FLOOD CONTROL DISTRICT
RECEIVED
SEP 22, 1992
REMARKS

ESTRELLA FREEWAY
STATE ROUTE 303L

S.R. 85 TO INTERSTATE 17
MARICOPA COUNTY, ARIZONA
(GRAND AVENUE TO DYSART ROAD)

HYDROLOGY AND HYDRAULICS FOR DESIGN CONCEPT REPORT

SEPTEMBER 9, 1992

PREPARED FOR ARIZONA DEPARTMENT OF TRANSPORTATION

PROJECT RAM-600-0-301

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PREPARED BY
STANLEY CONSULTANTS, INC.
3117 N. 16TH STREET
PHOENIX, ARIZONA 85016

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OR RECORDING

Registered Professional Engineer (Civil)
CERTIFICATE NO.
20206
CLARK C.
CLATANOFF
Date Signed 9/21/92
ARIZONA

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Interoffice Memorandum

To : AMM A From: MRD Date: Oct. 14, 1992

Cc : FT

Cc : RSP 10/15

Subject: Review of Estrella Freeway Hydrology and Hydraulics for Design Concept Report dated Sept 9, 1992 by Stanley Consultants, Inc. for ADOT

I have reviewed the HEC-1 modeling in the report. My comments are as follows:

1. The previous HEC-1 model for Sun City West Expansion was developed for existing desert condition. Previous data on soils and land use were used in the latest model in which some surface disturbances will be made. Comparative peak discharge estimates are practically the same for both.

2. Based on culvert length of 225' and total freeway length of 7400' the area to be occupied by freeway will be about 38 acres or roughly 14% of total area for sub-basins C1 - C4 and D1 - D4. Thus, the loss rate parameters (Green and Ampt) will be affected with a decrease in IA, XKSAT and Dtheta and an increase in RTIMP. These were not considered in the model.

3. The watershed roughness coefficient Kb may be reduced to account for ground surface smoothing at the freeway site.

4. Sub-basin C2 has 38 end-of-period ordinates in the model output, which is greater than the specified 36 ordinates in the IT record. Maybe a value of 40 will be more appropriate.

5. If right-of-way will not be a limiting factor, natural earth channel (with proper landscaping) may used instead of the gunite channel in the HEC-1 model. It may be more economical to use earth channel.

STANLEY CONSULTANTS, INC.

3117 North 16th Street • Phoenix, AZ 85016 Tel: 602/279-0901 • Fax: 602/230-7655

TO: Flood Control District
2801 W Durango St.
Phx Az 85009

DATE: 9-17-92

PROJECT: Estrella Freeway Realignment

ATTN: Felicia Terry

PROJECT #: 11292

FLOOD CONTROL DISTRICT RECEIVED SEP 22 1992 2:00 PM

THE FOLLOWING ITEMS ARE TRANSMITTED:

COPIES	ORIGINALS	DESCRIPTION
1		Estrella Freeway Hydrology and
		Hydraulics for Design Concept
		Report 9-9-92

THE ABOVE ITEMS ARE SUBMITTED:

- ☐ AT YOUR REQUEST
- ☐ FOR YOUR REVIEW
- ☐ FOR YOUR APPROVAL
- ☐ FOR YOUR SIGNATURE
- ☐ AS REVISED
- ☑ YOUR INFORMATION

REMARKS:

Copy to:
Clark Clatlanoff

BY: Scott Buchanan

RECEIVED:

DATE:

TABLE OF CONTENTS

	Page
Introduction	1
Hydrology	3
Hydraulics	5
Cost Estimate	7
Conclusions and Recommendations	8

Appendices

Appendix A	Hydrology
Appendix B	Hydraulics
Appendix C	Preliminary Estrella Freeway Plan and Profile Preliminary Sun City West Expansion North Channel
Appendix D	Excerpt from Cella Barr Hydrologic Investigation Report, July 14, 1987
Appendix E	Excerpt from Cella Barr Technical Memorandum - Estrella Freeway Drainage; Northwest Loop, January 16, 1990, revised December 21, 1990.
Appendix F	Excerpt from Master Drainage Report for Sun City West Expansion Area, Stanley Consultants, August 11, 1992

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Registered Professional Engineer (Civil)
CERTIFICATE NO.
20206
CLARK C.
CLATANOFF
Date Signed 9/21/92

INTRODUCTION

The purpose of this report is to analyze the preliminary hydrology and hydraulics for the Estrella Freeway from Grand Avenue to Dysart Road. This section of freeway is being re-aligned from the original design concept route presented by Cella Barr and Associates in 1987 and revised in 1990. The new alignment runs north of the original alignment and accommodates development of the Sun City West Expansion Area which is currently in the beginning stages of construction.

This report is prepared as an addenda to two Cella Barr documents that accompanied the previous preliminary freeway location plan and profile. The first document is the Estrella Freeway Hydrologic Investigation Report dated July 14, 1987. The second document is the Technical Memorandum - Estrella Freeway Drainage; Northwest Loop dated January 16, 1990 and revised December 21, 1990. The Technical Memorandum contains a discussion of proposed drainage design concept and a preliminary cost analysis of proposed drainage structures.

The Sun City West Expansion Area is a master planned residential community on roughly 840 acres located north of Deer Valley Drive between 135th Avenue and 147th (or Bullard) Avenue. Right-of-way for the Estrella Freeway adjacent to the Sun City West Expansion Area will be dedicated to ADOT by the developer, Del E. Webb Development Company. Construction of the freeway is not envisioned to start for several years.

The offsite contributing drainage area for this section of the Estrella Freeway is relatively small in comparison to the rest of the freeway because it has been cut off by the existing McMicken Dam Outlet Channel and Diversion Dike located just north of the freeway alignment. This

flood control facility has been designed to carry the 100-year discharge from McMicken Dam as well as the concurrent 100-year local drainage. The original offsite drainage area is reduced with the proposed shift in freeway alignment to the north.

The original drainage concept for the Estrella Freeway presented by Cella Barr and Associates was to pass local drainage under the freeway at the larger washes via drainage cross culverts. Sheet flow and drainage from smaller washes would be intercepted by roadside ditch on the north side of the freeway and directed to one of the nearby culverts. The freeway profile was elevated above grade on the order of 8 to 12 feet. There was no detention of runoff proposed for any of the freeway right-of-way.

The drainage concept presented in this report will be essentially the same as that proposed by Cella Barr with one exception. A drainage channel will be constructed along the north side of the Sun City West Expansion Area. This channel will be in place prior to freeway construction. It will intercept drainage from the north and carry it to a point roughly 850 feet west of the east limit of the development. At this point, it will enter the development and be carried in a system of drainage easement, golf course and open space channels. The Estrella Freeway cross culverts, when constructed, will drain into the Sun City West Expansion Area north channel.

HYDROLOGY

Cella Barr hydrology for their design concept was based on an area-discharge curve they developed from TR-55 results for several sample sub-basins. Each contributing drainage area was delineated, its area measured and a peak flow was estimated from the curve. All hydrology for local contributing areas was based on a 50-year return frequency. A copy of part of the Cella Barr Hydrologic Investigation Report has been included in Appendix D of this report.

Methods used to estimate preliminary design flows and size drainage cross-culverts for the Estrella Freeway realignment covered in this report are essentially the same as those used by Cella Barr. Contributing flow rates are generally less since the offsite area has incidentally been reduced through re-alignment of the freeway. The general reduction in contributing flow also allows for a slight reduction in the number of cross-culvert locations in the re-aligned section of freeway. Preliminary hydrology for the re-aligned section is summarized in Appendix A of this report.

Hydrology for the Sun City West Expansion Area north channel is based on methods from the Drainage Design Manual for Maricopa County, Volume 1, Hydrology. This hydrology is consistent with that from the Master Drainage Report for Sun City West Expansion Area dated August 11, 1992 which has been approved by the Flood Control District of Maricopa County. A brief explanation of the methodology, summaries of basic input parameters and one of the HEC-1 models has been excerpted from the Master Drainage Report for Sun City West Expansion Area and are presented in Appendix F.

Hydrology for the north channel is based on a 100-year return frequency. A 2-year return frequency was also considered. Two-year discharges were estimated based on the ratio of 2-year to 100-year precipitation. The offsite contributing area was assumed to be in existing condition for both the 2-year and 100-year discharges.

For freeway drainage cross culverts, contributing areas were estimated based on a lower limit corresponding to the proposed south freeway right-of-way line. Contributing area to the proposed Sun City West Expansion Area north channel includes all of the above and an additional sliver of adjacent Sun City West Expansion onsite area.

HYDRAULICS

It has been assumed in this report that the basic design concept envisioned by Cella Barr was to set cross-culvert grades at or slightly below the existing wash flow line. This concept will continue to be followed from Grand Avenue to Bullard Avenue (Bullard Avenue being the west limit of the proposed Sun City West Expansion Area). However, in order to lower the freeway profile adjacent to the Expansion Area, it is proposed to set culvert grades up to about 2 feet below existing flow lines adjacent to the proposed development. It is also proposed to limit the culverts in this area to reinforced concrete pipe with a diameter of 36 inches.

A drop-style inlet would be incorporated with this culvert design concept. Scour protection would be necessary at both the inlet and outlet of each drop inlet culvert. A short section of channel would be necessary to connect culvert outlets with the Sun City West Expansion Area north channel. Schematic and typical illustrations are included in Appendix B which show the proposed culvert design concept. Preliminary hydraulic analysis is also included in Appendix B for two selected culverts. Culvert hydraulics are based on methods presented in Hydrologic Engineering Circular #5. A brief weir flow analysis was performed to evaluate controlling hydraulics at a typical culvert drop inlet.

Design options for the Sun City West Expansion Area north channel consist of either an earth channel with a 5 to 10 foot bottom width and 3:1 side slopes or a gunite lined channel with 8 to 10 foot bottom and 1/2-1 to 1 side slopes. An earth channel would require some type of lining at all the drainage inflow points along its reach to prevent scour. The general depth of either the earth or gunite channel is on the order of 4 to 5 feet below existing grade. This would allow

for positive outfall of discharge from future freeway culverts, positive movement of suspended sediment loads through the culverts and allowance of the inlet control assumption in culvert hydraulic design. Preliminary hydraulic design of the proposed channel is summarized in Appendix B of this report. Preliminary plan and profile sheets illustrating the alignment and grade of the proposed channel and adjacent culverts is included in Appendix C.

COST ESTIMATE

A preliminary cost estimate was done for all the culverts from Station 1141+23 near Grand Avenue to Station 1317+95 just east of the 135th Avenue alignment. This cost estimate is only for drainage cross culverts and does not reflect any earthwork, pavement, channels or other improvements. It was done on the same unit cost basis as the estimate by Cella Barr in their 1990 memorandum.

Station	Culvert	Cost
1141 + 23	3-36" RCP x 250'	$ 67,500
1144 + 00	2-6' x 6' CBC x 225'	108,900
1158 + 60	2-8' x 6' CBC x 225'	131,500
1169 + 80	4-36" RCP x 225'	81,000
1179 + 50	1-36" RCP x 225'	20,250
1187 + 70	1-36" RCP x 225'	20,250
1201 + 50	1-36" RCP x 225'	20,250
1214 + 80	2-36" RCP x 225'	40,500
1226 + 50	1-36" RCP x 225'	20,250
1235 + 50	2-36" RCP x 225'	40,500
1249 + 80	2-36" RCP x 225'	40,500
1265 + 50	6-36" RCP x 225'	121,500
1279 + 30	5-36" RCP x 225'	101,250
1285 + 25	3-36" RCP x 225'	60,750
1294 + 55	5-36" RCP x 225'	101,250
1294 + 75	8-36" RCP x 225'	162,000
1303 + 90	9-36" RCP x 225'	182,250
1317 + 95	3-8' x 6' CBC x 225'	182,800
		$ 1,503,200

Culverts/Costs:

Pipe - $2.50 per diameter-inch per linear foot
Box - $300.00 per cubic yard of concrete (includes wingwalls and rebar)

CONCLUSIONS AND RECOMMENDATIONS

To be consistent with the previous design concept, culvert hydrology in this report uses the same area-discharge methodology presented by Cella Barr and Associates. Hydrology for the Sun City West Expansion Area north channel is based on the County's Hydrology Manual, which the County requires, and is consistent with methods and general hydrology for that development. The 50-year peak flows from Cella Barr curves are generally (and sometimes significantly) higher than the 100-year Hydrology Manual flows. This gives the appearance that either the Cella Barr method yields high results or the County method yields low results or both.

Cella Barr acknowledges in their report that the area-discharge methods they used tend to produce conservatively high results. Their method also incorporates a 20 percent safety factor. In addition, contributing areas to proposed culverts in this report are slightly overestimated because they include the freeway itself.

In a theoretical sense, the County's Hydrology Manual should yield more accurate results because it considers specific watershed characteristics and parameters as opposed to generalized curves. Peak discharges for individual sub-basins C1-C4 and D1-D4 in this report may be slightly underestimated. However, with kinematic wave hydrograph routing in the north channel, hydrograph peaks are almost directly additive which would result in higher peak flows. Preliminary hydraulic design of the channel includes a 100-year freeboard of from 1 to 3 feet.

Hydrology for cross culverts in this report is not intended to go into great depth or detail since the freeway is many years away from construction and ADOT is currently revising its drainage methodology and requirements. Nor does hydraulic analysis of cross culverts go to great depth or detail. The number of culvert barrels suggested in this report at some locations is excessive in terms of conventional culvert design. This reflects a very preliminary and simplistic approach intended to allow for the lowest reasonable roadway profile adjacent to the Sun City West Expansion Area and for estimating associated drainage costs along the entire realignment.

The preliminary hydraulic analysis for the two selected culverts in Appendix B is typical of all the culvert locations involving multiple barrel concrete pipes. A reduction in the number of 36-inch culvert barrels can be achieved through the use of oval concrete pipe. A typical hydraulic analysis sheet is included in Appendix B for oval 53" wide by 34" high concrete pipe indicating it can convey more than half again as much as 36" diameter concrete pipe.

It has been recommended by ADOT in past coordination meetings that, where concrete box culverts are proposed, the minimum height should be 6 feet. This recommendation has been followed for culverts at stations 1144+00 and 1158+60. These culverts were originally proposed by Cella Barr as double 8' x 4' and double 10' x 4' boxes respectively. These culverts are now a double 6' x 6' box and double 8' x 6' box respectively. At all pipe culvert installations, we recommend a minimum of 36" diameter or 34" height on oval pipe.

In the original preliminary design by Cella Barr, there were a total of 21 culvert locations in this section of freeway. With the realignment in this report and associated reduction in

contributing drainage area, the total number of culverts has been reduced to 18. The total cost of Cella Barr's 21 culverts was $1,678,688. The total cost of the 18 culverts in this report is $1,503,200. The additional cost of drop inlets to the culverts adjacent to the Sun City West Expansion Area is not reflected in the revised cost estimate. However, this cost would be more than offset by the savings in culvert cost and reduction in earthwork effort associated with the lower freeway profile that the culvert concept enables.

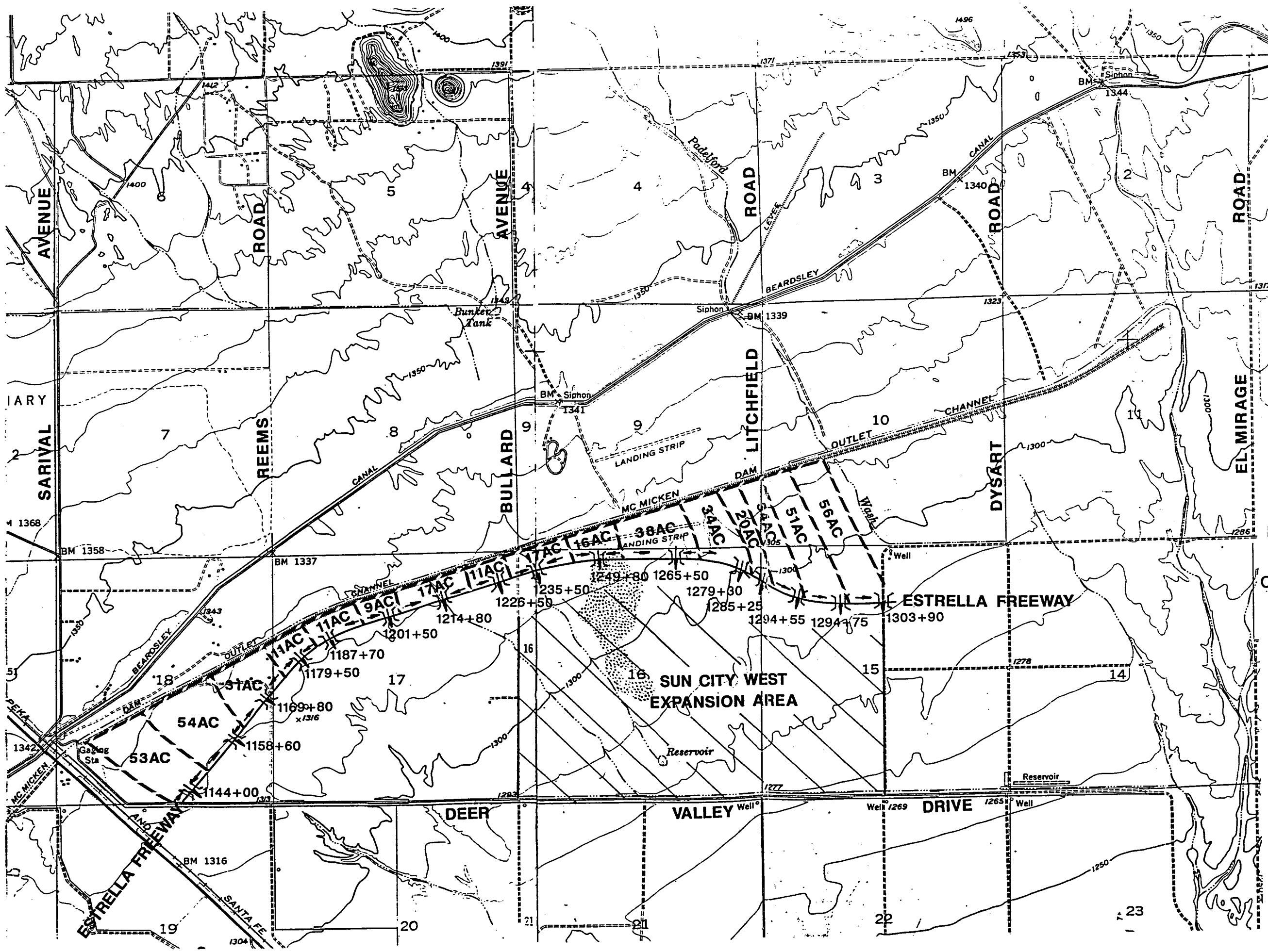
APPENDIX A
HYDROLOGY

BASIC INPUT PARAMETERS FOR HEC-1 MODEL 11292A

		Acres			Sq. Mi.	Ft./Mi.					Hrs/Min.	Hrs.
Sub-Basin	Culvert Station	Offsite Area	Onsite Area	Total Area	Total Area	Length	El(High)	El(Low)	Slope In Ft. Per Mi.	Kb	TC	R
C1	1235+50	17	1	18	0.028	1350/0.256	1318	1315	11.7	0.08	0.479/28.8	0.422
C2	1249+80	16	1	17	0.027	1600/0.303	1317	1313	13.2	0.08	0.512/30.8	0.531
C3	1265+50	38	3	41	0.064	2100/0.398	1316	1308	20.1	0.074	0.488/29.3	0.382
C4	1279+30	34	3	37	0.058	2400/0.455	1315	1303	26.4	0.075	0.479/28.8	0.441
D1	1285+25	20	1	21	0.033	2100/0.398	1314	1301	32.7	0.079	0.408/24.5	0.458
D2	1294+55	34	1	35	0.055	2600/0.492	1313	1298	30.5	0.075	0.475/28.5	0.480
D3	1294+75	51	1	52	0.081	3100/0.587	1312	1294	30.7	0.073	0.533/32.0	0.504
D4	1303+90	56	1	57	0.089	3100/0.587	1311	1292	32.4	0.072	0.512/30.8	0.457

Loss Rates for Green and AMPT Record

SUB-BASIN	IA	DTHETA	PSIF	X KSAT	RTIMP
C1-C4	0.35	0.35	6.05	0.20	1
D1-D4	0.35	0.35	4.34	0.24	1


ESTRELLA FREEWAY
NORTHWEST
LOOP SECTION
PROPOSED CULVERT LOCATIONS
AND
CONTRIBUTING DRAINAGE AREAS
N
SCALE:1"=2000'
LEGEND
SUB-BASIN BOUNDARY
38AC CONTRIBUTING AREA IN ACRES
FLOW DIRECTION
PROPOSED CULVERT
1144+00 CULVERT STATION
STANLEY CONSULTANTS, INC.
SCI #11292
SUN CITY WEST
EXPANSION AREA
ESTRELLA FREEWAY
DEER VALLEY DRIVE
SARIVAL AVENUE
REEMS ROAD
BULLARD AVENUE
LITCHFIELD ROAD
DYSART ROAD
EL MIRAGE ROAD
BEARDSLEY CANAL
MC MICKEN DAM
OUTLET CHANNEL
LANDING STRIP
Paddleford
Bunker Tank
Siphon
Substation
Reservoir
Well
Gaging Sta
SANTA FE
GILA AND SALT RIVER
17AC
16AC
38AC
34AC
20AC
51AC
56AC
11AC
9AC
54AC
53AC
1235+50
1249+80
1265+50
1279+30
1285+25
1294+55
1294+75
1303+90
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1158+60
1144+00

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*          609 SECOND STREET            *
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*           (916) 756-1104              *
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THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

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  5           ID
              *DIAGRAM
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  7           IO       3

  8           KK   SUBC1        RUNOFF HYDROGRAPH FROM AREA SUBC1
  9           BA    .028
 10           IN       5
 11           PB   2.770
 12           PC    .000    .011    .018    .023    .028    .032    .046    .071    .100    .137
 13           PC    .176    .232    .327    .601    .743    .863    .901    .930    .954    .962
 14           PC    .970    .979    .982    .992   1.000
 15           LG     .35     .35    6.05     .20       1
 16           UC    .479    .422
 17           UA       0       3       5       8      12      20      43      75      90      96
 18           UA     100

 19           KK   RCHC2        ROUTE HYDROGRAPH SUBC1 THRU REACH C2; GUNITE CHANNEL
 20           RK    1400    .005    .016            TRAP      10      .5

 21           KK   SUBC2        RUNOFF HYDROGRAPH FROM AREA SUBC2
 22           BA    .027
 23           LG     .35     .35    6.05     .20       1
 24           UC    .512    .531
 25           UA       0       3       5       8      12      20      43      75      90      96
 26           UA     100

 27           KK   SUMC2        COMBINE HYDROGRAPHS RCHC2 AND SUBC2
 28           HC

 29           KK   RCHC3        ROUTE HYDROGRAPH SUMC2 THRU REACH C3; GUNITE CHANNEL
 30           RK    1600    .005    .016            TRAP      10      .5

 31           KK   SUBC3        RUNOFF HYDROGRAPH FROM AREA SUBC3
 32           BA    .064
 33           LG     .35     .35    6.05     .20       1
 34           UC    .488    .382
 35           UA       0       3       5       8      12      20      43      75      90      96
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 36          UA     100

 37          KK   SUMC3        COMBINE HYDROGRAPHS RCHC3 AND SUBC3
 38          HC

 39          KK   RCHC4        ROUTE HYDROGRAPH SUMC3 THRU REACH C4; GUNITE CHANNEL
 40          RK    1400    .005    .016            TRAP      10      .5
1                                          HEC-1 INPUT                                                    PAGE  2

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


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 42          BA    .058
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 48          HC

 49          KK   RCHD1        ROUTE HYDROGRAPH SUMC4 THRU REACH D1; GUNITE CHANNEL
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 51          KK   SUBD1        RUNOFF HYDROGRAPH FROM AREA SUBD1
 52          BA    .033
 53          LG     .35     .35    4.34     .26       1
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 56          UA     100

 57          KK   SUMD1        COMBINE HYDROGRAPHS RCHD1 AND SUBD1
 58          HC

 59          KK   RCHD2        ROUTE HYDROGRAPH SUMD1 THRU REACH D2; GUNITE CHANNEL
 60          RK     900    .005    .016            TRAP      10      .5

 61          KK   SUBD2        RUNOFF HYDROGRAPH FROM AREA SUBD2
 62          BA    .055
 63          LG     .35     .35    4.34     .26       1
 64          UC    .475    .480
 65          UA       0       3       5       8      12      20      43      75      90      96
 66          UA     100

 67          KK   SUMD2        COMBINE HYDROGRAPHS RCHD2 AND SUBD2
 68          HC

 69          KK   RCHD3        ROUTE HYDROGRAPH SUMD2 THRU REACH D3; GUNITE CHANNEL
 70          RK     850    .005    .016            TRAP      10      .5

 71          KK   SUBD3        RUNOFF HYDROGRAPH FROM AREA SUBD3
 72          BA    .081
 73          LG     .35     .35    4.34     .26       1
 74          UC    .533    .504
 75          UA       0       3       5       8      12      20      43      75      90      96
 76          UA     100

 77          KK   SUMD3        COMBINE HYDROGRAPHS RCHD3 AND SUBD3
 78          HC
1                                          HEC-1 INPUT                                                    PAGE  3

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 79          KK   SUBD4        RUNOFF HYDROGRAPH FROM AREA SUBD4
 80          BA    .089
 81          LG     .35     .35    4.34     .26       1
 82          UC    .512    .457
 83          UA       0       3       5       8      12      20      43      75      90      96
 84          UA     100

 85          KK   RCHD4        ROUTE HYDROGRAPH SUBD4 THRU REACH D4; GUNITE CHANNEL
 86          RK     850    .005    .016            TRAP      10      .5

 87          KK   SUMD4        COMBINE HYDROGRAPHS RCHD4 AND SUMD3
 88          HC
 89          ZZ
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     SCHEMATIC DIAGRAM OF STREAM NETWORK
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               V
               V
  19       RCHC2
               .
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  21           .       SUBC2
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               V
               V
  29       RCHC3
               .
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  31           .       SUBC3
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               .           .
  37       SUMC3............
               V
               V
  39       RCHC4
               .
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               .           .
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               V
  49       RCHD1
               .
               .
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               V
               V
  59       RCHD2
               .
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               .           .
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               V
  69       RCHD3
               .
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  71           .       SUBD3
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  79           .       SUBD4
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               .           V
  85           .       RCHD4
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*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
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                         ESTRELLA FREEWAY       PROJECT RAM-600-0-301
                         FILENAME : 11292A      DATE : SEPTEMBER 4, 1992
                         NORTH CHANNEL 100YR-2HR    SUN CITY WEST EXP AREA

  7 IO        OUTPUT CONTROL VARIABLES
                    IPRNT          3  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT        HYDROGRAPH TIME DATA
                     NMIN          5  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ         36  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      1   0  ENDING DATE
                   NDTIME       0255  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .08 HOURS
                     TOTAL TIME BASE    2.92 HOURS

          ENGLISH UNITS
              DRAINAGE AREA          SQUARE MILES
              PRECIPITATION DEPTH    INCHES
              LENGTH, ELEVATION      FEET
              FLOW                   CUBIC FEET PER SECOND
              STORAGE VOLUME         ACRE-FEET
              SURFACE AREA           ACRES
              TEMPERATURE            DEGREES FAHRENHEIT


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


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            *            *
  8 KK      *     SUBC1  *            RUNOFF HYDROGRAPH FROM AREA SUBC1
            *            *
            **************

 10 IN        TIME DATA FOR INPUT TIME SERIES
                    JXMIN          5  TIME INTERVAL IN MINUTES
                   JXDATE      1   0  STARTING DATE
                   JXTIME          0  STARTING TIME

              SUBBASIN RUNOFF DATA

  9 BA        SUBBASIN CHARACTERISTICS
                    TAREA        .03  SUBBASIN AREA

              PRECIPITATION DATA

 11 PB              STORM       2.77  BASIN TOTAL PRECIPITATION

 12 PI          INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                    .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                    .01       .00       .01       .01

 15 LG        GREEN AND AMPT LOSS RATE
                   STRTL        .35  STARTING LOSS
                     DTH        .35  MOISTURE DEFICIT
                    PSIF       6.05  WETTING FRONT SUCTION
                   XKSAT        .20  HYDRAULIC CONDUCTIVITY
                   RTIMP       1.00  PERCENT IMPERVIOUS AREA

 16 UC        CLARK UNITGRAPH
                      TC        .48  TIME OF CONCENTRATION
                       R        .42  STORAGE COEFFICIENT

 17 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                    .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
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                100.0

                                                    ***

                                              UNIT HYDROGRAPH PARAMETERS
                                       CLARK   TC=   .48 HR,       R=   .42 HR
                                      SNYDER   TP=   .42 HR,      CP=   .65

                                                UNIT HYDROGRAPH
                                           31 END-OF-PERIOD ORDINATES
                 1.       3.       6.      17.      28.      28.      24.      20.      16.      13.
                11.       9.       7.       6.       5.       4.       3.       3.       2.       2.
                 2.       1.       1.       1.       1.       1.       0.       0.       0.       0.
                 0.

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

                       HYDROGRAPH AT STATION    SUBC1

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     36.       1.50          9.          9.          9.          9.
                        (INCHES)      1.417       1.417       1.417       1.417
                         (AC-FT)         2.          2.          2.          2.

                        CUMULATIVE AREA =     .03 SQ MI


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


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            *            *
  19 KK     *     RCHC2  *            ROUTE HYDROGRAPH SUBC1 THRU REACH C2; GUNITE CHANNEL
            *            *
            **************

              HYDROGRAPH ROUTING DATA

  20 RK         KINEMATIC WAVE STREAM ROUTING
                          L       1400.  CHANNEL LENGTH
                          S       .0050  SLOPE
                          N        .016  CHANNEL ROUGHNESS COEFFICIENT
                         CA         .00  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       10.00  BOTTOM WIDTH OR DIAMETER
                          Z         .50  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                 ELEMENT    ALPHA       M        DT        DX       PEAK    TIME TO     VOLUME    MAXIMUM
                                                                             PEAK                  CELERITY
                                                (MIN)      (FT)     (CFS)     (MIN)      (IN)      (FPS)

                 MAIN         1.75      1.49      1.15    466.67     35.78     92.76      1.41      7.11

CONTINUITY SUMMARY (AC-FT) - INFLOW= .2117E+01  EXCESS= .0000E+00 OUTFLOW= .2099E+01 BASIN STORAGE= .2070E-01 PERCENT ERROR=   -.1

                                   INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                 MAIN         1.75      1.49      5.00               35.77     95.00      1.40

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

                       HYDROGRAPH AT STATION    RCHC2

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
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                                    6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     36.       1.58                  9.          9.          9.          9.
                         (INCHES)    1.399       1.399       1.399       1.399
                          (AC-FT)      2.          2.          2.          2.

                         CUMULATIVE AREA =     .03 SQ MI


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


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            *            *
  21 KK     *     SUBC2  *            RUNOFF HYDROGRAPH FROM AREA SUBC2
            *            *
            **************

              SUBBASIN RUNOFF DATA

  22 BA         SUBBASIN CHARACTERISTICS
                      TAREA         .03  SUBBASIN AREA

                PRECIPITATION DATA

  11 PB               STORM        2.77  BASIN TOTAL PRECIPITATION

  12 PI           INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                    .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                    .01       .00       .01       .01

  23 LG         GREEN AND AMPT LOSS RATE
                      STRTL         .35  STARTING LOSS
                        DTH         .35  MOISTURE DEFICIT
                       PSIF        6.05  WETTING FRONT SUCTION
                      XKSAT         .20  HYDRAULIC CONDUCTIVITY
                      RTIMP        1.00  PERCENT IMPERVIOUS AREA

  24 UC         CLARK UNITGRAPH
                         TC         .51  TIME OF CONCENTRATION
                          R         .53  STORAGE COEFFICIENT

  25 UA         ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                     100.0
                                                          ***

                                                UNIT HYDROGRAPH PARAMETERS
                                          CLARK   TC=   .51 HR,       R=   .53 HR
                                         SNYDER   TP=   .47 HR,      CP=   .63

                                                  UNIT HYDROGRAPH
                                              38 END-OF-PERIOD ORDINATES
                 1.        2.        4.       11.       20.       23.       21.       18.       16.       13.
                11.       10.        8.        7.        6.        5.        4.        4.        3.        3.
                 2.        2.        2.        1.        1.        1.        1.        1.        1.        1.
                 0.        0.        0.        0.        0.        0.        0.        0.

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

                         HYDROGRAPH AT STATION    SUBC2

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                    6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     30.       1.58                  8.          8.          8.          8.
                         (INCHES)    1.371       1.371       1.371       1.371
                          (AC-FT)      2.          2.          2.          2.

                         CUMULATIVE AREA =     .03 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

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          *            *
  27 KK   *     SUMC2  *            COMBINE HYDROGRAPHS RCHC2 AND SUBC2
          *            *
          **************

  28 HC         HYDROGRAPH COMBINATION
                     ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                          ***

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

                       HYDROGRAPH AT STATION    SUMC2

 PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                   6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                         (CFS)
+     66.      1.58                17.         17.         17.         17.
                       (INCHES)    1.385       1.385       1.385       1.385
                        (AC-FT)     4.          4.          4.          4.

                       CUMULATIVE AREA =     .05 SQ MI


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

          **************
          *            *
  29 KK   *     RCHC3  *            ROUTE HYDROGRAPH SUMC2 THRU REACH C3; GUNITE CHANNEL
          *            *
          **************

             HYDROGRAPH ROUTING DATA

  30 RK         KINEMATIC WAVE STREAM ROUTING
                          L       1600.  CHANNEL LENGTH
                          S       .0050  SLOPE
                          N        .016  CHANNEL ROUGHNESS COEFFICIENT
                         CA         .00  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       10.00  BOTTOM WIDTH OR DIAMETER
                          Z         .50  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                 ELEMENT    ALPHA       M        DT        DX       PEAK    TIME TO     VOLUME    MAXIMUM
                                                                              PEAK                  CELERITY
                                                (MIN)      (FT)     (CFS)    (MIN)       (IN)      (FPS)

                 MAIN         1.75      1.49      1.13    533.33     65.71    97.29      1.37      8.70

CONTINUITY SUMMARY (AC-FT) - INFLOW= .4064E+01  EXCESS= .0000E+00 OUTFLOW= .4029E+01 BASIN STORAGE= .4724E-01 PERCENT ERROR=   -.3

                                  INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                 MAIN         1.75      1.49      5.00               64.04    95.00      1.37

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

                       HYDROGRAPH AT STATION    RCHC3

 PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                   6-HR       24-HR       72-HR      2.92-HR
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+   (CFS)       (HR)
                          (CFS)
+      64.      1.58                  17.         17.         17.         17.
                         (INCHES)    1.367       1.367       1.367       1.367
                          (AC-FT)      4.          4.          4.          4.

