AGUA FRIA FREEWAY
INITIAL DRAINAGE REPORT
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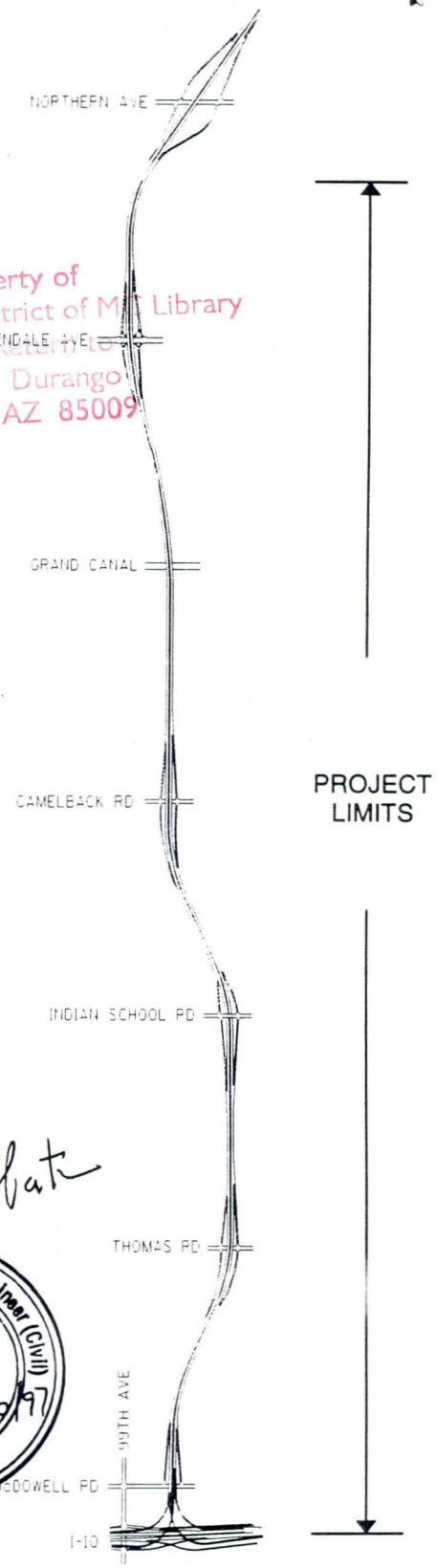

VOLUME I
OFFSITE HYDROLOGY
CONCEPT DRAINAGE DESIGN

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NOVEMBER 1997

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this drainage report is to present a functional design for the off-site drainage systems along the proposed Agua Fria Freeway between Interstate 10 (I-10) and the southern end of the existing freeway south of Northern Avenue. The design is based on the existing condition hydrologic and hydraulic analyses. This report will explain the procedures, methodology, and criteria to be used in the final design and will present any unusual aspects of the design that may require special attention.

The purpose of the off-site drainage analysis was to determine the 100-year, 24-hour peak discharge values generated by the contributing watershed and to present the proposed design for the off-site drainage systems. The design of the off-site drainage facilities was based on the development of a project specific hydrologic analysis using the Maryvale Area Drainage Master Study (ADMS) prepared for the Flood Control District of Maricopa County (District) and completed in February 1997. The HEC-RAS computer program was utilized for hydraulic analyses of the off-site drainage system.

This report documents the procedures, methodologies, and criteria utilized in the engineering analyses and provides detailed descriptions of unique aspects of the design. The design presented in this report collects and routes stormwater runoff to an appropriate outfall in accordance with ADOT criteria.

1.2 Drainage Issues

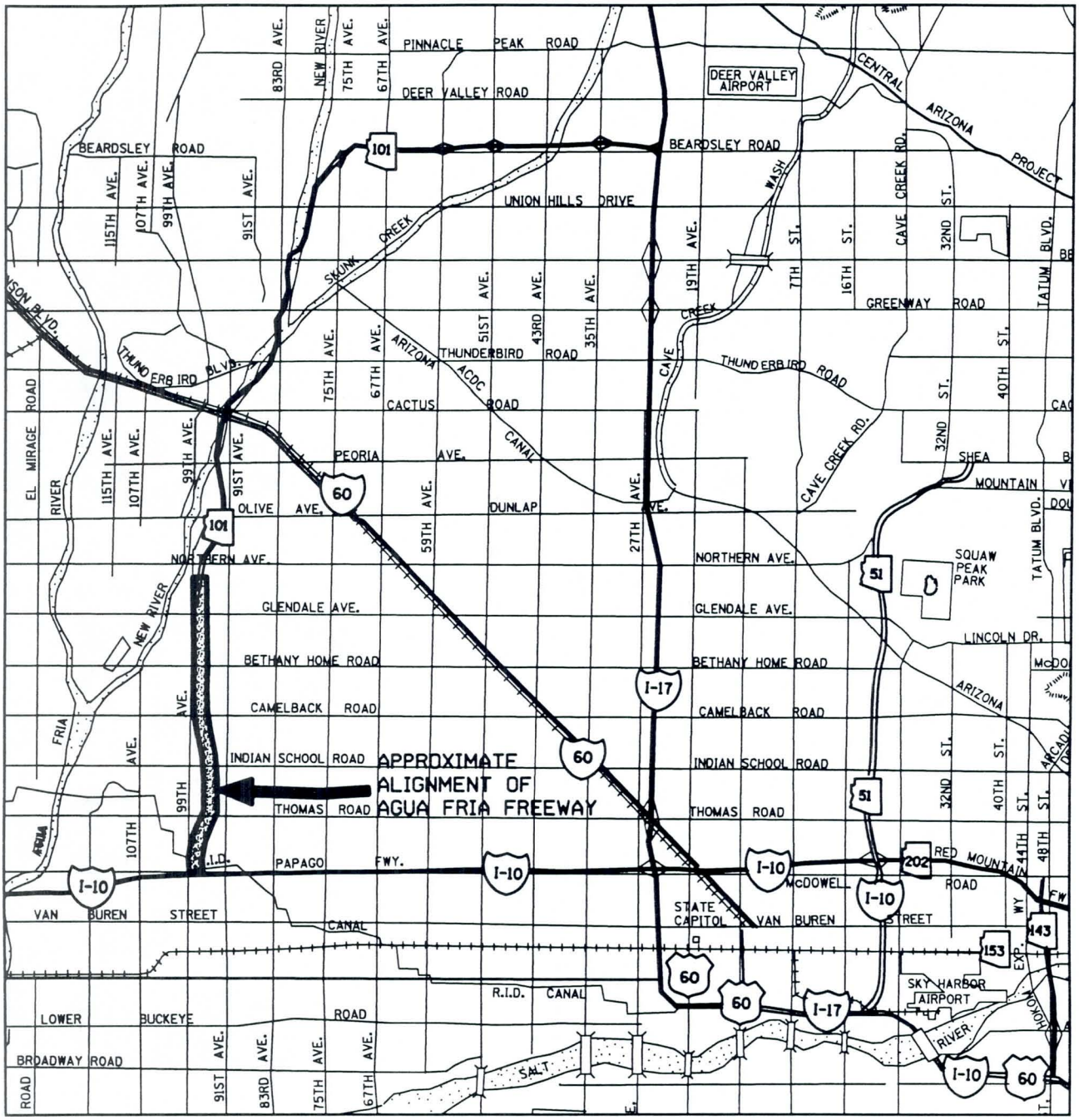
The principal project feature that impacts drainage is the construction of a new freeway between Interstate 10 (I-10) and the southern end of the existing freeway section south of Northern Avenue. Off-site flows will be collected along and within the proposed east right-of-way.

1.3 Conceptual Drainage Reports

Hydrologic analyses for the Agua Fria Freeway were originally performed by The WLB Group, Inc. (WLB) as documented in the reports Off-site Drainage Concept Study, Outer Loop Highway and Addendum to Off-site Drainage Concept Study, Outer Loop Highway.

1.4 Project Description

This section of the Agua Fria Freeway will extend from I-10 north to the southern end of the existing freeway section south of Northern Avenue. When completed, the entire length of the Agua Fria Freeway will extend from the Agua Fria/I-10 Interchange north to Beardsley Road and continue to the east as part of the outer loop freeway system (SR 101). This reach of the freeway will provide northwest valley residents and businesses with an alternative route that avoids the surface street arterial grid system, enhancing the flow of traffic and access for all of Maricopa County (Figure 1).



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SCALE, In MILES

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VICINITY MAP

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FIGURE 1

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2.0 OFF-SITE WATERSHED CHARACTERISTICS

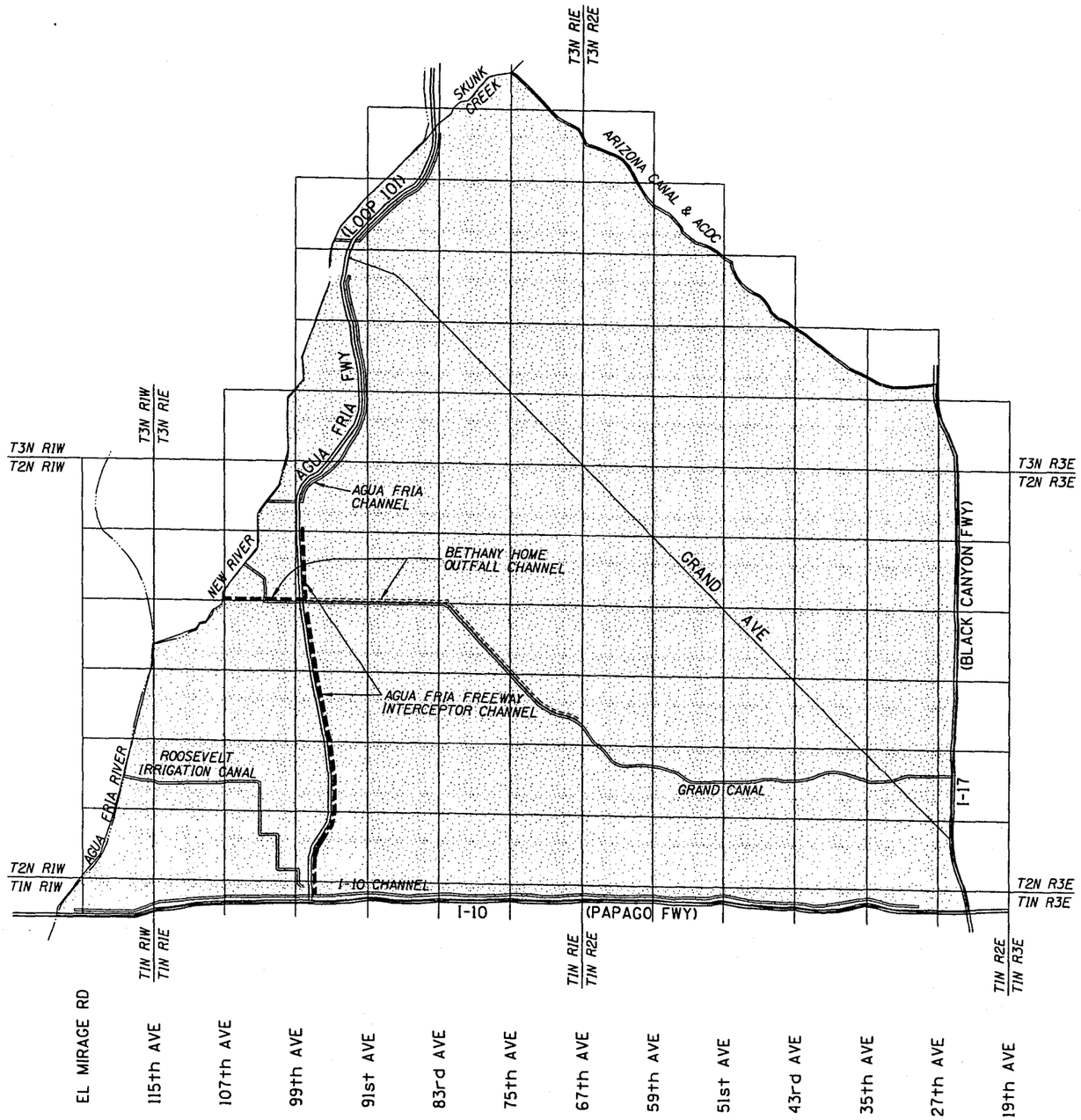
2.1 Drainage Area

The off-site drainage area contributing to the Agua Fria Freeway is included in the drainage area covered by the District's Maryvale Area Drainage Master Study (1997). The project study limits and off-site watershed boundary are illustrated in Figure 2. The total off-site contributing drainage area for the Agua Fria Freeway off-site drainage system is approximately 80 square miles.

2.2 Land Use, Vegetation & Soil Type

For the Maryvale ADMS, the District provided land use and soil map data in GIS format. Refer to the Maryvale ADMS (1997) for this information. GIS software was used to compute the sub-basin areas, the area of each soil unit in each sub-basin, and the area of each land use category in each sub-basin. This information was used as input data for the District's DDMS software. The various parameters assigned to each land use type are as given in Appendix A. The percent impervious specified for each land use (i.e. RTIMP) was assumed to be 100% effective.

Soil data is compiled from the USDA Soil Conservation Service (SCS) Report for Maricopa County, Central Part. Appendix A contains a list of the soil types identified in the off-site watershed and the corresponding rainfall loss parameters assigned to each soil group. Refer to the Maryvale ADMS (1997) for a complete listing of land uses and soil types for each individual sub-basin and the corresponding weighted rainfall loss parameters calculated.



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LEGEND

- OFF-SITE WATERSHED BOUNDARY
- EXISTING FLOOD CONTROL CHANNEL
- PROPOSED FLOOD CONTROL CHANNEL
- INTERSTATE OR STATE HIGHWAY
- PROPOSED AGUA FRIA FREEWAY INTERCEPTOR CHANNEL

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OFF-SITE DRAINAGE AREA MAP

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FIGURE 2

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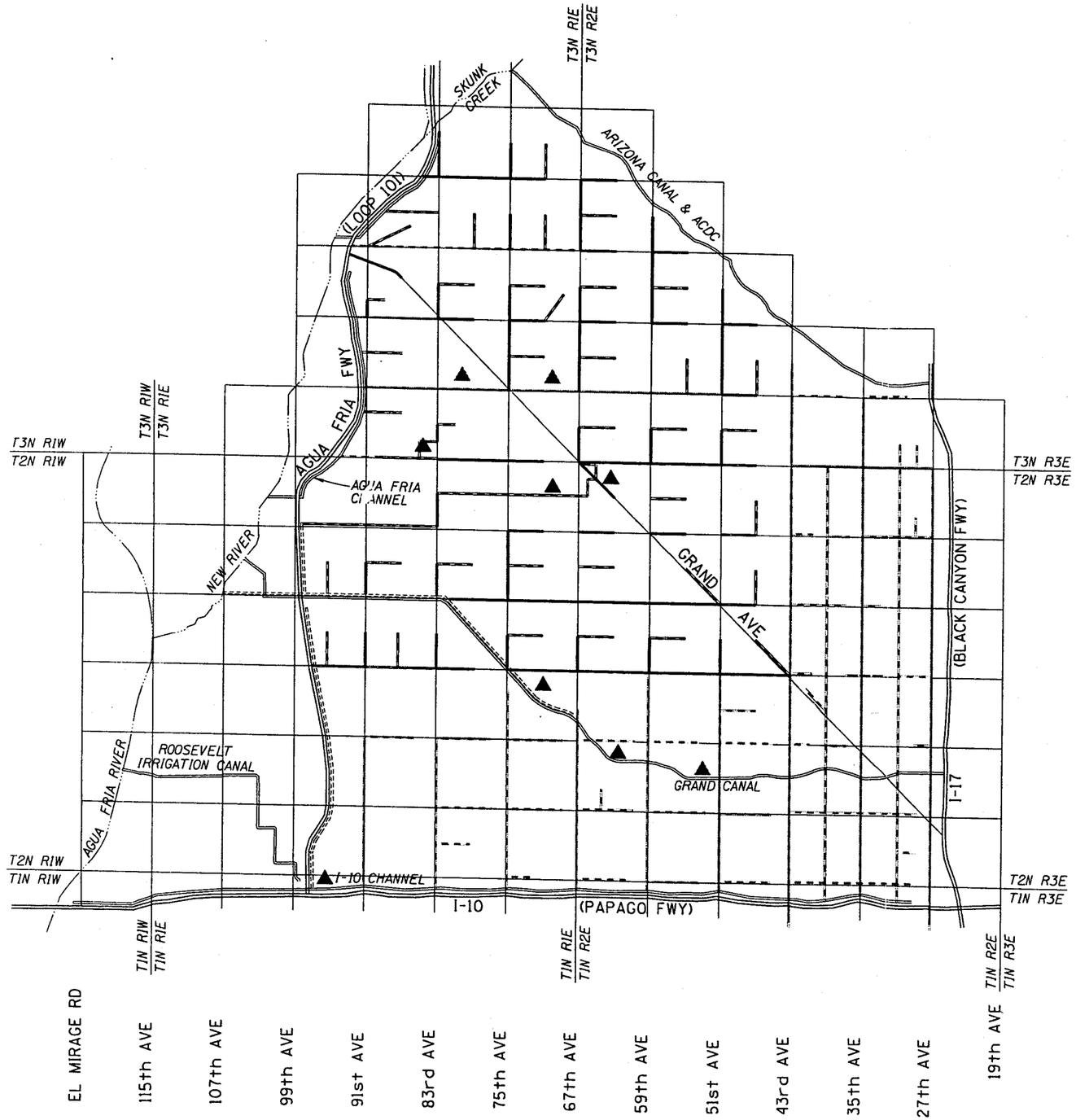
2.3 Existing Drainage Facilities

The City of Phoenix has a complex system of storm drains that conveys stormwater from as far north as Northern Avenue south to the Salt River. Primary components of this system include storm drains along 27th, 35th, 39th, 43rd, 51st, 67th, 83rd, and 91st Avenues. Only the 27th and 43rd Avenue storm drains outfall to the Salt River, the remainder of north to south systems outfall to the I-10 Interceptor Channel which outfalls to the Agua Fria River. Figure 3 illustrates these existing and future drainage systems. The design capacities for these storm drain systems are generally estimated to be between the 2-year and 10-year events.

Several future storm drain systems were included in the HEC-1 model for "existing conditions." Since these future systems are already funded for the design and construction within the immediate future, the District concurred that they should be included in the model as existing facilities. These future systems include storm drains along Butler Drive, Northern Avenue, and Orangewood/Glendale Avenues. In addition, the Cactus Road storm drain system was assumed to be completed to outfall into the existing Agua Fria Freeway channel.



THUNDERBIRD RD

CACTUS RD

PEORIA AVE

OLIVE AVE/DUNLAP AVE

NORTHERN AVE

GLENDALE AVE

BETHANY HOME RD

CAMELBACK RD

INDIAN SCHOOL RD

THOMAS RD

MCDOWELL RD

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LEGEND

- EXISTING SURGE BASIN
- PROPOSED SURGE/OFF-LINE BASIN
- EXISTING STORM DRAIN SYSTEM
- PROPOSED STORM DRAIN SYSTEM
- FUTURE STORM DRAIN SYSTEM
- EXISTING FLOOD CONTROL CHANNEL
- PROPOSED FLOOD CONTROL CHANNEL
- INTERSTATE OR STATE HIGHWAY

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STORM DRAIN SCHEMATIC

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FIGURE 3

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3.0 HYDROLOGY

ADOT has adopted the 1997 HEC-1 model developed by the Flood Control District of Maricopa County in their Maryvale Area Drainage Master Study (1997). The ADMS model was modified as follows:

- The model was revised to account for the proposed freeway alignment. The proposed alignment required several new sub-basins and hydrograph combinations.

- The District's proposed Bethany Home Outfall Channel (BHOC) was modeled in order to design the Channel west of the Agua Fria Freeway.

Three factors contributed to the decision to utilize the District's model from the Maryvale ADMS for the Agua Fria Freeway:

1. The hydrologic conditions in the watershed have changed since the time of the WLB studies. At the time the studies were performed, the Paradise Freeway was under consideration. Its proposed alignment lay just south of Bethany Home Road between the Agua Fria Freeway and I-17. In the Paradise Freeway scenario, the 100-year flow from the northeast was cut off by a collector channel along the north side of the freeway and diverted to the west. The flow was then carried past the Agua Fria Freeway to the New River in a facility known as the Bethany Home Outfall Channel. Flow from the Agua Fria Freeway collector channel north of Bethany Home Road also discharged into the New River via the BHOC. The Paradise Freeway has since been removed from ADOT's transportation plan.

2. New development has taken place within the watershed in the decade since the WLB studies. Changes in impervious area, retention/detention, and storm drains all affect the hydrologic response of the watershed.

3. ADOT's hydrologic modeling requirements have also changed since the late 1980's. The WLB HEC-1 models were developed using the SCS Dimensionless Unit Hydrograph, the SCS Curve Number soil infiltration loss method, and kinematic wave channel routing. The new ADOT methodology calls for a simplified Clark Unit Hydrograph, the Green-Ampt infiltration method, and the normal depth (modified Puls) channel routing procedure, all of which are consistent with the District's HEC-1 model, with the exception of the

Clark Unit hydrograph. The District's Clark Unit hydrograph is based on the textbook approach of time of concentration (T_c) as a function of rainfall, while ADOT's simplified Clark Unit hydrograph uses a different method to calculate T_c which is independent of rainfall. Refer to Table 3.1 for specific details.

The following sources of data were used to develop the HEC-1 input parameters:

- Detailed topographic mapping (i.e., 1" =200' with a contour interval of 1 or 2 feet) prepared by Kenney Aerial Mapping, Inc., based on photogrammetric mapping flown in March, 1994.

- 1990/1991 land use data provided in GIS format by the District.

- Soil type data, based on the Soil Survey of Maricopa County, Arizona; Central Part (SCS, 1997), as provided in GIS format by the District.

- Precipitation data from isopluvials as reproduced from NOAA Atlas 2, Volume VIII (Miller, Frederick & Tracey, 1973).

Detailed documentation and computation sheets for the various components of the HEC-1 model for the ADMS are provided in the appendices of the Maryvale Area Drainage Master Study - Hydrology (February 1997). Detailed documentation and summary sheets for the modifications to the ADMS model for the Agua Fria Freeway are provided in Appendix B.

3.1 Existing Off-site Hydrologic Analyses

As stated preciously, the Maryvale ADMS (1997) was utilized for the off-site watershed model for the Proposed Agua Fria Freeway. Slight modifications to the existing ADMS model were made to account for the proposed freeway alignment.

3.2 Revised Off-site Hydrologic Analysis (HEC-1)

3.2.1 General Discussion

This section describes the development of the Maryvale ADMS model, including revisions to model the proposed freeway alignment as previously discussed. The HEC-1 base model was developed during the Maryvale Area Drainage Master Study - Hydrology phase. For this Study, southerly diversions, sub-basin computations and hydrograph combinations along the proposed alignment of the

Agua Fria Freeway were inserted into the ADMS model to reflect field conditions with the freeway in-place. Diversions via BHOC along the Grand Canal from 67th Avenue to the west were also coded to represent the in-place effect of the BHOC west of the Agua Fria Freeway.

As discussed previously, there are slight differences in the hydrologic methods performed for this off-site watershed and ADOT's recommended methods, as outlined in their Highway Drainage Design Manual (1994). The following table lists hydrologic parameters and shows the difference, if any, between the two methods.

TABLE 3.1
Summary of Hydrologic Parameters

Parameter	This Study per District Methods	ADOT Methods
Rainfall Depth	NOAA Atlas 2	NOAA Atlas 2
Design Storm Frequency/Duration	100-Year , 24-hour (1)	100-Year, 24-hour
Design Storm Distribution	SCS Type II(2)- represents regions in which high rates of runoff are generated by large winter storm cells.	Corps Hypothetical - simplified and idealized representation of the temporal distribution of rainfall.
Rainfall Losses	Green and Ampt	Green and Ampt
Unit Hydrograph	Clark	Simplified Clark
Time of Concentration	Dependent on rainfall	Independent of rainfall
Storage Coefficient(3)	Dependent on Tc	Dependent on Tc
Time Area Relation (4)	Based on reconstitution of recorded rainfall runoff events	Based on reconstitution of recorded rainfall runoff events
Channel Routing	Normal depth	Normal depth

Table Notes:

(1) District's criteria is the greater of either the 100-year, 6-hour, or the 100-year 24-hour. For this Study, the 100-year, 24-hour storm controls.

(2) For the 100-year 24-hour storm, the SCS type II distribution is utilized.

(3) The storage coefficient R, is the same equation for both methods.

(4) The time area relations for both methods are the same, and are also dependent on land use.

3.2.2 Drainage Pattern & Sub-Basin Delineation

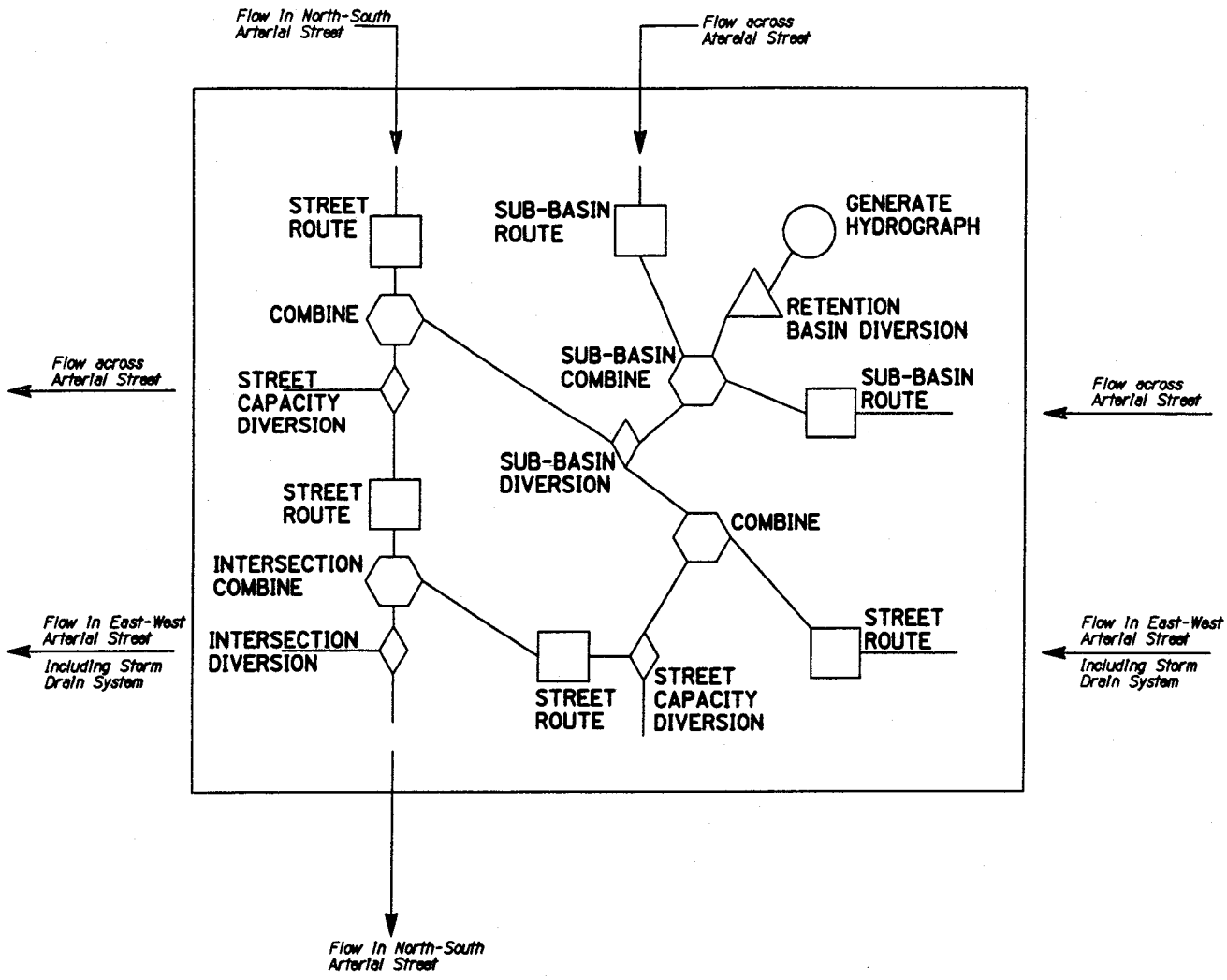
During development of the hydrologic model for the Maryvale ADMS project, it was essential to develop a modeling approach that was adaptable and representative of the watershed. The HEC-1 Hydrology Study first evaluated the drainage patterns within a 3.8-square-mile pilot study area. The selected pilot study area appeared to be reasonably representative of the highly urbanized portion of the total 100-square-mile study area. Detailed evaluation of the topographic mapping and site conditions for the pilot study area indicated that:

- Arterial streets are very important conveyors of storm water; however, the capacity of the arterial streets will typically be exceeded during the 10-year event. Stormwater flows will split out of typical arterial streets as weir flow and travel down local side streets.

- Since the arterial streets are the primary conveyors of stormwater, it is logical to consider the approximately 1-square-mile area bounded by arterial streets as a sub-basin. However, it is important to recognize that stormwater can cross all four sides of the essentially square sub-basin at any point along the four mile perimeter and that the sub-basin does not have a single concentration point. Instead, each sub-basin has a concentration line that extends along the arterial streets along the downstream sides of the essentially square sub-basin.

- The flow patterns within a typical 1-square-mile sub-basin are very complex and can vary significantly during the course of a rainfall event. However, the flow patterns within the sub-basin are primarily controlled by residential and collector street patterns.

Thus, sub-basins were delineated based on arterial street patterns. This provides homogeneity within the off-site watershed. Figure 4 is a HEC-1 schematic diagram for a typical sub-basin. This figure illustrates the key elements and structure of the HEC-1 modeling approach used. Refer to Appendix C for the HEC-1 element nomendature used for this study. The HEC-1 schematic diagram for the entire off-site watershed is shown on Exhibit A. The local off-site drainage areas directly to the east of the Freeway are depicted on Exhibit B.



