

9904HBR/1087

Concept Drainage Design Report

WATERSHED MANAGEMENT LIBRARY

from

Scatter Wash To Cave Creek

Sta. 1170+00 To Sta. 1395+00

Outer Loop Highway

Prepared For:

DeLeuw, Cather & Company

Outer Loop Management Consultants

and

Arizona Department of Transportation

Property of  
Flood Control District #1 MC  
Please Return to  
2001 W. Dunlap  
Phoenix, AZ 85009

Prepared By:

Greiner Engineering Sciences, Inc.

Phoenix, Arizona

October 1987

**Greiner**

CONCEPT DRAINAGE DESIGN REPORT  
FROM  
SCATTER WASH TO CAVE CREEK  
STA. 1170+00 TO STA. 1395+00  
OUTER LOOP HIGHWAY

Prepared For:  
**DELEUW CATHER AND COMPANY**  
Outer Loop Management Consultants  
and  
**ARIZONA DEPARTMENT OF TRANSPORTATION**

Prepared By:  
**GREINER, INC.**  
7310 North 16th Street, Suite 160  
Phoenix, Arizona 85020  
(602) 275-5400

Job. No. E-112-013  
October 1987



INTEROFFICE CORRESPONDENCE

DATE: September 27, 1989

TO: File  
LOCATION:

FROM: Wiley Smith/Tom Engel  
LOCATION:  
PHONE:

*Tom Engel*

SUBJECT: Coordination of Drainage Design  
with Flood Control District

FILE: DR-DP-288-22

Meeting Date: September 21, 1989

Time: 8:30 a.m.

Place: ADOT Arizona Room

Attendees:

FCD

T. Donaldson  
J. Rodriguez  
D. Plasencia  
J. Tran

DCCO

T. Engel  
W. Smith

ADOT

R. DeBoer  
F. Medina

FLOOD CONTROL DISTRICT RECEIVED		
SEP 29 1989		
CH ENG		P & PM
DEP	2	HYDRO <i>DRS</i>
ADMIN		LMGT
FINANCE	3	FILE <i>EAL</i>
C & G	1	<i>JST</i>
ENGR		
REMARKS		

The meeting was held at the request of the Flood Control District to review the proposed drainage at Scatter Wash, Skunk Creek and Cave Creek. DeLeuw Cather presented the proposed channel modifications at Scatter Wash and Skunk Creek and a schematic drawing of a connector channel north of the Outer Loop as requested by the FCD. Upon review of this plan, the adverse effects to modification of the existing schedules for construction and other development in the area became apparent. As a result, the proposal to divert Scatter Wash to Skunk Creek north of the OLH was dropped. The FCD was invited to present any proposals they might have for connecting the downstream end of the ADOT channelization to the Overland Hills channels. FCD will review ADOT plans and make a response, if a drainage opportunity is identified.

In the area north of Beardsley Road from 16th Street to Cave Creek, the FCD would like ADOT to consider diverting all flows

*Flowage  
amount 5.7*

DeLEUW  
CATHER

Coordination of Drainage Design  
with Flood Control District  
September 21, 1989  
Page 2

west to the Cave Creek channel. A flood plain study being performed under direction of the FCD for contributing drainage areas will be complete within two months. The FCD will make this available to DeLeuw, Cather for use in evaluating the impacts of such a diversion. If, upon reevaluation, this option is feasible and more economical than the existing plan, the diversion option can be adopted. If cost implications become a negative factor, the FCD will be notified and invited to comment regarding possible alternatives.

FCD noted that the East Fork Cave Creek detention basin should be constructed by June 1990. Consultant selection is currently underway.

Meeting concluded at 9:20 a.m..

TAE:drl

cc: R. Simeon, ADOT  
R. Jordan, ADOT  
Attendees

OUTER LOOP MANAGEMENT CONSULTANT  
for the Arizona Department of Transportation

**DeLEUW  
CATHER**

De Leuw, Cather & Company • One Gateway Center 426 N. 44th Street Suite 252 Phoenix, Arizona 85008 (602) 244-9096

**WATERSHED MANAGEMENT LIBRARY**

February 3, 1988

Mr. John Rodriguez  
Flood Control District  
3335 W. Durango Street  
Phoenix, Arizona 85009

Subject: Offsite Drainage Concept Study  
Buckeye Road to Northern Avenue

Dear Mr. Rodriguez:

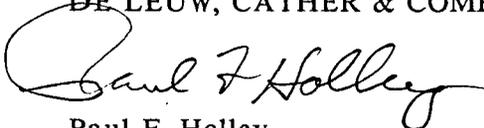
Enclosed for your information is the referenced three-volume Outer Loop Highway hydrology/design concept report, including:

- A. Offsite Hydrology (2 volumes)
- B. Concept Designs (1 volume)

Should you have any questions, feel free to contact Pat Fyie of our office.

Very truly yours,

DE LEUW, CATHER & COMPANY



Paul F. Holley  
Manager, Environmental Coordination and Design

PFH:ath

cc: L. Langer, ADOT  
J. Melanson

EN-47A-2-T.30-21

FLOOD CONTROL DISTRICT	
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DEP	HYDRO
ADGM	LEGT
FINANCE	FILE
C. & S.	
ENGA	
REMARKS	

*DSP*

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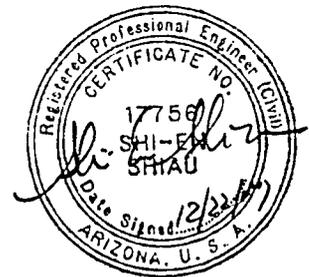


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### III. INTRODUCTION

Greiner Engineering Sciences, Inc. was retained as a subconsultant to DeLeuw, Cather and Company, the Outer Loop Highway Project Management Consultant (PMC) for the Arizona Department of Transportation, to prepare a drainage concept plan for the segment of the Outer Loop Highway between Bell Road and the Central Arizona Project Canal (approximately 14.7 miles).

The Outer Loop Highway is a controlled access freeway which passes through rapidly developing sections of the Metropolitan Phoenix area. Due to this rapid growth, early identification of the right-of-way requirements is important. Consequently, an optimum concept drainage plan must be developed, analyzed and compared with other alternatives to limit the affect of the Outer Loop Highway on existing drainage patterns and to avoid adverse affects on adjacent areas.

The drainage concept plan (study) was prepared in two parts. A detailed hydrologic analysis titled "Hydrology Report, Off-Site Hydrology Existing Conditions" was previously submitted by Greiner Engineering Sciences on August 11, 1986. This analysis included a site investigation to identify existing drainage conditions and to determine existing drainage patterns. Flows for areas contributing to the Outer Loop Highway were calculated for the 10-, 50- and 100-year storm events using the Unit Hydrograph method in conjunction with the United States Army Corps of Engineers HEC-1 computer program. The hydrology report was subsequently modified by the PMC in February 1987 and May 1987 (Ref. 15 and 16).

The second part (Concept Drainage Design Report) was prepared in three separate reports as follows:

Bell road to Skunk Creek, Sta. 811+00 to Sta. 1170+00  
Skunk Creek to Cave Creek, Sta. 1170+00 to Sta. 1395+00  
Cave Creek to the CAP Canal, Sta. 1395+00 to Sta. 1585+00

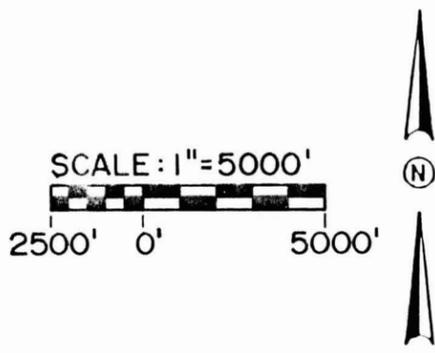
These reports were divided on the basis of major drainage areas and the division of the Outer Loop Highway segments (see Plate 1, Vicinity Map). They formulate various alternative drainage plans from which the proposed design plans can be selected. For each alternative, the approximate type, size and location of the drainage facilities have been determined and order of magnitude cost estimates have been developed. Each alternative has been analyzed based on its advantages and disadvantages and a concept drainage plan has been recommended by Greiner.

This report documents the development of the concept drainage plan for the Outer Loop Highway from Scatter Wash, Station 1170+00 to Cave Creek, Station 1395+00. This section of the highway is within construction Design Segments 5C, 6 and 7A.

The Outer Loop Highway in this study section parallels the Beardsley Road alignment. From Station 1170 to Station 1248 the roadway is elevated. From Station 1248 to Station 1296 the roadway is depressed and passes under I-17. The roadway rises to cross over 19th Avenue at approximately Station 1311 then drops below grade and remains depressed to Station 1375, just east of Seventh Avenue. Highway features include an urban interchange at 35th Avenue, a four-level stack interchange with I-17, an urban interchange at 19th Avenue and an urban interchange at Seventh Avenue (refer to Plate 2, Aerial Map).

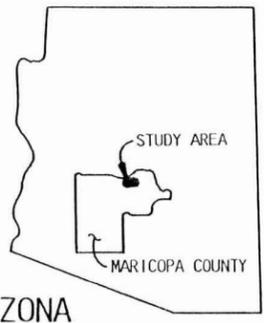
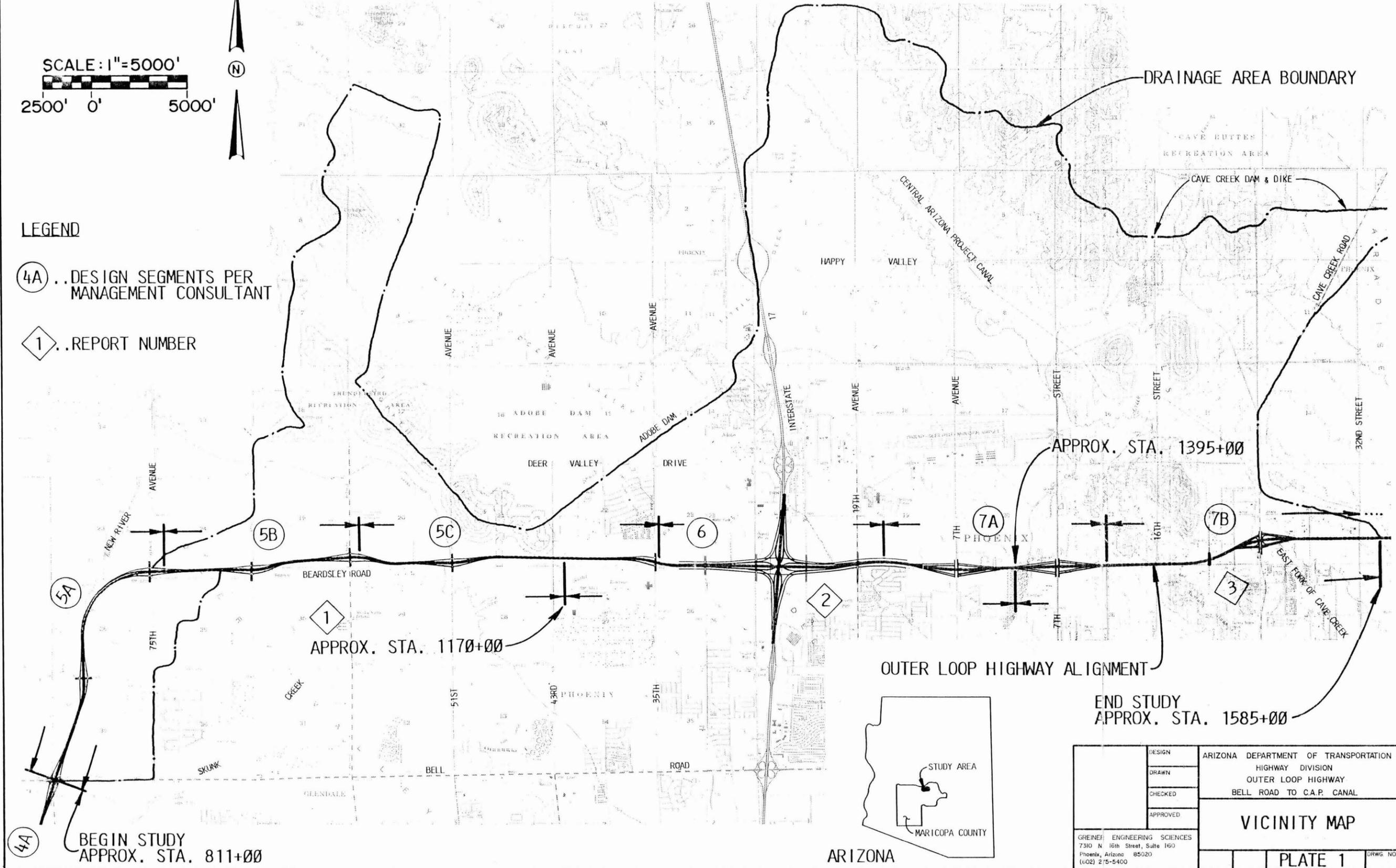
The watershed area contributing stormwater runoff to this section of the Outer Loop Highway is comprised of the Scatter Wash drainage area and drainage areas tributary to Cave Creek. The Scatter Wash drainage area is bounded on the south by the Outer Loop Highway, on the west by Adobe Dam and I-17 and on the north and east by the Union Hills Ridge line north of the C.A.P. Canal.

