	0.47	0.57
1/2 Acre	25	0.15	0.20	0.22	0.28	0.30	0.36	0.37	0.46	0.41	0.51	0.46	0.56
1 Acre	20	0.12	0.17	0.20	0.26	0.27	0.34	0.35	0.44	0.40	0.50	0.44	0.55
Industrial													
Light Areas	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Heavy Areas	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Parks and Cemeteries	7	0.05	0.09	0.12	0.19	0.20	0.29	0.30	0.40	0.34	0.46	0.39	0.52
Playgrounds	13	0.07	0.13	0.16	0.23	0.24	0.31	0.32	0.42	0.37	0.48	0.41	0.54
Railroad Yard Areas	40	0.23	0.28	0.30	0.35	0.36	0.42	0.42	0.50	0.46	0.54	0.50	0.58
Undeveloped Areas													
Historic Flow Analysis--Greenbelts, Agriculture	2	0.03	0.05	0.09	0.16	0.17	0.26	0.26	0.38	0.31	0.45	0.36	0.51
Pasture/Meadow	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Forest	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50
Exposed Rock	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Offsite Flow Analysis (when landuse is undefined)	45	0.26	0.31	0.32	0.37	0.38	0.44	0.44	0.51	0.48	0.55	0.51	0.59
Streets													
Paved	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Gravel	80	0.57	0.60	0.59	0.63	0.63	0.66	0.66	0.70	0.68	0.72	0.70	0.74
Drive and Walks	100	0.89	0.89	0.90	0.90	0.92	0.92	0.94	0.94	0.95	0.95	0.96	0.96
Roofs	90	0.71	0.73	0.73	0.75	0.75	0.77	0.78	0.80	0.80	0.82	0.81	0.83
Lawns	0	0.02	0.04	0.08	0.15	0.15	0.25	0.25	0.37	0.30	0.44	0.35	0.50