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TYPICAL HEC-1 SCHEMATIC OF A ONE SQUARE MILE SUB-BASIN

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FIGURE 4

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The HEC-1 model for a typical sub-basin includes the following standard elements listed below.

- Hydrograph computations for the sub-basin per the District's methodologies.
- Normal depth channel routings for the arterial streets.
- Normal depth composite-channel routings for flow passing through a sub-basin along multiple streets.
- In some cases, reservoir routings for ponding areas and regional retention basin systems within a sub-basin.
- Hydrograph combinations along streets and within sub-basins.

Within the study area, the slope of the land is generally from the northeast to the southwest at approximately 0.4 percent. Hence, stormwater flowing within a typical sub-basin is directed and conveyed to the arterial streets along the west and south sides of the sub-basin by residential and collector streets. That is, some of the stormwater is conveyed west to the north-south arterial street by residential and collector streets, while the remainder of the stormwater is conveyed south to the east-west arterial street by residential and collector streets.

Sub-basin diversions are used to separate or divide the hydrograph for the stormwater within a sub-basin into a southerly and a westerly component. The hydrograph for the stormwater within a sub-basin includes runoff generated within a sub-basin and typically the flow entering a sub-basin from the adjacent arterial streets.

Sub-basin diversion data have been computed based on the drainage patterns within each of the sub-basins. The drainage patterns within the sub-basins have been evaluated using the topographic mapping for the study area and site observations. The sub-basin diversion data computations are documented in Appendix C of the Maryvale ADMS (1997).

3.2.3 Rainfall Data

Adjusted point rainfall depths for the 100-year, 24-hour event were computed for the study area. The point rainfall values were computed using the U.S. Bureau of Reclamation's PREFRE computer program. This program automates the statistical procedures outlined in the ADOT Highway Drainage Design Manual, Hydrology (1994). However, PREFRE has the capability of statistically analyzing four or twelve input point precipitation values. The twelve point input option was used for the Maryvale ADMS Study and repeated for the off-site watershed analysis of this project. The input point rainfall depth computations are documented in Appendix D, and the resulting depth-duration-frequency rainfall data is shown in Table 3.2.

TABLE 3.2

Rainfall Depth-Duration-Frequency Data

	Point precipitation for each Return Period, in inches					
Duration	**2-yr**	**5-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**
5-min	0.35	0.44	0.50	0.59	0.66	0.72
15-min	0.64	0.83	0.96	1.14	1.28	1.42
1-hour	1.03	1.37	1.59	1.92	2.16	2.41
2-hours	1.10	1.47	1.73	2.08	2.36	2.63
3-hours	1.14	1.55	1.82	2.20	2.49	2.78
6-hours	1.23	1.68	1.99	2.41	2.73	3.06
12-hours	1.30	1.82	2.16	2.64	3.01	3.37
24-hours	1.37	1.95	2.34	2.87	3.28	3.69

The 100-year 24-hour point precipitation depth of 3.69 inches was distributed over the entire off-site watershed using the SCS-Type II distribution per the District's Criteria.

3.2.3.1 Multiple versus Single Storm Event

The District's DDMS software allows computation of sub-basin parameters (i.e. Clark Unit Hydrograph parameters "Tc" and "R") for either "multiple" or "single" storm events. When the single storm option is used, the HEC-1 model has a single point rainfall value and a single rainfall distribution that corresponds to a specified drainage area. The "multiple storm" HEC-1 model uses point rainfall values and rainfall distributions from the multiple point rainfall values and distributions listed in the HEC-1 data set,

based on the drainage area specified for each sub-basin and hydrograph combination operation. The multiple storm option has been used to model the general "existing conditions."

3.2.4 Interception and Infiltration Losses

The Green and Ampt precipitation loss option was used for all sub-basins. Green and Ampt parameters for each sub-basin were computed using the DDMS software, based on the land use and soil data.

3.2.5 Unit Hydrographs

The synthetic unit hydrograph procedure adopted for this study is the Clark unit hydrograph as described in the District's Drainage Design Manual for Maricopa County (1995). This procedure requires estimation of two parameters: the time of concentration (Tc), the storage coefficient (R), and a time-area relation.

In order to properly develop a unit hydrograph for a particular watershed, an adequate database (rainfall and runoff records) is required. Since very few watersheds in Arizona (including the subject watershed) have adequate data, an indirect method is usually used to develop a synthetic unit hydrograph. This synthetic hydrograph is representative of all of the composite effects of the storm and watershed characteristics that result in excess runoff from the watershed. The input parameters for the subject watershed were estimated as described in the following paragraphs.

The time of concentration is the travel time, during the corresponding period of most intense rainfall excess, for a flood wave to travel from the hydraulically most distant point in the watershed to the point of interest. The Tc equation utilized for the project watershed is presented below:

$$T_c = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$

where:

T_c	=	Time of concentration, (hours);
L	=	Length of the flow path for T_c, (miles);
Kb	=	Representative watershed resistance coefficient
S	=	Watercourse slope, (feet/mile);
i	=	The average rainfall excess intensity during the time T_c (inches/hour).

The storage coefficient is a Clark unit hydrograph parameter that relates the effects of direct runoff storage in the watershed to unit hydrograph shape. The equation for estimating the storage coefficient (R) is:

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

where:

R	=	Storage coefficient (hours);
T_c	=	Time of concentration (hours);
A	=	Drainage area (square miles);
L	=	Length of flow path (miles).

Appendix A of the Maryvale ADMS (1997) lists the T_C and R parameters calculated for each sub-basin, while T_C and R parameters for the sub-basins revised for the proposed freeway alignment are shown in Appendix B of this Report.

3.2.6 Hydrograph Routing and Diversion Parameters

The uniqueness of the proposed HEC-1 modeling approach lies in its structure and the use of various categories of flow diversions. The ability to model flow diversions flexibly was the key for developing a modeling approach for the study area that meets the project objectives. As indicated on Figure 4, flow diversions are used in five distinctly different ways:

1. **Street Capacity Diversions.** Street capacity diversions are used to compute the flow being conveyed by a major/arterial street and the flow that exits the arterial street and enters the adjacent sub-basin via both residential and collector streets.

2. **Street Intersection Diversions.** Street intersection diversions are used to distribute the flow passing through an intersection. Intersection diversion rating curves for arterial streets are based on relative street capacities and the capacity of existing or future storm drain systems.

3. **Sub-basin Diversions.** Sub-basin diversions are used to identify the southerly and westerly components of runoff generated within a sub-basin and the flow entering a sub-basin from adjacent arterial streets. Rating curves for these diversions are primarily based on easily measured areas; however, some judgment is required.

4. **Retention Basin Diversions.** In cases where a portion of a sub-basin drains to a retention basin or system of retention basins, flow diversions are used to divert the volume of water corresponding to the measured capacities of the retention basins. The percentage of the flow rate that can be diverted (i.e., the DQ-record information) corresponds to the percentage of the sub-basin area that drains to the retention basin(s).

5. **Surge Basin Diversions.** The Olive Avenue, Northern Avenue, and Orangewood/Glendale Avenue storm drain systems contain surge basins, as indicated on Figure 3. The proposed Agua Fria Freeway Interceptor Channel and the existing I-10 Interceptor Channel divert flow into a proposed off-line detention basin located near 97th Avenue and McDowell Road. Flow diversions are used to simulate the diversion of flow from a storm drain or channel system into a basin.

The schematic for the Agua Fria Freeway HEC-1 model is shown on Exhibit A. The computational sequence of the HEC-1 model has been set up to minimize the number of hanging hydrographs and emphasize the east-west streets. Emphasizing or following east-west streets simplifies the task of modifying the model to reflect storm drain alternatives that may extend along the east-west streets. Yet, the structure of the model is such that the computational path for the north-south streets is relatively easy to identify and follow.

In addition, the structure of the HEC-1 modeling approach is such that:

- Flow can be routed into and out of a typical 1-square-mile sub-basin across essentially all four sides of the sub-basin.

- Flow can be routed along all four sides of a typical 1-square-mile sub-basin.

- Street intersection, street capacity, and sub-basin diversions can be modified to reflect future or existing storm drain systems, along arterial and collector streets.

- Retention basin diversions can be added and modified to reflect future retention facilities.

The HEC-1 element names are based on section numbers and street names. A detailed description of the element name nomenclature is documented in Appendix C and in the ID-records of the HEC-1 models.

3.2.6.1 Arterial Street Routes

The Normal-Depth Channel Routing option in HEC-1 is used for arterial street routes. The input data for arterial street routes are based on a typical arterial street section and measured street slopes and reach lengths. Detailed documentation for each arterial street route is provided in Appendix D of the Maryvale Area Drainage Master Study - Hydrology (1997). Revisions to both street routes and composite route reaches for the proposed freeway alignment are shown in Appendix B.

3.2.6.2 Sub-basin Street Routes

The Normal-Depth Channel Routing option in HEC-1 is used for sub-basin street routes. The input data for sub-basin street routes was based on a composite section and measured street slopes and reach lengths. Detailed documentation for each sub-basin street route is provided in Appendix D of the Maryvale Area Drainage Master Study - Hydrology (1997).

3.2.6.3 Street Capacity Diversions

Street capacity diversions are used to compute the flow being conveyed by arterial streets and the flow that exits the arterial streets and enters the adjacent sub-basins via both residential and collector streets. Two general cases of street capacity diversions have been evaluated. The typical case (Case 1) is when flow exits the arterial street as weir flow into the side streets. Along most arterial streets, the side streets have been designed with a high point or grade break near the intersection. This prevents stormwater flowing in the gutter of the arterial from being directly conveyed into the side street. However, a special case that occurs at several locations is when stormwater can exit the arterial street directly into the side street. In this case, normal depth calculations are used to develop rating data for both the arterial and side street(s). As indicated in the detailed documentation given in Appendix F of the Maryvale Area Drainage Master Study - Hydrology (1997), spreadsheets have been used to compute the rating curves for the street capacity diversions based on easily measured physical parameters and future/existing storm drain system capacities.

3.2.6.4 Street Intersection Diversions

Street intersection diversions are used to distribute the flow passing through an intersection. Intersection diversion rating curves for arterial streets are based on relative street capacities and the capacity of existing or future storm drain systems. Two general types of street intersections have been evaluated. *Type A--Arterial Street Intersections* are the typical type of arterial street intersections within the study area. The characteristics of a Type A intersection are as follows:

- Continuous pavement crowns in both directions; that is, valley gutters are **not** used to direct stormwater through the intersection.
- Street slopes in the vicinity of the intersection are relatively mild (i.e., less than 1%).
- The intersection is subject to low velocity inundation.

The special case, *Type B--Arterial Street Intersections*, refers to the condition where the pavement crown is continuous in only one direction through the intersection. In this case, the intersection diversion is based on normal depth and weir flow computations. The intersection diversion data collected for the study area are documented in detail in Appendix G of the Maryvale Area Drainage Master Study - Hydrology (1997).

3.2.6.5 Storm Drain Systems - Existing Storm Drain Systems within the Cities of Peoria and Glendale

There are three major storm drain systems in the northern portion of the study area, as shown schematically on Figure 3. The Cactus Road storm drain system currently extends from approximately 67th Avenue west to 83rd Avenue. This storm drain system will be extended to the ADOT channel system along the east side of the Agua Fria Freeway, with an expected completion date of July, 1997. The Olive Avenue storm drain system extends from approximately 51st Avenue west to the Agua Fria Freeway channel system. The Olive Avenue storm drain system contains two surge basins located at approximately 71st Avenue and 83rd Avenue. This storm drain system has a 10-year event design capacity. The Peoria Avenue storm drain system extends from approximately Grand Avenue to the Agua Fria Freeway channel system.

Existing Storm Drain Systems within the City of Phoenix

As shown schematically on Figure 3, the City of Phoenix has a complex system of storm drains that conveys stormwater from as far north as Northern Avenue south to the Salt River. Primary components of this system include storm drains along 27th, 35th, 39th, 43rd, 51st, 67th, 75th, 83rd, and 91st Avenues. The design capacities for these storm drain systems are generally estimated to be between the 2-and 10-year event. However, only the 27th Avenue and 43rd Avenue storm drains connect to the Salt River, while the remainder drains to the I-10 interceptor channel.

The capacities of the storm drain systems located within the City of Phoenix have been estimated based on pipe slopes and diameters, assuming pipe full conditions.

The Peoria Avenue, Cactus Road, and Olive Avenue storm drain systems have been incorporated into the HEC-1 model by modification of the appropriate street intersection and street capacity diversion rating curves. The Cactus Road storm drain system has been modeled assuming the system is complete and outfalls to the Agua Fria Freeway Channel. Storm drain capacity data for these systems are based on the capacities given in the design reports for these storm drain systems. The storm drain capacity data and detailed documentation describing how the storm drain systems are reflected in the HEC-1 model are provided in Appendix H of the Maryvale Area Drainage Master Study - Hydrology (1997).

Future Storm Drain Systems Included in "Existing Conditions"

As described in Section 2.3 of this report, several future storm drain systems were included in the HEC-1 model for "existing conditions." These future systems include:

- The storm drain systems evaluated and proposed in the Northern/Orangewood Storm Drain Project: Concept Routing Study FCD #94-12 by Wood, Patel & Associates, Inc. (1996). The study proposed systems along Butler Drive, Northern Avenue, and Orangewood/Glendale Avenues.

- Extension and completion of the Cactus Road storm drain system. The Cactus Road storm drain system will be extended to the ADOT channel system along the east side of the Agua Fria Freeway, with an expected completion date of July, 1997.

3.2.6.7 Retention Basin and Ponding Area Data

Retention Basin Data

In cases where a portion of a sub-basin drains to a retention basin or system of retention basins, flow diversions are used to divert the volume of water corresponding to the measured capacities of the retention basins. The percentage of the flow rate that can be diverted (i.e., the DQ-record information) corresponds to the percentage of the sub-basin area that drains to the retention basin(s). The retention basin computation sheets for each sub-basin are included in Appendix E of the Maryvale Area Drainage Master Study - Hydrology (1997).

Ponding Area Data

During significant rainfall events, stormwater ponds at several locations along the upstream side of the Roosevelt Canal, the Grand Canal, and Grand Avenue and/or the adjacent railroad embankment. Storage volume, ponding elevation, and outfall data were computed based on the detailed topographic mapping and supplemental surveyed spot elevations. The ponding area computation sheets are given in Appendix E of the Maryvale Area Drainage Master Study - Hydrology (1997).

3.2.7 Cumulative Area Computations for Hydrograph Combines

When hydrographs generated from diverts are combined, HEC-1 allows a drainage area to be specified on the HC-record. This area is used to compute an interpolated hydrograph for the "combined hydrograph," based on the data given in the JD-records (HEC-1,1990).

For the Maryvale ADMS, areas were computed for each combine node based on the total area of all the sub-basins located upstream of the combine node. These "Cumulative Area Computations," given in Appendix I of the Maryvale Area Drainage Master Study - Hydrology (1997), list the areas and names for all of the upstream sub-basins for each combine node. This project requires several sub-basin areas to be revised along the proposed freeway alignment. Total area computations for this project are provided in Appendix B.

The drainage area specified for each of the combine nodes represents the maximum drainage area that may contribute flow to the combine node. It is recognized that a combine node may only receive a small fraction or none of the runoff hydrograph for some of the upstream sub-basins.

3.2.8 Data Management

The HEC-1 model for this Study area is composed of approximately 12,320 lines of data. The model includes approximately:

- 150 Sub-Basins
- 400 Arterial Street Routes
- 330 Composite Street Routes
- 200 Street Capacity Diversions
- 140 Sub-Basin Diversions
- 90 Intersection Diversions
- 30 Retention Basin Diversions
- 24 Ponding Areas (i.e., reservoir routes)
- 80 Miles of Storm Drain Systems

When possible, Excel spreadsheets were used to compute and manipulate the data required to generate the input for the HEC-1 model. As provided in the appendices of the Maryvale Area Drainage Master Study - Hydrology (1997), listings of these spreadsheets were also used to document the input data development.

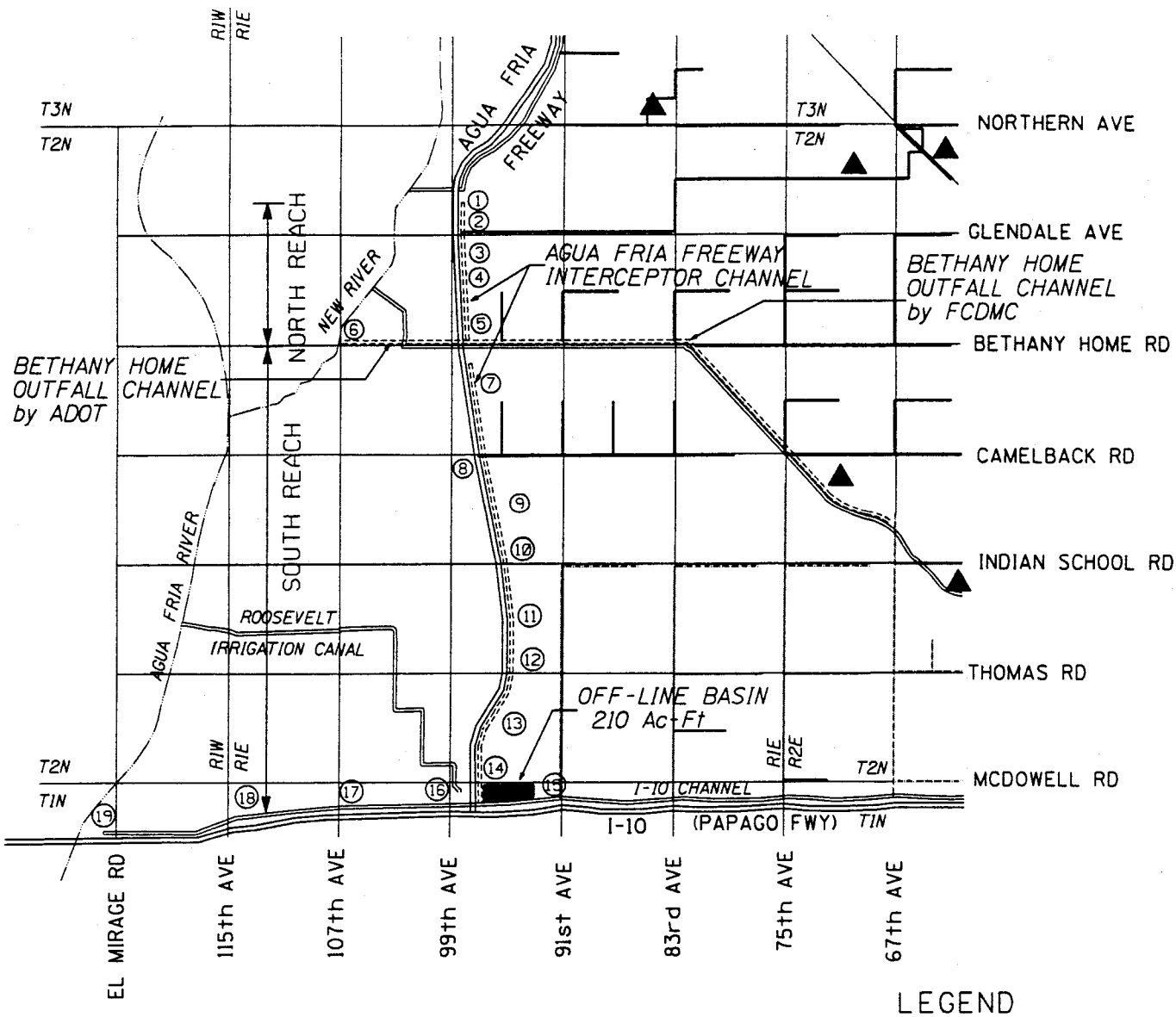
Developing the sub-basin data for the HEC-1 model involved the manipulation of a large amount of soil and land use data. GIS software, more specifically ArcInfo, was used to compute the total area for each sub-basin and the portions thereof within each of the soil groups and land use categories.

For this project, two HEC-1 models are necessary to model the 100-year 24-hour event. The first model simulates the rainfall runoff response of the off-site watershed for the proposed Agua Fria Freeway alignment, as shown on Figure 5. The second model is used to simulate the effects of the District's proposed BHOC, while incorporating the proposed Agua Fria alignment. The reasons for the two models will be explained in detail in Section 5.

3.3 Summary of Off-Site Hydrology

Section 3.0 of this report stated the hydrologic analysis for the off-site watershed was based on the most up to date existing condition watershed data available. Figure 5 details the 100-year 24-hour existing condition flow rates determined by this study. Future development can alter drainage patterns and quantities of flows documented herein. However, local governments require the majority of runoff (100-year, 2-hour storm) to be retained on-site within the limits of future developments. Enforcement of these local drainage requirements is the key to minimizing the impact of future development on this project's drainage infrastructure.

An important part of understanding the hydrology for this off-site watershed is the fact that the HEC-1 model is a computer simulation of what happens during a rainfall event. As discussed in Section 3.2.2 of this report, there are no exact concentration points. The concentration points shown on Exhibit A are representative of the magnitude of sheet flows occurring at any location along the length of the arterial street defining the sub-basin boundaries. This concept is also important in understanding the hydraulic design phase. Spillway provisions for potential inlets were assumed to occur at 1/4 mile increments along the proposed channel alignment, due to the fact that exact inlet locations can not be located. The off-site channels must be designed to handle the entire inlet flow at any point along its run, thus a total of 2 feet of turn down is used along the eastern inlet side of the channel. An extra 1 foot (a total of 3 feet) of turn down is utilized at the 1/4 mile incremental locations. Refer to Section 5.3 for more specific information regarding channel inlet considerations.



SUMMARY OF 100-yr 24-hr HYDROLOGY

ID	Q (cfs)	DESCRIPTION
1	135	1/2 MI N of GLENDALE AVE
2	435	U/S SIDE OF SD
2	935	D/S SIDE OF SD
3	1250	1/4 MI S of GLENDALE
4	1550	U/S of BETHANY HOME RD
5	4600	AT CONFLUANCE
6	4700	AT NEW RIVER
7	150	1/2 MI N of CAMELBACK RD
8	500	AT CAMELBACK RD
9	900	1/2 MI N of INDIAN SCHOOL
10	1350	AT INDIAN SCHOOL RD
11	1600	1/2 MI N of THOMAS RD
12	1850	AT THOMAS RD
13	2100	1/2 MI N of McDOWELL RD
14	2300	AT McDOWELL RD
15	9200	I-10 Channel U/S of BASIN
16	9000	AT BASIN (After diversions)
17	9300	I-10 AT 107th
18	9600	I-10 AT 115th
19	9800	I-10 AT AGUA FRIA RIVER

1 1/2 0 1

SCALE in MILES

LEGEND

- EXISTING SURGE BASIN
- PROPOSED SURGE/OFF-LINE BASIN
- EXISTING STORM DRAIN SYSTEM
- PROPOSED STORM DRAIN SYSTEM
- FUTURE STORM DRAIN SYSTEM
- EXISTING FLOOD CONTROL CHANNEL
- PROPOSED FLOOD CONTROL CHANNEL
- INTERSTATE OR STATE HIGHWAY
- (13) LOCATION OF HEC-1 HYDROGRAPH COMBINE OPERATION

SUMMARY OF OFF-SITE DRAINAGE COMPONENTS

Wood, Patel & Associates, Inc.
1550 East Missouri, Suite 203
Phoenix, Arizona 85014 (602) 234-1344

DRAWN BY: DTP

JOB NO: 95271.05

FIGURE 5

4.0 DRAINAGE DESIGN CRITERIA

4.1 Off-site Drainage Criteria

This Report is intended to be a 30% submittal, therefore, designs within this report are of a conceptual nature. They are not intended to be used for construction or recording purposes.

The off-site drainage channels were designed in accordance with the design guidelines and drainage procedures presented in the document entitled *Roadway Design Guidelines*. Because the flow in the off-site drainage channels is subcritical, a minimum freeboard of 1 foot for the off-site channels was maintained for the design event of 100-year frequency.

Details of the criteria used to design the off-site drainage channels from Camelback Road to Northern Avenue are provided in Volume II of this Report.

5.0 CONCEPT OFF-SITE DRAINAGE DESIGN

5.1 Initial Investigation

The hydraulic design portion of this document is intended to be conceptual in nature. The purpose of the off-site hydrologic analysis was to determine 100-year 24-hour peak discharge values generated by the contributing watershed. This information was used to develop the proposed hydraulic design for the off-site drainage systems. The HEC-RAS computer program was utilized for hydraulic analyses of the preliminary off-site drainage system. This section documents the procedures, methodologies, and criteria utilized in the engineering analyses and provides detailed descriptions of unique aspects of the design.

During the initial stage of this the project, several options to handle off-site drainage were developed. In September 1997, ADOT accepted the District's Maryvale ADMS hydrology model for the purpose of off-site hydrology for the Agua Fria Freeway. Since that time, the project team has developed the recommended alternative to its current state.

5.2 Concept Design

The results from the 100-year, 24-hour HEC-1 model were used in the design of the selected alternative for off-site drainage. The off-site concept design consists of two reaches as described below.

North Reach

The North Reach of the Agua Fria Freeway Interceptor Channel is from Northern Avenue south to the Bethany Home Outfall Channel (BHOC). The proposed interceptor channel is sized to convey the 100-year, 24-hour peak flow rates. The channel will follow the proposed freeway alignment and lie within the specified right-of-way on the east side of the Freeway. As shown on Figure 5, the BHOC directs stormwater west to the New River along the Bethany Home Road alignment. The HEC-1 input file name for this 100-year, 24-hour scenario is 100AF1.ih1. Refer to Appendix D for electronic copies of the HEC-1 input and output files.

A unique component of this reach is the utilization of the BHOC to convey stormwater collected in the proposed interceptor channel, north of Bethany Home Road westerly to the New River. An Inter-governmental Agreement (IGA) between ADOT and the District is underway to determine the cost sharing for this channel from the proposed freeway to the New River. The District intends to extend the BHOC easterly, north of the Grand Canal from Agua Fria Freeway east to 83rd Avenue and then southeasterly to terminate at 67th Avenue. This future channel will outlet to the BHOC constructed with ADOT's Freeway Project. The District's extension of the BHOC from 67th Avenue west will provide a

benefit to ADOT by reducing flows in the proposed Agua Fria Freeway Interceptor Channel south of Bethany Home Road by about 10%, thus increasing the factor of safety for this reach. It has been decided, in the interest of public safety, that the flows used to design the Agua Fria Freeway Interceptor Channel will not take into account the future improvements of the District's BHOC as shown on Figure 5. However, the BHOC is designed to convey the full BHOC flow of 4700 cfs. This variation in off-site simulation required an additional HEC-1 model. The input file name for the 100-year, 24-hour BHOC scenario is 100AFBH.ih1. Details of the criteria used to design the off-site drainage channels from Camelback Road to Northern Avenue are provided in Volume II of this Report.

South Reach

The Agua Fria Freeway Interceptor Channel begins approximately 1/4 mile south of Bethany Home Road alignment and continues south to the existing I-10 Channel. The proposed Interceptor Channel is designed to convey the 100-year, 24-hour peak flow rates as determined earlier. The channel will follow the proposed freeway and lie within the specified right-of-way on the east side of the freeway. (At the time of preparation of this Report, the right-of-way description for the Agua Fria Freeway was not finalized for the alignment south of Camelback Road. Therefore, the proposed channel's horizontal alignment data cannot be finalized.) In general, however, the channel will be located immediately west and parallel to the east right-of-way line.

A unique component of the selected alternative for the South Reach is an off-line basin in the northeast quadrant of the confluence of the proposed Agua Fria Freeway Interceptor Channel and the existing I-10 Channel. The I-10 Channel, in its existing condition, cannot safely contain the current 100-year flood peak. When the proposed Agua Fria Freeway is constructed, the additional flows would further cause the I-10 channel to be overtopped near 99th Avenue.

To ensure the I-10 Channel is not overtopped, the off-line basin is designed to "shave off" the peak of the inflow hydrographs, thus reducing the combined flood peak to a safely conveyable value (9,000 cfs) for the I-10 Channel. Inflow and outflow hydrographs at this location are shown in Appendix F. Two spillways have been designed to allow flows to enter the off-line basin from both interceptor channels. Appendix F, Proposed Off-Line Basin at I-10 and Agua Fria Freeway, includes concept design for the basin and provides information on design assumptions, channel backwater analysis, and the side weir concepts. The final designer will be required to evaluate the cost-effectiveness of the type of spillway to be used at this location. Since the spillway widths are anticipated to be 200 feet for the

Agua Fria Freeway Interceptor Channel and 600 feet for the I-10 Channel, respectively, an interceptor-type channel to collect the spillover flow into the basin may be more suitable (see Appendix F, Plate F-1). The off-line basin will intercept flows in excess of 7,300 cfs from the existing I-10 Channel, and flows in excess of 1,700 cfs from the proposed Agua Fria Freeway Interceptor Channel.

The off-line basin will hold approximately 210 Ac-ft of stormwater during the 100-year 24-hour event, and the combined flow in the I-10 Channel downstream of the off-line basin will be reduced from the 11,500 cfs existing conditions to 9,000 cfs. The off-line basin's lowest invert elevation will be approximately 1000 ft. (MSL) (which is about 1 ft. above the existing I-10 Channel invert, thus the basin will gravity drain). To prevent the channel flows from backing up into the basin through the outlet pipe, a backflow preventing flap gate will be required. The outlet pipe will be required to drain the basin within 36 hours after the storm event. The outlet pipe is estimated to be 48" in size (see calculations in Appendix F). The HEC-1 input file name for this 100-year 24-hour scenario is 100AF1. Refer to Figure 5 for a graphical representation of the various components mentioned. Appendix F contains a plan view of the proposed off-line basin and typical channel cross-section details are shown in Appendix G. Exhibit B depicts a schematic diagram of an overall view of the off-site drainage design system for the Agua Fria Freeway. The I-10 Channel backwater analysis (HEC-RAS) is included in Appendix I. The I-10 Channel profile is depicted on Plate I-1.

