PHASE I DRAINAGE REPORT AND PLAN
FOR
WILLOW CREEK PUD
YOSEMITE ST. AND PARK MEADOWS DR.

LONE TREE, COLORADO

Prepared for:

Willow Creek PUD
Park Meadows Dr. & Yosemite Dr.
Lone Tree, Douglas County, CO

Contact: Vogel & Associates
Phone: (303) 893-4288

Prepared by:

Bowman

1526 Cole Blvd, Suite 100
Lakewood, Colorado 80401

Contact: Thomas Pannell, PE
Phone: (303) 801-2900

JN: 020460-01-001
April 2023

Signature Page

"This report (and plan) for the Phase I drainage design of Willow Creek PUD was prepared under my direct supervision in accordance with the provisions of the Douglas County Storm Drainage Design and Technical Criteria for the owners thereof. I understand that the City of Lone Tree does not and will not assume liability for drainage and erosion control facilities designed by others.

_____
Thomas Pannell, PE
State of Colorado No. 53615
For and on behalf of Bowman Consulting

Furniture Row Colo, LLC hereby certifies that the drainage facilities for Willow Creek PUD shall be constructed according to the design presented in this report. I understand that the City of Lone Tree does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the City of Lone Tree reviews drainage plans pursuant to Lone Tree Municipal Code, Chapter 15, Article 1; but cannot, on behalf of Willow Creek PUD, guarantee that final drainage design review will absolve Furniture Row Colo, LLC and/or their successors and/or assigns of future liability for improper design. I further understand that approval of the Site Improvement Plan and Final Plat does not imply approval of my engineer's drainage design."

_____
Name of Developer

_____
Authorized Signature

1. General Location and Description

1.1 Site Location

Willow Creek PUD (hereafter, the Site) is located in the City of Lone Tree, Portions of the West half of Section 3 and the Northeast quarter of Section 4, Quarter Section NW ¼, Township 6 South, Range 67W, Douglas County, Colorado. The Site is located in the northeast quadrant of the intersection of Park Meadows Drive and Yosemite Street. The Site consists of Tract E and BA of the Park Meadows Subdivision, Filing 1, 1st Amendment and is bound by C-470 to the north, Yosemite Street to the east, Park Meadows Drive to the south, and Willow Creek to the west. The Site is also bordered to the west by the undeveloped Tracts I(A) and I(B) of the Park Meadows Subdivision, Filing 1, 1st Amendment, which includes a 200' ingress/egress easement.

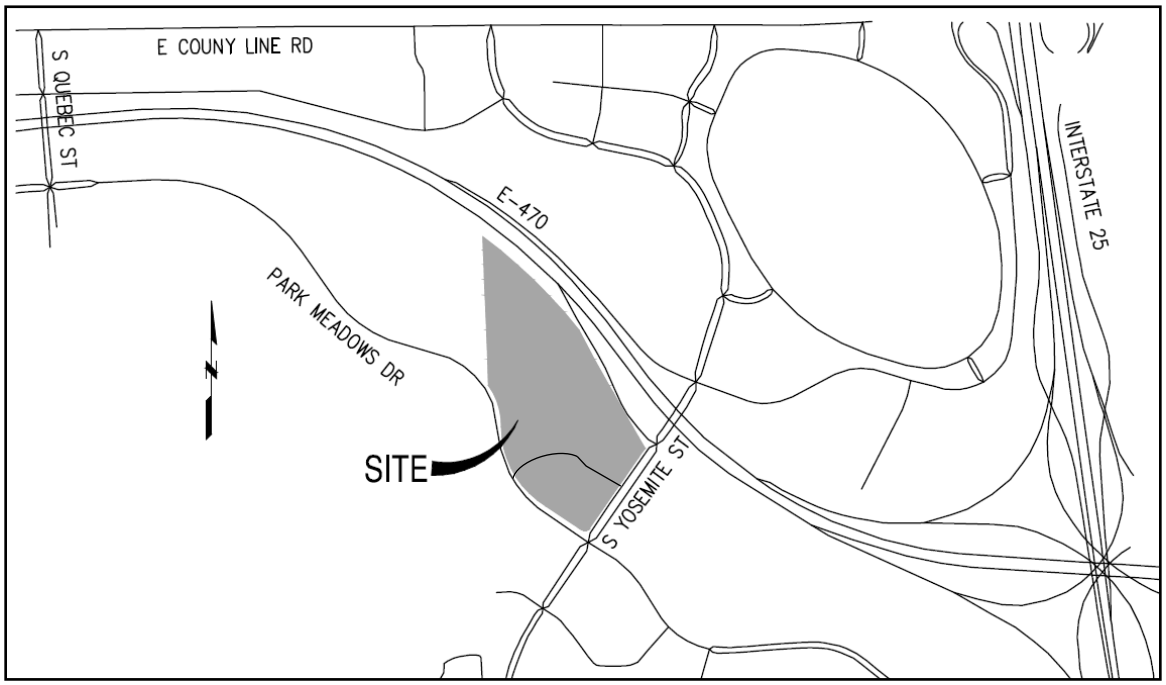


Figure 1-1
Vicinity Map

1.2 Description of Property

The total area of the property is 14.12 acres. The ground cover is mainly short grasses with some trees and shrubs. Existing grades on the Site are moderate, ranging from 0-20% and averaging around 4-7%. The slopes closer to Willow Creek are steeper, with some slopes over 30% near the creek banks. The Site generally slopes to the west towards Willow Creek.

The Site is within a portion of the Willow Creek watershed which is a tributary of Little Dry Creek. The majority of the watershed is developed according a Flood Hazard Area Delineation (FHAD) report for Willow Creek by CH2MHill completed for Urban Drainage and Flood Control District in 2010.

Soils for the site are classified as NRCS hydrologic soils groups D per the Web Soil Survey from the USDA Natural Resources Conservations Service.

A small portion of the Site is within a regulatory floodplain per the Douglas County and City of Lone Tree Flood Insurance Rate Map (FIRM) Panel 42 Map No. 08035C0042G.

There are no existing irrigation canals on the site. There are no stock ponds located on the site.

The current zoning is Commercial C3 for Tract E and Business for Tract BA. The proposed road access bridge to the site from Park Meadows is located within the Tract I(B) which is zoned for Parks and Open Space.

2. Drainage Basins and Sub-Basins

Existing Drainage Basins

Existing available drainage studies that impact the site are:

- Flood Hazard Area Delineation – Willow Creek, CH2MHILL, December 2010.
- Flood Insurance Rate Map, Douglas County and City of Lone Tree, Panel 42 Map No. 08035C0042G.
- Drainage Analysis for Park Meadows/C-470 and Starika Property, Carroll and Lange, Inc., March 1996, Last Revised April 1999.
- Construction Plans for C-470/Yosemite Interchange, Felsburg Holt & Ullevig, December 1995.

See Appendix E for the above drainage studies.

Proposed Major Drainage Basins

Basin A1 (8.87 ac) covers most of the Site and encompasses the proposed residential units, driveways, and landscaping areas. It runs along the east side of Willow Creek. This basin consists of 52.1% landscaping area, 30.4% hardscape, and 17.5% roof area. The 5-yr runoff coefficient is 0.42, the 100-yr runoff coefficient is 0.68, and the overall imperviousness is 47.2%. Runoff will be collected in a detention facility. (Q5=7.71 cfs, Q100=25.77 cfs).

Basin A2 (4.49 ac) covers the south portion of the site along the north corner of Park Meadows Drive and South Yosemite Street. This basin consists of 33.9% landscaping area, 47.2% hardscape, and 18.9% roof area. The 5-yr runoff coefficient is 0.56, the 100-yr runoff coefficient is 0.75, and the overall imperviousness is 64.9%. Runoff will be collected in a detention facility. (Q5=7.60 cfs, Q100=20.92 cfs).

Basin UD1 (0.76 ac) covers undetained sections of the Willow Creek streambank that flow off-site into the stream. This area consists of 100% landscaping area and has a 5-yr runoff coefficient of 0.05 and a 100-yr runoff coefficient of 0.49. The overall imperviousness is 2.0%. (Q5=0.12 cfs, Q100=2.31 cfs).

3. Drainage Design Criteria

3.1 Development Criteria Reference

The Site was designed to comply with the Douglas County Storm Drainage Design and Technical Criteria Manual.

3.2 Hydrologic Criteria

The Site is located within the Willow Creek Tributary watershed which was studied in the FHAD Report previously mentioned completed by CH2MHill. The basins that encompass The Yard at Lone Tree are Basin 26 and Basin 23 of the FHAD study. Sub-watershed characteristics information from the FHAD can be found in Appendix E of this report. A drainage analysis was previously prepared for Park Meadows/C-470 and Starika Property by Carroll & Lange, Inc in 1999 which examined the properties within the watershed upstream of the Site. Computations from this study were utilized to determine the flows of the 66" pipe which currently runs through the site. The existing pipe will be rerouted to avoid proposed site features, maintain adequate capacity to convey the existing flows, and will outfall to Willow Creek in generally the same location as they exist today. Large retaining walls along the western property line of the Site, which is also the low side of the site, constrain the ability to meet WQCV, EURV, and 100-year detention facility. A 100-year detention facility will be located on-site to provide water quality, EURV, and 100-year detention. Appendix F outlines the potential areas where above ground and below ground detention facilities could be implemented.

3.3 Hydraulic Criteria

The Rational method was used to determine historic and developed flow rates. Runoff was calculated for the 5 and 100-year events. Times of concentration, rainfall intensities, and runoff coefficients were determined using the Douglas County Storm Drainage Design and Technical

Criteria Manuals and Urban Drainage and Flood Control District Manual, Volume 1. See Appendix A for Hydrological Calculations.

4. Drainage Facility Design

4.1 General Concept – Proposed Stormwater Conveyance/Storage Facilities

Proposed on-site stormwater conveyance will consist of a series of storm inlet connections to a full spectrum detention facility, that outfall into Willow Creek. Flows from the entire site will drain to this detention facility with a detention volume of 1.162 acre-feet. This detention volume may be in one or multiple ponds that will be determined at a later phase of development. See Appendix D for sizing calculations for the proposed pond.

Emergency overflow paths will be incorporated into the development. In particular, paths will be provided at the low points in the development to allow water to leave the Site during events exceeding the 100-year event, or if a failure occurs in the stormwater systems. Additionally, 1 foot of freeboard will be provided for the full spectrum detention pond with an overflow weir to allow for storm events larger than the 100-year event to safely pass through the facilities.

Proposed Storage Facilities					
ID	Area (acres)	Imperviousness	EURV (acre-ft)	WQCV (acre-ft)	100-YR Detention Volume (acre-ft)
Detention Facility	14.12	50.4%	0.674	0.244	1.162

5. Summary

The proposed stormwater management design outlined in this report is in general conformance with the City of Lone Tree, Douglas County Storm Drainage Design and Technical Criteria Manual, and the Urban Drainage Manual. Stormwater runoff will continue to follow existing drainage patterns to Willow Creek and all undetained flows will bypass the proposed detention facility and continue to Willow Creek as they have historically done. The proposed detention facility will provide Water Quality, EURV, and 100-year detention for the majority of the proposed site. The anticipated imperviousness of the site is 50.4%. Outflows from the detention facility will be released at or below the allowable release rates and will not adversely affect Willow Creek or any downstream properties. There is also proposed drainage improvements along Willow Creek by others that are shown in Appendix G.

LIST OF APPENDICES

Appendix A – Drainage Basin Map

Appendix B – Hydrologic Computations

Appendix C – Soil Map

Appendix D – Detention Pond Sizing Spreadsheet

Appendix E – Referenced Information

Appendix F - Proposed Detention Facility Areas Map

Appendix G - Proposed Willow Creek Minimal Impact Drainage Plan

APPENDIX A – DRAINAGE BASIN MAP

LEGEND:

- DESIGN POINT
- PROPOSED BASIN BOUNDARY
- EMERGENCY OVERFLOW PATH
- BASIN DESIGNATION — C1 — PROPOSED BASIN
  - BASIN AREA: 2.11 AC.
  - C5: 0.08
  - C100: 0.96
- 350 — EX. MAJOR CONTOUR
- 349 — EX. MINOR CONTOUR
- 350 — PROP. MAJOR CONTOUR
- 349 — PROP. MINOR CONTOUR

BASIN SUMMARY TABLE

Basin	Area (acres)	5-yr (cfs)	100-yr (cfs)
A1	8.87	7.71	25.8
A2	4.49	7.60	20.9
UD1	0.76	0.12	2.3

DESIGN POINT SUMMARY TABLE

Design Point	Contributing Basins	Area (acres)	5-yr (cfs)	100-yr (cfs)
1	A1	8.87	7.71	25.77
2	A2	4.49	7.60	20.92
3	A1, A2	13.36	12.95	40.21
4	UD1	0.76	0.12	2.31

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 ft.