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9	ARIZONA				



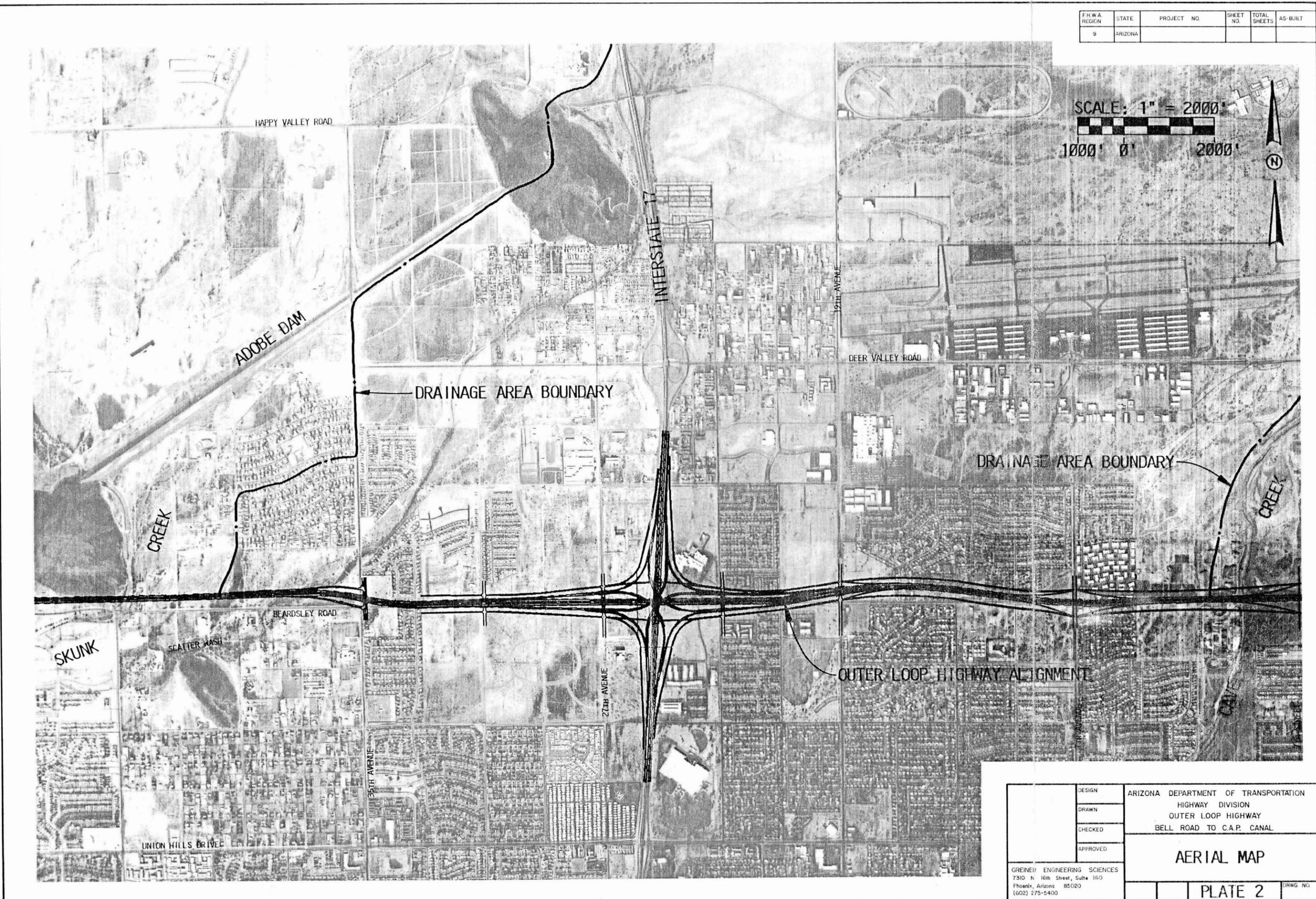
LEGEND

- (4A) ..DESIGN SEGMENTS PER MANAGEMENT CONSULTANT
- 1 ..REPORT NUMBER



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
CHECKED	
APPROVED	
<b>VICINITY MAP</b>	
GREINER ENGINEERING SCIENCES 7310 N 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	<b>PLATE 1</b>
	DRWG. NO.

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



SCALE: 1" = 2000'

1000' 0' 2000'



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
CHECKED	
APPROVED	
<b>AERIAL MAP</b>	
GREINER ENGINEERING SCIENCES 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	
<b>PLATE 2</b>	
DRWG. NO.	

The Cave Creek tributary drainage areas are bounded on the south by the Outer Loop Highway, I-17 on the west, the Scatter Wash drainage area divide on the north, the C.A.P. on the northeast and the Cave Creek ridge line on the east. Scatter Wash is the only major drainageway crossing the Outer Loop Highway alignment in this study section. The 100-year storm peak discharge in Scatter Wash has been estimated by the Corps of Engineers to be 6100 cfs (Ref. 14).

Land uses in the vicinity of the highway include residential, commercial and light industrial. A cemetery is located along the north side of Beardsley Road east of Third Avenue. This section of the highway is within the City of Phoenix corporate limits.

Interstate 17 and the C.A.P. Canal have major impacts on the area's drainage patterns. I-17 bisects the Scatter Wash drainage area from north to south. The existing culverts under I-17 generally do not have the capacity to convey flows in excess of the 50-year storm event. Stormwater runoff in excess of culvert capacities ponds on the east side of the highway or flows into the depressed roadway sections under the highway. Design recommendations for improving drainage under I-17 were presented in an August 1986 study (Ref.17). The C.A.P. Canal, constructed and maintained by the Bureau of Reclamation, crosses the watershed area in a southeasterly arc. An average 15 foot high dike on the upstream side of the canal directs runoff to overchute pipes that discharge into the existing washes downstream of the canal.

#### IV. OBJECTIVES

The objective of the drainage concept plan for the Outer Loop Highway is to develop an optimum plan to provide floodwater protection for the roadway. In addition, the plan will ensure that there will be no adverse effects on adjacent areas.

The objective of this report is to develop the floodwater protection plans for the section of Outer Loop Highway extending from Scatter Wash to Cave Creek. The concept plan will include the types, sizes, alignment and locations, as appropriate, for channels, culverts and detention basins. Tables and/or exhibits will be developed which document the proposed drainage system. Order of magnitude costs will be prepared. If more than one concept is developed, the advantages and disadvantages of each alternative will be analyzed and a recommendation made for implementation of the optimum plan.

The need for additional rights-of-way for the drainage concept plan will be identified.

## V. PROCEDURES AND METHODOLOGY

Alternative concept plans were developed for the 100-year, 24-hour storm event for existing watershed development conditions. The concept plans include the conveyance of off-site drainage impacting the highway right-of-way to alternative outfalls only. Alternative concepts studied were multiple conveyance systems versus a single conveyance system, use of multiple outfalls versus a single outfall, closed conduits versus open channel or a combination of both, and detention systems.

For each alternative concept, a HEC-1 computer model was developed and existing condition flows were routed through the system. Based on the results of the hydrologic modeling the types, sizes and locations of the proposed drainage facilities for all alternatives were identified.

Each alternative was evaluated in terms of costs, effectiveness, ease of maintenance, ease of construction and compatibility with other projects and plans. The alternative concept plans were reviewed by the Project Management Consultant and ADOT and their recommendations, modifications and refinements were incorporated into the selected plan development.

### A. Concept Plan Development

The alternative and selected concept plans are comprised of systems of open channels, detention basins and closed conduits. The factors considered in developing the range of alternative systems are as follows:

- o Location and magnitude of runoff concentrating at the Outer Loop Highway
- o Location and adequacy of outfalls
- o Availability of and previously purchased land by ADOT along the Outer Loop Highway suitable for open channels or detention basins

- o Approved and ongoing projects and plans proposed by federal, state and local jurisdictions
- o Horizontal and vertical alignments of the proposed Outer Loop Highway

**B. Hydrologic and Hydraulic Procedures**

The off-site hydrologic models previously developed in the Hydrology Report were reanalyzed wherever runoff was diverted from its existing flow path into a proposed collection system. The HEC-1 program was used to route flows through the alternative concept drainage systems and to calculate the new 100-year peak discharge values at the outfalls.

Preliminary structure sizes were assumed and incorporated into the hydrologic models. The resultant calculated peak discharges were then used to resize the drainage structures. Open channels were sized for normal depth of flow using the Manning Equation. The Federal Highway Administration "Hydraulic Charts for the Selection of Highway Culverts" (HEC No. 5) was used for sizing closed conduits.

The calculated drainage structure sizes were re-input into the hydrologic model. If the resultant peak discharges were significantly different from the previously calculated discharge values, the structure sizes were recalculated.

## VI. DESIGN CRITERIA

Concept plans were developed using established design and special criteria provided by the Project Management Consultant. The following criteria were used:

- o Open channels were sized to convey the 100-year storm runoff with an additional 20 percent added to the discharge value as freeboard per ADOT requirements.
- o The proposed off-site drainage facilities for the highway will not worsen flooding outside of the right-of-way from the 100-year storm runoff.
- o Flow velocities in concrete lined channels were kept under twelve feet per second.
- o Open channels were designed using the following parameters:
  - Channel Type: Trapezoidal
  - Channel Lining: Concrete
  - Side Slope: 2:1
  - Minimum Bottom Width: 8 feet
  - Manning n Value: 0.018
- o Detention basins were designed with two feet of freeboard and with maximum side slopes of 3:1. A minimum 15 foot buffer zone was provided around the perimeter of the basin to allow for landscaping or other aesthetic treatment. Basins were designed to drain within 36 hours of peak storage.
- o Storm Sewer Pipes/Culverts were assumed to be concrete with a Manning "n" value of 0.012.

## VII. ALTERNATIVE CONCEPT PLANS

Alternative off-site drainage systems were evaluated. In general, system alignments were selected to conform to topographic features of the drainage areas. The off-site drainage system may be utilized for conveyance of on-site stormwater runoff. Inverts of large drainage channels were set sufficiently deep to provide positive drainage from the highway median drains or catch basins. Grader ditches are provided where off-site stormwater runoff flowing parallel to the roadway is 25 cfs or less. At the time of final design, a hydraulic analysis should be performed to determine the extent of flow spread and whether a collector channel is required to contain the flow so as not to adversely impact either the highway or adjacent properties.

Drainage concepts were not provided for existing or proposed frontage roads. Where necessary, the drainage facilities were extended through the frontage roads to provide the necessary protection to the highway.

The major elements of the alternative drainage systems including open channels, culverts and detention basins are described on the following pages.

### Alternative 1

Alternative 1 is comprised of an interconnected system of open channels, three detention basins, closed conduits and storm drains that convey off-site drainage to Scatter Wash.

Station 1323+00 to Station 1395+00 (19th Avenue to Central Avenue). Runoff from Drainage Areas 8A, 8 and 9A is intercepted by an open channel and conveyed into Detention Basin A which is located between 14th Avenue and 15th Avenue north of the Outer Loop Highway alignment. The combined inflow into Detention Basin A is 2047 cfs and the outflow is 921 cfs. Basin outflow is discharged through culverts for conveyance into Detention Basin

B, located between 19th Avenue and 21st Avenue north of the Outer Loop Highway alignment.

Runoff from Drainage Area P9 is intercepted by an open channel and conveyed into Detention Basin B. Runoff from Drainage Area P10 will flow directly into the basin. The combined inflow into detention Basin B, including the outflow from Detention Basin A, is 2909 cfs. Outflow from Detention Basin B is 1110 cfs; it is discharged and conveyed via culverts to Detention Basin E which is located between 23rd Avenue and I-17, south of the proposed Outer Loop Highway alignment.

Station 1270+00 to Station 1312+00 (I-17 to 19th Avenue). Runoff from Drainage Area P10A and 11B (Intel) will be intercepted by a 66 inch storm drain and conveyed to the west across I-17. The storm drain will outlet into a drainageway at approximately Station 1265+00. Runoff from Drainage Area P10A and 11B shall be picked up by catch basins to be located in existing detention basins along 23rd Avenue and Beardsley road (Drainage Area P10A) or in the depressed areas of the Intel property parking lot and detention facilities (Drainage Area 11B).

Detention Basin E is located on the south side of the proposed Outer Loop Highway and will drain westward across I-17 via culverts at the rate of 649 cfs.

Station 1192+00 to Station 1270+00 (Scatter Wash to I-17). An open channel located along the north right-of-way of the Outer Loop Highway alignment, between Station 1265+00 and Scatter Wash, will intercept runoff from Drainage Areas P11D, P11C and P11B. This channel will also convey discharge from the storm drain crossing under I-17 from Drainage Areas 11B and P10A.

At approximately Station 1242+00, the culverts draining Detention Basin C will outlet into this channel. The culverts first cross I-17 south of the Outer Loop at approximately I-17 Station 739+50, then turn northward and follow the south right-of-way of the Outer Loop Highway. The culverts

cross the interceptor channel at approximately Station 1242+00. Refer to Plate 3 for a schematic of Alternative 1.

### Alternative 2

Alternative 2 is comprised of an interconnected system of open channels, two detention basins and closed conduit that ultimately discharge storm runoff into Scatter Wash.

Station 1312+00 to Station 1395+00 (19th Avenue to Central Avenue). Hydrology and concept design for this section of highway are the same as Alternative 1, except that Detention Basin B drains directly to the west via culverts. Detention Basin E has been eliminated from Alternative 2.

Station 1270+00 to Station 1312+00 (I-17 to 19th Avenue). Culverts draining Detention Basin B head westward along the north right-of-way of the Outer Loop Highway alignment. Storm runoff from Drainage Areas P10A and 11B (Intel) will be intercepted by catch basins and discharged into the culvert outletting from Detention Basin B. These catch basins will be located within the existing off-site detention areas, along 23rd Avenue and Beardsley Road, and the Intel parking lot and detention facilities.

### Alternative 3

Alternative 3 is comprised of an interconnected system of open channels, five detention basins and closed conduits that convey off-site drainage to Scatter Wash.

Station 1312+00 to Station 1395+00 (19th Avenue to Central Avenue). An open channel will be located between Detention Basin A and Central Avenue as in Alternatives 1 and 2. An intermediate detention basin (Basin F) will be located in the northeast quadrant of the Outer Loop and Seventh Avenue. Flows up to 523 cfs will be diverted into this basin from the open channel. Channel flows in excess of 523 cfs will continue in the channel to Basin A.

Basin F will gravity drain via underground conduit to Basin A. As in Alternative 2 Basin A will drain into Basin B and Basin B will gravity drain westward under I-17 via closed conduit.

Station 1270+00 to Station 1312+00 (I-17 to 19th Avenue). The closed conduit conveying discharges from Basin B will also convey stormwater runoff from drainage areas P10A, 11B and P11D. This conduit will continue to the west side of 27th Avenue where it will discharge into an open channel.

Drainage area PRC9 will have runoff collected by an unlined channel located along Ramp D (I-17 eastbound off-ramp). The channel will be connected to detention Basin E located within the I-17 and Outer Loop Highway ramps. This basin will drain southward along the west side of I-17 and tie into existing 2-24" CMP culvert located approximately 1200 feet south of Beardsley Road.

Stations 1205+00 to Station 1270+00 (35th Avenue to I-17). Two detention basins (Basin D) will be located along the north side of Rose Garden Lane, on the east and west sides of I-17, to intercept runoff from Drainage Area 11C. These basins will reduce an inflow rate of 353 cfs to an outflow rate of 34 cfs. The basin on the east side of I-17 will drain into the west side basin which, in turn, will drain southward in an underground conduit. This conduit will convey flows southward along the west side of I-17 and discharge into the culvert conveying flows from Basin B and Drainage Areas P10A and 11B.