Appendix J includes output results from HEC-RAS analysis for the South Reach. Plate J1 depicts the water surface profile for the Agua Fria Freeway Interceptor Channel.

5.3 Unique Aspects of Hydraulic Design

Some unique aspects of hydraulic design are common to both reaches of the proposed Agua Fria Freeway Interceptor Channel. First, due to shallow relief of the off-site watershed, concentrated flow locations are not specifically designated. Based on engineering judgment together with available topographic maps and surface flow hydrograph components of the off-site watershed HEC-1 model, inlets for the proposed interceptor channel are located every ¼ mile along the channel alignment (approximately at the arterial street crossings). Refer to Appendix H for inlet location descriptions, length, and depth of turn down utilized at each location. A 2-foot turn down was utilized for the entire length of the eastern side of the proposed channel. However, where concentrated flows are anticipated (typically at each 1/4 mile location), a 3-foot turndown is recommended. It is anticipated that the final designer will need to refine the spillway inlet details based on more specific site hydraulics.

The possibility of utility conflicts exists at each arterial street crossing. The potential conflicts on the North Reach are the crossings at Glendale Avenue, 99th Avenue, and the Grand Canal Wasteway (which parallels the Roosevelt Irrigation District (RID) return flow canal). The potential conflicts on the I-10 Channel are the crossings at Camelback Road, Indian School Road, Thomas Road, and McDowell Road. The potential utility conflicts based on available existing data along the proposed alignment for the interceptor channel are outlined in Table 5.1.

TABLE 5.1

Listing of Potential Utility Conflicts along Proposed Channel Alignment

Reach ID	Crossing Location	Utility ID		Proposed
		Description	Invert EL	Invert EL
North	Glendale Avenue	Cross over existing 15" sanitary sewer	1054.8±	1059.5
North	99th Avenue	Crosses over existing 42" RCP sanitary sewer	1041.8±	1047.0
North	Grand Canal Wasteway	Cross under proposed CBC	1047.5±	1035.7
South	Camelback Road	Cross over existing 48" sanitary sewer	1033.8±	1040.7
South	Indian School Road	No conflict for proposed design	--	1028.2
South	Thomas Road	No conflict for proposed design	--	1022.4
South	North of McDowell Road	Cross over proposed sanitary sewer (relocated)	1007.4±	1012.5
South	RID Canal N of McDowell	Cross under existing RID Canal	1015.5±	1002.5

It should also be noted that future storm drains can connect into the proposed channel at the time of their construction. It is beyond the scope of this project to design stub-outs for future storm drain connections.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The concept design documented in this Report generally follows ADOT methodology and will safely intercept and convey the 100-year 24-hour storm around the proposed Freeway alignment. As noted earlier, the hydrologic information was obtained from a modified version of the Maryvale ADMS. Sub-basin boundaries and flowpaths were adjusted, as necessary, to estimate the future flow distributions and magnitudes along the proposed freeway alignment.

The off-line basin proposed for the confluence of the Agua Fria Freeway Interceptor Channel and the I-10 Channel could also serve as a dual-use facility for the local community, who would then be responsible for maintenance of the basin.

The excavation of the basin will also result in a significant amount of excess material which could be used as fill material for the Freeway embankment.

7.0 REFERENCES

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APPENDIX A

Rainfall Loss Parameters by Land Use & Soil Type

- TABLE A1: Rainfall Loss & Synthetic Unit Hydrograph Parameters by Land-use
- TABLE A2: Rainfall Loss Parameters by Soil Type

TABLE A1
Rainfall Loss and Synthetic Unit Hydrograph Parameters by Landuse

Land Use Type	DTHETA Condition	Veg. Cover %	RTIMP %	IA inches	Kn Roughness Type	Kb Roughness Type
Desert	Dry	25	0	0.35	0.03	Low
Open	Dry	10	0	0.20	0.02	Min
VLDR	Normal	30	5	0.30	0.05	Hi
LDR	Normal	50	15	0.30	0.05	Hi
MDR	Normal	50	30	0.25	0.05	Hi
MFR	Normal	50	45	0.25	0.05	Hi
Ind	Normal	60	55	0.15	0.03	Min
Comm	Normal	75	80	0.10	0.02	Min
Park	Normal	90	10	0.20	0.10	Hi
Rowcrop	Normal	85	0	0.50	0.10	Hi
School1	Normal	80	45	0.29	0.05	Hi

Note: Synthetic Unit Hydrograph Roughness Parameters per FCDMC criteria
Kn = S Graph
Kb = Clark Unit Hydrograph

TABLE A2
Rainfall Loss Parameters by Soil Type

USDA SCS		Dominant Soil	XKSAT	RTIMP
Map ID	Soil Family Name	Texture	in/hr	%
Aa	Agualt	Loam	0.26	0
AbA	Antho	Sandy Loam	0.38	0
AbB	Antho	Sandy Loam	0.39	0
AfA	Antho Carrizo	Sandy Loam	0.38	0
An	Avonda	Clay Loam	0.05	0
Ao	Avondale	Clay Loam	0.04	0
BP1 (Borrow Pit)	N/A	Clay Loam	0.04	0
Br	Brios	Loamy Sand	1.05	0
Bs	Brios	Sandy Loam	0.39	0
Bt	Brios	Loam	0.25	0
CA2	Calciorthids / Torriorthents	Sandy Loam	0.38	0
Cb	Carrizo	Sandy Loam	0.40	0
CO	Cherioni	Sandy Loam	0.29	20
Cp	Coolidge	Sandy Loam	0.40	0
CrB	Coolidge	Sandy Loam	0.40	0
Es	Estrella	Loam	0.25	0
Ge	Gilman	Loam	0.26	0
GgA	Gilman	Loam	0.25	0
Gr	Glenbar	Loam	0.23	0
Gt	Glenbar	Clay Loam	0.04	0
Gv	Glenbar	Clay	0.01	0
GxA	Gunsight / Rillito	Loam	0.23	0
Lb	Laveen	Sandy Loam	0.40	0
LcA	Laveen	Loam	0.25	0
LcB	Laveen	Loam	0.25	0
Le	Laveen	Clay Loam	0.04	0
Ma	Maripo	Sandy Loam	0.40	0
Mo	Mohall	Sandy Loam	0.39	0
Mp	Mohall	Loam	0.25	0
Mr	Mohall	Clay Loam	0.05	0
Ms	Mohall	Clay	0.01	0
PeA	Perryville	Sandy Loam	0.37	0
PsA	Pinal	Loam	0.25	0
RaB	Rillito	Sandy Loam	0.39	0
RbA	Rillito	Loam	0.26	0
RpE	Perryville / Pinal Rillito	45% Sandy Loam, 30% Loam	0.29	0
Ta	Toltec	Loam	0.25	0
Tc	Torriorthents	Sandy Loam	0.40	0
TD	Torripsamments / Torrifluvents	Loamy Sand	1.20	0
TfA	Tremant	Sandy Loam	0.37	0
Tg	Tremant	Clay Loam	0.04	0
Th	Tremant	Clay Loam	0.04	0
Tt	Trix	Clay Loam	0.04	0
Tu	Tucson	Loam	0.25	0

TABLE A2
Rainfall Loss Parameters by Soil Type

USDA SCS		Dominant Soil	XKSAT	RTIMP
Map ID	Soil Family Name	Texture	in/hr	%
Tw	Tucson	Clay Loam	0.05	0
Va	Valencia	Sandy Loam	0.39	0
Ve	Vecont	Loam	0.25	0
Vf	Vecont	Clay	0.01	0
Vg	Vint	Loamy Sand	0.91	0
Vh	Vint	Loam	0.27	0
Vk	Vint	Loam	0.26	0

APPENDIX B

Revised Hydrologic Parameters for Proposed Freeway Models

- TABLE B1: Sub-Basin Parameters Revised for Proposed Freeway
- TABLE B2: Rainfall Loss Parameters for Green & Ampt Method for Each Sub-Basin
- TABLE B3: Route Reaches Revised for Proposed Freeway
- Total Drainage Areas at Combines (Revised for proposed freeway)

Table B1
Sub-Basin Parameters Revised for Proposed Freeway

Sub-Basin ID [1]	Drainage Area mi² [2]	Flowpath Length miles [3]	Flowpath Elevation, in ft top [4]	Flowpath Elevation, in ft bottom [5]	Flowpath Slope ft/mi [6]	Clark UH Roughness Kb [7]	MCUHP Generated Tc hrs [8]	MCUHP Generated R hrs [9]
4-21	0.8848	1.659	1095	1062	19.9	0.080	1.50	0.93
5-21	0.4217	0.740	1074	1062.2	15.9	0.053	0.70	0.32
9-21E	0.8563	1.724	1078	1051	15.7	0.080	1.50	0.98
9-21W	0.1107	1.080	1066	1050	14.8	0.080	1.35	1.93
16-21E	0.8382	1.534	1063	1039	15.6	0.078	1.50	0.90
16-21W	0.1838	1.136	1068	1041	23.8	0.078	1.02	1.10
21-21E	0.7186	1.799	1055	1027	15.6	0.079	1.50	1.12
21-21W	0.2884	1.117	1043	1030	11.6	0.079	1.40	1.19
28-21E	0.5340	1.421	1045	1020	17.6	0.080	1.42	1.03
28-21W	0.4650	1.402	1036	1026	7.1	0.080	1.50	1.18
33-21E	0.7276	1.496	1036	1011.5	16.4	0.077	1.48	0.95
33-21W	0.2634	1.303	1031	1020	8.4	0.077	1.50	1.53
4-11E	0.1451	0.879	1020	1001	21.6	0.093	1.00	1.00
4-11W	0.0309	0.311	1020	1000	64.4	0.093	0.31	0.28

Note: (1) Soil parameters and land use values are assumed to be the same for each revised sub-basin as estimated for the Maryvale ADMS.
(2) All revised sub-basins are urban land use, thus time-area relation is urban.
(3) Tc & R are generated using the District's MCUHP program.

Table B2
Rainfall loss parameters for Green and Ampt method for each sub-basin

Sub-Basin ID [1]	Drainage Area mi² [2]	Values per Maryvale ADMS					Area of Freeway mi² [8]	Revised RTIMP % [9]
		IA inches [3]	DTHETA [4]	PSIF inches [5]	XKSAT in/hr [6]	RTIMP % [7]		
4-21	0.8848	0.49	0.19	6.60	0.22	2	0.017	2.02
5-21	0.4217	0.32	0.27	6.40	0.19	11	--	--
9-21E	0.8563	0.50	0.15	7.00	0.18	0	0.022	0.03
9-21W	0.1107	0.50	0.15	7.00	0.18	0	--	--
16-21E	0.8382	0.46	0.15	8.80	0.09	4	0.022	4.03
16-21W	0.1838	0.46	0.15	8.80	0.09	4	--	--
21-21E	0.7186	0.50	0.15	9.70	0.07	0	0.024	0.03
21-21W	0.2884	0.50	0.15	9.70	0.07	0	--	--
28-21E	0.5340	0.49	0.15	8.80	0.09	2	0.023	2.04
28-21W	0.4650	0.49	0.15	8.80	0.09	2	--	--
33-21E	0.7276	0.48	0.14	9.70	0.07	4	0.024	4.03
33-21W	0.2634	0.48	0.14	9.70	0.07	4	--	--
4-11E	0.1451	0.48	0.15	8.80	0.09	4	0.003	4.02
4-11W	0.0309	0.48	0.15	8.80	0.09	4	--	--

CONCLUSION: Freeway does <u>not</u> increase RTIMP for off-site watershed

Table B2
Rainfall loss parameters for Green and Ampt method for each sub-basin

Sub-Basin ID [1]	Drainage Area mi² [2]	Values per Maryvale ADMS					Area of Freeway mi² [8]	Revised RTIMP % [9]
		IA inches [3]	DTHETA [4]	PSIF inches [5]	XKSAT in/hr [6]	RTIMP % [7]		
4-21	0.8848	0.49	0.19	6.60	0.22	2	0.017	2.02
5-21	0.4217	0.32	0.27	6.40	0.19	11	--	--
9-21E	0.8563	0.50	0.15	7.00	0.18	0	0.022	0.03
9-21W	0.1107	0.50	0.15	7.00	0.18	0	--	--
16-21E	0.8382	0.46	0.15	8.80	0.09	4	0.022	4.03
16-21W	0.1838	0.46	0.15	8.80	0.09	4	--	--
21-21E	0.7186	0.50	0.15	9.70	0.07	0	0.024	0.03
21-21W	0.2884	0.50	0.15	9.70	0.07	0	--	--
28-21E	0.5340	0.49	0.15	8.80	0.09	2	0.023	2.04
28-21W	0.4650	0.49	0.15	8.80	0.09	2	--	--
33-21E	0.7276	0.48	0.14	9.70	0.07	4	0.024	4.03
33-21W	0.2634	0.48	0.14	9.70	0.07	4	--	--
4-11E	0.1451	0.48	0.15	8.80	0.09	4	0.003	4.02
4-11W	0.0309	0.48	0.15	8.80	0.09	4	--	--

CONCLUSION: Freeway does <u>not</u> increase RTIMP for adjacent sub-basins.

Table B3
Route Reaches Revised for Proposed Freeway

Maryvale ADMS			Revised for Proposed AFF Alignment						
Route Reach ID [1]	Length ft [2]	Slope ft/ft [3]	Length mi [4]	Slope ft/ft [5]	Manning's n [6]	Geometry Type [7]	B, ft [8]	H, ft [9]	New ID [10]
RGA15	2690	0.0005	1580	0.0029	n/a	n/a	n/a	n/a	n/a
R99A (1)	2610	0.0026	2700	0.0024	0.015	Trap	8	5.7	RAF1 (1)
R921W	5280	0.0024	4200	0.0024	Composite Route		--	--	--
n/a	--	--	3735	0.0010	0.015	Rect	15	10	RDC2-3 (2)
n/a	--	--	3735	0.0010	0.015	Rect	15	10	RDC3-4 (2)
RBH12 (2)	5222	0.0031	5225	0.0010	0.015	Rect	20	10	RBH12 (2)
RBH13 (2)	5290	0.0023	4150	0.0036	0.015	Rect	40	10	RBH13 (2)
RBH14	2270	0.0009	2406	0.0010	0.015	Trap	26	8	n/a
R99B (1)	2580	0.0030	2580	0.0008	0.015	Trap	12	8	RAF2 (1)
R99C (1)	2220	0.0018	2520	0.0008	0.015	Trap	20	8	RAF3 (1)
R1621W	5300	0.0022	4200	0.0022	Composite Route		--	--	--
RCB13	2640	0.0023	1400	0.0050	n/a	n/a	n/a	n/a	n/a
R99E (1)	2620	0.0026	2620	0.0018	0.015	Trap	15	5	RAF4 (1)
R2121W	5050	0.0027	3660	0.0027	Composite Route		--	--	--
R99F (1)	2660	0.0019	2720	0.0017	0.015	Trap	15	9	RAF5 (1)
R99G (1)	2680	0.0019	2880	0.0017	0.015	Trap	15	9	RAF6 (1)
R2821W	5300	0.0026	2600	0.0026	Composite Route		--	--	--
R99H (1)	2650	0.0009	2640	0.0010	0.015	Trap	15	12	RAF7 (1)
R99I (1)	2600	0.0009	2640	0.0010	0.015	Trap	15	12	RAF8 (1)
R3321W	5300	0.0008	3700	0.0008	Composite Route		--	--	--
R99J (1)	2690	0.0003	2960	0.0017	0.015	Trap	20	10	RAF9 (1)
R99K (1)	2640	0.0016	3100	0.0017	0.015	Trap	20	10	RAF10 (1)
R411W	5220	0.0008	4400	0.0008	I-10 Channel Route, (no change)				--
RMD16A	2660	0.0006	1420	0.0067	n/a	n/a	n/a	n/a	n/a

Note: (1) The ADMS routing reach was copied and used for east of the proposed freeway.
(2) Geometry revisions for BHROC model only (100AFBH.*)

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT ADOT-GC / AFF

PROJECT No. 95271.05 SHEET No. 1 OF 2

CALCULATED BY DTP DATE 16 OCT 97 CHECKED BY SZ DATE 18 OCT 97

HYDROLOGY

TOTAL DRAINAGE AREAS at COMBINES for PROPOSED FREEWAY

HEC-1 ID	MARYVALE ADMS TOTAL DRAINAGE AREA, in mi^2	DRAINAGE AREA TO WEST of Prop. Freeway, mi^2		REVISED TOTAL DRAINAGE AREA mi^2
C4-21	35.336	0.074		35.262
CGA9	35.336	0.074		35.262
CGA AF (CGA99)	35.336	0.074		35.262
C9-21	45.158	0.111		44.973
CAFA	N/A	0.111	+0.074 = 0.185	44.973
CBH AF	N/A	0.111		44.973
CBH6	45.158	0		45.158
C16-21	50.641	0.184		50.272
CCB7	50.641	0.184	+ 0.185 = 0.369	50.272
CCBAF	N/A	0.184		50.272
C99B	50.641	0		50.641
CCB99	50.641	0		50.641
C21-21	59.105	0.288		58.448
CIS8	59.105	0.288	+0.369 = 0.657	58.448
CAF B	N/A	0.288		58.448
CISAF	N/A	0.288		58.448
C99C	59.105	0		59.105
CIS99	59.105	0		59.105
C28-21	70.436	0.465		69.314
CTR8	70.436	0.465	+0.657 = 1.122	69.314
CAFC	N/A	0.465		69.314
CTRAF	N/A	0.465		69.314
C99D	70.436	0		70.436
CTR99	70.436	0		70.436

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CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT ADOT - GC / AFE

PROJECT NO. 95271.05 SHEET NO. 2 OF 2

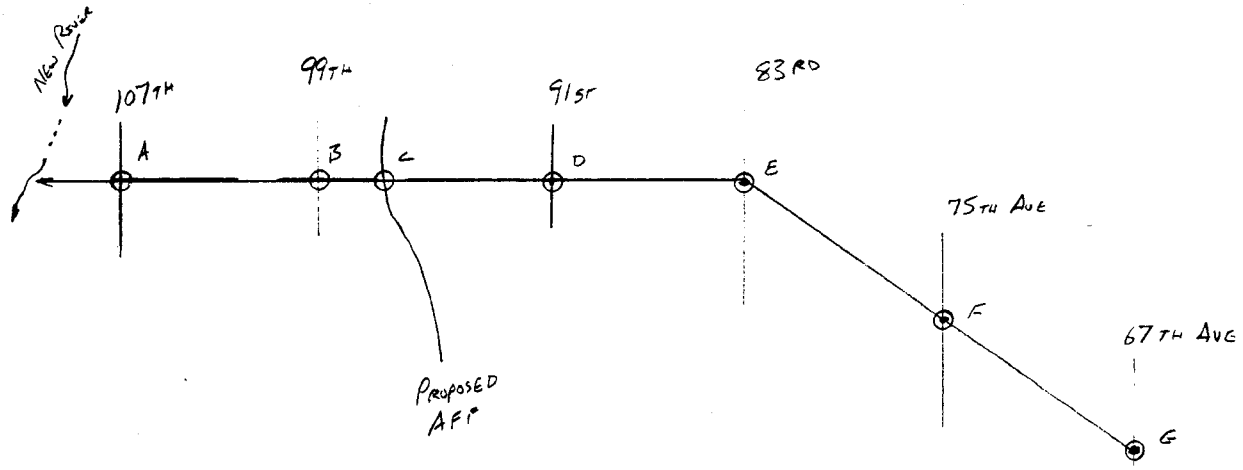
CALCULATED BY DM DATE 16 Apr 97 CHECKED BY SZ DATE 18 Oct 97

HEC-1 ID	MARYVALE ADMS TOTAL DRAINAGE AREA, in mi^2	DRAINAGE AREA TO WEST & PROP. FREEWAY, mi^2		REVISED TOTAL DRAINAGE AREA mi^2
C33-21	81.256	0.263		79.871
CMD9	81.256	0.263	+1.122 = 1.385	79.871
CAFD	N/A	0.263		79.871
CMDAF	N/A	0.263		79.871
C99E	81.256	0		81.256
CMD99	81.256	0		81.256
CI-10	N/A	0.031	+ 1.385 = 1.416	81.693
CI10AF	N/A	0.031		81.693
C4-11	83.109	0		83.109

ADOT - GC / AFF

DRAINAGE AREA REVISIONS to MARYVALE ADMS Model — 20 OCT 97

BETHANY HOME ROAD OUTFALL CHANNEL — DTP



LOCATION	MARYVALE ADMS DRAINAGE AREA (Sm)	Incremental W/S Sub-Basin Area (Sm)	REVISED Sm PROPOSED BHROC DRAINAGE AREA (Sm)
A	46.290	1.258	47.548
B	45.158		46.416
C	N/A (44.973)		46.231
D	43.317		44.575
E	34.871	0.432, Σ = 1.258	43.317
F	37.078	0.413, Σ = 0.826	37.904
G	28.700	0.413	29.113

APPENDIX C

HEC-1 Element Nomenclature

ADOT-GC Agua Fria Freeway

HEC-1 Element Nomenclature

○ **SUB-BASIN HYDROGRAPH GENERATION:**

Format: (section no.) - (township no.) (range no.)(optional alphanumeric)

Example: **17-32N**

Generate hydrograph for the northern portion of Section 17, T3N, R2E.

◇ **SUB-BASIN DIVERSION:**

Format: **D**(section no.)(**W, S, E,** or **N**)

Example: **D17S**

Southerly component of flow diversion of Section 17.

□ **SUB-BASIN ROUTE:**

Format: **R**(section no.)(township no.) (range no.)(**W, S, E,** or **N**)

Example: **R1732S**

Southerly component of flow route through Section 17, T3N, R2E.

△ **SUB-BASIN RESERVOIR ROUTE OR SURGE BASIN DIVERSION:**

Format: **RES**(section no.)

Example: **RES17**

Reservoir route or surge basin diversion in Section 17. Reservoir routes were used to model "regional retention basins" and "ponding areas."

In the Maryvale Mitigation Area, an alternate format was used to be consistent with a previous study. This format is:

PA(street no.)

Example: **PA43**

This corresponds to a ponding area at 43rd Avenue & the Grand Canal.

◇ SUB-BASIN RETENTION BASIN DIVERSION: Subdivision Retention Basins

Format: **RET**(section no.)

Example: **RET19**

Retention basin diversion in Section 19.

□ **STREET ROUTE:**

Format: **R**(street ID, up to 3 characters per street code)(sequential alphanumeric)

Example: **RPA1**

First route for Peoria Avenue.

Example: **R67C**

Third route for 67th Avenue.

◇ **STREET CAPACITY DIVERSION:**

Format: **S**(street ID, up to 3 characters) (sequential alphanumeric) (**W, S, E,** or **N**)

Example: **SPA1S**

First diversion from Peoria Avenue to the south.

Example: **S67CW**

Third diversion from 67th Avenue to the west.

◇ **STREET INTERSECTION DIVERSION:**

Format: **D**(street ID, up to 3 characters) (street ID, up to 3 characters)

Example: **DPA67**

Flow component in Peoria Avenue from diversion at Peoria & 67th Avenues.

Example: **D67PA**

Flow component in 67th Avenue from diversion at Peoria & 67th Avenues.

⬡ **STREET INTERSECTION COMBINE:**

Format: **C**(street ID, up to 3 characters) (street ID, up to 3 characters)

Example: **CPA67**

Flow combine at the intersection of Peoria & 67th Avenues.

STREET COMBINE:

Format: C(street ID, up to 3 characters) (sequential alphanumeric character)

Example: **CPA2**

Second flow combine along Peoria Avenue.

SUB-BASIN COMBINE:

Format: **C**(section no.) - (township no.) (range no.)(optional alphanumeric)

Example: **C17-32**

Hydrograph combine in Section 17, T3N, R2E.

Alternate formats C1732N, C1732A, C1732B, & ETC ... ...

These formats are used when there are multiple combines within a sub-basin and/or when the section is sub-divided into multiple sub-basins.

"NULL" COMBINE:

Format: **NULL**(sequential alphanumeric character)

Example: **NULL2**

Second NULL flow combine. NULL flow combines are strictly used to combine computational paths that terminate along the west side of the study area. Hence; the hydrographs associated with the NULL combines are meaningless.

STREET NAME CODES FOR NAMED STREETS

Street Name	Code
Thunderbird Road	TB
Cactus Road	CR
Peoria Avenue	PA
Olive Avenue	OA
Northern Avenue	NA
Glendale Avenue	GA
Bethany Home Road	BH
Camelback Road	CB
Indian School Road	IS
Thomas Road	TR
McDowell Road	MD
Agua Fria Freeway	AF

Note: The codes for numbered streets simply corresponds to the street number. For example the code for 51st Avenue is "51." The study area extends west from 27th Avenue to approximately 120th Avenue.

APPENDIX D

Rainfall Data

- Rainfall Depth-Duration-Frequency Data
- Rainfall Isopluvials for Maricopa County, Arizona

APPENDIX D

Rainfall Depth-Duration-Frequency Data

*** O U T P U T D A T A ***

REVISED JUNE 1988 TO UPDATE COMPUTATION OF SHORT-DURATION VALUES

PRECIPITATION FREQUENCY VALUES FOR ADOT-GC / Agua Fria Freeway,
PRIMARY ZONE NUMBER= 7
SHORT-DURATION ZONE NUMBER= 8

OPTION NUMBER 2 --- INPUT OF 12 PRECIP VALUES
LATITUDE 33.50N LONGITUDE 113.80W ELEVATION 1200 FEET

POINT VALUES

RETURN PERIOD

DURATION	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR	
5-MIN	.35	.44	.50	.59	.66	.72	.88	5-MIN
10-MIN	.52	.66	.76	.90	1.00	1.11	1.36	10-MIN
15-MIN	.64	.83	.96	1.14	1.28	1.42	1.75	15-MIN
30-MIN	.84	1.11	1.29	1.54	1.73	1.93	2.38	30-MIN
1-HR	1.03	1.37	1.59	1.92	2.16	2.41	2.98	1-HR
2-HR	1.10	1.47	1.73	2.08	2.36	2.63	3.27	2-HR
3-HR	1.14	1.55	1.82	2.20	2.49	2.78	3.45	3-HR
6-HR	1.23	1.68	1.99	2.41	2.73	3.06	3.81	6-HR
12-HR	1.30	1.82	2.16	2.64	3.01	3.37	4.22	12-HR
24-HR	1.37	1.95	2.34	2.87	3.28	3.69	4.63	24-HR

* IF YOUR SITE IS IN ARIZONA OR NEW MEXICO, PLEASE CONSULT THE
FOLLOWING PAPER FOR REVISED DEPTH-AREA VALUES:
DEPTH-AREA RATIOS IN THE SEMI-ARID SOUTHWEST UNITED STATES
NOAA TECHNICAL MEMORANDUM NWS HYDRO-40
ZEHR AND MYERS
AUGUST 1984

INPUT DATA

PROJECT NAME=ADOT-GC / Agua Fria Freeway,
ZONE= 7 SHORT-DURATION ZONE= 8
LATITUDE= 33.50 LONGITUDE= 113.80 ELEVATION= 1200
12-VALUE PRECIPITATION OPTION
PRECIPITATION VALUE:

1.20	1.70
2.00	2.40
2.80	3.00
1.40	2.00
2.30	2.80
3.20	3.80

* * * * E N D O F R U N * * * *

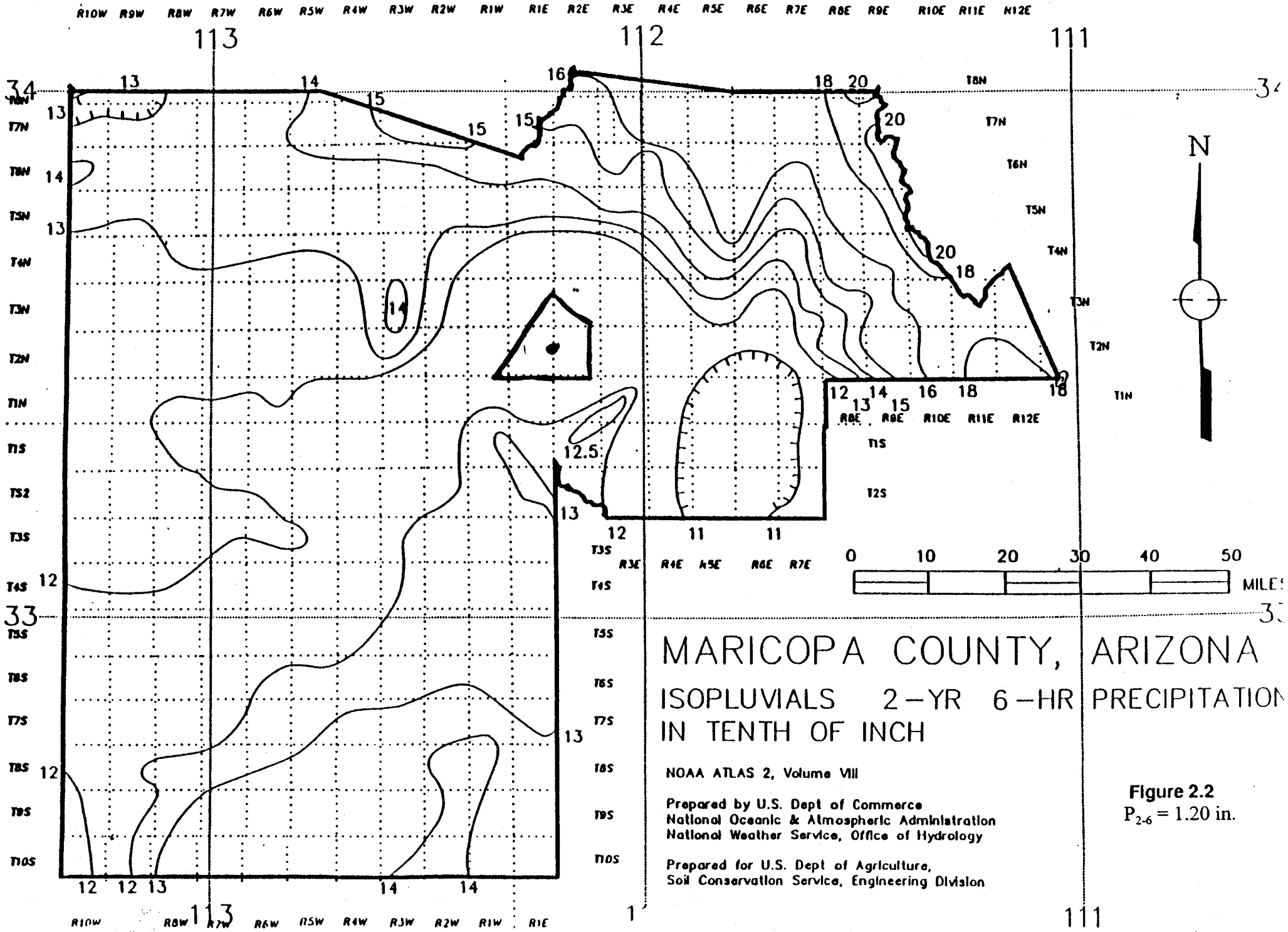


Figure 2.2
$P_{2\text{-}6} = 1.20$ in.

