berge-brewer & associates, inc.

phone (719) 227-7181 - fax (719) 227-7188 - 711 north cascade avenue - colorado springs, co 80903

ENGINEERS
PLANNERS
SURVEYORS

MASTER DEVELOPMENT DRAINAGE PLAN

BENTLEY COMMONS

PREPARED FOR:

BENTLEY, LLC

269 HARDWICK CT

CASTLE ROCK, CO 80108

PREPARED BY:

BERGE-BREWER AND ASSOCIATES, INC.

711 N. CASCADE AVENUE

COLORADO SPRINGS, CO 80903

Prepared by: Anna C. Sparks, EIT
Reviewed by: Roger G. Berge, PE & PLS
December 23, 2002
Revised: January 14, 2003

CERTIFICATION:

Engineers Statement:

This attached drainage plan and report for "Bentley Commons" were prepared under my direction and supervision and is correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the City of Colorado Springs\El Paso County for drainage reports and said report is in conformity with the master plan of the Sand Creek Drainage Basin. I accept responsibility for any liability caused by any acts, errors of omissions on my part in preparing this report.

Roger G. Berge, Professional Engineer No. 9646 1/15/03
For and on behalf of Berge-Brewer & Associates, Inc.

Developers Statement:

The developer has read and will comply with all of the requirements specified in this report and plan.

BENTLEY LIMITED LIABILITY COMPANY
Business Name:

By: Douglas E. Fast

Title: Managing Member

Address: 269 HARDWICK COURT

CASTLE ROCK, CO 80108-9042

City of Colorado Springs:

Filed in accordance with Section 15-3-906 the Code of the City of Colorado Springs, 1980, as amended.

BY: For the City Engineer 1/28/03
DATE

CONDITIONS:

11/18/02 10:22am P. 002
NOV 18 02 05:08p Douglas Fast 303-753-0060 P.2

LOCATION AND PURPOSE:

"Bentley Commons" is located in the Northwest Quarter of Section 34, Township 14 South, Range 66 West of the Sixth P. M. in the City of Colorado Springs, El Paso County, Colorado. This 7.8 acre site is zoned R-5 (Multi-family Residential) with the Northeasterly portion having "conditions of record." The site is proposing to construct condominiums in phases.

The site is bounded on the northeast and southeast by unplatted property. Across Hancock Expressway to the southwest are "Astrozon Place Sub." and "Astrozon Place Sub. Fil. No. 2". Across Sand Creek Drainage Way to the northwest is "Pikes Peak Park Sub. No. 13". The project is located in the Sand Creek Drainage Basin.

SITE CHARACTERISTICS:

This site is presently vacant with mostly grasses and few trees.

SOILS:

The soils in this area consist of Ellicott loamy coarse sand, 0 to 5% slopes (see enclosed soils map). Ellicott Soils are classified as hydrologic group A. A small portion of Off-site Basin 1 may extend into Blakeland soil type, also hydrologic group A, designated with an 8 on the soils map.

METHOD:

This drainage report was prepared in accordance with the latest revision of the City of Colorado Springs/El Paso County "Drainage Criteria Manual" dated November 1991 and amended October 1994. Drainage basins were analyzed using the Rational Method to determine runoff peaks for the 5 year and 100 year storms. The Sand Creek Drainage Basin Planning Study (DBPS) prepared by Kiowa Engineering Corporation and dated 1995 was referenced for this project.

EXISTING DRAINAGE:

The project area drains into the adjacent Sand Creek Drainage Way. An existing concrete channel, that is located mostly within the site boundary, carries stormwater along Hancock Expressway and into Sand Creek. Basin A consists of the site, which includes a portion of the concrete channel. Historic flows for Basin A, established using the current conditions of the site, are $Q_5 = 4.05$ cfs/$Q_{100} = 10.94$ cfs.

Two (2) off-site drainage basins enter the project area. Off-site Basin 1 was delineated using a combination of the USGS Quadrangle map, the Sand Creek DBPS, and the project contours on the drainage plan. The extent of Off-site Basin 1 is shown on the USGS

Quadrangle map. The stormwater within Off-site Basin 1 flows through the northerly side of the Northeast corner of the project. Off-site Basin 1 historic flows are Q_5 = 1.36 cfs/Q_{100} = 3.40 cfs. The stormwater within Off-site Basin 2 flows through the easterly side of the Northeast corner of the project. Off-site Basin 2 historic flows are Q_5 = 0.30 cfs/Q_{100} = 0.74 cfs.

The existing concrete channel's drainage basins were analyzed in the "Addenda to Drainage Report and Plan, Astrozon Plaza Subdivision" (Astrozon Study) prepared by Leigh Whitehead & Associates dated Sept. 1985. The Astrozon Study sized a culvert to pass the 100 year storm event flowing through the existing concrete channel under Astrozon Boulevard. The study utilized the SCS Method for analysis, no longer used for these sizes of basins. Enclosed is the Astrozon Study's analysis using the Rational Method. The 100 year flow into the existing concrete channel prior to flowing on-site is currently 361.56 cfs, and is expected to be 517.62 cfs under developed conditions.

The Astrozon Study's stormwater runoff areas to the existing concrete channel were confirmed with current topography. Enclosed is a copy of a Facilities Information Management System (FIMS) map with basin overlay from the Astrozon Study. Basin boundaries were adjusted as necessary from the original Astrozon Study. The North system was constructed across Academy Boulevard, across Astrozon Boulevard and to Sand Creek. In addition, a riprap channel was constructed from Jet Wing Drive to the North system's entrance. According to the DBPS, the riprap channel has a Q_{100} = 110 cfs and the North system's entrance has a pipe capacity of Q_{cap} = 150 cfs. The additional research and analysis of the existing concrete channel demonstrated that the channel will pass a 100 year storm event.

The existing concrete channel flows into an existing 58" CMP prior to discharge into the creek. The 58" pipe has the capacity to pass 470.62 cfs, however, due to inlet/outlet control the pipe will discharge 136.36 cfs in the 100 year storm event. Under existing conditions, the existing pipe is expected to discharge 136.36 cfs of the 100 year storm event and overflow the remaining amount, 225.20 cfs, to the existing riprap area. The overflow during the peak of the 100 year storm event will flow Northwesterly through the existing riprap to the creek.

Existing D-10-R curb-opening inlets exist along the North line of Hancock Expressway to the East of the site, as described in this paragraph. On both sides of Boychuk Avenue (extension into commercial parking area) one 6' D-10-R exists on each side. Just West of the Academy Boulevard access (prior to the intersection of Hancock and Academy), an 8' D-10-R exists. To the East of the Academy Boulevard and its access drives, a 15' D-10-R exists. Continuing East along Hancock, two more 15' D-10-Rs exist prior to Jet Wing Drive. Just to the East of the intersection of Jet Wing and Hancock, an existing channel crosses under Hancock Expressway.

PROPOSED DRAINAGE:

Basin A developed flows, Q_5 = 14.71 cfs/Q_{100} = 33.11 cfs, are based upon the developed conditions. Stormwater from Basin A was split into three sub-basins for outlet sizing. Sub-basins A1 and A2 are proposed to outfall into the creek by way of inlets and piping at a 45° angle downstream (above the 100 year floodplain elevation), onto proposed riprap on top of the soil over the 100 year riprap lining in the creek banks. The access drive and parking areas on-site will be constructed with curb and gutter. The curb and gutter will help convey stormwater from Basin A to low points adjacent to the creek. The future shared access to Astrozon Boulevard will not be a part of this project.

