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DRAINAGE REPORT
FOR
SAGUARO SHADOWS TWO

Clouse Engineering, Inc.
ENGINEERS ▪ SURVEYORS

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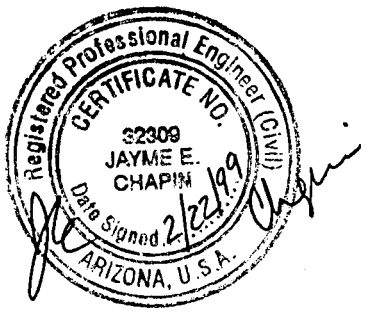
DRAINAGE REPORT
FOR
SAGUARO SHADOWS TWO

February 22, 1999



CLOUSE ENGINEERING, INC.
JOB NO. 970507

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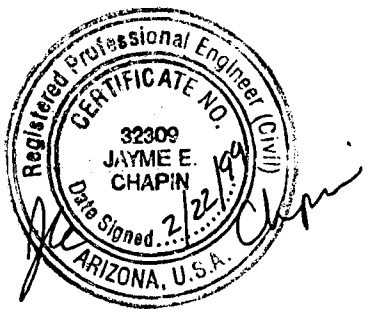


LIST OF ENCLOSURES

- Enclosure #1 - Onsite Drainage Map

1. INTRODUCTION

1.1 PURPOSE/SCOPE OF REPORT

SAGUARO SHADOWS TWO is a proposed custom lot development located on approximately 17.5 acres within the City of Mesa. The purpose of the subject report is to provide design details for both onsite and offsite drainage impacting the site. Preliminary onsite and offsite drainage concepts for SAGUARO SHADOWS TWO have been outlined in the approved drainage report prepared by Standage & Truitt Engineering, Ltd. entitled; "Conceptual Drainage Report for Saguaro Shadows," dated May, 1996. The drainage concepts presented in the subject report conform substantially to the Preliminary Report. It should be noted that at the time of the Preliminary Report the site was located within Maricopa County. The City of Mesa has subsequently annexed the area encompassed by the site. Accordingly, design details presented in the subject report conform to City of Mesa Standards.

1.2 SITE LOCATION

SAGUARO SHADOWS TWO is located within the City of Mesa and lies south of McLellan Road and west of the 96th Street alignment. Legally, the development lies in the S.W. ¼ of Section 10, T. 1 N., R. 7 E., G. & S. R. B. & M., Maricopa County, Arizona. Figure 1.1 illustrates the site's location.

1.3 SITE TOPOGRAPHY

The site currently consists of natural desert terrain generally sloping to the southeast at an average slope of 2.8 percent. Hills within the Usery Mountain Recreation Area border the site on the north. The summit of the range rises approximately 300 feet above its base. Natural desert exists to the east and west of the site. Several minor washes and one major wash traverse the site from northwest to southeast. The Signal Butte Floodway and an ajacent intake structure border the site diagonally on the south.

1.4 FIRM MAP

The site does not lie within a flood hazard area and is indicated to be within Zone B. This zone delineation has been established by the F.I.R.M. for Maricopa County, Map Numbers 04013C2210-D and 04013C2230-D, with an effective date of September 30, 1995.

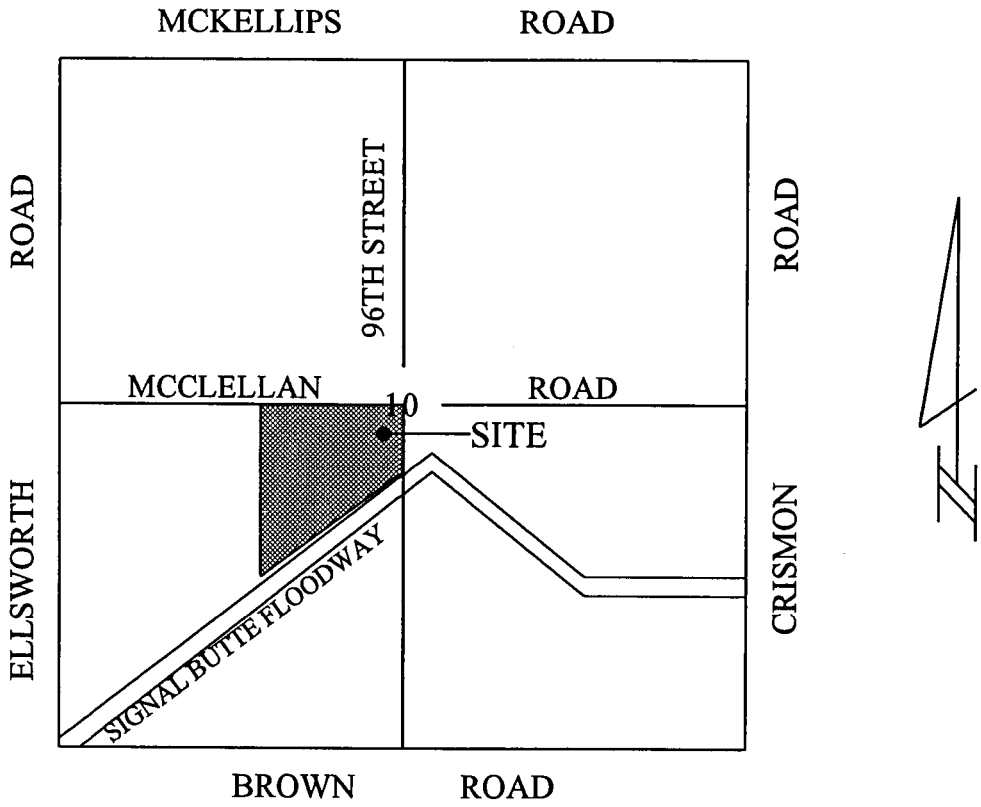


Figure 1.1 - Site Location

2. DRAINAGE CONCEPTS

2.1 OFFSITE/EXISTING CONDITIONS

2.1.1 Area North of Site (Areas A, C, and D)

The subject site lies within the study area of the Spook Hill Area Drainage Master Study (ADMS) prepared for the Flood Control District of Maricopa County, the City of Mesa, and the Maricopa County Highway Department. The subject site is located within Watershed #6 as indicated in Figure 6 from the ADMS (see APPENDIX A). According to the ADMS, 920 cfs from the Usery Mountain Recreation Area drains to the site from the north (Area A). The Offsite Drainage Map on Page 4 illustrates that just north of the site, runoff is concentrated as it drains through two peaks. The Quadrangle Map which has been used for the Offsite Drainage Map shows the flowline exiting the peaks and draining to the southwest. However, field inspection of this area indicates that the area to the west has been built up, causing flows to be directed to the subject site. Accordingly, it will be assumed that the entire 920 cfs will enter the subject site at Point A. Runoff from approximately 5 acres of the peak which lies directly north of the site also drains to the north property line (Areas C and D). An analysis of the existing site indicates that during minor events offsite flows may become concentrated in the small washes which traverse the site. However, during major storm events the wash capacities will be exceeded and runoff will drain to the Signal Butte Floodway primarily as sheet flow spreading across the majority of the site.

2.1.2 Area East of Site (Area E)

Runoff from approximately 12 acres of the peak east of the site drains towards the east property line. The runoff is intercepted by an existing swale on the east side of the east property line. The swale discharges to the Signal Butte Floodway. Calculations in the Hydraulics section indicate that the swale has capacity to intercept and convey runoff from a 100 year event. Accordingly, no offsite flows from the east will impact the proposed development.

2.1.3 Area West of Site (Area B)

Area B consists of approximately 8 acres of natural desert terrain and some residential development on one acre lots. Runoff from Area B currently drains to a swale which borders the west property line. The swale enters the subject site at Point B and continues southerly to the Signal Butte Floodway.

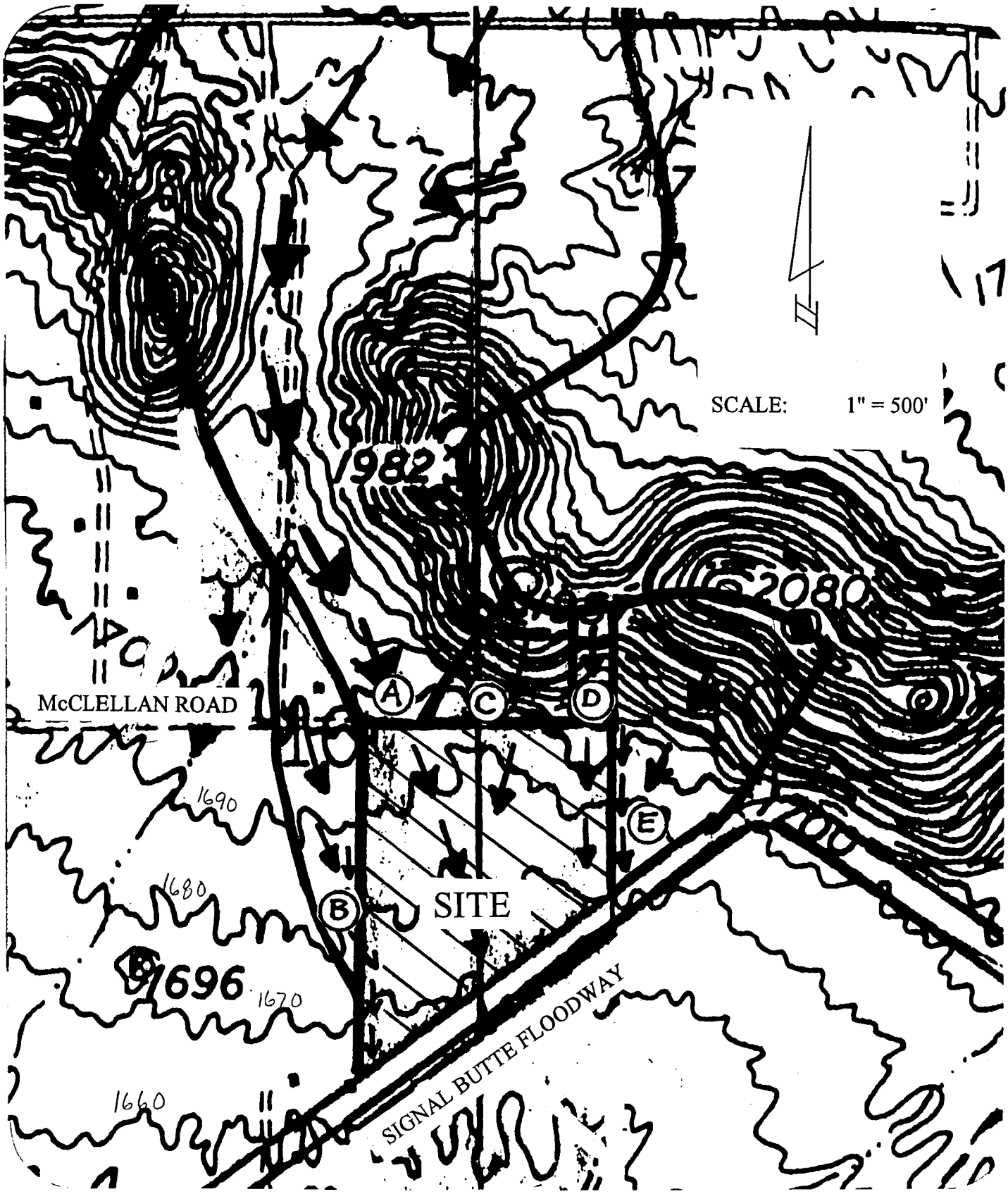


Figure 2.1 - Offsite Drainage Map

2.2 PROPOSED CONDITIONS

2.2.1 Offsite

With the development of the site it is proposed that a channel be constructed from Point A to the Signal Butte Floodway to convey flows from Area A to the Floodway. Box culverts will be constructed beneath McLellan Road and North Aaron Road to convey flows beneath the roadways.

A pipe culvert will be constructed beneath the west end of North Aaron to intercept flows from Area B. The culvert will discharge to a proposed swale along the west side of Lot 10. The swale will discharge to the Signal Butte Floodway.

Runoff from Area C will be intercepted by a swale on the north side of McLellan Road. The swale will drain to a storm drain inlet on the north side of the intersection of McLellan Road and North Aaron. Runoff will be conveyed in the storm drain to the Signal Butte Floodway.

Runoff from Area D will drain to a catch basin located in the cul-de-sac at the east end of McLellan Road. The catch basin will discharge to a swale graded on the east side of Lots 15 and 16. The swale will discharge to the Signal Butte Floodway.

2.2.2 Onsite

Runoff generated by the site will drain to the Signal Butte Floodway. Because this is a custom lot development, no lot grading will occur prior to building construction. Individual grading and drainage plans will be required for each lot as it develops. Finished floor elevations and actual drainage patterns on each lot will be established with the individual grading and drainage plan. It is anticipated that final lot grading will not effect the historical outfall for each lot. For this reason, the existing topography has been used to establish onsite drainage patterns and it has been assumed that each lot will ultimately outfall to its historic outfall location. These assumptions are reflected by the drainage areas and patterns outlined on the enclosed Onsite Drainage Map. The following discussion summarizes the drainage patterns associated with each area.

Runoff from Area 1 will drain to a catch basin located in the cul-de-sac at the west end of North Aaron. The catch basin will discharge to the swale on Lot 10. Combined flows from Offsite Area B and Onsite Area 1 will be conveyed by the swale to the Signal Butte Floodway.

Runoff from Area 2 will be intercepted and conveyed by North Aaron to the sump located at Point 5. Runoff will discharge to the Signal Butte Floodway via a scupper.

Runoff from Area 3 will drain to the swale located on Lots 15 and 16. The swale will convey flows to the Signal Butte Floodway.

Runoff from Lots 10, 11, 12 and 17 will drain directly to the Signal Butte Floodway.

It is possible that future wall construction on Lots 3, 9 and 16 could block the historical outfall for lots 2, 7 and 15. Drainage easements will be recorded on Lots 2, 7, and 15 to ensure that a clear path is maintained for drainage. Openings will be required in any future walls which cross the drainage easements.

3. HYDROLOGY

3.1 OFFSITE - AREA A

Hydrology for Offsite Area A will be extracted from the Spook Hill ADMS. The ADMS indicates that the peak 100 year, 24 hour flow for Area A is 920 cfs. Pertinent excerpts from the ADMS are contained in APPENDIX A.

3.2 RATIONAL METHOD

Peak flows for Offsite Areas B thru E and Onsite Areas 1 thru 8 will be calculated using the Rational Method:

$$Q = c\,i\,A$$

where:

Q = Peak runoff (cfs)

c = runoff coefficient

i = rainfall intensity (in/hr)

A = contributing drainage area (ac)

Individual drainage areas and the respective points of concentration are indicated on the Offsite and Onsite Drainage Maps. Due to the steep terrain, times of concentration for Offsite Areas C thru E are considered to be less than 5 minutes. Times of concentration within the site consider an initial time of 5 minutes plus the travel time in the street. Rainfall intensities are extracted from the I-D-F Curves for the City of Mesa. Table 3.1 contains weighted runoff coefficient calculations for the various areas within the site. Where runoff from different land uses intermingles, runoff coefficients are weighted accordingly. Based on these parameters, Table 3.2 summarizes the 10 and 100 year peak flows calculated at each point of concentration.

COVER	AREA (/ft)	C	A x C
Lotted Area			
Roof	3,500	0.85	2,975
Concrete	1,000	0.95	950
Landscape	25,500	0.55*	14,025
Σ	30,000		17,950
Weighted "C" = AxC/A = 17,950/30,000 = 0.60			
McLellan Road			
Asphalt	22.5	0.85	19.1
Concrete	7.0	0.95	6.7
Landscape	10.5	0.70	7.4
Σ	40.0		33.2
Weighted "C" = AxC/A = 33.2/40.0 = 0.83			
Typical Interior Street			
Asphalt	31.0	0.85	26.4
Concrete	12.0	0.95	11.4
Landscape	7.0	0.70	4.9
Σ	50.0		42.7
Weighted "C" = AxC/A = 42.7/50.0 = 0.85			
* Assumes a higher percentage of desert landscaping.			

Table 3.1 - Weighted Runoff Coefficient Calculations

POINT OF CONC.	AREA (ac)	C	Tc (min)	i_{10} (in/hr)	i_{100} (in/hr)	Q_{10} (cfs)	Q_{100} (cfs)
A	1600.00	----	----	-----	----	----	920.0
B	8.00	0.45	8	4.6	8.0	16.6	28.8
C	4.00	0.70	<5	5.2	9.0	14.6	25.2
D	1.30	0.70	<5	5.2	9.0	4.7	8.2
E	12.00	0.70	<5	5.2	9.0	43.7	75.6
1	0.60	0.60	<5	5.2	9.0	1.9	3.2
2	8.60	0.46	8	4.6	8.0	18.2	31.6
3	5.50	0.60	8	4.8	8.0	15.8	26.4
4	3.70	0.60	<5	5.2	9.0	11.5	20.0
5	9.20	0.60	8	4.8	8.0	26.5	44.2
6	1.50	0.69	<5	5.2	9.0	5.4	9.3
7	1.10	0.60	<5	5.2	9.0	3.4	5.9
8	2.60	0.65	<5	5.2	9.0	8.8	15.2
Lot 2	0.5	0.60	<5	5.2	9.0	1.6	2.7
Lot 7	0.5	0.60	<5	5.2	9.0	1.6	2.7
Lot 15	0.4	0.60	<5	5.2	9.0	1.2	2.2

Table 3.2 - Peak Flows

4. HYDRAULICS

4.1 STREETS

Streets are designed to convey the 10-year event at or below the top of curb elevation and the 100-year event is conveyed within the right of way. Depths of flow within the street at flow-by points of concentration are calculated using Manning's Equation with n = 0.015 and the pertinent street geometry and slope. The typical interior street is 34 feet in width to the face of curbs with a 0.39 foot crown and vertical (6 inch) curb. Depths located in a sump are dictated by the catch basin opening inlet or scupper inlet. Table 4.1 summarizes the depth of flow at each point of concentration indicated on the Drainage Map. Depths are measured in feet from the gutter.

POINT OF CONC.	Q_{10} (cfs)	Q_{100} (cfs)	TYPE OF CURB	SLOPE (ft/ft)	D_{10} (ft)	D_{100} (ft)	10 YR capacity (cfs)
1	1.9	3.2	6"	SUMP	0.14	0.17	58
3	29.2	48.6	6"	0.0050	0.48	0.61	32
4	11.5	20.0	6"	0.0025	0.40	0.48	23
5	26.5	44.2	6"	SUMP	0.49	0.68	27
6	5.0	8.6	6"	SUMP	0.20	0.25	63

Table 4.1 - Street Depths

4.2 INLET SIZING

Catch basin inlet opening sizes are determined using the methods outlined in the Federal Highway Departments HEC-12 Circular, March 1984. Sizing includes reduction factors as indicated in Table 3.2 in the Maricopa County Hydraulics Manual. A copy of the table as well as detailed sizing calculations are contained in APPENDIX B.

4.3 STORM DRAIN

Hydraulic grade line calculations for the storm drain lines are contained in APPENDIX B. Reference should be made to the Onsite Drainage Map for location and indication of each identification letter or number listed. Storm drain lines have been sized to convey the 100-year event to the Signal Butte Floodway.

4.4 DRAINAGE SWALES

Detailed swale calculations based on Manning's Equation are contained in APPENDIX B. Table 4.2 summarizes the swale geometries and capacities.

Location	Shape	Lining	"n"	Min. Slope (ft/ft)	Depth (ft)	Side Slopes	Bottom Width (ft)	$Q_{capacity}$	Q_{design}
N. side of McLellan	"v"	Rock	0.035	0.040	2.0	6 to 1 3 to 1	0	175	25.2
Area E Swale	trap	Natural	0.025	0.030	1.5	3 to 1	2	90	75.6
Lot 10	"v"	Rock	0.035	0.005	1.5	3 to 1	0	35	31.6
Lots 15 and 16	"v"	Rock	0.035	0.030	1.5	3 to 1	0	53	15.2

Table 4.2 Drainage Swale Summary

4.5 CULVERTS

Culvert sizing calculations indicate that a four barrel 10 foot by 3 foot box culvert will be required to convey the 100 year flow of 920 cfs beneath McLellan Road and North Apron. Culverts are sized using the methods outlined in the Federal Highway Department's HEC-5 Circular. Sizing calculations and the appropriate charts from the HEC-5 Circular are provided in APPENDIX B.

4.6 DRAINAGE CHANNEL

The drainage channel which will be constructed from Point A to the Signal Butte Floodway will be trapezoidal in shape with a 32 foot bottom width, 3 to 1 side slopes, and lined with loose rock riprap. The slope of the ground in the location of the channel is approximately 3.0 percent. A channel designed with this slope would flow supercritical and would require concrete lining.

Because it is the desire of the City of Mesa and the developer of the property to have a "natural" looking channel, the slope has been decreased by incorporating four vertical riprap basin drops into the channel design. The drops have designed in accordance with Section 6 of the Flood Control District of Maricopa County Hydraulics Manual. Detailed drop structure calculations are contained in APPENDIX B.

A hydraulic analysis of the channel and drop structures was performed using the U.S. Army Corps of Engineer's HEC-RAS River Analysis System. The model demonstrates that the channel has sufficient capacity to convey the offsite flows while maintaining a minimum of one foot of freeboard. The HEC-RAS Model is contained in APPENDIX B. Cross-section locations are indicated on the Onsite Drainage Map.

4.7 FINISHED FLOORS

Finished floor elevations will be established with individual grading and drainage plans. Finished floors adjacent to the channel should be set a minimum of one foot above the adjacent water surface elevation. The individual grading and drainage plans shall direct runoff away from the structures and to the historical outfall for the lot.

REFERENCES

Flood Control District of Maricopa County, Drainage Design Manual for Maricopa County, - Volume 1, Hydrology, June, 1992.

Flood Control District of Maricopa County, Drainage Design Manual for Maricopa County, - Volume 2, Hydraulics, September, 1992.

Standage & Truitt Engineering, Ltd., Conceptual Drainage Report for Saguaro Shadows, May, 1996.

U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements, March, 1984.

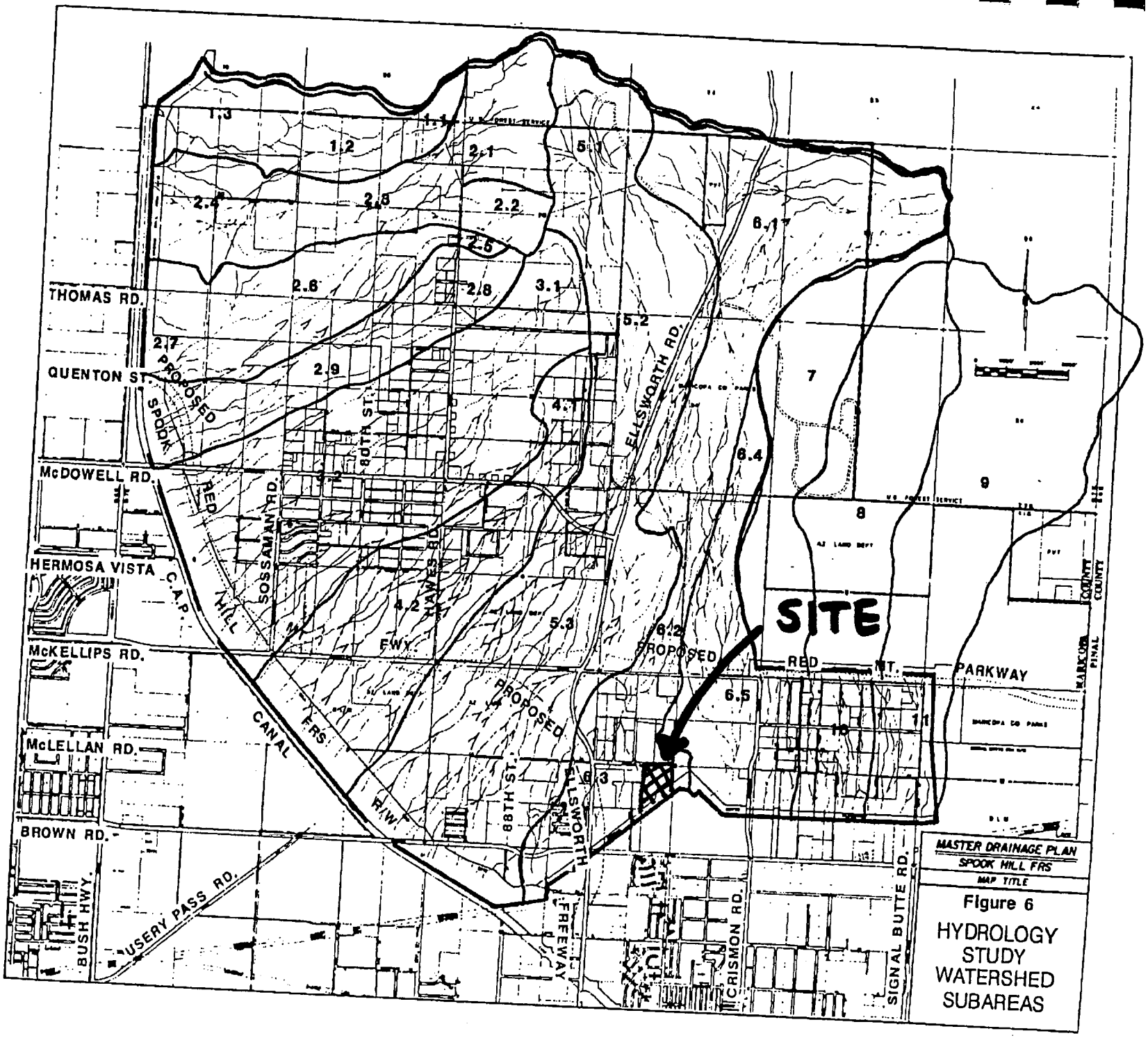
City of Mesa, Engineering Department Development Review, Engineering and Design Standards, Section 6: Storm Drainage, July, 1991.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System, Version 1.0, July 1995.

APPENDIX A

Hydrologic Calculations

Spook Hill ADMS


THOMAS RD.
QUENTON ST.
McDOWELL RD.
HERMOSA VISTA
McKELLIPS RD.
McLELLAN RD.
BROWN RD.
USERY PASS RD.
BUSH HWY.
PROPOSED SPOOK HILL FRS
RED
SOSSAMAN RD.
88TH ST.
HAWES RD.
C.A.P.
CANAL
FWY.
PROPOSED
88TH ST.
ELLSWORTH FREEWAY
ELLSWORTH RD.
PROPOSED
RED MT. PARKWAY
CRISMON RD.
SIGNAL BUTTE RD.
SITE
1.3
1.1
1.2
2.1
5.1
2.4
2.3
2.2
2.5
6.1
2.6
2.8
3.1
5.2
2.7
2.9
4.1
7
6.4
9
8
4.2
5.3
6.2
6.5
10
11
6.3
MASTER DRAINAGE PLAN
SPOOK HILL FRS
MAP TITLE
Figure 6
HYDROLOGY STUDY WATERSHED SUBAREAS

This study was funded by equal contributions from
THE FLOOD CONTROL DISTRICT OF MARICOPA
COUNTY, THE CITY OF MESA, and THE
MARICOPA COUNTY HIGHWAY DEPARTMENT.

SPOOK HILL AREA
DRAINAGE MASTER STUDY

(Master Drainage Plan for the Spook
Hill FRS Watershed, Phase 1)

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TABLE A-1

AVERAGE CURVE NUMBERS FOR DRAINAGE SUBAREAS

WATERSHED	CURRENT LAND USE	FUTURE LAND USE
1.1	81.7	85.4
1.2	82.2	87.3
1.3	83.4	87.6
2.1	84.2	85.9
2.2	82.7	85.3
2.3	76.7	84.4
2.4	83.1	88.5
2.5	87.0	85.2
2.6	79.6	86.2
2.7	83.0	88.1
2.8	81.9	87.5
2.9	78.7	85.1
3.1	83.4	86.7
3.2	80.1	85.9
4.1	79.8	86.4
4.2	75.8	83.0
5.1	85.3	87.0
5.2	75.1	76.8
5.3	76.9	83.6
6.1	76.9	83.6
6.1	78.9	79.5
6.2	79.8	84.4
6.3	79.3	86.3
6.4	74.3	74.3
6.5	79.1	83.1
10	81.8	87.7
11	76.8	83.8

TABLE A-4

100-YEAR 24-HOUR STORM ROUTED HYDROLOGY

STATION	CURRENT WATERSHED CONDITIONS PEAK FLOW cfs	TIME PEAK hours	MAX. STAGE feet	TIME MAX. STAGE hours	FUTURE WATERSHED CONDITIONS PEAK FLOW cfs	TIME PEAK hours	MAX. STAGE feet	TIME MAX. STAGE hours
PASS MOUNTAIN DIVERSION WATERSHED								
SB 7	629	12.67			629	12.67		
SB 8	1433	12.33			1433	12.33		
CB78	1856	12.33			1856	12.33		
SB 9	2201	12.33			2201	12.33		
CB89	3802	12.33			3802	12.33		
SPOOK HILL WATERSHED MODEL								
SIGNAL BUTTE FRS DIS-CHARGE	156	2.67			156	2.67		
SB11	472	12.67			671	12.67		
SB10	917	12.67			1186	12.67		
SB 6.5	1162	13.00			1490	13.00		
SB 6.3	1952	13.00			2410	13.00		
SB 5.3	2749	13.00			3531	13.00		
SB 4.2	3247	13.00			4350	13.00		
SB 3.2	4314	13.00			5901	13.00		
SB 2.9	4757	13.00			6423	13.00		
SPOOK HILL FRS RES	940	17.67	1582.51	17.67	1144	17.33	1583.25	17.33
SB 2.7	983	17.33			1197	17.00		
SB 2.4	1290	13.00			1762	13.00		
SB 1.3	1713	13.00			2404	12.67		

See HEC-1 attached. OFF site flow is about 920 cfs.