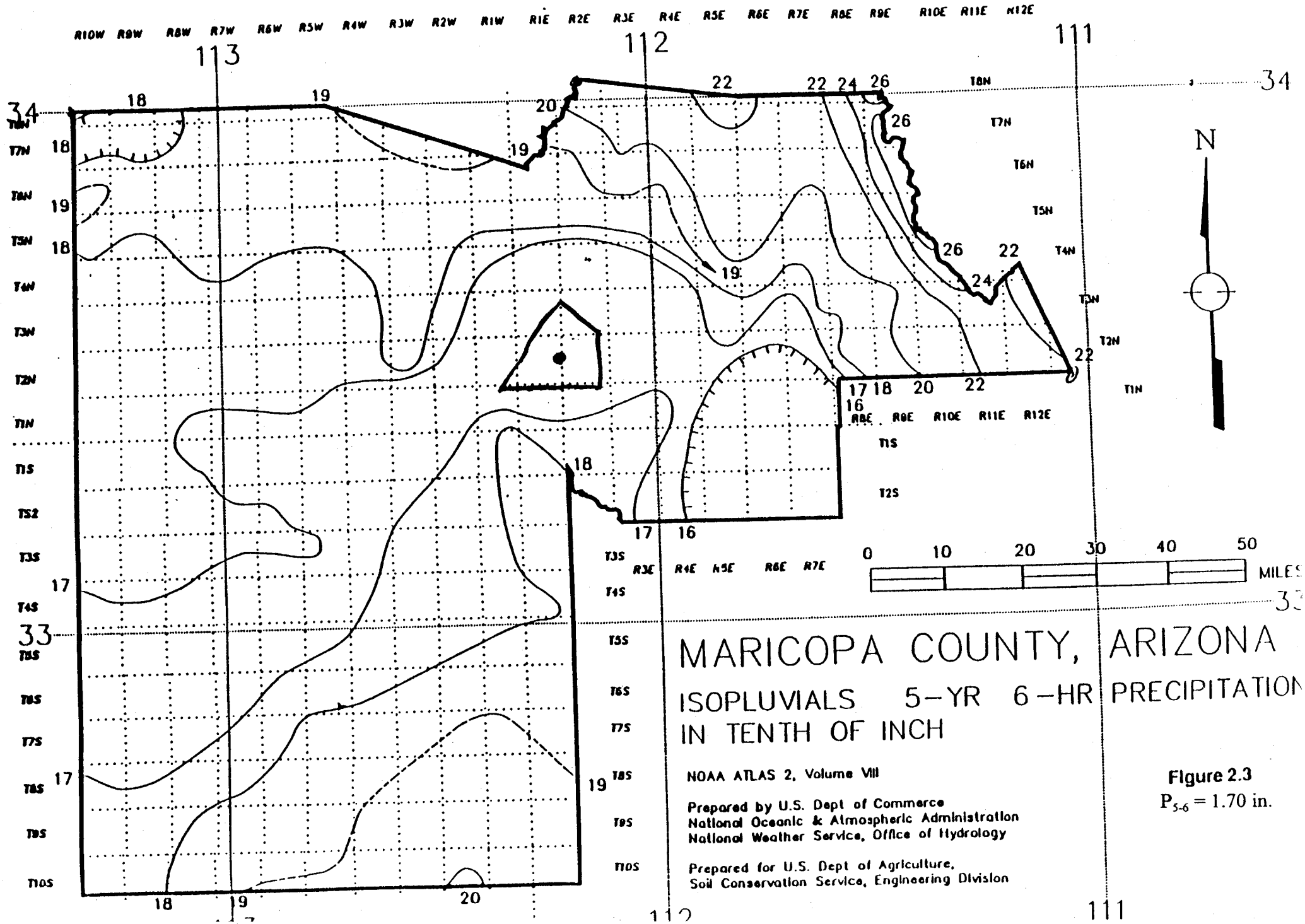


Figure 2.3
$P_{5\text{-}6} = 1.70$ in.

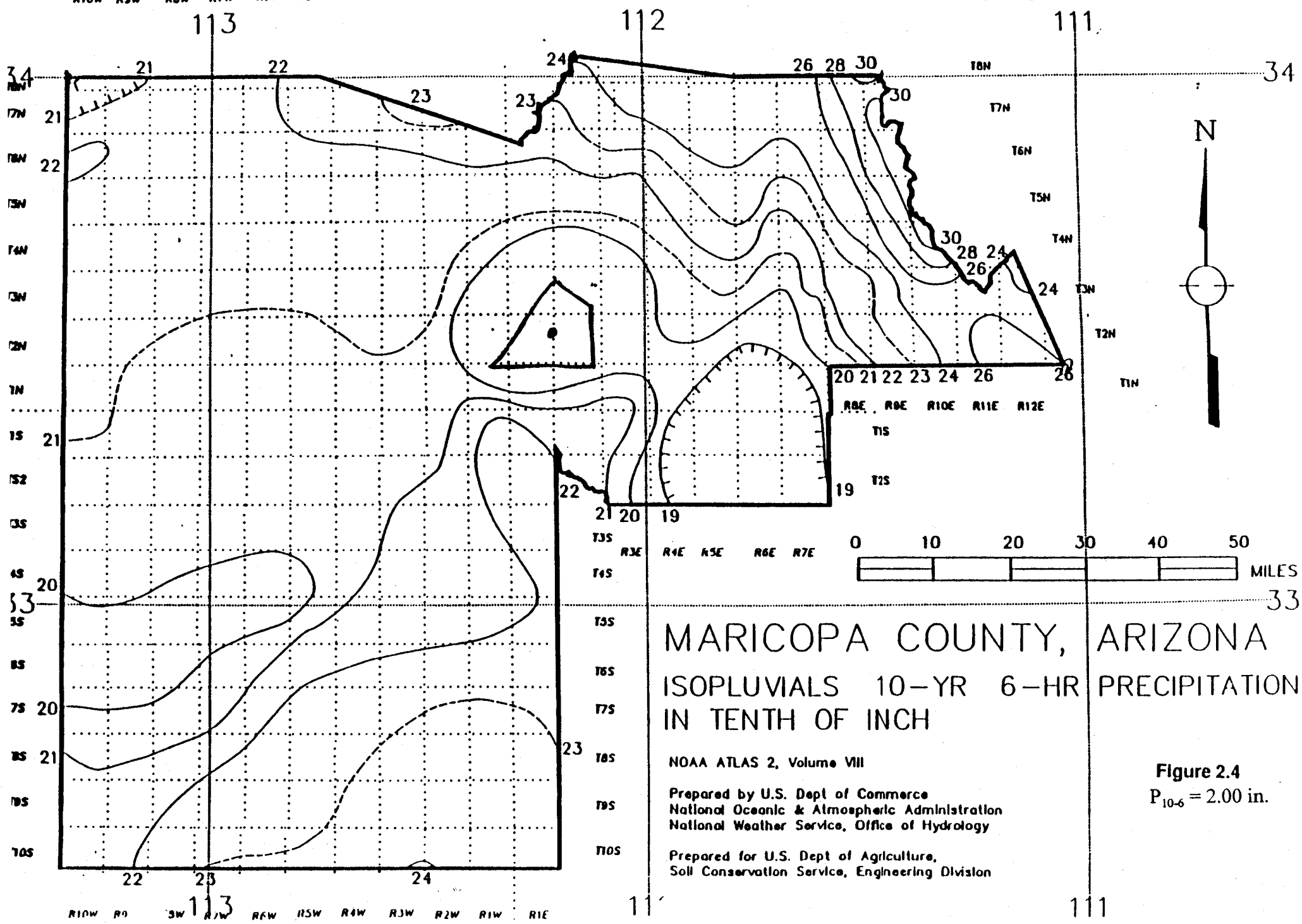


Figure 2.4
$P_{10\text{-}6} = 2.00$ in.

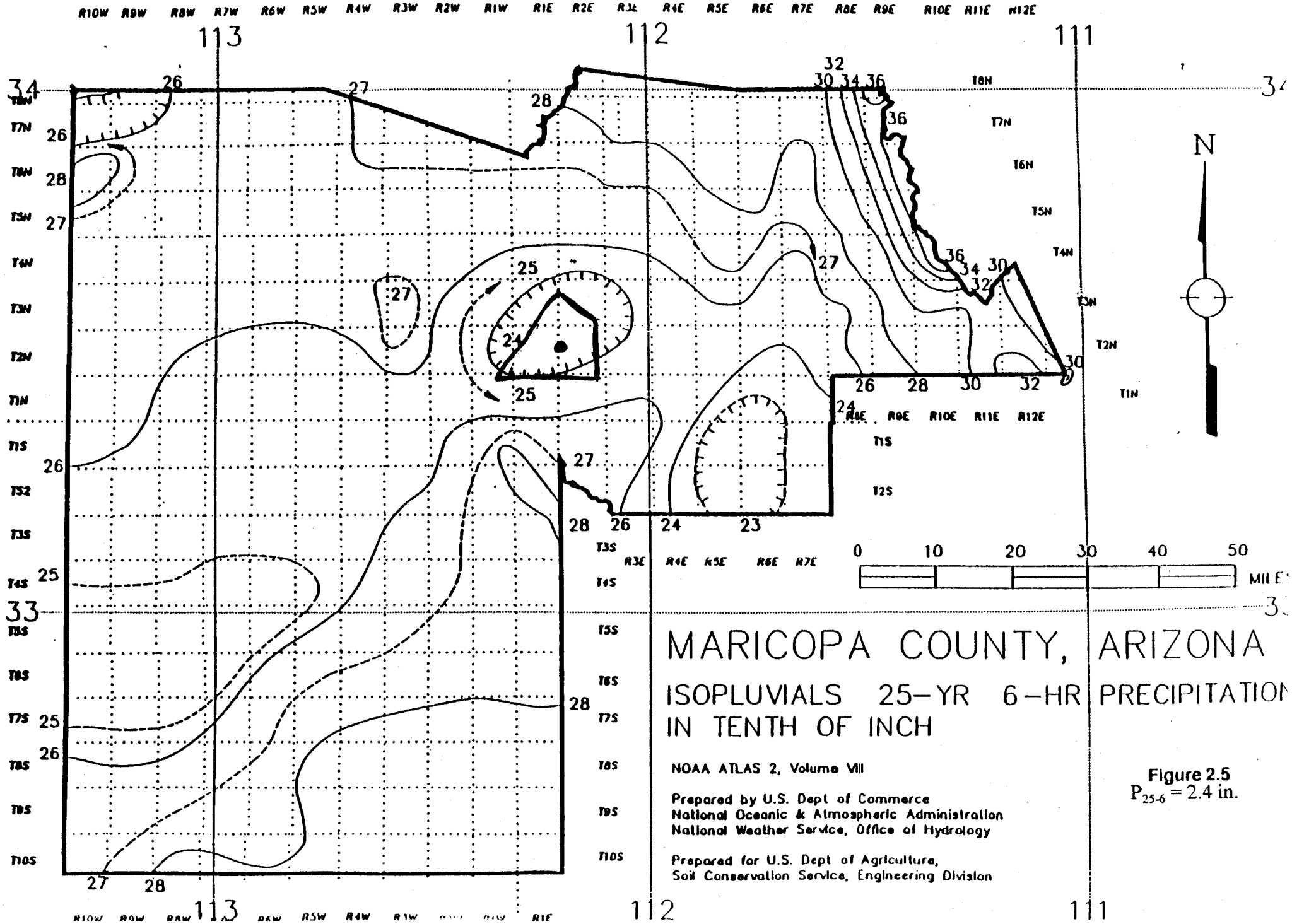


Figure 2.5
$P_{25\text{-}6} = 2.4$ in.

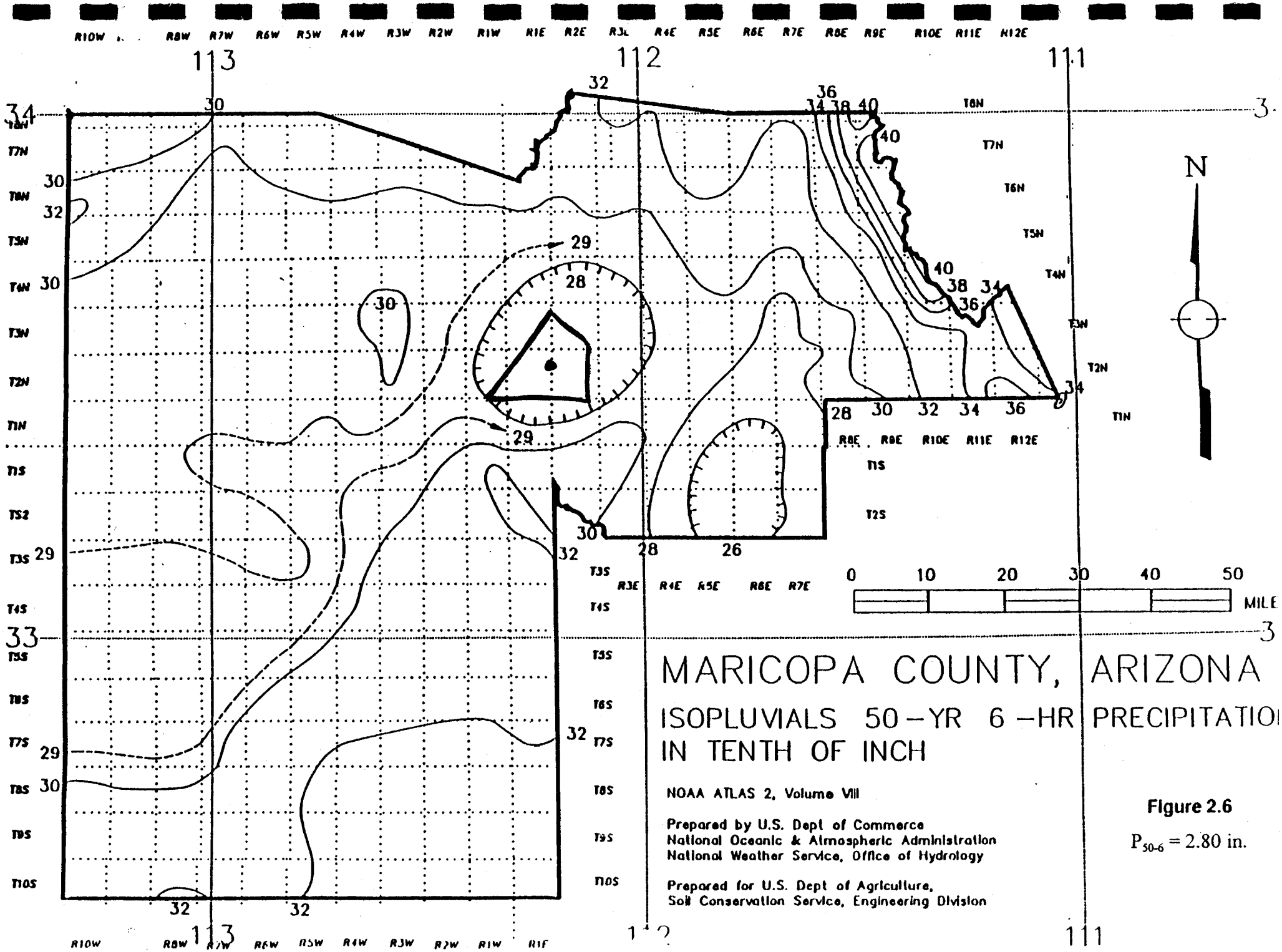


Figure 2.6

$P_{50\text{-}6} = 2.80$ in.

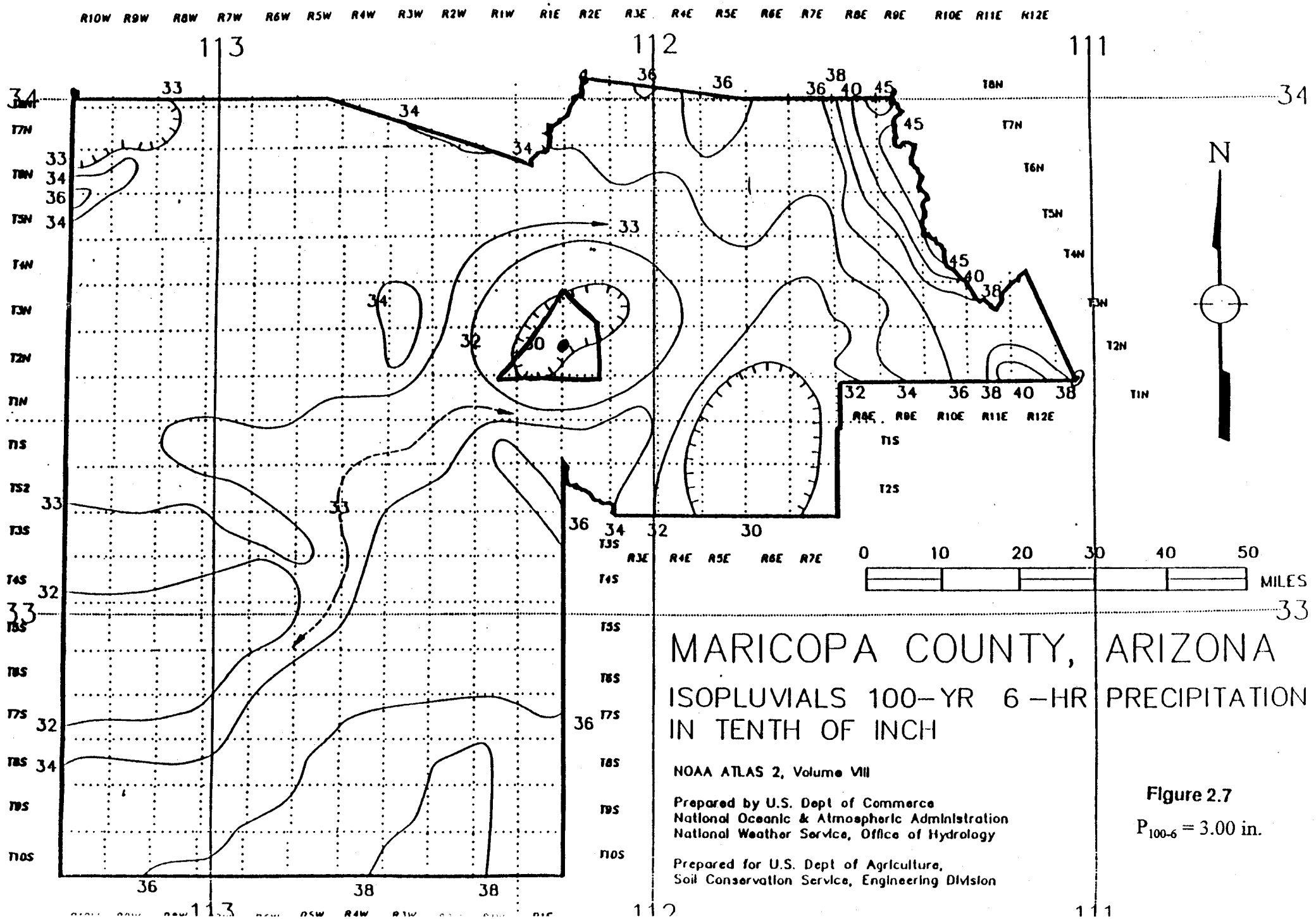


Figure 2.7

$P_{100\text{-}6} = 3.00$ in.

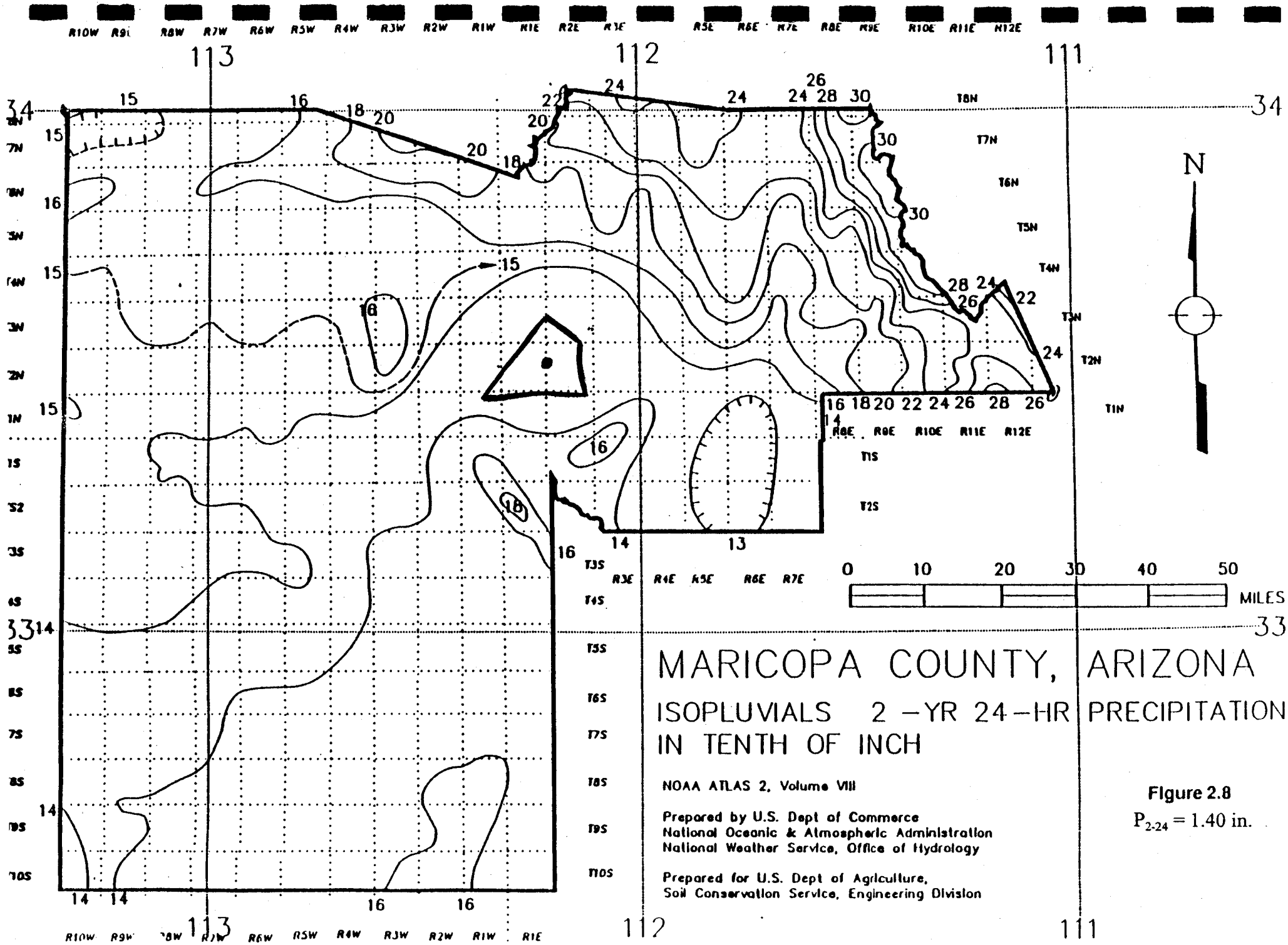


Figure 2.8

$P_{2\text{-}24} = 1.40$ in.

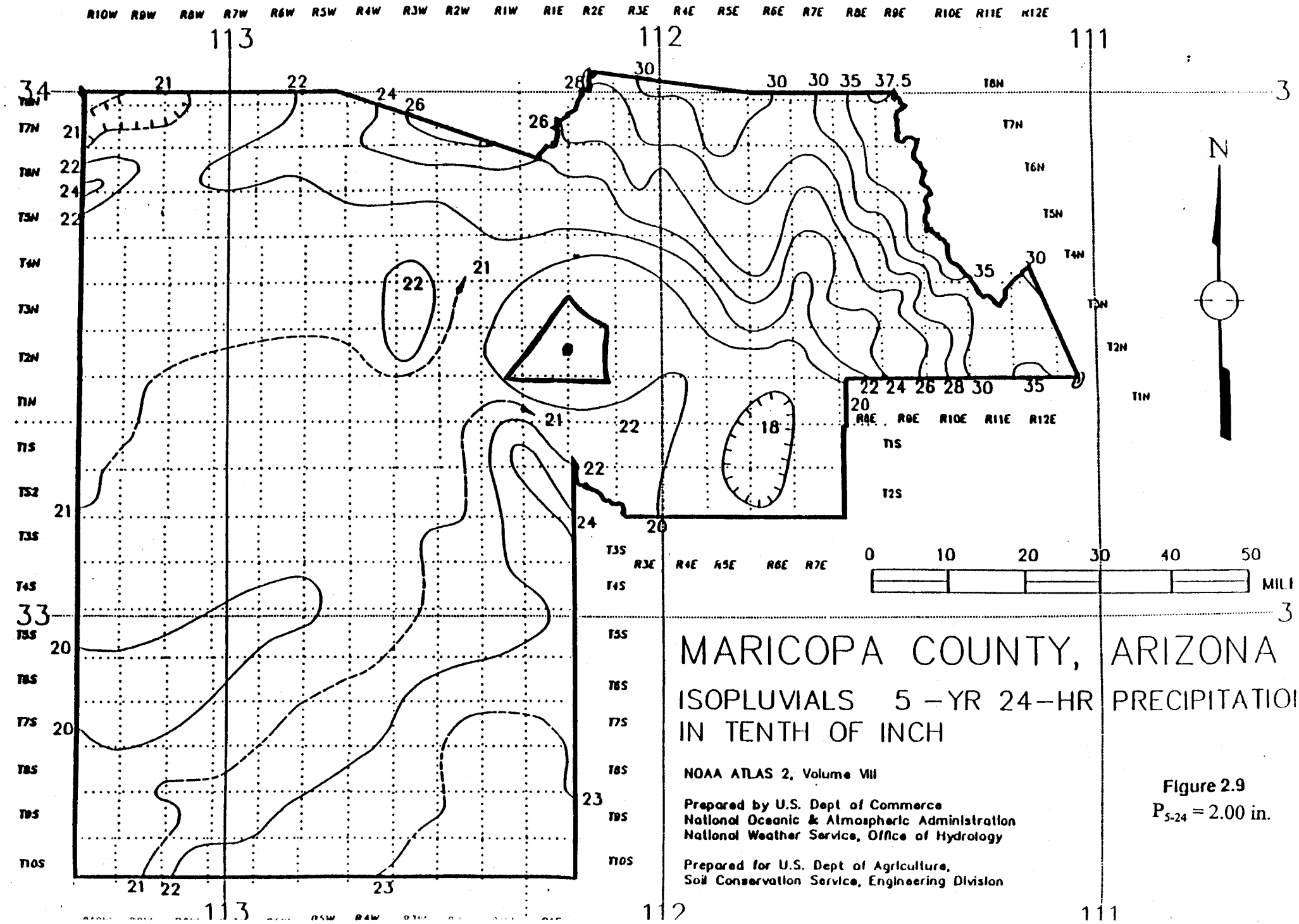


Figure 2.9
$P_{5\text{-}24} = 2.00$ in.