N

Cad file name: V:\020460 - Willow Creek PUD\020460-01-001 (ENG)\Engineering\Engineering Plans\Drainage\020460-01-001 DDM.dwg

Bowman
Phone: (303) 801-2800
www.bowman.com
1526 Cole Blvd, Suite 100
Lakewood, CO 80401

REVISIONS

REVISION	DESCRIPTION	DATE
---	---	---

DRAINAGE BASIN MAP

WILLOW CREEK PUD

LONE TREE, COLORADO

SEAL

NOT FOR CONSTRUCTION

DESIGN	DRAWN	CHKD
KP	KP	TP

SCALE: H: 1" = 150' V: 1" = 150'

JOB No. 020460-01-001

DATE : 03/23/2023

SHEET
1 OF 1

APPENDIX B – HYDROLOGIC COMPUTATIONS

1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com

Summary of Site Hydrology
Willow Creek PUD Lone Tree, CO

Cells of this color are for required user-input

Tips for using spreadsheet

1. if you need to override any values/equations in this spreadsheet - go to review tab, and choose "unprotect sheet" (this will make cells unlocked)
2. These equations are based on Urban Drainage Volume 1 from January 2016 (please check urban drainage for most recent version)
http://udfcd.org/volume-one

BASIN SUMMARY TABLE

Basin	Area (acres)	5-yr (cfs)	100-yr (cfs)
A1	8.87	7.71	25.8
A2	4.49	7.60	20.9
UD1	0.76	0.12	2.3

DESIGN POINT SUMMARY TABLE

Design Point	Contributing Basins	Area (acres)	5-yr (cfs)	100-yr (cfs)
1	A1	8.87	7.71	25.77
2	A2	4.49	7.60	20.92
3	A1, A2	13.36	12.95	40.21
4	UD1	0.76	0.12	2.31

POST-DEVELOPMENT C VALUES

Designer: KP
Company: BOWMAN
Date: 3/31/2023
Project: Willow Creek PUD
Location: Lone Tree, CO

Global Parameters[1]	
Land Use	% Imp.
Open Space/Landscaping	2
Hardscape	100
Roof	90

Summary	
Total Area (ac)	14.12
Composite Impervious	50.4%

Bowman CONSULTING

Cells of this color are for required user-input
Cells of this color are for optional user-input

[1] From Table 6-3 in UDFCD Volme 1
[2] From Table 6-4 in UDFCD Volme 1

Subcatchment Name	Area (ac)	NRCS Hydrologic Soil Group	Open Space/Landscaping		Hardscape		Roof		% Check	Percent Imperviousness	Runoff Coefficient, C^2						
			Area (ac)	%	Area (ac)	%	Area (ac)	%			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
A1	8.87	C	4.62	52.1%	2.70	30.4%	1.55	17.5%	100.00%	47.2%	0.36	0.42	0.48	0.58	0.63	0.68	0.74
A2	4.49	C	1.52	33.9%	2.12	47.2%	0.85	18.9%	100.00%	64.9%	0.51	0.56	0.61	0.68	0.71	0.75	0.79
UD1	0.76	C	0.76	100.0%	0.00	0.0%	0.00	0.0%	100.00%	2.0%	0.01	0.05	0.15	0.33	0.40	0.49	0.59

TIME OF CONCENTRATION

Designer:	KP
Company:	BOWMAN
Date:	3/31/2023
Project:	Willow Creek PUD
Location:	Lone Tree, CO

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L_i}}{S_i^{0.33}}$$

Computed $t_c = t_i + t_t$

$t_{minimum}$ = 5 (urban)
$t_{minimum}$ = 10 (non-urban)

$$t_t = \frac{L_t}{60K\sqrt{S_t}} = \frac{L_t}{60V_t}$$

Regional $t_c = (26 - 17i) + \frac{L_t}{60(14i + 9)\sqrt{S_t}}$

Selected $t_c = \max\{t_{minimum}, \min(\text{Computed } t_c, \text{Regional } t_c)\}$

Cells of this color are for required user-input

Subbasin Data				Overland (Initial) Flow Time			Channelized (Travel) Flow Time					Time of Concentration			
Sub-Basin	Area	% Impervious	C5	Overland Flow Length L_i (ft)	Overland Flow Slope S_i (ft/ft)	Overland Flow Time t_i (min)	Channelized Flow Length L_t (ft)	Channelized Flow Slope S_t (ft/ft)	NRCS Conveyance Factor K	Channelized Flow Velocity V_t (ft/sec)	Channelized Flow Time t_t (min)	Computed t_c (min)	Regional t_c (min)	Selected t_c (min)	
A1	8.87	47.2%	0.42	300.00	0.030	14.80	1000.00	0.020	17	2.40	6.93	21.74	25.52	21.74	
A2	4.49	64.9%	0.56	100.00	0.025	7.15	450.00	0.020	20	2.83	2.65	9.80	17.89	9.80	
UD1	0.76	2.0%	0.05	150.00	0.250	8.02	0.00	0.010	20	2.00	0.00	8.02	25.66	10.00	

STORM DRAINAGE SYSTEM DESIGN - 5-YEAR DESIGN STORM

Designer:	KP
Company:	BOWMAN
Date:	3/31/2023
Project:	Willow Creek PUD
Location:	Lone Tree, CO

Bowman CONSULTING

Cells of this color are for required user-input

Cells of this color are for optional user-input

DESGIN POINT	STREET/ CONTRIBUTING BASINS	DIRECT RUNOFF							TOTAL RUNOFF					STREET		PIPE			TRAVEL TIME					
		Area Design	Area (ac)	Coeff C	Tc (min)	C*A (ac)	I	Q (cfs)	Tc (min)	Sum Area (ca)	Sum C*A (ac)	I in/hr	Q cfs	Slope %	Street Q cfs	Design Q cfs	Slope %	PIPE SIZE	L ft	VEL ft/sec	Tt min	Q add'l		Remarks
		A1	8.87	0.42	21.7	3.72	2.07	7.7								7.7								
1	A1								21.7	8.9	3.7	2.07	7.71			7.7								
		A2	4.49	0.56	9.8	2.53	3.00	7.6								7.6								
2	A2								9.8	4.5	2.5	3.00	7.60			7.6								
		UD1	0.76	0.05	10.0	0.04	2.98	0.1								0.1								
3	A1, A2								21.7	13.4	6.3	2.07	12.95			13.0								
4	UD1								10.0	0.8	0.0	2.98	0.12			0.1								

STORM DRAINAGE SYSTEM DESIGN - 100-YEAR DESIGN STORM

Designer:	KP
Company:	BOWMAN
Date:	3/31/2023
Project:	Willow Creek PUD
Location:	Lone Tree, CO

Bowman CONSULTING

Cells of this color are for required user-input

Cells of this color are for optional user-input

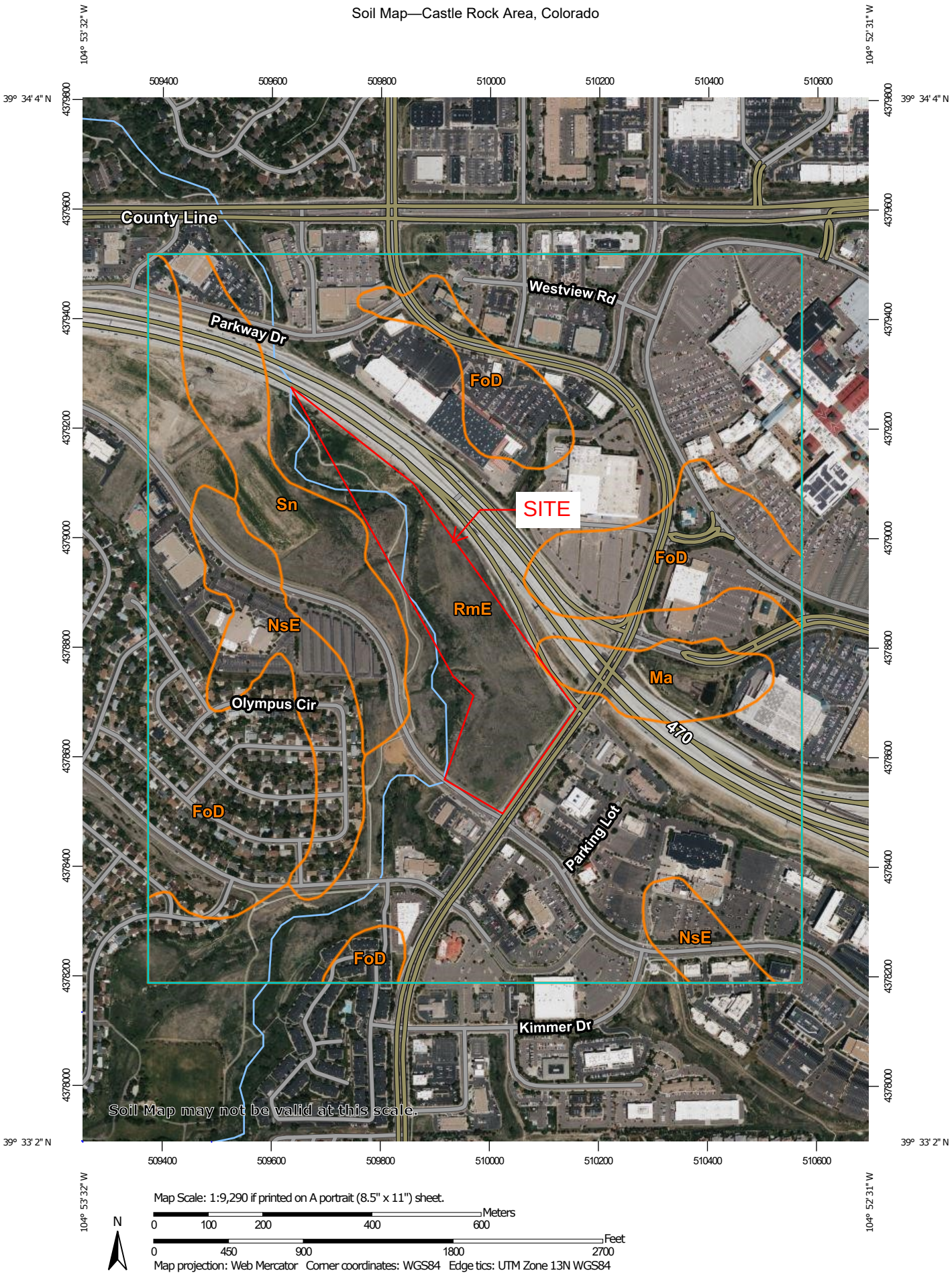
DESGIN POINT	STREET/ CONTRIBUTING BASINS	DIRECT RUNOFF							TOTAL RUNOFF					STREET		PIPE			TRAVEL TIME					
		Area Design	Area (ac)	Coeff C	Tc (min)	C*A (ac)	I	Q (cfs)	Tc (min)	Sum Area (ca)	Sum C*A (ac)	I in/hr	Q cfs	Slope %	Street Q cfs	Design Q cfs	Slope %	PIPE SIZE	L ft	VEL ft/sec	Tt min	Q add'l		Remarks
		A1	8.87	0.68	21.7	6.01	4.29	25.8								25.8								
1	A1								21.7	8.9	6.0	4.29	25.77			25.8								
		A2	4.49	0.75	9.8	3.37	6.22	20.9								20.9								
2	A2								9.8	4.5	3.4	6.22	20.92			20.9								
		UD1	0.76	0.49	10.0	0.37	6.17	2.3								2.3								
3	A1, A2								21.7	13.4	9.4	4.29	40.21			40.2								
4	UD1								10.0	0.8	0.4	6.17	2.31			2.3								

Rainfall Data
Willow Creek PUD
Lone Tree, CO

Recurrence Interval (yrs)	1-hr Rainfall Depth (in)
2	0.84
5	1.10
10	1.33
25	1.68
50	1.97
100	2.28
500	3.08

APPENDIX C – SOIL MAP

1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com


104° 53' 32" W
104° 52' 31" W
509400
509600
509800
510000
510200
510400
510600
39° 34' 4" N
39° 33' 2" N
4379800
4379600
4379400
4379200
4379000
4378800
4378600
4378400
4378200
4378000
County Line
Parkway Dr
Westview Rd
FoD
Sn
SITE
RmE
NsE
Olympus Cir
Ma
470
Parking Lot
Kimmer Dr
Soil Map may not be valid at this scale.
Map Scale: 1:9,290 if printed on A portrait (8.5" x 11") sheet.
N
Meters
0 100 200 400 600
Feet
0 450 900 1800 2700
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Castle Rock Area, Colorado
Survey Area Data: Version 15, Sep 1, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 9, 2021—Jun 12, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FoD	Fondis clay loam, 3 to 9 percent slopes	84.2	21.3%
Ma	Manzanola clay loam	11.8	3.0%
NsE	Newlin-Satanta complex, 5 to 20 percent slopes	27.7	7.0%
RmE	Renohill-Buick complex, 5 to 25 percent slopes	242.6	61.3%
Sn	Satanta loam	29.5	7.4%
Totals for Area of Interest		**395.7**	**100.0%**

APPENDIX D – DETENTION POND SIZING SPREADSHEET

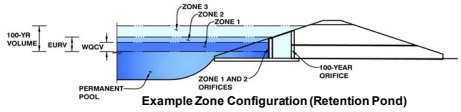
1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com

DETENTION BASIN STAGE-STORAGE TABLE BUILDER

MHFD-Detention, Version 4.04 (February 2021)

Project: _____

Basin ID: _____



Example Zone Configuration (Retention Pond)

Watershed Information

Selected BMP Type =	**EDB**	
Watershed Area =	14.12	acres
Watershed Length =	800	ft
Watershed Length to Centroid =	500	ft
Watershed Slope =	0.025	ft/ft
Watershed Imperviousness =	50.40%	percent
Percentage Hydrologic Soil Group A =	0.0%	percent
Percentage Hydrologic Soil Group B =	0.0%	percent
Percentage Hydrologic Soil Groups C/D =	100.0%	percent
Target WQCV Drain Time =	40.0	hours
Location for 1-hr Rainfall Depths =	Lone Tree - Municipal Court	

After providing required inputs above including 1-hour rainfall depths, click 'Run CUHP' to generate runoff hydrographs using the embedded Colorado Urban Hydrograph Procedure.