The channel beginning at 27th Avenue will continue along the north side of the Outer Loop Highway to just east of 35th Avenue. A detention basin (Basin C) will be located in the northeast quadrant of 35th Avenue and the highway. The channel described above will be designed to spill flows in excess of 250 cfs into Basin C. Flows remaining in the channel will be conveyed to Scatter Wash. Basin C will gravity drain via underground conduit to Skunk Creek. Refer to Plate 5 for a schematic of Alternative 3.

### SCATTER WASH

Both bridge and culvert crossings at Scatter Wash and the Outer Loop Highway were evaluated. The 100-year discharge value of 6100 cfs developed by the U.S. Army Corps. of Engineers (COE) was used as the design flow. The 100-year floodplain delineation of Scatter Wash by the COE was also used. To clear span the 1800 foot wide floodplain, a Type IV AASHTO Girder Bridge with 20-93 foot spans will be required. The PMC developed a culvert crossing concept that includes a ten barrel 10' x 8' box culvert under the highway with channelization and diking upstream to intercept flow within the 100-year floodplain and downstream channelization to transition flows back into the existing channel (Ref. 18). At the direction of the PMC, the culvert crossing with channelization was adopted as the preferred plan. An open channel along the highway right-of-way between station 1174 and 1186 will direct off-site runoff from D.A. 12 to Scatter Wash.

A detailed investigation is required at the time of final design to evaluate the affect of the Scatter Wash channelization on the stability of upstream and downstream reaches as well as to determine the potential for erosion or scour within the channelized section if no protection is provided.

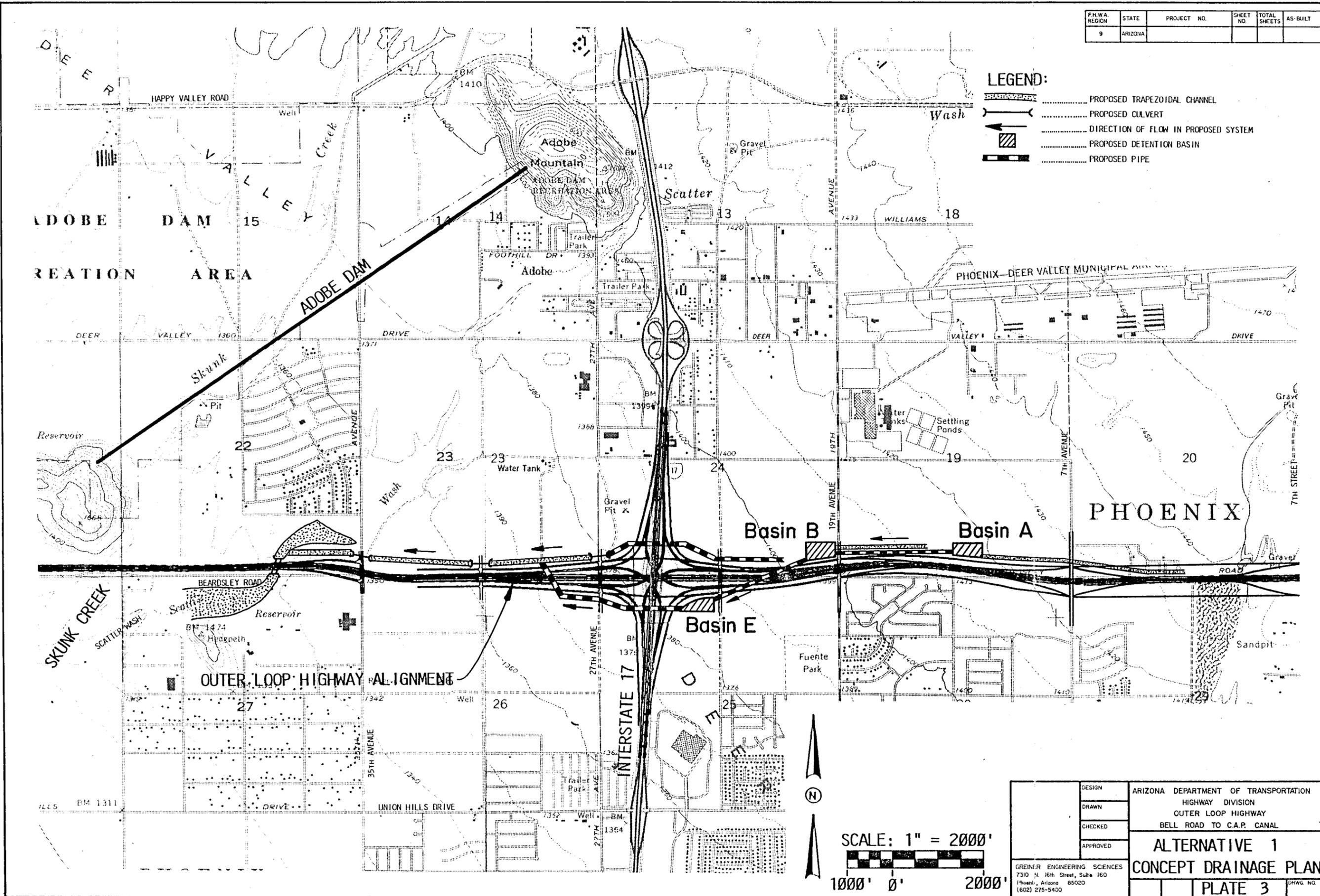
### ON-SITE RUNOFF

The PMC has determined that the most economical way to drain the depressed section of the Outer Loop Highway is by an underground gravity drained conduit that will convey on-site runoff to Scatter Wash.

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

**LEGEND:**

-  PROPOSED TRAPEZOIDAL CHANNEL
-  PROPOSED CULVERT
-  DIRECTION OF FLOW IN PROPOSED SYSTEM
-  PROPOSED DETENTION BASIN
-  PROPOSED PIPE



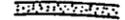
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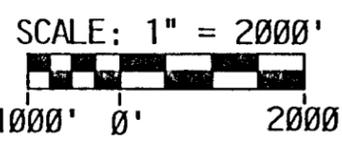
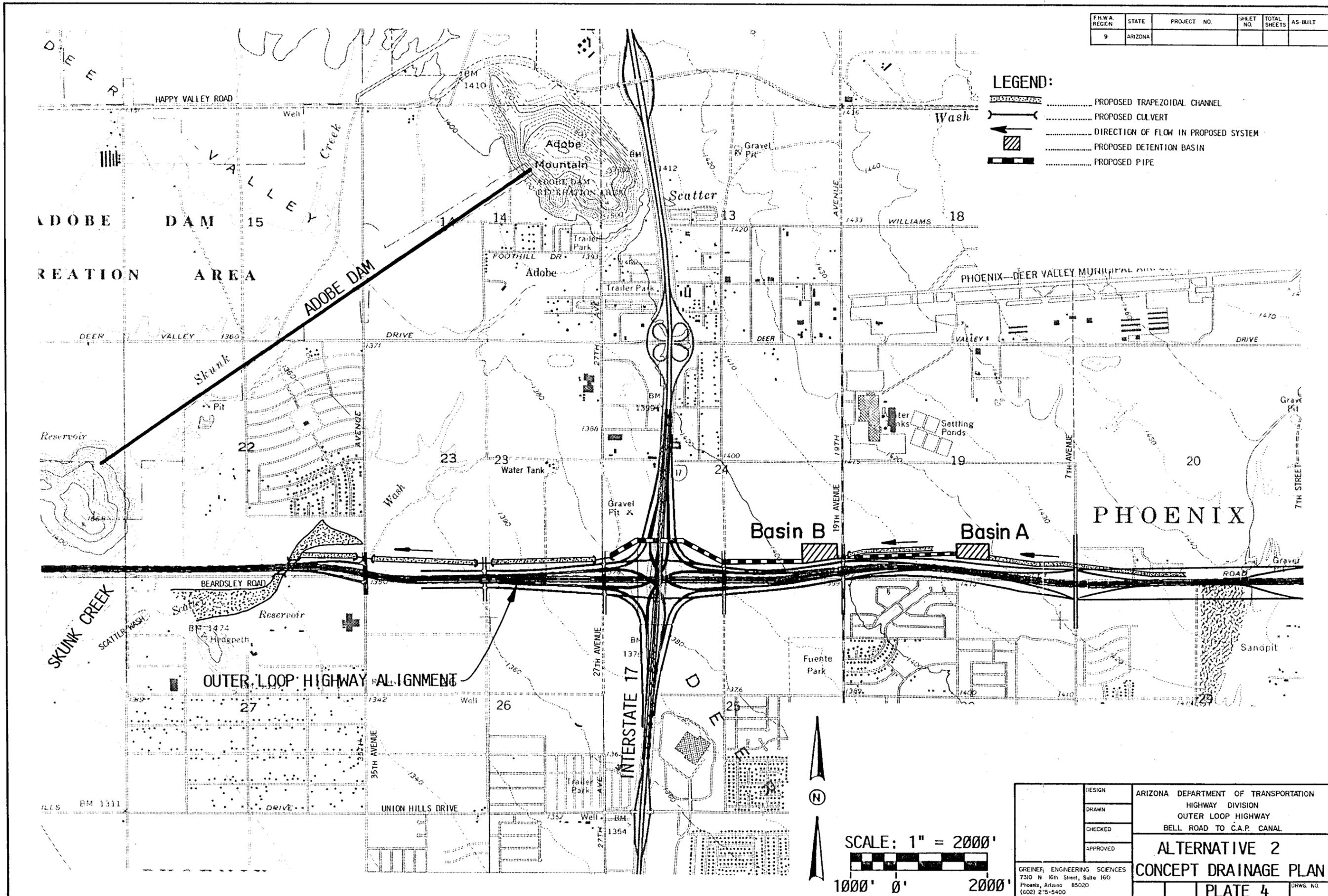
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DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
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APPROVED	
<b>ALTERNATIVE 1</b>	
<b>CONCEPT DRAINAGE PLAN</b>	
GREIM, R. ENGINEERING SCIENCES 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 275-5400	<b>PLATE 3</b>

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

**LEGEND:**

-  PROPOSED TRAPEZOIDAL CHANNEL
-  PROPOSED CULVERT
-  DIRECTION OF FLOW IN PROPOSED SYSTEM
-  PROPOSED DETENTION BASIN
-  PROPOSED PIPE

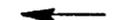


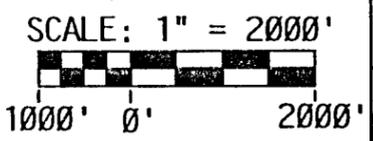
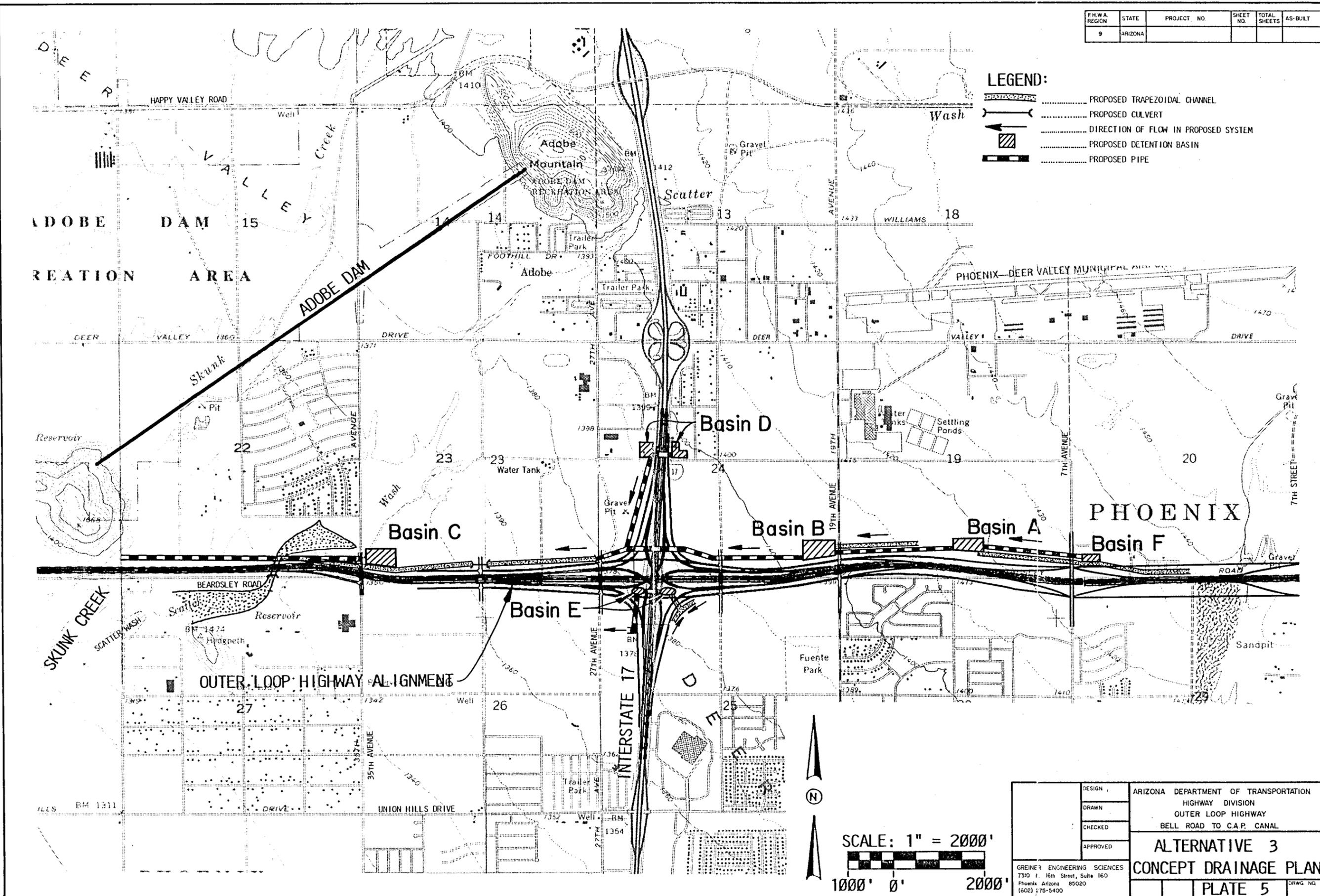
DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
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APPROVED	
<b>ALTERNATIVE 2</b>	
<b>CONCEPT DRAINAGE PLAN</b>	
PLATE 4	

GREINER ENGINEERING SCIENCES  
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(602) 255-5400

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

**LEGEND:**

-  PROPOSED TRAPEZOIDAL CHANNEL
-  PROPOSED CULVERT
-  DIRECTION OF FLOW IN PROPOSED SYSTEM
-  PROPOSED DETENTION BASIN
-  PROPOSED PIPE



DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL  <b>ALTERNATIVE 3</b> <b>CONCEPT DRAINAGE PLAN</b>  PLATE 5
DRAWN	
CHECKED	
APPROVED	
GREINER ENGINEERING SCIENCES 7310 E. 16th Street, Suite 160 Phoenix, Arizona 85020 (602) 775-5400	
DRWG. NO.	