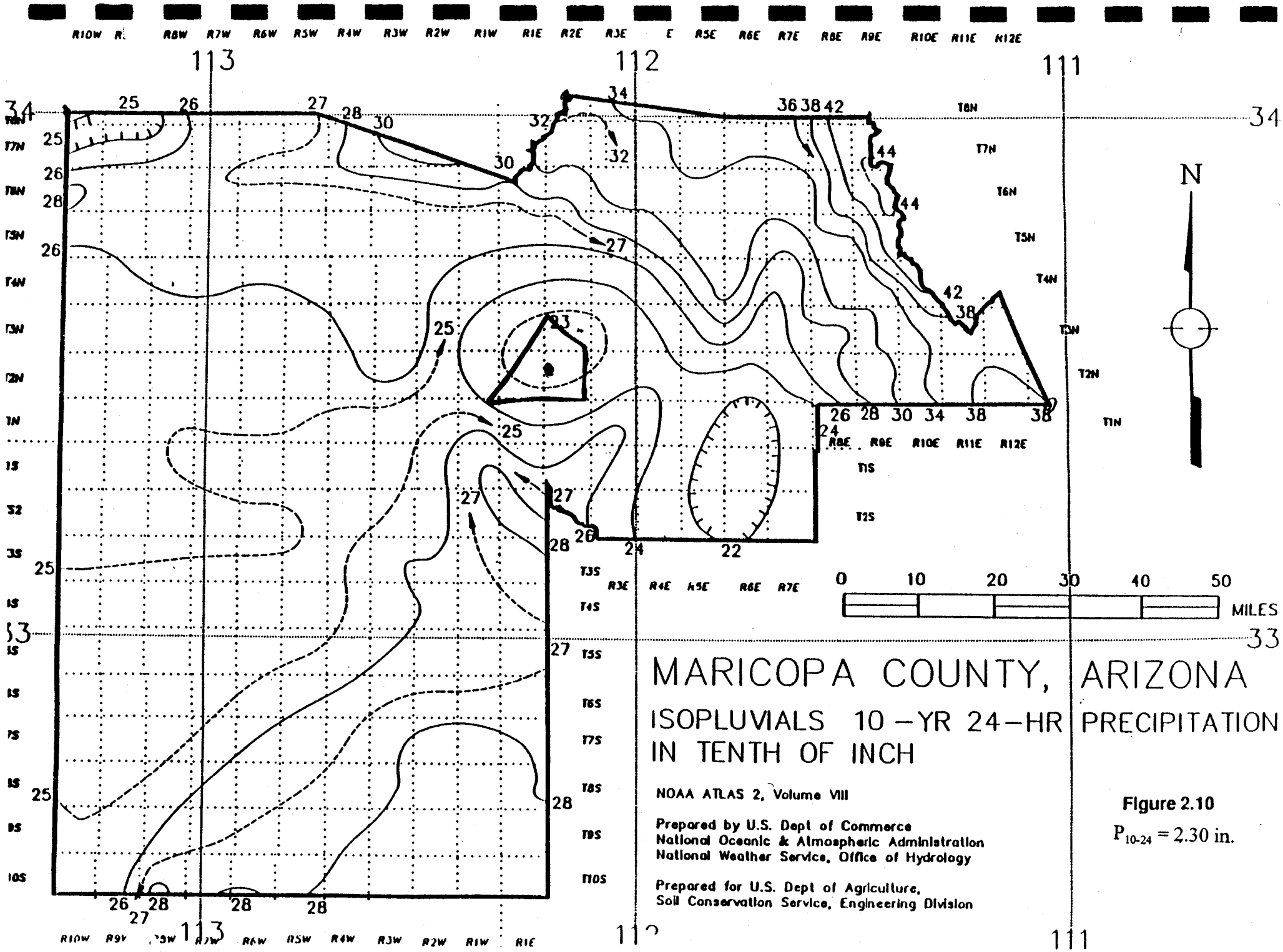


Figure 2.10

$P_{10\text{-}24} = 2.30$ in.

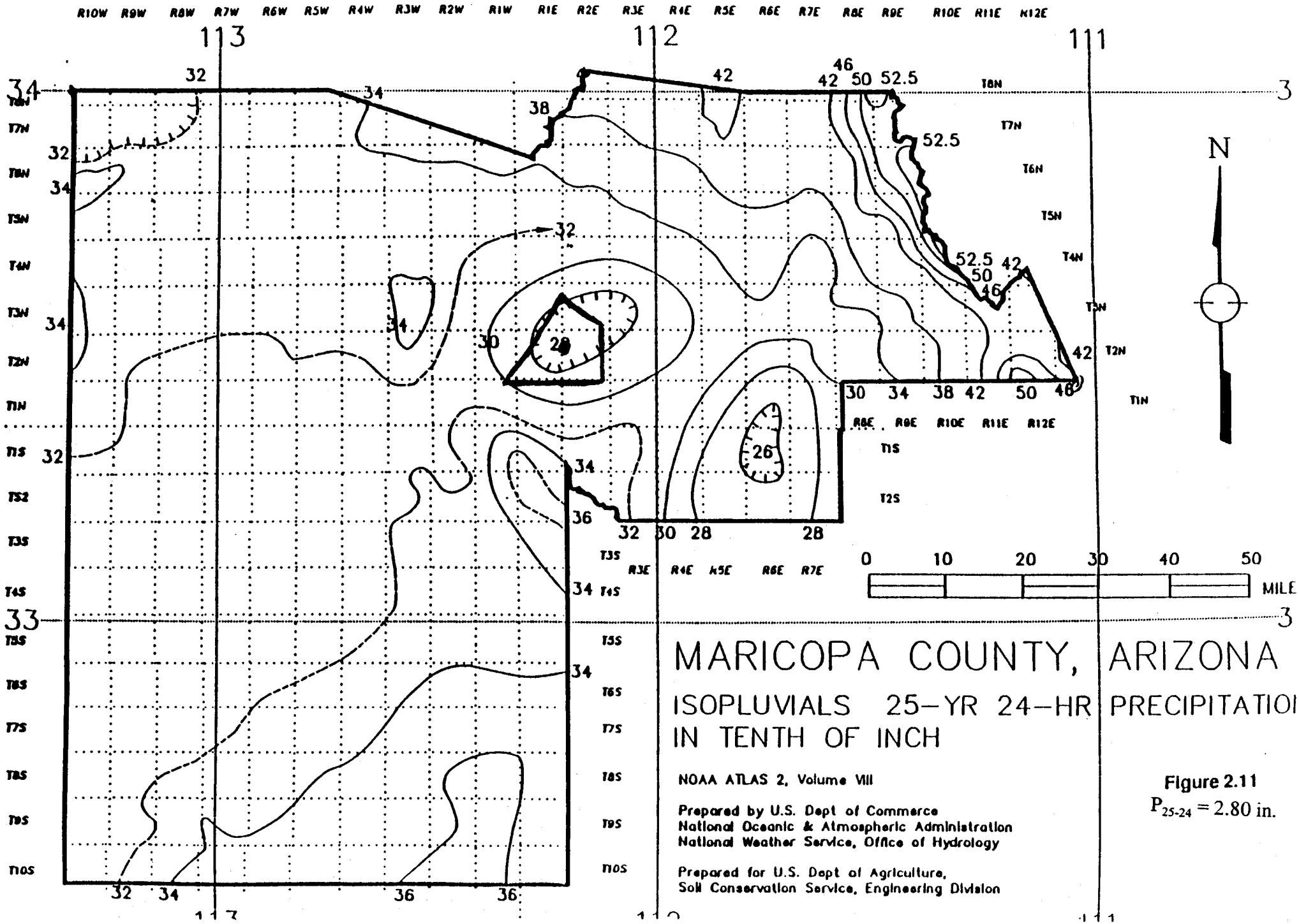


Figure 2.11
$P_{25\text{-}24} = 2.80$ in.

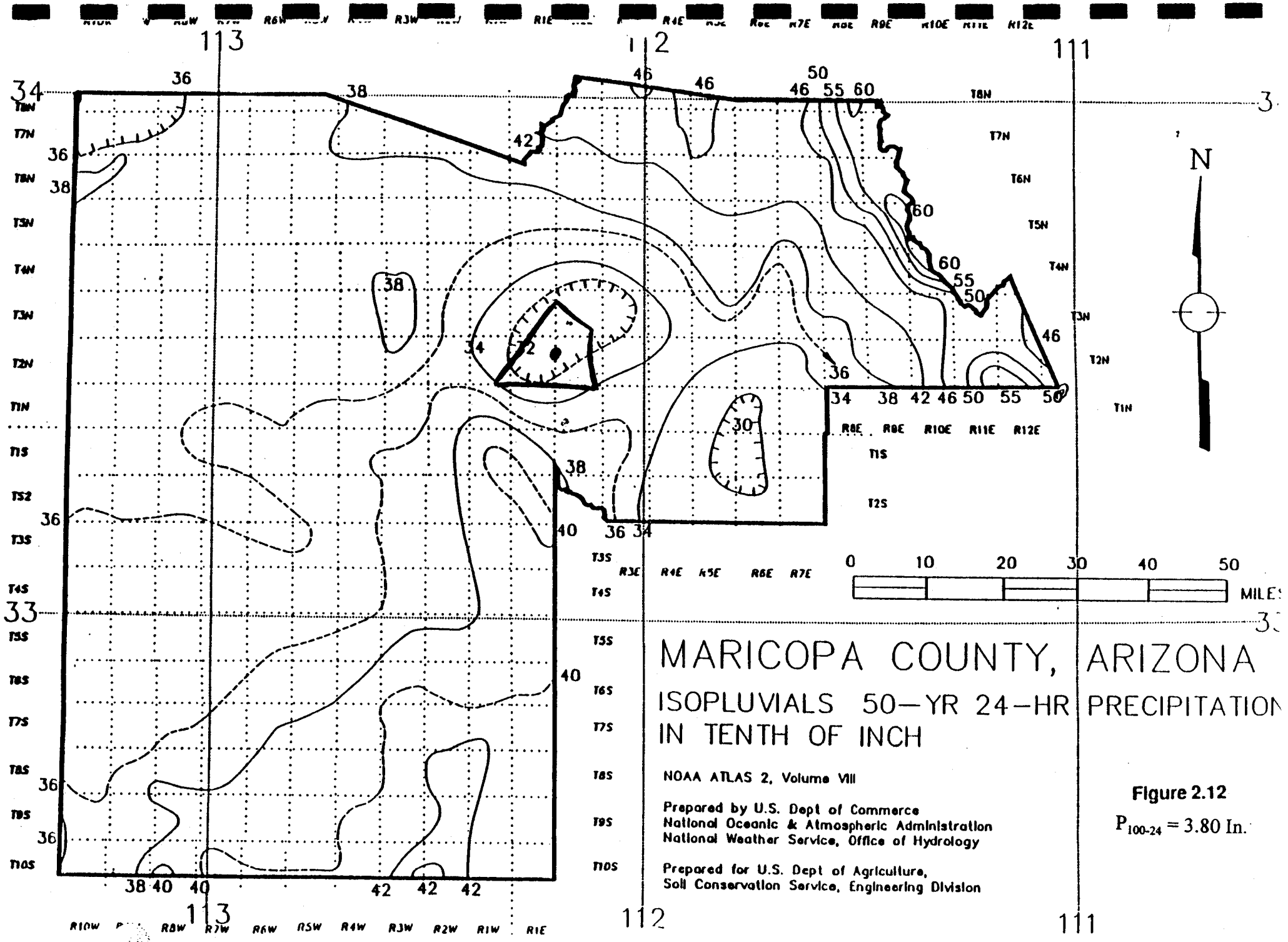


Figure 2.12

$P_{100\text{-}24} = 3.80$ In.

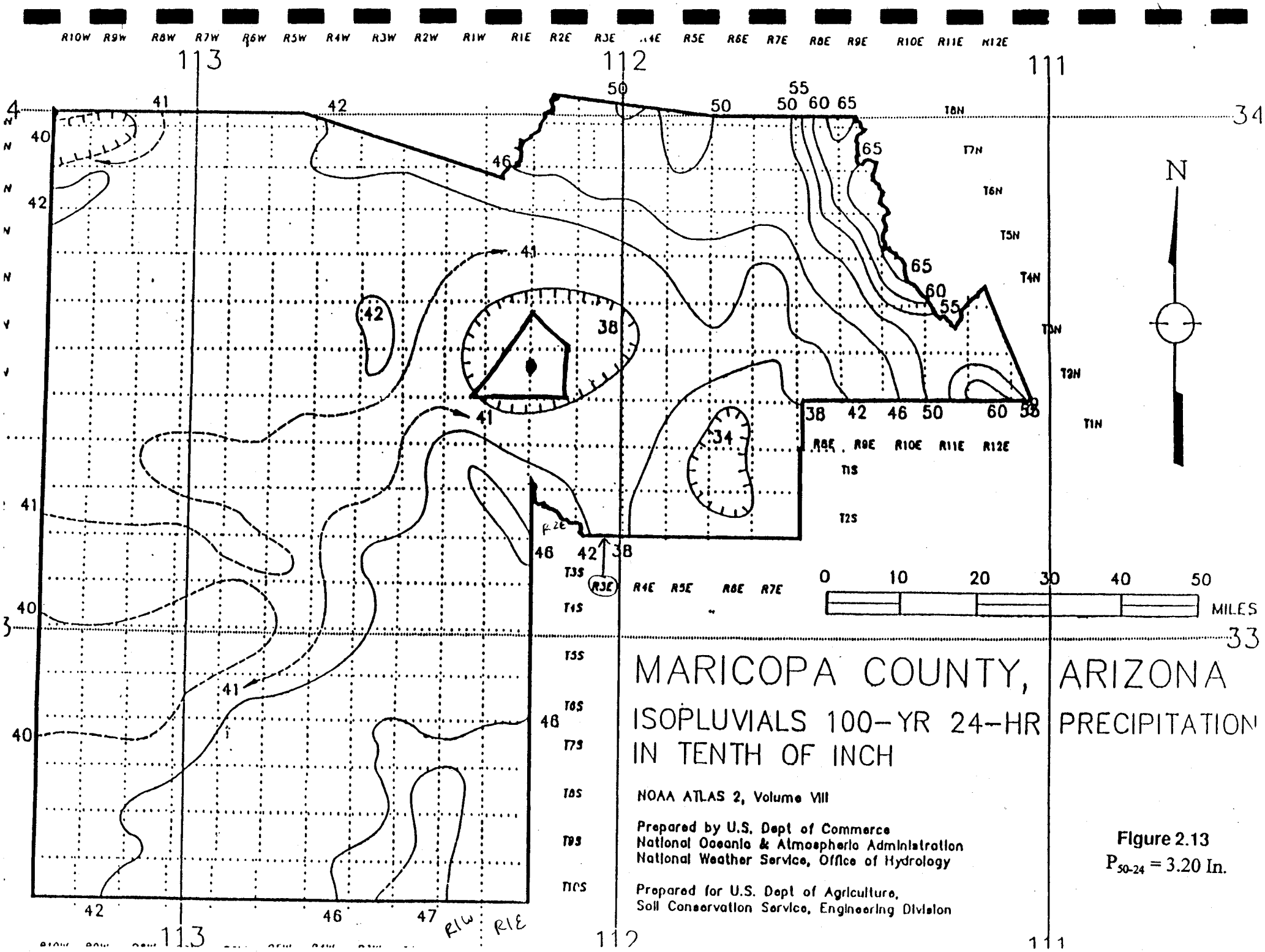


Figure 2.13
$P_{50\text{-}24}$ = 3.20 In.

APPENDIX E

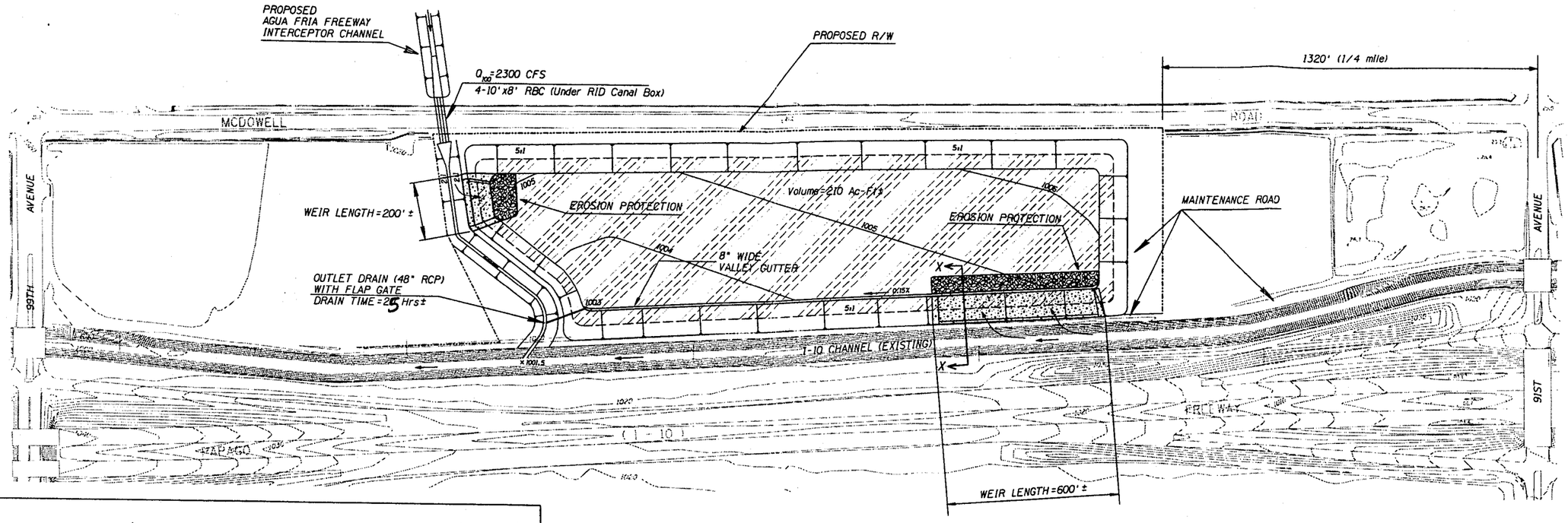
Electronic Copies of HEC-1 & HEC-RAS Models

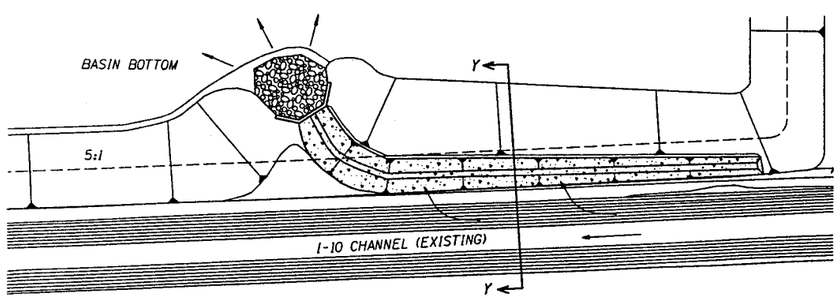
- Electronic Copies of HEC-1 Data
- Electronic Copies of HEC-RAS Data

APPENDIX F

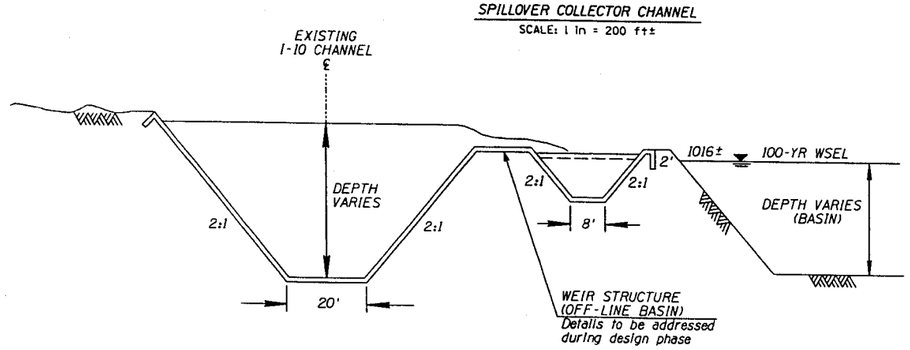
Proposed Off-Line Basin at I-10 and Agua Fria Freeway

- Preliminary Plan of Proposed Off-line Basin at I-10 & Agua Fria Freeway
- Hydrographs at Off-line basin
- Side Weir Concept Design
- Outlet Pipe Concept Design

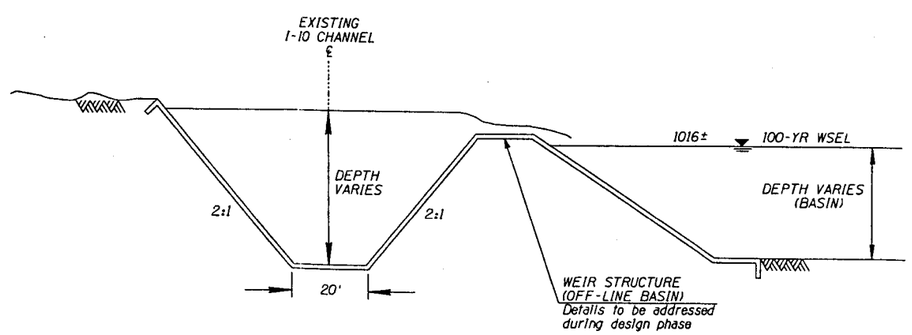




SPILLOVER COLLECTOR CHANNEL
SCALE: 1 in = 200 ft±



SECTION Y-Y
LOOKING WEST
(Option 2)



SECTION X-X
LOOKING WEST
(Option 1)

N

0 100 200 400
SCALE: 1 in = 400 ft

ARIZONA DEPARTMENT OF TRANSPORTATION

PRELIMINARY
NOT FOR
CONSTRUCTION
OR RECORDING

PROPOSED OFF-LINE BASIN

Wood, Patel & Associates, Inc.
1550 East Missouri, Suite 203
Phoenix, Arizona 85014 (602) 234-1344

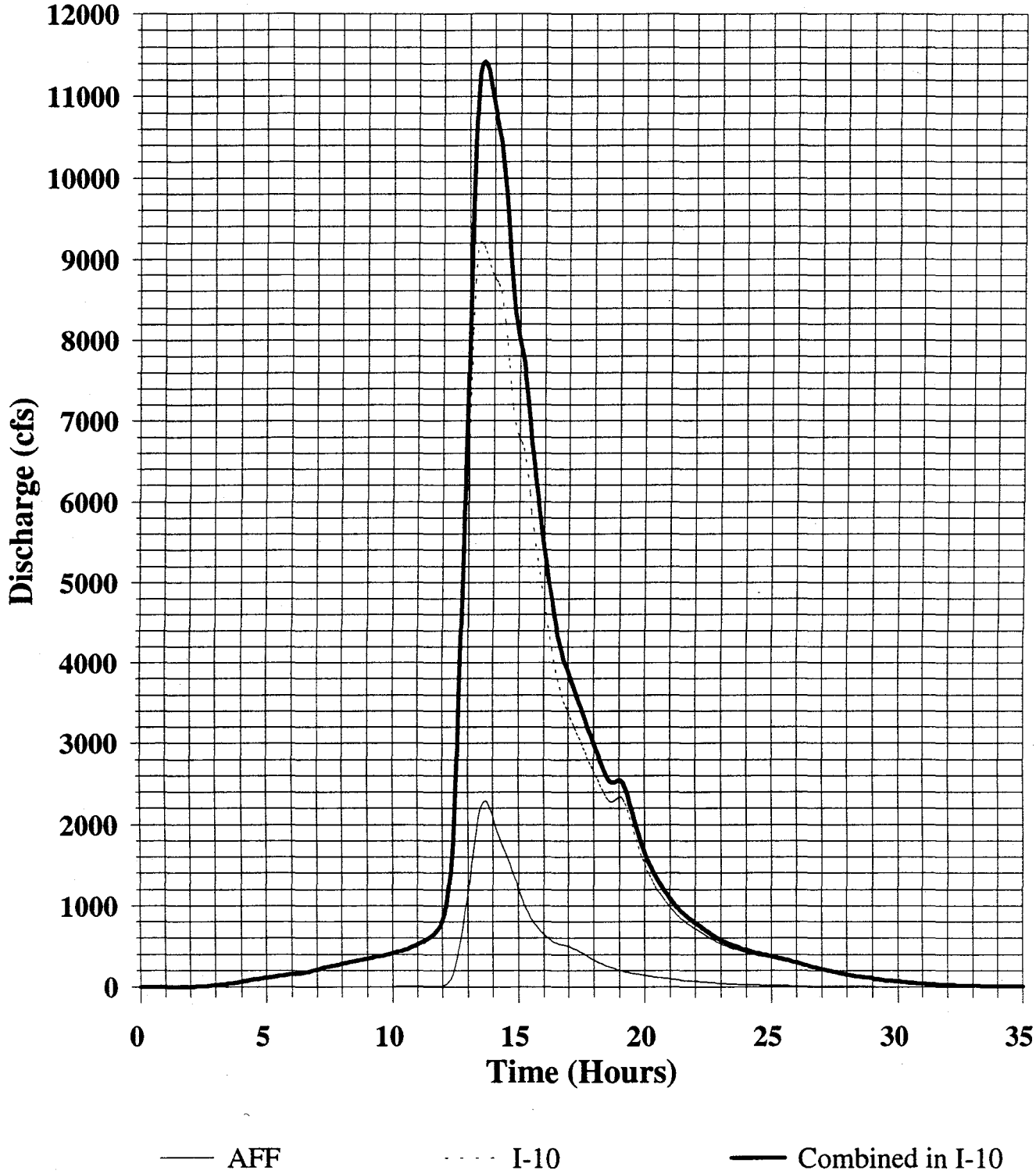
DRAWN BY: dtp
JOB NO: 95271.05

PLATE F-1

File = V:\970906\FIG F1.dgn 19-NOV-97

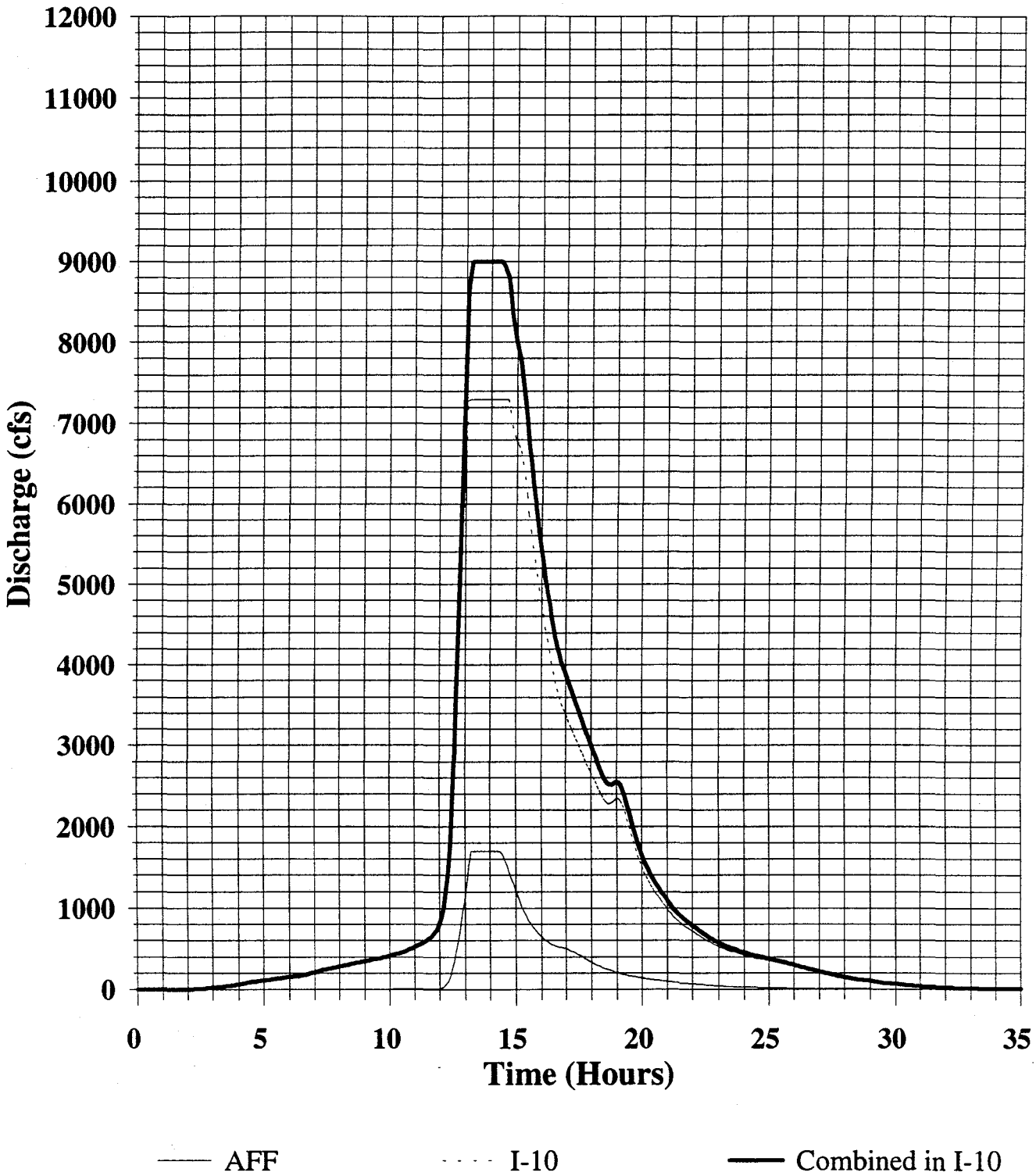
AFF INTERCEPTOR - Model 100AF1
I-10 & AFF @ Basin (100-yr, 24-hr)

INFLOW HYDROGRAPHS - WITHOUT BASIN



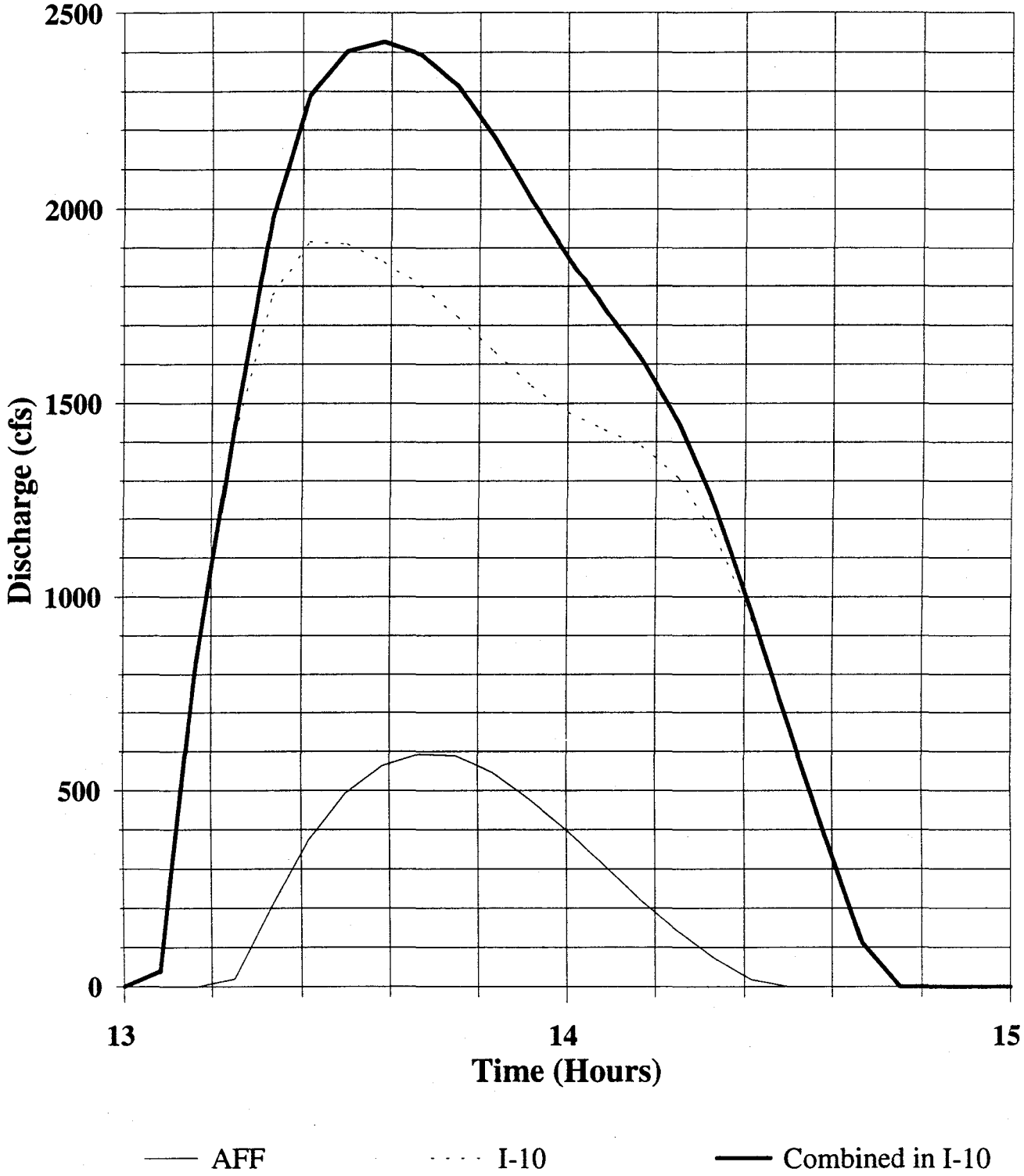
AFF INTERCEPTOR - Model 100AF1
I-10 & AFF @ Basin (100-yr, 24-hr)

HYDROGRAPHS for Channel Flow - WITH BASIN



AFF INTERCEPTOR - Model 100AF1
I-10 & AFF @ Basin (100-yr, 24-hr)

INFLOW HYDROGRAPHS - INTO BASIN



Side Weir Concept Design
Off-Line Basin at I-10 and Agua Fria Freeway

1. Hydrology

The simulated surface water runoffs for the 100-year 24-hour storm event from the revised Maryvale ADMS HEC-1 model are 2,294 cfs in AFF interceptor channel near I-10 and 9,217 cfs in I-10 channel near AFF. The combined peak flow is 11,422 cfs. In order to satisfy the I-10 downstream channel requirement (Qmax = 9,000), an off-line basin with 210 acre-foot storage is designed at the corner of the I-10 channel and AFF interceptor channel. To reduce the total flow to 9,000 cfs from 11,422 cfs, and divert 210 acre-foot flood water to the basin, 594 cfs from AFF interceptor channel and 1,917 cfs from the I-10 channel are required to be diverted to the basin. Therefore, 1,700 cfs from AFF interceptor channel and 7,300 cfs from I-10 channel (total 9,000 cfs) will by-pass to the I-10 downstream channel. The concept design of the basin is depicted on Plate F-1.