			Optional User Overrides	
Water Quality Capture Volume (WQCV) =	0.244	acre-feet		acre-feet
Excess Urban Runoff Volume (EURV) =	0.674	acre-feet		acre-feet
2-yr Runoff Volume (P1 = 0.84 in.) =	0.433	acre-feet	0.84	inches
5-yr Runoff Volume (P1 = 1.1 in.) =	0.647	acre-feet	1.10	inches
10-yr Runoff Volume (P1 = 1.33 in.) =	0.876	acre-feet	1.33	inches
25-yr Runoff Volume (P1 = 1.68 in.) =	1.322	acre-feet	1.68	inches
50-yr Runoff Volume (P1 = 1.97 in.) =	1.653	acre-feet	1.97	inches
100-yr Runoff Volume (P1 = 2.28 in.) =	2.055	acre-feet	2.28	inches
500-yr Runoff Volume (P1 = 3.08 in.) =	3.009	acre-feet	3.08	inches
Approximate 2-yr Detention Volume =	0.419	acre-feet		
Approximate 5-yr Detention Volume =	0.649	acre-feet		
Approximate 10-yr Detention Volume =	0.767	acre-feet		
Approximate 25-yr Detention Volume =	0.916	acre-feet		
Approximate 50-yr Detention Volume =	0.989	acre-feet		
Approximate 100-yr Detention Volume =	1.162	acre-feet		

Define Zones and Basin Geometry

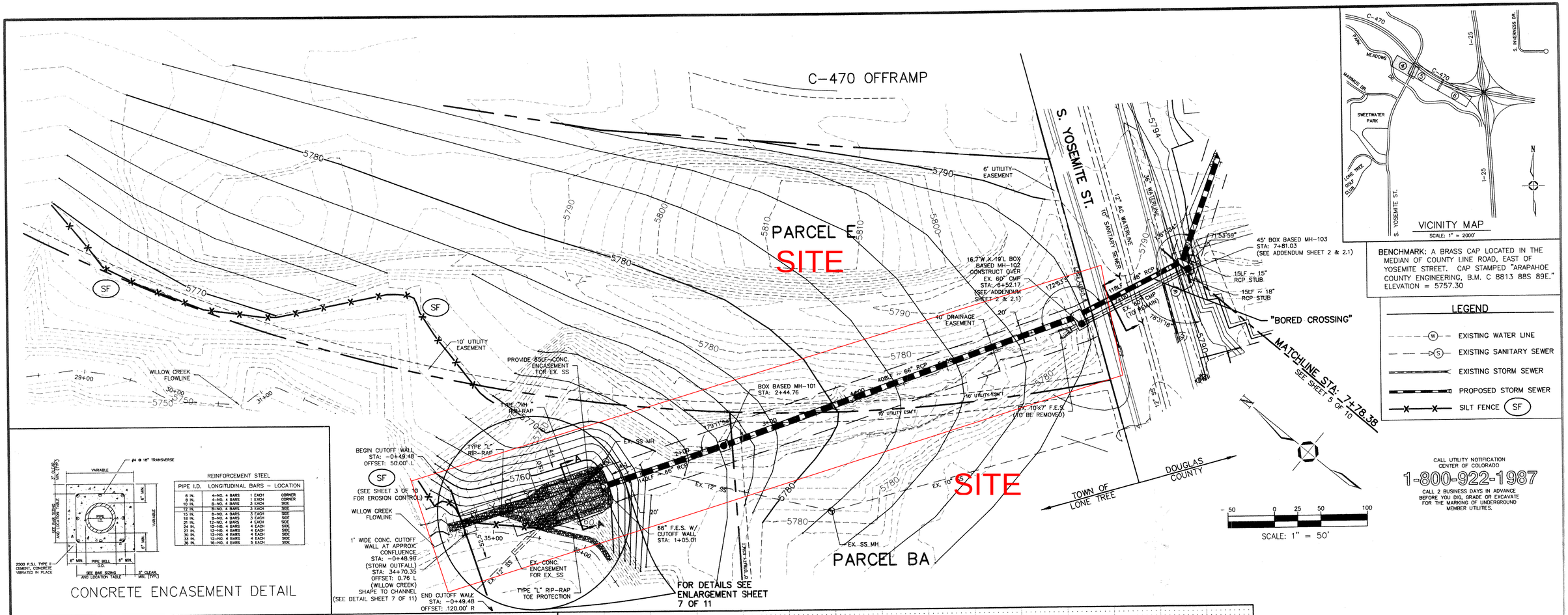
Select Zone 1 Storage Volume (Required) =		acre-feet
Select Zone 2 Storage Volume (Optional) =		acre-feet
Select Zone 3 Storage Volume (Optional) =		acre-feet
Total Detention Basin Volume =		acre-feet
Initial Surcharge Volume (ISV) =		ft^3
Initial Surcharge Depth (ISD) =		ft
Total Available Detention Depth (H_{total}) =		ft
Depth of Trickle Channel (H_{TC}) =		ft
Slope of Trickle Channel (S_{TC}) =		ft/ft
Slopes of Main Basin Sides (S_{main}) =		H:V
Basin Length-to-Width Ratio ($R_{L/W}$) =		
Initial Surcharge Area (A_{ISV}) =		ft^2
Surcharge Volume Length (L_{ISV}) =		ft
Surcharge Volume Width (W_{ISV}) =		ft
Depth of Basin Floor (H_{FLOOR}) =		ft
Length of Basin Floor (L_{FLOOR}) =		ft
Width of Basin Floor (W_{FLOOR}) =		ft
Area of Basin Floor (A_{FLOOR}) =		ft^2
Volume of Basin Floor (V_{FLOOR}) =		ft^3
Depth of Main Basin (H_{MAIN}) =		ft
Length of Main Basin (L_{MAIN}) =		ft
Width of Main Basin (W_{MAIN}) =		ft
Area of Main Basin (A_{MAIN}) =		ft^2
Volume of Main Basin (V_{MAIN}) =		ft^3
Calculated Total Basin Volume (V_{total}) =		acre-feet

Depth Increment = 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									

APPENDIX E – REFERENCED INFORMATION

1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com



VICINITY MAP
SCALE: 1" = 2000'

BENCHMARK: A BRASS CAP LOCATED IN THE MEDIAN OF COUNTY LINE ROAD, EAST OF YOSEMITE STREET. CAP STAMPED "ARAPAHOE COUNTY ENGINEERING, B.M. C 8813 88S 89E." ELEVATION = 5757.30

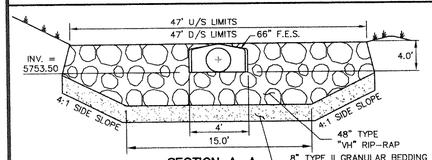
LEGEND

- EXISTING WATER LINE
- EXISTING SANITARY SEWER
- EXISTING STORM SEWER
- PROPOSED STORM SEWER
- SILT FENCE (SF)

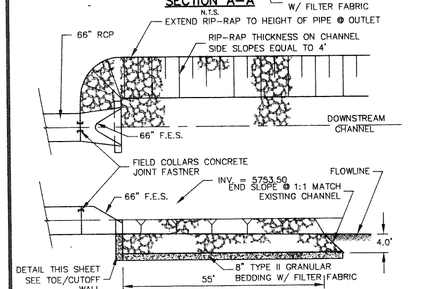
CALL UTILITY NOTIFICATION CENTER OF COLORADO
1-800-922-1987
CALL 2 BUSINESS DAYS IN ADVANCE BEFORE YOU DIG, GRADE OR EXCAVATE FOR THE MARKING OF UNDERGROUND MEMBER UTILITIES.

REINFORCEMENT STEEL			
PIPE I.D.	LONGITUDINAL BARS – LOCATION		
6 IN.	4–NO. 4 BARS	1 EACH	CORNER
8 IN.	4–NO. 4 BARS	1 EACH	CORNER
10 IN.	8–NO. 4 BARS	3 EACH	SIDE
12 IN.	8–NO. 4 BARS	3 EACH	SIDE
15 IN.	8–NO. 4 BARS	3 EACH	SIDE
18 IN.	8–NO. 4 BARS	3 EACH	SIDE
21 IN.	12–NO. 4 BARS	4 EACH	SIDE
24 IN.	12–NO. 4 BARS	4 EACH	SIDE
27 IN.	12–NO. 4 BARS	4 EACH	SIDE
30 IN.	12–NO. 4 BARS	4 EACH	SIDE
33 IN.	12–NO. 4 BARS	4 EACH	SIDE
36 IN.	16–NO. 4 BARS	5 EACH	SIDE

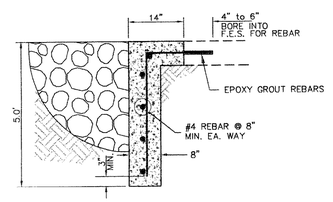
CONCRETE ENCASEMENT DETAIL



SECTION A–A
N.T.S.



RIPRAP DETAIL
N.T.S.

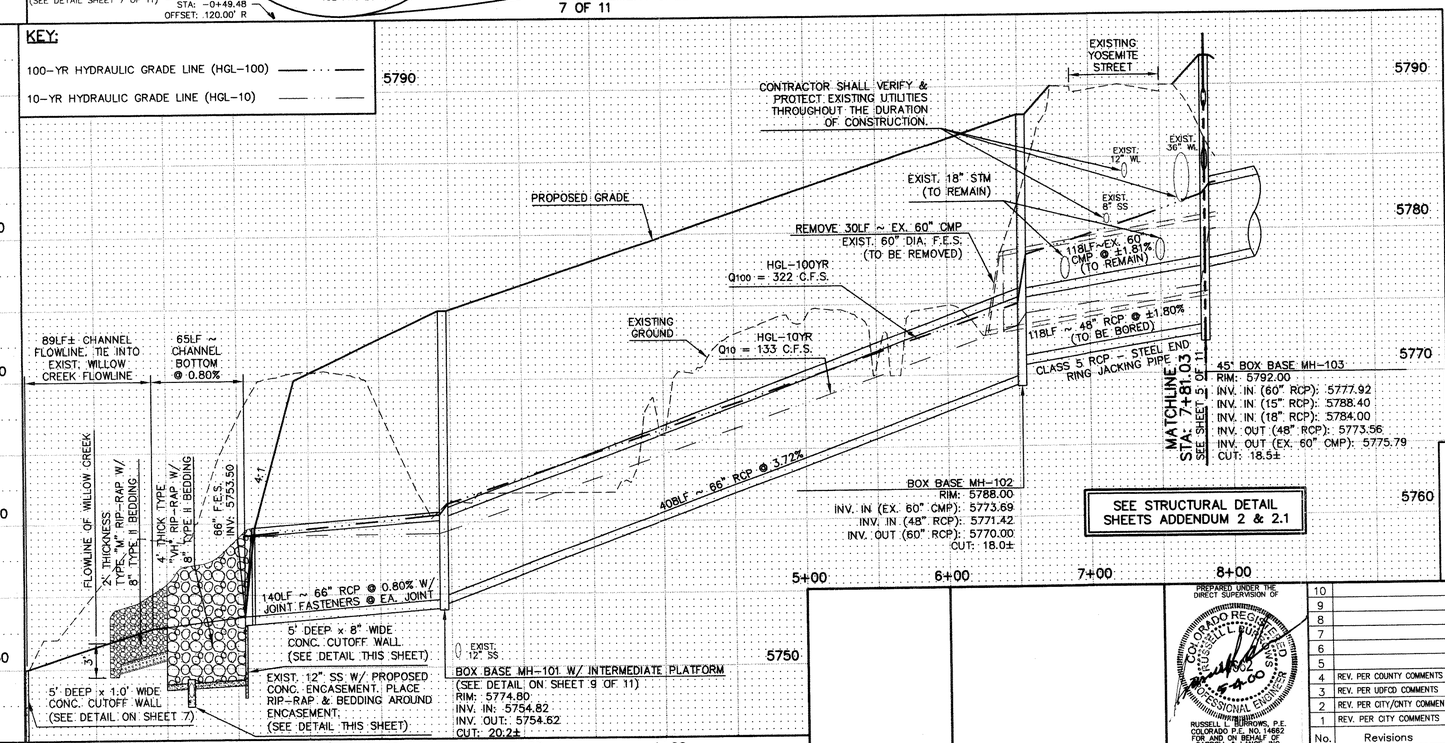


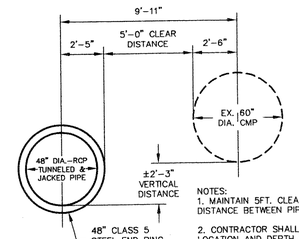
TOE / CUT-OFF WALL
N.T.S.

