STACKED 40s
SCOTTSDALE, ARIZONA
REZONING DRAINAGE REPORT
Case #345-PA-02

July 29, 2002

WP #021584

Prepared for:

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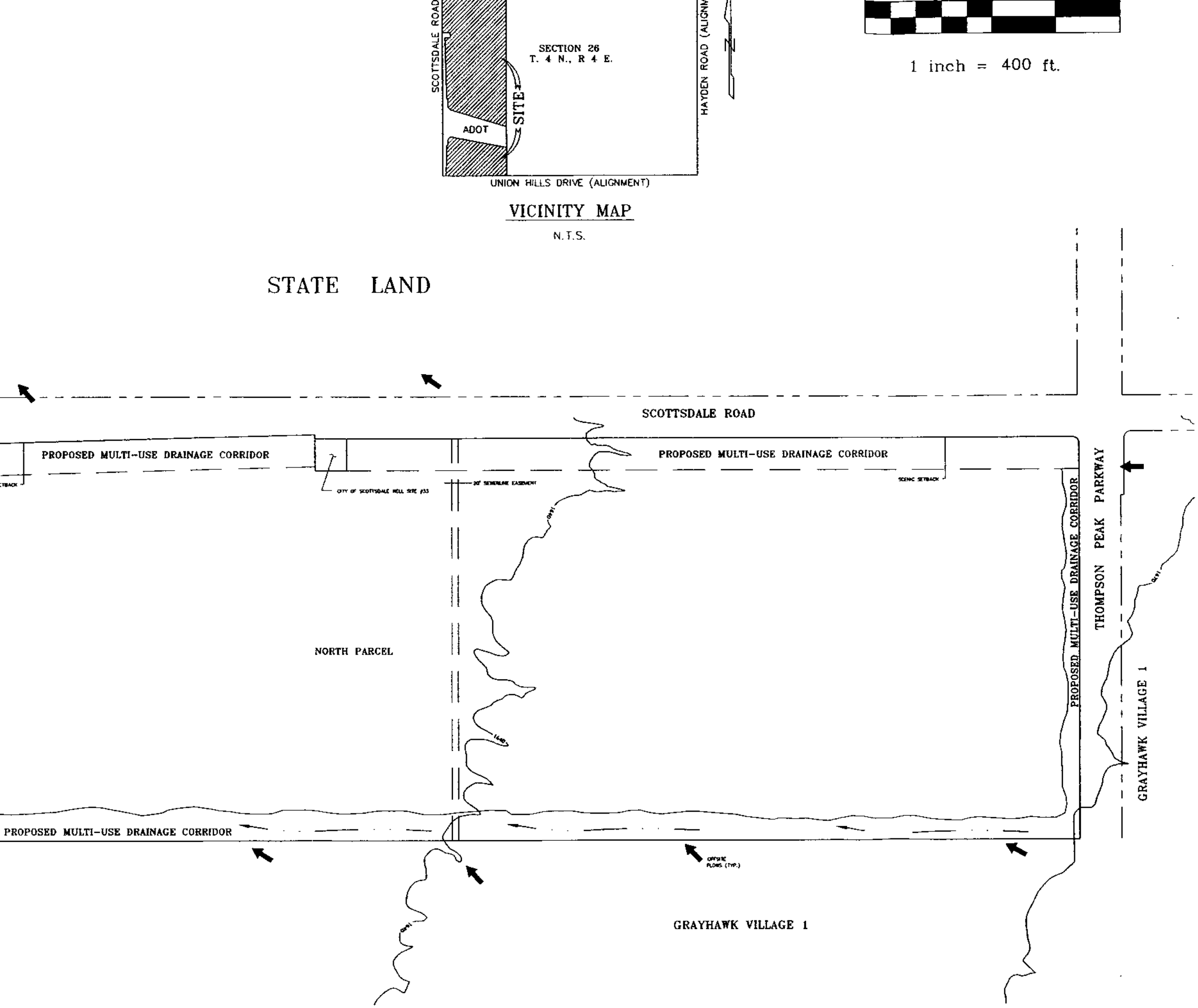
Date Signed 7.29.02
ARIZONA, U.S.A.



STACKED 40

DRAINAGE CONCEPT EXHIBIT

EXHIBIT 4

PRELIMINARY
NOT
FOR
CONSTRUCTION
OR RECORDING

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HYDROLOGISTS
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ENGINEER
DESIGNER
CAD TECHNICIAN
SCALE (HORIZONTAL)

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Appendix A ADOT's *Final Drainage Design Report, Pima Freeway 9A, Point 11, Scottsdale Road to Pima*, March 26, 2001, prepared by HDR Engineering, Inc. (portions of report)

jmb

Y:\WP\Reports\021584 Zoning DR for Stacked 40.doc

1.0 INTRODUCTION

This Drainage Report has been prepared to meet the submission requirements in accordance with the City of Scottsdale for the proposed rezoning case of an approximate 160-acre (gross) project known as the Stacked 40s (the "Project"). The Project is located at the northeast corner of Scottsdale Road and Union Hills Road extending north to Thompson Peak Parkway, Scottsdale Arizona. Exhibit 1 – Location Map displays the project location, hereafter referred to as the "Site." This report summarizes previous hydrological reports, as well as presents the drainage concept for the proposed Project.

The Site consists of undeveloped desert terrain with limited vegetation and slopes toward the southwest at an approximate slope of one and one-half percent (1.5%).

The Site has been bisected by the Arizona Department of Transportation ("ADOT") 101 Freeway. The freeway is a raised embankment with three culverts, located near the Site, serving to allow drainage to be conveyed downstream.

Approximately 119.1 acres of undeveloped land are located north of ADOT Freeway 101 and 19.6 acres are located south of ADOT Freeway 101.

There are no Section 404 "Waters of the U.S." watercourses per the U.S. Army Corps of Engineers' letter, dated February 5, 2002 (see Exhibit 2) on the Site.

2.0 DRAINAGE DESCRIPTION

2.1 Existing Conditions

The Site lies in a Federal Emergency Management Association ("FEMA") designated Zone AO, per Flood Insurance Rate Map ("FIRM") Panel 1245 of 4350, dated July 19, 2001 (see Exhibit 3). Zone AO is defined by FEMA as follows:

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

The average depth displayed on the FEMA FIRM for this Site is one (1) foot and velocity is shown as three (3) feet per second. It is understood that the City of Scottsdale (the "City") requires the lowest floor elevation to be at or above the anticipated 100-year high water.

In a rainfall/runoff event, the Site receives runoff from the north after it passes through Grayhawk, a master planned community to the north and east of the Site, and State Trust Land to the northeast. Numerous significant drainage studies have been completed for the watershed and were most recently summarized by ADOT's *Final Drainage Report, Pima Freeway 9A, Point 11, Scottsdale Road to Pima*, dated May 26, 2001, prepared by HDR Engineering, Inc (the "Report") (See Appendix A for relevant portions of the Report). The Report is believed to be the most comprehensive surface water hydrology available. For final design parameters, 100-year peak discharge will be taken from the City approved Grayhawk and ADOT drainage reports of record.

The following is Wood/Patel's understanding of the Report: The ADOT Freeway 101 has been designed and built as a pass-through drainage system not dependent on the once proposed Desert Greenbelt Project. A culvert(s) has been placed at each of the U.S. Army Corps of Engineers' "jurisdictional wash" locations. The culvert(s) has been designed to not increase the 100-year flood inundation level on the upstream side.

2.2 Proposed Conditions

The proposal is to develop the Site as a phased mixed-use development. The land use will be compatible with final zoning and may include single-family residential use in the northern portion of the Site, continuing south with multi-family residential uses, a hotel use, a mixed-use office, retail, and residential use, and commercial uses adjacent to the north side of ADOT Freeway 101. The parcel of the Site south of the ADOT Freeway 101 could be developed with office/retail uses, including an auto dealership.

No problems are anticipated with designing a drainage system that meets the City criteria for the proposed land uses. The proposal for the development is to provide onsite retention in accordance with City criteria. If underground retention storage is proposed, the additional requirements imposed by the City will be satisfied.

The proposed post-development drainage system will mimic pre-development conditions at historical exiting locations. An open channel system is proposed along the east boundary of the Site to intercept and convey floodwater south to the ADOT culverts, similar to pre-development conditions. Entry points of offsite drainage to the north of the Site will be matched with a drainage system to convey floodwaters to the southwest of the Site and exit along Scottsdale Road similar to existing conditions (see Exhibit 4 – Drainage Concept Exhibit).