## VIII. EVALUATION OF ALTERNATIVE CONCEPT PLANS

The three alternative concept plans were evaluated and ranked in terms of cost, effectiveness, compatibility with other projects and plans, ease of maintenance and ease of construction. Matrices with ranking (+,0,-) were developed for comparison of the alternative concepts for each drainage area. A plus (+) was given for the higher ranking alternative; a neutral (0) was given to the alternatives if they ranked equally or had no negative impacts; and a minus (-) was given for a lower ranking.

### A. Estimated Costs

Construction costs for all alternative concept plans and the selected concept plan were estimated. Unit costs for reinforced concrete pipe (RCP), reinforced concrete box culverts (RCBC) and excavation and concrete lining were obtained from the PMC.

Thirty percent was added to the estimated construction costs for the drainage facilities to include associated appurtenances and contingencies. Appurtenances include the cost of outlet or inlet works, junction structures, manholes, laterals, catch basins, erosion protection, bank stabilization, minor street reconstruction, minor utility relocation and conflicts resolution.

Costs did not include right-of-way acquisition, major utility relocations, pumping stations, major street reconstruction, landscaping, maintenance, administration and engineering to cover survey, design, contract administration, field engineering and inspection services.

The estimated construction costs of each alternative are found in Tables 1, 2 and 3.

**Table 1  
Estimated Costs**

Alternative 1

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
1192-1217 Lt.	Channel: Excavation Concrete	20,500 CY 11,100 SY	\$ 2.50 35.00	\$ 51,000 389,000
1205 Lt.	72" RCP	980 LF	150.00	176,000
1217-1232 Lt.	Channel: Excavation Concrete	13,200 CY 16,700 SY	2.50 35.00	33,000 585,000
1231+50 Lt.	72" RCP	280 LF	150.00	50,000
1232-1257 Lt.	Channel: Excavation Concrete	31,400 CY 10,200 SY	2.50 35.00	79,000 357,000
1258 Lt.	66" RCP	240 LF	145.00	42,000
1310-1315 Lt.	Channel: Excavation Concrete	8,400 CY 5,500 SY	2.50 35.00	21,000 193,000
1311 Lt	48" RCP	3,100 LF	98.00	365,000
1315-1364 Lt.	Channel: Excavation Concrete	47,700 CY 30,400 SY	2.50 35.00	119,000 1,064,000
1363+30 Lt.	48" RCP	2,650 LF	98.00	312,000
1364-1387 Lt.	Channel: Excavation Concrete	18,500 CY 12,300 SY	2.50 35.00	46,000 431,000
Basin A	Basin: Excavation 72" Outlet	152,000 CY 8,700 LF	2.50 150.00	380,000 1,566,000
Basin B	Basin: Excavation 72" Outlet	368,000 CY 7,080 LF	2.50 150.00	920,000 1,062,000
Basin C	Basin: Excavation 72" Outlet	381,000 CY 7,000 LF	2.50 150.00	953,000 1,050,000
DA P10/11B Storm Drain	66" RCP	3,000 LF	145.00	435,000
<b>Sub-Total</b>				<b>\$10,679,000</b>
<b>30% Appurtenances and Contingencies</b>				<b>3,204,000</b>
<b>Sub-Total</b>				<b>\$13,883,000</b>
<b>Scatter Wash Crossing*</b>				<b>4,899,000</b>
<b>Total Estimated Cost</b>				<b>\$18,782,000</b>

\*Cost provided by PMC

Table 2  
Estimated Costs

Alternative 2

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
1192-1205 Lt.	Channel: Excavation Concrete	13,500 CY 8,100 SY	\$ 2.50 35.00	\$ 34,000 284,000
1205 Lt.	72" RCP	1,400 LF	150.00	252,000
125-1232 Lt.	Channel: Excavation Concrete	28,000 CY 16,800 SY	2.50 35.00	70,000 588,000
1231+50	72" RCP	700 LF	150.00	126,000
1232-1267 Lt.	Channel: Excavation Concrete	44,900 CY 11,600 SY	2.50 35.00	112,000 406,000
1258 Lt.	36" RCP	240 LF	69.00	17,000
1310-1316 Lt.	Channel: Excavation Concrete	8,400 CY 5,500 SY	2.50 35.00	21,000 193,000
1311 Lt.	48" RCP	3,100 LF	98.00	365,000
1316-1364 Lt.	Channel: Excavation Concrete	47,700 CY 30,400 SY	2.50 35.00	119,000 1,064,000
1363+30 Lt.	48" RCP	2,650 LF	98.00	312,000
1364-1387 Lt.	Channel: Excavation Concrete	18,500 CY 12,300 SY	2.50 35.00	46,000 431,000
Basin A	Basin: Excavation 2-6' x 7' RCBC Outlet	152,000 CY 2,900 LF	2.50 435.00	380,000 1,514,000
Basin B	Basin: Excavation 2-8' x 6' RCBC Outlet	368,000 CY 4,200 LF	2.50 540.00	920,000 2,722,000
<b>Sub-Total</b>				<b>\$ 9,976,000</b>
<b>30% Appurtenances and Contingencies</b>				<b>2,993,000</b>
<b>Sub-Total</b>				<b>\$12,969,000</b>
<b>Scatter Wash Crossing*</b>				<b>4,899,000</b>
<b>Total Estimated Cost</b>				<b><u>\$17,868,000</u></b>

\*Cost provided by PMC

**Table 3  
Estimated Costs**

**Alternative 3**

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
1205	10' x 3' RCBC	140 LF	\$ 265.00	\$ 37,000
1231+50	2-10' x 5' RCBC	70 LF	546.00	38,000
1311	5-10' x 5' RCBC	180 LF	1293.00	233,000
1363	3-10' x 5' RCBC	140 LF	791.00	111,000
1374	5-10' x 5' RCBC	70 LF	1293.00	91,000
1187-1206	42" RCP	5.050 LF	83.00	419,000
1267 Lt.	36" RCP	2.400 LF	69.00	166,000
1265 Rt.	24" RCP	450 LF	39.00	18,000
1267-1299	8' x 5' RCBC	4.400 LF	222.00	977,000
1310-1337	78" RCP	2.900 LF	165.00	479,000
1342-1364	48" RCP	2.300 LF	98.00	225,000
1187-1210	Channel: Excavation Concrete	3,200 CY 5,400 SY	2.50 35.00	8,000 189,000
1210-1232	Channel: Excavation Concrete	8,000 CY 7,800 SY	2.50 35.00	20,000 273,000
1232-1252	Channel: Excavation Concrete	7,900 CY 7,300 SY	2.50 35.00	18,000 26,000
1252-1257	Channel: Excavation Concrete	1,700 CY 1,700 SY	2.50 35.00	4,000 60,000
1310-1332	Channel: Excavation Concrete	16,700 CY 12,000 SY	2.50 35.00	42,000 420,000
1342-1362	Channel: Excavation Concrete	12,000 CY 9,300 SY	2.50 35.00	30,000 326,000
1367-1380	Channel: Excavation Concrete	7,600 CY 5,900 SY	2.50 35.00	19,000 207,000
1380-1387	Channel: Excavation Concrete	985 CY 1,600 SY	2.50 35.00	2,000 56,000

Table 3 (continued)

<u>Location (Station-Station)</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
35th Avenue	Det. Basin C	156,000 CY	2.50	391,000
Rose Garden	Det. Basin D	40,000 CY	2.50	101,000
I-17 & O.L.H	Det. Basin E	18,000 CY	2.50	44,000
19th Avenue	Det. Basin B	469,000 CY	2.50	1,174,000
15th Avenue	Det. Basin A	224,000 CY	2.50	561,000
7th Avenue	Det. Basin F	26,000 CY	2.50	65,000
<u>Sub-Total</u>				<u>\$ 6,830,000</u>
<u>30% Appurtenances and Contingencies</u>				<u>2,049,000</u>
Sub-Total				8,879,000
<u>Scatter Wash Channelization*</u>				<u>4,899,000</u>
Total Estimated Cost				<u>\$13,778,000</u>

\*Cost provided by PMC

## B. Effectiveness

Effectiveness is defined as the ability of the alternative concepts to meet the objective of the Drainage Concept Plan. The objective of the plan is to protect the Outer Loop Highway during the 100-year storm event, while ensuring that upstream and downstream conditions will not be worsened. To achieve this, all alternative concept plans were developed for the 100-year storm event. Therefore, they all meet the effectiveness criteria and received a (0) ranking.

## C. Compatibility with Other Projects and Plans

The compatibility of the proposed alternative concept plans with other projects and plans, including existing and proposed drainage and flood control projects and existing roadways and utilities, were evaluated. A higher ranking was given if utility conflicts and street reconstruction were minor in comparison with other alternatives.

All three alternatives are generally equally compatible with existing utilities, streets and proposed area stormwater drainage plans. By intercepting stormwater flows at Beardsley Road and diverting them westward to Scatter Wash, the highway plan will provide drainage relief to downstream streets and drainage facilities. Alternative 3 will receive a (+) rating, however, because Basin D will provide additional drainage relief to the area along the east side of I-17 between Rose Garden Lane and Beardsley Road.

D. Ease of Construction and Maintenance

Ease of construction and maintenance is a measure of the overall complexity of the structures to be constructed including the use of special or non-standard structures and the degree of frequency and intensity of maintenance during the life of the project.

All three alternatives require the use of open channels, detention basins and underground conduits. Alternative 1 will receive a (-) ranking because it incorporates more detention basin surface area requiring maintenance than the other two alternatives. The conduit crossing under the highway from Basin B to Basin C may also require special treatment during construction. Alternative 2 will require the least maintenance costs because only two detention basins are utilized. A (+) ranking will, therefore, be assigned. Alternative 3 falls between Alternatives 1 and 2 with respect to maintenance and will be given a neutral rating (0). None of the alternatives have design features that are unusually complex.

E. Evaluation Matrices

Table 4  
Evaluation Matrix

	<u>Capital Costs</u>	<u>Effectiveness</u>	<u>Compatibility with other Project &amp; Plans</u>	<u>Ease of Construction &amp; Maintenance</u>	<u>Net Score</u>
Alternative 1	-	0	0	-	-2
Alternative 2	0	0	0	+	+1
Alternative 3	+	0	+	0	+2

On the basis of the above evaluation, Alternative 3 is recommended as the drainage plan for the Outer Loop Highway between Scatter Wash and Cave Creek.

## IX. PRELIMINARY DRAINAGE PLANS

Preliminary plans of the selected facilities for the Outer Loop Highway were developed. The plans include sizes, profiles, alignments and locations as appropriate for channels, pipes, trunk mains, culverts and detention basins. The plans were prepared initially on 1"=2000' scale plan and profile sheets prior to reduction for inclusion in this report. The plan sheets are found at the end of this section.

The plan portion depicts drainage area divides; subarea numbers adjacent to the Outer Loop Highway with their respective 100-year peak discharge values; the proposed right-of-way; the highway alignment including interchanges, ramps and frontage roads; topographic features with two foot contour intervals; 100-year floodplain limits for major rivers, creeks and washes; street names; highway stationing and station ticks every 100 feet. Design discharges used for the 100-year drainage facilities are also shown. These values do not include the 20 percent freeboard factor. The location of grader ditches is not shown but should be assumed to be located within the highway right-of-way.

Proposed right-of-way limits were obtained from ADOT right-of-way maps. Existing drainage facilities were inventoried in the field and verified with as-built plans.

One hundred year floodplain limits were obtained from the current FEMA and FIRM maps or from more recent floodplain work maps obtained from the Flood Control District of Maricopa County.

Shown in the profile is the existing ground profile, major street crossings, the cross-section and location of existing crossing drainage structures, the cross-section and location of existing and planned major utilities crossing the Outer Loop Highway and the profiles of the proposed drainage facilities.

The existing ground profile was plotted from the topographic aerial base maps provided by the PMC. The current centerline (vertical alignment) of the Outer

Loop Highway has also been shown in the profile. Quarter section maps for water, sanitary sewer, gas, buried and overhead electric lines and cable TV were used. The as-built plans for storm drains and critical utilities were also used wherever they were available. Shown in cross-section are water lines eight inches in diameter and larger, sanitary sewers, major electric lines, gas lines and high pressure lines crossing the Outer Loop Highway.

The stationing is based on the stationing proposed by the PMC.

The horizontal alignments of the drainage facilities was set to conform to the proposed Outer Loop Highway alignment and geometrics including interchanges, ramps, cut/fill slopes, structures, frontage roads and right-of-way.

The vertical profiles of the proposed drainage facilities were established to provide adequate cover for the structure; ensure positive drainage to the outfalls; ensure that the hydraulic grade line of the drainage facilities will be within the freeboard requirements of tributary laterals and catch basins; avoid conflict with utilities, particularly sanitary sewers and large water distribution pipes; and match existing or proposed drainage facilities by others. Structure lengths, sizes and design discharges are provided in profile.

On the following pages, the features of the proposed drainage facilities are reviewed on a sheet by sheet basis. (See the plan sheets at the end of this section.) The purpose of this review is to assist the designers of the drainage facilities by bringing to their attention the rationale use in establishing the vertical alignment, potential utility conflicts and necessary coordination with other agencies or consultants. Table 5 is a channel summary which identifies the channels by location with respect to highway stationing, structure type, design discharge or volume, slope, channel characteristics [depth and top width (TW)] and length. Table 5 is a detention basin summary and Table 8 is a culvert summary. Refer to Plate 6 and Plate 7 for a schematic and summary of the recommended plan hydrology.

## Sheet 8

### Scatter Wash

A detailed description of the preliminary hydraulics and design of the Scatter Wash improvements is found in reference 18, prepared by the PMC. The invert of the improved Scatter Wash channel will have to be set to ensure stability of the wash. From Station 1174+00 to Scatter Wash, an open channel will be provided along the north right-of-way to convey off-site stormwater flows from D.A. 12 to Scatter Wash.

### Station 1209+00

Detention Basin C, located in the northeast quadrant of the Outer Loop Highway and 35th Avenue will be 20 feet deep. A 42" diameter pipe will provide gravity drainage from the basin to Skunk Creek. The pipe alignment should be adjusted so it will remain within the available right-of-way.

### Station 1187+00 to Station 1210+00

An open concrete lined channel will convey flows bypassing Basin C to Scatter Wash. A 10' x 3' RCBC will convey these flows under 35th Avenue. A 12 inch water line and a four inch gas line will have to be relocated for the box culvert.