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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
 79 KK      *     SB6.3  *
            *            *
            **************
                                KINE WAVE OVERLAND FLOW 6.3

              SUBBASIN RUNOFF DATA

 81 BA          SUBBASIN CHARACTERISTICS
                      TAREA        2.50  SUBBASIN AREA

                PRECIPITATION DATA

 29 PT           TOTAL STORM STATIONS        G1
  0 PW                       WEIGHTS      1.00

 28 PR             RECORDING STATIONS        G1
  0 PW                       WEIGHTS      1.00

 82 LS          SCS LOSS RATE
                      STRTL         .52  INITIAL ABSTRACTION
                     CRVNBR       79.30  CURVE NUMBER
                      RTIMP         .00  PERCENT IMPERVIOUS AREA

                KINEMATIC WAVE
 83 UK            OVERLAND-FLOW ELEMENT NO. 1
                          L      23800.  OVERLAND FLOW LENGTH
                          S       .0600  SLOPE
                          N        .050  ROUGHNESS COEFFICIENT
                         PA       100.0  PERCENT OF SUBBASIN
                      DXMIN           5  MINIMUM NUMBER OF DX INTERVALS

                KINEMATIC WAVE
 84 RK            MAIN CHANNEL
                          L       6300.  CHANNEL LENGTH
                          S       .0150  SLOPE
                          N        .013  CHANNEL ROUGHNESS COEFFICIENT
                         CA        2.50  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       14.00  BOTTOM WIDTH OR DIAMETER
                          Z         .00  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS
                     RUPSTQ          NO  ROUTE UPSTREAM HYDROGRAPH
                                                                  ***
```

PRECIPITATION STATION DATA

STATION	TOTAL	AVG. ANNUAL	WEIGHT
G1	4.18	.00	1.00

TEMPORAL DISTRIBUTIONS

STATION G1, WEIGHT = 1.00

.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.01	.01	.01	.01	.01
.01	.01	.01	.01	.02	.03	.04	.04	.04	.05
.06	.09	.10	.25	.52	1.65	.42	.15	.10	.08
.06	.04	.04	.04	.03	.02	.02	.01	.01	.01
.01	.01	.01	.01	.01	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	

COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
PLANE1	7.30	1.67	20.00	4760.00	927.20	801.52	1.99	3.53
MAIN	2.42	1.67	.78	2100.00	915.87	818.61	1.97	48.73

CONTINUITY SUMMARY (AC-FT) - INFLOW= .0000E+00 EXCESS= .2846E+03 OUTFLOW= .2623E+03 BASIN STORAGE= .1511E+02 PERCENT ERROR= 2.5

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN	2.42	1.67	20.00	915.87	820.00	1.98

*** *** *** *** ***

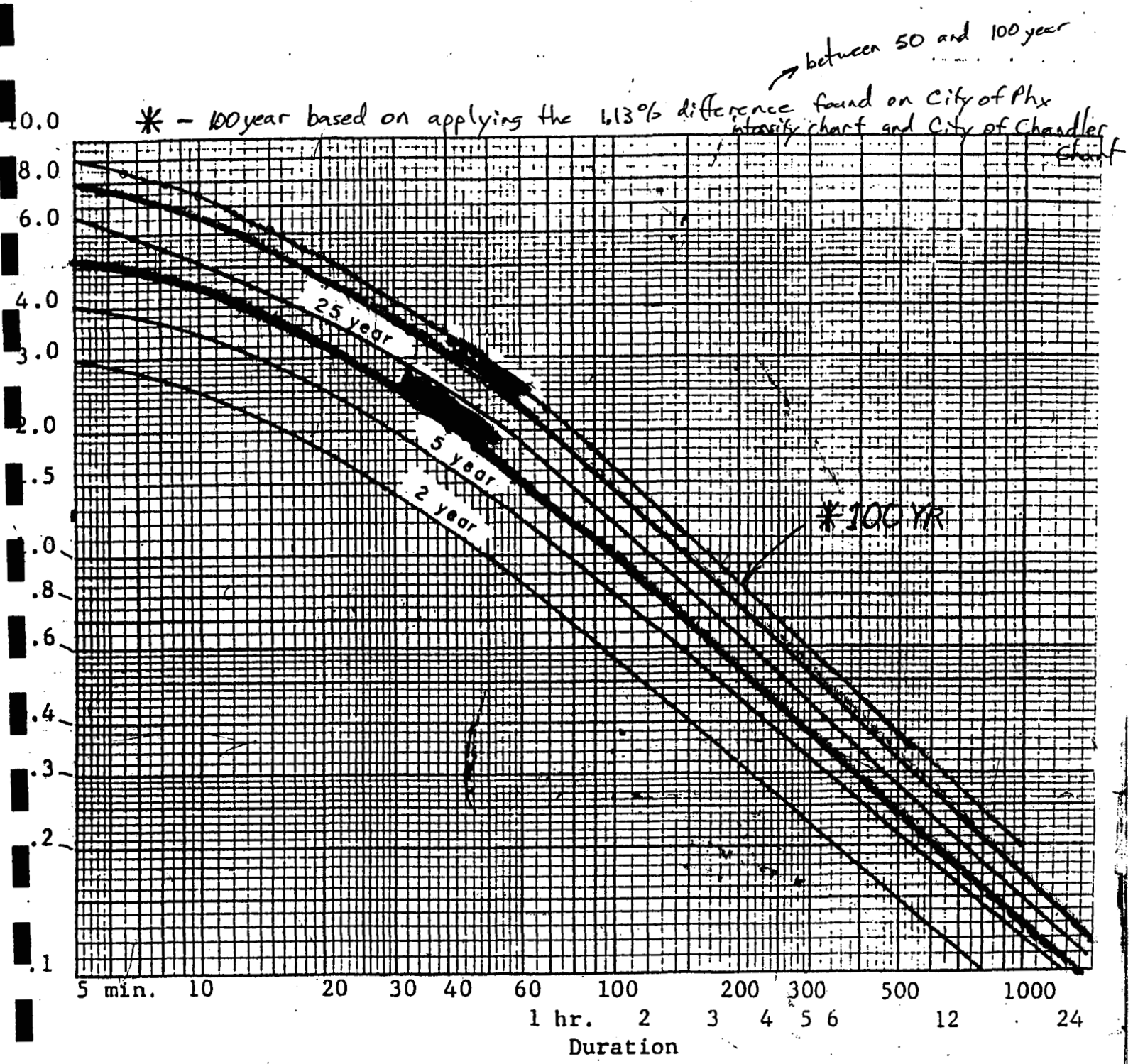
HYDROGRAPH AT STATION SB6.3

TOTAL RAINFALL = 4.18, TOTAL LOSS = 2.05, TOTAL EXCESS = 2.13

	PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	23.00-HR
+	916.	13.67	(CFS)	466.	139.	139.	139.
			(INCHES)	1.733	1.977	1.977	1.977
			(AC-FT)	231.	264.	264.	264.

CUMULATIVE AREA = 2.50 SQ MI

City of Mesa I-D-F Curves



RAINFALL INTENSITY - DURATION - FREQUENCY RELATION
FOR MESA, ARIZONA

(Partial Duration Series)

Curves are based on methods of U.S. Weather Bureau Technical Paper No. 40, Technical Memorandum WBTM WR-44, and rainfall data from pages 37c through 39 of the Arizona Highway Department Hydrologic Design Manual (1970 Revision).

APPENDIX B

Hydraulic Calculations

Inlet Sizing Calculations

JOB NAME: SAGUARO SHADOWS TWO

JOB NO. 970507

SUMP CATCH BASIN/SCUPPER CALCULATIONS

Catch basin openings are determined using the methods outlined in the Federal Highway Departments HEC-12 Circular, March 1984.
The following equations are used to determine the interception capacity of depressed curb-opening inlets and grated inlets.

Curb Opening Equation

$$Qi = Cw(L + 1.8W)d^{1.5}$$

Where:
Qi = interception capacity of depressed curb-opening inlet (cfs)
Cw = 2.3
L = length of curb opening (ft)
W = lateral width of depression (ft)
d = depth at curb measured from the normal cross slope (ft)

Grate Opening Equation

$$Qi = CwPd^{1.5}$$

Where:
Qi = interception capacity of grated inlet (cfs)
Cw = 3.0
P = perimeter of grate (disregarding bars and side against curb)
d = depth at curb measured from the normal cross slope (ft)

Point	Grate Perimeter (ft)	Depressed Curb Opening Length (ft)	Standard Detail	d10 (ft)	d100 (ft)	Q10 heoretical (cfs)	Q100 Theoretical (cfs)	Reduction Factor	Q10 Actual (cfs)	Q100 Actual (cfs)	Design Q10 (cfs)	Design Q100 (cfs)
PT 1	0	6.0	MAG 533-1, L=3'	0.24	0.34	2.4	4.0	0.8	1.9	3.2	1.9	3.2
PT 6	0	40.0	40' SCUPPER	0.49	0.68	33.7	55.1	0.8	26.9	44.1	26.5	44.2
PT 7	0	6.0	MAG 533-1, L=3'	0.46	0.66	6.2	10.7	0.8	5.0	8.6	5.0	8.6

Table 3.2
Reduction Factors to Apply to Catch Basins

Condition	Inlet Type	Reduction Factor
Sump	Curb Opening	0.80
Sump	Grated	0.50
Sump	Combination	0.65
Continuous Grade	Curb Opening	0.80
Continuous Grade	Longitudinal Bar Grate	0.75
	Longitudinal Bar Grate with recessed transverse bars	0.60
Continuous Grade	Combination(1)	Apply factors separately to grate and curb opening
Shallow Sheet Flow(2)	Slotted Drains	0.80

(1) See Section 3.3.4.3, Combination Catch Basins.

(2) Slotted drains are most effective for shallow sheet flow conditions. With greater depths and flows, a different type of inlet should be used.

The allowable capacity of a catch basin should be determined by applying the applicable factor from Table 3.2 to the theoretical capacity calculated in accordance with the appropriate design charts.

The percentage of theoretical capacity allowed may be even lower when the catch basin is likely to intercept large amounts of sediment or debris. For instance, the first catch basin to a pipe network draining a high debris-yielding area may actually accept only 20 percent of the theoretical capacity allowed because of clogging. Sediment traps should not be designed into the catch basin. A sediment trap formed by lowering the floor of the catch basin below the elevation of the outlet pipe is unnecessary and undesirable since there is too much turbulence for effective trapping at design flow rates, and cleaning is costly. Catch basins should be self-scouring, even under low-flow conditions.

3.3.4 Design Procedures

Figures 3.9 to 3.19 (pages 3-24 to 3-34) are capacity curves for standard catch basins. When designing a *nonstandard* catch basin, use the equations and procdures outlined herein. The approval of the governing municipality should be obtained before designing a nonstandard catch basin. The procedures and equations in this section are adapted from the Federal Highway Administration Hydraulic Engineering Circular No. 12 (HEC-12), *Drainage of Highway Pavements* (FHWA, 1984). Refer to Section 3.1 for definitions of coefficients used in the following equations.

3.3.4.1 Curb Opening Catch Basins

On-Grade: The length of curb opening catch basin required for total interception of gutter flow on a pavement section with a straight cross slope is expressed as:

$$L_T = 0.6Q^{0.42} S^{0.3} \left(\frac{1}{nS_x}\right)^{0.6} \tag{3.3}$$

Storm Drain Calculations

Project: SAGUARO SHADOWS TWO **Job No: 970507**