The proposed Project drainage improvements will not change the FEMA designated floodplain. The Site will be developed in compliance with the City's FEMA criteria for development in the 100-year floodplain. It is noted that the channel system could eliminate part or all of the estimated 100-year flood event onsite and its associated floodplain from the Site, but, currently, FEMA does not acknowledge the proposed benefits of the channel system and, therefore, the FEMA floodplain remains. Wood/Patel has proven experience in engineering projects that are compliant with FEMA and the City's floodplain criteria.

Since there are no Section 404 "Waters of the U.S." watercourses on the Site (see Exhibit 2), there are no "Waters of the U.S." compliance issues with the U.S. Army Corps of Engineers.

3.0 CONCLUSION

The Stacked 40s Project can and will be designed to be compliant with the City of Scottsdale's current drainage criteria.

The Site is located in a FEMA designated 100-year floodplain (Zone AO) of potential shallow flooding in both pre- and post-development conditions. The Project will be subject to City of Scottsdale/FEMA compliance issues. No problems are anticipated with engineering the Project to be compliant with floodplain regulations.

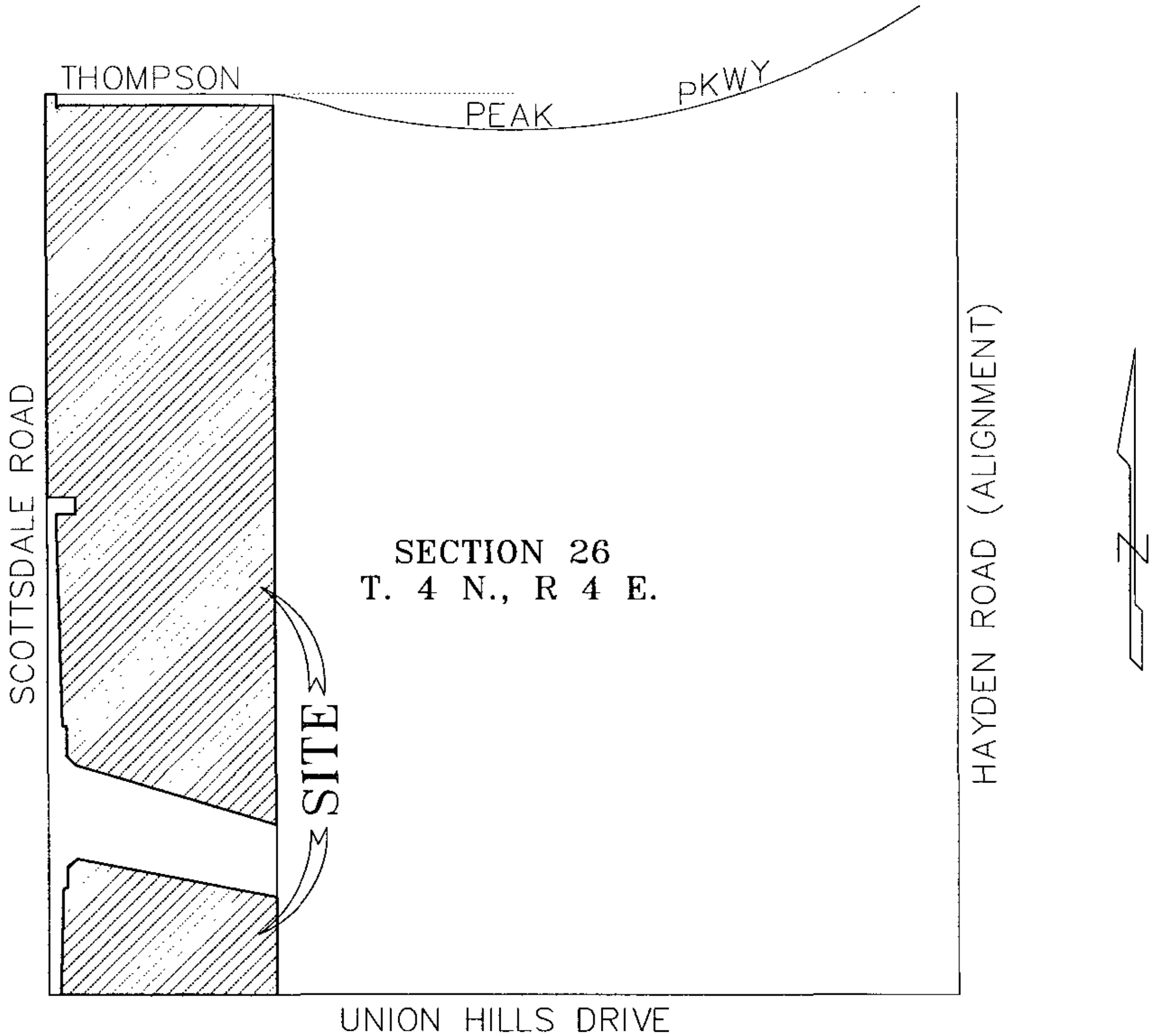
A drainage conveyance system is proposed to intercept and convey floodwaters downstream, exiting similar to historic pre-development locations, i.e. areas along Scottsdale Road and ADOT culverts, thus meeting the City requirements.

The watershed has significant past hydrology studies with the referenced 2001 ADOT Report being the most comprehensive. The ADOT Report will be used for 100-year peak discharges and supplemented as necessary with approved studies from the Grayhawk development.

As documented within this Drainage Report, the Site is not subject to the jurisdiction of the U.S. Army Corps of Engineers for Section 404, "Waters of the U.S." issues.

EXHIBIT 1

LOCATION MAP



VICINITY MAP

N.T.S.

EXHIBIT 1
VICINITY MAP

STACKED 40
SCOTTSDALE, ARIZONA

WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
Construction Managers
(602) 335-8500

EXHIBIT 2

U.S. ARMY CORPS OF ENGINEERS' LETTER

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
ARIZONA-NEVADA AREA OFFICE
3636 NORTH CENTRAL AVENUE, SUITE 760
PHOENIX, ARIZONA 85012-1936

REPLY TO

February 5, 2002

Office of the Chief
Regulatory Branch

Corrigan Real Estate Investment LLC
and Corrigan Land & Livestock Limited Partnership
C/O Robert D. Anderson
Withey, Anderson & Morris
3101 North Central Avenue, Suite 1690
Phoenix, Arizona 85012-2615

File Number: 2002-00484-RWF

Dear Mr. Anderson:

Reference is made to your letter of July 5, 2001 and the accompanying information provided by Wood, Patel & Associates in which you inquired as to whether or not a Clean Water Act Section 404 permit is required from the U.S. Army Corps of Engineers to construct a commercial development within a 160 acre parcel (Stack 40) situated along Scottsdale Road, north of the Central Arizona Project aqueduct at (Section 26, T4N, R4E), Scottsdale, Maricopa County, Arizona.

We have reviewed our records and have determined that the waters of the United States that historically transversed the subject property have been impacted and redirected by the construction of the GrayHawk development. The washes observed on the Stack 40 parcel are remnants of watercourses that no longer receive upstream flows. Since there are no longer any waters of the United States within the Stack 40 proposed project area, no Section 404 permit is required from our office.

The receipt of your application and/or letter is appreciated. If you have questions, please contact Ron Fowler at (602) 640-5385 x 226.

