Update title to Final Drainage Report.

DRAINAGE PLAN AND REPORT

16140 OLD DENVER ROAD

PART OF THE NW1/4 SEC. 28, T.11S., R.67W., 6th P.M.

EL PASO COUNTY

February 3, 2017

Revised
January 5, 2018

Prepared for

All About Outdoor Storage

Oliver E. Watts, Consulting Engineer, Inc.
Colorado Springs, Colorado

Add "PCD File No. PPR-16-037"

OLIVER E. WATTS, PE-LS
OLIVER E. WATTS, CONSULTING ENGINEER, INC.
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Celebrating over 38 years in business

January 8, 2018

El Paso County D.O.T.
2880 International Circle
Colorado Springs, CO 80910

ATTN: *Gilbert LaFarge*

SUBJECT: Drainage Plan and Report
All About Outdoor Storage PPR-16-037

Transmitted herewith for your review and approval is the drainage plan and report for All About Outdoor Storage at 16140 Old Denver Road in El Paso County. This report will accompany the change in use request for subject development, as requested in you review letter of January 6, 2017. It has been revised in accordance with our meeting with you and Elizabeth Nijkamp April 17, 2017, and subsequent additional surveys performed at your request.

Please contact me if I may provide any further information.

Oliver E. Watts, Consulting Engineer, Inc.

BY: ______________________________
Oliver E. Watts, President

Encl:
- Drainage Report 4 pages
- Computations, 7 pages
- FEMA Map Panel No. 08041C0286 F
- SCS Soils Map and Interpretation Sheet
- Backup Information, 6 sheets
- Drainage Plan, Dwg 17-4958-03

1. 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 applicable 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.

Oliver E. Watts, Consulting Engineer, Inc.

____

Oliver E. Watts Colo. PE-LS No. 9853

2. OWNERS / DEVELOPER'S STATEMENT:

I the owner / developer have read and will comply with all of the requirements specified in this drainage report and plan.

All About Outdoor Storage

By: ____
16140 Old Denver Road
P.O. Box 73
Monument, CO 80132-0073

3. EL PASO COUNTY:

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

____

Jennifer Irvine, P.E., date
County Engineer / ECM Administrator

Conditions:

Discuss major drainageways and existing downstream facilities in the surrounding area.
- Which drainage basin is the site located in and does the basin have a DBPS?
Identify all nearby facilities and other obstructions which could iinfluence or be influenced by the site drainage.

4. LOCATION AND DESCRIPTION:

All About Outdoor Storage is located at 16140 Old Denver Road adjacent to the Southerly City limits for the Town of Monument in Section 26, T.11S., R.67W. of the 6th P.M. in El Paso County. A change is land use from a landscape rock yard to a RV storage use was requested, and this report is a result of the 1st County review letter of January 6, 2017. The effect of this change in use is analyzed.

The front portion of the total property is leased and used by All About Outdoor Storage, and the rear is used for equipment storage by another owner, as shown on the drainage plan. A detention pond was constructed sometime in the 1990's; however the County files could not be found.

5. FLOOD PLAIN STATEMENT:

This subdivision is not within the limits of a flood plain or flood hazard area, according to FEMA map panel number 08041C0286 F, dated March 17, l997, a copy of which is enclosed for reference.

6. METHOD AND CRITERIA:

The method used for all computations is that specified in the City-County Drainage Criteria Manual, using the rational method for areas of the size of the development. All computations are enclosed for reference and review.

The soils in the subdivision have been mapped by the local USDA/SCS office, and a soils map and interpretation sheet are enclosed for reference. All soils in this area are of hydrologic group **"B"** within the affected area.

1. Identify design storm recurrence interval.
2. Identify detention detention discharge and storage calculation method.

7. DESCRIPTION OF RUNOFF:

The major change in the development resulting from the proposed change of use is a change in the pavement over the storage site from gravel to a shaved asphalt surface, in order to mitigate dust. The site is totally graded and runoff is westerly to an existing detention pond in the southwest corner adjacent to the D&RG railroad right of way. Existing and proposed runoffs are computed contrasting the two pavement types and the detention pond is analyzed in accordance with its intended use as a full spectrum extended detention basin.

Basin A consists of the total All About Outdoor Storage property and sheet flows to the westerly boundary where the historic runoff of 15.9 cfs / 31.8 cfs (5-year / 100- year runoffs), increases to 22.7 cfs / 49.9 cfs. The historic gravel surface of this site is analyzed to represent total shaved asphaltic pavement, rolled and compacted in place over the entire property, including the entrance roadway. This runoff will sheet flow in the historic manner into the equipment storage portion of the site. No change in grading will be required, nor will drainage structures of any sort be required.

Basis B consists of the majority of the equipment storage portion of the property, and will remain in its current state, consisting of a native gravel surface with numerous pieces of construction equipment in storage. Vegetation is reclaiming the majority of this site. An existing metal building constructed in 1999 will remain in place. The total runoff will sheet flow to the existing detention pond in the southwest corner of the site. The combined historic runoff at the pond site of 19.1 cfs / 41.5 cfs will be increased to 22.7 cfs / 49.9 cfs. No additional drainage provisions will be required other than normal maintenance of existing facilities.

The UD-Detention calculation was for a sand filter basin. Revise the narrative or the calculation to match.

The existing detention pond was originally constructed in 1994 as a detention basin for peak flow mitigation, along with those of similar structures on the two adjacent northerly lots. No design details are on file. For the required full spectrum pond a water quality capture volume (WQCV) of 0.155 Acre Feet (AF) would be required, along with a 100-year detention of 1.049 AF and other required volumes as shown on the enclosed Stage-storage builder computation sheet. Based on the as-built topography shown on the enclosed drainage plan, the pond extends to a total depth of over four feet to an existing spillway in the northwest corner of the pond. The total storage in the pond to the spillway is 0.335 acre feet, with 0.572 acre feet available to the top of the embankment. There are two 8-inch drains stubbed into the pond, exiting into a 5 foot diameter vertical RCP outlet works, with an 8- inch pvc outlet works, discharging onto the owner's property to the south. This vertical outlet works and outfall pipe can accommodate the total 100-year runoff of 49.9 cfs at an elevation of 83.97, leaving a freeboard of 2.03 feet to top of pond. The 8-inch PVC outlet pipe would require replacement by a 27" HDPE to fully contain the 100-year runoff.

In order to contain the required WQCV, the pond invert is lowered one foot and enlarged to the point that the WQCV level corresponds to the top of the 60" riser. The pond above this level is further enlarged to contain the 100-year detention. The inflow hydrographs were computed and routed through the pond as shown on the enclosed detention and infiltration design data sheets. The 100 year outflow is reduced to 34.8 cfs at a depth of 2.97 feet above pond bottom. Just above that level, a spillway is provided in the form of a 6' trapezoidal channel two feet deep on a 3:1 slope to pass the complete 100-year inflow as required, in case the outlet is totally plugged.

The pond, however, shows no sign of erosion at the spillway or along the embankment, and there is no sign that the outlet pipe has ever carried runoff. It apparently has functioned adequately since its construction in 1994, giving it a current history of nearly 24 years adequate service. It would appear that the existing pervious nature of the pond bottom, supplemented by a proposed underdrain would be considerably more that the 0.05 CFS estimated, so that the total drain volumes would be less than the 32 hours required, rather that the slightly greater value shown on the printout.