                         CUMULATIVE AREA =     .05 SQ MI


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


            **************
            *            *
   31 KK    *     SUBC3  *            RUNOFF HYDROGRAPH FROM AREA SUBC3
            *            *
            **************

              SUBBASIN RUNOFF DATA

   32 BA        SUBBASIN CHARACTERISTICS
                      TAREA          .06  SUBBASIN AREA

                PRECIPITATION DATA

   11 PB              STORM        2.77  BASIN TOTAL PRECIPITATION

   12 PI          INCREMENTAL PRECIPITATION PATTERN
                     .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                     .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                     .01       .00       .01       .01

   33 LG        GREEN AND AMPT LOSS RATE
                      STRTL         .35  STARTING LOSS
                        DTH         .35  MOISTURE DEFICIT
                       PSIF        6.05  WETTING FRONT SUCTION
                      XKSAT         .20  HYDRAULIC CONDUCTIVITY
                      RTIMP        1.00  PERCENT IMPERVIOUS AREA

   34 UC        CLARK UNITGRAPH
                         TC         .49  TIME OF CONCENTRATION
                          R         .38  STORAGE COEFFICIENT

   35 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                       .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                    100.0

                                                   ***

                                                UNIT HYDROGRAPH PARAMETERS
                                         CLARK   TC=   .49 HR,       R=   .38 HR
                                        SNYDER   TP=   .42 HR,      CP=   .70

                                                UNIT HYDROGRAPH
                                            28 END-OF-PERIOD ORDINATES
                 2.        6.       14.       41.       67.       69.       58.       47.       38.       30.
                24.       20.       16.       13.       10.        8.        7.        5.        4.        3.
                 3.        2.        2.        1.        1.        1.        1.        1.

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

                        HYDROGRAPH AT STATION    SUBC3

     TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+      87.      1.58                  20.         20.         20.         20.
                         (INCHES)    1.429       1.429       1.429       1.429
                          (AC-FT)      5.          5.          5.          5.

                         CUMULATIVE AREA =     .06 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
  37 KK     *     SUMC3  *            COMBINE HYDROGRAPHS RCHC3 AND SUBC3
            *            *
            **************

  38 HC          HYDROGRAPH COMBINATION
                      ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                          ***

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

                        HYDROGRAPH AT STATION    SUMC3

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                    6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                         (CFS)
+    151.      1.58                37.         37.         37.         37.
                       (INCHES)    1.401       1.401       1.401       1.401
                        (AC-FT)      9.          9.          9.          9.

                       CUMULATIVE AREA =     .12 SQ MI


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

            **************
            *            *
  39 KK     *     RCHC4  *            ROUTE HYDROGRAPH SUMC3 THRU REACH C4; GUNITE CHANNEL
            *            *
            **************

             HYDROGRAPH ROUTING DATA

  40 RK        KINEMATIC WAVE STREAM ROUTING
                        L       1400.  CHANNEL LENGTH
                        S       .0050  SLOPE
                        N        .016  CHANNEL ROUGHNESS COEFFICIENT
                       CA         .00  CONTRIBUTING AREA
                    SHAPE        TRAP  CHANNEL SHAPE
                       WD       10.00  BOTTOM WIDTH OR DIAMETER
                        Z         .50  SIDE SLOPE
                   NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                 ELEMENT    ALPHA       M        DT        DX       PEAK    TIME TO     VOLUME    MAXIMUM
                                                                              PEAK                  CELERITY
                                                     (MIN)     (FT)     (CFS)    (MIN)      (IN)      (FPS)

                 MAIN         1.75      1.49        .79    466.67    150.17     96.55      1.39     11.44

CONTINUITY SUMMARY (AC-FT) - INFLOW= .8889E+01  EXCESS= .0000E+00 OUTFLOW= .8838E+01 BASIN STORAGE= .6064E-01 PERCENT ERROR=   -.1

                                      INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                 MAIN         1.75      1.49       5.00              148.12     95.00      1.39

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

                        HYDROGRAPH AT STATION    RCHC4

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                    6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                         (CFS)
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+    148.      1.58                    37.         37.         37.         37.
                          (INCHES)    1.391       1.391       1.391       1.391
                           (AC-FT)      9.          9.          9.          9.

                          CUMULATIVE AREA =     .12 SQ MI


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


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            *            *
  41 KK     *     SUBC4  *            RUNOFF HYDROGRAPH FROM AREA SUBC4
            *            *
            **************

               SUBBASIN RUNOFF DATA

  42 BA          SUBBASIN CHARACTERISTICS
                       TAREA         .06  SUBBASIN AREA

                 PRECIPITATION DATA

  11 PB                STORM        2.77  BASIN TOTAL PRECIPITATION

  12 PI            INCREMENTAL PRECIPITATION PATTERN
                     .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                     .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                     .01       .00       .01       .01

  43 LG          GREEN AND AMPT LOSS RATE
                       STRTL         .35  STARTING LOSS
                         DTH         .35  MOISTURE DEFICIT
                        PSIF        6.05  WETTING FRONT SUCTION
                       XKSAT         .20  HYDRAULIC CONDUCTIVITY
                       RTIMP        1.00  PERCENT IMPERVIOUS AREA

  44 UC          CLARK UNITGRAPH
                          TC         .48  TIME OF CONCENTRATION
                           R         .44  STORAGE COEFFICIENT

  45 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                     100.0

                                                   ***

                                                UNIT HYDROGRAPH PARAMETERS
                                          CLARK   TC=   .48 HR,       R=   .44 HR
                                         SNYDER   TP=   .42 HR,      CP=   .63

                                                UNIT HYDROGRAPH
                                            32 END-OF-PERIOD ORDINATES
                 2.        5.       12.       35.       56.       56.       49.       40.       33.       28.
                23.       19.       16.       13.       11.        9.        7.        6.        5.        4.
                 3.        3.        2.        2.        2.        1.        1.        1.        1.        1.
                 1.        0.

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

                        HYDROGRAPH AT STATION    SUBC4

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                           (CFS)
+     72.       1.58                     18.         18.         18.         18.
                          (INCHES)    1.411       1.411       1.411       1.411
                           (AC-FT)      4.          4.          4.          4.

                          CUMULATIVE AREA =     .06 SQ MI


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              *            *
   47 KK      *     SUMC4  *            COMBINE HYDROGRAPHS RCHC4 AND SUBC4
              *            *
              **************

   48 HC          HYDROGRAPH COMBINATION
                       ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                                  ***

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

                        HYDROGRAPH AT STATION    SUMC4

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                            (CFS)
+    220.       1.58                 55.         55.         55.         55.
                          (INCHES)  1.398       1.398       1.398       1.398
                           (AC-FT)   13.         13.         13.         13.

                          CUMULATIVE AREA =     .18 SQ MI


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


              **************
              *            *
   49 KK      *     RCHD1  *            ROUTE HYDROGRAPH SUMC4 THRU REACH D1; GUNITE CHANNEL
              *            *
              **************

                HYDROGRAPH ROUTING DATA

   50 RK          KINEMATIC WAVE STREAM ROUTING
                            L        600.  CHANNEL LENGTH
                            S       .0050  SLOPE
                            N        .016  CHANNEL ROUGHNESS COEFFICIENT
                           CA         .00  CONTRIBUTING AREA
                        SHAPE        TRAP  CHANNEL SHAPE
                           WD       10.00  BOTTOM WIDTH OR DIAMETER
                            Z         .50  SIDE SLOPE
                       NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                     ELEMENT    ALPHA       M        DT        DX      PEAK    TIME TO     VOLUME    MAXIMUM
                                                                                  PEAK                CELERITY
                                                     (MIN)     (FT)    (CFS)    (MIN)       (IN)      (FPS)

                      MAIN        1.75      1.49       .30    200.00   220.05    95.51       1.39     12.97

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1319E+02  EXCESS= .0000E+00 OUTFLOW= .1316E+02 BASIN STORAGE= .3453E-01 PERCENT ERROR=    .0

                                        INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                      MAIN        1.75      1.49      5.00             218.66    95.00      1.40

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

                        HYDROGRAPH AT STATION    RCHD1

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                            (CFS)
+    219.       1.58                 55.         55.         55.         55.
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                    (INCHES)     1.396       1.396       1.396       1.396
                     (AC-FT)      13.         13.         13.         13.

                    CUMULATIVE AREA =     .18 SQ MI


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


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          *            *
 51 KK    *    SUBD1   *          RUNOFF HYDROGRAPH FROM AREA SUBD1
          *            *
          **************

            SUBBASIN RUNOFF DATA

 52 BA        SUBBASIN CHARACTERISTICS
                   TAREA         .03  SUBBASIN AREA

              PRECIPITATION DATA

 11 PB             STORM        2.77  BASIN TOTAL PRECIPITATION

 12 PI          INCREMENTAL PRECIPITATION PATTERN
                  .01      .01      .01      .01      .00      .01      .03      .03      .04      .04
                  .06      .09      .27      .14      .12      .04      .03      .02      .01      .01
                  .01      .00      .01      .01

 53 LG        GREEN AND AMPT LOSS RATE
                   STRTL         .35  STARTING LOSS
                     DTH         .35  MOISTURE DEFICIT
                    PSIF        4.34  WETTING FRONT SUCTION
                   XKSAT         .26  HYDRAULIC CONDUCTIVITY
                   RTIMP        1.00  PERCENT IMPERVIOUS AREA

 54 UC        CLARK UNITGRAPH
                      TC         .41  TIME OF CONCENTRATION
                       R         .46  STORAGE COEFFICIENT

 55 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .41 HR,       R=   .46 HR
                                   SNYDER   TP=   .39 HR,      CP=   .62

                                          UNIT HYDROGRAPH
                                     33 END-OF-PERIOD ORDINATES
              1.       4.      12.      27.      33.      30.      25.      21.      17.      14.
             12.      10.       8.       7.       6.       5.       4.       3.       3.       2.
              2.       2.       1.       1.       1.       1.       1.       1.       0.       0.
              0.       0.       0.

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

                     HYDROGRAPH AT STATION    SUBD1

   TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.32, TOTAL EXCESS =    1.45

  PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR      72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     41.       1.50                10.        10.        10.        10.
                    (INCHES)     1.405      1.405      1.405      1.405
                     (AC-FT)      2.         2.         2.         2.

                    CUMULATIVE AREA =     .03 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
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            **************
            *            *
  57 KK     *     SUMD1  *            COMBINE HYDROGRAPHS RCHD1 AND SUBD1
            *            *
            **************

  58 HC          HYDROGRAPH COMBINATION
                      ICOMP           2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                                  ***

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

                        HYDROGRAPH AT STATION    SUMD1

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                   6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                          (CFS)
+    258.      1.58                65.         65.         65.         65.
                        (INCHES)    1.397       1.397       1.397       1.397
                         (AC-FT)    16.         16.         16.         16.

                        CUMULATIVE AREA =     .21 SQ MI


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


            **************
            *            *
  59 KK     *     RCHD2  *            ROUTE HYDROGRAPH SUMD1 THRU REACH D2; GUNITE CHANNEL
            *            *
            **************

             HYDROGRAPH ROUTING DATA

  60 RK          KINEMATIC WAVE STREAM ROUTING
                          L        900.  CHANNEL LENGTH
                          S       .0050  SLOPE
                          N        .016  CHANNEL ROUGHNESS COEFFICIENT
                         CA         .00  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       10.00  BOTTOM WIDTH OR DIAMETER
                          Z         .50  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                 ELEMENT    ALPHA       M         DT        DX       PEAK    TIME TO     VOLUME    MAXIMUM
                                                                              PEAK                  CELERITY
                                                   (MIN)     (FT)     (CFS)    (MIN)       (IN)      (FPS)

                 MAIN         1.75      1.49        .49    300.00    256.63    95.76       1.39     13.66

CONTINUITY SUMMARY (AC-FT) - INFLOW= .1565E+02  EXCESS= .0000E+00 OUTFLOW= .1559E+02 BASIN STORAGE= .5920E-01 PERCENT ERROR=    .0

                                        INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                 MAIN         1.75      1.49       5.00              254.78    95.00       1.39

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

                        HYDROGRAPH AT STATION    RCHD2

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                   6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                          (CFS)
+    255.      1.58                65.         65.         65.         65.
                        (INCHES)    1.394       1.394       1.394       1.394
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                    (AC-FT)       16.         16.         16.         16.

                    CUMULATIVE AREA =     .21 SQ MI


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


          **************
          *            *
 61 KK    *     SUBD2  *            RUNOFF HYDROGRAPH FROM AREA SUBD2
          *            *
          **************

             SUBBASIN RUNOFF DATA

 62 BA         SUBBASIN CHARACTERISTICS
                    TAREA         .05  SUBBASIN AREA

               PRECIPITATION DATA

 11 PB              STORM        2.77  BASIN TOTAL PRECIPITATION

 12 PI           INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                    .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                    .01       .00       .01       .01

 63 LG         GREEN AND AMPT LOSS RATE
                    STRTL         .35  STARTING LOSS
                      DTH         .35  MOISTURE DEFICIT
                     PSIF        4.34  WETTING FRONT SUCTION
                    XKSAT         .26  HYDRAULIC CONDUCTIVITY
                    RTIMP        1.00  PERCENT IMPERVIOUS AREA

 64 UC         CLARK UNITGRAPH
                       TC         .47  TIME OF CONCENTRATION
                        R         .48  STORAGE COEFFICIENT

 65 UA         ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .47 HR,       R=   .48 HR
                                    SNYDER   TP=   .42 HR,      CP=   .60

                                              UNIT HYDROGRAPH
                                          34 END-OF-PERIOD ORDINATES
              2.        5.       11.       32.       50.       50.       44.       37.       31.       26.
             22.       18.       16.       13.       11.        9.        8.        7.        5.        5.
              4.        3.        3.        2.        2.        2.        1.        1.        1.        1.
              1.        1.        0.        0.

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

                        HYDROGRAPH AT STATION    SUBD2

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.32, TOTAL EXCESS =    1.45

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                             (CFS)
+     65.       1.58                     17.         17.         17.         17.
                           (INCHES)    1.392       1.392       1.392       1.392
                            (AC-FT)       4.          4.          4.          4.

                        CUMULATIVE AREA =     .05 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
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              **************
              *            *
   67 KK      *     SUMD2  *            COMBINE HYDROGRAPHS RCHD2 AND SUBD2
              *            *
              **************

   68 HC          HYDROGRAPH COMBINATION
                       ICOMP           2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                                  ***

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

                          HYDROGRAPH AT STATION    SUMD2

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                             (CFS)
+     320.      1.58                     82.         82.         82.         82.
                         (INCHES)     1.393       1.393       1.393       1.393
                          (AC-FT)      20.         20.         20.         20.

                         CUMULATIVE AREA =     .27 SQ MI


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


              **************
              *            *
   69 KK      *     RCHD3  *            ROUTE HYDROGRAPH SUMD2 THRU REACH D3; GUNITE CHANNEL
              *            *
              **************

              HYDROGRAPH ROUTING DATA

   70 RK          KINEMATIC WAVE STREAM ROUTING
                            L        850.  CHANNEL LENGTH
                            S       .0050  SLOPE
                            N        .016  CHANNEL ROUGHNESS COEFFICIENT
                           CA         .00  CONTRIBUTING AREA
                        SHAPE        TRAP  CHANNEL SHAPE
                           WD       10.00  BOTTOM WIDTH OR DIAMETER
                            Z         .50  SIDE SLOPE
                       NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                     ELEMENT    ALPHA       M        DT        DX      PEAK    TIME TO     VOLUME    MAXIMUM
                                                                                 PEAK                  CELERITY
                                                     (MIN)      (FT)     (CFS)    (MIN)      (IN)      (FPS)

                     MAIN         1.75      1.49       .35    283.33    319.62    95.67      1.39     14.67

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1969E+02  EXCESS= .0000E+00 OUTFLOW= .1964E+02 BASIN STORAGE= .6719E-01 PERCENT ERROR=   -.1

                                          INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                     MAIN         1.75      1.49      5.00              316.63    95.00      1.39

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

                          HYDROGRAPH AT STATION    RCHD3

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                             (CFS)
+     317.      1.58                     82.         82.         82.         82.
                         (INCHES)     1.390       1.390       1.390       1.390
                          (AC-FT)      20.         20.         20.         20.
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                    CUMULATIVE AREA =     .27 SQ MI

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

          **************
          *            *
 71 KK    *    SUBD3   *          RUNOFF HYDROGRAPH FROM AREA SUBD3
          *            *
          **************

            SUBBASIN RUNOFF DATA

 72 BA        SUBBASIN CHARACTERISTICS
                   TAREA         .08  SUBBASIN AREA

              PRECIPITATION DATA

 11 PB             STORM        2.77  BASIN TOTAL PRECIPITATION

 12 PI          INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .00      .01      .03      .03      .04      .04
                   .06      .09      .27      .14      .12      .04      .03      .02      .01      .01
                   .01      .00      .01      .01

 73 LG        GREEN AND AMPT LOSS RATE
                   STRTL         .35  STARTING LOSS
                     DTH         .35  MOISTURE DEFICIT
                    PSIF        4.34  WETTING FRONT SUCTION
                   XKSAT         .26  HYDRAULIC CONDUCTIVITY
                   RTIMP        1.00  PERCENT IMPERVIOUS AREA

 74 UC        CLARK UNITGRAPH
                      TC         .53  TIME OF CONCENTRATION
                       R         .50  STORAGE COEFFICIENT

 75 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                   CLARK   TC=   .53 HR,      R=   .50 HR
                                  SNYDER   TP=   .49 HR,     CP=   .67

                                          UNIT HYDROGRAPH
                                     36 END-OF-PERIOD ORDINATES
             2.       6.      11.      30.      59.      72.      67.      58.      49.      42.
            35.      30.      25.      21.      18.      15.      13.      11.       9.       8.
             7.       6.       5.       4.       3.       3.       2.       2.       2.       2.
             1.       1.       1.       1.       1.       1.

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

                    HYDROGRAPH AT STATION    SUBD3

   TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.32, TOTAL EXCESS =    1.45

  PEAK FLOW     TIME                      MAXIMUM AVERAGE FLOW
                                   6-HR      24-HR      72-HR     2.92-HR
+   (CFS)       (HR)
                            (CFS)
+     93.       1.58                25.        25.        25.        25.
                         (INCHES)  1.376      1.376      1.376      1.376
                          (AC-FT)    6.         6.         6.         6.

                    CUMULATIVE AREA =     .08 SQ MI

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

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                *            *
 77 KK          *    SUMD3   *          COMBINE HYDROGRAPHS RCHD3 AND SUBD3
                *            *
                **************

 78 HC            HYDROGRAPH COMBINATION
                        ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                                  ***

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

                          HYDROGRAPH AT STATION    SUMD3

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                       6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                            (CFS)
+    409.       1.58                   106.        106.        106.        106.
                        (INCHES)     1.387       1.387       1.387       1.387
                         (AC-FT)       26.         26.         26.         26.

                        CUMULATIVE AREA =     .35 SQ MI


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


                **************
                *            *
 79 KK          *    SUBD4   *          RUNOFF HYDROGRAPH FROM AREA SUBD4
                *            *
                **************

              SUBBASIN RUNOFF DATA

 80 BA          SUBBASIN CHARACTERISTICS
                        TAREA        .09  SUBBASIN AREA

                PRECIPITATION DATA

 11 PB                  STORM       2.77  BASIN TOTAL PRECIPITATION

 12 PI            INCREMENTAL PRECIPITATION PATTERN
                      .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                      .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                      .01       .00       .01       .01

 81 LG          GREEN AND AMPT LOSS RATE
                        STRTL        .35  STARTING LOSS
                          DTH        .35  MOISTURE DEFICIT
                         PSIF       4.34  WETTING FRONT SUCTION
                        XKSAT        .26  HYDRAULIC CONDUCTIVITY
                        RTIMP       1.00  PERCENT IMPERVIOUS AREA

 82 UC          CLARK UNITGRAPH
                           TC        .51  TIME OF CONCENTRATION
                            R        .46  STORAGE COEFFICIENT

 83 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                         .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                       100.0

                                                                  ***

                                                   UNIT HYDROGRAPH PARAMETERS
                                            CLARK   TC=   .51 HR,       R=   .46 HR
                                           SNYDER   TP=   .46 HR,      CP=   .69

                                                      UNIT HYDROGRAPH
                                                 33 END-OF-PERIOD ORDINATES
                2.        7.       15.       41.       76.       86.       77.       64.       54.       45.
               37.       31.       26.       22.       18.       15.       12.       10.        9.        7.
                6.        5.        4.        3.        3.        2.        2.        2.        1.        1.
                1.        1.        1.

     ***            ***            ***            ***            ***
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                    HYDROGRAPH AT STATION    SUBD4

   TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.32, TOTAL EXCESS =    1.45

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     109.      1.58                  28.         28.         28.         28.
                         (INCHES)    1.398       1.398       1.398       1.398
                          (AC-FT)      7.          7.          7.          7.

                         CUMULATIVE AREA =     .09 SQ MI


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


            **************
            *            *
  85 KK     *     RCHD4  *            ROUTE HYDROGRAPH SUBD4 THRU REACH D4; GUNITE CHANNEL
            *            *
            **************

               HYDROGRAPH ROUTING DATA

  86 RK          KINEMATIC WAVE STREAM ROUTING
                            L        850.  CHANNEL LENGTH
                            S       .0050  SLOPE
                            N        .016  CHANNEL ROUGHNESS COEFFICIENT
                           CA         .00  CONTRIBUTING AREA
                        SHAPE        TRAP  CHANNEL SHAPE
                           WD       10.00  BOTTOM WIDTH OR DIAMETER
                            Z         .50  SIDE SLOPE
                       NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

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

                 ELEMENT    ALPHA       M        DT        DX       PEAK    TIME TO     VOLUME    MAXIMUM
                                                                              PEAK                  CELERITY
                                                  (MIN)     (FT)     (CFS)    (MIN)      (IN)      (FPS)

                 MAIN         1.75      1.49       .56    283.33    108.66    96.17      1.39      10.28

CONTINUITY SUMMARY (AC-FT) - INFLOW= .6634E+01  EXCESS= .0000E+00 OUTFLOW= .6607E+01 BASIN STORAGE= .3084E-01 PERCENT ERROR=    .0

                                   INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                 MAIN         1.75      1.49      5.00              108.08    95.00      1.39

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

                    HYDROGRAPH AT STATION    RCHD4

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR      2.92-HR
+   (CFS)       (HR)
                          (CFS)
+     108.      1.58                  27.         27.         27.         27.
                         (INCHES)    1.393       1.393       1.393       1.393
                          (AC-FT)      7.          7.          7.          7.

                         CUMULATIVE AREA =     .09 SQ MI


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


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87 KK      *     SUMD4  *            COMBINE HYDROGRAPHS RCHD4 AND SUMD3
           *            *
           **************

88 HC          HYDROGRAPH COMBINATION
                    ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                          ***

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

                        HYDROGRAPH AT STATION    SUMD4

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR      2.92-HR
+  (CFS)       (HR)
                                   (CFS)
+    517.      1.58                  134.        134.        134.        134.
                                 (INCHES)      1.388       1.388       1.388       1.388
                                  (AC-FT)       32.         32.         32.         32.

                        CUMULATIVE AREA =     .44 SQ MI

1
                                                   RUNOFF SUMMARY
                                              FLOW IN CUBIC FEET PER SECOND
                                            TIME IN HOURS,  AREA IN SQUARE MILES

                                          PEAK   TIME OF    AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN    MAXIMUM    TIME OF
          OPERATION        STATION       FLOW    PEAK                                          AREA     STAGE     MAX STAGE
+                                                          6-HOUR      24-HOUR     72-HOUR

          HYDROGRAPH AT
+                          SUBC1          36.    1.50        9.          9.          9.        .03
          ROUTED TO
+                          RCHC2          36.    1.58        9.          9.          9.        .03
          HYDROGRAPH AT
+                          SUBC2          30.    1.58        8.          8.          8.        .03
          2 COMBINED AT
+                          SUMC2          66.    1.58       17.         17.         17.        .05
          ROUTED TO
+                          RCHC3          64.    1.58       17.         17.         17.        .05
          HYDROGRAPH AT
+                          SUBC3          87.    1.58       20.         20.         20.        .06
          2 COMBINED AT
+                          SUMC3         151.    1.58       37.         37.         37.        .12
          ROUTED TO
+                          RCHC4         148.    1.58       37.         37.         37.        .12
          HYDROGRAPH AT
+                          SUBC4          72.    1.58       18.         18.         18.        .06
          2 COMBINED AT
+                          SUMC4         220.    1.58       55.         55.         55.        .18
          ROUTED TO
+                          RCHD1         219.    1.58       55.         55.         55.        .18
          HYDROGRAPH AT
+                          SUBD1          41.    1.50       10.         10.         10.        .03
          2 COMBINED AT
+                          SUMD1         258.    1.58       65.         65.         65.        .21
          ROUTED TO
+                          RCHD2         255.    1.58       65.         65.         65.        .21
          HYDROGRAPH AT
+                          SUBD2          65.    1.58       17.         17.         17.        .05
          2 COMBINED AT
+                          SUMD2         320.    1.58       82.         82.         82.        .27
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          ROUTED TO
+                         RCHD3      317.    1.58        82.        82.        82.       .27

          HYDROGRAPH AT
+                         SUBD3       93.    1.58        25.        25.        25.       .08

          2 COMBINED AT
+                         SUMD3      409.    1.58       106.       106.       106.       .35

          HYDROGRAPH AT
+                         SUBD4      109.    1.58        28.        28.        28.       .09

          ROUTED TO
+                         RCHD4      108.    1.58        27.        27.        27.       .09

          2 COMBINED AT
+                         SUMD4      517.    1.58       134.       134.       134.       .44
1
                                   SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                      (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                          INTERPOLATED TO
                                                                       COMPUTATION INTERVAL
          ISTAQ    ELEMENT      DT       PEAK    TIME TO     VOLUME      DT       PEAK    TIME TO     VOLUME
                                                   PEAK                                     PEAK

                              (MIN)     (CFS)     (MIN)      (IN)    (MIN)     (CFS)     (MIN)      (IN)

            RCHC2  MANE        1.15     35.78     92.76      1.41     5.00     35.77     95.00      1.40

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .2117E+01 EXCESS= .0000E+00 OUTFLOW= .2099E+01 BASIN STORAGE= .2070E-01 PERCENT ERROR=   -.1

            RCHC3  MANE        1.13     65.71     97.29      1.37     5.00     64.04     95.00      1.37

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .4064E+01 EXCESS= .0000E+00 OUTFLOW= .4029E+01 BASIN STORAGE= .4724E-01 PERCENT ERROR=   -.3

            RCHC4  MANE         .79    150.17     96.55      1.39     5.00    148.12     95.00      1.39

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .8889E+01 EXCESS= .0000E+00 OUTFLOW= .8838E+01 BASIN STORAGE= .6064E-01 PERCENT ERROR=   -.1

            RCHD1  MANE         .30    220.05     95.51      1.39     5.00    218.66     95.00      1.40

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1319E+02 EXCESS= .0000E+00 OUTFLOW= .1316E+02 BASIN STORAGE= .3453E-01 PERCENT ERROR=    .0

            RCHD2  MANE         .49    256.63     95.76      1.39     5.00    254.78     95.00      1.39

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1565E+02 EXCESS= .0000E+00 OUTFLOW= .1559E+02 BASIN STORAGE= .5920E-01 PERCENT ERROR=    .0

            RCHD3  MANE         .35    319.62     95.67      1.39     5.00    316.63     95.00      1.39

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1969E+02 EXCESS= .0000E+00 OUTFLOW= .1964E+02 BASIN STORAGE= .6719E-01 PERCENT ERROR=   -.1

            RCHD4  MANE         .56    108.66     96.17      1.39     5.00    108.08     95.00      1.39

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .6634E+01 EXCESS= .0000E+00 OUTFLOW= .6607E+01 BASIN STORAGE= .3084E-01 PERCENT ERROR=    .0


*** NORMAL END OF HEC-1 ***
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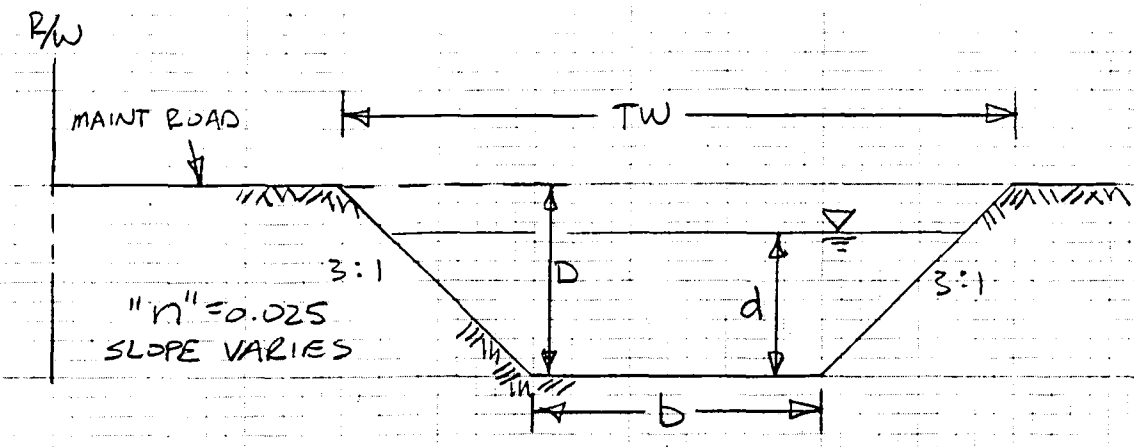
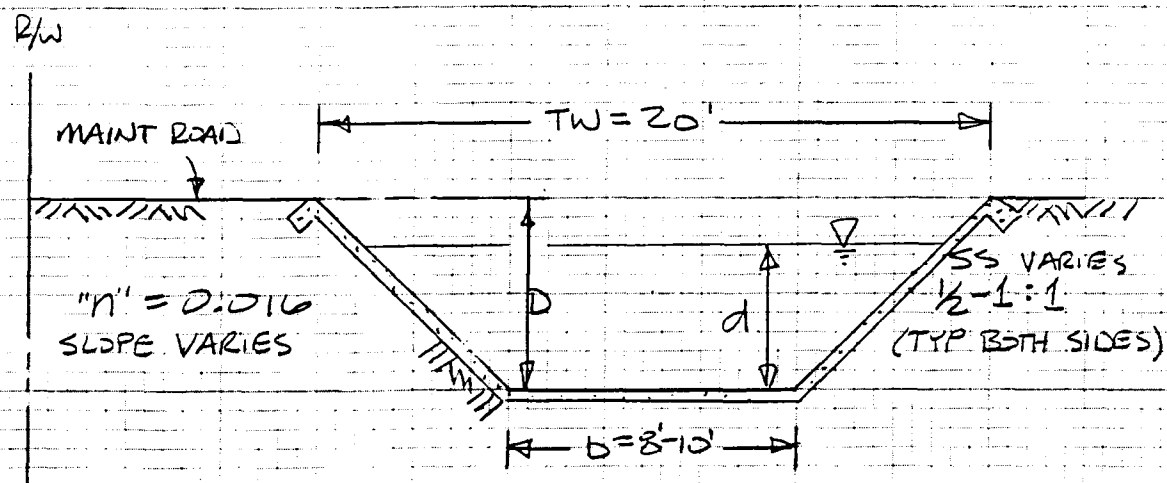
APPENDIX B
HYDRAULICS

DESIGNED BY GSB	DATE 7-1-92	SHEET NO. 1	PAGE NO.
CHECKED BY	DATE	OF 2	JOB NO.
REVIEWED BY	DATE	SUBJECT: ESTRELLA FREEWAY	
APPROVED BY	DATE	TYPICAL CHANNEL SECTIONS	



TYPICAL EARTH CHANNEL

SEE SUMMARY TABLE ON SHT 2 OF 2
FOR SLOPE, D, d, b, TW



TYPICAL GUNITE CHANNEL

SEE SUMMARY TABLE ON SHT 2 OF 2
FOR SLOPE, D AND d.