FROM	TO	OUTLET WS (feet)	PIPE DIAM (in)	Q (cfs)	MNG'S "n"	PIPE LNGTH (feet)	FRCTN SLOPE (ft/ft)	FRCTN LOSS (feet)	FLOW VEL. (fps)	V^2/2g (feet)	INLET LOSS (feet)	OUTLET LOSS (feet)	PIPE COLLAR BEND ANGLE (dgrs)	PIPE COLLAR BEND LOSS (feet)	SUM OF HD LOSS (feet)	TOTAL HD LOSS (feet)	INLET WS (feet)	RIM ELEV (feet)
Storm Drain Line 3 Calculations (100 Year Event)																		
INLET	MH A	83.42	24	25.20	0.013	382	0.0124	4.74	8.02	1.00	0.25	0.35	0	0	0.60	5.34	88.76	95.00
MH A	MH B	81.56	24	25.20	0.013	102	0.0124	1.27	8.02	1.00	0.25	0.35	0	0	0.60	1.86	83.42	85.80
MH B	MH C	81.01	30	25.20	0.013	80	0.0038	0.30	5.13	0.41	0.10	0.14	0	0	0.25	0.55	81.56	85.19
MH C	OUTLET	80.50	30	25.20	0.013	70	0.0038	0.26	5.13	0.41	0.10	0.14	0	0	0.25	0.51	81.01	84.13

*NOTE: Starting WS at OUTLET corresponds to crown elevation of pipe at outlet.

Inlet loss = 0.25 v^2\2g Outlet loss = 0.35 v^2/2g Pipe Collar Bend loss = K v^2/2g

Sum of head loss = inlet + outlet + bend losses

Total head loss = sum + friction loss

90 degrees > K = 0.70	60 degrees > K = 0.55	30 degrees > K = 0.28
80 degrees > K = 0.66	50 degrees > K = 0.47	20 degrees > K = 0.16
70 degrees > K = 0.61	40 degrees > K = 0.38	15 degrees > K = 0.10

JOB NAME: SAGUARO SHADOWS TWO

JOB NO. 970507

STORM DRAIN HYDRAULIC GRADE LINE CHART

FROM	TO	OUTLET WS (feet)	PIPE DIAM (in)	Q (cfs)	MNG'S "n"	PIPE LNGTH (feet)	FRCTN SLOPE (ft/ft)	FRCTN LOSS (feet)	FLOW VEL. (fps)	V^2/2g (feet)	INLET LOSS (feet)	OUTLET LOSS (feet)	PIPE COLLAR BEND ANGLE (dgrs)	PIPE COLLAR BEND LOSS (feet)	SUM OF HD LOSS (feet)	TOTAL HD LOSS (feet)	INLET WS (feet)	RIM ELEV (feet)
Storm Drain Line 1 Calculations (10 Year Event)																		
CB 1	OUTLET	1674.75	15	1.90	0.013	36	0.0009	0.03	1.55	0.04	0.01	0.01	0	0	0.02	0.05	1674.80	1678.60
Storm Drain Line 2 Calculations (10 Year Event)																		
CB ~~X~~ 6	OUTLET	1700.25	15	5.00	0.013	16	0.0060	0.10	4.07	0.26	0.06	0.09	0	0	0.15	0.25	1700.50	1701.96

*NOTE: Starting WS at OUTLET is the crown height of the pipe.

Inlet loss = 0.25 v^2\2g Outlet loss = 0.35 v^2/2g

Sum of head loss = inlet + outlet + bend losses

Total head loss = sum + friction loss

Pipe Collar Bend loss = K v^2/2g

90 degrees > K = 0.70 60 degrees > K = 0.55 30 degrees > K = 0.28

80 degrees > K = 0.66 50 degrees > K = 0.47 20 degrees > K = 0.16

70 degrees > K = 0.61 40 degrees > K = 0.38 15 degrees > K = 0.10

Swale Calculations

SWALE LOT 10

WETTED PERIM..WP= 12.64911 ft

HYDR. RADIUS...R= .9486833 ft

TOP WIDTH.....T= 12 ft

FROUDE NUMBER...= .8441629

TO CONTINUE ENTER 0 FOR NEW SECTION ENTER 1 OR EXIT ENTER 2?

SELECTED SECTION IS A TRIANGLE -- INPUT THE FOLLOWING

FLOWRATE.....Q= (Q=0 MUST INPUT d)? 35

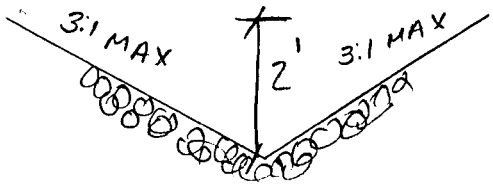
ROUGHNESS COEFF..n= ? .035

SLOPE.....s= ? .005

DEPTH .....d= ? 2

BTM LEFTSIDE SLOPE RUN ..Z1= ? 3

BTM RIGHTSIDE SLOPE RUN .Z2= ? 3



SELECTED SECTION IS A TRIANGLE 08-17-1998

	THE CALCULATED VALUES	VALUES ENTERED
FLOWRATE.....Q=	35.17379 cfs	35
ROUGHNESS COEF.n=	.035	.035
SLOPE.....S=	.005 ft/ft	.005
DEPTH.....D=	2.008401 ft	2
VELOCITY.....V=	2.906678 fps	
AREA.....A=	12.10103 sf	
WETTED PERIM..WP=	12.70225 ft	
HYDR. RADIUS...R=	.9526684 ft	
TOP WIDTH.....T=	12.05041 ft	
FROUDE NUMBER...=	.3614463	

TO CONTINUE ENTER 0 FOR NEW SECTION ENTER 1 OR EXIT ENTER 2?

SWALE LOT 15 AND 16

WETTED PERIM..WP= 12.36932 ft

HYDR. RADIUS...R= .7276069 ft

TOP WIDTH.....T= 12 ft

FROUDE NUMBER...= .3614463

TO CONTINUE ENTER 0 FOR NEW SECTION ENTER 1 OR EXIT ENTER 2?

SELECTED SECTION IS A TRIANGLE -- INPUT THE FOLLOWING

FLOWRATE.....Q= (Q=0 MUST INPUT d)? 53.5

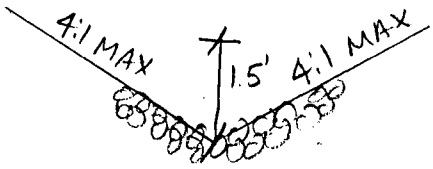
ROUGHNESS COEFF..n= ? .035

SLOPE.....s= ? .03

DEPTH .....d= ? 1.5

BTM LEFTSIDE SLOPE RUN ..Z1= ? 4

BTM RIGHTSIDE SLOPE RUN .Z2= ? 4



SELECTED SECTION IS A TRIANGLE 08-17-1998

	THE CALCULATED VALUES	VALUES ENTERED
FLOWRATE.....Q=	53.76572 cfs	53.5
ROUGHNESS COEF.n=	.035	.035
SLOPE.....S=	.03 ft/ft	.03
DEPTH.....D=	1.50236 ft	1.5
VELOCITY.....V=	5.955218 fps	
AREA.....A=	9.028337 sf	
WETTED PERIM..WP=	12.38877 ft	
HYDR. RADIUS...R=	.7287514 ft	
TOP WIDTH.....T=	12.01888 ft	
FROUDE NUMBER...=	.8562149	

TO CONTINUE ENTER 0 FOR NEW SECTION ENTER 1 OR EXIT ENTER 2?

AREA "E" SWALE

FLOWRATE.....Q= (Q=0 MUST INPUT d)? 90

ROUGHNESS COEFF..n= ? .025

SLOPE.....s= ? .03

BOTTOM DEPTH ....db= ? 1.5

TOP DEPTH.....dt= ? 0

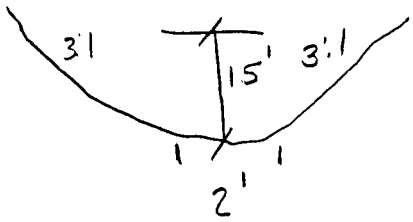
BOTTOM WIDTH.....bb= ? 2

BTM LEFTSIDE SLOPE RUN ..Z1= ? 3

BTM RIGHTSIDE SLOPE RUN .Z2= ? 3

TOP LEFTSIDE SLOPE RUN . Z3= ? 0

TOP RIGHTSIDE SLOPE RUN .Z4= ? 0-



Redo from start
TOP RIGHTSIDE SLOPE RUN .Z4= ? 0
DEPTH..(D=0 FOR ITERATION)..D= ? 1.5

SELECTED SECTION IS A TRAPEZOID 08-17-1998

	THE CALCULATED VALUES	VALUES ENTERED
FLOWRATE.....Q=	89.98709 cfs	90
ROUGHNESS COEF.n=	.025	.025
SLOPE.....S=	.03 ft/ft	.03
DEPTH.....D=	1.5 ft	1.5
VELOCITY.....V=	9.229445 fps	
AREA.....A=	9.75 sf	
WETTED PERIM..WP=	11.48683 ft	
HYDR. RADIUS...R=	.848798 ft	
TOP WIDTH.....T=	11 ft	
FROUDE NUMBER...=	1.328012	

TO CONTINUE ENTER 0 FOR NEW SECTION ENTER 1 OR EXIT ENTER 2?

Swale - North side of McLellan
Worksheet for Triangular Channel

Depth Calculation

Project Description	
Worksheet	Triangular Channel - 1
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.040000	ft/ft
Left Side Slope	0.17	V : H
Right Side Slope	0.33	V : H
Discharge	25.20	cfs

Results		
Depth	0.97	ft
Flow Area	4.2	ft²
Wetted Perimeter	8.95	ft
Top Width	8.71	ft
Critical Depth	1.14	ft
Critical Slope	0.016381	ft/ft
Velocity	5.99	ft/s
Velocity Head	0.56	ft
Specific Energy	1.52	ft
Froude Number	1.52	
Flow Type	Supercritical	

Swale - North side of McLellan
Worksheet for Triangular Channel

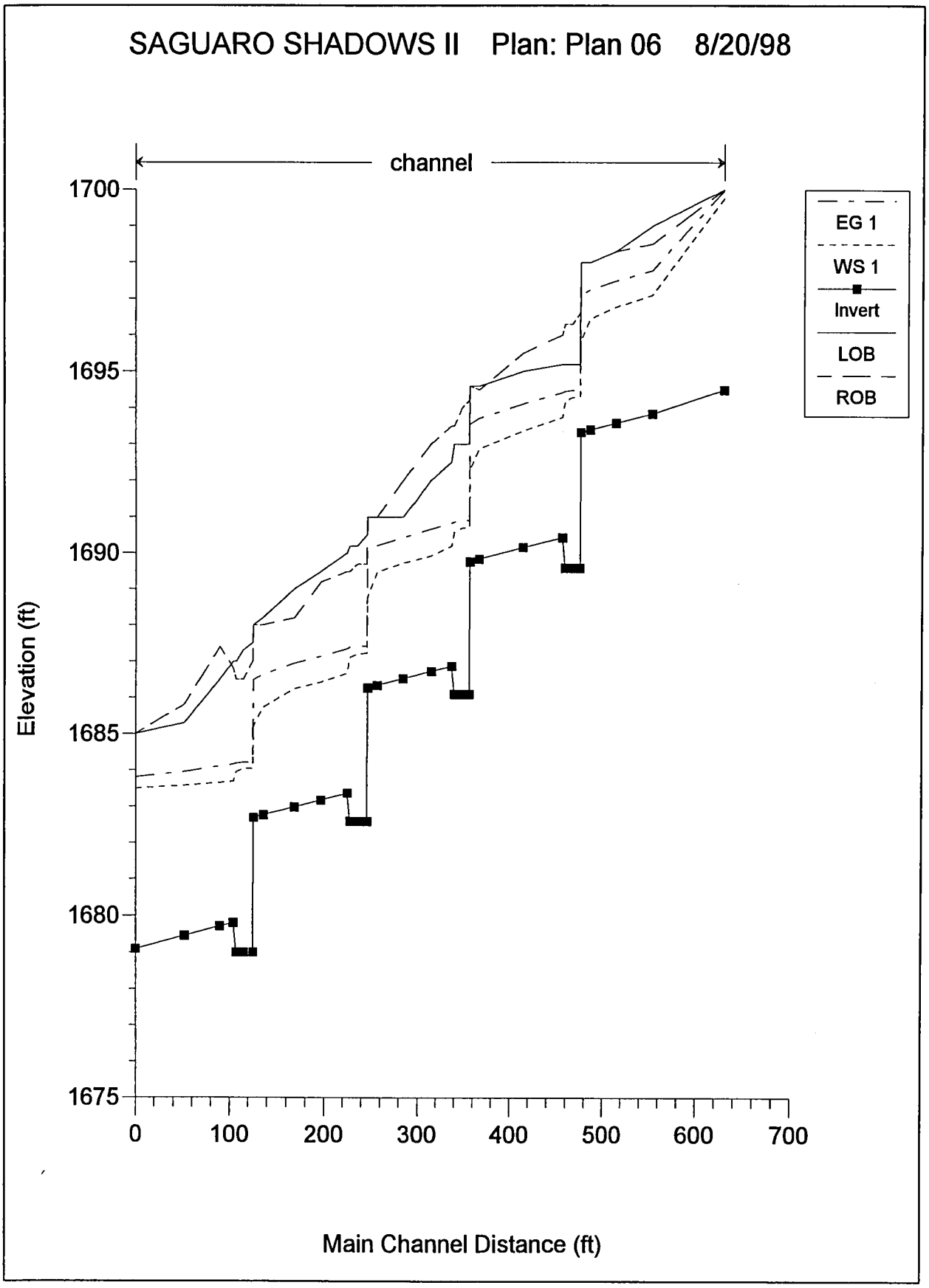
Capacity Calculations

Project Description	
Worksheet	Triangular Channel - 1
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.030	
Slope	0.040000	ft/ft
Depth	2.00	ft
Left Side Slope	0.17	V : H
Right Side Slope	0.33	V : H

Results		
Discharge	175.53	cfs
Flow Area	18.0	ft²
Wetted Perimeter	18.52	ft
Top Width	18.04	ft
Critical Depth	2.48	ft
Critical Slope	0.012646	ft/ft
Velocity	9.73	ft/s
Velocity Head	1.47	ft
Specific Energy	3.47	ft
Froude Number	1.72	
Flow Type	Supercritical	

HEC-RAS Model


SAGUARO SHADOWS II Plan: Plan 06 8/20/98
channel
1700
1695
1690
1685
1680
1675
Elevation (ft)
0
100
200
300
400
500
600
700
Main Channel Distance (ft)
EG 1
WS 1
Invert
LOB
ROB

HEC-RAS Plan: Plan 06 Reach: channel 8/20/98

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
733	920.00	1694.50	1699.75		1699.97	0.001088	3.73	246.51	47.91	0.29
657	920.00	1693.84	1697.11		1697.78	0.006887	6.60	139.34	53.34	0.72
618	920.00	1693.58	1696.77		1697.50	0.007529	6.83	135.10	54.20	0.75
590	920.00	1693.40	1696.44		1697.26	0.008947	7.25	127.76	53.82	0.81
580	920.00	1693.33	1695.86	1695.86	1697.11	0.014910	8.96	103.08	42.50	1.00
579	920.00	1689.60	1694.30		1694.50	0.001240	3.55	259.38	69.48	0.32
569	920.00	1689.60	1694.30		1694.49	0.001243	3.54	259.88	70.01	0.32
561	920.00	1689.60	1694.19		1694.47	0.001949	4.27	215.58	61.33	0.40
558	920.00	1690.43	1693.73		1694.42	0.006822	6.66	138.20	51.76	0.72
516	920.00	1690.16	1693.36		1694.11	0.007649	6.94	132.59	50.85	0.76
469	920.00	1689.84	1692.86	1692.53	1693.71	0.009253	7.36	124.92	50.63	0.83
459	920.00	1689.77	1692.29	1692.29	1693.55	0.015118	9.00	102.22	41.04	1.01