Basin "C" consists of an area adjacent to the D&RG right of way that was constructed to provide a dike routing the runoff into the pond, and is a range land type cover. The runoff is 0.1cfs /0.5cfs into the right of way

8. COST ESTIMATE:
All items are private.

Item No.	Description	Quantity	Unit Cost	Cost
1	Pond Excavation	1597 CY	$ 5.00	$ 7985.00
2	Pond Embankment	28 CY	10.00	280.00
3	Modify riser pipe	LS	300.00	300.00
4	27" HDPE	38 LF	20	760.00
	Subtotal Construction Cost			$ 9325.00
	Engineering	10%		932.50
	Total Estimated Cost			$ 10257.50

9. FEES:
Fees are not applicable

Discuss maintenance access to the pond.

Add a section for the 4-step process (ECM Appendix I Section I.7.2).
List each step and under each step provide a narrative discussing how the particular step was considered/implemented.

Provide a reference section. Reference all criteria, reports, etc used for report preparation and design.

Provide a summary section. State whether or not the site will or will not adversely affect the surrounding development. State that the pond is private and identify who will own and maintain the pond.

MOVE MAJOR BASIN	SUB BASIN	AREA		BASIN		T_C MIN	I		SOIL GRP	DEV. TYPE	C		FLOW		RETURN PERIOD	
		PLANIM READ	ACRES	LENGTH	HEIGHT								qp	qp		
HISTORIC	A	COGO		100	S=2.7%	6.6									5	100
			S=1.69%	+650	V=2.6	+4.2										
			6.89			10.8	3.9	6.6	B	GRAVEL	0.59	0.70	15.9	31.8	5	100
	B		4.66	+380	V=1.7	+3.6			B	STORE	0.30	0.50				
	TOTAL		11.55			14.4	3.5	5.8	B	MIX	0.473	0.619	19.1	41.5	5	100
	C		0.35	300	1.64%	34	2.2	3.7	B	MDW	0.09	0.\36	0.1	0.5	5	100
DEVELOPED	A			100	S=2.7%	4.6			B	AC GRAV						
			S=1.69%	+650	V=2.6	+4.2										
			6.89			8.8	4.3	7.3			0.74	0.83	21.9	41.7	5	100
	B		4.66	+380		+3.6			B	STORE	0.30	0.50				
	TOTAL		11.55			12.4	3.5	6.2	B	80%	0.562	0.697	22.7	49.9	5	100

HYDROLOGICAL COMPUTATION – BASIC DATA
PROJ: 16140 OLD DENVER ROAD BY: O.E. WATTS
RATIONAL METHOD DATE: 1-27-17

OLIVER E. WATTS, CONSULTING ENGINEER, INC.
614 ELKTON DRIVE COLORADO SPRINGS, CO 80907

STREET AND STORM SEWER CALCULATIONS

STREET	LOCATION	DISTANCE	ELEVATION & SLOPE	TOTAL RUNOFF	STREET FLOW / CAPACITY	PIPE FLOW	TYPE PIPE, CATCH BASIN & SLOPE %
EXIST OUTLET			TOP=82.84	19.1/41.5		49.9	5’ DIA RCP VERT, d=0.90’
			WS 84.02 S=0.94%			49.9	8” PVC, CAP = 1.52 REPLACE 30” RCP S=0.97% MIN hi=1.65 WS=84.85

Stormwater Detention and Infiltration Design Data Sheet

Stormwater Detention and Infiltration Design Data Sheet

Stormwater Facility Name: **16140 Old Denver Road, All About Outdoor Storage, El Paso County**

Facility Location & Jurisdiction: **Full Spectrum Detention Pond** **O.E. Watts 1-8-18**

User Input: Watershed Characteristics

Watershed Slope =	0.024	ft/ft
Watershed Length =	1130	ft
Watershed Area =	11.56	acres
Watershed Imperviousness =	48.0%	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

Location for 1-hr Rainfall Depths (use dropdown):

User Input

WQCV Treatment Method = Extended Detention

1. Revise to Sand Filter per the UD-Detention worksheet.

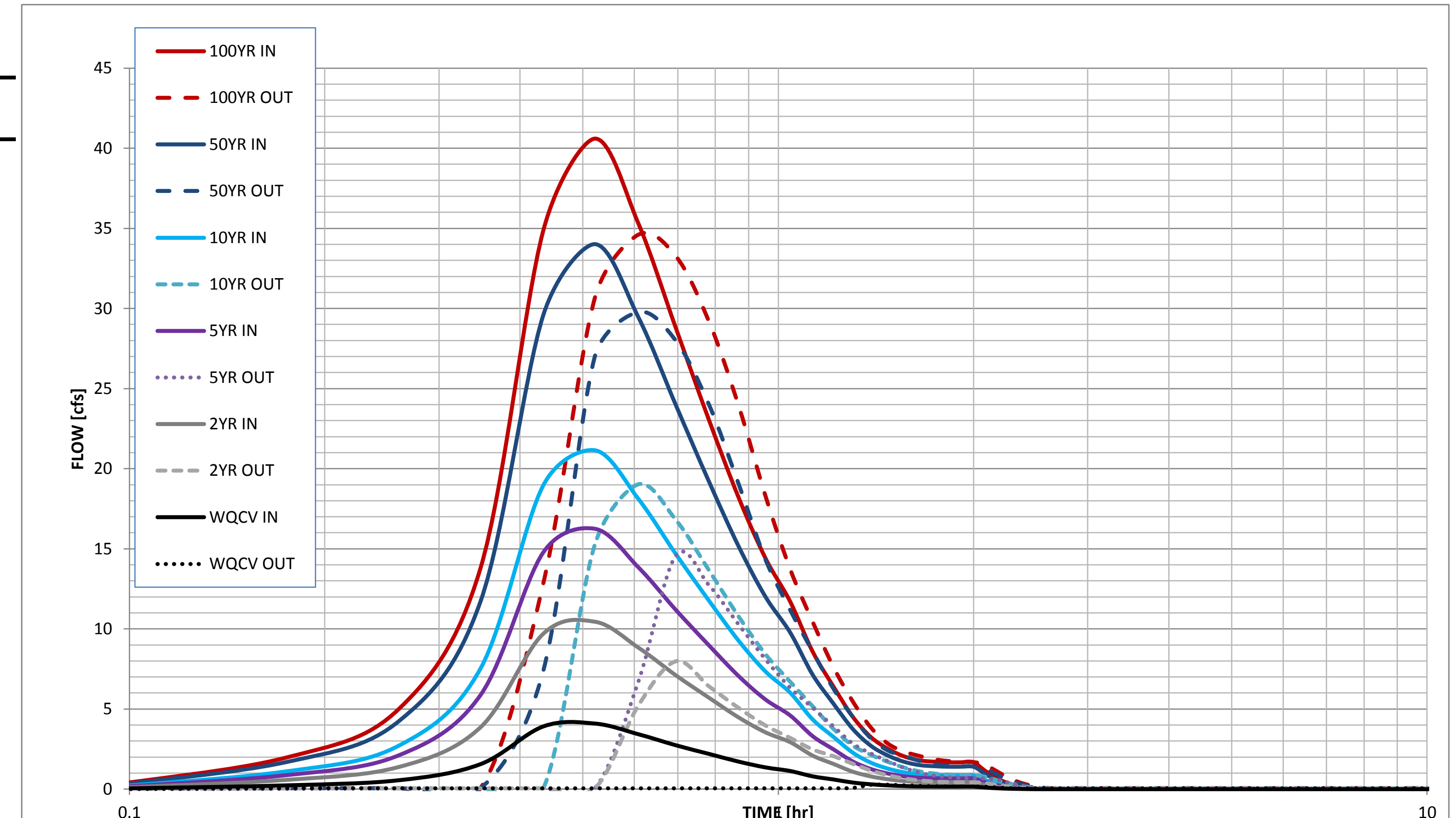
2. Remove the SDI Worksheet from the drainage report and upload it the dedicated SDI Worksheet slot in the electronic submittal.

