

# DRAINAGE LETTER

## ROLLING THUNDER BUSINESS PARK, FILING 1B

A REPLAT OF LOT 11, ROLLING THUNDER BUSINESS PARK

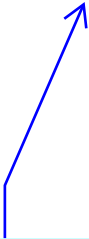
### EL PASO COUNTY

April 2, 2021

Prepared for

Ruckus Development

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



The submitted application is for a site development plan. If there will be a replat application submitted concurrently then please also add that file number to the report.

Please add PCD File No. PPR2124

**OLIVER E. WATTS, PE-LS**  
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Celebrating over 42 years in business

April 2, 2021

El Paso County Planning and Community Development  
2880 International Circle  
Colorado Springs, CO 80910

ATTN: *Jennifer Irvine, P.E.*

SUBJECT: Drainage Letter  
Rolling Thunder Business Park, Filing 1B

Transmitted herewith for your review and approval is the drainage plan and report for The Rolling Thunder Business Park, Filing No. 1B in El Paso County. This report will accompany the filing plat submittal for the Replat of Lot 11, Rolling Thunder Business Park. 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, 4 pages  
FEMA Panel No. 08041C0535 G  
SCS Soils Map and Interpretation Sheet  
Backup Information, 9 sheets  
Drainage Plan, Historic, Dwg 20-5509-08  
Drainage Plan, Developed, Dwg 20-5509-04

**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.

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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.

Ruckus Investments, LLC

By: \_\_\_\_\_  
Jeffrey Wesson  
2041 Meadowbrook Parkway  
Colorado Springs, CO 80951-4732  
660-8990

**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.,  
County Engineer / ECM Administrator

---

date

Conditions:

#### 4. LOCATION AND DESCRIPTION:

The Rolling Thunder Business Park, Filing No. 1B is located north of the intersection of Maltese Point and Rolling Thunder Way, and south of Woodmen Road, as shown on the enclosed site plan. It is a replat of Lot 11, Rolling Thunder Subdivision, and a subdivision of a portion of the NE1/4 of Section 11, Township 13 South, Range 65 West of the 6<sup>th</sup> P.M. in El Paso County, Colorado. The total size of the subdivision is 2.00 acres. Two lots are proposed: Lot 1 (1.09 ac.) Lot 2 (0.91 ac.) will each be developed with a commercial building.

Per the attached FIRM map the panel no. is 08041C0535G. Please revise

#### 5. FLOOD PLAIN STATEMENT:

This subdivision is not within the limits of a designated flood plain or flood hazard area, as identified on FEMA panel no. 08041C0545-G, dated December 7, 2018, a copy of which is enclosed for reference.

Please state the name and date of the previously approved report i.e. Rolling Thunder Business Park Preliminary /Final Drainage report by Springs Engineering, dated September 2008

#### 6. DESCRIPTION OF RUNOFF:

##### A: Existing Conditions:

As stated above, this Site was previously platted as Lot 11 in the Rolling Thunder Business Park in 2008. At that time a drainage report was submitted and approved by El Paso County, Colorado. This lot has been zoned for industrial or commercial uses since that time, and runoff was computed on that basis. The lot was rough graded and an erosion control pond, known as the "Fire House Pond" was constructed as shown on the enclosed existing conditions drainage plan, occupying approximately 3000 square feet to a depth of four feet. The historic runoff for the original ground range land condition is computed to be 0.3 cfs / 2.4 cfs) 5-year / 100- year runoffs). The outfall to the pond is a private 8 foot grated inlet and 24" RCP running westerly to a manhole, where a 30" RCP from the Lot 10 pond combines and runs south in a 36" RCP across Rolling Thunder Way.

Please also state that permanent water quality is required as disturbance is greater than 1 acre.

Water quality storage exists on the "Southwest Pond" in lot 10, westerly of this lot, as shown on the drainage plan, and in the "Tank Pond" east of this site. These ponds are shown on the drainage plan for the Rolling Thunder Business Park enclosed in the backup material of this report. Therefore, a water quality pond is required for the development of this lot.

Please state how this impervious percentage compares with the previously approved drainage report.

##### B: Proposed Conditions:

Those portions of the lot within the paved portions of Fire House View and Maltese Point will not be modified. The remainder of the lot (1.664 acre) will be developed as shown on the enclosed drainage plan, and runoff will be directed by the grading shown to a private water quality pond in the Southeast corner. The landscaped areas shown on the plan total 18,830 square feet, or 26.0% of Basin A. An impervious percentage of 75% was used for computation purposes.

18" is provided on the drainage plan. Revise

A minor (private) storm sewer is provided along the north sides of the two main buildings to provide adequate drainage capacity and prevent winter ice problems. The existing pond has been relocated to allow for optimum use of the lot. A sand filter basin is proposed which requires a total bottom area of 699 square feet at a depth of two feet with 3:1 side slopes as shown on the enclosed SFB computation form. A pond bottom area of 741.3 square feet is provided as shown on the drainage plan, and the total pond storage is 2205 cubic feet. The total runoff from the lot will be 2.8 cfs / 5.8 CFS. A 6-foot curb outlet will discharge the 100 year runoff into the pond, a standard grated inlet at the two foot level will capture the 100-year runoff and a 12" HDPE will be routed to the existing grated inlet, which will end up being in the parking lot and will be capped. The existing RCP storm sewers described above are more than adequate to convey the 100-year runoff as shown in the enclosed computations.

Please provide comparison of this flow with the flow from this site from the previously approved drainage report.

Please identify the drainage basin that the site is in.