Sub-basin A1 is expected to generate Q_5 = 3.90 cfs/ Q_{100} = 8.48 cfs. At the low point of the parking area of Sub-basin A1, adjacent to the creek, a 7' D-10-R is proposed to intercept the 100 year storm event. The outfall for the 7' D-10-R inlet will be through proposed 24" CMP and onto riprap. Sub-basin A2 is expected to generate Q_5 = 6.87 cfs/ Q_{100} = 15.45 cfs. At the low point of the parking area of Sub-basin A2, adjacent to the creek, an 8' D-10-R is proposed. The outfall for the 8' D-10-R inlet will be through proposed 24" CMP and onto riprap to intercept the 5 year storm event. 100 year storm event overflow was provided for the 8' D-10-R within a proposed swale. Off-site Basin 1 and 2 stormwater was included for the Sub-basin A2 outlet. Sub-basin A3 is expected to generate Q_5 = 6.92 cfs/ Q_{100} = 3.24 cfs. Sub-basin A3 will discharge into a proposed swale along the proposed concrete fence. The proposed swales will have 4:1 (H:V) side slopes and outfall into the creek with proposed riprap on the bank. The proposed swales were sized for conveyance of the 100 year storm event. To be conservative, the small area of Off-site Basin 1 entering Sub-basin A1 was added to the area of the Sub-basin prior to calculating runoff. To be conservative with Sub-basin A2, the entire Off-site Basin 1 was added to the runoff of the Sub-basin, even though one small area of Off-site Basin 1 is not expected to drain into the Sub-basin.

The site's access drive off of Hancock Expressway will cross over 4 proposed 7'X2.5' box culverts. A transition will be constructed from the existing concrete channel to the box culverts on both ends. The culverts were designed to pass the 100 year storm event under the access drive.

Channel improvements are being proposed in accordance with the Sand Creek DBPS. Two erosion control checks are being proposed across the width of the creek, as proposed in the DBPS. The details on the enclosed Sand Creek Improvements plan and profile sheet were duplicated from the DBPS details. The side slopes of the creek along the site are being proposed to contain 100 year storm event riprap.

In the existing channel, prior to discharge into the existing pipe, the City suggested removal of the existing asphalt to provide positive flow toward the creek in the 100 year storm. The Cross-section "For City" was provided along this alignment, as requested by the City. Along this alignment, a slope of ¼" per foot (2%) toward the creek is proposed. The area adjacent to the alignment will also be regraded to provide positive flow toward the creek.

FLOODPLAIN STATEMENT:

This site is located on Map No. 08041CO742 F of the Federal Emergency Management Agency's Flood Insurance Rate Map (FEMA FIRM) dated March 17, 1997. A very small portion of the site in the North corner is located within the 100 year floodplain (Zone AE). Through lineal interpolation between the creek cross-sections, the Zone AE 100 year floodplain elevation would be 5881.8± in that North corner of the site. Two (2) different areas of Zone X are located on the site. Part of the site was determined to be in the Zone X outside of the 500 year floodplain. The other Zone X area is labeled in the drainage plan as Zone X floodplain. This Zone X floodplain is believed to be an area of 100 year flood with average depths of less than 1 foot, as stated in the FEMA FIRM legend. The base floor elevations for the proposed buildings will be a minimum of 1' above the 100 year floodplain elevation. See the drainage plan for the proposed first floor (FF) elevations of the buildings. The proposed retaining walls along the creek bank will be above the 100 year developed flowrate specified in the DBPS. After the proposed Sand Creek improvements, the floodplain will be confined within the channel. A Floodplain Development Permit will be acquired prior to the commencement of construction within the Sand Creek Drainage Way 100 year floodplain.

DRAINAGE IMPROVEMENTS:

The following public drainage improvements for this project will be required as a result of this development:

7'X2.5' box culvert – 4 qty. - 61 LF ea. @ $180/LF	$ 43,920.00
Concrete channel transition – 56 CY @ $200/CY	$ 11,200.00
2 qty. - Concrete erosion control check – 87 CY total @ $200/CY	$ 17,400.00
Riprap erosion control check, Type 'H' – 865 CY @ $44/CY	$ 38,060.00
Riprap 100 yr lining, Type 'L' to 'H' – 1,960 CY @ $44/CY	$ 86,240.00
4 qty. - Riprap for outfalls – 5 CY ea. @$35/CY	$ 700.00
1' wide chase – 1 qty. @ $2,000 ea.	$ 2,000.00
7' D-10-R – 1 qty. @ $3,000 ea.	$ 3,000.00
8' D-10-R – 1 qty. @ $3,000 ea.	$ 3,000.00
24" CMP – 98 LF @ $30/LF	$ 2,940.00
Sub-Total	$208,460.00
15% Contingencies	$ 31,269.00
TOTAL	$239,729.00

FEES:

Sand Creek Drainage Fees:

7.8 acres @ $6,915/acre	$53,937.00

Sand Creek Bridge Fees:

7.8 acres @ $412/acre	$3,213.60

Sand Creek Pond Fees (Land):

7.8 acres @ $448/acre	$3,494.40

Sand Creek Pond Fees (Facility):

7.8 acres @ $1,543/acre	$12,035.40

EROSION CONTROL:

Erosion control in conformance with an approved Grading and Erosion Control Plan will be installed during the construction phase of this development. The stormwater will be safely conveyed to Sand Creek through the site and by adequate outfalls. Construction of the proposed drainage and erosion control facilities will ensure that this subdivision will not adversely affect downstream or surrounding areas.

REFERENCES

1. City of Colorado Springs/El Paso County Drainage Criteria Manual dated November 1991.

2. "Soil Survey for El Paso County Area," USDA Soil Conservation Service.

3. Sand Creek Drainage Basin Planning Study (DBPS) prepared by Kiowa Engineering Corp. dated 1995.

4. "Drainage Report & Plan, Astrozon Plaza Subdivision" prepared by Leigh Whitehead & Associates dated Nov. 1984.

5. "Addenda to Drainage Report and Plan, Astrozon Plaza Subdivision" prepared by Leigh Whitehead & Associates dated Sept. 1985.

