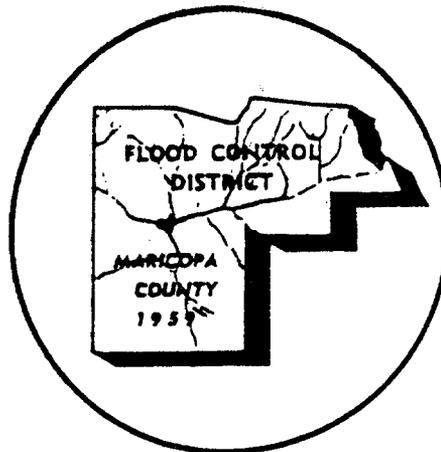


**BELL ROAD PROJECT DRAINAGE STUDY**  
**Volume IV**  
**SELECTED STORMWATER / FLOODWATER**  
**MANAGEMENT PLANS**

**FOR**

**MARICOPA COUNTY FLOOD CONTROL DISTRICT**



**PREPARED BY**

**GREINER ENGINEERING SCIENCES, INC.**

**PHOENIX, ARIZONA**

**October, 1987**

**CONTRACT FCD 86-20**

**PROJECT No. E123061**

**Greiner**

Property of  
Flood Control District of MC Library  
Return to  
W. Durango  
Phoenix, AZ 85009

BELL ROAD PROJECT DRAINAGE STUDY  
VOLUME IV  
SELECTED STORMWATER/FLOODWATER MANAGEMENT  
PLAN

Prepared For:

MARICOPA COUNTY FLOOD CONTROL DISTRICT  
3335 West Durango  
Phoenix, AZ 85009

Prepared By:

GREINER ENGINEERING SCIENCES, INC.  
7310 North 16th Street, Suite 160  
Phoenix, AZ 85020  
(602) 275-5400

October 1987

Contract FCD 86-20  
Project No. E-123-061



TABLE OF CONTENTS

	<u>Page</u>
I. List of Plates.....	iii
II. List of Tables.....	iv
III. List of Exhibits.....	vi
IV. Introduction.....	1
V. Objectives.....	5
VI. Procedures and Methodology.....	7
A. Plan Development.....	7
B. Hydrologic and Hydraulic Procedures.....	8
VII. Design Criteria.....	11
VIII. Selected Stormwater/Floodwater Management Plan.....	12
IX. Preliminary Concept Drainage Plans.....	56
X. Capital Costs.....	76
XI. Right-of-Way and Easement Requirements.....	116
XII. Analysis of Impacts on Major Drainage Facilities South of Bell Road.....	118
XIII. Conclusions and Recommendations.....	121
XIV. References.....	131
XV. Appendix A -- Drainage Design Criteria	



I. LIST OF PLATES

	<u>Page</u>
1. Selected Plan Drainage Area 1 and 2.....	18
2. Selected Plan Drainage Area 2.....	24
3. Selected Plan Drainage Area 3.....	28
4. Selected Plan Drainage Area 4 (Sheet 1 of 2).....	33
5. Selected Plan Drainage Area 4 (Sheet 2 of 2).....	34
6. Selected Plan Drainage Area 5 (Sheet 1 of 2).....	38
7. Selected Plan Drainage Area 5 (Sheet 2 of 2).....	39
8. Selected Plan Drainage Area 6 and 7.....	43
9. Selected Plan Drainage Area 7.....	47
10. Selected Plan Drainage Area 8 (Sheet 1 of 2).....	52
11. Selected Plan Drainage Area 8 (Sheet 2 of 2).....	53

II. LIST OF TABLES

	<u>Page</u>
1. Structure Summary - Drainage Area 1.....	17
2. Structure Summary - Drainage Area 2.....	23
3. Structure Summary - Drainage Area 3.....	27
4. Structure Summary - Drainage Area 4.....	31
5. Structure Summary - Drainage Area 5.....	37
6. Structure Summary - Drainage Area 6.....	42
7. Structure Summary - Drainage Area 7.....	46
8. Structure Summary - Drainage Area 8.....	50
9. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 1.....	78
10. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 2.....	80
11. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 3.....	85
12. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 4.....	87
13. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 5.....	91
14. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 6.....	93
15. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 7.....	96
16. Estimated Costs for Facilities North of and Along Bell Road -- Drainage Area 8.....	100
17. Estimated Costs for Facilities South of Bell Road -- Drainage Area 2.....	102
18. Estimated Costs for Facilities South of Bell Road -- Drainage Area 3.....	103
19. Estimated Costs for Facilities South of Bell Road -- Drainage Area 4.....	104
20. Estimated Costs for Facilities South of Bell Road -- Drainage Area 5.....	106

II. LIST OF TABLES (Continued)

	<u>Page</u>
21. Estimated Costs for Facilities South of Bell Road -- Drainage Area 6.....	107
22. Estimated Costs for Facilities South of Bell Road -- Drainage Area 7.....	109
23. Estimated Costs for Facilities South of Bell Road -- Drainage Area 8.....	110
24. Summary of Estimated Costs.....	111
25. Drainage Concentration Points Meeting Downstream Impact Analysis Criteria.....	119
26. Construction Schedule for Bell Road Expansion Project.....	120
27. Master Schedule for Bell Road Project Coordination.....	124
28. Construction Schedule for Drainage Facilities.....	128
29. Summary of Costs for the Drainage Facilities Along Bell Road.....	129

III. LIST OF EXHIBITS

	<u>Page</u>
1. Major Drainage Areas.....	4

#### IV. INTRODUCTION

The Flood Control District of Maricopa County retained Greiner Engineering Sciences, Inc. (GES) to prepare a stormwater/floodwater management plan for the expansion of Bell Road. The expanded Bell Road is conceived as a six lane urban arterial street extending twenty five miles from Grand Avenue to Scottsdale Road.

The Selected Stormwater/Floodwater Management Plan report is the fourth report prepared by GES for the Bell Road Project Drainage Study. The other reports are:

- Phase I, Evaluation, August 1986 (Volume I)
- Hydrologic Modeling, September 1986 (Volumes I and II)
- Alternate Stormwater/Floodwater Management Concept Plans, January 1987 (Volume III)

This report documents the procedures, methodology, objectives and criteria used to develop the selected stormwater/floodwater management plan for Bell Road and to develop preliminary plans for drainage facilities along Bell Road to be installed/constructed for the Bell Road expansion. The Bell Road drainage study is located between Grand Avenue and Scottsdale Road and has been divided into ten major off-site drainage areas. These areas are briefly described as follows:

Area 1: Bound by Bell Road on the south, Grand Avenue on the west, McMicken Dam Outlet Channel on the north and the west boundary of Sun City West on the east. This drainage area is approximately 0.3 square miles.

On-site limits are the Bell Road right-of-way from Grand Avenue to the west bank of the Agua Fria River.

Area 2: Bound by Bell Road on the south, the Agua Fria River to the west, the ridge on the mountain in Section 4, Township 4 North, Range 1 East on the north and the New River on the east. This drainage area is approximately 10.2 square miles.

On-site limits are the Bell Road right-of-way from the 115th Avenue alignment to the New River.

Area 3: Bound by Bell Road on the south, New River on the west, Skunk Creek on the east and Union Hills Drive on the north. This drainage area is approximately 1.5 square miles.

On-site limits are the Bell Road right-of-way from New River to Skunk Creek.

Area 4: Bound by Bell Road on the south, Skunk Creek on the west, Beardsley Road on the north and Interstate-17 on the east. This drainage area is approximately 8.0 square miles.

On-site limits are the Bell Road right-of-way from Skunk Creek to I-17.

Area 5: Bound by Bell Road on the south, Interstate-17 on the west, the ridge line of the Union Hills on the north and Cave Creek on the east. This drainage area is approximately 9.0 square miles.

On-site limits are the Bell Road right-of-way from I-17 to Cave Creek.

Area 6: Bound by Bell Road on the south, Cave Creek on the west, a ridge line just north of Beardsley Road on the north and East Fork of Cave Creek on the east. This drainage area is approximately 4.0 square miles.

On-site limits are the Bell Road right-of-way from Cave Creek to 20th Street.

Area 7: East Fork of Cave Creek watershed. This drainage area is approximately 4.8 square miles.

On-site limits are the Bell Road right-of-way from 20th Street to just east of 34th Way.

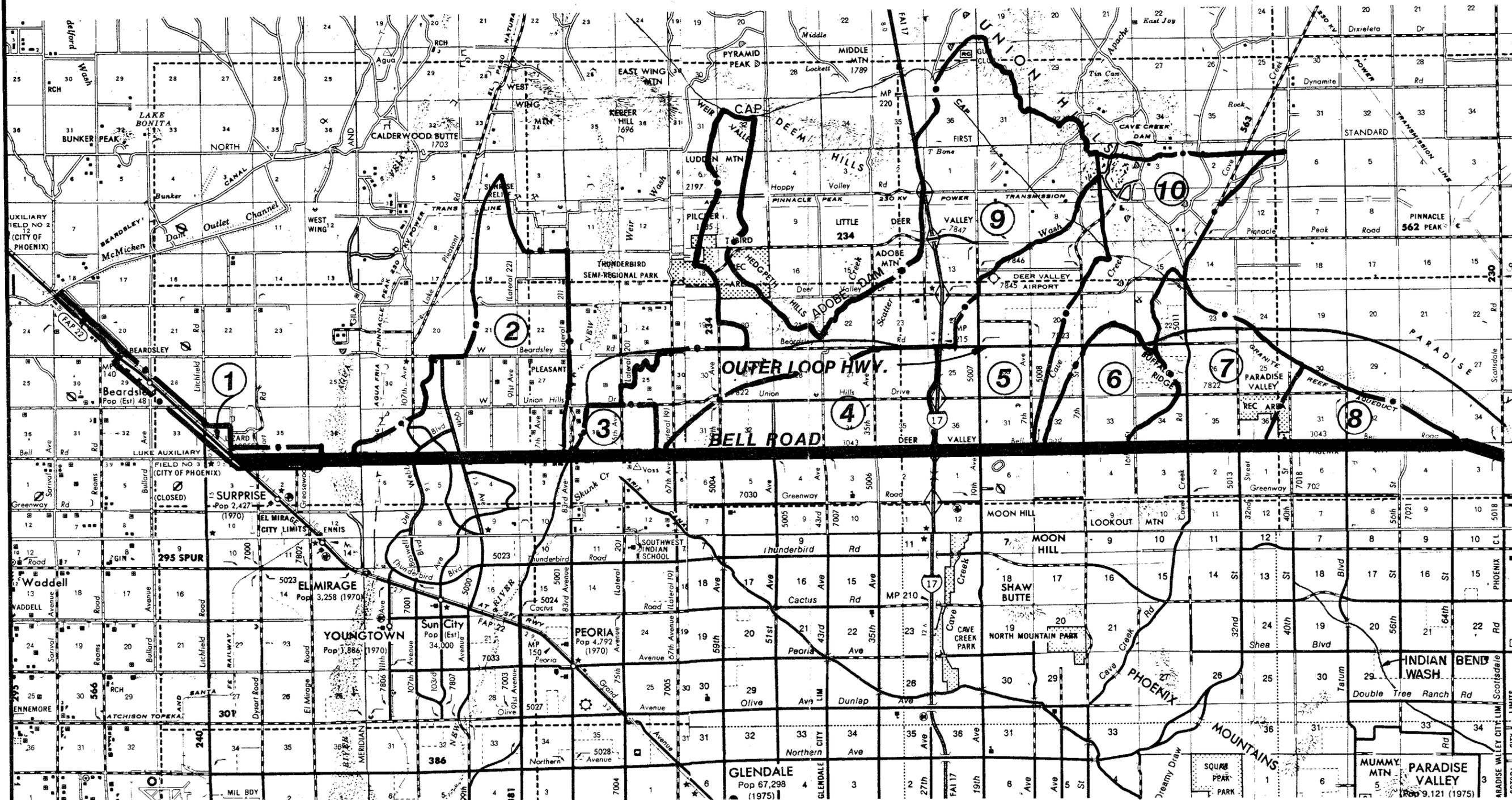
Area 8: Bound by Bell Road on the south, East Fork of Cave Creek drainage divide on the west and the Central Arizona Project on the north and east. This drainage area is approximately 7.3 square miles.

On-site limits are the Bell Road right-of-way from just west of 36th Street to Scottsdale Road.

Area 9: Skunk Creek watershed. This drainage area is approximately 7.3 square miles.

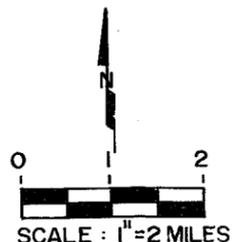
Area 10: Cave Creek watershed. This drainage area is approximately 6.9 square miles.

The limits of all drainage areas are shown on Exhibit 1.



**LEGEND**

-  MAJOR DRAINAGE AREA BOUNDARIES
-  MAJOR DRAINAGE AREA NUMBERS



Revisions

**Greiner Engineering**  
 Greiner Engineering Services, Inc.  
 2500 North American Way, Tucson, Arizona 85712 602-275-5400  
 2500 North American Way, Tucson, Arizona 85712 602-275-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: FC  
 Check: M.S.S.  
 Scale: 1" = 2 Mi.

**BELL ROAD PROJECT**  
**DRAINAGE STUDY**  
 MAJOR DRAINAGE AREAS

Date: JAN. 1987  
 Job No.: E 123061  
 Sheet: 1 of 1

## V. OBJECTIVES

The objective of the study is to develop a stormwater/floodwater management plan for the expansion of Bell Road from Grand Avenue to Scottsdale Road which includes a cost-effective method of handling on-site drainage and provides flooding protection for the roadway. In addition, the plan will ensure that downstream drainage facilities can handle discharged flows or that new facilities can be provided to an adequate outfall. Upstream properties will not be adversely impacted by the construction of the roadway or drainage facilities.

The objective of this report is to develop the selected stormwater/floodwater plan based on the review committee's comments and recommendations from the development of alternative concept plans. The system proposed for the drainage master plan will be developed to a preliminary plan level for facilities along Bell Road.

The preliminary plans will include sizes, slopes, profiles, alignments and locations as appropriate for channels, pipes, trunk mains, culverts and detention basins. Tables and/or exhibits will be developed that document all of the drainage systems proposed for the Bell Road master plan. These tables and/or exhibits will document each structure by number, type, size, slope, depth, volume and area required for channels, pipes, trunk mains, culverts and detention basins. Existing and required rights-of-way will be determined and preliminary quantities and costs for each element of the plan will be estimated. The impacts of the design storm on major drainage facilities downstream of Bell Road shall also be analyzed.

Design criteria shall be developed as standards and guidelines for the design and implementation of the drainage improvements proposed for Bell Road.

The goal of the selected plan is to allow for travel on the proposed Bell Road expansion during the post-development (future) condition design storm event, as selected by each jurisdiction, as well as ensure that downstream and upstream conditions will not be worsened in the 100-year event. At a minimum, four lanes of Bell Road must remain open during the selected design storm event.

## VI. PROCEDURES AND METHODOLOGY

The selected stormwater/floodwater management plan for Bell Road was developed from alternative concept plans previously submitted to the Flood Control District of Maricopa County (FCD) in January 1987, and through discussions with the Review Committee comprised of representatives from the Town of Surprise, City of Peoria, City of Glendale, City of Phoenix and Maricopa County Highway Department and Flood Control District. Alternative stormwater/floodwater management concept plans were developed for the 100-year and 10-year frequency storm events. Each alternative was evaluated in terms of capital costs, effectiveness, environmental impacts and compatibility with other projects and plans. Matrices for ranked comparison of alternative concepts were prepared.

The alternative stormwater/floodwater management concept plans were reviewed by the Review Committee which then selected the concept for development to the preliminary plan level. The City of Glendale and Maricopa County Highway Department selected the 10-year storm as the preferred design level for the Bell Road facilities within their jurisdiction. The City of Peoria and City of Phoenix requested that the drainage facilities proposed for the segments of Bell Road within their respective jurisdictions be downsized to the 2-year storm design level. The design storm frequencies specified by the City of Glendale and City of Phoenix ensure that the design of the Bell Road Project drainage facilities within their jurisdictions are consistent with their adopted stormwater management plans. Facilities within the Town of Surprise will be designed for the 10-year frequency storm.

### A. Selected Plan Development

The selected stormwater/floodwater management plan is comprised of interconnected systems of open channels, detention basins and/or closed conduits. A number of factors were considered in developing drainage systems for each drainage area. These factors are:

- o Location and magnitude of runoff concentrating at Bell Road
- o Location and adequacy of outfalls
- o Availability of vacant land along Bell Road or in the upper watershed suitable for open channels or detention basins
- o Approved and ongoing storm drainage plans proposed by federal, state and local jurisdictions

To ensure that stormwater flows in excess of the design capacity of the Bell Road drainage facilities continue in their historic path, existing dip sections and major cross-culverts should be maintained.

The location and types of components for each system are shown in Plates 1 through 11 found in Section VIII.

#### **B. Hydrologic and Hydraulic Procedures**

The off-site hydrology is summarized in the "Hydrologic Modeling" report dated September 17, 1986. The design storms used for this report are the 10-year, 24-hour storm and the 2-year, 24-hour storm. Discharge values were determined by utilizing the HEC-1 computer program. The hydrologic modeling used to develop the selected plans was performed for post-development (future) watershed conditions. Existing and proposed drainage systems, as proposed by approved and/or ongoing area drainage master studies and master storm drain plans, were incorporated in the models.

The off-site hydrologic models previously developed for the 2-year and 10-year storms were re-analyzed and incorporated the components of the selected drainage systems. The HEC-1 program was used to route flows through the selected drainage systems and to calculate the revised 10-year or 2-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 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 final peak discharge values routed through the components of the selected drainage systems are shown on Plates 1 through 11.

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

The following criteria and procedures were followed in sizing and analyzing the selected drainage systems.

- o A Manning's Roughness Coefficient ( $n$ ) of 0.027 was used for earthen channels. A value of 0.012 was used for concrete pipe storm drains.
- o Storm drain culvert slopes were approximate to the existing ground slope, as determined from 7.5 minute quadrangle maps and City of Phoenix AP #40 maps.
- o The outfall structures were sized reflecting the facilities proposed in approved and ongoing area drainage master studies and master storm drain plans.
- o Potential impacts on downstream facilities or watercourses were evaluated at concentration points along Bell Road meeting the following criteria:
  - a. The 10-year or 2-year rate (whichever agrees with the selected design storm frequency for each jurisdiction) passed through Bell

Road (with selected drainage system in place) is greater than 200 cfs or 60 cfs respectively, and

- b. the capacity of the existing or planned receiving system is exceeded.

On-site runoff generated within the Bell Road right-of-way width of 110 feet was calculated using the Rational Equation,  $Q=CIA$ . It was determined that six cfs of runoff is generated per 0.25 miles of roadway (one-half street) for the 10-year storm and two cfs for the 2-year storm. Since on-site runoff will peak earlier than off-site stormwater runoff, the flows were not combined for the purpose of storm drain sizing, where off-site runoff was the major contributor of flow.

## VII. DESIGN CRITERIA

The selected stormwater/floodwater management concept plan was developed using established design and special criteria provided by the Flood Control District, as well as currently accepted engineering practices. The drainage design criteria and standards of state and local municipalities and organizations were reviewed for the purpose of developing the criteria utilized in this report. A listing of the source material used can be found in References, Section XIV.

Design criteria standards and guidelines for the development and implementation of the drainage improvements proposed for the Bell Road selected stormwater/floodwater management plan were also prepared for use by the project designers. These criteria are found in Appendix A.

## VIII. SELECTED STORMWATER/FLOODWATER MANAGEMENT PLAN

The major elements of the selected stormwater/floodwater management plan, including trunk lines, on-site storm drains, detention basins and open channels are described on the following pages.

In addition to a description of the major elements of the drainage systems for each drainage area, information is provided on the location of major stormwater runoff concentration points along Bell Road and the design frequency of the selected drainage systems. The alternative, or modified alternative from the Alternative Stormwater/Floodwater Management Concept Plans report prepared by Greiner in January 1987 and selected for development to the preliminary plan level is identified with the rationale for the selection. Effectiveness, environmental impacts and compatibility with other projects and plans are also discussed. The outfalls for the selected drainage systems are described including their status and design frequency.

Exhibits on 11"x17" sheets have been prepared for the selected stormwater/floodwater management systems for each drainage area and are found immediately following the description of the selected systems for each drainage area. The alignments and types of structures are graphically shown. Facilities proposed by this study are represented by a solid line pattern. Existing or proposed facilities from ongoing or approved master drainage studies are represented by broken line patterns. Structures are identified by reference numbers which also appear in the structure summary tables and cost estimate tables. Structure numbers are not assigned to existing facilities. Structures are all assigned a three digit number with the first digit representing the drainage area identification. Peak flow values and structure sizes for proposed open channels and conduits are also provided on the exhibits. The 11"x17" exhibits are preceded by a Structure Summary Table which identifies the structures by location with respect to Bell Road, structure number, structure type, design frequency, design discharge or volume (conduits or basins respectively), slope, channel characteristics [depth and top width (TW)] and length.

The existing bridges along Bell Road (Agua Fria River, New River, Skunk Creek and Cave Creek) were only analyzed for their adequacy to convey the 100-year storm flow. Regulatory flood delineation maps were used to evaluate the structures' adequacy. Widening of the bridges was not evaluated based on the future expansion of Bell Road. This issue should be addressed by the Management Consultant or the segment designers.

Some of the structures presented in this study were initially developed by previous or on-going studies. These studies are referenced by abbreviations in the Structure Summary tables and in the cost summary tables in Section X. These reports and the adopted abbreviation are as follows:

Glendale-Peoria Area Drainage Master Plan (Glendale-Peoria ADMS), prepared by Camp, Dresser & McKee Inc., and James M. Montgomery, Consulting Engineers, Inc. in April 1986.

Glendale Storm Water Management Plan (SWMP), prepared by Camp, Dresser & McKee Inc. in 1986.

Northwest Storm Drainage Study (NSDS), prepared by Arthur Beard Engineers, Inc. in 1977.

North Central Area Master Storm Drainage Study - West Half (NCMSD), prepared by SCI Consulting Engineers in 1980.

Upper East Fork of Cave Creek Area Drainage Master Study (UEFCC ADMS), on-going study by NBS/Lowry Engineers.

Northeast Area Master Storm Drainage Study (NMMSD), prepared by Southwest Computing, Inc. in 1979.

Bell Road Project Drainage Study (BRPD), currently being developed by Greiner Engineering Sciences, Inc.

Other standard abbreviations used in the following sections are:

CMP	Corrugated Metal Pipe
RCP	Reinforced Concrete Pipe
RCBC	Reinforced Concrete Box Culvert
Basin	Detention Basin
CB	Catch Basin

For the purpose of this study (BRPD), proposed facilities along Bell Road are identified as being proposed by the BRPD study, including structures recommended by previous or other on-going studies. This designation is also carried through into the summary cost tables in Section X. However, the facilities proposed by the UEFCC ADMS for Bell Road are designed for the 100-year frequency storm. They are, therefore, broken out separately in the cost summaries for Drainage Areas 6 and 7.

Drainage Area 1: The selected facilities for off-site drainage in Drainage Area 1 are within the jurisdiction of Maricopa County. Runoff collects at three existing culverts along Grand Avenue and the Atchison-Topeka and Santa Fe Railroad rights-of-way. The locations of these culverts are shown on Sheet 3 of the Preliminary Concept Drainage Plans in Section IX. The culverts were analyzed for the 2-year frequency storm. The two westerly culverts, a 36" RCP and a 24" RCP were found to be adequate. The easternmost culvert, a 24" CMP, was found to be inadequate and should be replaced with a 36" RCP with a design capacity of 53 cfs. Culvert discharges will continue to flow in their historic paths along the railroad right-of-way. A gunite channel has been proposed by the Grand Avenue Corridor Study at this location as part of the Grand Avenue Expressway. The Grand Avenue Expressway project is not scheduled for construction before the year 2000. At that time the culvert can be connected to the drainageway.

Off-site runoff from east of the culvert locations is intercepted by the Sun City West drainage system and conveyed to the Agua Fria River without impacting Bell Road.

On-Site Runoff: Bell Road within Drainage Area 1 (Grand Avenue to the Agua Fria River) is within the jurisdiction of the Maricopa County Highway Department and the Town of Surprise. The on-site drainage facilities are designed for the 10-year storm event. Runoff generated between Grand Avenue to approximately 900 feet east of Dysart Road will be conveyed by a 24"-30" storm drain to the existing drainageway located north and parallel to Bell Road. This drainageway discharges easterly to the Agua Fria River. The drainageway is privately owned by the developer of Sun City West and an agreement and temporary construction easement from the owner will be required.

Runoff generated from 900 feet east of Dysart Road to the Agua Fria River will be intercepted by catch basins that will discharge directly via laterals to the above referenced drainageway. This was found to be more cost-effective than installing a continuous storm drain along Bell Road. An agreement and temporary construction easement will also be required for these structures.

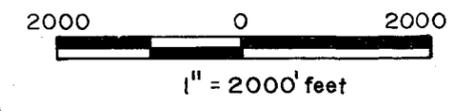
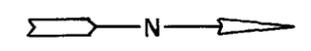
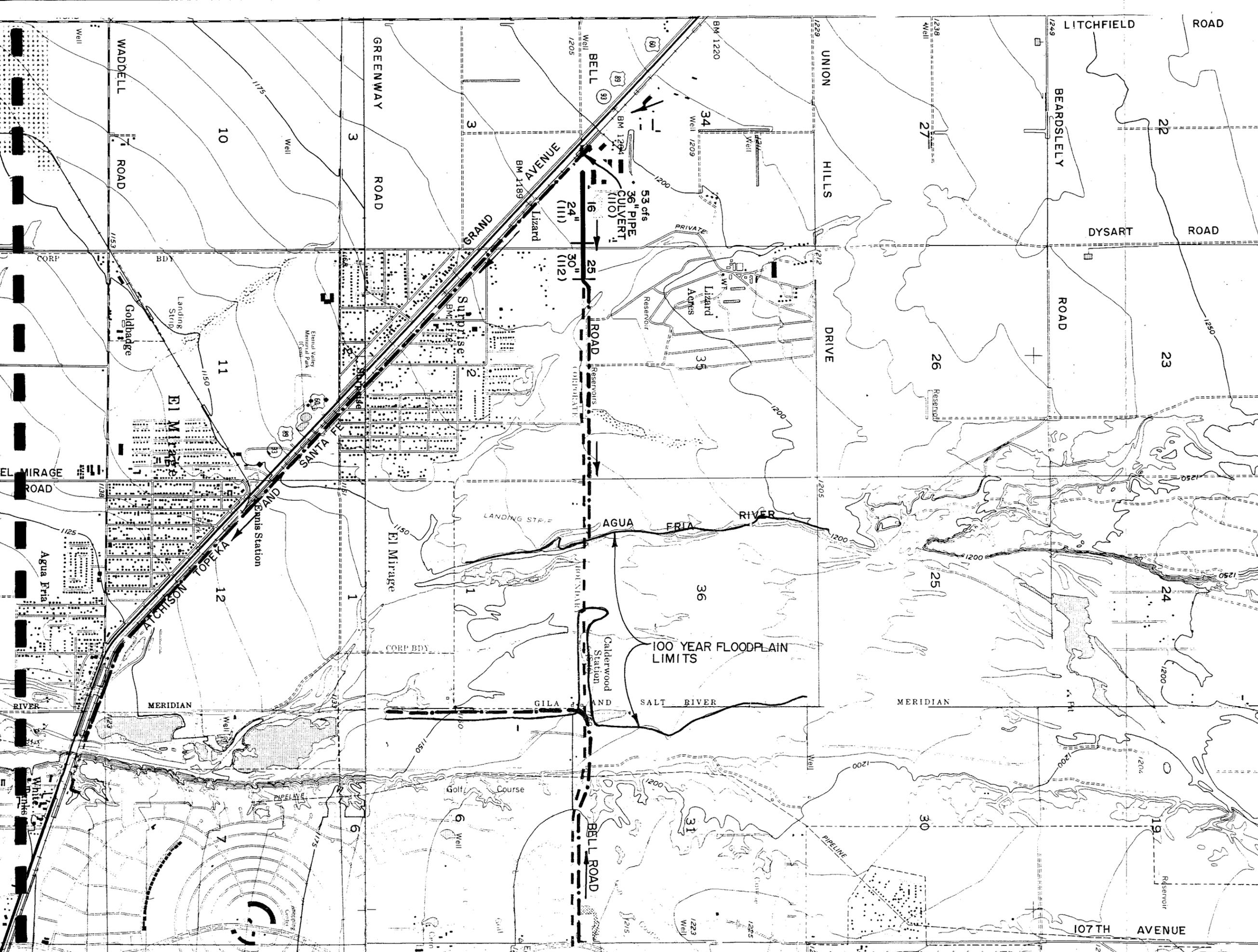
Refer to Plate 1 for a general schematic of the drainage facilities and to Sheets 3, 4 and 5 of the Preliminary Concept Drainage Plans in Section IX for more detail of both the off-site and on-site drainage facilities. Refer to Table 1 for the summary description of the structures within Drainage Area 1.

The selected stormwater/floodwater facilities for Drainage Area 1 are effective in intercepting and conveying the design flows to adequate outfalls. The proposed drainageway for the Grand Avenue Expressway will be designed to at least the 50-year frequency storm level. The existing Sun City West drainageway was designed to the 100-year storm level. There will be no long-term adverse environmental impacts. There will be minor short-term impacts associated with the construction of the drainage facilities such as noise, dust and disruption of traffic.

TABLE 1

**STRUCTURE SUMMARY  
DRAINAGE AREA 1**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
Along Bell Road	110	36" RCP	2-yr	53	--	--	110
	111	24" RCP	10-yr	16	0.0060	--	1,720
	112	30" RCP	10-yr	25	0.0060	--	980
	N/A	22 CB's with 15" laterals	10-yr	2 cfs/CB	--	--	--



- LEGEND**
- CONDUIT
  - OPEN CHANNEL
  - DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- TOP WIDTH
  - DEPTH
  - FACILITIES PROPOSED BY THIS STUDY
  - PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE I**  
**SELECTED PLAN**  
**DRAINAGE AREA 1&2**

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner**  
**Engineering**

**Drainage Area 2:** The selected facilities for Drainage Area 2 are within the City of Peoria. Major off-site runoff concentration points along Bell Road are at 91st Avenue and 87th Avenue. The selected system was designed for the 2-year storm event per City of Peoria's guidance and is a modification of the 10-year storm Alternative 4. This alternative was selected with modification, because parallel storm drain systems with detention basins along 91st Avenue and 87th Avenue were determined to be the most cost-effective. The 91st Avenue system is comprised of an open channel from Deer Valley Road to Beardsley Road and a storm drain system between Beardsley Road and Bell Road. South of Bell Road, the storm drain system discharges into a channel with an outfall to the New River at Greenway Road.

Detention basins will be located at the northeast corner of Beardsley Road and 91st Avenue and at the northeast corner of Union Hills Drive and 91st Avenue.

The 87th Avenue system consists of an open channel from Deer Valley Road to Beardsley Road and a storm drain system along 87th Avenue between Beardsley Road and Union Hills Drive. At Union Hills Drive, the system heads eastward along Union Hills Drive to its outfall at the New River near 83rd Avenue. A detention basin will be located at the northeast corner of Union Hills Drive and 87th Avenue. Storm drain pipes along Bell Road from 87th Avenue to the New River and between 95th and 91st Avenues, will intercept off-site runoff draining to these segments of Bell Road from areas to the north.

The 91st Avenue system was proposed by the Master Plan of Storm Drainage for the City of Peoria, prepared in 1986 by James M. Montgomery, Consulting Engineers. The system was initially designed for the 10-year storm event. At the direction of the City, this system was downsized to the 2-year frequency storm design level. In that study, the channel south of Bell Road continued along the 91st Avenue alignment south of Greenway Road, through the Desert Anchors subdivision, then discharged into the New River where it intercepts 91st Avenue. It was determined from field investigations that Desert Anchors was constructed on fill and an earthen berm along Greenway diverts runoff to the east to New River. Therefore, the open channel

follows the 91st Avenue alignment to Greenway Road, then heads east along Greenway Road to the New River.

The open channels along 91st Avenue and 87th Avenue may be interchanged with closed conduits if the adjacent property is developed prior to construction of the stormwater facilities. Final conduit sizes will be determined in accordance with the City of Peoria Master Plan for Storm Drainage.

Off-site runoff from north of Bell Road between the Agua Fria River and the 115th Avenue alignment is intercepted by a large earthen channel north of Bell Road, conveyed around the Agua Fria Bridge spur dike and discharged into the river. The integrity of the earthen channel must be maintained to protect the roadway. According to current floodplain maps, bridge and channel improvements to the Agua Fria River direct the 100-year discharge in the river through the Bell Road bridge with no impacts to the roadway. One hundred year frequency off-site runoff from between 115th Avenue to 91st Avenue is intercepted and conveyed by the Sun City drainage system to the Agua Fria River.

On-site Runoff: Bell Road within Drainage Area 2 is within the jurisdiction of the Town of Surprise (Agua Fria River to 115th Avenue), Maricopa County (115th Avenue to the east end of Sun City and 89th Avenue to New River) and City of Peoria (Sun City to 89th Avenue). These on-site drainage facilities within County and Town of Surprise jurisdictions are designed for the 10-year frequency storm. Facilities within the City of Peoria are designed for the 2-year frequency storm.

Facilities from the Agua Fria River to Del Webb Boulevard (107th Avenue) are comprised of catch basins with laterals discharging directly to the private earthen channel or gunite drainageway located north of and parallel to Bell Road. These open channels convey runoff to the Agua Fria River. Runoff from Del Webb Boulevard to 105th Avenue will be conveyed by a storm drain that will tie into an existing 48" storm drain at 105th Avenue. This storm drain was designed by the developer of Sun City to intercept runoff from 105th Avenue and Boswell Boulevard (approximately 1,100 feet west of 99th Avenue). The storm drain discharges into a gunite drainageway at 99th

Avenue. This drainageway conveys storm water runoff to the New River. The drainageway was designed for the 100-year storm event. New catch basins will be connected to the existing 48" storm drain. The ability of the existing 48" storm drain to convey additional on-site runoff will have to be carefully evaluated at the time of final design. An agreement will have to be obtained from the developer of Sun City to tie into this storm drain. Similar agreements and temporary construction easements will be required for all of the Bell Road drainage facilities between the Agua Fria River and Burns Avenue.

On-site runoff from Burns Drive to 99th Avenue will be conveyed westward via storm drain to the 99th Avenue drainageway. On-site runoff from Burns Avenue to 91st Avenue will be conveyed eastward via storm drain to the open channel south of Bell Road along 91st Avenue.

This storm drain is designed for the 10-year frequency storm. On-site runoff from 91st Avenue to the New River will be conveyed by the storm drain located along Bell Road designed to intercept off-site runoff from the City of Peoria.

Refer to Plates 1 and 2 for schematics of the proposed on-site and off-site facilities for Drainage Area 2. Refer to Sheets 5 through 10 of the Preliminary Plans for more detail on the drainage facilities along Bell Road. Refer to Table 2 for summary descriptions of the structures.

The selected stormwater/floodwater facilities for Drainage Area 2 are effective in intercepting and conveying the design flows to adequate outfalls. The existing stormwater drainage facilities in Sun City were designed for the 100-year frequency storm.

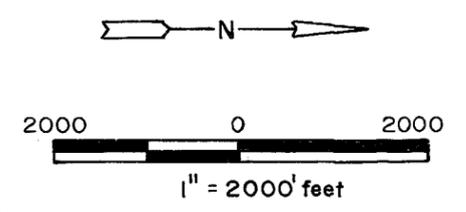
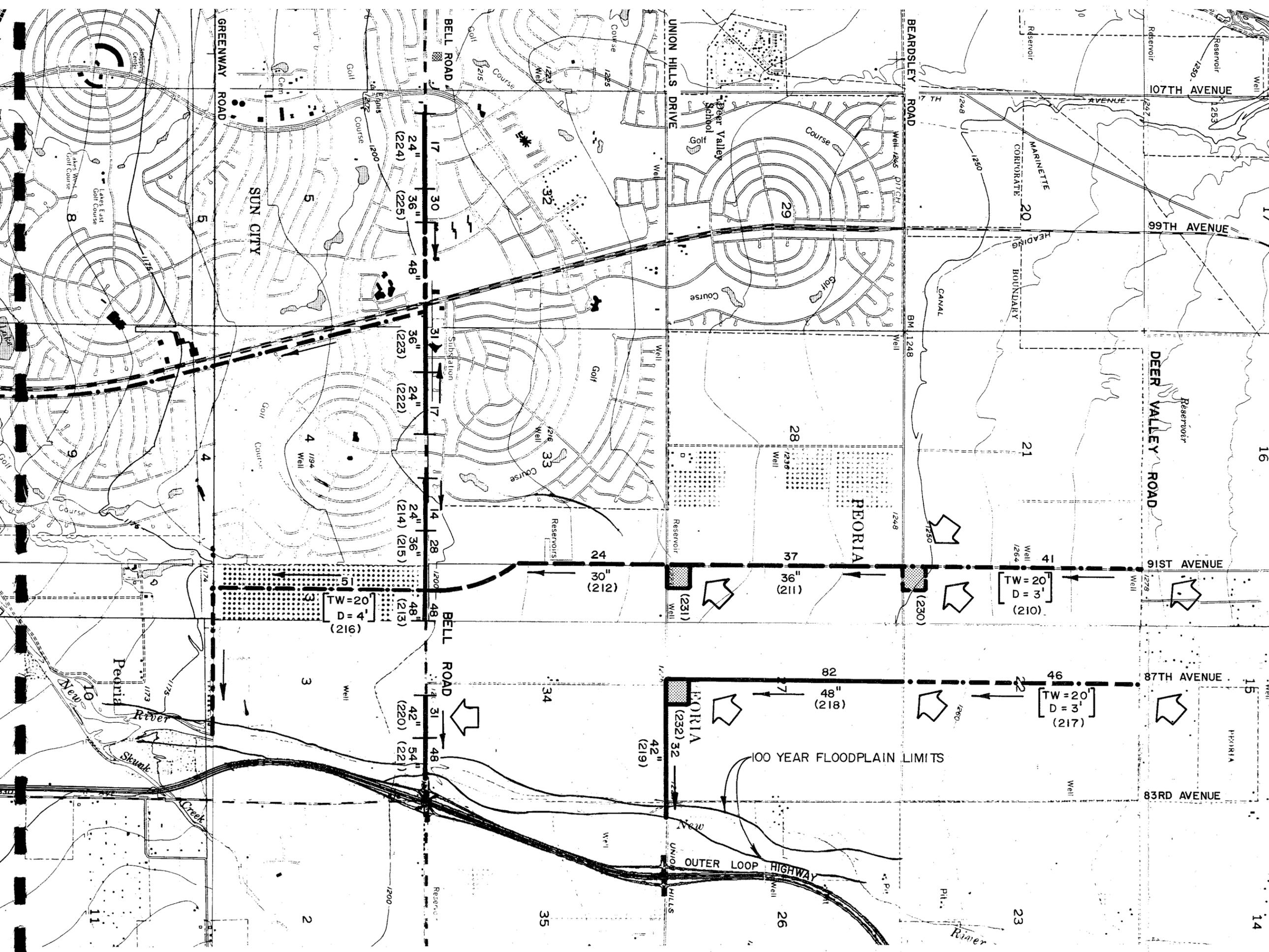
Both existing and new facilities convey storm water runoff to either the Agua Fria River or the New River and have the capacity to convey the 100-year flow through Bell Road. Environmental impacts along Bell Road will be minor and short-term.

The construction of the facilities north of Bell Road, including storm drains, open channels and detention basins can be phased with the future development of the area. The exact alignments of the channels and conduits and the configuration of the basins can be integrated with the master development of the area. Open channels may be replaced at the time of full development with closed conduits.

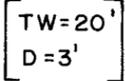
TABLE 2

**STRUCTURE SUMMARY  
DRAINAGE AREA 2**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	210	Channel	2-yr	41	0.0057	3/20	5,280
	211	36" RCP	2-yr	37	0.0047	--	5,280
	212	30" RCP	2-yr	24	0.0044	--	5,200
	217	Channel	2-yr	46	0.0057	3/20	5,280
	230	Basin	2-yr	9	--	--	--
	218	48" RCP	2-yr	82	0.0053	--	5,200
	219	42" RCP	2-yr	32	0.0010	--	2,700
	231	Basin	2-yr	8	--	--	--
	232	Basin	2-yr	9	--	--	--
Along Bell Road	213	48" RCP	2-yr	48	0.0010	--	650
	220	42" RCP	2-yr	31	0.0013	--	630
	221	54" RCP	2-yr	48	0.0011	--	1,820
	215	36" RCP	2-yr	28	0.0010	--	1,550
	214	24" RCP	2-yr	14	0.0010	--	1,200
	222	24" RCP	10-yr	17	0.0006	--	1,420
	223	36" RCP	10-yr	31	0.0013	--	1,550
	224	24" RCP	10-yr	17	0.0010	--	1,650
	225	36" RCP	10-yr	30	0.0010	--	750
	N/A	30 CB's with 15" laterals	10-yr	2 cfs/CB	--	--	--
South of Bell Road	216	Channel	2-yr	51	0.0015	4/20	8,000



- LEGEND**
-  CONDUIT
  -  OPEN CHANNEL
  -  DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
-  TOP WIDTH  
DEPTH
  -  FACILITIES PROPOSED BY THIS STUDY
  -  PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 2**  
**SELECTED PLAN**  
**DRAINAGE AREA 2**

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner**  
**Engineering**

Drainage Area 3: The selected facilities for off-site drainage in Drainage Area 3 are within the City of Glendale and the City of Peoria. Per City guidance, these facilities are designed for the 10-year frequency storm event. Major flows concentrate at 77th and 75th Avenues.

The selected system is comprised of a single storm drain system outletting into Skunk Creek at 75th Avenue. The storm drain will extend northward along 75th Avenue to approximately three-quarters of a mile north of Bell Road. A trunk line will also extend west on Bell Road to the 77th Avenue alignment. The area north of Bell Road is an abandoned citrus orchard zoned for commercial development.

On-site Runoff: On-site runoff along Bell Road from the New River to the 77th Avenue alignments will be conveyed by a 30" storm drain to the New River. On-site runoff from the 77th Avenue alignment to 75th Avenue will be picked up by the 72" storm drain for off-site flows. A 30" storm drain from 75th Avenue to Skunk Creek will convey on-site runoff westward to the storm drain at 75th Avenue.

Refer to Plate 3 for the schematic of the selected facilities for Drainage Area 3. Refer to Sheets 10, 11 and 12 of the Preliminary Concept Drainage Plans in Section IX for more detail on the facilities along Bell Road. Refer to Table 3 for the structures summary.

The selected stormwater/floodwater facilities for Drainage Area 3 are effective in intercepting and conveying the design flows to adequate outfalls. The selected facilities discharge into either the New River or Skunk Creek which are major water courses. There will be no long-term adverse environmental impacts. There will be minor short-term impacts associated with the construction of the drainage facilities such as noise, dust and disruption of traffic.

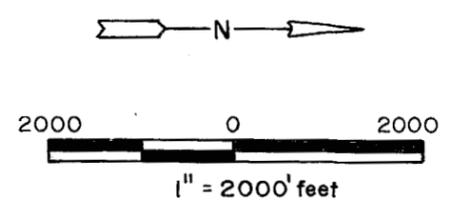
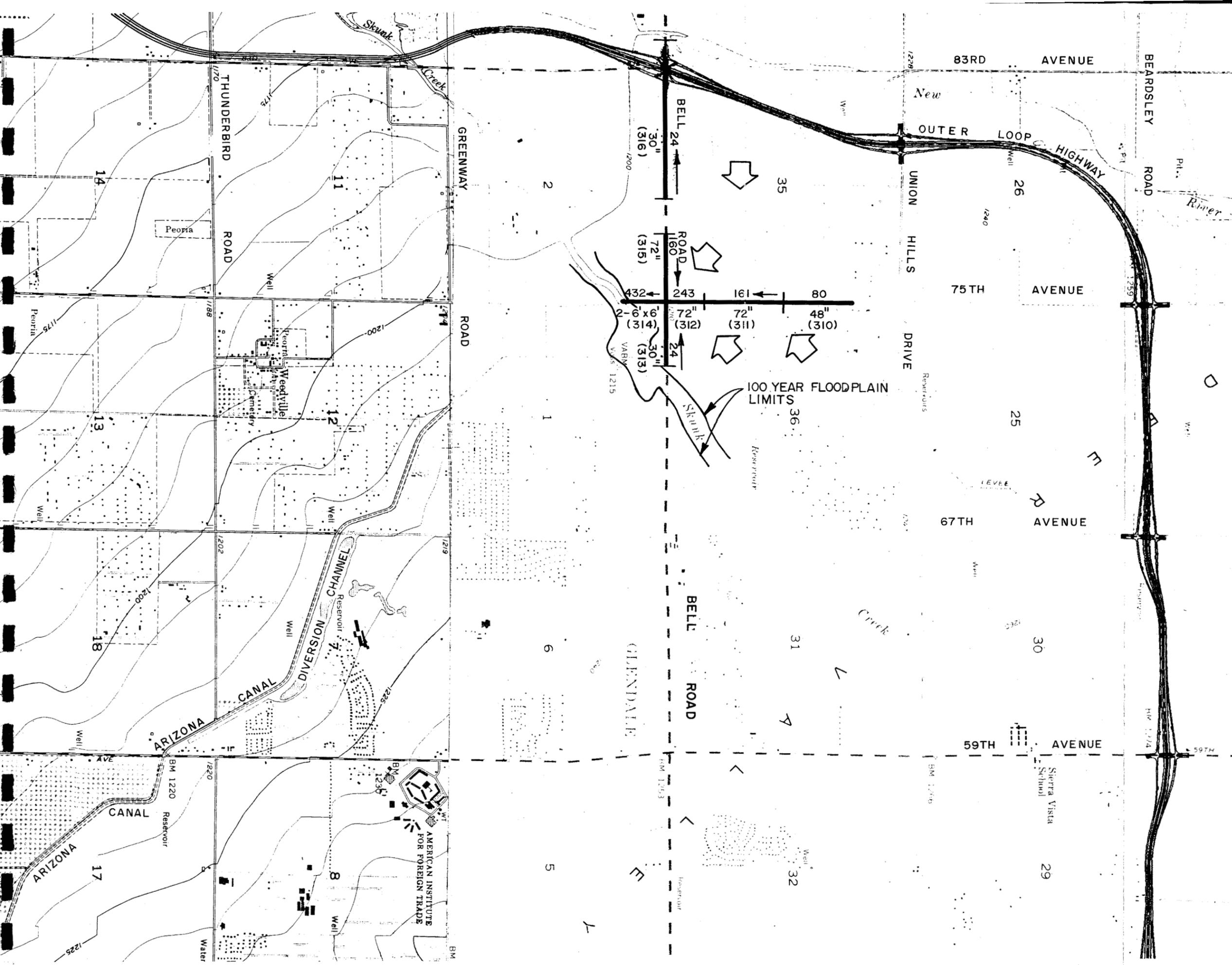
The Outer Loop Highway will cross Bell Road east of New River and west of 83rd Avenue which will be re-aligned. The Outer Loop Highway interchange at Bell Road is scheduled for completion in 1989. Drainage facilities associated with the Outer Loop will ensure that no flows will be diverted to Bell Road. The drainage facilities proposed by this study (BRPD) will be located within the Bell Road pavement and will not be affected by the construction of the Outer Loop Highway.

For consistence with Glendale's stormwater management plan, the 10-year, 2-hour storm will be used for final design of the proposed structures.

TABLE 3

**STRUCTURE SUMMARY  
DRAINAGE AREA 3**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	310	48" RCP	10-yr	80	0.0041	--	1,500
	311	72" RCP	10-yr	161	0.0029	--	1,750
	312	72" RCP	10-yr	243	0.0029	--	800
Along Bell Road	313	30" RCP	10-yr	24	0.0067	--	1,480
	315	72" RCP	10-yr	160	0.0010	--	1,320
	316	30" RCP	10-yr	24	0.0009	--	3,660
South of Bell Road	314	2-6'x6' RCBC	10-yr	432	0.0010	--	1,000



- LEGEND**
-  CONDUIT
  -  OPEN CHANNEL
  -  DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- |        |           |
|--------|-----------|
| TW=20' | TOP WIDTH |
| D=3'   | DEPTH     |
-  FACILITIES PROPOSED BY THIS STUDY
  -  PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 3**  
**SELECTED PLAN**  
**DRAINAGE AREA 3**

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner**  
**Engineering**

**Drainage Area 4:** The selected stormwater/floodwater facilities in Drainage Area 4 are within the jurisdictions of the City of Glendale (Skunk Creek to 51st Avenue) and the City of Phoenix (51st Avenue to I-17). Major off-site runoff concentration points along Bell Road are at 67th Avenue, 59th Avenue, 51st Avenue, 43rd Avenue and 35th Avenue. The selected systems for the City of Glendale are designed for the 10-year frequency storm event. Their alignments were presented as Alternate 1 in the Alternate Stormwater/Floodwater Management Concept Plans report. The selected system is comprised of trunk storm drains along 67th Avenue and 59th Avenue. Major laterals will extend eastward along Bell Road for one-half mile to intercept additional off-site flows. Storm drains will also extend north of Bell Road for one-half mile along 59th Avenue and 55th Avenue. The 67th Avenue and 59th Avenue storm drain systems were designed for the 2-hour duration storm as adopted by the City of Glendale SWMP.

The selected systems for the City of Phoenix were developed for the 2-year frequency storm per City guidance. Major trunk storm drains will be located along 51st Avenue, 43rd Avenue and 35th Avenue. The storm drains will be extended north of Bell Road for one-half mile and east along Bell Road and Grovers Avenue (one-half mile north of Bell Road). These alignments were previously adopted by the City of Phoenix NSDS. The storm drain along Bell Road extending eastward from 35th Avenue was up-sized by the BRPD because culvert discharges crossing I-17 were included in the BRPD model that were not incorporated by the NSDS.

The trunk storm drains within the City of Glendale and City of Phoenix drain southward to the Arizona Canal Diversion Channel (ACDC) which conveys floodwaters to Skunk Creek. The ACDC from 29th Avenue to Skunk Creek has already been completed. The reach from I-17 to 29th Avenue is scheduled for completion in 1989. The existing 48" outlet into the ACDC at 67th Avenue is inadequate to convey the proposed discharges from the SWMP. The type and location of outlets to convey the required discharges should be evaluated at the time of final design.

On-site Runoff: On-site runoff along Bell Road will be conveyed via storm drain extensions in Bell Road to the storm drains required for off-site runoff. The extensions within the City of Glendale are sized for the 10-year frequency storm. The extensions in the City of Phoenix are sized for the 2-year frequency storm.

Refer to Plates 4 and 5 for schematics of the selected on-site and off-site facilities in Drainage Area 4. Refer to Sheets 12 through 19 of the Preliminary Concept Drainage Plans in Section IX for more detail. Refer to Table 4 for the structures summary.

The selected stormwater/floodwater facilities for Drainage Area 4 are effective in intercepting and conveying the design flows to adequate outfalls. The trunk storm drains discharge into the ACDC which is designed for the 100-year frequency storm event. There will be no long-term adverse impacts. There will be minor, short-term impacts associated with the construction of the drainage facilities such as noise, dust and disruption of traffic and access to businesses.