## 7. FEES:

This Site has been previously platted; therefore fees are computed on the basis of a computed increase in impervious cover. The following is a summary of the computations:

Total developed area:	1.664 ac.
Landscaped area:	0.432 ac. 26.0%
Impervious area:	74%

Drainage Fees have been computed in accordance with the computations for the Rolling Thunder Business Park, which are enclosed in the attached back up material. The area involved is for basins D-3, D-7 and D-8 of that study with assumed an impervious area of 100%. Therefore, fees are not due for this replat.

Per the previously approved drainage report fees were calculated based on an 85% impervious area. see excerpt below. Please revise accordingly.

### ***Drainage Fees***

The proposed development falls within the Sand Creek Drainage Basin. The entire development occupies approximately 12.42 acres. Fees will be based on 11.13 acres for the business park. This area was determined by removing the existing tank site. Right-of-way adjacent to the site is 3.48 acres. Based on an 85% impervious area for the site, the area which the fees will be based on is 9.46 acres for the business park and 2.96 acres for the right-of-way.

Please provide a conclusions section and state whether or not this drainage letter is consistent with the previously approved drainage report and whether or not this development will adversely affect the downstream or adjacent properties.

MAJOR BASIN	SUB BASIN	AREA		BASIN		T <sub>c</sub> MIN	I in./hr.		SOIL GRP	DEV. TYPE	C		FLOW		RETURN PERIOD -years-	
		PLANIM READ	ACRES	LENGTH -FT.-	HEIGHT -FT.-								5-ry	100-yr		
													qp -CFS-	qp -CFS-		
EXISTING	A	COGO	1.664	300	4	29	2.4	1.1	B	R/L	0.08	0.35	0.3	2.4	5	100
DEVELOPED	A	COGO	1.664	300	3	17.1			B	75%	0.554	0.675				
				+130		+2.0										
						19.1	3.0	5.1					2.8	5.8	5	100
<b>HYDROLOGICAL COMPUTATION – BASIC DATA</b> PROJ: FOLLING THUNDER BUSINESS PARK F 1B    BY:O.E. WATTS RATIONAL METHOD                      DATE: 4/2/21   2/23/21							<b>OLIVER E. WATTS, CONSULTING ENGINEER, INC.</b> 614 ELKTON DRIVE COLORADO SPRINGS, CO 80907							PAGE 1 OF 4		

## STREET AND STORM SEWER CALCULATIONS

STREET	LOCATION	DISTANCE -ft.-	ELEVATION & SLOPE	TOTAL RUNOFF -cfs- 5-yr./100-yr	STREET FLOW / CAPACITY -cfs- 5-yr./100-yr	PIPE FLOW -cfs-	TYPE PIPE, CATCH BASIN & SLOPE %
PARKING	OUTFALL		77.0	2.8/5.8	5.8		6' CURB OUTLET d=0.46'
		6	3:1				
	POIND		75.0				
	GRATE		TOP=77.0 INV=75.5		5.8	5.8	FB GRATE h=0.4' ok
		33.27	6.64%			5.8	18" HDPE
	EXIST. O/L		73.29				hi=0.16V2=0.17' < 0.4
STREET AND STORM SEWER CALCULATIONS PROJECT: ROLLING THUNDER BUS. PK #1b BY: O.E. WATTS				OLIVER E. WATTS, CONSULTING ENGINEER, INC. 614 ELKTON DRIVE COLORADO SPRINGS, CO 80907			Page:2 Of Pages:4
DATE: 2/23/21							

# Design Procedure Form: Sand Filter (SF)

UD-BMP (Version 3.07, March 2018)

Sheet 1 of 2

Designer: OE Watts  
 Company: \_\_\_\_\_  
 Date: February 18, 2021  
 Project: Old Pond  
 Location: 10755 McElroy

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## 1. Basin Storage Volume

- A) Effective Imperviousness of Tributary Area,  $I_a$   
 (100% if all paved and roofed areas upstream of sand filter)
- B) Tributary Area's Imperviousness Ratio ( $i = I_a/100$ )
- C) Water Quality Capture Volume (WQCV) Based on 12-hour Drain Time  
 $WQCV = 0.8 * (0.91 * i^3 - 1.19 * i^2 + 0.78 * i)$
- D) Contributing Watershed Area (including sand filter area)
- E) Water Quality Capture Volume (WQCV) Design Volume  
 $V_{WQCV} = WQCV / 12 * Area$
- F) For Watersheds Outside of the Denver Region, Depth of Average Runoff Producing Storm
- G) For Watersheds Outside of the Denver Region, Water Quality Capture Volume (WQCV) Design Volume
- H) User Input of Water Quality Capture Volume (WQCV) Design Volume  
 (Only if a different WQCV Design Volume is desired)

$I_a = 75.0$  %

$i = 0.750$

WQCV = 0.24 watershed inches

Area = 74,585 sq ft

$V_{WQCV} =$  cu ft

$d_s = 3.00$  in

$V_{WQCV \text{ OTHER}} = 10,391$  cu ft

$V_{WQCV \text{ USER}} =$  cu ft

## 2. Basin Geometry

- A) WQCV Depth
- B) Sand Filter Side Slopes (Horizontal distance per unit vertical, 4:1 or flatter preferred). Use "0" if sand filter has vertical walls.
- C) Minimum Filter Area (Flat Surface Area)
- D) Actual Filter Area
- E) Volume Provided

$D_{WQCV} = 2.0$  ft

$Z = 3.00$  ft / ft

DIFFICULT TO MAINTAIN, INCREASE WHERE POSSIBLE

$A_{Min} = 699$  sq ft

$A_{Actual} =$  sq ft

$V_T =$  cu ft

## 3. Filter Material

Please identify the filter media

- Choose One
- ☐ 18" CDOT Class B or C Filter Material
- ☐ Other (Explain):

## 4. Underdrain System

- A) Are underdrains provided?
- B) Underdrain system orifice diameter for 12 hour drain time
- i) Distance From Lowest Elevation of the Storage Volume to the Center of the Orifice
- ii) Volume to Drain in 12 Hours
- iii) Orifice Diameter, 3/8" Minimum

Please identify the underdrain system to be used.