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	Rational	10.94	1	34	22,321	100	----	------	------	Basin A current
2	Rational	4.05	1	38	9,236	5	----	------	------	Basin A current
3	Rational	33.11	1	15	29,802	100	----	------	------	Basin A developed
4	Rational	14.71	1	17	15,006	5	----	------	------	Basin A developed
5	Rational	5.95	1	22	7,859	100	----	------	------	Off-site Basin 1
6	Rational	2.27	1	23	3,138	5	----	------	------	Off-site Basin 1
7	Rational	1.29	1	15	1,165	100	----	------	------	Off-site Basin 2
8	Rational	0.49	1	16	475	5	----	------	------	Off-site Basin 2
9	Rational	8.48	1	10	5,086	100	----	------	------	Sub-basin A1
10	Rational	3.90	1	11	2,576	5	----	------	------	Sub-basin A1
11	Rational	15.45	1	15	13,907	100	----	------	------	Sub-basin A2
12	Rational	6.87	1	17	7,003	5	----	------	------	Sub-basin A2
13	Rational	6.92	1	5	2,076	100	----	------	------	Sub-basin A3
14	Rational	3.24	1	6	1,165	5	----	------	------	Sub-basin A3

Proj. file: 010367-Q.GPW | IDF file: colorado.IDF | Run date: 09-05-2002

Bentley Condominium

Storm Water Intensity

Hydrograph No.	Description	Return Period (years)	Area (acre)	C	Intensity (in/hr)
1	Basin A – current	100	7.8	0.36	3.90
2	Basin A – current	5	7.8	0.26	2.00
3	Basin A – developed	100	7.8	0.70	6.06
4	Basin A – developed	5	7.8	0.60	3.14
5	Off-site Basin 1 – historic	100	3.4	0.20	5.00
6	Off-site Basin 1 – historic	5	3.4	0.15	2.68
7	Off-site Basin 2 – historic	100	0.05	0.35	6.06
8	Off-site Basin 2 – historic	5	0.05	0.25	3.24
9	Sub-basin A1 – developed	100	1.68	0.35	7.21
10	Sub-basin A1 – developed	5	1.68	0.25	3.87
11	Sub-basin A2 – developed	100	3.64	0.35	6.06
12	Sub-basin A2 – developed	5	3.64	0.25	3.14
13	Sub-basin A3 – developed	100	1.10	0.35	8.98
14	Sub-basin A3 – developed	5	1.10	0.25	4.90

Hydrograph Summary Report

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Volume (cuft)	Return period (yrs)	Inflow hyd(s)	Maximum elevation (ft)	Maximum storage (cuft)	Hydrograph description
1	Rational	201.47	1	14	169,233	100	----	------	------	Basins 1 & 2a dev
2	Rational	99.05	1	14	83,203	5	----	------	------	Basins 1 & 2a dev
3	Rational	184.68	1	14	155,130	100	----	------	------	Basins 1 & 2a ex
4	Rational	86.67	1	14	72,803	5	----	------	------	Basins 1 & 2a ex
5	Rational	374.31	1	21	471,625	100	----	------	------	Basins 2 to 8 dev
6	Rational	202.99	1	21	255,765	5	----	------	------	Basins 2 to 8 dev
7	Rational	304.38	1	21	383,519	100	----	------	------	Basins 2 to 8 ex
8	Rational	157.88	1	21	198,928	5	----	------	------	Basins 2 to 8 ex
9	Rational	91.84	1	11	60,612	100	----	------	------	Off-site Basin 3 dev
10	Rational	51.22	1	11	33,805	5	----	------	------	Off-site Basin 3 dev
11	Rational	22.50	1	28	37,796	100	----	------	------	Off-site Basin 3 ex
12	Rational	8.62	1	29	15,001	5	----	------	------	Off-site Basin 3 ex

Astrozon Study

Storm Water Intensity

Hydrograph No.	Description	Return Period (years)	Area (acre)	C	Intensity (in/hr)
1	Basins 1 & 2a developed	100	44.7	0.72	6.26
2	Basins 1 & 2a developed	5	44.7	0.64	3.46
3	Basins 1 & 2a existing	100	44.7	0.66	6.26
4	Basins 1 & 2a existing	5	44.7	0.56	3.46
5	Basins 2 to 8 developed	100	80.2	0.91	5.13
6	Basins 2 to 8 developed	5	80.2	0.90	2.81
7	Basins 2 to 8 existing	100	80.2	0.74	5.13
8	Basins 2 to 8 existing	5	80.2	0.70	2.81
9	Off-site Basin 3 developed	100	14.7	0.90	6.94
10	Off-site Basin 3 developed	5	14.7	0.90	3.87
11	Off-site Basin 3 existing	100	14.7	0.35	4.37
12	Off-site Basin 3 existing	5	14.7	0.25	2.35

Existing Concrete Channel Flow

Prior to Flowing On-site – Existing Condition

Description	Unadjusted Q_{100}* (cfs)	Q_{100} (cfs)
Astrozon Study Basins 1 & 2a	184.68	34.68
Astrozon Study Basins 2 to 8		304.38
Off-site Basin 3 historic		22.50
Total		361.56

Prior to Flowing On-site – Developed Condition

Description	Unadjusted Q_{100}* (cfs)	Q_{100} (cfs)
Astrozon Study Basins 1 & 2a	201.47	51.47
Astrozon Study Basins 2 to 8		374.31
Off-site Basin 3 developed		91.84
Total		517.62

* The North Basin's (Basins 1 & 2a) Q_{100} less the Q_{cap} of 150 cfs (for the North System's existing pipe to Sand Creek) was included in the total flow as bypass.

Culvert Calculator Report
Proposed Culverts - Existing Condition

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	4.32	ft	Headwater Depth/Height	1.10	
Computed Headwater Elevation	2.90	ft	Discharge	361.56	cfs
Inlet Control HW Elev.	2.86	ft	Tailwater Elevation	1.59	ft
Outlet Control HW Elev.	2.90	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	0.14	ft	Downstream Invert	0.00	ft
Length	54.51	ft	Constructed Slope	0.002500	ft/ft

Hydraulic Profile					
Profile	M2		Depth, Downstream	1.73	ft
Slope Type	Mild		Normal Depth	1.95	ft
Flow Regime	Subcritical		Critical Depth	1.73	ft
Velocity Downstream	7.46	ft/s	Critical Slope	0.003505	ft/ft

Section					
Section Shape	Box		Mannings Coefficient	0.013	
Section Material	Concrete		Span	7.00	ft
Section Size	7 x 2.5 ft		Rise	2.50	ft
Number Sections	4				

Outlet Control Properties					
Outlet Control HW Elev.	2.90	ft	Upstream Velocity Head	0.72	ft
Ke	0.20		Entrance Loss	0.14	ft

Inlet Control Properties					
Inlet Control HW Elev.	2.86	ft	Flow Control	Unsubmerged	
Inlet Type	90° headwall w 45° bevels		Area Full	70.0	ft²
K	0.49500		HDS 5 Chart	10	
M	0.66700		HDS 5 Scale	2	
C	0.03140		Equation Form	2	
Y	0.82000				

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Culvert Calculator Report
Proposed Culverts - Developed Condition

Solve For: Headwater Elevation

Culvert Summary			
Allowable HW Elevation	4.32 ft	Headwater Depth/Height	1.51
Computed Headwater Elevation	3.90 ft	Discharge	517.62 cfs
Inlet Control HW Elev.	3.90 ft	Tailwater Elevation	1.99 ft
Outlet Control HW Elev.	3.64 ft	Control Type	Inlet Control

Grades			
Upstream Invert	0.14 ft	Downstream Invert	0.00 ft
Length	54.51 ft	Constructed Slope	0.002500 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	2.20 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.20 ft
Velocity Downstream	8.41 ft/s	Critical Slope	0.003627 ft/ft

Section			
Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	7.00 ft
Section Size	7 x 2.5 ft	Rise	2.50 ft
Number Sections	4		

Outlet Control Properties			
Outlet Control HW Elev.	3.64 ft	Upstream Velocity Head	0.91 ft
Ke	0.20	Entrance Loss	0.18 ft