2. Hydraulics

Since the HEC-RAS program does not explicitly model side-spillway hydraulic systems, the following procedure was utilized.

2.1 Determination of Weir Elevations

The HEC-RAS surface water model for I-10 channel design was modified to include the AFF channel junction. The weir elevations were determined by the HEC-RAS model using the reduced flow conditions (1,700 cfs for AFF interceptor channel and 7,300 cfs for I-10 channel). The simulated water surface elevations are the design weir elevations based on the definition of the off-line basin. Table A (HEC-RAS Plan: Reduced-Flow) shows the simulation results.

2.2 Determination of Entrance Water Surface Elevations

The entrance water surface elevations near the beginning of the weirs were computed by the HEC-RAS model using the full flow conditions (2,294 cfs for AFF interceptor channel and 9,217 cfs for I-10 channel) with given downstream friction slope. Table B (HEC-RAS Plan: Full-Flow) shows the simulation results.

2.3 Determination of Water Surface Profiles in the Transition Regions

In order to determine the weir length, the unit flow rate over the spillway needs to be computed which is a function of the water surface elevation in the channel. Theoretically, this transition water surface profile is nonlinear as described by Equation 12-8 of Chapter 12 - Spatially Varied

Flow (Open-Channel Hydraulics, Chow, 1959). For the concept design, the water surface elevations in the transition regions were assumed to decrease linearly from the entrance elevation to the downstream elevation of the spillway, and a single representative water surface elevation was used to estimate the average unit flow rate over the spillway.

2.4 Determination of Unit Flow Rate Over Spillway

The following equations (Equations 14-10 and 14-11 of Chapter 14 - Flow Over Spillways, Open-Channel Hydraulics, Chow, 1959) were used to compute the incremental flow diversion over the spillway:

$$q = C\Delta LH^{1.5} \qquad (14\text{-}10)$$

$$C = 3.27 + 0.40H/h \qquad (14\text{-}11)$$

where ΔL is the incremental length of the weir, H is the measured head above the crest excluding the velocity head, and h is the height of weir.

2.5 Determination of Side-Spillway Weir Length

Equations 14-10 and 14-11 with known H and h values from HEC-RAS model were used to estimate the spillway lengths for both I-10 channel and AFF interceptor channel.

A. I-10 Channel

Q = 1,917 cfs, h = 14.20 ft, Hmax = 2.02 ft, H = 1.01 ft, C = 3.298, L = 570 ft.

B. AFF Interceptor Channel

Q = 594 cfs, h = 12.77 ft, Hmax = 2.12 ft, H = 1.06, C = 3.303, L = 165 ft.

3. Conclusion

Based on concept drainage design, two spillways will be required to divert predetermined volume of flood peak from both the I-10 channel and AFF interceptor channel to the off-line basin.

I-10 Channel Side Weir:

Design Q_{100} = 1,917 cfs
Head = 0 ft to 2.02 ft
Spillway length = 570 ft (Rectangular) or 600 ft ± (Trapezoidal)

AFF Interceptor Channel Side Weir:

Design Q_{100} = 594 cfs
Head = 0 ft to 2.12 ft
Spillway length = 165 ft (Rectangular) or 200 ft ± (Trapezoidal).

Please note that, for the concept design a rectangular weir was used. However, the design can also be modified to accommodate a trapezoidal shape weir. Should a perimeter maintenance road is required, the trapezoidal weir can easily accommodate the roadway. The weir section can be modified with the proper trapezoidal section during the design stage of this project.

Spillway into Off-line Basin:

The weir flow needs to be spilled into the off-line basin in a safe manner. Two options are proposed for this purpose as shown on Plate F-1.

A sloping spillway depicted by Section X-X can be utilized to allow weir spillover flow. This option, however, will require a large lined surface to reduce erosion potential. To reduce the lining surface, a collector channel parallel to the weir is recommended as depicted by Section Y-Y. The designer of the basin will be required to finalize the optimum structure for both weir locations.

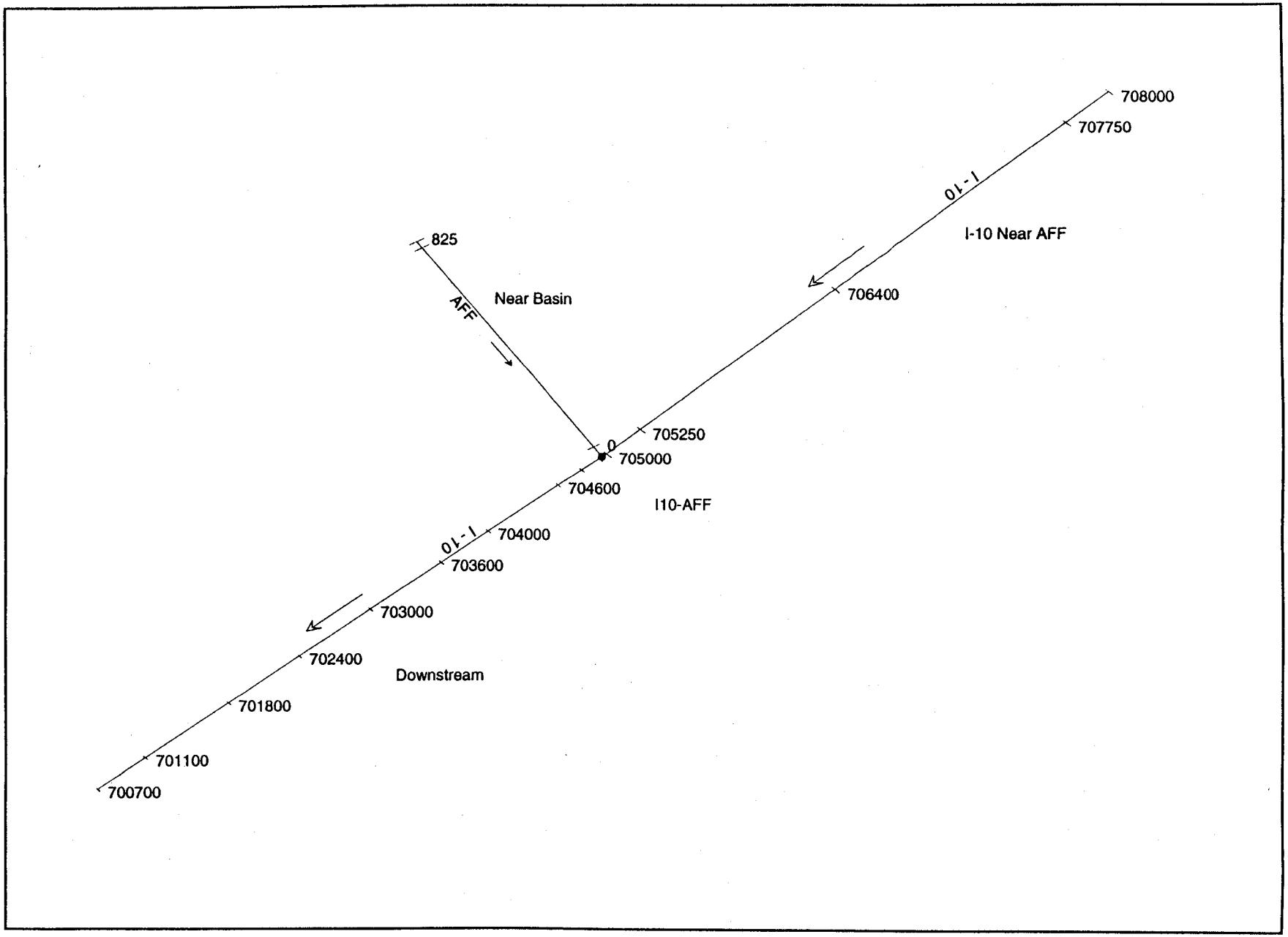

708000
707750
I-10
I-10 Near AFF
825
Near Basin
AFF
706400
705250
0
705000
704600
I10-AFF
I-10
704000
703600
703000
702400
Downstream
701800
701100
700700

Table A

HEC-RAS Plan: Reduced-Flow

River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
AFF	Near Basin	825	1700.00	1002.22	1014.97		1015.27	0.000101	5.81	427.57	59.06	0.29
AFF	Near Basin	800	1700.00	1002.20	1014.97		1015.27	0.000100	5.80	428.27	59.08	0.29
AFF	Near Basin	0	1700.00	1001.50	1014.93		1015.18	0.000079	5.34	468.36	61.73	0.26
I-10	I-10 Near AFF	708000	7300.00	1001.36	1014.93		1016.61	0.000586	10.38	703.39	80.54	0.62
I-10	I-10 Near AFF	707750	7300.00	1001.16	1014.81		1016.45	0.000574	10.30	708.51	80.74	0.61
I-10	I-10 Near AFF	706400	7300.00	1000.08	1014.30		1015.68	0.000461	9.44	773.71	85.67	0.55
I-10	I-10 Near AFF	705250	7300.00	999.16	1013.85		1015.15	0.000418	9.16	796.92	85.30	0.53
I-10	I-10 Near AFF	705000	7300.00	999.04	1013.73		1015.07	0.000429	9.28	786.65	83.93	0.53
I-10	Downstream	704950	9000.00	998.88	1012.21		1014.90	0.000960	13.15	684.26	79.58	0.79
I-10	Downstream	704800	9000.00	998.80	1011.86		1014.73	0.001047	13.58	662.70	78.41	0.82
I-10	Downstream	704600	9000.00	996.41	1011.68		1014.52	0.000976	13.52	665.84	73.58	0.79
I-10	Downstream	704000	9000.00	995.71	1010.62		1013.84	0.001141	14.42	624.34	70.07	0.85
I-10	Downstream	703600	9000.00	995.24	1010.15		1013.39	0.001147	14.45	622.93	69.89	0.85
I-10	Downstream	703000	9000.00	994.54	1009.59		1012.67	0.001077	14.08	639.13	71.26	0.83
I-10	Downstream	702400	9000.00	993.84	1008.85		1012.01	0.001110	14.27	630.62	70.34	0.84
I-10	Downstream	701800	9000.00	993.14	1007.89		1011.29	0.001215	14.79	608.69	68.81	0.88
I-10	Downstream	701100	9000.00	992.32	1007.08		1010.43	0.001197	14.68	613.05	69.39	0.87
I-10	Downstream	700700	9000.00	991.85	1006.78	1005.57	1009.90	0.001100	14.17	635.13	71.44	0.84

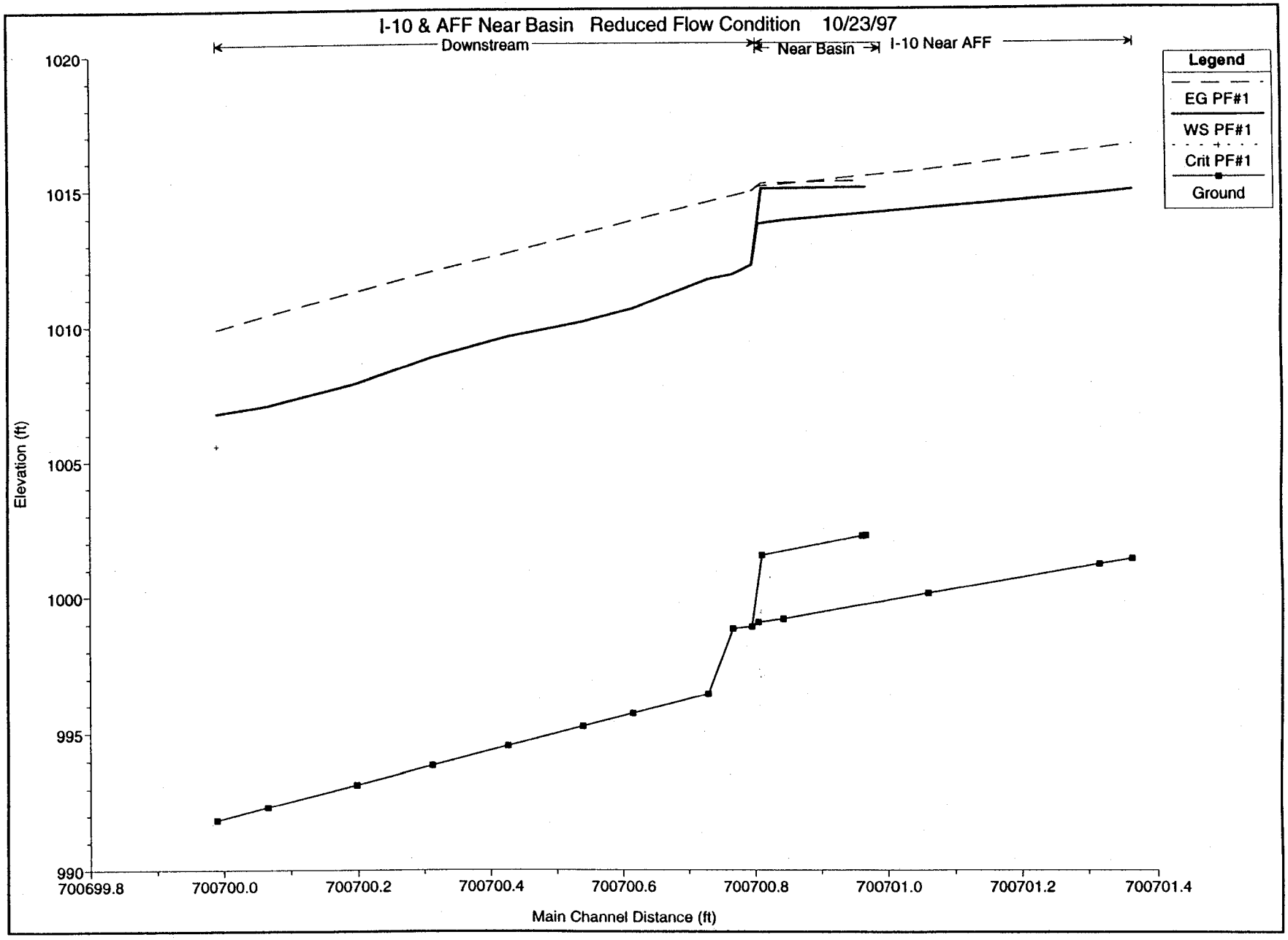
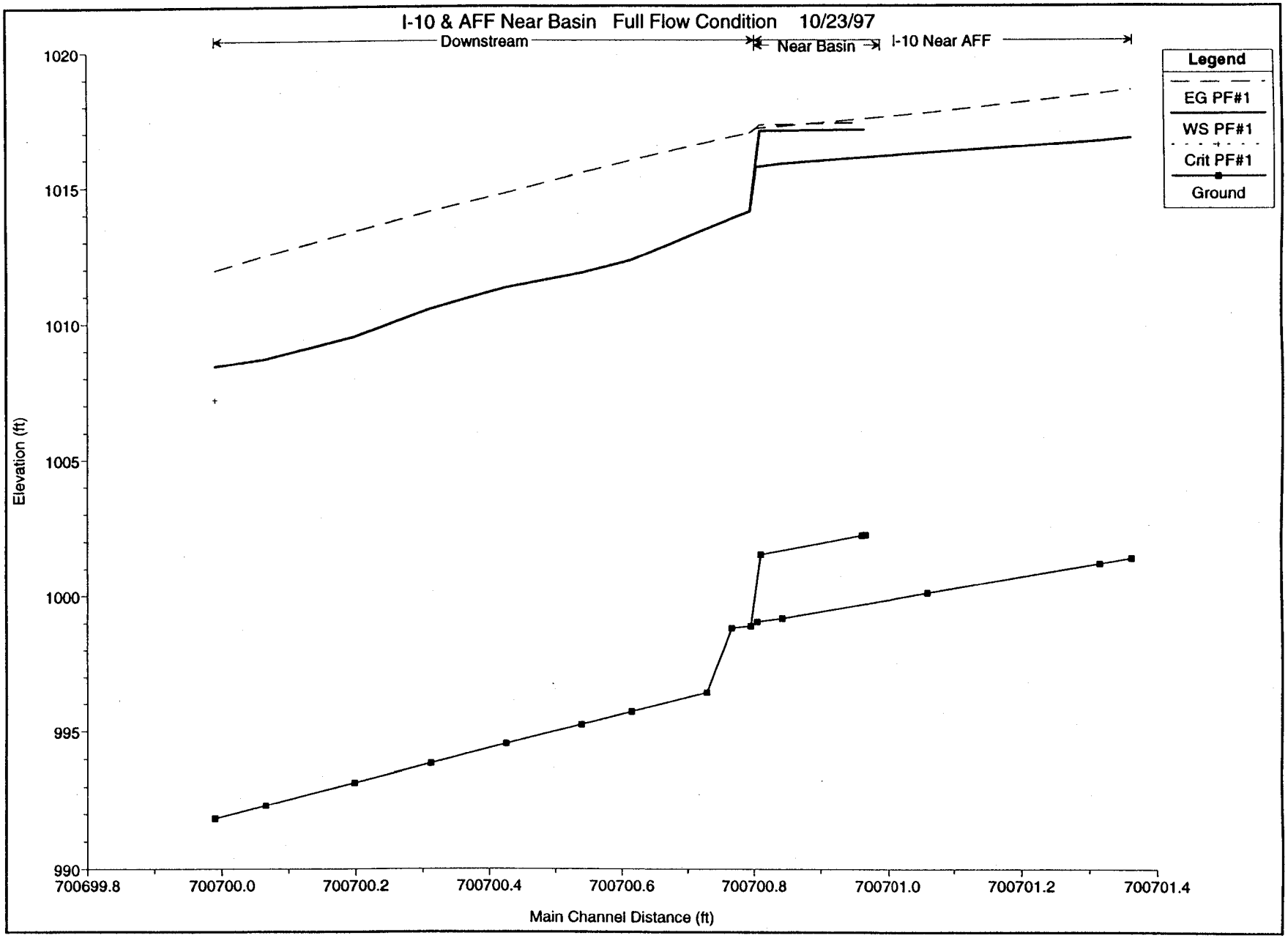

I-10 & AFF Near Basin Reduced Flow Condition 10/23/97
Downstream
Near Basin
I-10 Near AFF
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Elevation (ft)
1020
1015
1010
1005
1000
995
990
700699.8
700700.0
700700.2
700700.4
700700.6
700700.8
700701.0
700701.2
700701.4
Main Channel Distance (ft)

Table B

HEC-RAS Plan: Full-Flow

River	Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
AFF	Near Basin	825	2294.00	1002.22	1017.08		1017.34	0.000101	4.09	560.94	67.50	0.25
AFF	Near Basin	800	2294.00	1002.20	1017.08		1017.34	0.000100	4.08	561.66	67.51	0.25
AFF	Near Basin	0	2294.00	1001.50	1017.03		1017.25	0.000082	3.78	606.65	70.00	0.23
I-10	I-10 Near AFF	708000	9217.00	1001.36	1016.77		1018.56	0.000545	10.74	857.99	88.18	0.61
I-10	I-10 Near AFF	707750	9217.00	1001.16	1016.65		1018.42	0.000534	10.66	864.53	88.41	0.60
I-10	I-10 Near AFF	706400	9217.00	1000.08	1016.21		1017.69	0.000420	9.76	943.95	91.23	0.53
I-10	I-10 Near AFF	705250	9217.00	999.16	1015.81		1017.21	0.000385	9.49	971.17	91.68	0.51
I-10	I-10 Near AFF	705000	9217.00	999.04	1015.69		1017.12	0.000400	9.61	959.12	91.94	0.52
I-10	Downstream	704950	11422.00	998.88	1014.08		1016.95	0.000886	13.59	840.25	87.38	0.77
I-10	Downstream	704800	11422.00	998.80	1013.82		1016.80	0.000935	13.86	823.81	86.55	0.79
I-10	Downstream	704600	11422.00	996.41	1013.44		1016.59	0.000951	14.25	801.59	79.95	0.79
I-10	Downstream	704000	11422.00	995.71	1012.30		1015.93	0.001134	15.27	747.78	76.39	0.86
I-10	Downstream	703600	11422.00	995.24	1011.83		1015.47	0.001139	15.31	746.10	76.19	0.86
I-10	Downstream	703000	11422.00	994.54	1011.31		1014.75	0.001064	14.89	766.93	77.77	0.84
I-10	Downstream	702400	11422.00	993.84	1010.54		1014.10	0.001105	15.13	754.72	76.66	0.85
I-10	Downstream	701800	11422.00	993.14	1009.52		1013.37	0.001224	15.75	725.31	74.83	0.89
I-10	Downstream	701100	11422.00	992.32	1008.70		1012.50	0.001205	15.63	730.61	75.46	0.89
I-10	Downstream	700700	11422.00	991.85	1008.43	1007.19	1011.96	0.001102	15.06	758.40	77.78	0.85


I-10 & AFF Near Basin Full Flow Condition 10/23/97
Downstream
Near Basin
I-10 Near AFF
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Elevation (ft)
1020
1015
1010
1005
1000
995
990
700699.8
700700.0
700700.2
700700.4
700700.6
700700.8
700701.0
700701.2
700701.4
Main Channel Distance (ft)

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT [illegible] Freeway Off-Line Basin

PROJECT NO. 95271.05 SHEET NO. 1 OF 2

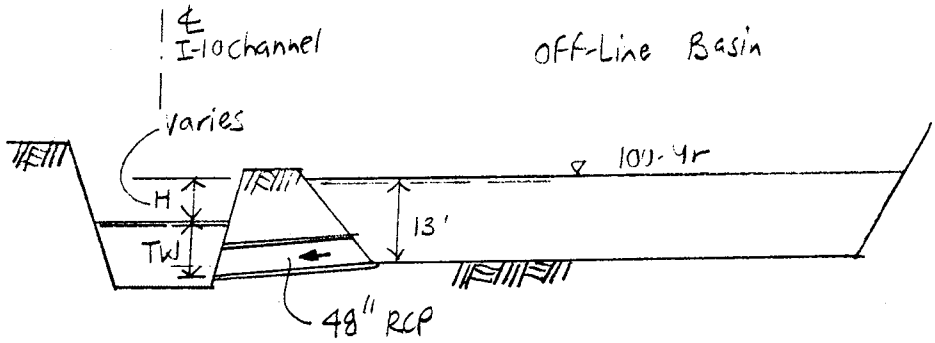
CALCULATED BY [illegible] DATE 11/97 CHECKED BY JKM DATE 11/97

Concept Design:

Off-Line Basin Drain Pipe

Given: [illegible] = [illegible]
Basin Bottom = [illegible] } head = 0' to 8'
Basin Storage = 210 AcFt

Assumptions:
- Assumed Tail water ≙ 4' (TW)
- Pipe to drain when the I-10 channel has receded.
- Drain time = 36 hours (maxm) after the storm



Cross-section

Based on are head ≙ 6.6 ft (see sht. 2/2)
capacity of 48" RCP outlet = 100 cfs ±

check drain time:

Storage volume = 210 × 43560 = 9,147,600 cft

Drain Time Reqd = $\frac{9,147,600}{100 \times 3600 \text{ sec}}$ = 25.4 hrs < 36 hrs ∴ OK

Conclusion: A 48" RCP is needed to meet the 36 hr drain time.
To prevent the basin to be flooded by the water from I-10 channel, a backflow (flapgate) prevention device will be required

Sht. 2/2

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

November 20, 1997
Off-Site Drainage
Agua Fria Freeway, OFF-LINE BASIN, Outlet Pipe
Outlet Capacity for Variable head conditions

==========

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet)	4.00
FHWA Chart Number (1,2 or 3)	1
Scale Number on Chart (Type of Culvert Entrance)	1
Manning's Roughness Coefficient (n-value)	0.0130
Entrance Loss Coefficient of Culvert Opening	0.50
Culvert Length (feet)	160.0
Culvert Slope (feet per foot)	0.0025

==========

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
50.0	4.00	3.12	4.16	2.46	2.12	4.00	3.98
75.0	4.00	4.12	4.86	3.45	2.62	4.00	5.97
100.0	4.00	5.22	5.85	4.00	3.03	4.00	7.96
125.0	4.00	6.62	7.11	4.00	3.36	4.00	9.95
150.0	4.00	8.35	8.65	4.00	3.60	4.00	11.94
175.0	4.00	10.40	10.48	4.00	3.75	4.00	13.93
200.0	4.00	12.76	12.58	4.00	3.85	4.00	15.92

==========

PIPE CULVERT ANALYSIS COMPUTER PROGRAM Version 1.7 Copyright (c)1986
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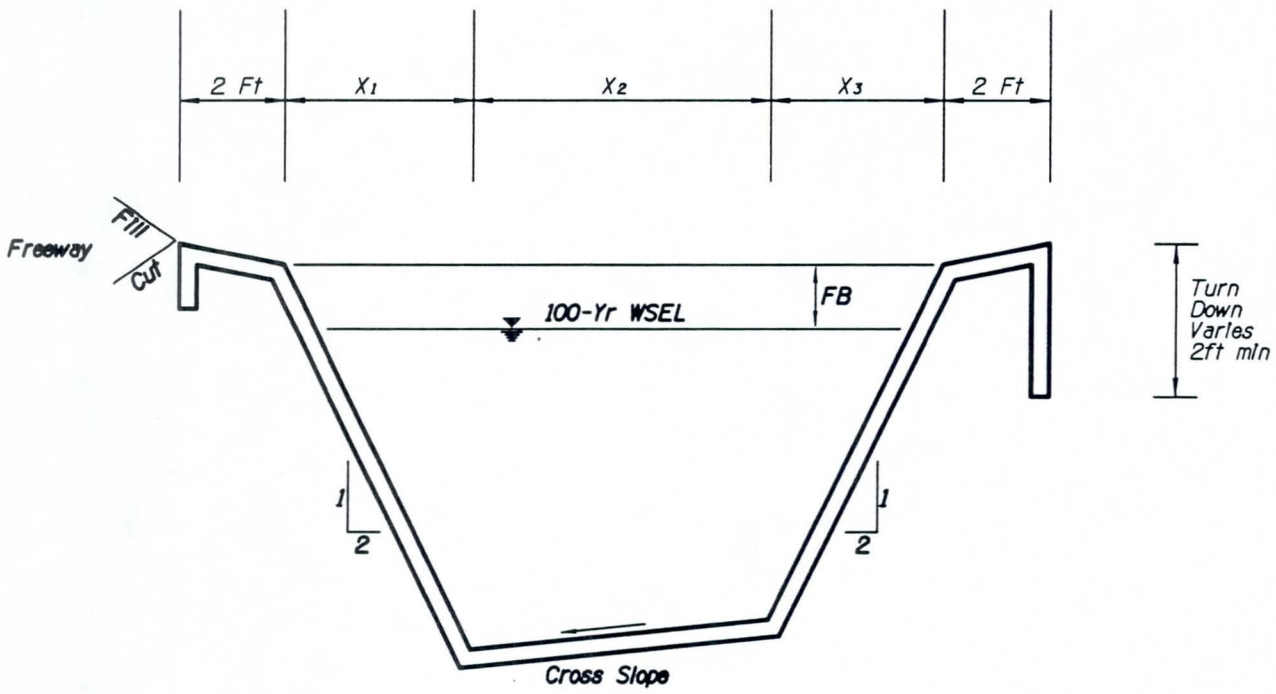
APPENDIX G

Typical Cross-Section Details

- TABLE G1: Typical Cross-Section Details
- TABLE G2: Summary of Roadway Crossings



Typical Channel Section
N.T.S.