KEY:

100-YR HYDRAULIC GRADE LINE (HGL-100)

10-YR HYDRAULIC GRADE LINE (HGL-10)





NOTES:
1. MAINTAIN 5FT. CLEAR DISTANCE BETWEEN PIPES.
2. CONTRACTOR SHALL VERIFY LOCATION AND DEPTH OF ALL EXISTING UTILITIES PRIOR TO CONSTRUCTION.
3. CONTRACTOR SHALL COMPLY WITH ALL OSHA REGULATIONS.

TYPICAL SECTION Y–Y
1" = 4'

DOUGLAS COUNTY
DEPARTMENT OF PUBLIC WORKS
DV 95-125 MAY 05 2000

County Engineer
5/15/00
Date

These construction plans have been reviewed by Douglas County for street and drainage improvements only.

Engineering Division Acceptance Block

City Engineer

Date

These construction plans have been reviewed by the City of Lonetree for drainage improvements only.

PREPARED UNDER THE DIRECT SUPERVISION OF
COLORADO REGISTERED PROFESSIONAL ENGINEER
RUSSELL L. BURROWS
5-4-00
RUSSELL L. BURROWS, P.E.
COLORADO P.E. NO. 14662
FOR AND ON BEHALF OF CARROLL & LANGE, INC.

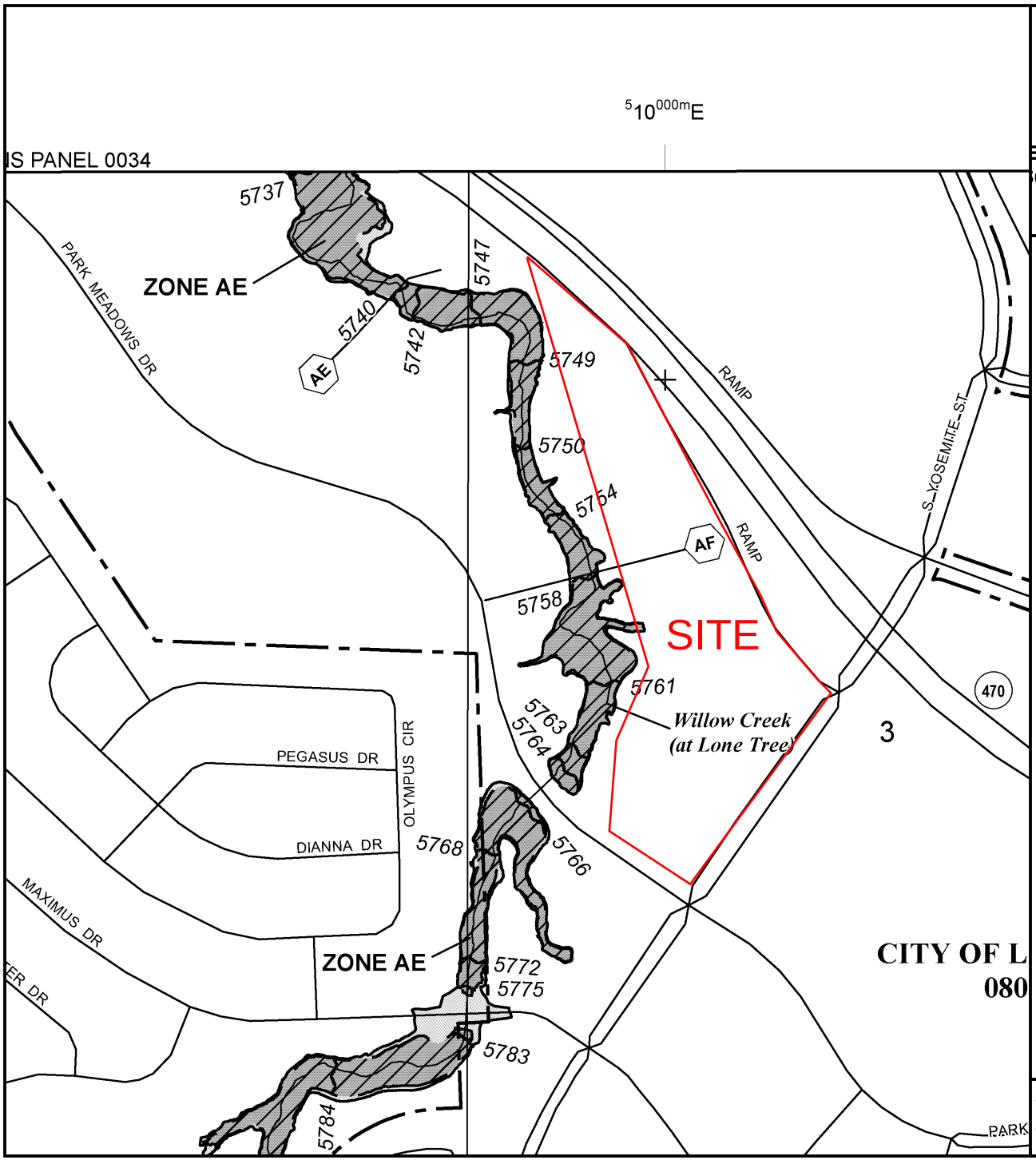
No.	Revisions	Date	By	Chk
10				
9				
8				
7				
6				
5				
4	REV. PER COUNTY COMMENTS	5/03/00	JAS	RLB
3	REV. PER UDFCD COMMENTS	7/12/99	JAS	RLB
2	REV. PER CITY/CNTY COMMENTS	4/09/99	JAS	RLB
1	REV. PER CITY COMMENTS	11/09/98	JAS	RLB

Carroll & Lange, inc.
Professional Engineers & Land Surveyors
165 South Union Blvd., Suite 156
Lakewood, Colorado 80228
(303) 980-0200

PRINTED MAY 04 2000

Project:	PARK MEADOWS / STARIKA SITE
Title:	STORM SEWER PLAN & PROFILE
Designed By: TWC	Scale: HORIZ: 1" = 50' VERT: 1" = 5'
Drawn By: JAS	Sheet 4 of 11
Checked By:	Job No. 1559
	Date: SEPTEMBER, 1997 File No. PROF-4

X:\1559\CONST\PROF-4.dwg Wed May 03 15:21:49 2000 CARROLL & LANGE, INC. JAS



MAP SCALE 1" = 500'

250 0 500 1000 FEET

0 0 150 300 MET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0042G

FIRM

FLOOD INSURANCE RATE MAP

DOUGLAS COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 42 OF 495

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
DOUGLAS COUNTY	080049	0042	G
LONE TREE, CITY OF	080319	0042	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
08035C0042G
MAP REVISED
MARCH 16, 2016

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

Carroll & Lange inc
165 South Union Blvd., Suite 156
Lakewood, Colorado 80228
303/980-0200
Fax: 303/980-0917