Inlet Control Properties			
Inlet Control HW Elev.	3.90 ft	Flow Control	Submerged
Inlet Type	90° headwall w 45° bevels	Area Full	70.0 ft²
K	0.49500	HDS 5 Chart	10
M	0.66700	HDS 5 Scale	2
C	0.03140	Equation Form	2
Y	0.82000		

Curb-Opening Inlet in Sump Condition Sizing

$Q_i F = 3.0 L_i d_i^{1.5}$

Where:
Q_i = capacity of the inlet, cfs;
F = adjustment factor for clogging, 1.25;
L_i = length of clear opening, ft (minimum);
d_i = depth of water above inlet lip, 0.67 ft for D-10-R

Sub-basin A1:

$Q_i = Q_{100} = 8.48$ cfs

$8.48 \text{ cfs } (1.25) = 3.0 L_i (0.67 \text{ ft})^{1.5}$

$L_i = 6.44$ ft = 7' D-10-R

Sub-basin A2:

$Q_i = Q_5$ Sub-basin A2 + Q_5 Off-site Basin 1 and 2 = 6.87 cfs + 2.27 cfs + 1.29 cfs = 10.43 cfs

$10.43 \text{ cfs } (1.25) = 3.0 L_i (0.67 \text{ ft})^{1.5}$

$L_i = 7.92$ ft = 8' D-10-R

Worksheet
Worksheet for Circular Channel

Project Description	
Worksheet	Circular Channel - Sub-basin A1 outlet to creek
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.010000	ft/ft
Diameter	24	in
Discharge	8.48	cfs

Results		
Depth	1.22	ft
Flow Area	2.0	ft²
Wetted Perimeter	3.59	ft
Top Width	1.95	ft
Critical Depth	1.04	ft
Percent Full	61.2	%
Critical Slope	0.016885	ft/ft
Velocity	4.21	ft/s
Velocity Head	0.28	ft
Specific Energy	1.50	ft
Froude Number	0.73	
Maximum Discharg	13.18	cfs
Discharge Full	12.25	cfs
Slope Full	0.004790	ft/ft
Flow Type	Subcritical	

Worksheet
Worksheet for Circular Channel

Project Description	
Worksheet	Circular Channel - Sub-basin A2 outlet to creek
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.024	
Slope	0.010000	ft/ft
Diameter	24	in
Discharge	10.43	cfs

Results		
Depth	1.42	ft
Flow Area	2.4	ft²
Wetted Perimeter	4.00	ft
Top Width	1.82	ft
Critical Depth	1.16	ft
Percent Full	70.9	%
Critical Slope	0.017988	ft/ft
Velocity	4.38	ft/s
Velocity Head	0.30	ft
Specific Energy	1.72	ft
Froude Number	0.67	
Maximum Discharg	13.18	cfs
Discharge Full	12.25	cfs
Slope Full	0.007246	ft/ft
Flow Type	Subcritical	

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Worksheet
Worksheet for Triangular Channel

Project Description	
Worksheet	Triangular Channel - Proposed Swale in Sub-basin A2
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.020000	ft/ft
Left Side Slope	4.00	H : V
Right Side Slope	4.00	H : V
Discharge	23.67	cfs

Results		
Depth	1.12	ft
Flow Area	5.1	ft²
Wetted Perimeter	9.28	ft
Top Width	9.00	ft
Critical Depth	1.17	ft
Critical Slope	0.016336	ft/ft
Velocity	4.68	ft/s
Velocity Head	0.34	ft
Specific Energy	1.46	ft
Froude Number	1.10	
Flow Type	Supercritical	

Worksheet
Worksheet for Triangular Channel

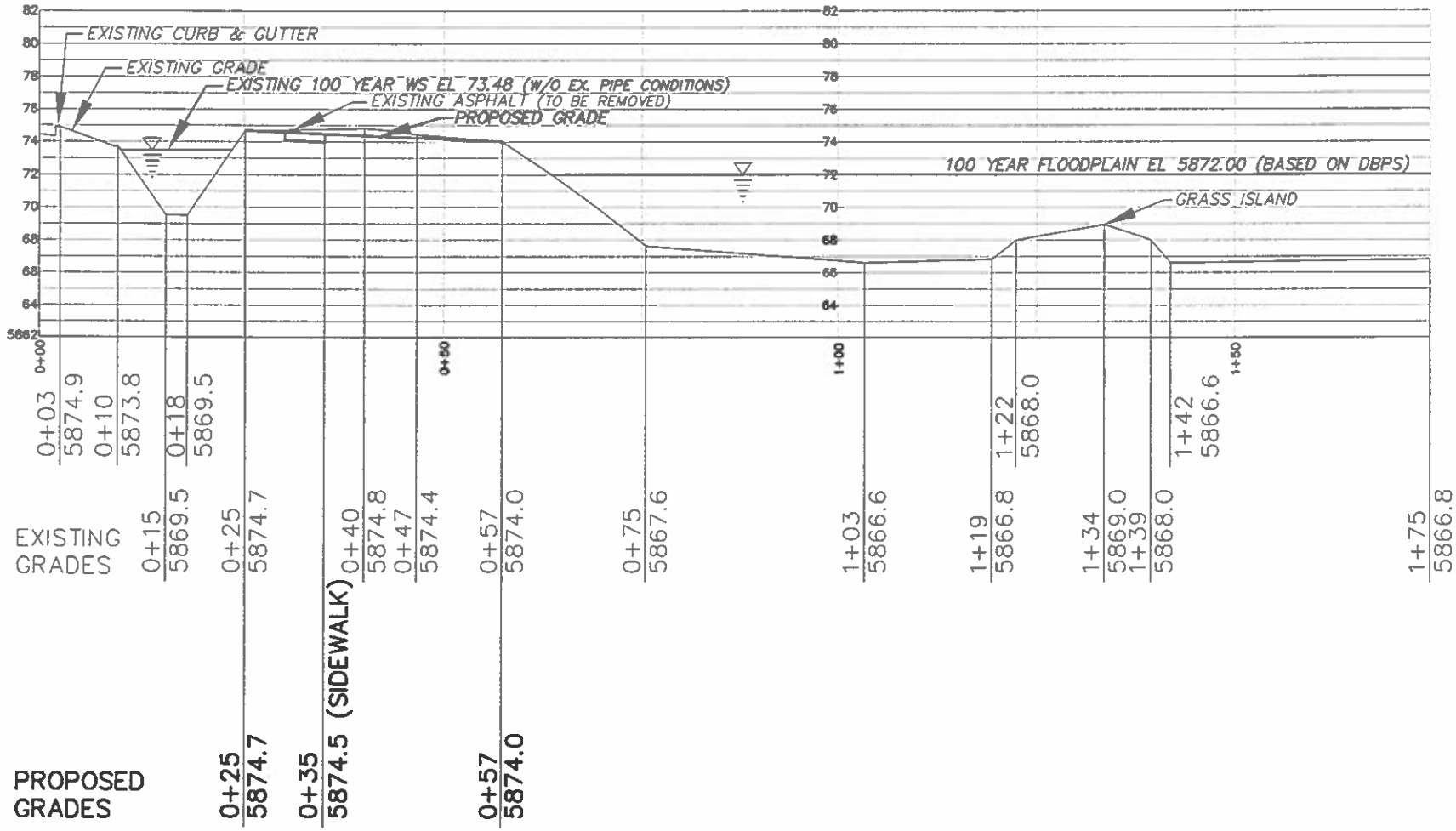
Project Description	
Worksheet	Triangular Channel - Proposed Swale in Sub-basin A3
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.005000	ft/ft
Left Side Slope	4.00	H : V
Right Side Slope	4.00	H : V
Discharge	6.92	cfs