## Sheet 9

### Station 1211+00

At approximately this location, a side weir or outlet pipe is required to divert a maximum of 250 cfs from the channel into Basin C. Slope protection will have to be provided for the basin embankment at this discharge point.

### Station 1210+00 to Station 1255+00

An open concrete channel will intercept runoff from Drainage Areas P11B, P11C and P11D. A double 10' x 5' RCBC is required to convey channel flows under 31st Avenue. A 12 inch water line may have to be relocated to accommodate this culvert.

Sheet 10

Station 1257+00 to Station 1288+00

An 8' x 5' RCBC will gravity drain Detention Basin A and convey flows westward under I-17. The culvert alignment was set to avoid conflicts with the depressed highway section, structures supporting the interchange stack and the existing I-17 bridge over Beardsley Road. The culvert outfall was set at Station 1257+00, on the west side of 27th Avenue to minimize the amount of cut required for the receiving open channel. Laterals along 23rd Avenue and 27th Avenue and drop inlets in Drainage Areas 11B and P10 may be required to intercept off-site stormwater runoff. At station 1267+00 the 36" RCP draining Detention Basin D will connect into the 8' x 5' RCBC.

Detention Basin E

Detention Basin E will be located along I-17 south of the Outer Loop Highway and within the stack interchange area. The basin will be comprised of east and west component basins that will be connected by a 24 inch RCP. The basins will intercept runoff from D.A. PRC9. The maximum basin depth will be four feet. The configuration of the basins will be adjusted to accommodate the structures supporting the interchange stack.

Basin E will be gravity drained southward along the west right-of-way of I-17 by a 24 inch RCP. This pipe will discharge into an existing improved earthen drainageway located at approximately I-17 Station 735+03. An existing double 24 inch RCP draining across I-17 from east to west also outlets into this drainage way.

At the time of final design the designer should verify the availability of fall from Basin E to the drainageway located at I-17 Station 735+03. The depth of Basin E may have to be decreased to provide positive drainage and the surface area increased to maintain the required storage volume. Alternative methods for draining Basin E may also have to be investigated including the use of dry wells or draining the basins directly into the on-site runoff storm

drain located in the depressed section of the Outer Loop highway. An earthen channel will be located along the inside radius of Ramp D to intercept runoff from D.A. PRC9 for conveyance to Detention Basin E.

### Sheet 11

#### Station 1288+00 to Station 1310+00

The alignment of the 8' x 5' RCBC outlet from Detention Basin B should be located within the existing right-of-way. It may be necessary to locate it under the frontage road. Detention Basin B located between 21st Avenue and 19th Avenue, will be 25 feet deep. Embankment protection may be required at locations where offsite drainage from either Drainage Area P10A or the open channel from D.A. P9 discharge into the basin.

#### Station 1310+00 to Station 1336+00

An open concrete channel will intercept stormwater runoff from D.A. P9 for conveyance to Detention Basin B. Total top width requirements for the channel, including the required 30 foot buffer, is approximately 80 feet. Wherever the available right-of-way is less than the required 80 feet, the designer should evaluate and compare the alternatives of either acquiring additional right-of-way, reducing the 30-foot buffer requirement, using buried conduit or a combination of the above. A five barrel 10' x 5' RCBC is required to convey these flows under 19th Avenue.

The 78 inch RCP gravity drain for Basin A will be located within the existing right-of-way south of the proposed channel alignment. As an alternative to the open channel collecting runoff from D.A. P9, the Basin A gravity drain may be increased to a five barrel 10' x 5' RCBC for intercepting runoff from D.A. P9 in addition to drainage from Basin A. Laterals along 19th Avenue, 17th Avenue and drop inlets into the 5-10' x 5' RCBCs may be required to fully intercept D.A. P9 runoff.

### Detention Basin A

Detention Basin A will be located in the northeast quadrant of 15th Avenue and the highway. The basin will be 25 feet deep. The basin will gravity drain to Basin B via a 78 inch RCP. If the 78 inch RCP is to be upsized to convey runoff from D.A. P9, the outlet to Basin A should be constricted to maintain the maximum allowable discharge rate of 263 cfs.

### Sheet 12

#### Station 1341+00

At approximately this location, both the 48 inch RCP outlet from Basin F and the open channel conveying stormwater runoff from the east discharge into Basin A. Outlet protection may be required to ensure the stability of the Basin A embankment.

#### Station 1342+00 to Station 1387+00

An open concrete channel will intercept offsite stormwater runoff from Drainage Areas P8A, P8 and P9A. The channel alignment will have to accommodate the proposed frontage road. Reduction of the required 30 foot channel buffer or the use of closed conduits may be required in areas of limited right-of-way availability. Culverts will be required to convey channel flows under Seventh Avenue and under the frontage road at approximately Stations 1374+00.

Detention Basin F will be located in the northeast quadrant of Seventh Avenue and the highway. The basin will be 20 feet deep. Flows up to 523 cfs will be diverted into this basin from the collector channel. Flows in excess of 523 cfs will remain in the channel for conveyance to Detention Basin A. Basin F will gravity drain to Basin A via a 48 inch RCP.

At the final design, if it is determined that the Basin F storage volume can be provided in Basins A and B, Basin F should be eliminated.

#### Station 1387+00 to Station 1395+00 (Cave Creek Ridge Line)

A grader ditch will be provided to convey minor off-site flows from the Cave Creek ridge line westward to the channel located at Station 1387+00.

Sheet 17

Detention Basin D will be located along I-17 north of Rose Garden Lane to intercept runoff from D.A. 11C. The basin will be comprised of east and west component basins that will be connected by a 24 inch RCP. The basins will be eight feet deep. Basin D will be gravity drained by a 36 inch RCP located within the west right-of-way of I-17. At Station 1267+00, the 36 inch RCP will discharge into the 8' x 5' RCBC conveying Detention Basin B outflows westward under I-17.

Table 5  
Channel Summary

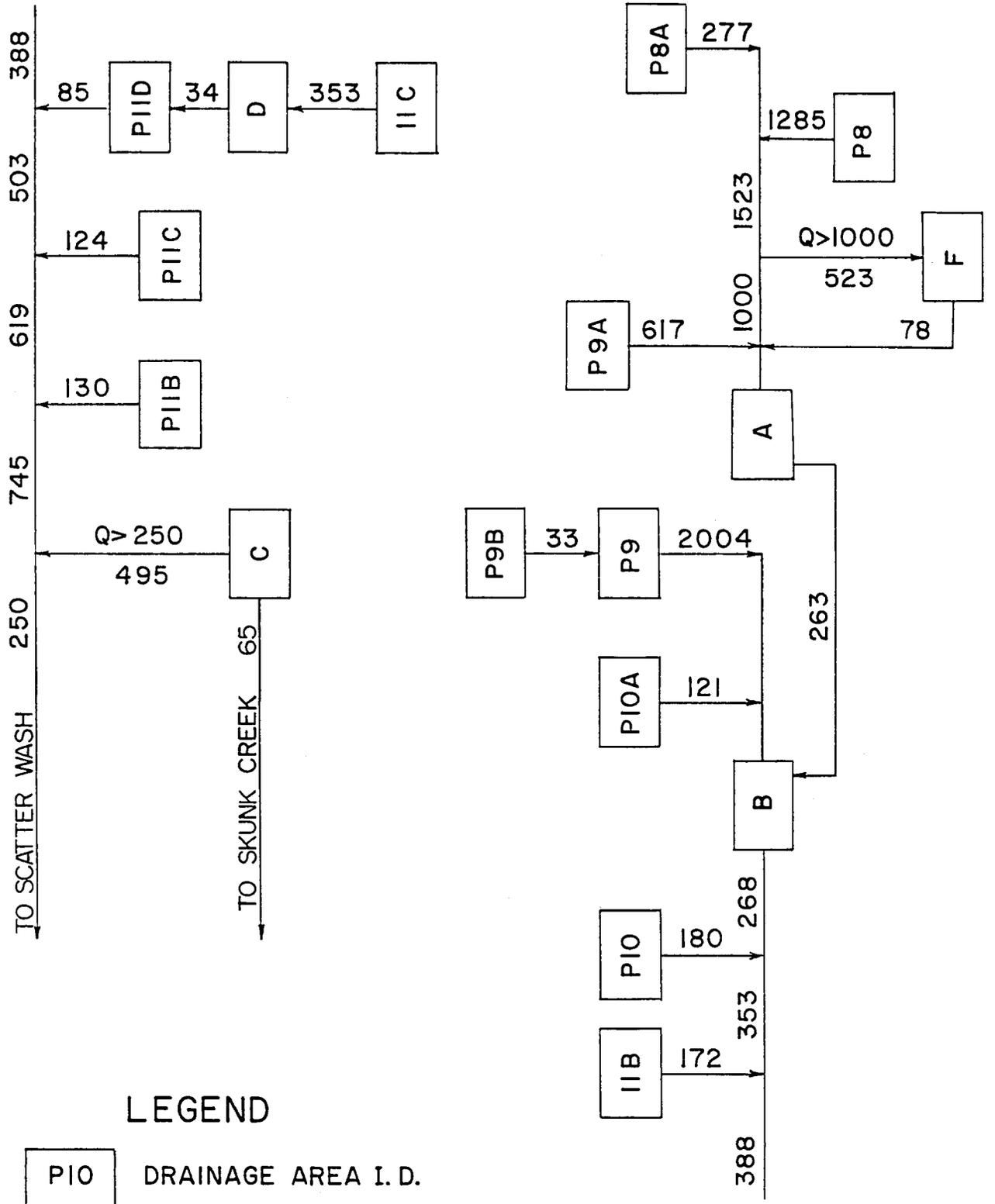
<u>Location (Station to Station)</u>	<u>Structure Type</u>	<u>Design Discharge (20% Freeboard Included)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Channel Bottom Width (ft.)</u>	<u>Velocity (fps)</u>	<u>Depth of Flow (ft.)</u>
1174-1186	Channel	144 cfs	0.0004	3.5/22	8	2.7	3.2
1187-1210	Channel	300 cfs	0.004	3/20	8	7.9	2.8
1210-1232	Channel	894 cfs	0.0027	5.5/30	8	9.1	5.3
1232-1252	Channel	743 cfs	0.0015	6/32	8	7.0	5.6
1252-1257	Channel	604 cfs	0.0015	5/28	8	6.6	5.0
1310-1332	Channel	2406 cfs	0.003	6/46	22	11.8	6.0
1342-1362	Channel	1925 cfs	0.0033	6/39	15	11.8	6.0
1367-1380	Channel	1828 cfs	0.0033	6/39	15	11.6	5.9
1380-1387	Channel	322 cfs	0.0047	3/20	8	8.5	2.8

**TABLE 6  
DETENTION BASIN SUMMARY**

<u>Basin</u>	<u>Location</u>	<u>Depth (FT)</u>	<u>Basin Volume (AF)</u>	<u>100-year Pear Storage (AF)</u>
A	15th Avenue	25	139	131
B	19th Avenue	25	291	287
C	35th Avenue	20	97	97
D	Rose Garden	8	25	18.3
E	I-17 & OLH	4	11	7.8
F	Seventh Avenue	20	16	16

**TABLE 7  
CULVERT SUMMARY**

<u>Station</u>	<u>Location</u>	<u>100-Year Design Discharge</u>	<u>Length</u>	<u>Structure Type</u>
1205	35th Avenue	250 cfs	140 LF	1-10'x3' RCBC
1231+50	31st Avenue	619 cfs	70 LF	2-10'x5' RCBC
1311	19th Avenue	2005 cfs	180 LF	5-10'x5' RCBC
1363	Seventh Avenue	1000 cfs	140 LF	3-10'X5' RCBC
1374	Frontage Road	1523 cfs	70 LF	5-10'X5' RCBC
1155-1206	Basin C Outlet	65 cfs	5050 LF	42" RCP
1267 Lt	Basin D Outlet	34 cfs	2400 LF	35" RCP
1265 Rt	Basin E Outlet	31 cfs	450 LF	24" RCP
1267-1299	Basin B Outlet	388 cfs	4400 LF	8'X5' RCBC
1310-1337	Basin A Outlet	263 cfs	2900 LF	78" RCP
1342-1364	Basin F Outlet	78 cfs	2300 LF	48" RCP