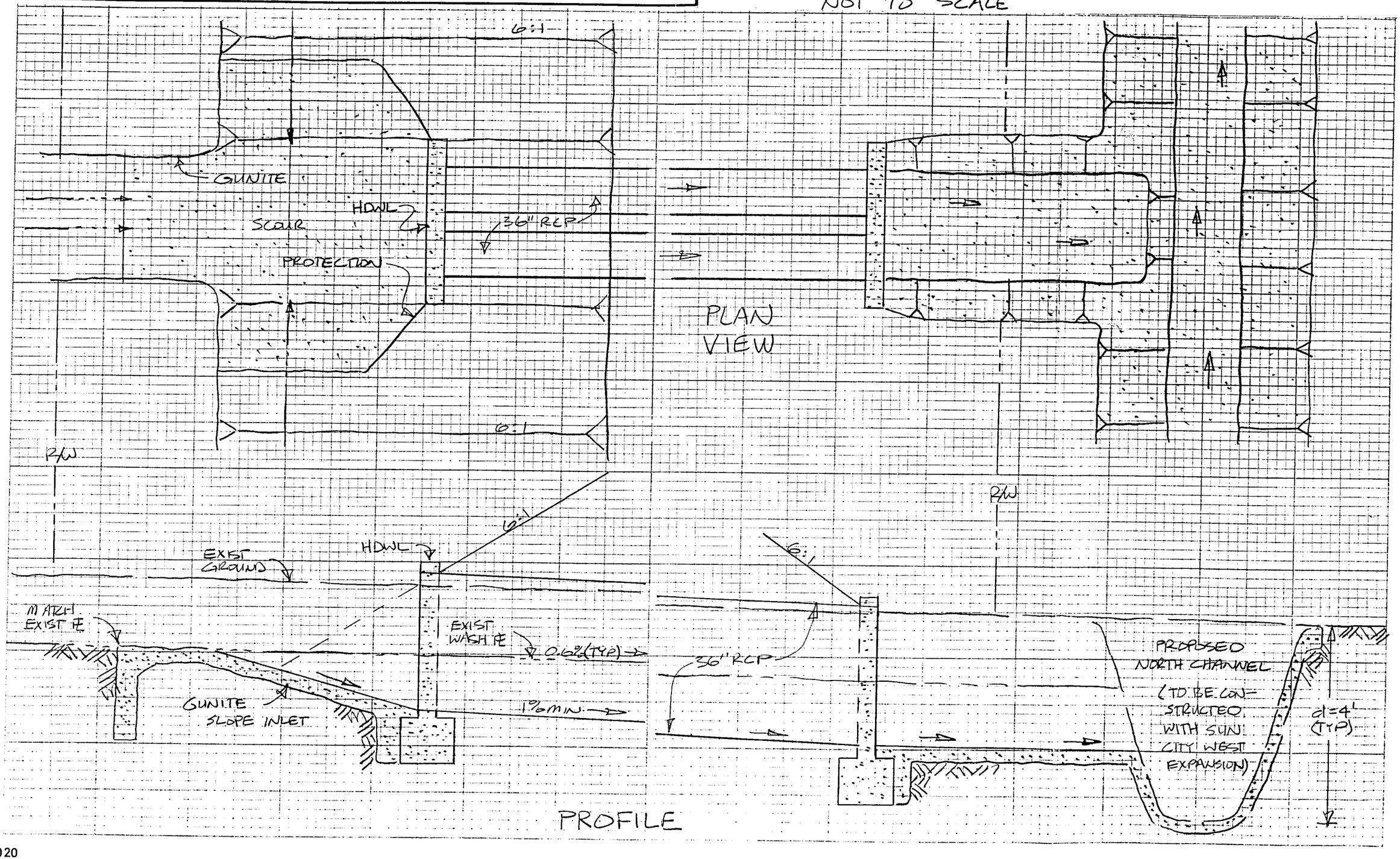
					Gunite Channel			Earth Channel				
Reach	Length	Slope	Depth D	Q2 Q100	Flow Depth	Avg. Vel.	Froude #	Flow Depth	Bottom Width b	Top Width TW	Avg. Vel.	Froude #
RCH C2	1430 Ft.	0.30%	3.0-5.0 Ft.	13 CFS	0.5 Ft.	3.1 Ft./Sec.	0.76	0.8	5 Ft.	23-35 Ft.	2.3 Ft.Sec.	0.52
				36 CFS	1.0 Ft.	4.4 Ft./Sec.	0.81	1.3	5 Ft.	23-35 Ft.	3.0 Ft./Sec.	0.55
RCH C3	1570 Ft.	0.30%	5.0 Ft.	24 CFS	0.7 Ft.	3.6 Ft./Sec.	0.79	1.1	5 Ft.	35 Ft.	2.7 Ft./Sec.	0.54
				66 CFS	1.2 Ft.	5.1 Ft./Sec.	0.84	1.8	5 Ft.	35 Ft.	3.6 Ft./Sec.	0.58
RCH C4	1380 Ft.	0.30%	4.0-9.0 Ft.	54 CFS	1.1 Ft.	4.8 Ft./Sec.	0.83	1.6	5 Ft.	29-59 Ft.	3.4 Ft./Sec.	0.57
				151 CFS	2.0 Ft.	6.8 Ft./Sec.	0.88	2.7	5 Ft.	29-59 Ft.	4.4 Ft.	0.61
RCH D1	620 Ft.	0.40%	4.0-5.0 Ft.	79 CFS	1.2 Ft.	6.0 Ft./Sec.	0.98	1.8	5 Ft.	29-35 Ft.	4.1 Ft.	0.67
				220 CFS	2.3 Ft.	8.4 Ft./Sec.	1.02	2.9	5 Ft.	29-35 Ft.	5.4 Ft.	0.71
RCH D2	930 Ft.	0.40%	5.5 Ft.	93 CFS	1.4 Ft.	6.3 Ft./Sec.	0.98	1.6	10 Ft.	43 Ft.	4.1 Ft.	0.67
				258 CFS	2.6 Ft.	8.9 Ft./Sec.	1.02	2.6	10 Ft.	43 Ft.	5.5 Ft.	0.72
RCH D3	850 Ft.	0.45%	5.5-6.0 Ft.	115 CFS	1.5 Ft.	7.1 Ft./Sec.	1.05	1.7	10 Ft.	43-46 Ft.	4.6 Ft.	0.72
				320 CFS	2.9 Ft.	9.9 Ft./Sec.	1.09	2.8	10 Ft.	43-46 Ft.	6.1 Ft.	0.77
RCH D4	850 Ft.	0.30%	4.0-5.0 Ft.	39 CFS	0.9 Ft.	4.3 Ft./Sec.	0.82	1.4	5 Ft.	29-35 Ft.	3.1 Ft.	0.56
				109 CFS	1.7 Ft.	6.1 Ft./Sec.	0.86	2.3	5 Ft.	29-35 Ft.	4.1 Ft.	0.59

Notes: All hydraulic data based on Manning normal depth.
Q_2 is estimated based on P_2/P_{100} xQ_{100}.

SHT 2/2

DESIGNED BY GSB	DATE 6-10-92	SHEET NO. 1	PAGE NO.
CHECKED BY WHH	DATE 9-15-92	OF 3	JOB NO. 11293
REVIEWED BY	DATE	SUBJECT: ESTRELLA FREEWAY	
APPROVED BY	DATE	TYPICAL CULVERT SCHEMATIC	

NOT TO SCALE



SC 3020

CROSS CULVERTS FOR REVISED ESTRELLA FREEWAY ALIGNMENT

Drainage Area	Station	Area	*Q50	Exist. Flow Line at Freeway Centerline	Culvert	CFS** Per Barrel	Head @ Culv. Inlet
	1144+00	53 AC	235 CFS	1318.9	2-6'x6' CBC	118 CFS	4.0
	1158+60	54	240	1318.0	2-8'x6' CBC	120	3.4
	1169+80	31	120	1322.2	4-36" RCP	30	2.9
	1179+50	11	28	1320.7	1-36" RCP	28	2.9
	1187+70	11	28	1320.2	1-36" RCP	28	2.9
	1201+50	9	25	1321.8	1-36" RCP	25	2.6
	1214+80	17	54	1315.4	2-36" RCP	27	2.8
	1226+50	11	28	1316.0	1-36" RCP	28	2.9
C1	1235+50	17	54	1312.6	2-36" RCP	27	2.8
C2	1249+80	16	48	1311.8	2-36" RCP	24	2.6
C3	1265+50	38	160	1307.2	6-36" RCP	27	2.8
C4	1279+30	34	140	1301.8	5-36" RCP	28	2.9
D1	1285+25	20	71	1299.2	3-36" RCP	24	2.6
D2	1294+55	34	140	1296.7	5-36" RCP	28	2.9
Sta 1301+07.57 BK = Sta 1292 + 84.34 AHD							
D3	1294+75	51	225	1293.2	8-36" RCP	28	2.9
D4	1303+90	56 AC	250 CFS	1291.5	9-36" RCP	28 CFS	2.9

* Q50 based on area discharge curve from Cella Barr Hydrologic Investigation Report dated 7/14/87.

** Head at culvert inlet based on HEC-5 Charts 1 and 2 assuming inlet control and entrance type (2).

PROJECT: ESTRELLA FREEWAY PROJECT RAM-600-0-301	STATION: 1279+30 SHEET ____ OF ____	CULVERT DESIGN FORM DESIGNER / DATE: GS / 9-1-92 REVIEWER / DATE: WHH / 9-15-92

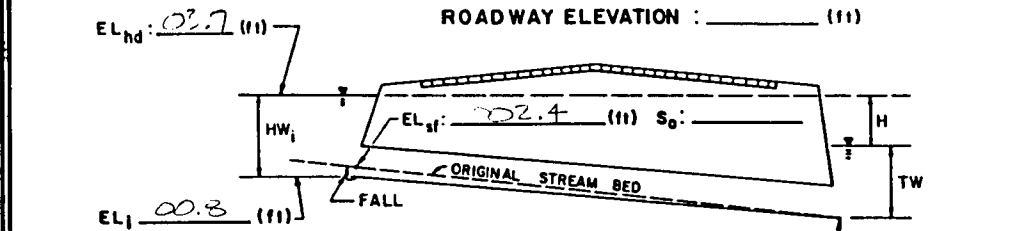
HYDROLOGICAL DATA

SEE ADD'L. SHTS.

- ☐ METHOD: CELLA BARR AREA-DISCHARGE
- ☐ DRAINAGE AREA: 34AC ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
50YR	140	1.5'



ASSUMING 33" DIA
"n" = 0.013
A = 5.94
WP = 8.64
R = 0.69

$S \approx S_o - FALL / L_a$
S = 0.01
L_a = 225

CULVERT DESCRIPTION:

MATERIAL - SHAPE - SIZE - ENTRANCE

CULVERT DESCRIPTION	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
5-36" RCP	140	28	0.95	2.9	1.6	03.7	1.5	1.8	2.4	2.4	0.5	1.5	03.4	03.7	9.0	

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) HW_i/D = HW/D OR HW_i/D FROM DESIGN CHARTS

(3) FALL = $HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

$V = Q/A = 28/5.94 = 4.7$

$V^2/2g = 0.34$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

→ TW ASSUMES CONCURRENT DEPTH OF 3 FT IN RECEIVING CHANNEL

→ OUTLET VEL ASSUMES NORMAL DEPTH

→ HYDRAULIC ANALYSIS ASSUMES 33" DIAM PIPE INSTEAD OF 36" DIAM AS A SAFETY FACTOR TO ACCOUNT FOR POSSIBLE SEDIMENT AND DEBRIS.

→ SCOUR PROTECTION NEEDED @ OUTLET

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____

ENTRANCE: ____

PROJECT: ESTRELLA FREEWAY PROJECT RAM-600-D-301	STATION: 1294+75 SHEET ____ OF ____	CULVERT DESIGN FORM DESIGNER / DATE: GSP / 9-2-92 REVIEWER / DATE: ____ / ____

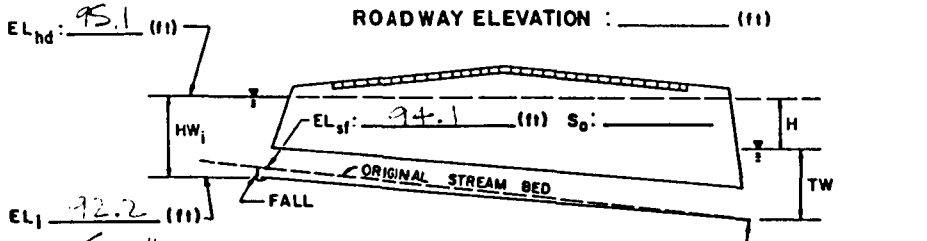
HYDROLOGICAL DATA

SEE ADD'L. SHTS.

- ☐ METHOD: CELLA BARR AREA DISCHARGE
- ☐ DRAINAGE AREA: 51 AC ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
50 YR	225	1.5



ASSUMING 33" DIA
"n" = 0.013
A = 5.94
WP = 8.64
R = 0.69

$S \approx S_o - FALL / L_a$
S = 0.0142
L_a = 225

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
8-36"	225	28	0.95	2.9	1.9	95.1	1.5	1.8	2.4	2.4	0.5	1.5	92.4	95.1	10.3	

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

$V = Q/A = 28/5.94 = 4.7$

$V^2/2g = 0.34$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

→ TW ASSUMES CONCURRENT DEPTH OF 3 FT IN RECEIVING CHANNEL
→ OUTLET VEL ASSUMES NORMAL DEPTH
→ HYDRAULIC ANALYSIS ASSUMES 33" DIA PIPE INSTEAD OF 36" DIAM. A SAFETY FACTOR TO ACCOUNT FOR POSSIBLE SEDIMENT AND DEBRIS.
→ SCOUR PROTECTION NEEDED @ OUTLET

CULVERT BARREL SELECTED:

SIZE: ____
SHAPE: ____
MATERIAL: ____
ENTRANCE: ____

PROJECT: ESTRELLA FREEWAY
PROJECT RAM-600-0-301

STATION: N/A

SHEET ____ OF ____

CULVERT DESIGN FORM

DESIGNER / DATE: GSB / 9-4-92

REVIEWER / DATE: ____ / ____

HYDROLOGICAL DATA

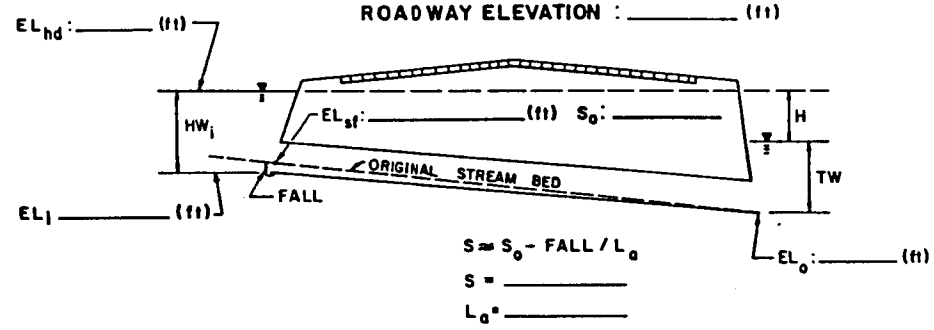
SEE ADD'L. SHTS.

- ☐ METHOD: ____
- ☐ DRAINAGE AREA: ____ ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ____ (ft)



$S = S_o - FALL / L_a$

$S =$ ____

$L_a =$ ____

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	HEADWATER CALCULATIONS: INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_hi (4)	OUTLET CONTROL TW (5)	d_c	(d_c+D)/2	h_o (6)	k_e	H (7)	EL_ho (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
53" X 34" OVAL CONC		44	1.0	3.0	—	—	—	—	—	—	—	—	—	—	—	ASSUME INLET CONTROL

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) h_o = TW or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29 n^2 L) / R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

DISCHARGE Q/N BASED ON 49" X 32" BARREL SIZE INSTEAD OF 53" X 34" AS A SAFETY FACTOR TO ACCOUNT FOR POSSIBLE SEDIMENT AND DEBRIS.

CULVERT BARREL SELECTED:

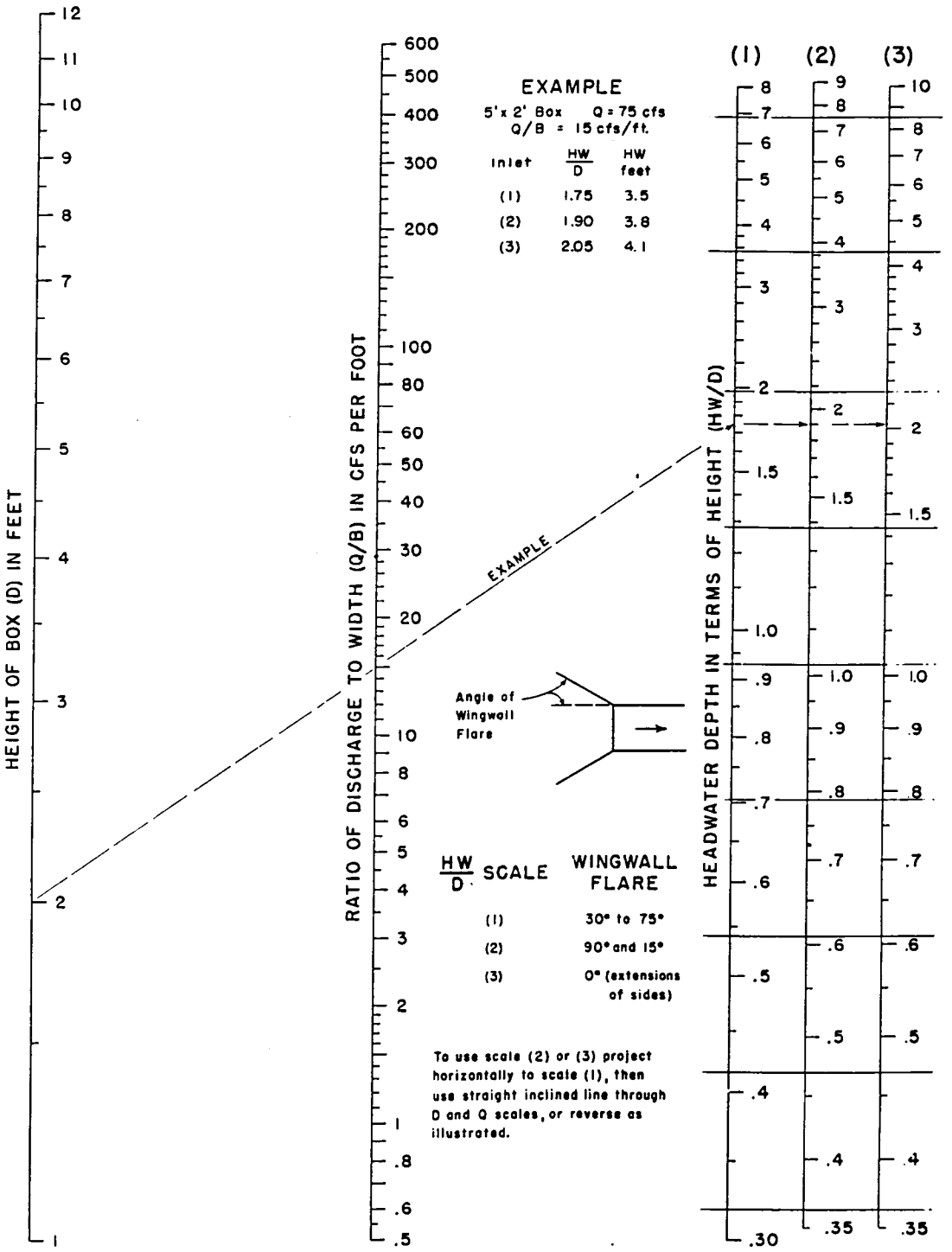
SIZE: ____

SHAPE: ____

MATERIAL: ____

ENTRANCE: ____

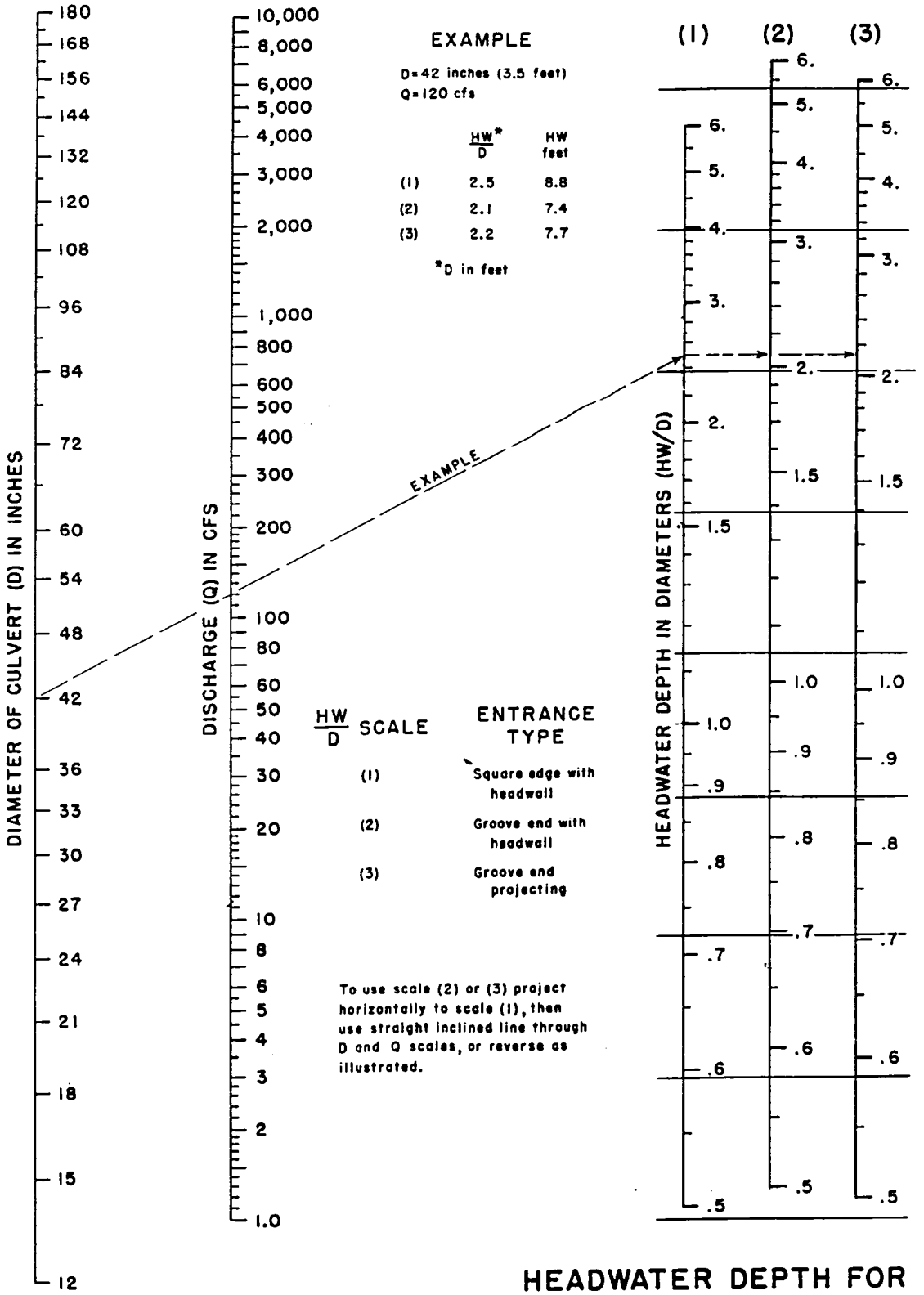
CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 2

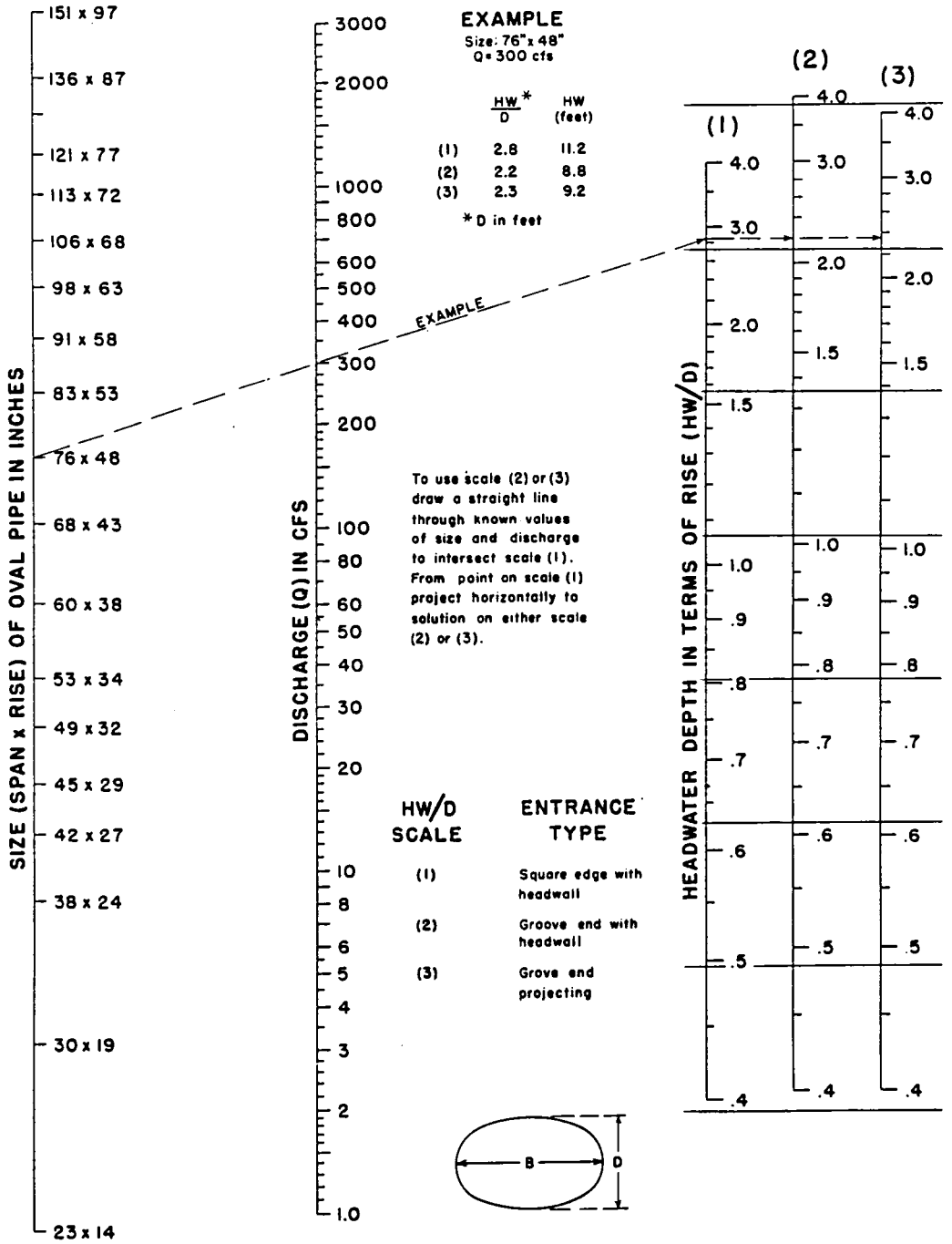


HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2&3
REVISED MAY 1964

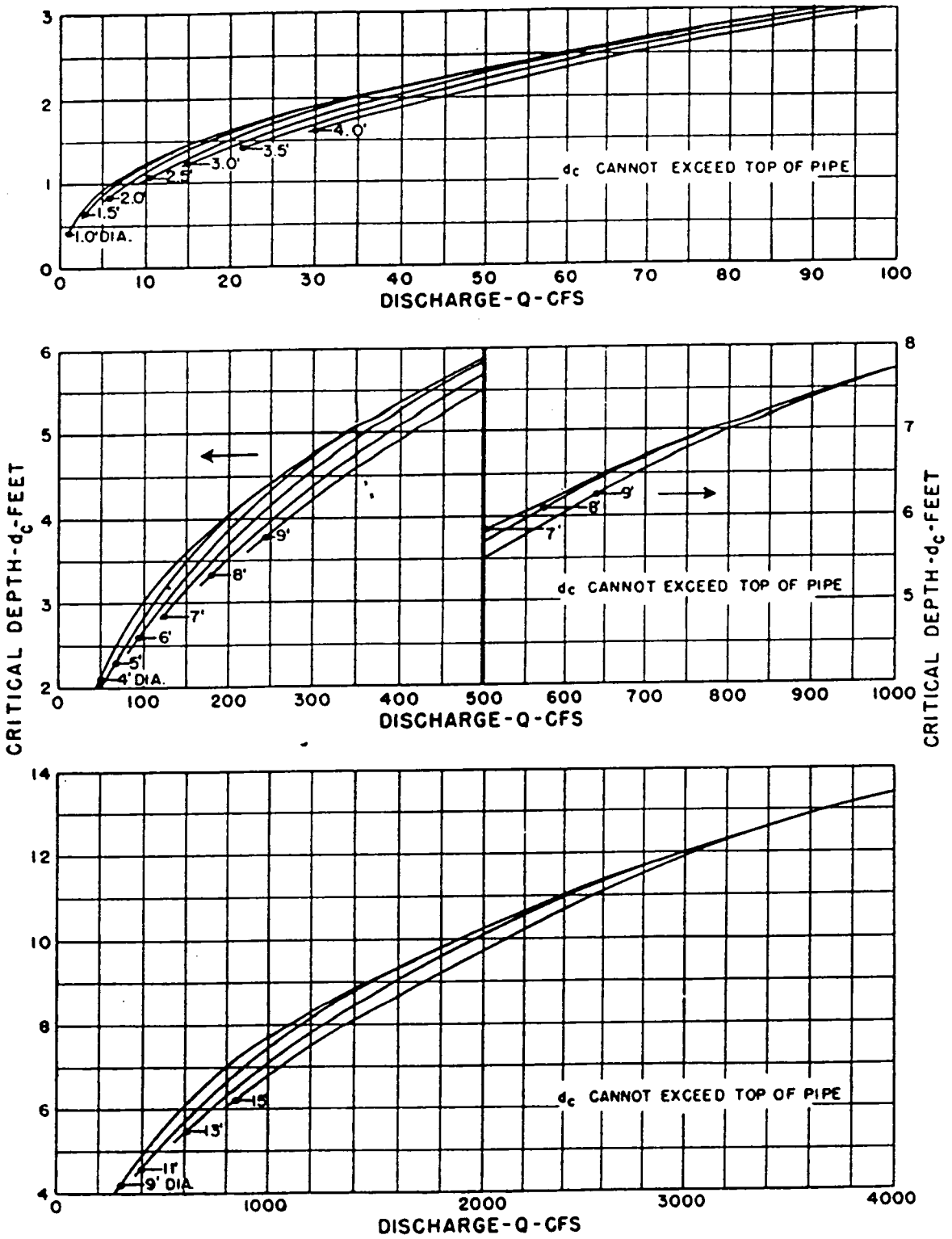
BUREAU OF PUBLIC ROADS JAN. 1963

CHART 3



HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963



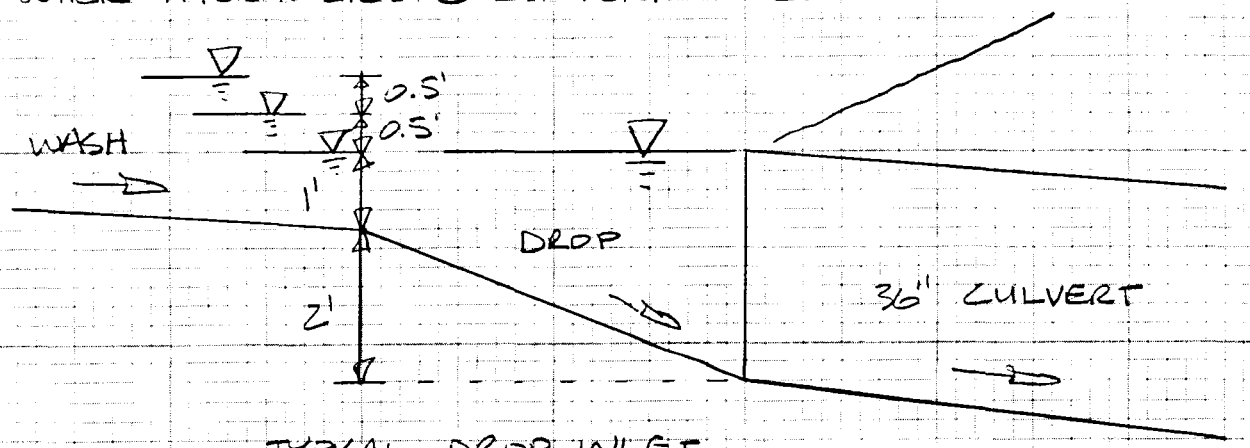
BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

DESIGNED BY GSB	DATE 9-10-92	SHEET NO.	PAGE NO.
CHECKED BY	DATE	OF	JOB NO. 11292
REVIEWED BY	DATE	SUBJECT: ESTRELLA FREEWAY	
APPROVED BY	DATE	DROP CULVERT INLET	

WIER HYDRAULICS @ CULVERT INLET



TYPICAL DROP INLET

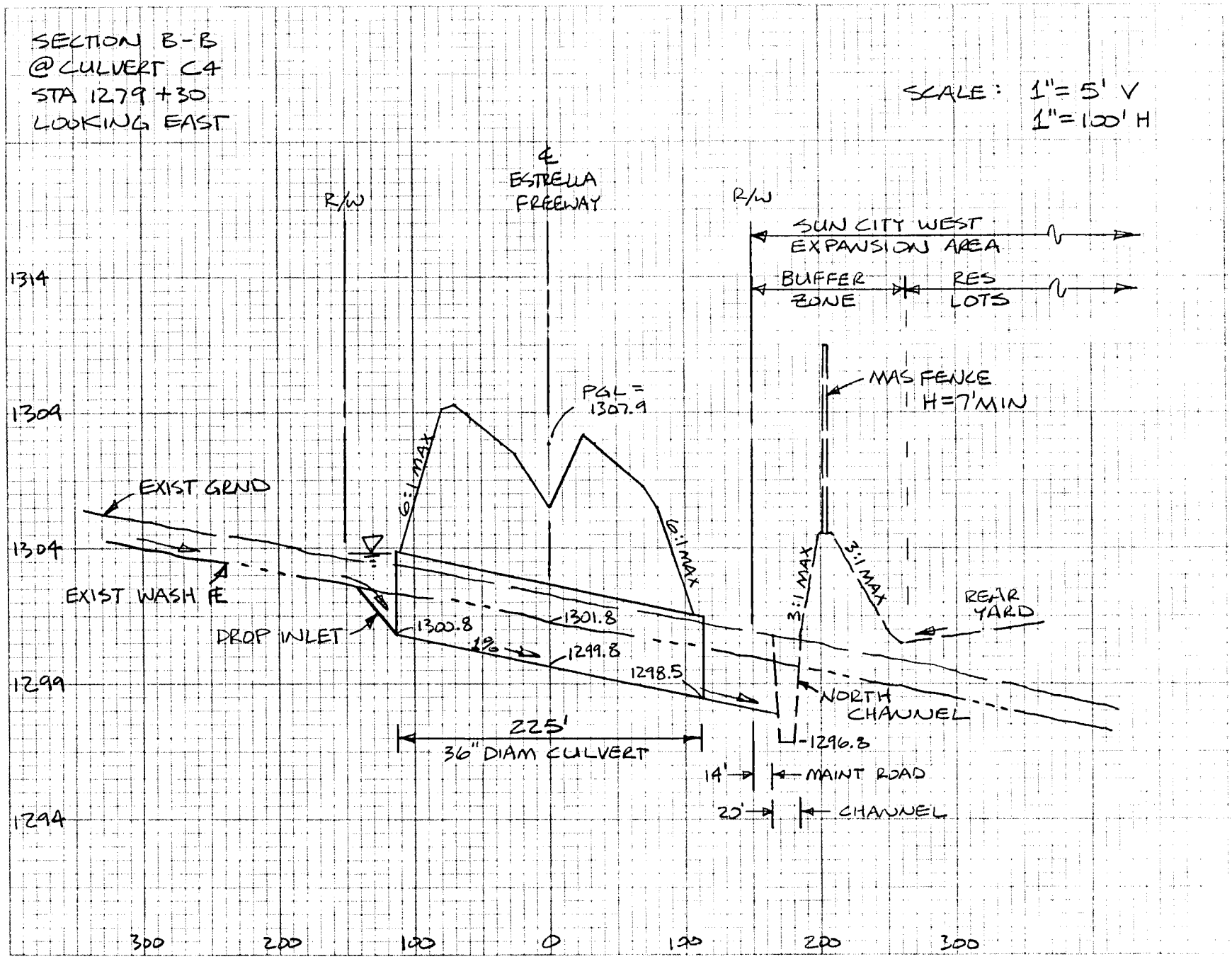
CULVERT INVERTS ARE TYPICALLY SET ABOUT 2 FT BELOW EXIST WASH FE. CULVERT HYDRAULICS TYPICALLY EXHIBIT INLET CONTROL. CULVERT BARRELS ARE HYDRAULICALLY SIZED SO THAT THE REQUIRED INLET HEAD IS NO HIGHER THAN THE TOP OF THE CULVERT. THIS REQUIRED HEAD WOULD CORRESPOND TO A DEPTH OF ABOUT 1 FT IN THE WASH JUST UPSTREAM OF IT. IF THE DROP INLET WERE VIEWED HYDRAULICALLY AS A SUBMERGED BROAD-CRESTED RECTANGULAR WIER AT PEAK FLOOD STAGE, THE FOLLOWING RELATIONSHIP RESULTS BETWEEN THE DEPTH IN THE WASH AND THE DISCHARGE CAPACITY FOR EACH 10 FT LENGTH OF WIER:

$$Q_{FREE} = C L H^{3/2} \qquad Q_{SUB} = Q_{FREE}\left[1-\left(\frac{H_{DOWNSTREAM}}{H_{UPSTREAM}}\right)^{3/2}\right]^{0.385}$$