TABLE 4  
STRUCTURE SUMMARY  
DRAINAGE AREA 4

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	437**	54" RCP	10-yr, 2-hr	90	--	--	2,640
	436**	84" RCP	10-yr, 2-hr	210	--	--	2,640
	457**	Basin	10-yr, 2-hr	6/13	--	--	--
	401	54" RCP	2-yr	107	*	--	2,640
	402	60" RCP	2-yr	133	*	--	2,640
	414	42" RCP	2-yr	50	*	--	2,640
	415	48" RCP	2-yr	71	*	--	2,640
	426	33" RCP	2-yr	24	*	--	2,640
Along Bell Road	438**	24" RCP	10-yr, 2-hr	12	0.0049	--	2,140
	440**	24" RCP	10-yr, 2-hr	30	0.0020/0.0069	--	2,700
	446**	24" RCP	10-yr, 2-hr	8	0.0050	--	860
	447**	30" RCP	10-yr, 2-hr	18	0.0050	--	1,320
	448**	66" RCP	10-yr, 2-hr	210	0.0040	--	2,330
	455**	24" RCP	10-yr, 2-hr	12	0.0046	--	1,400
	456**	30" RCP	10-yr, 2-hr	24	0.0020	--	1,050
	403	24" RCP	2-yr	8	0.0020	--	1,200
	404	36" RCP	2-yr	36	0.0034	--	2,810
	416	24" RCP	2-yr	12	0.0050	--	1,640
	417	42" RCP	2-yr	52	0.0050	--	2,670
	427	24" RCP	2-yr	12	0.0050	--	1,550
	428	30" RCP	2-yr	24	0.0050	--	2,670
	South of Bell Road	437	54" RCP	10-yr, 2-hr	90	--	--
441**		18" RCP	10-yr, 2-hr	8	--	--	2,140
442**		54" RCP	10-yr, 2-hr	120	--	--	2,640
443**		24" RCP	10-yr, 2-hr	340	--	--	2,640
444**		60" RCP	10-yr, 2-hr	120	--	--	2,640
445**		96" RCP	10-yr, 2-hr	420	--	--	600
449**		72" RCP	10-yr, 2-hr	250	--	--	2,640
450**		84" RCP	10-yr, 2-hr	310	--	--	2,640
451**		108" RCP	10-yr, 2-hr	500	--	--	2,800
458**		Basin	10-yr, 2-hr	--	--	--	--
459**		Basin	10-yr, 2-hr	--	--	--	--
405	60" RCP	2-yr	177	*	--	2,640	

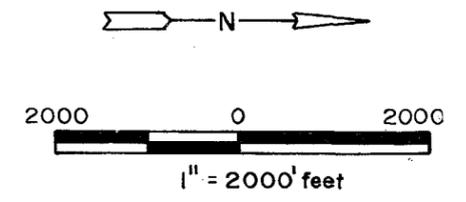
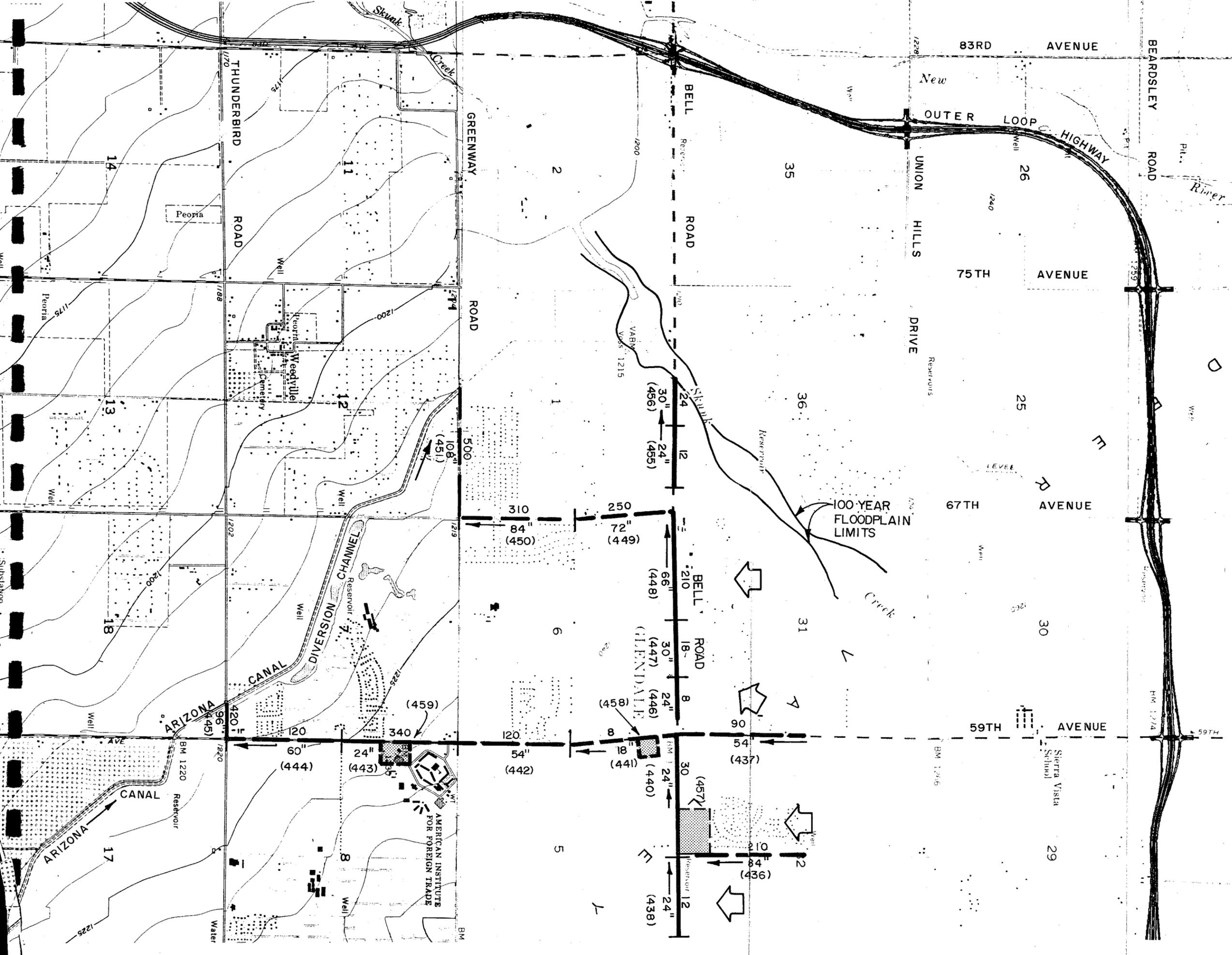
TABLE 4 CONTINUED

STRUCTURE SUMMARY  
DRAINAGE AREA 4

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
South of Bell Road	418	60" RCP	2-yr	125	*	--	2,640
	419	66" RCP	2-yr	161	*	--	2,640
	420	72" RCP	2-yr	193	*	--	2,640
	421	78" RCP	2-yr	235	*	--	2,640
	422	78" RCP	2-yr	283	*	--	2,640
	423	84" RCP	2-yr	329	*	--	2,640
	424	84" RCP	2-yr	383	*	--	2,640
	425	90" RCP	2-yr	417	*	--	2,600
	429	36" RCP	2-yr	26	*	--	2,640
	430	48" RCP	2-yr	95	*	--	2,640
	431	66" RCP	2-yr	144	*	--	2,640
	432	66" RCP	2-yr	176	*	--	2,640
	433	78" RCP	2-yr	232	*	--	2,640
	434	78" RCP	2-yr	272	*	--	2,640
	435	84" RCP	2-yr	310	*	--	300

\*Design by NSDS

\*\*Discharge values and pipe sizes provided by SWMP

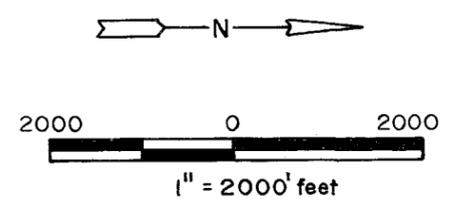
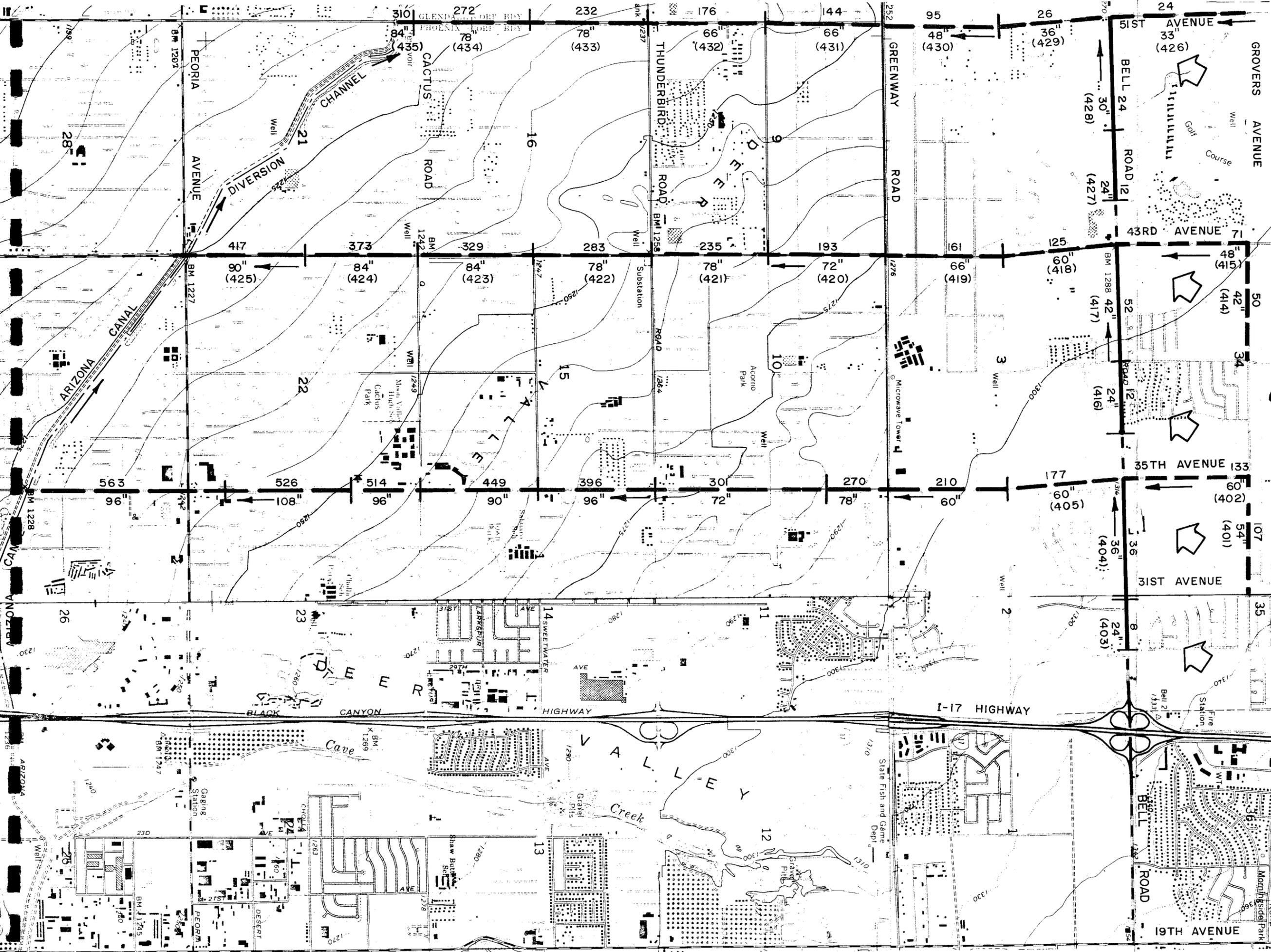


- LEGEND**
- CONDUIT
  - OPEN CHANNEL
  - DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- TOP WIDTH  
D=3' DEPTH
  - FACILITIES PROPOSED BY THIS STUDY
  - PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 4**  
**SELECTED PLAN**  
 DRAINAGE AREA 4  
 (SHEET 1 OF 2)  
 BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner Engineering**



- LEGEND**
- CONDUIT
  - OPEN CHANNEL
  - DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- |        |           |
|--------|-----------|
| TW=20' | TOP WIDTH |
| D=3'   | DEPTH     |
- FACILITIES PROPOSED BY THIS STUDY
  - PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 5**  
**SELECTED PLAN**  
 DRAINAGE AREA 4  
 (SHEET 2 OF 2)

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner Engineering**

**Drainage Area 5:** The selected stormwater/floodwater facilities for off-site runoff in Drainage Area 5 are within the jurisdiction of the City of Phoenix. Per City guidance, the facilities are designed for the 2-year frequency storm event. The major concentration point for off-site runoff along Bell Road is at 19th Avenue. Minor off-site flows impact Bell Road at 21st Avenue, 17th Avenue and 15th Avenue. The selected storm drainage system is comprised of a major trunk storm drain along 19th Avenue extending northward to Utopia Road. Laterals will extend eastward along Bell Road, Grovers Avenue and Utopia Road. The trunk storm drain (90" pipe) has already been installed along Bell Road from the outfall at Cave Creek to Grovers Avenue. A 42" stub has been provided at Bell Road.

The 19th Avenue storm drain system was adopted by the City of Phoenix NCMSD in 1980. Subsequently, the drainage facilities associated with the Outer Loop Highway propose to divert flows from north of Beardsley Road away from 19th Avenue. The BRPD re-evaluated pipe sizes between Grovers Avenue and Beardsley Road to reflect this change. A storm drain will intercept off-site runoff from I-17 to 21st Avenue and will convey flows south along the I-17 station 625+00 (approximately 1,100 feet south of Bell Road) and discharge into the existing drainageway on the west side of I-17. This drainageway conveys on-site runoff from I-17 and discharges from the pump station in the depressed section of Bell Road under I-17 to a drainageway along Paradise Lane for conveyance to a detention basin at the 31st Avenue alignment.

The possibility of directing the storm drain northward from Bell Road along I-17 was also investigated but found to not be feasible due to the lack of adequate cover.

**On-site Runoff:** On-site runoff from Bell Road in Drainage Area 5 will be collected by the off-site system. Flows entering the depressed section of Bell Road under I-17 will be pumped out by the existing pumps and discharged into the drainageway on the west side and conveyed south to Paradise Lane. These pumps were recently evaluated by PRC Engineering for ADOT (Interstate 17 Drainage Design Study Initial Design Report, August 1986) and rated at 0.94 percent capacity of the 25-year peak inflow.

Refer to Plates 6 and 7 for schematics of the on-site and off-site facilities. Refer to Sheets 19 through 21 of the Preliminary Concept Drainage Plans for more details of the facilities along Bell Road. Refer to Table 5 for the structures summary.

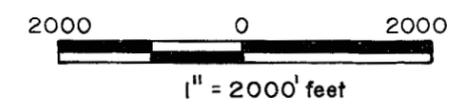
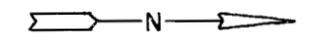
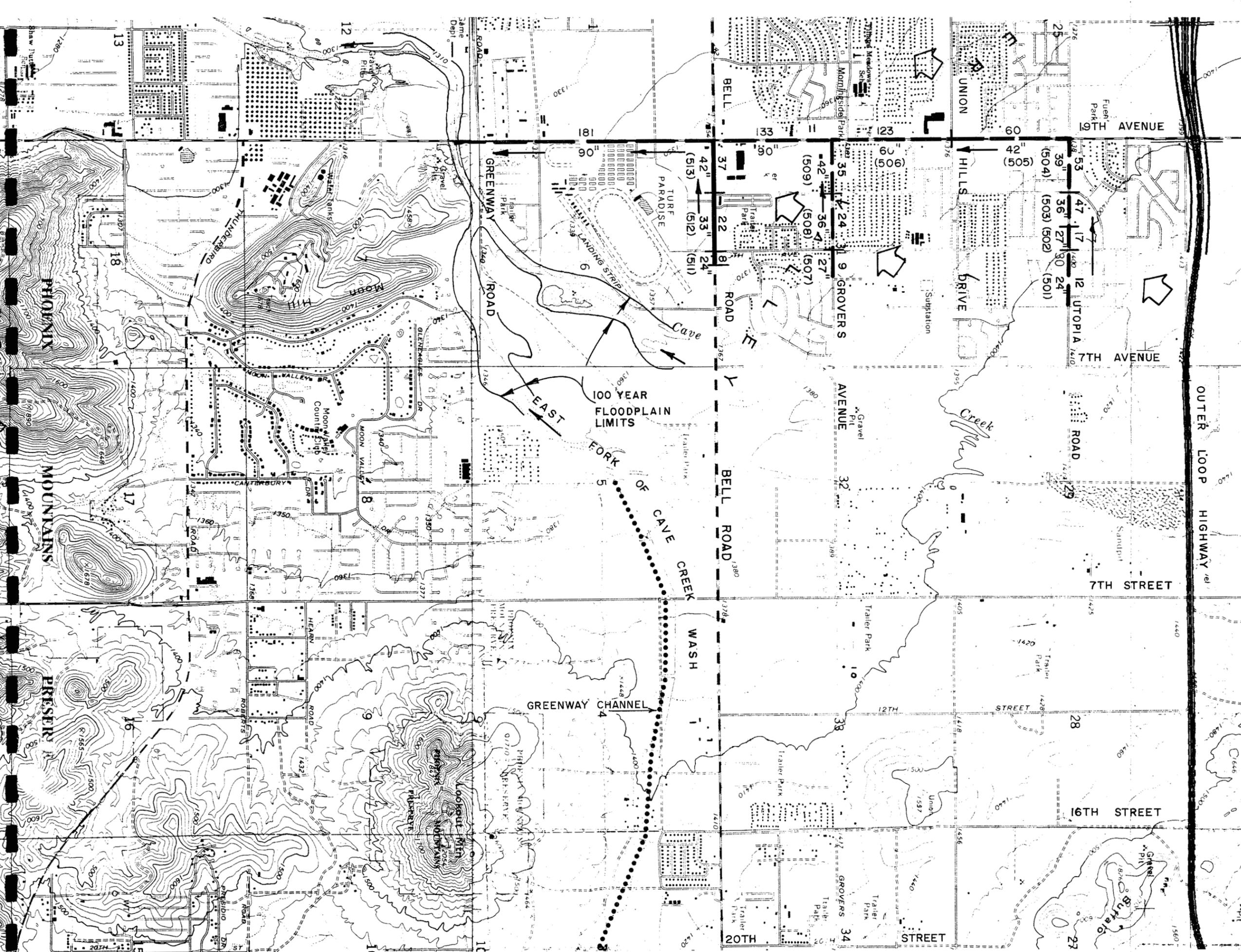
The selected stormwater/floodwater facilities for Drainage Area 5 are effective in intercepting and conveying the design flows to adequate outfalls. The facilities proposed by the BRPD study will tie into the existing 90" storm drain at 19th Avenue and to an existing gunite drainageway on the west side of I-17. There will be no long-term adverse environmental impacts. Short-term temporary construction impacts are anticipated including noise, dust and disruption of traffic and access to businesses.

TABLE 5

**STRUCTURE SUMMARY**  
**DRAINAGE AREA 5**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	501	24" RCP	2-yr	12	*	--	1,320
	502	27" RCP	2-yr	17	*	--	500
	503	36" RCP	2-yr	47	*	--	820
	504	39" RCP	2-yr	53	*	--	1,320
	505	42" RCP	2-yr	60	*	--	2,640
	506	60" RCP	2-yr	123	*	--	2,640
	507	27" RCP	2-yr	9	*	--	650
	508	36" RCP	2-yr	24	*	--	1,320
	509	42" RCP	2-yr	35	*	--	1,320
Along Bell Road	511	24" RCP	2-yr	8	0.0041	--	320
	512	33" RCP	2-yr	22	0.0046	--	1,310
	513	42" RCP	2-yr	37	0.0046	--	1,055
	515	18" RCP	2-yr	8	0.0050	--	820
	516	42" RCP	2-yr	45	0.0030	--	2,040
South of Bell Road	517	42" RCP	2-yr	45	0.0025	--	1,700

\*Design by NCMSD



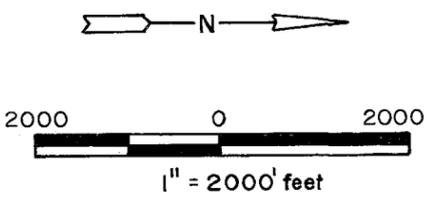
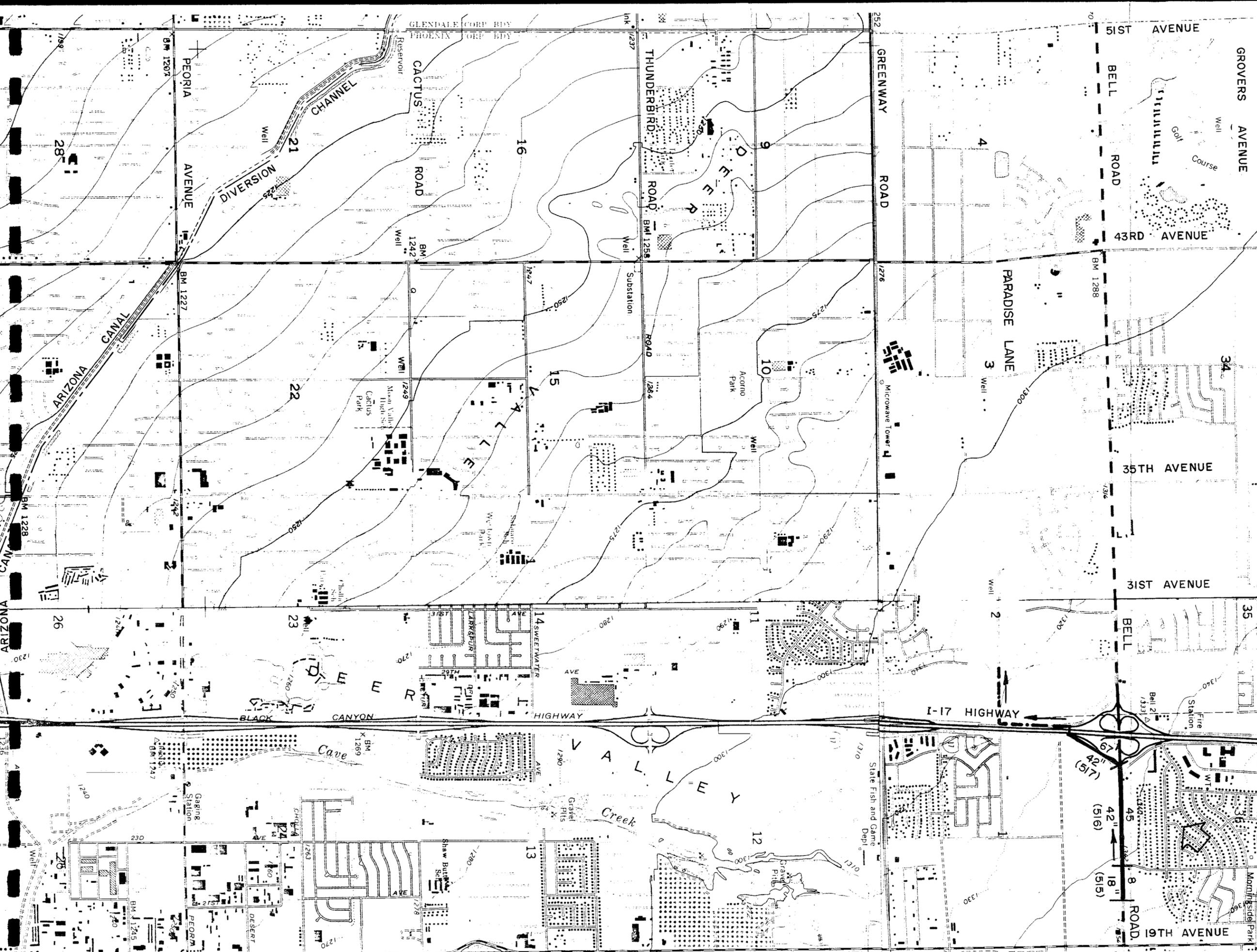
- LEGEND**
- CONDUIT
  - OPEN CHANNEL
  - DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- |        |           |
|--------|-----------|
| TW=20' | TOP WIDTH |
| D=3'   | DEPTH     |
- FACILITIES PROPOSED BY THIS STUDY
  - PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

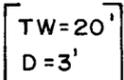
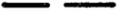
**PLATE 7**  
**SELECTED PLAN**  
 DRAINAGE AREA 5  
 (SHEET 2 OF 2)

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner Engineering**



- LEGEND**
-  CONDUIT
  -  OPEN CHANNEL
  -  DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
-  TW=20' TOP WIDTH  
D=3' DEPTH
  -  FACILITIES PROPOSED BY THIS STUDY
  -  PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 6**  
**SELECTED PLAN**  
 DRAINAGE AREA 5  
 (SHEET 1 OF 2)

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner Engineering**

Drainage Area 6: The selected facilities for off-site runoff in Drainage Area 6 are within the jurisdiction of the City of Phoenix. The current study by NBS/Lowry Engineers, "Upper East Fork Cave Creek Area Drainage Master Study" (UEFCC ADMS) has developed a drainage and flood control master plan for the 100-year storm event in this area. Per the FCD's guidance, Greiner has incorporated the NBS/Lowry proposal into the Bell Road study. Additional drainage facilities were evaluated only where required to protect Bell Road from off-site drainage not intercepted by the NBS/Lowry System. Conduit sizes and alignments are subject to change pending the adoption of the UEFCC ADMS by both the City of Phoenix and the Flood Control District.

The stormwater/floodwater facilities for Drainage Area 6 are comprised of three independent systems draining into the proposed Greenway Parkway flood control channel located south of Bell Road between Cave Creek Road and the Cave Creek channel. Storm drain systems will be located north of Bell Road on Seventh Street. A combination storm drain/detention basin system is proposed for Ninth Street. The detention basins would be located on the northeast corner of Ninth Street and Campobello Drive and on the southwest corner of Union Hills Drive and Ninth Street. The storm drain along Bell Road east of Ninth Street developed by the UEFCC ADMS was extended by this study (BRPD) to one-quarter mile east of 16th Street to pick up additional off-site flows.

The discharge values shown on Plate 8 are for the 100-year frequency storm developed by the UEFCC ADMS, except the storm drains proposed by the BRPD study (Central Avenue storm drain and Bell Road, 16th Street to one-quarter mile east) and are shown with the 2-year frequency values.

On-Site Runoff: On-site runoff along Bell Road in Drainage Area 6 will be picked up by the storm drains provided for off-site runoff. An additional storm drain for on-site flows only will extend along Bell Road from one-quarter mile west of Central Avenue to Cave Creek.

Refer to Plate 8 for a schematic of the selected on-site and off-site facilities for Drainage Area 6. Refer to Sheets 22 through 25 of the Preliminary

Concept Drainage Plans for more detail on the facilities along Bell Road. Refer to Table 6 for the structures summary.

The selected stormwater/floodway facilities for Drainage Area 6 are effective in intercepting and conveying the design flows to adequate outfalls. The selected facilities discharge into either Cave Creek or the proposed Greenway Parkway channel. At the direction of the Flood Control District, the potential for adverse impacts was only evaluated for the facilities along Bell Road. There is an existing archaeological site which surrounds the intersection of Central Avenue and Bell Road. The Pueblo Grande Museum staff verified that this site is Hohokam culture from the late sedentary through classic period (A.D. 1050-1400). This is an extensive shard (pottery) area. Numerous lava boulder concentrations were noted which suggest possible structures. Monitoring will probably be required during construction.

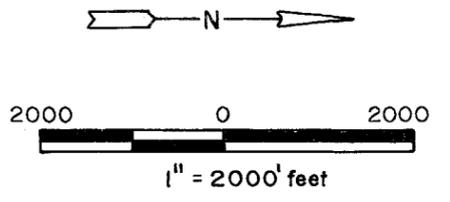
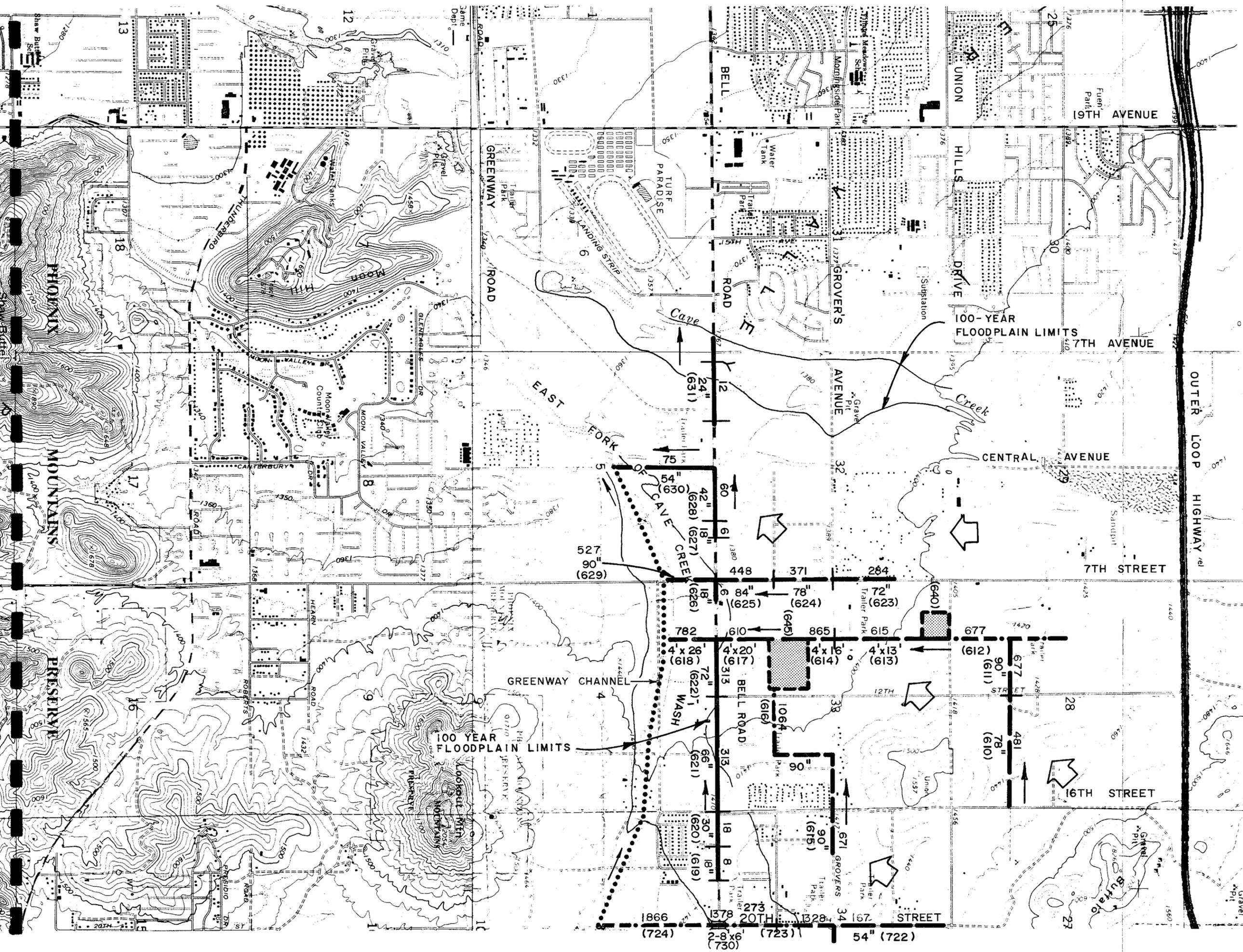
Other impacts will be minimal and short-term, associated with the construction of the drainage facilities and limited to noise, dust and disruption of traffic and access to businesses. The area north of Bell Road between Cave Creek and Central Avenue is currently undeveloped.

TABLE 6

**STRUCTURE SUMMARY  
DRAINAGE AREA 6**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>	
North of Bell Road	610	78" RCP	100-yr	481	*	--	2,640	
	611	90" RCP	100-yr	677	*	--	1,320	
	612	Channel	100-yr	677	*	*	2,700	
	613	4'x13' RCBC	100-yr	615	*	--	2,000	
	614	4'x16' RCBC	100-yr	865	*	--	950	
	615	90" RCP	100-yr	671	*	--	3,820	
	616	Channel	100-yr	1,064	*	*	1,600	
	617	4'x20' RCBC	100-yr	610	*	--	1,150	
	623	72" RCP	100-yr	284	*	--	1,320	
	624	78" RCP	100-yr	371	*	--	1,320	
	625	84" RCP	100-yr	448	*	--	1,320	
	640	Basin	100-yr	623	*	*	--	
	645	Basin	100-yr	131	*	*	--	
	Along Bell Road	621	66" RCP	100-yr	313	0.0081	--	2,280
		622	72" RCP	100-yr	313	0.0020	--	1,320
619		18" RCP	2-yr	8	0.0150	--	800	
620		30" RCP	2-yr	18	0.0050	--	1,200	
626		18" RCP	2-yr	6	0.0050	--	280	
627		18" RCP	2-yr	6	0.0270	--	300	
628		42" RCP	2-yr	60	0.0020	--	1,350	
631		24" RCP	2-yr	12	0.0033	--	2,150	
South of Bell Road		618	4'x26' RCBC	100-yr	782	*	--	1,200
	629	90" RCP	100-yr	527	*	--	1,200	
	630	54" RCP	2-yr	75	0.0012	--	2,100	

\*Design by UEFCC ADMS



- LEGEND**
- CONDUIT
  - OPEN CHANNEL
  - DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER

- OPEN CHANNELS**
- |        |           |
|--------|-----------|
| TW=20' | TOP WIDTH |
| D=3'   | DEPTH     |
- FACILITIES PROPOSED BY THIS STUDY
  - PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 8**  
**SELECTED PLAN**  
**DRAINAGE AREA 687**

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner Engineering**

**Drainage Area 7:** Drainage Area 7 is the eastern portion of the East Fork of Cave Creek Wash watershed. Drainage and flood control facilities proposed by the UEFCC ADMS were incorporated by Greiner for this area. The facilities are designed for the 100-year frequency storm event and no additional facilities were determined to be required for the 2-year frequency event. The selected facilities west of Cave Creek Road are within the jurisdiction of the City of Phoenix. Facilities east of Cave Creek Road and north of Bell Road are within County jurisdiction. Conduit sizes and alignments are subject to change pending final approval of the UEFCC ADMS.

The drainage/flood control facilities developed by the UEFCC ADMS are comprised of two separate drainage systems conveying runoff to the proposed Greenway Parkway flood control channel located south of Bell Road between Cave Creek Road and Cave Creek.

One system intercepts flows in the primary floodplain of the East Fork of Cave Creek Wash. The system consists of a detention basin located along the northern right-of-way of Beardsley Road at 26th Street (not shown on Plate 9) and a basin located at the northwest corner of Grovers Avenue and Cave Creek Road. The latter basin discharges into an open channel which conveys flows along 20th Street to the Greenway Parkway channel. A storm drain extending from 28th Street to 20th Street along Bell Road discharges flows into a channel at 20th Street. A culvert will be required at 20th Street and Bell Road to convey channel flows.

The second system is comprised of storm drains along Union Hills Drive, Grovers Avenue, Bell Road and Paradise Lane that conveys runoff to a storm drain along 32nd Street. A detention basin will be located south of Paradise Lane between Cave Creek Road and 26th Street. Outflows from this basin will discharge into the Greenway Parkway channel. The existing 60" storm drain located along 32nd Street between Hartford Avenue and the IBW will remain.

The proposed Squaw Peak Parkway will follow the alignment of 38th Street through Drainage Area 7 north of Bell Road. The Parkway is scheduled for completion to Bell Road in 1997. According to information provided by the County, the drainage facilities associated with the Parkway will remain independent of the Bell Road Project facilities.

On-site Runoff: On-site runoff from Bell Road in Drainage Area 7 will be picked up by the facilities developed for off-site runoff.

Refer to Plates 8 and 9 for schematics of the on-site and off-site facilities developed for Drainage Area 7. Refer to Sheets 25, 26 and 27 of the Preliminary Concept Drainage Plans in Section IX for more detail. Refer to Table 7 for the summary of structures. The discharge values shown in Plates 8 and 9 for the 100-year frequency storm were developed by the UEFCC ADMS.

The selected stormwater/floodwater facilities for Drainage Area 7 are effective in intercepting and conveying the design flows to adequate outfalls. At the direction of the Flood Control District, the potential for adverse environmental impacts were only evaluated for the facilities along Bell Road. There will be no long-term adverse impacts. There will be minor, short-term impacts associated with construction of the drainage facilities including noise, dust, disruption of traffic and access to businesses.

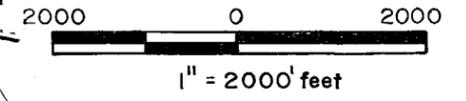
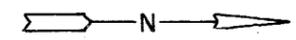
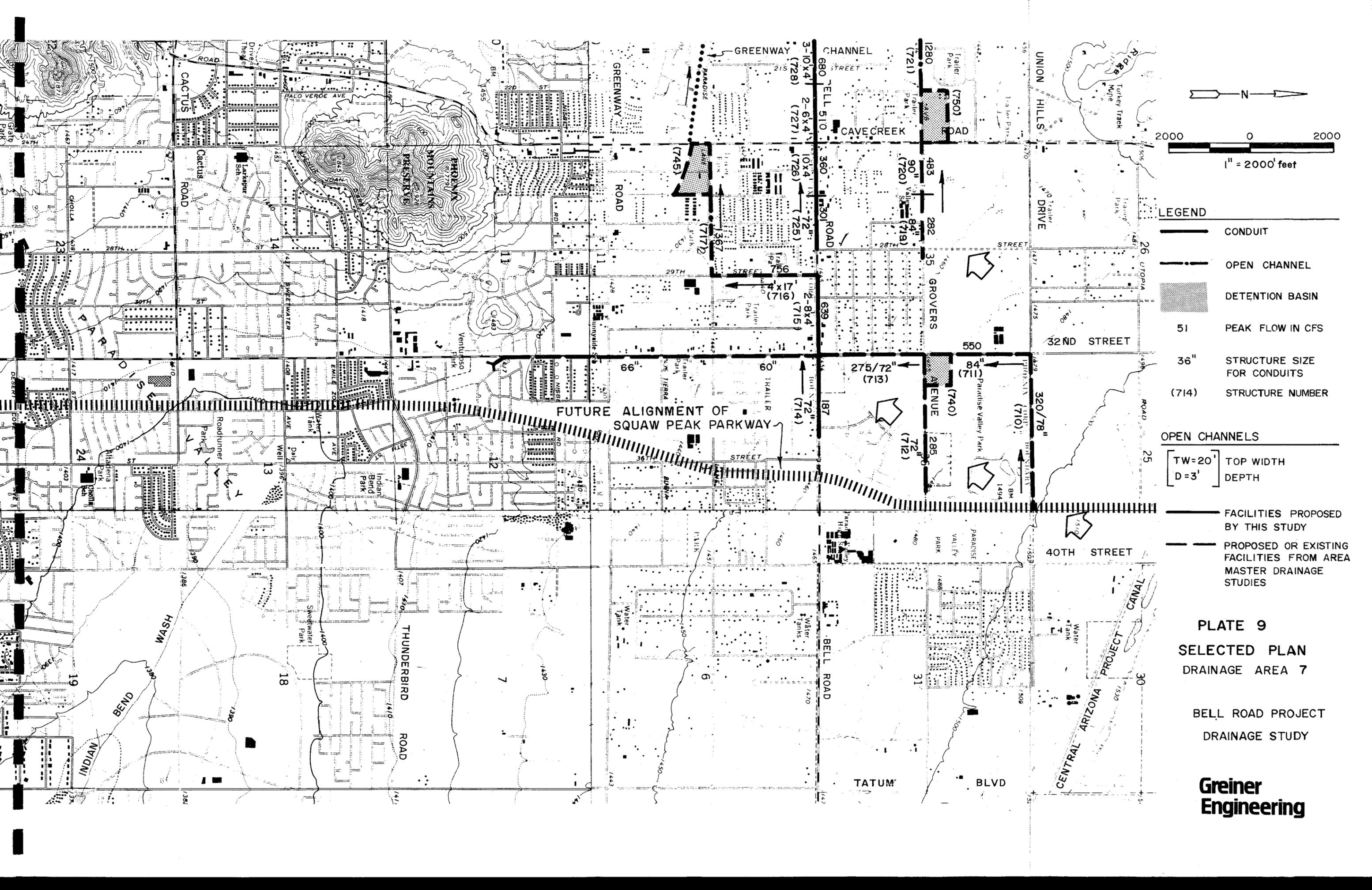
An agreement to implement the recommendations of the UEFCC ADMS has not yet been concluded by the City and County. For the purpose of this study (BRPD) jurisdiction for the facilities was assumed to conform to the delineated jurisdictional boundaries. It is possible, however, that there will be more County involvement in the design, construction and funding of facilities within the City or visa-versa.

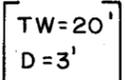
TABLE 7

**STRUCTURE SUMMARY  
DRAINAGE AREA 7**

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	750	Basin	100-yr	101	--	--	--
	721	Channel	100-yr	1,280	*	*	1,500
	722	54" RCP	100-yr	167	*	*	2,640
	723	Channel	100-yr	1,328	*	*	2,640
	710	78" RCP	100-yr	320	*	--	5,200
	711	84" RCP	100-yr	550	*	--	2,640
	712	72" RCP	100-yr	285	*	--	2,640
	713	72" RCP	100-yr	225	*	--	2,640
	719	84" RCP	100-yr	282	*	--	1,400
	720	90" RCP	100-yr	483	*	--	1,320
	740	Basin	100-yr	73	--	--	--
Along Bell Bell Road	714	72" RCP	100-yr	187	0.0020	--	2,240
	715	2-8'x4' RCBC	100-yr	639	0.0020	--	2,000
	725	72" RCP	100-yr	301	0.006	--	1,330
	726	10'x4' RCBC	100-yr	360	0.0060	--	1,310
	727	2-6'x4' RCBC	100-yr	510	0.0020	--	1,300
	728	3-10'x4' RCBC	100-yr	680	0.0020	--	1,360
	730	2-8'x6' RCBC	100-yr	1,378	0.001	--	110
South of Bell Road	724	Channel	100-yr	1,866	*	*	2,900
	716	4'x17' RCBC	100-yr	756	*	--	2,640
	717	Channel	100-yr	1,367	*	*	2,100
	745	Basin	100-yr	*	--	--	*

\*Design by UEFCC ADMS



- LEGEND**
-  CONDUIT
  -  OPEN CHANNEL
  -  DETENTION BASIN
  - 51 PEAK FLOW IN CFS
  - 36" STRUCTURE SIZE FOR CONDUITS
  - (714) STRUCTURE NUMBER
- OPEN CHANNELS**
-  TOP WIDTH  
DEPTH
  -  FACILITIES PROPOSED BY THIS STUDY
  -  PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 9**  
**SELECTED PLAN**  
**DRAINAGE AREA 7**

BELL ROAD PROJECT  
 DRAINAGE STUDY

**Greiner**  
**Engineering**

**Drainage Area 8:** Drainage Area 8 is within the jurisdictions of the City of Phoenix and Maricopa County. The south right-of-way of Bell Road generally serves as the jurisdictional boundary between the two, except where the City has annexed development north of Bell Road. The selected storm drain facilities are a modification of Alternate 1 presented in the Alternate Stormwater/Floodwater Management Concept Plans report. The modifications were made to bring the selected system into conformity with the NAMSD plan adopted by the City of Phoenix. All of the selected facilities have been identified as being within the jurisdiction of the City of Phoenix including those within County rights-of-way. These facilities are all designed for the 2-year frequency storm per the NAMSD.

Major off-site stormwater runoff concentration points along Bell Road are at 36th Street, 40th Street, 44th Street, Tatum Boulevard (48th Street), 52nd Street and 56th Street. Per the NAMSD, trunk storm drains have been set along these streets. The storm drain along 40th Street has already been installed to Bell Road. Laterals along Bell Road and north of Bell Road have also been incorporated as necessary to intercept off-site flows. Off-site runoff from areas east of 60th Street (one-half mile east of 56th Street) to Scottsdale Road will continue to concentrate along the north Bell Road right-of-way at the existing culverts for conveyance south under Bell road. These culverts were found to be adequate for the design flows.

**On-site Runoff:** On-site runoff generated from Bell Road between 36th Street and 60th Street will be intercepted by catch basins and conveyed to the storm drains for off-site runoff. Runoff from the north half right-of-way of Bell Road between 60th Street and Scottsdale Road will be conveyed to a grader ditch along the north right-of-way that will convey flow to the existing culverts under Bell Road. On-site runoff from the Bell Road and Scottsdale Road intersection will flow south along the west shoulder of Scottsdale Road (which has no curb) to Greenway Road where it will be picked up by an existing storm drain. Runoff from the south half of the Bell Road right-of-way between 60th Street and Scottsdale Road will continue to turn southward at every street opening. This runoff will be conveyed either by

streets or existing drainageways to the proposed detention basin at 68th Street and Tierra Buena (not shown on the Plate).

Refer to Plates 10 and 11 for schematics of the proposed on-site and off-site facilities. Refer to Sheets 31, 32 and 33 of the Preliminary Concept Drainage Plans in Section IX for more detail of the facilities along Bell Road. Refer to Table 9 for the structures summary.

The selected stormwater/floodwater facilities for Drainage Area 8 are effective in intercepting and conveying runoff to adequate outfalls. The storm drain systems along 36th Street, 40th Street, 44th Street, Tatum Boulevard, 52nd Street and 56th Street outfall at the Indian Bend Wash project (IBW) which has been designed for the 100-year frequency storm event.

There will be no adverse long-term environmental impacts. There will be minor short-term impacts associated with construction of the drainage facilities including noise, dust, disruption of traffic and access to businesses. These impacts should be mitigated at the 40th Street and Bell Road location of the Humana Hospital. Two hawks were noted in the area along Bell Road between 43rd Street and Tatum Boulevard. Construction may disturb their habitat or nesting site.

Monitoring of construction should be considered. Environmental planners should be consulted by the section designers as to methods for mitigating any adverse impacts.

TABLE 8

**STRUCTURE SUMMARY  
DRAINAGE AREA 8**

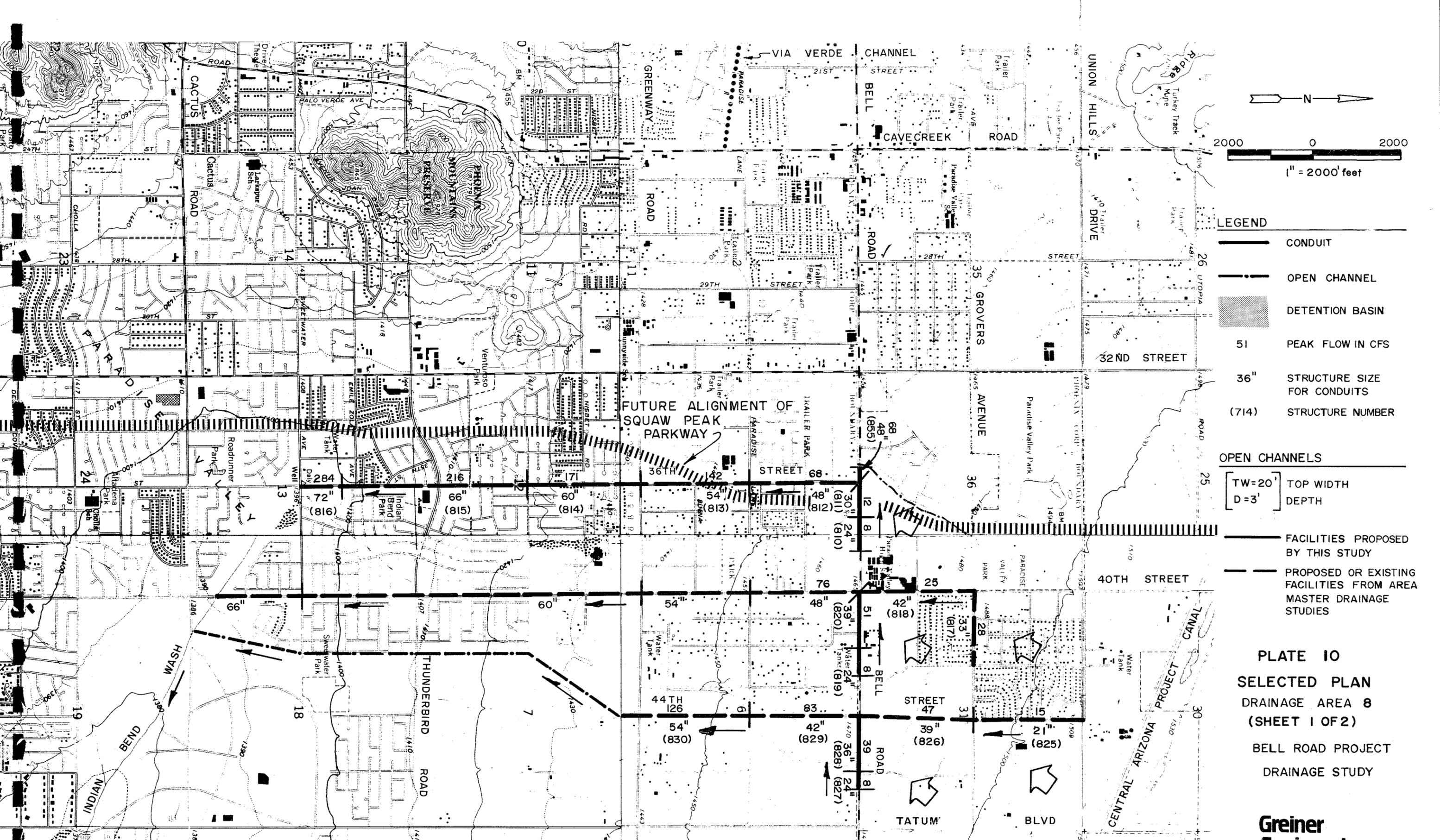
<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
North of Bell Road	817	33" RCP	2-yr	28	*	--	1,800
	818	42" RCP	2-yr	25	*	--	2,640
	825	21" RCP	2-yr	15	*	--	2,640
	826	39" RCP	2-yr	47	*	--	2,640
	831	30" RCP	2-yr	12	*	--	1,320
	832	30" RCP	2-yr	12	*	--	2,640
	842	30" RCP	2-yr	12	*	--	1,320
	843	30" RCP	2-yr	12	*	--	2,630
Along Bell Road	810	24" RCP	2-yr	8	0.0015	--	720
	811	30" RCP	2-yr	12	0.0020	--	920
	819	24" RCP	2-yr	8	0.0039	--	630
	820	39" RCP	2-yr	51	0.0050	--	1,300
	827	24" RCP	2-yr	8	0.0020	--	400
	828	36" RCP	2-yr	39	0.0020	--	1,300
	833	18" RCP	2-yr	6	0.0030	--	280
	834	39" RCP	2-yr	45	0.0030	--	1,300
	844	18" RCP	2-yr	5	0.0030	--	340
	845	30" RCP	2-yr	12	0.0030	--	1,300
	855	48" RCP	2-yr	68	0.0117	--	300
	861	18" RCP	2-yr	8	0.0034	--	940
	862	30" RCP	2-yr	20	0.0070	--	830
	863	42" RCP	2-yr	42	0.0044	--	860
South of Bell Road	812	48" RCP	2-yr	68	*	--	2,640
	813	54" RCP	2-yr	142	*	--	2,640
	814	60" RCP	2-yr	171	*	--	2,640
	815	66" RCP	2-yr	216	*	--	4,350
	816	72" RCP	2-yr	284	*	--	1,000
	829	42" RCP	2-yr	83	*	--	2,640
	830	54" RCP	2-yr	126	*	--	3,100
	835	39" RCP	2-yr	61	*	--	2,640
	836	48" RCP	2-yr	96	*	--	2,640

TABLE 8 CONTINUED

STRUCTURE SUMMARY  
DRAINAGE AREA 8

<u>Location</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Design Frequency</u>	<u>Discharge/ Volume (cfs/AF)</u>	<u>Slope (ft./ft.)</u>	<u>Channel Depth/TW (ft.)</u>	<u>Length (ft.)</u>
South of Bell Road	837	54" RCP	2-yr	127	*	--	2,640
	838	54" RCP	2-yr	147	*	--	2,640
	846	36" RCP	2-yr	43	*	--	2,640
	847	42" RCP	2-yr	90	*	--	2,640
	848	54" RCP	2-yr	110	*	--	2,640
	849	54" RCP	2-yr	150	*	--	2,640
	850	54" RCP	2-yr	183	*	--	2,640
	851	66" RCP	2-yr	200	*	--	2,640
	852	66" RCP	2-yr	224	*	--	2,640
	853	72" RCP	2-yr	250	*	--	2,200
864	42" RCP	2-yr	42	*	--	11,880	

\*Design by NSDS

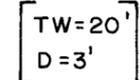


2000 0 2000  
 1" = 2000' feet

**LEGEND**

-  CONDUIT
-  OPEN CHANNEL
-  DETENTION BASIN
- 51 PEAK FLOW IN CFS
- 36" STRUCTURE SIZE FOR CONDUITS
- (714) STRUCTURE NUMBER

**OPEN CHANNELS**

-  TOP WIDTH  
DEPTH
-  FACILITIES PROPOSED BY THIS STUDY
-  PROPOSED OR EXISTING FACILITIES FROM AREA MASTER DRAINAGE STUDIES

**PLATE 10**  
**SELECTED PLAN**  
**DRAINAGE AREA 8**  
**(SHEET 1 OF 2)**  
**BELL ROAD PROJECT**  
**DRAINAGE STUDY**

**Greiner**  
**Engineering**



**Drainage Area 9:** Drainage Area 9 is the Skunk Creek channel crossing of Bell Road. It was determined from the current flood boundary maps, dated 1983, that the 100-year flood is contained within the Skunk Creek Channel at Bell Road. Therefore, no drainage facilities or improvements to the existing bridge are proposed. Refer back to the discussion under Drainage Area 4 for the storm drain outfall to Skunk Creek.