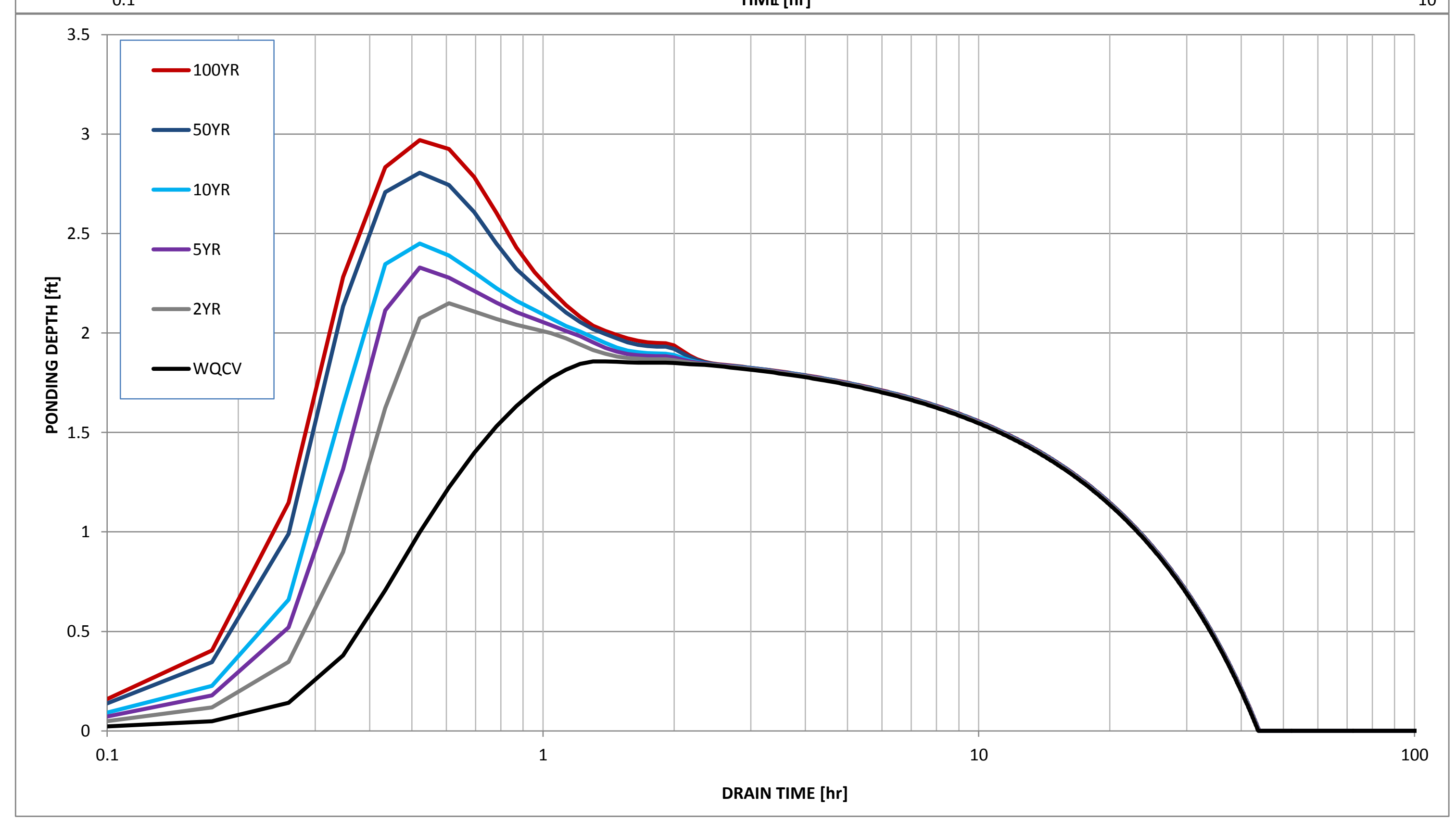
User Defined Stage [ft]	User Defined Area [ft^2]	User Defined Stage [ft]	User Defined Discharge [cfs]
0.00	0	0.00	0.00
0.01	3,340	0.01	0.05
0.50	3,718	0.50	0.05
1.00	4,112	1.00	0.05
1.50	4,522	1.50	0.05
1.84	4,812	1.84	0.05
2.00	4,984	2.00	2.49
2.50	8,381	2.50	20.89
3.00	13,262	3.00	35.56
3.50	13,942	3.50	40.51
4.00	14,636	4.00	44.92
4.50	15,345	4.50	48.93
5.00	16,068	5.00	52.63

After completing and printing this worksheet to a pdf, go to:
https://maperture.digitaldataservices.com/gvh/?viewer=cswdif
create a new stormwater facility, and
attach the pdf of this worksheet to that record.

Routed Hydrograph Results

Design Storm Return Period =	WQCV	2 Year	5 Year	10 Year	50 Year	100 Year	
One-Hour Rainfall Depth =	0.53	1.19	1.50	1.75	2.25	2.52	in
Calculated Runoff Volume =	0.191	0.489	0.762	0.994	1.600	1.912	acre-ft
OPTIONAL Override Runoff Volume =							acre-ft
Inflow Hydrograph Volume =	0.191	0.488	0.762	0.993	1.600	1.911	acre-ft
Time to Drain 97% of Inflow Volume =	42.3	40.3	**38.3**	36.7	32.3	30.1	hours
Time to Drain 99% of Inflow Volume =	43.3	42.7	42.1	41.5	40.1	**39.4**	hours
Maximum Ponding Depth =	1.86	2.15	2.33	2.45	2.81	2.97	ft
Maximum Ponded Area =	0.111	0.137	0.165	0.184	0.260	**0.297**	acres
Maximum Volume Stored =	0.173	0.207	0.234	0.256	0.334	0.380	acre-ft





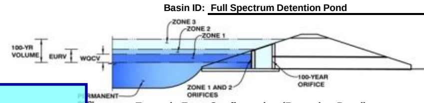
Note the corresponding actual elevation in the description.

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

UD-Detention, Version 3.07 (February 2017)

Project: All About Outdoor Storage, 16140 Old Denver Road, El Paso County, Colorado

Basin ID: Full Spectrum Detention Pond



Example Zone Configuration (Retention Pond)

Provide the calculation for the watershed imperviousness.