LEGEND

- PIO DRAINAGE AREA I. D.
- A DETENTION BASIN

234 DISCHARGE IN CFS

SCHMATIC OF  
SELECTED PLAN HYDROLOGY

**Greiner**

OUTER LOOP HIGHWAY  
100-YR 24-HR  
RUNOFF SUMMARY  
FLOW IN CUBIC FEET PER SECOND  
TIME IN HOURS, AREA IN SQUARE MILES

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

OPERATION	Basin	Basin Area	Curve Number	LAG TIME	PEAK FLOW	TIME OF PEAK	VOLUME (AC-FT)
Hydrograph At	P8A	0.23	80	0.34	277	12.50	25
Routed To	P8	-----	--	----	267	12.50	25
Hydrograph At	P8	1.30	83	0.58	1285	12.67	158
2 Combined At	P8	1.53	--	----	1526	12.67	183
Divert To	Basin F	-----	--	----	523	12.67	20
Routed To	P9A	-----	--	----	1000	12.50	163
Basin Routing	Det Basin F	-----	--	----	78	13.00	20
Hydrograph At	P9A	0.46	85	0.40	617	12.50	60
2 Combined At	Det Basin A	1.99	--	----	1604	12.67	244
Basin Routing	Det Basin A	-----	--	----	263	14.50	244
Routed To	Det Basin B	-----	--	----	263	14.50	244
Hydrograph At	P9B	0.39	83	0.59	382	12.67	48
Routed To	P9	-----	--	----	33	16.67	47
Hydrograph At	P9	2.26	82	0.63	2004	12.83	264
2 Combined At	P9	2.65	--	----	2005	12.83	312
Hydrograph At	P10A	0.18	84	1.07	121	13.17	23
3 Combined At	Det Basin B	4.82	--	----	2298	12.83	578
Basin Routing	Det Basin B	-----	--	----	268	20.83	578
Hydrograph At	Q10	0.20	87	0.83	180	13.00	28
2 Combined At	P10	5.02	--	----	353	13.17	606
Hydrograph At	Q11B	0.11	80	0.46	172	12.33	14
2 Combined At	11B	5.13	--	----	388	13.00	620
Routed To	P11D	5.13	--	----	388	13.00	620
Hydrograph At	DA11C	0.21	86	0.27	353	12.33	28
Basin Routing	Det Basin D	-----	--	----	34	13.33	28
Routed To	P11D	-----	--	----	34	13.50	28
Hydrograph At	P11D	0.13	82	1.01	85	13.17	15
3 Combined At	P11D	5.47	--	----	503	13.00	663
Routed To	P11C	-----	--	----	501	13.12	663
Hydrograph At	P11C	0.22	83	1.27	124	13.50	27
2 Combined At	P11C	5.67	--	----	619	13.50	690
Routed To	P11B	-----	--	----	614	13.50	690
Hydrograph At	P11B	0.18	90	1.27	130	13.33	28
2 Combined At	P11B	5.85	--	----	745	13.33	718
Divert To	Det Basin C	-----	--	----	495	12.50	
Routed To	Scatter Wash	-----	--	----	250	12.67	
Hydrograph At	DA12	0.17	82	0.91	120	13.00	20
Hydrograph At	D11L	1.33	86	0.64	1609	12.67	193
Routed To	11G	-----	--	----	88	17.83	158
Hydrograph At	DA11K	0.53	85	0.31	812	12.33	74
Routed To	11G	-----	--	----	38	16.83	66
Hydrograph At	DA11J	1.18	87	0.44	1648	12.50	177
Routed To	11G	-----	--	----	87	16.83	157
Hydrograph At	DA11G	3.05	80	0.77	2169	12.83	330
4 Combined At	11G	6.09	--	----	2203	13.00	711
Routed To	11F	-----	--	----	2139	13.17	709
Hydrograph At	DA11I	0.93	85	0.53	1104	12.67	131
Routed To	11F	-----	--	----	60	17.67	108
Hydrograph At	DA11F	1.57	80	0.68	1247	12.83	170
3 Combined At	11F	8.59	--	----	3281	13.00	987
Hydrograph At	DA11H	0.38	85	0.37	556	12.50	53
Routed To	11E	-----	--	----	34	18.33	50
Hydrograph At	DA11E	1.02	81	0.68	847	12.83	115
3 Combined At	11E	9.99	--	----	4056	13.00	1152
Routed To	Scatter Wash	-----	--	----	3967	13.17	1150
Hydrograph At	DA11D	0.45	86	0.31	683	12.33	61
Routed To	Scatter Wash	-----	--	----	573	12.67	61
Combine	At Scatter Wash	10.44	--	----	4295	13.00	1211
Hydrographs	Wash						
Hydrograph At	DA11A	1.80	88	0.62	2035	12.67	257
2 Combined At	Scatter Wash	12.24	--	----	5593	13.00	1468
Basin Routing	Det Basin C	-----	--	----	65	20.00	79
3 Combined At	Scatter Wash	18.11	--	----	5843	13.00	2277

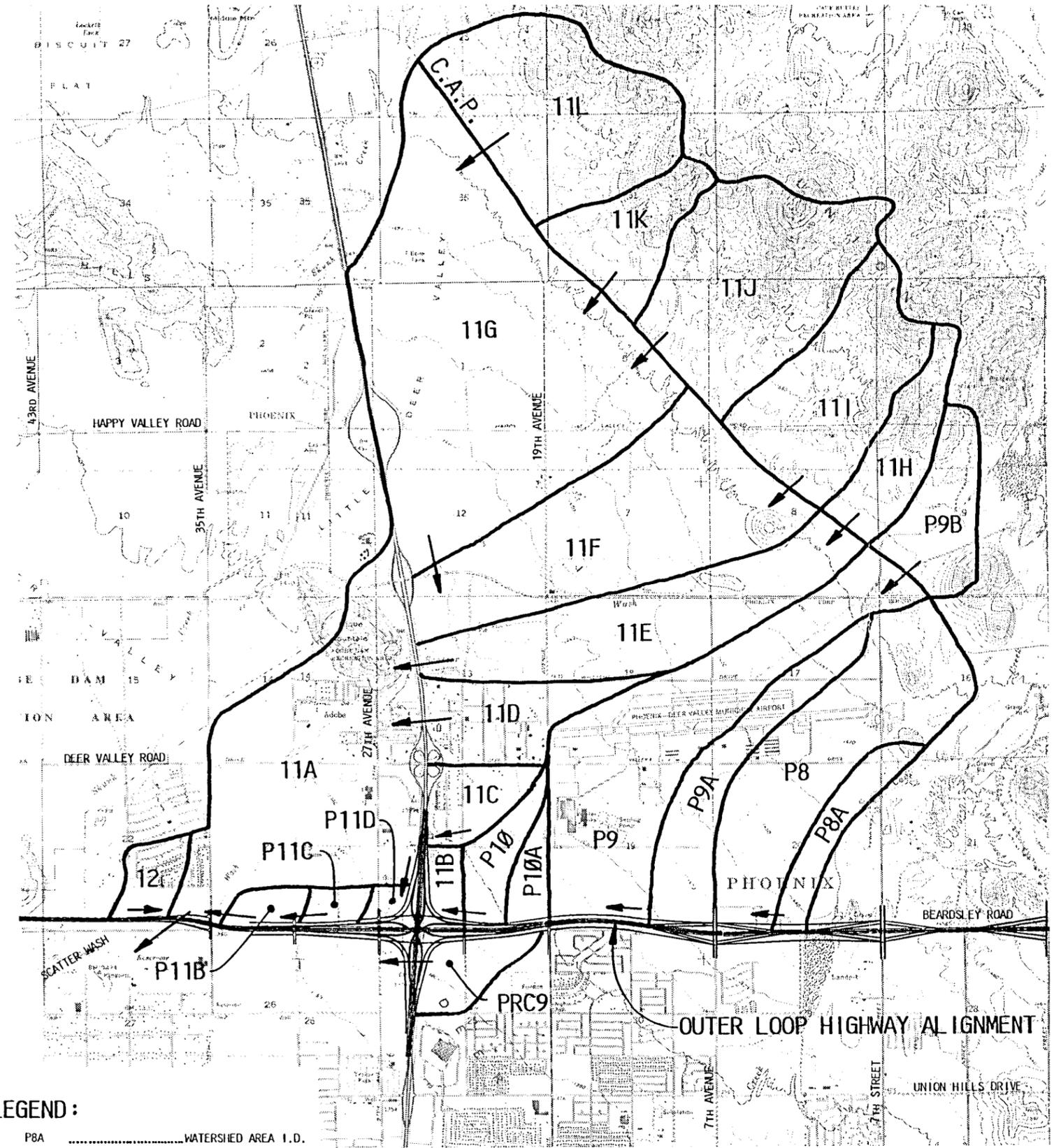
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 P8A ..... WATERSHED AREA I.D.  
 - - - - - WATERSHED BOUNDARY  
 ← - - - - - DIRECTION OF FLOW

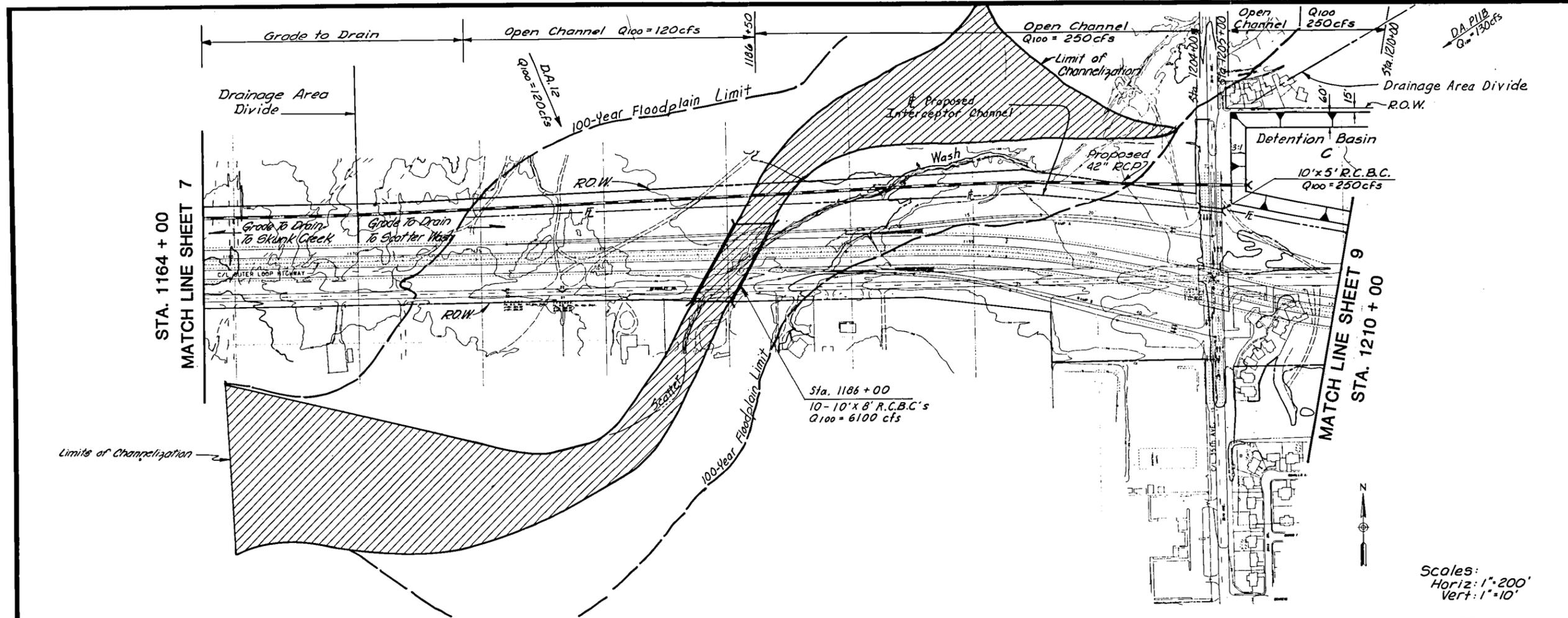


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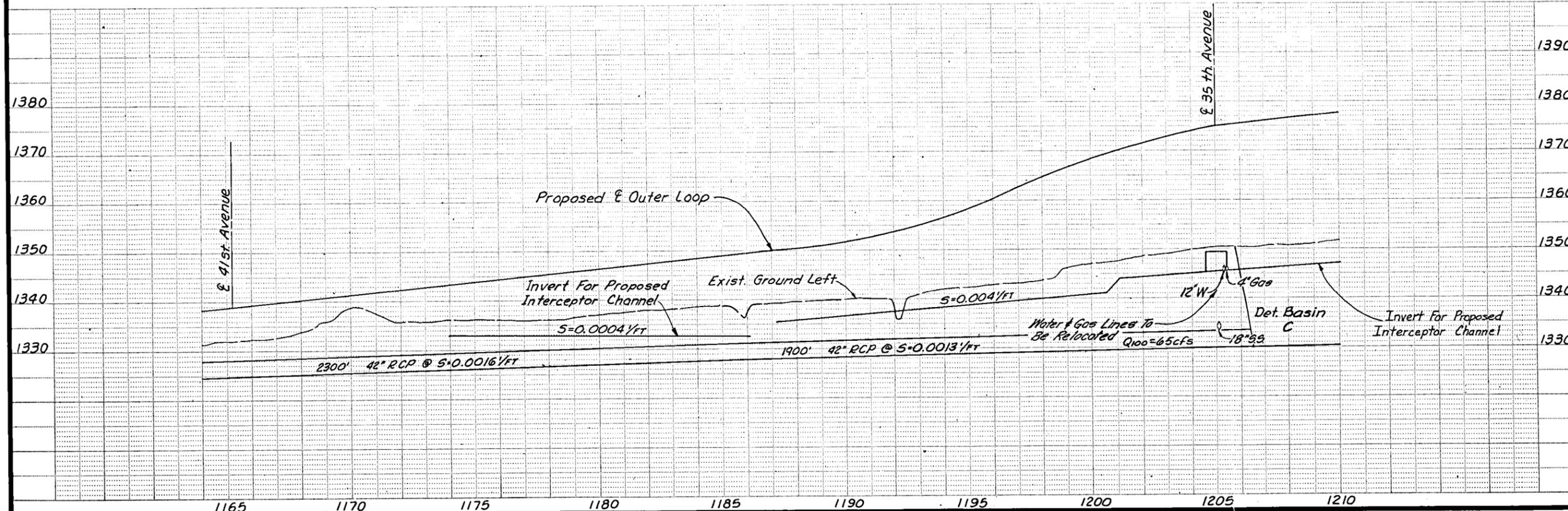
DESIGN	ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAY DIVISION OUTER LOOP HIGHWAY BELL ROAD TO C.A.P. CANAL
DRAWN	
CHECKED	
APPROVED	
<b>HYDROLOGIC SUMMARY</b>	
(RECOMMENDED)	
<b>PLATE 7</b>	

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 Phoenix, Arizona 85020  
 (602) 275-5400





Scales:  
 Horiz: 1" = 200'  
 Vert: 1" = 10'



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 2560 North American Way/Facets, Adelaide 527.1502/527.5413