Drainage Area 10: Drainage Area 10 is the Cave Creek channel crossing of Bell Road. According to the floodplain maps, dated April 25, 1978, the 100-year flood would inundate approximately 900 feet of Bell Road. A proposal has been made for channel and floodplain improvements on the property north of Bell Road along Cave Creek to contain the 100-year flood within the channel and bridge crossing. This proposal was reviewed by the Maricopa County Highway Department Management Consultant for the Bell Road expansion and they determined that the channelization would be adequate to achieve the stated goal. The 100-year flood would be contained within the channel banks at Bell Road. At the Management Consultants and Flood Control Districts direction, no drainage facilities or improvements to the existing bridge were proposed because of the above. Specific measures to protect the bridge from scour may be required at the time of final design according to the Management Consultant. The bridge protection work can be accomplished independently of the Bell Road Project improvements developed by the BRPD study.

## IX. PRELIMINARY CONCEPT DRAINAGE PLANS

Preliminary plans of the selected stormwater/floodwater facilities for Bell Road were developed. The plans include sizes, slopes, profiles, alignments and locations as appropriate for channels, pipes, trunk mains, culverts and detention basins. The plans were prepared initially on 1"=200' scale plan and profile sheets prior to reduction for inclusion in this report.

The plan view is an aerial photograph base developed from a 1986 fly-over of Bell Road. The aerial provides coverage of approximately 800 feet on each side of the Bell Road centerline. Shown in the plan view are the names of major streets and other special features, Bell Road rights-of-way limits, Bell Road centerline with 500 foot station ticks, jurisdictional boundaries, existing drainage facilities, floodplain limits and the drainage facilities proposed by the BRPD study. Bell Road rights-of-way limits were obtained from current City Quarter Section Maps and Maricopa County Assessor maps. Jurisdictional boundaries along Bell Road were provided by the street maintenance departments from the participating municipalities and the County Highway Department. Jurisdictional boundaries were also obtained from County Assessor maps and subsequently verified with maps provided by the Bell Road Management Consultant. Existing drainage facilities were inventoried in the field and verified with as-built plans where necessary.

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 and the local jurisdictions.

In the profile, the existing ground profile at the centerline of Bell Road is shown along with major street crossings, bridge profiles, the cross-section and location of existing crossing drainage structures, the cross-section and location of utilities crossing Bell Road and the profiles of the proposed Bell Road drainage facilities.

The existing ground profile at the centerline of Bell Road was obtained from the as-built plans for Bell Road provided to Greiner by the County Highway Department. As-built plans for the bridges at the Agua Fria River, New River, Skunk Creek and Cave Creek were also obtained from the County Highway Department. The location and cross-sections of cross-culverts on Bell road were also obtained from these as-built plans and verified in the field. Quarter section maps for water, sanitary sewer, gas, buried and overhead electric lines and cable TV were obtained. The as-built plans for storm drains and critical utilities were also obtained wherever necessary. Shown in cross-section are water lines 12" and larger in size, all sanitary sewers, major electric lines, gas lines greater than 6" in diameter and all high pressure lines crossing Bell Road.

For the purpose of these plans, the survey line intersection point of the Grand Avenue and Bell Road centerlines was established as the starting station of 10+00 with the stationing increasing from west to east. The stationing was established with no field control and is not intended for design or construction purposes. This stationing does not necessarily correspond to the stationing on the roadway as-built plans.

The horizontal alignment of storm drains along Bell Road was set to avoid utility conflicts and conflicts with proposed roadway features of the Bell Road expansion. The travel lanes of the north half of Bell Road was found to be free of conflicts with paralleling utilities. The centerline of the proposed storm drains was set at five feet north of the Bell Road centerline. This alignment minimizes the potential for conflict with existing or future utilities.

The vertical profiles of the proposed storm drains were set to provide adequate cover for the structure to ensure position drainage to the outfalls; ensure that the hydraulic grade line of the main storm drain would 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, slopes and design discharges are provided in profile. The locations of manholes and catch basins tying into the storm

drains are minor feature and are not shown. The locations of special junction structures and catch basins with laterals tying into existing drainageways, however, are shown.

On the following pages, the features of the proposed drainage facilities are reviewed on a sheet by sheet basis. The plan sheets are found 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 used by Greiner for establishing the vertical alignment; potential utility conflicts; and necessary coordination with other agencies or consultants. General roadway design guidance is also provided where necessary to ensure that the roadway expansion project will not create or worsen drainage problems either upstream or downstream of the roadway. Sheets 1 and 2 are the cover and index sheets for the plan set.

#### Sheet 3 (Station 10+00 to Station 52+00)

The existing 24" RCP at Station 12+00 and the 36" RCP at Station 13+70 have adequate capacity for the two-year design discharge. They may need to be lengthened or replaced in kind to accommodate the roadway improvements. The inlet and outlet of the proposed 36" RCP at Station 14+30 should be set to match existing ground. Discharges from this culvert should continue to flow along the north right-of-way of the Atchison-Topeka and Santa Fe Railroad. The proposed 24" - 30" storm drain from Station 18+00 to approximately Station 44+40 will tie into the existing private gunite drainageway north of Bell Road. A prior agreement with the developer of Sun City West and a temporary construction easement will be required.

#### Sheet 4 (Station 52+00 to Station 94+00)

No off-site runoff impacts this section of Bell Road. From Station 49+00 (sheet 3) to Station 100+00 (sheet 5), catch basins will be set at approximately 500-foot intervals to intercept on-site drainage with laterals to discharge flows into the existing private gunite drainageway along the north side of Bell Road. The catch basin intervals were set based on the pavement

spread criteria for street flow. These intervals were set on a uniform pavement cross-slope of two percent and a constant longitudinal roadway slope. The intervals will have to be adjusted to reflect final design cross-slopes and longitudinal slopes. A prior agreement with the developer of Sun City West and a temporary construction easement will be required.

#### Sheet 5 (Station 94+00 to Station 136+00)

The bridge over the Agua Fria River was determined to have the capacity to convey the 100-year flood. The adequacy of bridge deck drainage was not evaluated; however, the catch basins at Station 100+00 and Station 117+00 should have the capacity to intercept runoff from the bridge deck.

The catch basins between Station 117+00 and Station 137+00 (sheet 6) will discharge into an existing earthen drainageway north of Bell Road. This drainageway also intercepts off-site flows from the north and diverts them to the Agua Fria River. At the time of final design and prior to construction, an agreement will have to be obtained from the property owner to maintain the drainageway and ensure that a positive outfall to the Agua Fria River is kept open. Ponding behind the bridge spur dike should be prevented through proper grading. The double 16'x12' concrete box culvert equipment pass at Stations 123+30 should remain.

#### Sheet 6 (Station 136+00 to Station 178+00)

No off-site runoff impacts this section of Bell Road. Catch basins will be set to intercept roadway drainage for conveyance to the existing private gunite drainageway north of Bell Road. The location of the catch basins at Station 162+00 will have to be adjusted to avoid conflict with a 6" high pressure gas line and a 12" sanitary sewer line. An agreement and temporary construction easements will have to be obtained from the developer of Sun City to tie into the drainageway.

The double 9'x5' box culvert at Station 142+00 (115th Avenue alignment) conveys flows from the gunite drainageway and is to remain.

Sheet 7 (Station 178+00 to Station 220+00)

No off-site runoff impacts this section of Bell Road. From Station 178+00 to Dell Webb Boulevard, catch basins will be set to intercept roadway drainage for conveyance to the existing private gunite drainageway north of Bell Road.

From Station 200+70 to Station 220+00, a 24" - 36" storm drain will convey stormwater runoff to the east. A prior agreement with the developer of Sun City and a temporary construction easement will be required.

Sheet 8 (Station 220+00 to Station 262+00)

No off-site runoff impacts this section of Bell Road. The 36" storm drain described under Sheet 7 will tie into the existing 48" storm drain at approximately Station 224+80. This storm drain is located along the south right-of-way of Bell Road and discharges into the existing private gunite drainageway along 99th Avenue. Laterals extend northward from the 48" storm drain along 105th Avenue and Boswell Boulevard. The 48" storm drain and its laterals are set shallow, thereby precluding the use of a separate storm drain for the Bell Road project. At the time of final design, a hydrologic and hydraulic analysis should be performed of the complete system to ensure no adverse impacts to the 48" storm drain and its laterals. Because the proposed 24" - 36" storm drain is set shallow, it may have to be oversized to ensure that the hydraulic grade line is within the freeboard limits of the catch basins that will tie into this storm drain.

From the 99th Avenue Station 272+15 (sheet 9), a 24" - 36" storm drain will convey street runoff westward to the existing private gunite drainageway at 99th Avenue.

Sheet 9 (Station 262+00 to Station 304+00)

No off-site runoff impacts this section of Bell Road. Future development of the vacant land east of Sun City will be required to adhere to the City of

Peoria's policy requiring on-site detention of the 10-year frequency storm. A 24" - 36" storm drain from Station 282+20 to 91st Avenue (Sheet 10) will convey roadway drainage to the proposed open channel at 91st Avenue. This channel will convey runoff to the New River at Greenway Road. The existing roadway dip crossing at Station 300+00 conveys runoff from the undeveloped land north of Bell Road to an earthen drainageway south of Bell Road. A determination should be made at the time of final design as to whether development plans are in progress for the vacant land north of Bell Road and whether runoff from the site can be picked up by the proposed storm drain along Bell Road. The dip in the road may be eliminated and excess flows from the site may be allowed to flow east on Bell Road and discharge into the proposed channel at 91st Avenue through curb openings.

Sheet 10 (Station 304+00 to Station 352+00)

Major off-site runoff concentration points are at 91st Avenue, 89th Avenue and 87th Avenue. An open channel will be set along the 91st Avenue alignment to accept discharges from the 36" storm drain to the west, a 30" storm drain from the north and a 48" storm drain from the east. The invert of the channel should be set at the time of final design to ensure adequate cover for the three contributing storm drains. At the time of construction of the Bell Road project, a 30" stub out can be constructed along 91st Avenue to the Bell Road right-of-way and plugged for future completion at the time of implementation of the Glendale-Peoria ADMS.

The 48" storm drain between 91st Avenue and 89th Avenue and the 42" - 54" storm drain between 87th Avenue and New River should be designed in coordination with the future development of the vacant land north of Bell Road. Stub outs may be required for laterals along 89th Avenue, 87th Avenue and other future street alignments to the north.

The 42" - 54" storm drain conveying stormwater to the New River may have to be oversized at the time of final design to ensure the hydraulic grade line remains within the freeboard requirements of future catch basins along Bell Road.

Erosion protection measures at the storm drain outlet may be required to protect the New River bridge and the storm drain outfall. It was determined from current floodplain maps that the New River bridge can convey the 100-year discharge in the New River within the channel banks. No determination has been made as to the stability of the river bed or banks. Coordination with the Outer Loop Highway project will be required. The highway will parallel the New River along its east bank. An interchange with Bell Road will be constructed. It is possible that the Outer Loop Highway will require a drainage outfall to the New River along Bell Road. However, it is anticipated that the Bell Road Project and Outer Loop Highway drainage facilities will be independent of each other.

Sheet 11 (Station 352+00 to Station 394+00)

No significant off-site flows impact this section of Bell Road. A 30" storm drain is proposed to convey roadway drainage from Station 385+50 westward to the New River. It is recommended that the existing 36" CMP at Station 335+70 and the 18"x29" CMP at Station 366+50 remain until the final design plans for the Outer Loop Highway and the realignment of 83rd Avenue have been reviewed. It may also be possible to eliminate the dip crossing at 83rd Avenue. It was assumed for the Bell Road Project Drainage Study that the citrus orchard north of Bell Road between 83rd Avenue and 75th Avenue (Sheet 12) will be master planned for commercial development with a single drainage outlet at the approximate 77th Avenue alignment (Station 396+00, Sheet 12). The dip crossing at Station 382+00 should remain.

Sheet 12 (Station 394+00 to Station 436+00)

Major concentration points for off-site runoff are located at the 77th Avenue alignment (Station 395+00) and at 75th Avenue. A 72" storm drain will extend along Bell Road from 75th Avenue to 77th Avenue to pick up off-site flows concentrating at that location. This storm drain will tie into a double 6'x6' box culvert at 75th Avenue that heads south along 75th Avenue to Skunk Creek. A 30" storm drain will extend from 75th Avenue eastward to Station 423+20 to convey roadway drainage to the double 6'x6' box culvert. A 72" storm drain extending north of Bell Road along 75th Avenue will also

tie into the double 6'x6' box culvert at Bell Road. For the purpose of the Bell Road project, the double 6'x6' box culvert outfall to Skunk Creek will have to be constructed in conjunction with the 72" and 30" storm drains along Bell Road. A 72" stub out can be constructed to the north Bell Road right-of-way to accommodate future construction of the 72" storm drain along 75th Avenue north of Bell Road.

The upstream invert of the double 6'x6' box culvert should be set as low as possible with respect to the outfall at Skunk Creek to maximize the available cover for the 72" storm drain along Bell Road.

It was determined from current floodplain maps of Skunk Creek that the 100-year flow is contained within the bank of Skunk Creek at Bell Road. No determination has been made as to river bed or bank stability. Erosion protection should be evaluated for the 30" storm drain outfall at the east bank. The need for bridge widening should be evaluated by the section designers.

#### Sheet 13 (Station 436+00 to Station 478+00)

Major off-site flows concentrate at 67th Avenue. The 24" - 30" storm drain west of 67th Avenue and outfalling at Skunk Creek (Sheet 12) is for conveying roadway drainage. A 66" storm drain (continuation from Sheet 14) will convey on-site and off-site flows to a 72" storm drain at 67th Avenue. This outfall was adopted by the City of Glendale SWMP. No date has been set for its construction. The vertical profile of the 66" storm drain and 72" outfall were set to avoid the 12" water line at 67th Avenue. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch.

Sheet 14 (Station 478+00 to Station 520+00)

Major off-site concentration points along Bell Road are at 63rd Avenue, 61st Avenue and 59th Avenue. A 24" - 30" - 66" storm drain will convey on-site and off-site stormwaters to the 72" outfall at 67th Avenue (Sheet 13). The vertical profile of the storm drain was set sufficiently deep to avoid the 12" waterline at 63rd Avenue. At the time of final design, stub outs may be provided for future laterals along 63rd Avenue and 61st Avenue to extend north of Bell Road. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch.

A 24" storm drain will extend along Bell Road east of 59th Avenue (continuation from Sheet 15). The storm drain will tie into a 60" outfall at 59th Avenue. The outfall storm drain continues south along 59th Avenue to the ACDC. Diversions into detention basins occur at two locations along this outfall. The alignment of the 60" outfall should be set east of the 59th Avenue centerline to avoid a 30" waterline. At the time of construction, a 54" stub out should be provided along 59th Avenue to accommodate a storm drain proposed by the Glendale SWMP. No date has been set for the construction of the outfall. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch.

Sheet 15 (Station 520+00 to Station 568+00)

Major off-site flows concentrate along Bell Road at 55th Avenue and 51st Avenue. No off-site flows impact Bell Road between 55th Avenue and 51st Avenue. A 24" storm drain will convey on-site stormwater flows to the 59th Avenue outfall (Sheet 14). Off-site flows from 55th Avenue will be diverted by a future project into a detention basin located along Bell Road between 57th Avenue and 55th Avenue as proposed by the Glendale SWMP. Basin

outflows will be metered out to the 24" Bell Road storm drain. A stub out will also be provided for the future detention basin.

The vertical profile of the Bell Road storm drain was set to avoid a 10" sanitary sewer at 57th Avenue and a 12" waterline at 55th Avenue. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch.

A 30" storm drain will extend east from 51st Avenue (continuation from sheet 16) and tie into the proposed 36" storm drain along 51st Avenue. This storm drain conveys stormwater flows to the ACDC. The 36" storm drain is scheduled for completion to Bell Road during 1988-1989. At the time of construction of the Bell Road project improvements, a 33" stub out should be provided for the continuation of the 51st Avenue storm drain north of Bell Road.

Sheet 16 (Station 568+00 to Station 610+00)

No off-site flows impact this section of Bell Road. A 24" - 30" storm drain along Bell Road will convey roadway drainage to the 51st Avenue storm drain.

Sheet 17 (Station 610+00 to Station 652+00)

Major off-site flows concentrate along Bell Road at 43rd Avenue and 39th Avenue. A 24" - 42" storm drain (continued from Station 660+50, Sheet 18) will convey on-site and off-site flows to a 60" storm drain located at 43rd Avenue. The 43rd Avenue storm drain will convey stormwater flows to the ACDC. The 60" storm drain is scheduled for completion to Bell Road during 1988-1989. At the time of construction, a 48" stub out should be provided for the continuation of the 43rd Avenue storm drain north of Bell Road. The vertical profile of the 42" storm drain along Bell Road was set to avoid a 12" water line and a 21" sanitary sewer at 43rd Avenue. A 24" sanitary sewer at 39th Avenue should be avoided.

Sheet 18 (Station 652+00 to Station 694+00)

Major off-site flows concentrate at Bell Road and 35th Avenue. A 36" storm drain (continued from Station 697+50, Sheet 19) will convey on-site and off-site stormwater runoff to a proposed 60" storm drain at 35th Avenue. This storm drain will convey stormwater flows to the ACDC. The vertical profile of the 36" storm drain along 35th Avenue was set deep enough to avoid utility conflicts at 35th Avenue and at Station 676+00, Station 683+70, Station 688+40 and Station 692+80 with the sanitary sewers.

The 60" storm drain along 35th Avenue is scheduled for construction to Bell Road in 1988-1989. At the time of construction of the Bell Road facilities, a 60" stub out should be provided for the continuation of the 35th Avenue storm drain north of Bell Road.

Sheet 19 (Station 694+00 to Station 736+00)

From Station 698+50 to Station 610+50, a 24" - 36" storm drain will convey roadway to the proposed 35th Avenue storm drain (Sheet 18). The vertical profile of the 24" storm drain was set to avoid conflicts with utilities at 31st Avenue and 29th Avenue. A drop structure will be required at 31st Avenue at the junction of the 24" and 36" storm drains.

From Station 718+00 to Station 736+00, roadway drainage flows into the depressed section of Bell Road under I-17 where it will be intercepted by the existing catch basins and pumped out by the existing pumps recently rated at 94% of the 25-year storm inflow rate. Any modifications to the existing drainage system within the depressed section of Bell Road will have to be coordinated with ADOT. The 42" storm drain shown parallel to the I-17 northbound off-ramp will cross I-17 at approximately I-17 Station 625+00 and discharge into the existing drainageway paralleling the west side of I-17. Installation of this storm drain will also have to be coordinated with ADOT.

The roadway dip crossing at 31st Avenue should be maintained to permit runoff in excess of the storm drain design to continue to cross Bell Road to the south. The double 6'x3' box culvert at approximately Station 719+00 serve the drainageway along the west side of I-17 and should remain.

Sheet 20 (Station 736+00 to Station 778+00)

Off-site runoff concentrates along Bell Road at 21st Avenue and 19th Avenue. An 18" - 42" storm drain will convey on-site and off-site stormwater flows west to the drainageway on the west side of I-17 as described under Sheet 19. The vertical profile of the 18" - 42" storm drain was set to avoid major utility conflicts at 23rd Avenue, 21st Avenue and at Station 763+70. It is recommended that the existing 42" pipe culvert at Station 738+80 remain or be replaced in kind to convey flows in excess of the design storm frequency across Bell Road to the south. The existing 90" storm drain at 19th Avenue with a 42" stub out to the east along Bell Road will be discussed under Sheet 21. It is recommended that the double 22"x36" pipe culvert at 19th Avenue and Bell Road remain or be reconstructed to convey flows in excess of the design storm frequency across Bell Road along 19th Avenue.

Sheet 21 (Station 778+00 to Station 820+00)

Minor off-site flows concentrate along Bell Road at 17th Avenue and 15th Avenue. On-site roadway drainage from a high point at Station 816+50 carries runoff to the west toward 15th Avenue. A 24" - 33" - 42" storm drain will convey on-site and off-site stormwater flows to the 42" stub out from the existing 90" storm drain along 19th Avenue. The vertical profile of the storm drain along Bell Road was fixed by the upstream invert of the existing 42" stub out and the need to avoid conflicts with sanitary sewers at Station 783+70, Station 788+60, Station 795+10 and Station 801+50. At the time of construction of the Bell Road facilities, stub outs may be provided for minor laterals to extend north of Bell Road along 17th Avenue and 15th Avenue.

Sheet 22 (Station 820+00 to Station 862+00)

Major off-site flows concentrate at Cave Creek and Central Avenue. According to current floodplain maps of Cave Creek, the 100-year flood breaks out of the channel and covers approximately 900 feet of Bell Road. The developer of the vacant land north of Bell Road and west of 3rd Avenue is proposing to modify the Cave Creek channel and construct dikes so as to convey all 100-year flows in Cave Creek within the channel banks and through the Bell Road bridge. No modifications to the bridge over Cave Creek were, therefore, proposed by the BRPD study at the directions of the Flood Control District. The Bell Road Project Management Consultant has expressed the need for some erosion protection measures for the bridge.

A 24" storm drain will convey on-site runoff generated along Bell Road between Cave Creek and Central Avenue. The horizontal alignment of the storm drain was set to circumvent the existing double 6'x4' box culvert at Station 831+50. The vertical profile was established to avoid utility conflicts at Seventh Avenue. It is recommended that the double 6'x4' box culvert remain to convey off-site flows under Bell Road.

From Station 854+50 to Third Street (sheet 23), a 42" storm drain will convey off-site runoff concentrating at Third Street to a proposed 54" storm drain along Central Avenue. The profile of the 42" storm drain was set to avoid the existing double 10'x5' box culvert at Station 856+00 and the 10'x5' box culvert at Station 859+50. The invert of the 54" storm drain was set to avoid conflicts with 8" water lines and a 12" sanitary sewer at the Central Avenue and Bell Road intersection. The 54" storm drain will convey runoff to the proposed Greenway Parkway channel project, which is scheduled for completion in 1989. The design of the 54" storm drain will have to be coordinated with the design of the Greenway Parkway project to ensure that positive drainage is maintained.

At the time of final design for the 54" storm drain, provisions should be made for intercepting the 15 cfs that are flowing down Central Avenue. A stub out for a small lateral to extend along Central Avenue north of Bell

Road may have to be provided at the time of construction of the Bell Road facilities. The double 10'x5" box culvert and the 10'x5' box culvert should remain to provide drainage relief for flows in excess of the design storm frequency concentrating at the north right-of-way of Bell Road east of Central Avenue.

Sheet 23 (Station 862+00 to Station 904+00)

Major off-site concentration points are located at Seventh Street and Ninth Street. The Upper East Fork of Cave Creek ADMS (UEFCC, ADMS) is an on-going study that is proposing flood control measures for the 100-year frequency stormwaters from Seventh Street to 34th Way (Sheet 27). The structures developed by this study were incorporated into the Bell Road project at the direction of the Flood Control District. On-site runoff in the UEFCC ADMS study area will either be intercepted by facilities recommended by that study or by 2-year storm frequency storm drains developed by the Bell Road Project Drainage Study (BRPD). Supplemental 18" storm drains for on-site drainage are required east of Third Street (Third Street to Station 871+00) and east of Seventh Street (Seventh Street to Station 884+00). The inverts of the Seventh Street and Ninth Street storm drains should be set at the time of final design to avoid both utility conflicts and to ensure positive drainage to the Greenway Parkway channel. The channel is scheduled for completion in 1989. At the time of construction of the Bell Road facilities, stub outs should be provided to allow for the continuation of the proposed storm drains along Seventh Street and Ninth Street north of Bell Road to be constructed at a later date.

Sheet 24 (Station 904+00 to Station 946+00)

Major off-site flows concentrate at 12th Street, 14th Street, 16th Street and at the Juniper Street alignment. The storm drain along Bell Road was sized for the 100-year frequency storm per the UEFCC ADMS. An 18" extension from Station 942+00 to Station 950+00 (Sheet 25) is provided for on-site drainage.

The 18" - 30" - 66" - 72" storm drain will convey stormwater flows to the Ninth Street storm drain. The vertical profile of the storm drain was set sufficiently deep to avoid numerous utility conflicts such as sanitary sewers and major water transmission lines located at Station 913+70, 918+20, 920+40, 926+00 and 933+50. If the UEFCC ADMS is effective in intercepting off-site 100-year stormwater flows, the dip crossing between Station 924+00 and Station 935+00 may be removed. The 18" culverts at Station 917+70 and at Station 923+90 may also be removed or abandoned.

During construction of the Bell Road facilities, stub outs may be provided for laterals to extend along 12th Street, 14th Street and 16th Street north of Bell Road.

Sheet 25 (Station 946+00 to Station 988+00)

This section of Bell Road is within the 100-year floodplain of the East Fork of Cave Creek. The UEFCC ADMS has proposed a major storm drain to extend along Bell Road from 20th Street to 28th Street (Sheet 26). The storm drain is sized for the 100-year frequency storm and ranges from a 72" pipe to 3-10'x4' box culverts. The storm drain will discharge into an open channel at 20th Street that will follow the 20th Street alignment south to the Via Verde channel. The vertical alignment of the storm drain along Bell Road was set sufficiently deep to avoid conflicts with major utilities at Cave Creek Road and smaller utilities at 26th Street and 28th Street (Sheet 26). Special junction structures will be required at 22nd Street and Cave Creek Road to accommodate the changes in box culvert sizes. The dip crossing at Station 955+00 may be removed only in conjunction with construction of the 20th Street channel which will intercept upstream floodwaters.

If the 20th Street channel will not be constructed in conjunction with the Bell Road project, the inlets for the storm drain along Bell Road should be blocked until the outfall to the Via Verde channel has been completed. The double 8'x6' box culvert under Bell Road at 20th Street should be constructed in conjunction with the Bell Road project. Stub outs should be provided at 22nd Street, Cave Creek Road, 26th Street and 28th Street (Sheet 26) for future laterals to extend north of Bell Road.

Sheet 26 (Station 988+00 to Station 1030+00)

Refer to the previous discussion regarding Sheet 25 for the review of the storm drains west of 28th Street. A 72" - double 8'x4' storm drain box culvert will convey on-site and off-site stormwaters from 400 feet east of 34th Way (Sheet 27) to a proposed 4'x17' box culvert at 29th Street proposed by the UEFCC ADMS. The downstream invert of the double 8'x4' box culvert at 29th Street will have to be carefully set to ensure positive drainage for the 4'x17' outfall to the Via Verde channel. The invert of the storm drain along Bell Road must also be set sufficiently deep to avoid conflicts with the major utilities at 32nd Street and 34th Way (Sheet 27). At the time of construction of the Bell Road facilities, a stub out should be provided at 32nd Street (Sheet 27) to permit future continuation of the 72" storm drain north of Bell Road. The existing storm drain along 32nd Street (54" north of Bell Road, 60" south of Bell Road) will remain. Final disposition of this storm drain is pending the adoption of the UEFCC ADMS. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch. The roadway dip crossings at 25th Street and 26th Street should remain unless the upstream and downstream drainage improvements proposed by the UEFCC ADMS are constructed prior to the Bell Road project drainage improvements.

Sheet 27 (Station 1030+00 to Station 1072+00)

Refer to the previous discussion of Sheet 26 for a review of the storm drain west of 34th Way. Major off-site runoff concentrates 350 feet west of 36th Street where an existing drainageway crosses Bell Road in a dip section. A 48" storm drain with a headwall inlet will intercept flows in the drainageway and convey them to a proposed 48" storm drain at 36th Street. The existing dip crossing east of 36th Street should be maintained to permit flows in excess of the storm drain design capacity to allow flows to continue in their historic path. The 48" storm drain along 36th Street will convey stormwater flows to the existing Indian Bend Wash (IBW) project. The 36th Street storm drain is scheduled for construction up to Bell Road in 1990-1991. The proposed Bell Road improvements are scheduled for

1990-1991. The proposed Bell Road improvements are scheduled for construction in 1989-1990, one year prior to construction of the outfall. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch.

Sheet 28 (Station 1072+00 to Station 1114+00)

Major off-site runoff concentration points are located at 37th Court, 40th Street and 41st Street. A 24" - 30" storm drain will extend along Bell Road from Station 1082+50 heading westward to 36th Street and tying into the proposed 48" storm drain located along 36th Street. A 24" - 39" storm drain will extend from Station 1112+00 to the existing storm drain at 40th Street. A 39" stub out has already been provided for the continuation of the storm drain east of 40th Street along Bell Road. The existing roadway dip crossings at 37th Court, Station 1084+00 and 41st Street and the existing 43"x27" culverts at 40th Street should be maintained to provide drainage relief for flows in excess of the design storm.

The storm drain along Bell Road east of 40th Street was set sufficiently deep to avoid utility conflicts at 40th Street.

Sheet 29 (Station 1114+00 to Station 1156+00)

Major off-site runoff concentration points along Bell Road are located at 44th Street and 48th Street (Tatum Boulevard). A 24" - 36" storm drain along Bell Road will convey stormwater flow from Station 1139+00 to 44th Street where a proposed 42" storm drain will convey stormwater to the IBW. The 42" outfall to the IBW is not scheduled for completion until after 1992. If the Bell Road drainage improvements are constructed prior to construction of the outfall, temporary measures might be implemented such as tying the storm drain to a combination dry well manhole that will allow water to bubble up to the surface and discharge to a roadside grader ditch. The existing 22"x36" pipe culverts at Station 1124+50, Station 1130+70 and at

Station 1141+10 should remain to provide drainage relief for off-site flows in excess of the design storm impacting the north right-of-way of Bell Road. At the time of construction of the Bell Road drainage facilities, a 39" stub out should be provided for the storm drain proposed for 44th Street north of Bell Road.

A 39" storm drain (continued from Station 1165+00, Sheet 30) will convey on-site and off-site stormwater to the proposed 39" storm drain located at 48th Street (Tatum Boulevard) storm drain.

The vertical profile of the 39" storm drain along Bell Road was set sufficiently deep to avoid the 27"x43" culverts at 48th Street and the 22"x36" culverts east of 49th Street which should remain to provide drainage relief for flows in excess of the Bell Road project design storm. The 48th Street outfall is scheduled for completion to Bell Road in 1990-1991, within the same time frame for completion of the Bell Road project drainage improvements. At the time of construction of the Bell Road drainage facilities, a 30" stub out should be constructed to permit the future completion of the 48th Street storm drain north of Bell Road.

#### Sheet 30 (Station 1156+00 to Station 1198+00)

Major concentration points for off-site runoff along Bell Road are located at 49th Street, 52nd Street and 54th Street. An 18" - 39" storm drain will convey runoff from Station 1165+00 heading westward to 48th Street as described under Sheet 29. An 18" - 30" storm drain will convey on-site and off-site drainage from Station 1191+40 to the proposed 36" storm drain located along 52nd Street storm drain. The 52nd Street storm drain will convey stormwater to the IBW. The 52nd Street storm drain is scheduled for construction to Bell Road by 1989, which is within the same time frame for completion of the Bell Road Project drainage improvements for this segment.

The 18"x29" culverts at Station 1170+70, Station 1171+30 and Station 1174+30 should remain to provide drainage relief for flows in excess of the Bell Road project design storm. At the time of construction of the Bell Road

project facilities, a 30" stub out should be provided at 52nd Street to allow for the future completion of the 52nd Street storm drain north of Bell Road.

Sheet 31 (Station 1198+00 to Station 1240+00)

Major concentration points for off-site runoff along Bell Road are located at 56th Street, 57th Street and 58th Way. An 18" - 30" - 42" storm drain is proposed to convey on-site and off-site stormwater flows from 60th Street west to the proposed 42" storm drain located along 56th Street. The 56th Street storm drain will convey storm waters to the Sereno Park detention basin at 56th Street, one-half mile south of Thunderbird Road. The 56th Street storm drain is scheduled for completion to Bell Road in 1988-1989, which is prior to the scheduled construction of the Bell Road drainage facilities for this segment.

The vertical profile of the storm drain along Bell Road was set to cross over the 8" sanitary sewers located at 56th Street, 57th Street and 58th Way, and under a 42" water main at 56th Street.

At the time of construction of the Bell Road drainage facilities, stub outs should be provided for minor laterals at 56th Street, 57th Street and 58th Way to extend to the north of Bell Road. The existing culverts at 56th Street, Station 1205+10 and Station 1229+10 should be removed or abandoned as the highly urbanized nature of the area north of Bell Road should permit interception of off-site flows within the street rights-of-way north of Bell Road. The dip crossing located at Station 1216+00 should be maintained as a drainage relief for flows in excess of the design storm from the subdivision north of Bell Road so runoff can continue in their historic path south of Bell Road along 48th Street. The existing 22"x36" pipe culvert at Station 1239+00 should remain to provide a crossing for minor off-site flows draining from the northeast.

Sheet 32 (Station 1240+00 to Station 1282+00)

Minor off-site flows (two cfs) drain westward from Station 1274+00 (67th Street) to an existing 18"x29" pipe culvert at Station 1247+60. This culvert should remain or be replaced in kind during the construction of the Bell Road project improvements. A grader ditch should be provided along the north right-of-way of Bell Road to convey flows to the 18"x29" culvert. Curb opening inlets should be provided along Bell Road to divert on-site drainage from the north half of Bell Road to the proposed grader ditch. On-site drainage from the south pavement half of Bell Road should be permitted to turn southward and continue down the existing streets at 62nd Place, 64th Street, 65th Street, 66th Street and 67th Street. On-site runoff from 67th Street to Station 1282+00 will drain to the east to the existing dip crossing located at Station 1284+60 (Sheet 33) that conveys flows to a drainage easement in the subdivision located south of Bell Road.

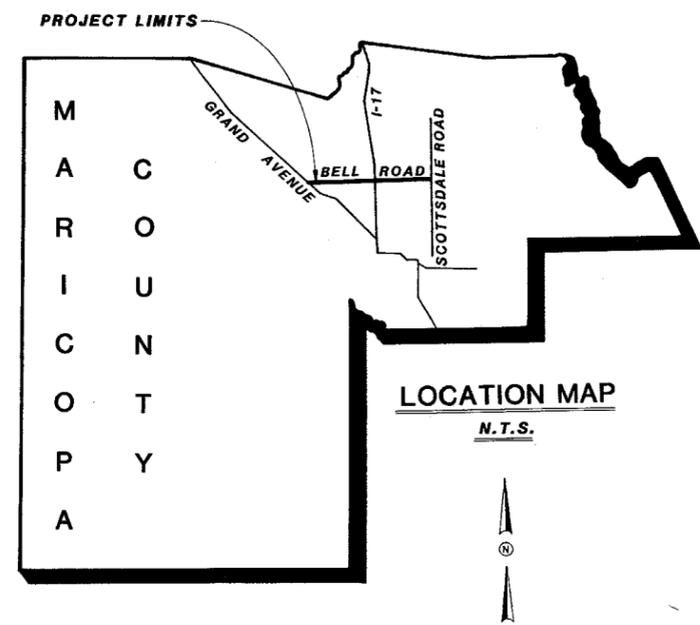
Sheet 33 (Station 1282+00 to Station 1308+80/Scottsdale Road)

Minor off-site flows (nine cfs) drain to an existing 18" culvert located at Station 1284+60.

This culvert should remain or be replaced in kind at the time of construction of the Bell Road drainage facilities. Minor off-site flows will also concentrate at the intersection of Bell Road and Scottsdale Road and flow south along the west shoulder of Scottsdale Road and will be intercepted by an existing storm drain located at Greenway Road.

On-site runoff from Bell Road will drain west from the high point located at Station 1297+00 to the dip crossing at Station 1285+00 (68th Street). Street drainage could either continue down 68th Street or be diverted by curb opening inlets to the inlet of the existing 18" culvert. On-site runoff from east of Station 1297+00 will drain to Scottsdale Road as gutter flow then turn south and flow along the west roadway shoulder of Scottsdale Road to the storm drain located at Greenway Road.

# PRELIMINARY CONCEPT DRAINAGE PLANS FOR BELL ROAD PROJECT DRAINAGE STUDY FOR FLOOD CONTROL DISTRICT OF MARICOPA COUNTY



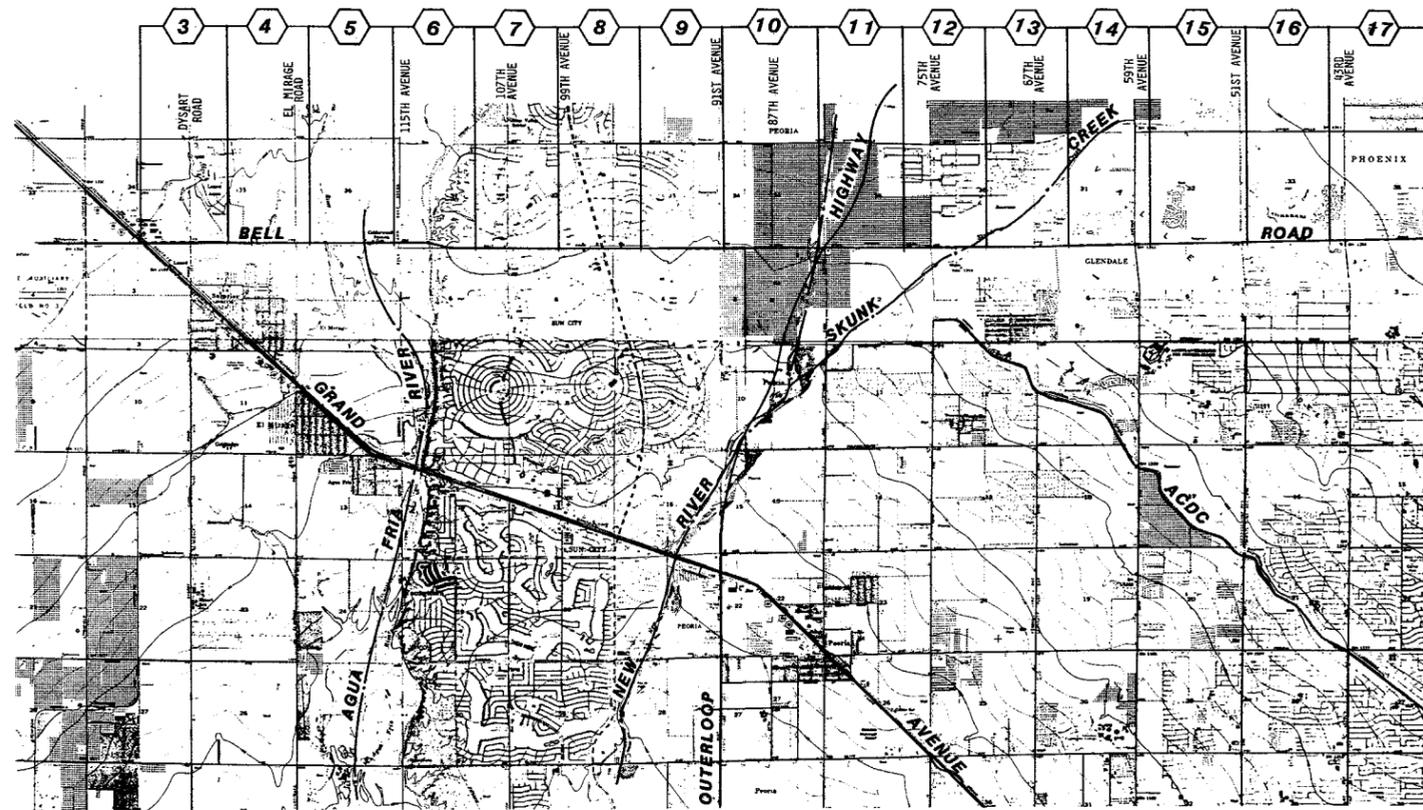
Revisions

**Greiner Engineering**  
A Greiner Engineering, Inc. Company  
Greiner Engineering Sciences, Inc.  
7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020-602 275-5400  
2590 North Avmon Way, Tucson, Arizona 85712-602 337-3413

Design *M.C./R.B.*  
G.S./M.O.  
Drawn *F.C./M.R.B.*  
Check *M.S.S.*  
*M.C.*  
Scale *N.T.S.*

**BELL ROAD PROJECT  
DRAINAGE STUDY**

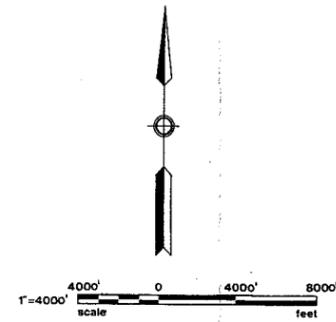
Date *OCT. 1987*  
Job No. *E 123061*  
Sheet *1* of *33*



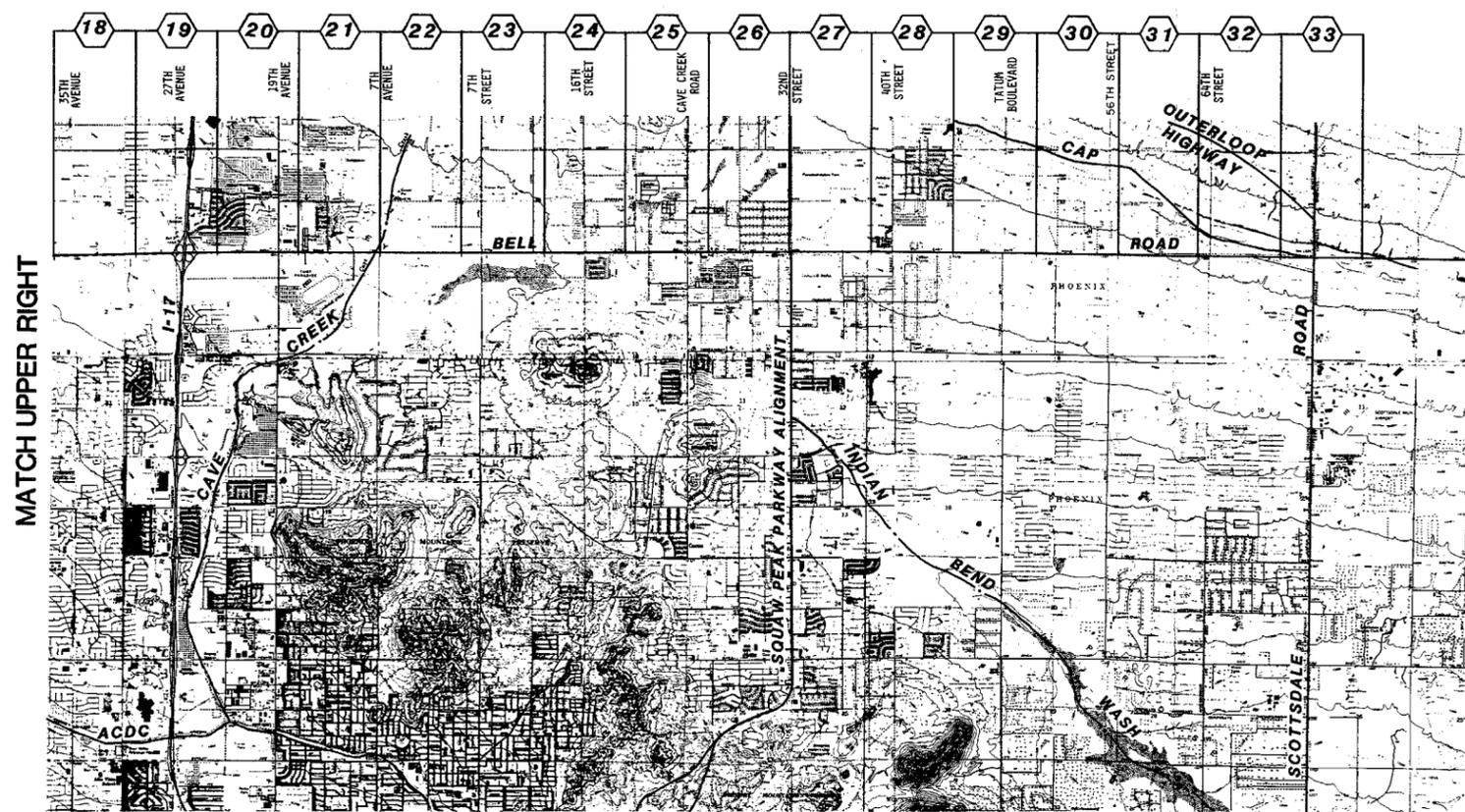
SHEET INDEX MAP

MATCH LOWER LEFT

- GENERAL NOTES**
1. THESE PLANS ARE DEVELOPED TO A CONCEPT LEVEL ONLY AND ARE NOT INTENDED FOR CONSTRUCTION PURPOSES. THE HORIZONTAL AND VERTICAL LOCATION OF ALL EXISTING AND PROPOSED DRAINAGE FACILITIES ARE APPROXIMATE.
  2. CATCH BASINS, LATERALS, MANHOLES AND OTHER STORM DRAIN APPURTENANCES ARE NOT SHOWN. THE CATCH BASINS WITH LATERALS DISCHARGING INTO THE EXISTING SUN CITY WEST AND SUN CITY DRAINAGEWAYS BETWEEN STATION 48+00 AND 195+00 ARE SHOWN BECAUSE THEY CONSTITUTE THE ON-SITE DRAINAGE FACILITIES FOR THIS SECTION OF BELL ROAD.
  3. REFER TO THE PLAN SHEET BY PLAN SHEET DESCRIPTIONS PROVIDED IN THIS REPORT FOR A DETAILED DESCRIPTION OF THE PROPOSED FACILITIES AND AN EXPLANATION OF GREINER'S RATIONALE IN DEVELOPING THE CONCEPT PLAN.
  4. STORM DRAIN STRUCTURES FOR THE SECTION OF BELL ROAD BETWEEN 7TH STREET AND 400 FEET EAST OF 34TH WAY WERE SIZED BY MBS/LOWRY FOR THE UPPER EAST FORK OF CAVE CREEK AREA DRAINAGE MASTER STUDY.