Required Volume Calculation

Selected BMP Type =	**SF**			
Watershed Area =	11.55	acres		
Watershed Length =	1,130	ft		
Watershed Slope =	0.024	ft/ft		
Watershed Imperviousness =	48.00%	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 =	12.0	hours		
Location for 1-hr Rainfall Depths =	User Input			
Water Quality Capture Volume (WQCV) =	0.155	acre-feet	Optional User Override 1-hr Precipitation	
Excess Urban Runoff Volume (EURV) =	0.591	acre-feet		
2-yr Runoff Volume (P1 = 1.19 in.) =	0.474	acre-feet	1.19	inches
5-yr Runoff Volume (P1 = 1.5 in.) =	0.650	acre-feet	1.50	inches
10-yr Runoff Volume (P1 = 1.75 in.) =	0.887	acre-feet	1.75	inches
25-yr Runoff Volume (P1 = 2 in.) =	1.253	acre-feet	2.00	inches
50-yr Runoff Volume (P1 = 2.25 in.) =	1.505	acre-feet	2.25	inches
100-yr Runoff Volume (P1 = 2.52 in.) =	1.836	acre-feet	2.52	inches
500-yr Runoff Volume (P1 = 0 in.) =	0.000	acre-feet		inches
Approximate 2-yr Detention Volume =	0.444	acre-feet		
Approximate 5-yr Detention Volume =	0.610	acre-feet		
Approximate 10-yr Detention Volume =	0.814	acre-feet		
Approximate 25-yr Detention Volume =	0.894	acre-feet		
Approximate 50-yr Detention Volume =	0.935	acre-feet		
Approximate 100-yr Detention Volume =	1.049	acre-feet		

Stage-Storage Calculation

Zone 1 Volume (WQCV) =	0.155	acre-feet
Zone 2 Volume (EURV - Zone 1) =	0.436	acre-feet
Zone 3 Volume (100-year - Zones 1 & 2) =	0.458	acre-feet
Total Detention Basin Volume =	1.049	acre-feet
Initial Surcharge Volume (ISV) =	N/A	ft^3
Initial Surcharge Depth (ISD) =	N/A	ft
Total Available Detention Depth (H_{total}) =	user	ft
Depth of Trickle Channel (H_{TC}) =	N/A	ft
Slope of Trickle Channel (S_{TC}) =	N/A	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_{ISV}) =	user	ft^2
Surcharge Volume Length (L_{ISV}) =	user	ft
Surcharge Volume Width (W_{ISV}) =	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 = 0.5 ft

1130

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)
Media Surface	--	0.00	--	--	--	3,341	0.077		
	--	0.50	--	--	--	3,718	0.085	1,727	0.040
6782	--	1.00	--	--	--	4,112	0.094	3,681	0.085
	--	1.50	--	--	--	4,522	0.104	5,835	0.134
6783	--	2.00	--	--	--	4,948	0.114	8,199	0.188
	--	2.50	--	--	--	8,381	0.192	11,580	0.266
6784	--	3.00	--	--	--	13,262	0.304	16,991	0.390
	--	3.50	--	--	--	13,942	0.320	23,792	0.546
6785	--	4.00	--	--	--	14,636	0.336	30,937	0.710
	--	4.50	--	--	--	15,345	0.352	38,432	0.882
6786	--	5.00	--	--	--	16,068	0.369	46,285	1.063
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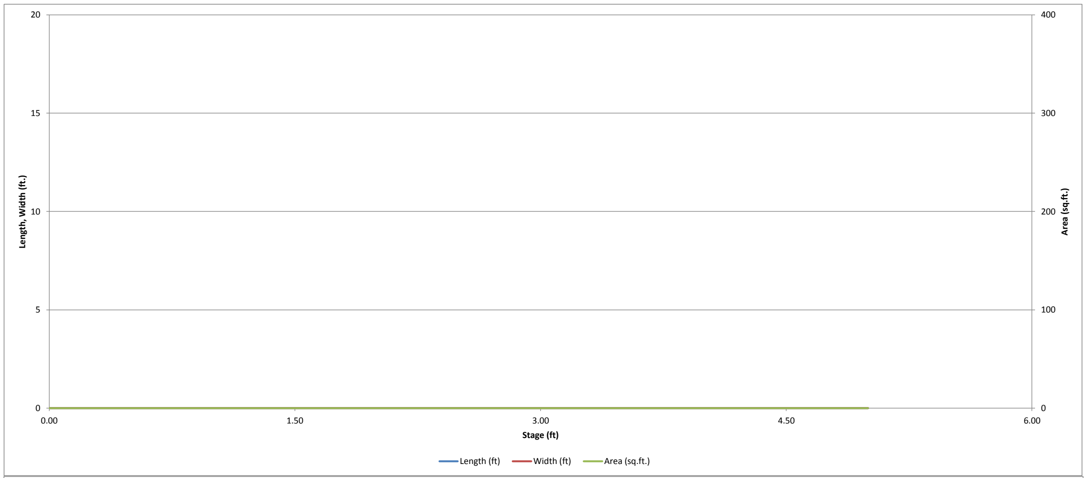
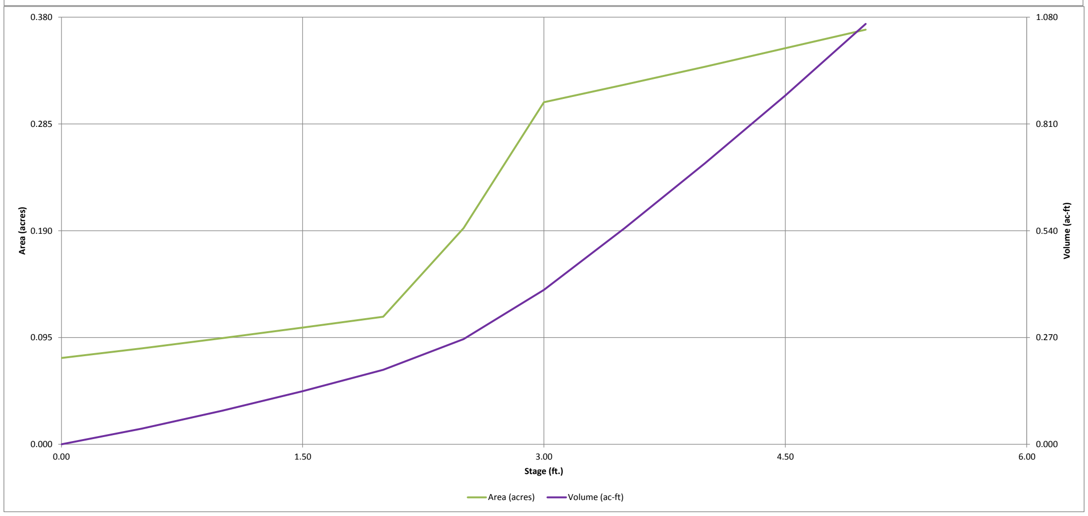
Spillway invert must be above the 100yr storage volume

Submit the outlet structure design tab of the UD-Detention worksheet.
- calculation for underdrain orifice diameter to match WQCV drain time is missing.
- The design does not appear to meet full spectrum detention. No restriction is in place to release design storm return periods below 100yr at or below historic rate.