$L = 10$ FT, $C = 2.70$

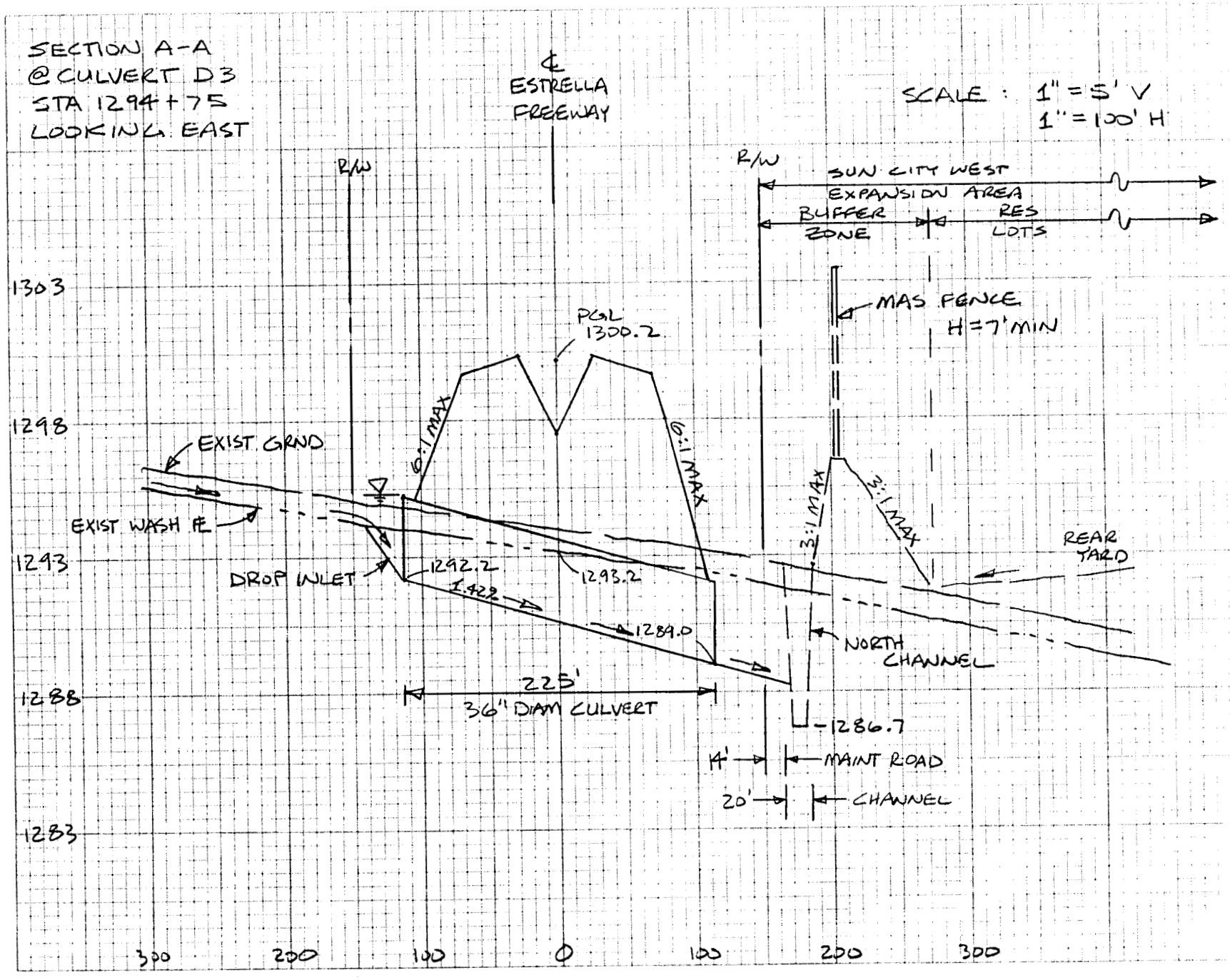
DEPTH IN WASH	H UPSTREAM	H DOWNSTREAM	Q_{FREE} (CFS)	Q_{SUB} (CFS)
1.0	1.0	1.0	27	0
1.5	1.5	1.0	50	37
2.0	2.0	1.0	76	65

FROM THESE RESULTS, A WIER LENGTH OF ABOUT 40 FT WOULD BE REQUIRED TO DISCHARGE THE GREATEST ESTIMATED FLOW OF 250 CFS @ CULVERT 1303+90 WITH A CORRESPONDING DEPTH OF 2 FT IN THE WASH UPSTREAM.



DESIGNED BY ....G.S.B.... DATE ....9-9-92.... SHEET NO. .... PAGE NO. ....
CHECKED BY .... DATE .... OF .... JOB NO. ....
REVIEWED BY .... DATE .... SUBJECT: ESTRELLA FREEWAY
APPROVED BY .... DATE .... PRELIM CULVERT PROFILE

SC 3020

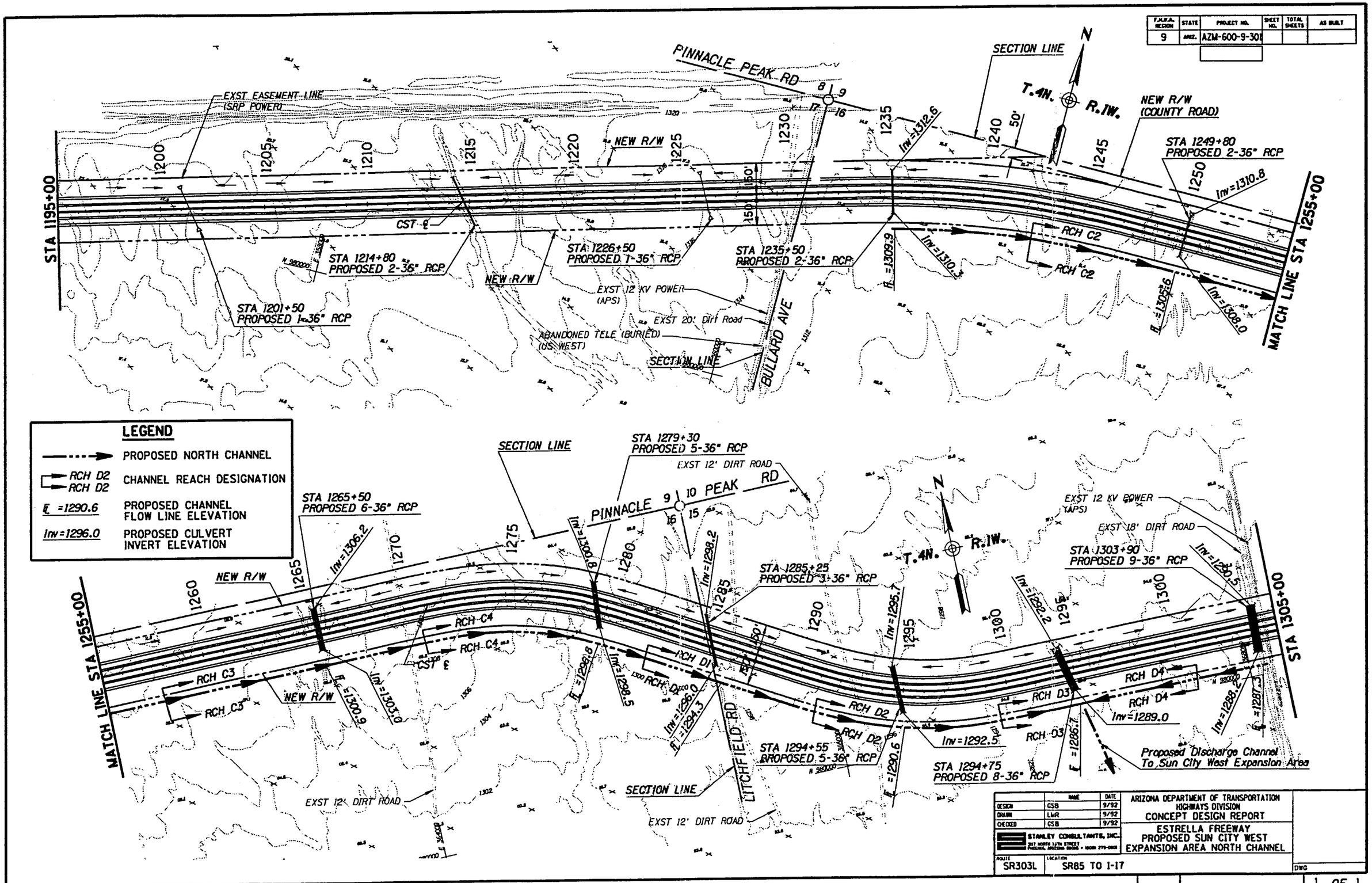


DESIGNED BY GSB DATE 9-9-92 SHEET NO. PAGE NO.
CHECKED BY DATE OF JOB NO.
REVIEWED BY DATE SUBJECT: ESTRELLA FREEWAY
APPROVED BY DATE PRELIM CULVERT PROFILE

SC 3020

APPENDIX C
ESTRELLA FREEWAY PLAN AND PROFILE
SUN CITY WEST EXPANSION NORTH CHANNEL

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	AZM-600-9-301			



	NAME	DATE
DESIGN	GSB	9/92
DRAWN	LWR	9/92
CHECKED	GSB	9/92

STANLEY CONSULTANTS, INC.
2117 NORTH 17TH STREET
PHOENIX, ARIZONA 85006 • (602) 275-0503

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT

ESTRELLA FREEWAY
PROPOSED SUN CITY WEST
EXPANSION AREA NORTH CHANNEL

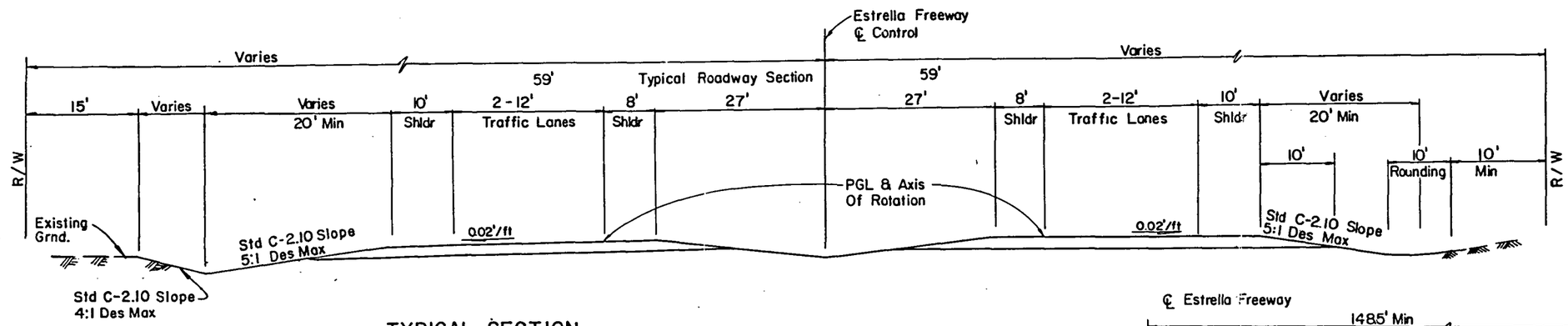
ROUTE: SR303L
LOCATION: SR85 TO I-17
DWG

1 OF 1

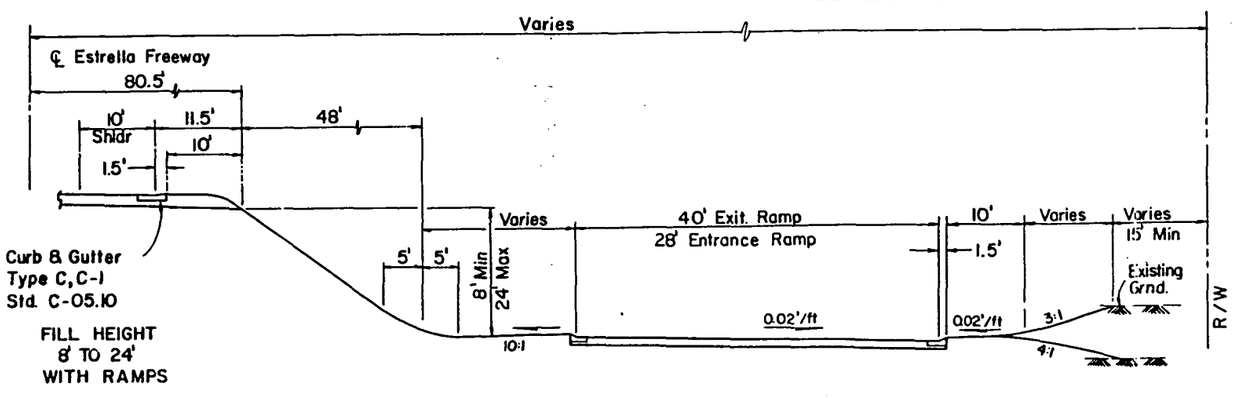
•••••DGN•SPECIFICATION••••• VIEW NAME: ESTREL02.DGN
•••••SYSTIME•••••
CONSTRUCTION DISPLAY ON

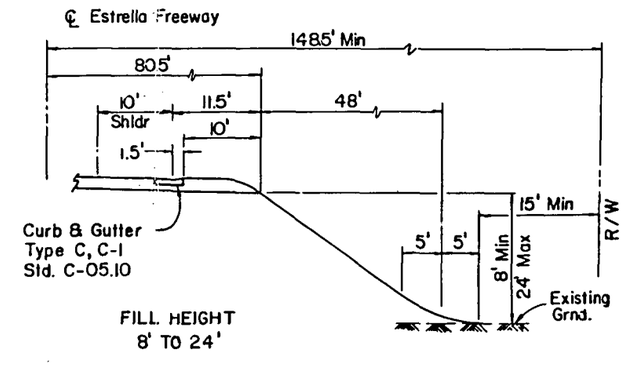
ESTRELLA FREEWAY

TYPICAL SECTION AND DESIGN CRITERIA



TYPICAL SECTION
FILL HEIGHT = 8'





DESIGN YEAR:	2015
DESIGN SPEED:	65 MPH-MAINLINE 50 MPH-RAMPS CROSSROADS
LANE WIDTH:	12 FEET
SHOULDER WIDTH:	MEDIAN-8 FEET OUTSIDE-10 FEET
MEDIAN WIDTH:	70 FEET (INCLUDING MEDIAN SHOLDER)
MAXIMUM GRADIENT:	3% MAINLINE 4% CROSSROADS 5% RAMPS

NUMBER OF LANES:	4
HORIZONTAL CURVATURE:	3° 30' MAINLANE (MAX.) 8° RAMPS (MAX.) CROSSROADS
RIGHT OF WAY WIDTH:	300 FEET (MIN.)
ACCESS CONTROL:	FULL
VERTICAL CLEARANCES:	16'-6" STANDARD 23'-0" OVER A.T.& S.F. RR.

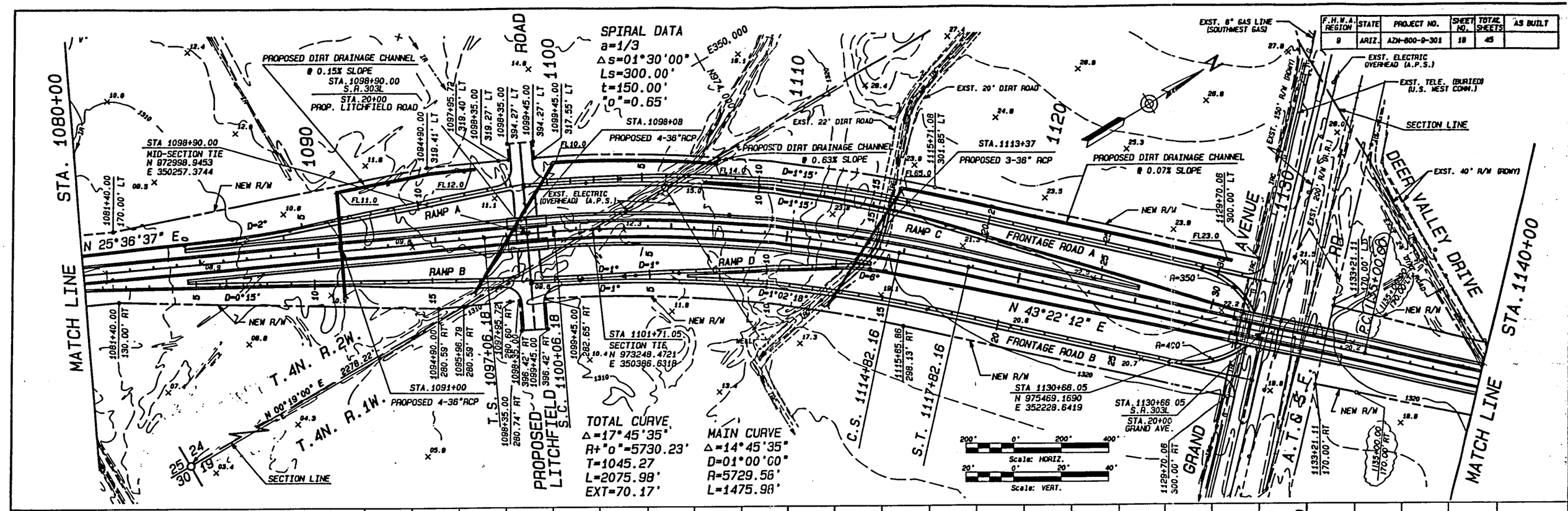
DRAINAGE:	PAVEMENT: 10 YEAR DEPRESSED AREA: 50 YEAR CROSS-DRAINAGE: 50 YEAR

NOTES:

1. ALL COORDINATES SHOWN ARE MODIFIED GRID.
2. THE DRAINAGE DESIGN FOR THIS PROJECT PROVIDES FOR A BOX CULVERT MINIMUM HEIGHT OF 6'-0". THIS MINIMUM HEIGHT SHOULD BE EVALUATED DURING FINAL DESIGN TO ACCOMODATE CURRENT MAINTENANCE AND OTHER REQUIREMENTS.

FIGURE 2

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	A2H-800-9-301	18	45	

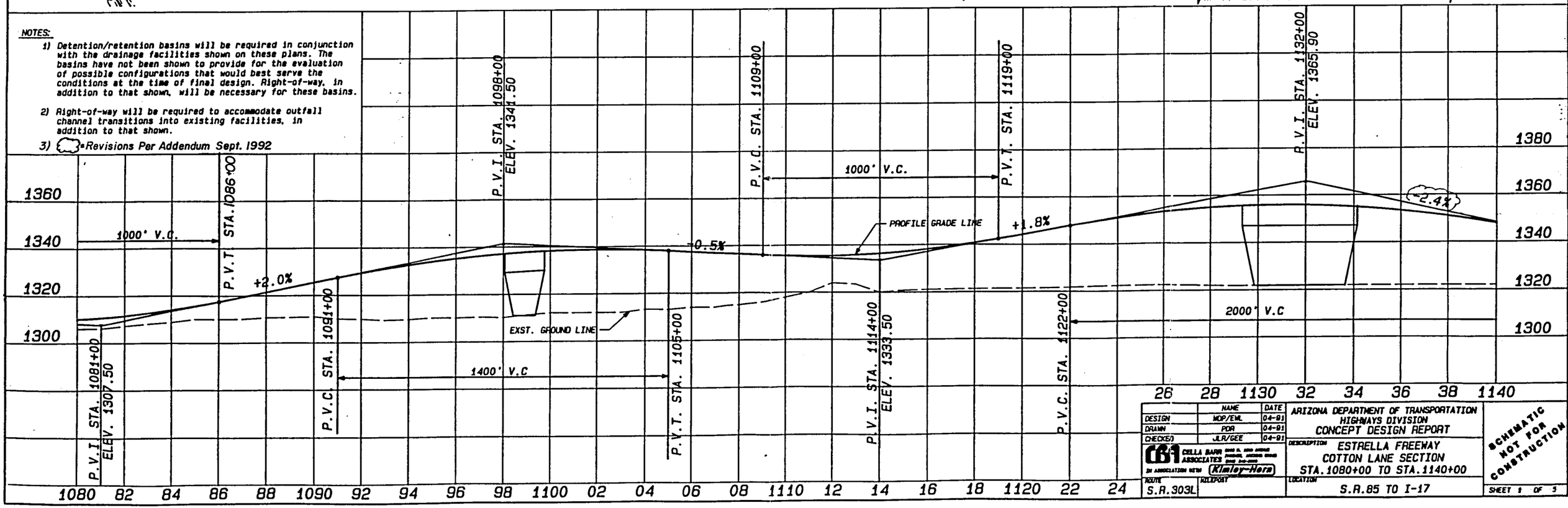


NOTES:

1) Detention/retention basins will be required in conjunction with the drainage facilities shown on these plans. The basins have not been shown to provide for the evaluation of possible configurations that would best serve the conditions at the time of final design. Right-of-way, in addition to that shown, will be necessary for these basins.

2) Right-of-way will be required to accommodate outfall channel transitions into existing facilities, in addition to that shown.

3) ⬭ = Revisions Per Addendum Sept. 1992



	NAME	DATE
DESIGN	WOP/EWL	04-91
DRAWN	PDR	04-91
CHECKED	JLR/GEE	04-91

CBA CELLA BARR ASSOCIATES
IN ASSOCIATION WITH Kimley-Horn

ROUTE S.R.303L
MILEPOST

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT

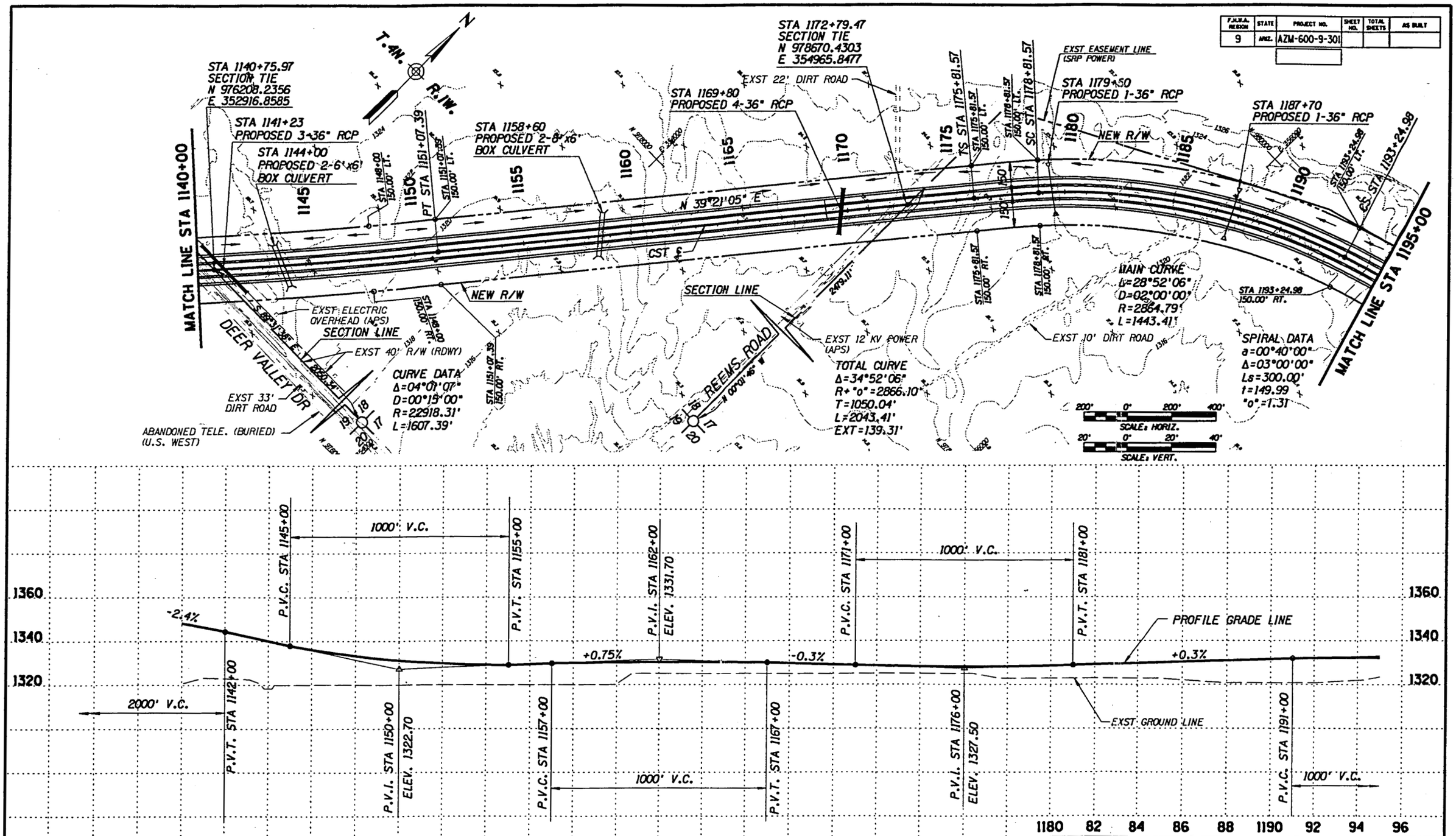
DESCRIPTION
ESTRELLA FREEWAY
COTTON LANE SECTION
STA.1080+00 TO STA.1140+00

LOCATION
S.R.85 TO I-17

SCHEMATIC NOT FOR CONSTRUCTION

SHEET 1 OF 5

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	AZM-600-9-301			



	NAME	DATE
DESIGN	MRC/CT	9/92
DRAWN	DJM/LMR	9/92
CHECKED	CCC	9/92

STANLEY CONSULTANTS, INC.
3117 NORTH 16TH STREET
PHOENIX, ARIZONA 85016 • (602) 279-0900

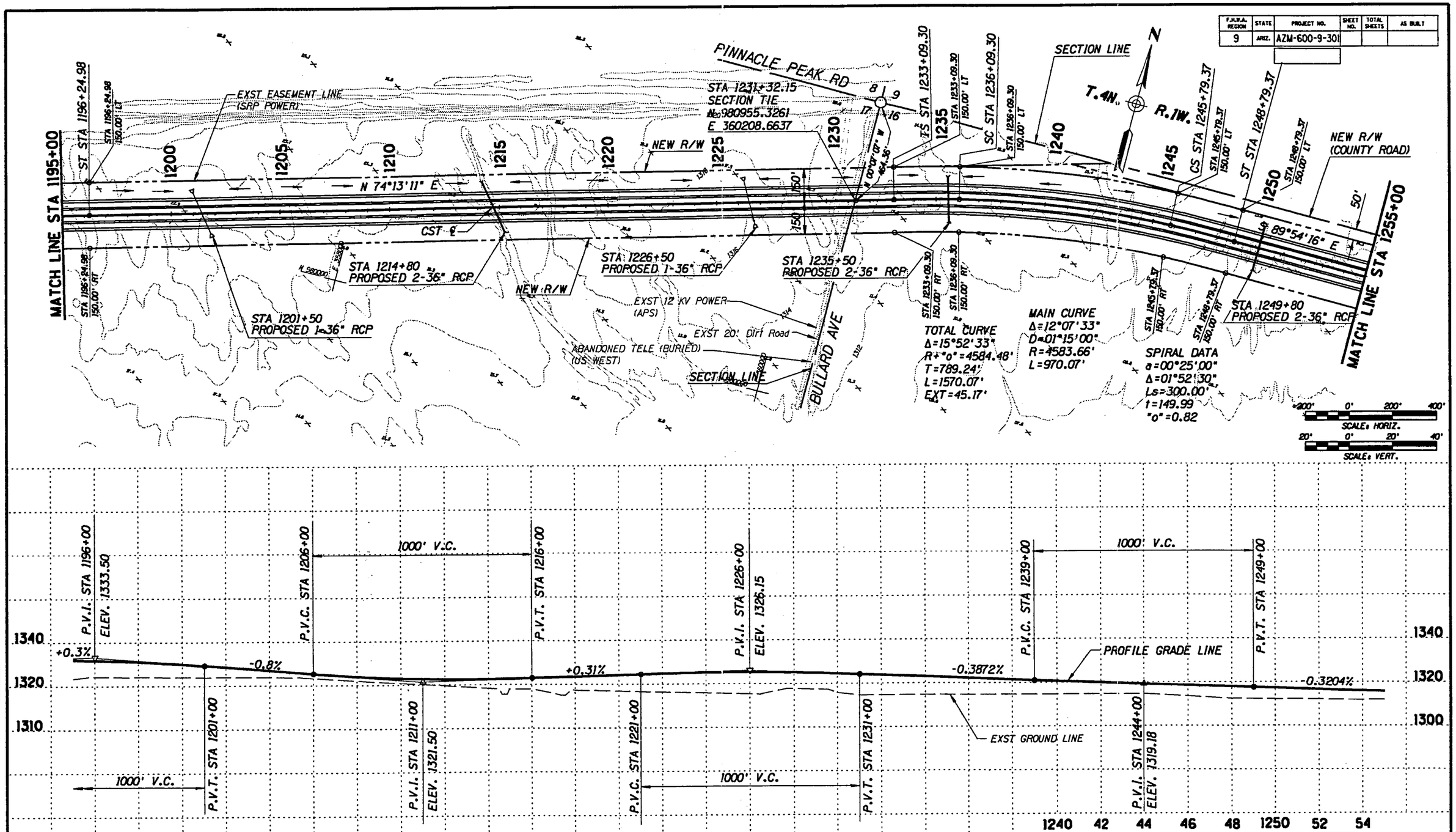
ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT
ESTRELLA FREEWAY
NORTHWEST LOOP SECTION
STA 1140+00 TO STA 1195+00

ROUTE: SR303L
LOCATION: SR85 TO I-17

DWG

•••••DGN•SPECIFICATION•••••
•••••SYSTIME•••••
VIEW NAME: ESTRELO1.DGN

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	AZM-600-9-301			



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DESIGN	MRC/CT	9/92
DRAWN	DJM/LMR	9/92
CHECKED	CCC	9/92

STANLEY CONSULTANTS, INC.
3117 NORTH 36TH STREET
PHOENIX, ARIZONA 85018 • (602) 279-0801

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT

ESTRELLA FREEWAY
NORTHWEST LOOP SECTION
STA 1195+00 TO STA 1255+00

ROUTE: SR303L
LOCATION: SR85 TO I-17

DWG

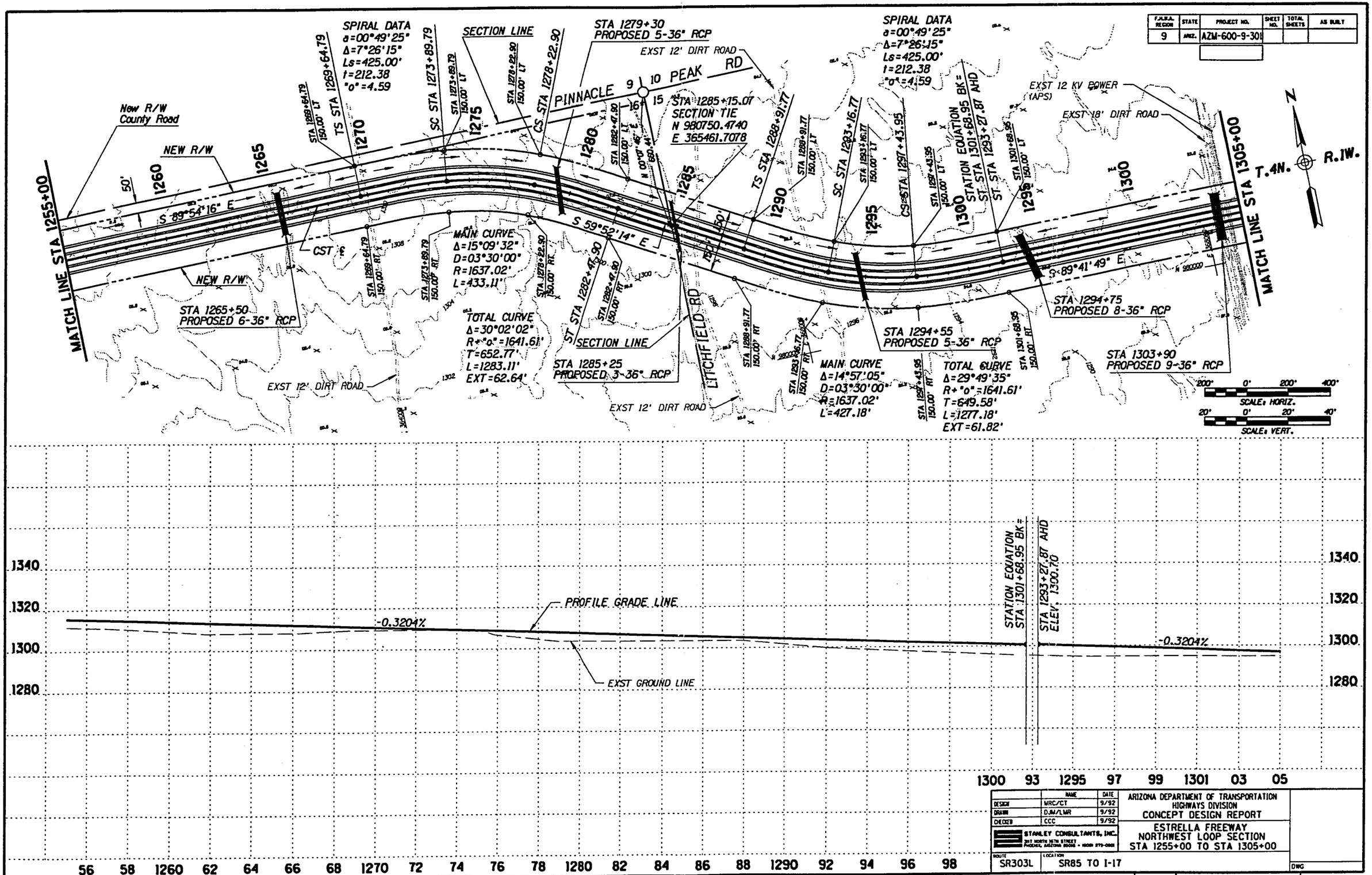
3 OF 5

•••••DGN•SPECIFICATION••••• VIEW NAME: ESTREL02.DGN
•••••SYSTIME•••••

SURVEY NO. | FINISHED PLANS | REVISIONS | LOCATION | DATE

CONSTRUCTION DISPLAY ON

F.A.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.	AZM-600-9-301			



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DESIGN	MRC/CT	9/92
DRAWN	DJM/LMR	9/92
CHECKED	CCC	9/92