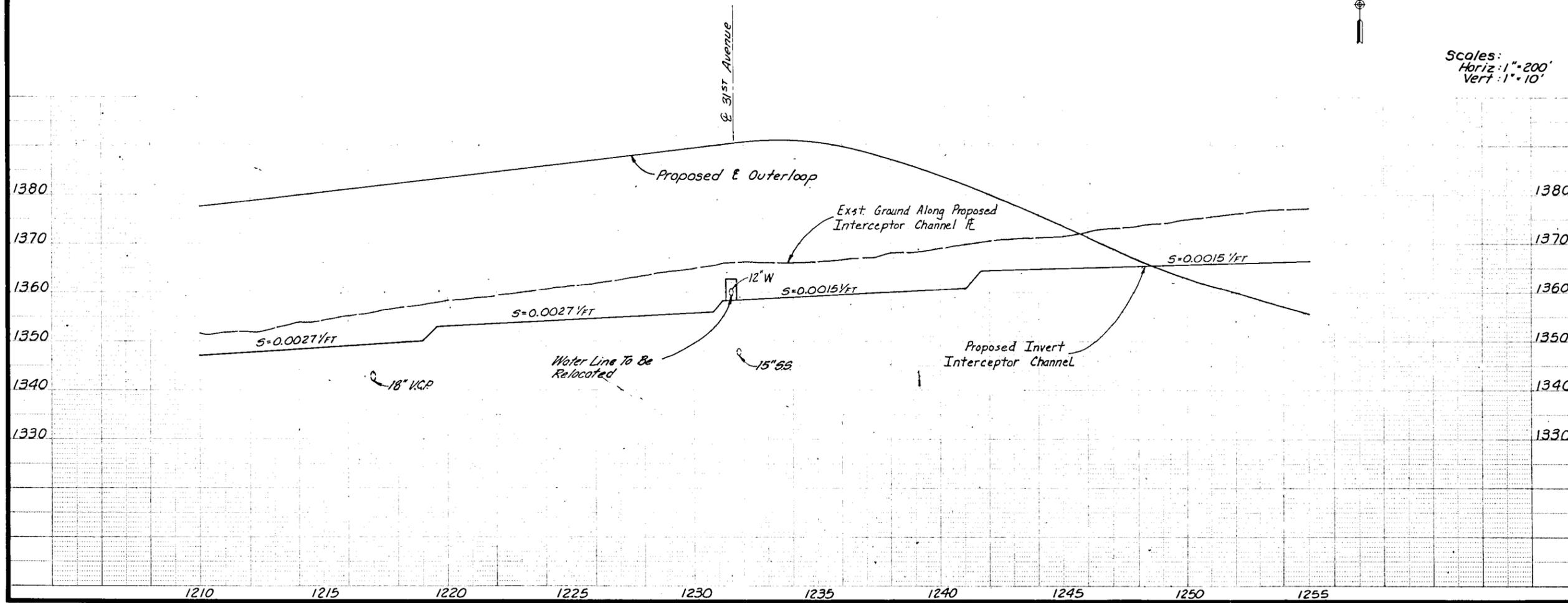
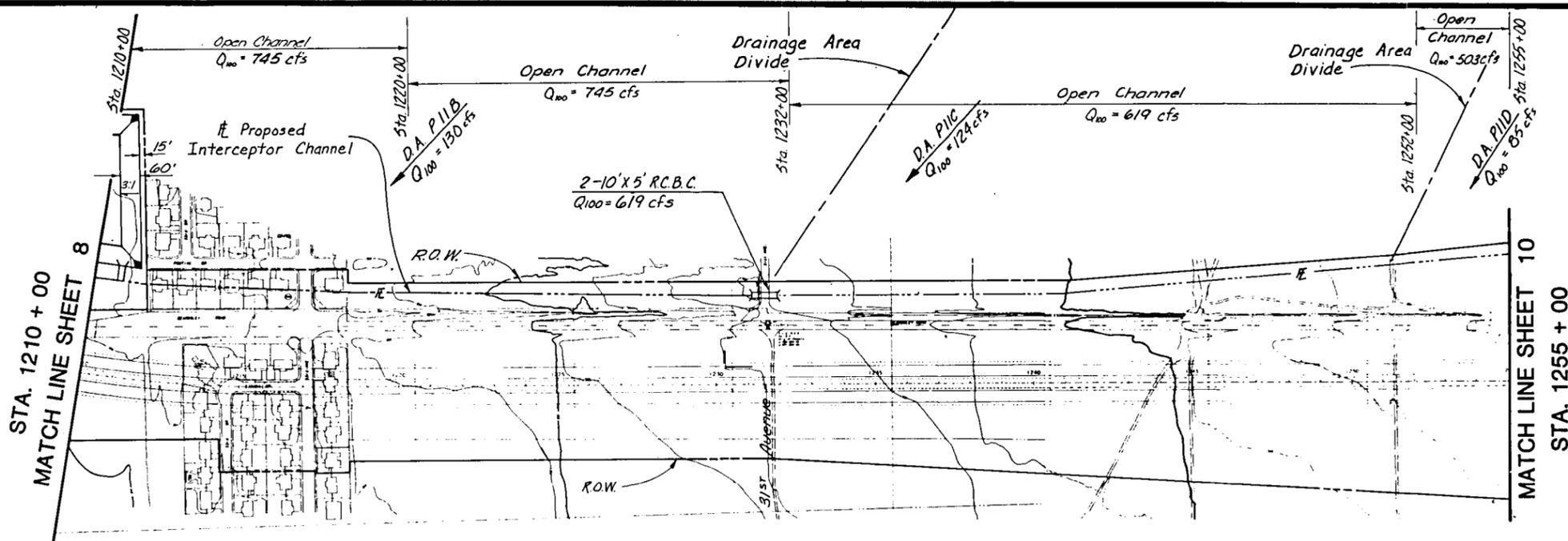
**OUTER LOOP HIGHWAY**  
**BELL ROAD TO C.A.P. CANAL**  
**PRELIMINARY DRAINAGE PLANS**

Design: [Signature]  
 Drawn: TYB/LAS  
 Check: MSS

Scale:  
 HORIZ. 1" = 200'  
 VERT. 1" = 10'

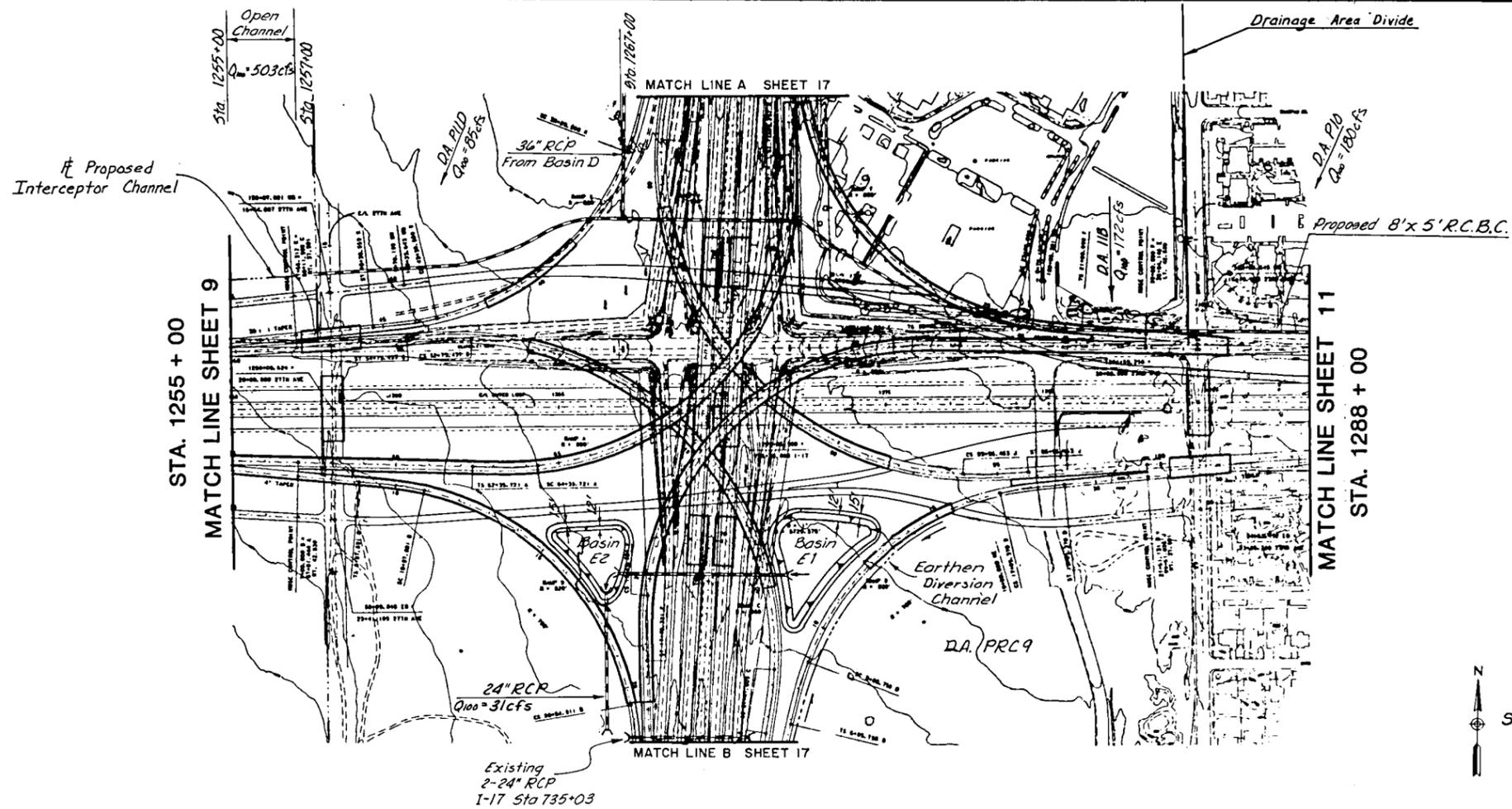
Date: OCTOBER 1987  
 Job No: E112013

Sheet 8 of 8

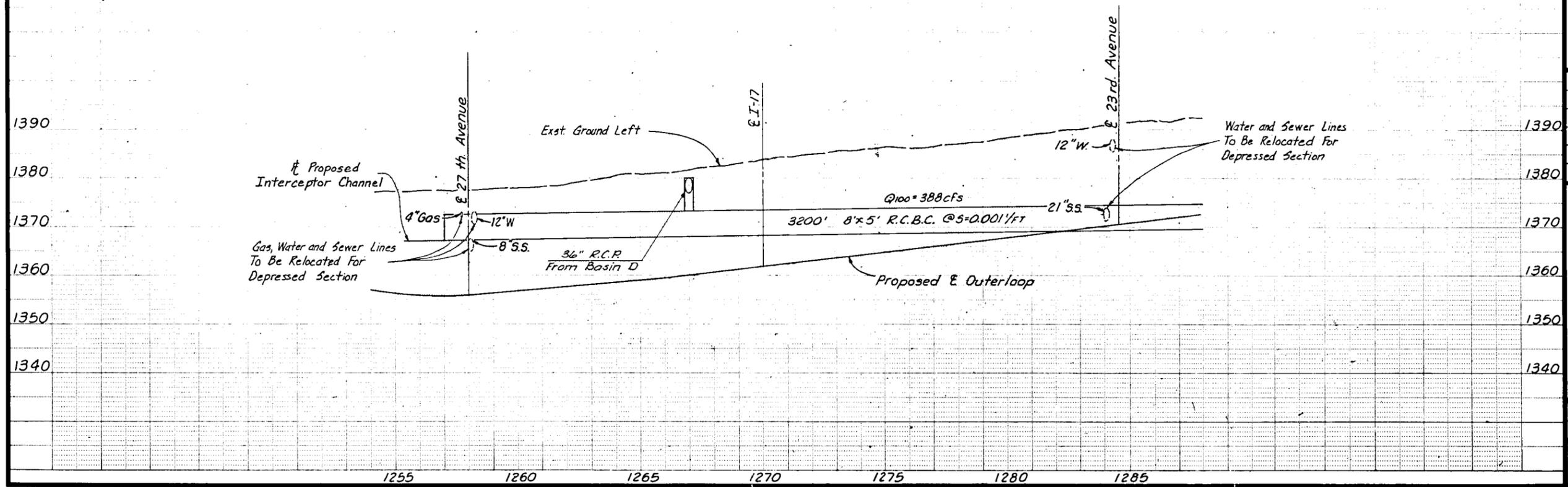


Scales:  
 Horiz: 1"=200'  
 Vert: 1"=10'

<p style="text-align: center;"><b>Greiner Engineering</b>  <small>A Greiner Engineering, Inc. Company</small>        Greiner Engineering, Inc.        7200 E. 10th Street, Suite 100 Phoenix, Arizona 85020-2022 275-6400        2500 North Averson Way/Tucson, Arizona 85712-2002 387-3413</p>	
Design	<i>DM</i>
Drawn	<i>TYB/LAS</i>
Check	<i>MS</i>
Scale	HORIZ. 1"=200' VERT. 1"=10'
<b>OUTER LOOP HIGHWAY</b> <b>BELL ROAD TO C.A.P. CANAL</b> <b>PRELIMINARY DRAINAGE PLANS</b>	
Date	OCTOBER 1987
Job No.	E112013
Sheet	9



Scales:  
 Horiz: 1" = 200'  
 Vert: 1" = 10'