Figure 6-25. Estimate of Average Concentrated Shallow Flow

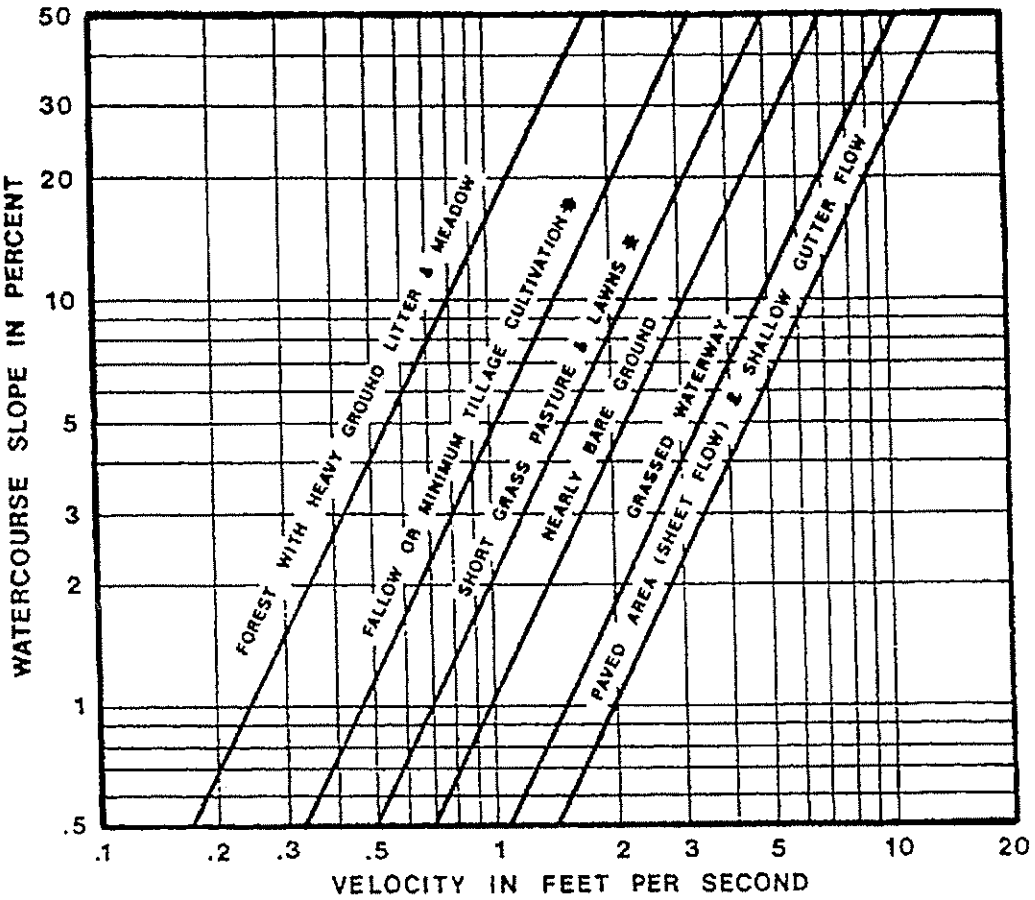
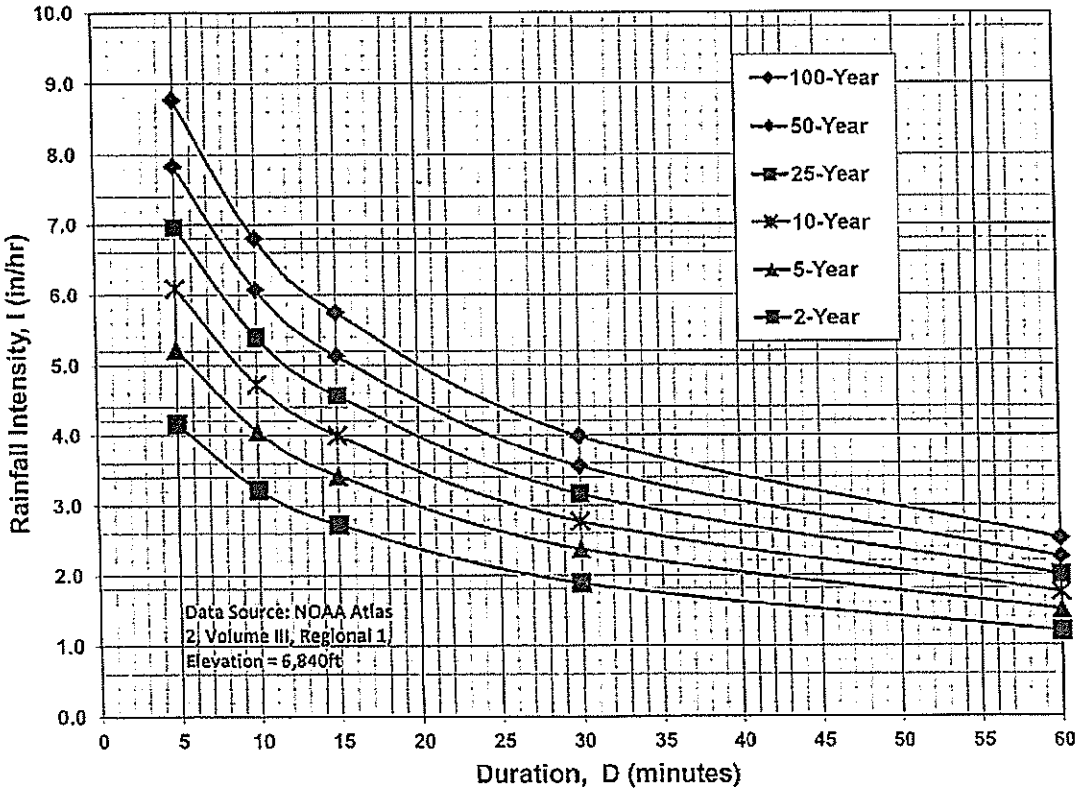


Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

$I_{100} = -2.52 \ln(D) + 12.735$

$I_{50} = -2.25 \ln(D) + 11.375$

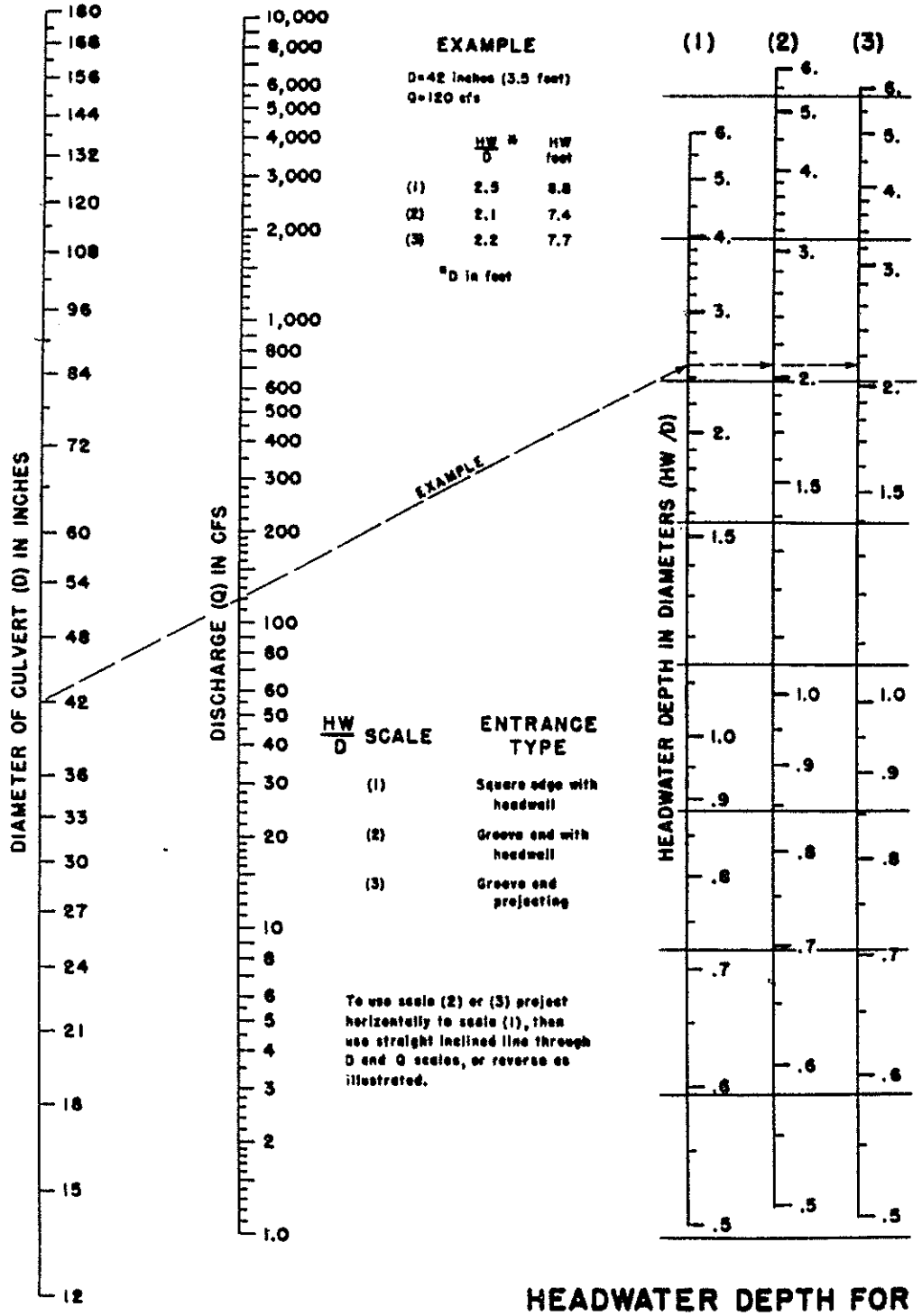
$I_{25} = -2.00 \ln(D) + 10.111$

$I_{10} = -1.75 \ln(D) + 8.847$

$I_{5} = -1.50 \ln(D) + 7.583$