- LEGEND**
- ..... JURISDICTION BOUNDARY
  - BELL ROAD ALIGNMENT
  - PROPOSED STORM DRAIN
  - STORM DRAIN PROPOSED BY OTHERS
  - PROPOSED CATCH BASIN WITH LATERALS
  - EXISTING DRAINAGEWAY
  - PROPOSED DRAINAGEWAY OR SWALE
  - 100 YEAR FLOODPLAIN LIMIT
  - RIGHT-OF-WAY
  - DIRECTION OF FLOW
  - PROPOSED DROP STRUCTURE
  - PROPOSED HEADWALL
  - EXISTING STORM DRAIN
  - TRANSITION JUNCTION STRUCTURE
  - EXISTING CULVERT



SHEET INDEX MAP

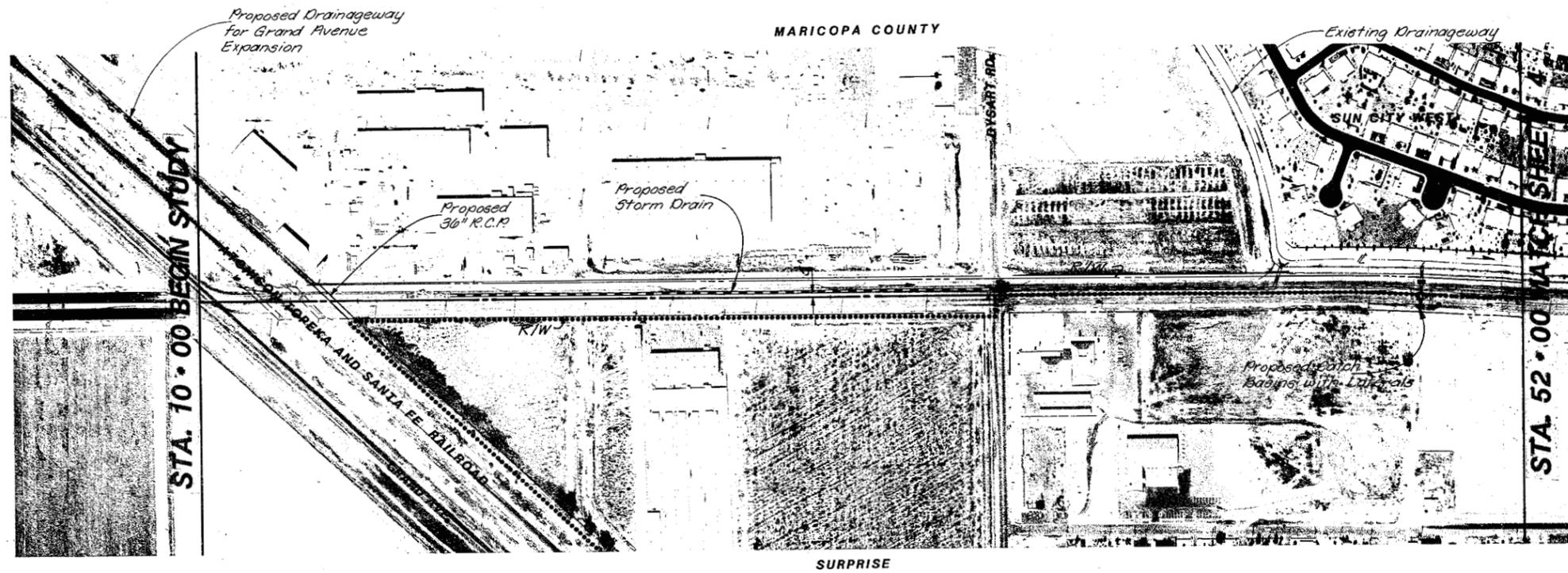
MATCH UPPER RIGHT

**Greiner Engineering**  
 Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7910 N. 16th Street, Suite 160 Phoenix, Arizona 85020-0022 275-5400  
 2590 North Avramon Way/Tucson, Arizona 85712-8002 327-9413

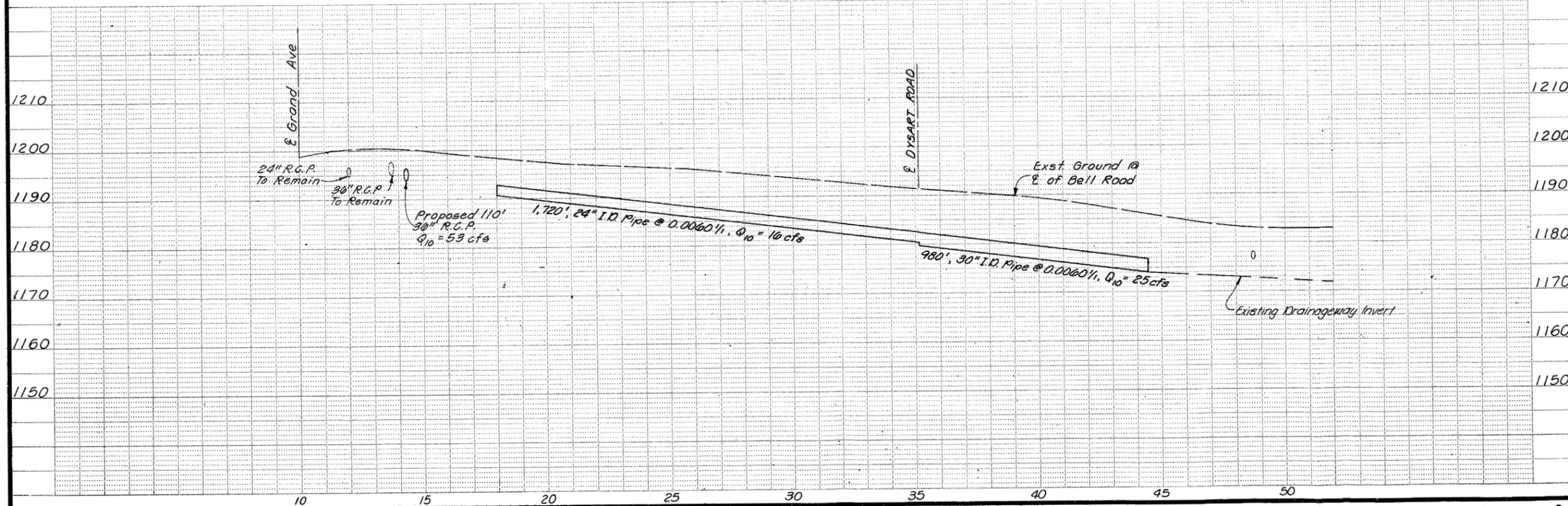
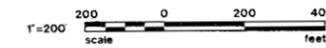
Design M.C./M.O.  
 R.B./G.S.  
 Drawn F.C.  
 Check M.S.S.  
 M.C.  
 Scale 1" = 4000'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 SHEET INDEX MAP

Date OCT. 1987  
 Job No. E123061  
 Sheet of 2 33



**BELL ROAD**



Revisions

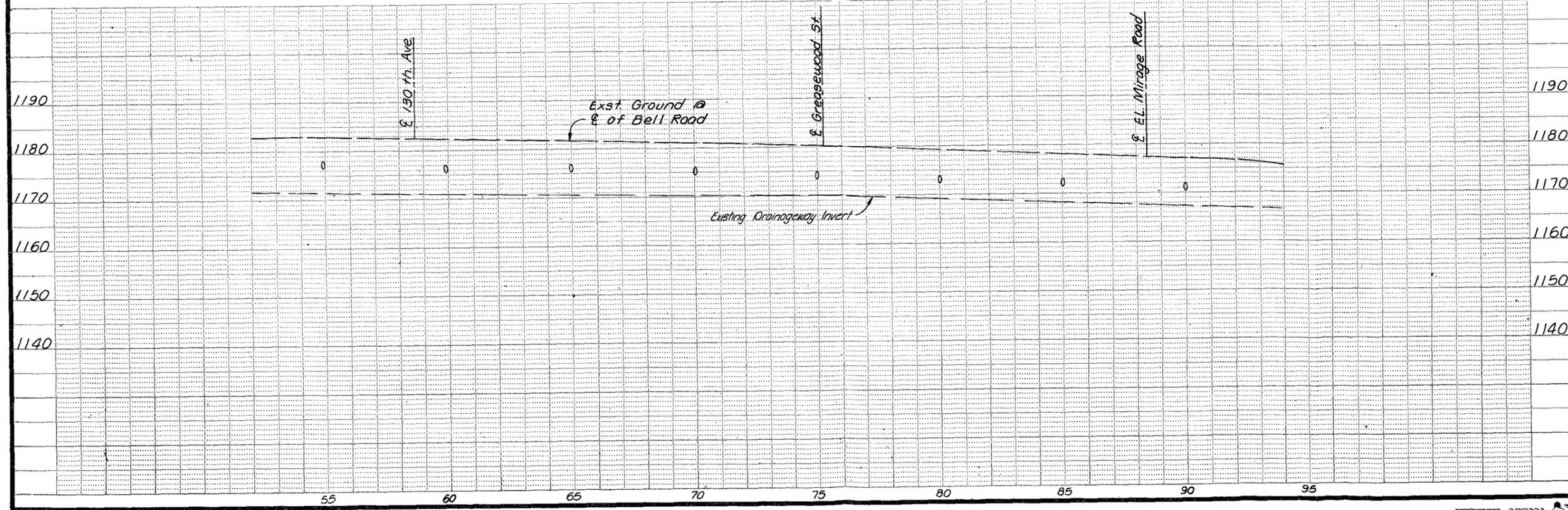
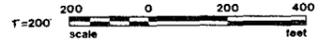
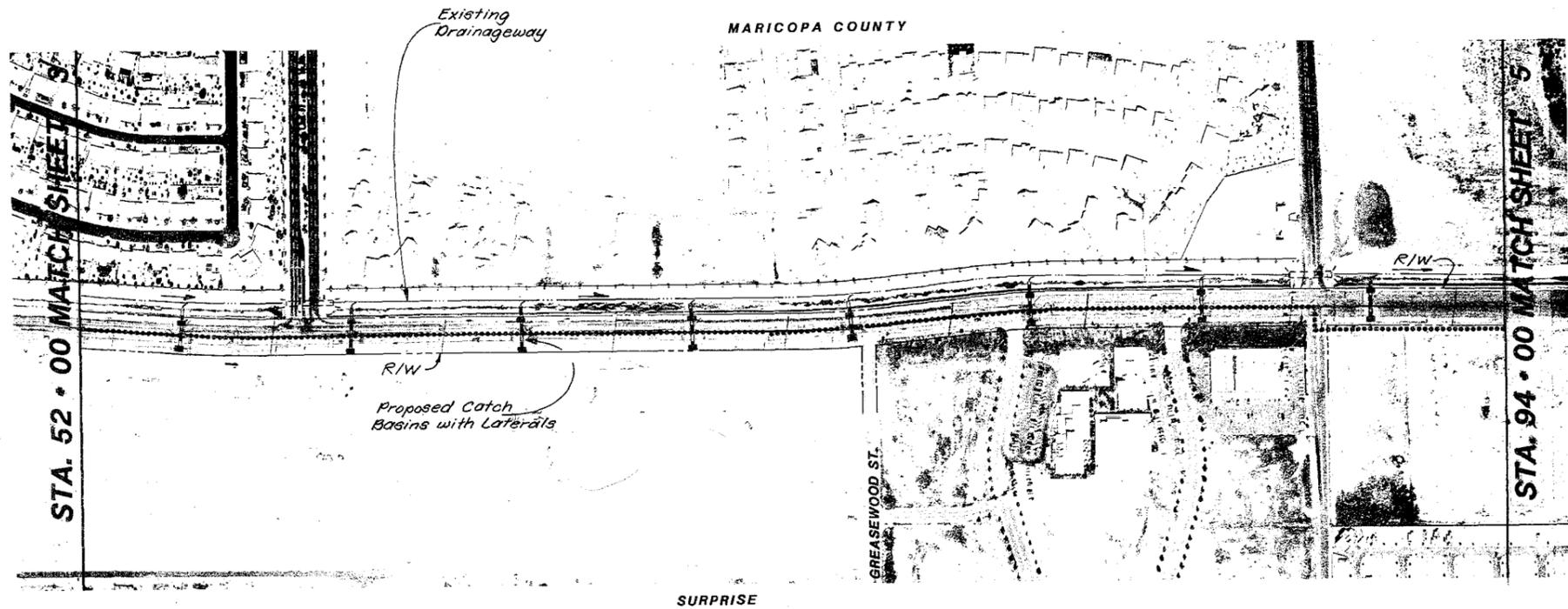


**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 7200 N. 18th Street, Suite 100 Phoenix, Arizona 85020/602 275-6400  
 2550 North Averson Way Tucson, Arizona 85712/602 327-3413

Design: **M.C./R.B./G.S./M.O.**  
 Drawn: **F.C./W.R.B.**  
 Check: **M.G.S.**  
 Scale: **HORIZ. 1" = 200'**  
**VERT. 1" = 10'**

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: **OCT. 1987**  
 Job No.: **E123061**  
 Sheet of: **3 33**



Revisions

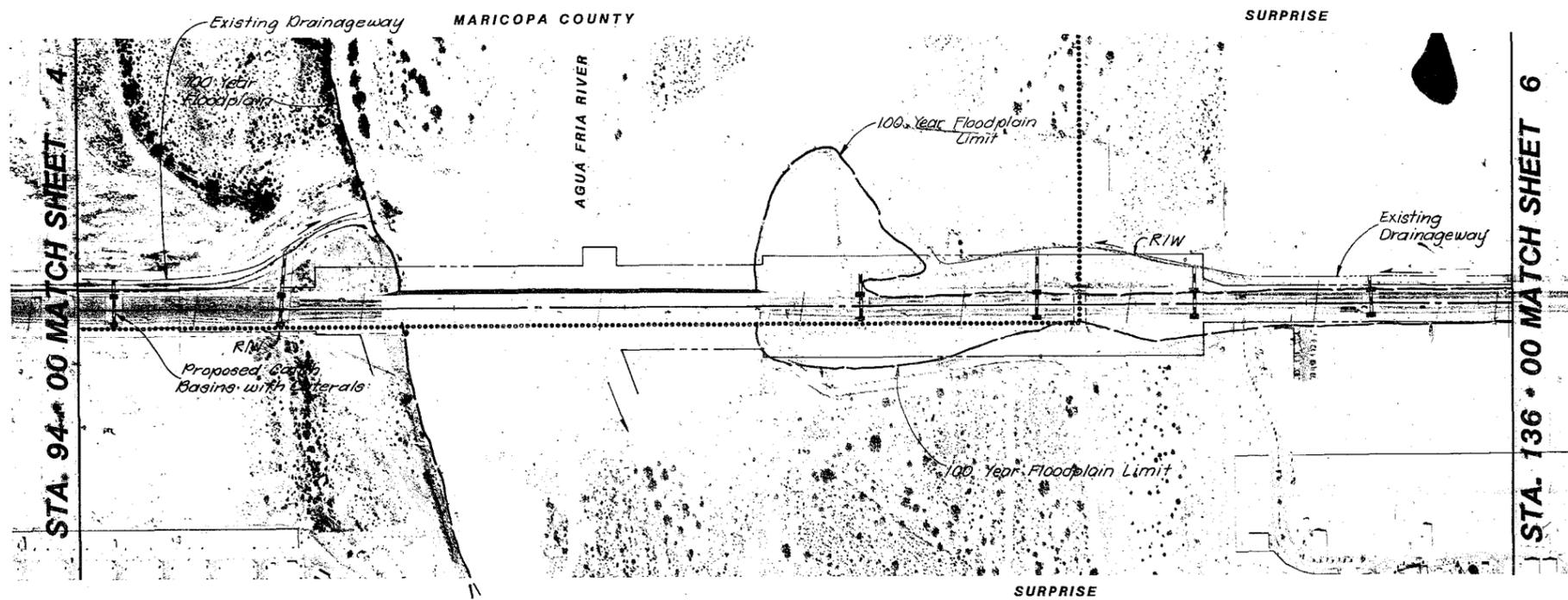
**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 7310 N. 18th Street, Suite 100/Phoenix, Arizona 85020-632 275-5400  
 2500 North Alhambra Way/Tucson, Arizona 85712-602 327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.G.  
 M.C.

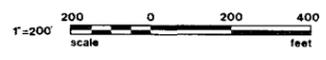
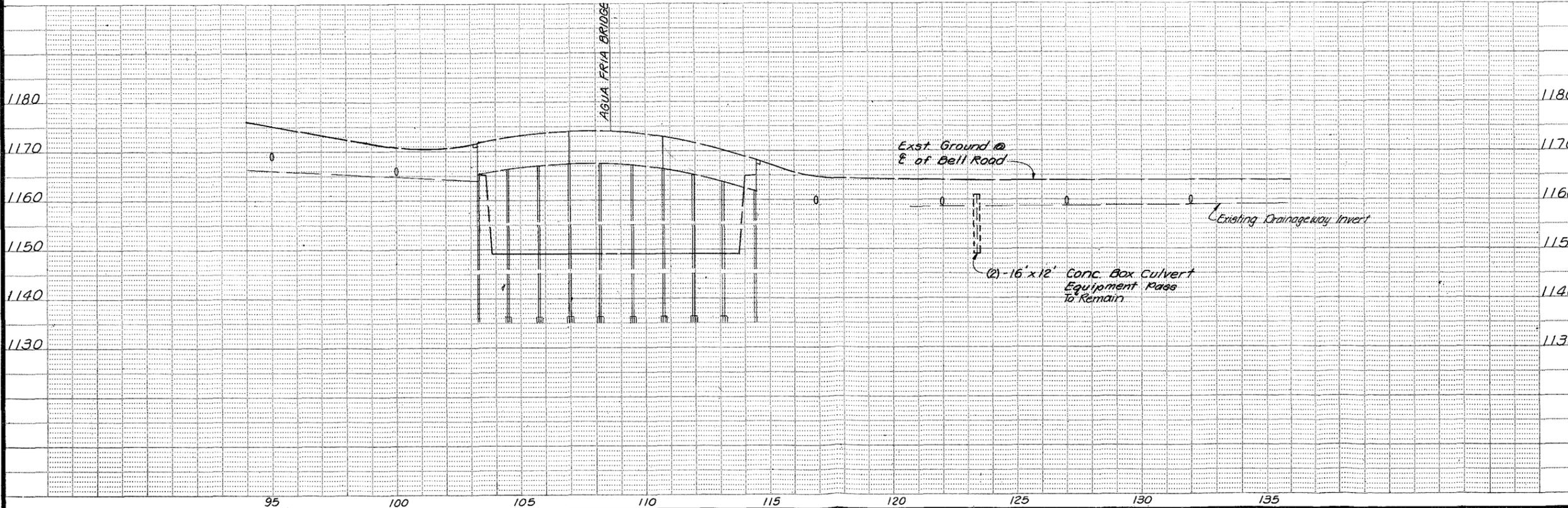
Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 4 of 33



**BELL ROAD**

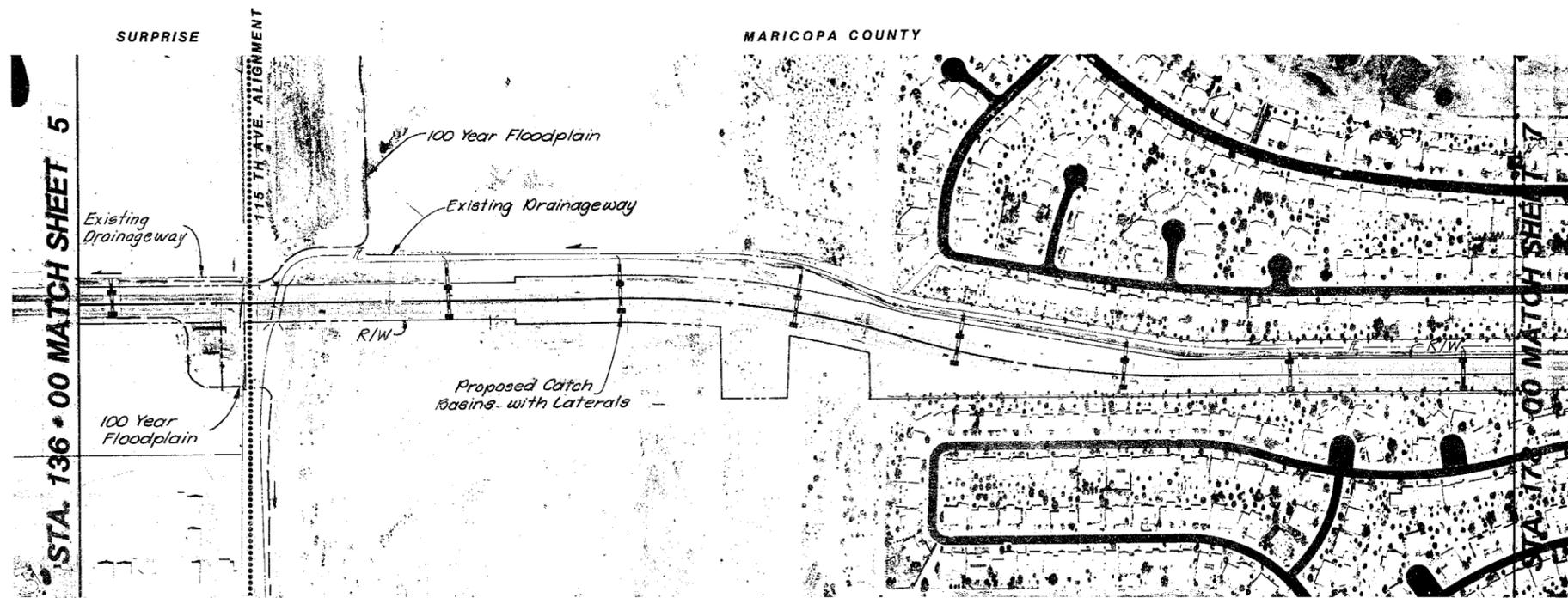


**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020/602 275-5400  
 2590 North Avemont Way/Tucson, Arizona 85712/602 327-3413

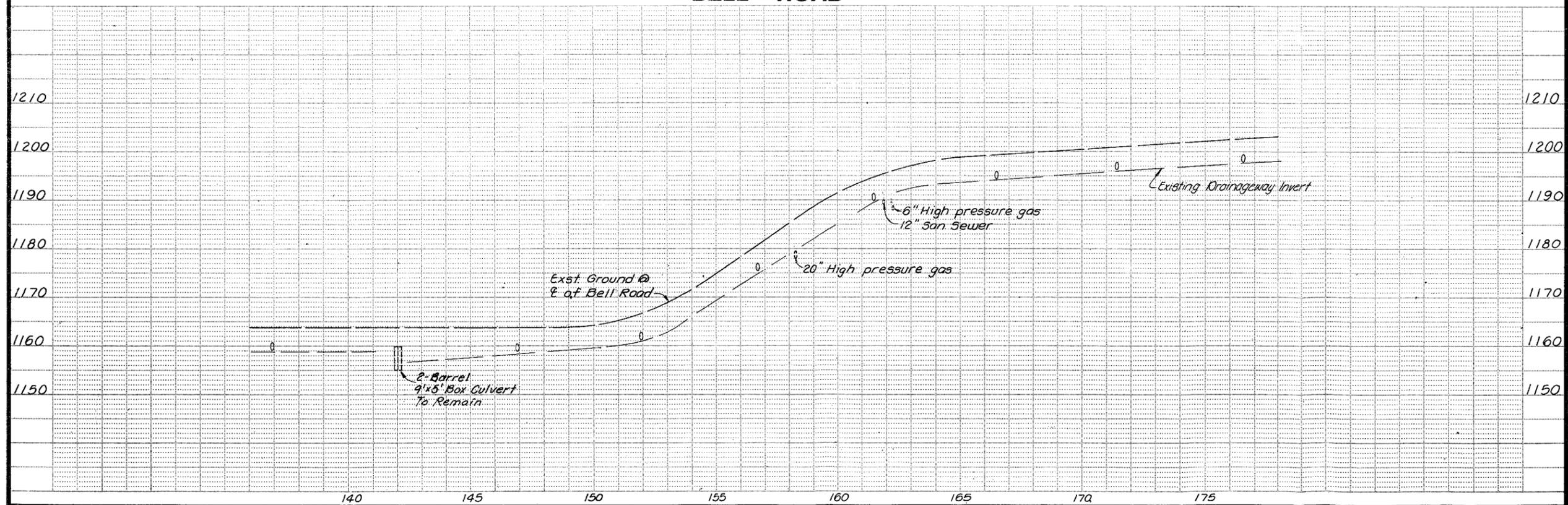
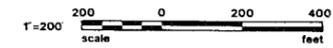
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.O.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061  
 Sheet 5 of 33



**BELL ROAD**



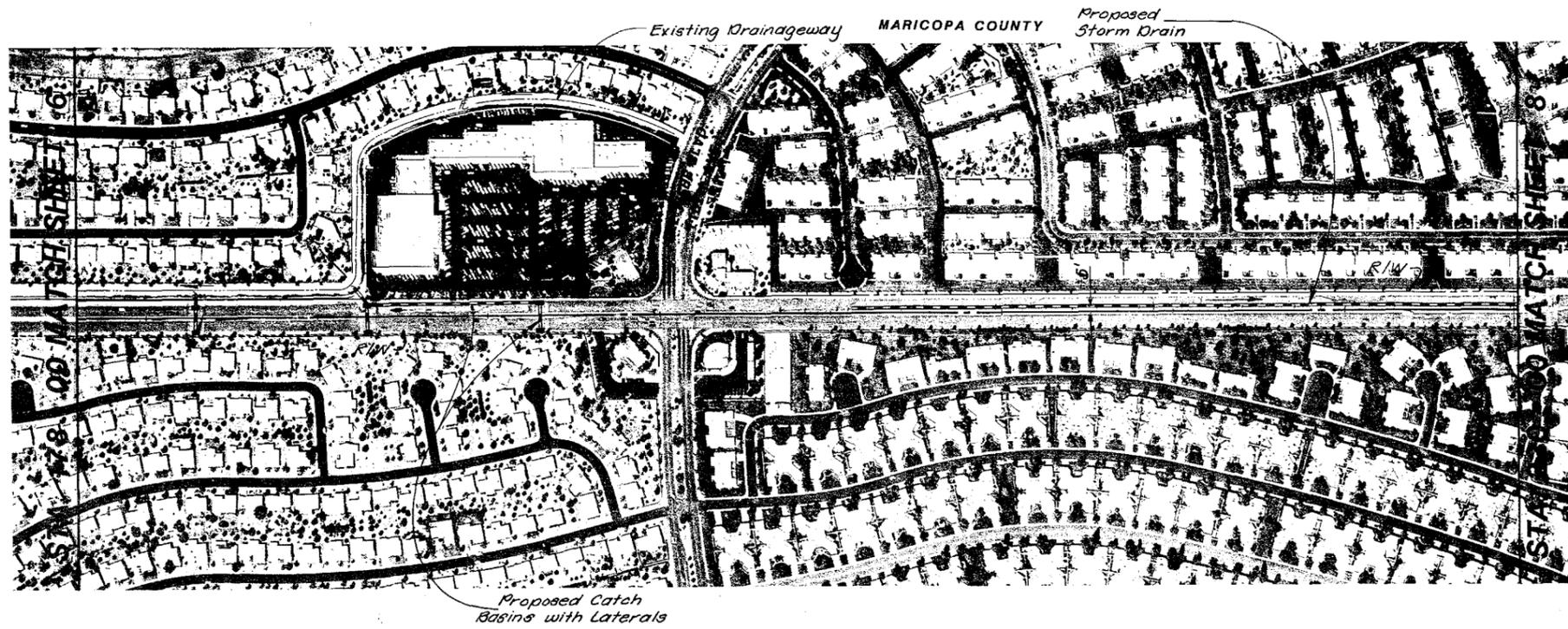
Revisions

**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 2500 N. 16th Street, Suite 100 Phoenix, Arizona 85016-9922 275-5400  
 2500 North Vermont Way Tucson, Arizona 85712-8002 327-5913  
 A Greiner Engineering, Inc. Company

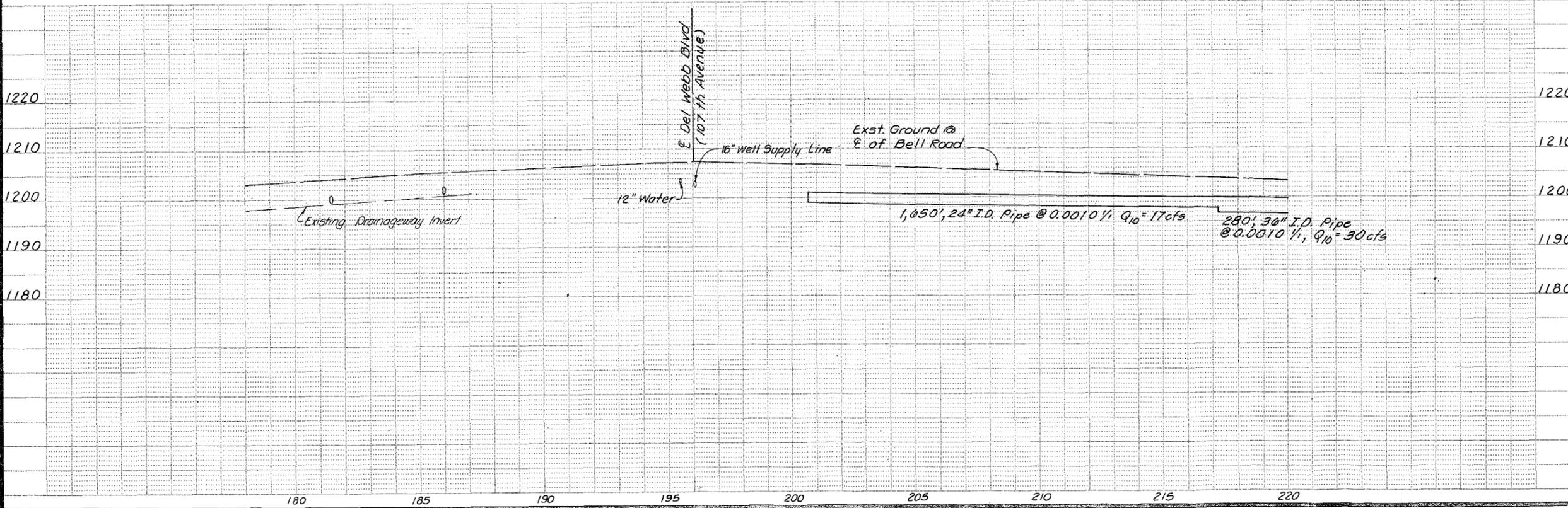
Design: *M.C./R.B./G.S./M.O.*  
 Drawn: *F.C./W.R.B.*  
 Check: *M.S.B.*  
 Scale: *M.C.*  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: *OCT. 1987*  
 Job No.: *E123061*  
 Sheet of: **6 | 33**



**BELL ROAD**



Revisions

---

A Greiner Engineering, Inc. Company

**Greiner Engineering**

Greiner Engineering Sciences, Inc.  
7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020/602 275-5400  
2550 North Alverton Way Tucson, Arizona 85712/602 327-9413

---

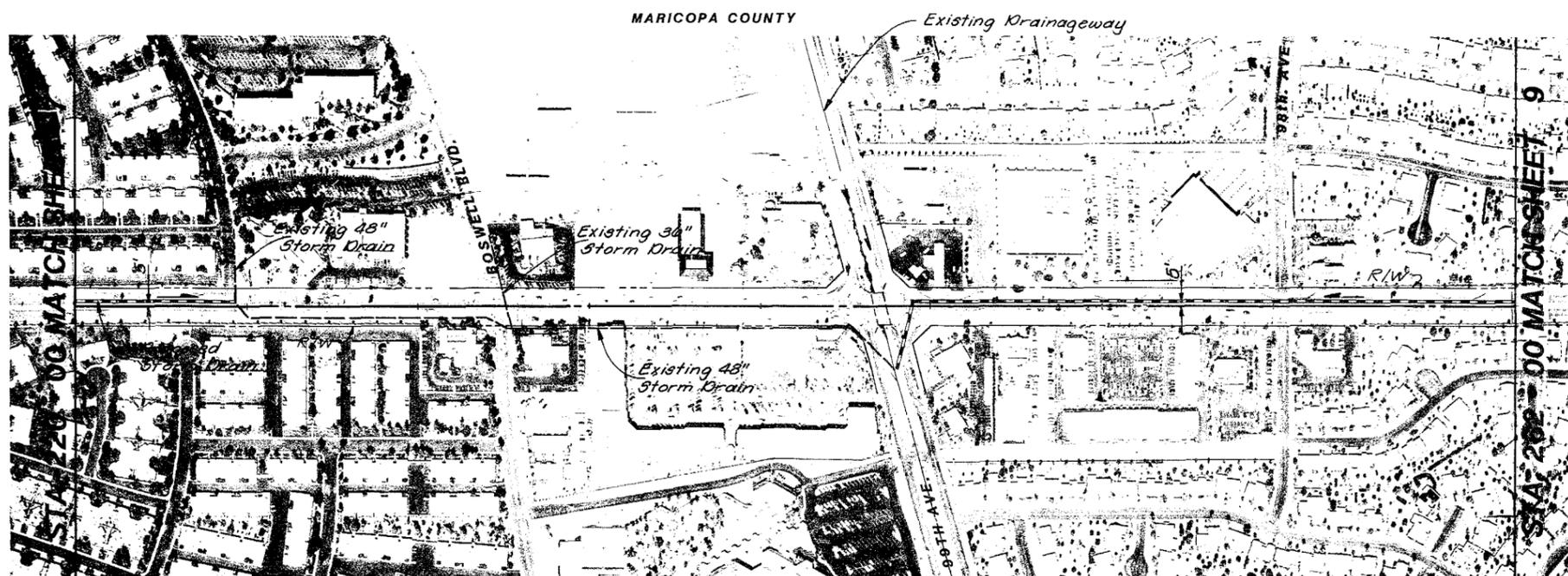
Design: M.C./R.B./G.S./M.O.  
Drawn: F.C./W.R.B.  
Check: M.G.G.  
Scale: HORIZ. 1" = 200'  
VERT. 1" = 10'

---

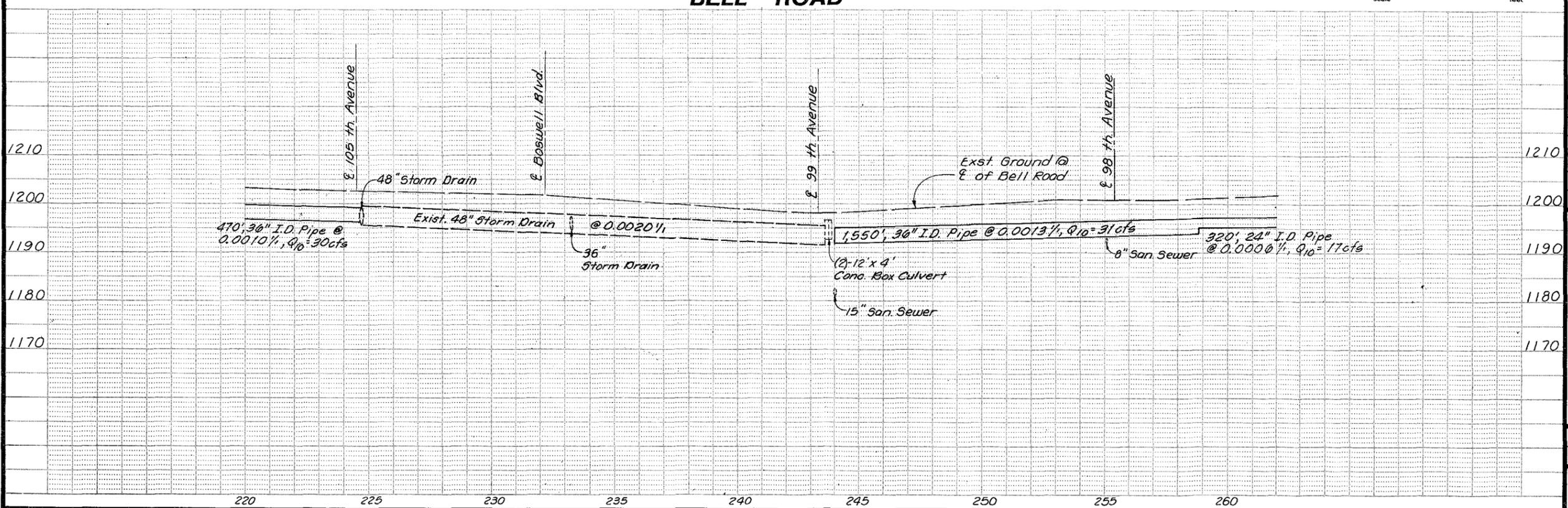
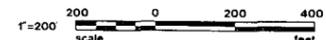
**BELL ROAD PROJECT**  
DRAINAGE STUDY  
PRELIMINARY PLANS

---

Date: OCT. 1987  
Job No. E123061  
Sheet 7 of 33



**BELL ROAD**



Revisions

---

A Greiner Engineering, Inc. Company  
**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 1671 State Street, Suite 100 Phoenix, Arizona 85009 (602) 275-5400  
 2330 North Avondale Pkwy. Tucson, Arizona 85712 (520) 282-9413

---

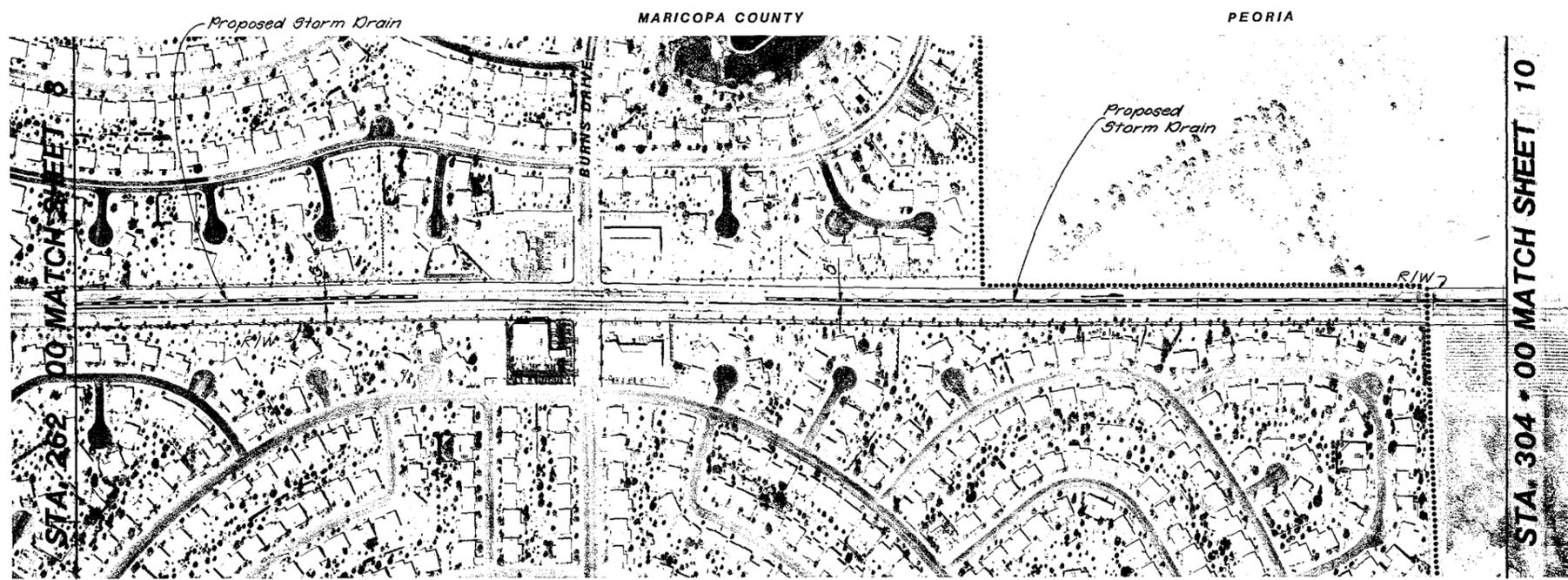
Design: **M.C./R.B./G.S./M.O.**  
 Drawn: **F.C./W.R.B.**  
 Check: **M.S.S.**  
 Scale: **M.C.**  
 Scale: **HORIZ. 1" = 200'**  
**VERT. 1" = 10'**

---

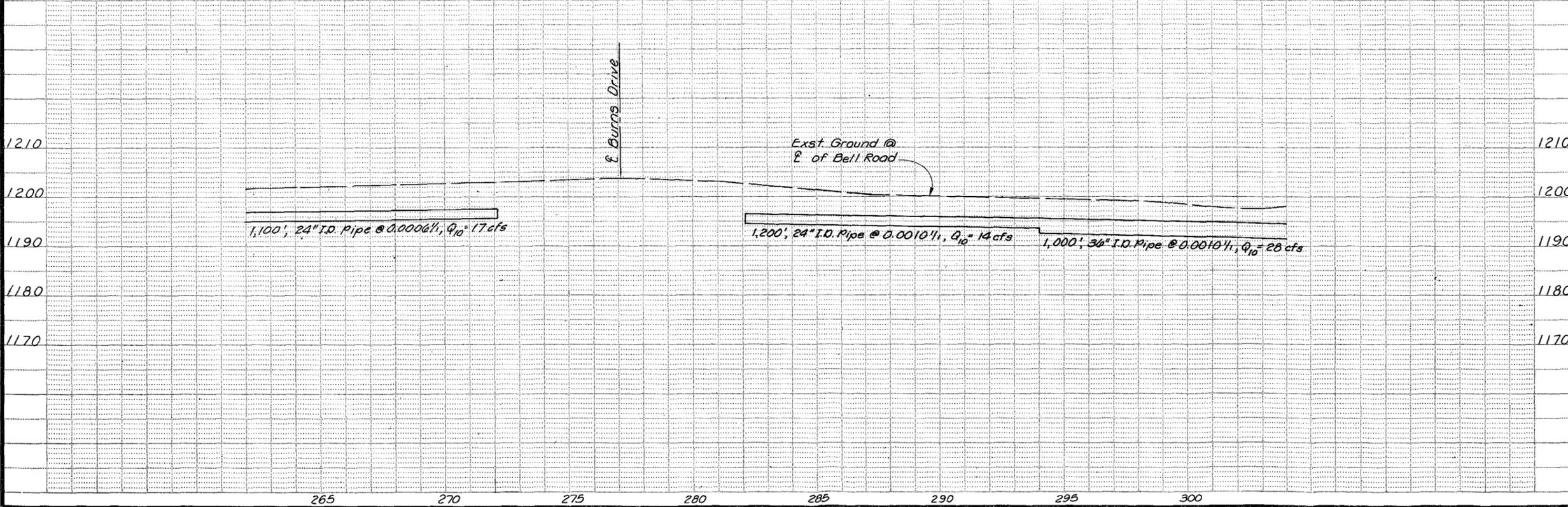
**BELL ROAD PROJECT**  
**DRAINAGE STUDY**  
**PRELIMINARY PLANS**

---

Date: **OCT. 1987**  
 Job No.: **E123061**  
 Sheet of: **8 33**



**BELL ROAD**



Revisions

---

A Greiner Engineering, Inc. Company

**Greiner Engineering**

Greiner Engineering Sciences, Inc.  
7310 N. 16th Street, Suite 150 Phoenix, Arizona 85020-6602 275-5400  
2550 North Avemont Way/Tucson, Arizona 85712-6052 327-3413

---

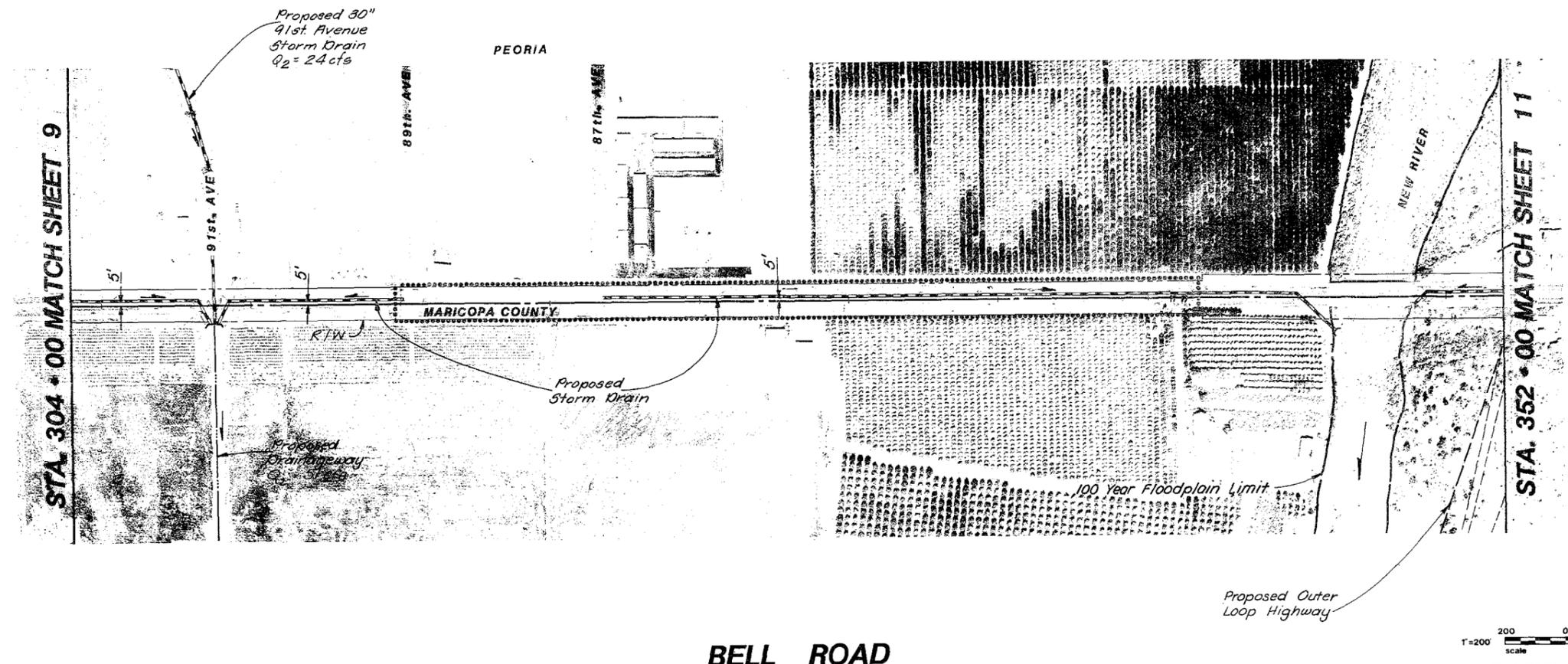
Design: M.C./R.B./G.S./M.O.  
Drawn: F.C./W.R.B.  
Check: M.S.G.  
Scale: M.G.  
Scale: HORIZ. 1" = 200'  
VERT. 1" = 10'

---

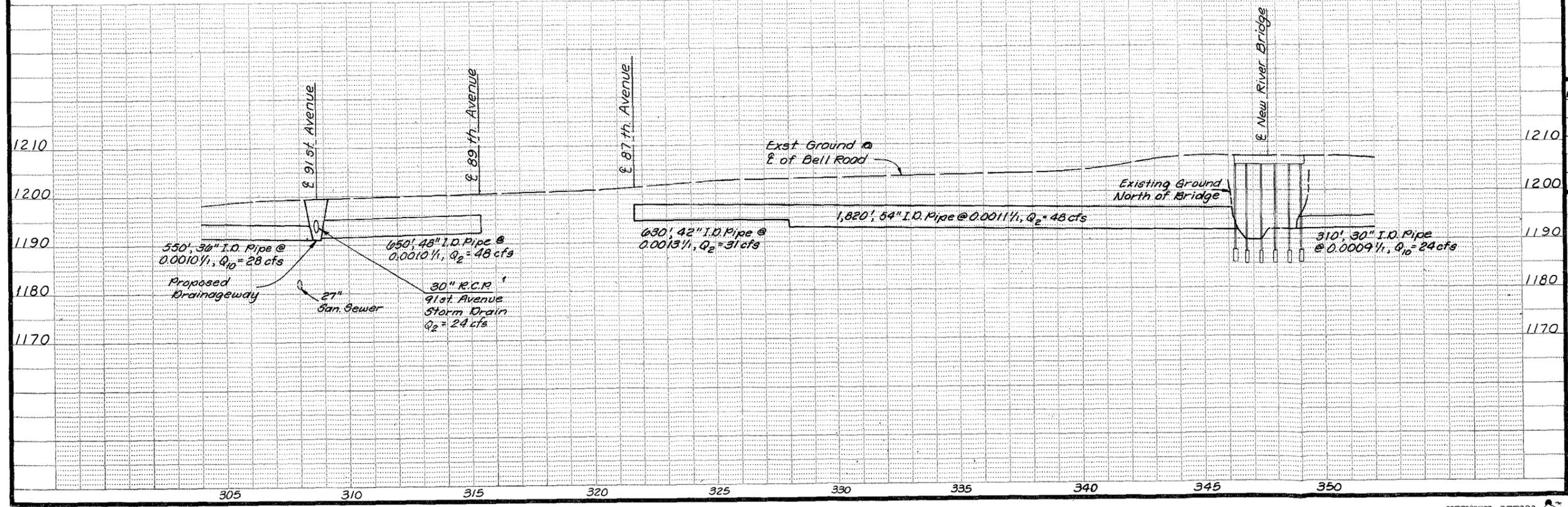
**BELL ROAD PROJECT**  
DRAINAGE STUDY  
PRELIMINARY PLANS

---

Date: OCT. 1987  
Job No. E123061  
Sheet of  
9 33



**BELL ROAD**



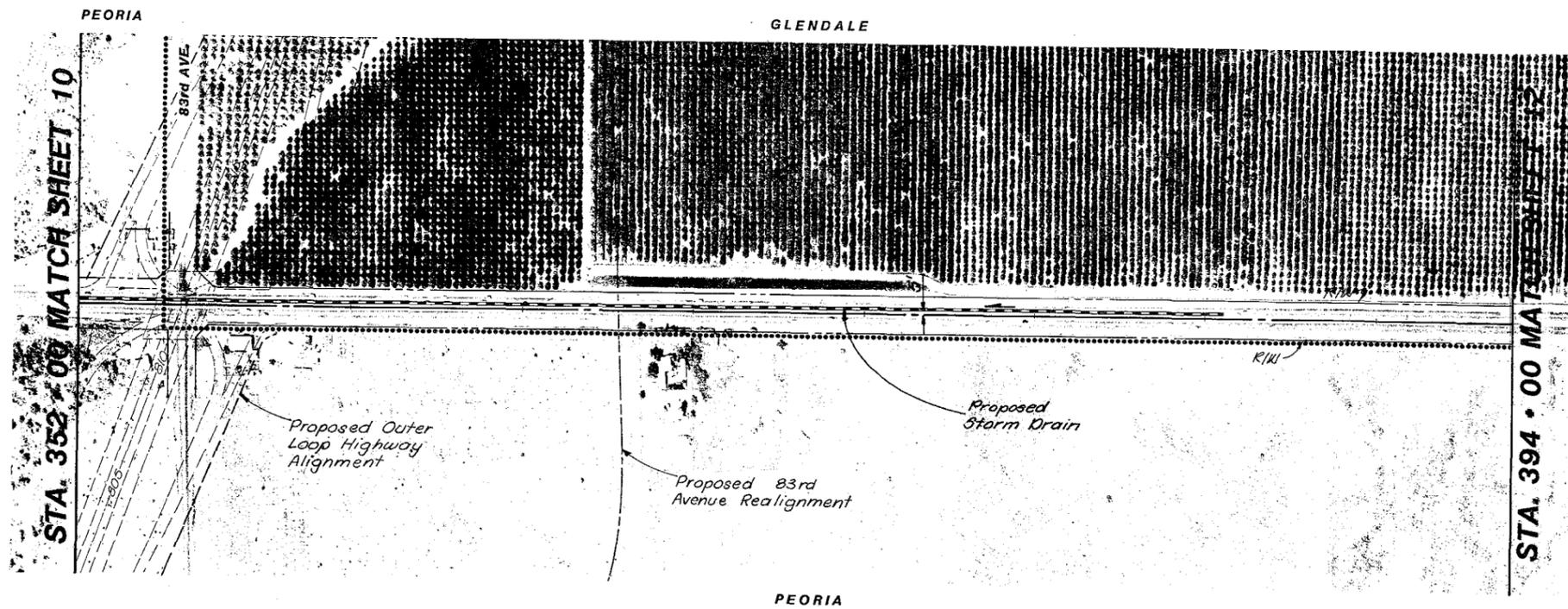
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering, Inc.  
 9410 N. 15th Street, Suite 100, Phoenix, Arizona 85020-8602 275-5400  
 2550 North Avmon Way, Tucson, Arizona 85712-5022 327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.C.