Job. No. 1559

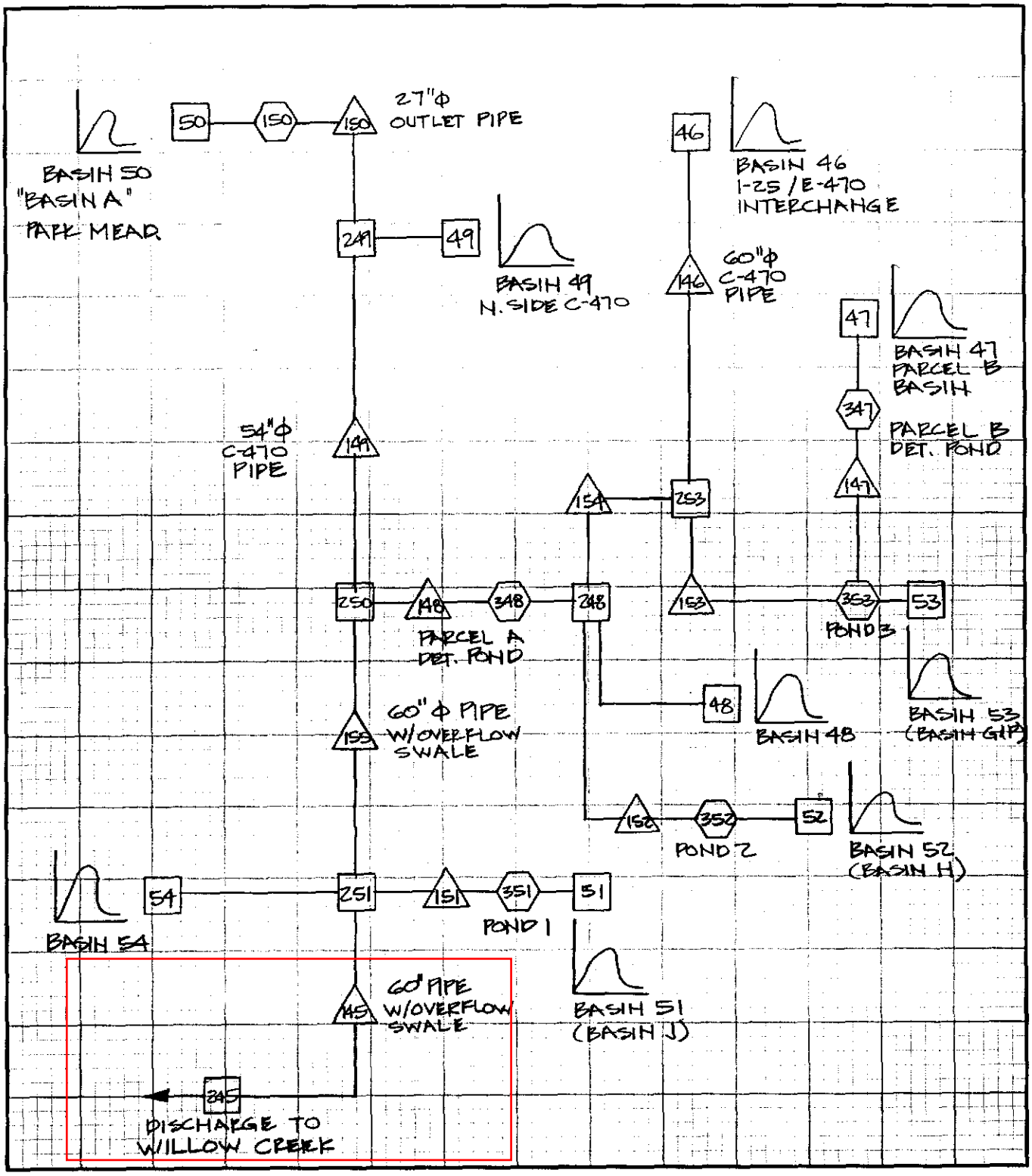
Date 11 / 6 / 98

PROJECT PARK MEADOWS

Sheet ____ of ____

Subject DEV. BASINS W/ PARCEL A & B DET. PONDS & WESTBROOK DET. PONDS

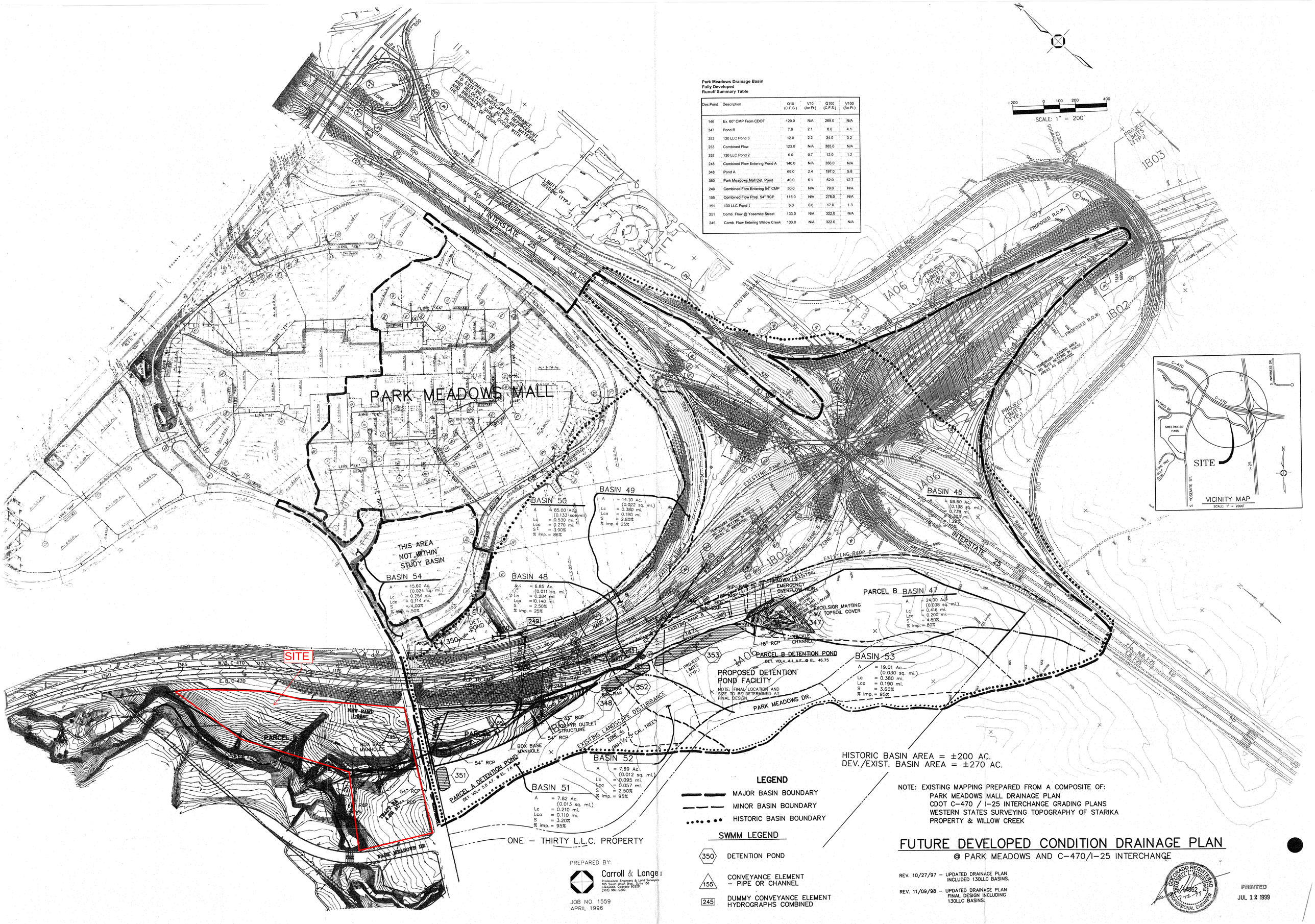
By RLB



DOUGLAS COUNTY - WILLOW CREEK 100-YR DEV. COND., WITH PK MEAD/E470 BASINS/STRAM
CARROLL & LANGE, INC. HYD.FILE: 1559DEHP.HY4

*** PEAK FLOWS, STAGES AND STORAGES OF GUTTERS AND DETENSION DAMS ***

CONVEYANCE ELEMENT	PEAK (CFS)	STAGE (FT)	STORAGE (AC-FT)	TIME (HR/MIN)
47	108.	(DIRECT FLOW)		0 35.
347	8.	.1	4.1	1 35.
53	91.	(DIRECT FLOW)		0 35.
147	8.	.4		1 40.
353	24.	.1	3.2	1 15.
46	289.	(DIRECT FLOW)		0 35.
52	64.	(DIRECT FLOW)		0 30.
153	24.	(DIRECT FLOW)		1 15.
146	269.	5.0	.3	0 40.
352	12.	.1	1.2	0 55.
253	385.	(DIRECT FLOW)		0 45.
50	422.	(DIRECT FLOW)		0 35.
152	12.	(DIRECT FLOW)		0 55.
48	19.	(DIRECT FLOW)		0 35.
154	328.	2.7		0 35.
350	52.	.1	12.7	1 20.
248	356.	(DIRECT FLOW)		0 35.
49	36.	(DIRECT FLOW)		0 40.
150	52.	1.3		1 20.
348	197.	.1	5.8	1 0.
249	79.	(DIRECT FLOW)		0 50.
51	71.	(DIRECT FLOW)		0 30.
148	197.	(DIRECT FLOW)		1 0.
149	80.	1.4		0 45.
351	17.	.1	1.3	0 50.
250	275.	(DIRECT FLOW)		0 55.
54	62.	(DIRECT FLOW)		0 35.
151	17.	.7		0 50.
155	278.	2.8		0 55.
251	322.	(DIRECT FLOW)		0 55.
145	322.	3.5		0 55.
245	322.	(DIRECT FLOW)		0 55.



Park Meadows Drainage Basin
Fully Developed
Runoff Summary Table

Des Point	Description	Q10 (C.F.S.)	V10 (Ac.Ft.)	Q100 (C.F.S.)	V100 (Ac.Ft.)
146	Ex. 60" CMP From CDOT	120.0	N/A	269.0	N/A
347	Pond B	7.0	2.1	8.0	4.1
353	130 LLC Pond 3	12.0	2.2	24.0	3.2
253	Combined Flow	123.0	N/A	385.0	N/A
352	130 LLC Pond 2	6.0	0.7	12.0	1.2
248	Combined Flow Entering Pond A	140.0	N/A	356.0	N/A
348	Pond A	69.0	2.4	197.0	5.8
350	Park Meadows Mall Det. Pond	40.0	6.1	52.0	12.7
249	Combined Flow Entering 54" CMP	50.0	N/A	79.0	N/A
155	Combined Flow Prop. 54" RCP	118.0	N/A	278.0	N/A
351	130 LLC Pond 1	6.0	0.8	17.0	1.3
251	Comb. Flow @ Yosemite Street	133.0	N/A	322.0	N/A
245	Comb. Flow Entering Willow Creek	133.0	N/A	322.0	N/A

LEGEND

- MAJOR BASIN BOUNDARY
- MINOR BASIN BOUNDARY
- HISTORIC BASIN BOUNDARY

SWMM LEGEND

- 350 DETENTION POND
- 155 CONVEYANCE ELEMENT – PIPE OR CHANNEL
- 245 DUMMY CONVEYANCE ELEMENT HYDROGRAPHS COMBINED

NOTE: EXISTING MAPPING PREPARED FROM A COMPOSITE OF:
PARK MEADOWS MALL DRAINAGE PLAN
CDOT C-470 / I-25 INTERCHANGE GRADING PLANS
WESTERN STATES SURVEYING TOPOGRAPHY OF STARIKA PROPERTY & WILLOW CREEK

FUTURE DEVELOPED CONDITION DRAINAGE PLAN

@ PARK MEADOWS AND C-470/I-25 INTERCHANGE

REV. 10/27/97 – UPDATED DRAINAGE PLAN INCLUDED 130LLC BASINS.

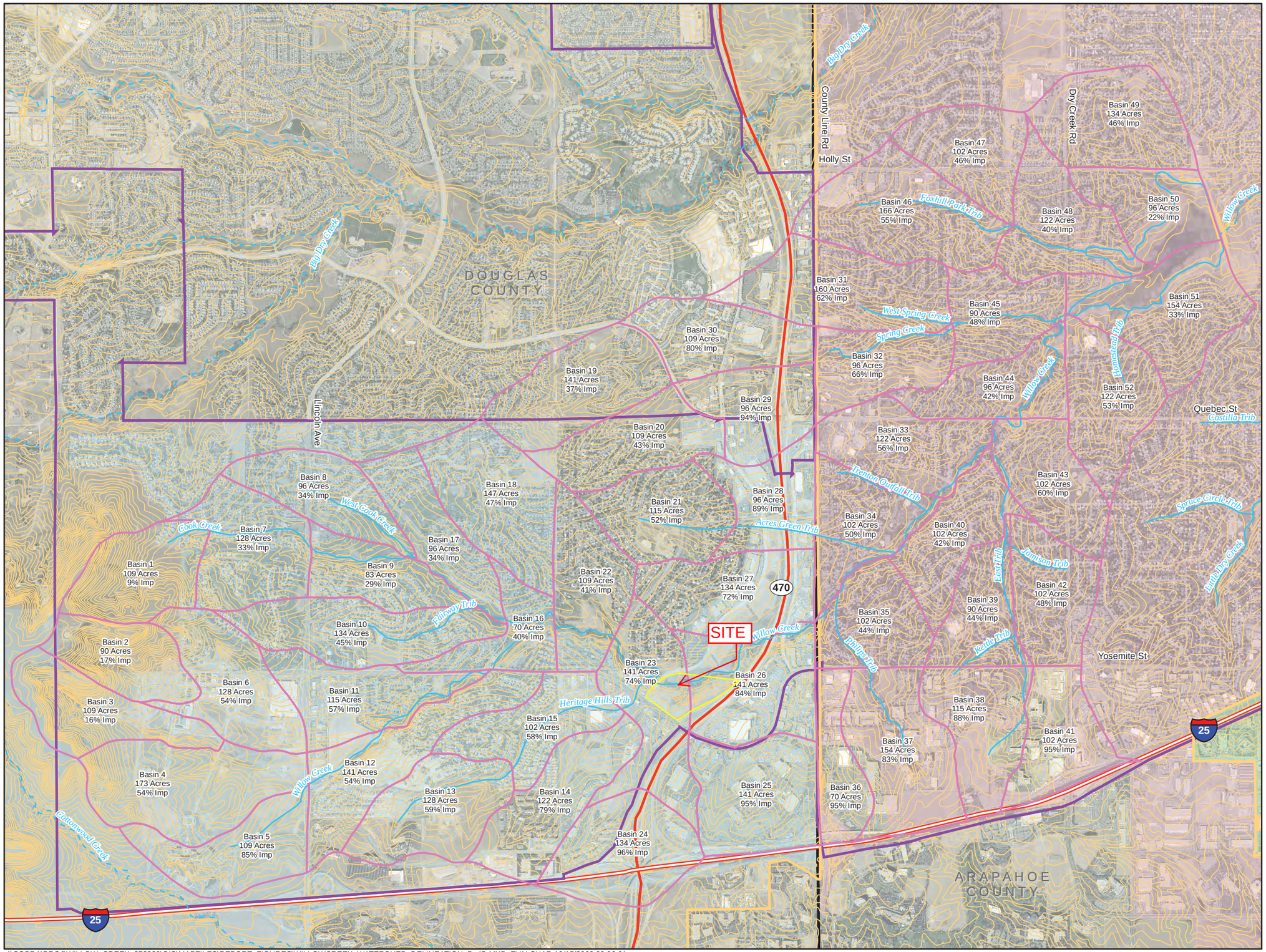
REV. 11/09/98 – UPDATED DRAINAGE PLAN FINAL DESIGN INCLUDING 130LLC BASINS.