Choose One

- ☐ YES
- ☐ NO

$y =$  ft

$Vol_{12} =$  cu ft

$D_o =$  in



# Design Procedure Form: Sand Filter (SF)

Sheet 2 of 2

Designer: \_\_\_\_\_  
Company: \_\_\_\_\_  
Date: February 18, 2021  
Project: PLD Pond  
Location: \_\_\_\_\_

4/4

## 5. Impermeable Geomembrane Liner and Geotextile Separator Fabric

A) Is an impermeable liner provided due to proximity of structures or groundwater contamination?

Please choose one

Choose One

☐ YES ☐ NO

## 6. Inlet / Outlet Works

A) Describe the type of energy dissipation at inlet points and means of conveying flows in excess of the WQCV through the outlet

Notes:



# National Flood Hazard Layer FIRMeTte



38°56'37.30"N



## 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, Areas 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		Area of Minimal Flood Hazard Zone X
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone I
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		Cross Sections with 1% Annual Chance Water Surface Elevation
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent 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 1/22/2020 at 12:00:29 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.



OLIVER E. WATTS  
CONSULTING ENGINEER, INC.  
COLORADO SPRINGS

ROLLING THUNDER BUSINESS PARK  
FILING NO. 1B  
SOILS MAP  
1"=2000'





TABLE 16.--SOIL AND WATER FEATURES

[Absence of an entry indicates the feature is not a concern. See "flooding" in Glossary for definition of terms as "rare," "brief," and "very brief." The symbol > means greater than]

Soil name and map symbol	Hydro-logic group	Flooding			Bedrock		Potential frost action
		Frequency	Duration	Months	Depth	Hardness	
Alamosa: 1-----	C	Frequent-----	Brief-----	May-Jun	In >60	---	High.
Ascalon: 2, 3-----	B	None-----	---	---	>60	---	Moderate.
Badland: 4-----	D	---	---	---	---	---	---
Bijou: 5, 6, 7-----	B	None-----	---	---	>60	---	Low.
Blakeland: 8-----	A	None-----	---	---	>60	---	Low.
19: Blakeland part-----	A	None-----	---	---	>60	---	Low.
Fluvaquentic Haplaquolls part-----	D	Common-----	Very brief----	Mar-Aug	>60	---	High.
Blendon: 10-----	B	None-----	---	---	>60	---	Moderate.
Bresser: 11, 12, 13-----	B	None-----	---	---	>60	---	Low.
Brussett: 14, 15-----	B	None-----	---	---	>60	---	Moderate.
Chaseville: 16, 17-----	A	None-----	---	---	>60	---	Low.
118: Chaseville part-----	A	None-----	---	---	>60	---	Low.
Midway part-----	D	None-----	---	---	10-20	Rippable	Moderate.
Columbine: 19-----	A	None to rare	---	---	>60	---	Low.
Connerton: 120: Connerton part-----	B	None-----	---	---	>60	---	High.
Rock outcrop part-----	D	---	---	---	---	---	---
Cruckton: 21-----	B	None-----	---	---	>60	---	Moderate.
Cushman: 22, 23-----	C	None-----	---	---	20-40	Rippable	Moderate.
124: Cushman part-----	C	None-----	---	---	20-40	Rippable	Moderate.
Kutch part-----	C	None-----	---	---	20-40	Rippable	Moderate.
Elbeth: 25, 26-----	B	None-----	---	---	>60	---	Moderate.
127: Elbeth part-----	B	None-----	---	---	>60	---	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
<b>Business</b>													
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
<b>Residential</b>													
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
<b>Industrial</b>													
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
<b>Parks and Cemeteries</b>													
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
<b>Undeveloped Areas</b>													
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
<b>Streets</b>													
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
<b>Drive and Walks</b>													
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.

$$t_c = t_i + t_t$$

(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.

$$t_i = \frac{0.395(1.1 - C_s)\sqrt{L}}{S^{0.33}}$$

(Eq. 6-8)

Where:

 $t_i$  = overland (initial) flow time (min) $C_s$  = 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).

$$V = C_v S_w^{0.5}$$

(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 ( $t_o$ ) 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.