458	920.00	1686.10	1690.70		1690.91	0.001321	3.62	254.42	69.48	0.33
448	920.00	1686.10	1690.69		1690.90	0.001328	3.62	254.32	69.73	0.33
440	920.00	1686.10	1690.58		1690.87	0.002070	4.33	212.33	61.87	0.41
437	920.00	1686.87	1690.19		1690.83	0.006424	6.42	143.28	54.31	0.70
415	920.00	1686.73	1689.92		1690.67	0.007640	6.91	133.14	51.37	0.76
385	920.00	1686.53	1689.73		1690.43	0.007276	6.68	137.66	54.00	0.74
357	920.00	1686.34	1689.49	1689.01	1690.21	0.007736	6.83	134.76	53.62	0.76
347	920.00	1686.27	1688.79	1688.79	1690.05	0.015078	8.99	102.31	41.07	1.00
346	920.00	1682.60	1687.22		1687.42	0.001302	3.60	255.46	69.45	0.33
336	920.00	1682.60	1687.21		1687.41	0.001317	3.62	254.39	69.32	0.33
328	920.00	1682.60	1687.11		1687.39	0.001969	4.27	215.24	61.58	0.40
325	920.00	1683.37	1686.67		1687.34	0.006719	6.58	139.79	52.72	0.71
297	920.00	1683.18	1686.43		1687.14	0.007222	6.79	135.54	51.47	0.74
269	920.00	1682.99	1686.24		1686.94	0.007134	6.72	136.87	52.32	0.73
236	920.00	1682.77	1685.72	1685.47	1686.64	0.010215	7.67	119.93	49.18	0.87
226	920.00	1682.70	1685.22	1685.22	1686.48	0.015149	9.01	102.14	40.95	1.01
225	920.00	1679.00	1684.04		1684.21	0.000967	3.28	280.43	69.92	0.29
215	920.00	1679.00	1684.04		1684.20	0.000963	3.26	282.44	71.08	0.29
207	920.00	1679.00	1683.94		1684.18	0.001544	3.94	233.21	62.64	0.36
204	920.00	1679.80	1683.69		1684.16	0.003807	5.47	168.23	54.47	0.55
190	920.00	1679.71	1683.65		1684.10	0.003625	5.37	171.33	54.95	0.54
152	920.00	1679.45	1683.58		1683.95	0.002952	4.93	186.60	58.45	0.49
100	920.00	1679.09	1683.50	1681.69	1683.80	0.002134	4.40	209.17	60.86	0.42

Plan: Plan 06 Reach: channel Riv Sta: 733 Profile: 1 8/20/98

W.S. Elev (ft)	1699.75	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.22	Wt. n-Val.		0.035	
E.G. Elev (ft)	1699.97	Reach Len. (ft)	60.00	76.00	92.00
E.G. Slope (ft/ft)	0.001088	Flow Area (sq ft)		246.51	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	47.91	Top Width (ft)		47.91	
Vel Total (ft/s)	3.73	Avg. Vel. (ft/s)		3.73	
Max Chl Dpth (ft)	5.25	Hydr. Depth (ft)		5.15	
Crit W.S. (ft)		Wetted Per. (ft)		56.67	
Conv. Total (cfs)	27887.5	Conv. (cfs)		27887.5	

Plan: Plan 06 Reach: channel Riv Sta: 657 Profile: 1 8/20/98

W.S. Elev (ft)	1697.11	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.68	Wt. n-Val.		0.035	
E.G. Elev (ft)	1697.78	Reach Len. (ft)	39.00	39.00	39.00
E.G. Slope (ft/ft)	0.006887	Flow Area (sq ft)		139.34	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	53.34	Top Width (ft)		53.34	
Vel Total (ft/s)	6.60	Avg. Vel. (ft/s)		6.60	
Max Chl Dpth (ft)	3.27	Hydr. Depth (ft)		2.61	
Crit W.S. (ft)		Wetted Per. (ft)		54.32	
Conv. Total (cfs)	11085.8	Conv. (cfs)		11085.8	

Plan: Plan 06 Reach: channel Riv Sta: 618 Profile: 1 8/20/98

W.S. Elev (ft)	1696.77	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.72	Wt. n-Val.	0.035	0.035	
E.G. Elev (ft)	1697.50	Reach Len. (ft)	28.00	28.00	28.00
E.G. Slope (ft/ft)	0.007529	Flow Area (sq ft)	0.55	134.55	
Q Total (cfs)	920.00	Flow (cfs)	0.72	919.28	
Top Width (ft)	54.20	Top Width (ft)	1.91	52.29	
Vel Total (ft/s)	6.81	Avg. Vel. (ft/s)	1.31	6.83	
Max Chl Dpth (ft)	3.19	Hydr. Depth (ft)	0.29	2.57	
Crit W.S. (ft)		Wetted Per. (ft)	2.56	53.27	
Conv. Total (cfs)	10602.4	Conv. (cfs)	8.3	10594.2	

Plan: Plan 06 Reach: channel Riv Sta: 590 Profile: 1 8/20/98

W.S. Elev (ft)	1696.44	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.81	Wt. n-Val.	0.035	0.035	
E.G. Elev (ft)	1697.26	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.008947	Flow Area (sq ft)	1.24	126.51	
Q Total (cfs)	920.00	Flow (cfs)	2.39	917.61	
Top Width (ft)	53.82	Top Width (ft)	2.64	51.18	
Vel Total (ft/s)	7.20	Avg. Vel. (ft/s)	1.93	7.25	
Max Chl Dpth (ft)	3.04	Hydr. Depth (ft)	0.47	2.47	
Crit W.S. (ft)		Wetted Per. (ft)	3.74	52.12	
Conv. Total (cfs)	9726.2	Conv. (cfs)	25.3	9700.9	

Plan: Plan 06 Reach: channel Riv Sta: 580 Profile: 1 8/20/98

W.S. Elev (ft)	1695.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.24	Wt. n-Val.	0.035	0.035	
E.G. Elev (ft)	1697.11	Reach Len. (ft)	1.00	1.00	1.00
E.G. Slope (ft/ft)	0.014910	Flow Area (sq ft)	0.47	102.61	
Q Total (cfs)	920.00	Flow (cfs)	0.86	919.14	
Top Width (ft)	42.50	Top Width (ft)	1.42	41.08	
Vel Total (ft/s)	8.93	Avg. Vel. (ft/s)	1.83	8.96	
Max Chl Dpth (ft)	2.53	Hydr. Depth (ft)	0.33	2.50	
Crit W.S. (ft)	1695.86	Wetted Per. (ft)	2.22	45.18	
Conv. Total (cfs)	7534.5	Conv. (cfs)	7.0	7527.4	

Plan: Plan 06 Reach: channel Riv Sta: 579 Profile: 1 8/20/98

W.S. Elev (ft)	1694.30	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.035	
E.G. Elev (ft)	1694.50	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.001240	Flow Area (sq ft)		259.38	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.48	Top Width (ft)		69.48	
Vel Total (ft/s)	3.55	Avg. Vel. (ft/s)		3.55	
Max Chl Dpth (ft)	4.70	Hydr. Depth (ft)		3.73	
Crit W.S. (ft)		Wetted Per. (ft)		70.96	
Conv. Total (cfs)	26131.4	Conv. (cfs)		26131.4	

Plan: Plan 06 Reach: channel Riv Sta: 569 Profile: 1 8/20/98

W.S. Elev (ft)	1694.30	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.19	Wt. n-Val.		0.035	
E.G. Elev (ft)	1694.49	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.001243	Flow Area (sq ft)		259.88	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	70.01	Top Width (ft)		70.01	
Vel Total (ft/s)	3.54	Avg. Vel. (ft/s)		3.54	
Max Chl Dpth (ft)	4.70	Hydr. Depth (ft)		3.71	
Crit W.S. (ft)		Wetted Per. (ft)		71.45	
Conv. Total (cfs)	26095.8	Conv. (cfs)		26095.8	

Plan: Plan 06 Reach: channel Riv Sta: 561 Profile: 1 8/20/98

W.S. Elev (ft)	1694.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.28	Wt. n-Val.		0.035	
E.G. Elev (ft)	1694.47	Reach Len. (ft)	3.00	3.00	3.00
E.G. Slope (ft/ft)	0.001949	Flow Area (sq ft)		215.58	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	61.33	Top Width (ft)		61.33	
Vel Total (ft/s)	4.27	Avg. Vel. (ft/s)		4.27	
Max Chl Dpth (ft)	4.59	Hydr. Depth (ft)		3.52	
Crit W.S. (ft)		Wetted Per. (ft)		62.73	
Conv. Total (cfs)	20841.8	Conv. (cfs)		20841.8	

Plan: Plan 06 Reach: channel Riv Sta: 558 Profile: 1 8/20/98

W.S. Elev (ft)	1693.73	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.69	Wt. n-Val.		0.035	
E.G. Elev (ft)	1694.42	Reach Len. (ft)	42.00	42.00	42.00
E.G. Slope (ft/ft)	0.006822	Flow Area (sq ft)		138.20	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	51.76	Top Width (ft)		51.76	
Vel Total (ft/s)	6.66	Avg. Vel. (ft/s)		6.66	
Max Chl Dpth (ft)	3.30	Hydr. Depth (ft)		2.67	
Crit W.S. (ft)		Wetted Per. (ft)		52.83	
Conv. Total (cfs)	11138.6	Conv. (cfs)		11138.6	

Plan: Plan 06 Reach: channel Riv Sta: 516 Profile: 1 8/20/98

W.S. Elev (ft)	1693.36	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.75	Wt. n-Val.		0.035	
E.G. Elev (ft)	1694.11	Reach Len. (ft)	47.00	47.00	47.00
E.G. Slope (ft/ft)	0.007649	Flow Area (sq ft)		132.59	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	50.85	Top Width (ft)		50.85	
Vel Total (ft/s)	6.94	Avg. Vel. (ft/s)		6.94	
Max Chl Dpth (ft)	3.20	Hydr. Depth (ft)		2.61	
Crit W.S. (ft)		Wetted Per. (ft)		51.91	
Conv. Total (cfs)	10519.0	Conv. (cfs)		10519.0	

Plan: Plan 06 Reach: channel Riv Sta: 469 Profile: 1 8/20/98