Sincerely,

Cindy Lester

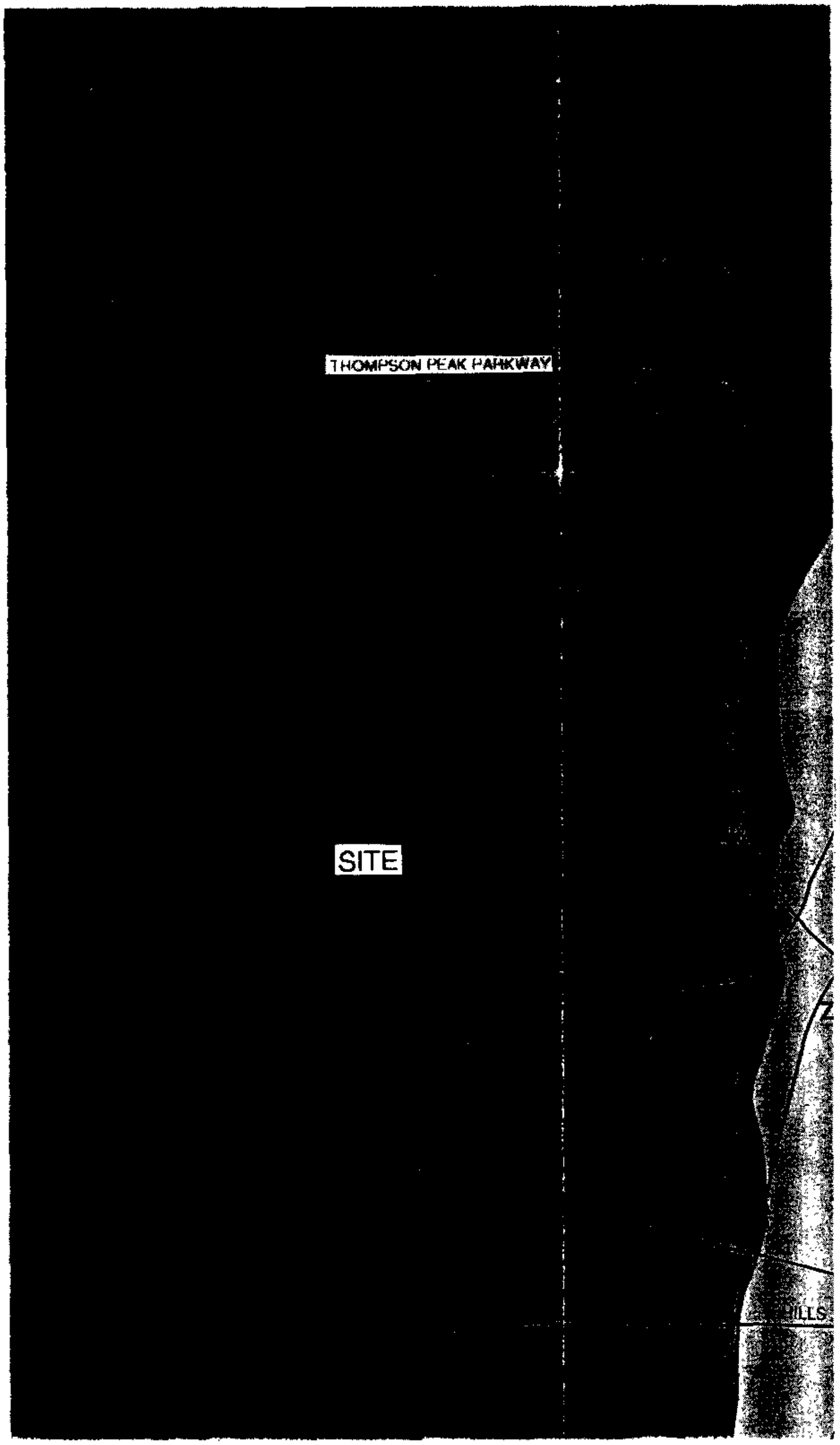
Cindy Lester
Chief, Arizona Section
Regulatory Branch

Enclosure

EXHIBIT 2

EXHIBIT 3

FEMA MAP



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1245 OF 4350

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY, UNINCORPORATED AREAS	040037	1245	G
PHOENIX, CITY OF	040051	1245	G
SCOTTSDALE, CITY OF	045012	1245	G

MAP NUMBER 04013C1245 G

MAP REVISED: JULY 19, 2001

Federal Emergency Management Agency

EXHIBIT 3
FEMA MAP

STACKED 40
SCOTTSDALE, ARIZONA

WOOD/PATEL ASSOCIATES
Civil Engineers
Hydrologists
Land Surveyors
Construction Managers
(602) 335-8500

EXHIBIT 4

DRAINAGE CONCEPT EXHIBIT

APPENDIX A

ADOT'S *FINAL DRAINAGE DESIGN REPORT, PIMA FREEWAY 9A, POINT 11, SCOTTSDALE ROAD TO PIMA*, MARCH 26, 2001, PREPARED BY HDR ENGINEERING, INC. (PORTIONS OF REPORT)

FINAL DRAINAGE REPORT
PIMA FREEWAY 9A, PART II

ARIZONA DEPARTMENT OF TRANSPORTATION

SCOTTSDALE ROAD TO PIMA ROAD

PROJECT NO. RAM-600-1-564, TRACS NO. H 3230 02C

HDR

Registered Professional Engineer (Civil)
CERTIFICATE NO.
33435
MICHAEL A.
LUECKER
Date Signed 3/26/01
ARIZONA, U.S.A.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
24007
TIMOTHY D.
MORRISON
Date Signed 3-26-01
ARIZONA, U.S.A.

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I. INTRODUCTION

A. Scope and Purpose

This report summarizes the hydrologic and hydraulic analyses performed for the off-site and on-site drainage systems for the SR101L Pima Freeway, Scottsdale Road to Pima Road, Project No. RAM 600-1-350, Arizona Department of Transportation (ADOT). The report covers analysis and design of the drainage system at the 95% level of completion. A set of drainage plans for the 95% completion level is included in Appendix A. This document is based upon the draft Final Drainage Report, Pima Freeway 9A, Part II sealed by Jerome Zovne, P.E. January 10, 2001. Items within that report such as the hydrology, diversions of flow within the upper watershed, and design discharge(s) were not objected to by any of the reviewers and are therefore presented unchanged in this report.

B. Project Background and Description

The Arizona Department of Transportation (ADOT) has retained HDR Engineering, Inc. (HDR) to design Project No. RAM 600-1-350 on the Scottsdale-Pima Highway Outer Loop Design Section 9a (Pima 9a). The project consists of the design of approximately 1.75 miles of Pima Freeway just north of Bell Road in north Scottsdale. Initially this design included the ultimate six-lane facility, the Scottsdale Road, Hayden Road and Pima Road T.I.'s and was previously completed by HDR in February 1999. However, the construction of this segment of freeway was placed on hold because the drainage system was dependent upon the construction of the off-site Desert Greenbelt Pima Road Three Basins Project, which had not been implemented as planned by the City of Scottsdale.

Subsequently, ADOT requested that HDR repackage the design with a Phase I "Bridges and Crossroads" only project to construct the Scottsdale and Pima Road bridges and associated crossroad work. This design was completed and is currently under construction.

Phase II was to have been the completion of the mainline between bridges per HDR's original design when the Desert Greenbelt Project was approved. However, the concept of a Desert Greenbelt Project has been abandoned as of this writing. In order to meet the governor's plan to open the freeway to traffic by May 2003, ADOT directed HDR to redesign Phase II as a "pass-through" drainage system that would not be dependent upon the Desert Greenbelt. Details of the design of this system are reported herein.

HDR is responsible for the overall project management and design of the off-site drainage facilities, whereas, Premier Engineering Corporation is responsible for the design of the on-site system.

C. Description of Improvements

1. Pass-through Plan

The pass-through drainage plan required substantial changes to the original roadway design. The Desert Greenbelt Pima Three Basins Project was to manage storm water upstream of the freeway with three regional detention basins and collector channels. The only off-site discharge under the roadway was to have been a twin 96" and a single 48" pipe culvert at the Hayden Road undercrossing to be constructed as part of the Pima Three Basins Project. Other principal features of this project were linear detention basins (2) along the north Right Way(R/W) east and west of Hayden Road and another detention basin at the intersection of Deer Valley and Pima roads. A large pipeline along Pima Road and a major channel along the Salt River Project power easement, known as the Powerline Corridor Channel, would have connected the basins and delivered off-site flows to the freeway detention basins. This system was to have completely controlled and managed the off-site storm water that presently reaches the freeway as sheet flow along the north right-of-way. The original freeway vertical alignment was nearly at grade between the overpasses because pass-through culverts were not required.

Without the Three Basins Project, off-site sheet flows that reach the freeway must be passed primarily by large, multiple barrel box culverts. The culverts must be six feet high to allow for maintenance. This required raising the freeway up to eight feet between the overpasses, greatly increasing the amount of fill required for the freeway. Analysis of off-site hydrology and freeway design flows is presented in Section II.

2. 404 Permit

The culverts are located at "jurisdictional" washes, the lateral limits of which were identified on a map prepared by the City of Scottsdale for the United States Army Corps of Engineers. A map that identifies the washes is included in this report as Exhibit 1. The term "jurisdictional" refers to ADOT's permit under Section 404 of the Clean Water Act, Nationwide Permit No. 14. Exhibit 1 shows that the individual washes that pass through the freeway corridor range in width from 3' to 12' and the corridor width is approximately 400'. A culvert or pipe has been located at each of the identified washes and are labeled from 1 to 16 on the drainage plans in Appendix A. The washes identified on Exhibit 1 were more precisely located in the corridor by field survey methods. In several cases two or more branches upstream of the corridor converge to a single wash within or just downstream of the corridor. In these cases only one culvert or pipe was provided to maintain low flow in the downstream wash.