Results		
Depth	0.92	ft
Flow Area	3.4	ft²
Wetted Perimeter	7.58	ft
Top Width	7.36	ft
Critical Depth	0.71	ft
Critical Slope	0.019246	ft/ft
Velocity	2.04	ft/s
Velocity Head	0.06	ft
Specific Energy	0.98	ft
Froude Number	0.53	
Flow Type	Subcritical	

BENTLEY COMMONS
JOB NO.: 010367

CROSS-SECTION "FOR CITY"
HORIZONTAL SCALE: 1"=20'
VERTICAL SCALE: 1"=10'



Culvert Calculator Report
Existing 58" CMP

Comments: The tailwater elevation was taken from the Sand Creek DBPS 100 year storm event elevation.

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	5,875.15	ft	Headwater Depth/Height	1.18	
Computed Headwater Elevation	5,875.15	ft	Discharge	136.36	cfs
Inlet Control HW Elev.	5,874.49	ft	Tailwater Elevation	5,867.00	ft
Outlet Control HW Elev.	5,875.15	ft	Control Type	Entrance Control	

Grades					
Upstream Invert	5,869.46	ft	Downstream Invert	5,865.91	ft
Length	26.62	ft	Constructed Slope	0.133358	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	2.08	ft
Slope Type	Steep		Normal Depth	1.78	ft
Flow Regime	Supercritical		Critical Depth	3.38	ft
Velocity Downstream	18.00	ft/s	Critical Slope	0.016061	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.024	
Section Material	CMP		Span	4.83	ft
Section Size	58 inch		Rise	4.83	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	5,875.15	ft	Upstream Velocity Head	1.54	ft
Ke	0.50		Entrance Loss	0.77	ft

Inlet Control Properties					
Inlet Control HW Elev.	5,874.49	ft	Flow Control	Unsubmerged	
Inlet Type	Headwall		Area Full	18.3	ft²
K	0.00780		HDS 5 Chart	2	
M	2.00000		HDS 5 Scale	1	
C	0.03790		Equation Form	1	
Y	0.69000				

Worksheet
Worksheet for Circular Channel

Project Description	
Worksheet	Circular Channel - Ex. 58" CMP
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.024	
Slope	0.133358	ft/ft
Depth	4.83	ft
Diameter	58	in

Results		
Discharge	470.62	cfs
Flow Area	18.3	ft²
Wetted Perimeter	15.18	ft
Top Width	2.54e-5	ft
Critical Depth	4.79	ft
Percent Full	100.0	%
Critical Slope	0.123488	ft/ft
Velocity	25.65	ft/s
Velocity Head	10.22	ft
Specific Energy	15.06	ft
Froude Number	0.01	
Maximum Discharg	506.25	cfs
Discharge Full	470.62	cfs
Slope Full	0.133359	ft/ft
Flow Type	Subcritical	

Notes: Per the City, using inlet/outlet control (see Culvertmaster software); this is the capacity of the pipe without headwater or tailwater.

Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	X-sect of Creek @ Cross-section "1" - Currently
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.014000	ft/ft
Discharge	13,540.00	cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Metho	Improved Lotter's Method
Closed Channel Weighting Meth	Horton's Method

Results		
Mannings Coefficient	0.031	
Water Surface Elevation	5,872.43	ft
Elevation Range	5,867.13 to 5,876.00	
Flow Area	880.7	ft²
Wetted Perimeter	201.38	ft
Top Width	198.24	ft
Actual Depth	5.30	ft
Critical Elevation	5,873.27	ft
Critical Slope	0.008055	ft/ft
Velocity	15.37	ft/s
Velocity Head	3.67	ft
Specific Energy	5,876.11	ft
Froude Number	1.29	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	1+14	0.030
1+14	1+40	0.045
1+40	2+13	0.030

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	5,876.00
0+05	5,874.00
0+10	5,872.00
0+15	5,870.00
0+19	5,868.00
0+22	5,867.28
0+29	5,867.38
0+70	5,867.43
0+86	5,867.64
1+14	5,867.90

Worksheet
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+18	5,867.62
1+19	5,868.00
1+27	5,870.00
1+32	5,870.41
1+36	5,870.00
1+39	5,868.00
1+40	5,867.77
1+59	5,867.13
1+78	5,867.26
1+95	5,867.49
1+95	5,868.00
2+01	5,870.00
2+06	5,872.00
2+10	5,874.00
2+13	5,876.00

Notes: @ Bldg Midpoint; The 100 year floodplain will remain the same after improvements.

X-SECT "1" - CURRENTLY ... CONTINUED

Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	X-sect of Creek @ Cross-section "1A" - Currently
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.014000	ft/ft
Discharge	13,540.00	cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Metho	Improved Lotter's Method
Closed Channel Weighting Meth	Horton's Method

Results		
Mannings Coefficient	0.031	
Water Surface Elevation	5,875.47	ft
Elevation Range	5,870.69 to 5,878.00	
Flow Area	940.4	ft²
Wetted Perimeter	234.69	ft
Top Width	232.36	ft
Actual Depth	4.78	ft
Critical Elevation	5,876.17	ft
Critical Slope	0.008389	ft/ft
Velocity	14.40	ft/s
Velocity Head	3.22	ft
Specific Energy	5,878.70	ft
Froude Number	1.26	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	1+16	0.030
1+16	1+50	0.045
1+50	2+44	0.030

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	5,878.00
0+10	5,872.00
0+15	5,871.03
1+16	5,871.03
1+18	5,872.00
1+30	5,872.92
1+48	5,872.00
1+50	5,871.07
1+85	5,870.86
2+18	5,870.69

Worksheet
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
2+21	5,872.00
2+32	5,874.00
2+38	5,876.00
2+44	5,878.00

Notes: The 100 year floodplain will remain the same after improvements.

X-SECT "1A" - CURRENTLY... CONTINUED

Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	X-sect of Creek @ Cross-section "2" - Currently
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.013000	ft/ft
Discharge	13,540.00	cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Metho	Improved Lotter's Method
Closed Channel Weighting Meth	Horton's Method

Results		
Mannings Coefficient	0.031	
Water Surface Elevation	5,881.55	ft
Elevation Range	5,876.61 to 5,884.00	
Flow Area	934.5	ft²
Wetted Perimeter	217.94	ft
Top Width	215.38	ft
Actual Depth	4.94	ft
Critical Elevation	5,882.20	ft
Critical Slope	0.008297	ft/ft
Velocity	14.49	ft/s
Velocity Head	3.26	ft
Specific Energy	5,884.82	ft
Froude Number	1.23	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	1+52	0.030
1+52	1+77	0.045
1+77	2+25	0.030

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	5,884.00
0+03	5,882.00
0+07	5,880.00
0+10	5,878.00
0+13	5,876.61
0+46	5,876.67
1+17	5,877.18
1+52	5,877.38
1+54	5,878.00
1+55	5,878.43

Worksheet
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+69	5,878.00
1+77	5,876.69
2+09	5,876.70
2+12	5,878.00
2+16	5,880.00
2+20	5,882.00
2+25	5,884.00

Notes: @ Bldg Midpoint Prior to Improvements; The 100 year floodplain will remain the same after improvements.