W.S. Elev (ft)	1692.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.84	Wt. n-Val.		0.035	
E.G. Elev (ft)	1693.71	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.009253	Flow Area (sq ft)		124.92	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	50.63	Top Width (ft)		50.63	
Vel Total (ft/s)	7.36	Avg. Vel. (ft/s)		7.36	
Max Chl Dpth (ft)	3.02	Hydr. Depth (ft)		2.47	
Crit W.S. (ft)	1692.53	Wetted Per. (ft)		51.59	
Conv. Total (cfs)	9564.2	Conv. (cfs)		9564.2	

Plan: Plan 06 Reach: channel Riv Sta: 459 Profile: 1 8/20/98

W.S. Elev (ft)	1692.29	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.26	Wt. n-Val.		0.035	
E.G. Elev (ft)	1693.55	Reach Len. (ft)	1.00	1.00	1.00
E.G. Slope (ft/ft)	0.015118	Flow Area (sq ft)		102.22	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	41.04	Top Width (ft)		41.04	
Vel Total (ft/s)	9.00	Avg. Vel. (ft/s)		9.00	
Max Chl Dpth (ft)	2.52	Hydr. Depth (ft)		2.49	
Crit W.S. (ft)	1692.29	Wetted Per. (ft)		45.15	
Conv. Total (cfs)	7482.4	Conv. (cfs)		7482.4	

Plan: Plan 06 Reach: channel Riv Sta: 458 Profile: 1 8/20/98

W.S. Elev (ft)	1690.70	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.91	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.001321	Flow Area (sq ft)		254.42	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.48	Top Width (ft)		69.48	
Vel Total (ft/s)	3.62	Avg. Vel. (ft/s)		3.62	
Max Chl Dpth (ft)	4.60	Hydr. Depth (ft)		3.66	
Crit W.S. (ft)		Wetted Per. (ft)		70.90	
Conv. Total (cfs)	25315.9	Conv. (cfs)		25315.9	

Plan: Plan 06 Reach: channel Riv Sta: 448 Profile: 1 8/20/98

W.S. Elev (ft)	1690.69	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.90	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.001328	Flow Area (sq ft)		254.32	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.73	Top Width (ft)		69.73	
Vel Total (ft/s)	3.62	Avg. Vel. (ft/s)		3.62	
Max Chl Dpth (ft)	4.59	Hydr. Depth (ft)		3.65	
Crit W.S. (ft)		Wetted Per. (ft)		71.13	
Conv. Total (cfs)	25245.6	Conv. (cfs)		25245.6	

Plan: Plan 06 Reach: channel Riv Sta: 440 Profile: 1 8/20/98

W.S. Elev (ft)	1690.58	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.29	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.87	Reach Len. (ft)	3.00	3.00	3.00
E.G. Slope (ft/ft)	0.002070	Flow Area (sq ft)		212.33	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	61.87	Top Width (ft)		61.87	
Vel Total (ft/s)	4.33	Avg. Vel. (ft/s)		4.33	
Max Chl Dpth (ft)	4.48	Hydr. Depth (ft)		3.43	
Crit W.S. (ft)		Wetted Per. (ft)		63.19	
Conv. Total (cfs)	20222.5	Conv. (cfs)		20222.5	

Plan: Plan 06 Reach: channel Riv Sta: 437 Profile: 1 8/20/98

W.S. Elev (ft)	1690.19	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.64	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.83	Reach Len. (ft)	22.00	22.00	22.00
E.G. Slope (ft/ft)	0.006424	Flow Area (sq ft)		143.28	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	54.31	Top Width (ft)		54.31	
Vel Total (ft/s)	6.42	Avg. Vel. (ft/s)		6.42	
Max Chl Dpth (ft)	3.32	Hydr. Depth (ft)		2.64	
Crit W.S. (ft)		Wetted Per. (ft)		55.28	
Conv. Total (cfs)	11478.2	Conv. (cfs)		11478.2	

Plan: Plan 06 Reach: channel Riv Sta: 415 Profile: 1 8/20/98

W.S. Elev (ft)	1689.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.74	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.67	Reach Len. (ft)	30.00	30.00	30.00
E.G. Slope (ft/ft)	0.007640	Flow Area (sq ft)		133.14	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	51.37	Top Width (ft)		51.37	
Vel Total (ft/s)	6.91	Avg. Vel. (ft/s)		6.91	
Max Chl Dpth (ft)	3.19	Hydr. Depth (ft)		2.59	
Crit W.S. (ft)		Wetted Per. (ft)		52.40	
Conv. Total (cfs)	10525.3	Conv. (cfs)		10525.3	

Plan: Plan 06 Reach: channel Riv Sta: 385 Profile: 1 8/20/98

W.S. Elev (ft)	1689.73	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.69	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.43	Reach Len. (ft)	28.00	28.00	28.00
E.G. Slope (ft/ft)	0.007276	Flow Area (sq ft)		137.66	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	54.00	Top Width (ft)		54.00	
Vel Total (ft/s)	6.68	Avg. Vel. (ft/s)		6.68	
Max Chl Dpth (ft)	3.20	Hydr. Depth (ft)		2.55	
Crit W.S. (ft)		Wetted Per. (ft)		54.91	
Conv. Total (cfs)	10785.3	Conv. (cfs)		10785.3	

Plan: Plan 06 Reach: channel Riv Sta: 357 Profile: 1 8/20/98

W.S. Elev (ft)	1689.49	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.72	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.21	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.007736	Flow Area (sq ft)		134.76	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	53.62	Top Width (ft)		53.62	
Vel Total (ft/s)	6.83	Avg. Vel. (ft/s)		6.83	
Max Chl Dpth (ft)	3.15	Hydr. Depth (ft)		2.51	
Crit W.S. (ft)	1689.01	Wetted Per. (ft)		54.52	
Conv. Total (cfs)	10459.8	Conv. (cfs)		10459.8	

Plan: Plan 06 Reach: channel Riv Sta: 347 Profile: 1 8/20/98

W.S. Elev (ft)	1688.79	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.26	Wt. n-Val.		0.035	
E.G. Elev (ft)	1690.05	Reach Len. (ft)	1.00	1.00	1.00
E.G. Slope (ft/ft)	0.015078	Flow Area (sq ft)		102.31	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	41.07	Top Width (ft)		41.07	
Vel Total (ft/s)	8.99	Avg. Vel. (ft/s)		8.99	
Max Chl Dpth (ft)	2.52	Hydr. Depth (ft)		2.49	
Crit W.S. (ft)	1688.79	Wetted Per. (ft)		45.16	
Conv. Total (cfs)	7492.3	Conv. (cfs)		7492.3	

Plan: Plan 06 Reach: channel Riv Sta: 346 Profile: 1 8/20/98

W.S. Elev (ft)	1687.22	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.035	
E.G. Elev (ft)	1687.42	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.001302	Flow Area (sq ft)		255.46	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.45	Top Width (ft)		69.45	
Vel Total (ft/s)	3.60	Avg. Vel. (ft/s)		3.60	
Max Chl Dpth (ft)	4.62	Hydr. Depth (ft)		3.68	
Crit W.S. (ft)		Wetted Per. (ft)		70.88	
Conv. Total (cfs)	25495.5	Conv. (cfs)		25495.5	

Plan: Plan 06 Reach: channel Riv Sta: 336 Profile: 1 8/20/98

W.S. Elev (ft)	1687.21	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.20	Wt. n-Val.		0.035	
E.G. Elev (ft)	1687.41	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.001317	Flow Area (sq ft)		254.39	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.32	Top Width (ft)		69.32	
Vel Total (ft/s)	3.62	Avg. Vel. (ft/s)		3.62	
Max Chl Dpth (ft)	4.61	Hydr. Depth (ft)		3.67	
Crit W.S. (ft)		Wetted Per. (ft)		70.74	
Conv. Total (cfs)	25348.9	Conv. (cfs)		25348.9	

Plan: Plan 06 Reach: channel Riv Sta: 328 Profile: 1 8/20/98

W.S. Elev (ft)	1687.11	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.28	Wt. n-Val.		0.035	
E.G. Elev (ft)	1687.39	Reach Len. (ft)	3.00	3.00	3.00
E.G. Slope (ft/ft)	0.001969	Flow Area (sq ft)		215.24	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	61.58	Top Width (ft)		61.58	
Vel Total (ft/s)	4.27	Avg. Vel. (ft/s)		4.27	
Max Chl Dpth (ft)	4.51	Hydr. Depth (ft)		3.50	
Crit W.S. (ft)		Wetted Per. (ft)		62.97	
Conv. Total (cfs)	20735.7	Conv. (cfs)		20735.7	

Plan: Plan 06 Reach: channel Riv Sta: 325 Profile: 1 8/20/98

W.S. Elev (ft)	1686.67	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.67	Wt. n-Val.		0.035	
E.G. Elev (ft)	1687.34	Reach Len. (ft)	28.00	28.00	28.00
E.G. Slope (ft/ft)	0.006719	Flow Area (sq ft)		139.79	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	52.72	Top Width (ft)		52.72	