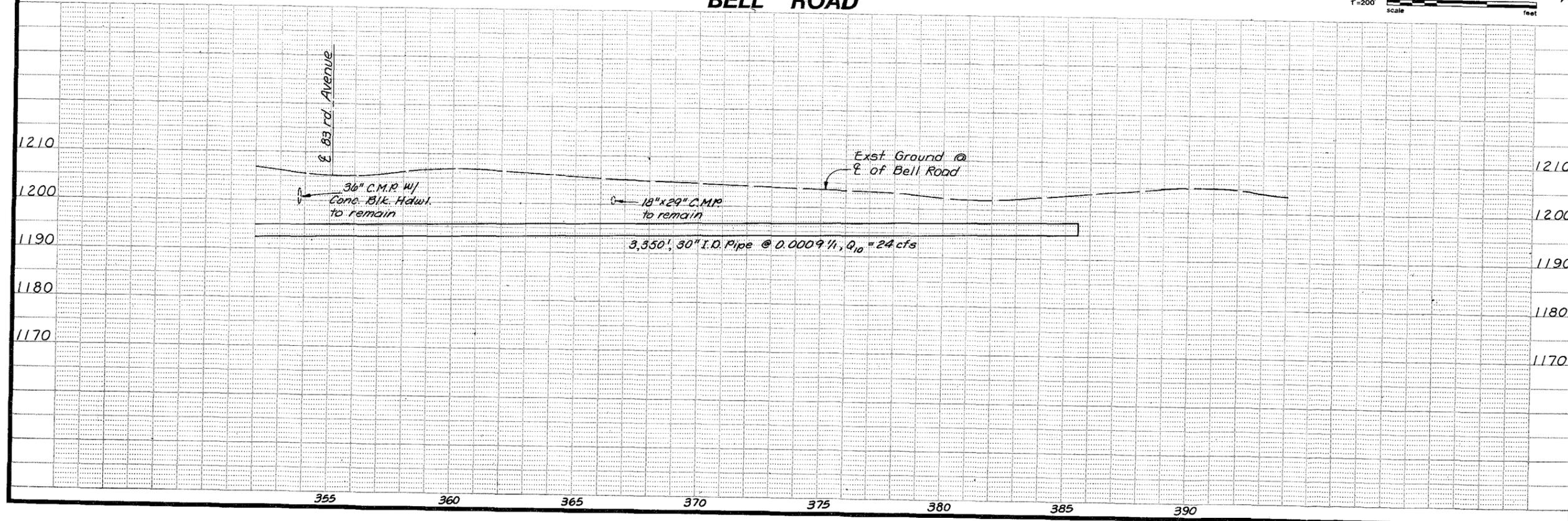
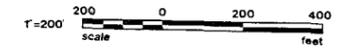
Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 10 of 33



**BELL ROAD**



Revisions

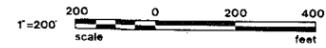
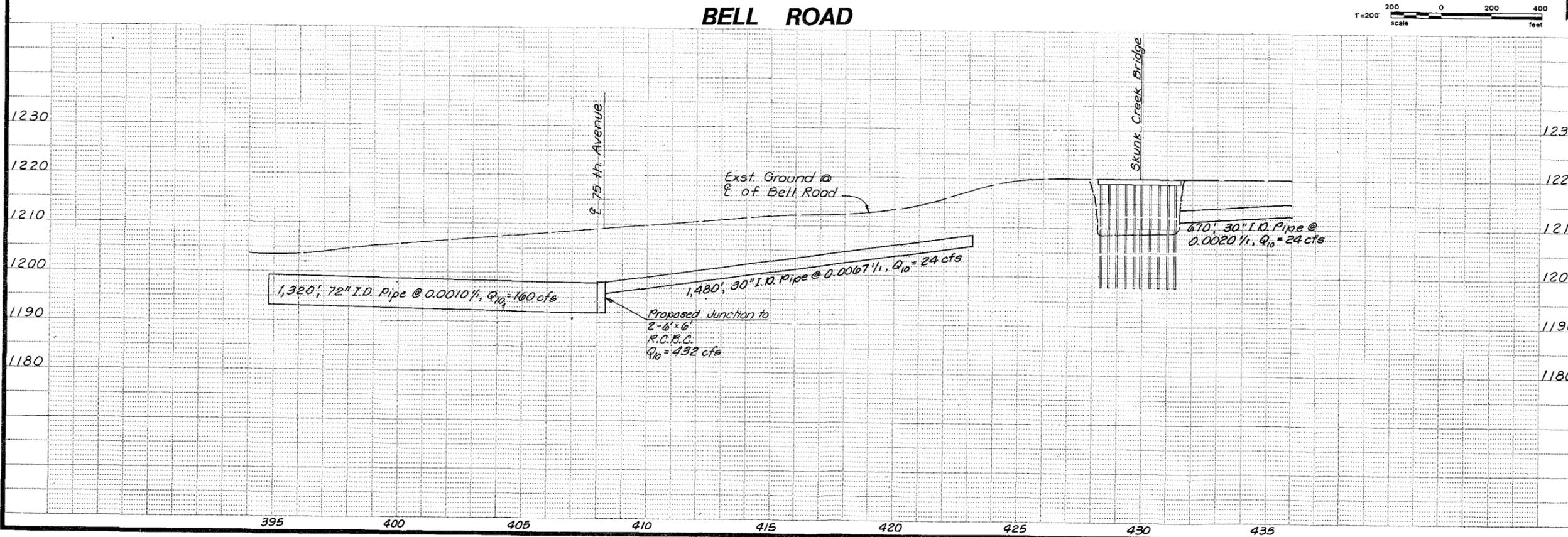
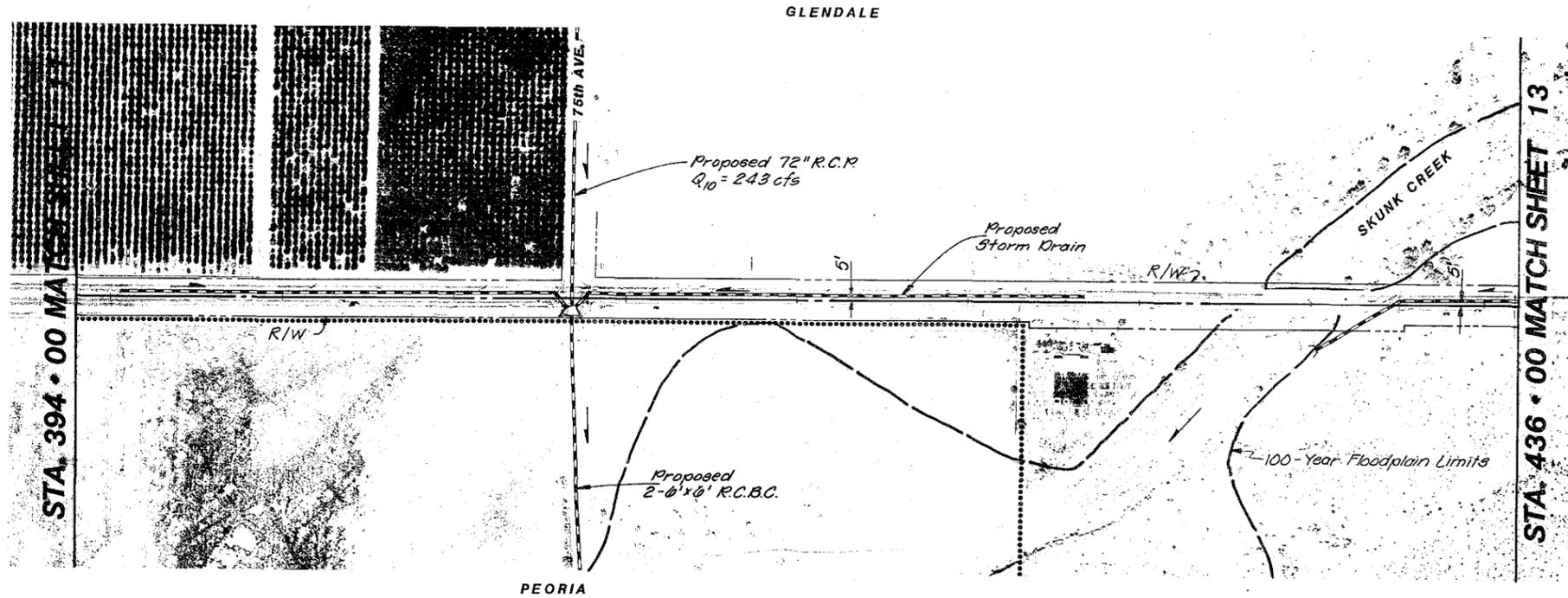
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 160/Phoenix, Arizona 85020/602-275-5400  
 2590 North Alverton Way/Tucson, Arizona 85715/602-327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061

Sheet of 11 | 33



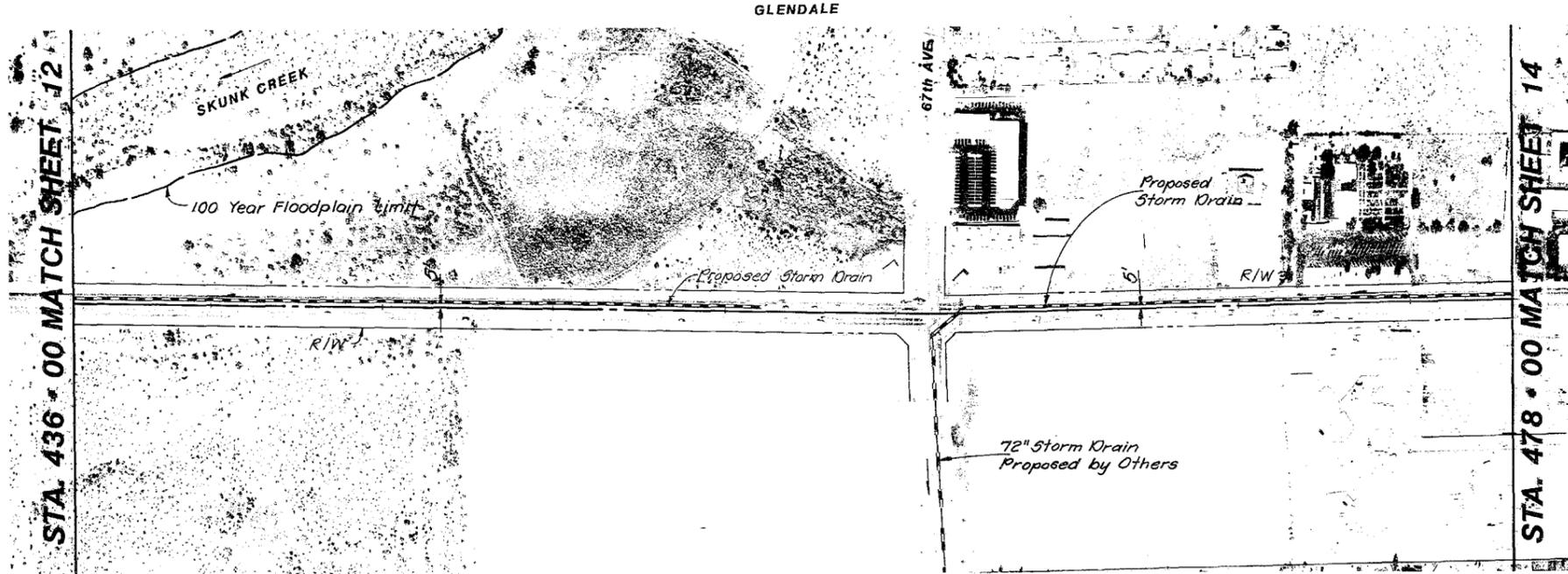
**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 2250 North Avenida Puy, Tucson, Arizona 85712  
 2800 North Avenida Puy, Tucson, Arizona 85712  
 2800 North Avenida Puy, Tucson, Arizona 85712

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.C.

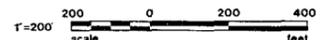
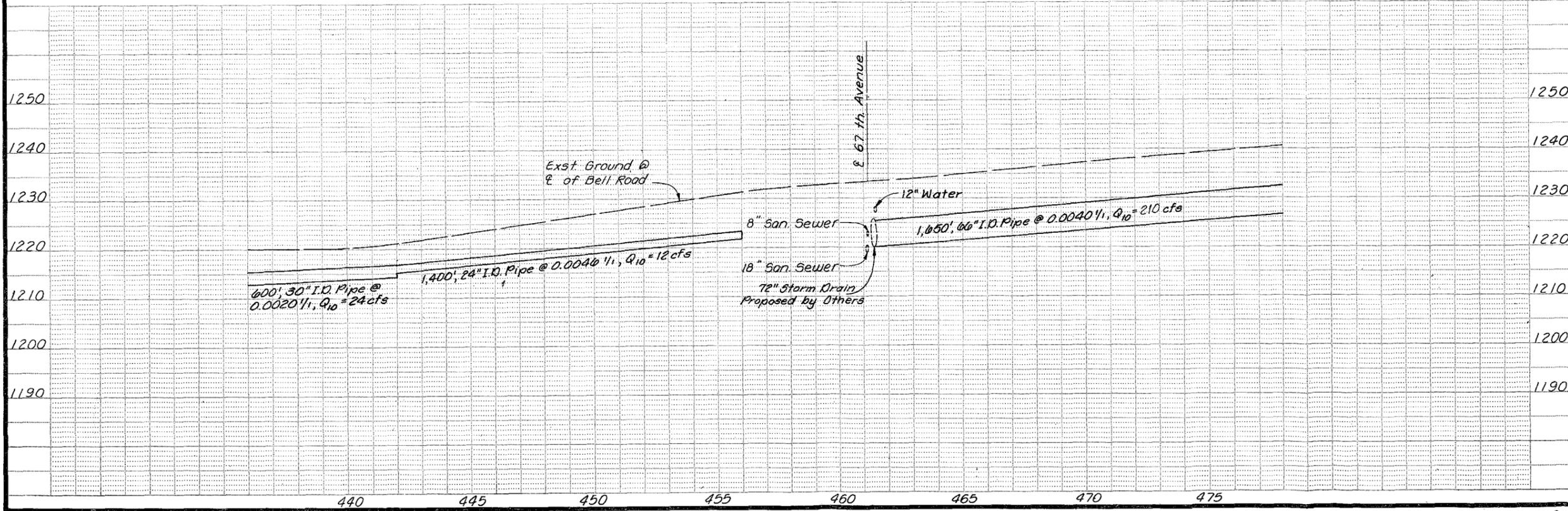
Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 12 of 33



**BELL ROAD**



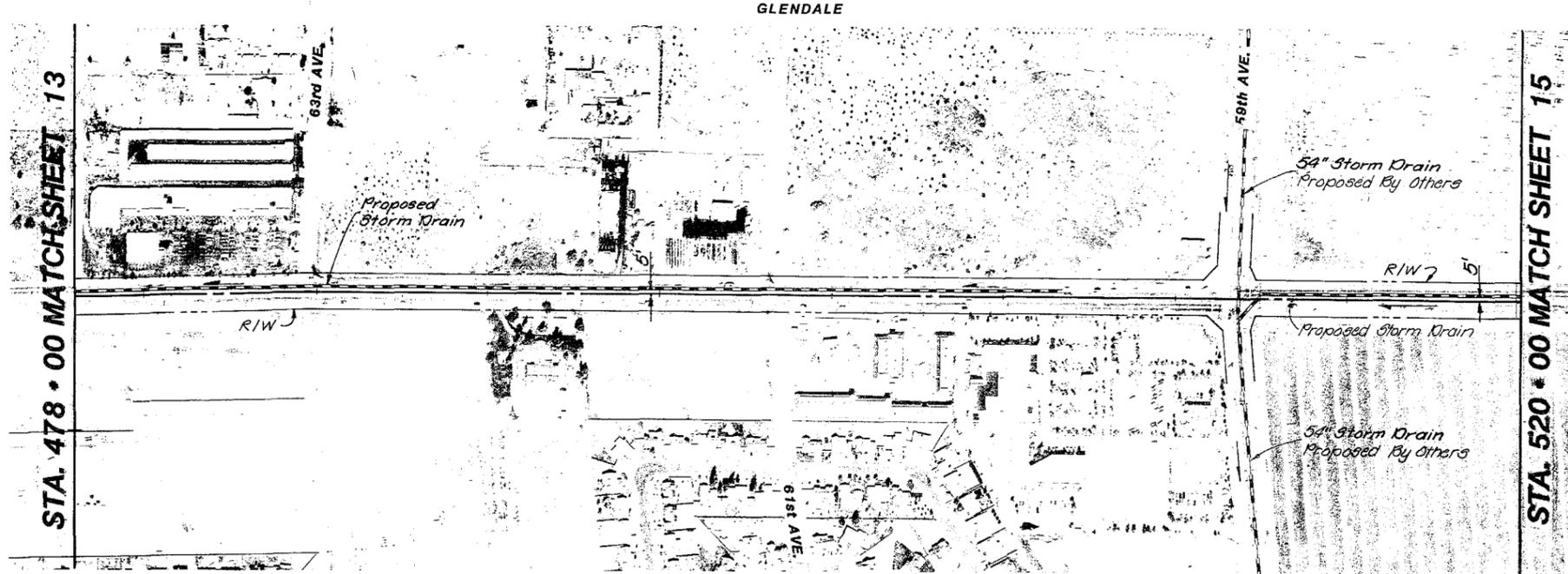
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering, Inc.  
 2590 North Alhambra Way/Tucson, Arizona 85712-0023-2413  
 Office: 520-298-1111  
 Fax: 520-298-1112

Design: **M.C./R.B./G.S./M.O.**  
 Drawn: **F.C./W.R.B.**  
 Check: **M.S.G.**  
**M.C.**

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

**BELL ROAD PROJECT**  
**DRAINAGE STUDY**  
**PRELIMINARY PLANS**

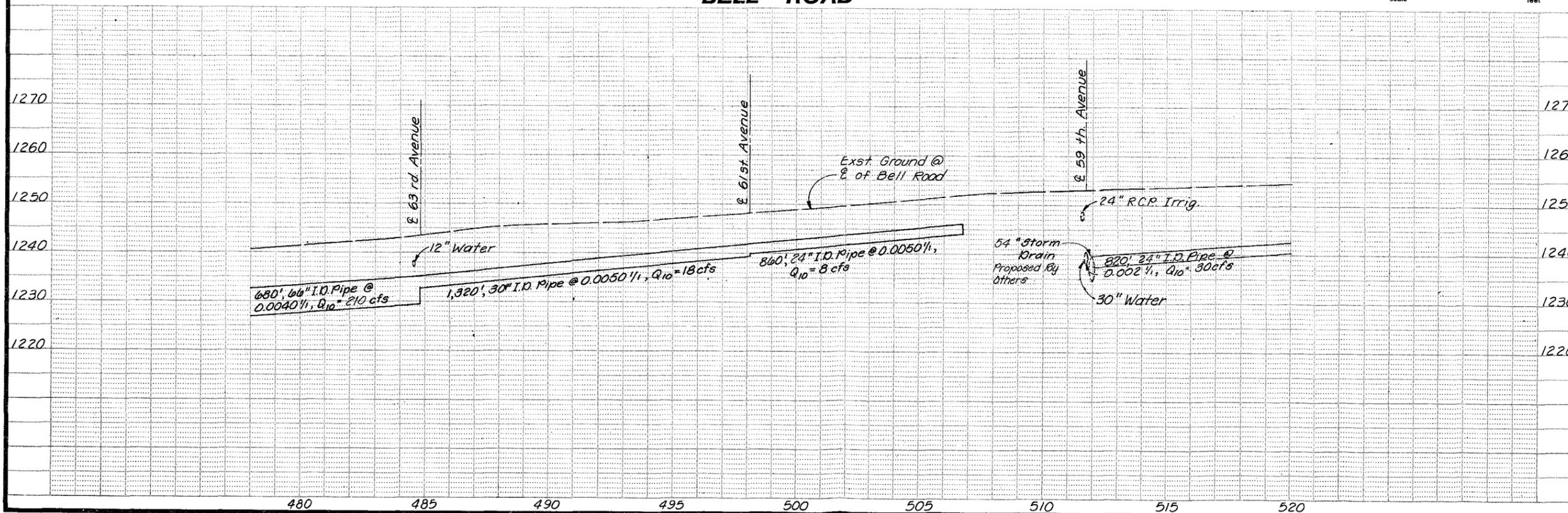
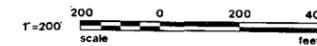
Date: **OCT. 1987**  
 Job No: **E123061**  
 Sheet of: **13 33**



STA. 478 + 00 MATCH SHEET 13

STA. 520 + 00 MATCH SHEET 15

BELL ROAD



Revisions

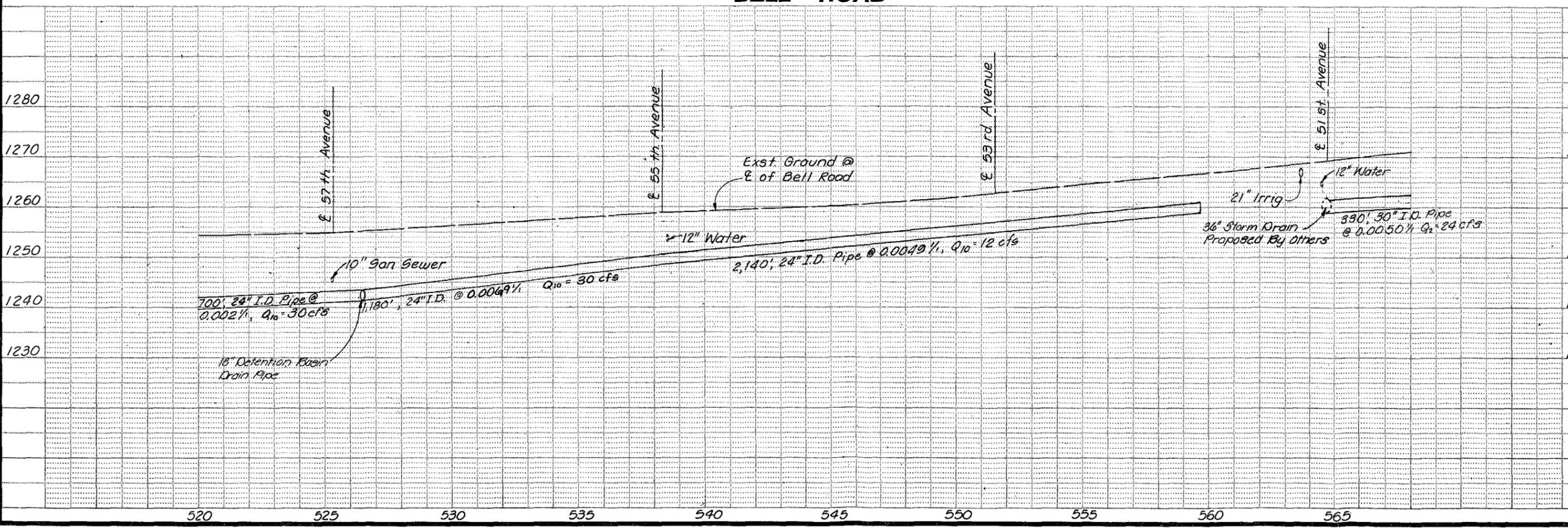
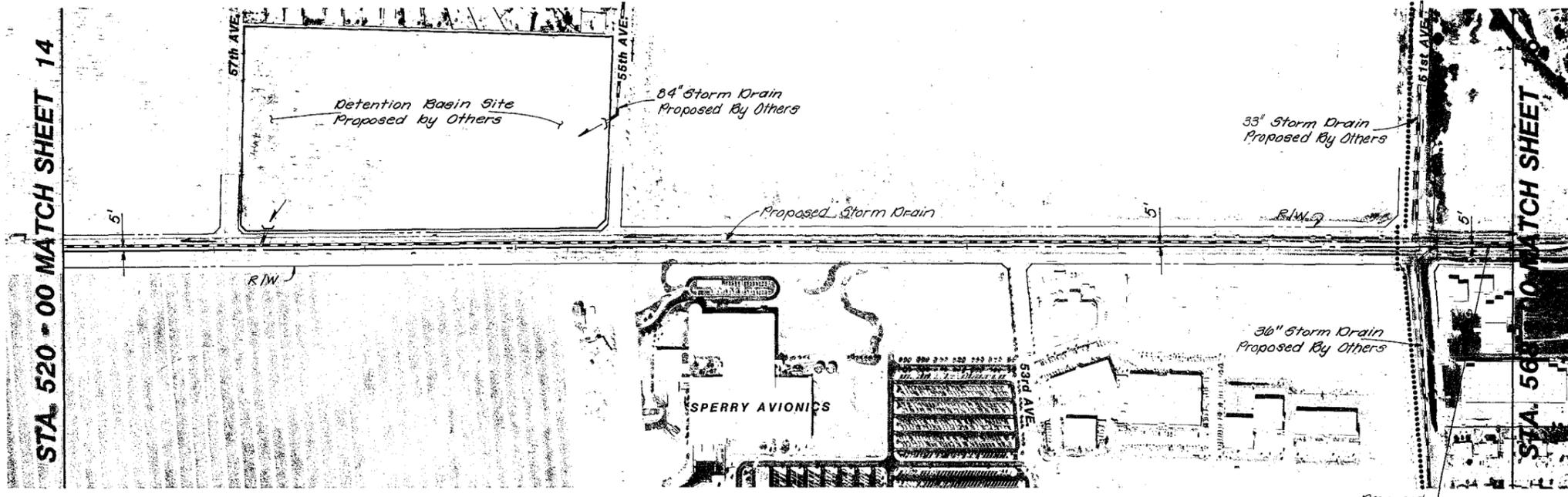
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Science, Inc.  
 7101 N. 16th Street, Phoenix, Arizona 85028-8902 P.O. Box 4400  
 2590 North Avonway, Tucson, Arizona 85718-9002 327-5415

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.  
 M.G.

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

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061  
 Sheet of: 14 | 33



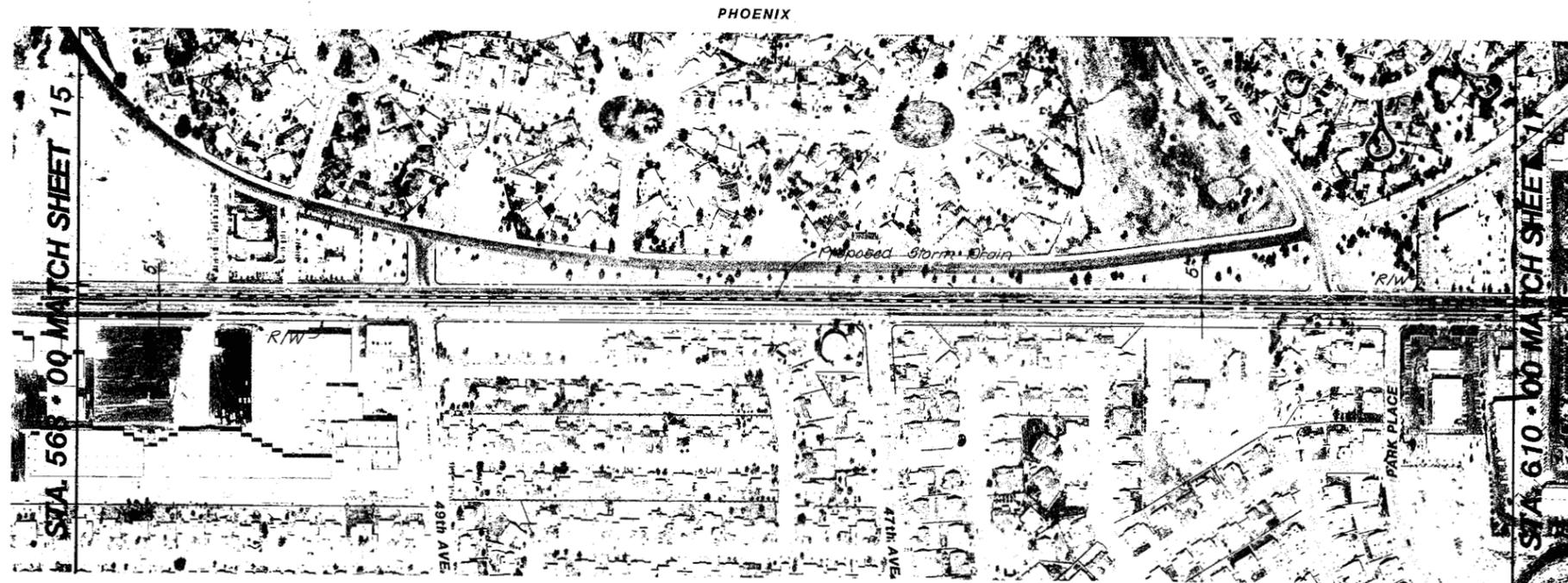
Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 150 Phoenix, Arizona 85020/602 275-5400  
 2500 North Avenue Way/Tucson, Arizona 85712/602 337-3413

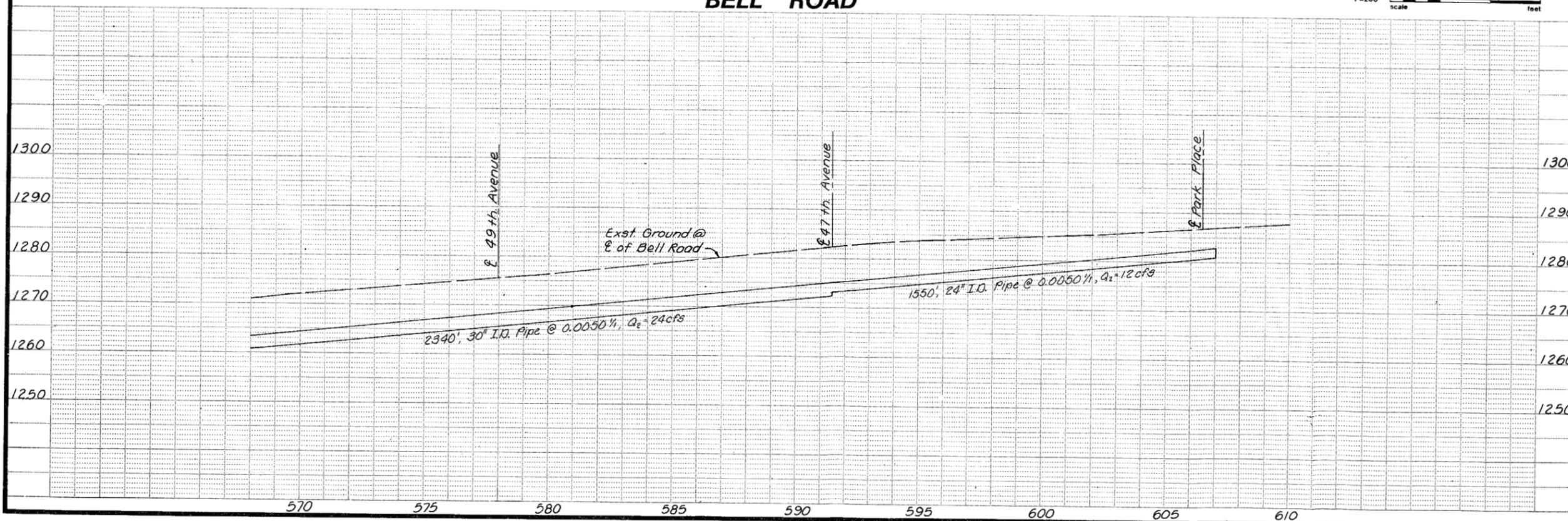
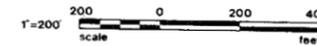
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./J.W.R.B.  
 Check: M.G.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123081  
 Sheet of: 15 | 33



**BELL ROAD**



Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7510 N. Central Expressway, Suite 200  
 2590 North Avonway, Tucson, Arizona 85712-2002-207-5413

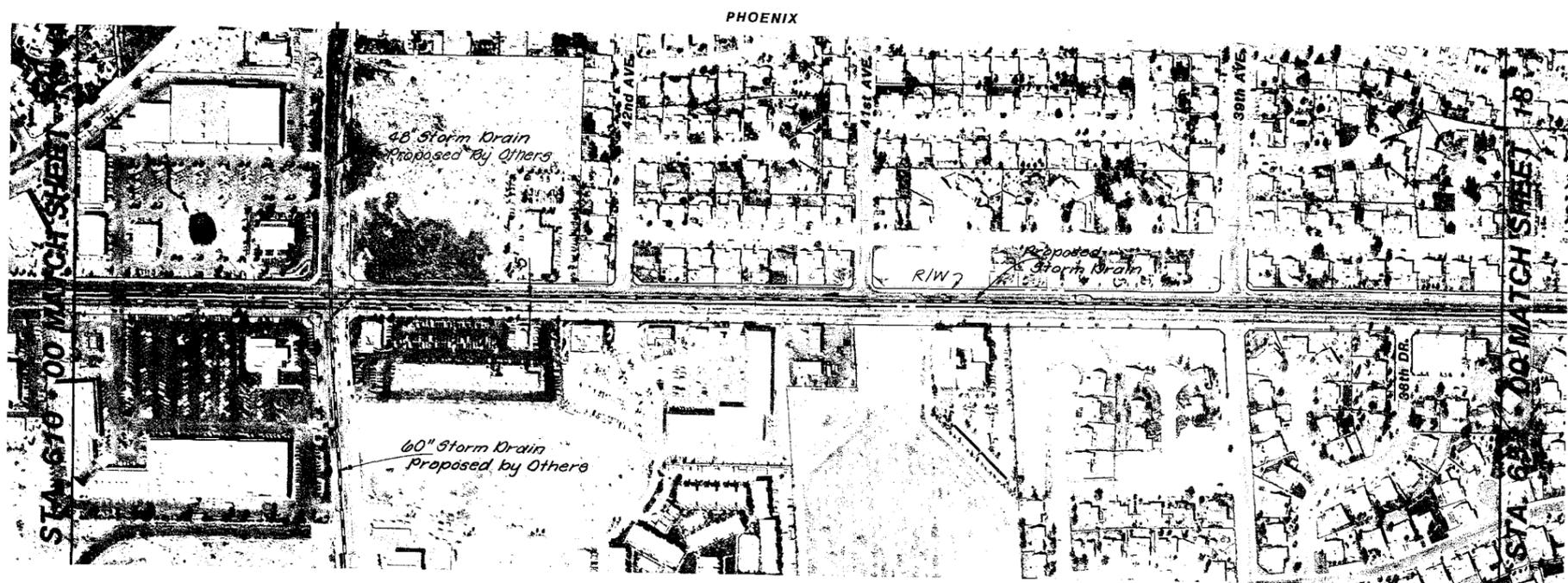
Design: **M.C./R.B./G.S./M.O.**  
 Drawn: **F.C./W.R.B.**  
 Check: **M.S.S.**  
**M.G.**

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

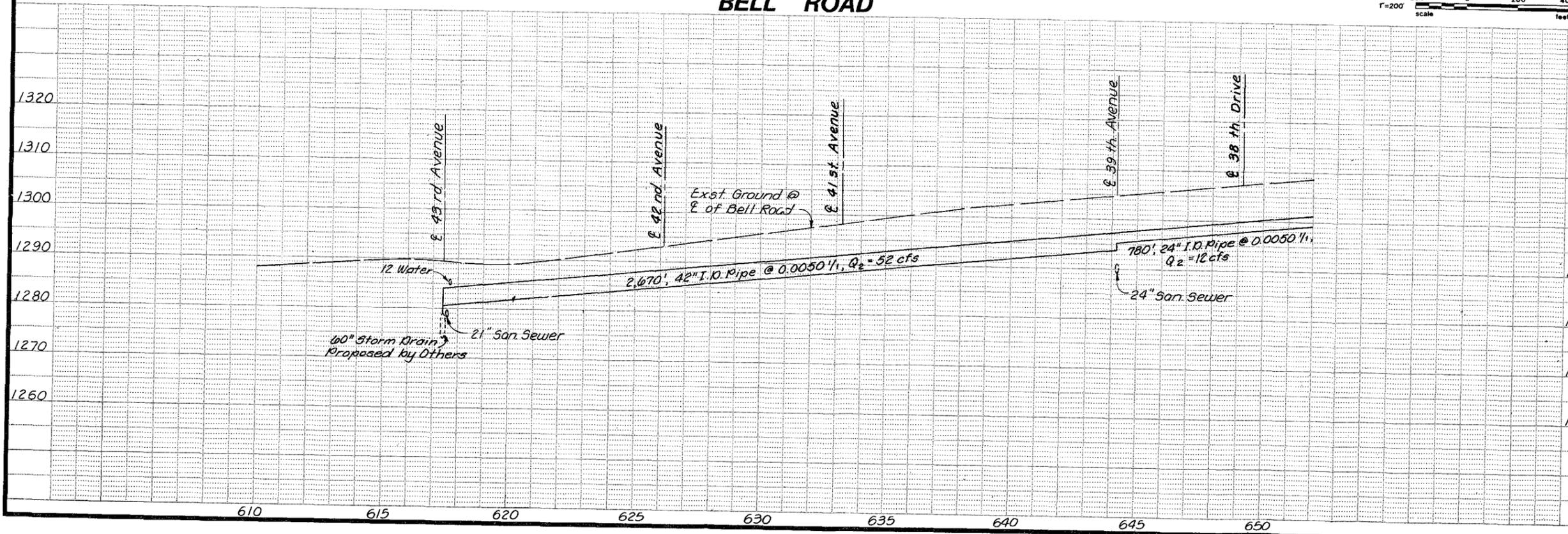
**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: **OCT. 1987**  
 Job No.: **E123061**

Sheet of  
**16 | 33**



**BELL ROAD**



Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 150 Phoenix, Arizona 85020-6622 275-5400  
 2590 North Alhambra Way, Tucson, Arizona 85712-9802 327-5413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.S.  
 M.G.

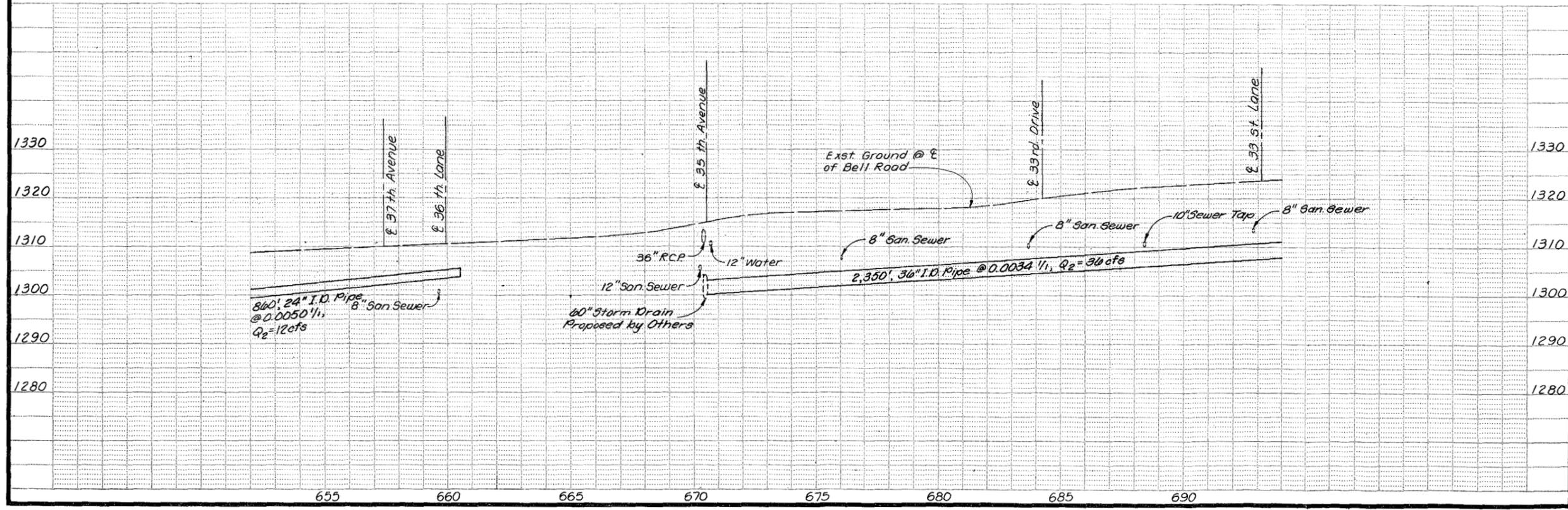
Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet of 33  
**17 33**



**BELL ROAD**



Revisions

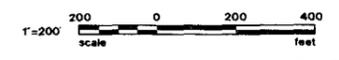
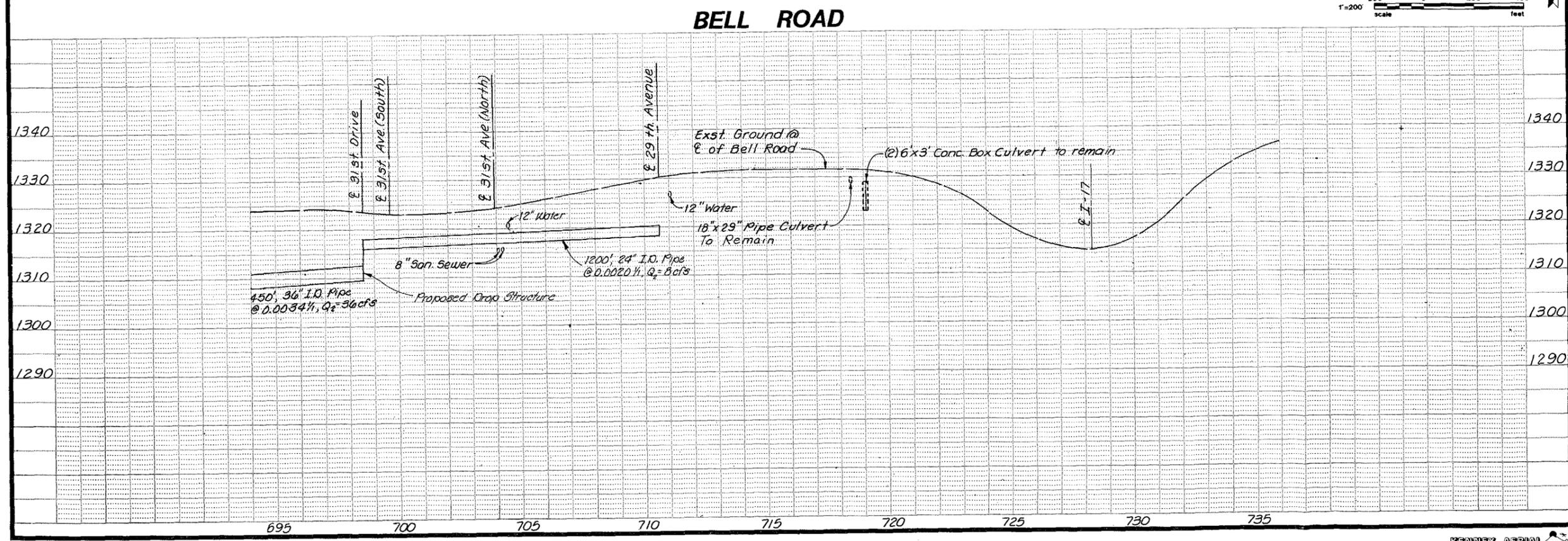
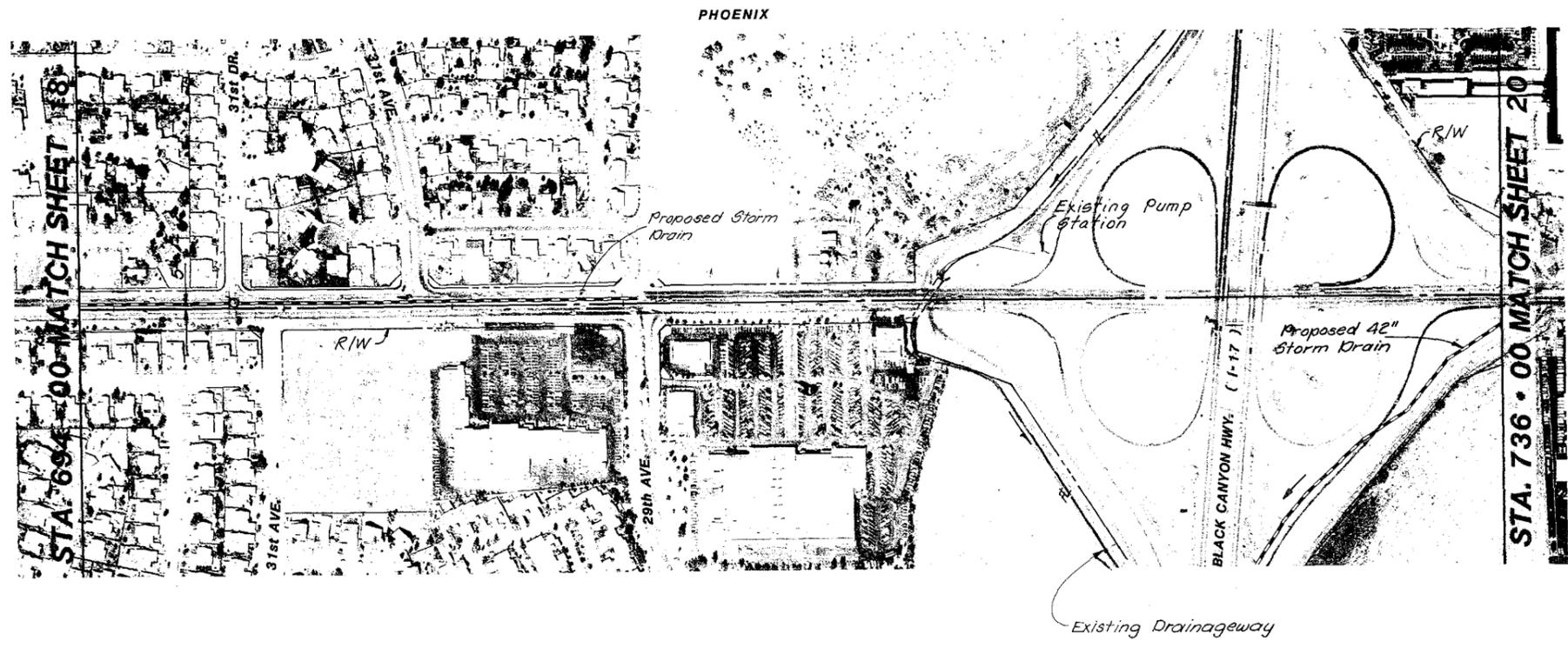
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering, Inc.  
 2300 N. 48th Street, Suite 100  
 Phoenix, Arizona 85018-1000  
 2590 North American Way, Tucson, Arizona 85712-9023-2413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.S.  
 M.C.

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

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 18 of 33

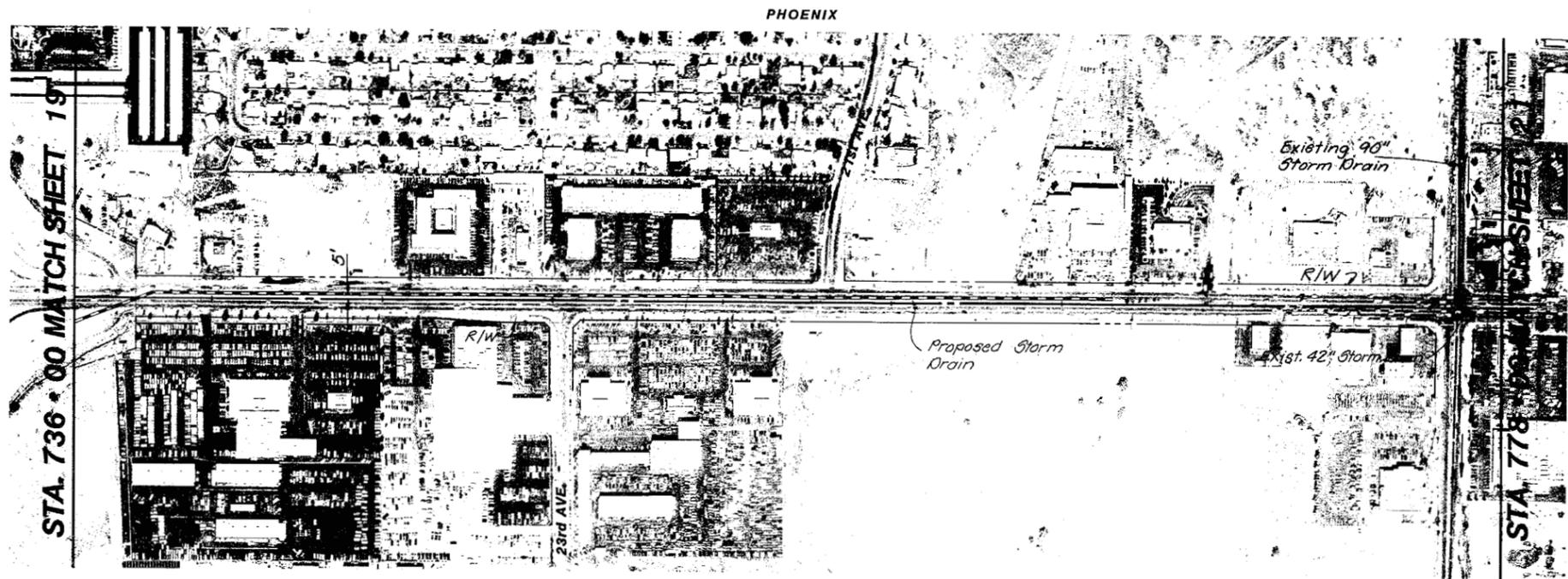


  
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7910 N. 19th Street, Suite 100/Phoenix, Arizona 85020/602 275-5400  
 250 North Avramon Way/Tucson, Arizona 85712/520 327-5415

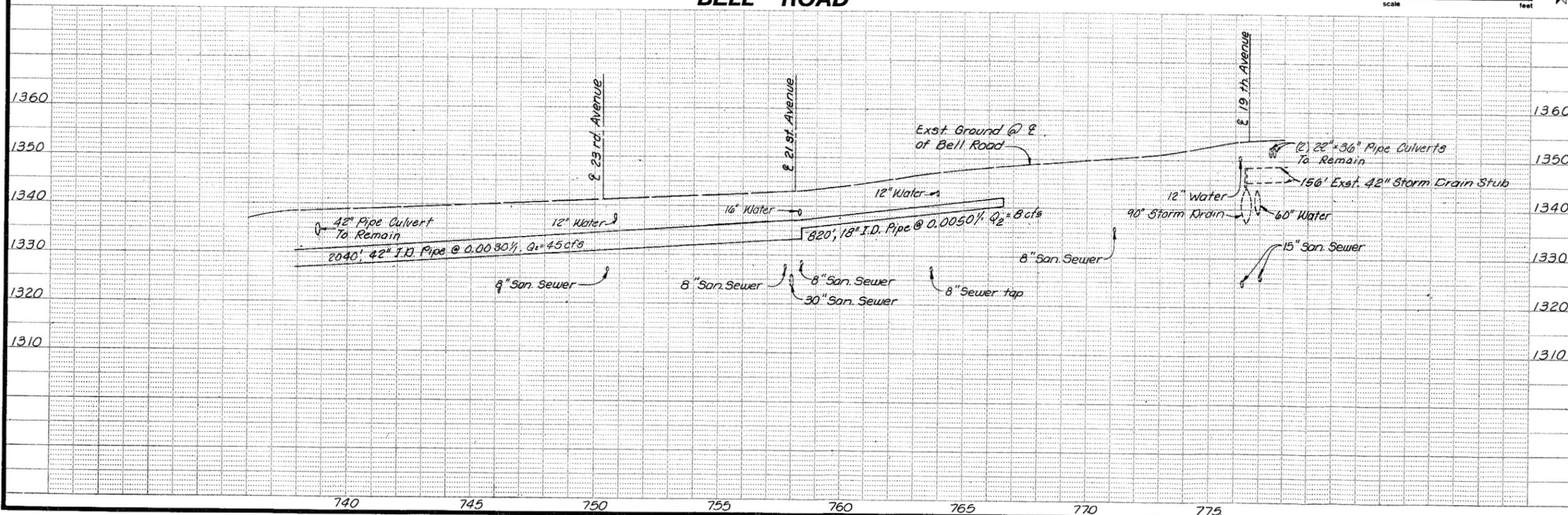
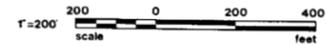
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./H.R.B.  
 Check: M.S.G.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
**DRAINAGE STUDY**  
**PRELIMINARY PLANS**

Date: OCT. 1987  
 Job No. E123061  
 Sheet 19 of 33



**BELL ROAD**



Revisions

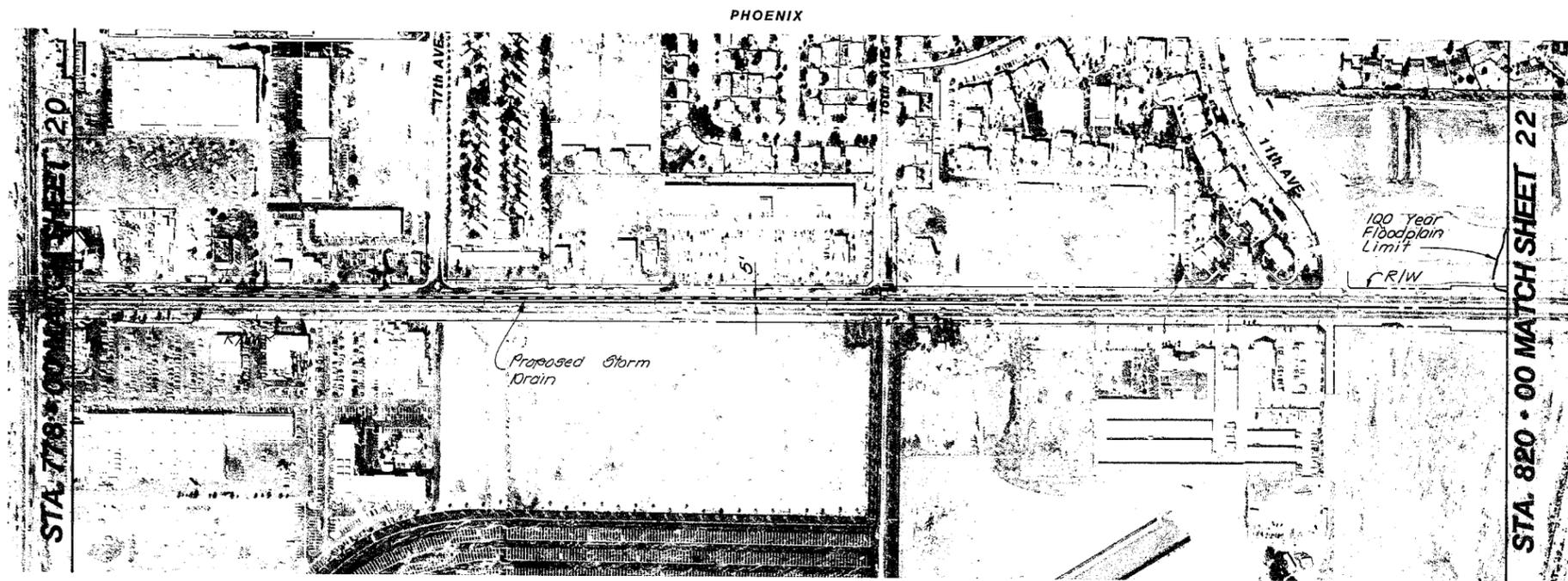
A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7210 N. 19th Street, Suite 160 Phoenix, Arizona 85020-0622 275-5400  
 2500 North Antennas Way Tucson, Arizona 85712-8502 327-3413

**Greiner Engineering**

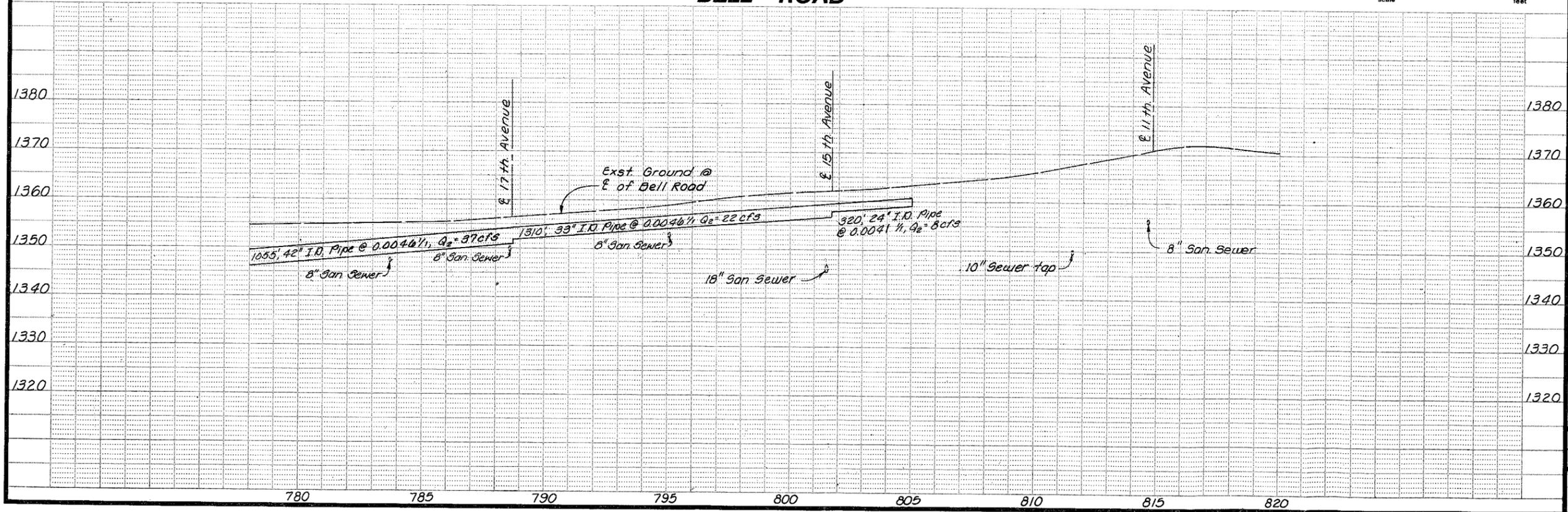
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.G.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061  
 Sheet 20 of 33



**BELL ROAD**



Revisions

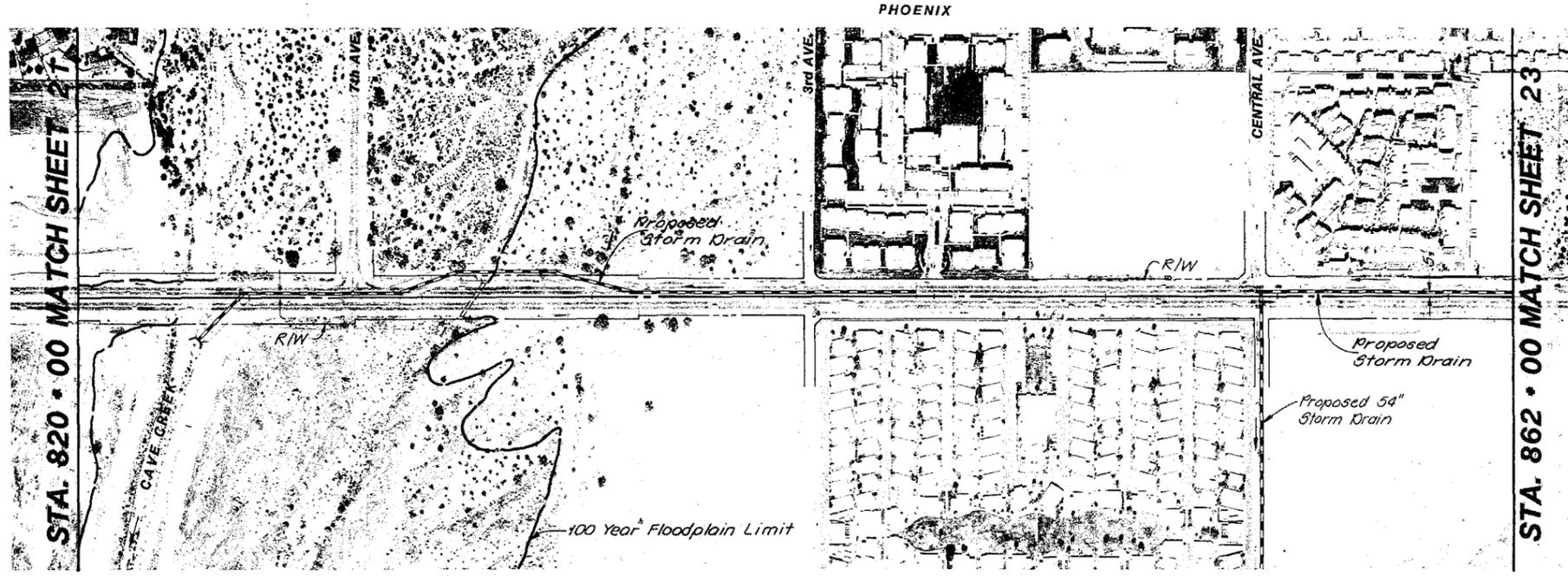
**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020-6902 275-5400  
 2590 North Avenon Way Tucson, Arizona 85719-6602 327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.S.  
 M.C.