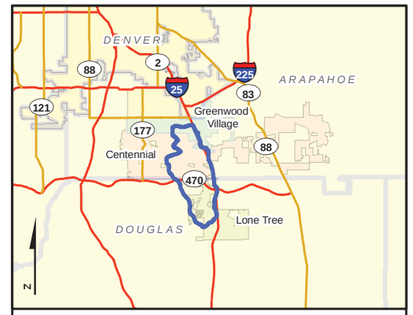
PREPARED BY:
Carroll & Lange
Professional Engineers & Land Surveyors
165 South Union Blvd., Suite 156
Lakewood, Colorado 80228
(303) 980-0200

JOB NO. 1559
APRIL 1996

COLORADO REGISTERED PROFESSIONAL ENGINEER
RUSSELL L. BURROW
14862
7-12-99

PRINTED
JUL 12 1999





Watershed Location

Willow Creek, Litte Dry Creek, and Greenwood Gulch Outfall Systems Planning Study

Legend

- Studied Stream Reaches
- Non Studied Streams Reaches
- USGS 10ft Contours
- SEMSWA Service Area
- SSPRD Boundary
- County Boundary

Watershed

- Willow Creek

Municipalities

- Centennial
- Greenwood Village
- Lone Tree

W S N E

0 1,000 2,000

Feet

WILLOW CREEK BASIN DELINEATION FIGURE B-4B

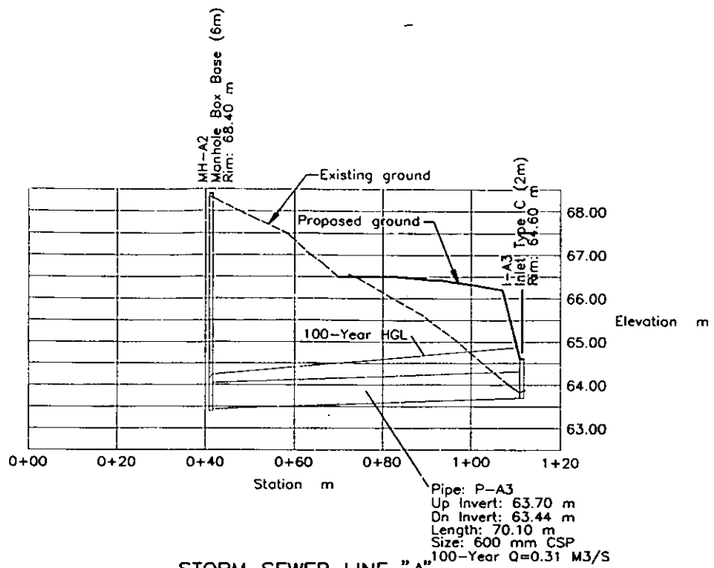
CH2MHILL

\\COBRA\PROJ\WILLOW_CREEK_372380\GIS\MAPFILES\REPORT_FIGURES\WILLOWCREEK_WATERSHED_DELINEATION_B_4B.MXD ZVALCHAR 10/15/2009 09:06:01

AS CONSTRUCTED			
NO REVISIONS ☐	REVISED ☐	VOID ☐	

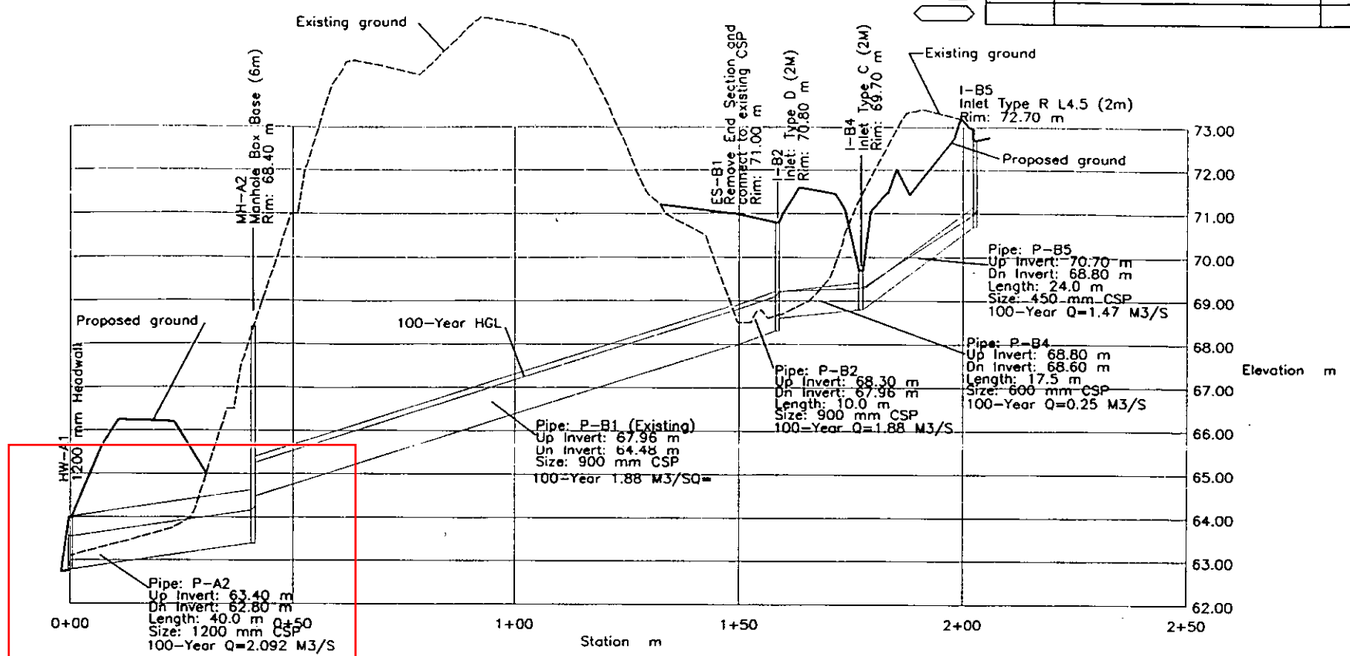
FEDERAL RD REGION NO.	DIVISION	PROJ. NO.	SHEET NO.	TOTAL SHEETS
VIII	COLORADO	CC 4701-082	73	

REVISIONS		



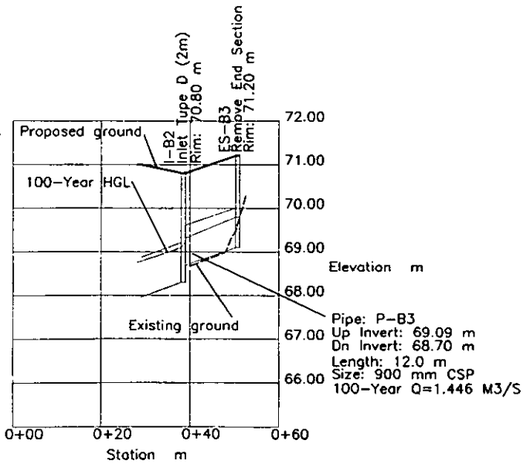
STORM SEWER LINE "A"

STA. 1+737, 14.0 RT TO 1+748.5 13.0 LT.



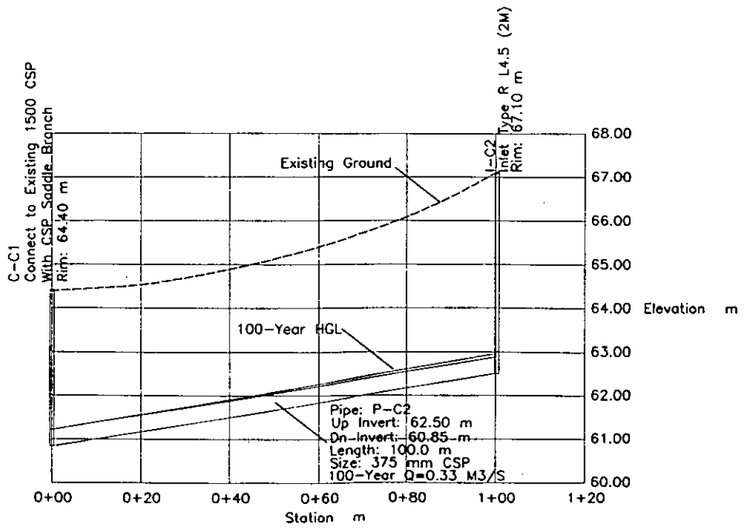
STORM SEWER LINE "A-B"

STA. 1+737, 14.0 RT. TO STA. 0+321.418, 13.958 LT.



STORM SEWER LINE "B"

STA. 1+737, 14.0 RT TO 1+748.5 13.0 LT.



STORM SEWER LINE "C"

YOSEMITE STREET STA. 0+045, 11 LT. TO 0+146.602, 12.054 LT.

STORM SEWER PROFILES

NOTE: WHOLE NUMBERS INDICATE MILLIMETERS
DECIMAL NUMBERS INDICATE METERS

FELSBURG HOLT & ULLEVIG

C-470/YOSEMITE INTERCHANGE

STORM SEWER PROFILES

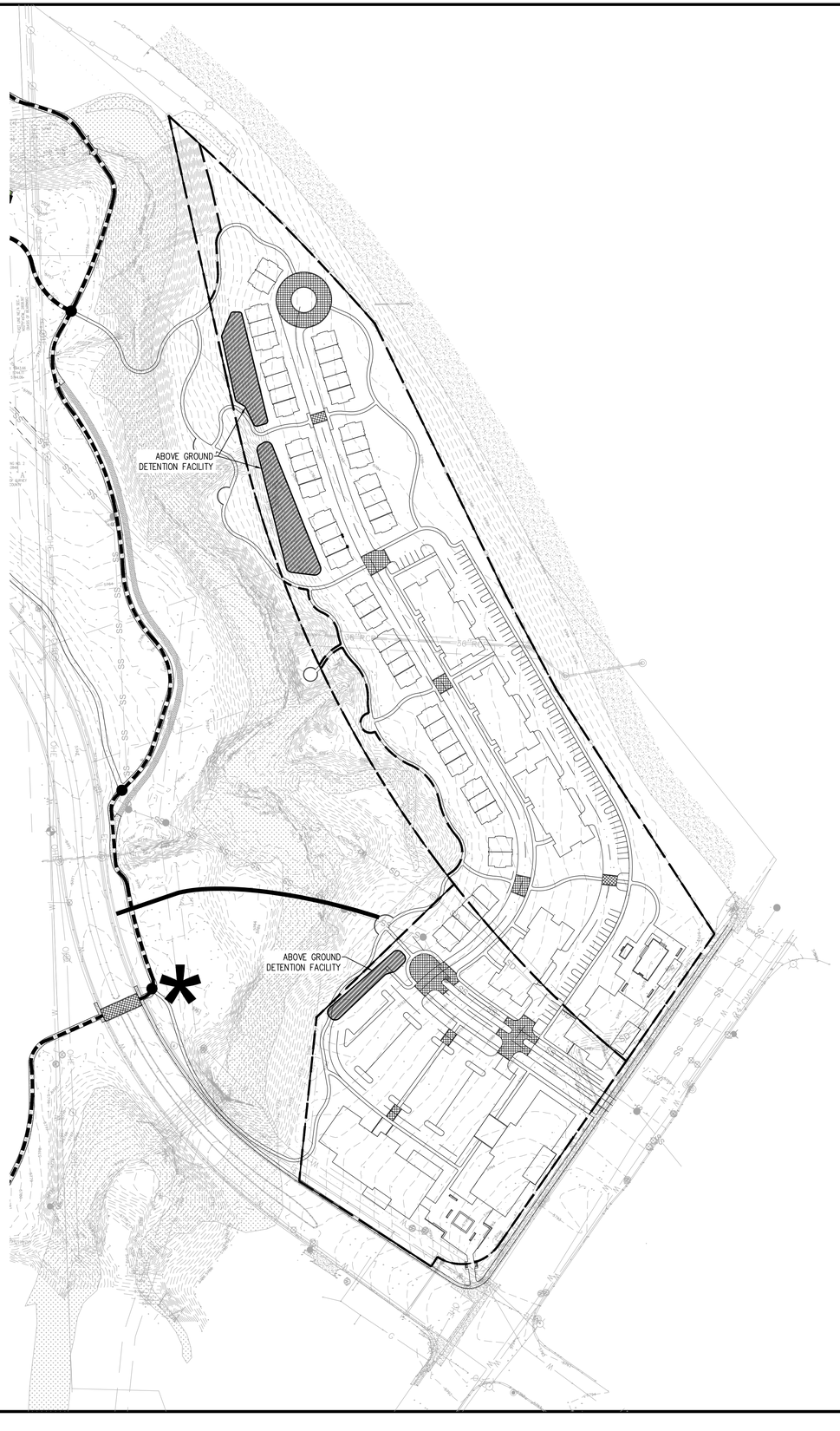
DATE	PROJECT NO.	DESIGNED BY EL	DRAWN BY SS	CHECKED BY DB	SHEET NO. 1 OF 2 SHEETS	DRAWING NO. ST-1
DEC 95	95-088					

G:\95088\ACAD\A5088420.dwg, 1:1, 11/30/95 at 14:04

COMPUTER GENERATED DRAWING DO NOT ALTER MANUALLY

APPENDIX F- PROPOSED DETENTION FACILITY AREAS MAP

1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com



LEGEND:

- DESIGN POINT
- PROPOSED BASIN BOUNDARY
- EMERGENCY OVERFLOW PATH
- EX. MAJOR CONTOUR
- EX. MINOR CONTOUR
- PROP. MAJOR CONTOUR
- PROP. MINOR CONTOUR
- PROP. ABOVE GROUND DETENTION FACILITY

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 ft.