X-SECT "2" - CURRENTLY ... CONTINUED

Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	X-sect of Creek @ Cross-section "2" - After Improvement
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.013000	ft/ft
Discharge	13,540.00	cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Metho	Improved Lotter's Method
Closed Channel Weighting Meth	Horton's Method

Results		
Mannings Coefficient	0.031	
Water Surface Elevation	5,881.55	ft
Elevation Range	5,876.61 to 5,886.00	
Flow Area	934.5	ft²
Wetted Perimeter	217.94	ft
Top Width	215.38	ft
Actual Depth	4.94	ft
Critical Elevation	5,882.20	ft
Critical Slope	0.008299	ft/ft
Velocity	14.49	ft/s
Velocity Head	3.26	ft
Specific Energy	5,884.82	ft
Froude Number	1.23	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	1+52	0.030
1+52	1+77	0.045
1+77	2+21	0.030
2+21	2+22	0.013
2+22	2+48	0.030

Natural Channel Points

Station (ft)	Elevation (ft)
0+00	5,884.00
0+03	5,882.00
0+07	5,880.00
0+10	5,878.00
0+13	5,876.61
0+46	5,876.67
1+17	5,877.18
1+52	5,877.38

Worksheet
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+54	5,878.00
1+55	5,878.43
1+69	5,878.00
1+77	5,876.69
2+09	5,876.70
2+12	5,878.00
2+16	5,880.00
2+20	5,882.00
2+21	5,882.12
2+21	5,885.48
2+22	5,885.48
2+48	5,886.00

Notes: @ Bldg Midpoint; The 100 year floodplain will remain the same after improvements.

X-SECT "2" - PROPOSED.. CONTINUED

Worksheet
Worksheet for Irregular Channel

Project Description	
Worksheet	X-sect of Creek @ Cross-section "2A" - Currently
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.013000	ft/ft
Discharge	13,540.00	cfs

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Metho	Improved Lotter's Method
Closed Channel Weighting Meth	Horton's Method

Results		
Mannings Coefficient	0.031	
Water Surface Elevation	5,882.17	ft
Elevation Range	5,877.18 to 5,886.00	
Flow Area	933.9	ft²
Wetted Perimeter	218.04	ft
Top Width	214.91	ft
Actual Depth	4.99	ft
Critical Elevation	5,882.81	ft
Critical Slope	0.008302	ft/ft
Velocity	14.50	ft/s
Velocity Head	3.27	ft
Specific Energy	5,885.43	ft
Froude Number	1.23	
Flow Type	Supercritical	

Roughness Segments

Start Station	End Station	Mannings Coefficient
0+00	1+49	0.030
1+49	1+74	0.045
1+74	2+35	0.030

Natural Channel Points

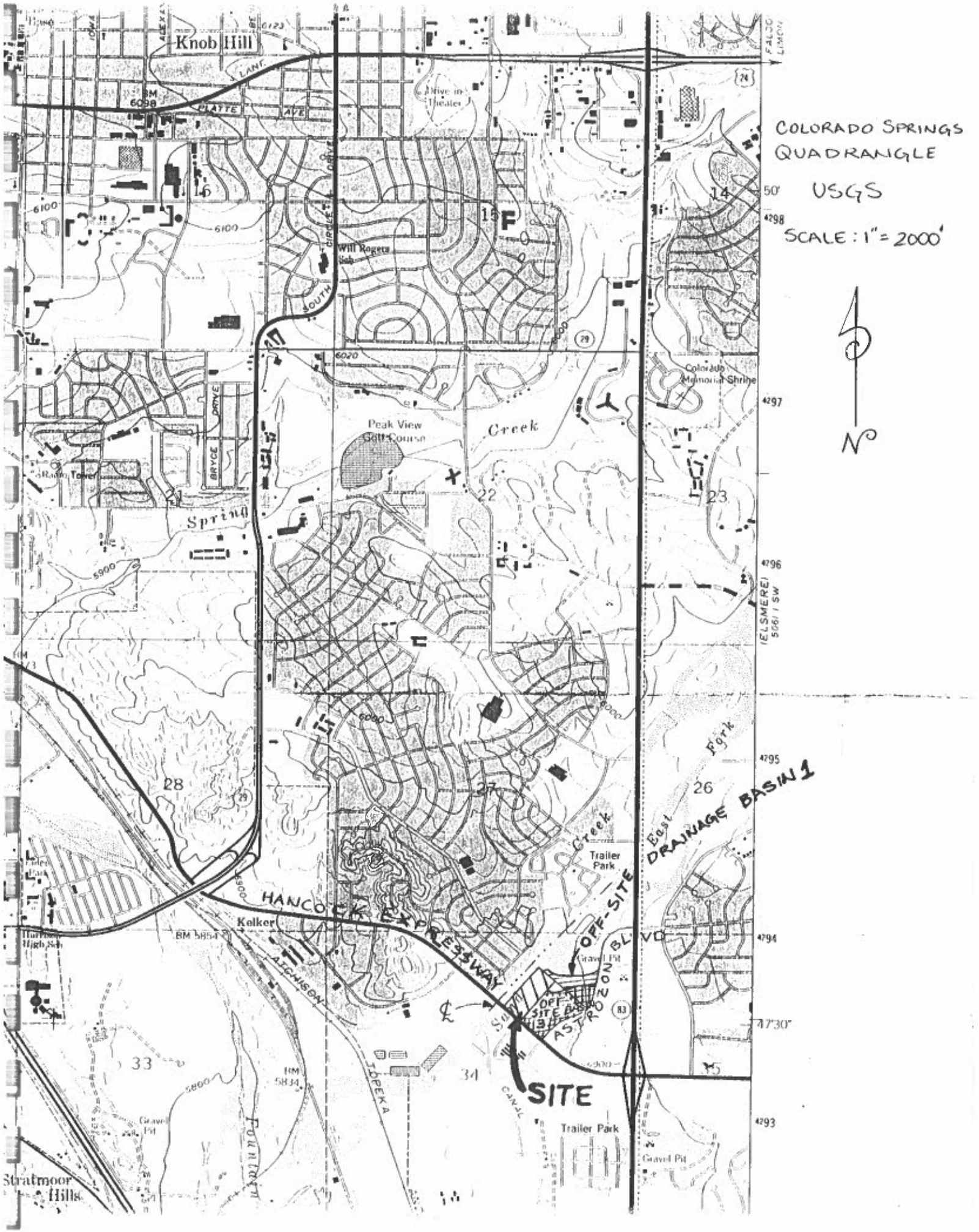
Station (ft)	Elevation (ft)
0+00	5,886.00
0+13	5,878.00
0+13	5,877.18
0+47	5,877.39
1+16	5,877.81
1+41	5,878.00
1+49	5,878.07
1+52	5,878.69
1+72	5,878.57
1+73	5,878.00

Worksheet
Worksheet for Irregular Channel

Natural Channel Points	
Station (ft)	Elevation (ft)
1+74	5,877.19
2+11	5,877.26
2+12	5,878.00
2+17	5,880.00
2+20	5,882.00
2+26	5,884.00
2+29	5,886.00
2+35	5,886.00

Notes: The 100 year floodplain will remain the same after improvements.