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

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

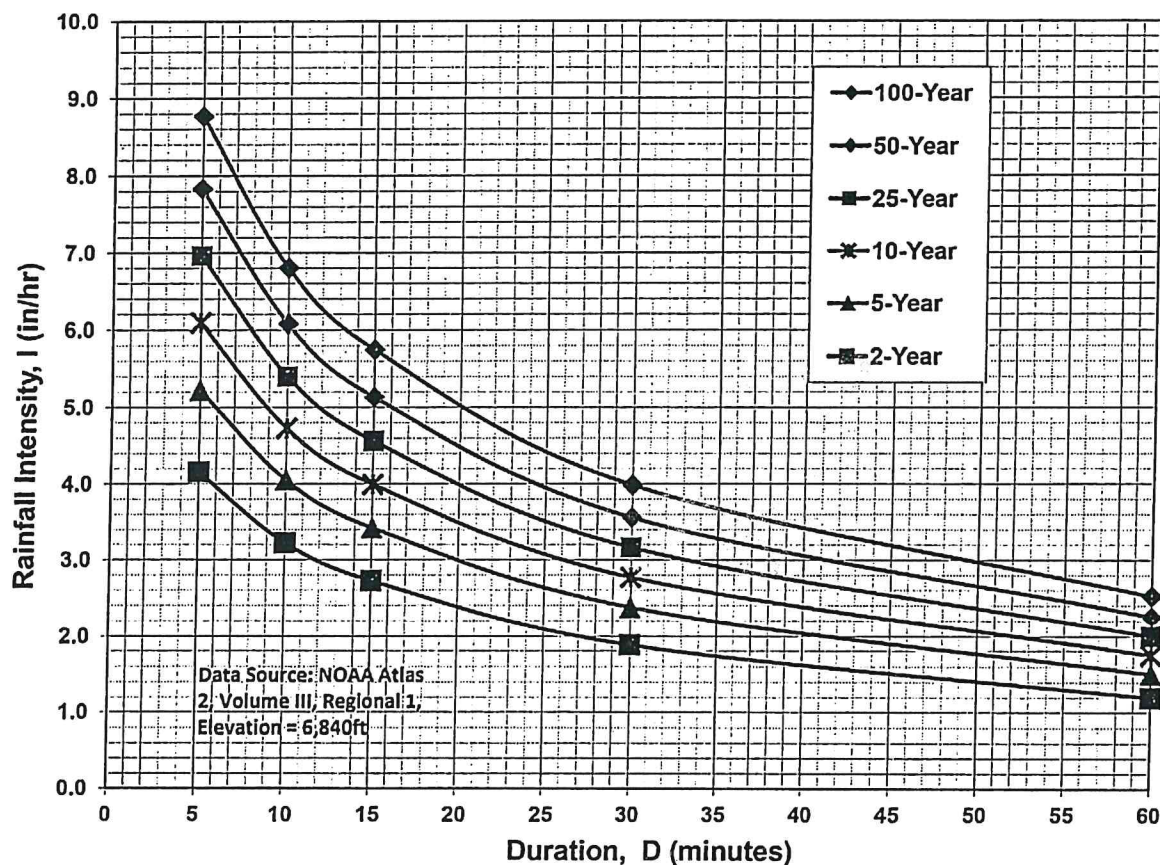
If the calculations result in a  $t_c$  of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum  $t_c$  for urbanized areas is 5 minutes.