3. Floodplain Requirements

All culverts are hydraulically designed to not impact (that is, not increase) the 100-year flood inundation level upstream of the corridor. The corridor is located in FEMA Flood Hazard Zone AO, Depth 1, Velocity 3 fps, which requires the lowest floor of residential structures to be at least two feet above the highest adjacent grade [FEMA FIRM Map No. 04013C1245 F and ARS 48-3601 (Regulatory Flood Elevation) and 48-3609.B.4]. In this alluvial fan area, the 100-year flood will most likely arrive at the freeway as a sheet flow 1.5 feet or less in depth [SLA, 1987, p. 26].

Design details of the off-site drainage system are presented in Section III.

4. Probable Maximum Flood Requirements

The Bureau of Reclamation (BOR) maintains dikes in Reach 11 of the Central Arizona Project (CAP) to protect the irrigation canal. The dikes are designed to contain a percentage of the Probable Maximum Flood. A study was performed by HDR in January 1998 to define the requirements of the freeway design to prevent PMF flows from being diverted from Reach 3 (Pima 9A reach) and Reach 4 (East of Pima Road). The text of the study is included in Appendix E. As a result of this study, a containment dike was incorporated into the future Union Hills Road alignment in the original plans. The new pass through drainage plan resulted in a need to shift the contain   ıt dike to the northeast corner of the F   . Road TI, as can be seen in the drainage plans. This closely resembles the concept found in the 1989 Concept Drainage Design [SLA, March 1989]. Hydraulic analysis performed to design the dike is detailed in Section III.

5. On-site Drainage System

Pavement drainage generated within the corridor is managed by a system of catch basins and lateral pipes that generally drain to the nearest cross-culvert. This system is described in Section IV.

II. OFF-SITE HYDROLOGY

A. Previous Studies

There have been two major hydrologic studies of the contributing watershed to this segment of the freeway. Simons, Li and Associates (SLA) performed the first major study for ADOT in 1987 [SLA, April 1987]. Plate 3 from that report is included in this report as Exhibit 2. HDR added the subareas F and G and the 100-year and 50-year 24 hour flows from the report to Plate 3 for reference. At that time the contributing sub basins F and G were virtually undeveloped and the lower part of the watershed where the freeway is located was described as large alluvial fan terrace. The principal flow characteristic of this fan terrace is that flash floods often exceed the capacity of multiple small channels and washes resulting in a wide and shallow sheet flow pattern. The 100-year flood, for example, is likely to be a sheet flow with average depth less than 18 inches. The network of small channels and washes also becomes unstable during these events do to erosion and sediment deposition processes.

The 1987 study by SLA quantified the 50-year and 100-year hydrology for basins F and G that were virtually undeveloped at the time. The study also quantified the capacity of the drainage network to confirm the probable existence of sheet flow for the 50-year and 100-year flood events. At the present time there is little development within ¼ to ½ mile north of the freeway that would alter the basic sheet flow pattern of large flood events that approach the freeway from the north, although the watershed has experienced significant development away from the freeway that will likely influence the distribution of sheet flows that approach the freeway. This is discussed in subsequent Sections B, C and D.

The second major off-site hydrology study was performed for the Scottsdale Desert Greenbelt Pima Road Three Basins Project [Stantec, 1999]. The three detention basins that were included in the project were regional basins that would have significantly reduced the off-site flows at the freeway. One was located in the northwest quadrant of the intersection of Deer Valley and Pima roads known as the Deer Valley Basin and the other two were linear basins along the north right-of-way of the freeway, one east and one west of the future Hayden Road crossing, thus known as the East and West basins. The basic structure of the hydrologic model for 1999 study was selected to develop the freeway off-site hydrologic model for the pass-through design, although the basins had to be removed from the model. The 1999 model was used because the hydrologic analysis accounted for the substantial development that has occurred in the watershed since 1987 and because ADOT, the City of Scottsdale and the Flood Control District of Maricopa County had previously approved the hydrologic model approach.

Exhibit 3 is a composite watershed map from the Three Basins hydrology report [Stantec, 1999]. In addition to removing the three detention basins from the model, the other major change to the 1999 model for the current design study was to add in the so-called Reata Pass watershed. The Reata Pass watershed would have been diverted away by another major channel segment of the Desert Greenbelt Project east of DC Ranch, but without this channel, it is estimated that up to about 80% of the discharge at the Reata Pass apex could potentially reach the freeway and therefore must be included in the pass-through system design. Details are presented in Sections C and D.

The one regional draina hannel in the watershed that is substar ly constructed as planned and is large enough to divert and concentrate 100-year flows is the channel located within the Salt River Project (SRP) power easement known herein as the Powerline Corridor Channel. This is discussed in greater detail in subsequent sections.

B. Coordination

Several meetings were held at the beginning of the project to develop the pass-through concept, since the an off-site drainage concept had not previously been developed for this section of the Pima Freeway.[1] Meeting minutes and attachments and correspondence are included in Appendix F. In particular the October 30, 2000 response to September 26, 2000 meeting has a more detailed description of previous studies with supporting attachments.

Several items in the minutes to the September 26, 2000 meeting are further clarified, as follows:

- Item 1-- The one Stantec model that was run with the Reata Pass apex flow modeled an 80% split of flow to the Pima 9A segment, not 60% as was thought at the time. HDR has adopted the 80% split to the Pima 9a segment and these flows are included in our plan.

- Item 2--The only regional drainage feature associated with upstream development included in the Greenbelt hydrologic model that was found to be significant enough to affect the magnitude and location of 100-year flow to the freeway was the Powerline Corridor Channel, as subsequently discussed in this report. The 100-year flows are assumed to follow historical paths through the new subdivisions except for the Powerline Corridor Channel.

- Item 5—Collector channels have been designed based on an approximate unit discharge. Concrete aprons will prevent scour and fix the grade at the inlet end of culverts to match the invert of the identified jurisdictional washes. On the downstream side, outlets are depressed two feet below grade and riprap basins will dissipate energy and respread the outflow to the downstream wash. The culverts will pass suspended sediment except for the sediment that is captured after a major event. Major events are anticipated initially to flush accumulated sediment from the culvert on the rising limb and redeposit suspended and bed load sediment in the lower one to two feet of the barrel on the declining limb. The design is intended to minimize impact to natural sheet flow and erosion, scour and deposition processes that presently occur both upstream and downstream of the project.

C. Description of Watershed

Exhibit 3 is a composite map of the watershed taken from the *Pima Road Three Basins Report, Ultimate Condition Hydrology Report* [Stantec, 1999]. Note that separate maps are included in this report detailing the DC Ranch and Grayhawk developments within the basin. These are the major new developments within the watershed since 1987, although there are others that are

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[1] The meetings were held to reach a level of common understanding among participants on general off-site drainage approach and concepts, since Stage I (Concept Level) and Stage II (30% Level) drainage plans had not previously been developed for the "pass-through" system. The off-site drainage system was to have been the Desert Greenbelt Project to be constructed by others.

incorporated into the hy ogic model. Areas north of Pinnacle l : Road and north of subarea 1A1 do not contribute to the Pima 9A alignment. They are shown on the map because they would have been included in the *Ultimate* project.

Subareas immediately adjacent to the freeway on the north side are undeveloped at this time. Flow is concentrated by the Powerline Corridor Channel that terminates about ½ mile north of the freeway at the future Hayden Road crossing, but the concentrated flow should essentially respread as a sheet flow by the time it reaches the freeway alignment. The difficulty is to determine the flow split to the west or the east side of the Hayden Road alignment which forms a local ridge running north from the freeway crossing. Therefore freeway culverts both east and west of the Hayden Road alignment have been somewhat over designed as is discussed in Section IV.

Two separate "Three Basins" reports were issued simultaneously in 1999, *Ultimate Condition* and *Interim Condition*. The *Interim Condition* and *Ultimate Condition* refer to phases of the Greenbelt Project. The *Interim Condition* hydrologic model was used because it more similar to existing conditions and the model required fewer changes than the *Ultimate Condition* model. Neither interim nor ultimate models included the Reata Pass[2] watershed, which was to have been diverted into a separate channel east of DC Ranch. However, the original 1987 model included the Reata Pass watershed. Exhibit 4 is a composite overlay of the 1987 and 1999 watersheds. The two maps match very well except that the 1987 map includes Reata Pass.

The inclusion of Reata Pass watershed has a profound effect upon the freeway design flow, nearly doubling the Q100 flow that is assumed to reach the freeway. However, it is

recommended that 80% of the Reata Pass flow be included in the freeway model because of the Reata Pass Channel, east of DC Ranch.