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

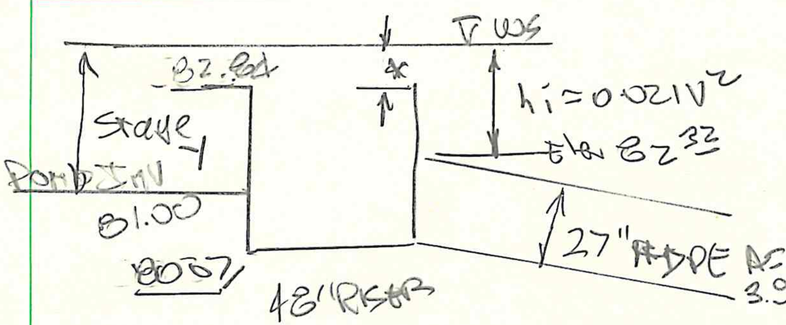
UD-Detention, Version 3.07 (February 2017)





All About Outdoors
17-4958

Outlet Capacity | OEW | 1/10/18 | 7/7



$* Q = 3.1 L h^{3/2}$ $L = 12^{57}$

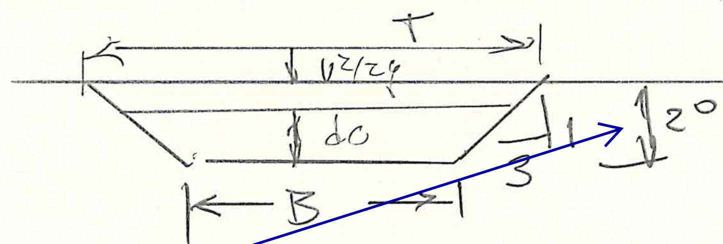
$= 38.967 h^{3/2}$

Use Q_{max} + Infiltration

Stage Y	WS Elev	48" RCP h	48" RCP Q	27" RCP h_i	27" RCP V	Q
0.00	81.00 Inv		-0-			-0-
1.84			-0-			N/A
2.00	83.00	0.16	2.49	0.68	5.69	22.63
2.50	83.50	0.66	20.89	1.18	7.50	29.80
3.00	84.00	1.16	40.68	1.68	8.94	35.56
3.50	84.50	1.66	83.34	2.18	10.19	40.61
4.00	85.00	2.16	123.70	2.68	11.30	44.92
4.50	85.50	2.66	169.05	3.18	12.30	48.93
5.00	86.00 Top	3.16	218.89	3.68	13.24	52.63

N/O (for stages 2.00–2.50); Use (for 27" RCP Q at stages 3.00–5.00)

SPILLWAY



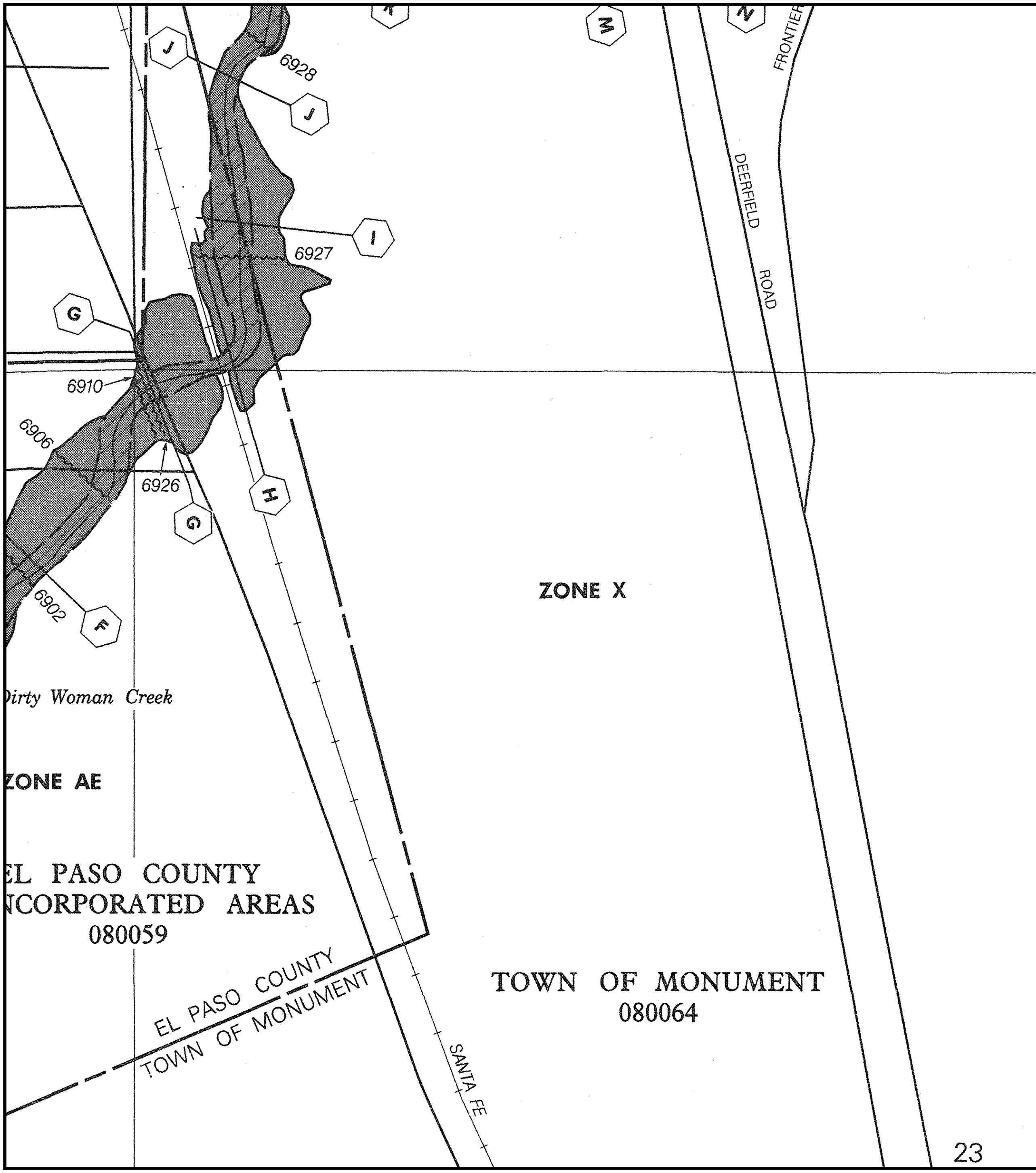
Freeboard is 2' above the spillway design flow depth.