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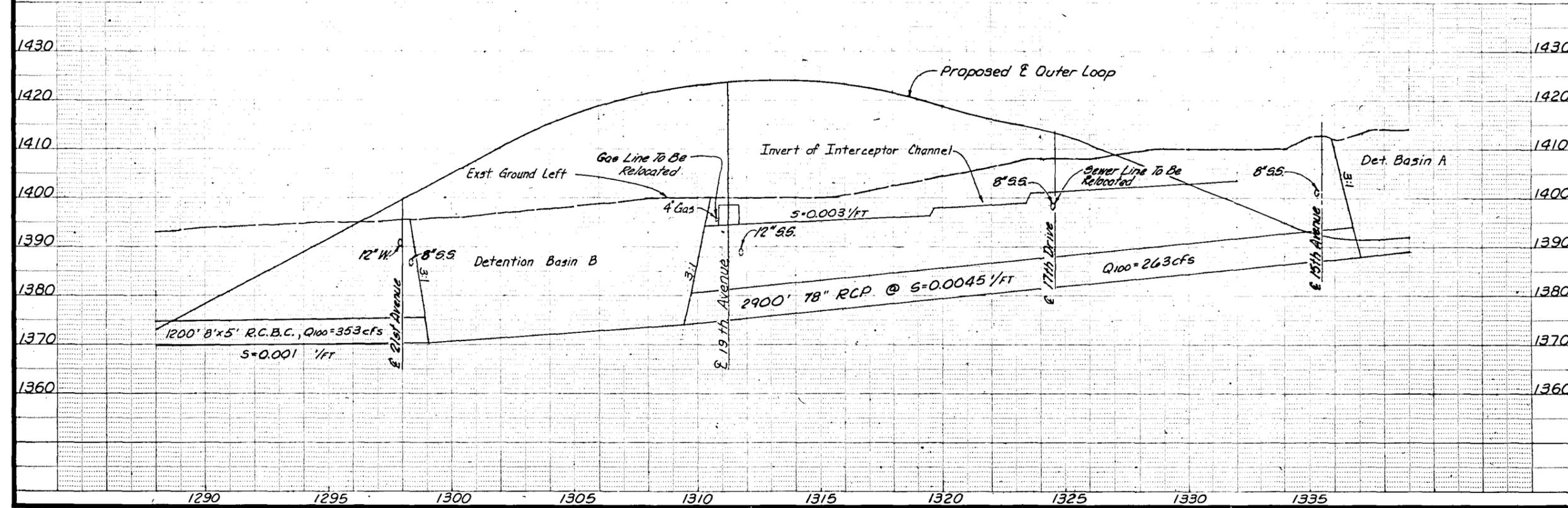
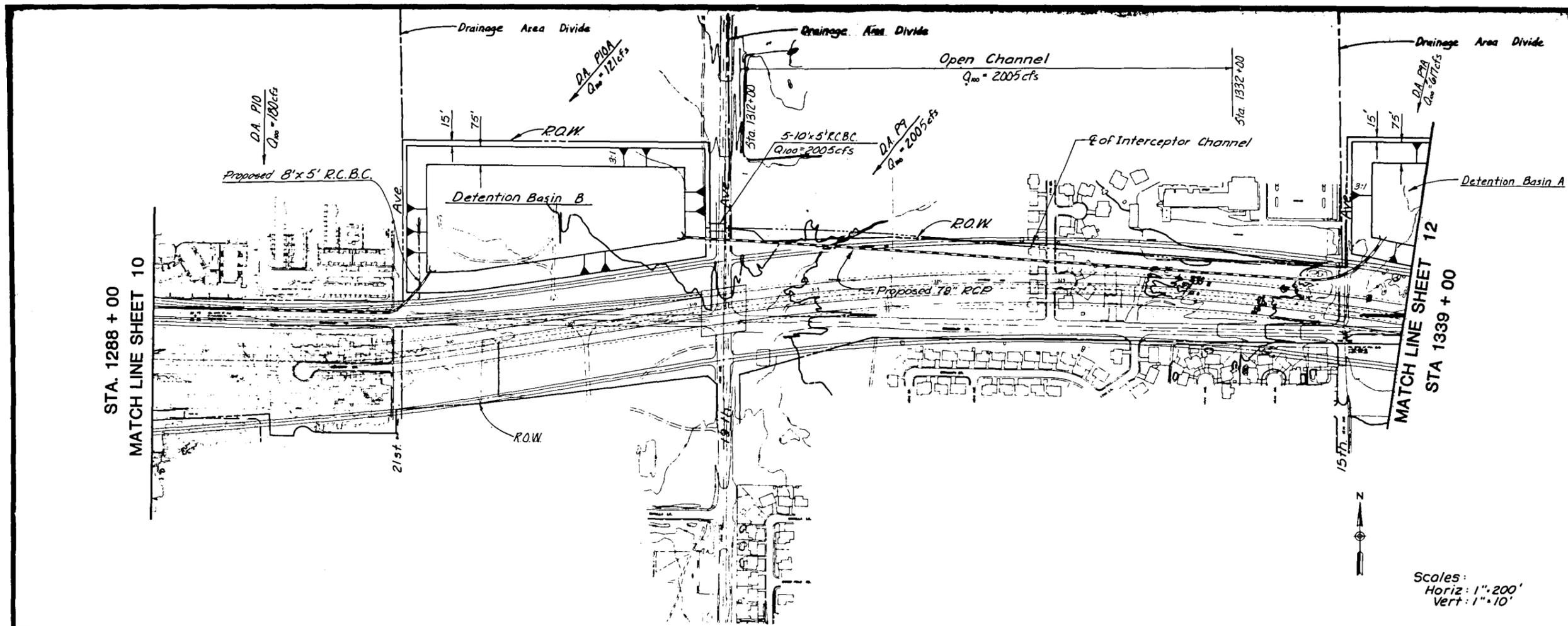
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Scale:  
 HORIZ. 1" = 200'  
 VERT 1" = 10'

**OUTER LOOP HIGHWAY**  
**BELL ROAD TO C.A.P. CANAL**  
**PRELIMINARY DRAINAGE PLANS**

Date: OCTOBER 1987  
 Job No: E112013

Sheet 10



Scales:  
 Horiz: 1"=200'  
 Vert: 1"=10'

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 2200 North American Way, Tucson, Arizona 85712-0023-267-6113

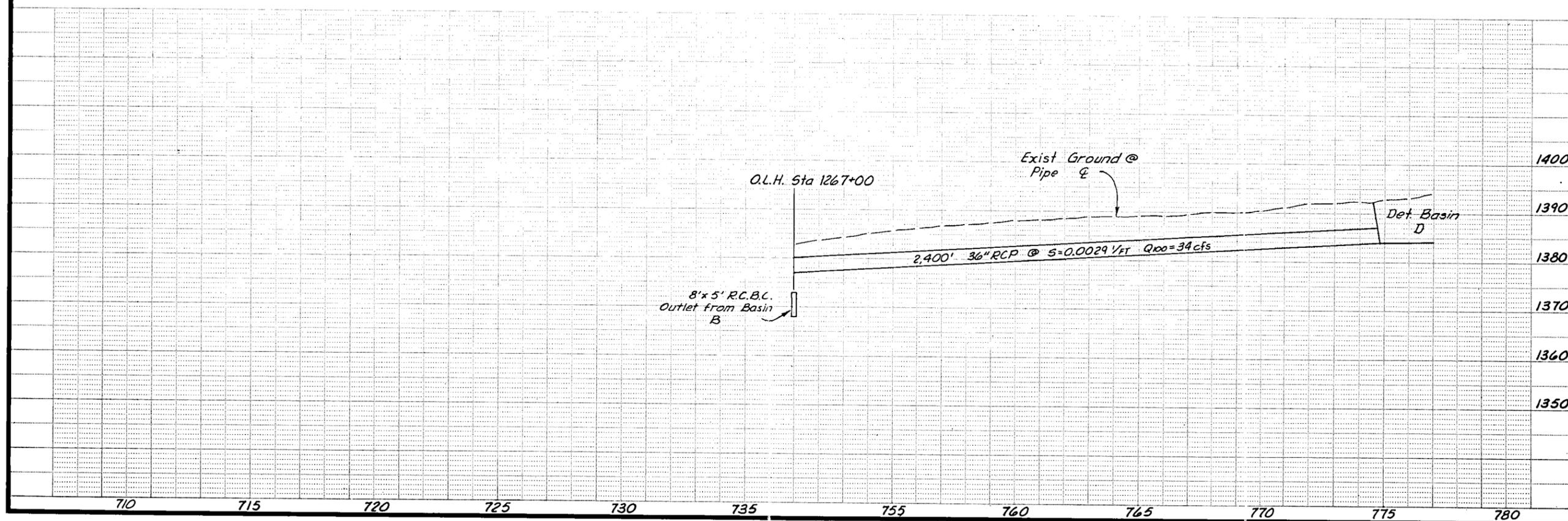
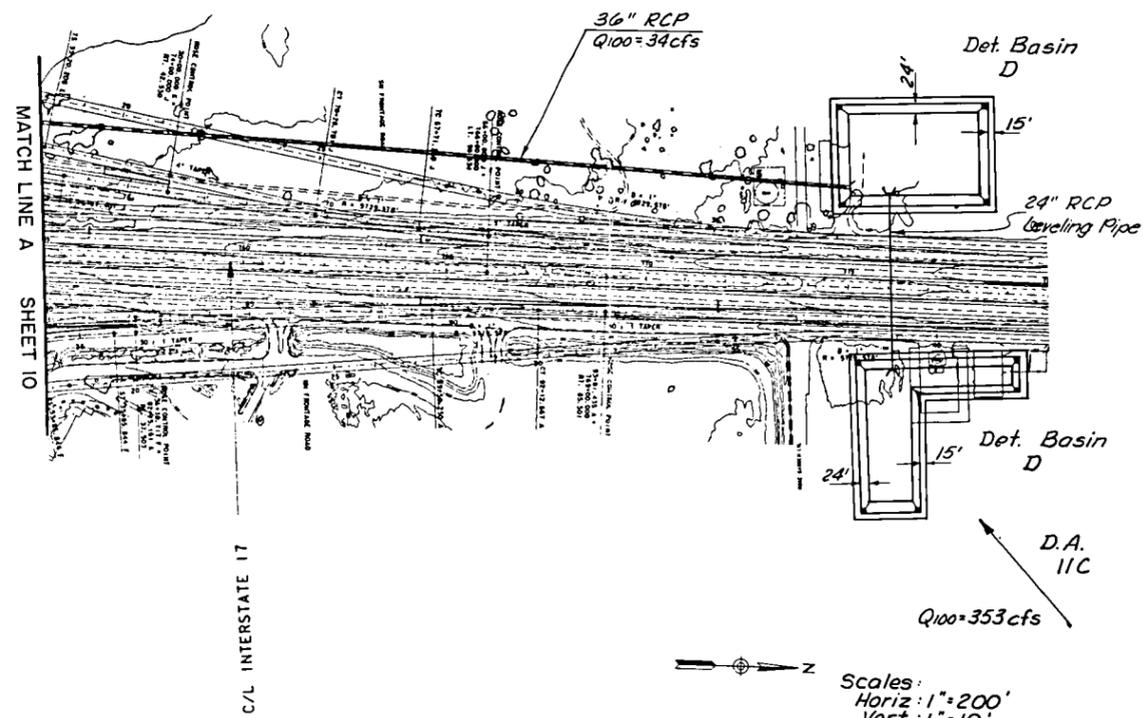
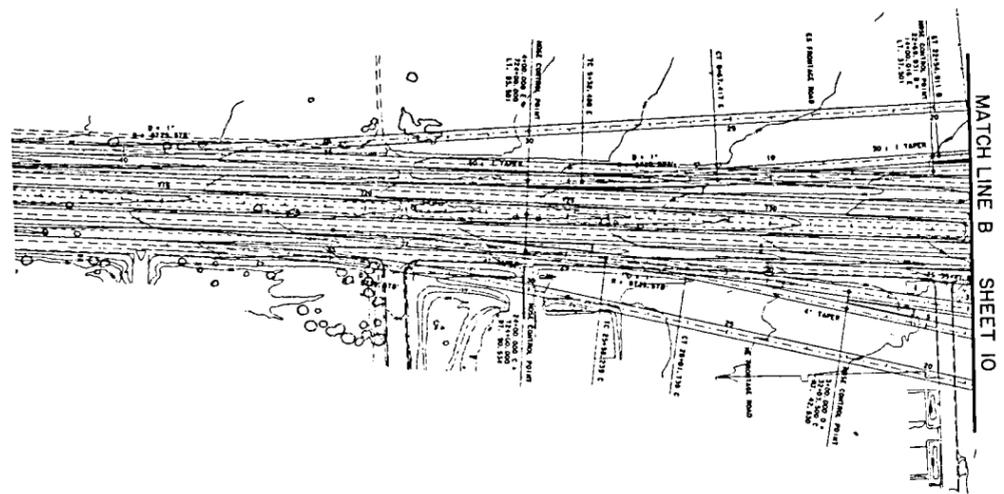
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 VERT. 1"=10'

**OUTER LOOP HIGHWAY**  
**BELL ROAD TO C.A.P. CANAL**  
**PRELIMINARY DRAINAGE PLANS**

Date: OCTOBER 1987  
 Job No: E112013

Sheet: 11





Revisions

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Design: M.C.  
 Drawn: AS  
 Check: M.S.S.

Scale: HORIZ. 1"=200'  
 VERT 1"=10'

**OUTER LOOP HIGHWAY**  
**BELL ROAD TO C.A.P. CANAL**  
**PRELIMINARY DRAINAGE PLANS**

Date: OCTOBER 1987  
 Job No. E 1120 13

Sheet of  
**17**

## X. ADDITIONAL RIGHT-OF-WAY REQUIREMENTS

Additional right-of-way requirements are identified in areas where the existing or proposed right-of-way, as provided to Greiner Engineering by the PMC, are insufficient to accommodate the recommended drainage facilities. At a number of locations, the need for additional right-of-way is directly dependent on the highway's vertical horizontal geometry, use of retaining walls, piers and embankment fill for elevation. For these locations, the design assumptions made by Greiner are identified. Minimum right-of-way requirements for open channels were defined by the PMC as the required channel top width, plus an additional 30 feet for buffer. Locations and descriptions of additional rights of way required are as follows.

### Station 1312+00 to Station 1332+00

The total top width requirement for the open channel is approximately 80 feet. Depending on the final alignment for the frontage road, additional right-of-way may be required.

### Station 1342+00 to Station 1380+00

The total top width requirement for the open channel is approximately 70 feet. Depending on the final alignment for the frontage road, additional right-of-way may be required.

## XI. CONCLUSIONS

An optimum drainage concept plan has been developed that will provide floodwater protection to the Outer Loop Highway between Scatter Wash and Cave Creek. The plan ensures that there will be no adverse affects on adjacent areas and that downstream drainage receiving facilities or natural watercourses have adequate capacity to handle off-site stormwater flows from the Outer Loop Highway.

The costs to construct the Outer Loop Highway drainage facilities for off-site runoff were evaluated. Total estimated costs for the recommended plan, not including right-of-way acquisition, is 13.8 million dollars.

Channel locations where additional right-of-way may be required were identified. The actual amount of right-of-way needed is dependent on the location of adjacent frontage roads and either the reduction of the 30 foot buffer requirement or the use of underground conduit as alternatives to open channels.

## XII. REFERENCES

1. U.S. Department of Agriculture, Soil Conservation Service General Soil Map, Maricopa County, Arizona, 1973.
2. Arizona Bureau of Mines, University of Arizona, Geological Map of Maricopa County, 1957.
3. National Oceanic and Atmospheric Administration, Atlas 2, Volume VIII - Arizona, Precipitation Frequency Atlas of the Western United States, Washington, D.C., 1973.
4. U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, T.R. No. 55, 1975.
5. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1972.
6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1, Flood Hydrograph Package Users Manual, September 1981, Revised 1983.
7. Brater and King, Handbook of Hydraulics, Sixth Edition, 1976.
8. U.S. Army Corps of Engineers, Adobe Dam Design Memorandum No. 3, Phase II, Part 2.
9. U.S. Army Corps of Engineers, Cave Buttes Dam Design Memorandum No. 3, Phase II, Part 1.
10. U.S. Army Corps of Engineers, Gila River Basin, Phoenix, Arizona and Vicinity (Including New River) Design Memorandum No. 2, Hydrology Part 2.

11. Bureau of Reclamation, Central Arizona Project, GRA, Reach 10 Hydrology (unpublished calculations).
12. Topographic and Highway Geometric and Layout Plans for the Outer Loop Highway; DeLeuw, Cather and Company.
13. Utility Maps from Mountain Bell, City of Glendale, Southwest Gas, Arizona Public Service and Dimension Cable.
14. Flood Plain Delineation Maps for New River, Skunk Creek, Scatter Wash and Cave Creek U.S.C.O.E./ F.E.M.A.
15. Outer Loop Highway Project, SR-417, Drainage Guidelines, Section 6, 35th Avenue to 19th Avenue, Memorandum of February 18, 1987, DeLeuw, Cather & Company.
16. Ibid; Revised May 27, 1987.
17. I-17 Drainage Design Study, A.D.O.T. Project No. IR-17-1(151), PRC Engineering, Initial Design Report, August 1986.
18. Concept Study for Outer Loop Highway Crossing Scatter Wash (Station 1192), Memorandum of May 1987; DeLeuw, Cather & Company.