Looking Upstream
FB=1 Ft Min
n=0.016
Freeboard (FB)=1ft min

For details on channel dimentions and cross section locations, see table G-1

TYPICAL CROSS SECTION

Wood, Patel & Associates, Inc.
1550 East Missouri, Suite 203
Phoenix, Arizona 85014 (602) 234-1344

DRAWN BY: SCOTT HARTSTEIN
JOB NO: 95271.05

FIGURE G-1

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TABLE G1
Typical Channel Cross Section Details for Agua Fria Freeway Off-Site Drainage System

Reach	Approximate Section Location	Dimentions, in ft			Slope, in ft/ft		Depth ft ±
		X1	X2	X3	Cross	Longitudinal	
AGUA FRIA FREEWAY INTERCEPTOR CHANNEL NORTH OF BETHANY HOME ROAD							
North	1/2 mi. South of Northern Ave.	9.9	8	9.4	0.020	0.0025	(b) (a)
North	3/4 mi. South of Northern Ave.	10	8	9.7	0.020	0.0022	(b)
North	Upstream of Glendale Ave.	10	8	9.7	0.020	0.0022	(b)
North	Downstream of Glendale Ave.	18	17	17.3	0.020	0.0005	(b)
North	1/4 mi. South of Glendale Ave.	18	17	17.3	0.020	0.0005	(b)
North	1/2 mi. South of Glendale Ave.	18	23	17.1	0.020	0.0005	(b)
North	3/4 mi. South of Glendale Ave.	18	23	17.1	0.020	0.0005	(b)
North	U/S of Junction w/ AFF outfall	18	23	17.1	0.020	0.0005	(b)
North	D/S of Junction w/ AFF Outfall	17.3	58	15.3	0.017	0.0010	(b)
BETHANY HOME OUTFALL CHANNEL, From Agua Fria Freeway to New River							
North	1/4 mi. East of 99th Ave. (AFF Outfall U/S of Junction)	18.3	38	17	0.017	0.0010	(b)
North	99th Ave Bridge	17.8	58	15.8	0.017	0.0010	(b)
North	1/4 mi. West of 99th Ave.	16.8	58	14.8	0.017	0.0010	(b)
North	U/S of Grand Canal Wasteway	17.8	58	15.8	0.017	0	(b)
North	D/S of Grand Canal Wasteway	20.1	44	18.3	0.020	0.0015	(b)
North	1/4 mi. East of New River	22.4	44	20.6	0.020	0.0010	(b)
North	U/S of Confluance @ New River	25.1	44	23.3	0.020	0.0010	(b)
AGUA FRIA FREEWAY INTERCEPTOR CHANNEL SOUTH OF BETHANY HOME ROAD							
South	1/4 mi. South of Bethany Home	7.7	10	7.3	0.020	0.00175	2.2
South	1/2 mi. South of Bethany Home	7.4	10	7	0.020	0.00175	2.2
South	3/4 mi. South of Bethany Home	9	25	8	0.020	0.00198	1.6
South	Upstream of Camelback Road	8.4	25	7.4	0.020	0.00198	3.6
South	Downstream of Camelback Rd.	10.8	15	10.2	0.020	0.0017	3.0
South	1/4 mi. South of Camelback	14	15	13.4	0.020	0.0017	3.9
South	1/2 mi. South of Camelback Rd.	12.4	15	11.8	0.020	0.0017	4.8
South	3/4 mi. South of Camelback Rd.	15.8	15	15.2	0.020	0.0017	5.6
South	Upstream of Indian School Rd.	19.3	15	18.7	0.020	0.0017	6.8
South	D/S of Indian School Rd.	18.8	15	18.2	0.020	0.0010	6.7
South	1/4 mi. South of Indian School	21.4	15	20.8	0.020	0.0010	6.9
South	1/2 mi. South of Indian School	24	15	23.5	0.020	0.0010	7.2
South	3/4 mi. South of Indian School	20.8	15	20.2	0.020	0.0010	7.4
South	Upstream of Thomas Road	17	15	16	0.020	0.0010	6.1
South	Downstream of Thomas Road	18.2	20	18	0.020	0.0017	6.3
South	1/4 mi. South of Thomas Road	17.4	20	16.6	0.020	0.0017	6.4
South	1/2 mi. South of Thomas Road	15.8	20	15	0.020	0.0017	6.6
South	3/4 mi. South of Thomas Road	16.2	20	16.2	0.020	0.0017	6.8
South	Upstream of McDowell Road	17	20	16	0.020	0.0017	6.3
South	Downstream of McDowell Rd.	34.6	10	35.2	0.020	0.0010	14.9

Note: (a) Side Slopes = 3:1 (h:v)
(b) Refer to Volume II for North Reach Hydraulic Design

TABLE G2
Summary of Roadway Culvert/Bridge Crossings

Reach ID	Station Station Location	Description	Culvert or Bridge Size	Length, ft	Inlet Inv, ft	Outlet Inv, ft	Slope ft/ft
North	Glendale Ave.	Box Culvert	1-10'x5'	181	1059.50	1058.19	0.00724
North	99th Avenue	Bridge	Single Span	85±	1047.00	1046.95	0.00100
North	Grand Canal Wasteway	Box Culvert	6-6'x7'	180	1035.75	1035.57	0.00100
South	Camelback Rd.	Box Culvert	3-10'x4'	105	1040.40	1039.94	0.00438
South	Indian School Rd.	Box Culvert	3-10'x8'	226	1028.20	1027.70	0.00221
South	Thomas Rd.	Box Culvert	4-10'x8'	226	1022.40	1021.80	0.00265
South	McDowell Rd.	Box Culvert	4-10'x4'	270	1002.50	1002.25	0.00093

APPENDIX H

Proposed Channel Side Inlet Considerations

- TABLE H1: Channel Side Inlet Locations & Details

TABLE H1
Channel Side Inlet Locations and Details

Reach ID	Approximate Section Location	Type	Turn Down	
			Depth, ft	Length, ft
AGUA FRIA FREEWAY INTERCEPTOR CHANNEL NORTH OF BETHANY HOME ROAD				
North	1/2 mi. South of Northern Ave.	Spillway	3	100
North	3/4 mi. South of Northern Ave.	Spillway	3	100
North	Upstream of Glendale Ave.	Spillway	3	200
North	1/4 mi. South of Glendale Ave.	Spillway	3	100
North	1/2 mi. South of Glendale Ave.	Spillway	3	100
North	3/4 mi. South of Glendale Ave.	Spillway	3	100
North	U/S of Junction w/ AFF outfall	Spillway	3	200
BETHANY HOME OUTFALL CHANNEL, From Agua Fria Freeway				
North	1/4 mi. East of 99th Ave. (AFF Outfall U/S of Junction)	Spillway	3	200
North	East of 99th Ave Bridge	Spillway	3	100
North	1150 ft West of 99th Ave.	Drop (a)	--	--
North	U/S of Grand Canal Wasteway	Spillway	3	200
North	1/4 mi. East of New River	Drop (a)	--	--
North	300 ft East of New River	Drop (a)	--	--
AGUA FRIA FREEWAY INTERCEPTOR CHANNEL SOUTH OF BETHANY HOME ROAD				
South	1/4 mi. South of Bethany Home	Spillway	3	100
South	1/2 mi. South of Bethany Home	Spillway	3	100
South	3/4 mi. South of Bethany Home	Spillway	3	100
South	Upstream of Camelback Road	Spillway	3	200
South	1/4 mi. South of Camelback	Spillway	3	100
South	1/2 mi. South of Camelback Rd.	Spillway	3	100
South	3/4 mi. South of Camelback Rd.	Spillway	3	100
South	Upstream of Indian School Rd.	Spillway	3	200
South	1/4 mi. South of Indian School	Spillway	3	100
South	1/2 mi. South of Indian School	Spillway	3	100
South	3/4 mi. South of Indian School	Spillway	3	100
South	Upstream of Thomas Road	Spillway	3	200
South	1/4 mi. South of Thomas Road	Spillway	3	100
South	1/2 mi. South of Thomas Road	Spillway	3	100
South	3/4 mi. South of Thomas Road	Spillway	3	100
South	Upstream of McDowell Road	Spillway	3	200

Notes:

(a) The Bethany Home Outfall Channel's north bank is raised to the elevation of the Standard Project Flood. This condition will create ponding for the area upstream of the north bank of the channel. To mitigate this situation, a collection system of channel, drop inlet, flapgate, and outlet pipe will be needed to allow the local flow to enter the BHOC. The designer will need to address this issue during the design phase of the project.

APPENDIX I

HEC-RAS Output, I-10 Channel

- TABLE I1: HEC-RAS Output Summary for I-10 Channel
- PLATE I1: Profile Plot for I-10 Channel

HEC-RAS Output Cover Page

Summary of Hydraulic Parameters Used in HEC-RAS Model

I-10 Channel	
Expansion Coefficent:	0.1
Contraction Coefficent:	0.3
Manning's "n"	
Varies:	0.016 -0.035
Minimum Freeboard:	1 ft

Culvert/Bridge Crossings	
Expansion Coefficent:	0.3
Contraction Coefficent:	0.5

TABLE I1

HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	
AFR to 75th AVE	720860	7920	1022.75	1036.99	1035.49	1039.68	0.000865	13.17	601.45	70.96	0.80	**
AFR to 75th AVE	720662.*	7920	1022.59	1036.81	1035.33	1039.52	0.000869	13.19	600.43	70.91	0.80	
AFR to 75th AVE	720465.*	7920	1022.42	1036.64	1035.17	1039.35	0.000871	13.20	599.82	70.87	0.80	
AFR to 75th AVE	720268.*	7920	1022.26	1036.46	1035.00	1039.18	0.000874	13.22	598.93	70.82	0.80	
AFR to 75th AVE	720071.*	7920	1022.09	1036.29	1034.84	1039.01	0.000877	13.24	598.32	70.80	0.80	
AFR to 75th AVE	719874.*	7920	1021.93	1036.11	1034.67	1038.84	0.000883	13.27	596.72	70.71	0.81	
AFR to 75th AVE	719677.*	7920	1021.76	1035.93	1034.51	1038.67	0.000886	13.29	595.84	70.65	0.81	
AFR to 75th AVE	719480.*	7920	1021.60	1035.74	1034.35	1038.50	0.000893	13.33	594.23	70.57	0.81	
AFR to 75th AVE	719282.*	7920	1021.44	1035.55	1034.19	1038.33	0.000899	13.36	592.65	70.48	0.81	
AFR to 75th AVE	719085.*	7920	1021.27	1035.36	1034.02	1038.15	0.000909	13.42	590.32	70.34	0.82	
AFR to 75th AVE	718888.*	7920	1021.11	1035.16	1033.85	1037.98	0.000919	13.47	587.78	70.19	0.82	
AFR to 75th AVE	718691.*	7920	1020.94	1034.96	1033.69	1037.80	0.000928	13.52	585.73	70.08	0.82	
AFR to 75th AVE	718494.*	7920	1020.78	1034.69	1033.52	1037.60	0.000959	13.69	578.61	69.67	0.84	
AFR to 75th AVE	718297.*	7920	1020.61	1034.35	1033.36	1037.39	0.001018	14.00	565.88	68.93	0.86	
AFR to 75th AVE	718100	7920	1020.45	1033.59	1033.19	1037.11	0.00124	15.06	525.82	66.56	0.94	
AFR to 75th AVE	717910.*	7920	1020.20	1033.37	1032.94	1036.87	0.001229	15.01	527.57	66.67	0.94	
AFR to 75th AVE	717720.*	7920	1019.96	1033.05	1032.71	1036.62	0.001264	15.17	522.13	66.34	0.95	
AFR to 75th AVE	717531.*	7920	1019.71	1032.83	1032.45	1036.37	0.001249	15.10	524.42	66.48	0.95	
AFR to 75th AVE	717341.*	7920	1019.47	1032.61	1032.21	1036.13	0.001239	15.05	526.08	66.58	0.94	
AFR to 75th AVE	717152.*	7920	1019.22	1032.40	1031.96	1035.89	0.001226	15.00	528.12	66.70	0.94	
AFR to 75th AVE	716962.*	7920	1018.98	1032.18	1031.72	1035.65	0.001215	14.95	529.79	66.80	0.94	
AFR to 75th AVE	716773.*	7920	1018.73	1031.97	1031.48	1035.41	0.001198	14.87	532.66	66.97	0.93	
AFR to 75th AVE	716583.*	7920	1018.49	1031.77	1031.23	1035.17	0.001181	14.79	535.49	67.14	0.92	
AFR to 75th AVE	716394.*	7920	1018.24	1031.58	1030.99	1034.93	0.001158	14.68	539.51	67.38	0.91	
AFR to 75th AVE	716204.*	7920	1018.00	1031.39	1030.75	1034.70	0.001142	14.60	542.30	67.55	0.91	
AFR to 75th AVE	716015	7920	1017.75	1030.51	1030.51	1034.39	0.001415	15.82	500.70	65.04	1.00	
AFR to 75th AVE	715855	7920	1016.75	1029.53	1029.53	1033.39	0.001404	15.77	502.13	65.12	1.00	
AFR to 75th AVE	715745	7920	1013.80	1028.48	1021.58	1029.58	0.000247	8.39	943.75	64.33	0.39	
AFR to 75th AVE	715655	Culvert										
AFR to 75th AVE	715565	7920	1013.50	1026.94	1021.30	1028.24	0.000321	9.17	863.61	64.33	0.44	
AFR to 75th AVE	715465	7920	1013.05	1024.18	1024.18	1027.94	0.001409	15.56	508.91	68.52	1.01	
AFR to 75th AVE	715275.*	7920	1012.72	1023.86	1023.86	1027.62	0.001408	15.56	509.00	68.52	1.01	
AFR to 75th AVE	715085.*	7920	1012.40	1023.73	1023.53	1027.29	0.00131	15.15	522.65	69.32	0.97	
AFR to 75th AVE	714895.*	7920	1012.08	1023.64	1023.21	1026.99	0.001207	14.70	538.60	70.24	0.94	

TABLE I1

HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AFR to 75th AVE	714705	7920	1011.75	1023.57	1022.88	1026.71	0.0011	14.21	557.26	71.29	0.90
AFR to 75th AVE	714512.*	7920	1011.54	1023.36	1022.67	1026.49	0.001098	14.21	557.54	71.32	0.90
AFR to 75th AVE	714320.*	7920	1011.32	1023.15	1022.45	1026.28	0.001096	14.20	557.85	71.31	0.89
AFR to 75th AVE	714127.*	7920	1011.11	1022.93	1022.24	1026.07	0.001099	14.21	557.33	71.30	0.90
AFR to 75th AVE	713935.*	7920	1010.89	1022.73	1022.02	1025.85	0.001095	14.19	558.07	71.33	0.89
AFR to 75th AVE	713742.*	7920	1010.68	1022.52	1021.81	1025.64	0.001091	14.17	558.89	71.39	0.89
AFR to 75th AVE	713550.*	7920	1010.46	1022.30	1021.60	1025.43	0.001094	14.19	558.21	71.33	0.89
AFR to 75th AVE	713357.*	7920	1010.25	1022.10	1021.38	1025.22	0.001087	14.15	559.56	71.42	0.89
AFR to 75th AVE	713165.*	7920	1010.04	1021.91	1021.17	1025.01	0.001081	14.12	560.79	71.51	0.89
AFR to 75th AVE	712972.*	7920	1009.82	1021.72	1020.96	1024.80	0.001073	14.09	562.25	71.56	0.89
AFR to 75th AVE	712780.*	7920	1009.61	1021.52	1020.74	1024.59	0.001066	14.05	563.64	71.65	0.88
AFR to 75th AVE	712587.*	7920	1009.39	1021.32	1020.52	1024.37	0.001061	14.03	564.60	71.69	0.88
AFR to 75th AVE	712395.*	7920	1009.18	1021.12	1020.31	1024.16	0.001055	14.00	565.83	71.78	0.88
AFR to 75th AVE	712202.*	7920	1008.96	1020.92	1020.10	1023.95	0.00105	13.97	566.82	71.81	0.88
AFR to 75th AVE	712010	7920	1008.75	1019.89	1019.89	1023.64	0.001405	15.55	509.43	68.55	1.01
AFR to 75th AVE	711960	7920	1005.35	1017.25	1015.30	1019.41	0.000694	11.79	671.58	81.21	0.72
AFR to 75th AVE	711788.*	7920	1005.07	1017.23	1015.03	1019.26	0.000637	11.43	692.76	82.26	0.69
AFR to 75th AVE	711616.*	7920	1004.78	1017.21	1014.75	1019.12	0.000585	11.08	714.51	83.30	0.67
AFR to 75th AVE	711445.*	7920	1004.50	1017.19	1014.47	1018.99	0.000537	10.75	736.91	84.38	0.64
AFR to 75th AVE	711273.*	7920	1004.22	1017.18	1014.20	1018.87	0.000494	10.43	759.53	85.45	0.62
AFR to 75th AVE	711101.*	7920	1003.93	1017.17	1013.92	1018.76	0.000454	10.11	783.12	86.53	0.59
AFR to 75th AVE	710930	9100	1003.65	1015.97	1014.40	1018.55	0.000798	12.89	706.14	82.90	0.78
AFR to 75th AVE	710788.*	9100	1003.53	1016.02	1014.12	1018.38	0.000711	12.32	738.45	85.15	0.74
AFR to 75th AVE	710646.*	9100	1003.42	1016.06	1013.82	1018.23	0.000637	11.80	770.92	87.38	0.70
AFR to 75th AVE	710505	9100	1003.30	1016.10	1013.52	1018.09	0.000573	11.32	803.65	89.59	0.67
AFR to 75th AVE	710305.*	9100	1003.14	1015.86	1013.49	1017.96	0.000613	11.63	782.32	88.09	0.69
AFR to 75th AVE	710105.*	9100	1002.97	1015.58	1013.45	1017.82	0.000664	12.00	758.04	86.42	0.71
AFR to 75th AVE	709905.*	9100	1002.81	1015.23	1013.42	1017.66	0.000737	12.49	728.34	84.49	0.75
AFR to 75th AVE	709705	9100	1002.65	1014.73	1013.39	1017.46	0.000865	13.27	685.80	81.91	0.81
AFR to 75th AVE	709519.*	9100	1002.50	1014.56	1013.23	1017.31	0.000869	13.29	684.69	81.85	0.81
AFR to 75th AVE	709334.*	9100	1002.35	1014.39	1013.08	1017.15	0.000876	13.33	682.63	81.75	0.81
AFR to 75th AVE	709148.*	9100	1002.19	1014.22	1012.93	1016.99	0.000879	13.35	681.83	81.73	0.81
AFR to 75th AVE	708963.*	9100	1002.04	1014.05	1012.78	1016.83	0.000884	13.37	680.47	81.65	0.82
AFR to 75th AVE	708777.*	9100	1001.89	1013.88	1012.63	1016.67	0.000891	13.42	678.33	81.54	0.82

TABLE I1

HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AFR to 75th AVE	708592.*	9100	1001.74	1013.69	1012.47	1016.51	0.000902	13.47	675.41	81.40	0.82
AFR to 75th AVE	708406.*	9100	1001.59	1013.49	1012.33	1016.34	0.000917	13.55	671.37	81.20	0.83
AFR to 75th AVE	708221.*	9100	1001.43	1013.29	1012.17	1016.17	0.000929	13.62	668.23	81.05	0.84
AFR to 75th AVE	708035.*	9100	1001.28	1013.06	1012.03	1016.00	0.000954	13.75	661.90	80.74	0.85
AFR to 75th AVE	707850	9100	1001.13	1011.88	1011.88	1015.70	0.001372	15.67	580.65	76.60	1.00
AFR to 75th AVE	707750	9100	1000.90	1011.59	1010.27	1014.09	0.000836	12.67	718.12	90.78	0.79
AFR to 75th AVE	707557.*	9100	1000.75	1011.43	1010.12	1013.93	0.000839	12.69	717.10	90.74	0.80
AFR to 75th AVE	707365.*	9100	1000.59	1011.27	1009.96	1013.77	0.000842	12.71	716.20	90.70	0.80
AFR to 75th AVE	707173.*	9100	1000.44	1011.10	1009.81	1013.61	0.000846	12.73	714.92	90.64	0.80
AFR to 75th AVE	706980.*	9100	1000.28	1010.93	1009.65	1013.46	0.000849	12.74	714.16	90.60	0.80
AFR to 75th AVE	706788.*	9100	1000.13	1010.76	1009.50	1013.30	0.000856	12.78	712.03	90.51	0.80
AFR to 75th AVE	706596.*	9100	999.98	1010.58	1009.35	1013.13	0.000862	12.81	710.14	90.43	0.81
AFR to 75th AVE	706403.*	9100	999.82	1010.40	1009.19	1012.97	0.000872	12.87	707.30	90.30	0.81
AFR to 75th AVE	706211.*	9100	999.67	1010.22	1009.04	1012.81	0.00088	12.91	705.12	90.20	0.81
AFR to 75th AVE	706019.*	9100	999.52	1010.03	1008.88	1012.64	0.000893	12.97	701.54	90.05	0.82
AFR to 75th AVE	705826.*	9100	999.36	1009.83	1008.73	1012.47	0.000909	13.05	697.21	89.86	0.83
AFR to 75th AVE	705634.*	9100	999.21	1009.60	1008.58	1012.30	0.000934	13.18	690.57	89.56	0.84
AFR to 75th AVE	705442.*	9100	999.05	1009.37	1008.43	1012.12	0.00096	13.31	683.87	89.25	0.85
AFR to 75th AVE	705250	9000	998.90	1009.23	1008.21	1011.91	0.000933	13.13	685.30	89.32	0.84
AFR to 75th AVE	705100	9000	998.80	1008.95	1008.11	1011.76	0.001	13.45	668.92	88.59	0.86
AFR to 75th AVE	704900	9000	998.60	1008.77	1007.92	1011.55	0.000988	13.38	672.69	89.11	0.86
AFR to 75th AVE	704800	9000	998.50	1007.83	1007.83	1011.35	0.001381	15.06	597.54	85.30	1.00
AFR to 75th AVE	704600	9300	996.30	1007.15	1006.65	1010.46	0.001145	14.61	636.63	81.80	0.92
AFR to 75th AVE	704405.*	9300	996.07	1006.92	1006.42	1010.23	0.001147	14.61	636.34	81.78	0.92
AFR to 75th AVE	704210.*	9300	995.84	1006.69	1006.19	1010.00	0.001145	14.61	636.56	81.80	0.92
AFR to 75th AVE	704015.*	9300	995.61	1006.46	1005.96	1009.77	0.001144	14.60	636.86	81.81	0.92
AFR to 75th AVE	703820.*	9300	995.38	1006.23	1005.73	1009.54	0.001146	14.61	636.52	81.79	0.92
AFR to 75th AVE	703625.*	9300	995.15	1006.01	1005.50	1009.32	0.001142	14.59	637.26	81.83	0.92
AFR to 75th AVE	703430.*	9300	994.92	1005.79	1005.27	1009.09	0.001137	14.57	638.10	81.86	0.92
AFR to 75th AVE	703235.*	9300	994.70	1005.54	1005.04	1008.86	0.001146	14.61	636.49	81.79	0.92
AFR to 75th AVE	703040.*	9300	994.47	1005.32	1004.81	1008.63	0.001142	14.59	637.23	81.82	0.92
AFR to 75th AVE	702845.*	9300	994.24	1005.09	1004.59	1008.40	0.001144	14.60	636.77	81.80	0.92
AFR to 75th AVE	702650.*	9300	994.01	1004.85	1004.36	1008.17	0.001146	14.62	636.31	81.78	0.92
AFR to 75th AVE	702455.*	9300	993.78	1004.63	1004.13	1007.94	0.001146	14.61	636.38	81.78	0.92

TABLE I1

HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AFR to 75th AVE	702260.*	9300	993.55	1004.40	1003.90	1007.71	0.001143	14.60	636.95	81.81	0.92
AFR to 75th AVE	702065.*	9300	993.32	1004.17	1003.67	1007.48	0.001146	14.61	636.39	81.79	0.92
AFR to 75th AVE	701870.*	9300	993.09	1003.94	1003.44	1007.25	0.001143	14.60	637.00	81.82	0.92
AFR to 75th AVE	701675.*	9300	992.86	1003.73	1003.21	1007.03	0.001138	14.58	638.06	81.87	0.92
AFR to 75th AVE	701480.*	9300	992.63	1003.51	1002.98	1006.80	0.001134	14.56	638.77	81.90	0.92
AFR to 75th AVE	701285.*	9300	992.40	1003.32	1002.75	1006.58	0.00112	14.49	641.74	82.05	0.91
AFR to 75th AVE	701090.*	9300	992.17	1003.11	1002.52	1006.35	0.001111	14.45	643.42	82.12	0.91
AFR to 75th AVE	700895.*	9300	991.95	1002.90	1002.30	1006.13	0.001104	14.42	645.01	82.21	0.91
AFR to 75th AVE	700700.*	9300	991.72	1002.71	1002.07	1005.90	0.001089	14.35	648.14	82.36	0.90
AFR to 75th AVE	700505.*	9300	991.49	1002.51	1001.84	1005.68	0.001076	14.29	650.83	82.48	0.90
AFR to 75th AVE	700310.*	9300	991.26	1002.33	1001.61	1005.46	0.001057	14.20	655.08	82.69	0.89
AFR to 75th AVE	700115.*	9300	991.03	1002.15	1001.38	1005.24	0.00104	14.11	658.92	82.88	0.88
AFR to 75th AVE	699920	9300	990.80	1001.98	1001.15	1005.03	0.001017	14.00	664.11	83.13	0.87
AFR to 75th AVE	699800	9300	990.70	1001.57	1001.05	1004.87	0.001135	14.56	638.57	81.89	0.92
AFR to 75th AVE	699613.*	9300	990.48	1001.35	1000.83	1004.65	0.001138	14.58	637.92	81.86	0.92
AFR to 75th AVE	699427.*	9300	990.26	1001.14	1000.61	1004.43	0.001134	14.56	638.84	81.91	0.92
AFR to 75th AVE	699240.*	9300	990.05	1000.91	1000.40	1004.21	0.001138	14.58	638.00	81.89	0.92
AFR to 75th AVE	699054.*	9300	989.83	1000.72	1000.18	1004.00	0.001129	14.54	639.65	81.96	0.92
AFR to 75th AVE	698868.*	9300	989.61	1000.53	999.96	1003.78	0.001118	14.49	642.03	82.07	0.91
AFR to 75th AVE	698681.*	9300	989.39	1000.33	999.74	1003.57	0.00111	14.45	643.71	82.15	0.91
AFR to 75th AVE	698495.*	9300	989.17	1000.13	999.52	1003.36	0.001102	14.41	645.28	82.22	0.91
AFR to 75th AVE	698309.*	9300	988.95	999.94	999.31	1003.14	0.001091	14.36	647.68	82.33	0.90
AFR to 75th AVE	698122.*	9300	988.74	999.76	999.09	1002.93	0.001077	14.29	650.64	82.49	0.90
AFR to 75th AVE	697936.*	9300	988.52	999.59	998.87	1002.72	0.001056	14.19	655.29	82.71	0.89
AFR to 75th AVE	697750	9300	988.30	998.66	998.66	1002.43	0.001371	15.58	596.99	79.83	1.00
AFR to 75th AVE	697550	9300	986.70	995.55	994.51	997.79	0.000875	12.00	775.21	112.21	0.80
AFR to 75th AVE	697354.*	9300	986.53	995.37	994.34	997.62	0.000885	12.04	772.21	112.13	0.81
AFR to 75th AVE	697158.*	9300	986.37	995.18	994.19	997.45	0.000896	12.09	769.01	112.04	0.81
AFR to 75th AVE	696963.*	9300	986.20	994.99	994.03	997.28	0.000904	12.13	766.77	111.99	0.82
AFR to 75th AVE	696767.*	9300	986.03	994.80	993.86	997.10	0.000916	12.19	763.23	111.87	0.82
AFR to 75th AVE	696572.*	9300	985.87	994.60	993.69	996.93	0.000928	12.24	759.86	111.73	0.83
AFR to 75th AVE	696376.*	9300	985.70	994.39	993.52	996.75	0.000944	12.31	755.52	111.56	0.83
AFR to 75th AVE	696181.*	9300	985.53	994.19	993.35	996.56	0.00096	12.37	751.58	111.43	0.84
AFR to 75th AVE	695985.*	9300	985.37	993.97	993.18	996.38	0.000981	12.46	746.16	111.20	0.85