X-SECT "2A" - CONTINUED...


COLORADO SPRINGS
QUADRANGLE
USGS
SCALE: 1" = 2000'
N
Knob Hill
PLATTE AVE
Drive-in Theater
Will Rogers Sch
SOUTH CIRCLE DRIVE
Colorado Memorial Shrine
Peak View Golf Course
Creek
Spring
BRYCE DRIVE
Radio Tower
Trailer Park
East Fork
Creek
HANCOCK EXPRESSWAY
OFF-SITE DRAINAGE BASIN 1
OFF-SITE BASIN 3
ASTROZON BLVD
Kelker
ATCHISON TOPEKA
Gravel Pit
SITE
Trailer Park
Gravel Pit
Stratmoor Hills
Fountain
CANAL
(ELSMERE) 5061 I SW
FALCON LIMON
47'30"
50'
4298
4297
4296
4295
4294
4293
6100
6020
5900
6000
5800
BM 6098
BM 5854
BM 5834
14
15
16
21
22
23
26
27
28
33
34
35

SAND CREEK

S ACADEMY BLVD

ASTROZON BLVD

JET WING DR

SCALE: 1"=400'

FIMS
ASTROZON STUDY
OVERLAY

SITE
(SEE DRAINAGE PLAN)

2A

1

2

3

4

5

6

7

8

EX. DIOR

EX. CHAPEL

deed

... map to determine when national rates apply to structures in where elevations or depths have been established.

...ermine if flood insurance is available, contact an insurance agent or National Flood Insurance Program at (800) 638-6620.

APPROXIMATE SCALE IN FEET

500 0 500

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY, COLORADO AND INCORPORATED AREAS

PANEL 742 OF 1300

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLORADO SPRINGS, CITY OF	080060	0742	F
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0742	F

MAP NUMBER
08041C0742 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A No base flood elevations determined.

ZONE AE Base flood elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE A99 To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.

ZONE V Coastal flood with velocity hazard (wave action); no base flood elevations determined.

ZONE VE Coastal flood with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

ZONE X Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

OTHER AREAS

ZONE X Areas determined to be outside 500-year floodplain.

ZONE D Areas in which flood hazards are undetermined.

UNDEVELOPED COASTAL BARRIERS

Identified 1983 | Identified 1990 | Otherwise Protected Areas

Coastal barrier areas are normally located within or adjacent to Special Flood Hazard Areas.