Vel Total (ft/s)	6.58	Avg. Vel. (ft/s)		6.58	
Max Chl Dpth (ft)	3.30	Hydr. Depth (ft)		2.65	
Crit W.S. (ft)		Wetted Per. (ft)		53.75	
Conv. Total (cfs)	11223.5	Conv. (cfs)		11223.5	

Plan: Plan 06 Reach: channel Riv Sta: 297 Profile: 1 8/20/98

W.S. Elev (ft)	1686.43	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.72	Wt. n-Val.		0.035	
E.G. Elev (ft)	1687.14	Reach Len. (ft)	28.00	28.00	28.00
E.G. Slope (ft/ft)	0.007222	Flow Area (sq ft)		135.54	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	51.47	Top Width (ft)		51.47	
Vel Total (ft/s)	6.79	Avg. Vel. (ft/s)		6.79	
Max Chl Dpth (ft)	3.25	Hydr. Depth (ft)		2.63	
Crit W.S. (ft)		Wetted Per. (ft)		52.53	
Conv. Total (cfs)	10825.8	Conv. (cfs)		10825.8	

Plan: Plan 06 Reach: channel Riv Sta: 269 Profile: 1 8/20/98

W.S. Elev (ft)	1686.24	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.70	Wt. n-Val.		0.035	
E.G. Elev (ft)	1686.94	Reach Len. (ft)	33.00	33.00	33.00
E.G. Slope (ft/ft)	0.007134	Flow Area (sq ft)		136.87	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	52.32	Top Width (ft)		52.32	
Vel Total (ft/s)	6.72	Avg. Vel. (ft/s)		6.72	
Max Chl Dpth (ft)	3.25	Hydr. Depth (ft)		2.62	
Crit W.S. (ft)		Wetted Per. (ft)		53.33	
Conv. Total (cfs)	10892.5	Conv. (cfs)		10892.5	

Plan: Plan 06 Reach: channel Riv Sta: 236 Profile: 1 8/20/98

W.S. Elev (ft)	1685.72	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.91	Wt. n-Val.		0.035	
E.G. Elev (ft)	1686.64	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.010215	Flow Area (sq ft)		119.93	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	49.18	Top Width (ft)		49.18	
Vel Total (ft/s)	7.67	Avg. Vel. (ft/s)		7.67	
Max Chl Dpth (ft)	2.95	Hydr. Depth (ft)		2.44	
Crit W.S. (ft)	1685.47	Wetted Per. (ft)		50.17	
Conv. Total (cfs)	9102.7	Conv. (cfs)		9102.7	

Plan: Plan 06 Reach: channel Riv Sta: 226 Profile: 1 8/20/98

W.S. Elev (ft)	1685.22	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.26	Wt. n-Val.		0.035	
E.G. Elev (ft)	1686.48	Reach Len. (ft)	1.00	1.00	1.00
E.G. Slope (ft/ft)	0.015149	Flow Area (sq ft)		102.14	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	40.95	Top Width (ft)		40.95	
Vel Total (ft/s)	9.01	Avg. Vel. (ft/s)		9.01	
Max Chl Dpth (ft)	2.52	Hydr. Depth (ft)		2.49	
Crit W.S. (ft)	1685.22	Wetted Per. (ft)		45.14	
Conv. Total (cfs)	7474.8	Conv. (cfs)		7474.8	

Plan: Plan 06 Reach: channel Riv Sta: 225 Profile: 1 8/20/98

W.S. Elev (ft)	1684.04	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.17	Wt. n-Val.		0.035	
E.G. Elev (ft)	1684.21	Reach Len. (ft)	10.00	10.00	10.00
E.G. Slope (ft/ft)	0.000967	Flow Area (sq ft)		280.43	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	69.92	Top Width (ft)		69.92	
Vel Total (ft/s)	3.28	Avg. Vel. (ft/s)		3.28	
Max Chl Dpth (ft)	5.04	Hydr. Depth (ft)		4.01	
Crit W.S. (ft)		Wetted Per. (ft)		71.59	
Conv. Total (cfs)	29583.7	Conv. (cfs)		29583.7	

Plan: Plan 06 Reach: channel Riv Sta: 215 Profile: 1 8/20/98

W.S. Elev (ft)	1684.04	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.16	Wt. n-Val.		0.035	
E.G. Elev (ft)	1684.20	Reach Len. (ft)	8.00	8.00	8.00
E.G. Slope (ft/ft)	0.000963	Flow Area (sq ft)		282.44	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	71.08	Top Width (ft)		71.08	
Vel Total (ft/s)	3.26	Avg. Vel. (ft/s)		3.26	
Max Chl Dpth (ft)	5.04	Hydr. Depth (ft)		3.97	
Crit W.S. (ft)		Wetted Per. (ft)		72.68	
Conv. Total (cfs)	29638.9	Conv. (cfs)		29638.9	

Plan: Plan 06 Reach: channel Riv Sta: 207 Profile: 1 8/20/98

W.S. Elev (ft)	1683.94	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.24	Wt. n-Val.		0.035	
E.G. Elev (ft)	1684.18	Reach Len. (ft)	3.00	3.00	3.00
E.G. Slope (ft/ft)	0.001544	Flow Area (sq ft)		233.21	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	62.64	Top Width (ft)		62.64	
Vel Total (ft/s)	3.94	Avg. Vel. (ft/s)		3.94	
Max Chl Dpth (ft)	4.94	Hydr. Depth (ft)		3.72	
Crit W.S. (ft)		Wetted Per. (ft)		64.13	
Conv. Total (cfs)	23412.8	Conv. (cfs)		23412.8	

Plan: Plan 06 Reach: channel Riv Sta: 204 Profile: 1 8/20/98

W.S. Elev (ft)	1683.69	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.46	Wt. n-Val.		0.035	
E.G. Elev (ft)	1684.16	Reach Len. (ft)	9.00	14.00	19.00
E.G. Slope (ft/ft)	0.003807	Flow Area (sq ft)		168.23	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	54.47	Top Width (ft)		54.47	
Vel Total (ft/s)	5.47	Avg. Vel. (ft/s)		5.47	
Max Chl Dpth (ft)	3.89	Hydr. Depth (ft)		3.09	
Crit W.S. (ft)		Wetted Per. (ft)		55.78	
Conv. Total (cfs)	14909.8	Conv. (cfs)		14909.8	

Plan: Plan 06 Reach: channel Riv Sta: 190 Profile: 1 8/20/98

W.S. Elev (ft)	1683.65	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.45	Wt. n-Val.		0.035	
E.G. Elev (ft)	1684.10	Reach Len. (ft)	35.00	38.00	42.00
E.G. Slope (ft/ft)	0.003625	Flow Area (sq ft)		171.33	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	54.95	Top Width (ft)		54.95	
Vel Total (ft/s)	5.37	Avg. Vel. (ft/s)		5.37	
Max Chl Dpth (ft)	3.94	Hydr. Depth (ft)		3.12	
Crit W.S. (ft)		Wetted Per. (ft)		56.27	
Conv. Total (cfs)	15280.5	Conv. (cfs)		15280.5	

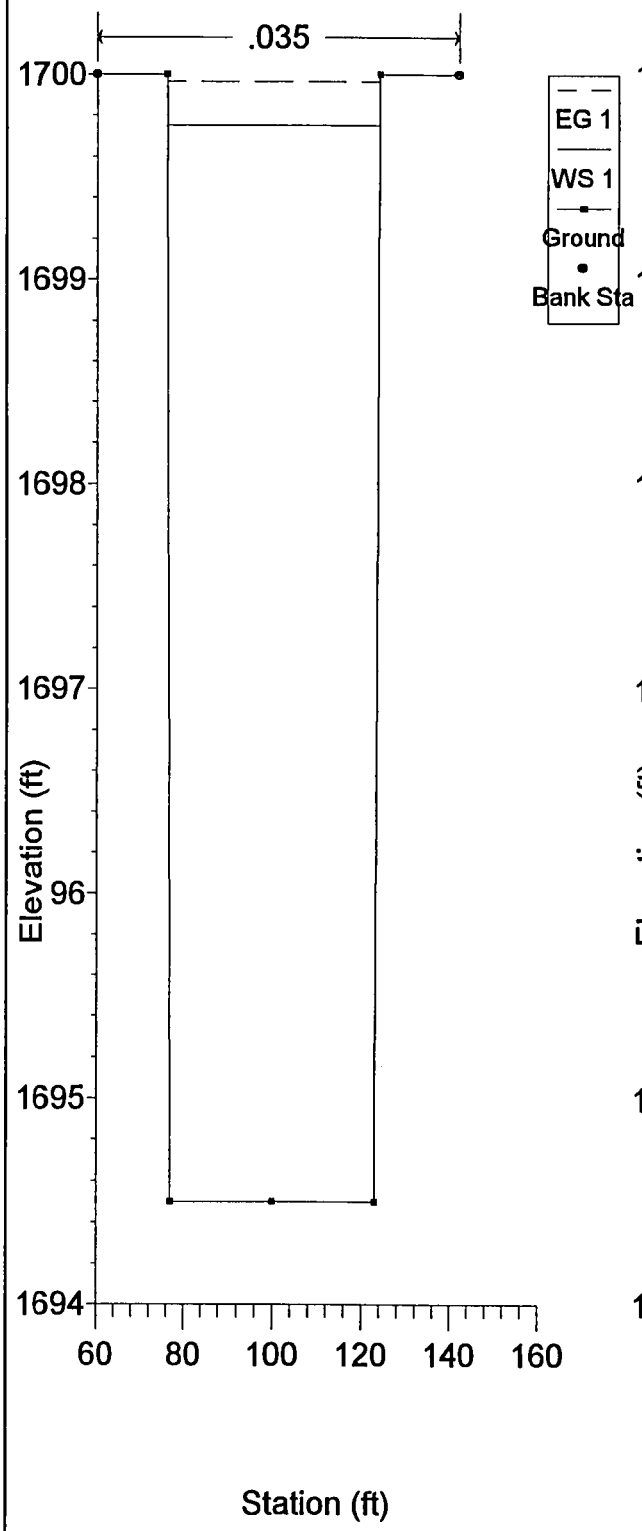
Plan: Plan 06 Reach: channel Riv Sta: 152 Profile: 1 8/20/98

W.S. Elev (ft)	1683.58	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.38	Wt. n-Val.		0.035	
E.G. Elev (ft)	1683.95	Reach Len. (ft)	52.00	52.00	52.00
E.G. Slope (ft/ft)	0.002952	Flow Area (sq ft)		186.60	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	58.45	Top Width (ft)		58.45	
Vel Total (ft/s)	4.93	Avg. Vel. (ft/s)		4.93	
Max Chl Dpth (ft)	4.13	Hydr. Depth (ft)		3.19	
Crit W.S. (ft)		Wetted Per. (ft)		59.71	
Conv. Total (cfs)	16932.8	Conv. (cfs)		16932.8	

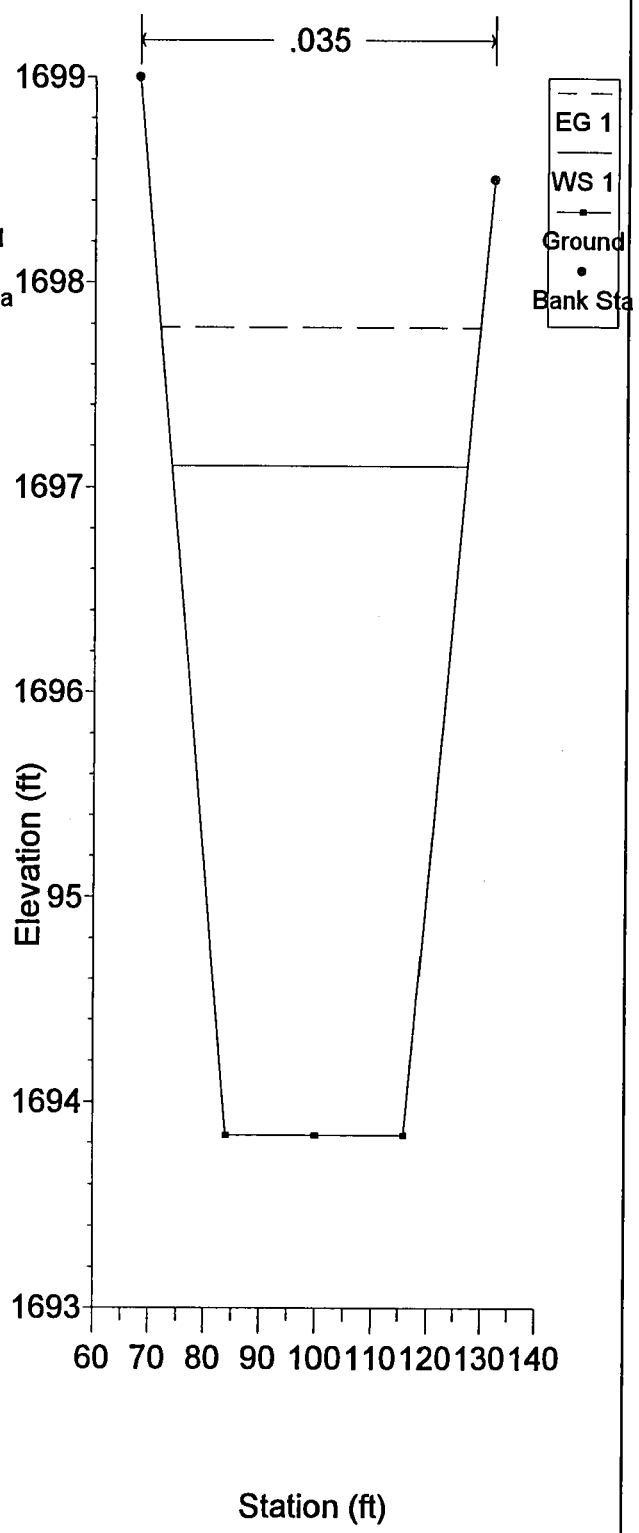
Plan: Plan 06 Reach: channel Riv Sta: 100 Profile: 1 8/20/98

W.S. Elev (ft)	1683.50	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.30	Wt. n-Val.		0.035	
E.G. Elev (ft)	1683.80	Reach Len. (ft)			
E.G. Slope (ft/ft)	0.002134	Flow Area (sq ft)		209.17	
Q Total (cfs)	920.00	Flow (cfs)		920.00	
Top Width (ft)	60.86	Top Width (ft)		60.86	
Vel Total (ft/s)	4.40	Avg. Vel. (ft/s)		4.40	
Max Chl Dpth (ft)	4.41	Hydr. Depth (ft)		3.44	
Crit W.S. (ft)	1681.69	Wetted Per. (ft)		62.27	
Conv. Total (cfs)	19917.6	Conv. (cfs)		19917.6	

SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 733 - CULVERT INLET

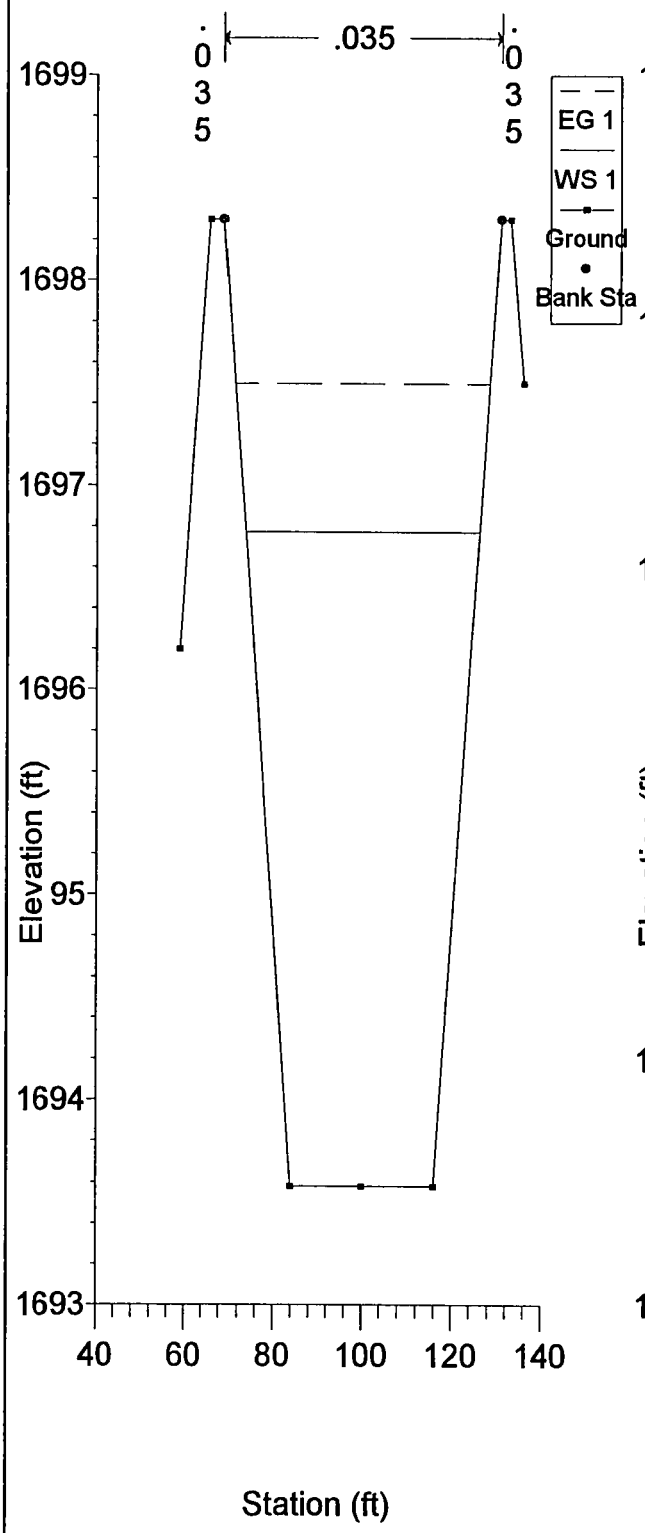


SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 657



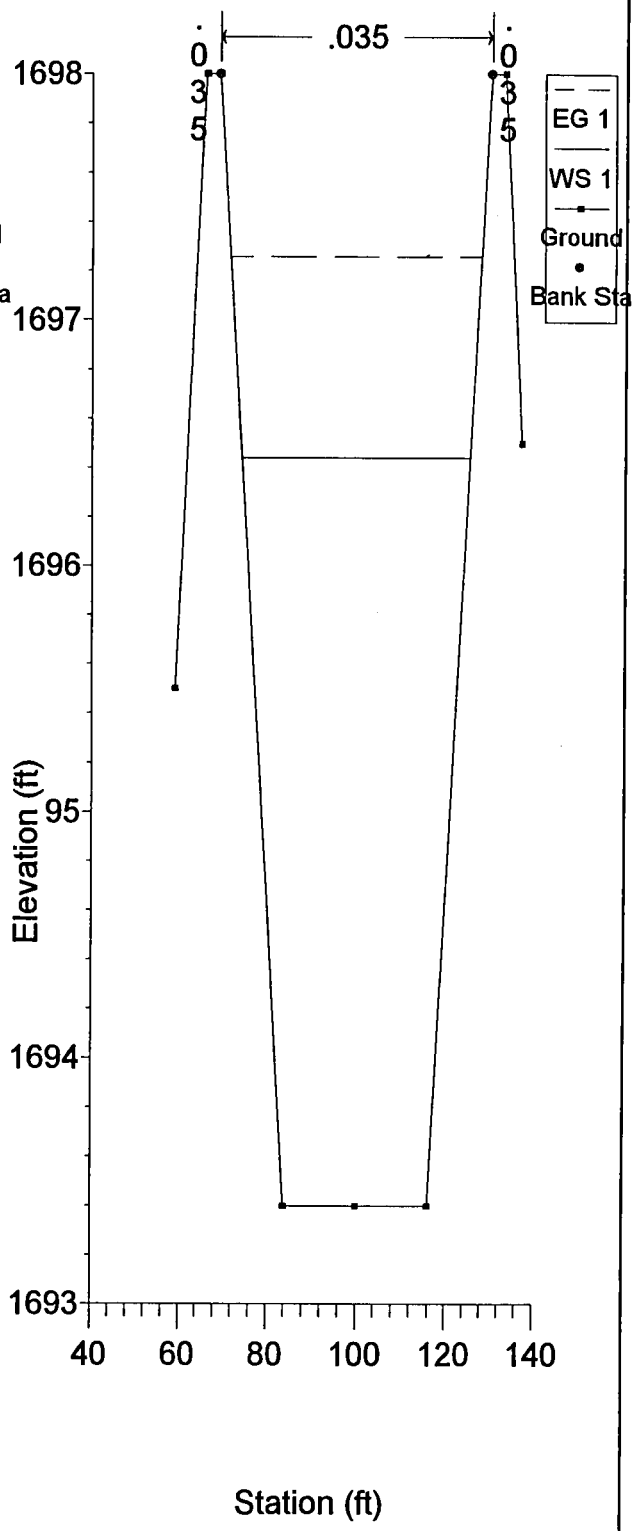
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 618



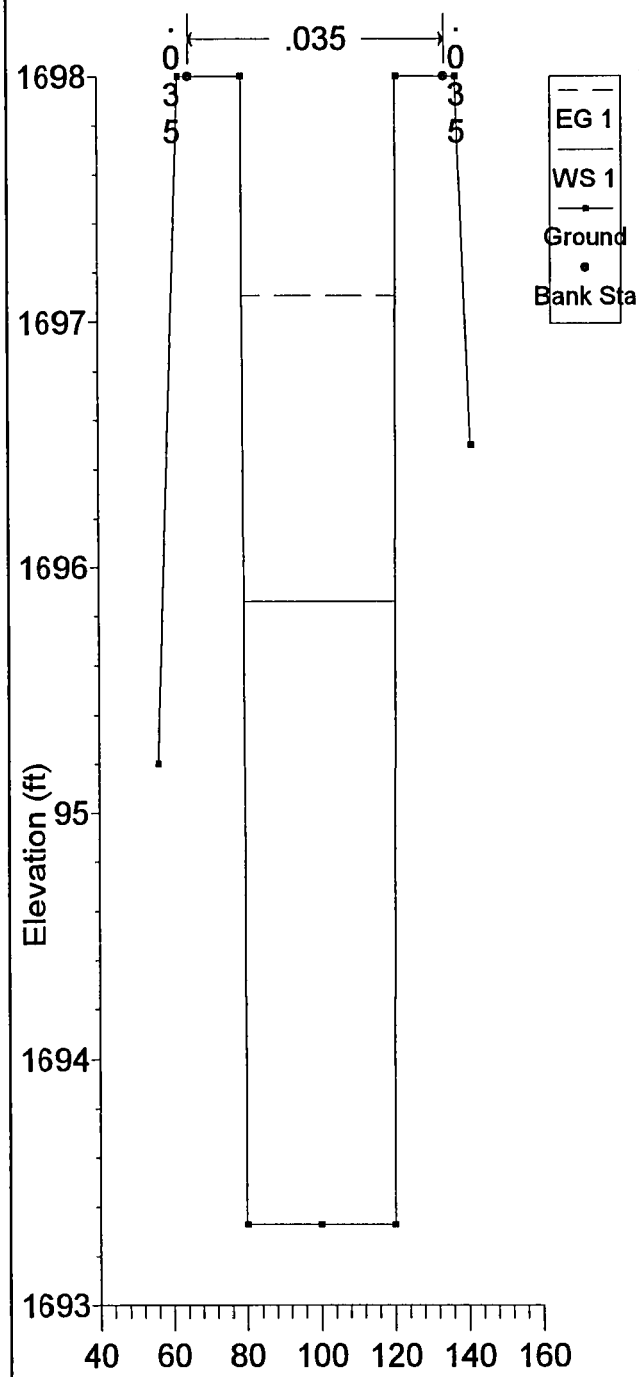
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 590



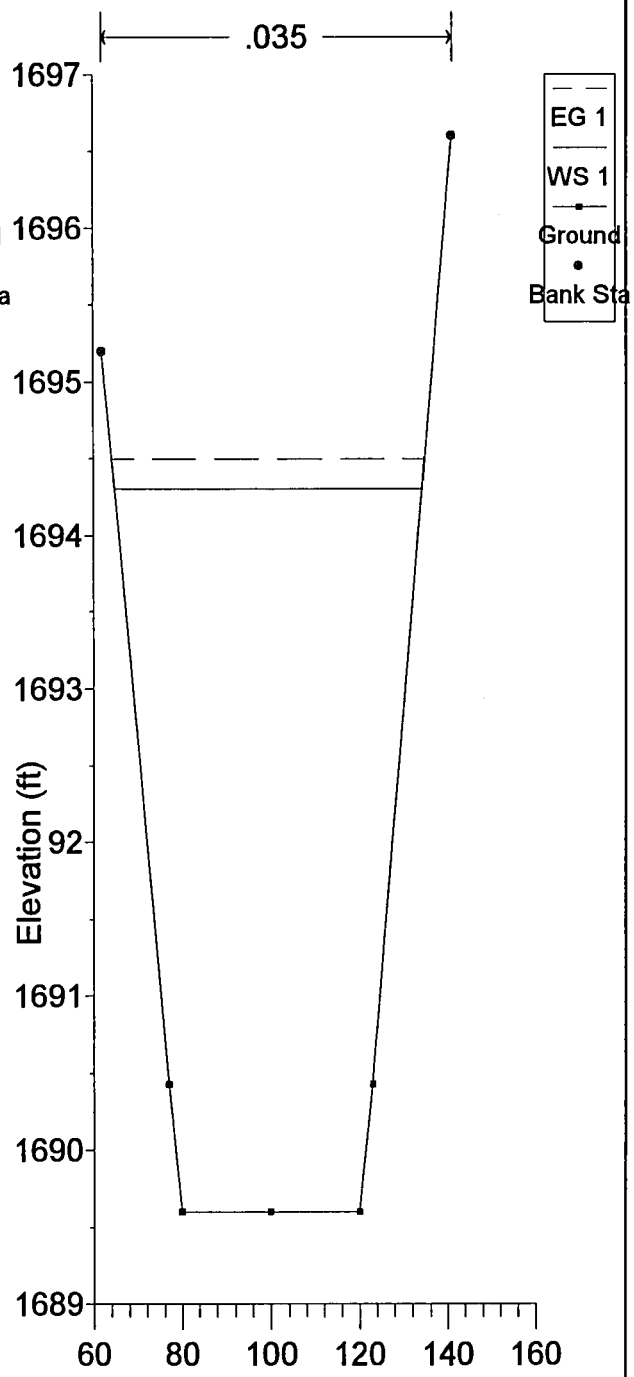
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 580 - TOP OF DROP

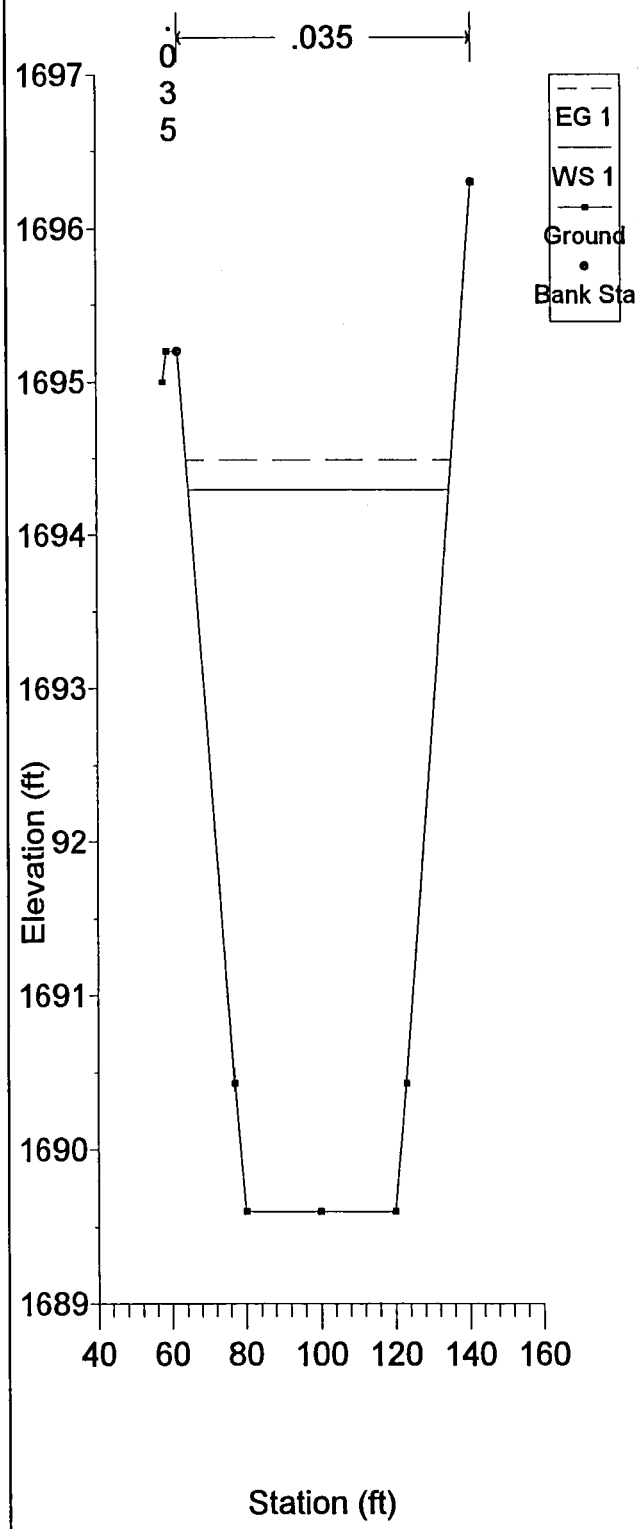


SAGUARO SHADOWS II Plan: Plan 06 8/20/98

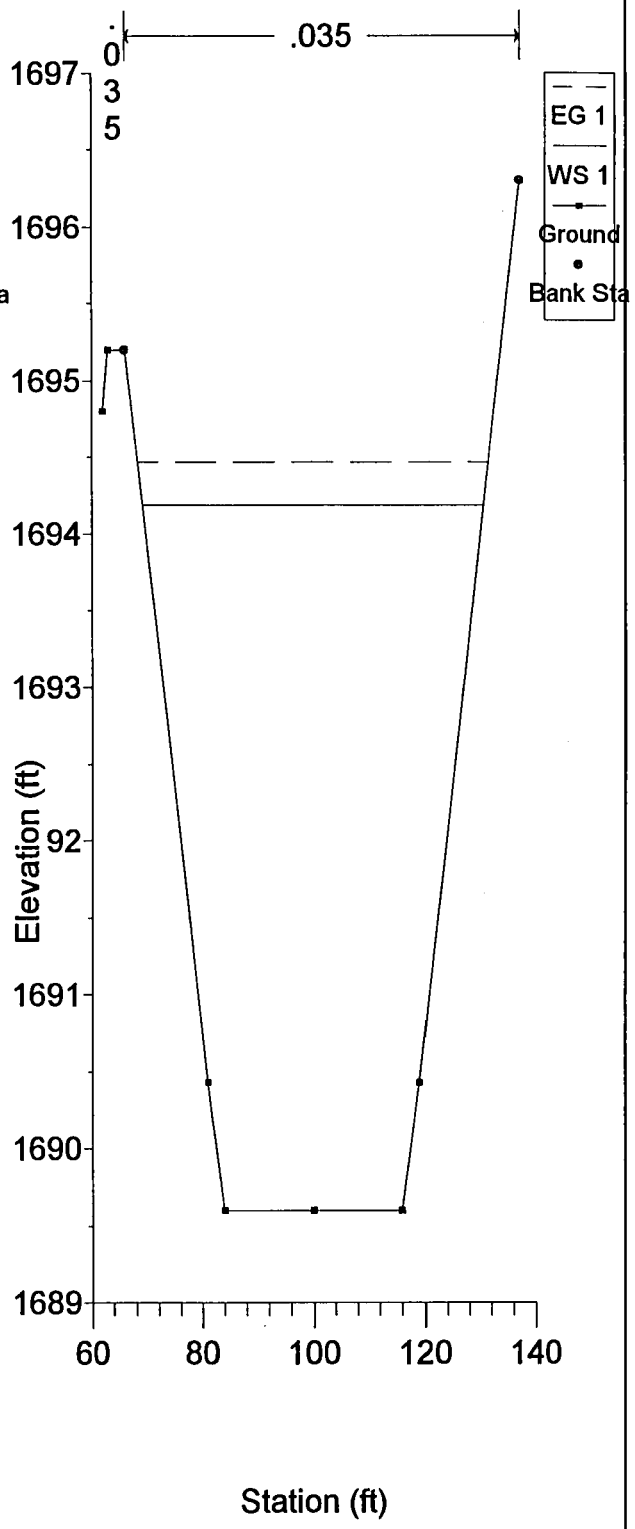
STA 579 - BOTTOM OF DROP



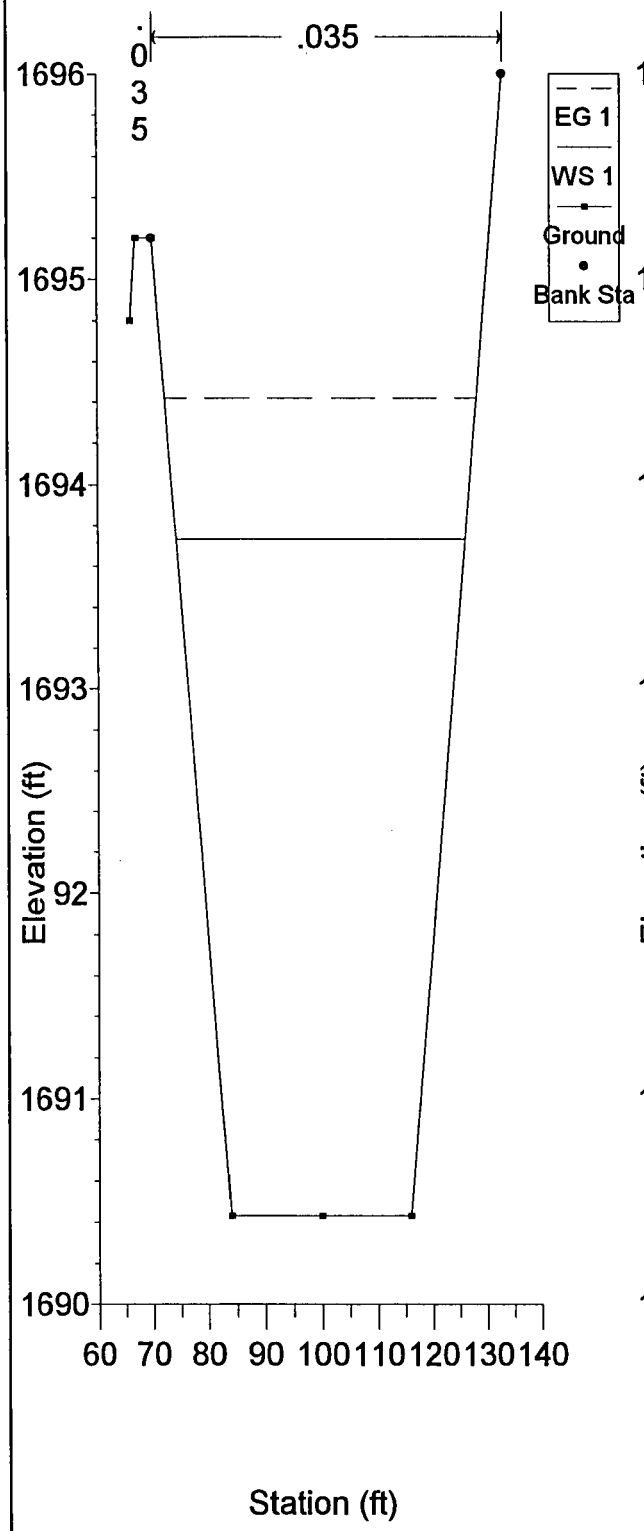
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 569 - BOTTOM OF PLUNGE POOL



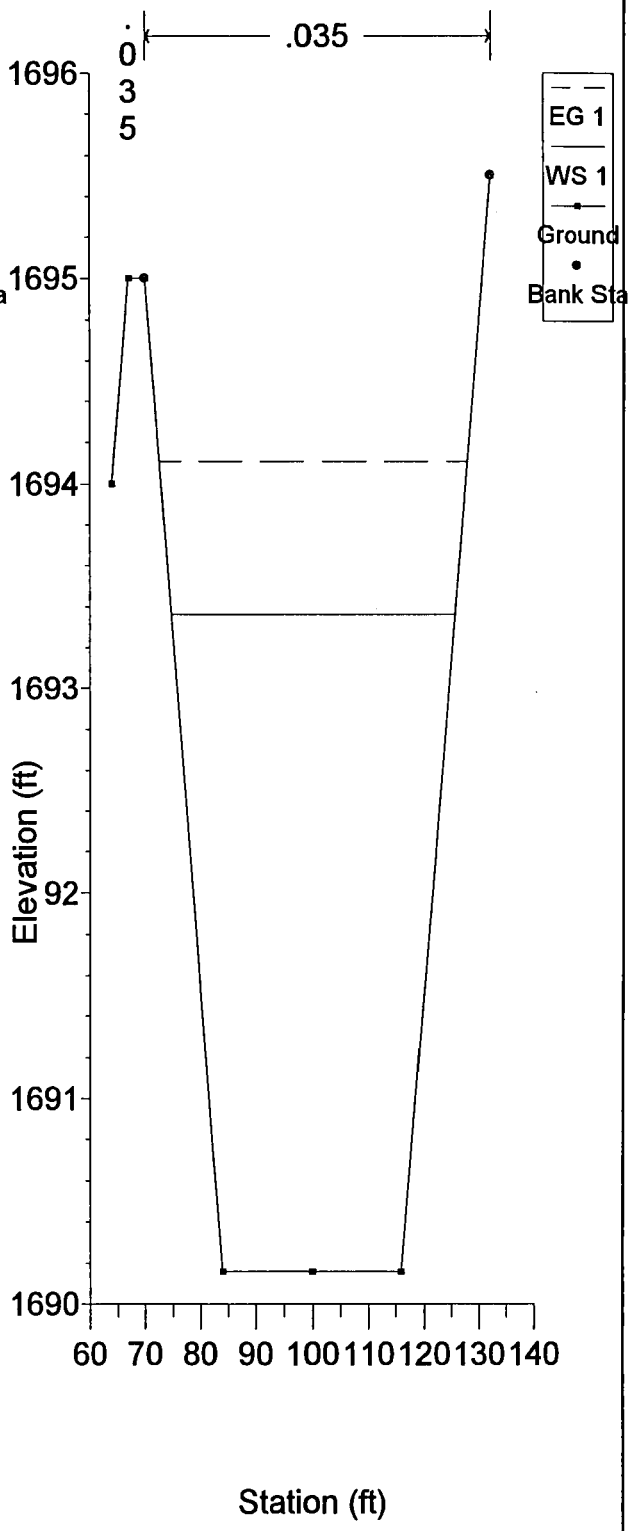
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 561 - BOTTOM OF PLUNGE POOL



SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 558 - OULET OF PLUNGE POOL