### 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.



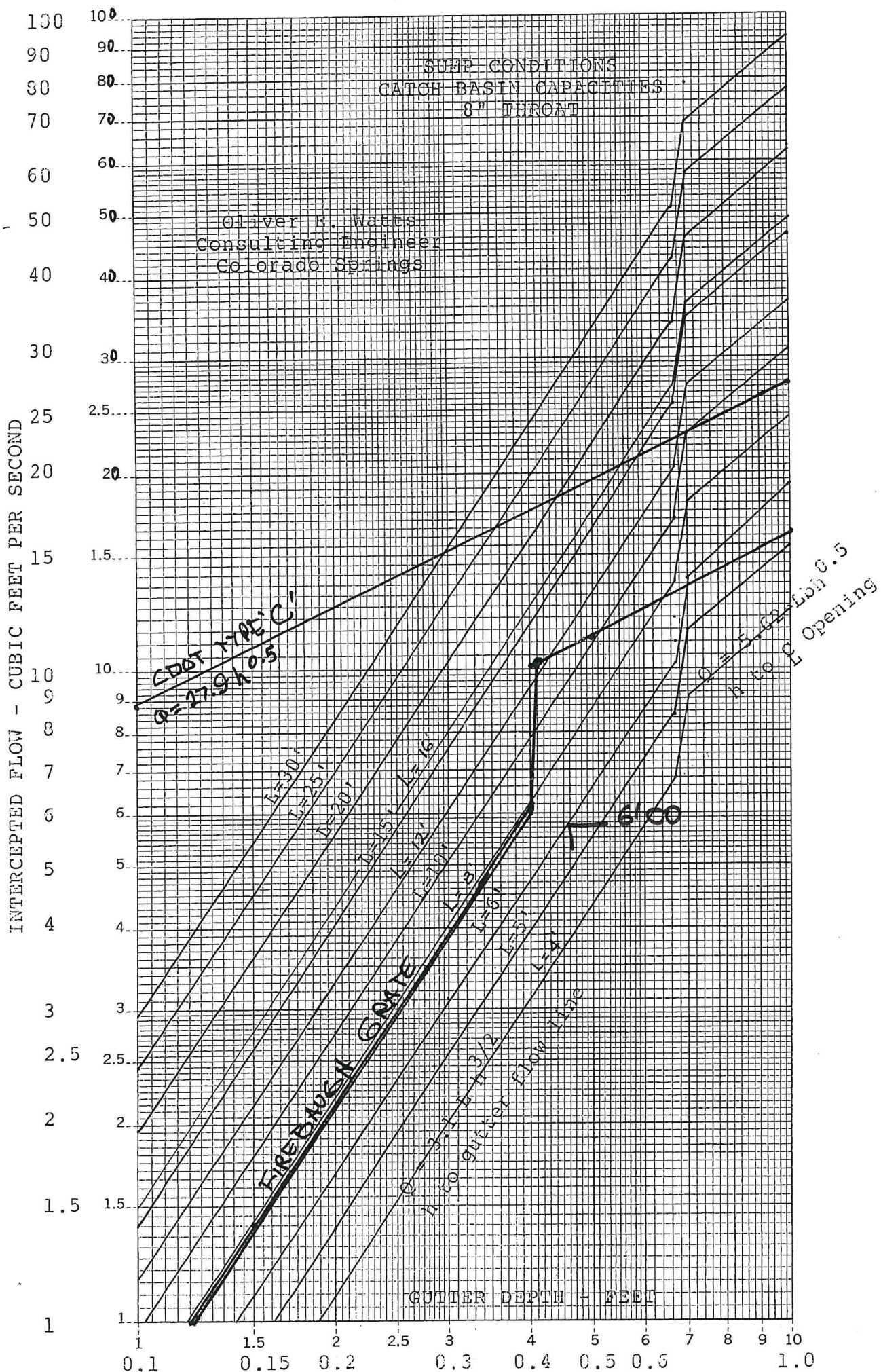
$$Q = \frac{0.463}{n} D^{8/3} S^{1/2}$$

$$Q = KS^{1/2}$$

DIAMETER - IN. -	AREA - FT <sup>2</sup> -	D 8/3 - FT -	K			
			N=0.010	N=0.013	N=0.024	N=0.026
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	52.50
21	2.40530	4.447400	205.9100	158.400	85.80	79.20
24	3.14160	6.349600	293.9900	226.140	122.49	113.07
27	3.97610	8.692700	402.4700	309.590	167.70	154.79
30	4.90870	11.512600	533.0300	410.030	222.10	205.02
33	5.93960	14.844100	---	528.680	---	---
36	7.06860	18.720800	866.7700	666.700	361.20	333.30
39	8.29580	23.175100	---	825.400	---	---
42	9.62110	28.238900	---	1005.000	544.80	502.50
48	12.56640	40.317500	---	1436.000	777.80	718.00
54	15.90430	55.195000	---	1966.000	1065.00	983.00
60	19.63500	73.100400	---	2604.000	1410.00	1302.00
66	23.75830	94.254200	---	3357.000	1818.00	1678.00
72	28.27430	118.869400	---	4234.000	2293.00	2117.00
78	33.18310	147.152900	---	5241.000	2839.00	2620.00
84	38.48450	179.306000	---	6386.000	3459.00	3193.00
90	44.17860	215.524500	---	7676.000	4158.00	3838.00
96	50.26550	256.000000	---	9118.000	4939.00	4559.00
108	63.61730	350.466600	---	12480.000	6761.00	6140.00
120	78.53980	464.158900	---	16530.000	8954.00	8265.00

Oliver E. Watts  
Consulting Engineer  
Colorado Springs

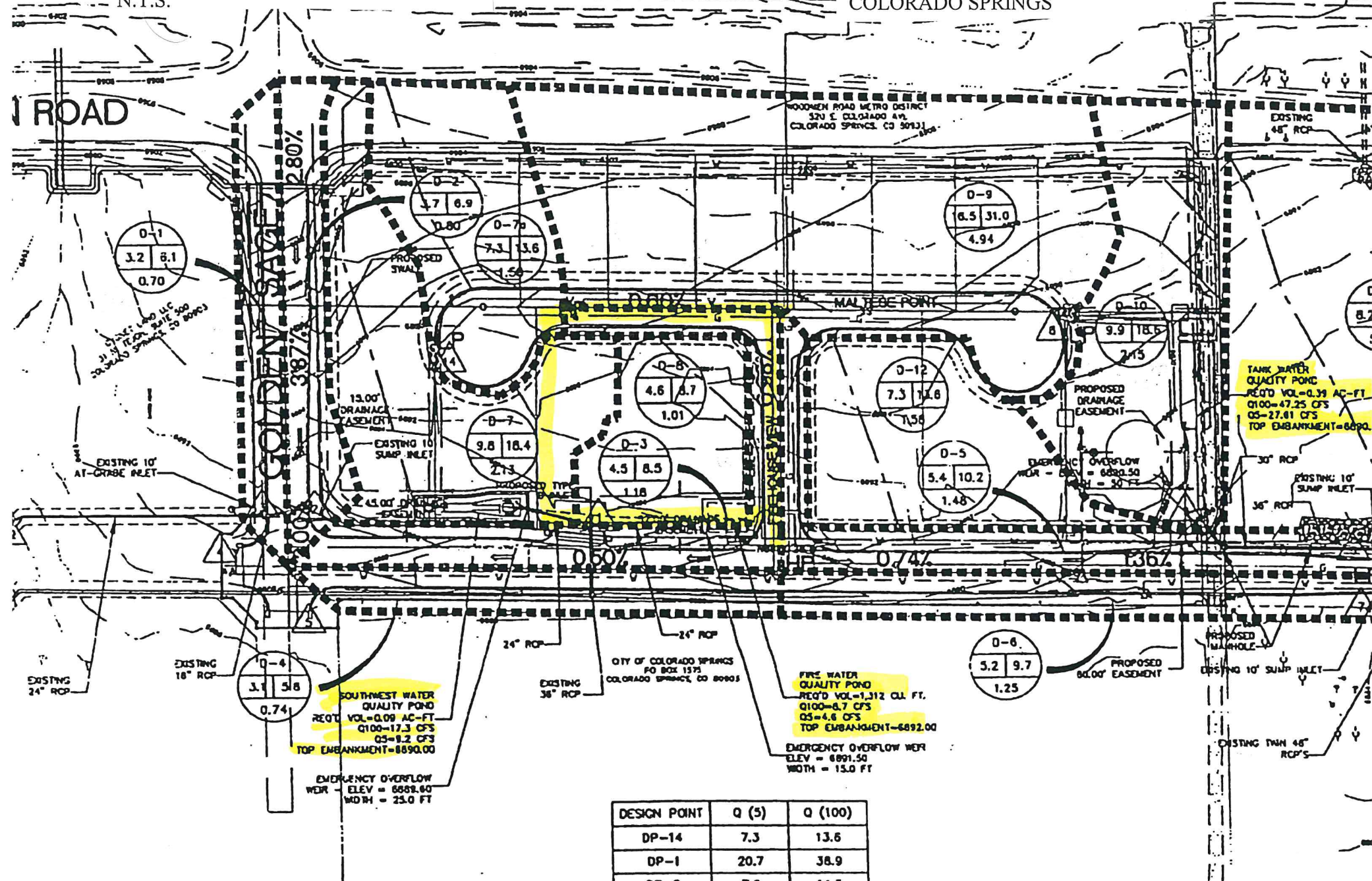






ROLLING THUNDER BUSINESS PARK  
DRAINAGE PLAN  
N.T.S.