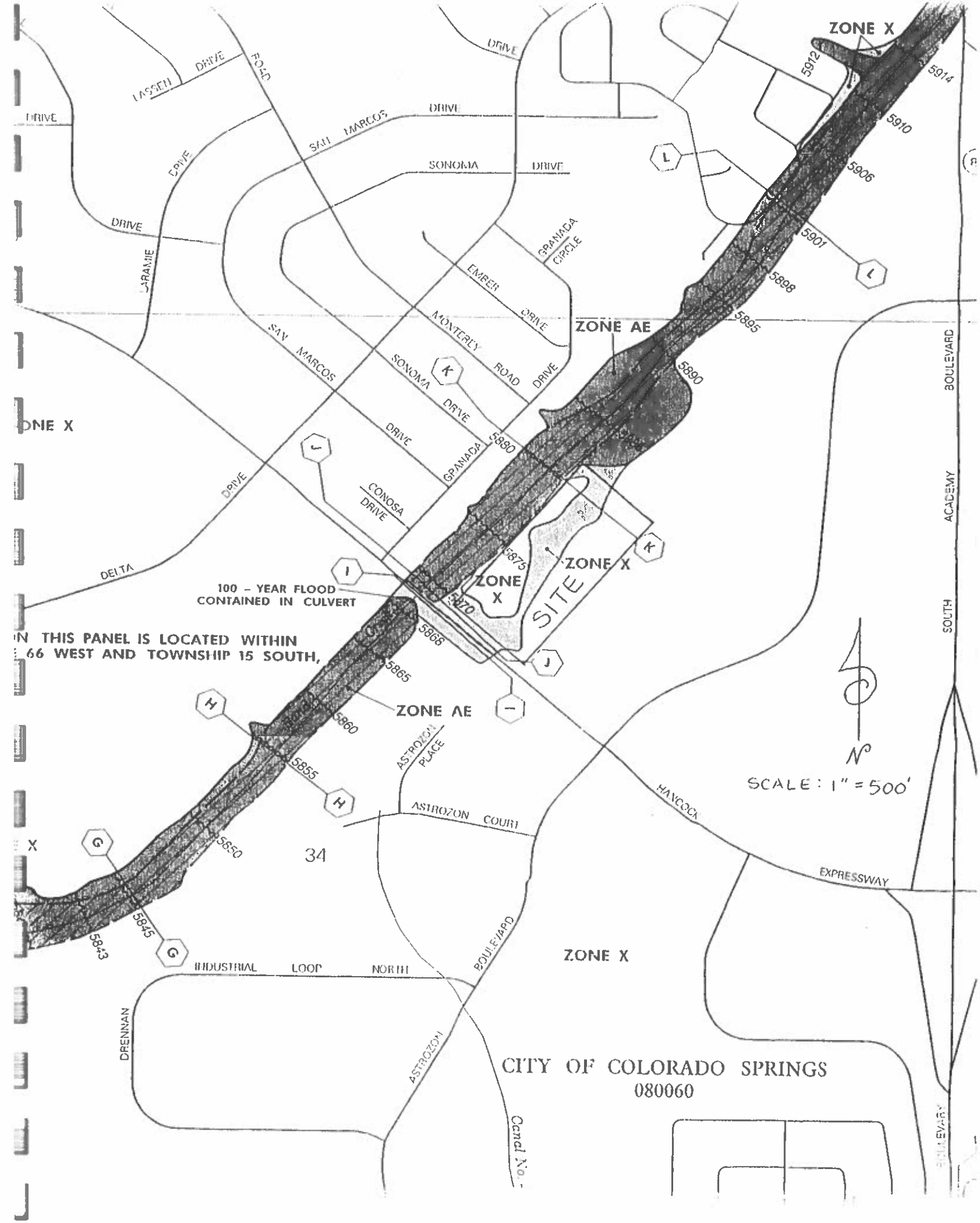
Flood Boundary

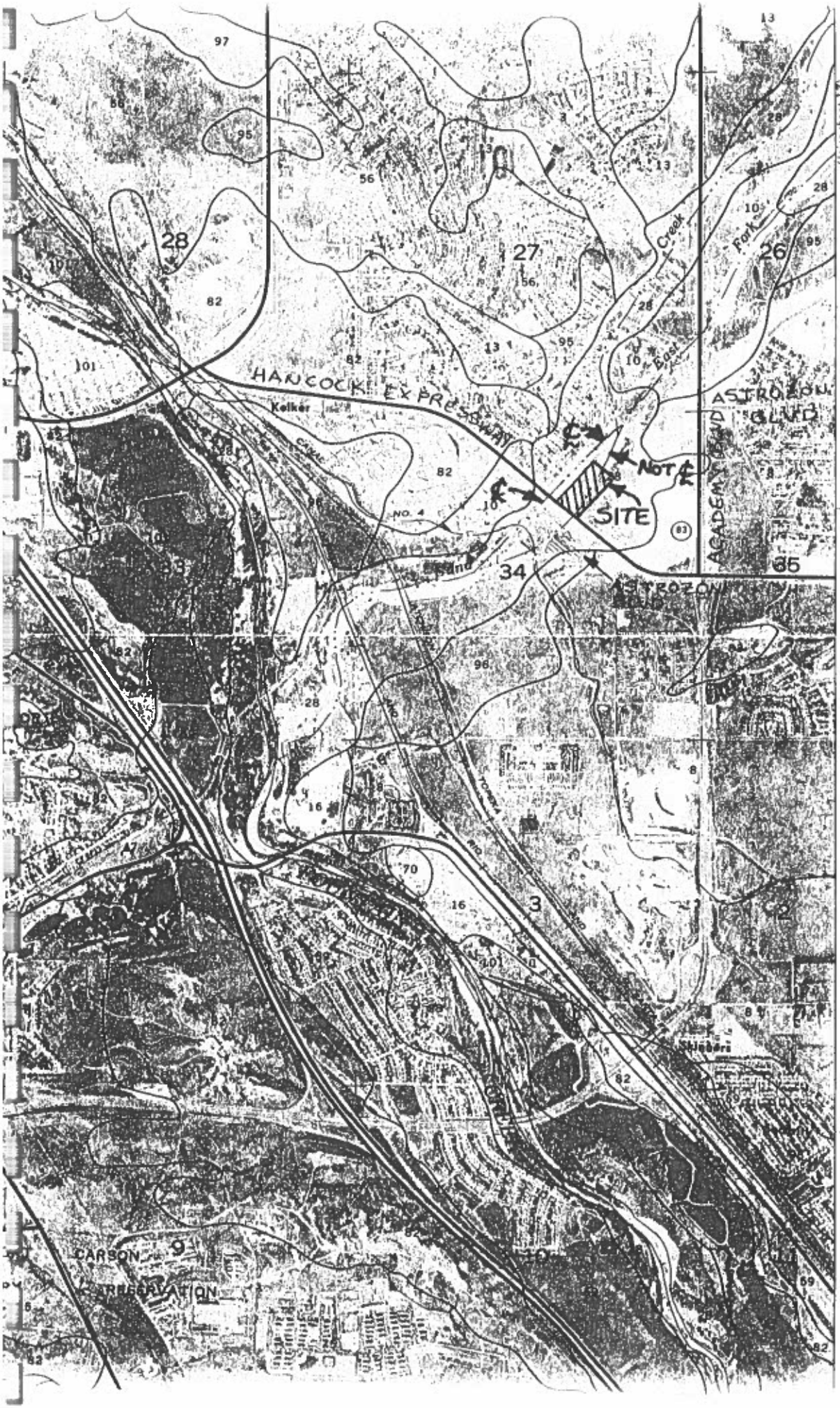
Floodway Boundary

Zone D Boundary

Boundary Dividing Special Flood Hazard Zones, and Boundary Dividing Areas of Different Coastal Base Flood Elevations Within Special Flood Hazard Zones.

~~~513~~~ Base Flood Elevation Line; Elevation in Feet. See Map Index for Elevation Datum.

(D)——(D) Cross Section Line

(EL 987) Base Flood Elevation in Feet Where Uniform Within Zone. See Map Index for Elevation Datum.

RM7 × Elevation Reference Mark

• M2 River Mile

97°07'30", 32°22'30" Horizontal Coordinates Based on North American Datum of 1927 (NAD 27) Projection.

NOTES

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas.

Coastal base flood elevations apply only landward of 0.0 NGVD, and include the effects of wave action; these elevations may also differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

Areas of Special Flood Hazard (100-year flood) include Zones A, AE, AH, AO, A99, V, and VE.
~~~


ZONE X
5912
5914
5910
5906
5901
5898
5895
5890
5880
5875
5870
5868
5865
5860
5855
5850
5845
5843
ZONE AE
ZONE X
ZONE X
ZONE
X
SITE
ZONE AE
ZONE X
100 – YEAR FLOOD
CONTAINED IN CULVERT
N THIS PANEL IS LOCATED WITHIN
66 WEST AND TOWNSHIP 15 SOUTH,
SCALE: 1" = 500'
34
CITY OF COLORADO SPRINGS
080060
DRIVE
LASSEN
ROAD
SAN MARCOS
SONOMA
GRANADA CIRCLE
EMBER
MONTEREY
ROAD
CONOSA
DRIVE
GRANADA
DELTA
ASTROZON PLACE
ASTROZON COURT
HANCOCK
EXPRESSWAY
ACADEMY
BOULEVARD
SOUTH
INDUSTRIAL LOOP
NORTH
DRENNAN
ASTROZON
Canal No.
L
K
J
I
H
G



N

SCALE: 1" = 2000'

NOTE: SAND CREEK DRAINAGE CHANNEL WAS DRAWN IN TO MORE ACCURATELY PORTRAY THE CENTERLINE, ℄.

T. 14 S.
T. 15 S.

SHEET NO. 16
SOIL SURVEY OF
EL PASO COUNTY
AREA, COLORADO
USDA SCS

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		
Elbeth:							
Pring part-----	B	None----------	---	---	>60	---	Moderate.
Ellicott:							
28----------	A	Frequent------	Brief---------	Mar-Jun	>60	---	Low.
Fluvaquentic Haplaquolls:							
29----------	B/D	Frequent------	Brief---------	Mar-Jul	>60	---	High.
Fort Collins:							
30, 31----------	B	None to rare	---	---	>60	---	Moderate.
Fortwingate:							
[1]32:							
Fortwingate part----------	C	None----------	---	---	20-40	Hard	Low.
Rock outcrop part----------	D	---	---	---	---	---	---
Heldt:							
33----------	C	None----------	---	---	>60	---	Moderate.
Holderness:							
34, 35, 36-------	C	None----------	---	---	>60	---	Moderate.
Jarre:							
37----------	B	None----------	---	---	>60	---	Moderate.
[1]38:							
Jarre part-----	B	None----------	---	---	>60	---	Moderate.
Tecolote part--	B	None----------	---	---	>60	---	Moderate.
Keith:							
39----------	B	None----------	---	---	>60	---	High.
Kettle:							
40, 41----------	B	None----------	---	---	>60	---	Moderate.
[1]42:							
Kettle part----	B	None----------	---	---	>60	---	Moderate.
Rock outcrop part----------	D	---	---	---	---	---	---
Kim:							
43----------	B	None----------	---	---	>60	---	Moderate.
Kutch:							
44, 45----------	C	None----------	---	---	20-40	Rippable	Moderate.
Kutler:							
[1]46:							
Kutler part----	C	None----------	---	---	20-40	Rippable	Low.
Broadmoor part-	C	None----------	---	---	20-40	Rippable	Low.
Rock outcrop part----------	D	---	---	---	---	---	---
Limon:							
47----------	C	Occasional----	Brief---------	May-Sep	>60	---	Moderate.
Louviers:							
48----------	D	None----------	---	---	10-20	Rippable	Moderate.
49----------	D	None----------	---	---	10-20	Rippable	Low.

See footnote at end of table.