STANLEY CONSULTANTS, INC.
2917 NORTH 16TH STREET
PHOENIX, ARIZONA 85016 • (602) 279-0801

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT

ESTRELLA FREEWAY
NORTHWEST LOOP SECTION
STA 1255+00 TO STA 1305+00

ROUTE: SR303L
LOCATION: SR85 TO I-17

DWG

•••••DGN•SPECIFICATION•••••
•••••SYSTIME•••••
VIEW NAME: ESTREL03.DGN
CONSTRUCTION DISPLAY ON

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
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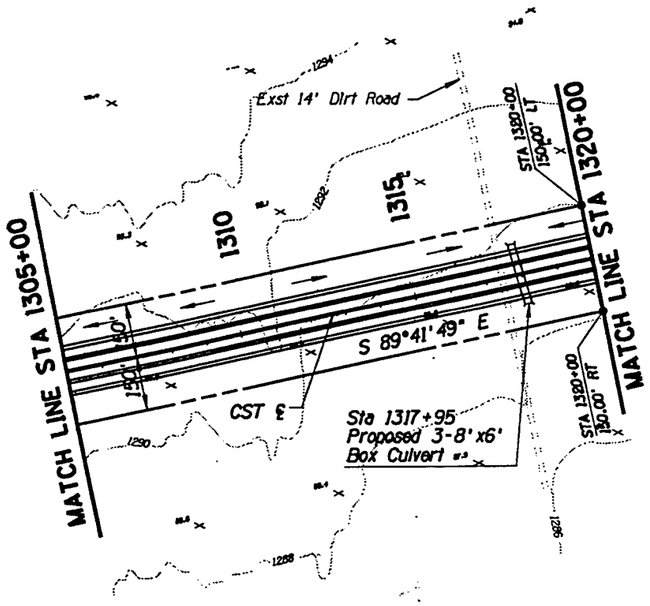
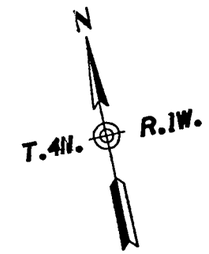
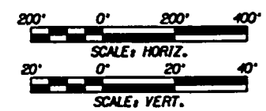
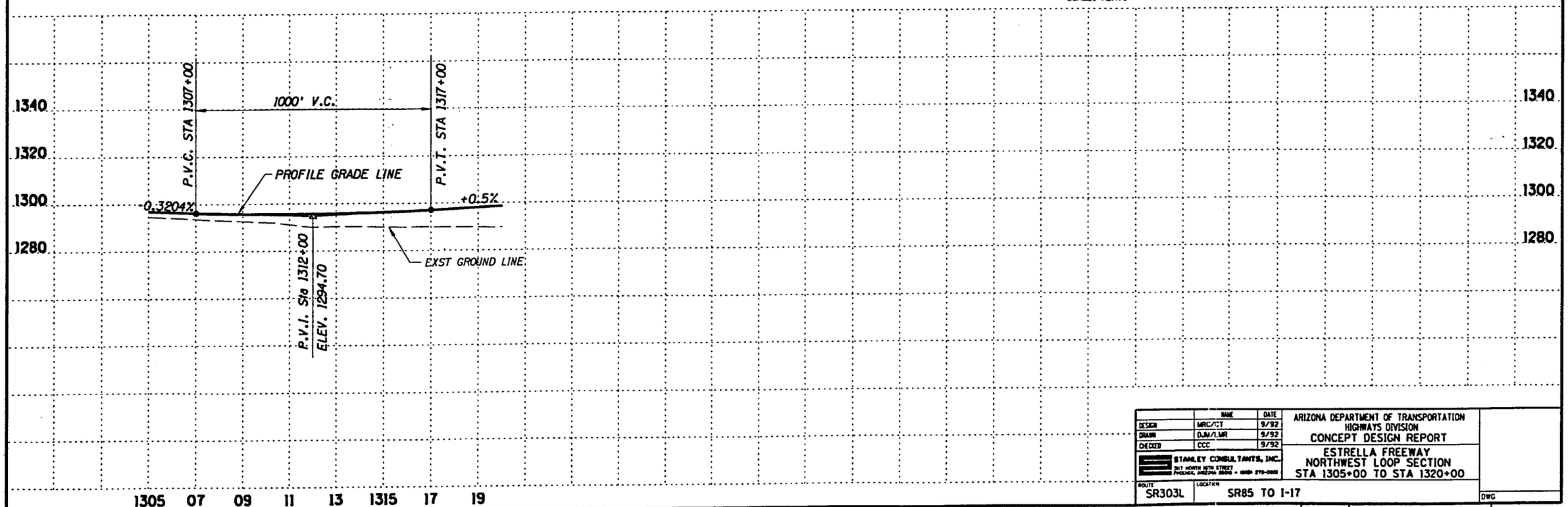








	NAME	DATE
DESIGN	MRC/CT	9/92
DRAWN	DJM/LMR	9/92
CHECKED	CCC	9/92

STANLEY CONSULTANTS, INC.
2117 NORTH 16TH STREET
PHOENIX, ARIZONA 85006 • (602) 279-0600

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
CONCEPT DESIGN REPORT

ESTRELLA FREEWAY
NORTHWEST LOOP SECTION
STA 1305+00 TO STA 1320+00

ROUTE: SR303L
LOCATION: SR85 TO I-17

DWG

5 OF 5

•••••DGN•SPECIFICATION••••• VIEW NAME: ESTREL04.DGN
•••••SYSTIME•••••

CONSTRUCTION DISPLAY ON

APPENDIX D
CELLA BARR HYDROLOGY

ADOT
URBAN HIGHWAY SECTION
ORIGINAL FILE COPY
7/28/87

ESTRELLA FREEWAY
HYDROLOGIC INVESTIGATION REPORT

PREPARED FOR:
ARIZONA DEPARTMENT OF TRANSPORTATION
PREPARED BY:
CELLA BARR ASSOCIATES

Cella Barr Associates
5062 North 19th Avenue
Phoenix, Arizona 85015
July, 14, 1987

CBA File No. 40955-02-30
JHN-21

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
PROCEDURES	2
Hydrologic Setting	2
Watersheds	2
Known Discharges	3
Discharge Computations	5
Drainage Structures	6
CONCLUSIONS	7
REFERENCES	8

LIST OF FIGURES

FIGURE 1 Vicinity Map

FIGURE 2 Major Drainage Basin Boundaries (Cotton Lane Area)

FIGURE 3 Major Drainage Basin Boundaries (Northwest Loop/Agua Fria Area)

FIGURE 3A Watersheds Contributing to McMicken Dam Outlet Channel

FIGURE 4 Major Drainage Concentration Points Cotton Lane Area)

FIGURE 5 Major Drainage Concentration Points (Northwest Loop/Agua Fria Area)

FIGURE 6 Drainage Area/Discharge Curves

FIGURE 7 Drainage Area/Discharge Curves

APPENDICES

APPENDIX A Sample TR-55 Calculations and Watersheds for Drainage Area/Discharge Curves

APPENDIX B TR-55 Calculations and Watersheds for Beardsley Canal Overchutes

APPENDIX C Table of Discharges

ESTRELLA FREEWAY

HYDROLOGIC INVESTIGATION REPORT

INTRODUCTION

This is a hydrologic investigation for the Estrella Freeway Route Location study, and has been prepared to establish peak discharge values that will be used as a basis for preliminary design assessments. The Estrella Freeway, formerly the Cotton Lane/Northwest Loop Freeway, will proceed north along (or parallel to) Cotton Lane from State Route 85 to Grand Avenue and then bend northeasterly extending through mountain and foothill slopes to eventually intersect with I-17 near the Central Arizona Project Canal. In the construction schedule of all the valley freeways, the Estrella Freeway has the lowest priority and is not projected to be completed until the year 2005.

In October 1986, the Arizona Department of Transportation contracted with Cella Barr Associates, in association with Kimley-Horn and Associates, Inc., to complete the route location study and preliminary design for the Estrella Freeway. The purpose of the route location study is to be established and preserve the right-of-way required for future freeway construction. The right-of-way requirements will be based, in part, on the location and preliminary sizing of drainage channels, detention/ retention basins, flood control structures, and additional areas needed for backwater ponding behind culvert and bridge crossings. Drainage costs will be assessed for channels, culverts, bridges, detention/ retention facilities and other drainage control structures to aid in the selection process for a preferred alignment.

The level of detail providing the basis for this hydrologic report is not overly intensive in consideration of the fact that present hydrologic conditions and accepted methodologies will change prior to implementation of final design in the future. This hydrologic investigation has utilized reasonable assumptions and levels of conservatism in the establishment of watershed boundaries and discharges to provide projections for right-of-way needs that have a strong likelihood of being adequate for future freeway construction.

PROCEDURES

Hydrologic Setting:

The Estrella Freeway Corridor traverses through roughly 39 miles of arid desert and agricultural land to the west and north of Phoenix. The climate is temperate with summer highs reaching as much as 120 degrees and winter lows dipping below freezing. Rainfall in the area averages 7.11 inches per year (verbal reference, National Weather Service).

The Corridor is impacted by a wide variety of drainage features, ranging from small local watersheds to large regional watersheds, such as the Agua Fria River (Figure 1). Drainage conditions for the Cotton Lane section also differ dramatically from those conditions present in the Agua Fria and Northwest Loop area, which extends between Grand Avenue and I-17.

The Cotton Lane section is comprised mainly of agricultural land and small farmsteads. The slope of the land is relatively flat which produces lower peak discharges and longer times of concentration. The Agua Fria and Northwest Loop area consists of natural desert and mountainous areas with few scattered areas of development. Characteristically, steeper slopes create higher peak discharges and shorter times of concentration than those of the flatter Cotton Lane section.

Watersheds:

Watershed conditions differ appreciably between the Cotton Lane section of the corridor, and the Agua Fria and Northwest Loop area. The Cotton Lane section is characterized by watersheds extending upstream to the west consisting of natural alluvial fan areas and graded farm fields on the east face of the White Tank Mountains (Figure 2). Due to the complexity of drainage across agricultural lands, watershed boundaries were determined by detailed field inspection of the area. Arterial roadways form the most common east-west watershed boundaries with Cotton Lane and

various parallel roadways forming some north-south boundaries. The Beardsley Canal is significantly elevated throughout the study area and serves as a boundary until it's height decreases in the southernmost portion near I-10 and allows flow to cross it. The Trilby Wash and SCS White Tanks detention basins are assumed to be effective flood control structures which define limitations on upstream watershed boundaries. Internal watershed boundaries are valid for low flow, however, there is a strong possibility that during extreme storm events, spillover from one watershed to another may occur. The low flow, internal boundaries were utilized as a reasonable assumption with respect to anticipated future conditions.

The watersheds in the Agua Fria and Northwest Loop area are less complex and are generally comprised of more defined, naturally-shaped basins extending upstream to the north (Figure 3 and 3A). These boundaries were determined from recent aerial photographs taken of the region, U.S.G.S. quad sheets and limited field investigation, as appropriate.

Concentration points are located along each of the proposed alignments extending throughout the entire corridor based on the watershed boundary information as shown on Figures 4 & 5. In the Cotton Lane area, these concentration points typically fall in the southeastern corner of each watershed, where the majority of the flow is believed to concentrate before spilling over into adjoining watersheds. In the Agua Fria and Northwest Loop area, concentration points are located in topographical low spots of each basin.

Known Discharges:

There are four significant points of concentration where discharges are known (or previously established) within the Corridor, all of which are in the Agua Fria and Northwest Loop area.

1. The Agua Fria River has an established 100-year discharge of about 121,000 cfs based upon information obtained from the Flood Control District of Maricopa County (Concentration Point 183).

2. Construction of the New River Dam by the U.S. Army Corps of Engineers has reduced the 100-year flow for New River to 2,350 cfs immediately downstream of the dam (Concentration Point 221), (Reference 5).

3. A flood control channel was built by the U.S. Army Corps of Engineers on Skunk Creek at I-17 with the capacity to contain in excess of the 100-year discharge (Concentration Point 280), (Reference 5). Two overchutes on the Central Arizona Project Canal have a combined capacity of 16,600 cfs (Reference 5). The adopted 100-year discharge is 39,000 cfs along Skunk Creek above Adobe Dam, according to the Flood Control District of Maricopa County.

4. The outlet structure of the McMicken Dam has a capacity of 4,400 cfs (Concentration Point 284), (Reference 3 and 5).

5. The 100-year discharge collected along the McMicken Dam Outlet Channel has been estimated to be approximately 16,300 cfs at it's point of release into a natural channel (Concentration Point 151). This value represents the sum of the discharge from the dam and the flow entering the Outlet Channel via 3 overchutes along the Beardsley Canal to the north. Computations for the 3 northern watersheds are shown in Appendix B. These watershed boundaries are shown on Figure 3A.

The above 100-year discharges will be implemented in determining drainage structure sizes as appropriate along freeway alignment segments due to considerations of Federal regulations, interfacing of flood control improvements, damage potential and magnitude of discharge. All other drainage structures are proposed to be designed on a 50-year storm event.

Discharge Computations:

The remainder of the concentration points within the Corridor, for which established discharges ~~to~~ do not exist, were evaluated using a general procedure discussed in a meeting with Mr. Ray Jordan and Mr. Art May from the Arizona Department of Transportation (ADOT) held on May 28, 1987. The procedures outlined in the U.S. Department of Agriculture, Soil Conservation Service Technical Release No. 55, entitled, Urban Hydrology for Small Watersheds (TR-55) were implemented to determine the 50-year peak discharges for a sample set of watersheds (Reference 7). Rainfall data used in the TR-55 computations were obtained from the Arizona Highway Department publication entitled, Hydrologic Design for Highway Drainage in Arizona (Reference 1). Eight sample watersheds were evaluated, four of which were located within the Cotton Lane area and four within the Agua Fria and Northwest Loop area.

In the Cotton Lane section, the watersheds ranged in size from 320 acres to 2,880 acres, and produced 50-year discharges ranging from 259 cfs to 779 cfs. In the Agua Fria and Northwest Loop area, the watersheds ranged in size from 13 acres to 2,099 acres, and produced 50-year discharges of 28 cfs to 2,461 cfs. The Agua Fria and Northwest Loop area has a tendency to produce higher discharge rates per acre than the Cotton Lane section. Representative TR-55 work sheets are contained in Appendix A.

The resultant discharges derived from the TR-55 computations were plotted on log-log paper (2 x 2 cycles for the Cotton Lane section and 3 x 3 cycles for the Northwest Loop area), and a curve of best fit was drawn for each group of four values. A second curve was then drawn at 20% above the actual computed values to apply a reasonable factor of safety (Figure 6). The 20% conservative upper curve for the 2 characteristic areas was then used to compute discharges at all of the respective concentration points (excluding those having adopted discharge values), based on the area of their contributing watersheds (Appendix C). This generalized method of obtaining discharges was deemed acceptable by ADOT based on the fact that present hydrologic conditions and accepted methodologies will change prior to the implementation of final design in the future.

A more detailed study will be conducted in the future during the final design phase of the Estrella Freeway.

Drainage Structures:

Drainage structure sizes are not presented in this report and will be represented to the level of detail required in later versions of the Location Design Report for the Estrella Freeway. Drainage structures, such as channels, culverts, bridges and detention/retention facilities are to be sized to accommodate the discharges computed for each concentration point. Culverts will be sized using procedures outlined in the U.S. Department of Transportation, Hydraulic Charts for the Selection of Highway Culverts (HEC-5) publication (Reference 8), and channels are to be sized using the Manning's Equation. Bridge lengths are to be calculated by means of the U.S. Army Corps of Engineers HEC-2 Water Surface Profiles generalized computer program. Most detention/retention facilities are to be sized according to methods outlined in the TR-55 manual (Reference 4). However, when the desired ratio of peak outflow to peak inflow is greater than 0.8, the method from the draft version of Pima County's Department of Transportation report entitled, Drainage and Channel Design Standards for Local Drainage, Section VI will be used (Reference 2). The times to peak for this method will be obtained from Hydrologic Design for Highway Drainage, (Reference 1).

CONCLUSIONS

1. This hydrologic investigation has been prepared to establish discharges to be incorporated into the concept and preliminary design of drainage improvements associated with the Estrella Freeway Route Location Study.

2. Established discharges have been adopted for major washes and watercourses when available, as appropriate.

3. For watersheds where hydrologic information is presently unavailable, discharges have been computed based on the development of simplified drainage area/discharge curves as contained in this report. One curve (each) was developed for watersheds impacting the Cotton Lane section, and the Agua Fria and Northwest Loop area, based on a sample set of watershed computations using TR-55 methodologies. A 20% "safety factor" increase was applied to all discharges computed via this simplified procedure.

4. The 50-year discharge will be used for the sizing of drainage structures, with the exception of the Agua Fria River, New River and the natural channel outletting the McMicken Dam Outlet Channel. In these instances, the 100-year discharge will be used, based on considerations of Federal regulations, interfacing of flood control improvements, damage potential and magnitude of discharge.

REFERENCES

1) Arizona Highway Department, "Hydrologic Design for Highway Drainage in Arizona," December 1968, (Revised June 1975).

2) Pima County Department of Transportation and Flood Control District, "Drainage and Channel Design Standards for Local Drainage," (draft version), Section VI, June 1984.

3) Sergent, Hauskins and Beckwith, "McMicken Dam Restoration Study", 1983.

4) U.S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-2 Water Surface Profiles, November 1976.

5) U.S. Army Corps of Engineers, "New River Dam, Including New River to Skunk Creek," November 1982.

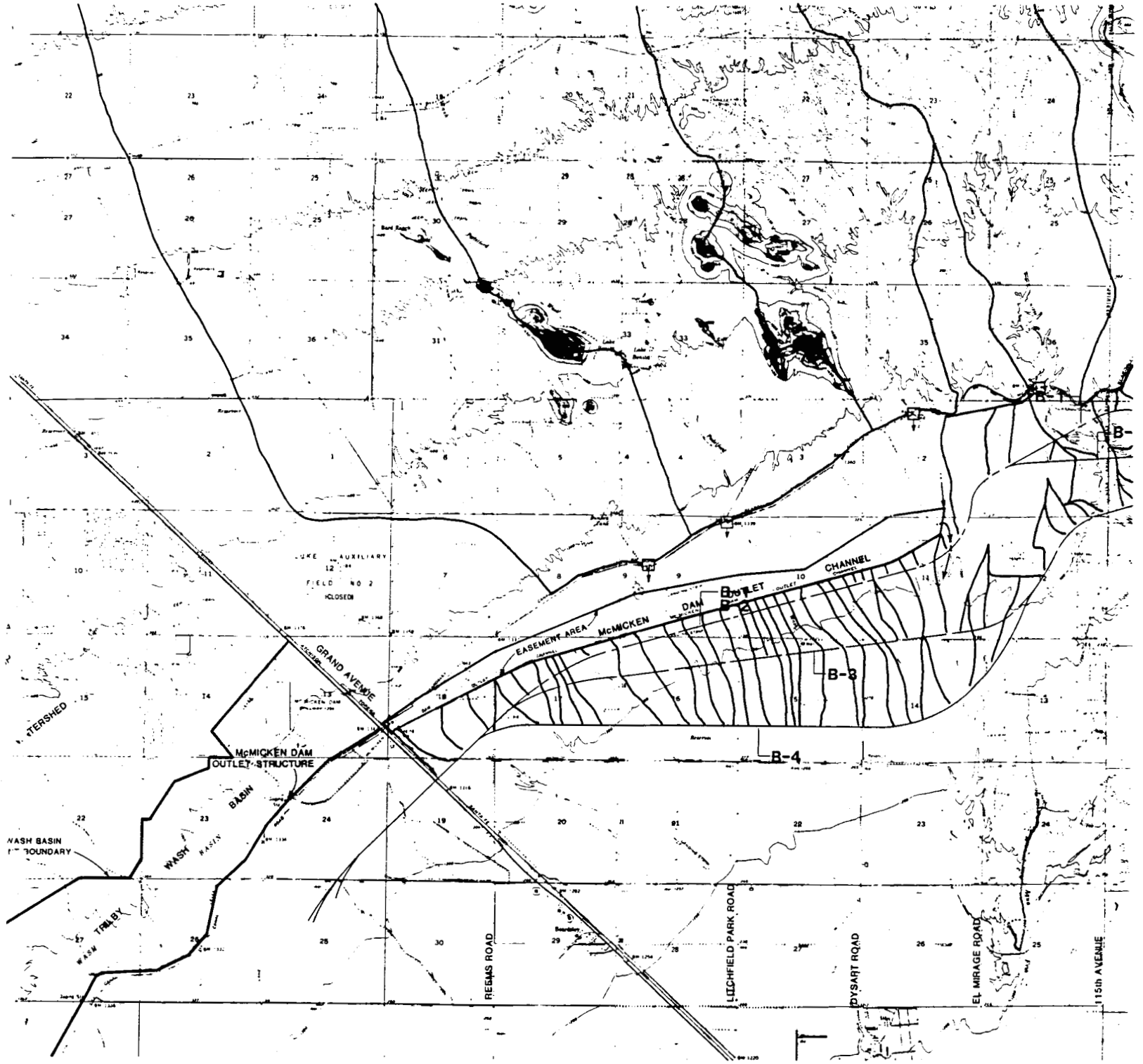
6) U.S. Bureau of Reclamation, Central Arizona Project, "Location Map, Granite Reef Agueduct Reach 10", June 1980.

7) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, "Urban Hydrology for Small Watersheds," June 1986.

8) U.S. Department of Transportation, Hydraulic Engineering Circular No. 5, "Hydraulic Charts for the Selection of Highway Culverts," December 1965.

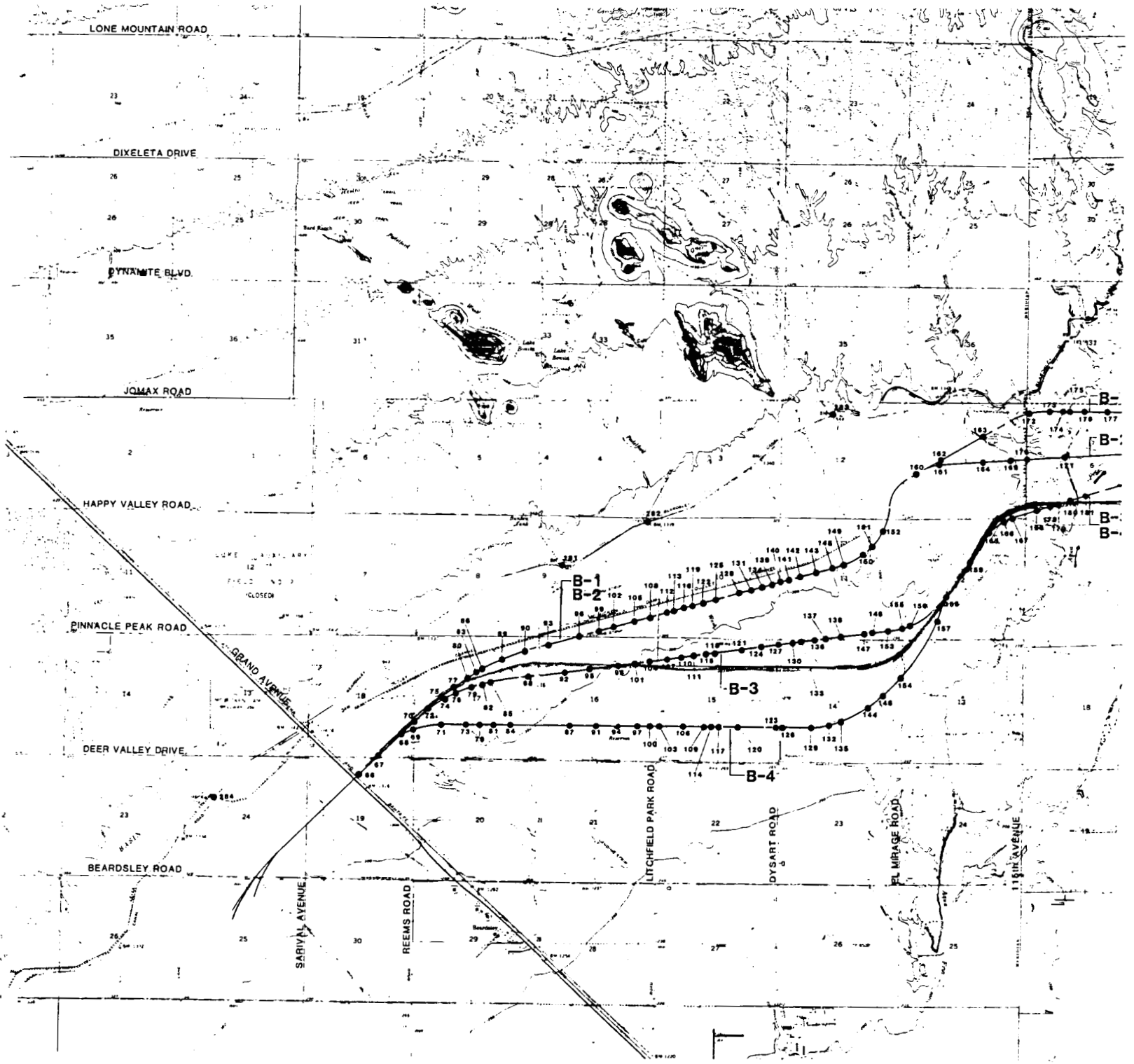
9) U.S. Geological Survey, Avondale SW, Baldy Mountain, Biscuit Flat, Calderwood Butte, Daisy Mountain, Hedgepeth Hills, Hieroglyphic Mountains SW, McMicken Dam, New River, New River SE, Perryville, Union Hills, and Waddell 7.5 Minute Quadrangle Maps.

E


EASEMENT AREA
McMICKEN DAM
OUTLET
CHANNEL
B-1
B-2
B-3
B-4
GRAND AVENUE
McMICKEN DAM
OUTLET STRUCTURE
WASH BASIN
WASH BASIN
WASH BASIN
BOUNDARY
WASH TRIBUTARY
REEMS ROAD
LITCHFIELD PARK ROAD
DYSART ROAD
EL MIRAGE ROAD
115th AVENUE
LAKE AUXILIARY
FIELD NO 2
(CLOSED)

ESTF

DRA


LONE MOUNTAIN ROAD
DIXELETA DRIVE
DYNAMITE BLVD.
JOMAX ROAD
HAPPY VALLEY ROAD
PINNACLE PEAK ROAD
GRAND AVENUE
DEER VALLEY DRIVE
BEARDSLEY ROAD
SARIVAL AVENUE
REEMS ROAD
LITCHFIELD PARK ROAD
DYSART ROAD
EL MIRAGE ROAD
115TH AVENUE
B-1
B-2
B-3
B-4

ESTRELLA FREEWAY

NORTHWEST LOOP AREA

50-YEAR DRAINAGE AREA/DISCHARGE CURVES

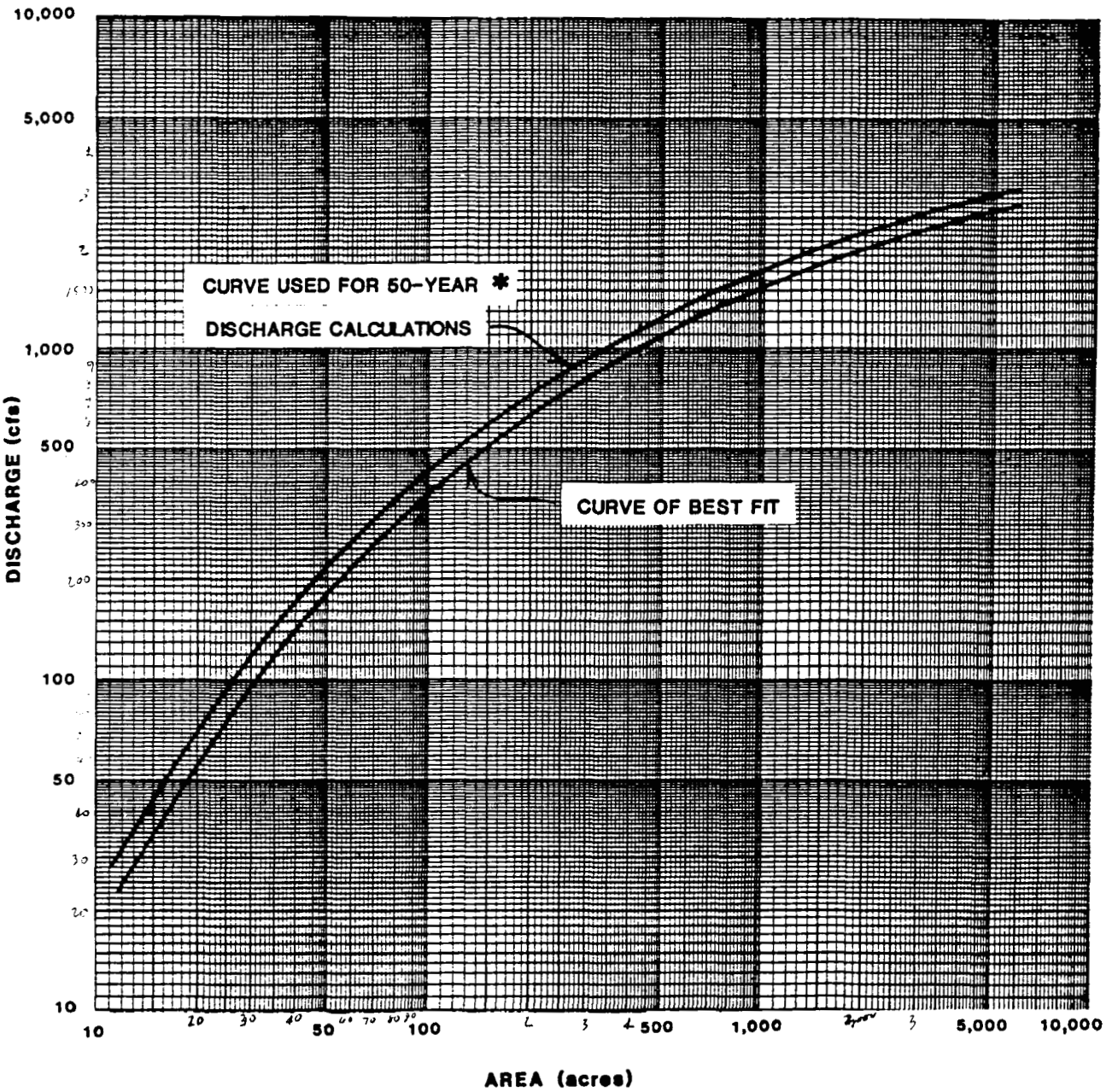


FIGURE 7

* DERIVED BY ADDING 20% SAFETY FACTOR TO CURVE OF BEST FIT

CONC. PT.	CONTRIB. AREA ACRES	Q50 (CFS)
62	134	545
63	70	315
64	96	415
65	83	370
66	19	415
67	70	315
68	64	285
69	51	222
70	45	189
71	19	62
72	6	10
73	77	340
74	32	130
75	26	96
76	26	96
77	19	62
78	38	158
79	19	62
80	13	39
81	32	130
82	13	39
83	6	10
84	51	222
85	13	39
86	6	10
87	179	670
88	51	222
89	13	39
90	6	10
91	83	365

CONC. PT.	CONTRIB. AREA ACRES	Q50 (CFS)
92	38	158
93	6	10
94	70	315
95	38	158
96	13	39
97	38	158
98	19	62
99	6	10
100	45	189
101	19	62
102	6	10
103	45	189
104	26	96
105	6	10
106	70	315
107	26	96
108	6	10
109	109	460
110	19	62
111	19	62
112	3	10
113	3	10
114	58	257
115	19	62
116	3	10
117	45	189
118	19	62
119	3	10
120	90	390
121	19	62

CONC. PT.	CONTRIB. AREA ACRES	Q50 (CFS)
122	3	10
123	154	600
124	26	96
125	6	10
126	58	257
127	45	189
128	6	10
129	122	503
130	32	130
131	3	10
132	70	315
133	26	96
134	6	10
135	147	585
136	109	460
137	13	39
138	90	390
139	3	10
140	3	10
141	6	10
142	6	10
143	13	39
144	51	222
145	13	39
146	McMicken Outlet	17,860
147	102	440
148	McMicken Outlet	17,630
149	19	62
150	6	10
151	McMicken Outlet	16,300

APPENDIX E
CELLA BARR TECHNICAL MEMORANDUM

ADOT COPY

AVOID VERBAL MESSAGES

CELLA BARR ASSOCIATES

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SACRAMENTO, CA 95825
[916] 649-3137
FAX [916] 649-8797

FILE JRB00163.83M
40955-07-83

DATE 1/16/90;Revised12/21/90

TO Tim Wilson, ADOT FROM Jim Nelson

SUBJECT **Technical Memorandum - Estrella Freeway Drainage; Northwest Loop**

General

The Northwest Loop section of the proposed Estrella Freeway extends from Grand Avenue to Interstate 17 and is primarily impacted by moderately to well-defined watersheds extending upstream in a northerly direction. The alignment is also impacted by major drainage features such as the McMicken Dam Outlet Channel, the Agua Fria River, the New River Dam Outlet Channel and the Central Arizona Project Canal (CAP).

Watershed conditions in the Northwest Loop section consist of natural desert foothills, mountainous areas with steeper slopes and a few scattered areas of development. This type of terrain generally produces well-defined paths of low flow that intersect the proposed roadway. The locations of logical points of drainage conclusion are readily available throughout this area, and the proposed drainage design consists primarily of cross-drainage structures at existing points of drainage concentration.

Proposed Drainage Design Concept

Drainage conditions in the Northwest Loop section of the Estrella Freeway differ dramatically from those conditions present in the Cotton Lane section. Watersheds in this section are more defined, and therefore, require a less complicated drainage design concept to effectively convey flows across the roadway. However, major bridge crossings are required at the outfall for the McMicken Dam Outlet Channel, the Agua Fria River, and the CAP Canal. Overall, the proposed drainage design includes utilization of reinforced concrete pipes (RCPs), concrete box culverts, the bridged crossings mentioned above, and attendant flow collection features. The proposed freeway alignment and major drainage features are shown on the attached exhibit.