D. Description of Model

Offsite hydrology was analyzed using the US Army Corps of Engineers HEC-1 Flood Hydrograph Package, Version 4.0.3E [COE, 1992]. The 100-year 6-hour model (HEC-1 File: EX100-6.IH1) from the *Interim Condition* report was selected as basis for the freeway design model for the area east of the future Hayden Road alignment. This model differed from the *Ultimate* condition model in that areas north of subareas 1A1 and 1A2 were not included in the model.[3] The 100-year 6-hour model (HEC-1 File: WB100-6.IH1) from the *Ultimate Condition* report was selected as basis for the freeway design model for the area west of the future Hayden Road alignment because this model best reflects existing conditions west of Hayden Road south of the Powerline Corridor Channel (See Section F). The east and west models were combined to determine a total inflow to the freeway alignment.

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[2] The Reata Pass watershed is above the apex of the alluvial fan. The direction of flow or flow distribution downstream of a fan apex is unpredictable and at the present time the Reata Pass apex is uncontrolled.

[3] The areas to the north of Pinnacle Peak Road include the future Happy Valley Detention Basin and Pima Road channel extension that were proposed as Phase 2 of the Desert Greenbelt Pima Three Basins Project. Under existing conditions these flows would not reach the Pima 9a alignment.

After combining the east . west models, the combined model re. ed with several modifications to adapt it to the freeway as an existing condition model, as follows.

1. Add Reata Pass.

80% of the Reata Pass flow at the apex was routed to the freeway alignment between Hayden and Pima Road crossings. The Reata Pass watershed and routing parameters were provided by Stantec [Personal Communication, 9/22/00]. The Reata Pass watershed is added near the end of the model as noted in the model output file in Appendix B. It increases the 100-year 6-hour design flow at the freeway by approximately 4000 cfs. This is a significant increase of about 80% of the inflow without Reata Pass.

2. Remove Three Detention Basins.

The original Desert Greenbelt "Three Basins" interim condition model included three detention basins, one at the Deer Valley/Pima Road intersection (DVB) and two linear basins along the north edge of the freeway, WEST-I and EAST-I. The basin routing models were removed from the job stream, but otherwise the model routings remained essentially unchanged.

3. Existing Powerline Corridor Channel Impacts

The channel is constructed in the SRP power easement, thus known as the Powerline Corridor Channel. The grass-lined channel is completed from approximately Beardsley Road to the Thompson Peak Parkway crossing. It has been extended in the southeasterly direction as an unlined earth channel to the vicinity of the future Hayden Road crossing. This was to be lined and extended to the freeway East Basin in the ultimate plan for the Desert Greenbelt project, however it has not been extended beyond the Hayden Road crossing at this time.

Since the channel ends north of the freeway at Hayden Road and concentrates a high flow of about 1,010 cfs along the power line corridor, the flow in that channel could split in unknown proportion to the east or west side of the future Hayden Road alignment, similar to the Reata Pass apex. For design purposes, it was assumed that (1) 50% of the discharge at the end of the earth channel could arrive at the freeway as a sheet flow west of the future Miller Road alignment, (2) 100% of the flow could arrive at the freeway alignment between Miller and Hayden Road crossings, or (3) 100% of the flow could continue to the east and arrive as a sheet flow between Hayden and Union Hills crossings. The impact of the 1010 cfs flow on the east side of Hayden Road is minimal because the flow arriving there is 8,500 cfs, including the Reata Pass flow. However, it does have a significant impact on the flow west of Hayden Road since the existing contributing area is small and largely from undeveloped areas adjacent to the freeway.

4. Design Flows at Freeway

HEC-1 Node	Location	100-yr 6hr Peak Flow cfs	Comments
REATA	80% of Reata Pass at Apex	7676	Watershed Area = 7.87 sq. mi.

RAPEX	80%Reata Pass Routed to Freeway	5759	Assumed to arrive as sheet flow between Hayden and Pima Road Crossings.
CPC3A	End Powerline Corridor Earth Channel	1010	Flows can spread to the east or west of Hayden alignment
CP5D	Sheet Flow Arriving between Hayden and Pima Road Crossings w/o Reata Pass Flow	4494	Includes Powerline Channel, Excludes Reata Pass
EAST-I	Combined Flow between Hayden and Pima Crossings	8501	Includes Reata Pass
WEST-I	Sheet Flow between Scottsdale and Hayden Crossings	953	Includes Grayhawk and undeveloped areas south and west of Powerline Channel only
TOTAL	Combined Total Inflow to Corridor, Scottsdale to Pima Road	8842	Watershed Area = 15.73 sq.mi.

III. OFF-SITE DRAINAGE DESIGN

A. General Discussion

The culvert design approach is a pass-through design similar to the concept prepared by Simons, Li & Associates in 1989 [SLA, 1989]. Although there has been significant development in the watershed, there is little development adjacent to the freeway that would change the basic character of the alluvial fan watershed in the vicinity of the freeway. Off-site flow for the 100-year event is anticipated to arrive at the freeway as a shallow sheet flow with a high concentration of suspended sediment. The culverts are designed to pass these flows while minimizing both the upstream downstream impacts.

The general approach to passing the off-site design flows determined in Section II is to provide multiple barrel box culverts or pipe culverts at the location of the jurisdictional washes as shown in Exhibit 1. Multiple barrel box culverts were located at mainline undercrossings, whereas, small diameter pipelines were used where headroom was limited by ramp profiles that are typically much lower than the mainline profiles. All box culverts are six feet high to allow for maintenance, but the width and number of barrels varies from location to location. Pipe culverts range from 24-inch to 36-inch diameter.

Box culverts were lowered below existing grade at the outlet by up to two feet to limit the roadway fill height, as all of the fill must be imported for this project and is a critical cost consideration. Special inlet apron and outlet details were developed to reduce the potential scour effects resulting from the placing the culvert inverts below grade. It was assumed conservatively that the sheet flow will arrive at the freeway with depth not exceeding 18 inches. Culverts were sized to pass the 100-year flow with no impact on the hydraulic grade line outside of the freeway right-of-way. It is not possible to calculate a 100-year design flow for each of the jurisdictional washes defined in Exhibit 1 because the 100-year flow is assumed to arrive as a sheet flow. The method of proportioning the total design flow between culverts is discussed in Section B. Bank full discharges were examined to determine the impact of the dominant discharge on culvert operation. The RCBC have sufficient velocity at the bank full discharge to transport sediment from the upstream natural system.

As mentioned, the Probable Maximum Flood (PMF) flows must not be diverted by the freeway corridor. A dike was located near the Princess/Pima Road crossing to prevent PMF flows from being diverted into the CAP Reach 4 dike pool east of Pima Road. The analysis and design of the dike is discussed in Section F.

B. Culvert Design Flows

Off-site sheet flows were proportioned by segments between roadway crossings, as follows (See Table below):

- Scottsdale to Future Miller Road Alignment.

In this segment there are four jurisdictional washes at which a culvert is located. From the HEC-1 model, subareas CNA1 and CA2 contribute a total of 142 + 474 = 616 cfs to this segment, plus it is assumed that up to 50% of the Powerline Channel flow of 1010 cfs

= 500 cfs could g) this segment. Therefore the total 1('ear design flow to this segment is 1200 c.., which is apportioned equally among the culverts.

- Miller Road to Future Hayden Road Alignment.

In this segment there are also four jurisdictional wash locations and two local subareas SCNA3 and SCNA that contribute 126 + 204 = 330 cfs to this segment plus it assumed that up to 100% of the Powerline Corridor Channel discharge = 1010 cfs could be diverted into this segment. Thus the total 100-year design flow of about 1340 cfs is proportioned between both box and pipe culverts. However, in general, where a small pipe culvert is substituted for a large box culvert, the pipe is designed for a minimum flow and the remaining allocation for that location is proportioned equally among the other box culverts. This was case for Pipe 1 in this segment.

- Hayden Road to Princess/Pima Crossing.

Virtually the entire EAST-I flow of 8501 cfs, including the Powerline Channel and Reata Pass flow could be distributed along this segment. However, there may be a tendency for Reata Pass flows to concentrate toward the eastern end of the segment and for Powerline Channel flows to concentrate towards the western end. Therefore, box culverts were oversized by about 8 % in this segment to account for the possibility of concentrations in these areas. Thus the entire segment could theoretically pass a design flow of about 9,000 cfs with no upstream impacts if the flow arrived fully and equally distributed along the alignment.