OLIVER E. WATTS  
CONSULTING ENGINEER, INC.  
COLORADO SPRINGS



**ROLLING THUNDER BUSINESS PARK - FDR - DEVELOPED CONDITIONS**  
**(RATIONAL METHOD Q=CIA)**

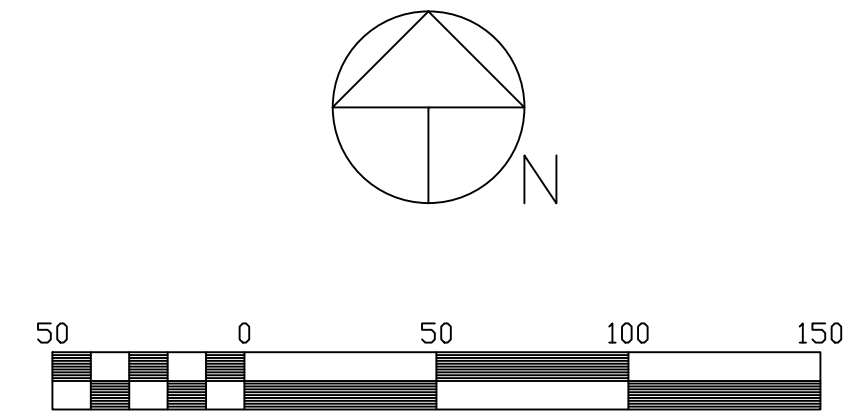
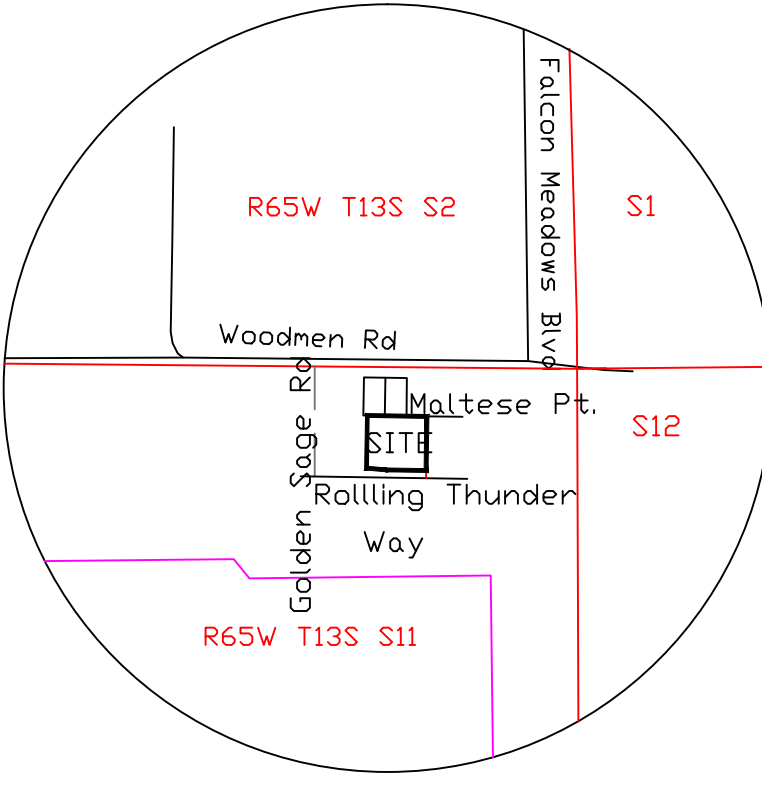
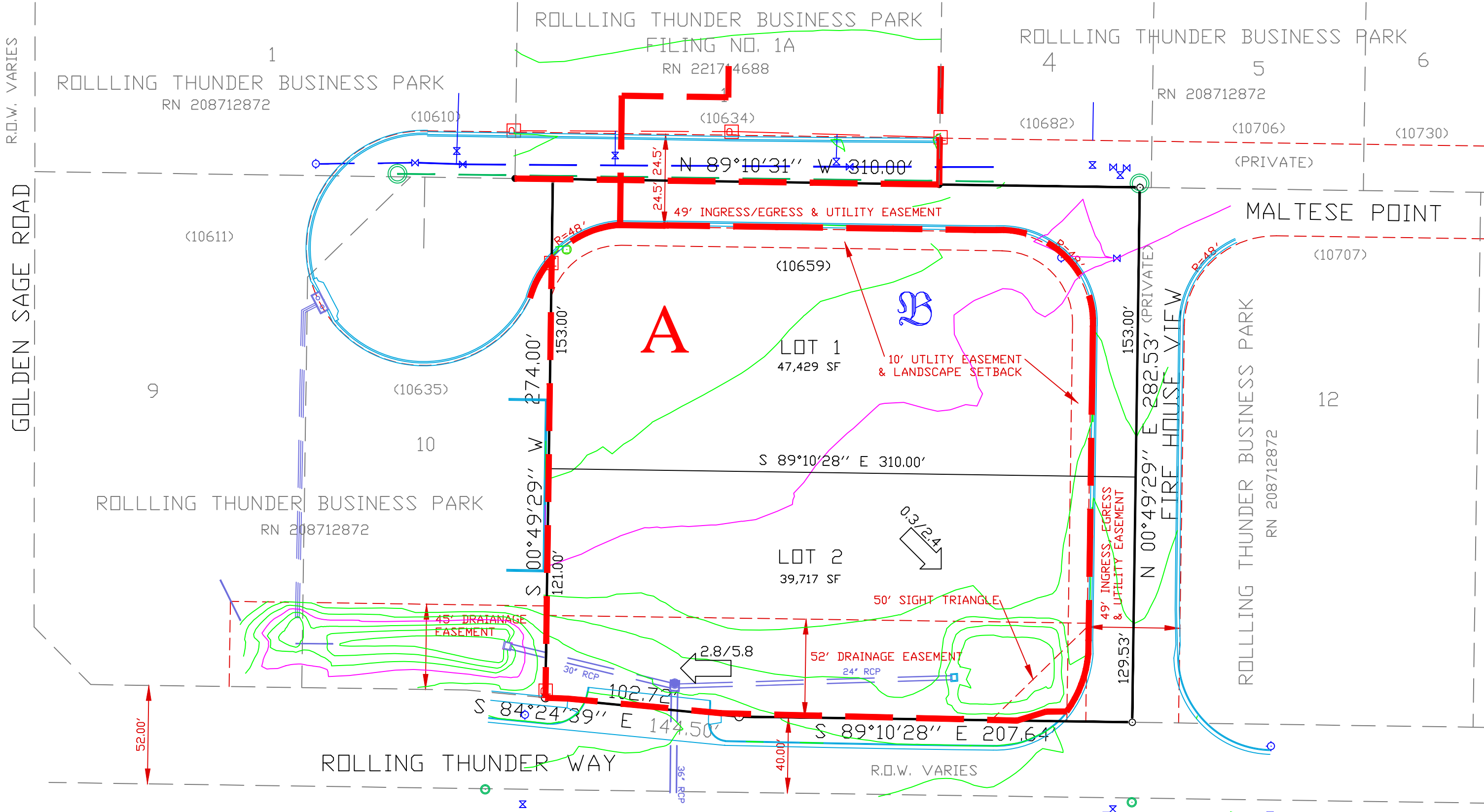
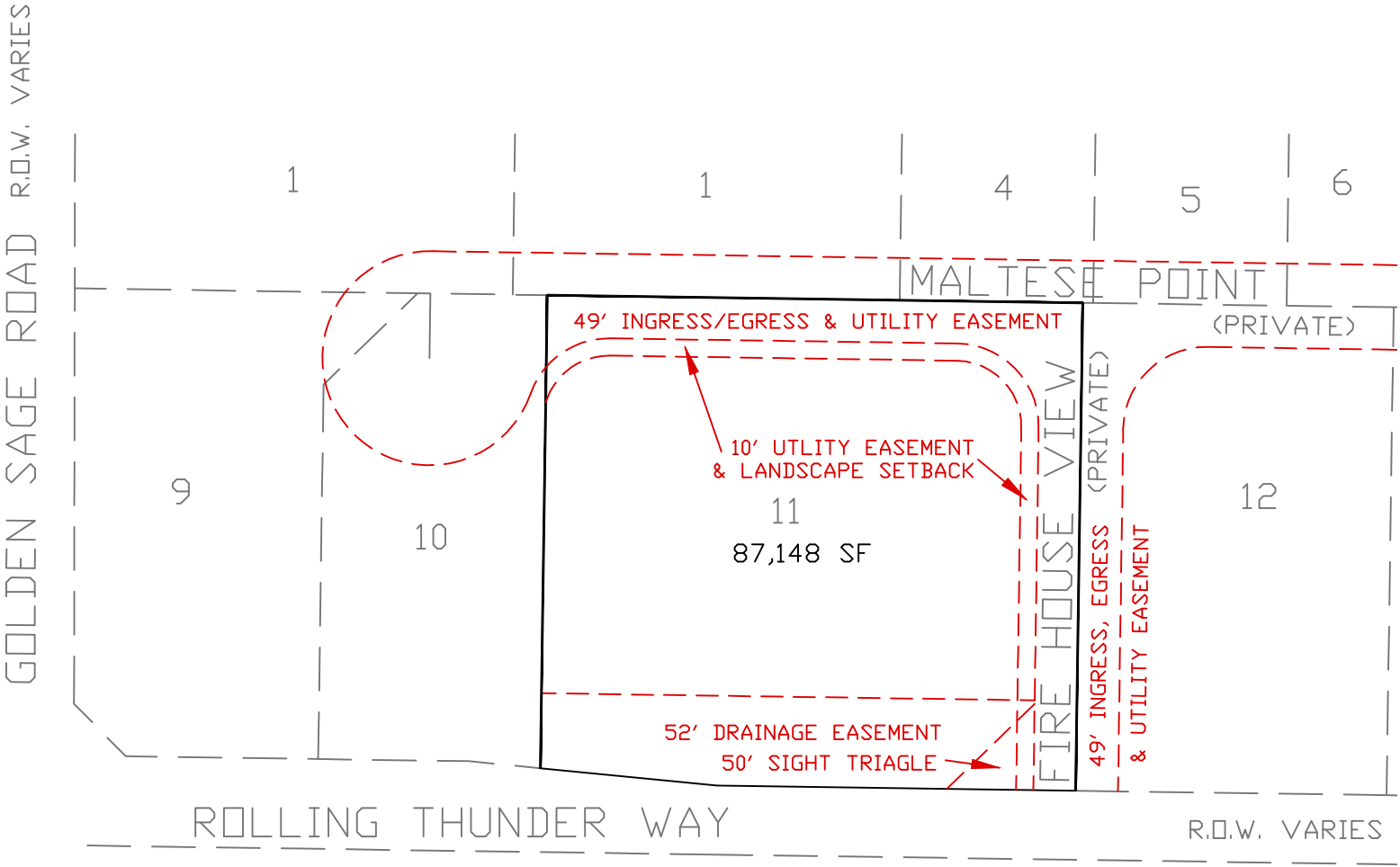
BASIN	TOTAL FLOWS						AREA TOTAL (Ac)	WEIGHTED		OVERLAND				CHANNEL				Tc TOTAL (min)	INTENSITY			COMMENTS
	Q2 (c.f.s.)	Q3 (c.f.s.)	Q100 (c.f.s.)	2 YR	5 YR	100 YR		C3	C100	C3	Length (ft)	Slope (ft)	Tco (min)	Length (ft)	Slope (%)	Velocity (fps)	Tcc (min)		I2 (in/hr)	I3 (in/hr)	I100 (in/hr)	
D-1	2.3	3.2	6.1	0.6	0.63	0.67	0.70	0.90	0.95	0.90	5	2.0%	0.7	500	3.5%	3.7	2.2	5.0	3.7	5.1	9.1	
D-2	2.7	3.7	6.9	0.7	0.72	0.76	0.80	0.90	0.95	0.90	5	2.0%	0.7	500	3.5%	3.7	2.2	5.0	3.7	5.1	9.1	
D-3	3.3	4.5	8.5	1.1	1.06	1.12	1.18	0.90	0.95	0.90	40	2.0%	1.9	715	0.7%	1.7	7.1	9.0	3.1	4.3	7.6	
D-4	2.2	3.1	5.8	0.7	0.67	0.71	0.74	0.90	0.95	0.90	5	2.0%	0.7	560	0.5%	1.4	6.6	7.3	3.3	4.6	8.2	
D-5	3.9	5.4	10.2	1.3	1.33	1.41	1.48	0.90	0.95	0.90	40	2.0%	1.9	1,000	1.0%	2.0	8.3	10.2	3.0	4.1	7.2	