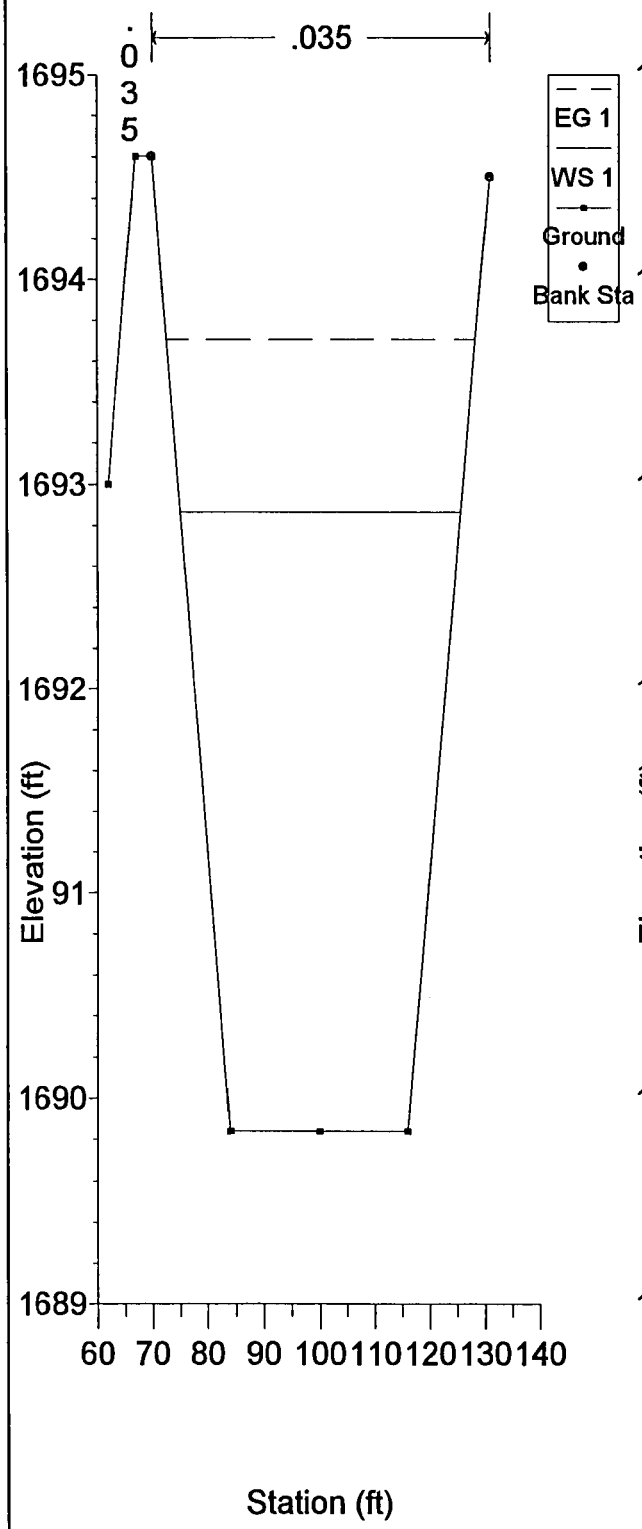


SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 516



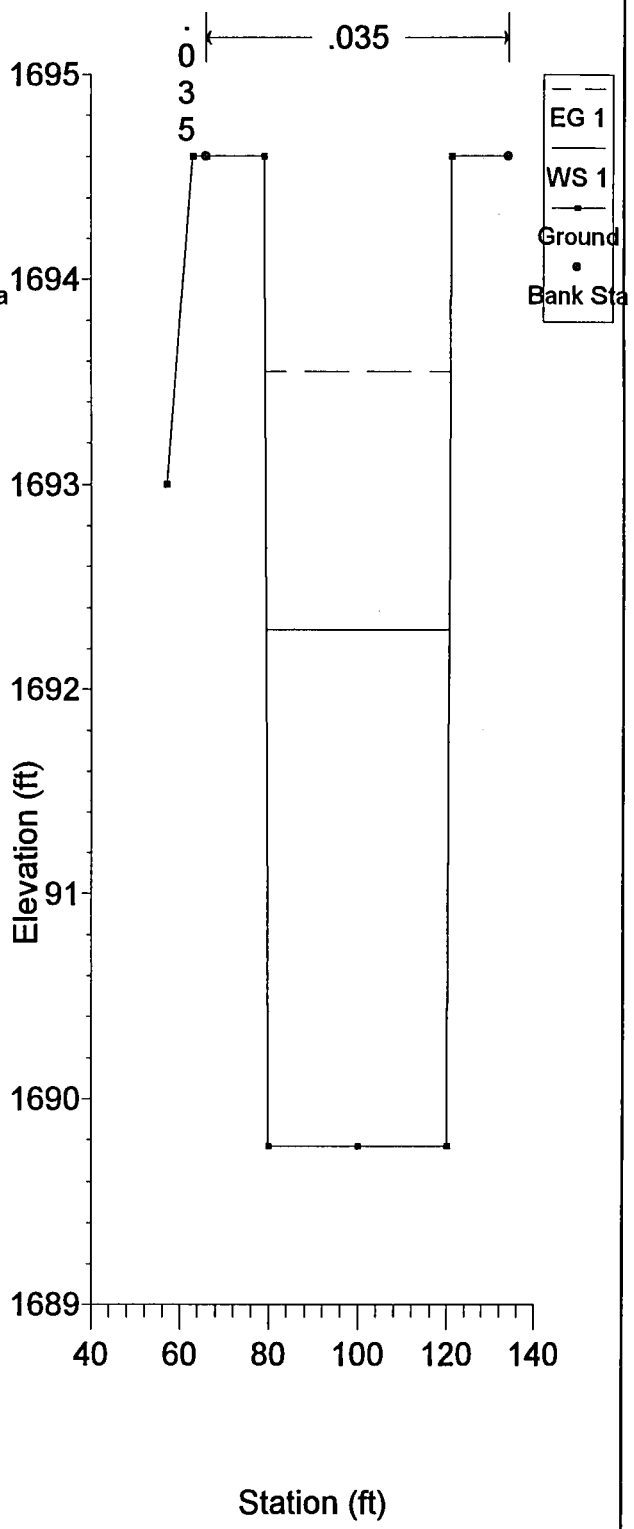
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 469

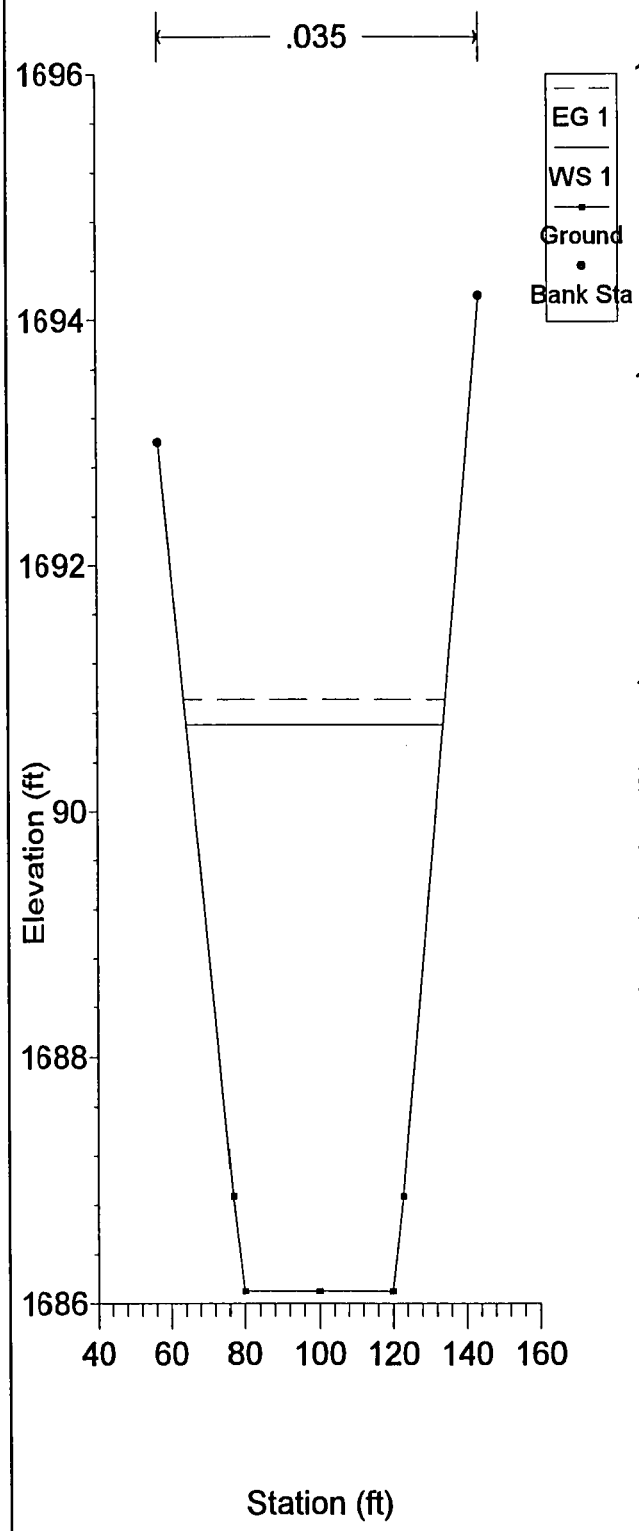


SAGUARO SHADOWS II Plan: Plan 06 8/20/98

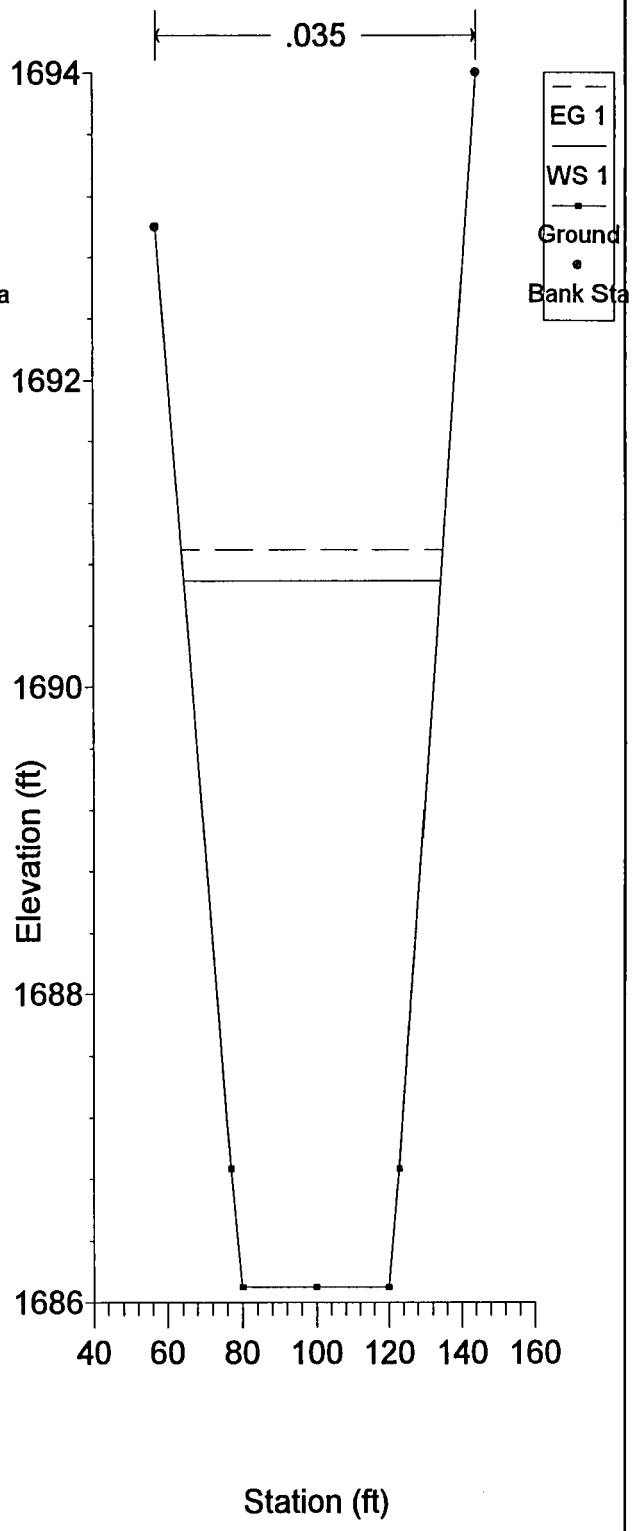
STA 459 - TOP OF DROP



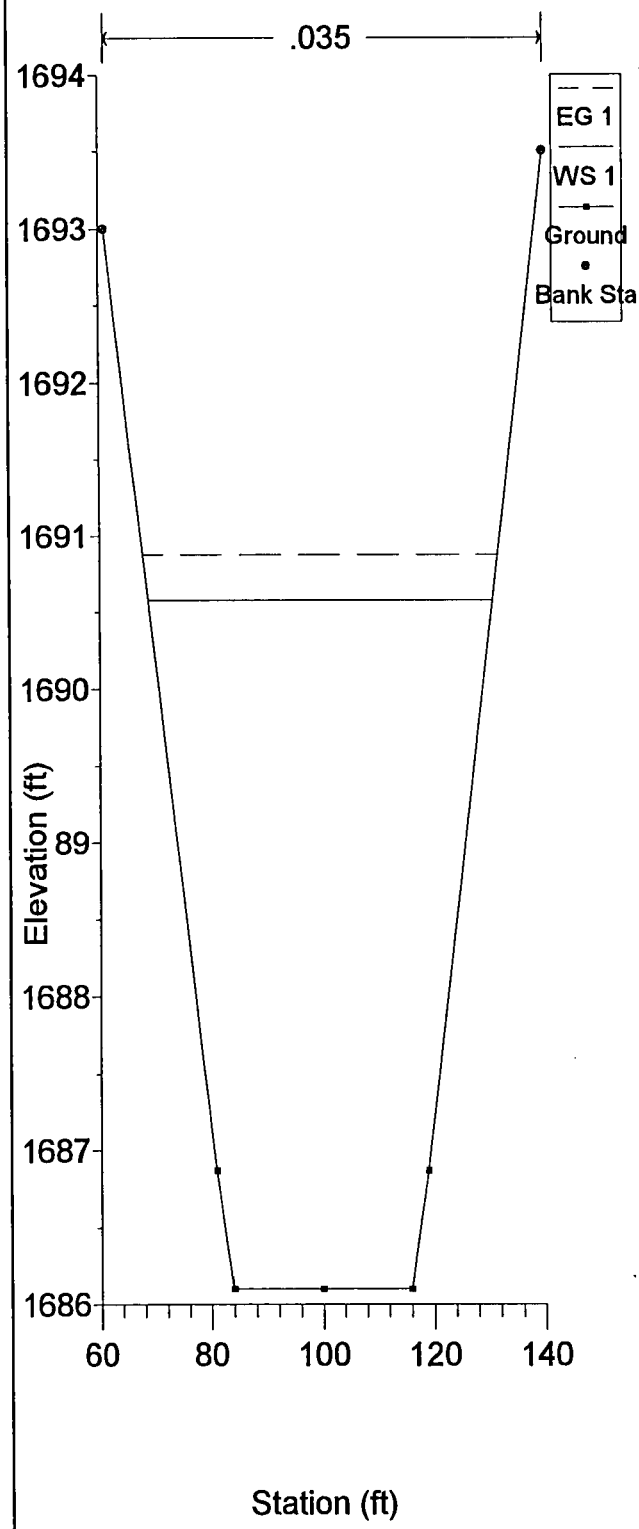
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 458 - BOTTOM OF DROP



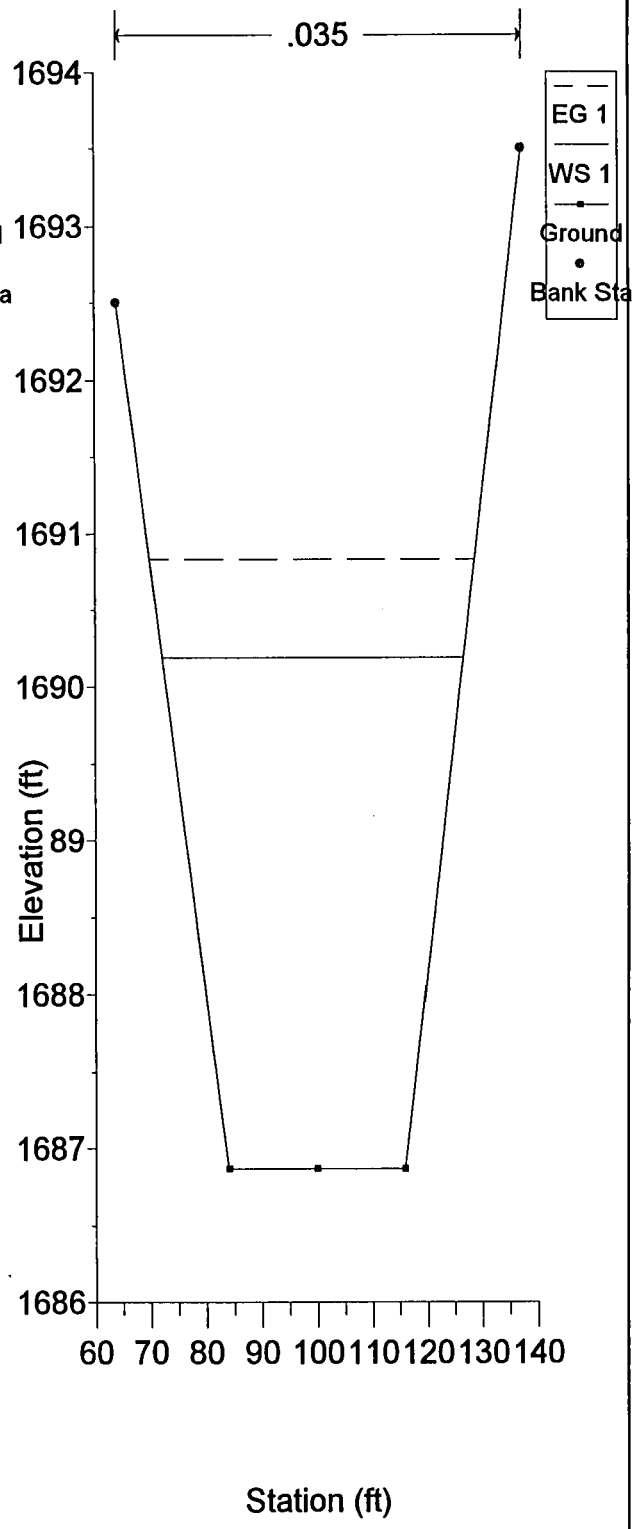
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 448 - BOTTOM OF PLUNGE POOL



SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 440 - BOTTOM OF PLUNGE POOL

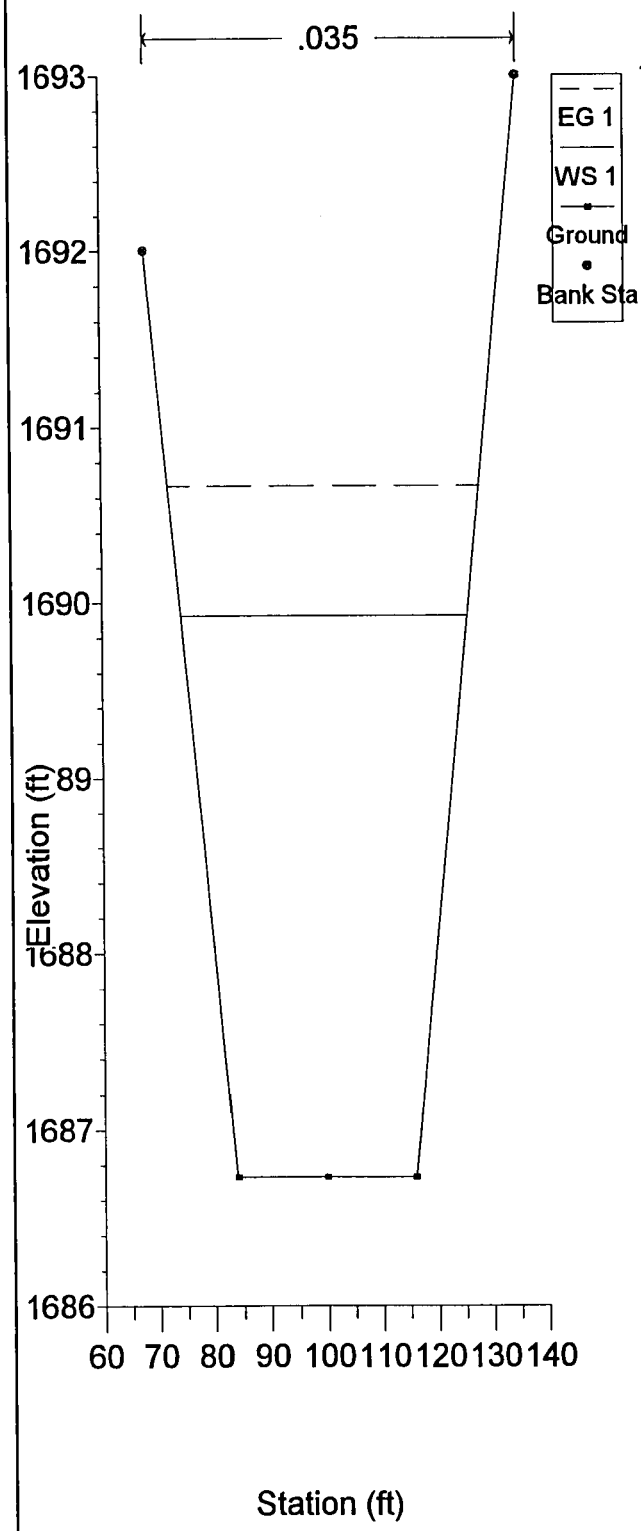


SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 437 - OUTLET OF PLUNGE POOL



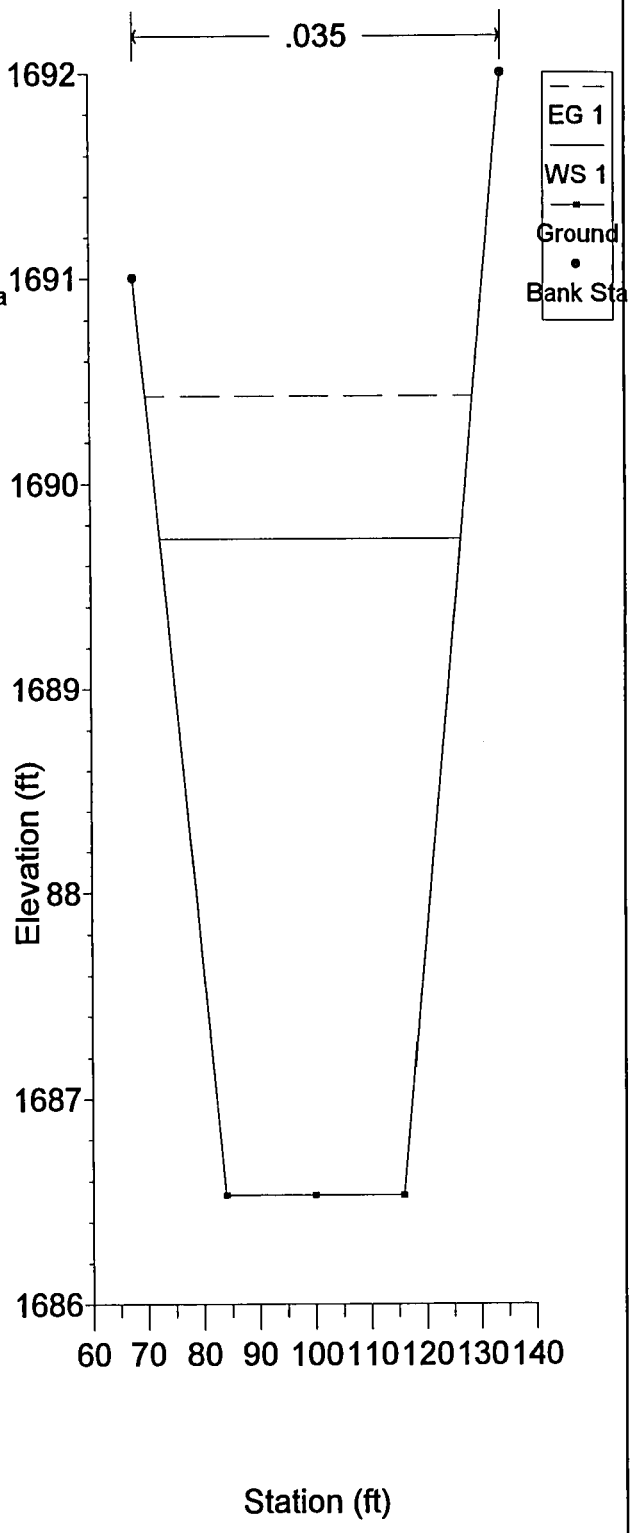
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 415



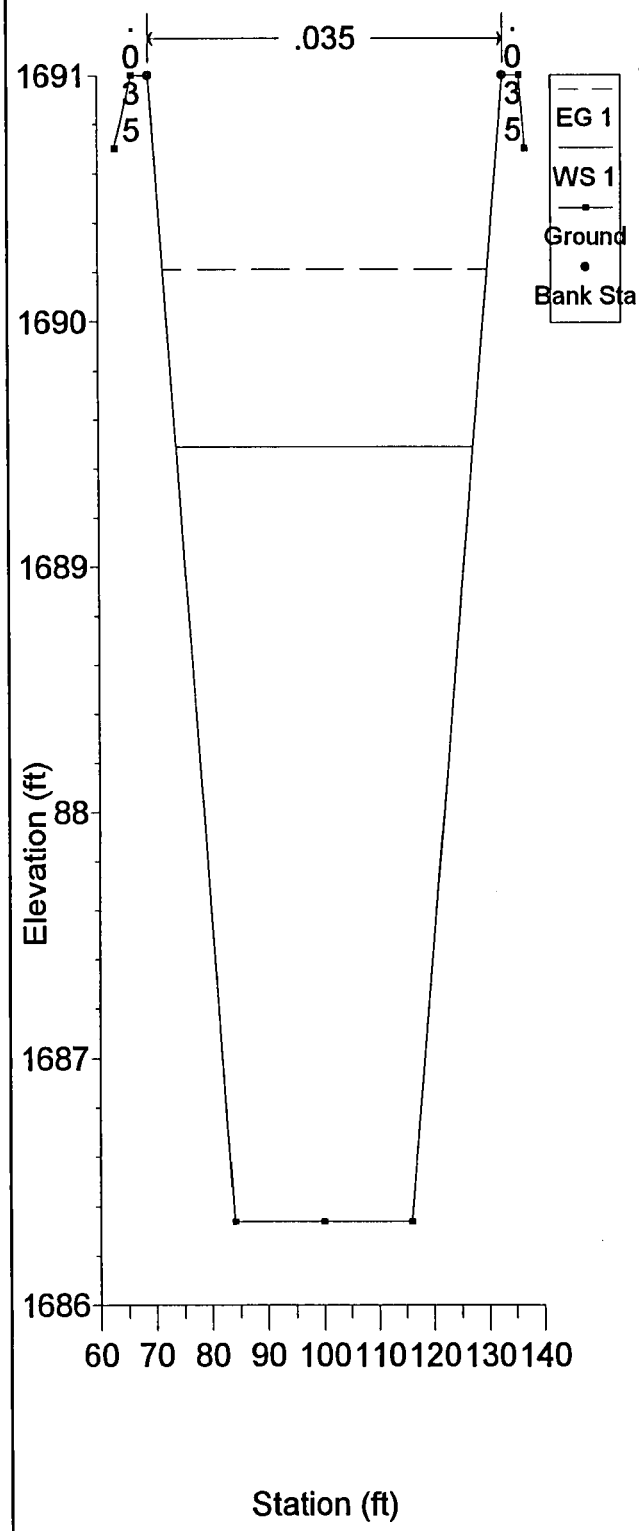
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 385



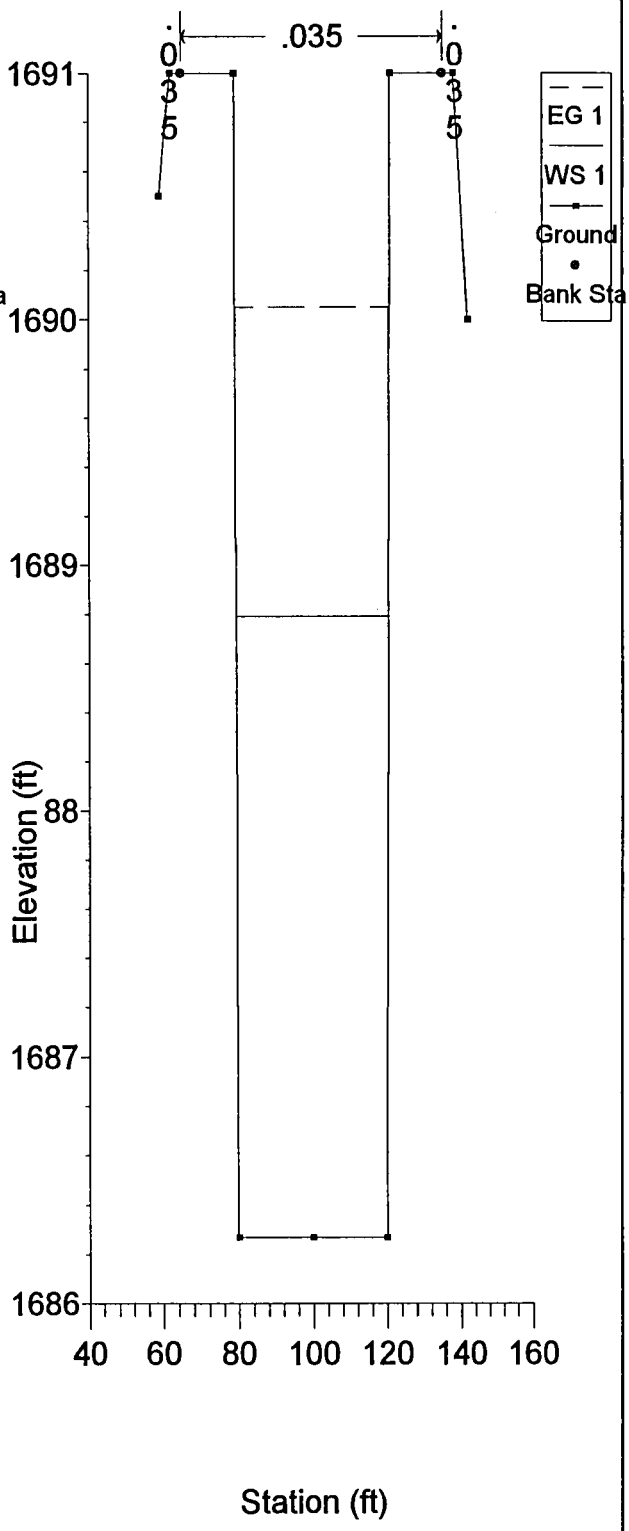
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 357

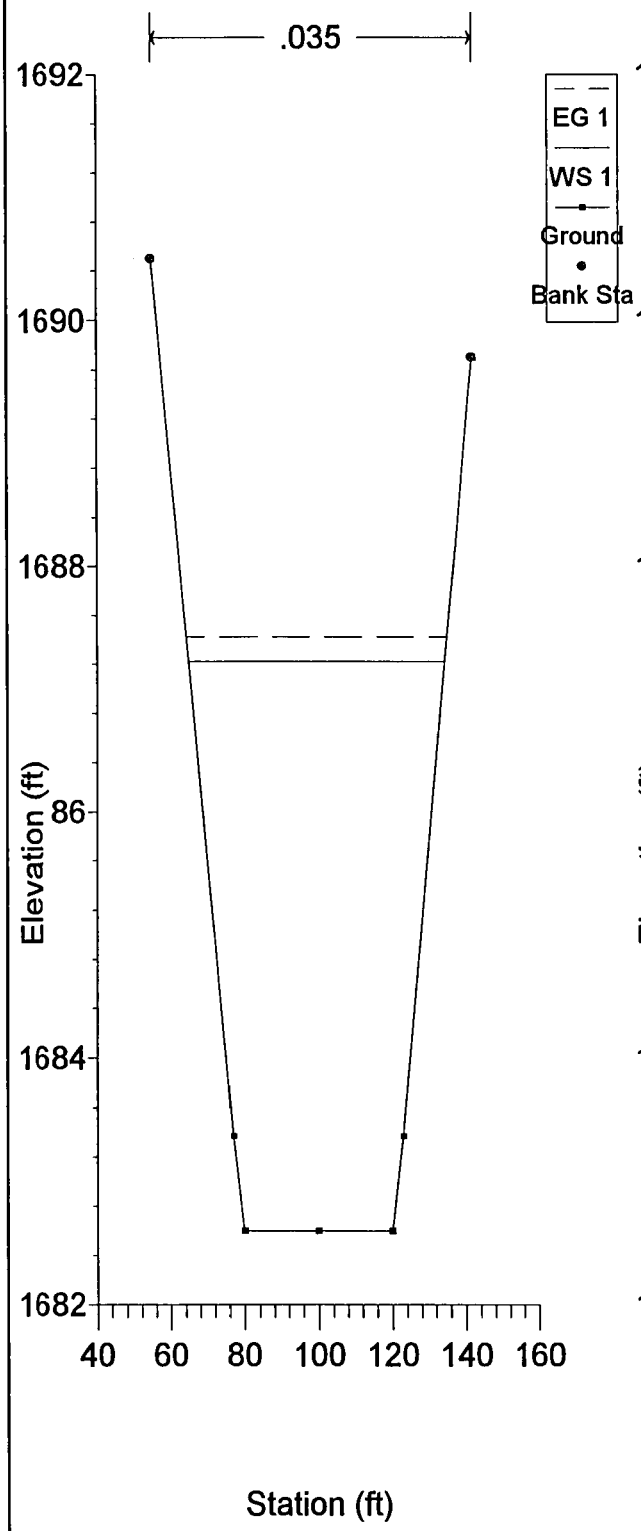


SAGUARO SHADOWS II Plan: Plan 06 8/20/98

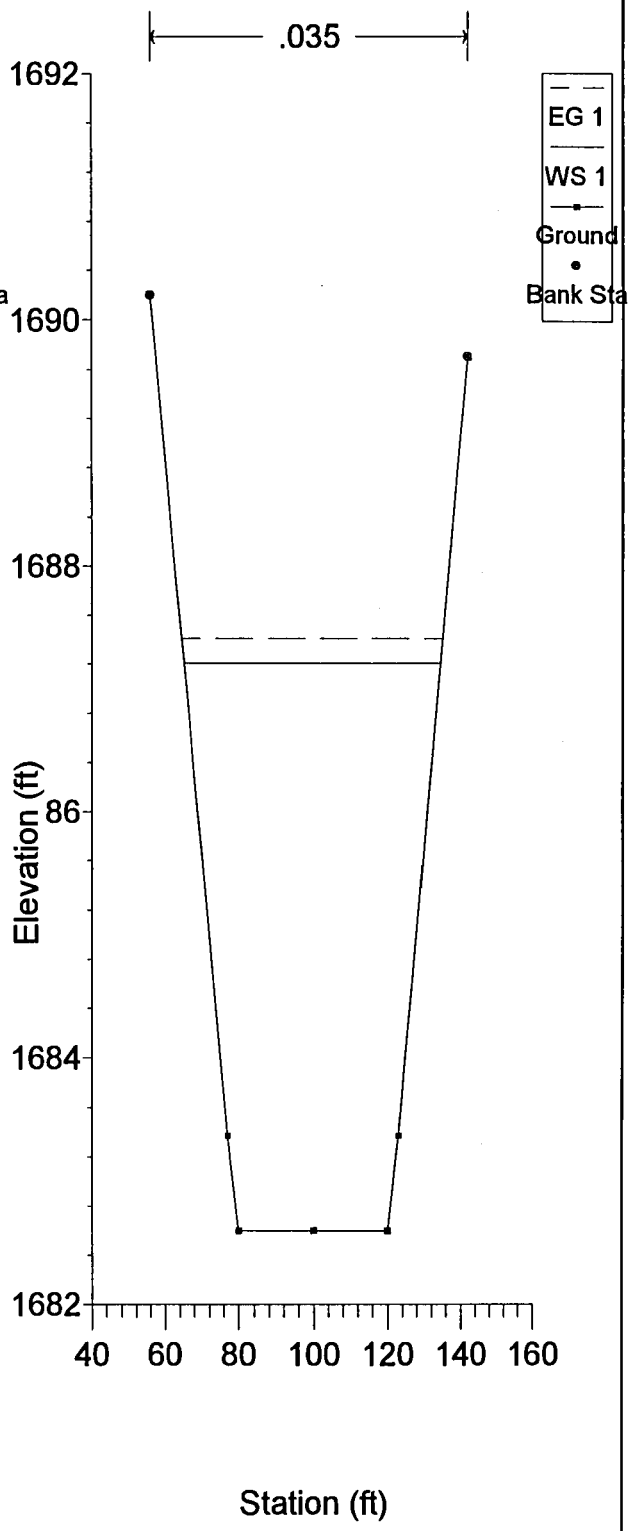
STA 347 - TOP OF DROP



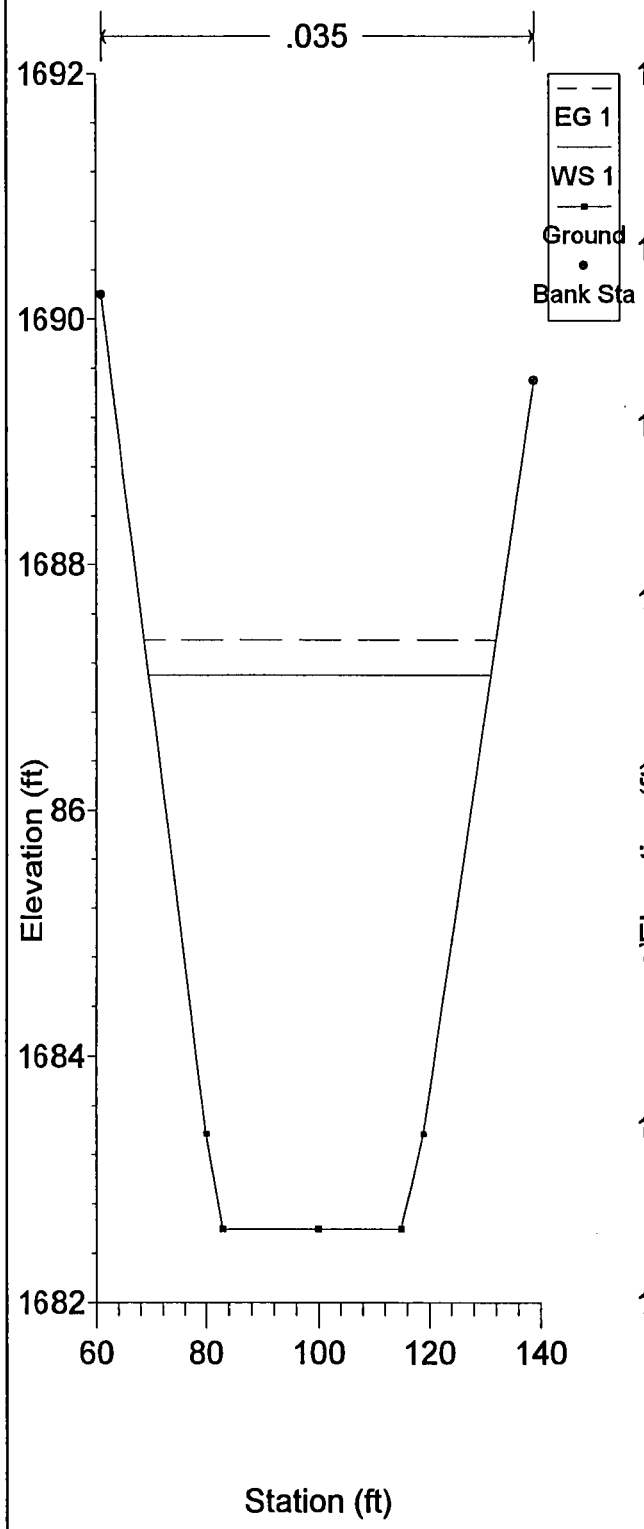
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 346 - BOTTOM OF DROP



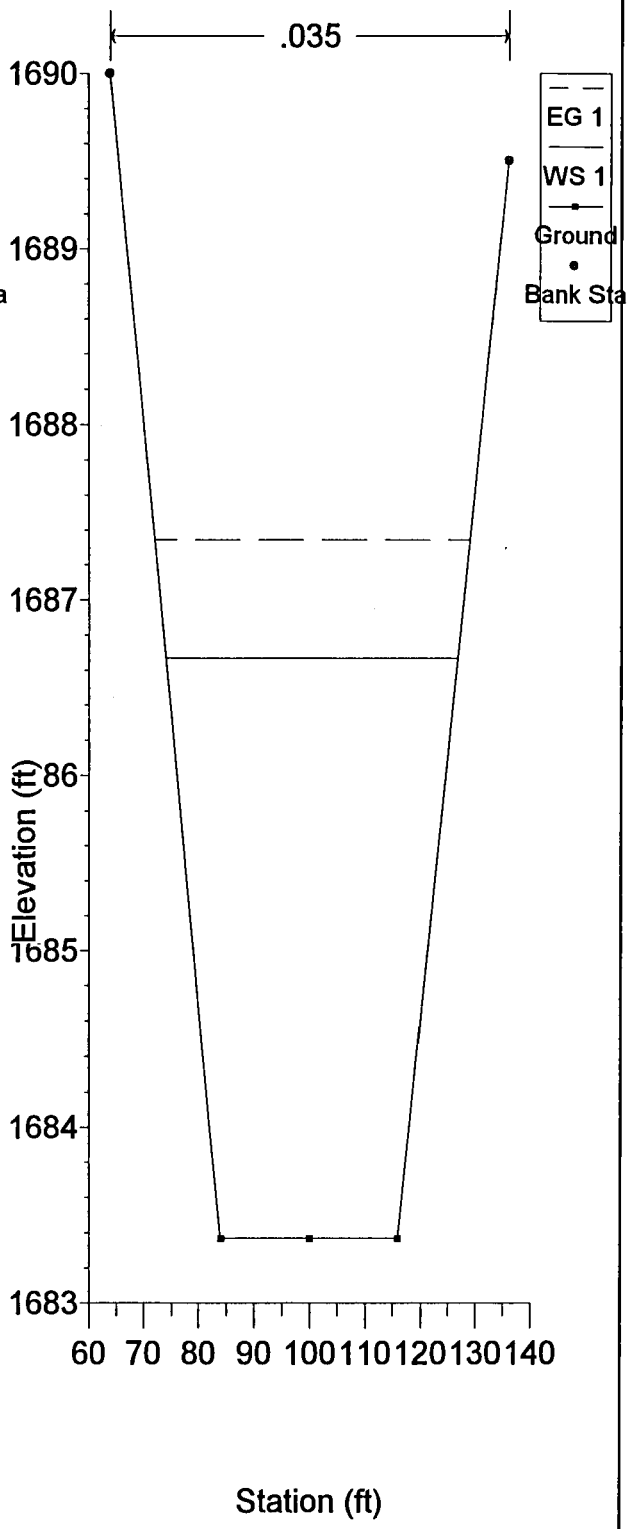
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 336 - BOTTOM OF PLUNGE POOL



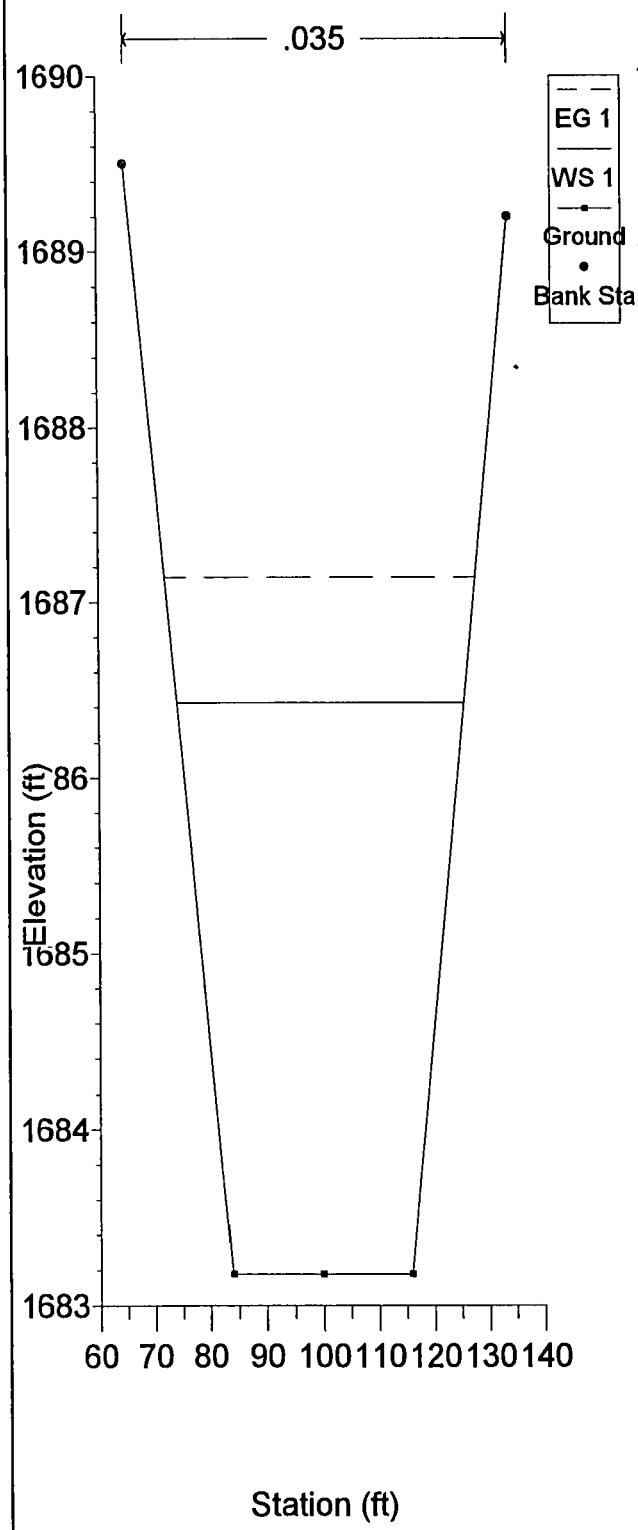
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 328 - BOTTOM OF PLUNGE POOL



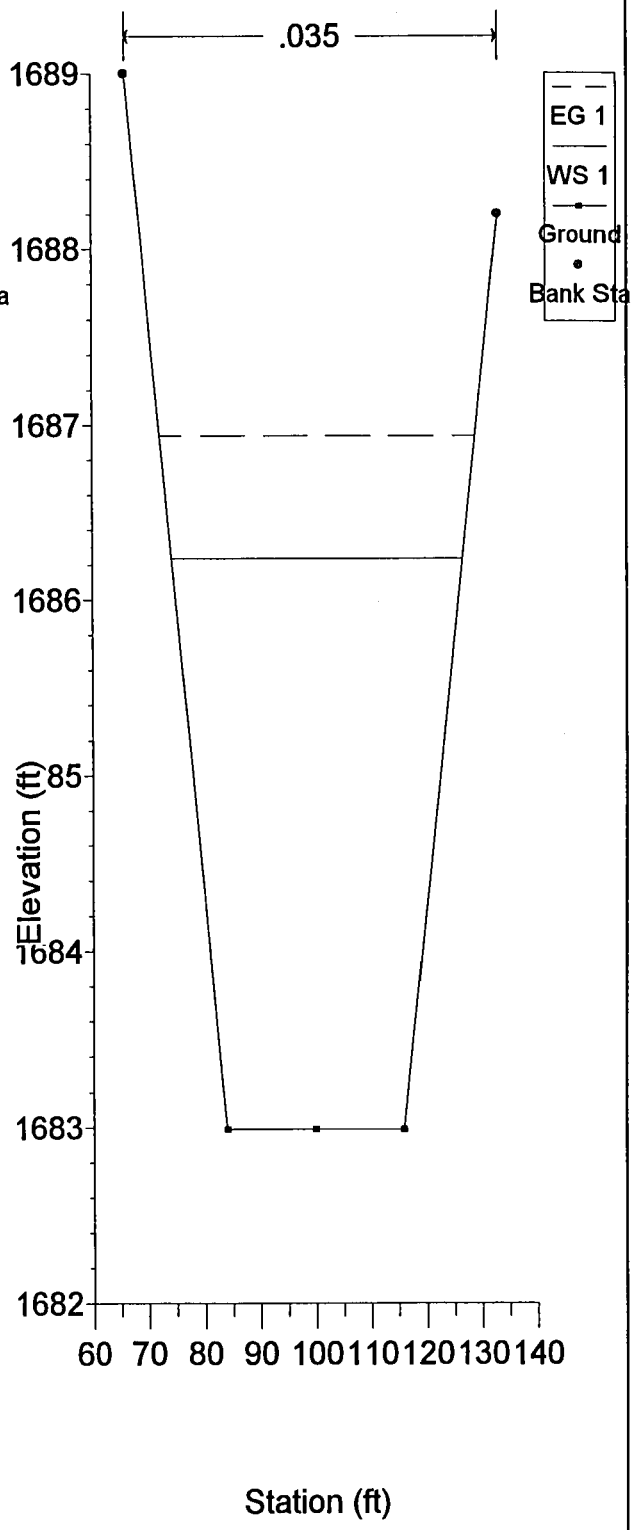
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 325 OUTLET OF PLUNGE POOL



SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 297

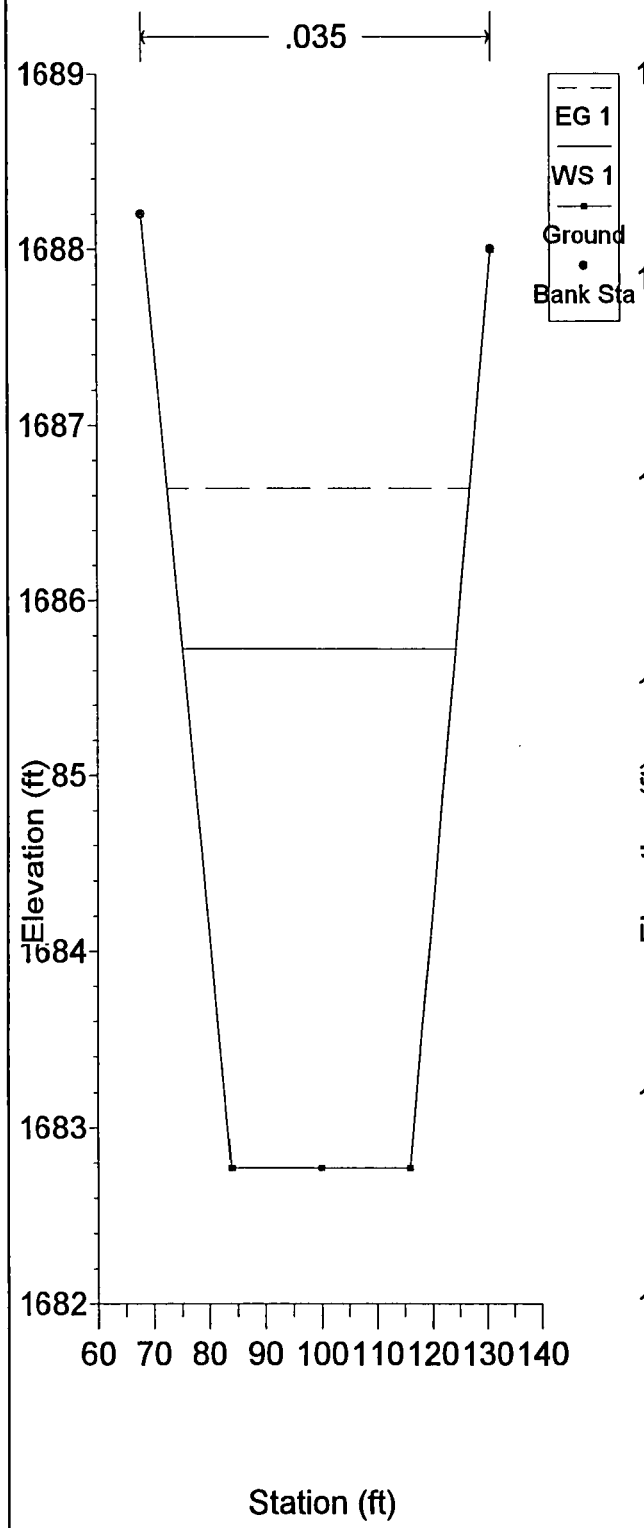


SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 269



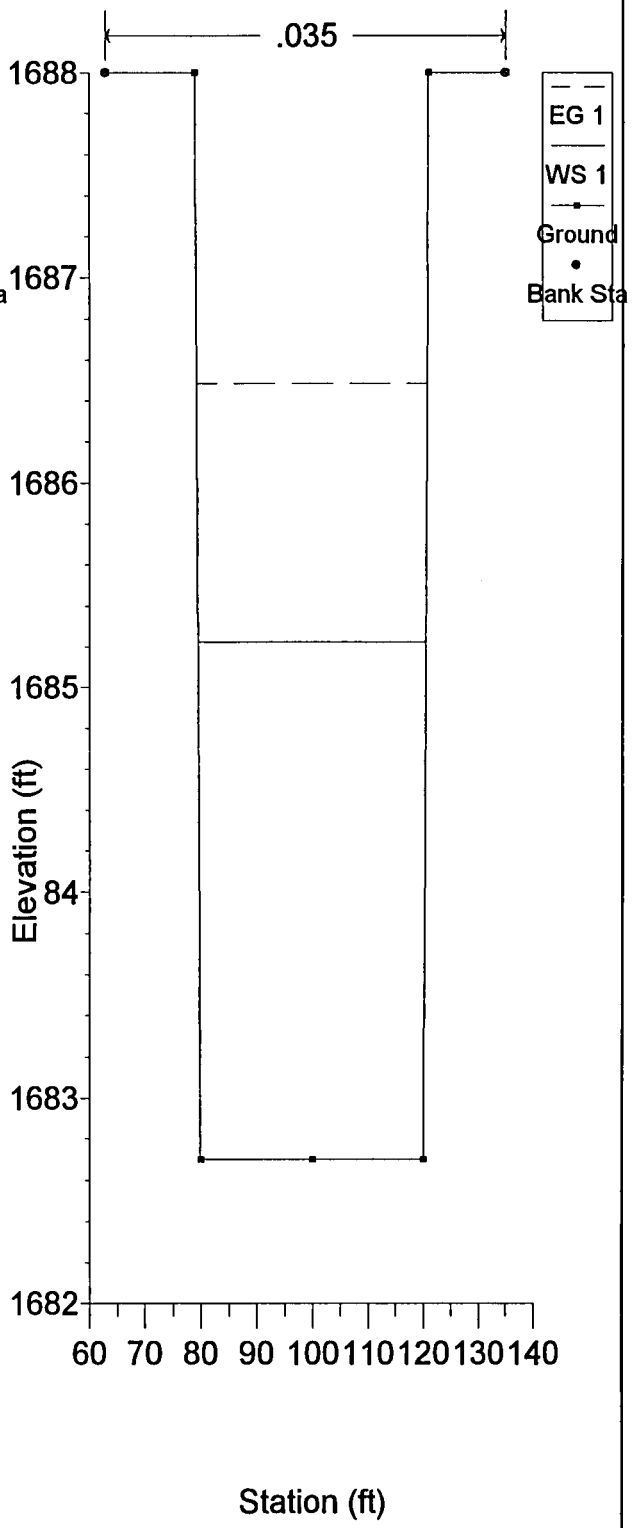
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 236



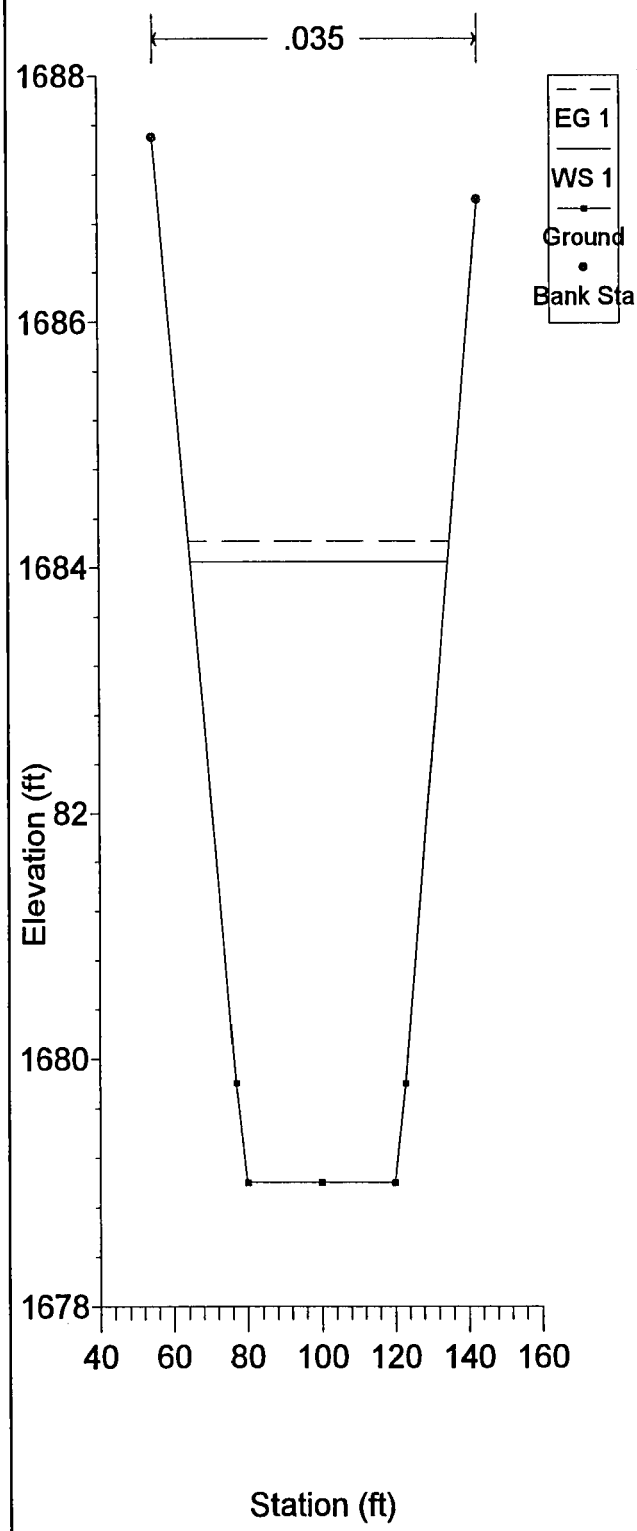
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 226 - TOP OF DROP



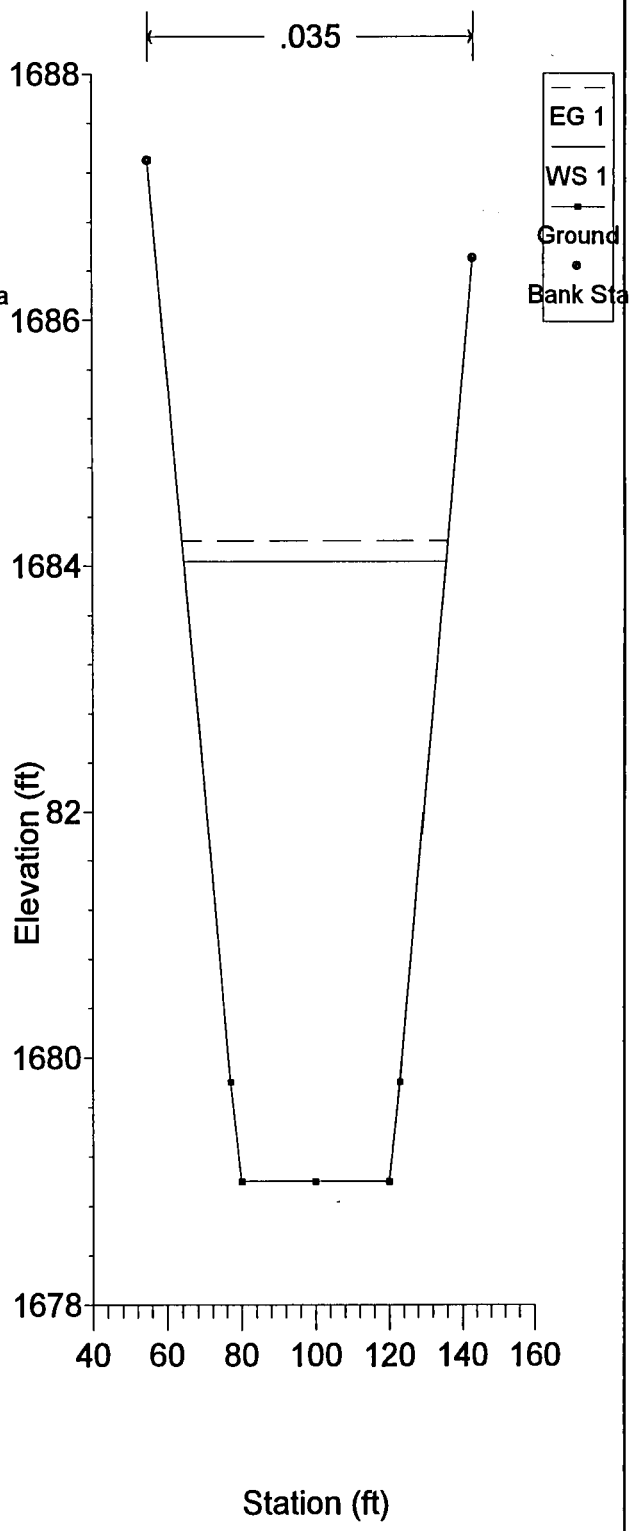
SAGUARO SHADOWS II Plan: Plan 06 8/20/98

STA 225 - BOTTOM OF DROP

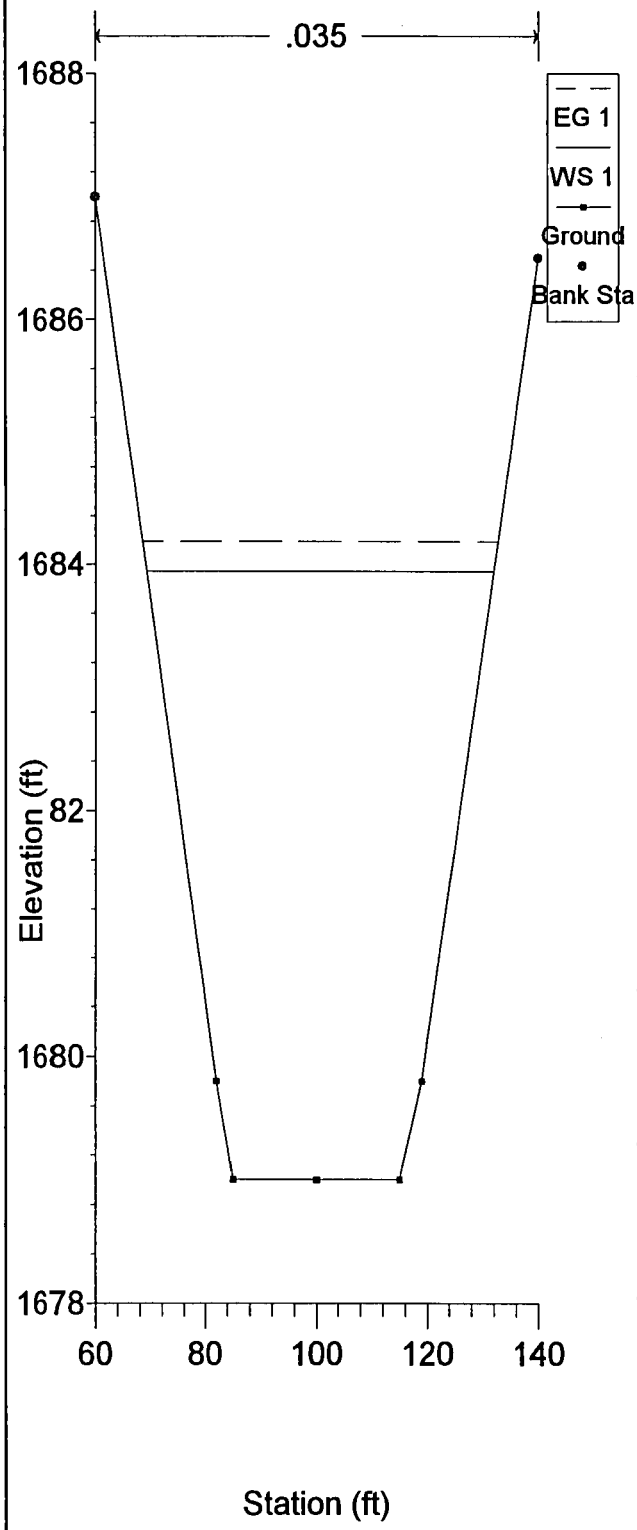


SAGUARO SHADOWS II Plan: Plan 06 8/20/98

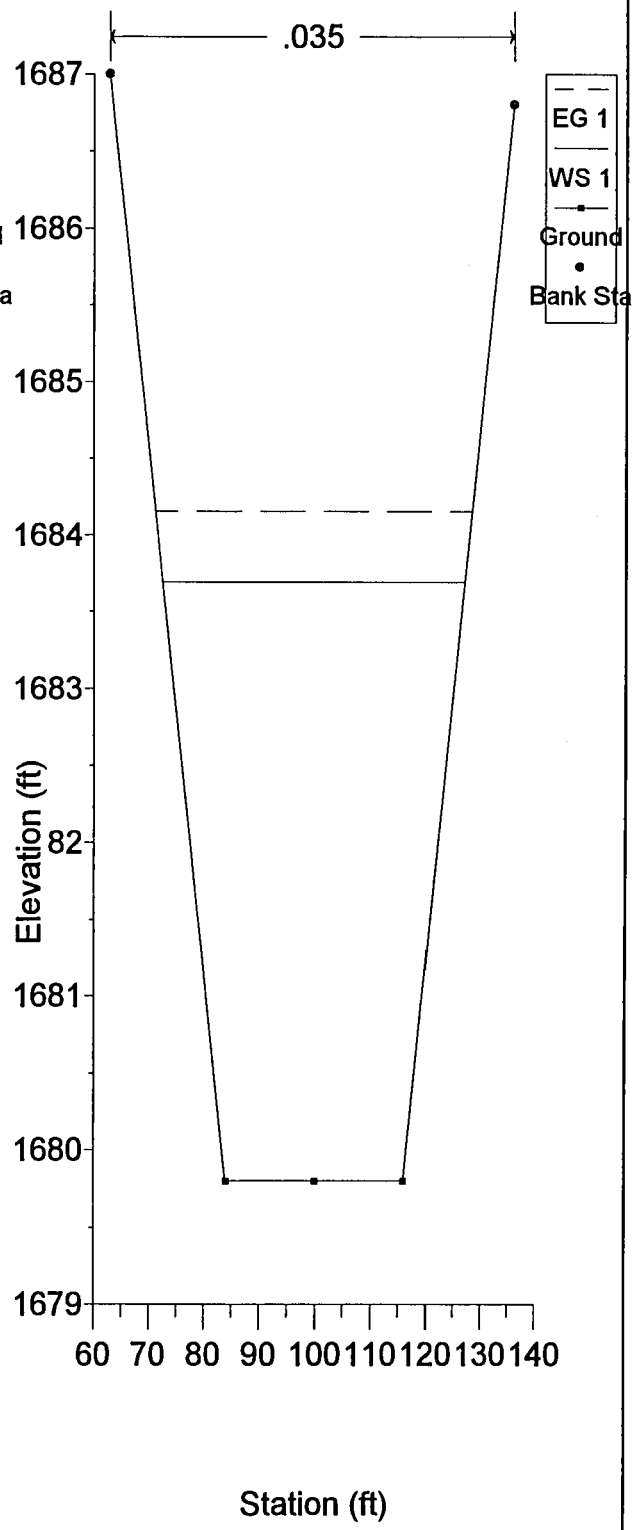
STA 215 - BOTTOM OF PLUNGE POOL



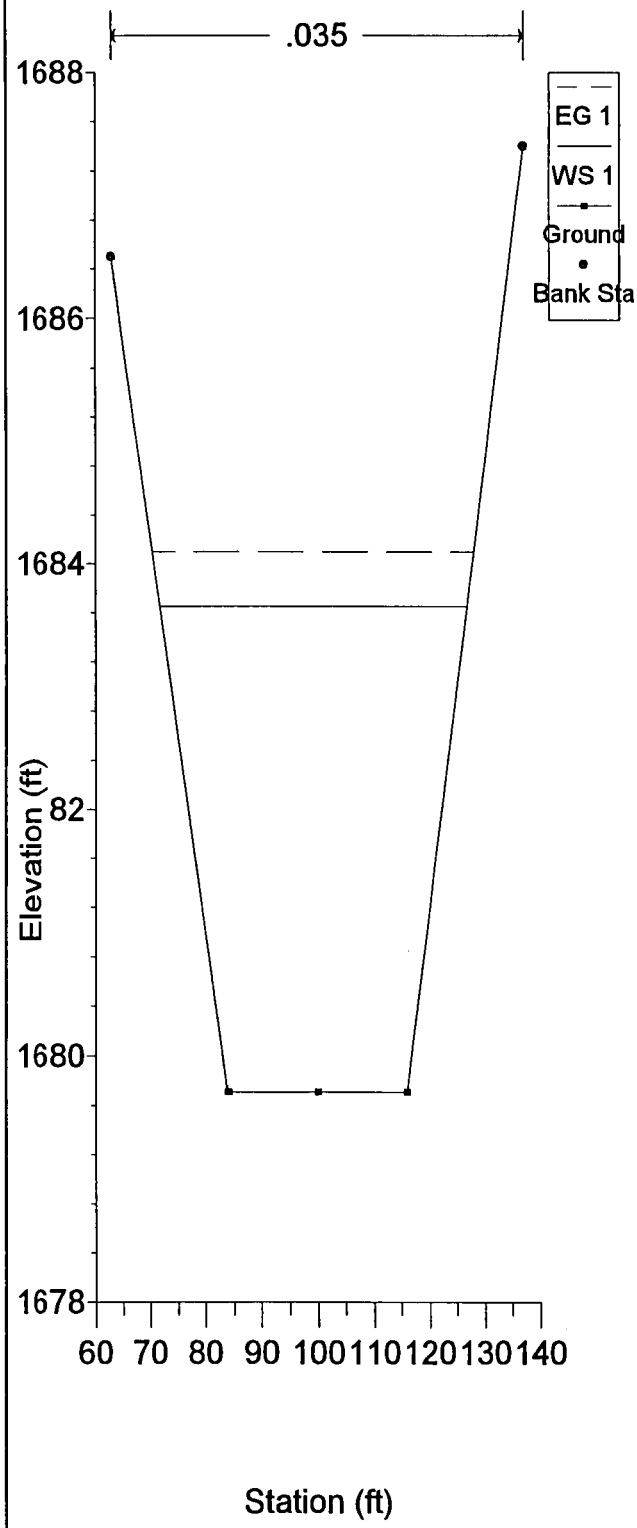
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 207 - BOTTOM OF PLUNGE POOL



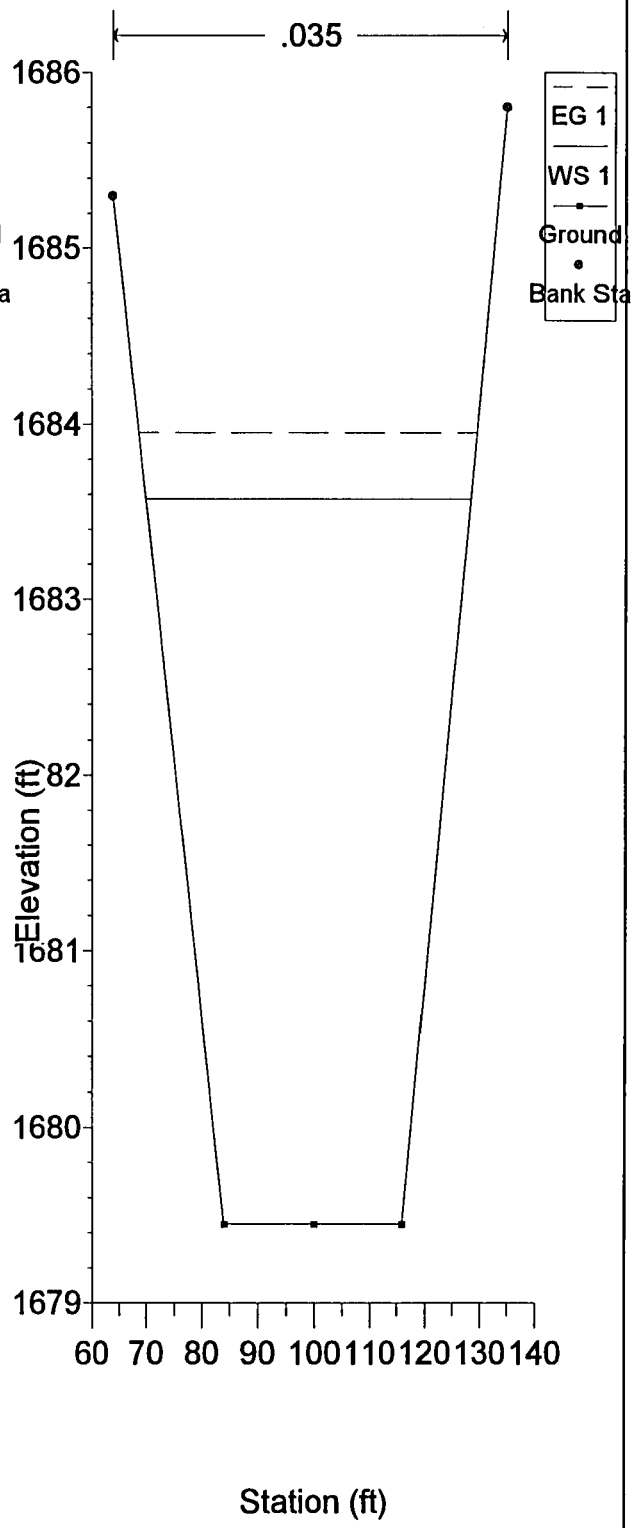
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 204 - OUTLET OF STILLING BASIN



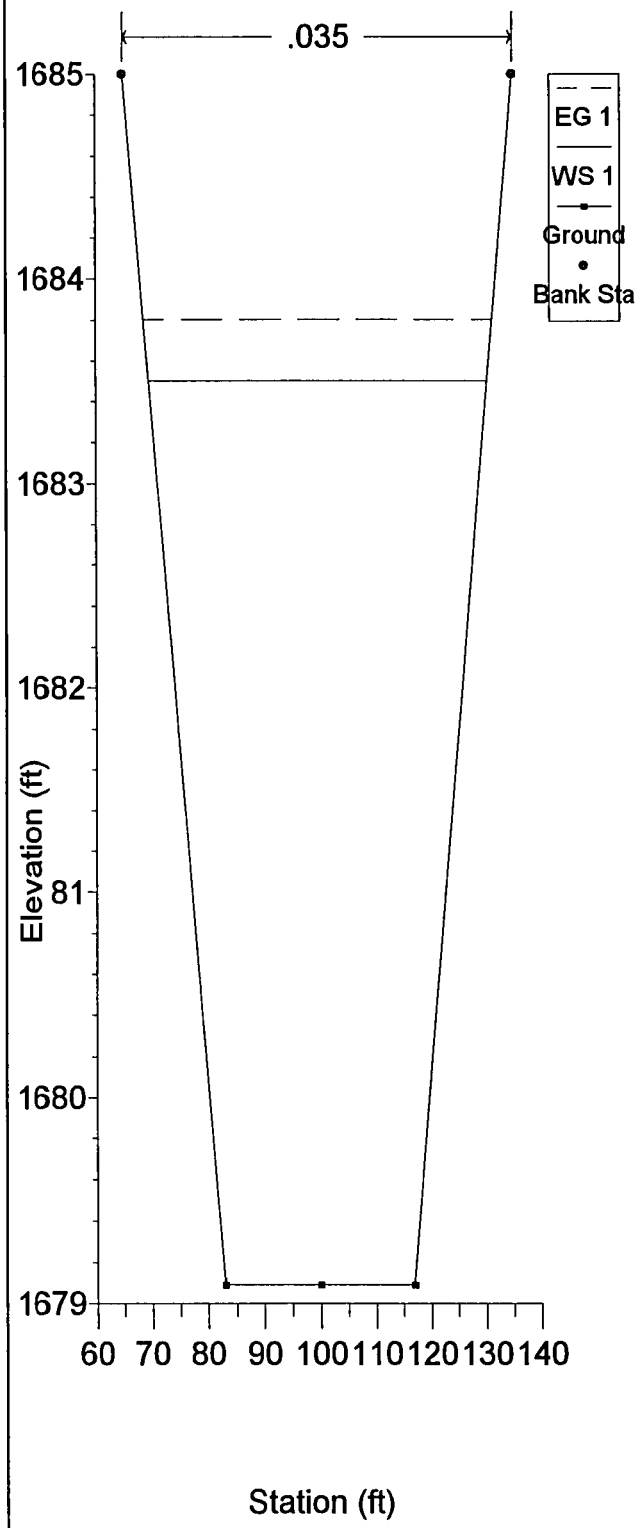
SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 190



SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 152



SAGUARO SHADOWS II Plan: Plan 06 8/20/98
STA 100 - ENTRANCE TO CULVERT



Errors Warnings and Notes for Plan : Plan 06

Summary for Profiles:1
Reach: channel Riv Sta: 207 Profile: 1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Reach: channel Riv Sta: 226 Profile: 1
Warning - The energy equation could not be balanced within the specified number of iterations.
The program used critical depth for the water surface and continued on with the
calculations.
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the
need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous
cross section. This may indicate the need for additional cross sections.
Warning - During the standard step iterations, when the assumed water surface was set equal
to critical depth, the calculated water surface came back below critical depth. This
indicates that there is not a valid subcritical answer. The program defaulted to critical
depth.
Reach: channel Riv Sta: 328 Profile: 1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Reach: channel Riv Sta: 347 Profile: 1
Warning - The energy equation could not be balanced within the specified number of iterations.
The program used critical depth for the water surface and continued on with the
calculations.
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the
need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous
cross section. This may indicate the need for additional cross sections.
Warning - During the standard step iterations, when the assumed water surface was set equal
to critical depth, the calculated water surface came back below critical depth. This
indicates that there is not a valid subcritical answer. The program defaulted to critical
depth.
Reach: channel Riv Sta: 357 Profile: 1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the
need for additional cross sections.
Reach: channel Riv Sta: 440 Profile: 1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)

Errors Warnings and Notes for Plan : Plan 06 (continued)

is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Reach: channel Riv Sta: 459 Profile: 1
Warning - The energy equation could not be balanced within the specified number of iterations.
The program used critical depth for the water surface and continued on with the
calculations.
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the
need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous
cross section. This may indicate the need for additional cross sections.
Warning - During the standard step iterations, when the assumed water surface was set equal
to critical depth, the calculated water surface came back below critical depth. This
indicates that there is not a valid subcritical answer. The program defaulted to critical
depth.
Reach: channel Riv Sta: 561 Profile: 1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Reach: channel Riv Sta: 580 Profile: 1
Warning - The energy equation could not be balanced within the specified number of iterations.
The program used critical depth for the water surface and continued on with the
calculations.
Warning - Divided flow computed for this cross-section.
Warning - The cross-section end points had to be extended vertically for the computed water
surface.
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the
need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance)
is less than 0.7 or greater than 1.4. This may indicate the need for additional cross
sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous
cross section. This may indicate the need for additional cross sections.
Warning - During the standard step iterations, when the assumed water surface was set equal
to critical depth, the calculated water surface came back below critical depth. This
indicates that there is not a valid subcritical answer. The program defaulted to critical
depth.
Reach: channel Riv Sta: 590 Profile: 1
Warning - Divided flow computed for this cross-section.
Warning - The cross-section end points had to be extended vertically for the computed water
surface.
Reach: channel Riv Sta: 618 Profile: 1
Warning - Divided flow computed for this cross-section.

Errors Warnings and Notes for Plan : Plan 06 (continued)

Warning - The cross-section end points had to be extended vertically for the computed water surface.
Reach: channel Riv Sta: 733 Profile: 1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