- Culvert Design Flows.

The following table summarizes pipe and culvert design flows and other data.

Designation	Station	RCBC	RCP	Inlet Elev	Outlet Elev	Length	Q	Inlet
							CFS	WSE
Scottsdale Road	**1855+**							
Detail D1 RCBC1	1863+77	2-8x6		1596.5	1594	374	300	1601.1
Detail D2 RCBC2	1868+65	2-8x6		1597.5	1595	297	300	1602.1
Detail D3 RCBC3	1875+43	2-6x6		1597.6	1596.4	233	300	1603.2
Detail D4 RCBC4	1883+53	2-6x6		1600.5	1598	250	300	1606.2
Miller Road	**1885+**							
Detail D5 RCBC5a	1892+93	5-10x6		1601.2	1599	234	1125	1606.5
Detail D6 Pipe5b	1895+10		3-36"	1604.5	1600.9	334	150	1608.2

Detail D7 Pipe 6	1902+79		3-36"	1603.3	1597.5	446	150	1607.3
Detail D8 Pipe 7	1905+89		1-30"	1602.1	1600	513	15	1609.0
Hayden Road	**1910+**							
Detail D9 Pipe 8a	1915+69		3-36"	1603.9	1600	458	150	1607.6
Detail D10 Pipe 8b	1917+35		3-36"	1606	1601.6	435	150	1609.7
Detail D11 RCBC9	1923+81	4-10x6		1603	1601	314	1263	1609.0
Detail D12 RCBC10	1934+33	5-10x6		1604.2	1602	245	1263	1608.8
Detail D13 RCBC11	1937+00	5-10x6		1604.1	1601.8	241	1263	1609.4
Detail D14 RCBC12	1941+06	4-10x6		1601.8	1599.6	248	1263	1608.1
Union Hills	**1943+**							
Detail D15 RCBC13	1948+40	5-10x6		1596.5	1594	318	1263	1601.8
Detail D16 RCBC14a	1949+86	5-10x6		1596.4	1593.8	328	1263	1601.8
Detail D17 RCBC14b	1951+66	4-10x6		1595.1	1593.8	306	1263	1601.4
Detail D18 Pipe 15	1956+75		1-36"	1593.4	1590	439	40	1596.8
Detail D19 Pipe 17	24+51 Spur Dike		1-24"	1600.1	1599.5	60	10	1601.6
Princess/Pima	**1965+**							

C. Culvert Design Criteria

Criteria utilized in the analysis is found in ADOT's *Roadway Design Guidelines*, 1996 and is project specific as follows:

- Culverts were sized based on the design discharge of a 100-year event (an event with a 1% chance of occurring in any one year).
- Upstream water surface elevations and downstream tailwater elevations are assumed to be a uniform 1.5 feet due to the distributary's/sheet flow environment. SFHA Zone AO depth 1, definition is an area of between 0.5 and 1.5 feet of flow during a 100-year event.
- Surcharge of water surface elevations by the new facilities was limited to the existing and proposed right-of-way or as noted in accordance with section 611.3.C

- Culverts should b[illegible]esigned to be self-cleaning, section 6[illegible].E. Conveyance of the culverts were compared with the upstream bank full discharge conveyance.

- RCBC and RCP should be provided with adequate cover.

D. Culvert Hydraulics

The hydraulic analysis of new culverts was performed using Haestad Methods' *Culvertmaster v1.0.* Reinforced Concrete Pipe (RCP) culverts were utilized where cover was limited under the ramps. Reinforced Concrete Box Culverts (RCBC) was utilized where possible. The natural slope of the terrain ranges from 1 to 1.5 percent allowing for culverts to be set into the grade on the upstream (inlet) end and still provide a "self-cleaning slope" in excess of the critical slope. The larger RCBC in the system were designed to accommodate sediment by the allowance of an additional 1.0 feet in box height. This area is assumed to be dynamic during a large event and is reserved for bed load. RCBC were designed based on 2.0 feet into the grade on the outlet end with tailwater limited to 1.5 feet above natural ground.

Pipe 17 is designed to maintain the continuity of the wash system per section 404 of the Clean Water Act. It has been sized to convey frequent low flows under the PMF dike located near Pima Road. During a large event 10 cfs is estimated to pass under the dike at this location and will be added to the 11 acres of drainage area at a catch basin located at the northwest corner of Pima Road and SR101.

Culvert hydraulic analyses can be found in Appendix C.

E. Inlet and Outlet Details

Inlet invert elevations were set by establishing the downstream invert elevation for either a RCP or RCBC, providing clearance under the subgrade, and establishing the most hydraulically efficient upstream invert elevation (typically where inlet and outlet control converge).

The inlets for the RCP are either drop inlets or standard end sections as the conditions may allow. RCBC inlets are standard ADOT headwalls and wing walls with a reinforced concrete apron sloping to the invert from either natural ground or the invert of a collector channel as the conditions required.

Outlets for the RCP are standard ADOT end sections with a riprap apron. RCBC's are fitted with standard ADOT wing walls, concrete apron (for easier maintenance) and riprap aprons/energy dissipaters as depicted on the plans. Sizing of the riprap is in accordance with USDOT, FHWA, HEC-11, 1978 and apron with the Drainage Design Manual for Maricopa County, Arizona, 1996, (Figures 7-21 and 7.24 as adopted from USDOT, FHWA, HEC-14, 1983). Spreader basins have been incorporated to simulate the existing sheet flow environment.

F. Collector Channels

Collector channels were incorporated to accommodate collection of the sheet flow and to avoid upstream ponding on adjacent properties. The collector channels also serve to increase the efficiency of the RCBCs, and reduce head cutting. Due to the topography and limited Right-of-Way the collector channels tend to have shallow slopes that will collect sediment. Therefore an invert width of 8 feet was selected to accommodate maintenance access.

G. PMF Dike Design

A PMF Dike is included in the drainage plans. It is located just north of Pima Road. The dike was originally recommended in the 1989 report by SLA [SLA, March 1989] and was later also recommended by the Bureau of Reclamation (BOR). Documentation of BOR and HDR studies leading to the current design are provided in Appendix E.

The current pass-through drainage design required elevating the freeway embankment by about eight feet to accommodate the six-foot high culverts. This resulted in several changes to PMF Dike design, including relocating it back to the vicinity of the Pima Road crossing and lowering the top elevation from 1617.10 to 1608, as shown in the plans. The location of the dike near Pima Road provides greater assurance that the PMF flows that reach the freeway between Hayden and Pima Road crossings will not be diverted southeasterly along the roadway embankment and back into the Dike 4 storage basin.

The dike crest elevation of 1608 was determined by hydraulic capacity analysis of the pass-through design culverts and the Scottsdale and Hayden Road bridge openings for the PMF flow. The analysis is included in Appendix E. Elevation 1608 was determined to be the elevation required to force the PMF through the road and culvert openings without overtopping the freeway. The hydraulic capacity analysis was split into culvert analyses for three roadway segments and the two roadway openings. The results are as follows:

Description	Capacity @ Elevation 1108, cfs	Comments
Culverts-Union Hills to Pima	14,000	18-10x6 culverts @ average inlet invert 1597
Culverts- Hayden to Union Hills	6,600	24-10x6 culverts @ average inlet invert 1603
Hayden Road Opening	6,500	Assumed uniform flow through at Hayden Road trap opening at 1.4% road profile grade; pavement elevation at freeway 1606
Culverts-Scottsdale to Hayden	5,000	12-10x6 culverts @ average inlet invert 1602
Scottsdale Road Opening	41,000	Assumed uniform flow through at Scottsdale Road trap opening at 1.4% road profile grade; pavement elevation at Crossing 1602

Total Capacity @ 1608	**73,100**	**Reach 2 PMF = 73,200 [4]**

The table indicates that more than half of the PMF flow would discharge through the Scottsdale Road opening. Downstream of the Scottsdale Road bridge opening, the flow could split to either side of Scottsdale Road and thus discharge to either Dike 2 or Dike 3 storage basins. The BOR report (3-11-96) indicates that flow through this opening to either Dike 2 or Dike 3 is acceptable. The storage basins of the two dikes combine at 10 feet below the top of the dike and will therefore equalize.