N

Bowman
1526 Cole Blvd, Suite 100
Lakewood, CO 80401
Phone: (303) 861-2800
www.bowman.com

REVISIONS

REVISION	DESCRIPTION	DATE
---	---	---

PROPOSED DETENTION FACILITY MAP

WILLOW CREEK PUD

LONE TREE COLORADO

SEAL

NOT FOR CONSTRUCTION

DESIGN	DRAWN	CHKD
CR	CR	TP

SCALE H: 1" = 150'
V: 1" = 150'

JOB No. 020460-01-001

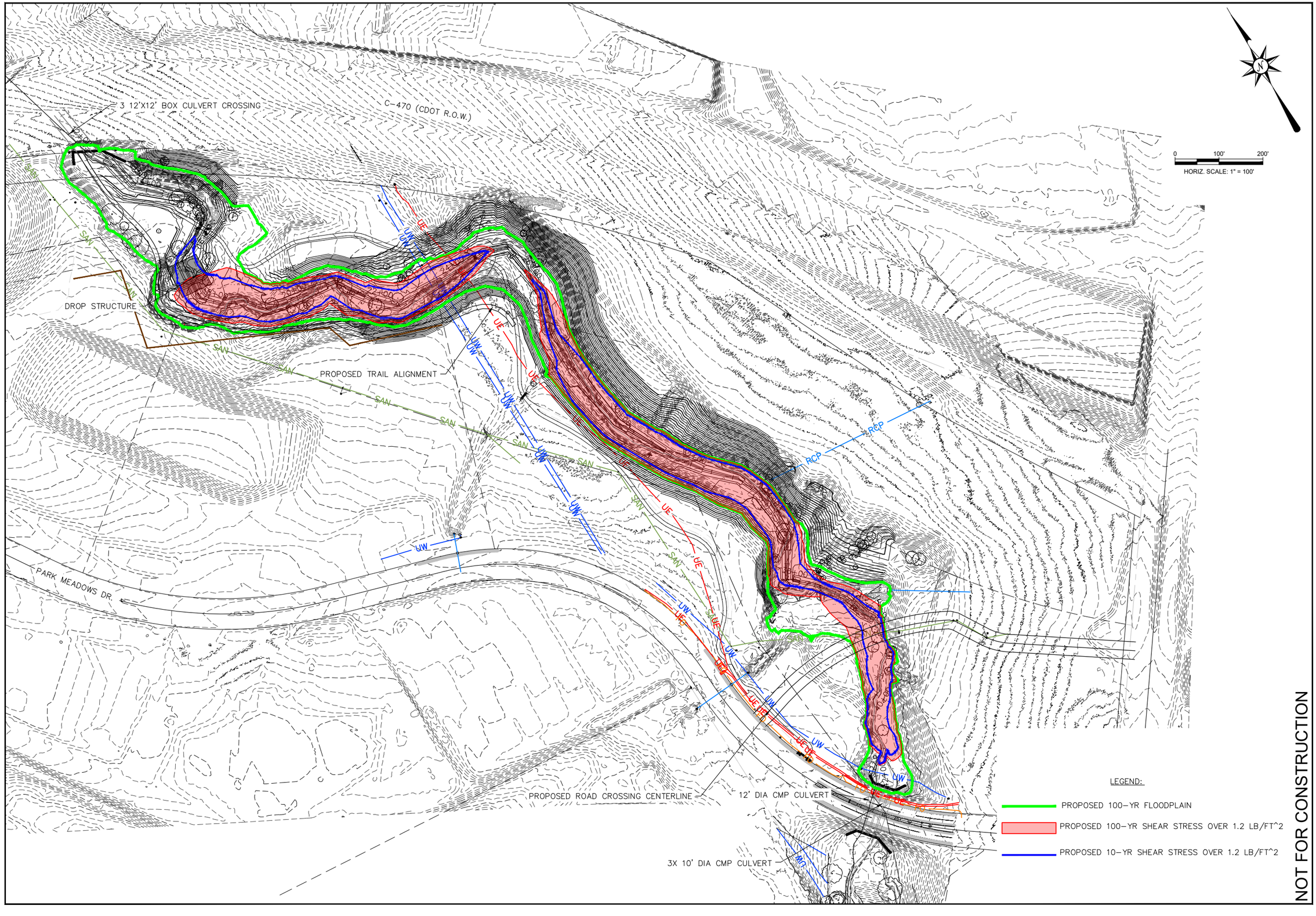
DATE : 03/23/2023

SHEET
1 OF 1

Cad file name: V:\020460 - Willow Creek PUD\020460-01-001 (ENG)\Engineering\Engineering Plans\Drainage\020460-01-001 PROP-DET-POND.dwg

APPENDIX G- WILLOW CREEK MINIMAL IMPACT DRAINAGE PLAN

1526 Cole Boulevard, Suite 100, Lakewood, Colorado 80401
P: 303.801.2900
bowman.com



NOT FOR CONSTRUCTION

PREPARED BY:

LOEWEN Engineering Inc.

7388 S REVERE PKWY
SUITE 601
CENTENNIAL, CO 80112
O: (720) 667-2063

PREPARED FOR:

MHFD MILE HIGH FLOOD DISTRICT

CITY OF LONE TREE

VERIFY SCALE:
BAR IS ONE INCH ON ORIGINAL DRAWINGS

811 Know what's below. Call before you dig.

WILLOW CREEK PARK MEADOWS TO C470

OVERALL PLAN

#	DATE	DESCRIPTION	INITIALS

DRAWN BY: PCVL
DESIGNED BY: PCVL
CHECKED BY: DPL

DATE
NOV 2023

SHEET
1

PROPOSED RETAINING WALL

DROP STRUCTURE

REM EX TRAIL

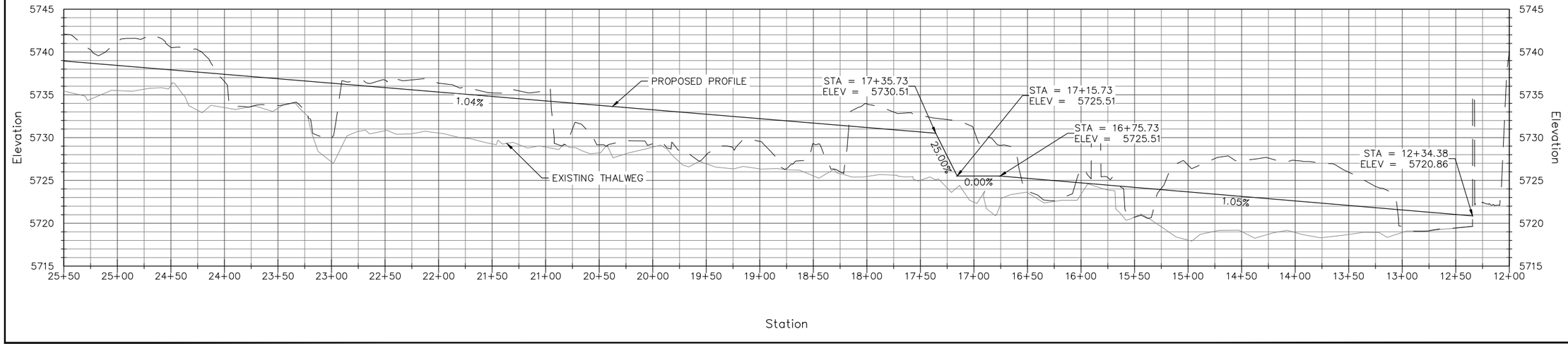
3 12'X12' BOX CULVERT CROSSING

0 50' 100'
HORIZ. SCALE: 1" = 50'

LEGEND:

- PROPOSED 100-YR FLOODPLAIN
- PROPOSED 100-YR SHEAR STRESS OVER 1.2 LB/FT^2
- PROPOSED 10-YR SHEAR STRESS OVER 1.2 LB/FT^2

PROPOSED WILLOW CREEK PROFILE



NOT FOR CONSTRUCTION

PREPARED BY:
LOEWEN Engineering Inc.
7388 S REVERE PKWY
SUITE 601
CENTENNIAL, CO 80112
O: (720) 667-2063

PREPARED FOR:
MHFD MILE HIGH FLOOD DISTRICT
CITY OF LONE TREE

VERIFY SCALE:
BAR IS ONE INCH ON ORIGINAL DRAWINGS

811 Know what's below. Call before you dig.

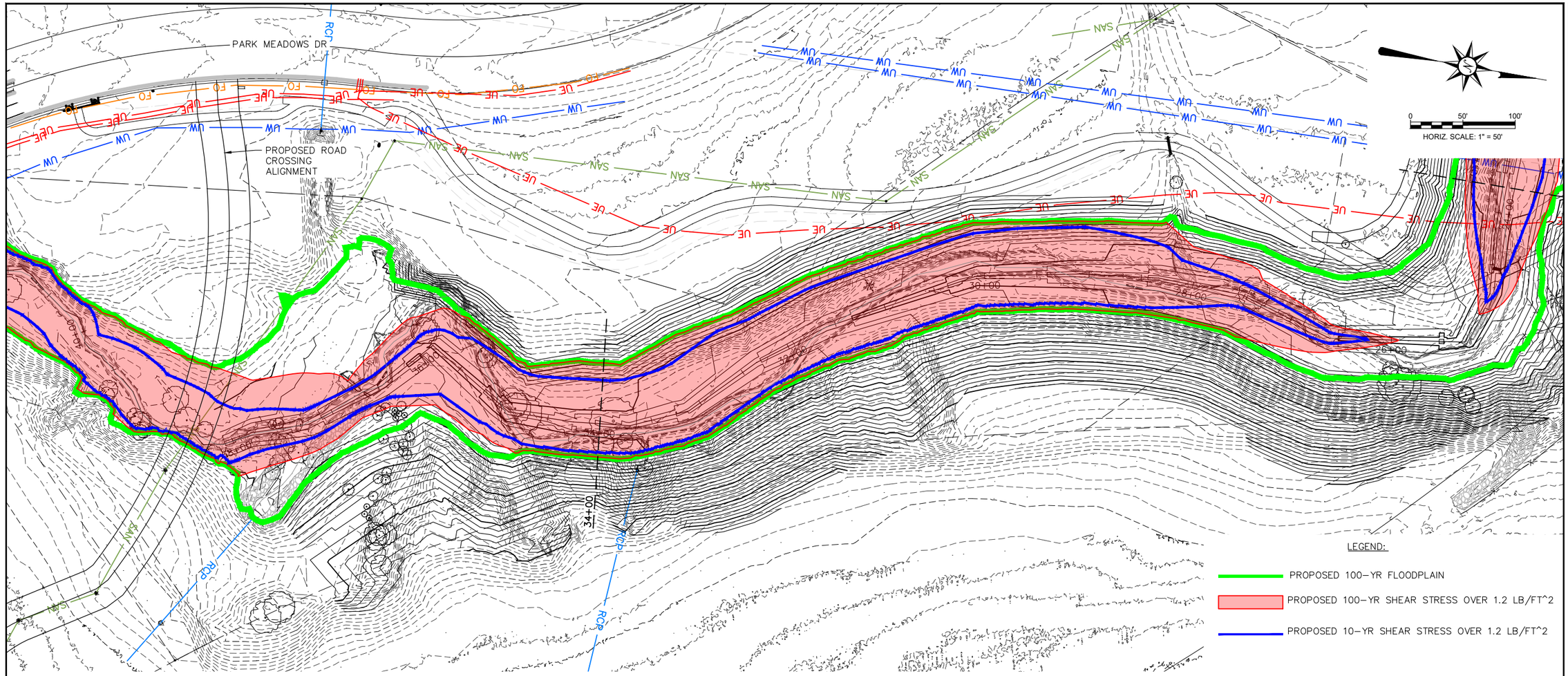
WILLOW CREEK PARK MEADOWS TO C470
PLAN AND PROFILE (1 OF 2)