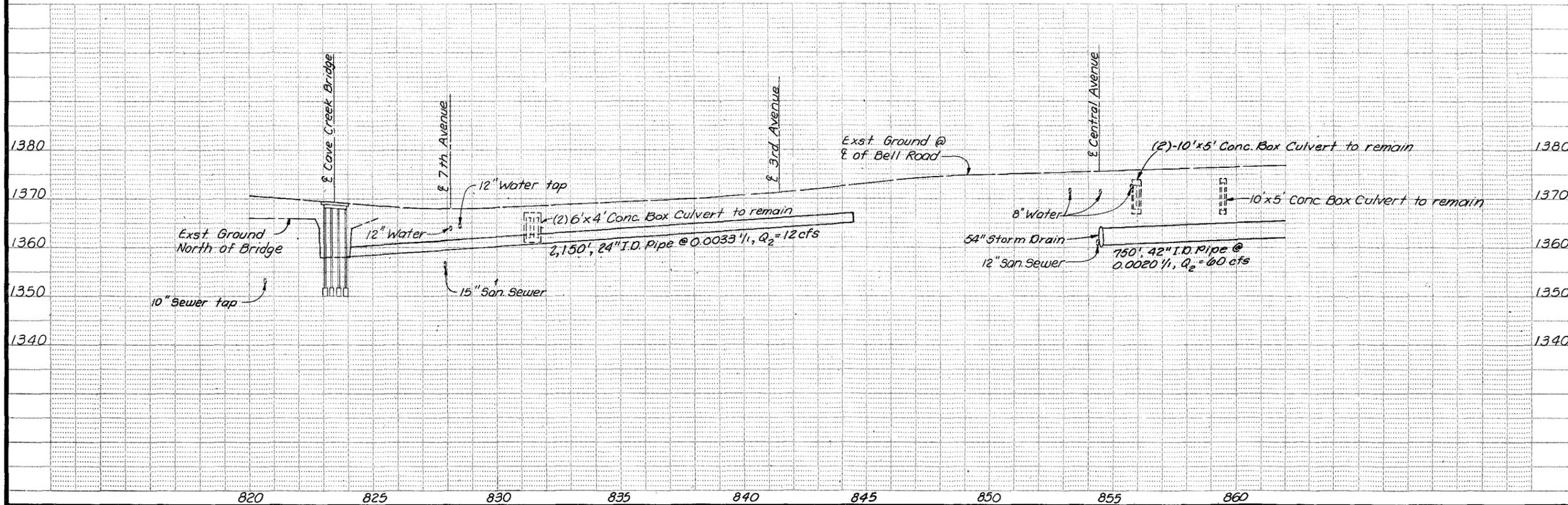
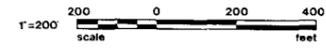
Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 21 of 33



**BELL ROAD**



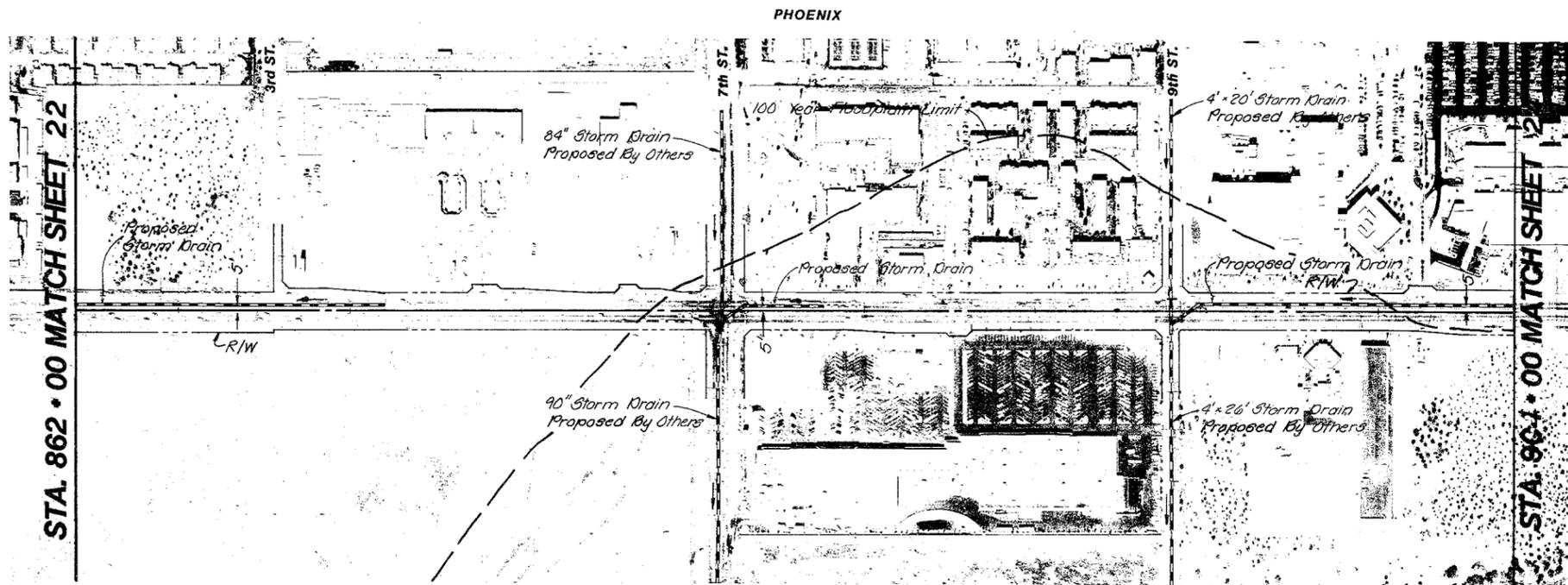
Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 1000 N. 18th Street, Suite 100 Phoenix, Arizona 85006-6527 215-5400  
 2800 North Arrow Way Tucson, Arizona 85712 520-227-5413

Design: M.C./R.B./G.S./M.O.  
 Drawn: E.C./J.S.B.  
 Check: M.S.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

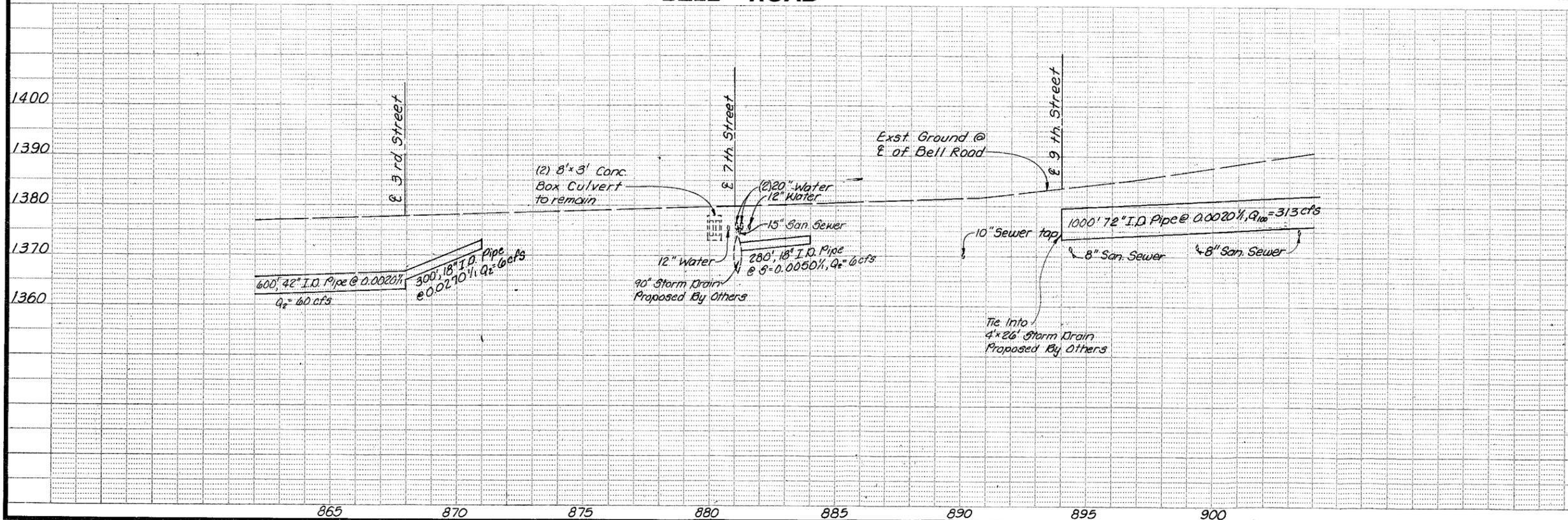
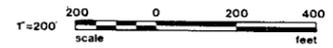
Date: OCT. 1987  
 Job No: E123061  
 Sheet 22 of 33



STA. 862 + 00 MATCH SHEET 22

STA. 901 + 00 MATCH SHEET 12

BELL ROAD



Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 160 Phoenix, Arizona 85020 602 275-5400  
 2590 North Alvernon Way/Tucson, Arizona 85712 602 327-3413

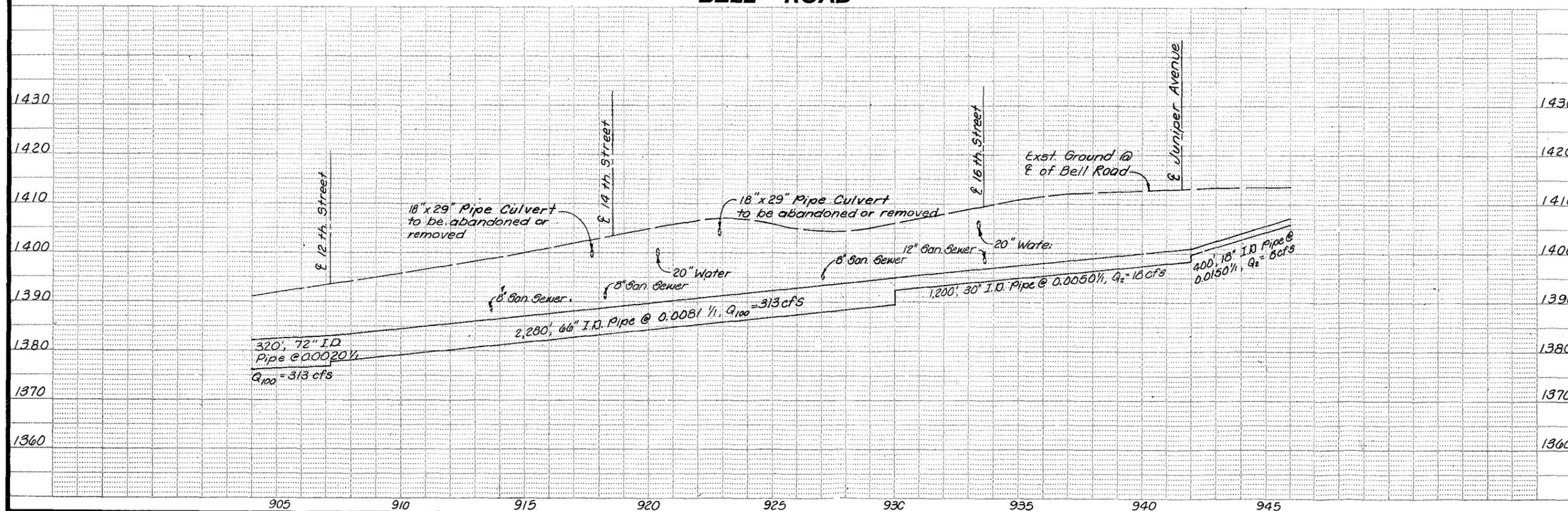
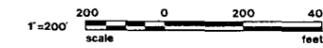
Design: M.C./R.B./G.S./M.O.  
 Drawn: E.C./S.G.  
 Check: M.S.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet of 23 33



BELL ROAD



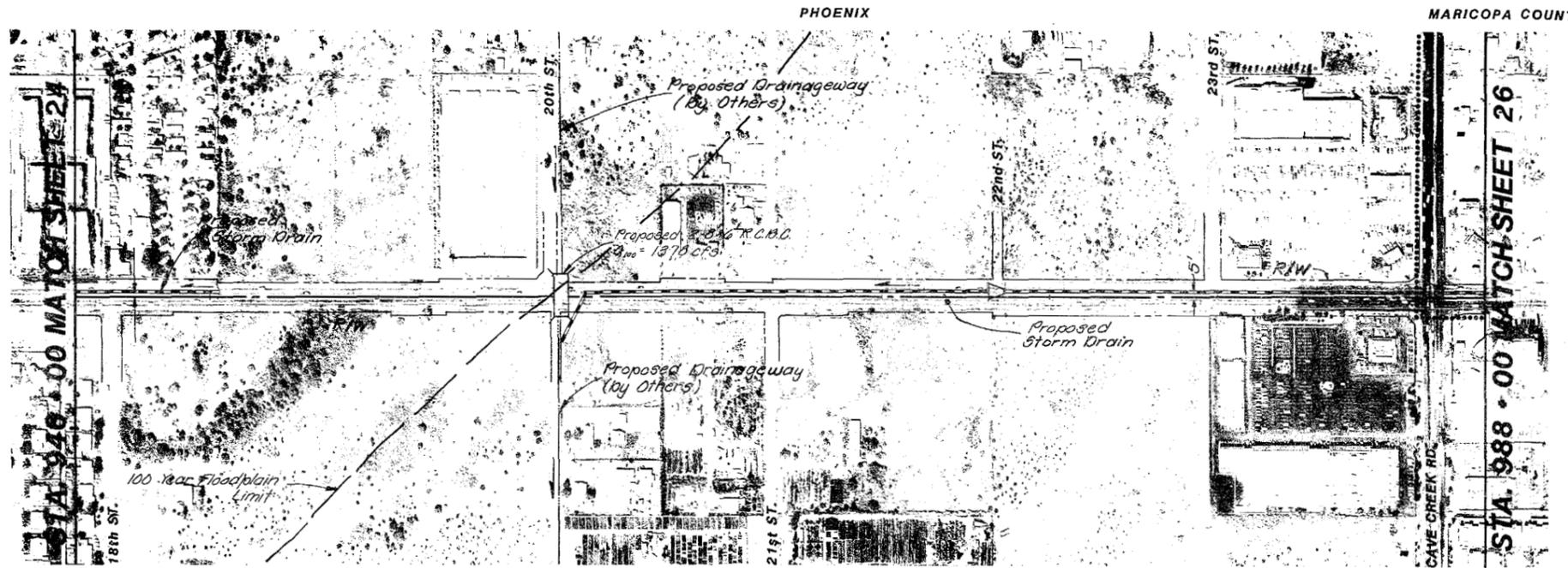
Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Services, Inc.  
 7340 N. 16th Street, Suite 400, Phoenix, Arizona 85020-9022 275-5400  
 2520 North Alverton Way/Tucson, Arizona 85712-9922 327-3413

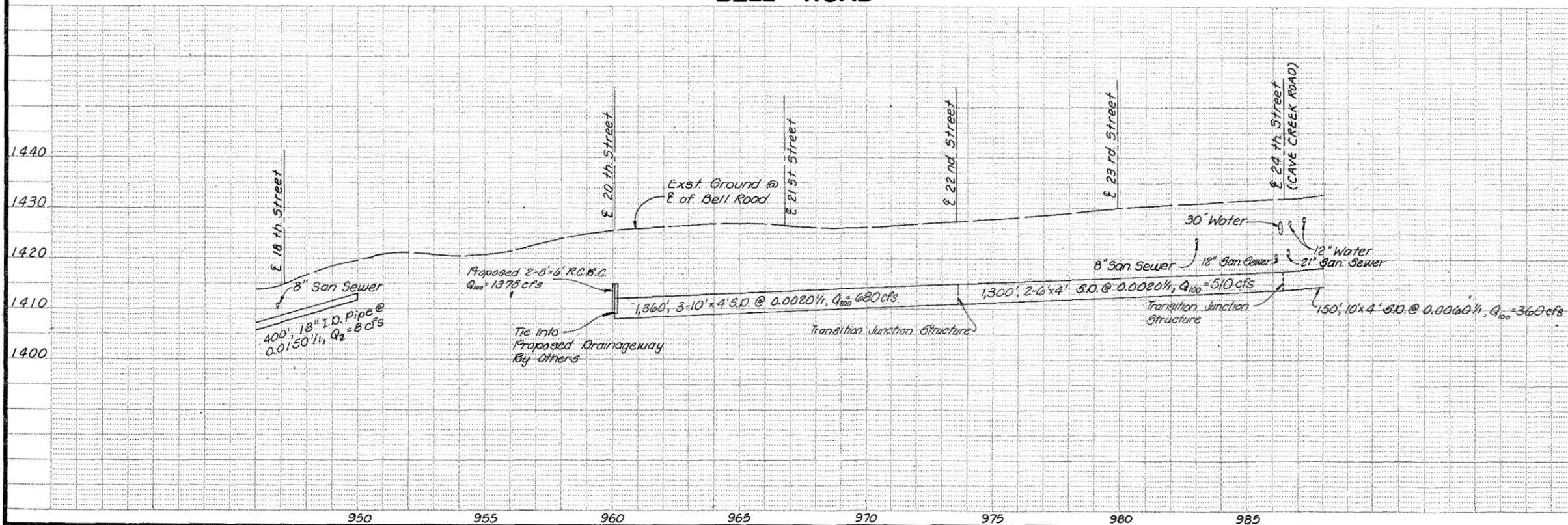
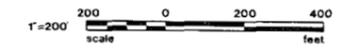
Design: M.C./R.B./G.S./M.O.  
 Drawn: E.C./W.R.B.  
 Check: M.G.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No: E123061  
 Sheet of  
 24 | 33



**BELL ROAD**



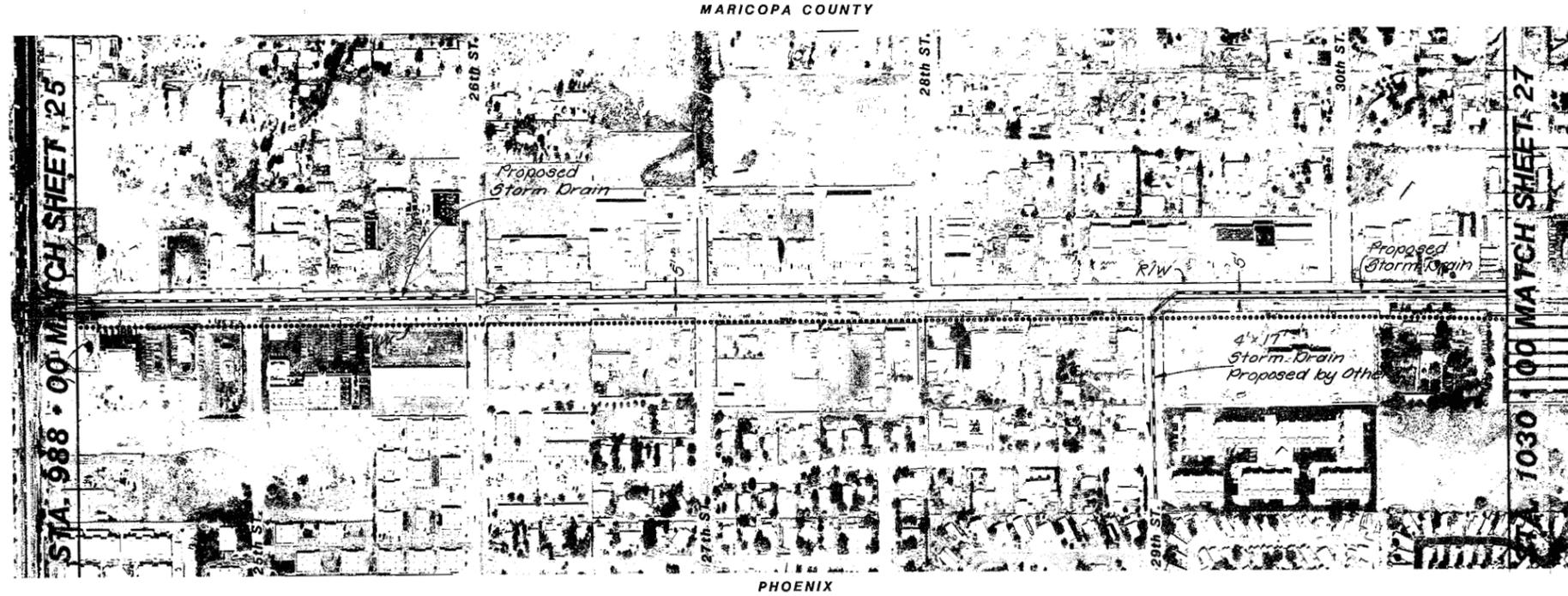
Revisions

**Greiner Engineering**  
 Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 Phoenix, Arizona 85009-9293 975-5400  
 2590 North Alhambra Way/Tucson, Arizona 85719-9602 327-3415

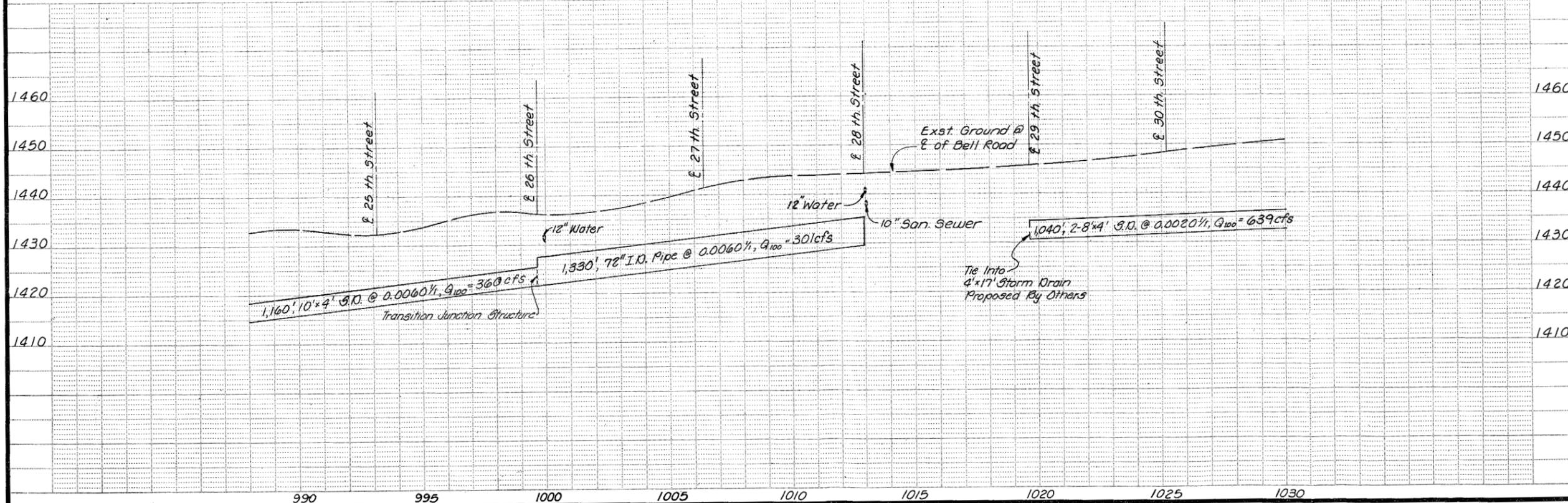
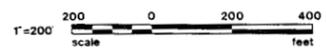
Design: M.C.R.B./G.S.M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No: E123061  
 Sheet of: 25 | 33



**BELL ROAD**



REVISIONS

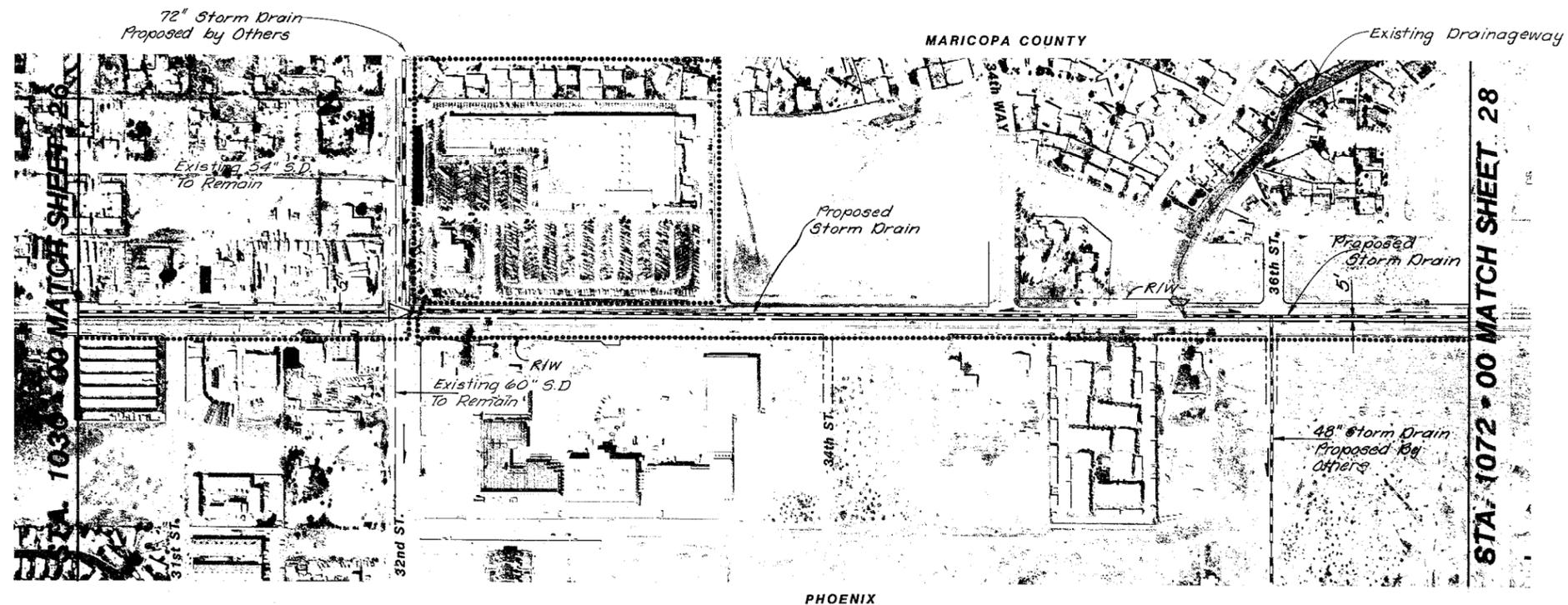
**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc., Arizona 85006/602 275-5400  
 2500 North Averson Way/Tucson, Arizona 85712/602 327-3413

Design M.C./R.B./G.S./M.O.  
 Drawn F.C./W.R.B.  
 Check M.S.S.  
 M.C.

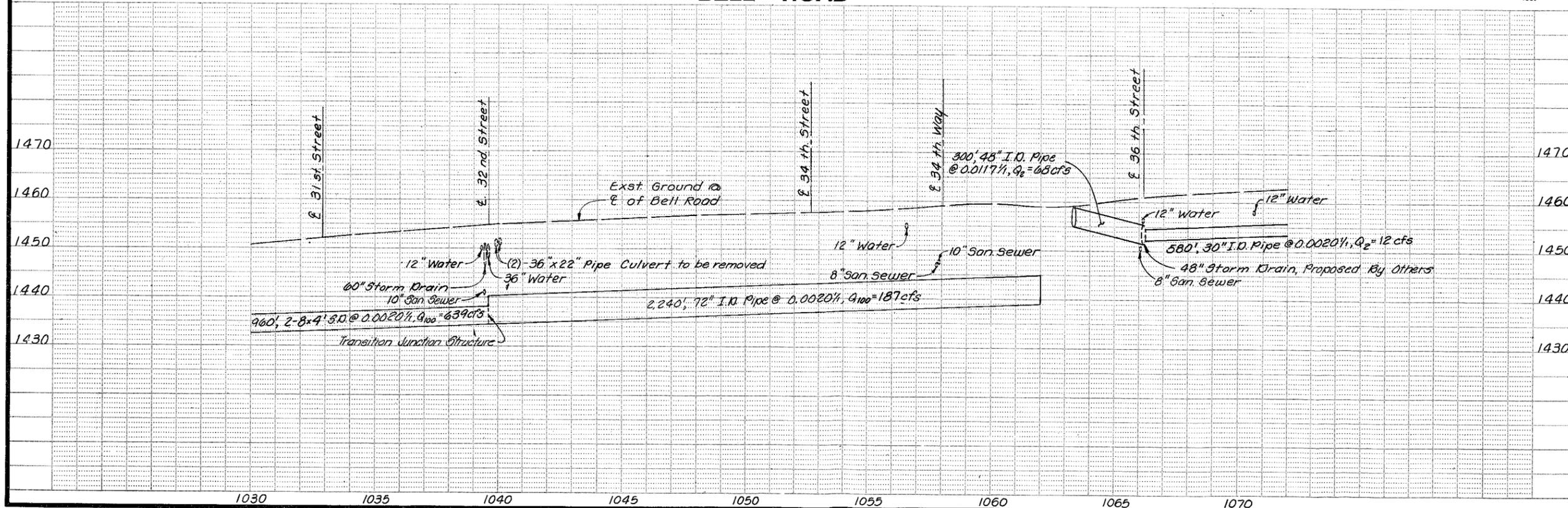
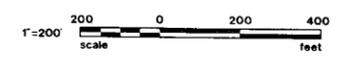
Scale  
 HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date OCT. 1987  
 Job No. E123061  
 Sheet 26 of 33



**BELL ROAD**



Revisions

---

A Greiner Engineering, Inc. Company

**Greiner Engineering**

Greiner Engineering Sciences, Inc.  
7310 N. 18th Street, Suite 160/Phoenix, Arizona 85020/602-275-5400  
2590 North Alvarado Way/Tucson, Arizona 85712/602-337-3413

---

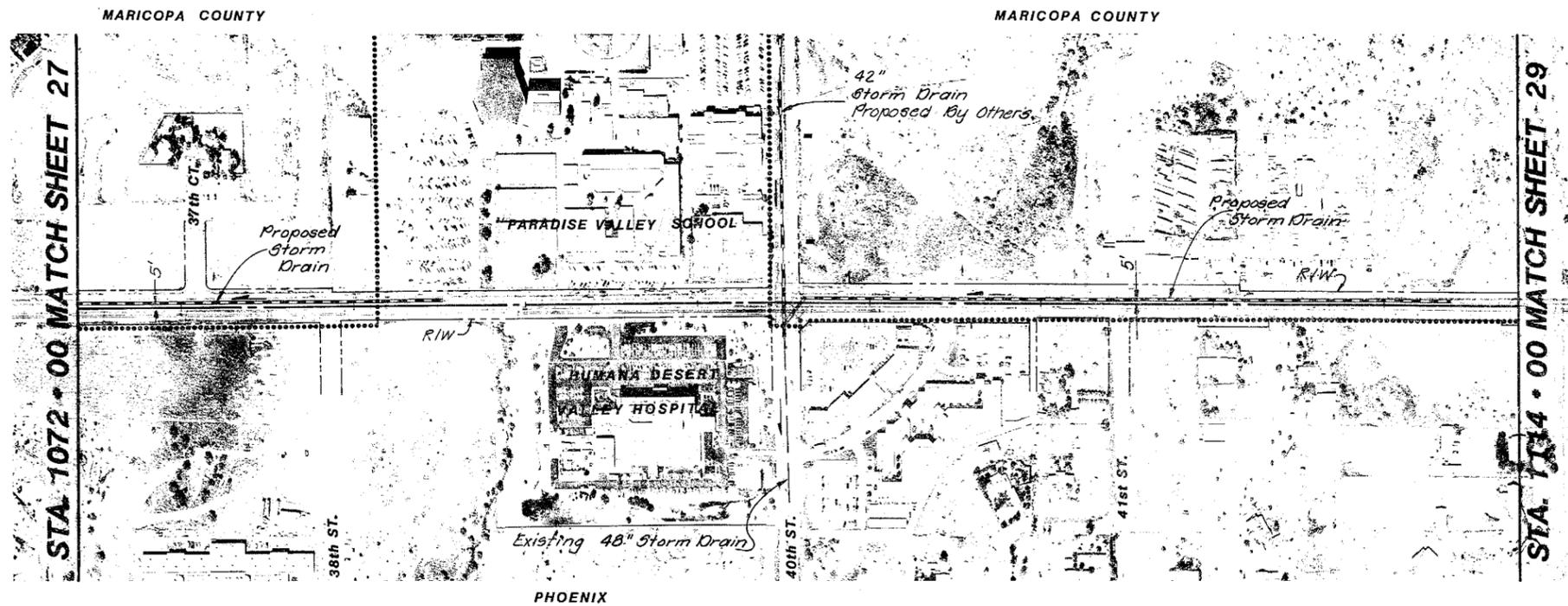
Design: M.C./R.B./G.S./M.O.  
 Drawn: E.C./W.R.B.  
 Check: M.S.S.  
 M.G.

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

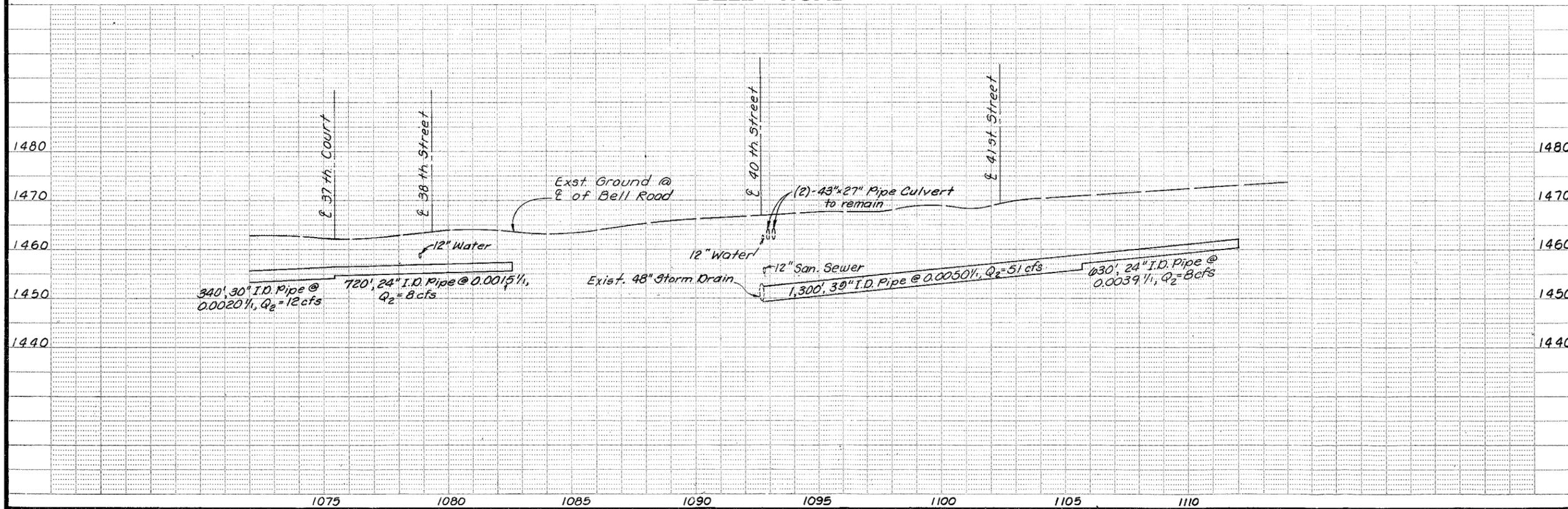
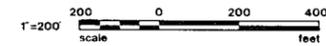
**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

---

Date: OCT. 1987  
 Job No.: E123061  
 Sheet 27 of 33



**BELL ROAD**



**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 150/Phoenix, Arizona 85020/602-275-5400  
 2550 North Avraon Way/Tucson, Arizona 85712/602-327-3413

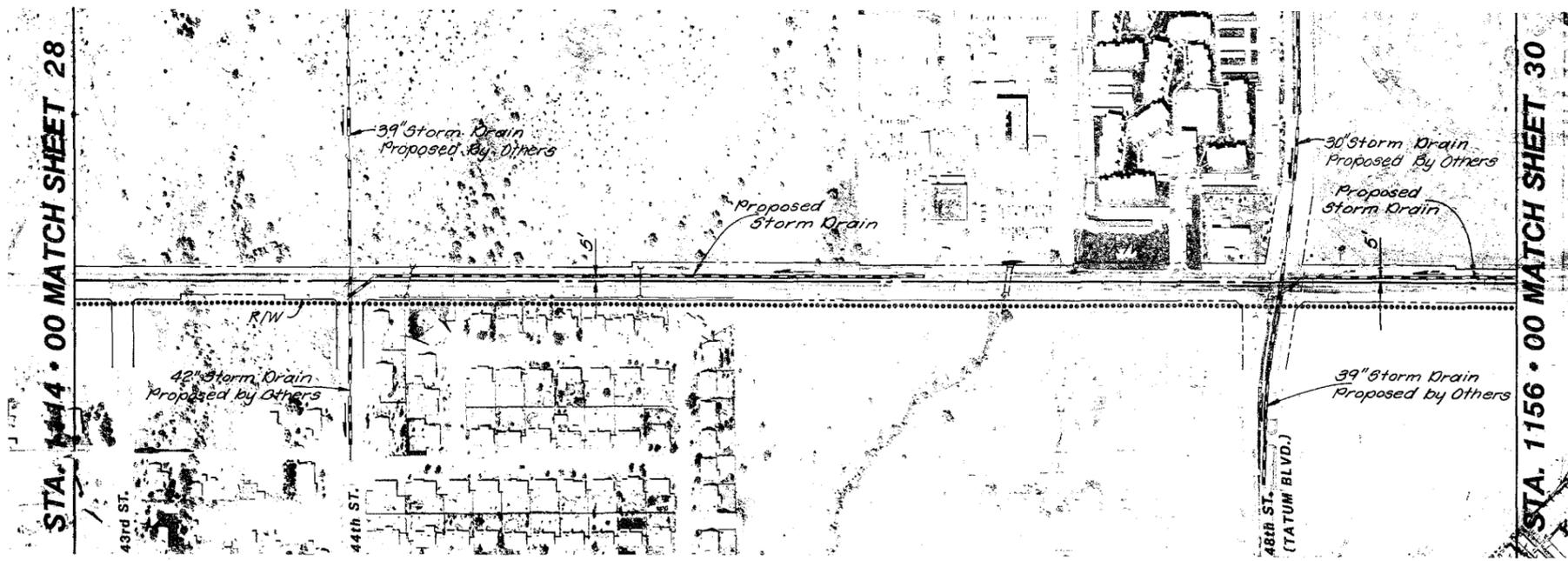
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.G.  
 M.C.

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

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

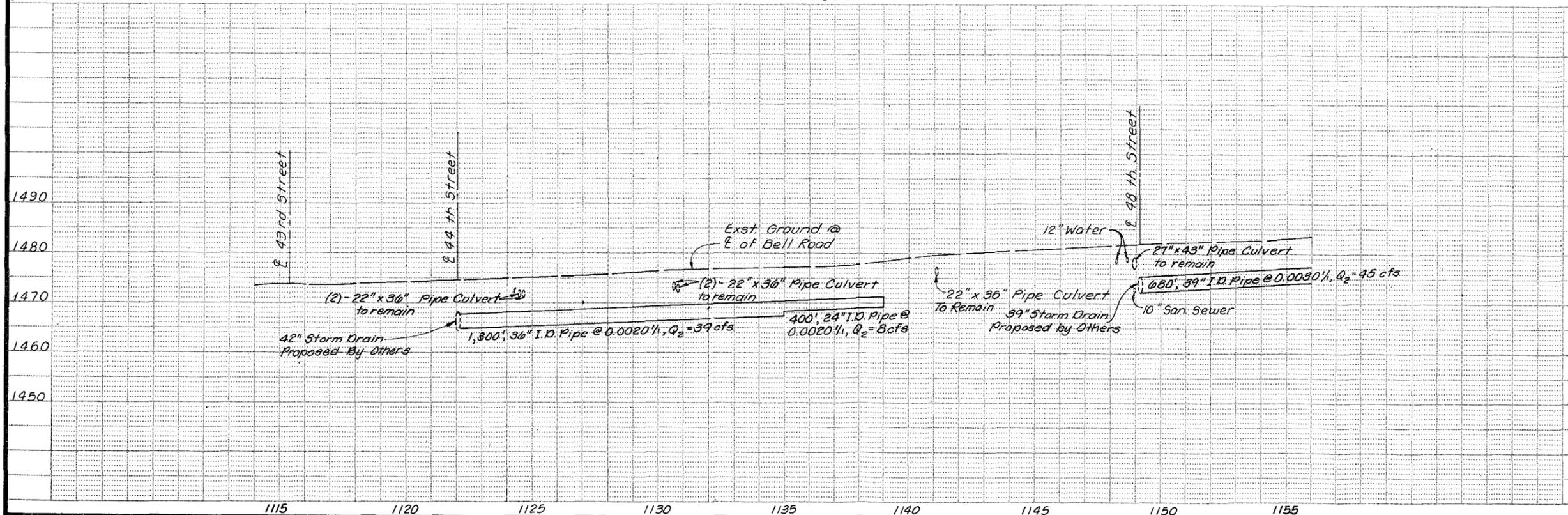
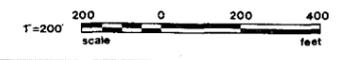
Date: OCT. 1987  
 Job No.: E123061  
 Sheet of: 28 33

MARICOPA COUNTY



PHOENIX

### BELL ROAD



Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 100/Phoenix, Arizona 85020/602-275-5400  
 2590 North Avmon Way/Tucson, Arizona 85712/602-327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.S.S.  
 M.C.