Although a dike had originally been proposed at Scottsdale Road to prevent flow from Dike 3 to Dike 2, the BOR report indicated that this dike was not needed and even undesirable, as it would increase the possibility of flow being diverted from the Dike 2 basin to the Dike 3 basin. The Dike 3 basin is at capacity for the PMF flow (between Hayden and Pima Road the BOR estimated 49,300 cfs, whereas the subbasin between Scottsdale and Hayden receives 23,900 cfs). The BOR noted that there is a small natural ridge along the Hayden Road alignment to the north of the freeway that does tend to separate these two subbasins. However, in HDR's analysis the flows to the two subbasins within Dike 3 were combined (73,100 cfs) because the PMF Dike crest elevation of 1608 is about two feet above the Hayden Road profile at the freeway opening. Thus PMF flow to the two reaches would tend to equalize across the entire length of the freeway from the PMF Dike to Scottsdale Road. The PMF Dike therefore not only prevents PMF flows from being diverted from Dike 3 to Dike 4, but encourages flow from Dike 3 to Dike 2.

[4] Combined PMF flow of 49,300 cfs for Hayden to Pima reach and 23,900 cfs for Scottsdale to Hayden reach (BOR 3-11-96).

IV. ON-SITE DRAINAGE DESIGN (PREMIER)

A. General Discussion

The objective of this section is to document the design of the on-site storm drain system for SR101 freeway between Scottsdale Road and Pima Road. The mainline has an elevated rolling profile. The mainline is elevated over Scottsdale Road, Hayden Road and Pima Road. The profile was elevated (above grade) to accommodate the "pass-through" drainage system. In addition, curb and gutter was added to the freeway and ramps. The freeway sags and crests are at the following locations:

Feature	Station	Cross-street
Crest	1850+37	Scottsdale Road
Sag	1872+43	Not applicable
Crest	1883+92	Not applicable
Sag	1891+94	Not applicable
Crest	1910+04	Hayden Road
Sag	1927+98	Not applicable
Crest	1933+94	Not applicable
Sag- Westbound	1953+28	Not applicable
Sag- Eastbound	1953+59	Not applicable
Crest - Westbound	1963+70	Pima Road
Crest - Eastbound	1963+42	Pima Road

Since the entire project reach is above grade, the onsite drainage facilities will be designed for the 10-year storm event. Due to the changes in the profile and the addition of curb and gutter, the onsite analyses for the 60% (submitted Jan 2001) and the 95% (submitted March 2001) changed significantly since the 100% plans, which assumed the greenbelt concept (submitted February 1999). Inlet spacing and storm sewer layout was revised based on revisions to the roadway profile, typical sections and accommodation for the ultimate freeway condition.

B. On-site Drainage

The drainage design criteria for this project was based on the ADOT publications entitled,

- *Roadway Design Gui   nes, Urban Highway Section – Desig   ocedures Manual*
- *Highway Drainage Design Manual – Hydrology,*

and on the FHWA publications entitled,

- *Drainage Design of Highway Pavements (HEC-12),* and,
- *Urban Drainage Design Manual (HEC-22).*

Hydrologic calculations for this project were performed in English units.

The design storm frequency for components of the project, as defined in the Roadway Design Guidelines, is as follows,

Elevated Mainline	10-year design storm
Directional Ramps	Criteria for the Elevated Mainline or Depressed Mainline applies
Other Ramps	10-year design storm
Cross Roads/Frontage Roads	10-year design storm for elevated/at-grade sections and depressed mainline criteria for the depressed section

1) Rainfall

Rainfall values were obtained using the procedures and equations presented in the ADOT publication entitled "Highway Drainage Design Manual – Hydrology". Due to the short flowpaths encountered, a 10-minute time of concentration, Tc, was used to determine the rainfall intensities, i, for locating all inlets.

The rainfall depth-duration-frequency (DDF) statistics for Arizona were obtained from information displayed in NOAA Atlas 2, Volume V11, Arizona (Miller, 1973). The DDF values were used in conjunction with equations in the ADOT hydrology manual to obtain intensity-duration-frequency (IDF) values for various storm durations and recurrence intervals, including the 10-year, 10-minute storm and 50-year, 10-minute storm. Rainfall calculations can be found in Appendix D.

2) Runoff

The Rational Method was utilized to estimate peak discharges for onsite drainage design. The Rational Method (English) is based on the following equation:

$$Q = CiA$$

Where, Q = peak discharge, in ft^3/s, of selected return period;

C = the runoff coefficient;

i = average rainfall intensity, in in/hr; and

A = the contributing drainage area, in acres.

Runoff Coefficient, C

Runoff coefficients are defined in the ADOT publication entitled *Urban Highway Section – Design Procedures Manual* and the FHWA publication entitled *Roadside Drainage Channels (HDS No.4)*. Runoff coefficients utilized for this project were,

Surface	Coefficient
Pavement	0.95
Highway Slopes	0.70

Rainfall Intensity, i

The intensity in the Rational Equation is the average intensity in inches/hour for the period of maximum rainfall of a specified return period (frequency) having a duration equal to the time of concentration (T_c) for the drainage area.

The Papadakis and Kazan Equation was utilized to determine the time of concentration. The time of concentration equation is defined as follows:

$$T_c = 11.4\, L^{0.5} K_b^{0.52} S^{-0.31} I^{-0.38}$$

Where: T_c = time of concentration, in hours;

L = length of longest flow path, in miles

K_b = watershed resistance coefficient;

S = slope of the longest flow path, in ft/mile;

I = average rainfall intensity, in inches/hour.

The calculation of T_c using this method is an iterative process. T_c is dependent on an intensity (i) that varies with T_c. The minimum T_c used for calculation was ten minutes. All of the inlets had a T_c of less than ten minutes. Therefore, the minimum value (ten minutes) was applied.

Delineation of areas for the rational method is dependent upon roadway plan and profile. The alignment was analyzed to determine the crest and sag points, elevated and depressed areas, ramp transitions, etc. Inlets were located based on spread requirements outlined in the Roadway Design Guidelines. Determination of inlet location is an iterative process with several variables (longitudinal slope, cross slope, area, curb type, spread, etc.).

It was anticipated that, ultimately, additional traffic lanes would be added in the median area. Therefore, two scenarios were utilized in the design of the drainage system. First, the interim system was designed. Area inlets (C-15.80) were utilized to drain the median area. Second, the ultimate system was designed. Barrier separated the freeway and C-15.92 inlets were utilized, as shown in the typical future mainline sections roadway plans. The worst case condition was utilized for the design.

3) Inlet Design

The onsite drainage system for this project consists of numerous drainage area sub-basins that contribute to the total runoff peak discharge and volume. The individual drainage areas are collected at pavement catch basins and area inlets. Catch basins were located in accordance with criteria defined in the Roadway Design Guidelines.