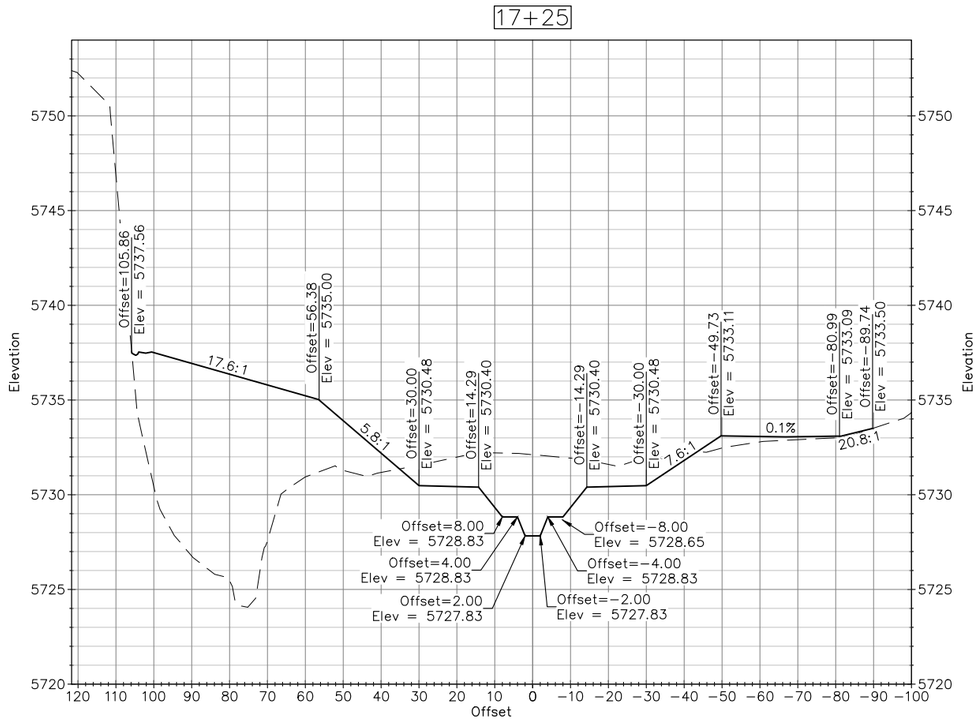
#	DATE	DESCRIPTION	INITIALS

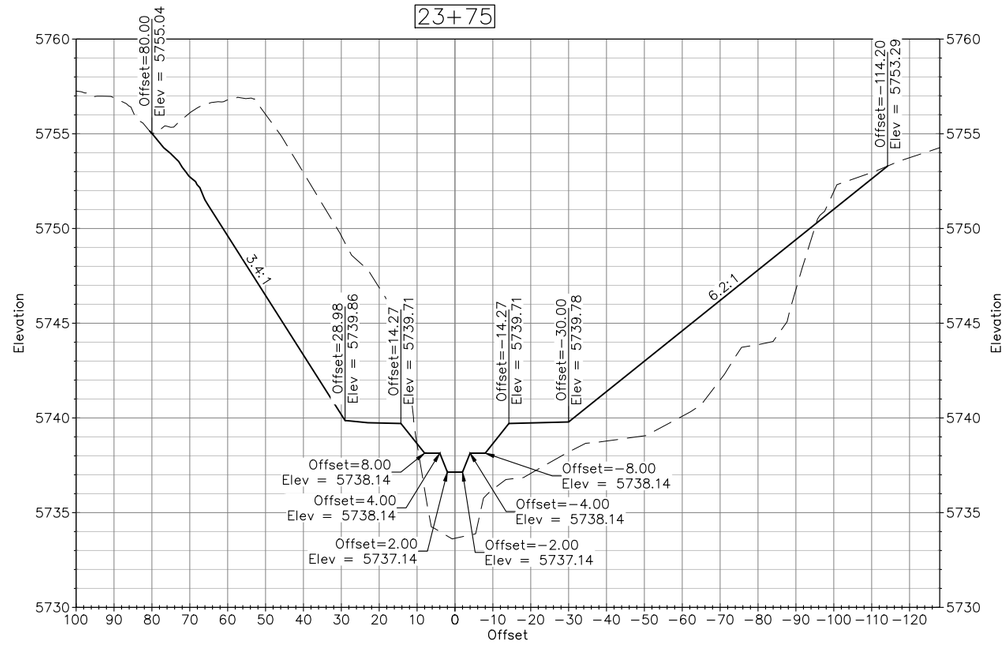
DRAWN BY: PCVL
DESIGNED BY: PCVL
CHECKED BY: DPL

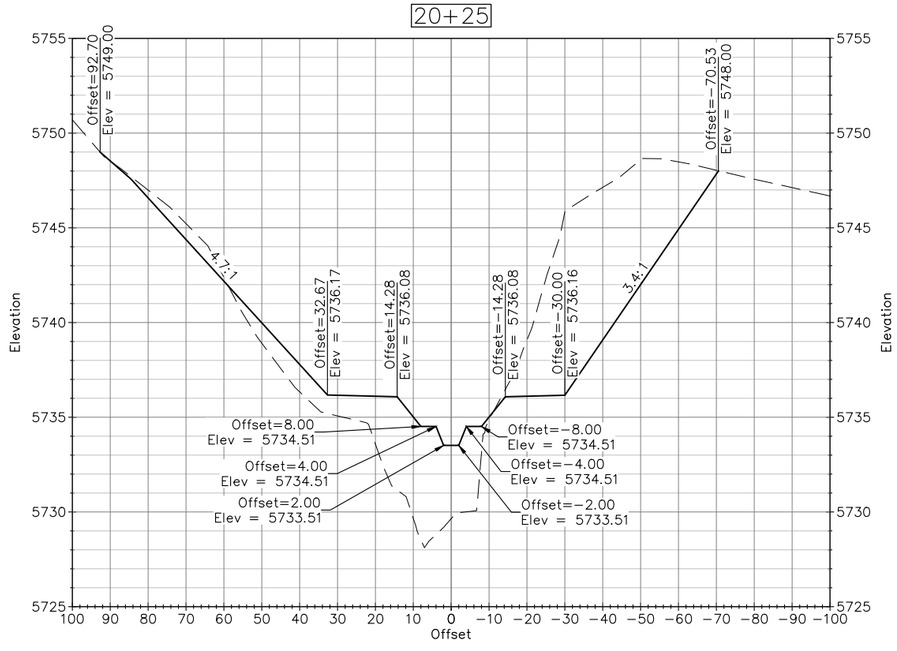
DATE
NOV 2023

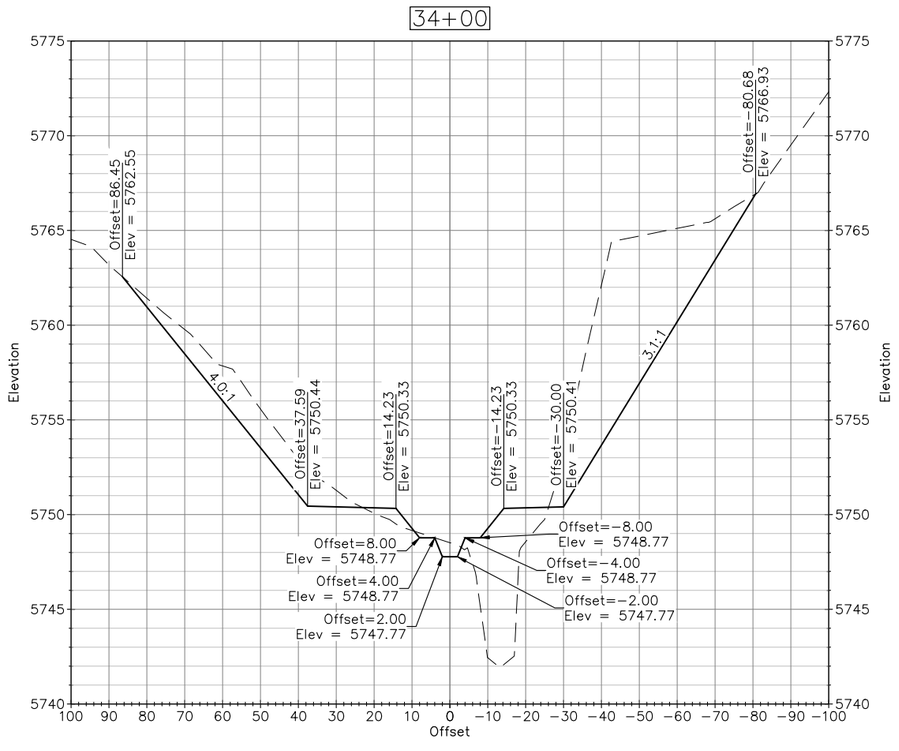
SHEET
2


PARK MEADOWS DR
RCP
PROPOSED ROAD CROSSING ALIGNMENT
RCP
RCP
RCP









NOT FOR CONSTRUCTION

PREPARED BY:
LOEWEN Engineering Inc.
7388 S REVERE PKWY
SUITE 601
CENTENNIAL, CO 80112
O: (720) 667-2063

PREPARED FOR:
MHFD MILE HIGH FLOOD DISTRICT
CITY OF LONE TREE

VERIFY SCALE:
BAR IS ONE INCH ON ORIGINAL DRAWINGS

811 Know what's below. Call before you dig.

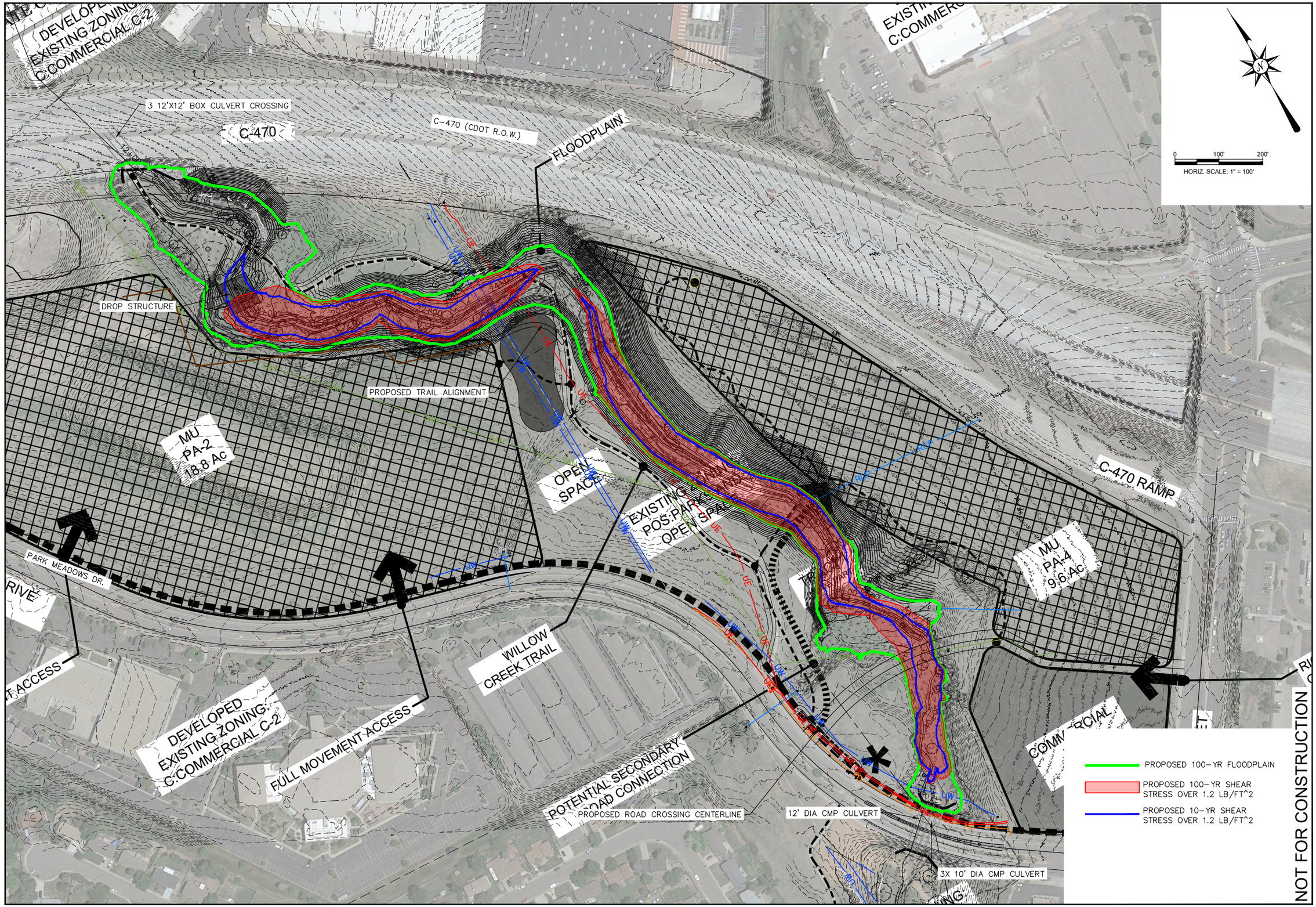
WILLOW CREEK PARK MEADOWS TO C470
CROSS SECTIONS

#	DATE	DESCRIPTION	INITIALS

DRAWN BY: PCVL
DESIGNED BY: PCVL
CHECKED BY: DPL

DATE
NOV 2023

SHEET
4



PREPARED BY:
LOEWEN Engineering Inc.
7388 S REVERE PKWY
SUITE 601
CENTENNIAL, CO 80112
O: (720) 667-2063

PREPARED FOR:
MHFD MILE HIGH FLOOD DISTRICT
CITY OF LONE TREE

VERIFY SCALE:
BAR IS ONE INCH
ON ORIGINAL
DRAWINGS

811 Know what's below. Call before you dig.

WILLOW CREEK PARK MEADOWS TO C470
MINIMAL IMPACT APPROACH

#	DATE	DESCRIPTION	INITIALS

DRAWN BY: PCVL
DESIGNED BY: PCVL
CHECKED BY: DPL

DATE
NOV 2023

SHEET