The drainage design concept for the Northwest Loop section generally consists of conveyance of flows beneath the proposed freeway for release on the downstream side into existing natural points of concentration. Attenuation of flow is not considered to be an important factor in the system due to the fact that existing flows are collected and released into their natural flow paths at point locations and the freeway construction is not likely to significantly impact downstream discharges along this section. The latter is true since the installation of major collection and conveyance channels along this segment of the freeway is not proposed.

Design discharges for the Northwest Loop section were derived from the Estrella Freeway, Northwest Loop Area, 50-year Area/Discharge curves contained in the report entitled "Estrella Freeway Hydrologic Investigation Report" prepared by CBA in July,

1987 and were used for the sizing of all drainage structures, with the exception of the natural channel outfall for the McMicken Dam Outlet Channel, the Agua Fria River and New River. In these excepted instances, the 100-year discharge was established by other means as described in subsequent paragraphs, and was used, based on considerations of federal regulations, interfacing of flood control improvements, damage potential and magnitudes of discharge.

As stated previously, the major drainage features that are encountered by the alignment at various locations are:

- McMicken Dam Outlet Channel
- Agua Fria River
- New River Dam Outlet Channel
- Central Arizona Project Canal (CAP)

The proposed freeway drainage design at each of these major drainage features is discussed in the following paragraphs.

Drainage behind McMicken Dam is diverted easterly along the McMicken Dam Outlet Channel located north of the proposed freeway alignment. The 100-year discharge collected along the McMicken Dam Outlet Channel has been estimated as descibed in the "Estrella Freeway Hydrologic Investigation Report" to be approximately 16,300 cfs at its point of release into a natural channel. This value represents the sum of the discharge from the dam, the flow entering the outlet channel via 3 overchutes along the Beardsley Canal to the north, and runoff generated within a local watershed area between the Beardsley Canal and the McMicken Dam Outlet Channel alignment. Runoff collected in the natural channel is conveyed south to cross the freeway alignment at roughly Station 1372+50. Local widening, narrowing, and stabilizing of the natural channel will be required to transition a 120 foot wide natural channel to a 200 foot long bridge crossing and then back to the natural channel downstream. Appropriate drainage right-of-way is also needed for these channel improvements and to cover backwater areas.

The Agua Fria River has an established 100-year discharge of 135,000 cfs as represented in the preliminary Flood Insurance Study for Maricopa County, Arizona and Incorporated Areas published by the Federal Emergency Management Agency in May, 1990. However, the bridge and attendant feature design requirements may be appreciably lessened upon the completion of New Waddell Dam at Lake Pleasant by the Bureau of Reclamation. Although there is no official value for the reduction in downstream flows that will result from the completion of New Waddell Dam, the Bureau of Reclamation has unofficially indicated that the new 100-year discharge immediately downstream of the dam will be 26,000 cfs as described in the draft document entitled "Hydrology for Evaluation of Flood Reduction by New Waddell Dam, Agua Fria River below New Waddell Dam to the New River Confluence" prepared by the U.S. Army Corps of Engineers and furnished by ADOT. This would translate to a value of roughly 37,000 cfs at the freeway alignment due to the addition of runoff contributions from local watersheds between the dam and the freeway, including Morgan City Wash. No values are available at this time for the

New Waddell Dam spillway, however, unofficially spillway flows are not proposed to occur until a flood event well in excess of the 100-year event has been experienced. It is suggested that the Estrella Freeway crossing of the Agua Fria River be re-evaluated at the time of dam completion, in roughly two to three years, when the dam's operating manual is published. However, for the purpose of this Technical Memorandum, ADOT has instructed that the bridge design concept be based upon the unofficial information currently available. Consequently, this crossing is proposed to be spanned by a bridge of roughly 800 feet in length between stations 1493+40 and 1501+40 to convey roughly 37,000 cfs. The 800 foot length was established by allowing a maximum backwater of 1.0 feet to occur upstream of the bridge, based on HEC-2 evaluations performed by CBA for this reach of the Agua Fria River, during the passage of a 37,000 cfs flow, and in consideration of existing low flow channel locations and geometries. Appropriate drainage easements will be required to accommodate proposed spur dike construction and to accommodate backwater areas.

Construction of the New River Dam across New River just north of the proposed freeway alignment has reduced the 100-year flow for New River to 2,350 cfs collected in the New River Dam Outlet Channel immediately downstream of the dam according to the U.S. Army Corps of Engineers' Design Memorandum No. 3, "New River Dam, Including New River to Skunk Creek," November, 1982. According to this memorandum, there will not be any flow over the emergency spillway during the 100-year flood or the Standard Project Flood. However, during the Probable Maximum Flood (PMF), the emergency spillway would pass a peak flow of 29,850 cfs, resulting in the washout of this segment of freeway in its downstream path. However, this is not considered to be of any practical significance to consider in the freeway drainage design due to the extremeness and low probability of occurrence of the PMF event that is disproportionate to typical freeway design. The 100-year discharge of 2,350 cfs at the New River Dam Outlet Channel crossing at Station 2147+70 will be conveyed underneath the freeway by a 4 cell 10' x 7' concrete box culvert. The outlet channel will be extended downstream to a point just past the roadway to provide uniform flow with no flow breakouts that could potentially damage the roadway during a 100-year event.

The CAP Canal will be spanned at Station 2262+53 by a proposed bridge of sufficient size to clear the physical features of the aqueduct and accompanying maintenance roads, as well as to provide for drainage interflow between both sides of the freeway within an area upstream of the canal prone to ponding.

These major drainage crossings account for a significant amount of the drainage costs in the Northwest Loop section, but are still relatively minor in comparison with the drainage costs encountered along the Cotton Lane portion of the Estrella Freeway. The remainder of the drainage structures required along the Northwest Loop section consist of reinforced concrete pipe culverts (RCP) of various diameters ranging from 24" to 42" and concrete box culverts ranging in size from 2 cell 6' x 4' structures to a 6 cell 10' x 6' structure. Small earthen channels will need to be constructed parallel to the upstream side of the freeway and inside the right-of-way at some locations to guide local flow into nearby culverts. This is to minimize the possibility of ponding occurring on the upstream side of the roadway. In the event that ponding is identified as occurring

behind some of the box culverts that convey the larger flows, additional right-of-way has been set aside to account for backwater and preclude damage to adjacent properties.

Estimated Costs

Following are estimated costs for construction of the drainage facilities for the Northwest Loop section:

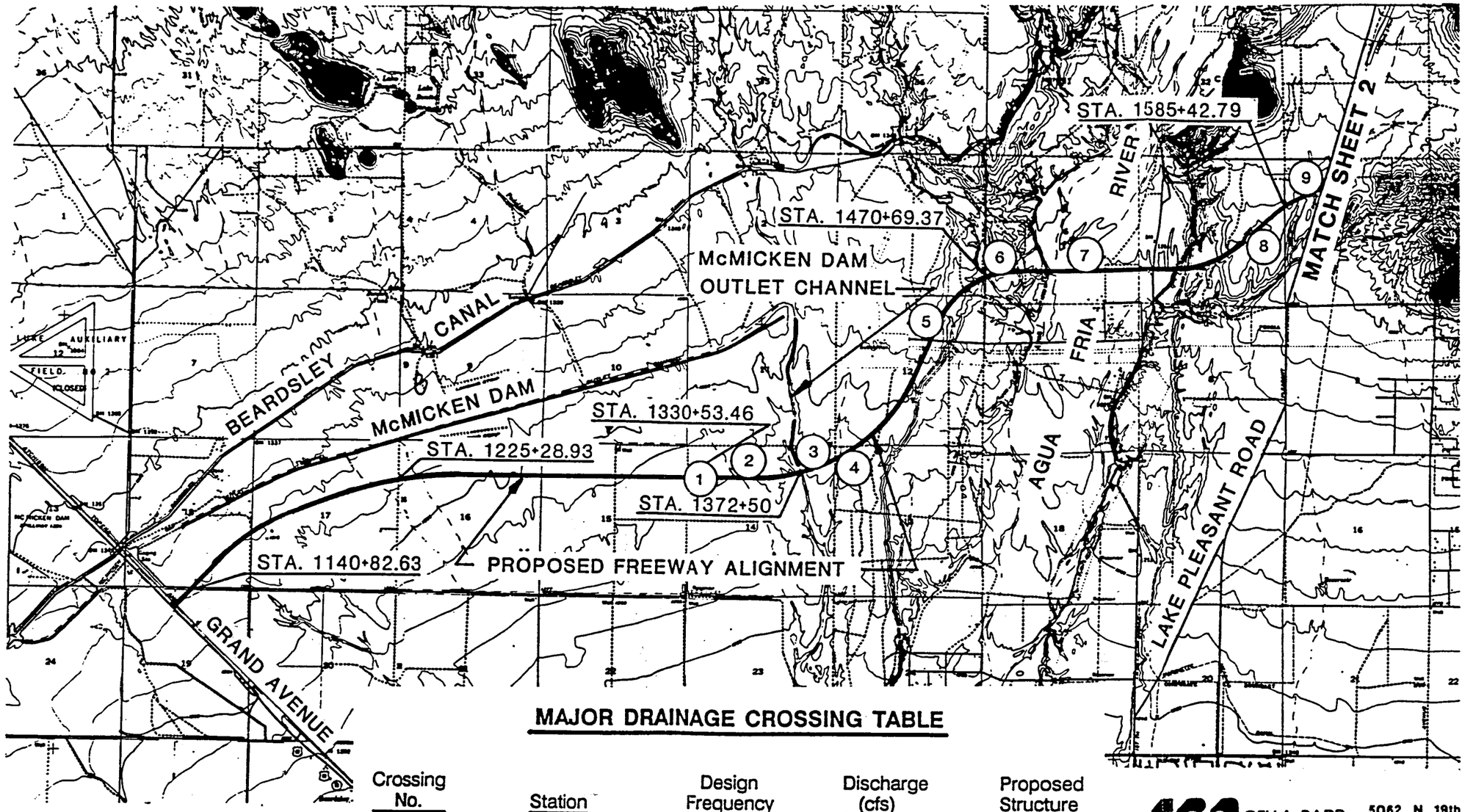
McMicken Dam Outlet Channel	$ 1,298,333
Agua Fria River	4,273,333
New River Dam Outlet Channel	254,445
CAP Canal	983,333
All other crossings	7,783,592
TOTAL	**$14,593,036**

A detailed breakdown of all drainage improvement costs and a typical assumed roadway section are provided as attachments to this technical memorandum.

Summary

This technical memorandum has been prepared to describe and discuss the preliminary design and costs associated with the Northwest Loop section of the proposed Estrella Freeway. The freeway alignment and major drainage features are represented in plan view on the attached exhibit. A detailed cost estimate breakdown for drainage improvements is also provided as attached.

cc: All task leaders



MAJOR DRAINAGE CROSSING TABLE

Crossing No.	Station	Design Frequency	Discharge (cfs)	Proposed Structure
1	1330+69	Q50	500	4-8'X4'CBC
2	1356+66	Q50	800	5-10'X4'CBC
3	1372+50	Q100	16,300	Bridge
4	1384+53	Q50	940	6-10'X4'CBC
5	1443+00	Q50	800	5-10'X4'CBC
6	1471+41	Q50	3,000	6-10'X6'CBC
7	1501+40	Q100	37,000	Bridge
8	1572+29	Q50	650	5-8'X4'CBC
9	1592+69	Q50	1,650	5-10'X5'CBC

4000 2000 0 4000 8000
SCALE IN FEET

CELLA BARR ASSOCIATES
5062 N. 19th Avenue,
Phoenix, Arizona 85015
(602) 242-2999

ESTRELLA FREEWAY
NORTHWEST LOOP
PROPOSED ALIGNMENT AND MAJOR DRAINAGE FEATURES

JANUARY, 1990
SHEET 1 of 2

CBA FILE No. 40955-07-83

ESTRELLA FREEWAY
DRAINAGE COST ESTIMATES FOR MILE
STA 1140+00 to STA 1200+00

	* CHANNELS	** CULVERTS	*** BRIDGES	**** EXCAVATION	***** R.O.W	DESCRIPTION
		67,500				3-36" RCP X 250'
		95,919				2-8'X4' CBC X 190'
		119,412				2-10'X4' CBC X 180'
		64,800				4-36" RCP X 180'
		21,600				2-24" RCP X 180'
		72,000				4-36" RCP X 200'
		42,750				3-30" RCP X 190'
		85,500				5-36" RCP X 190'
TOTALS		$569,481				

GRAND TOTAL FOR MILE $569,481

* CHANNELS --- $180.00 per cubic yard of gunite (excludes excavation)
** CULVERTS --- PIPE -- $ 2.50 per inch in diameter per linear foot
BOX -- $300.00 per cubic yard of cement
(includes wing walls and rebar)
*** BRIDGES --- $50.00 per square foot of bridge crossing
**** EXCAVATION --- $2.00 per cubic yard of earthwork
***** RIGHT-OF-WAY --- ( ) denotes cost per acre

ESTRELLA FREEWAY
DRAINAGE COST ESTIMATES FOR MILE
STA 1200+00 to STA 1260+00

	CHANNELS *	CULVERTS **	BRIDGES ***	EXCAVATION ****	R.O.W *****	DESCRIPTION
		27,000				2-30" RCP X 180'
		64,800				4-36" RCP X 180'
		56,700				2-42" RCP X 270'
		32,400				2-36" RCP X 180'
		81,360				2-6'X4' CBC X 200'
		128,723				2-10'X4' CBC X 195'
		119,421				2-10'X4' CBC X 180'
TOTALS		$510,404				

GRAND TOTAL FOR MILE $510,404

* CHANNELS --- $180.00 per cubic yard of gunite (excludes excavation)
** CULVERTS --- PIPE -- $2.50 per inch in diameter per linear foot
BOX -- $300.00 per cubic yard of cement
(includes wing walls and rebar)
*** BRIDGES --- $50.00 per square foot of bridge crossing
**** EXCAVATION --- $2.00 per cubic yard of earthwork
***** RIGHT-OF-WAY --- ( ) denotes cost per acre

ESTRELLA FREEWAY
DRAINAGE COST ESTIMATES FOR MILE
STA 1260+00 to STA 1320+00

	CHANNELS *	CULVERTS **	BRIDGES ***	EXCAVATION ****	R.O.W *****	DESCRIPTION
		11,400				1- 24" RCP X 190'
		77,622				2-6'X4' CBCX 195'
		73,884				2-6'X4' CBCX 180'
		136,143				3-8'X4' CBCX 190'
		129,405				3-8'X4' CBCX 180'
		170,349				3-10'X4' CBCX 180'
TOTALS		$598,803				

GRAND TOTAL FOR MILE $598,803

* CHANNELS --- $180.00 per cubic yard of gunite (excludes excavation)
** CULVERTS --- PIPE -- $2.50 per inch in diameter per linear foot
BOX -- $300.00 per cubic yard of cement (includes wing walls and rebar)
*** BRIDGES --- $60.00 per square foot of bridge crossing
**** EXCAVATION --- $2.00 per cubic yard of earthwork
***** RIGHT-OF-WAY --- ( ) denotes cost per acre

APPENDIX F
SUN CITY WEST EXPANSION AREA
HYDROLOGY

MASTER DRAINAGE REPORT

FOR

SUN CITY WEST EXPANSION AREA

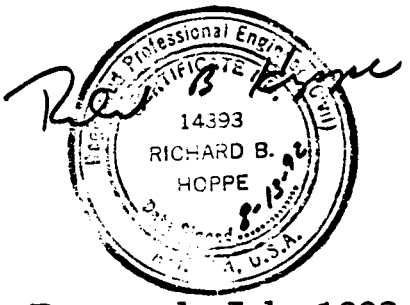
Prepared For

DEL E. WEBB DEVELOPMENT CO. L.P.,
a Delaware Limited Partnership,
Developer

DEL WEBB HOME CONSTRUCTION, INC.
an Arizona Corporation,
Owner

Prepared By

STANLEY CONSULTANTS INC.
3117 North 16th Street
Phoenix, Arizona 85016
(602) 279-0901



Prepared: July, 1992

Revised: August 11, 1992

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TDD (602) 506-5897

BOARD OF DIRECTORS

P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

D. E. Sagramoso, P.E., Chief Engineer and General Manager

AUG 28 1992

MEMO TO: Dennis Zwagerman, Planning and Development Director

ATTN: Debra W. Stark, Planner III

FROM: Edward A. Raleigh, Chief, Engineering Division

SUBJECT: Z 92-36 (Sun City West Expansion Phase I-TAC)

The subject property is not within a delineated 100-year floodplain. The proposed use would not be in conflict with any existing or proposed Flood Control District projects. We have no objections to the change of zoning.

Prior to Preliminary Plat approval, a drainage report must be submitted for review and approval. This report must address the offsite hydrology, onsite hydrology and manner in which the proposed subdivision will maintain the continuity of local drainage.

Drainage improvements are considered to be a part of the required infrastructure for this development. These features must be fully operational prior to the issuance of a drainage clearance for individual lots and issuance of the final drainage clearance

If you have any questions, please contact Felicia Terry at 506-1501.

Edward A. Raleigh, P.E.

Steven Tucker

Steven L. Tucker, P.E.
Stormwater Drainage Branch Manager

EAR/SLT/FT/lab

Copy to: Gerald Toscano, MCDOT
Tim Goodrich, Del Webb Home Construction, Inc.
Stanley Consultants, Inc.

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
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BOARD OF DIRECTORS

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Carole Carpenter
Tom Freestone

D. E. Sagramoso, P.E., Chief Engineer and General Manager

APR 09 1992

MEMO TO: Dennis Zwagerman, Planning and Development Director

ATTN: Jill Herberg-Kusy, Principal Planner

FROM: Edward A. Raleigh, Chief, Engineering Division

Subject: MP 92-1 (Sun City West Master Plan Amendment)

The subject property is not within a delineated 100-year floodplain. The proposed use would not be in conflict with any existing or proposed Flood Control District projects. We have no objections to the Master Plan Amendment.

Drainage improvements are considered to be a part of the required infrastructure for this development. These drainage features must be fully operational prior to the construction of any units or subdivisions. A detailed hydraulic analysis addressing drainage and roadway infrastructure of the Master Planned Development will need to be submitted and approved prior to approval of any individual subdivisions.

If you have any questions, please contact Felicia Terry at 262-1501.

Edward A. Raleigh, P.E.

Steven Tucker

Steven L. Tucker, P.E.
Stormwater Drainage Branch Manager

EAR/SLT/FT/rmc

Copy to: County Highway Department
Del Webb Home Construction, Inc.
Stanley Consultants, Inc.

TABLE OF CONTENTS

Page

Introduction 1

Basic Design Criteria 10

Proposed Drainage System 13

Hydrologic Assumptions and Methods 17

Hydrologic Models 25

Hydraulic Assumptions and Methods 26

Interim Drainage Facilities and First Construction Phase 29

Conclusions 30

Bibliography 35

APPENDICES

Appendix A (Inside Pocket)

a. Figure 3 - Master Drainage Plan

b. Figure 4 - Key Map for Hydraulic Design

c. Figure 5 - Existing Onsite Topography

d. HEC-1 and HEC-2 Input Files on Diskette

Appendix B (Hydrology and Supporting HEC-1 Data)

Appendix C (HEC-1 Printout)

Appendix D (Hydraulic Analyses)

Appendix E (1977 Sun City West Master Drainage)

FIGURES

		Page
1	Vicinity Map	2
2	Flood Insurance Map	9
3	Master Drainage Plan	Appendix A
4	Key Map for Hydraulic Design	Appendix A
5	Existing Onsite Topography	Appendix A
6	Watershed Map Overall Basin	Appendix B
7	Watershed Map Offsite & Onsite	Appendix B
8	Soils Map	Appendix B
9	HEC-1 Routing Schematic	Appendix B

TABLES

1	Watershed Resistance Coefficient Parameters	19
2	Rainfall Losses for Onsite Areas	23
3	Peak Flows and Runoff Volumes for Onsite Sub-basins	33
4	Detention Basin Data	34

PLATES

1	Onsite Existing Desert	5
2	Typical Onsite Wash	5
3	McMicken Dam Outlet Channel	6
4	Drainageway, East Side of Property	6
5	Drainageway Along Deer Valley Drive	7
6	Drainageway Along Deer Valley Drive	7

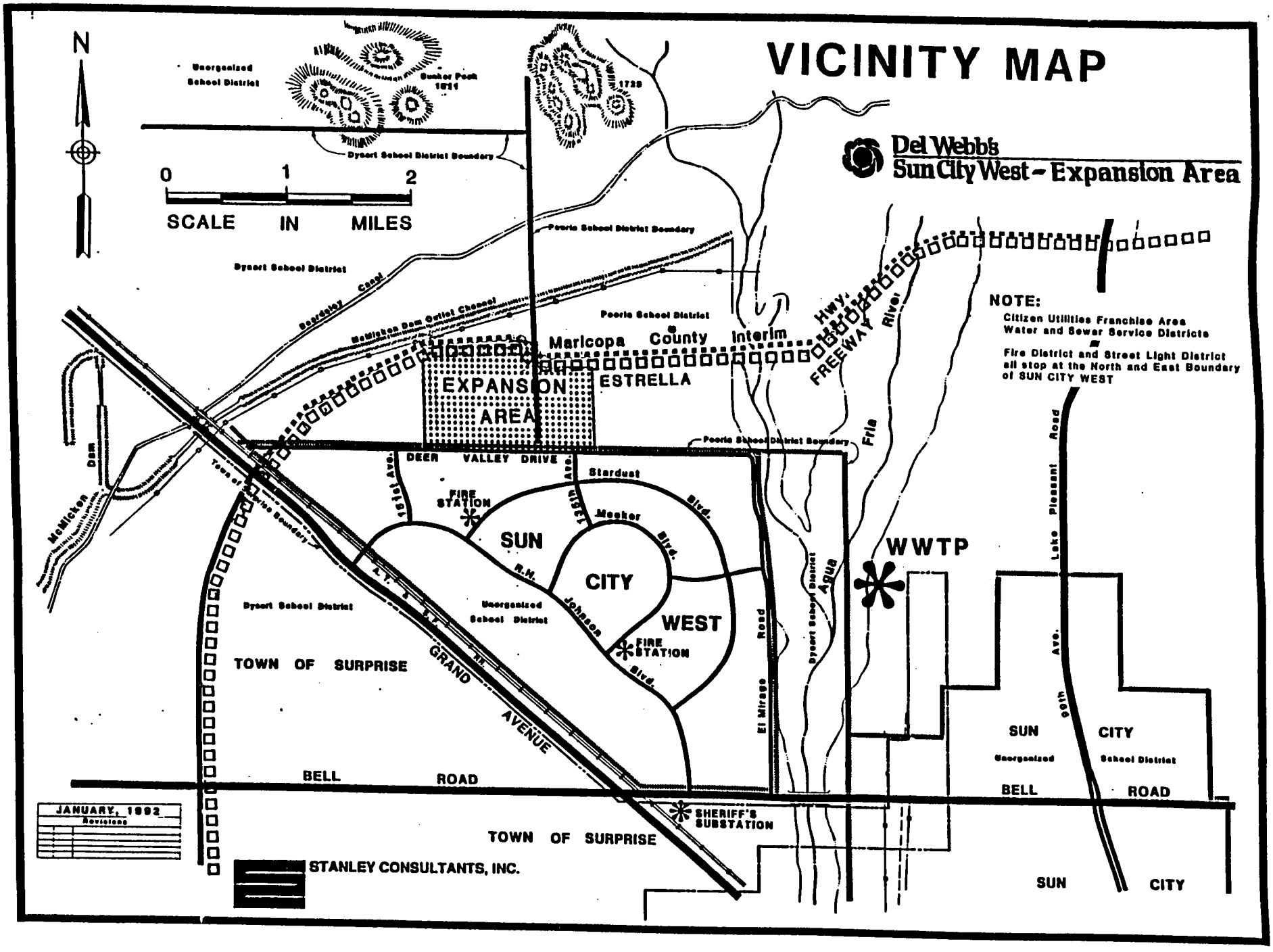

VICINITY MAP
Del Webb's
Sun City West - Expansion Area
N
0 1 2
SCALE IN MILES
Unorganized School District
Bunker Peak 1611
1729
Dysart School District Boundary
Peoria School District Boundary
Dysart School District
Beardsley Canal
McMicken Dam Outlet Channel
Peoria School District
Maricopa County Interim Hwy.
FREEWAY
Fria River
EXPANSION AREA
ESTRELLA
NOTE:
Citizen Utilities Franchise Area
Water and Sewer Service Districts
Fire District and Street Light District
all stop at the North and East Boundary
of SUN CITY WEST
McMicken Dam
Town of Surprise Boundary
DEER VALLEY DRIVE
151st Ave.
135th Ave.
Stardust Blvd.
Meeker Blvd.
FIRE STATION
SUN CITY WEST
R.H. Johnson Blvd.
FIRE STATION
Unorganized School District
Dysart School District
TOWN OF SURPRISE
A.T.&S.F.
GRAND AVENUE
El Mirage Road
Dysart School District
Agua Fria
WWTP
Lake Pleasant Road
99th Ave.
SUN CITY
Unorganized School District
BELL ROAD
BELL ROAD
SHERIFF'S SUBSTATION
TOWN OF SURPRISE
SUN CITY
JANUARY, 1992
Revisions
STANLEY CONSULTANTS, INC.

FIGURE 1

HYDROLOGIC ASSUMPTIONS AND METHODS

The Corps of Engineers HEC-1 computer hydrograph program, version 4.0 dated September 1990 was used in this report to generate and route synthetic hydrographs. This version contains Green-Ampt loss rate functions, which, along with the Clark Unitgraph option are required by the Flood Control District's Hydrologic Design Manual for contributing areas greater than 160 acres. Clark Unitgraph hydrology will be used as the basis of design for storm water detention, offsite and major onsite drainage channels, golf course conveyance, storm drain trunklines and other major drainage features on an overall master plan basis.

A version of the Rational Runoff Method is also presented in the Hydrology Manual. It will not be used for design in this report but may be used to estimate peak flows for drainage design of future individual parcels within the Expansion Master Plan. Generally, its use would be limited to those applications where only volume and peak flow estimates are needed and hydrograph routing is not involved. For example, it might be used as the basis for checking street flow capacity, design of minor drainage channels and swales, catch basin inlets and minor storm drain laterals.

A similar combination of methods was used with the existing Sun City West development south of Deer Valley Drive. The SCS TR-20 method was used for hydrograph routing and design of major drainage features while the Rational Runoff Method is used for individual subdivisions. Certain adjustments have been made to Rational Method parameters in Sun City West so that flow rates are comparable to those from TR-20.

Since there will be circumstances in the future where either the Clark Unitgraph or Rational Method are applicable, a brief evaluation of comparative results will be presented in this report for three selected onsite sub-basins. These comparative calculations will be made using the same basic area, length, slope, resistance coefficient and rainfall data. Calculations and results will be discussed in the conclusion section of this report.

Rainfall data for this report is taken from the Hydrology Manual. The 100-year 2-hour rainfall amount for use with the Clark Unitgraph method is estimated at 2.77 inches. This storm total was used in conjunction with the 2-hour distribution from Table 2.2 of the Hydrology Manual. No aerial reduction was assumed for the HEC-1 model. Future Rational Method calculations will use the rainfall intensity-duration-frequency relation of Figure 3.2 of the Hydrology Manual. No location adjustment was made for rational rainfall intensity in the comparisons to the Clark Unitgraph contained in this report.

Drainage sub-basins for the HEC-1 models are shown on Figures 3, 6, and 7 in Appendices A and B. Their areas were estimated through the use of a digital planimeter. Right-of-way for the proposed Estrella Freeway was considered as offsite area, existing desert. Areas are estimated to the nearest 0.001 square mile. The HEC-1 program uses this level of accuracy in its computations but rounds off the output data to the nearest 0.01 square miles. Rational method will use area in acres.

Times of concentration are estimated using essentially the same methodology for both the Clark Unitgraph and Rational Methods. Both methods use the same basic equation (equation

3.2/5.5 of the Hydrology Manual) to estimate floodwave travel time as a function of watershed length, resistance, slope and rainfall intensity. This equation is:

$$Tc = 11.4L^{0.5} Kb^{0.52} S^{-0.31} i^{-0.38}$$

The only difference in application is that Clark Unitgraph uses the intensity of rainfall excess and the Rational Method uses direct rainfall intensity. Slopes and lengths have been estimated for the HEC-1 model based on preliminary street layout and mass grading plans.

The watershed resistance coefficient, Kb, in the time of concentration equation is estimated using the following equation from the Hydrology Manual:

$$Kb = m \log A + b$$

where A is the contributing area in acres and m and b are equation parameters taken from Table 3.1/5.1 of the Hydrology Manual. For contributing areas with more than one land use, m and b parameters are area-weighted. Table 1 summarizes the basic parameters used in the HEC-1 model. In relative terms, residential and commercial land use has the least resistance, golf course and open space has the greatest resistance and existing desert falls mid-range between the two.

TABLE 1 RESISTANCE COEFFICIENT PARAMETERS

	m	b
Residential, Commercial, Rec. Center	-0.00625	0.04
Existing Desert	-0.016	0.10
Golf Course/Open Space	-0.025	0.15

Watershed storage coefficient, R, is a function of time of concentration, area and length based on equation 5.6 of the Hydrology Manual. This equation is:

$$R = 0.37\ Tc^{1.11}\ A^{-0.57}\ L^{0.80}$$

Test runs indicate that Tc and R are particularly sensitive to selection of m and b parameters used in estimating Kb. Tc and R for Clark Unitgraph are calculated using the MCUHP1 program dated revised December 16, 1991. MCUHP1 is used in conjunction with a Lotus 123 spreadsheet developed by Stanley Consultants which processes raw data, assembles the results and redirects them as a batch file through MCUHP1. Rational Method Tc is calculated by hand.

The time-area relationship for urban watersheds from Table 5.2 of the Hydrology Manual was used for all onsite developed sub-basins. All offsite sub-basins and the existing condition onsite area use the natural watershed time-area relationship from Table 5.2. The HEC-1 computation time interval was chosen at 5 minutes.

Green Ampt rainfall loss rates for all offsite sub-basins and the onsite existing condition sub-basin are area-weighted values based on soil texture classifications and the parameters in Table 4.2 of the Hydrology Manual. All soils found in the study area are classified in hydrologic soil group B. DTHETA is based on the dry value and XKSAT is adjusted assuming a vegetation cover of 25%. Initial surface retention loss, IA, for existing conditions was assumed to be 0.35 inches and impervious area was assumed to be 1 percent. The existing surface cover of gravel which occurs in parts of the study area was assumed to not affect rainfall losses.

Procedures for estimating Green and Ampt loss rates and percent impervious for urbanized areas are not directly presented in the Hydrology Manual so a number of interpretations and assumptions have been made. Contributing area is assumed to consist of either impervious or pervious land use. The impervious land use is further broken into connected and non-connected area.

Connected impervious is considered separately in HEC-1. It consists of such things as roofs, driveways, sidewalks, streets and parking lots which are directly connected to a means of runoff conveyance such as a street or drainage channel. Estimates of connected impervious are entered in HEC-1 as percent of total area. This area produces 100 percent runoff. Estimates range from 1 percent for golf course and existing desert to 25 percent for residential to 80 percent for commercial and recreation center land use.

A non-connected impervious area is not directly connected to a means of runoff conveyance. Its runoff must flow over adjacent landscaped or other pervious surfaces where infiltration may occur. Non-connected impervious area is included with pervious area and loss rates for both are assumed to be reflected by soil parameters DTHETA, PSIF and XKSAT.

Basic soil parameters for the developed condition were assumed to be the same as the weighted parameters for the onsite existing condition. This presumes no change due to grading and earthwork. DTHETA assumes the dry condition except for the golf course and open space areas which assume half dry and half normal conditions. XKSAT is modified assuming 25 percent vegetative cover (same as existing condition) except in the golf course/open space area where half is assumed to have 100 percent cover and the other half is assumed at 25 percent.

In addition to the connected impervious and Green-Ampt soil loss considerations, HEC-1 also considers an initial rainfall abstraction or surface retention loss. In HEC-1, this loss only applies to pervious and non-connected impervious land use. Estimates of surface retention loss are estimated from Table 4.1 of the Hydrology Manual and range from 0.10 inches for commercial and recreation center to 0.15 inches for residential land use to 0.35 inches for existing desert or proposed golf and open space.

Rainfall losses for the Rational Method are estimated by a single runoff coefficient parameter. This coefficient varies according to land use. Coefficients were selected based on Table 3.2 of the Hydrology Manual. A 100-year frequency factor of 1.25 is applied to runoff coefficients in anticipation of the next revision of the Hydrology Manual.

In general, all loss rate parameters for onsite developed conditions are area-weighted for sub-basins consisting of multiple land use. A summary of Green and Ampt loss rate parameters, initial abstract and percent impervious as well as Rational runoff coefficients and associated rainfall excess is presented in Table 2.

Hydrograph routing in HEC-1 for this report is performed using kinematic wave and modified Puls options. Kinematic wave routing applies only to concrete lined trapezoidal channels and roadways. Modified Puls routing applies to both channel and detention basin routing in the golf/open space areas. Cross sections for routing purposes are derived from grading and golf course plans. No infiltration/percolation losses are assumed for any modified Puls routing. Longitudinal channel slopes are estimated based on grading and golf course plans. The

TABLE 2

RAINFALL LOSSES FOR ONSITE AREAS

(Rainfall Excess Based on 100-Year, 2-Hour Storm of 2.77 Inches)

CLARK UNITGRAPH LOSS RATES

Land Use	Initial Loss (Inches)	DTHETA	PSIF (Inches)	XKSAT (In/Hr)	RTIMP (Percent)	Rainfall Excess (Inches)
Single Family Residential & Casita	0.15	0.35	5.05	0.23	25	1.87
Golf/Open Space	0.35	0.30	5.05	0.23	1	1.39
Commercial & Recreation Center	0.10	.0.35	5.05	0.30	80	2.53
Exist. Onsite Desert	0.35	0.35	5.05	0.23	1	1.46

RATIONAL METHOD RUNOFF COEFFICIENTS

Land Use	Base Runoff Coefficient C	Frequency Factor	Adjusted Runoff Coefficient C	Rainfall Excess (Inches)
Single Family Residential & Casita	0.50	1.25	0.63	1.75
Golf/Open Space	0.28*	1.25	0.35	0.97
Commercial & Recreation Center	0.70	1.25	0.88	2.43

* Composite C based on half turf @ C = 0.20 and the other half desert @ C = 0.35

number of routing steps is one (1) for reservoir routing. For channel routing, it is estimated based on reach length divided by an assumed average flow velocity of 5 feet/second divided by the computation time interval of 5 minutes (or 300 seconds).