D-6	3.8	5.2	9.7	1.1	1.12	1.19	1.25	0.90	0.95	0.90	5	2.0%	0.7	775	1.0%	2.0	6.5	7.1	3.4	4.6	8.2	
D-7	7.1	9.8	18.4	1.9	1.92	2.02	2.13	0.90	0.95	0.90	40	2.0%	1.9	515	3.1%	3.5	2.4	5.0	3.7	5.1	9.1	
D-7a	5.3	7.3	13.6	1.4	1.42	1.50	1.58	0.90	0.95	0.90	40	2.0%	1.9	285	4.3%	4.1	1.2	5.0	3.7	5.1	9.1	
D-8	3.4	4.6	8.7	0.9	0.91	0.96	1.01	0.90	0.95	0.90	5	2.0%	0.7	245	1.2%	2.2	1.8	5.0	3.7	5.1	9.1	
D-9	12.0	16.5	31.0	4.4	4.45	4.69	4.94	0.90	0.95	0.90	300	2.0%	5.2	715	0.6%	1.5	7.7	12.8	2.7	3.7	6.6	
D-10	7.2	9.9	18.6	1.9	1.94	2.04	2.15	0.90	0.95	0.90	60	2.0%	2.3	300	2.0%	2.8	1.8	5.0	3.7	5.1	9.1	
D-11	5.9	8.2	19.4	1.6	1.60	2.13	5.33	0.30	0.40	0.90	60	2.0%	2.3	500	2.8%	3.3	2.5	5.0	3.7	5.1	9.1	
D-12	5.3	7.3	13.6	1.4	1.42	1.50	1.58	0.90	0.95	0.90	10	2.0%	0.9	250	1.6%	2.5	1.6	5.0	3.7	5.1	9.1	
Offsite	68.8	94.7	194.5	32.5	32.50	37.50	50.00	0.65	0.75	0.35	100	2.0%	11.2	1,500	1.5%	2.4	10.2	21.4	2.1	2.9	5.2	
Formula:	C*I*A	C*I*A			Q/I	Q/I	86.95						*1			*2	*3	Tco+Tcc	*4	*5	*6	
																20			1.09	1.5	2.67	