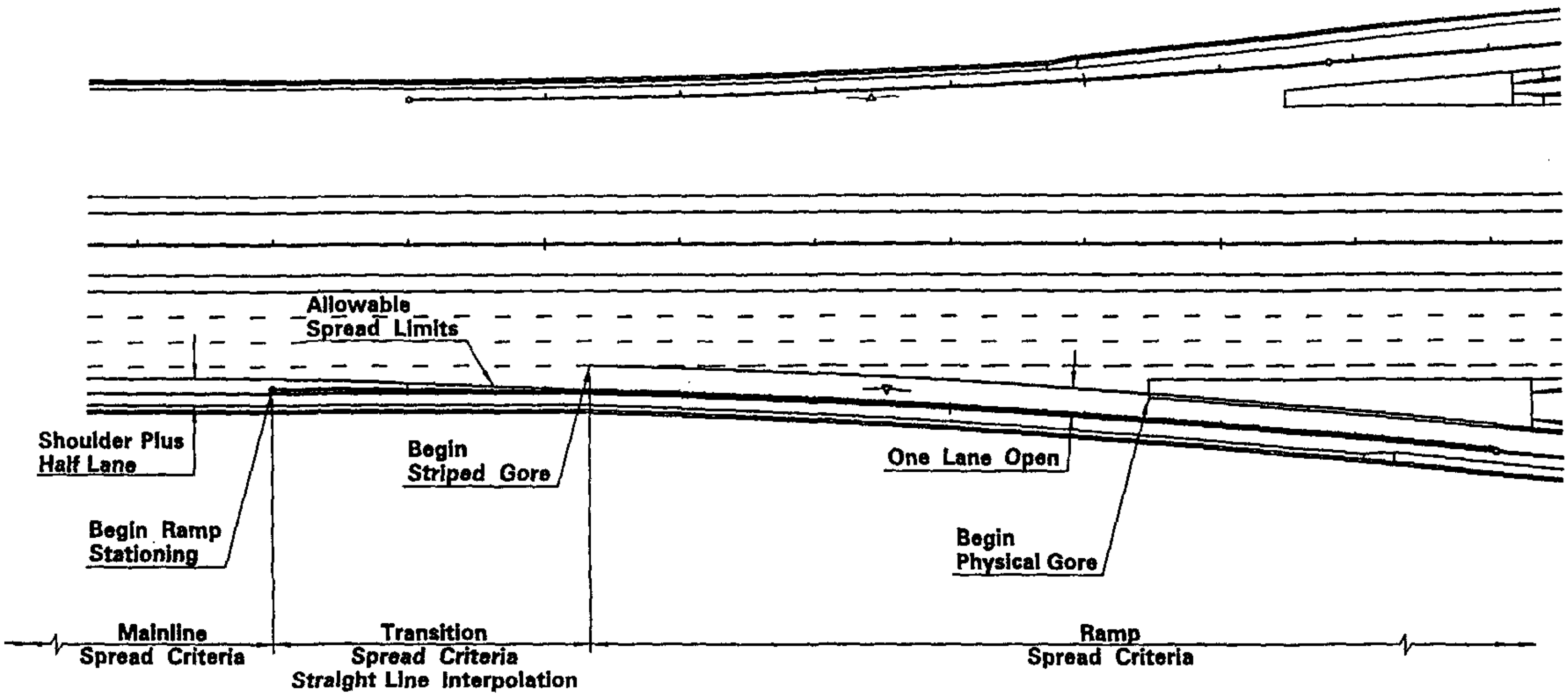
In general, at-grade or elevated segments of the freeway mainline have a maximum spread of 16 ft (width of freeway gutter 2.5 ft, shoulder 7.5 ft, parking lane and/or distress lane, and one-half of the adjacent lane 6 ft) during the 10-year event, in curb and gutter sections. The 60% plans utilized a 2.5 ft gutter for barrier sections. However, the 95% plans identify barrier sections with a 4.5 ft gutter, which increases the allowable spread by 2-ft. In addition, the 10-year flow depth shall not exceed the top of curb elevation (see new C-5.10 detail). Typically, the 10-year criteria is the controlling factor for inlet placement. The revised C-5.10 curb type works well on the mainline sections (optimized spread), but ramp sections are inefficient due to the reduced spread limitation. The gutter depth was modified from 2 inches to 5/8 of an inch in the revised C-5.10 detail.

Ramp spread criteria requires that a 12 ft clear width be maintained. The ramps typically had a maximum spread width of 8.0 ft (5.5-ft shoulder and 2.5 ft gutter). In ramp transition areas the maximum spread was determined by linearly interpolating between the two spread criteria (ramp and mainline) along the segment of roadway from the beginning of the ramp stationing to the beginning of the gore striping. Figure 1 shows the spread criteria for these areas.

ADOT standard C-15.91 inlets were utilized on the mainline and ramps (with type "B" and "C" curb and gutter). ADOT standard C-15.92 inlets were used adjacent to barriers. Slotted drains were added to many inlets to improve their efficiency. ADOT standard C-15.80 inlets were used for median areas. The location of future C-15.92 inlets in the median utilized a spread criteria of no flooding in the left lane during the 10-year event. This more stringent spread criteria was utilized since the traveling public does not anticipate the left lane (fast lane) to be flooded during a storm event.

Inlet capacities were determined using ADOT's Pavement Drainage Analysis Program, Version 3.40. Computation sheets for the inlets are provided in Appendix D. Inlets were sized so that

• the combined capacity of the grate and slotted drain intercepted between 80% and 100% of the design flow. In general, the optimum capture ratio is approximately 80%.



PREMIER
ENGINEERING CORPORATION

PROJECT NO. 9728 | DRAWN BY MR
DATE 1/9/91 | CHECKED BY HA

Spread Criteria On Ramp Tapers

FIGURE 1

Inlets were designed with 100% interception when the bypass would flow across a ramp. This occurred along the mainline where bypass would flow across the end of gore and then across the adjacent ramp in a concentrated flow path. This situation is undesirable to vehicular traffic and was avoided by placing inlets just prior to the end of the gore along the mainline.

Inlets were designed with 100% interception immediately upstream of super elevation rollovers. This occurs when the cross slope changes from positive to negative. Essentially, the low point in the gutter switches from one side of the road to the other. This can create concentrated flows from one gutter flowing across the mainline pavement during a super elevation rollover and also creates an area where there is zero cross slope. This situation is undesirable to vehicular traffic and is reduced by placing inlets immediately upstream of the rollover, to minimize the amount of concentrated flow traversing across the pavement.

Flanking inlets were located on each side of sag locations to reduce the possibility of excessive ponding and to provide relief for the sag inlet. The flanking catch basin locations were determined by procedures outlined in HEC-12.

Median catch basin spacing was based on interim-condition parameters. Median catch basins were located to match future catch basin locations in super-elevated sections, as previously discussed.

4) Storm Drain Design

This section describes the proposed layout of the storm drain systems. The storm drain systems collect runoff from the freeway mainline, ramps, slopes, medians and route them to an appropriate outlet location. Hydraulic computations have been provided for the onsite storm drain system(s). Hydraulic calculations were not performed on systems that had less than 3 inlets draining to an offsite cross culvert, since flows in this situation would be well below the 24-inch storm drain capacity.

The *Hydraflow Storm Sewers* software, version 2000, by Intelisolve Storm was used to determine hydraulic gradeline elevations for the storm drain design. Peak discharge values for storm drain pipe sizing were calculated using the Rational equation using actual time of concentration values at each pipe based on the travel time to each inlet and the travel time within the storm drain pipe. *Hydraflow* calculates the travel time within the pipe to determine the rainfall intensity value and cumulative CA value within each junction of the storm sewer system. Rainfall values are input into Hydraflow to generate an IDF curve so intensity values that correspond to the actual time of concentration can be utilized. *Hydra flow* uses the standard step method for hydraulic calculations, with default junction loss values (K values) based on HEC-22 criteria. Storm drain analysis assumes that each inlet captures 100% of the flows, which is conservative, since each inlet is designed to only capture 80 to 100% of the design flow. *Hydraflow* calculations are provided in Appendix D.

5) Issues to be resolved

A cover problem may exist at Hayden Road Ramp D. The Digital Terrain Model (DTM) does not appear to conform to the topographic mapping (approximately 1.8 feet difference at pipe 241). The DTM may not have the break lines required to accurately model the small washes adjacent to Hayden Road. Due to the low roadway profile, verification of accurate topographic data is critical to the pro' ' in numerous locations. It is recomm' 'ed that the design team identify key outlet locations and that survey crews verify the existing ground elevation. This will help to optimize the design and minimize long-term maintenance.

Pipe 241, located at Hayden Road Ramp "D", is an example of the design concern stated above. Originally, pipe 241 was designed to outlet into the City of Scottsdale's large diameter storm drain in Hayden Road. When Scottsdale abandoned their regional drainage concept, pipe 241 was forced to drain to an existing watercourse. The vertical profile of Hayden Ramp "D" is slightly below grade near pipe 241. The outfall elevation of pipe 241 is 1600.00 (refer to pipe 241 profile in the plan set). The flowline elevation at the sump inlet at Sta 1+73, Hayden Road Ramp D is 1602.02. The minimum structure depth is approximately 3.5-ft for a C-15.91 inlet without slotted drain. In order to provide a positive drainage outlet, a channel will need to be graded downstream of Pipe 241 to an elevation of 1598 +/-. Team members will perform field surveys to verify the outfall elevations. .

Another drainage concern is located at the Pima Road T.I. Offsite flows concentrate north of Pima Road Ramp "A" (station 1957+00). HDR has designed a berm north of Pima Road Ramp "A" that will convey most of the offsite flow to a culvert at Sta 1957+00 (Pipe 15). HDR has proposed a 24-inch culvert at the berm location to allow a portion of the existing condition flows to pass due to 404 permit requirements. During the 100-year event, approximately 10 cfs will concentrate to the Pima Road and Pima Road Ramp "A" intersection.

Team members have met to determine the best solution to convey this offsite flow across the freeway corridor. The flow cannot be conveyed to the east, so it must be conveyed to the southwest corner of Pima Road Ramp B and Pima Road intersection. The offsite flow (10 cfs) will be routed into the onsite drainage system and routed across the freeway corridor. The onsite storm drain is located along the west side of Pima Road. Typically, onsite and offsite storm systems are independent. Incorporation of offsite storm water into onsite storm systems may increase the long-term maintenance of the system. The proposed storm drain system is shown in the plan set.

Team members may adjust the pipe profiles once the topographic mapping has been verified.

V. REFERENCES

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VI. EXHIBITS (IN MAP POCKET)