Detention basin volumes are estimated by HEC-1 on the basis of elevation-area input. Areas are estimated with the use of a digital planimeter. As mentioned previously, many detention basins reflect the sum of several sub-detention basins within them. The maximum possible depth of any detention basin is 6 feet measured from the lowest ground surface to the highest possible water surface stage. The hydraulics of detention basin outlets is discussed in the Hydraulic Assumptions and Methods section of this report.

HYDROLOGIC MODELS

There are three HEC-1 models presented in this report. Model 11389A1 considers the entire contributing area to the southeast corner of the proposed expansion as one basin, existing conditions. Model 11389A2 takes the same existing condition basin in 11389A1 and breaks it into sub-basins according to onsite and offsite areas. Model 11389B takes the onsite sub-basin in 11389A2 and breaks it into developed condition sub-basins with channel and detention basin routing. In addition to these HEC-1 models, this report will present a comparison of peak flows and volumes from the Rational Method to those from Clark Unitgraph for three selected onsite developed sub-basins.

HEC-1 models 11389A1 and 11389A2 are intended to provide an existing condition peak discharge for comparison to the previous estimate by HDR and to the proposed developed condition. These two models also compare, between each other, the effects of breaking the total area into smaller sub-basins. Offsite flows in model 11389A2 are routed through the onsite area in hypothetical channels. An abbreviated output of HEC-1 model 11389B is included in Appendix C. Full input files of all HEC-1 models are provided on diskette in Appendix A.

STANLEY

JOB SUN CITY WEST EXPANSION
SHEET NO. 1 OF 4
CALCULATED BY GSS DATE
CHECKED BY DATE
SCALE

PRECIPITATION: (REFER TO HYDROLOGY MANUAL, CHAPTER 2)

DURATION

FREQUENCY	6-HOUR	24-HOUR
2 YEAR	1.2"	1.5"
5 YEAR	1.7"	2.1"
10 YEAR	2.1"	2.6"
25 YEAR	2.6"	3.2"
50 YEAR	2.9"	3.6"
100 YEAR	3.3"	4.1"

FIGURES 2.2 THRU 2.13

FOR 1-HOUR DURATION:

2 YEAR = $-0.011 + 0.942(1.2)(1.2/1.5) = 0.89$

100 YEAR = $0.494 + 0.755(3.3)(3.3/4.1) = 2.50$

5 " = 1.25"
10 " = 1.55"
25 " = 1.9"
50 " = 2.2"

FIGURE 2.14

FOR 2-HOUR DURATION

2 YEAR = $0.341(1.2) + 0.659(0.89) = 1.00$

100 YEAR = $0.341(3.3) + 0.659(2.5) = 2.77$

FOR 3-HOUR DURATION:

2 YEAR = $0.569(1.2) + 0.431(0.89) = 1.07$

100 YEAR = $0.569(3.3) + 0.431(2.5) = 2.96$

FOR 12 HOUR DURATION REFER TO FIG. 2.15

FOR LESS THAN 1 HR DURATION:

	2YR	5YR	10YR	25YR	50YR	100YR
5MIN	0.30	0.43	0.53	0.65	0.75	0.85
10MIN	0.45	0.64	0.79	0.97	1.12	1.28
15MIN	0.55	0.78	0.96	1.18	1.36	1.55
30MIN	0.60	1.03	1.27	1.56	1.80	2.05

PRODUCT 205-1 NEBS Inc., Groton, Mass. 01471. To Order PHONE TOLL FREE 1-800-225-6380

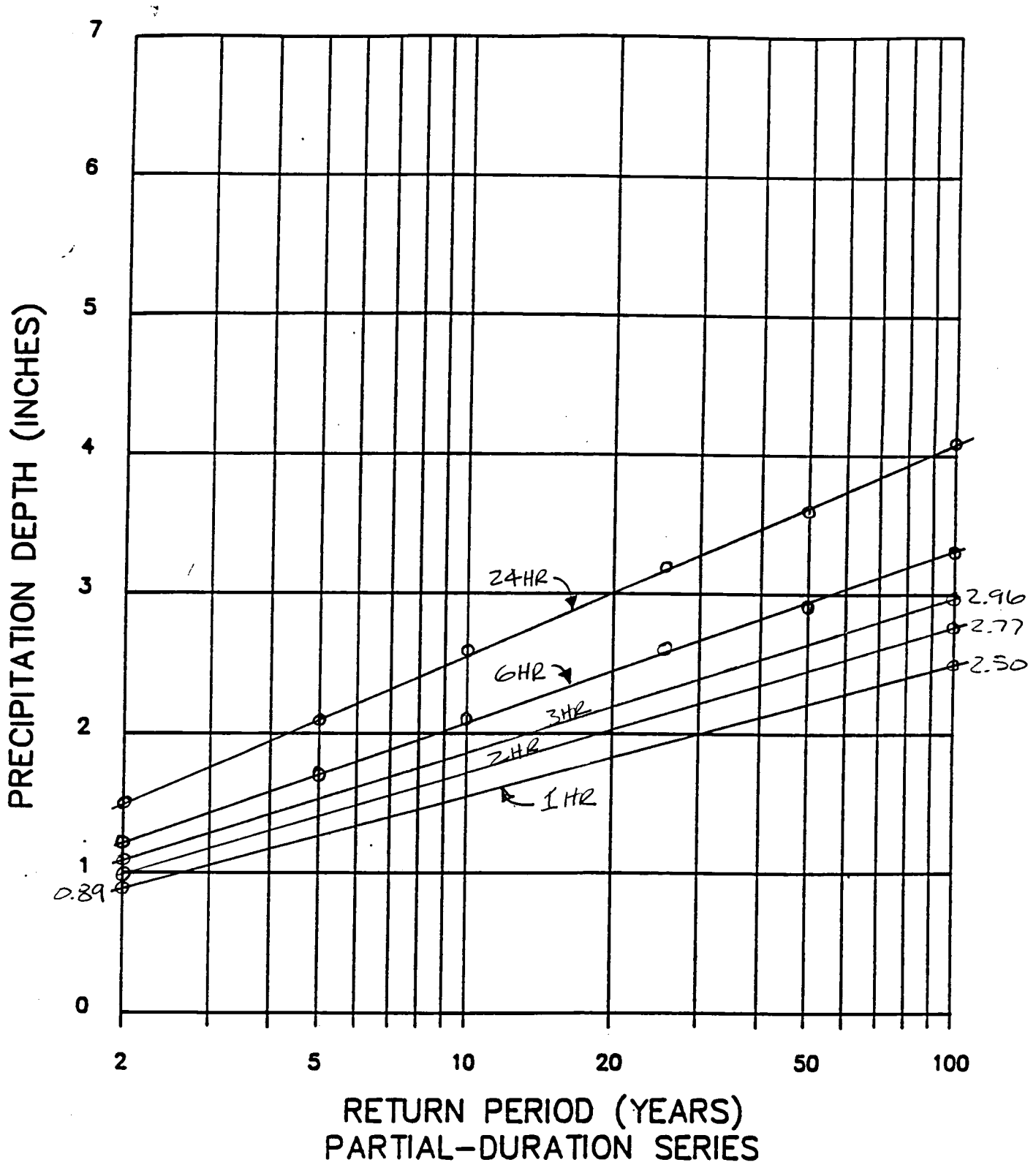


Figure 2.14
Precipitation Depth versus Return Period for Partial-Duration Series

3 of 4

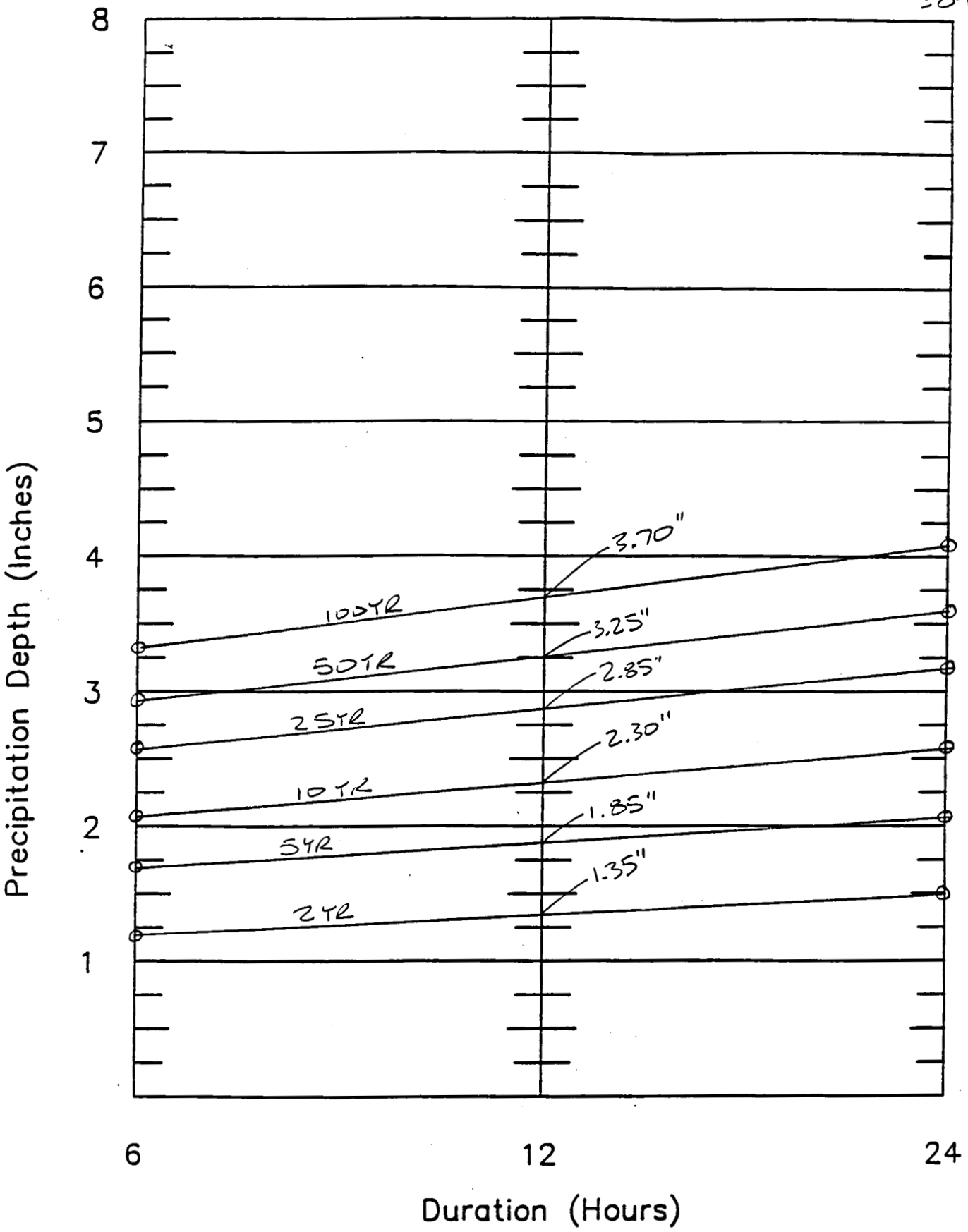


Figure 2.15
Precipitation Depth-Duration Diagram (6 to 24 hour)

STANLEY

JOB SUN CITY WEST EXPANSION

SHEET NO. 4 OF 4

CALCULATED BY GSB DATE

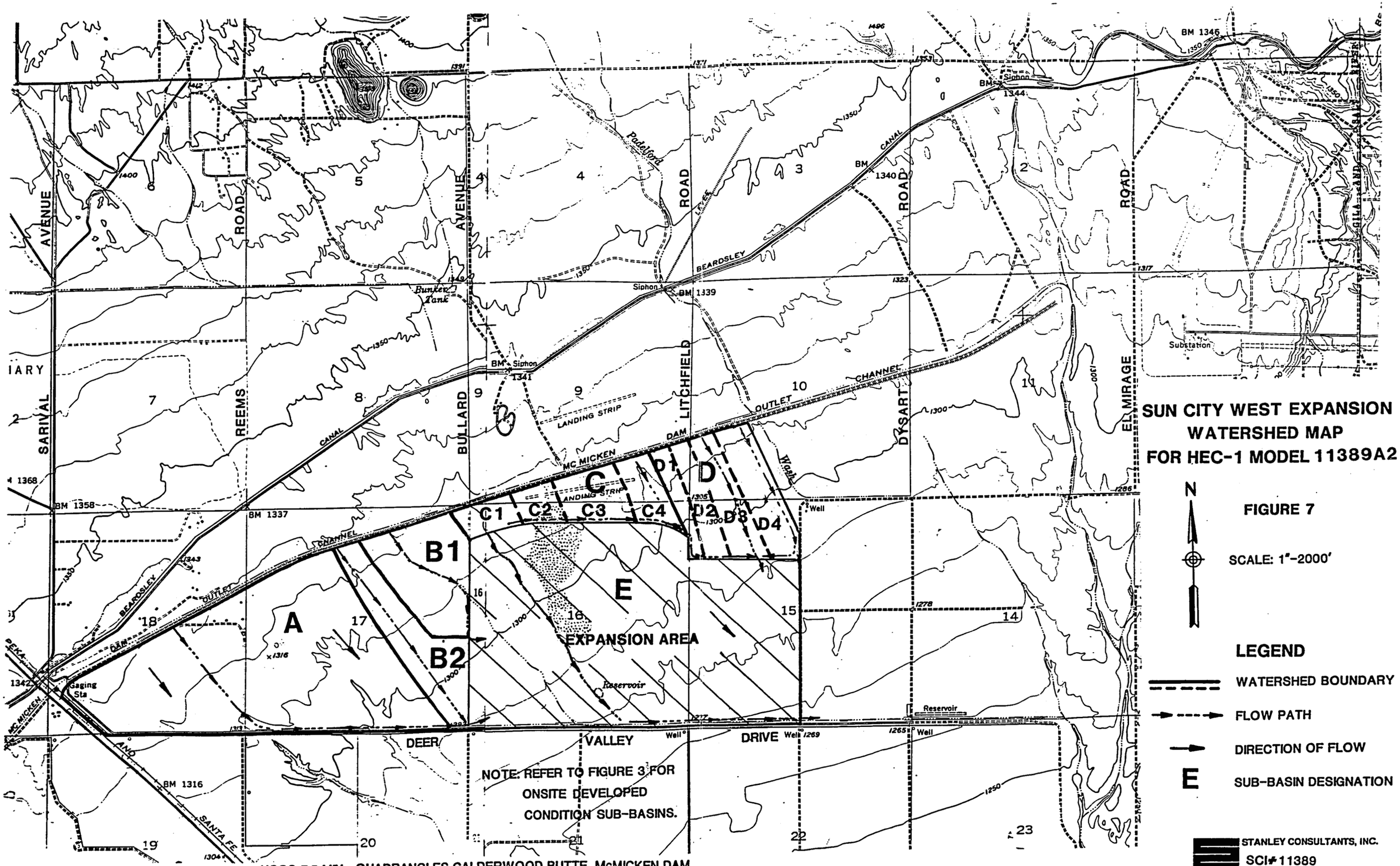
CHECKED BY DATE

SCALE

DEPTH DURATION FREQUENCY TABLE
FOR SUN CITY WEST EXPANSION:

DURATION	FREQUENCY 2YR	5YR	10YR	25YR	50YR	100YR
5 MIN	0.30	0.43	0.53	0.65	0.75	0.85
10 MIN	0.45	0.64	0.79	0.97	1.12	1.28
15 MIN	0.55	0.78	0.96	1.18	1.36	1.55
30 MIN	0.60	1.03	1.27	1.56	1.80	2.05
1 HR	0.89	1.25	1.55	1.90	2.20	2.50
2 HR	1.00	1.40	1.70	2.15	2.45	2.77
3 HR	1.07	1.50	1.85	2.30	2.65	2.96
6 HR	1.20	1.70	2.10	2.60	2.90	3.30
12 HR	1.35	1.85	2.30	2.85	3.25	3.70
24 HR	1.50	2.10	2.60	3.20	3.60	4.10

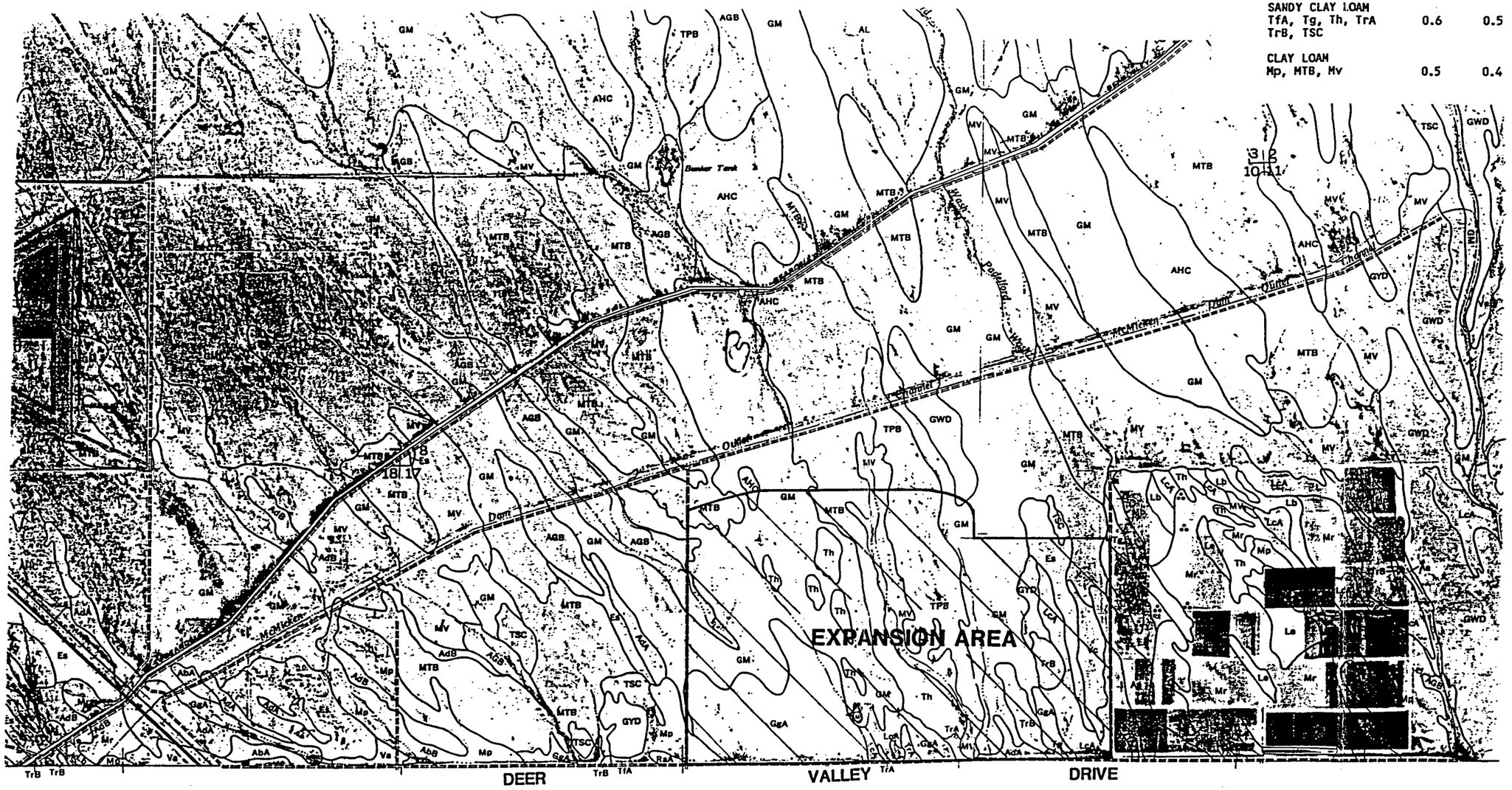
PRODUCT 205-1 NEBS Inc., Groton, Mass. 01471. To Order PHONE TOLL FREE 1-800-225-6380


SUN CITY WEST EXPANSION
WATERSHED MAP
FOR HEC-1 MODEL 11389A2
FIGURE 7
SCALE: 1"=2000'
N
LEGEND
WATERSHED BOUNDARY
FLOW PATH
DIRECTION OF FLOW
E SUB-BASIN DESIGNATION
STANLEY CONSULTANTS, INC.
SCI# 11389
A
B1
B2
C
C1
C2
C3
C4
D
D1
D2
D3
D4
E
EXPANSION AREA
NOTE: REFER TO FIGURE 3 FOR
ONSITE DEVELOPED
CONDITION SUB-BASINS.
USGS 7.5 MIN. QUADRANGLES CALDERWOOD BUTTE, McMICKEN DAM
SARIVAL AVENUE
REEMS ROAD
BULLARD AVENUE
LITCHFIELD ROAD
DYSART ROAD
EL MIRAGE ROAD
DEER VALLEY DRIVE
BEARDSLEY CANAL
McMICKEN DAM OUTLET CHANNEL
LANDING STRIP
Paddleford Creek
Bunker Tank
Siphon
Gaging Sta
Reservoir
Substation
Well
BM 1346
BM 1344
BM 1340
BM 1339
BM 1341
BM 1358
BM 1337
BM 1316
SANTA FE

NOTE: THIS MAP REPRODUCED FROM SOIL SURVEY OF MARICOPA COUNTY, ARIZONA – CENTRAL PART, SOIL CONSERVATION SERVICE, SEPTEMBER 1977, SHEETS 2 & 3. REFER TO THAT SURVEY FOR DESCRIPTION OF SOILS.

GREEN AND AMPT RAINFALL LOSS PARAMETERS BY SCS SOIL TYPE

SCS SOIL TYPE	IA (dry)	IA (norm)	DTHETA (dry)	DTHETA (norm)	PSIF	XKSAT
SANDY LOAM AbA, AdA, AdB AGB, AHC, GYD GWD, RaA, Va, Va	0.7	0.6	0.35	0.25	4.3	0.4
LOAM Es, GgA, GM, LcA	0.6	0.5	0.35	0.25	3.5	0.25
SANDY CLAY LOAM TfA, Tg, Th, TrA TrB, TSC	0.6	0.5	0.25	0.15	8.6	0.06
CLAY LOAM Mp, MTB, Mv	0.5	0.4	0.25	0.15	8.2	0.04



N

SCALE: 1"=2000'

FIGURE 8

SUN CITY WEST EXPANSION SOILS MAP – EXISTING CONDITIONS

STANLEY CONSULTANTS, INC.
SCI# 11389

DESIGNED BY GSB DATE 3-13-92 SHEET NO. PAGE NO.
CHECKED BY DATE OF JOB NO.
REVIEWED BY DATE SUBJECT: SUN CITY WEST EXPANSION
APPROVED BY DATE SOIL GLASS BREAKDOWN

EXISTING CONDITION SOILS

AREA	% SL	% L	% SCL	% CL	TOTAL AREA (ACRES)
A	24.3	23.8	4.4	47.5	555
B	30.7	41.1	4.3	23.9	223
C	16.3	33.7	17.4	32.6	125
D	6.4	77.0	2.8	13.8	145
E	8.4	61.7	19.0	10.9	330

PROCEDURE FOR WEIGHTING GREEN & AMPT LOSS RATE PARAMETERS IS FROM CHAPTER 4 OF HYDROLOGY MANUAL. BASIC PARAMETERS ARE FROM TABLE 4.2. DTHETA ASSUMES DRY CONDITION FOR EXIST SUB-BASINS. XKSAT IS MODIFIED BY CK ASSUMING 25% VEGETATIVE COVER. ALL PARAMETERS ARE AREA-WEIGHTED.

SC 3020

BASIC SUB-BASIN PARAMETERS 7-15-92

RESIST COEFF PARAMETERS

m(res, comm) =	-0.00625
m(desert) =	-0.01600
m(golf, o.s.) =	-0.02500
b(res, comm) =	0.04000
b(desert) =	0.10000
b(golf, o.s.) =	0.15000

LAND USE	IA	DTHETA	PSIF	XKSAT	RTIMP
Res SF	0.150	0.350	5.050	0.230	25.000
Res CAS	0.150	0.350	5.050	0.230	25.000
Golf/O.S.	0.350	0.300	5.050	0.300	1.000
Comm	0.100	0.350	5.050	0.230	80.000
Exst des	0.350	**	**	**	1.000

SPECIFIC SUB-BASIN DATA (MCUHP1 input file) WEIGHTED GREEN / AMPT PARAMETERS

Sub-Basin #	Area (mi^2)	Length (mi)	Resist. Coeff, Kb	Slope (ft/mi)	IA	DTHETA	PSIF	XKSAT	RTIMP (%)	Tc (hr)	R (hr)
OFFSITE											
A	0.867	1.515	0.056	26.4	0.350	0.350	6.150	0.210	1.0	0.996	0.557
B1	0.188	0.568	0.067	29.9	0.350	0.350	5.090	0.280	1.0	0.508	0.288
B2	0.161	1.000	0.068	38.0	0.350	0.350	5.090	0.280	1.0	0.717	0.724
C1	0.028	0.256	0.080	11.7	0.350	0.350	6.050	0.200	1.0	0.479	0.422
C2	0.027	0.303	0.080	13.2	0.350	0.350	6.050	0.200	1.0	0.512	0.531
C3	0.064	0.398	0.074	20.1	0.350	0.350	6.050	0.200	1.0	0.488	0.382
C4	0.058	0.455	0.075	26.4	0.350	0.350	6.050	0.200	1.0	0.479	0.441
D1	0.033	0.398	0.079	32.7	0.350	0.350	4.340	0.260	1.0	0.408	0.458
D2	0.055	0.492	0.075	30.5	0.350	0.350	4.340	0.260	1.0	0.475	0.480
D3	0.081	0.587	0.073	30.7	0.350	0.350	4.340	0.260	1.0	0.533	0.504
D4	0.089	0.587	0.072	32.4	0.350	0.350	4.340	0.260	1.0	0.512	0.457
E	1.297	1.840	0.053	26.1	0.350	0.350	5.050	0.230	1.0	1.104	0.580
TOTAL	2.930	2.650	0.048	23.0	0.350	0.350	5.550	0.220	1.0	1.504	0.688
ONSITE											
5	0.031	0.375	0.032	22.667	0.150	0.350	5.050	0.230	25.000	0.233	0.243
10	0.008	0.239	0.084	8.381	0.225	0.325	5.050	0.265	40.500	0.504	0.863
15	0.013	0.337	0.034	26.697	0.150	0.350	5.050	0.230	25.000	0.213	0.330
20	0.012	0.218	0.034	20.661	0.150	0.350	5.050	0.230	25.000	0.179	0.202
25	0.008	0.172	0.036	17.407	0.150	0.350	5.050	0.230	25.000	0.175	0.205
30	0.026	0.295	0.041	23.692	0.170	0.345	5.050	0.237	22.600	0.233	0.222
35	0.023	0.254	0.033	25.612	0.150	0.350	5.050	0.230	25.000	0.179	0.157
40	0.014	0.178	0.108	44.936	0.310	0.310	5.050	0.286	5.800	0.254	0.232
45	0.011	0.110	0.110	54.621	0.310	0.310	5.050	0.286	5.800	0.179	0.123
50	0.010	0.155	0.111	48.293	0.310	0.310	5.050	0.286	5.800	0.229	0.224
55	0.015	0.352	0.034	28.387	0.150	0.350	5.050	0.230	25.000	0.213	0.315
60	0.031	0.417	0.032	19.200	0.150	0.350	5.050	0.230	25.000	0.262	0.302
65	0.017	0.227	0.106	22.000	0.310	0.310	5.050	0.286	5.800	0.404	0.422
70	0.015	0.295	0.034	15.231	0.150	0.350	5.050	0.230	25.000	0.242	0.316
75	0.009	0.210	0.035	21.405	0.150	0.350	5.050	0.230	25.000	0.179	0.231
80	0.013	0.153	0.109	29.333	0.310	0.310	5.050	0.286	5.800	0.275	0.234
85	0.014	0.180	0.108	30.568	0.310	0.310	5.050	0.286	5.800	0.300	0.281
90	0.016	0.352	0.034	13.626	0.150	0.350	5.050	0.230	25.000	0.283	0.418
95	0.012	0.252	0.034	18.659	0.150	0.350	5.050	0.230	25.000	0.183	0.262
100	0.024	0.288	0.094	55.579	0.290	0.315	5.050	0.279	8.200	0.287	0.287

Sub-Basin #	Area (mi^2)	Length (mi)	Resist. Coeff, Kb	Slope (ft/mi)	IA	DTHETA	PSIF	XKSAT	RTIMP (%)	Tc (hr)	R (hr)
105	0.013	0.220	0.034	11.379	0.150	0.350	5.050	0.230	25.000	0.225	0.250
110	0.025	0.210	0.033	22.357	0.150	0.350	5.050	0.230	25.000	0.171	0.122
115	0.026	0.256	0.032	22.684	0.150	0.350	5.050	0.230	25.000	0.183	0.152
120	0.020	0.259	0.033	23.124	0.150	0.350	5.050	0.230	25.000	0.188	0.182
125	0.019	0.303	0.105	56.100	0.310	0.310	5.050	0.286	5.800	0.321	0.386
130	0.030	0.352	0.032	22.710	0.150	0.350	5.050	0.230	25.000	0.225	0.226
135	0.021	0.246	0.033	28.431	0.145	0.350	5.050	0.230	30.500	0.171	0.153
140	0.037	0.496	0.031	16.525	0.140	0.350	5.050	0.230	36.000	0.300	0.363
145	0.011	0.140	0.110	64.216	0.310	0.310	5.050	0.286	5.800	0.196	0.164
150	0.014	0.121	0.108	53.625	0.310	0.310	5.050	0.286	5.800	0.188	0.121
155	0.022	0.250	0.033	22.000	0.150	0.350	5.050	0.230	25.000	0.188	0.168
160	0.021	0.250	0.033	22.000	0.150	0.350	5.050	0.230	25.000	0.188	0.172
165	0.036	0.386	0.040	23.294	0.170	0.345	5.050	0.237	22.600	0.271	0.270
170	0.013	0.170	0.034	17.600	0.150	0.350	5.050	0.230	25.000	0.167	0.146
175	0.022	0.294	0.103	28.955	0.310	0.310	5.050	0.286	5.800	0.421	0.468
180	0.022	0.277	0.033	21.699	0.150	0.350	5.050	0.230	25.000	0.200	0.196
185	0.029	0.498	0.032	30.114	0.150	0.350	5.050	0.230	25.000	0.250	0.342
190	0.031	0.225	0.109	70.992	0.330	0.305	5.050	0.293	3.400	0.250	0.174
195	0.009	0.136	0.035	22.000	0.150	0.350	5.050	0.230	25.000	0.133	0.117
196	0.056	0.436	0.103	24.104	0.330	0.305	5.050	0.293	3.400	0.637	0.597
200	0.014	0.210	0.098	61.838	0.275	0.315	5.050	0.279	24.700	0.229	0.236
205	0.009	0.218	0.035	32.139	0.150	0.350	5.050	0.230	25.000	0.154	0.201
210	0.009	0.076	0.112	52.800	0.310	0.310	5.050	0.286	5.800	0.146	0.081
215	0.029	0.324	0.032	28.407	0.150	0.350	5.050	0.230	25.000	0.196	0.185
220	0.015	0.167	0.107	15.000	0.310	0.310	5.050	0.286	5.800	0.383	0.334
225	0.016	0.095	0.034	31.680	0.150	0.350	5.050	0.230	25.000	0.092	0.042
230	0.038	0.509	0.040	20.610	0.170	0.345	5.050	0.237	22.600	0.338	0.416
235	0.007	0.155	0.114	45.073	0.310	0.310	5.050	0.286	5.800	0.242	0.291
240	0.045	0.455	0.039	19.800	0.170	0.345	5.050	0.237	22.600	0.313	0.317
245	0.014	0.275	0.099	32.772	0.290	0.315	5.050	0.279	8.200	0.363	0.487
250	0.027	0.284	0.102	44.000	0.310	0.310	5.050	0.286	5.800	0.338	0.317
255	0.008	0.246	0.132	28.431	0.350	0.300	5.050	0.300	1.000	0.463	0.803
260	0.015	0.294	0.034	28.955	0.150	0.350	5.050	0.230	25.000	0.192	0.243
270	0.012	0.142	0.109	31.680	0.310	0.310	5.050	0.286	5.800	0.254	0.211
280	0.031	0.398	0.032	20.114	0.150	0.350	5.050	0.230	25.000	0.254	0.280
290	0.013	0.218	0.034	29.843	0.150	0.350	5.050	0.230	25.000	0.158	0.168
295	0.010	0.104	0.121	38.400	0.330	0.305	5.050	0.293	3.400	0.208	0.146
300	0.013	0.155	0.118	61.171	0.330	0.305	5.050	0.293	3.400	0.221	0.185
305	0.023	0.318	0.033	20.429	0.150	0.350	5.050	0.230	25.000	0.221	0.238
310	0.015	0.256	0.034	23.467	0.100	0.350	5.050	0.230	80.000	0.183	0.207
315	0.014	0.369	0.034	29.785	0.150	0.350	5.050	0.230	25.000	0.217	0.348
320	0.019	0.358	0.033	22.908	0.100	0.350	5.050	0.230	80.000	0.221	0.291
325	0.028	0.360	0.032	20.842	0.150	0.350	5.050	0.230	25.000	0.233	0.249
330	0.047	0.386	0.088	24.588	0.280	0.315	5.050	0.279	19.200	0.479	0.436
335	0.028	0.227	0.032	33.000	0.150	0.350	5.050	0.230	25.000	0.150	0.106

TOTAL ONSITE AREA 1.298 SQ.MI.

SHEET 2 OF 2

** GREEN AND AMPT RAINFALL LOSS PARAMETERS FOR EXISTING DESERT ARE WEIGHTED BY AREA OF INDIVIDUAL SOIL TYPES WITHIN EACH SUB-BASIN.