$Q_{100} = 49.9CF$ (Q_{100} In) $FR = 1$ @ $dc = \frac{V}{\sqrt{gy}}$

$dc + V^2/2g = 2^0$ $Y = A/T$

dc	A	T	Y	$V^2/2g$	E
1^0	9^{00}	12^{00}	0.7^5	048	~~1.48~~ 48
1^5	15^{75}	15^{00}	1.0^5	0.16	1.66
1^8	20^{52}	16^{00}	1.28	0.09	1.89
1^9	22^{23}	17^{40}	1.28	0.08	1.98

Use 6 x 2 + 3:1



APPROXIMATE SCALE IN FEET

500 0 500

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 278 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

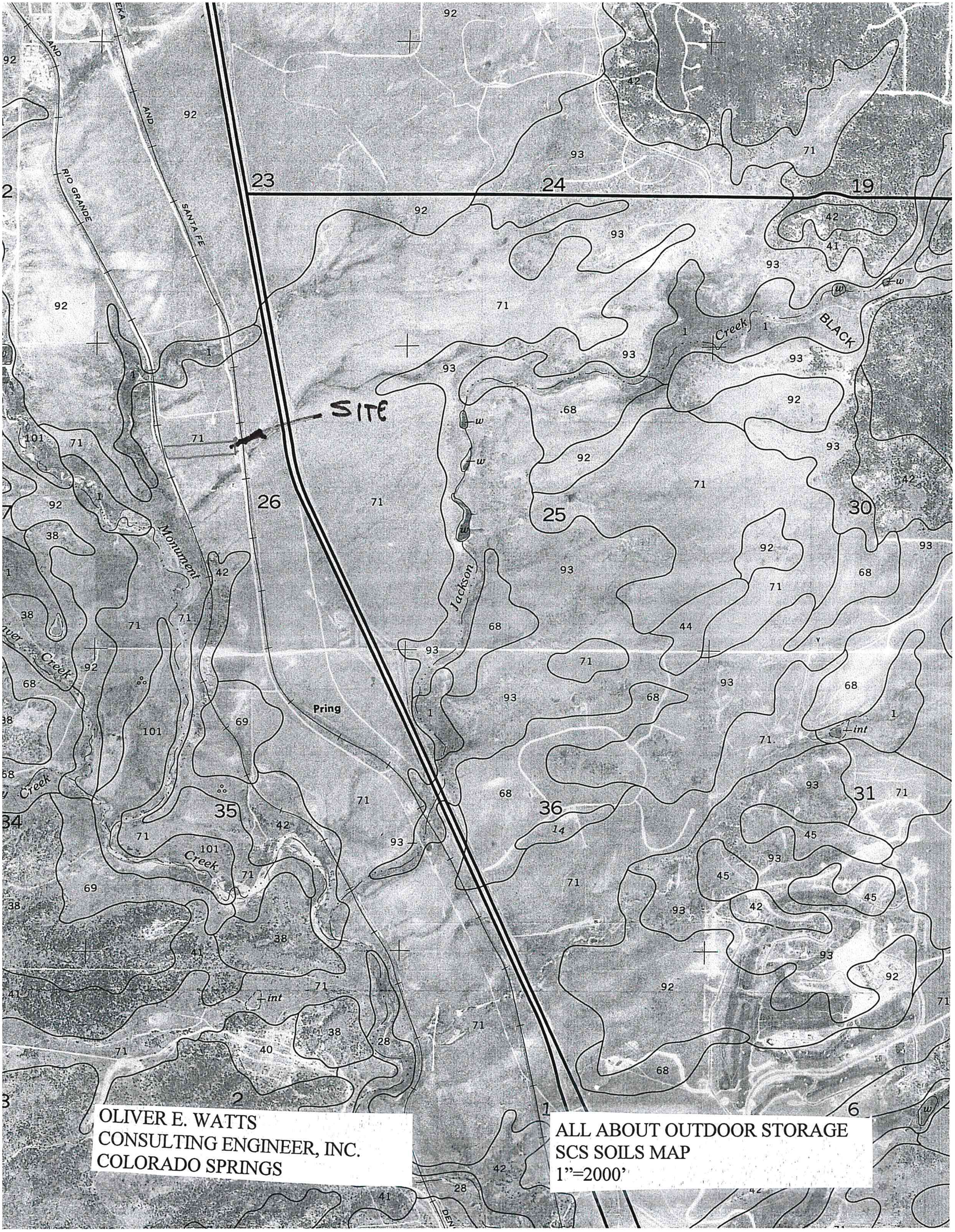
COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0278	F
MONUMENT, TOWN OF	080064	0278	F

MAP NUMBER
08041C0278 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



OLIVER E. WATTS
CONSULTING ENGINEER, INC.
COLORADO SPRINGS

ALL ABOUT OUTDOOR STORAGE
SCS SOILS MAP
1"=2000'

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
					In		
Manvel:							
50	C	None	---	---	>60	---	High.
Manzanola:							
51, 52, 53	C	None to rare	---	---	>60	---	Moderate.
Midway:							
54	D	None	---	---	10-20	Rippable	Moderate.
Nederland:							
55	B	None	---	---	>60	---	Moderate.
Nelson:							
[1]56:							
Nelson part	B	None	---	---	20-40	Rippable	Low.
Tassel part	D	None	---	---	10-20	Rippable	Low.
Neville:							
57	B	None	---	---	>60	---	High.
[1]58:							
Neville part	B	None	---	---	>60	---	High.
Rednun part	C	None	---	---	>60	---	Moderate.
Nunn:							
59	C	None	---	---	>60	---	Moderate.
Olney:							
60, 61	B	None	---	---	>60	---	Moderate.
[1]62:							
Olney part	B	None	---	---	>60	---	Moderate.
Vona part	B	None	---	---	>60	---	Moderate.
Paunsaugunt:							
[1]63:							
Paunsaugunt part	D	None	---	---	10-20	Hard	Moderate.
Rock outcrop part	D	---	---	---	---	---	---
Penrose:							
[1]64:							
Penrose part	D	None	---	---	10-20	Rippable	Low.
Manvel part	C	None	---	---	>60	---	High.
Perrypark:							
65	B	None	---	---	>60	---	Moderate.
Peyton:							
66, 67	B	None	---	---	>60	---	Moderate.
[1]68, [1]69:							
Peyton part	B	None	---	---	>60	---	Moderate.
Pring part	B	None	---	---	>60	---	Moderate.
Pits, gravel:							
70	A	---	---	---	---	---	---
Pring:							
71, 72	B	None	---	---	>60	---	Moderate.
Razor:							
73, 74	C	None	---	---	20-40	Rippable	Moderate.

See footnote at end of table.

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

3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration (t_c) consists of an initial time or overland flow time (t_i) plus the travel time (t_t) in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time (t_i) plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion (t_t) of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

$$t_c = t_i + t_t \qquad \text{(Eq. 6-7)}$$

Where:

t_c = time of concentration (min)

t_i = overland (initial) flow time (min)

t_t = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

3.2.1 Overland (Initial) Flow Time

The overland flow time, t_i, may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}} \qquad \text{(Eq. 6-8)}$$

Where:

t_i = overland (initial) flow time (min)
C_5 = runoff coefficient for 5-year frequency (see Table 6-6)
L = length of overland flow (300 ft maximum for non-urban land uses, 100 ft maximum for urban land uses)
S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time, t_t, which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time, t_t, can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_v S_w^{\ 0.5} \qquad \text{(Eq. 6-9)}$$

Where:

V = velocity (ft/s)

C_v = conveyance coefficient (from Table 6-7)

S_w = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient, C_v

Type of Land Surface	C_v
Heavy meadow	2.5
Tillage/field	5
Riprap (not buried)*	6.5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

*For buried riprap, select C_v value based on type of vegetative cover.

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration (t_c) is then the sum of the overland flow time (t_i) and the travel time (t_t) per Equation 6-7.