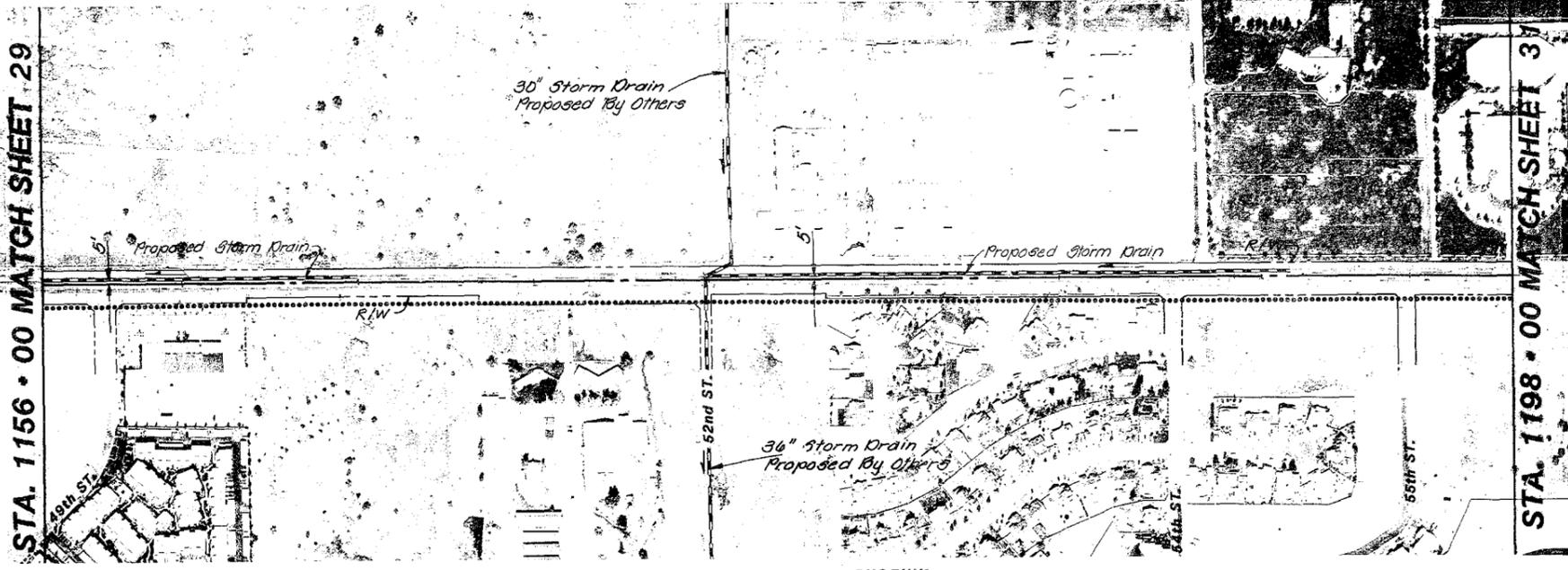
Scale:  
 HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061

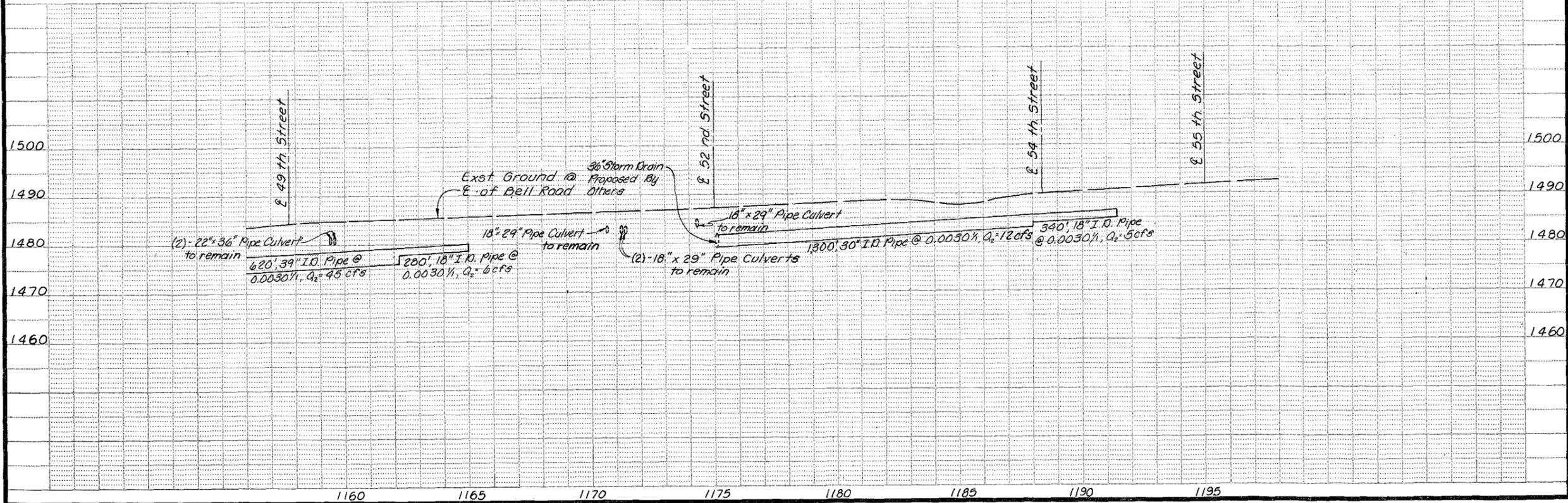
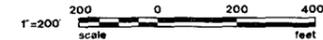
Sheet of  
 29 33

MARICOPA COUNTY



PHOENIX

BELL ROAD



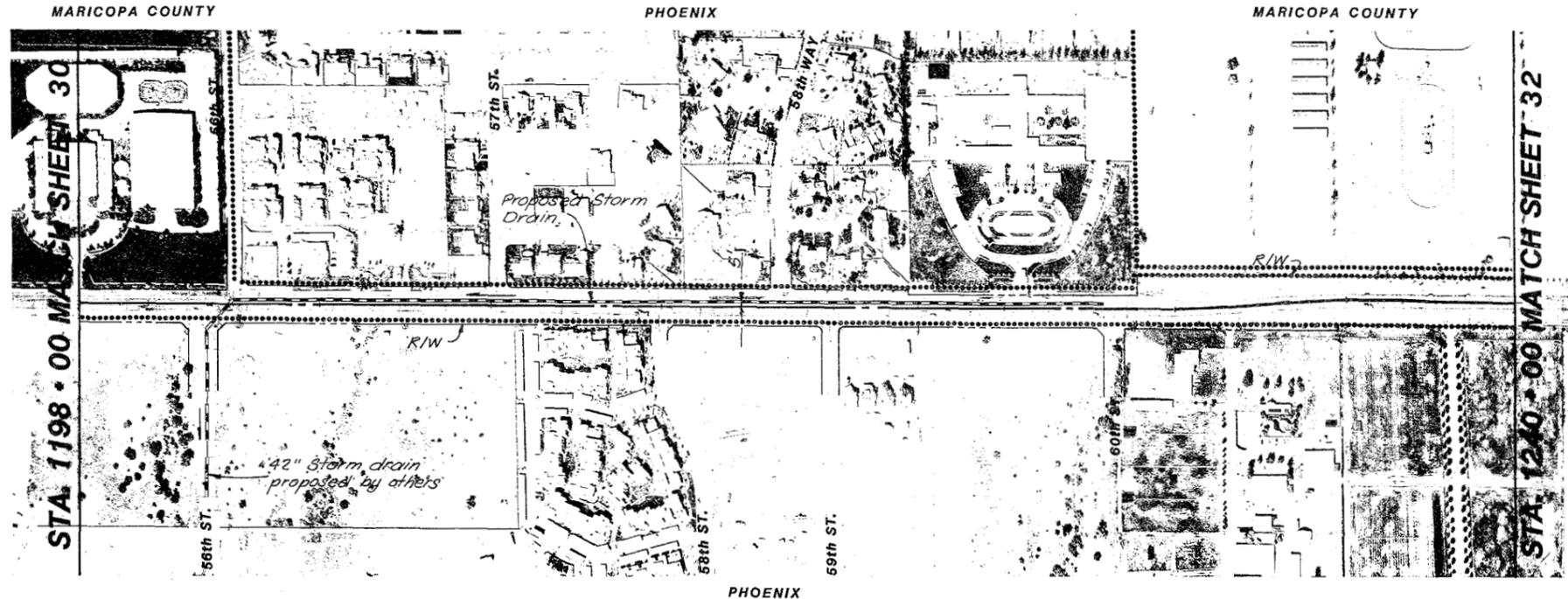
Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 18th Street, Suite 150/Phoenix, Arizona 85020-0327-5400  
 2390 North Alhambra Way/Tucson, Arizona 85712-5627-3413

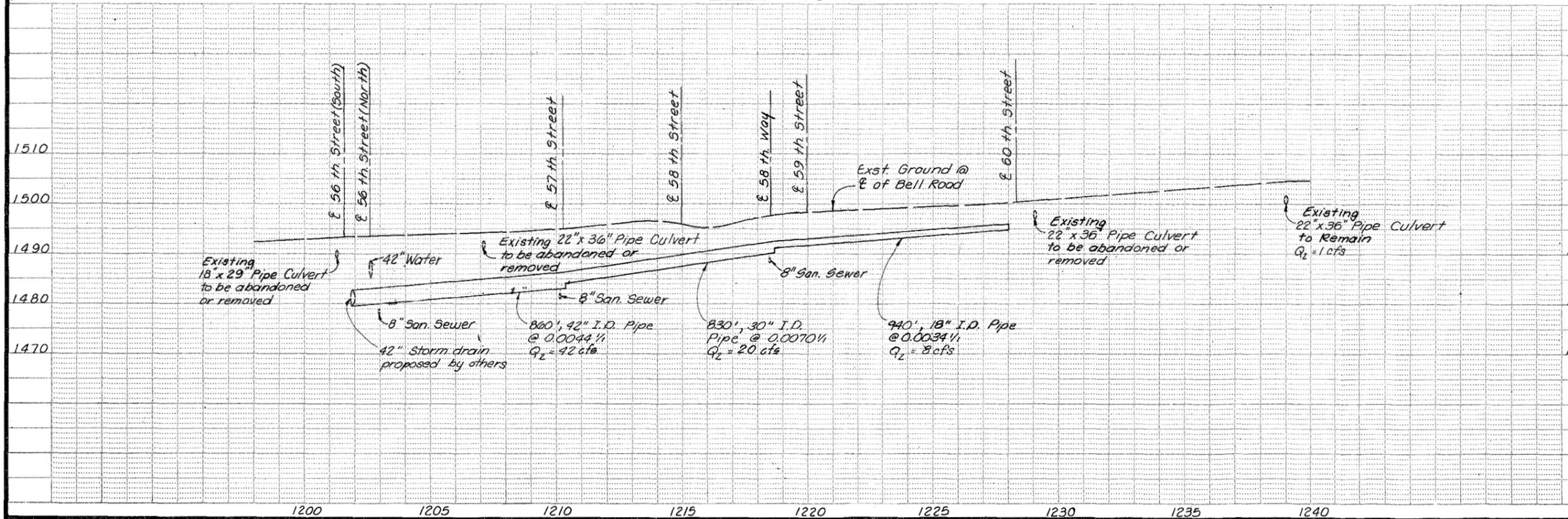
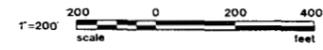
Design: M.C./R.B./G.S./M.O.  
 Drawn: J.C./M.R.B.  
 Check: M.G.S.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061  
 Sheet of: 30 33



**BELL ROAD**



Revisions

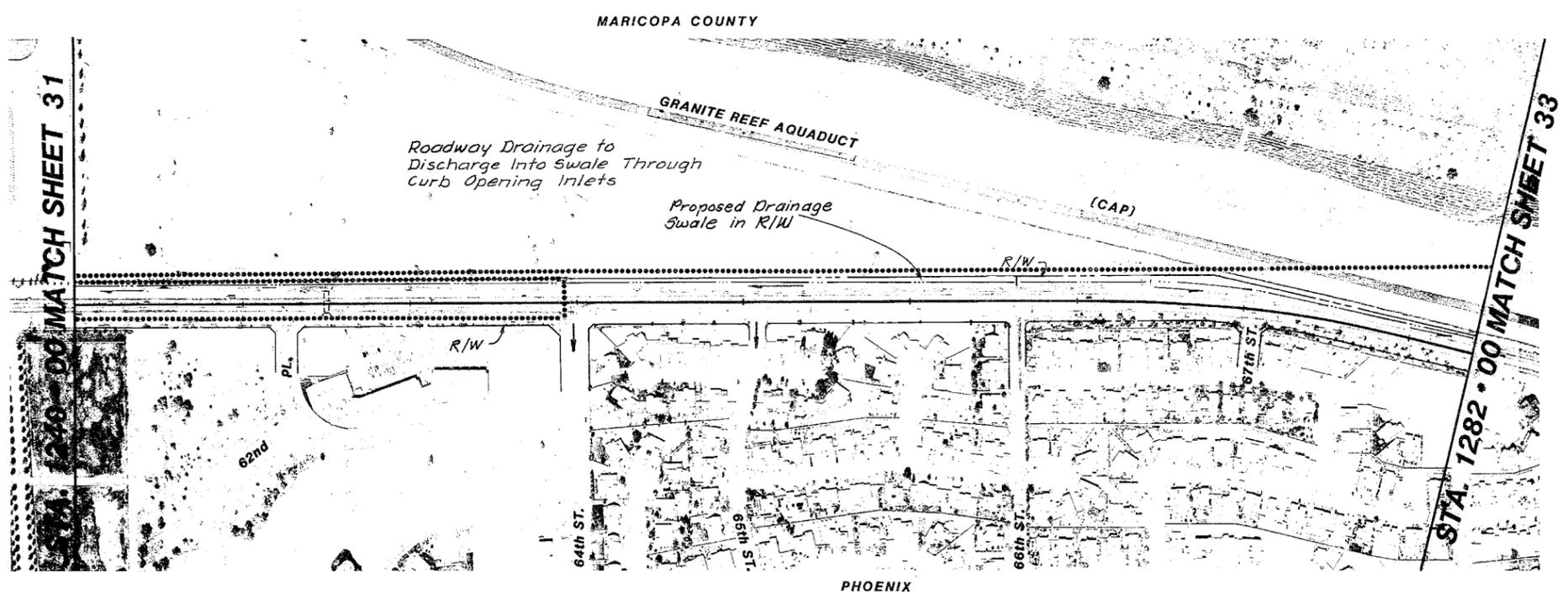
**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 100/Phoenix, Arizona 85020/602-275-5400  
 2500 North Avonway Tucson, Arizona 85712/602-327-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: E.C./W.R.B.  
 Check: M.S.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

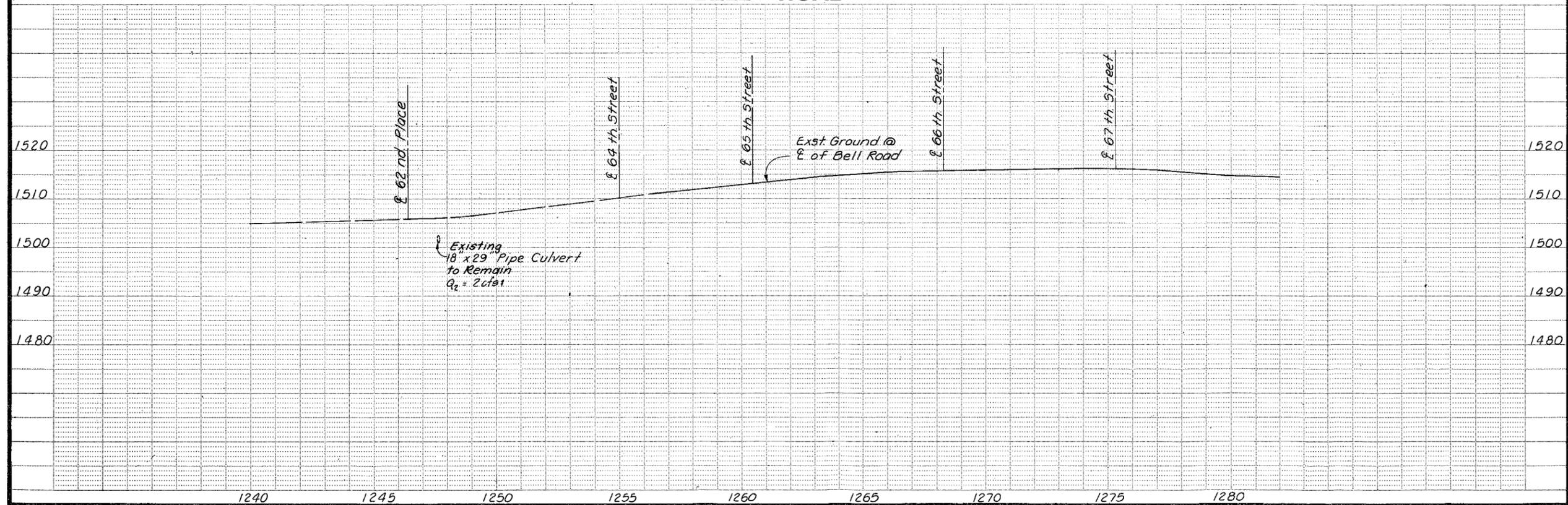
**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061

Sheet of  
**31** | **33**



**BELL ROAD**



Revisions

**Greiner Engineering**  
 Greiner Engineering Sciences, Inc.  
 7310 N. 16th Street, Suite 100/Phoenix, Arizona 85020/602-275-5400  
 2500 North American Way Tucson, Arizona 85718/602-527-5413

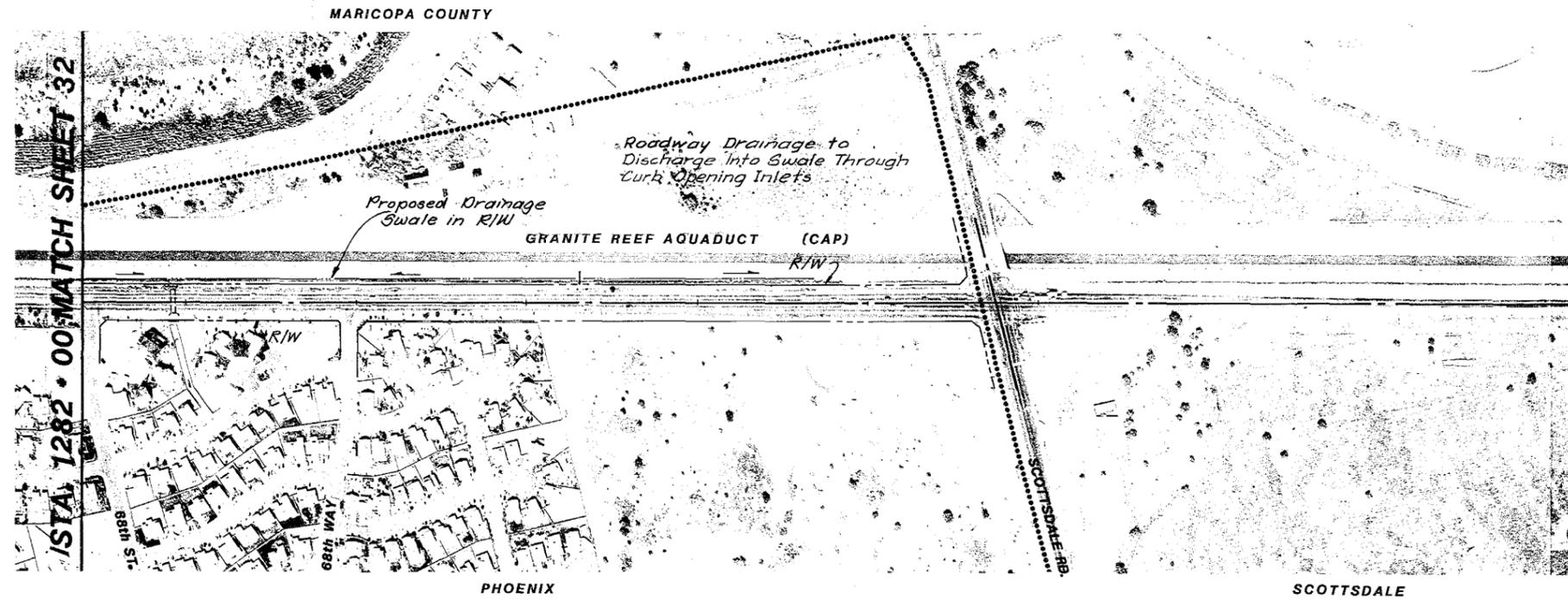
Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.G.  
 M.C.

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

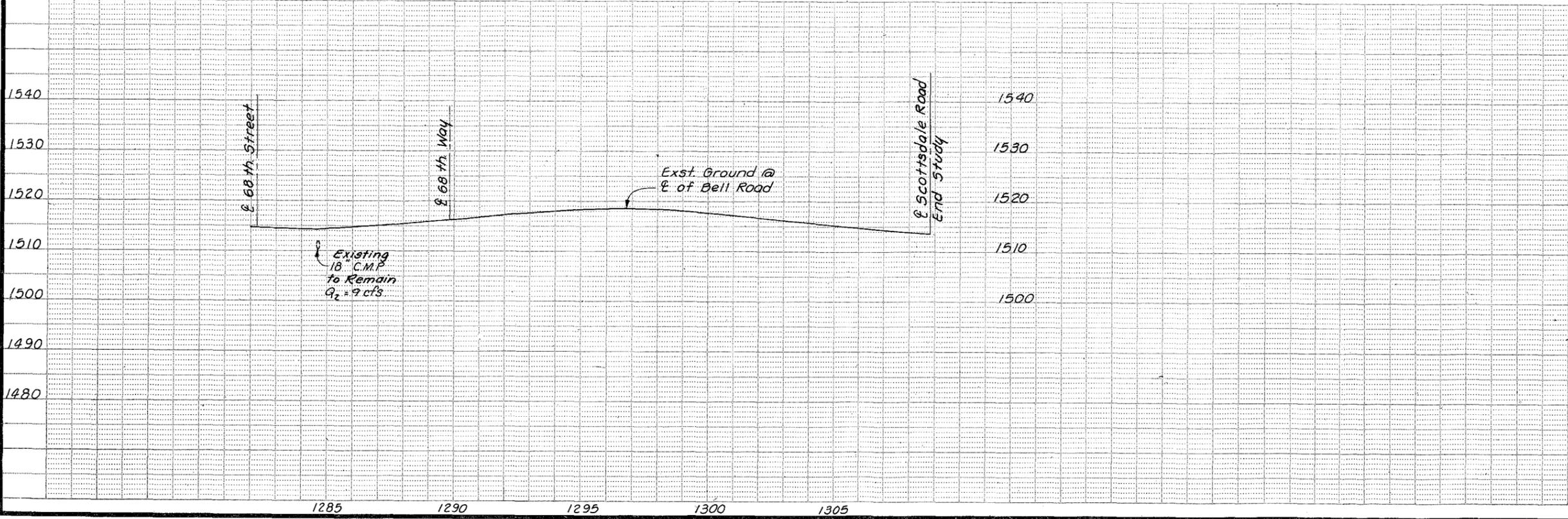
**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No.: E123061

Sheet of  
**32** of **33**



**BELL ROAD**



Revisions

**Greiner Engineering**  
 A Greiner Engineering, Inc. Company  
 Greiner Engineering, Inc.  
 2300 N. 18th Street, Suite 100  
 2590 North Alhambra Way, Tucson, Arizona 85712-9023-3413

Design: M.C./R.B./G.S./M.O.  
 Drawn: F.C./W.R.B.  
 Check: M.G.S.  
 M.C.  
 Scale: HORIZ. 1" = 200'  
 VERT. 1" = 10'

**BELL ROAD PROJECT**  
 DRAINAGE STUDY  
 PRELIMINARY PLANS

Date: OCT. 1987  
 Job No. E123061  
 Sheet 33 of 33

## X. CAPITAL COSTS

Costs for the selected stormwater/floodwater management systems were developed for construction, engineering, administration and land acquisition. Construction costs for the on-site and off-site drainage systems included the costs for storm drain trunk line conduit (concrete pipe or box culvert) and excavation (channels and detention basins).

Unit costs for reinforced concrete pipe (RCP), reinforced concrete box culverts (RCBC) and excavation were derived from unit costs recently developed for preliminary cost estimates for the Outer Loop Highway. The unit costs for conduit include the cost of installation. All costs are in 1987 dollars.

Thirty (30%) percent was added to the estimated construction costs for the on-site and off-site drainage facilities to include costs associated with appurtenances to the trunk system such as outlet or inlet works, junction structures, manholes, laterals, catch basins, erosion protection, bank stabilization, minor street reconstruction, minor utility relocation and conflict resolutions, etc. This fee was estimated on the basis of recently completed roadway drainage and flood control design projects.

Twenty (20%) percent of the construction costs was added for engineering and administration to cover the costs for survey, design, contract administration, field engineering and inspection services.

Land acquisition costs for additional right-of-way for open channels and detention basins were based on per acre values derived from either current County Assessor records and/or information recently developed by the City of Glendale for the Glendale Storm Water Management Plan.

A factor of twenty (20%) percent was then added for contingency costs to reflect the effects of unknown potential difficulties or changes during final design and construction. This cost was added to the above mentioned costs. Estimated costs did not include the following:

- o Major utility relocations
- o Major street reconstruction
- o Landscaping and maintenance

The costs of the selected systems for each of the drainage areas are summarized in Tables 9 through 23.

Not all costs developed in this report are associated with the costs of constructing the drainage facilities for the Bell Road expansion only. Other costs are broken out and included in the summary tables for proposed facilities both upstream and downstream of Bell Road that will be constructed either prior to and/or in the future of the system shown for Bell Road only. Costs in Tables 9 through 16 are for facilities located north of Bell Road and along Bell Road. Tables 17 through 23 are for the facilities south of Bell Road.

In all tables, the costs are also broken out by jurisdiction. Structures are identified by the structure number found on Plates 1 through 11 and in the Structure Summary Tables 1 through 8. Structures are identified by size and type, quantity, unit cost and estimated cost. For the facilities north and south of Bell Road proposed by other studies, uncommon structure sizes (33" RCP, 39" RCP, 4'x13' RCBC) were left as originally proposed.

The costs for catch basins and laterals are included under storm drain appurtenances. However, in Drainage Areas 1 and 2, catch basins are proposed to tie directly into existing drainageways. The costs of these catch basins and laterals are, therefore, directly accounted for with the other structures proposed in these drainage areas. No costs are provided for Drainage Areas 9 and 10, as no improvements are recommended in this study to the bridges over Skunk Creek and Cave Creek.

Table 24 is a summary of total costs broken out by drainage area, study of origin and jurisdiction. For each drainage area, total costs for facilities north of, along and south of Bell Road are presented vertically, with the total cost per jurisdiction presented horizontally.

TABLE 9  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 1

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (Maricopa County) Proposed by BRPD Only	110	36" RCP	110 L.F.	\$ 69.00	\$ 8,000
	111	24" RCP	1,720 L.F.	39.00	67,000
	112	30" RCP	490 L.F.	55.00	27,000
	N/A	CB's	14 EA.	2,300.00	32,000
<hr/>					
Sub-Total					\$ 134,000
30% Appurtenances					40,000
20% Engineering and Administration					35,000
<hr/>					
Sub-Total					\$ 209,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 209,000
20% Contingency					42,000
<hr/>					
Sub-Total					\$ 251,000

TABLE 9 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 1

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (Town of Surprise) Proposed by BRPD Only	112	30" RCP	490 L.F.	55.00	27,000
	N/A	CB's	8 EA.	2,300.00	18,000
<hr/>					
Sub-Total					\$ 45,000
30% Appurtenances					14,000
20% Engineering and Administration					12,000
<hr/>					
Sub-Total					\$ 70,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 70,000
20% Contingency					14,000
<hr/>					
Sub-Total					\$ 84,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 1</b>					<b>\$ 335,000</b>

TABLE 10  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 2

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Peoria) Proposed by Glendale-Peoria ADMS	210	Channel	8,200 C.Y.	\$ 2.50	\$ 21,000
	211	36" RCP	5,280 C.Y.	69.00	364,000
	212	30" RCP	5,200 L.F.	55.00	286,000
	217	Channel	8,200 C.Y.	2.50	21,000
	230	Basin	27,000 C.Y.	2.50	68,000
<hr/>					
Sub-Total					\$ 760,000
30% Appurtenances					228,000
20% Engineering and Administration					198,000
<hr/>					
Sub-Total					\$1,186,000
Land Acquisition	210	Channel	3.6 AC	90,000	324,000
	217	Channel	3.6 AC	90,000	324,000
	230	Basin	4.0 AC	90,000	360,000
<hr/>					
Sub-Total					\$2,194,000
20% Contingency					439,000
<hr/>					
Sub-Total					\$2,632,000

TABLE 10 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 2

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Peoria) Proposed by BRPD Study Only	218	48" RCP	5,200 L.F.	\$ 98.00	\$ 510,000
	219	42" RCP	2,700 L.F.	83.00	224,000
	231	Basin	27,000 C.Y.	2.50	68,000
	232	Basin	27,000 C.Y.	2.50	68,000
Sub-Total					\$ 870,000
30% Appurtenances					261,000
20% Engineering and Administration					226,000
Sub-Total					\$1,357,000
Land Acquisition	231	Basin	4 AC	90,000	360,000
	232	Basin	4 AC	90,000	360,000
Sub-Total					\$2,077,000
20% Contingency					415,000
Sub-Total					\$2,493,000

TABLE 10 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 2

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Peoria) Proposed by BRPD Study Only	213	48" RCP	650 L.F.	\$ 98.00	\$ 64,000
	220	42" RCP	630 L.F.	83.00	52,000
	221	54" RCP	1,820 L.F.	124.00	226,000
<hr/>					
Sub-Total					\$ 342,000
30% Appurtenances					103,000
20% Engineering and Administration					89,000
<hr/>					
Sub-Total					\$ 534,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 534,000
20% Contingency					107,000
<hr/>					
Sub-Total					\$ 641,000

TABLE 10 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 2

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along	215	36" RCP	1,550 L.F.	\$ 69.00	\$ 107,000
Bell Road (Mari-	214	24" RCP	1,200 L.F.	39.00	47,000
copa County) Pro-	222	24" RCP	1,420 L.F.	39.00	55,000
posed by BRPD	223	36" RCP	1,550 L.F.	69.00	107,000
Study Only	224	24" RCP	1,650 L.F.	39.00	64,000
	225	36" RCP	750 L.F.	69.00	52,000
	N/A	CB and Laterals	24 EA.	2,300.00	55,000
<hr/>					
Sub-Total					\$ 487,000
30% Appurtenances					146,000
20% Engineering and Administration					127,000
<hr/>					
Sub-Total					\$ 760,000
Land Acquisition					-0-
<hr/>					
Sub-Total					760,000
20% Contingency					152,000
<hr/>					
Sub-Total					\$ 912,000

TABLE 10 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 2

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (Town of Surprise) Pro- posed by BRPD Study Only	N/A	CB and Laterals	6 EA.	\$2,300.00	\$ 14,000
Sub-Total					\$ 14,000
30% Appurtenances					4,000
20% Engineering and Administration					4,000
Sub-Total					\$ 22,000
Land Acquisition					-0-
Sub-Total					22,000
20% Contingency					4,000
Sub-Total					\$ 26,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 2</b>					<b>\$6,704,000</b>

TABLE 11  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 3

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Glendale) Proposed by BRPD Study Only	310	48" RCP	1,500 L.F.	\$ 98.00	\$ 147,000
	311	72" RCP	1,750 L.F.	150.00	263,000
	312	72" RCP	800 L.F.	150.00	120,000
<hr/>					
Sub-Total					\$ 530,000
30% Appurtenances					159,000
20% Engineering and Administration					138,000
<hr/>					
Sub-Total					\$ 827,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 827,000
20% Contingency					165,000
<hr/>					
Sub-Total					\$ 992,000

TABLE 11 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 3

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Glendale) Proposed by BRPD Study Only	313	30" RCP	1,480 L.F.	\$ 55.00	\$ 81,000
	315	72" RCP	1,320 L.F.	150.00	198,000
	316	30" RCP	3,660 L.F.	55.00	201,000
<hr/>					
Sub-Total					\$ 480,000
30% Appurtenances					144,000
20% Engineering and Administration					125,000
<hr/>					
Sub-Total					\$ 749,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 749,000
20% Contingency					150,000
<hr/>					
Sub-Total					\$ 899,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 3</b>					<b>\$1,891,000</b>

TABLE 12  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 4

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Glendale) Proposed by SWMP	437	54" RCP	2,640 L.F.	\$ 124.00	\$ 327,000
	436	84" RCP	2,640 L.F.	180.00	475,000
	457	Basin	21,000 C.Y.	2.50	53,000
<hr/>					
Sub-Total					\$ 855,000
30% Appurtenances					257,000
20% Engineering and Administration					222,000
<hr/>					
Sub-Total					\$1,334,000
Land Acquisition	457	Basin	5 AC	90,000	\$ 450,000
<hr/>					
Sub-Total					\$1,784,000
20% Contingency					357,000
<hr/>					
Sub-Total					\$2,141,000

TABLE 12 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 4

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Phoenix) Proposed by NSDS	401	54" RCP	2,640 L.F.	\$ 124.00	\$ 327,000
	402	60" RCP	2,640 L.F.	140.00	370,000
	414	42" RCP	2,640 L.F.	83.00	219,000
	415	48" RCP	2,640 L.F.	98.00	259,000
	426	33" RCP	2,640 L.F.	62.00	164,000
<hr/>					
Sub-Total					\$1,339,000
30% Appurtenances					402,000
20% Engineering and Administration					348,000
<hr/>					
Sub-Total					\$2,089,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$2,089,000
20% Contingency					418,000
<hr/>					
Sub-Total					\$2,507,000

TABLE 12 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 4

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Glendale) Proposed by BRPD Study	438	24" RCP	2,140 L.F.	\$ 39.00	\$ 83,000
	440	24" RCP	2,700 L.F.	39.00	105,000
	446	24" RCP	860 L.F.	39.00	34,000
	447	30" RCP	1,320 L.F.	55.00	73,000
	448	66" RCP	2,330 L.F.	145.00	338,000
	455	24" RCP	1,400 L.F.	39.00	55,000
	456	30" RCP	1,050 L.F.	55.00	58,000
<hr/>					
Sub-Total					\$ 746,000
30% Appurtenances					224,000
20% Engineering and Administration					194,000
<hr/>					
Sub-Total					\$1,164,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$1,164,000
20% Contingency					233,000
<hr/>					
Sub-Total					\$1,397,000

TABLE 12 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 4

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Phoenix) Proposed by BRPD Study	403	24" RCP	1,200 L.F.	\$ 39.00	\$ 47,000
	404	36" RCP	2,810 L.F.	69.00	194,000
	416	24" RCP	1,640 L.F.	39.00	64,000
	417	42" RCP	2,670 L.F.	83.00	222,000
	427	24" RCP	1,550 L.F.	39.00	60,000
	428	30" RCP	2,670 L.F.	55.00	147,000
<hr/>					
Sub-Total					\$ 734,000
30% Appurtenances					220,000
20% Engineering and Administration					191,000
<hr/>					
Sub-Total					\$1,145,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$1,145,000
20% Contingency					229,000
<hr/>					
Sub-Total					\$1,374,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 4</b>					<b>\$7,419,000</b>

TABLE 13  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 5

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Phoenix) Proposed by NCMSD Study	501	24" RCP	1,320 L.F.	\$ 39.00	\$ 51,000
	502	27" RCP	500 L.F.	47.00	24,000
	503	36" RCP	820 L.F.	69.00	57,000
	504	39" RCP	1,320 L.F.	76.00	100,000
	505	42" RCP	2,640 L.F.	83.00	219,000
	506	60" RCP	2,640 L.F.	140.00	370,000
	507	27" RCP	650 L.F.	47.00	31,000
	508	36" RCP	1,320 L.F.	69.00	91,000
	509	42" RCP	1,320 L.F.	83.00	110,000
<hr/>					
Sub-Total					\$1,053,000
30% Appurtenances					316,000
20% Engineering and Administration					274,000
<hr/>					
Sub-Total					\$1,643,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$1,643,000
20% Contingency					329,000
<hr/>					
Sub-Total					\$1,972,000

TABLE 13 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 5

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Phoenix) Proposed by BRPD Study	511	24" RCP	320 L.F.	\$ 39.00	\$ 12,000
	512	33" RCP	1,310 L.F.	62.00	81,000
	513	42" RCP	1,055 L.F.	83.00	88,000
	515	18" RCP	820 L.F.	15.00	13,000
	516	42" RCP	2,040 L.F.	83.00	169,000
<hr/>					
Sub-Total					\$ 363,000
30% Appurtenances					109,000
20% Engineering and Administration					94,000
<hr/>					
Sub-Total					\$ 566,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 566,000
20% Contingency					114,000
<hr/>					
Sub-Total					\$ 680,000
<hr/>					
<b>TOTAL ESTIMATED COSTS FOR DRAINAGE AREA 5</b>					<b>\$2,652,000</b>

TABLE 14  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 6

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Phoenix) Proposed by UEFCC ADMS	610	78" RCP	2,640 L.F.	\$ 165.00	\$ 436,000
	611	90" RCP	1,320 L.F.	197.00	260,000
	612	Channel*	2,800 L.F.	250.00	700,000
	613	4'x13'RCBC	2,000 L.F.	260.00	520,000
	614	4'x16'RCBC	950 L.F.	320.00	304,000
	615	90" RCP	3,820 L.F.	197.00	753,000
	616	Channel*	1,320 L.F.	250.00	330,000
	617	4'x20'RCBC	1,150 L.F.	400.00	460,000
	623	72" RCP	1,320 L.F.	150.00	198,000
	624	78" RCP	1,320 L.F.	165.00	218,000
	625	84" RCP	1,320 L.F.	180.00	238,000
	640	Basin	126,000 C.Y.	2.50	315,000
	645	Basin	242,000 C.Y.	2.50	605,000
	<hr/>				
	Sub-Total				
30% Appurtenances					1,601,000
20% Engineering and Administration					1,388,000
<hr/>					
Sub-Total					\$ 8,326,000
Land Acquisition	640	Basin	13 AC	40,000	520,000
	645	Basin	25 AC	40,000	1,000,000
<hr/>					
Sub-Total					\$ 9,846,000
20% Contingency					1,969,000
<hr/>					
Sub-Total					\$11,815,000

TABLE 14 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 6

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Phoenix) Proposed by UEFCC ADMS	621	66" RCP	2,280 L.F.	\$ 145.00	\$ 331,000
	622	72" RCP	1,320 L.F.	150.00	198,000
<hr/>					
Sub-Total					\$ 529,000
30% Appurtenances					159,000
20% Engineering and Administration					138,000
<hr/>					
Sub-Total					\$ 826,000
Land Acquisition					-0-
<hr/>					
Sub-Total					826,000
20% Contingency					165,000
<hr/>					
Sub-Total					\$ 990,000

TABLE 14 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 6

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along	619	18" RCP	800 L.F.	\$ 15.00	\$ 12,000
Bell Road (City of	620	30" RCP	1,200 L.F.	55.00	66,000
Phoenix) Proposed	626	18" RCP	280 L.F.	15.00	4,000
by BRPD Study Only	627	18" RCP	300 L.F.	15.00	5,000
	628	42" RCP	1,350 L.F.	83.00	112,000
	631	24" RCP	2,150 L.F.	39.00	84,000
Sub-Total					\$ 283,000
30% Appurtenances					85,000
20% Engineering and Administration					74,000
Sub-Total					\$ 441,000
Land Acquisition					-0-
Sub-Total					\$ 441,000
20% Contingency					88,000
Sub-Total					\$ 530,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 6</b>					<b>\$ 13,335,000</b>

\*Quantities and unit cost provided by UEFCC ADMS

TABLE 15  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 7

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (City of Phoenix) Proposed by UEFCC ADMS	750	Basins	160,000 C.Y.	\$ 2.50	\$ 400,000
	721	Channel*	1,500 L.F.	100.00	150,000
	722	54" RCP	2,640 L.F.	124.00	327,000
	723	Channel*	2,640 L.F.	100.00	264,000
Sub-Total					\$ 1,141,000
30% Appurtenances					342,000
20% Engineering and Administration					297,000
Sub-Total					\$ 1,780,000
Land Acquisition	750	Basin	19 AC	40,000	760,000
	721	Channel (land) (residences)	7.6 AC 10 EA.	40,000 160,000	304,000 1,600,000
	723	Channel (land) (residences)	18.2 AC 5 EA.	40,000 160,000	728,000 800,000
	Sub-Total				
20% Contingency					1,194,000
Sub-Total					\$ 7,166,000

\*Quantities and Unit Cost Provided by UEFCC ADMS

TABLE 15 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES NORTH OF  
 AND ALONG BELL ROAD  
DRAINAGE AREA 7

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road (Maricopa County) Proposed by UEFCC ADMS	710	78" RCP	5,200 L.F.	\$ 165.00	\$ 858,000
	711	84" RCP	2,640 L.F.	180.00	475,000
	712	72" RCP	2,640 L.F.	150.00	396,000
	713	72" RCP	2,640 L.F.	150.00	396,000
	719	84" RCP	1,400 L.F.	180.00	252,000
	720	90" RCP	1,320 L.F.	197.00	260,000
	740	Basin	136,000 C.Y.	2.50	340,000
	<hr/>				
Sub-Total					\$ 2,977,000
30% Appurtenances					893,000
20% Engineering and Administration					774,000
<hr/>					
Sub-Total					\$ 4,644,000
Land Acquisition	740	Basin	14 AC	40,000	560,000
<hr/>					
Sub-Total					\$ 5,204,000
20% Contingency					1,041,000
<hr/>					
Sub-Total					\$ 6,245,000

TABLE 15 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 7

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (City of Phoenix) Proposed by UEFCC ADMS	727	2-6'x4'RCBC	1,300 L.F.	\$ 286.00	\$ 372,000
	728	3-10'x'4'RCBC	1,360 L.F.	600.00	816,000
	730	2-8'x6'RCBC	110 L.F.	432.00	48,000
<hr/>					
Sub-Total					\$ 1,236,000
30% Appurtenances					371,000
20% Engineering and Administration					321,000
<hr/>					
Sub-Total					\$ 1,928,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 1,928,000
20% Contingency					386,000
<hr/>					
Sub-Total					\$ 2,314,000

TABLE 15 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 7

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road (Maricopa County) Proposed by UEFCC	714	72" RCP	2,240 L.F.	\$ 150.00	\$ 336,000
	715	2-8'x4'RCBC	2,000 L.F.	381.00	762,000
	725	72" RCP	1,330 L.F.	150.00	200,000
	726	10'x4'RCBC	1,310 L.F.	200.00	262,000
<hr/>					
Sub-Total					\$ 1,560,000
30% Appurtenances					468,000
20% Engineering and Administration					406,000
<hr/>					
Sub-Total					\$ 2,434,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 2,434,000
20% Contingency					487,000
<hr/>					
Sub-Total					\$ 2,921,000
Channelization of Upper East Fork of Cave Creek*					\$10,100,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 7</b>					<b>\$28,746,000</b>

TABLE 16  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 8

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities North of Bell Road* (City of Phoenix) Proposed by NAMSD Study	817	33" RCP	1,800 L.F.	\$ 62.00	\$ 112,000
	818	42" RCP	2,640 L.F.	83.00	219,000
	825	21" RCP	2,640 L.F.	27.00	71,000
	826	39" RCP	2,640 L.F.	76.00	201,000
	831	30" RCP	1,320 L.F.	55.00	73,000
	832	30" RCP	2,640 L.F.	55.00	145,000
	842	30" RCP	1,320 L.F.	55.00	73,000
	843	30" RCP	2,630 L.F.	55.00	145,000
<hr/>					
Sub-Total					\$ 1,039,000
30% Appurtenances					312,000
20% Engineering and Administration					270,000
<hr/>					
Sub-Total					\$ 1,621,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 1,621,000
20% Contingency					324,000
<hr/>					
Sub-Total					\$ 1,945,000

\*Some of the proposed storm drains are located within Maricopa County rights-of-way.

TABLE 16 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES NORTH OF  
AND ALONG BELL ROAD  
DRAINAGE AREA 8

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
Facilities Along Bell Road* (City of Phoenix) Proposed by BRPD Study	810	24" RCP	720 L.F.	\$ 39.00	\$ 28,000
	811	30" RCP	920 L.F.	55.00	51,000
	819	24" RCP	630 L.F.	39.00	25,000
	820	39" RCP	1,300 L.F.	76.00	99,000
	827	24" RCP	400 L.F.	39.00	16,000
	828	36" RCP	1,300 L.F.	69.00	90,000
	833	18" RCP	280 L.F.	15.00	4,000
	834	39" RCP	1,300 L.F.	76.00	99,000
	844	18" RCP	340 L.F.	15.00	5,000
	845	30" RCP	1,300 L.F.	55.00	72,000
	855	48" RCP	300 L.F.	98.00	29,000
	861	18" RCP	940 L.F.	15.00	14,000
	862	30" RCP	830 L.F.	55.00	46,000
	863	42" RCP	860 L.F.	83.00	71,000
<hr/>					
Sub-Total					\$ 649,000
30% Appurtenances					195,000
20% Engineering and Administration					169,000
<hr/>					
Sub-Total					\$ 1,013,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 1,013,000
20% Contingency					202,000
<hr/>					
Sub-Total					\$ 1,215,000
<hr/>					
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 8</b>					<b>\$ 3,160,000</b>

\*Some of the proposed storm drains are located within Maricopa County rights-of-way.

TABLE 17  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF BELL ROAD  
 DRAINAGE AREA 2

<u>Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Peoria Proposed by Glendale-Peoria ADMS	216	Open Channel	116,000 c.y.	\$ 2.50	\$ 290,000
Sub-Total					\$ 290,000
30% Appurtenances					87,000
20% Engineering and Administration					75,000
Sub-Total					\$ 452,000
Land Acquisition					360,000
Sub-Total					\$ 812,000
20% Contingency					162,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 2</b>					<b>\$ 974,000</b>

TABLE 18  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF BELL ROAD  
 DRAINAGE AREA 3

<u>Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Glendale Proposed by BRPD Study Only	314	2-6x6'Box Culvert	1,000 L.F.	\$326.00	\$ 326,000
Sub-Total					\$ 326,000
30% Appurtenances					98,000
20% Engineering and Administration					85,000
Sub-Total					\$ 509,000
Land Acquisition					-0-
Sub-Total					\$ 509,000
20% Contingency					102,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 3</b>					<b>\$ 610,000</b>

TABLE 19  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF BELL ROAD  
 DRAINAGE AREA 4

<u>Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Glendale Proposed by SWMP	437	54" RCP	500 L.F.	\$124.00	\$ 62,000
	441	18" RCP	2,140 L.F.	\$15.00	\$ 32,000
	442	54" RCP	2,640 L.F.	124.00	327,000
	443	24" RCP	2,640 L.F.	39.00	103,000
	444	60" RCP	2,640 L.F.	140.00	370,000
	445	96" RCP	600 L.F.	215.00	129,000
	449	72" RCP	2,640 L.F.	150.00	396,000
	450	84" RCP	2,640 L.F.	180.00	475,000
	451	108" RCP	2,800 L.F.	270.00	756,000
Sub-Total					\$ 2,650,000
30% Appurtenances					795,000
20% Engineering and Administration					689,000
Sub-Total					\$ 4,134,000
Land Acquisition	458	Basin	3 AC	120,000	360,000
	459	Basin	9 AC	48,000	432,000
Sub-Total					\$ 4,926,000
20% Contingency					985,000
Sub-Total					\$ 5,911,000

TABLE 19 CONTINUED  
ESTIMATED COSTS  
FOR FACILITIES SOUTH OF BELL ROAD  
DRAINAGE AREA 4

<u>Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>	
City of Phoenix Proposed by NSDS	405	60" RCP	2,640 L.F.	\$140.00	\$ 370,000	
	418	60" RCP	2,640 L.F.	140.00	370,000	
	419	66" RCP	2,640 L.F.	145.00	383,000	
	420	72" RCP	2,640 L.F.	150.00	396,000	
	421-422	78" RCP	5,280 L.F.	165.00	871,000	
	423-424	84" RCP	5,280 L.F.	180.00	950,000	
	425	90" RCP	2,600 L.F.	197.00	512,000	
	429	36" RCP	2,640 L.F.	69.00	182,000	
	430	48" RCP	2,640 L.F.	98.00	259,000	
	431-432	66" RCP	5,280 L.F.	145.00	766,000	
	433-434	78" RCP	5,280 L.F.	165.00	871,000	
	435	84" RCP	300 L.F.	180.00	54,000	
	<hr/>					
	Sub-Total					\$ 5,984,000
	30% Appurtenances					1,795,000
20% Engineering and Administration					1,556,000	
<hr/>						
Sub-Total					\$ 9,335,000	
Land Acquisition					-0-	
<hr/>						
Sub-Total					\$ 9,335,000	
20% Contingency					1,867,000	
<hr/>						
Sub-Total					\$11,202,000	
<hr/>						
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 4</b>					<b>\$17,113,000</b>	

TABLE 20  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF BELL ROAD  
DRAINAGE AREA 5

<u>Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Phoenix Proposed by BRPD Only	517	42" RCP	1,700 L.F.	\$ 83.00	\$ 141,000
Sub-Total					\$ 141,000
30% Appurtenances					42,000
20% Engineering and Administration					37,000
Sub-Total					\$ 220,000
Land Acquisition					-0-
Sub-Total					\$ 220,000
20% Contingency					44,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 5</b>					<b>\$ 264,000</b>

TABLE 21  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF  
DRAINAGE AREA 6

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Phoenix Facilities Proposed by UEFCC ADMS	618	4x26' Box Culvert	1,200 L.F.	\$520.00	\$ 624,000
	629	90" RCP	1,200 L.F.	197.00	236,000
<hr/>					
Sub-Total					\$ 860,000
30% Appurtenances					258,000
20% Engineering and Administration					224,000
<hr/>					
Sub-Total					\$ 1,342,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$ 1,342,000
20% Contingency					268,000
<hr/>					
Sub-Total					\$ 1,610,000

TABLE 21 CONTINUED  
 ESTIMATED COSTS  
 FOR FACILITIES SOUTH OF  
DRAINAGE AREA 6

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Phoenix Facilities Proposed by BRPD Study Only	630	54" RCP	2,100 L.F.	\$ 124.00	\$ 260,000
Sub-Total					\$ 260,000
30% Appurtenances					78,000
20% Engineering and Administration					68,000
Sub-Total					\$ 406,000
Land Acquisition					-0-
Sub-Total					\$ 406,000
20% Contingency					81,000
Sub-Total					\$ 487,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 6</b>					<b>\$ 2,097,000</b>

TABLE 22  
ESTIMATED COSTS  
FOR FACILITIES SOUTH OF BELL ROAD  
DRAINAGE AREA 7

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Phoenix Proposed by UEFCC	724	Channel	2,900 L.F.	\$100.00	\$ 290,000
ADMS Only	716	4x17' RCBC Channel	2,640 L.F.	340.00	898,000
	717	Channel	2,100 L.F.	250.00	525,000
	745	Basin	117,000 C.Y.	2.50	293,000
Sub-Total					\$2,006,000
30% Appurtenances					602,000
20% Engineering and Administration					522,000
Sub-Total					\$3,130,000
Land Acquisition	724	Channel (land)	23.3 Ac	40,000	932,000
		(residences)	15 EA.	160,000	2,400,000
	745	Basin	12 Ac	40,000	480,000
Sub-Total					\$6,942,000
20% Contingency					1,388,000
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 7</b>					<b>\$8,330,000</b>

Final cost sharing agreement between the City of Phoenix and Maricopa County has not be executed.

TABLE 23  
ESTIMATED COSTS  
FOR FACILITIES SOUTH OF BELL ROAD  
DRAINAGE AREA 8

<u>Location and Jurisdiction</u>	<u>Structure No.</u>	<u>Structure Type</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Estimated Cost</u>
City of Phoenix Proposed by NAMSD Study	812	48" RCP	2,640 L.F.	\$ 98.00	\$ 259,000
	813	54" RCP	2,640 L.F.	124.00	327,000
	814	60" RCP	2,640 L.F.	140.00	370,000
	815	66" RCP	4,350 L.F.	145.00	631,000
	816	72" RCP	1,000 L.F.	150.00	150,000
	829	42" RCP	2,640 L.F.	83.00	219,000
	830	54" RCP	3,100 L.F.	124.00	384,000
	835	39" RCP	2,640 L.F.	76.00	201,000
	836	48" RCP	2,640 L.F.	98.00	259,000
	837-838	54" RCP	5,280 L.F.	124.00	655,000
	846	36" RCP	2,640 L.F.	69.00	182,000
	847	42" RCP	2,640 L.F.	83.00	219,000
	848-850	54" RCP	7,920 L.F.	124.00	982,000
	851-852	66" RCP	5,280 L.F.	145.00	766,000
	853	72" RCP	2,200 L.F.	150.00	330,000
	864	42" RCP	11,880 L.F.	83.00	986,000
<hr/>					
Sub-Total					\$ 6,920,000
30% Appurtenances					2,076,000
20% Engineering and Administration					1,799,000
<hr/>					
Sub-Total					\$10,795,000
Land Acquisition					-0-
<hr/>					
Sub-Total					\$10,795,000
20% Contingency					2,159,000
<hr/>					
<b>TOTAL ESTIMATED COST FOR DRAINAGE AREA 8</b>					<b>\$12,954,000</b>

TABLE 24

## SUMMARY OF ESTIMATED COSTS

<u>Drainage Area</u>	<u>Location Proposed by</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Totals</u>
1	Facilities Along Bell Road Proposed by the BRPDS Only	\$84,000	0	0	0	\$ 251,000	\$ 335,000
2	Facilities North of Bell Road Proposed by Glendale-Peoria ADMS	0	\$ 2,632,000	0	0	0	\$ 2,632,000
	Facilities North of Bell Road Proposed by BRPDS	0	\$ 2,493,000	0	0	0	\$ 2,493,000
	Facilities Along Bell Road Proposed by BRPD	26,000	\$ 641,000	0	0	\$ 912,000	\$ 1,579,000
	Facilities South of Bell Road Proposed by Glendale-Peoria ADMS	0	\$ 974,000	0	0	0	\$ 974,000
3	Facilities North of Bell Road Proposed by BRPDS	0	0	\$ 992,000	0	0	\$ 992,000
	Facilities Along Bell Road Proposed by BRPDS	0	0	\$ 899,000	0	0	\$ 899,000
	Facilities South of Bell Road Proposed by BRPDS	0	0	\$ 610,000	0	0	\$ 610,000

TABLE 24 CONTINUED

SUMMARY OF ESTIMATED COSTS

<u>Drainage Area</u>	<u>Location Proposed by</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Totals</u>
4	Facilities North of Bell Road Proposed by SWMP and NSDS	0	0	\$ 2,141,000	\$ 2,507,000	0	\$ 4,648,000
	Facilities Along Bell Road Proposed by BRPD	0	0	\$ 1,397,000	\$ 1,374,000	0	\$ 2,771,000
	Facilities South of Bell Road Proposed by SWMP and NSDS	0	0	\$ 5,911,000	\$11,202,000	0	\$17,113,000
5	Facilities North of Bell Road Proposed by NCSMD	0	0	0	\$ 1,972,000	0	\$ 1,972,000
	Facilities Along Bell Road Proposed by BRPDS	0	0	0	\$ 680,000	0	\$ 680,000
	Facilities South of Bell Road Proposed by BRPDS	0	0	0	\$ 264,000	0	\$ 264,000
6	Facilities North of Bell Road Proposed by UEFC	0	0	0	\$11,815,000	0	\$11,815,000
	Facilities Along Bell Road Proposed by UEFC	0	0	0	\$ 990,000	0	\$ 990,000
	Facilities Along Bell Road Proposed by BRPDS	0	0	0	\$ 530,000	0	\$ 530,000
	Facilities South of Bell Road Proposed by UEFC	0	0	0	\$ 1,610,000	0	\$ 1,610,000

TABLE 24 CONTINUED

SUMMARY OF ESTIMATED COSTS

<u>Drainage Area</u>	<u>Location Proposed by</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Totals</u>
6 (con.)	Facilities South of Bell Road Proposed by BRPDS	0	0	0	\$ 487,000	0	\$ 487,000
7*	Facilities North of Bell Road Proposed by UEFCC	0	0	0	\$ 7,166,000	\$ 6,245,000	\$13,411,000
	Facilities Along Bell Road Proposed by UEFCC	0	0	0	\$ 2,314,000	\$ 2,921,000	\$ 5,235,000
	Facilities South of Bell Road Proposed by UEFCC	0	0	0	\$ 8,330,000	0	\$ 8,330,000
8	Facilities North of Bell Road Proposed by NAMSD	0	0	0	\$ 1,945,000	0	\$ 1,945,000
	Facilities Along Bell Road Proposed by BRPDS	0	0	0	\$ 1,215,000	0	\$ 1,215,000
	Facilities South of Bell Road Proposed by NAMSD	0	0	0	\$12,954,000	0	\$12,954,000

\*The costs represented do not include \$10,100,000 for channelization of Upper East Fork of Cave Creek Wash as proposed in the UEFCC ADMS. These costs are added at the end of this table.

The costs shown for City of Phoenix and Maricopa County may change subject to the final cost sharing agreement.

TABLE 24 CONTINUED

SUMMARY OF ESTIMATED COSTS

<u>Drainage Area</u>	<u>Location Proposed by</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Totals</u>
Subtotals	North of Bell Road Proposed by Glendale- Peoria ADMS	0	\$ 2,632,000	0	0	0	\$ 2,632,000
	North of Bell Road Proposed by BRPDS	0	\$ 2,493,000	\$ 992,000			\$ 3,485,000
	North of Bell Road Proposed by NSDS	0	0	0	\$ 2,507,000	0	\$ 2,507,000
	North of Bell Road Proposed by NCMSD	0	0	0	\$ 1,972,000	0	\$ 1,972,000
	North of Bell Road Proposed by UEFCC	0	0	0	\$18,981,000	\$ 6,245,000	\$ 25,226,000
	North of Bell Road Proposed by NAMSD	0	0	0	\$ 1,945,000	0	\$ 1,945,000
	North of Bell Road Proposed by SWMP	0	0	\$ 2,141,000	0	0	\$ 2,141,000
<hr/>							
	Sub-Total	0	\$ 5,125,000	\$ 3,133,000	\$25,405,000	\$ 6,245,000	\$ 39,908,000
	Facilities Along Bell Road Proposed by BRPDS	110,000	\$ 641,000	\$ 2,296,000	\$ 3,799,000	\$ 1,163,000	\$ 8,009,000
	Facilities Along Bell Road Proposed by UEFCC	0	0	0	\$ 3,304,000	\$ 2,921,000	\$ 6,225,000
<hr/>							
	Sub-Total	110,000	\$ 641,000	\$ 2,296,000	\$ 7,103,000	\$ 4,084,000	\$ 14,234,000

TABLE 24 CONTINUED

SUMMARY OF ESTIMATED COSTS

<u>Drainage Area</u>	<u>Location Proposed by</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Totals</u>
Subtotals Continued	Facilities South of Bell Road Proposed by Glendale-Peoria ADMS	0	\$ 974,000	0	0	0	\$ 974,000
	Facilities South of Bell Road Proposed by BRPDS	0	0	\$ 610,000	\$ 751,000	0	\$ 1,361,000
	Facilities South of Bell Road Proposed by SWMP	0	0	\$ 5,911,000	0	0	\$ 5,911,000
	Facilities South of Bell Road Proposed by NSDS	0	0	0	\$11,202,000	0	\$ 11,202,000
	Facilities South of Bell Road Proposed by UEFCC	0	0	0	\$ 9,940,000	0	\$ 9,940,000
	Facilities South of Bell Road Proposed by NAMSD	0	0	0	\$12,954,000	0	\$ 12,954,000
	Sub-Total	0	\$ 974,000	\$ 6,521,000	\$34,847,000	0	\$ 42,342,000
<b>GRAND TOTAL*</b>		<b>\$110,000</b>	<b>\$ 6,740,000</b>	<b>\$11,950,000</b>	<b>\$67,355,000</b>	<b>\$10,329,000</b>	<b>\$ 96,484,000</b>
	Channelization of East Fork of Cave Creek Wash						\$ 10,100,000
<b>GRAND TOTAL</b>							<b>\$ 106,584,000</b>

## XI. RIGHT-OF-WAY AND EASEMENT REQUIREMENTS

The status of existing right-of-way and the requirements for additional temporary and permanent right-of-way easements were identified. The existing Bell Road right-of-way is shown on the Preliminary Concept Drainage Plans found in Section IX.