NOTE: GREEN AND AMPT RAINFALL LOSS PARAMETERS FOR ONSITE DEVELOPED AREAS ARE BASED ON EXISTING CONDITION ONSITE AREA WEIGHTED VALUES FROM SUB-BASIN "E".

```
1*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           SEPTEMBER 1990              *
*            VERSION 4.0                *
*                                       *
* RUN DATE  07/16/1992  TIME  20:09:43  *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                          HEC-1 INPUT                                                    PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID
  2           ID        SUN CITY WEST EXPANSION MASTER DRAINAGE
  3           ID        STANLEY CONSULTANTS JOB # 11389   DATE: 16 JUL 92
  4           ID        HEC-1 MODEL 11389A2  (EXISTING CONDITION; MULTI SUB-BASIN)
  5           ID
  6           ID        CLARK UNIT HYDROGRAPH
  7           ID
  8           ID        2-HR STORM DISTRIBUTION (TABLE 2.2) P100 = 2.77"
  9           ID        NO AREAL REDUCTION FACTOR
 10           ID
 11           ID        GREEN-AMPT LOSS RATES FOR EXISTING CONDITIONS BASED ON
 12           ID              AREA-WEIGHTED VALUES OF EXISTING SOILS ASSUMING DTHETA DRY
 13           ID              AND VEGETATIVE COVER 25 PERCENT.
 14           ID              IA ASSUMED TO BE 0.35 INCHES AND PERCENT IMPERVIOUS ASSUMED
 15           ID              TO BE 1 PERCENT.
 16           ID
 17           ID        Kb BASED ON m = -0.016 and b = 0.10
 18           ID
 19           ID        TIME OF CONCENTRATION AND STORAGE COEFFICIENT R
 20           ID              BASED ON RESULTS FROM MCUHP1 (REVISED 12-16-91)
 21           ID
 22           ID        TIME-AREA RELATION FROM TABLE 5.2, ALL AREAS USE A NATURAL
 23           ID              TIME-AREA UA RECORD
 24           ID
 25           ID        OFFSITE FLOWS ARE ROUTED THROUGH HYPOTHETICAL ONSITE CHANNELS
 26           ID              USING MODIFIED PULS ROUTING.  CHANNELS REFLECT EXISTING
 27           ID              CROSS-SECTIONS AND EXISTING ROUGHNESS.
 28           ID
 29           ID
              *DIAGRAM
 30           IT       5                    150
 31           IO       3

 32           KK   SUBB1        RUNOFF HYDROGRAPH FROM SUB-BASIN B1
 33           BA    .188
 34           IN       5
 35           PB   2.770
 36           PC    .000    .011    .018    .023    .028    .032    .046    .071    .100    .137
 37           PC    .176    .232    .327    .601    .743    .863    .901    .930    .954    .962
 38           PC    .970    .979    .982    .992   1.000
 39           LG    .350    .350    5.09     .28       1
 40           UC    .508    .288
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 41          UA      0      3      5      8     12     20     43     75     90     96
 42          UA    100

 43          KK   RCHAB        ROUTE HYDROGRAPH SUBB1 THRU REACH AB; HYPOTHETICAL CHANNEL
 44          RS      2   FLOW     -1
 45          RC   .050   .035   .050   2800   .005
 46          RX    500    500    513    525    530    542    550    550
 47          RY    100    100     97     95     95     97    100    100
1                                        HEC-1 INPUT                                          PAGE  2

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 48          KK    SUBA        RUNOFF HYDROGRAPH FROM SUB-BASIN A
 49          BA    .867
 50          LG     .35    .35   6.15    .21      1
 51          UC    .996   .557
 52          UA       0      3      5      8     12     20     43     75     90     96
 53          UA     100

 54          KK   SUBB2        RUNOFF HYDROGRAPH FROM SUB-BASIN B2
 55          BA    .161
 56          LG     .35    .35   5.09    .28      1
 57          UC    .717   .724
 58          UA       0      3      5      8     12     20     43     75     90     96
 59          UA     100

 60          KK   SUMAB        COMBINE HYDROGRAPH FROM RCHAB, SUBA & SUBB2
 61          HC       3

 62          KK  RCHSUM        ROUTE HYDROGRAPH SUMAB THRU REACH SUM; HYPOTHETICAL CHANNEL
 63          RS       6   FLOW     -1
 64          RC    .035   .050   .050   8670   .004
 65          RX    500    500    560    560    580    580    600    600
 66          RY    100    100     93     93     93     93    100    100

 67          KK    SUBC        RUNOFF HYDROGRAPH FROM SUB-BASIN C
 68          BA    .195
 69          LG     .35    .35   6.05     .2      1
 70          UC    .683   .494
 71          UA       0      3      5      8     12     20     43     75     90     96
 72          UA     100

 73          KK   RCHCD        ROUTE HYDROGRAPH SUBC THRU REACH CD; HYPOTHETICAL CHANNEL
 74          RS       1   FLOW     -1
 75          RC    .050   .035   .050   2020   .004
 76          RX    500    500    513    525    530    542    550    550
 77          RY    100    100     97     95     95     97    100    100

 78          KK    SUBD        RUNOFF HYDROGRAPH FROM SUB-BASIN D
 79          BA    .227
 80          LG     .35    .35   4.34    .26      1
 81          UC    .596   .397
 82          UA       0      3      5      8     12     20     43     75     90     96
 83          UA     100

 84          KK   SUMCD        COMBINE HYDROGRAPH FROM SUBC & SUBD
 85          HC       2

 86          KK  RCHSUM        ROUTE HYDROGRAPH SUMCD THRU REACH SUM; HYPOTHETICAL CHANNEL
 87          RS       4   FLOW     -1
 88          RC    .050   .035   .050   5520   .005
 89          RX    500    500    513    525    530    542    550    550
 90          RY    100    100     97     95     95     97    100    100
1                                        HEC-1 INPUT                                          PAGE  3

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 91          KK    SUBE        RUNOFF HYDROGRAPH FROM SUB-BASIN E
 92          BA   1.297
 93          LG     .35    .35   5.05    .23      1
 94          UC   1.104   .580
 95          UA       0      3      5      8     12     20     43     75     90     96
 96          UA     100

 97          KK  SUMTOT        COMBINE HYDROGRAPH FROM RCHSUM (WEST & NORTH)
 98          HC       3
 99          ZZ
1
```

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                SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   32       SUBB1
                V
                V
   43       RCHAB
                .
                .
   48           .        SUBA
                .           .
                .           .
   54           .           .       SUBB2
                .           .           .
                .           .           .
   60       SUMAB.......................
                V
                V
   62      RCHSUM
                .
                .
   67           .        SUBC
                .           V
                .           V
   73           .       RCHCD
                .           .
                .           .
   78           .           .        SUBD
                .           .           .
                .           .           .
   84           .       SUMCD............
                .           V
                .           V
   86           .      RCHSUM
                .           .
                .           .
   91           .           .        SUBE
                .           .           .
                .           .           .
   97      SUMTOT......................

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            SEPTEMBER 1990            *
*             VERSION 4.0              *
*                                      *
*  RUN DATE  07/16/1992  TIME  20:09:43 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 756-1104             *
*                                      *
****************************************
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SUN CITY WEST EXPANSION MASTER DRAINAGE
STANLEY CONSULTANTS JOB # 11389 DATE: 16 JUL 92
HEC-1 MODEL 11389A2 (EXISTING CONDITION; MULTI SUB-BASIN)

CLARK UNIT HYDROGRAPH

2-HR STORM DISTRIBUTION (TABLE 2.2) P100 = 2.77"
NO AREAL REDUCTION FACTOR

GREEN-AMPT LOSS RATES FOR EXISTING CONDITIONS BASED ON
AREA-WEIGHTED VALUES OF EXISTING SOILS ASSUMING DTHETA DRY
AND VEGETATIVE COVER 25 PERCENT.
IA ASSUMED TO BE 0.35 INCHES AND PERCENT IMPERVIOUS ASSUMED
TO BE 1 PERCENT.

Kb BASED ON m = -0.016 and b = 0.10

TIME OF CONCENTRATION AND STORAGE COEFFICIENT R
BASED ON RESULTS FROM MCUHP1 (REVISED 12-16-91)

```
                    TIME-AREA RELATION FROM TABLE 5.2, ALL AREAS USE A NATURAL
                         TIME-AREA UA RECORD

                    OFFSITE FLOWS ARE ROUTED THROUGH HYPOTHETICAL ONSITE CHANNELS
                         USING MODIFIED PULS ROUTING.  CHANNELS REFLECT EXISTING
                         CROSS-SECTIONS AND EXISTING ROUGHNESS.


 31 IO        OUTPUT CONTROL VARIABLES
                    IPRNT          3  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT        HYDROGRAPH TIME DATA
                     NMIN          5  MINUTES IN COMPUTATION INTERVAL
                    IDATE      1   0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ        150  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE      1   0  ENDING DATE
                   NDTIME       1225  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .08 HOURS
                     TOTAL TIME BASE   12.42 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT


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


            **************
            *            *
 32 KK      *     SUBB1  *          RUNOFF HYDROGRAPH FROM SUB-BASIN B1
            *            *
            **************

 34 IN        TIME DATA FOR INPUT TIME SERIES
                     JXMIN          5  TIME INTERVAL IN MINUTES
                   JXDATE      1   0  STARTING DATE
                   JXTIME          0  STARTING TIME

              SUBBASIN RUNOFF DATA

 33 BA        SUBBASIN CHARACTERISTICS
                    TAREA        .19  SUBBASIN AREA

              PRECIPITATION DATA

 35 PB              STORM       2.77  BASIN TOTAL PRECIPITATION

 36 PI          INCREMENTAL PRECIPITATION PATTERN
                   .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                   .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                   .01       .00       .01       .01

 39 LG        GREEN AND AMPT LOSS RATE
                   STRTL        .35  STARTING LOSS
                     DTH        .35  MOISTURE DEFICIT
                    PSIF       5.09  WETTING FRONT SUCTION
                   XKSAT        .28  HYDRAULIC CONDUCTIVITY
                   RTIMP       1.00  PERCENT IMPERVIOUS AREA

 40 UC        CLARK UNITGRAPH
                      TC        .51  TIME OF CONCENTRATION
                       R        .29  STORAGE COEFFICIENT

 41 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0
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                                                  ***

                                                UNIT HYDROGRAPH PARAMETERS
                                        CLARK   TC=   .51 HR,       R=   .29 HR
                                       SNYDER   TP=   .43 HR,      CP=   .85

                                                UNIT HYDROGRAPH
                                            23 END-OF-PERIOD ORDINATES
              8.       23.       45.      129.      228.      241.      197.      148.      111.       83.
             62.       46.       34.       26.       19.       14.       11.        8.        6.        4.
              3.        3.        2.

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

                        HYDROGRAPH AT STATION    SUBB1

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.40, TOTAL EXCESS =    1.37

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                          (CFS)
+     284.      1.50                28.         13.         13.         13.
                        (INCHES)   1.365       1.365       1.365       1.365
                         (AC-FT)    14.         14.         14.         14.

                        CUMULATIVE AREA =     .19 SQ MI


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


            **************
            *            *
  43 KK     *     RCHAB  *            ROUTE HYDROGRAPH SUBB1 THRU REACH AB; HYPOTHETICAL CHANNEL
            *            *
            **************

               HYDROGRAPH ROUTING DATA

  44 RS          STORAGE ROUTING
                      NSTPS           2  NUMBER OF SUBREACHES
                       ITYP        FLOW  TYPE OF INITIAL CONDITION
                      RSVRIC       -1.00  INITIAL CONDITION
                           X         .00 WORKING R AND D COEFFICIENT

  45 RC          NORMAL DEPTH CHANNEL
                        ANL        .050  LEFT OVERBANK N-VALUE
                       ANCH        .035  MAIN CHANNEL N-VALUE
                        ANR        .050  RIGHT OVERBANK N-VALUE
                      RLNTH       2800.  REACH LENGTH
                        SEL       .0050  ENERGY SLOPE
                      ELMAX          .0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                      CROSS-SECTION DATA
                          --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  47 RY       ELEVATION    100.00    100.00     97.00     95.00     95.00     97.00    100.00    100.00
  46 RX       DISTANCE     500.00    500.00    513.00    525.00    530.00    542.00    550.00    550.00

                                                  ***

                                      COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE        .00       .11       .28       .49       .77      1.09      1.47      1.90      2.38      2.90
          OUTFLOW        .00      1.85      6.74     15.09     27.43     44.30     66.20     93.64    130.36    178.41
        ELEVATION      95.00     95.26     95.53     95.79     96.05     96.32     96.58     96.84     97.11     97.37

          STORAGE       3.45      4.03      4.65      5.29      5.96      6.67      7.41      8.17      8.97      9.80
          OUTFLOW     232.95    293.99    361.56    435.70    516.44    603.85    698.00    798.95    906.78   1021.56
        ELEVATION      97.63     97.89     98.16     98.42     98.68     98.95     99.21     99.47     99.74    100.00

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

                        HYDROGRAPH AT STATION    RCHAB

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
```

```
+   (CFS)       (HR)
                          (CFS)
+     262.      1.67                28.        13.        13.        13.
                         (INCHES)   1.365      1.365      1.365      1.365
                          (AC-FT)    14.        14.        14.        14.

 PEAK STORAGE   TIME                       MAXIMUM AVERAGE STORAGE
                                   6-HR       24-HR      72-HR     12.42-HR
+  (AC-FT)      (HR)
       2.       1.67                 0.         0.         0.         0.

  PEAK STAGE    TIME                       MAXIMUM AVERAGE STAGE
                                   6-HR       24-HR      72-HR     12.42-HR
+   (FEET)      (HR)
    97.76       1.67               95.53      95.26      95.26      95.26

                         CUMULATIVE AREA =     .19 SQ MI


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


            **************
            *            *
  48 KK     *     SUBA   *          RUNOFF HYDROGRAPH FROM SUB-BASIN A
            *            *
            **************

              SUBBASIN RUNOFF DATA

  49 BA         SUBBASIN CHARACTERISTICS
                      TAREA         .87  SUBBASIN AREA

                PRECIPITATION DATA

  35 PB               STORM        2.77  BASIN TOTAL PRECIPITATION

  36 PI           INCREMENTAL PRECIPITATION PATTERN
                     .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                     .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                     .01       .00       .01       .01

  50 LG         GREEN AND AMPT LOSS RATE
                      STRTL         .35  STARTING LOSS
                        DTH         .35  MOISTURE DEFICIT
                       PSIF        6.15  WETTING FRONT SUCTION
                      XKSAT         .21  HYDRAULIC CONDUCTIVITY
                      RTIMP        1.00  PERCENT IMPERVIOUS AREA

  51 UC         CLARK UNITGRAPH
                         TC        1.00  TIME OF CONCENTRATION
                          R         .56  STORAGE COEFFICIENT

  52 UA         ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                     100.0

                                                   ***

                                              UNIT HYDROGRAPH PARAMETERS
                                       CLARK   TC=  1.00 HR,       R=   .56 HR
                                      SNYDER   TP=   .83 HR,      CP=   .88

                                                UNIT HYDROGRAPH
                                           43 END-OF-PERIOD ORDINATES
              12.       30.       45.       62.       86.      126.      231.      408.      553.      602.
             583.      539.      478.      412.      355.      305.      263.      226.      195.      168.
             144.      124.      107.       92.       79.       68.       59.       51.       43.       37.
              32.       28.       24.       21.       18.       15.       13.       11.       10.        8.
               7.        6.        5.

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

                         HYDROGRAPH AT STATION     SUBA

   TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.34, TOTAL EXCESS =    1.43

  PEAK FLOW     TIME                       MAXIMUM AVERAGE FLOW
```

```
                                    6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                          (CFS)
+    811.       1.92                133.         64.         64.         64.
                        (INCHES)    1.424       1.424       1.424       1.424
                         (AC-FT)     66.         66.         66.         66.

                        CUMULATIVE AREA =     .87 SQ MI


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


            **************
            *            *
  54 KK     *     SUBB2  *            RUNOFF HYDROGRAPH FROM SUB-BASIN B2
            *            *
            **************

               SUBBASIN RUNOFF DATA

  55 BA          SUBBASIN CHARACTERISTICS
                       TAREA          .16  SUBBASIN AREA

                 PRECIPITATION DATA

  35 PB                STORM        2.77  BASIN TOTAL PRECIPITATION

  36 PI            INCREMENTAL PRECIPITATION PATTERN
                      .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                      .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                      .01       .00       .01       .01

  56 LG          GREEN AND AMPT LOSS RATE
                       STRTL         .35  STARTING LOSS
                         DTH         .35  MOISTURE DEFICIT
                        PSIF        5.09  WETTING FRONT SUCTION
                       XKSAT         .28  HYDRAULIC CONDUCTIVITY
                       RTIMP        1.00  PERCENT IMPERVIOUS AREA

  57 UC          CLARK UNITGRAPH
                           TC         .72  TIME OF CONCENTRATION
                            R         .72  STORAGE COEFFICIENT

  58 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                     100.0

                                                          ***

                                                UNIT HYDROGRAPH PARAMETERS
                                         CLARK   TC=   .72 HR,       R=   .72 HR
                                        SNYDER   TP=   .63 HR,      CP=   .62

                                                   UNIT HYDROGRAPH
                                              52 END-OF-PERIOD ORDINATES
                 2.        6.       10.       16.       34.       69.       97.      102.       97.       88.
                79.       70.       63.       56.       50.       44.       39.       35.       31.       28.
                25.       22.       20.       18.       16.       14.       12.       11.       10.        9.
                 8.        7.        6.        6.        5.        4.        4.        4.        3.        3.
                 2.        2.        2.        2.        2.        1.        1.        1.        1.        1.
                 1.        1.

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

                        HYDROGRAPH AT STATION    SUBB2

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.40, TOTAL EXCESS =    1.37

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                    6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                          (CFS)
+    132.       1.75                 24.         11.         11.         11.
                        (INCHES)    1.364       1.364       1.364       1.364
                         (AC-FT)     12.         12.         12.         12.

                        CUMULATIVE AREA =     .16 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
  60 KK     *     SUMAB  *            COMBINE HYDROGRAPH FROM RCHAB, SUBA & SUBB2
            *            *
            **************

  61 HC          HYDROGRAPH COMBINATION
                       ICOMP          3  NUMBER OF HYDROGRAPHS TO COMBINE

                                                                  ***

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

                         HYDROGRAPH AT STATION    SUMAB

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                            (CFS)
+    1100.      1.83                184.        89.         89.         89.
                         (INCHES)  1.407       1.407       1.407       1.407
                          (AC-FT)   91.         91.         91.         91.

                         CUMULATIVE AREA =    1.22 SQ MI


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

            **************
            *            *
  62 KK     *    RCHSUM  *            ROUTE HYDROGRAPH SUMAB THRU REACH SUM; HYPOTHETICAL CHANNEL
            *            *
            **************

               HYDROGRAPH ROUTING DATA

  63 RS          STORAGE ROUTING
                       NSTPS          6  NUMBER OF SUBREACHES
                        ITYP       FLOW  TYPE OF INITIAL CONDITION
                       RSVRIC     -1.00  INITIAL CONDITION
                            X       .00 WORKING R AND D COEFFICIENT

  64 RC          NORMAL DEPTH CHANNEL
                         ANL       .035  LEFT OVERBANK N-VALUE
                        ANCH       .050  MAIN CHANNEL N-VALUE
                         ANR       .050  RIGHT OVERBANK N-VALUE
                       RLNTH      8670.  REACH LENGTH
                         SEL      .0040  ENERGY SLOPE
                       ELMAX         .0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                          CROSS-SECTION DATA
                          --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  66 RY       ELEVATION   100.00    100.00     93.00     93.00     93.00     93.00    100.00    100.00
  65 RX       DISTANCE    500.00    500.00    560.00    560.00    580.00    580.00    600.00    600.00

                                                                  ***

                                          COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE       .00      1.62      3.55      5.79      8.34     11.19     14.36     17.83     21.61     25.70
          OUTFLOW       .00      7.76     26.59     56.12     96.88    149.57    214.94    293.75    386.76    494.74
        ELEVATION     93.00     93.37     93.74     94.11     94.47     94.84     95.21     95.58     95.95     96.32

          STORAGE     30.10     34.81     39.83     45.16     50.79     56.73     62.99     69.55     76.42     83.60
          OUTFLOW    618.43    758.55    915.85   1091.02   1284.76   1497.76   1730.70   1984.24   2259.05   2555.77
        ELEVATION     96.68     97.05     97.42     97.79     98.16     98.53     98.89     99.26     99.63    100.00

     ***            ***            ***            ***            ***
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                    HYDROGRAPH AT STATION   RCHSUM

 PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+  (CFS)       (HR)
                          (CFS)
+    969.      2.33                 184.        89.         89.         89.
                        (INCHES)   1.403       1.407       1.407       1.407
                        (AC-FT)     91.         91.         91.         91.

 PEAK STORAGE  TIME                          MAXIMUM AVERAGE STORAGE
                                     6-HR       24-HR       72-HR     12.42-HR
+ (AC-FT)      (HR)
      7.       2.33                   2.          1.          1.          1.

 PEAK STAGE    TIME                          MAXIMUM AVERAGE STAGE
                                     6-HR       24-HR       72-HR     12.42-HR
+  (FEET)      (HR)
   97.53       2.33                 94.48       93.73       93.73       93.73

                        CUMULATIVE AREA =    1.22 SQ MI


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


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          *            *
  67 KK   *     SUBC   *          RUNOFF HYDROGRAPH FROM SUB-BASIN C
          *            *
          **************

             SUBBASIN RUNOFF DATA

  68 BA        SUBBASIN CHARACTERISTICS
                    TAREA         .19  SUBBASIN AREA

               PRECIPITATION DATA

  35 PB             STORM        2.77  BASIN TOTAL PRECIPITATION

  36 PI          INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                    .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                    .01       .00       .01       .01

  69 LG        GREEN AND AMPT LOSS RATE
                    STRTL         .35  STARTING LOSS
                      DTH         .35  MOISTURE DEFICIT
                     PSIF        6.05  WETTING FRONT SUCTION
                    XKSAT         .20  HYDRAULIC CONDUCTIVITY
                    RTIMP        1.00  PERCENT IMPERVIOUS AREA

  70 UC        CLARK UNITGRAPH
                       TC         .68  TIME OF CONCENTRATION
                        R         .49  STORAGE COEFFICIENT

  71 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                   ***

                                              UNIT HYDROGRAPH PARAMETERS
                                       CLARK   TC=   .68 HR,       R=   .49 HR
                                      SNYDER   TP=   .59 HR,      CP=   .75

                                                UNIT HYDROGRAPH
                                           37 END-OF-PERIOD ORDINATES
             4.       11.       18.       30.       67.      128.      163.      160.      143.      122.
           103.       87.       74.       62.       52.       44.       37.       32.       27.       23.
            19.       16.       14.       11.       10.        8.        7.        6.        5.        4.
             4.        3.        3.        2.        2.        2.        1.

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

                    HYDROGRAPH AT STATION     SUBC
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    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                            (CFS)
+     216.      1.67                 30.         15.         15.         15.
                         (INCHES)   1.451       1.451       1.451       1.451
                          (AC-FT)    15.         15.         15.         15.

                         CUMULATIVE AREA =     .19 SQ MI


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            *            *
  73 KK     *     RCHCD  *            ROUTE HYDROGRAPH SUBC THRU REACH CD; HYPOTHETICAL CHANNEL
            *            *
            **************

              HYDROGRAPH ROUTING DATA

  74 RS         STORAGE ROUTING
                     NSTPS          1  NUMBER OF SUBREACHES
                      ITYP       FLOW  TYPE OF INITIAL CONDITION
                    RSVRIC      -1.00  INITIAL CONDITION
                         X        .00 WORKING R AND D COEFFICIENT

  75 RC         NORMAL DEPTH CHANNEL
                       ANL       .050  LEFT OVERBANK N-VALUE
                      ANCH       .035  MAIN CHANNEL N-VALUE
                       ANR       .050  RIGHT OVERBANK N-VALUE
                     RLNTH      2020.  REACH LENGTH
                       SEL      .0040  ENERGY SLOPE
                     ELMAX         .0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                          --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  77 RY       ELEVATION   100.00   100.00    97.00    95.00    95.00    97.00   100.00   100.00
  76 RX       DISTANCE    500.00   500.00   513.00   525.00   530.00   542.00   550.00   550.00

                                                   ***

                                   COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE       .00      .08      .20      .36      .55      .79     1.06     1.37     1.72     2.09
          OUTFLOW       .00     1.65     6.03    13.49    24.53    39.62    59.21    83.75   116.59   159.58
        ELEVATION     95.00    95.26    95.53    95.79    96.05    96.32    96.58    96.84    97.11    97.37

          STORAGE      2.49     2.91     3.35     3.82     4.30     4.81     5.34     5.90     6.47     7.07
          OUTFLOW    208.36   262.96   323.39   389.70   461.92   540.10   624.31   714.60   811.05   913.71
        ELEVATION     97.63    97.89    98.16    98.42    98.68    98.95    99.21    99.47    99.74   100.00

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

                       HYDROGRAPH AT STATION    RCHCD

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                            (CFS)
+     199.      1.83                 30.         15.         15.         15.
                         (INCHES)   1.451       1.451       1.451       1.451
                          (AC-FT)    15.         15.         15.         15.

 PEAK STORAGE   TIME                          MAXIMUM AVERAGE STORAGE
                                      6-HR       24-HR       72-HR     12.42-HR
+  (AC-FT)      (HR)
       2.       1.83                  0.          0.          0.          0.

  PEAK STAGE    TIME                          MAXIMUM AVERAGE STAGE
                                      6-HR       24-HR       72-HR     12.42-HR
+   (FEET)      (HR)
    97.58       1.83                95.71       95.34       95.34       95.34
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                    CUMULATIVE AREA =     .19 SQ MI


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          *            *
 78 KK    *     SUBD   *            RUNOFF HYDROGRAPH FROM SUB-BASIN D
          *            *
          **************

             SUBBASIN RUNOFF DATA

 79 BA         SUBBASIN CHARACTERISTICS
                    TAREA          .23  SUBBASIN AREA

               PRECIPITATION DATA

 35 PB              STORM        2.77  BASIN TOTAL PRECIPITATION

 36 PI           INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                    .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                    .01       .00       .01       .01

 80 LG         GREEN AND AMPT LOSS RATE
                    STRTL         .35  STARTING LOSS
                      DTH         .35  MOISTURE DEFICIT
                     PSIF        4.34  WETTING FRONT SUCTION
                    XKSAT         .26  HYDRAULIC CONDUCTIVITY
                    RTIMP        1.00  PERCENT IMPERVIOUS AREA

 81 UC         CLARK UNITGRAPH
                       TC         .60  TIME OF CONCENTRATION
                        R         .40  STORAGE COEFFICIENT

 82 UA         ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                   ***

                                                UNIT HYDROGRAPH PARAMETERS
                                         CLARK   TC=   .60 HR,       R=   .40 HR
                                        SNYDER   TP=   .50 HR,      CP=   .77

                                                UNIT HYDROGRAPH
                                           30 END-OF-PERIOD ORDINATES
                 6.       17.       30.       68.      158.      226.      224.      194.      159.      128.
               104.       84.       68.       55.       45.       36.       29.       24.       19.       16.
                13.       10.        8.        7.        5.        4.        4.        3.        2.        2.

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

                       HYDROGRAPH AT STATION     SUBD

   TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.32, TOTAL EXCESS =    1.45

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                          (CFS)
+     293.      1.58                35.         17.         17.         17.
                         (INCHES)  1.446       1.446       1.446       1.446
                          (AC-FT)   18.         18.         18.         18.

                       CUMULATIVE AREA =     .23 SQ MI


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


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          *            *
 84 KK    *     SUMCD  *            COMBINE HYDROGRAPH FROM SUBC & SUBD
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          *           *
          **************

 85 HC          HYDROGRAPH COMBINATION
                     ICOMP           2  NUMBER OF HYDROGRAPHS TO COMBINE

                                                          ***

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

                       HYDROGRAPH AT STATION    SUMCD

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                            (CFS)
+     449.      1.67                 66.         32.         32.         32.
                         (INCHES)  1.448       1.448       1.448       1.448
                          (AC-FT)    33.         33.         33.         33.

                         CUMULATIVE AREA =     .42 SQ MI


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


          **************
          *           *
 86 KK    *   RCHSUM  *          ROUTE HYDROGRAPH SUMCD THRU REACH SUM; HYPOTHETICAL CHANNEL
          *           *
          **************

            HYDROGRAPH ROUTING DATA

 87 RS          STORAGE ROUTING
                     NSTPS           4  NUMBER OF SUBREACHES
                      ITYP        FLOW  TYPE OF INITIAL CONDITION
                     RSVRIC       -1.00  INITIAL CONDITION
                          X         .00 WORKING R AND D COEFFICIENT

 88 RC          NORMAL DEPTH CHANNEL
                       ANL        .050  LEFT OVERBANK N-VALUE
                      ANCH        .035  MAIN CHANNEL N-VALUE
                       ANR        .050  RIGHT OVERBANK N-VALUE
                     RLNTH       5520.  REACH LENGTH
                       SEL       .0050  ENERGY SLOPE
                     ELMAX          .0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                        --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
 90 RY       ELEVATION   100.00    100.00     97.00     95.00     95.00     97.00    100.00    100.00
 89 RX       DISTANCE    500.00    500.00    513.00    525.00    530.00    542.00    550.00    550.00

                                                          ***

                                   COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE        .00       .22       .54       .97      1.51      2.15      2.90      3.75      4.70      5.72
          OUTFLOW        .00      1.85      6.74     15.09     27.43     44.30     66.20     93.64    130.36    178.41
        ELEVATION      95.00     95.26     95.53     95.79     96.05     96.32     96.58     96.84     97.11     97.37

          STORAGE       6.81      7.95      9.16     10.43     11.76     13.15     14.60     16.11     17.69     19.33
          OUTFLOW     232.95    293.99    361.56    435.70    516.44    603.85    698.00    798.95    906.78   1021.56
        ELEVATION      97.63     97.89     98.16     98.42     98.68     98.95     99.21     99.47     99.74    100.00

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

                       HYDROGRAPH AT STATION   RCHSUM

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                            (CFS)
+     420.      1.92                 66.         32.         32.         32.
                         (INCHES)  1.447       1.448       1.448       1.448
                          (AC-FT)    33.         33.         33.         33.
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 PEAK STORAGE   TIME                          MAXIMUM AVERAGE STORAGE
                                     6-HR       24-HR       72-HR     12.42-HR
+  (AC-FT)      (HR)
       3.       1.92                   1.          0.          0.          0.

  PEAK STAGE    TIME                          MAXIMUM AVERAGE STAGE
                                     6-HR       24-HR       72-HR     12.42-HR
+   (FEET)      (HR)
    98.37       1.92                 96.01       95.49       95.49       95.49

                         CUMULATIVE AREA =     .42 SQ MI


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            *            *
  91 KK     *      SUBE  *            RUNOFF HYDROGRAPH FROM SUB-BASIN E
            *            *
            **************

               SUBBASIN RUNOFF DATA

  92 BA          SUBBASIN CHARACTERISTICS
                      TAREA        1.30  SUBBASIN AREA

                 PRECIPITATION DATA

  35 PB               STORM        2.77  BASIN TOTAL PRECIPITATION

  36 PI            INCREMENTAL PRECIPITATION PATTERN
                      .01       .01       .01       .01       .00       .01       .03       .03       .04       .04
                      .06       .09       .27       .14       .12       .04       .03       .02       .01       .01
                      .01       .00       .01       .01

  93 LG          GREEN AND AMPT LOSS RATE
                      STRTL         .35  STARTING LOSS
                        DTH         .35  MOISTURE DEFICIT
                       PSIF        5.05  WETTING FRONT SUCTION
                      XKSAT         .23  HYDRAULIC CONDUCTIVITY
                      RTIMP        1.00  PERCENT IMPERVIOUS AREA

  94 UC          CLARK UNITGRAPH
                         TC        1.10  TIME OF CONCENTRATION
                          R         .58  STORAGE COEFFICIENT

  95 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                     100.0

                                                   ***

                                                UNIT HYDROGRAPH PARAMETERS
                                         CLARK   TC=  1.10 HR,       R=   .58 HR
                                        SNYDER   TP=   .92 HR,      CP=   .91

                                                UNIT HYDROGRAPH
                                            46 END-OF-PERIOD ORDINATES
                15.       40.       59.       78.      103.      144.      229.      387.      617.      797.
               847.      821.      761.      685.      598.      518.      448.      388.      336.      291.
               252.      218.      189.      164.      142.      123.      106.       92.       80.       69.
                60.       52.       45.       39.       34.       29.       25.       22.       19.       16.
                14.       12.       11.        9.        8.        7.

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

                         HYDROGRAPH AT STATION     SUBE

    TOTAL RAINFALL =    2.77, TOTAL LOSS =    1.31, TOTAL EXCESS =    1.46

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+   (CFS)       (HR)
                          (CFS)
+   1167.       2.00                 202.         98.         98.         98.
                        (INCHES)    1.451      1.451       1.451       1.451
                         (AC-FT)     100.        100.        100.        100.
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CUMULATIVE AREA = 1.30 SQ MI

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          *            *
 97 KK    *   SUMTOT   *          COMBINE HYDROGRAPH FROM RCHSUM (WEST & NORTH)
          *            *
          **************

 98 HC          HYDROGRAPH COMBINATION
                     ICOMP          3  NUMBER OF HYDROGRAPHS TO COMBINE
                                                          ***

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

                     HYDROGRAPH AT STATION   SUMTOT

 PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR       72-HR     12.42-HR
+  (CFS)       (HR)
                              (CFS)
+   2275.      2.17                451.        218.        218.        218.
                            (INCHES)   1.429       1.432       1.432       1.432
                             (AC-FT)   224.        224.        224.        224.

                     CUMULATIVE AREA =    2.93 SQ MI

1
                                        RUNOFF SUMMARY
                                   FLOW IN CUBIC FEET PER SECOND
                                 TIME IN HOURS,  AREA IN SQUARE MILES

                                  PEAK   TIME OF    AVERAGE FLOW FOR MAXIMUM PERIOD     BASIN   MAXIMUM   TIME OF
        OPERATION       STATION   FLOW   PEAK                                          AREA    STAGE     MAX STAGE
+                                                    6-HOUR     24-HOUR     72-HOUR

        HYDROGRAPH AT
+                         SUBB1    284.   1.50        28.        13.        13.       .19
        ROUTED TO
+                         RCHAB    262.   1.67        28.        13.        13.       .19
+                                                                                     97.76      1.67
        HYDROGRAPH AT
+                          SUBA    811.   1.92       133.        64.        64.       .87
        HYDROGRAPH AT
+                         SUBB2    132.   1.75        24.        11.        11.       .16
        3 COMBINED AT
+                         SUMAB   1100.   1.83       184.        89.        89.      1.22
        ROUTED TO
+                         RCHSUM   969.   2.33       184.        89.        89.      1.22
+                                                                                     97.53      2.33
        HYDROGRAPH AT
+                          SUBC    216.   1.67        30.        15.        15.       .19
        ROUTED TO
+                         RCHCD    199.   1.83        30.        15.        15.       .19
+                                                                                     97.58      1.83
        HYDROGRAPH AT
+                          SUBD    293.   1.58        35.        17.        17.       .23
        2 COMBINED AT
+                         SUMCD    449.   1.67        66.        32.        32.       .42
        ROUTED TO
+                         RCHSUM   420.   1.92        66.        32.        32.       .42
+                                                                                     98.37      1.92
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          HYDROGRAPH AT
+                          SUBE      1167.    2.00        202.        98.        98.      1.30

          3 COMBINED AT
+                        SUMTOT      2275.    2.17        451.       218.       218.      2.93

*** NORMAL END OF HEC-1 ***
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