3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \qquad \text{(Eq. 6-10)}$$

Where:

t_c = maximum time of concentration at the first design point in an urban watershed (min)

L = waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

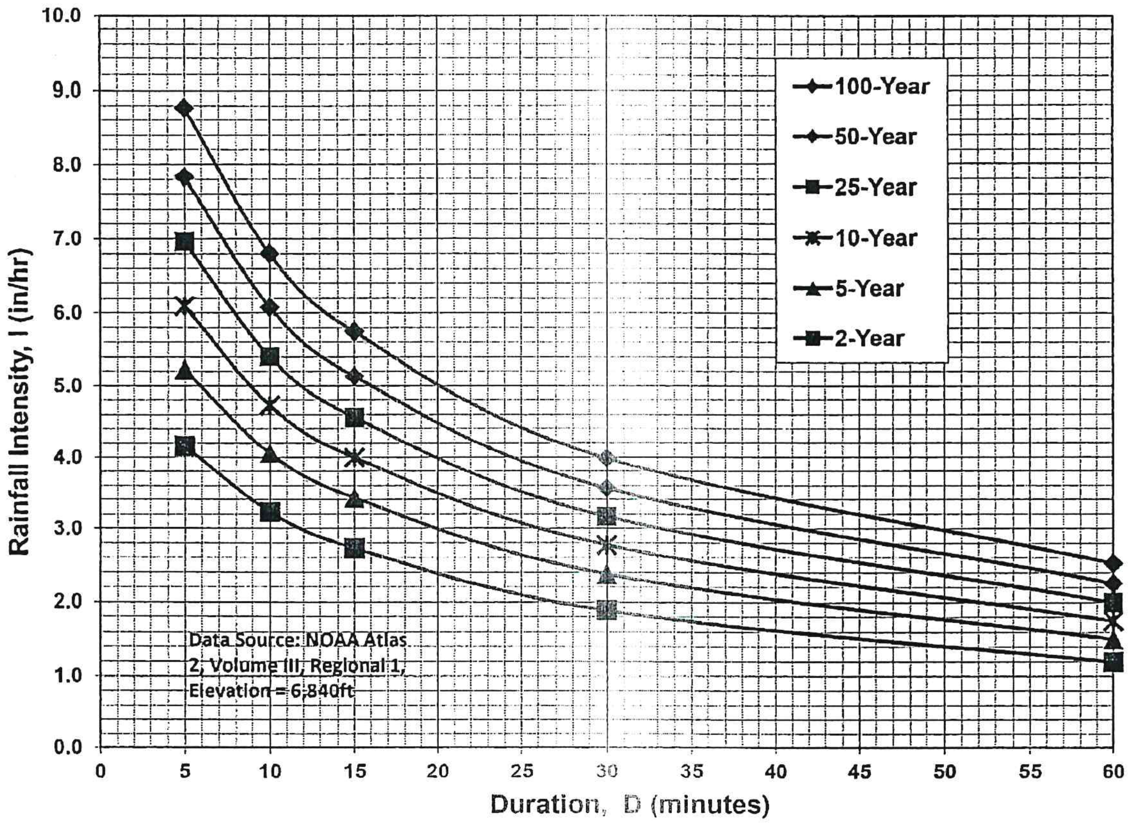
3.2.4 Minimum Time of Concentration

If the calculations result in a t_c of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum t_c for urbanized areas is 5 minutes.