Drop Structure Calculations

DESIGN OF VERTICAL DROP WITH RIPRAP BASIN

(from Section 6 of Flood Control District of Maricopa County Hydraulics Manual)

Four (4) vertical drops each 2.9 ft will be used to reduce the channel slope from 2.65% to 0.67%.

Approach Conditions: The approach channel is trapezoidal in cross-section with:

- bed width = B_o = 32 ft
- side slopes are 3 horizontal to 1 vertical
- design discharge = Q = 920 cfs
- depth of flow = y_o = 3.3 ft
- the average velocity = V_o = 6.80 ft/s
- the specific energy in the approach channel is

$$E_o = y_o + \frac{V_o^2}{2g} = 3.3 + \frac{(6.8)^2}{2(32.2)} = 4.0 \text{ ft}$$

Weir Crest: Make the length of the weir = B = 40 ft.

The head on the weir required to pass the design flow is:

$$H = \left[\frac{Q}{5.67\,B}\right]^{0.67}$$

$$H = \left[\frac{920}{5.67(40)}\right]^{0.67} = 2.56 \text{ ft.}$$

The height of the weir crest is:

$$P = E_o - H = 4.0 - 2.56 = 1.44 \text{ ft.}$$

Weir crest will be placed at bed level, ie, P = 0.

Need to find drop height D and rock size d_{50} such that Z is 2.9 ft.

Desired drop $- H_d = D - 0.67\, d_s$ (Eq. 6.13)

$Z = D - P - 0.67 d_s$ since $P = 0 \Rightarrow Z = H_d$

Relationship between d_{50}, D, H, and d_s is given in Figure 6.13 (see attached).

Check drop structure design to see if Eq. 6.13 is satisfied.

$D = 3.67$ ft $\quad d_{50} = 8$ in $= 0.67$ ft

$\frac{D}{d_{50}} = \frac{3.67}{0.67} = 5.5 \Rightarrow$ use chart for $D/d_{50} = 6$

$\frac{H}{D} = \frac{2.56}{3.67} = 0.70$

Assume $d_2 = 4.1$ ft $\quad \frac{d_2}{D} = \frac{4.1}{3.67} = 1.1$

Find $\frac{d_s}{D}$ from chart : $\frac{d_s}{D} = 0.33 \quad d_s = 1.21 \quad 0.67 d_s = 0.81$

$d_s = Y_2 + 0.67 d_s = 3.3 + 0.81 = 4.11$ <u>Ok</u>

$Z = D - 0.67 d_s = 3.67 - 0.81 = 2.86$ ft <u>Ok</u>

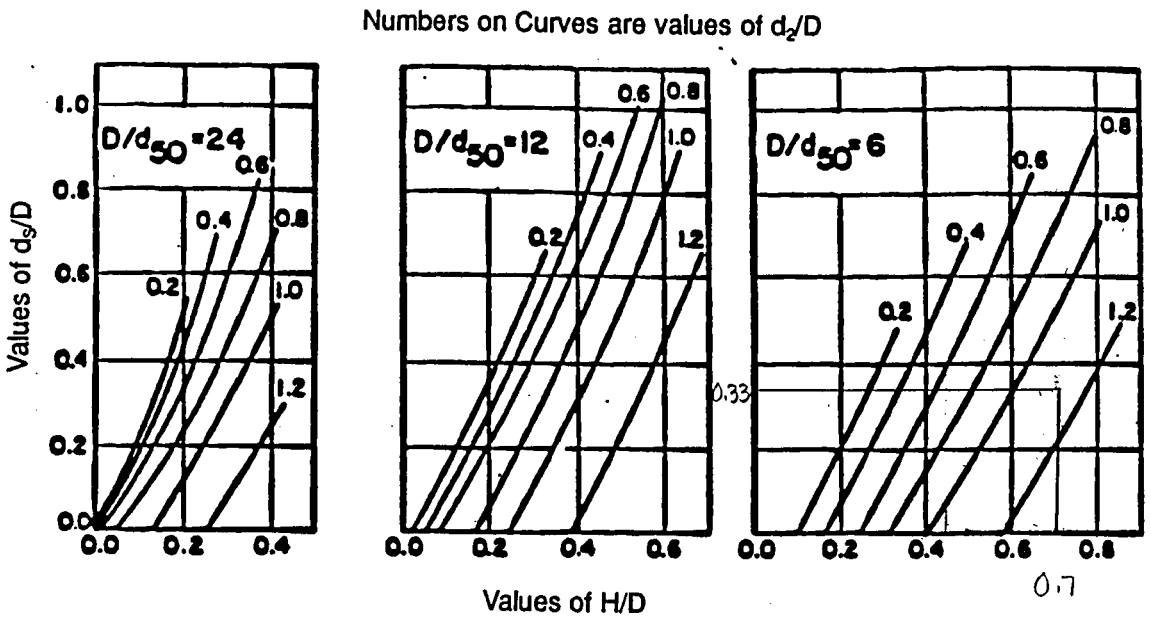
D_r = rock depth $= 1.5 d_s = 1.5(1.21) = 1.8$ ft

$D_r = 1.75\, d_{50}$ MIN $= 1.75(.67) = 1.2$ ft

$\Rightarrow$ use $\underline{d_{50} = 8 \text{ in}}$ $\underline{D_r = 2 \text{ ft}}$

$L_b = 4(H) + 0.25D = 4(2.56) + 0.25(3.67) = 11$ ft <u>use 20ft</u>

Extracted from FCDMC Hydraulics Manual



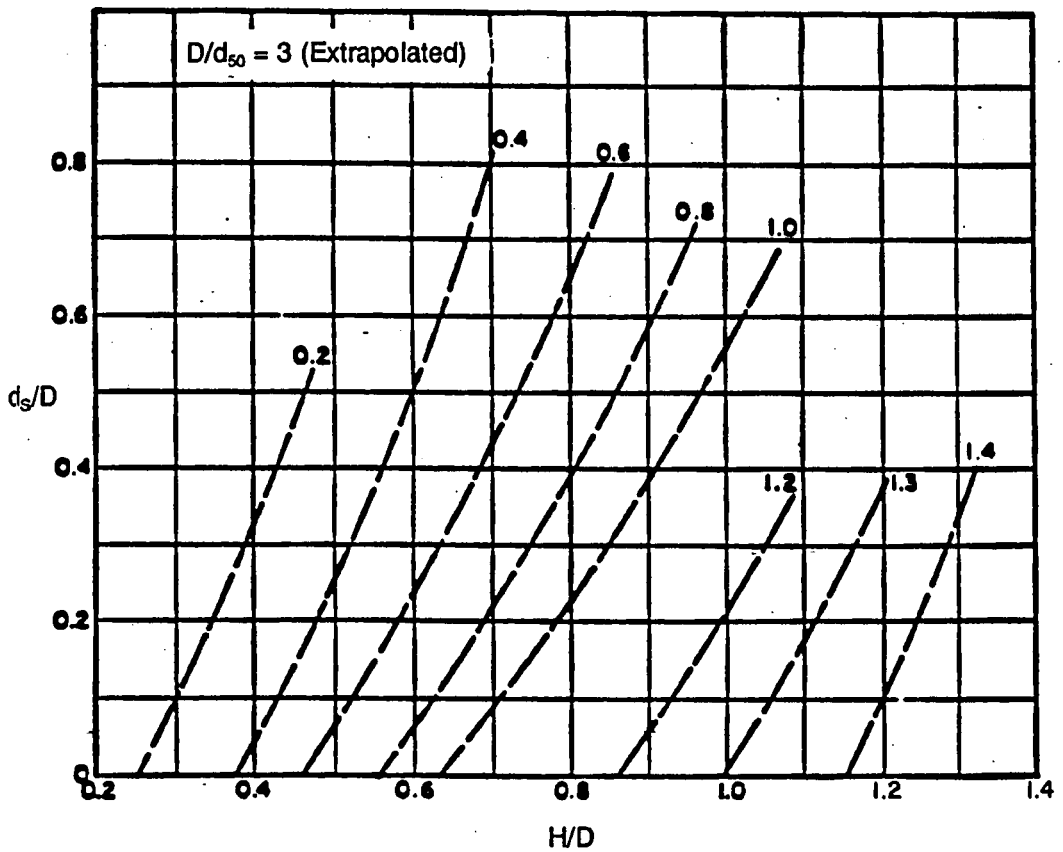


Figure 6.13
Curves for Scour Depth at Vertical Drop
(Stevens 1981)

Extracted from FCDMC Hydraulics Manual

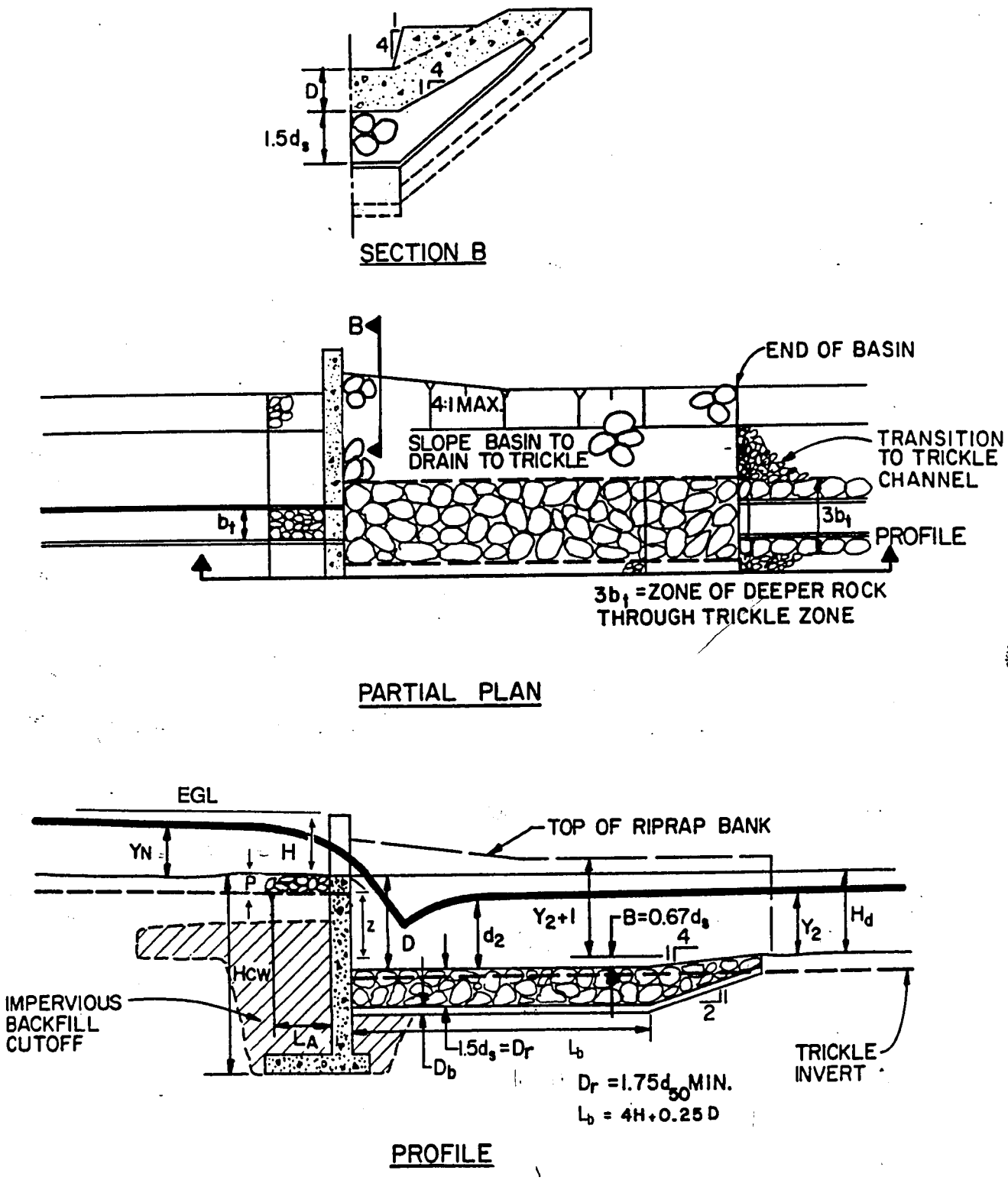
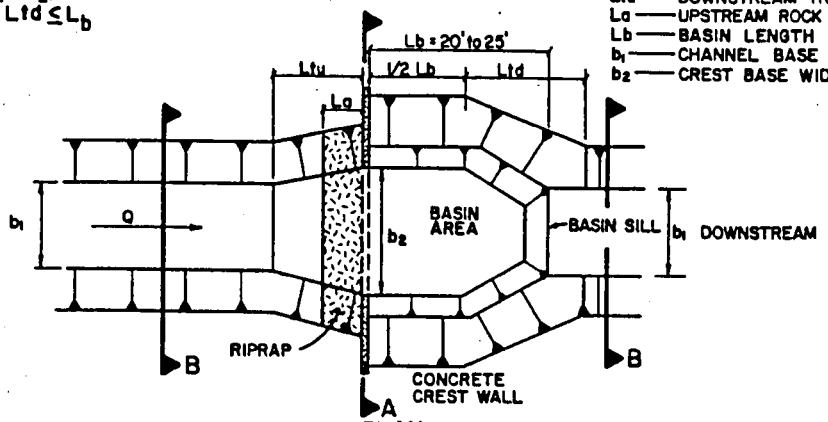


Figure 6.12
Vertical Riprap Basin Drop
(Stevens 1981)

Extracted from FCDMC Hydraulics Manual

NOTES:
$L_{tu} \geq (b_1 - b_2)$
$1/2\ L_b \leq L_{td} \leq L_b$

LEGEND
- L_{tu} — UPSTREAM TRANSITION LENGTH
- L_{td} — DOWNSTREAM TRANSITION LENGTH
- L_a — UPSTREAM ROCK APPROACH LENGTH
- L_b — BASIN LENGTH
- b_1 — CHANNEL BASE WIDTH
- b_2 — CREST BASE WIDTH



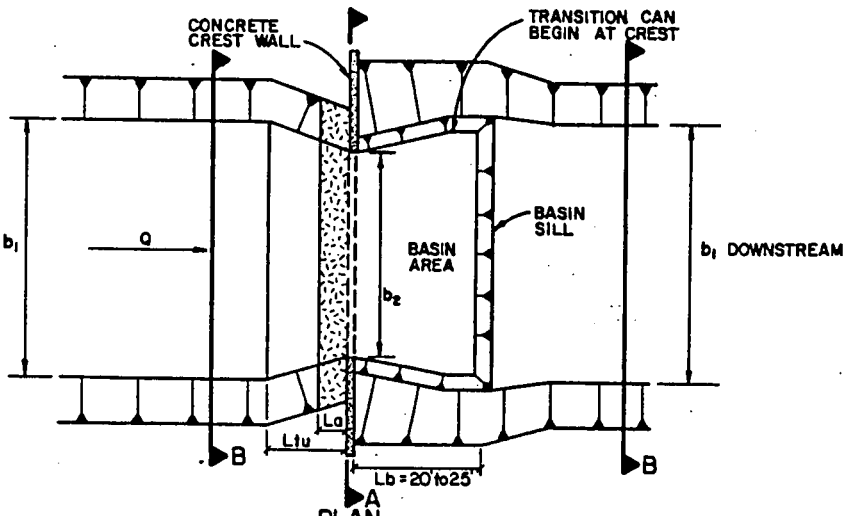
PLAN

VERTICAL DROP WITH CREST EXPANSION

$b_1 = 32$ ft.

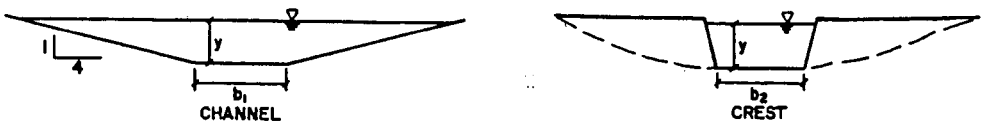
$b_2 = 40$ ft

$b_1 - b_2 = 8$



PLAN

VERTICAL DROP WITH CREST CONSTRICTION



SECTION B

SECTION A

LAYOUT OF DROPS WITH NEARLY RECTANGULAR CREST SECTION

Figure 6.3
Typical Vertical Drop Crest Configurations
(McLaughlin Water Engineers, Ltd. 1986)

Culvert Calculations

PROJECT: SAGUARO SHADOWS II

DESIGNER: J. Chapin

DATE: 6/98

HYDROLOGIC AND CHANNEL INFORMATION

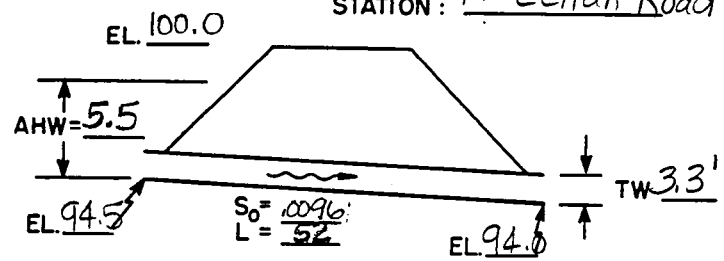
100yr Q_1 = 1088 cfs TW_1 = _____

50yr Q_2 = 870 cfs TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: McLellan Road



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION										CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
			INLET CONT.		OUTLET CONTROL HW=H + h_o − LS_o											
			HW/D	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW				
(4) 10X3	272		1.75	5.25	0.5	2.1	2.8	2.9	3.3	3.3	0.5	4.9	5.25			
(4) 10X3	218		1.4	4.2	0.5	1.6	2.7	2.85	3.0	3.0	0.5	4.1	4.2			

SUMMARY & RECOMMENDATIONS:

USE (4) Barrell 10 X 3 CBC

Figure 7

PROJECT: SAGUARO SHADOWS II

DESIGNER: J. Chapin

DATE: 6/98

HYDROLOGIC AND CHANNEL INFORMATION

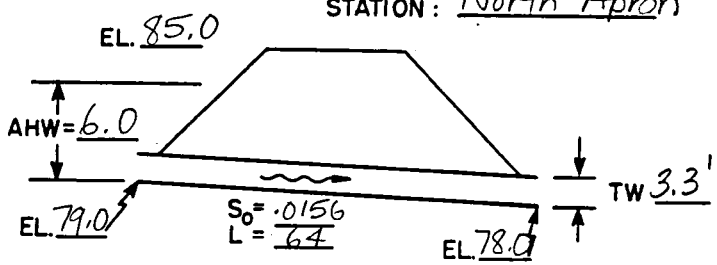
100yr Q_1 = 1088 cfs TW_1 = _____

50yr Q_2 = 870 cfs TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: North Apron



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

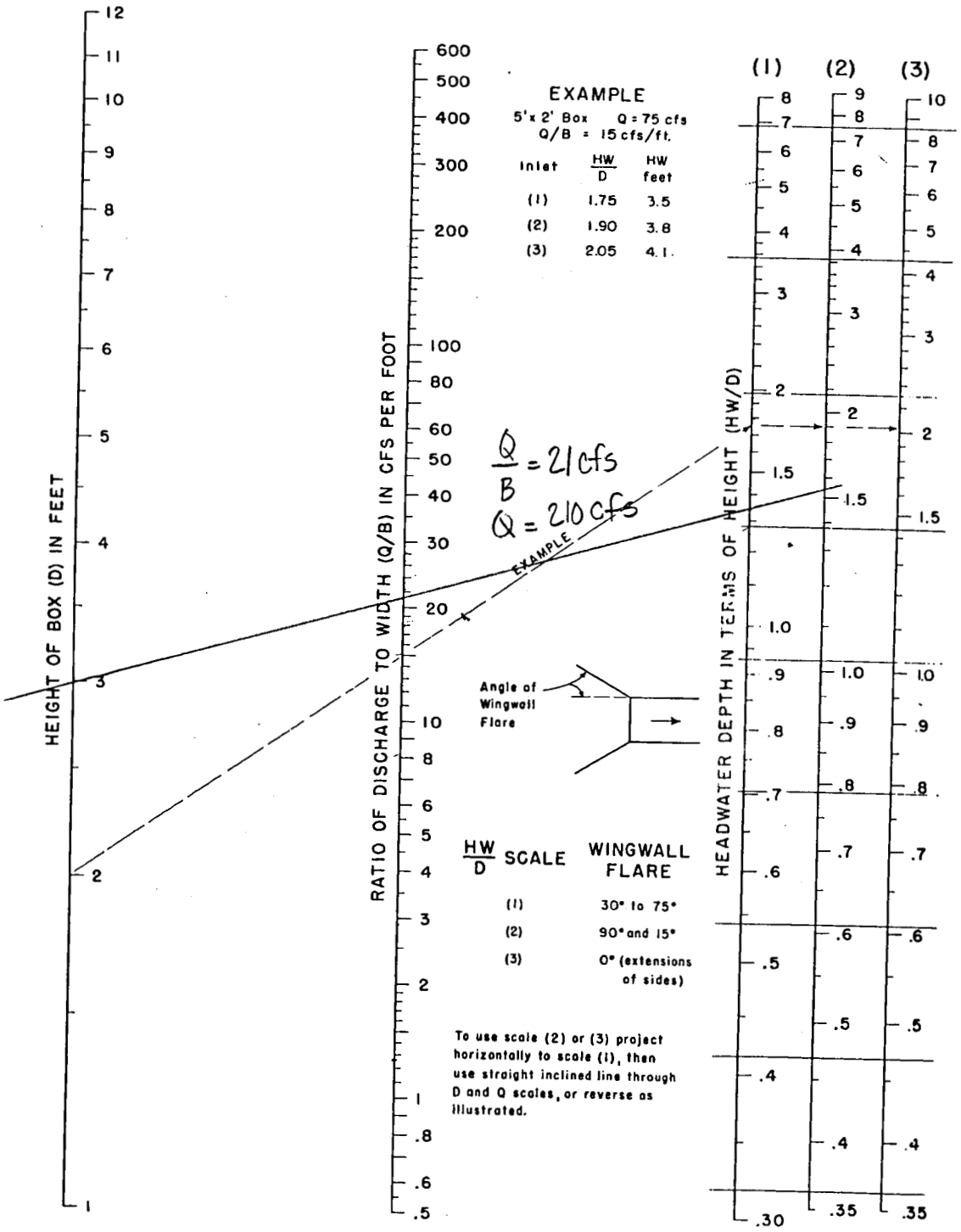
CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION										CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
			INLET CONT.		OUTLET CONTROL HW=H + h_o − LS_o											
			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW				
(4) 10X3	272		1.75	5.25	0.5	2.1	2.8	2.9	3.3	2.9	1.0	4.4	5.25			
(4) 10X 3	218		1.4	4.2	0.5	1.6	2.7	2.85	3.0	2.85	1.0	3.6	4.2			

SUMMARY & RECOMMENDATIONS:

USE (4) Barrell 10 X 3 CBC

Figure 7

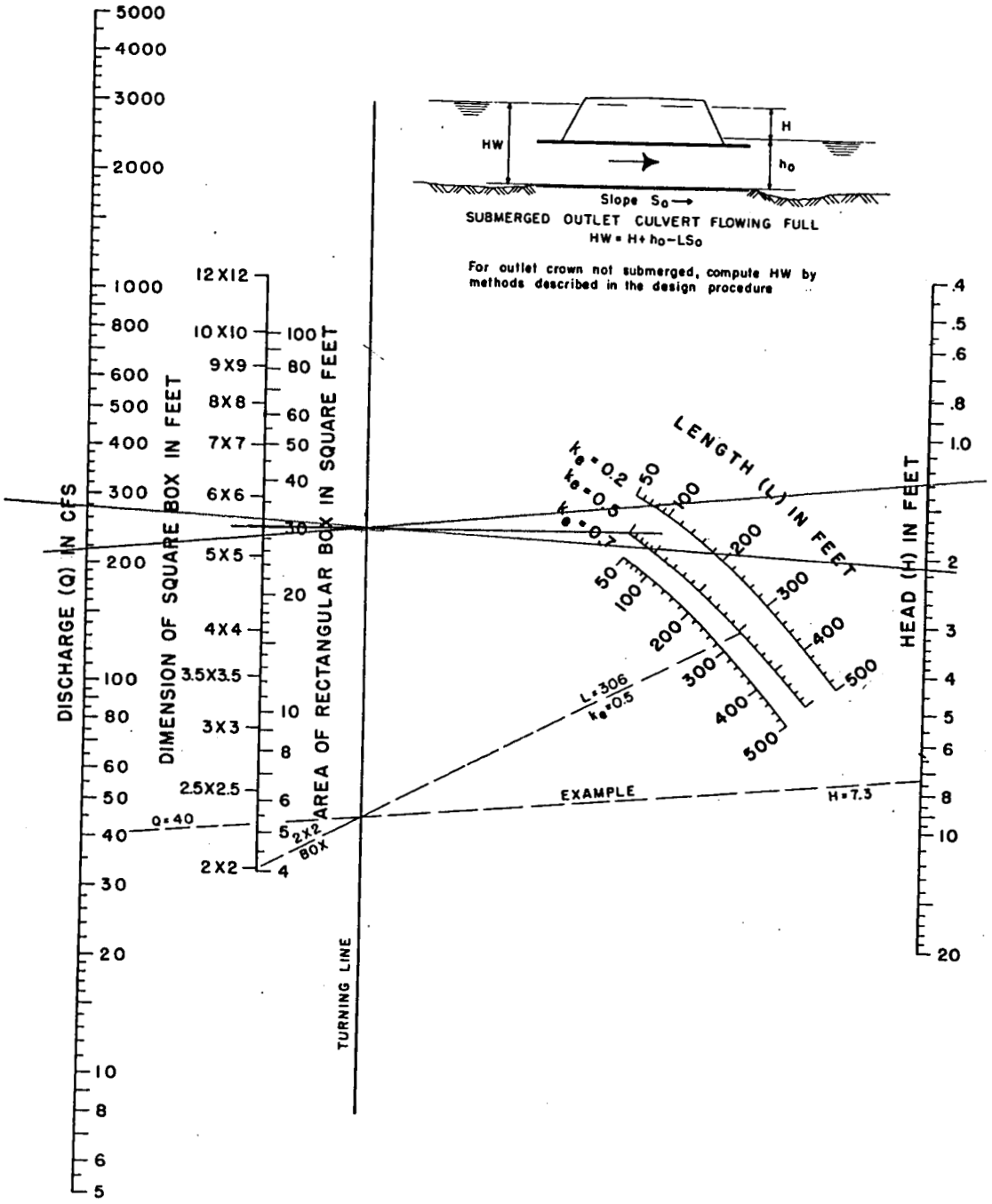
CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

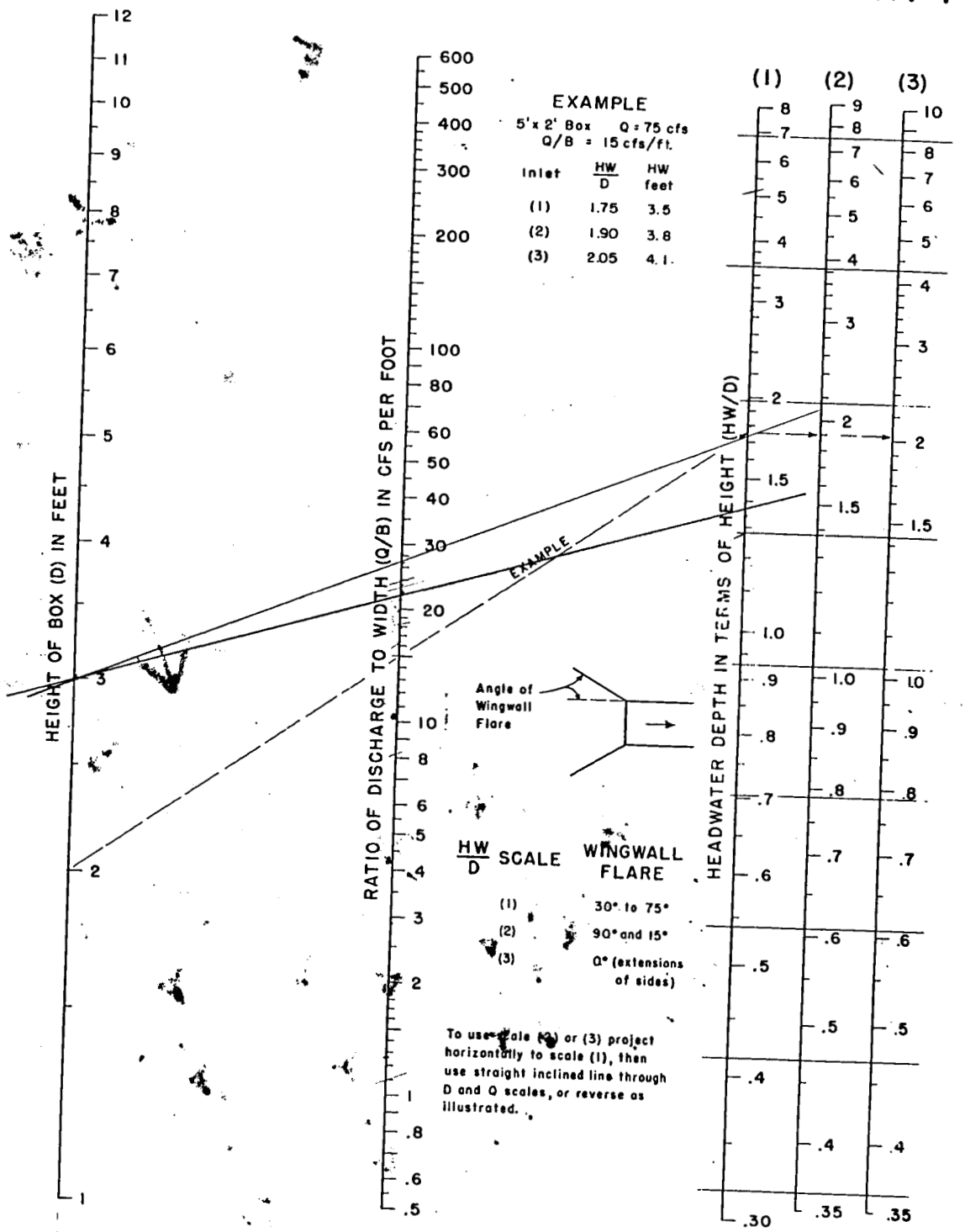
CHART 8



HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

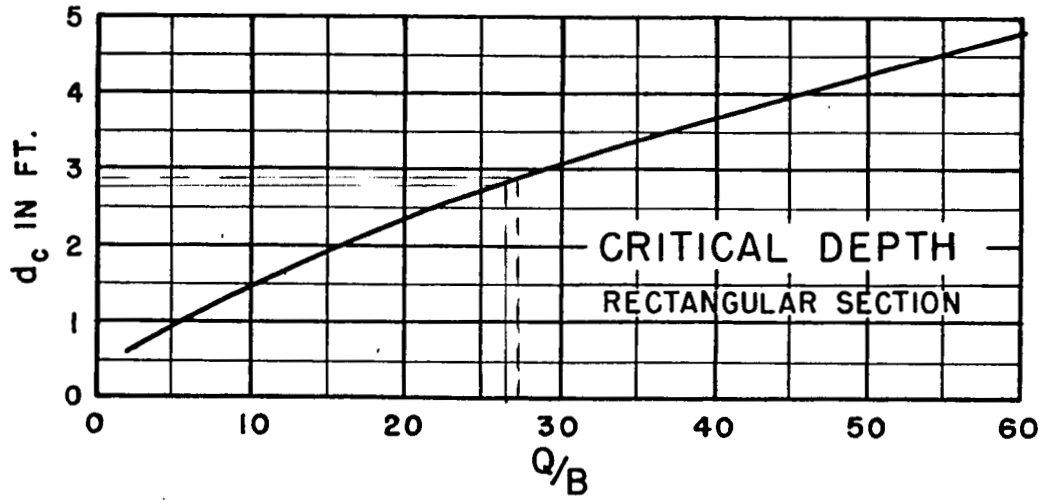
CHART I

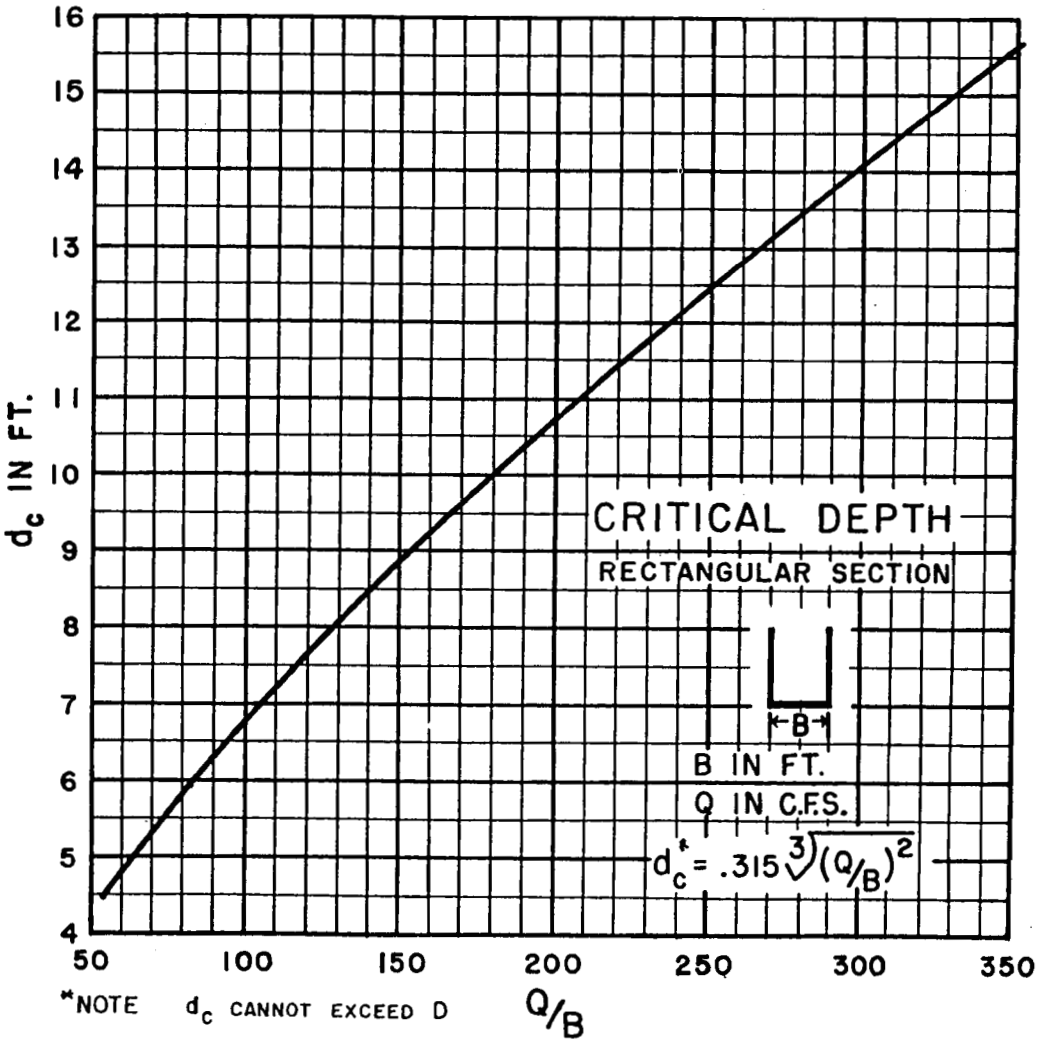


HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 15





*NOTE d_c CANNOT EXCEED D

BUREAU OF PUBLIC ROADS JAN. 1963

PROJECT: SAGUARO SHADOWS TWO

DESIGNER: J. Chapin

DATE: 8/98

HYDROLOGIC AND CHANNEL INFORMATION

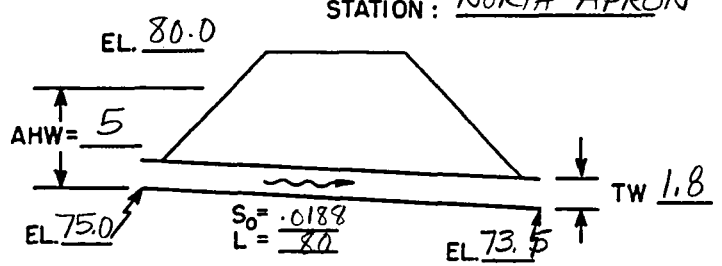
Q_1 = 28.8 TW_1 = _____

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE, SAY Q_{25}
Q_2 = CHECK DISCHARGE, SAY Q_{50} OR Q_{100})

SKETCH

STATION: WEST END OF NORTH APRON



MEAN STREAM VELOCITY = _____

MAX. STREAM VELOCITY = _____

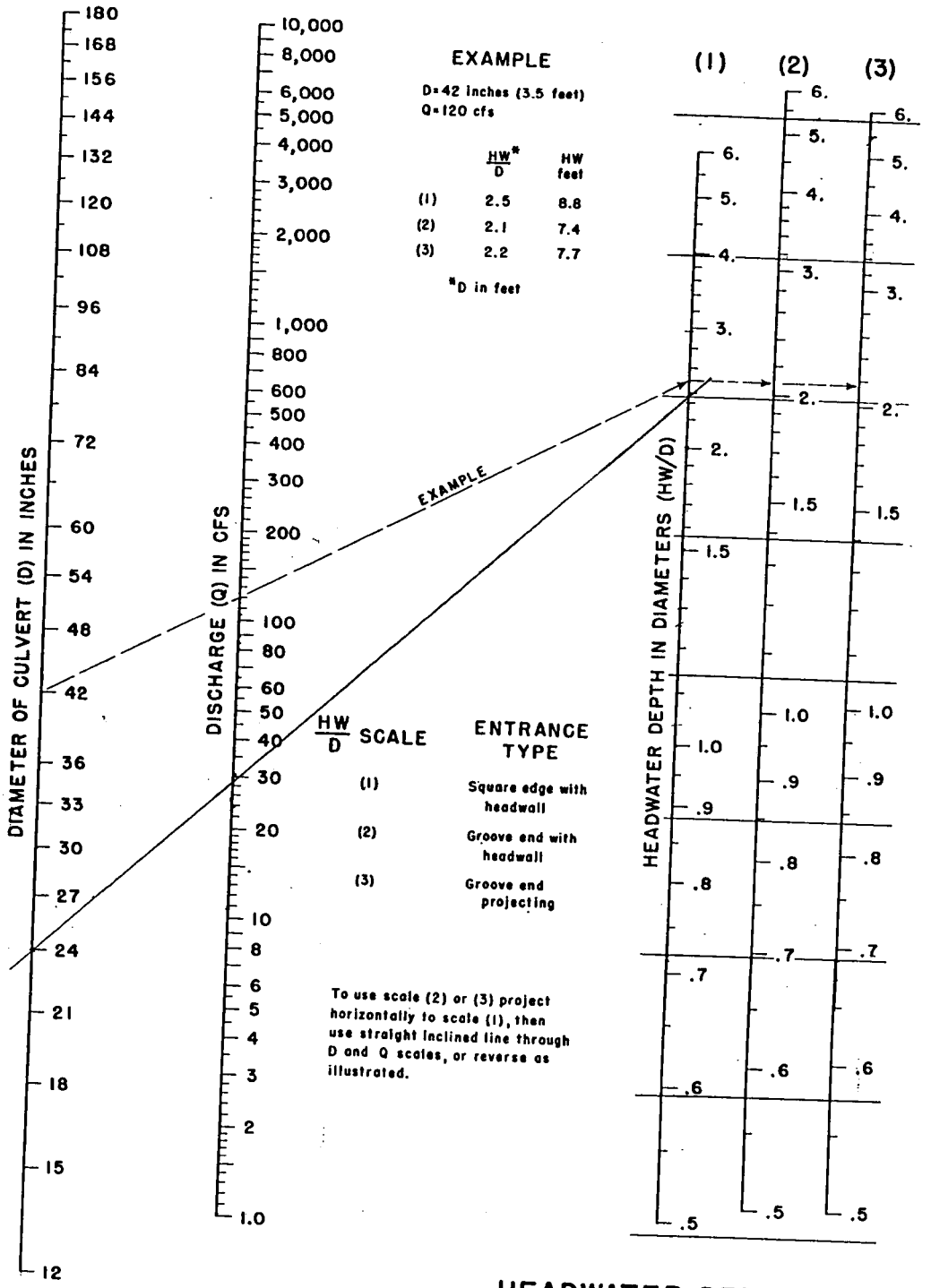
CULVERT DESCRIPTION (ENTRANCE TYPE)	Q	SIZE	HEADWATER COMPUTATION										CONTROLLING HW	OUTLET VELOCITY	COST	COMMENTS
			INLET CONT.		OUTLET CONTROL $HW=H+h_o-LS_o$											
			$\frac{HW}{D}$	HW	K_e	H	d_c	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW				
	28.8	24"	2.2	4.4	0.5	3.2	1.8	1.9	1.8	1.9	1.5	3.6	4.4			

SUMMARY & RECOMMENDATIONS:

24" Ø PIPE CULVERT

Figure 7

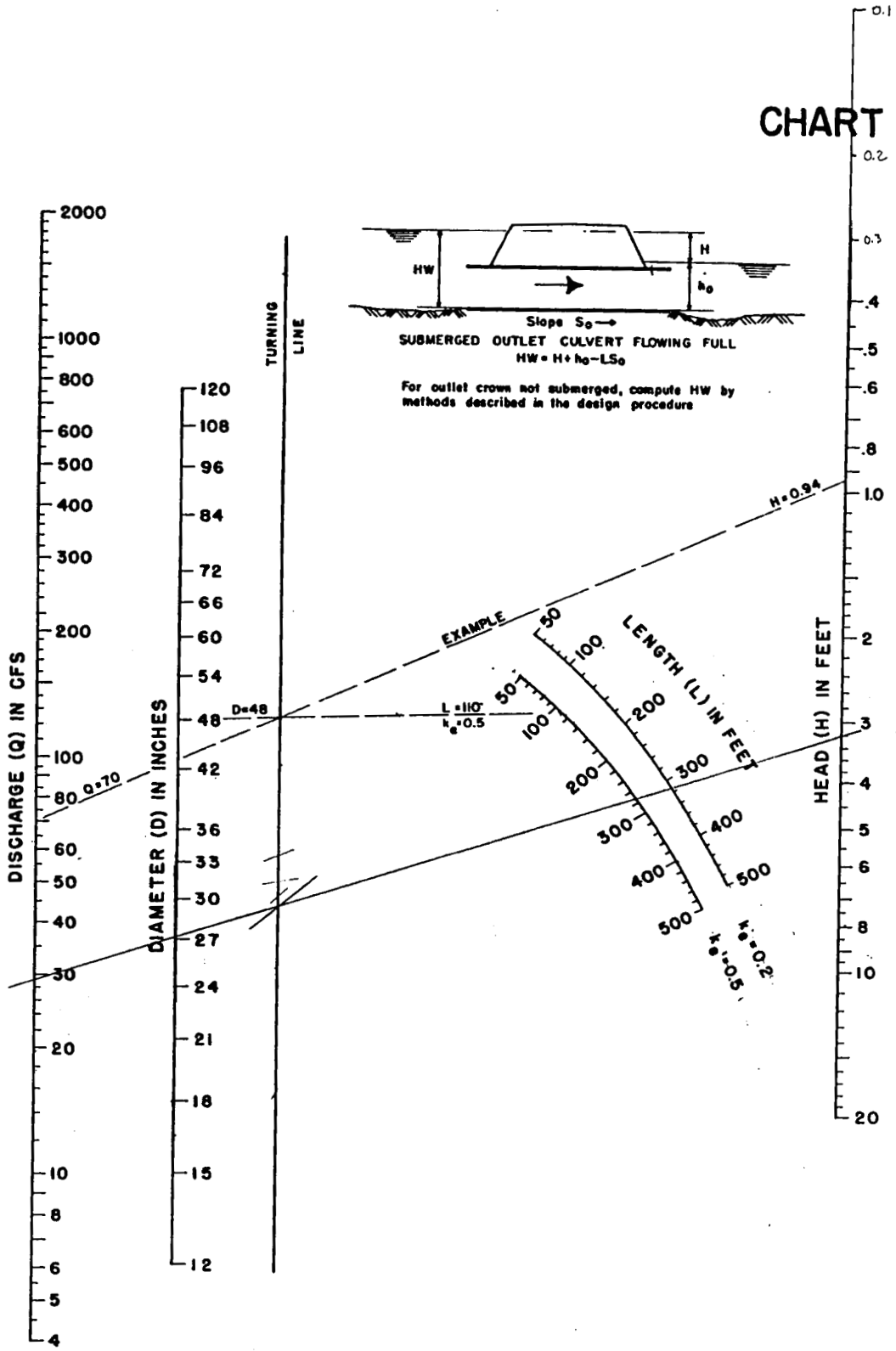
CHART 2



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

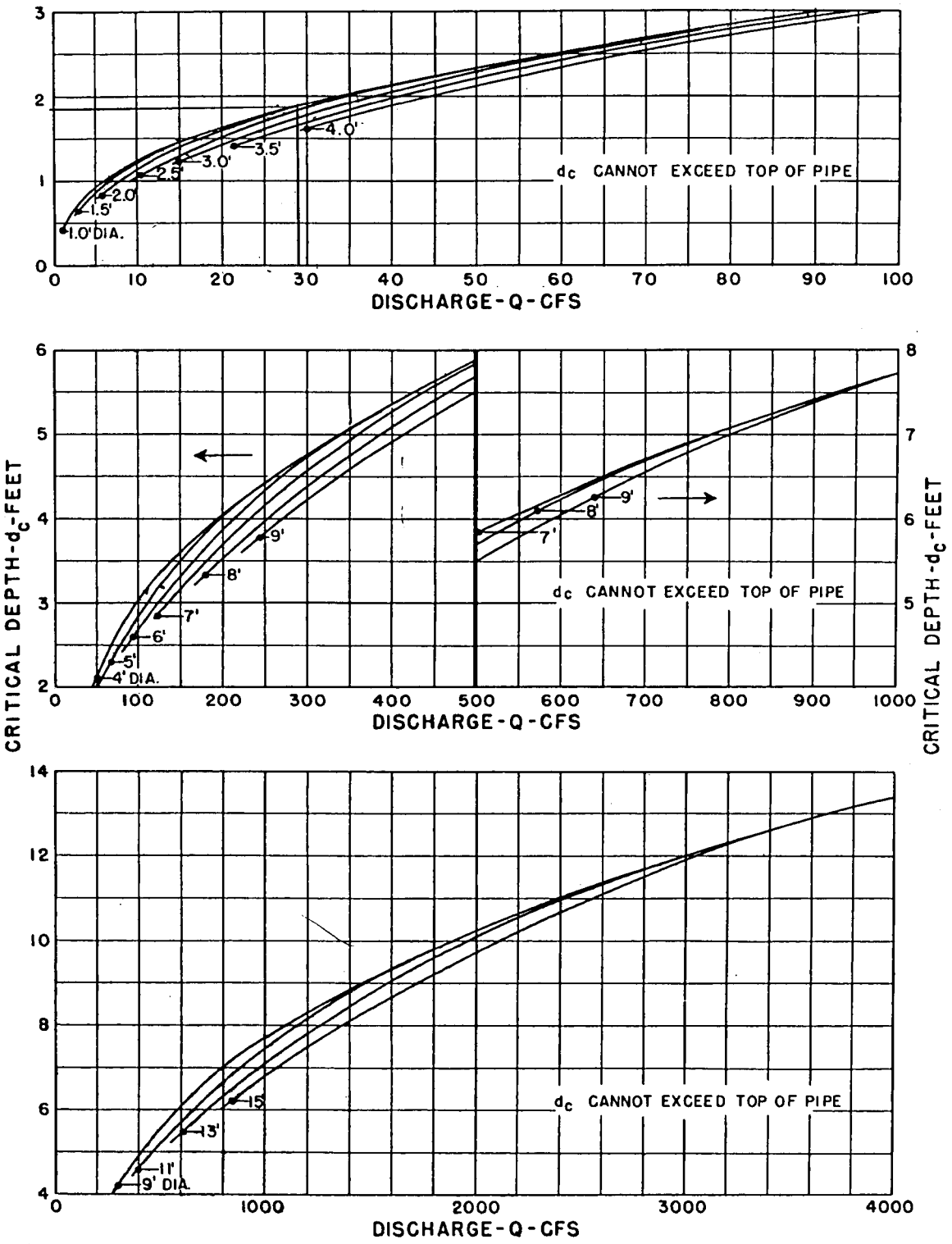
BUREAU OF PUBLIC ROADS JAN. 1963

CHART 9



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

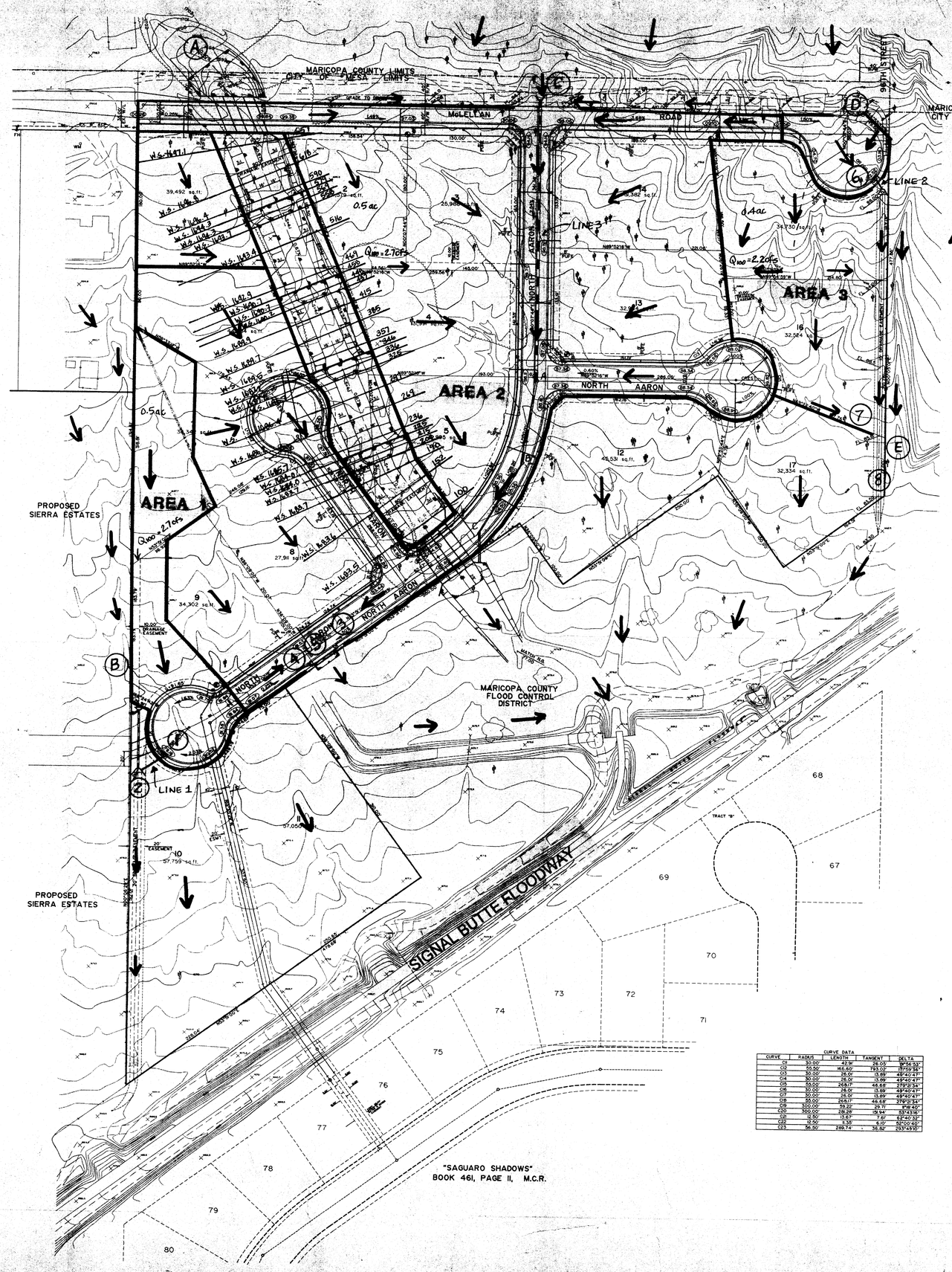
BUREAU OF PUBLIC ROADS JAN. 1963

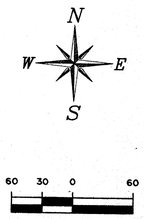


BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE





LEGEND

- DRAINAGE AREA BOUNDARY
- POINT OF CONCENTRATION
- CATCH BASINS/STORM DRAIN
- DEPRESSED CURB &S/W
- BOX CULVERT CROSSING
- 100 HEC-RAS CROSS-SECTION

CURVE DATA

CURVE	RADIUS	LENGTH	TANGENT	DELTA
C1	30.00'	42.91'	26.03'	81°56'53"
C2	55.50'	466.60'	793.02'	117°51'16"
C3	30.00'	26.01'	13.69'	49°40'47"
C4	30.00'	26.01'	13.69'	49°40'47"
C5	55.00'	268.17'	46.68'	279°31'34"
C6	30.00'	26.01'	13.69'	49°40'47"
C7	30.00'	26.01'	13.69'	49°40'47"
C8	55.00'	268.17'	46.68'	279°31'34"
C9	300.00'	59.22'	29.71'	8°18'40"
C20	300.00'	286.28'	154.94'	53°43'16"
C21	12.50'	13.67'	7.67'	62°40'33"
C22	12.50'	9.35'	5.01'	52°00'40"
C23	56.50'	269.74'	38.82'	273°49'10"

ENCLOSURE # 1

MAP.DWG

Clouse Engineering, Inc.
ENGINEERS ▪ SURVEYORS
1642 E. Orangewood Ave. ▪ Phoenix, Arizona 85020 ▪ TEL 395-9300 ▪ FAX 395-9310

Revisions

Date 8-19-98
Job No. 970507
SH. 1

ONSITE DRAINAGE MAP
FOR
SAGUARO SHADOWS TWO