$I_{2} = -1.19 \ln(D) + 6.035$

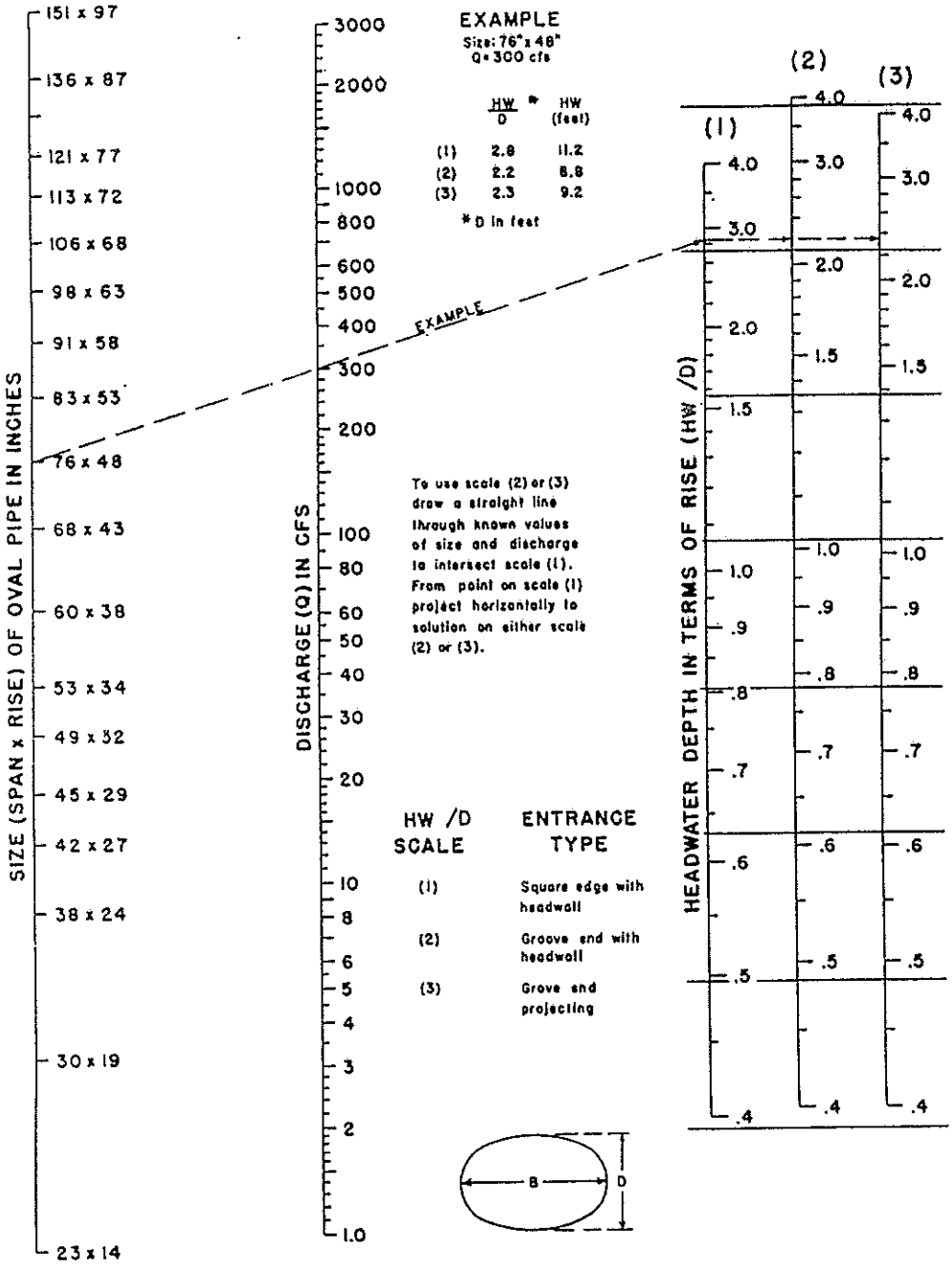
Note: Values calculated by equations may not precisely duplicate values read from figure.



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963



HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963