3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency



IDF Equations

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

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

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

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

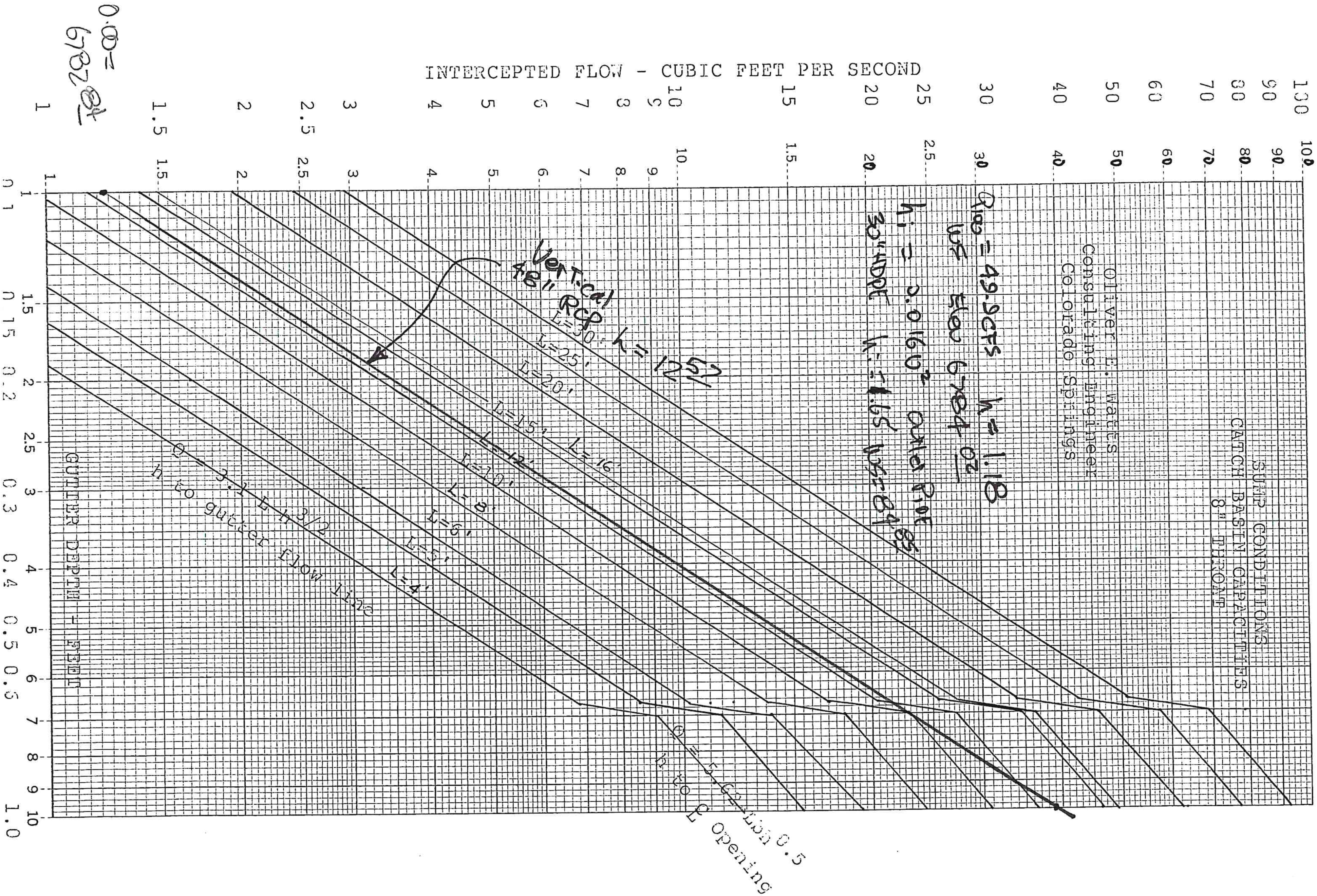
$I_{5} = -1.50 \ln(D) + 7.583$

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

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

K+E LOGARITHMIC 2 X 1 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7080



$$Q=\frac{0.463}{n}\ D^{8/3}S^{\frac{1}{2}}$$

$$Q=KS^{\frac{1}{2}}$$

DIAMETER -IN.-	AREA -FT2-	D 8/3 -FT-	K			
			N=0.010	N=0.013	N=0.024	N=0.02
2	0.02182	0.008413	0.3895	---	---	---
4	0.08727	0.053420	2.4733	---	---	---
6	0.19630	0.157500	7.2922	5.609	---	---
8	0.34910	0.339200	15.7050	12.081	---	---
10	0.54540	0.615000	28.4745	21.903	---	---
12	0.78540	1.000000	46.3000	35.615	---	---
15	1.22720	1.813100	83.9465	64.574	---	---
18	1.76710	2.948300	136.5100	105.000	56.88	52.5
21	2.40530	4.447400	205.9100	158.400	85.80	79.2
24	3.14160	6.349600	293.9900	226.140	122.49	113.
27	3.97610	8.692700	402.4700	309.590	167.70	154.7
30	4.90870	11.512600	533.0300	410.030	222.10	205.
33	5.93960	14.844100	---	528.680	---	---
36	7.06860	18.720800	866.7700	666.700	361.20	333.3
39	8.29580	23.175100	---	825.400	---	---
42	9.62110	28.238900	---	1005.000	544.80	502.5
48	12.56640	40.317500	---	1436.000	777.80	718.
54	15.90430	55.195000	---	1966.000	1065.00	983.
60	19.63500	73.100400	---	2604.000	1410.00	1302.
66	23.75830	94.254200	---	3357.000	1818.00	1678.
72	28.27430	118.869400	---	4234.000	2293.00	2117.
78	33.18310	147.152900	---	5241.000	2839.00	2620.
84	38.48450	179.306000	---	6386.000	3459.00	3193.
90	44.17860	215.524500	---	7676.000	4158.00	3838.
96	50.26550	256.000000	---	9118.000	4939.00	4559.
108	63.61730	350.466600	---	12480.000	6761.00	6140.
120	78.53980	464.158900	---	16530.000	8954.00	8265.

Oliver E. Watts
Consulting Engi
Colorado Spring

DETENTION POND VOLUMES

EXISTING

PRISMOIDAL METHOD

ORIGINAL SURFACE	EXISTING DETENTION POND
FINAL SURFACE	TOP OF POND
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	922.57 CY 0.572 AF

VOLUME BY SLICE METHOD

SLICE INTERVAL	STARTING ELEVATION	ENDING ELEVATION	CUT VOLUME	FILL VOLUME
1	6781.79 FT	6782.29 FT	0.00 CY	24.82 CY
2	6782.29 FT	6782.79 FT	0.00 CY	70.86 CY
3	6782.79 FT	6783.29 FT	0.00 CY	94.75 CY
4	6783.29 FT	6783.79 FT	0.00 CY	106.98 CY
5	6783.79 FT	6784.29 FT	0.00 CY	116.14 CY
6	6784.29 FT	6784.79 FT	0.00 CY	126.96 CY
7	6784.79 FT	6785.29 FT	0.00 CY	146.06 CY
8	6785.29 FT	6785.79 FT	0.00 CY	163.71 CY
9	6785.79 FT	6786.00 FT	0.00 CY	72.29 CY

WQCV

PRISMOIDAL METHOD

ORIGINAL SURFACE	TRY 1 POND
FINAL SURFACE	TRY 1 ELEV 82.84
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	276.46 CY = 0.171 AF

VOLUME BY SLICE METHOD

SLICE INTERVAL	STARTING ELEVATION	ENDING ELEVATION	CUT VOLUME	FILL VOLUME
1	6781.00 FT	6781.50 FT	0.00 CY	64.15 CY
2	6781.50 FT	6782.00 FT	0.00 CY	73.66 CY
3	6782.00 FT	6782.50 FT	0.00 CY	78.91 CY
4	6782.50 FT	6782.84 FT	0.00 CY	59.74 CY

TOTAL POND

PRISMOIDAL METHOD

ORIGINAL SURFACE	TRY 1 POND
FINAL SURFACE	TRY 1 TOP 6786
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	1699.63 CY 1.053 AF

VOLUME BY SLICE METHOD

SLICE INTERVAL	STARTING ELEVATION	ENDING ELEVATION	CUT VOLUME	FILL VOLUME
1	6781.00 FT	6781.50 FT	0.00 CY	64.14 CY
2	6781.50 FT	6782.00 FT	0.00 CY	73.67 CY
3	6782.00 FT	6782.50 FT	0.00 CY	78.63 CY
4	6782.50 FT	6783.00 FT	0.00 CY	88.96 CY
5	6783.00 FT	6783.50 FT	0.00 CY	110.26 CY
6	6783.50 FT	6784.00 FT	0.00 CY	211.14 CY
7	6784.00 FT	6784.50 FT	0.00 CY	247.85 CY
8	6784.50 FT	6785.00 FT	0.00 CY	263.96 CY
9	6785.00 FT	6785.50 FT	0.00 CY	272.20 CY
10	6785.50 FT	6786.00 FT	0.00 CY	288.82 CY

WQCV

FINAL SURFACE	TRY 1 ELEV 82.84
RAW FILL VOLUME	276.46 CY = 0.171 AF

PRISMOIDAL METHOD

ORIGINAL SURFACE	EXISTING GROUND LIMIT OF WORK
FINAL SURFACE	TRY 1 POND
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	1597.11 CY
RAW FILL VOLUME	27.84 CY
ASSUMED COMPACT. FACTOR	85%
HAUL TO WASTE	1564 CY

LEGEND:

- 10.5/20.4 RUNOFF IN CFS 5-YEAR/100-YEAR
- A LIMIT OF DRAINAGE BASIN AND DESIGNATION
- EXISTING STORM SEWER AS LABELED
- PROPOSED STORM SEWER AS LABELED
- 𝔅 LIMIT OF SOILS TYPE AND GROUP

EROSION CONTROL LEGEND:

- VEHICLE TRACKING CONTROL
- SILT FENCE
- SILT DAM
- UNLINED SWALE

CONTOUR LEGEND:

ORIGINAL CONTOURS:
- 1'
- 5'

FINISH CONTOURS:
- 1'
- 5'

LEGEND:

- FOUND 1/2" IRON PIPE
- FOUND YELLOW #31548 CAP ON #4 REBAR
- FOUND #4 REBAR
- FOUND ORANGE #25912 CAP ON #5 REBAR
- FOUND YELLOW #37009 CAP ON #5 REBAR
- TELEPHONE PEDESTAL
- LIGHT POLE
- RAILROAD PEDESTAL
- ELECTRICAL VAULT
- POWER POLE

N

50 0 50 100 150

Scale 1" = 50'

Contour Interval: 1'

DATUM: GPS OTHOMETRIC DATUM, 1984
BENCH MARKS ON PROPERTY CORNERS AS SHOWN

DRAWN BY: O.E.WATTS	APPROVED BY:	REVISIONS 4-28-17 ADD SEWAGE DUMP STATION OEW
DATE: 2-2-17	PROJ. NO.	1-8-18 REVISED DETENTION POND OEW
DWG. NO.: 17-4958-03	DWG.	
SURVEYED BY: OEW, ESW, 10-24-16 ,1-24-17 ,4-18-19		

OLIVER E. WATTS
CONSULTING ENGINEER
COLORADO SPRINGS

PROJECT
16140 OLD DENVER ROAD
PART NW1/4 SEC. 26, T.11S., R.67W. 6TH P.M.
EL PASO COUNTY

SHT. NAME
DRAINAGE PLAN

SHT. NO.
1 OF 1