- 1\*  $Tco = 1.87 * (1.1 - C3) * (L^{0.5}) * ((S * 100)^{-0.33})$  (DCM page 5-11)  
2\*  $Vc = 20 * S^{0.5}$  (USDCM RO-4)  
3\*  $Tcc = 1/V * L/60$   
4\*  $I2 = (26.65 * 1.09) / (10 + Tc)^{0.76}$  (City Letter of 1/7/2003)  
5\*  $I3 = (26.65 * 1.50) / (10 + Tc)^{0.76}$  (City Letter of 1/7/2003)  
6\*  $I100 = (26.65 * 2.67) / (10 + Tc)^{0.76}$  (City Letter of 1/7/2003)



# ROLLING THUNDER BUSINESS PARK FILING NO. 1B

A SUBDIVISION OF LOT 11, ROLLING THUNDER BUSINESS PARK  
EL PASO COUNTY, COLORADO



- LEGEND:
- FOUND #9853 WASHER ON PK NAIL
  - ◊ FOUND #4 REBAR (NOT ACCEPTED)
  - SET #9853 WASHER ON PK NAIL
  - SET 2" AL. CAP, #9853 ON #5 REBAR
  - ◊ (10659) ADDRESS

- 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

## DRAINAGE PLAN HISTORIC CONDITIONS

Please increase the scale of the drawing for clarity.

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