The selected drainage facilities along Bell Road can be built within the existing 110 foot rights-of-way, however, temporary construction easements and access agreements are required.

Requirements for these temporary construction easements for the proposed Bell Road facilities are described in the following sections by drainage area. Additional rights-of-way requirements for facilities north or south of Bell Road have been identified by the previous or on-going studies that developed the plans for those facilities. These studies were listed in Section VIII.

Drainage Area 1: A temporary construction easement will be required for construction of the storm drain outfall located approximately 900 feet east of Dysart Road. Temporary construction easements will also be required for the installation of the pipe laterals outletting from the catch basins located along Bell Road into the existing private Sun City West drainageway. An agreement will be required from the Del Webb Corporation, Sun City West developer, permitting the County to outlet the pipe laterals into this drainage way. Refer to sheets 3, 4 and 5 of the Preliminary Concept Drainage Plans in Section IX.

Drainage Area 2: Temporary construction easements will be required for the catch basin laterals outletting into the existing private drainageway along Bell Road in Sun City. An agreement with the developer of Sun City will be required for the County to outlet into this drainageway and the private drainageway along 99th Avenue. Approval from the developer will also be required for tying into the private storm drain at 105th

Avenue. Refer to Sheets 6, 7 and 8 of the Preliminary Concept Drainage Plans in Section IX.

Drainage Area 3: No additional right-of-way or temporary construction easements required.

Drainage Area 4: No additional right-of-way or temporary construction easements required.

Drainage Area 5: An agreement from the Arizona Department of Transportation (ADOT) will be required to install the proposed 42" storm drain along the I-17 off-ramp road and underneath I-17, tying into the existing channel along the westerly right-of-way of I-17. Refer to Sheet 19 of the Preliminary Concept Drainage Plans in Section IX and to Plate 6.

Drainage Area 6: No additional right-of-way or temporary construction easements required.

Drainage Area 7: No additional right-of-way or temporary construction easements required.

Drainage Area 8: A temporary construction easement may be required to construct the headwall and inlet pipe within the existing private drainage for the proposed 36th Street storm drain. Refer to Sheet 27 of the Preliminary Concept Drainage Plans in Section IX.

## XII. IMPACTS ON MAJOR DRAINAGE FACILITIES DOWNSTREAM OF BELL ROAD

The potential for impacts of the design storm on major facilities downstream of Bell Road was analyzed. The criteria for determining which concentration points along Bell Road will be analyzed is as follows:

- a. The 10-year or 2-year rate (whichever agrees with the selected design storm frequency for each jurisdiction) passed through Bell Road (with selected drainage system in place) is greater than 200 cfs or 60 cfs respectively, and
- b. The capacity of the existing or planned receiving drainage system is exceeded.

Table 25 summarizes by location, structure number and discharge rate, the concentration points which could potentially meet the above criteria. With the exception of structures 517 and 437/440, all of the reviewed storm drain facilities discharge into storm drains having sufficient capacity. These storm drains convey flows to improved or natural drainageways that have the capacity to convey the 100-year storm runoff. Therefore, there will be no adverse impacts to these downstream facilities.

Structure 517, a 42" storm drain, will discharge into the existing drainageway located along the west side of I-17 (see Plate 6). This drainageway conveys flow to a drainageway at Paradise Lane. Under present conditions, the runoff intercepted by structure 517 will either cross Bell Road to the south and flow along the east side of I-17 to Paradise Lane then cross over to the drainageway on the west side, or will flow into the depressed section of Bell Road under I-17 and be pumped out into the same drainageway on the west side.

In either case, the proposed 42" storm drain will not increase runoff to the drainageway along Paradise Lane.

TABLE 25

**DRAINAGE CONCENTRATION POINTS MEETING DOWNSTREAM  
IMPACT ANALYSIS CRITERIA**

Drainage Area	Location	Outletting Structure(s) at Bell Road			Receiving Drainage System Downstream of Bell Road			Regional Outfall
		Structure Number(s)	Design Storm Frequency	Design Discharge Rate	Structure Number	Design Storm Frequency	Design Discharge Rate	
3	75th Avenue	312/313/315	10-year	243/24/160	314	10-year	432	Skunk Creek
4	67th Avenue	448	10-year	160	449	10-year	250	A.C.D.C.
4	59th Avenue	437/440	10-year	156/112	441	10-year	140	A.C.D.C.
4	43rd Avenue	415/417	2-year	71/52	418	2-year	121	A.C.D.C.
4	35th Avenue	402/404	2-year	133/36	405	2-year	140	A.C.D.C.
5	I-17 Off-Ramp	517	2-year	67	N/A	25-year min.	Unknown	Un-named Detention Basin
6	Central Avenue	628	2-year	75	630	2-year	75	Via Verde Channel
8	36th Street	811/855	2-year	12/68	812	2-year	111	I.B.W.
8	40th Street	818/820	2-year	25/51	N/A	2-year	108	I.B.W.
8	44th Street	826/828	2-year	47/39	829	2-year	85	I.B.W.
8	Tatum Blvd.	832/834	2-year	12/45	835	2-year	67	I.B.W.

Structures 437, 440 and 441 were designed by the City of Glendale SWMP for the 10-year, 2-hour duration storm. A detention basin (structure 457) was designed by this study to detain upstream flows based on this design storm. The BRPD study hydrology was performed with the 10-year, 24-hour storm and produced a volume greater than the basin capacity. Therefore, with the BRPD model, greater flows concentrate at structure 441 than calculated by the SWMP. If the 24-hour storm duration is to be used in final design, structure 441 will have to be upsized from a 60" RCP to 72" RCP. If the 2-hour duration storm is used in design, the results of the BRPD study hydrologic model can be ignored.

### XIII. CONCLUSIONS AND RECOMMENDATIONS

A stormwater/floodwater management plan has been developed that will provide benefits to Bell Road by providing a cost-effective method of handling on-site drainage from the expansion of Bell Road and protection for the roadway from off-site runoff for the selected design storm. In addition, the plan ensures that downstream receiving drainage facilities and the ultimate regional stormwater/floodwater outfalls have the adequate capacity to handle the on-site and off-site stormwater flows from the Bell Road Expansion project.

The plan will also benefit upstream properties by providing for future storm drain laterals to be extended north of Bell Road to intercept drainage. Downstream properties will benefit by the reduction of stormwater and floodwater flows. The plan provides for stormwater flows in excess of the design capacity of the facilities to continue to flow in their historical path so as not to worsen upstream flood conditions or create new problem drainage areas.

Not only has the Bell Road project met the study roadway objectives, it has also provided the additional benefit of coordinating and integrating into one comprehensive plan nine Area Drainage Master Studies and Stormwater Master Drainage Plans developed for the participating jurisdictions between 1977 and 1986.

It is not anticipated during the expansion of Bell Road that all of the upstream and downstream stormwater management plans will have been implemented, however, all the drainage facilities proposed along Bell Road and future stub outs and connections will be constructed at this time. It will be necessary where downstream facilities are not constructed prior to the Bell Road facilities, that temporary measures be taken to provide a positive outfall for the Bell Road drainage facilities until such time as the permanent outfall system has been constructed to Bell Road. In either event, adverse impacts to upstream or downstream properties should be avoided.

A tentative construction schedule for the Bell Road project expansion has been prepared by the Bell Road Project Management Consultant, Parsons, Brinckerhoff, Quade and Douglas (PBQ&D), and transmitted to Greiner on May 14, 1987. It is shown as follows in Table 26.

TABLE 26

Construction Schedule  
for Bell Road  
Expansion Project

Fiscal Year

1989-1990	93rd Avenue to Outer Loop Highway 83rd Avenue to 67th Avenue 43rd Avenue to I-17 19th Avenue to 7th Street Cave Creek Road to 40th Street
1990-1991	115th Avenue to 93rd Avenue 67th Avenue to 51st Avenue I-17 to 19th Avenue 7th Street to Cave Creek Road 40th Street to 56th Street
1991-1992	Grand Avenue to 115th Avenue 51st Avenue to 43rd Avenue 56th Street to Scottsdale Road

The work at I-17 has not been scheduled and is pending the selection of the final ramp configuration.

The construction schedules of the downstream receiving drainage facilities as well as other significant projects that may impact the Bell Road expansion such as the Outer Loop Highway and Squaw Peak Parkway, were obtained from the Flood Control District, the City of Phoenix, City of Peoria, City of Glendale and the Outer Loop Highway Management Consultant. A master schedule matrix was developed to provide a graphic comparison between the Bell Road construction schedules and the schedules of the other projects. Refer to Table 27 for this comparison.

In this matrix, the Bell Road project design segments are first listed from west to east followed by the other projects also listed west to east from Grand Avenue to Scottsdale Road. The status of each project is indicated (i.e., proposed, complete, unscheduled) and bar graphs are used to represent the construction schedules.

From the matrix, it was determined that of the scheduled projects the Bell Road drainage facilities at the following two locations are scheduled for construction prior to scheduled completion of the outfall systems:

<u>Location</u>	<u>Bell Road Construction Schedule</u>	<u>Outfall Construction Schedule</u>
36th Street	1989-1990	1990-1991
44th Street	1990-1991	1992

At these locations, therefore, temporary measures should be implemented.

The staging of the Bell Road project drainage improvements with the construction phasing for the Bell Road roadway improvements as proposed by PBQ&D was also reviewed. Just as it is critical to ensure that downstream outfalls are operational before the Bell Road drainage facilities are completed, it is important that the downstream drainage facilities along Bell Road are completed before the upstream facilities along Bell Road. Also, to ensure the integrity of the final paving work, the utility relocations and construction of the drainage facilities must precede the pavement improvements.

TABLE 27  
 MASTER SCHEDULE FOR  
 BELL ROAD PROJECT COORDINATION

Greiner

PROJECT	STATUS	1987	1988	1989	1990	1991	1992	1993
BELL ROAD EXPANSION								
GRAND AVENUE TO 115TH AVE.	PROPOSED					▨		
115TH AVENUE TO 93RD AVENUE	PROPOSED				▨			
93RD AVENUE TO THE OUTERLOOP	PROPOSED			▨				
83RD AVENUE TO 67TH AVENUE	PROPOSED			▨				
67TH AVENUE TO 51ST AVENUE	PROPOSED				▨			
51ST AVENUE TO 43RD AVENUE	PROPOSED					▨		
43RD AVENUE TO I-17	PROPOSED			▨				
I-17 TO 19TH AVENUE	PROPOSED				▨			
19TH AVENUE TO 7TH STREET	PROPOSED			▨				
7TH STREET TO CAVE CREEK ROAD	PROPOSED				▨			
CAVE CREEK ROAD TO 40TH STREET	PROPOSED			▨				
40TH STREET TO 56TH STREET	PROPOSED				▨			
56TH STREET TO SCOTTSDALE ROAD	PROPOSED					▨		
I-17 INTERCHANGE	UNSCHEDULED							
A.D.O.T.								
GRAND AVENUE EXPRESSWAY	UNSCHEDULED							
CITY OF PEORIA								
91ST AVENUE STORM DRAIN	UNSCHEDULED							
A.D.O.T.								
OUTERLOOP HWY. TO 500' NORTH OF BELL ROAD	PROPOSED	▨						
CITY OF GLENDALE								
67TH AVENUE STORM DRAIN	UNSCHEDULED							
59TH AVENUE STORM DRAIN	UNSCHEDULED							

TABLE 27 CONTINUED

PROJECT	STATUS	1987	1988	1989	1990	1991	1992	1993
A.C.D.C.								
REACH 1 SKUNK CREEK TO CACTUS	COMPLETE							
CITY OF PHOENIX								
51ST AVENUE STORM DRAIN	PROPOSED							
45RD AVENUE STORM DRAIN	PROPOSED							
35TH AVENUE STORM DRAIN	PROPOSED							
A.C.D.C.								
REACH 2A CACTUS TO 47TH AVENUE	COMPLETE							
REACH 2B 47TH AVENUE TO 29TH AVENUE	PROPOSED							
A.D.O.T.								
I-17 PUMP STATION REHABILITATION	UNSCHEDULED							
CITY OF PHOENIX								
19TH AVENUE STORM DRAIN	COMPLETE							
A.C.D.C.								
REACH 2C 29TH AVENUE TO CAVE CREEK WASH	PROPOSED							
VIA VERDE	PROPOSED							
UEFCC ADMS	UNSCHEDULED							
SQUAW PEAK PARKWAY	PROPOSED							1997
CITY OF PHOENIX								
36TH STREET STORM DRAIN	PROPOSED							
40TH STREET STORM DRAIN	COMPLETE							
44TH STREET STORM DRAIN	PROPOSED							
48TH STREET STORM DRAIN	PROPOSED							
52ND STREET STORM DRAIN	PROPOSED							
56TH STREET STORM DRAIN	PROPOSED							
TIERRA BUENA DETENTION BASIN PROJECT	PROPOSED							

The bar graphs in Table 28 represent the construction dates for the segments of Bell Road as proposed by PBQ&D and broken out by drainage areas and location. Comments are provided as to whether there is a potential for conflict between the roadway construction schedules and the downstream to upstream staging of the Bell Road drainage facilities.

It was found that for all drainage areas, except for Drainage Area 7, there will be no conflicts between the roadway construction schedule and the need to stage the drainage facilities from downstream to upstream. In Drainage Area 7, a storm drain will extend along Bell Road from 28th Street to 20th Street, draining east to west. This section of Bell Road will be constructed in two stages as proposed by PBQ&D. The upstream stage, from Cave Creek Road (24th Street) to 36th Street, will be constructed in 1989-1990. The downstream stage, Cave Creek Road to 20th Street, will be constructed in 1990-1991. Either a temporary outfall for the 28th Street to Cave Creek Road section of the storm drain will have to be provided until 1991, or the schedule of the storm drain from Cave Creek Road to 20th Street (including the 20th Street channel from Bell Road to the Greenway Parkway channel) will be advanced one year prior to the roadway improvements in this section of Bell Road, or the sequence of roadway construction should be revised. This ensures that the Cave Creek Road to 20th Street segment is constructed at the same time or prior to the Cave Creek to 36th Street segment.

The costs to construct the Bell Road drainage facilities were also evaluated with respect to the proposed construction schedule. Table 29 presents costs by fiscal year and by jurisdictions for each design segment of Bell Road. This cost breakout will assist the participating jurisdictions in planning their budgets for each year during the project duration. Total project costs by jurisdictions and by fiscal year are also available from the table. Total Bell Road project costs (drainage facilities along Bell Road only) will be approximately \$14.2 million. Costs to the participating jurisdictions will be as follows:

Town of Surprise	\$0.1 million
City of Peoria	\$0.6 million
City of Glendale	\$2.3 million
City of Phoenix	\$7.1 million
Maricopa County	\$4.1 million

TABLE 28  
CONSTRUCTION SCHEDULE FOR  
DRAINAGE FACILITIES ALONG BELL ROAD

DRAINAGE AREA	LOCATION	1987	1988	1989	1990	1991	1992	COMMENTS
1	GRAND AVENUE - AGUA FRIA					▨		DRAINAGE AND ROADWAY PHASING, OK
2	AGUA FRIA - 115TH AVENUE 115TH AVENUE - 93RD AVENUE 93RD AVENUE - NEW RIVER			▨	▨	▨		DRAINAGE AND ROADWAY PHASING, OK
3	NEW RIVER TO OUTER LOOP 83RD AVENUE - SKUNK CREEK			▨ ▨				DRAINAGE AND ROADWAY PHASING, OK
4	SKUNK CREEK - 67TH AVENUE 67TH AVENUE - 51ST AVENUE 51ST AVENUE - 43RD AVENUE 43RD AVENUE - I-17			▨ ▨	▨	▨		DRAINAGE AND ROADWAY PHASING, OK
5	I-17 - 19TH AVENUE 19TH AVENUE - CAVE CREEK			▨	▨			DRAINAGE AND ROADWAY PHASING, OK
6	CAVE CREEK - 7TH STREET 7TH STREET - 20TH STREET			▨	▨			DRAINAGE AND ROADWAY PHASING, OK
7	20TH STREET - CAVE CREEK ROAD CAVE CREEK ROAD - 36TH STREET			▨	▨			ROADWAY AND/OR DRAINAGE PHASING WILL HAVE TO BE MODIFIED (REFER TO TEXT)
8	36TH STREET - 40TH STREET 40TH STREET - 56TH STREET 56TH STREET - SCOTTSDALE ROAD			▨	▨	▨		DRAINAGE AND ROADWAY PHASING, OK

**TABLE 29  
SUMMARY OF COSTS  
FOR THE  
DRAINAGE FACILITIES ALONG BELL ROAD**

<u>Fiscal Year</u>	<u>Location</u>	<u>Town of Surprise</u>	<u>City of Peoria</u>	<u>City of Glendale</u>	<u>City of Phoenix</u>	<u>Maricopa County</u>	<u>Total</u>
1989-1990	93rd Avenue to Outer Loop	\$ 0	\$ 641,000	\$ 0	\$ 0	\$ 0	\$ 641,000
	83rd Avenue to 67th Avenue	0	0	1,105,000	0	0	1,105,000
	43rd Avenue to I-17	0	0	0	986,000	0	986,000
	19th Avenue to 7th Street	0	0	0	716,000	0	716,000
	Cave Creek Road to 40th Street	0	0	0	236,000	2,921,000	3,157,000
Sub-Total		0	\$ 641,000	\$ 1,105,000	\$ 1,938,000	\$ 2,921,000	\$ 6,605,000
1990-1991	115th Avenue to 93rd Avenue	\$ 0	\$ 0	\$ 0	\$ 0	\$ 912,000	\$ 912,000
	67th Avenue to 51st Avenue	0	0	1,191,000	0	0	1,191,000
	I-17 to 19th Avenue	0	0	0	339,000	0	339,000
	7th Street to Cave Creek Road	0	0	0	3,425,000	0	3,425,000
	40th Street to 56th Street	0	0	0	768,000	0	768,000
Sub-Total		0	0	\$ 1,191,000	\$ 4,532,000	\$ 912,000	\$ 6,635,000
1991-1992	Grand Avenue to 115th Avenue	\$110,000	\$ 0	\$ 0	\$ 0	\$ 251,000	\$ 361,000
	51st Avenue to 43rd Avenue	0	0	0	388,000	0	388,000
	56th Street to Scottsdale Road	0	0	0	245,000	0	245,000
Sub-Total		\$110,000	\$ 0	\$ 0	\$ 633,000	\$ 251,000	\$ 994,000
<b>Total</b>		<b>\$110,000</b>	<b>\$ 641,000</b>	<b>\$ 2,296,000</b>	<b>\$ 7,103,000</b>	<b>\$ 4,084,000</b>	<b>\$ 14,234,000</b>

Drainage design criteria and guidelines were developed to ensure that the design hydrologic and hydraulic analysis are consistent with the assumptions and criteria used to develop the recommended plan. The criteria utilized to develop the recommended plan are consistent with current procedures in use by the participating jurisdictions. The criteria are found in Appendix A.

XIV. REFERENCES

## REPORTS

1. Glendale Storm Water Management Plan, 1986, Camp Dresser & Mckee: City of Glendale.
2. Northwest Storm Drainage Study, 1977, Project No. ST-74206.00, Arthur Beard Engineering, Inc.: City of Phoenix.
3. North Central Master Storm Drainage Study (West Half), 1980, Project NO. ST-79185.01, SCI Consulting Engineers, Inc.: City of Phoenix.
4. North Central Area Master Storm Drainage Study (East Half), 1981, Project No. ST-79190.01, Cella Barr Associates: City of Phoenix.
5. Northeast Area Master Storm Drainage Study, 1979, Project No. ST-78328.00, Southwest Computing, Inc.: City of Phoenix.
6. Bell Road Drainage Facilities - 67th Avenue to Scottsdale Road, 1982, Project No. P-824649, Dibble and Associates: City of Phoenix.
7. Drainage Study of East Fork Cave Creek Wash for Haspro Development, 1985, Cella Barr Associates.
8. Master Plan of Storm Drainage, City of Peoria, Arizona, May 1986, James M. Montgomery, Consulting Engineers, Inc., Draft Report.
9. Glendale-Peoria Area Drainage Master Plan, April 1986, Camp Dresser & McKee Inc. and James M. Montgomery, Consulting Engineers, Inc.
10. Sun City West Phase I Development Master Plan, July 1977, HDR.
11. Sun City West Master Plan Updates, November 1984, HDR.
12. Grand Avenue Corridor Study, April 1986, Interim Report, Parsons, Brinckerhoff, Quade & Douglas Inc., Draft Report.
13. Master Drainage Study for Sun City North of Bell Road: HDR Engineering, January 1976.
14. Hydrology Report, Off-Site Hydrology, Existing Conditions, Outer Loop Highway, Bell Road to Central Arizona Project Canal Crossing, Section B, Greiner Engineering Sciences, Inc., August 1986.
15. Upper East Fork Cave Creek Area Drainage Master Study, November 1986, Draft: NBS/Lowry Engineering for Maricopa County Flood Control District.

16. Interstate 17 Drainage Design Study, Initial Design Report, August 1986, PRC Engineering for Arizona Department of Transportation.
17. State Route 510, Squaw Peak Extension, Glendale Avenue - Outer Loop, Phase 1 Reconnaissance Report, June 1986, Gruen Associates.
18. Drainage Study 56th Street Storm Drain System, February 1982, Boyle Engineering Corp.
19. Alternate Stormwater/Floodwater Management Concept Plans, January 1987, Greiner Engineering Sciences, Inc.

## DRAINAGE CRITERIA

1. Drainage Policies and Standards for Maricopa County, Arizona, November 19, 1987, Boyle Engineering Corporation: Flood Control District of Maricopa County, Draft Report.
2. Final Drainage Design Report, Phoenix-Casa Grande Highway (Central Avenue - 16th Street), April 1986, Greiner Engineering Sciences, Inc.: Arizona Department of Transportation, Draft Report.
3. Subdivision Regulations for the Unincorporated Area of Maricopa County: Maricopa County.
4. Technical Memorandum, Drainage Design Criteria, Outer Loop Highway, DeLeuw, Cather and Company: Arizona Department of Transportation.
5. Storm Drain Design Manual, Storm Drains with Paving of Major Streets, August 1975: City of Phoenix.
6. Storm Drain Design Manual, Subdivision Drainage Designs, September 1985: City of Phoenix.
7. Design Guidelines for Site Development and Infrastructure Construction, 1985: City of Glendale, Public Works - Engineering.
8. Development Engineering Requirements: City of Chandler.
9. Procedure Manual, June 1983: City of Mesa Engineering.
10. Drainage and Channel Design Standard for Local Drainage, May 1984: Pima County Department of Transportation and Flood Control District.
11. Design Manual, Hydraulics, March 1982: Los Angeles County Flood Control District.
12. Design Facilities to Manage Stormwater Runoff, Section 3, Design Procedures and Criteria, October 1984: City of Scottsdale.
13. Engineering Design Standard for Far West States for Slope Stability, U.S. Department of Agriculture: Soil Conservation Service, 1956.
14. Hydrologic and Hydraulic Training Session: Arizona Highway Department, Structures Section, Hydraulics Branch, October 1972.
15. Drainage of Highway Pavements: Hydraulic Engineering Circular No. 12, U.S. Department of Transportation, Federal Highway Administration, March 1984.

16. Design of Urban Highway Drainage the State-of-the-Art: U.S. Department of Transportation, Federal Highway Administration, August 1979.
17. Design of Stable Channels with Flexible Linings: Hydraulic Engineering Circular No. 15, U.S. Department of Transportation, Federal Highway Administration, October 1975.
18. Sun Valley Parkway Drainage Design Criteria: Maricopa County Highway Department, Greiner Engineering Sciences, Inc., February 1987.

## ENVIRONMENTAL

1. Archaeological Survey - Field Report, Site No. T:8:7, Pueblo Grande Museum, November 14, 1974.
2. Water Quality Standards for Waters of the State, Chapter 21, Hand-out No. 11-86, Arizona Water Quality Control Council, July 9, 1986, Draft.
3. Application Procedures for Designation of Parkways, Historic and Scenic Roads, Parkways, Historic and Scenic Roads Advisory Committee, Undated.
4. Arizona Native Plant Law, Chapter 7, Arizona Commission of Agriculture and Horticulture, July 1981.
5. Native Plant Regulations, Article 6, Arizona Commission of Agriculture and Horticulture, May 15, 1984.
6. Noise Abatement Policy for State-Funded Projects, Arizona Department of Transportation, July 22, 1986.
7. Regulatory Program, Applicant Information, No. 1145-2-1, United States Army Corps of Engineers, May 1985.
8. Squaw Peak Extension, State Route 510, Phase 1 Reconnaissance Report, Gruen Associates, June 1986, Preliminary Report.
9. Cave Creek Wash Preliminary Master Plan, Wirth Associates, Inc., November 1981.

AERIAL MAPPING

1. Landis Aerial Surveys, 1" = 1200', Photodate: December 17, 1986, Photos J-12 through J-18 and K-12 through K-18.
2. City of Phoenix AP #40 Aerial Maps, 36-17 to 36-44 and 37-17 to 37-32, 1" = 100' scale.

DRAINAGE MANUALS

1. HEC-1 Flood Hydrograph Package User's Manual: U.S. Army Corps of Engineers, July 1983.
2. Hydraulic Charts for the Selection for Highway Culverts, HEC No. 5: Federal Highway Administration, 1965.
3. Handbook of Hydraulics: Brater, Ernest and King, Horace, Sixth Edition, 1976.

## MAPS

1. U.S. Geological Survey 7.5 Minute Quadrangle Maps, 1" = 2000'.
  - Calderwood Butte
  - Hedgpeth Hills
  - El Mirage
  - Glendale
  - Paradise Valley
  - Curry's Corner
  - Union Hills
  - Sunnyslope
2. Composite Land Use Plan Map for Maricopa County.
3. East Fork of Cave Creek Wash Work Map, Flood Boundary, and Floodway Map, U.S. Department of Housing and Urban Development, Federal Emergency Management Administration, April 1, 1980.
4. City of Phoenix Zoning Maps.
5. City of Glendale Zoning Maps, December 1985.
6. Floodplain Maps and Computer Output Summary for New River, Skunk Creek, and Agua Fria River.
7. Floodplain Delineation Maps for Cave Creek Wash and East Fork Cave Creek Wash.
8. City of Peoria Zoning Map.
9. City of Phoenix, Map of Existing Storm Drains Along Bell Road.

## MISCELLANEOUS

1. Westbrook Village Master Plan - Drainage; Collar, Williams and White Engineering, 1982.
2. Phoenix Supplemental Standard Details for Public Works Construction, 1981.
3. City of Phoenix Curve Numbers Based on Zoning and Soil Type.
4. Design Memorandum for Reaches 10 and 11, Granite Reef Aqueduct of the Central Arizona Project, Undated: U.S. Bureau of Reclamation.
5. Preliminary Storm Drainage Master Plan, Arrowhead Ranch, Glendale, Arizona; Dibble and Associates, July 1982.
6. Cave Buttes Dam Design Memorandum: U.S. Army Corps of Engineers, July 1976.
7. Adobe Dam Design Memorandum: U.S. Army Corps of Engineers, April 1978.
8. City of Phoenix Administrative Procedure No. 55, Design Policy for Street Slopes, August 1982.
9. Bell Road As-Built Plans, Maricopa County, Arizona.
10. Design Memorandum for Tribly Wash (McMicken Dam): U.S. Army Corps of Engineers, November 1953 and March 1954.
11. Large Scale Development Areas: Maricopa County Department of Planning and Development, October 1985.
12. Design Memorandum 1, Indian Bend Wash, Gila River Basin, Arizona, October 1973.
13. Atchison-Topeka - Santa Fe Railroad As-Builts for Drainage Facilities North of McMicken Dam to New River.
14. 51st Avenue and Bell Road Street Widening Project, Hess, Fogt, Rountree, Inc., March 1983.
15. As-Builts of Surface Improvements to Bell Road in Glendale, Arizona.
16. Interstate 17 As-Builts from South of Bell Road to Union Hills.
17. General Plan of Phoenix 1985/2000, City of Phoenix Planning Department, 1985.

**APPENDIX A**  
**Drainage Design Criteria**

TABLE OF CONTENTS

	<u>Page</u>
I. List of Figures.....	iii
II. List of Tables.....	iv
III. Introduction.....	1
IV. Pavement Drainage.....	2
A. Hydrology.....	2
B. Hydraulic Design.....	2
V. Storm Drain Design.....	4
A. Hydrology.....	4
B. Hydraulic Design.....	4
VI. Open Channels.....	6
A. Hydrology.....	6
B. Hydraulic Design.....	6
VII. Detention Basins.....	8
A. Hydrology.....	8
B. Hydraulic Design.....	8
VIII. Culverts.....	9
A. Hydrology.....	9
B. Hydraulic Design.....	9
IX. Criteria Used for HEC-1 Computer Modeling.....	11

I. LIST OF FIGURES

	<u>Page</u>
1. Factors for adjusting lag when the main channel has been hydraulically improved	19
2. Factors for adjusting lag when impervious areas occur in the watershed	19

II. LIST OF TABLES

	<u>Page</u>
1. Current City of Phoenix Engineering Department, 24-Hour Rainfall Distribution	14
2. Phoenix WBO Records (24-hour duration storm)	15
3. City of Phoenix Curve Numbers Based on Soils and Zoning	16
4. Zoning Classifications for Governmental Agencies Within the Watershed Areas	17
5. Estimating the Percent of Impervious Cover for Developed Areas	18

### III. INTRODUCTION

The drainage design criteria are presented in the following sections for pavement drainage, storm drains, improved open channels, detention basins and culverts. The criteria are intended as a supplement to current criteria of the jurisdictions participating in the Bell Road study. Criteria for bridge reconstruction (widening) or improvement of major watercourses (ie. Agua Fria River, New River, Skunk Creek and Cave Creek) have not been addressed in this study.

IV. PAVEMENT DRAINAGE

A. Hydrology

1. Design frequencies: 10-year storm for Maricopa County and City of Glendale; 2-year storm for City of Peoria and City of Phoenix.
2. Precipitation values: City of Phoenix rainfall intensity, duration and frequency curves.
3. Hydrologic methodology: Rational Method.
4. Runoff coefficients:
  - a. Paved surfaces.....0.9  
(Asphalt or Concrete)
  - b. Earthen Ditches.....0.5
5. Times of concentration: sum of gutter flow time or 10 minutes minimum.
6. Landscaped medians will retain all direct precipitation.

B. Hydraulic Design

1. Allowable spread: 4 lanes of Bell Road must remain open during the design storm event, therefore one wet lane in each direction is allowed.
2. Maximum allowable depth: 0.5 feet.
3. Spread and depth calculations: F.H.W.A. HEC No. 12.

4. Inlet, catch basin analysis: F.H.W.A. HEC No. 12.
  
5. Catch basin inlet clogging factors:
  - a. Curb-opening inlets on a continuous grade.....0.25
  - b. Inlets in sag locations.....0.50
  - c. Grate inlets on a continuous grade.....0.50
  - d. Combination Inlets.....F.H.W.A. HEC No. 12
  
6. Manning's "n":
  - a. Asphaltic concrete.....0.016
  - b. Concrete pavement.....0.013
  - c. Composite asphalt pavement with concrete gutter.....0.015

V. STORM DRAIN DESIGN

A. Hydrology

1. Design frequencies: 10-year, 24-hour storm for Maricopa County; 2-year, 24-hour storm for City of Peoria and City of Phoenix; 10-year, 2-hour storm for City of Glendale.
2. Hydrologic methodology: HEC-1 with procedures as outlined in Section IX.

B. Hydraulic Design

1. Method for hydraulic grade line analysis: Manning's Equation for friction losses, pressure and momentum method to analyze losses at bends, junctions, transitions and manholes.
2. Manning's "n":
  - a. Concrete pipe (RCP).....0.013
  - b. Concrete pipe (CIPP).....0.015
  - c. Corrugated metal pipe.....0.024
3. Minimum velocities:
  - a. Laterals.....3 fps
  - b. Trunk.....5 fps
4. Minimum pipe size:
  - a. Laterals.....15"
  - b. Trunk.....18"

5. Freeboard: hydraulic grade line must be 0.5 feet or more below gutter at intermediate inlets, and 3 feet or more below gutter at the uppermost inlet in a system.

6. Manhole intervals:

- a. Under 30".....330 feet
- b. 33" - 45".....440 feet
- c. 48" and greater.....660 feet

## VI. OPEN CHANNELS

### A. Hydrology

1. Design frequencies: 10-year, 24-hour storm for Maricopa County; 2-year, 24-hour storm for City of Peoria and City of Phoenix; 10-year, 2-hour storm for City of Glendale.
2. Hydrologic methodology: HEC-1 with procedures as outlined in Section IX.

### B. Hydraulic Design

1. Hydraulic methodology:

Normal depth flow analysis using the Manning Equation unless complex channel geometry or flow conditions require more detailed analysis.

2. Manning's "n":

- a. Uniform earthen channels.....0.027
- b. Gunitite channels.....0.020
- c. Concrete.....0.013
- d. Soil cement.....0.018
- e. Dumped rip-rap.....0.033
- f. Grouted rip-rap.....0.028

3. Velocities: Minimum and maximum allowable velocities should be evaluated on a case by case basis depending on soils, sediment conditions and proposed linings.
4. Side slopes (earthen channels): maximum 4:1, unless soil analysis indicates otherwise.

5. Freeboard:

- a. Subcritical --  $0.2 (d + V^2/2g)$
- b. Super-critical --  $0.25d$
- c. Minimum of 1.0 above HGL in all cases

6. Erosion and scour protection: F.H.W.A. HEC No. 15.

## VII. DETENTION BASINS

### A. Hydrology

1. Design frequencies: 10-year, 24-hour storm for Maricopa County; 10-year, 2-hour storm for City of Glendale; 2-year, 24-hour storm for City of Peoria and City of Phoenix.
2. Hydrologic methodology: HEC-1 with Modified Puls storage routing routine.

### B. Hydraulic Design

1. Outlet design: inlet and outlet control analysis as per FHWA HEC No. 5.
2. Maximum depth: 10 feet.
3. Maximum side slopes: 4:1.
4. Freeboard: 1.5 feet.
5. Drain time: Within 36 hours.
6. Provisions should be made for an emergency spillway to safely convey 100-year storm outflows.

## VIII. CULVERTS

### A. Hydrology

1. Design frequencies: 10-year, 24-hour storm for Maricopa County and City of Glendale; 2-year, 24-hour storm for City of Peoria and City of Phoenix.
2. Hydrologic methodology:
  - a. On-site -- Rational Method
  - b. Off-site -- HEC-1 with procedures as outlined in Section IX

### B. Hydraulic Design

1. Capacity calculations: F.H.W.A. HEC No. 5.
2. Maximum allowable headwater: One (1) foot below roadway shoulder or 1 foot below top of upstream channel bank.
3. Manning's "n":
  - a. Concrete pipe/box culvert.....0.012
  - b. Corrugated metal.....0.024

4. Culvert outlet protection: Ratio of outlet velocity to natural stream velocity per ADOT method.

<u>Ratio of Outlet Velocity to Natural Stream Velocity</u>	<u>Outlet Protection</u>
1.0 to 1.5	No protection required
1.5 to 2.0 with outlet velocity less than 10 fps	Dumped rock rip-rap
1.5 to 2.5 with outlet velocity greater than 10 fps	Wire tied or grouted rock rip-rap
Greater than 2.5	Concrete energy dissipator or consider larger culvert

5. Minimum size:

- a. Concrete box culvert.....6'x4'
- b. Circular pipe.....18"
- c. Elliptical Pipe.....18"x29"

IX. CRITERIA USED FOR HEC-1 COMPUTER MODELING

The following criteria were used for HEC-1 computer modeling of the selected stormwater/floodwater management plan, and should be used for consistency in developing the final plans:

- o A 24-hour storm duration
- o The City of Phoenix rainfall table for the 24-hour storm (City of Phoenix s-curve) (See Table 1).
- o The City of Phoenix precipitation depth values per Technical Memorandum WBTM WR-44 (See Table 2).
- o Precipitation depths need not be varied through the watersheds.
- o City of Phoenix curve numbers (CN's) are based on hydrologic soils groups and zoning (See Table 3). Where areas have not been identified on this table, the standard SCS techniques to develop curve numbers should be followed. For subareas within the City of Glendale, Peoria and Maricopa County, equivalent zoning classifications are translated to the City of Phoenix zoning classifications (See Table 4) and the City of Phoenix curve numbers based on hydrologic soil groups and zoning are applied.
- o The SCS unit graph method should be used for undeveloped areas only.
- o The kinematic wave method for calculating runoff should be used for developed areas. An average overland flow roughness coefficient of 0.17 should be used.
- o Two (2) different lag time equations should be used depending on the size and shape of the subareas as follows:

For small watersheds of regular shape, the following equation should be used. This is based on the SCS modified curve number method:

$$\text{Lag} = \frac{L^{0.8}(1000/\text{CN} - 9)^{0.7}}{(1900)s^{.5}}$$

where L = length of the longest watercourse (in feet)

s = the overall slope of the longest watercourse, from headwater to concentration point (in percent)

Lag = lag time (in hours)

Adjustments to lag time for this equation, based on the percent of the hydraulic length that has been modified and the percent of impervious area are made per SCS Technical Release 55, pages 3-8 and 3-9 (See Figures 1 and 2 and Table 5).

For large and/or elongated watersheds, the equation below should be used. This is based on the modified Snyder's equation:

$$\text{Lag} = 24n(LL_{ca}/s^{0.5})^{0.38}$$

where L = the length of the longest watercourse (in miles)

$l_{ca}$  = the upstream length along the longest watercourse to a point opposite the subbasin centroid (in miles)

s = the overall slope of the longest watercourse, from headwater to concentration point (in feet/mile)

n = the overland flow roughness factor for the subbasin

Lag = lag time (in hours)

Values of "n" for the above equation are as follows:

"n" values for undeveloped areas:

0.05 where slopes > 0.04'/ft

0.035 slopes from 0.01 to 0.04'/ft

0.030 slopes flatter than 0.01'/ft

"n" values for developed areas:

0.022 3-5 houses/acre

0.030 1-2 houses/acre

0.020 multiple residential and light commercial

TABLE 1  
 CURRENT CITY OF PHOENIX ENGINEER DEPARTMENT  
24-HOUR RAINFALL DISTRIBUTION

Time (hours)	Total Rainfall %	Time (hours)	Total Rainfall %
0	0.0	12.5	83.0
.5	0.4	13.0	86.0
1.0	0.8	13.5	88.0
1.5	1.3	14.0	89.3
2.0	1.8	14.5	90.7
2.5	2.2	15.0	92.0
3.0	2.6	15.5	92.4
3.5	3.1	16.0	92.8
4.0	3.5	16.5	93.3
4.5	4.0	17.0	93.7
5.0	4.4	17.5	94.2
5.5	4.8	18.0	94.7
6.0	5.3	18.5	95.1
6.5	5.7	19.0	95.6
7.0	6.2	19.5	96.0
7.5	6.6	20.0	96.4
8.0	7.1	20.5	96.9
8.5	7.5	21.0	97.3
9.0	8.0	21.5	97.8
9.5	9.3	22.0	98.2
10.0	10.7	22.5	98.7
10.5	12.0	23.0	99.1
11.0	14.0	23.5	99.5
11.5	17.0	24.0	1.0
12.0	50.0		

TABLE 2

PHOENIX WBO RECORDS\*

(24-HOUR DURATION STORM)

<u>Return Periods, Years</u>	<u>Precipitation, Inches</u>
1	1.02
2	1.44
5	2.10
10	2.53
25	3.12
50	3.57
100	4.04

\*Technical Memorandum WBTM WR-44

TABLE 3

CITY OF PHOENIX CURVE NUMBERS  
BASED ON SOILS AND ZONING

<u>Zoning</u>	Curve Numbers for Soil Type		
	<u>Type B</u>	<u>Type C</u>	<u>Type D</u>
RE-43) S-1)	79	83	86
RE-35	79	84	87
RE-25	79	84	87
R1-18	80	84	87
R1-14	80	85	88
R1-10	81	86	89
R1-8	82	87	90
R1-6	84	88	90
R -3	85	88	90
R -4 R -40 R -5	86	89	91
A -1 A -2	88	91	93
C -1 C -2 C -3	92	94	95
CO	88	91	93
PSC	95	95	95
HR	95	95	95
R4A	87	90	92

**TABLE 4**  
**ZONING CLASSIFICATIONS**  
**FOR GOVERNMENTAL**  
**AGENCIES WITHIN THE WATERSHED AREAS**

PHOENIX

Zoning	Use	Units/Acre
S 1	Ranch or Farm Residence	
S 2	Ranch or Farm Commercial	
RE-43	Single Family Residence 43,560 Sq. Ft. Lots Minimum	1.0
RE-35	Single Family Residence 1.10 Dwellings/Acre Base Density	1.1
RE-24	Single Family Residence 24,000 Sq. Ft. Lots Minimum	1.8
R1-18	Single Family Residence 1.95 Dwellings/Acre Base Density	1.95
R1-14	Single Family Residence 14,000 Sq. Ft. Lots Minimum	3.11
R1-10	Single Family Residence 3.50 Dwellings/Acre Base Density	3.5
R1-8	Single Family Residence 4.30 Dwellings/Acre Base Density	4.3
R1-6	Single Family Residence 5.30 Dwellings/Acre Base Density	5.3
R-2	Multi-Family Residence 10.0 Dwellings/Acre Base Density	10
R-3	Multi-Family Residence 14.5 Dwellings/Acre Base Density	14.5
R-3A	Multi-Family Residence 22.0 Dwellings/Acre Base Density	22.0
R-4	Multi-Family Residence 29.0 Dwellings/Acre Base Density	29.0
R-4A	Multi-Family Residence 43.5 Dwellings/Acre Base Density	43.5
R-5	Multi-Family Residence 43.5 Dwellings/Acre Base Density	43.5
P.A.D. 1-15	Planned Area Development District	
RH	Resort District 20/Acre Minimum 50 Guest Rooms	
RO	Residential Office	
CO	Commercial Office District Restricted Commercial	
C-1	Neighborhood Commercial	
C-2	Intermediate Commercial	
C-3	General Commercial	
M-R	Mid-Rise District Limited to 190'	
H-R	High Rise District Limited to 250'	
H-RI	High Rise District (Downtown)	
P.S.C.	Planned Shopping Center	
R.S.C.	Regional Shopping Center	
Ind. Pk.	Industrial Park	
A-1	Light Industrial	
A-2	Heavy Industrial	
P-1	Parking (Open)	
P-2	Parking (Structures)	
P-C	Planned Community	
S-P	Special Permit	
C/Z	Conditional Zoning	

MARICOPA COUNTY

Zoning	Use	Units/Acre
RURAL 190	Rural Zoning District 190,000 Sq. Ft. Per Dwelling Unit	0.23
RURAL 70	Rural Zoning District 70,000 Sq. Ft. Per Dwelling Unit	0.62
RURAL 43	Rural Zoning District One (1) Acre Per Dwelling Unit	1.0
R1-35	Single Family Residential Zoning District 35,000 Sq. Ft. Per Dwelling Unit	1.24
R1-18	Single Family Residential Zoning District 18,000 Sq. Ft. Per Dwelling Unit	2.42
R1-10	Single Family Residential Zoning District 10,000 Sq. Ft. Per Dwelling Unit	4.36
R1-8	Single Family Residential Zoning District 8,000 Sq. Ft. Per Dwelling Unit	5.45
R1-7	Single Family Residential Zoning District 7,000 Sq. Ft. Per Dwelling Unit	6.22
R1-6	Single Family Residential Zoning District 6,000 Sq. Ft. Per Dwelling Unit	7.26
R-5	Multiple Family Residential Zoning District	43.5
R-4	Multiple Family Residential Zoning District	21.80
R-3	Multiple Family Residential Zoning District	14.52
R-2	Two-Family Residential Zoning District	10.89
C-1	Neighborhood Commercial Zoning District	
C-2	Intermediate Commercial Zoning District	
C-3	General Commercial Zoning District	
C-S	Planned Shopping Center Zoning District	
C-0	Commercial Office Zoning District	
IND-1	Planned Industrial Zoning District	
IND-2	Light Industrial Zoning District	
IND-3	Heavy Industrial Zoning District	
SU	Special Uses	
NUP	Neighborhood Plan of Development	
RUP	Residential Plan of Development	
SC	Senior Citizen Overlay	
MHR	Manufactured House Residential Zoning District	

GLENDALE

Zoning	Use	Units/Acre
A-1	Agricultural Residence	1.0
SR-30	Suburban Residence	1.45
SR-17	Suburban Residence	2.56
SR-12	Suburban Residence	3.63
R1-10	Single Family Residence	4.36
R1-8	Single Family Residence	5.45
R1-7	Single Family Residence	6.22
R1-6	Single Family Residence	7.26
R-2	Two Family Residence	14.52
R-3	Multi Family Residence	43.50
R-4	Multi Family Residence	43.50
C-0	Commercial Office	
C-1	Neighborhood Retail	
C-2	General Commercial	
C-3	Unlimited Commercial	
M-P	Industrial Park	
M-1	Light Industrial	
M-2	Heavy Industrial	
P.A.D.	Planned Area Development	
P.R.D.	Planned Residential Development	
T.D.	Trailer District	

PEORIA

Zoning	Use
R1-35	Single Family Residential 35,000 Sq. Ft. Lots Minimum
R1-18	Single Family Residential 18,000 Sq. Ft. Lots Minimum
R1-8	Single Family Residential 8,000 Sq. Ft. Lots Minimum
R1-7	Single Family Residential 7,000 Sq. Ft. Lots Minimum
R1-6	Single Family Residential 6,000 Sq. Ft. Lots Minimum
RM-1	Multiple Residential
RMH-1	Residential Mobile Home Park
RMH-2	Mobile Home Park
O-1	Offices
C-1	Convenience Locations
C-2	Intermediate Commercial
C-3	Central Commercial
C-4	Highway Commercial
PC-1	Planned Community Commercial
I-1	Light Industrial
I-2	Heavy Industrial
AG	General Agriculture
PUD	Planned Unit Development

P.A.D. DISTRICTS

MAXIMUM DWELLING UNITS PER GROSS ACRE

P.A.D.-1	0.75
P.A.D.-2	1.00
P.A.D.-3	1.35
P.A.D.-4	1.75
P.A.D.-5	2.20
P.A.D.-6	2.75
P.A.D.-7	3.50
P.A.D.-8	4.75
P.A.D.-9	6.00
P.A.D.-10	8.00
P.A.D.-11	10.00
P.A.D.-12	12.00
P.A.D.-13	14.50
P.A.D.-14	29.00
P.A.D.-15	43.50

TABLE 5  
ESTIMATING THE PERCENT OF  
IMPERVIOUS COVER FOR  
DEVELOPED AREAS

*Type of Development <u>Anticipated in Watershed</u>	Percent of Impervious Cover		
	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
Suburban:			
(a) Less than 1 house/acre	5%	10%	20%
(b) 1 house/acre	15%	20%	25%
(c) 2/houses/acre	25%	30%	35%
Light to Moderate Urbanization:			
(a) 3 houses/acre	30%	35%	40%
(b) 4 houses/acre (detached)	35%	40%	45%
(c) 5 houses/acre (detached)	45%	50%	55%
Highly Urbanized:			
(a) Multiplied Dwellings (4 units/acre, or more)	50%	65%	90%
(b) Light Industrial & Commercial	50%	65%-75%	80%
(c) Heavy Industrial & Commercial	80%	85%-95%	100%

\*It is assumed, in all cases, that paved streets are adjacent to at least one side of a developed lot.

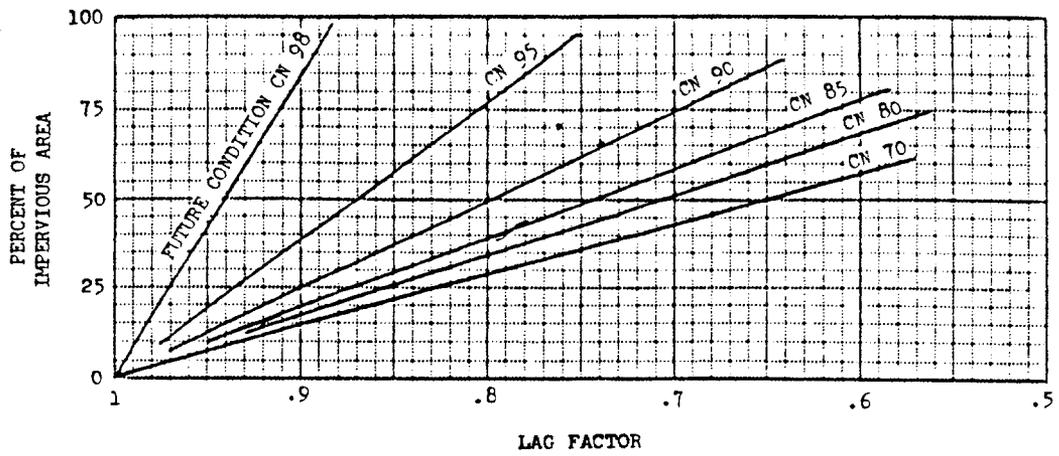


Figure 1 -- Factors for adjusting lag when the main channel has been hydraulically improved.

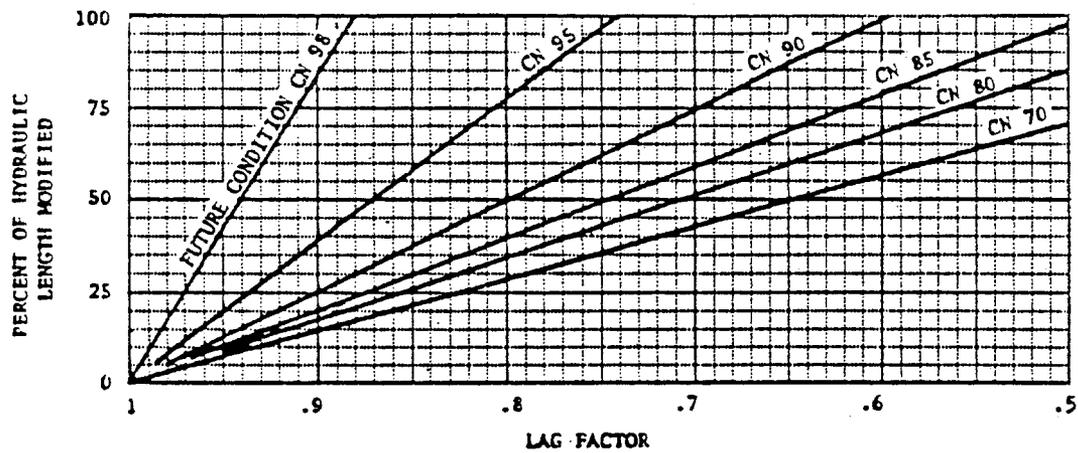


Figure 2 -- Factors for adjusting lag when impervious areas occur in the watershed.