TABLE I1
HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

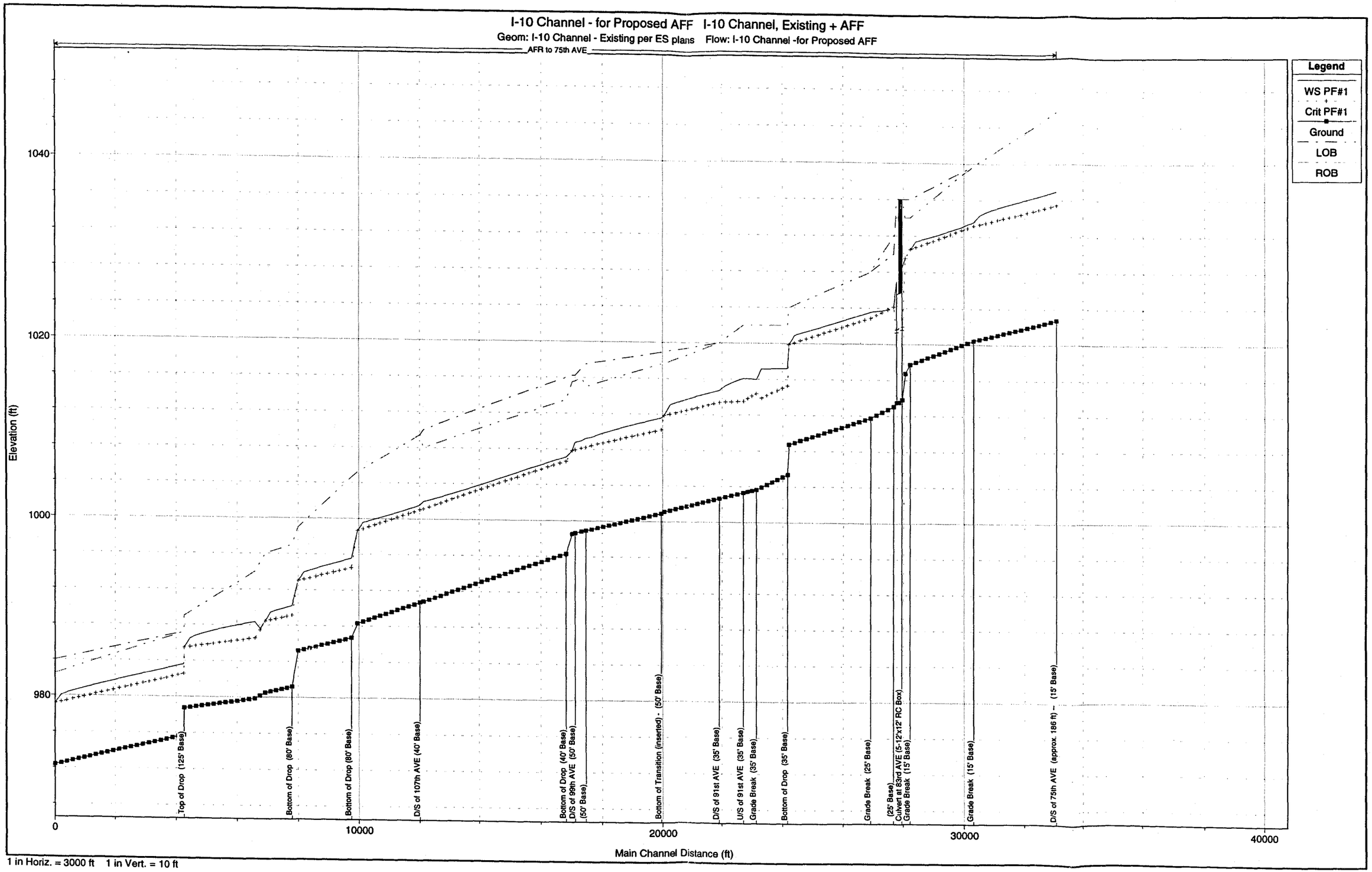
Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AFR to 75th AVE	695790	9300	985.20	993.01	993.01	996.09	0.001416	14.09	660.16	108.03	1.00
AFR to 75th AVE	695590	9600	981.20	990.20	989.14	992.48	0.000877	12.13	791.54	112.79	0.81
AFR to 75th AVE	695414.*	9600	981.06	990.03	989.00	992.33	0.000888	12.18	788.16	112.67	0.81
AFR to 75th AVE	695238.*	9600	980.92	989.85	988.86	992.18	0.000904	12.25	783.41	112.51	0.82
AFR to 75th AVE	695062.*	9600	980.78	989.65	988.72	992.02	0.000925	12.35	777.27	112.28	0.83
AFR to 75th AVE	694886.*	9600	980.64	989.42	988.58	991.85	0.00096	12.51	767.64	111.94	0.84
AFR to 75th AVE	694710	9600	980.50	988.45	988.45	991.59	0.001408	14.21	675.53	108.60	1.00
AFR to 75th AVE	694545.*	9600	980.17	987.61	987.46	990.28	0.001328	13.12	731.60	128.14	0.97
AFR to 75th AVE	694380	9600	979.85	988.38	986.57	989.76	0.000564	9.42	1019.20	154.12	0.65
AFR to 75th AVE	694187.*	9600	979.76	988.26	986.49	989.65	0.000573	9.47	1013.54	154.00	0.65
AFR to 75th AVE	693994.*	9600	979.67	988.13	986.40	989.54	0.000584	9.53	1007.55	153.85	0.66
AFR to 75th AVE	693801.*	9600	979.57	988.00	986.30	989.43	0.000595	9.59	1001.35	153.71	0.66
AFR to 75th AVE	693609.*	9600	979.48	987.86	986.21	989.31	0.00061	9.66	993.37	153.52	0.67
AFR to 75th AVE	693416.*	9600	979.39	987.71	986.12	989.19	0.000627	9.75	984.36	153.27	0.68
AFR to 75th AVE	693223.*	9600	979.30	987.56	986.03	989.06	0.000646	9.85	974.74	153.03	0.69
AFR to 75th AVE	693030.*	9600	979.21	987.39	985.94	988.93	0.000671	9.97	962.82	152.73	0.70
AFR to 75th AVE	692838.*	9600	979.12	987.21	985.85	988.80	0.000701	10.11	949.60	152.36	0.71
AFR to 75th AVE	692645.*	9600	979.03	987.01	985.76	988.65	0.00074	10.29	932.96	151.93	0.73
AFR to 75th AVE	692452.*	9600	978.93	986.79	985.66	988.50	0.000787	10.49	914.73	151.43	0.75
AFR to 75th AVE	692259.*	9600	978.84	986.50	985.56	988.33	0.000869	10.84	885.98	150.64	0.79
AFR to 75th AVE	692067	9600	978.75	985.46	985.46	988.04	0.001488	12.87	745.73	146.85	1.01
AFR to 75th AVE	692055	9800	975.75	983.62	982.54	985.39	0.000809	10.67	918.89	151.50	0.76
AFR to 75th AVE	691861.*	9800	975.60	983.47	982.38	985.24	0.00081	10.67	918.44	151.49	0.76
AFR to 75th AVE	691667.*	9800	975.44	983.31	982.23	985.08	0.000811	10.67	918.17	151.47	0.76
AFR to 75th AVE	691474.*	9800	975.29	983.15	982.07	984.92	0.000812	10.68	917.69	151.47	0.76
AFR to 75th AVE	691280.*	9800	975.13	982.99	981.92	984.77	0.000814	10.69	916.86	151.44	0.77
AFR to 75th AVE	691086.*	9800	974.98	982.84	981.76	984.61	0.000815	10.69	916.69	151.44	0.77
AFR to 75th AVE	690893.*	9800	974.82	982.68	981.61	984.45	0.000817	10.70	915.84	151.41	0.77
AFR to 75th AVE	690699.*	9800	974.67	982.52	981.46	984.30	0.000819	10.71	915.16	151.41	0.77
AFR to 75th AVE	690505.*	9800	974.51	982.36	981.30	984.14	0.000821	10.72	914.58	151.37	0.77
AFR to 75th AVE	690312.*	9800	974.36	982.20	981.15	983.99	0.000823	10.73	913.72	151.36	0.77
AFR to 75th AVE	690118.*	9800	974.20	982.04	980.99	983.83	0.000826	10.74	912.70	151.33	0.77
AFR to 75th AVE	689925.*	9800	974.05	981.87	980.84	983.67	0.000831	10.76	910.93	151.29	0.77
AFR to 75th AVE	689731.*	9800	973.90	981.71	980.68	983.51	0.000833	10.77	910.25	151.27	0.77

TABLE I1
HEC-RAS Output Summary for Existing I-10 Channel (Agua Fria River to 75th Avenue)

HEC-RAS Plan: I-10 + AFF River: I-10 Reach: AFR to 75th AVE

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
AFR to 75th AVE	689537.*	9800	973.74	981.55	980.53	983.35	0.000837	10.78	908.91	151.24	0.78
AFR to 75th AVE	689344.*	9800	973.59	981.38	980.38	983.20	0.000843	10.81	906.62	151.18	0.78
AFR to 75th AVE	689150.*	9800	973.43	981.22	980.22	983.03	0.000847	10.82	905.41	151.13	0.78
AFR to 75th AVE	688956.*	9800	973.28	981.04	980.07	982.87	0.000859	10.87	901.33	151.05	0.78
AFR to 75th AVE	688763.*	9800	973.12	980.87	979.91	982.71	0.000864	10.90	899.49	150.98	0.79
AFR to 75th AVE	688569.*	9800	972.97	980.69	979.76	982.55	0.000877	10.95	895.16	150.88	0.79
AFR to 75th AVE	688375.*	9800	972.81	980.50	979.60	982.38	0.00089	11.00	890.86	150.75	0.80
AFR to 75th AVE	688182.*	9800	972.66	980.29	979.45	982.21	0.000918	11.11	882.17	150.52	0.81
AFR to 75th AVE	687988.*	9800	972.50	980.07	979.29	982.03	0.000949	11.23	872.75	150.27	0.82
AFR to 75th AVE	687795	9800	972.35	979.14	979.14	981.74	0.001481	12.95	756.72	147.15	1.01

Notes: * HEC-RAS Interpolated Cross Section
** Starting Water Surface Elevation = 976.9


I-10 Channel - for Proposed AFF I-10 Channel, Existing + AFF
Geom: I-10 Channel - Existing per ES plans Flow: I-10 Channel -for Proposed AFF
AFR to 75th AVE
Legend
WS PF#1
Crit PF#1
Ground
LOB
ROB
Elevation (ft)
1040
1020
1000
980
0
10000
20000
30000
40000
Main Channel Distance (ft)
Top of Drop (125' Base)
Bottom of Drop (80' Base)
Bottom of Drop (80' Base)
D/S of 107th AVE (40' Base)
Bottom of Drop (40' Base)
D/S of 99th AVE (50' Base)
(50' Base)
Bottom of Transition (inserted) - (50' Base)
D/S of 91st AVE (35' Base)
U/S of 91st AVE (35' Base)
Grade Break (35' Base)
Bottom of Drop (35' Base)
Grade Break (25' Base)
(25' Base)
Culvert at 83rd AVE (5-12'x12' RC Box)
Grade Break (15' Base)
Grade Break (15' Base)
D/S of 75th AVE (approx. 186 ft) - (15' Base)
1 in Horiz. = 3000 ft 1 in Vert. = 10 ft

APPENDIX J

HEC-RAS Output, South Reach

- TABLE J1: HEC-RAS Output Summary for South Reach
- PLATE J1: Profile Plot for South Reach

HEC-RAS Output Cover Page
Summary of Hydraulic Parameters Used in HEC-RAS Model

Normal Channel Reach	
Expansion Coefficent:	0.1
Contraction Coefficent:	0.3
Manning's "n"	
Rough Concrete:	0.016
Minimum Freeboard:	1 ft

Culvert/Bridge Crossings	
Expansion Coefficent:	0.3
Contraction Coefficent:	0.5

TABLE J1

HEC-RAS Output Summary for Agua Fria Freeway Interceptor Channel, South Reach (Bethany Home Rd to I-10)

HEC-RAS Plan: AFF-S River: AFF Interceptor Reach: South

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	
South	21890	150	1047.75	1049.91	1049.54	1050.32	0.001775	5.16	29.08	18.23	0.72	**
South	21693.1*	150	1047.40	1049.56	1049.19	1049.97	0.00178	5.16	29.05	18.23	0.72	
South	21496.2*	150	1047.05	1049.21	1048.84	1049.62	0.001775	5.16	29.07	18.23	0.72	
South	21299.4*	150	1046.70	1048.86	1048.49	1049.27	0.00178	5.16	29.04	18.22	0.72	
South	21102.5*	150	1046.35	1048.51	1048.14	1048.92	0.001776	5.16	29.07	18.24	0.72	
South	20905.7*	150	1046.00	1048.16	1047.79	1048.57	0.001783	5.17	29.04	18.23	0.72	
South	20708.8*	150	1045.65	1047.81	1047.44	1048.22	0.001783	5.17	29.03	18.23	0.72	
South	20512	150	1045.30	1047.45	1047.09	1047.87	0.001791	5.17	28.99	18.21	0.72	
South	20327.*	150	1044.97	1047.12	1046.76	1047.54	0.001795	5.18	28.97	18.23	0.72	
South	20142.*	150	1044.63	1046.79	1046.43	1047.21	0.001787	5.17	29.00	18.23	0.72	
South	19957.*	150	1044.30	1046.46	1046.10	1046.88	0.001771	5.16	29.09	18.26	0.72	
South	19772.*	150	1043.97	1046.14	1045.76	1046.55	0.001742	5.13	29.27	18.29	0.71	
South	19587.*	150	1043.63	1045.85	1045.42	1046.23	0.001614	4.99	30.06	18.45	0.69	
South	19402	150	1043.30	1045.09	1045.09	1045.77	0.003644	6.64	22.60	16.75	1.01	
South	19252	150	1043.00	1044.59	1044.25	1044.84	0.001469	4.02	37.27	30.37	0.64	
South	19078.4*	150	1042.66	1044.43	1043.91	1044.62	0.000953	3.50	42.88	31.09	0.52	
South	18904.8*	150	1042.31	1044.35	1043.57	1044.48	0.000559	2.94	51.06	32.14	0.41	
South	18731.2*	150	1041.97	1044.30	1043.22	1044.40	0.000329	2.47	60.81	33.33	0.32	
South	18557.7*	150	1041.63	1044.28	1042.88	1044.34	0.000203	2.10	71.44	34.58	0.26	
South	18384.1*	150	1041.29	1044.26	1042.54	1044.31	0.00013	1.81	82.97	35.88	0.21	
South	18210.5*	150	1040.94	1044.25	1042.20	1044.29	0.000086	1.58	95.23	37.22	0.17	
South	18037	150	1040.60	1044.24	1041.85	1044.27	0.00006	1.39	108.01	38.58	0.15	
South	17937	500	1040.40	1043.91	1042.37	1044.22	0.000565	4.47	111.88	31.95	0.42	
South	17936.9	Culvert	@ Camelback Road: 3-10'x4' Box									
South	17832	500	1039.94	1043.61	1041.91	1043.90	0.000491	4.27	117.06	31.95	0.39	
South	17635	500	1039.50	1042.49	1042.49	1043.61	0.003088	8.52	58.71	26.35	1.01	
South	17632	500	1037.20	1040.66	1040.19	1041.42	0.001759	6.99	71.58	28.24	0.77	
South	17442.7*	500	1036.86	1040.33	1039.85	1041.08	0.001731	6.95	71.97	28.29	0.77	
South	17253.5*	500	1036.52	1040.02	1039.51	1040.76	0.001678	6.87	72.77	28.41	0.76	
South	17064.3*	500	1036.18	1039.73	1039.17	1040.44	0.001588	6.74	74.19	28.59	0.74	
South	16875.0*	500	1035.85	1039.47	1038.83	1040.14	0.001472	6.56	76.23	28.89	0.71	
South	16685.8*	500	1035.51	1039.25	1038.50	1039.86	0.001301	6.28	79.64	29.36	0.67	
South	16496.6*	500	1035.17	1039.07	1038.16	1039.61	0.001107	5.93	84.37	30.00	0.62	
South	16307.3*	500	1034.83	1038.93	1037.82	1039.40	0.000914	5.54	90.32	30.77	0.57	

TABLE J1

HEC-RAS Output Summary for Agua Fria Freeway Interceptor Channel, South Reach (Bethany Home Rd to I-10)

HEC-RAS Plan: AFF-S River: AFF Interceptor Reach: South

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South	16118.1*	500	1034.49	1038.82	1037.48	1039.23	0.000735	5.12	97.66	31.72	0.51
South	15928.9*	500	1034.15	1038.74	1037.14	1039.08	0.000586	4.72	105.94	32.74	0.46
South	15739.6*	500	1033.82	1038.68	1036.80	1038.97	0.000467	4.35	115.02	33.86	0.42
South	15550.4*	500	1033.48	1038.63	1036.47	1038.88	0.000371	4.00	124.99	35.00	0.37
South	15361.2*	500	1033.14	1038.59	1036.14	1038.80	0.000294	3.68	135.91	36.23	0.33
South	15172	900	1032.80	1037.61	1036.94	1038.59	0.001572	7.94	113.40	33.64	0.76
South	14972.*	900	1032.46	1037.32	1036.60	1038.27	0.001515	7.83	114.94	33.86	0.75
South	14772.*	900	1032.12	1037.05	1036.27	1037.97	0.001439	7.69	117.09	34.12	0.73
South	14572.*	900	1031.78	1036.81	1035.93	1037.68	0.001333	7.48	120.38	34.53	0.71
South	14372.*	900	1031.44	1036.60	1035.59	1037.40	0.001206	7.21	124.84	35.06	0.67
South	14172.*	900	1031.10	1036.42	1035.26	1037.16	0.00107	6.90	130.34	35.68	0.64
South	13972.*	900	1030.76	1036.27	1034.92	1036.94	0.000926	6.55	137.37	36.47	0.59
South	13772.*	900	1030.41	1036.15	1034.58	1036.74	0.000788	6.18	145.68	37.39	0.55
South	13572.*	900	1030.07	1036.05	1034.23	1036.58	0.000665	5.81	155.02	38.38	0.51
South	13372.*	900	1029.73	1035.98	1033.89	1036.44	0.000557	5.45	165.25	39.41	0.47
South	13172.*	900	1029.39	1035.91	1033.55	1036.32	0.000465	5.10	176.53	40.54	0.43
South	12972.*	900	1029.05	1035.86	1033.21	1036.22	0.000388	4.77	188.69	41.72	0.40
South	12772.*	900	1028.71	1035.82	1032.87	1036.13	0.000325	4.47	201.37	42.90	0.36
South	12572	1350	1028.37	1035.18	1033.52	1035.97	0.00087	7.15	188.93	41.70	0.59
South	12472	1350	1028.20	1035.28	1032.01	1035.84	0.000497	5.98	225.77	31.94	0.40
South	12471.9	Culvert	@ Indian School Road: 3-10'x8' Box								
South	12246	1350	1027.70	1034.62	1031.51	1035.21	0.000531	6.12	220.67	31.93	0.41
South	12146	1350	1027.60	1034.26	1032.75	1035.11	0.000958	7.40	182.36	41.03	0.62
South	11946.*	1350	1027.38	1034.08	1032.53	1034.92	0.000935	7.34	183.95	41.19	0.61
South	11746.*	1350	1027.16	1033.91	1032.31	1034.73	0.000908	7.26	185.87	41.38	0.60
South	11546.*	1350	1026.94	1033.74	1032.10	1034.54	0.000881	7.18	187.98	41.59	0.60
South	11346.*	1350	1026.72	1033.58	1031.88	1034.36	0.000848	7.08	190.56	41.84	0.58
South	11146.*	1350	1026.50	1033.43	1031.66	1034.19	0.000812	6.97	193.65	42.13	0.57
South	10946.*	1350	1026.27	1033.29	1031.43	1034.02	0.000772	6.84	197.23	42.45	0.56
South	10746.*	1350	1026.05	1033.16	1031.22	1033.86	0.000734	6.72	200.91	42.80	0.55
South	10546.*	1350	1025.83	1033.04	1030.99	1033.71	0.000693	6.58	205.16	43.19	0.53
South	10346.*	1350	1025.61	1032.93	1030.77	1033.57	0.000652	6.43	209.83	43.61	0.52
South	10146.*	1350	1025.39	1032.82	1030.56	1033.43	0.000611	6.28	214.94	44.07	0.50
South	9946.*	1350	1025.17	1032.72	1030.34	1033.31	0.000571	6.13	220.41	44.56	0.49

TABLE J1

HEC-RAS Output Summary for Agua Fria Freeway Interceptor Channel, South Reach (Bethany Home Rd to I-10)

HEC-RAS Plan: AFF-S River: AFF Interceptor Reach: South

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South	9746	1600	1024.95	1032.19	1030.59	1033.12	0.000952	7.73	206.91	43.32	0.62
South	9557.53*	1600	1024.76	1032.02	1030.41	1032.94	0.000949	7.72	207.17	43.35	0.62
South	9369.07*	1600	1024.57	1031.84	1030.22	1032.76	0.000942	7.70	207.71	43.41	0.62
South	9180.61*	1600	1024.38	1031.67	1030.04	1032.58	0.000935	7.68	208.23	43.47	0.62
South	8992.15*	1600	1024.20	1031.49	1029.85	1032.41	0.000929	7.66	208.80	43.56	0.62
South	8803.69*	1600	1024.01	1031.32	1029.67	1032.23	0.00092	7.64	209.55	43.63	0.61
South	8615.23*	1600	1023.82	1031.16	1029.48	1032.05	0.000907	7.60	210.60	43.72	0.61
South	8426.76*	1600	1023.63	1031.00	1029.29	1031.88	0.000894	7.56	211.74	43.83	0.61
South	8238.30*	1600	1023.44	1030.84	1029.10	1031.71	0.00088	7.51	212.98	43.94	0.60
South	8049.84*	1600	1023.25	1030.68	1028.91	1031.54	0.000865	7.46	214.34	44.06	0.60
South	7861.38*	1600	1023.07	1030.53	1028.72	1031.38	0.000845	7.40	216.18	44.25	0.59
South	7672.92*	1600	1022.88	1030.38	1028.53	1031.22	0.000825	7.33	218.15	44.41	0.58
South	7484.46*	1600	1022.69	1030.24	1028.35	1031.06	0.000802	7.26	220.42	44.61	0.58
South	7296	1850	1022.50	1028.60	1028.60	1030.67	0.002568	11.55	160.10	38.80	1.00
South	7196	1850	1022.40	1029.54	1026.27	1030.11	0.000453	6.06	305.51	42.87	0.40
South	7195.9	Culvert	@ Thomas Road: 4-10'x8' Box								
South	6970	1850	1021.80	1028.86	1025.69	1029.44	0.000469	6.12	302.08	42.85	0.41
South	6870	1850	1021.60	1027.87	1027.13	1029.28	0.001588	9.55	193.78	43.87	0.80
South	6670.*	1850	1021.28	1027.55	1026.81	1028.96	0.001583	9.53	194.04	43.92	0.80
South	6470.*	1850	1020.96	1027.24	1026.49	1028.64	0.001572	9.51	194.54	43.98	0.80
South	6270.*	1850	1020.64	1026.93	1026.17	1028.33	0.001562	9.49	195.04	44.06	0.79
South	6070.*	1850	1020.31	1026.63	1025.85	1028.01	0.001543	9.45	195.87	44.13	0.79
South	5870.*	1850	1019.99	1026.33	1025.52	1027.70	0.001511	9.37	197.39	44.29	0.78
South	5670.*	1850	1019.67	1026.05	1025.20	1027.39	0.001475	9.29	199.16	44.47	0.77
South	5470.*	1850	1019.35	1025.79	1024.88	1027.09	0.001422	9.17	201.82	44.73	0.76
South	5270.*	1850	1019.03	1025.54	1024.56	1026.80	0.001362	9.02	205.03	45.05	0.75
South	5070.*	1850	1018.71	1025.31	1024.24	1026.52	0.001287	8.84	209.34	45.45	0.73
South	4870.*	1850	1018.39	1025.10	1023.91	1026.25	0.001199	8.61	214.80	45.95	0.70
South	4670.*	1850	1018.06	1024.92	1023.59	1026.00	0.001104	8.36	221.29	46.49	0.68
South	4470.*	1850	1017.74	1024.76	1023.28	1025.77	0.001007	8.08	228.83	47.17	0.65
South	4270.*	1850	1017.42	1024.62	1022.96	1025.56	0.000907	7.78	237.80	47.94	0.62
South	4070	2100	1017.10	1023.71	1023.01	1025.26	0.00164	9.98	210.38	45.63	0.82
South	3874.10*	2100	1016.77	1023.39	1022.69	1024.93	0.001633	9.96	210.75	45.68	0.82
South	3678.21*	2100	1016.44	1023.07	1022.36	1024.61	0.001627	9.95	210.99	45.68	0.82

TABLE J1

HEC-RAS Output Summary for Agua Fria Freeway Interceptor Channel, South Reach (Bethany Home Rd to I-10)

HEC-RAS Plan: AFF-S River: AFF Interceptor Reach: South

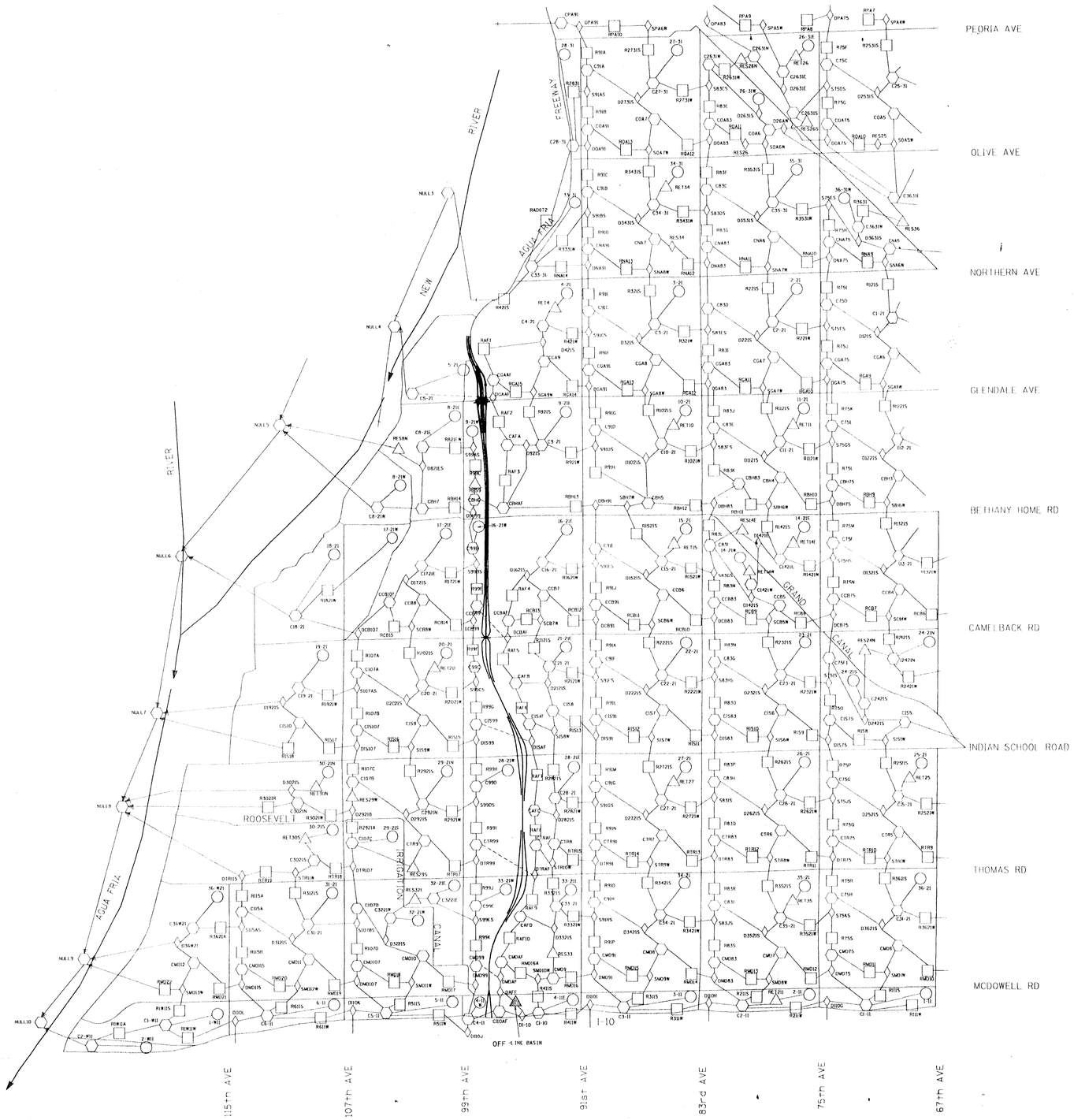
Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
South	3482.32*	2100	1016.11	1022.76	1022.04	1024.29	0.001614	9.92	211.63	45.75	0.81
South	3286.42*	2100	1015.79	1022.44	1021.72	1023.97	0.001609	9.91	211.86	45.77	0.81
South	3090.53*	2100	1015.46	1022.14	1021.40	1023.65	0.001584	9.86	213.04	45.88	0.81
South	2894.64*	2100	1015.13	1021.85	1021.07	1023.34	0.001559	9.80	214.23	45.96	0.80
South	2698.75*	2100	1014.80	1021.57	1020.75	1023.03	0.001513	9.70	216.59	46.17	0.79
South	2502.85*	2100	1014.47	1021.30	1020.42	1022.72	0.001459	9.57	219.48	46.43	0.78
South	2306.96*	2100	1014.14	1021.06	1020.09	1022.43	0.001395	9.42	223.02	46.71	0.76
South	2111.07*	2100	1013.81	1020.83	1019.77	1022.15	0.001317	9.22	227.74	47.13	0.74
South	1915.17*	2100	1013.49	1020.62	1019.45	1021.88	0.001236	9.01	233.03	47.57	0.72
South	1719.28*	2100	1013.16	1020.44	1019.13	1021.63	0.001141	8.75	239.91	48.16	0.69
South	1523.39*	2100	1012.83	1020.28	1018.80	1021.39	0.001044	8.48	247.74	48.79	0.66
South	1327.5	2300	1012.50	1018.77	1018.77	1020.98	0.002501	11.92	192.95	44.07	1.00
South	1320	2300	1002.50	1018.55	1006.96	1018.73	0.000067	3.34	688.49	42.97	0.15
South	1219.9	Culvert	@ McDowell Road: 4-10'x4' Box								
South	1050	2300	1002.25	1017.16	1006.72	1017.36	0.000083	3.60	639.24	42.97	0.16
South	1000	2300	1002.20	1017.10	1009.95	1017.35	0.000123	3.99	575.87	68.60	0.24

Notes: * HEC-RAS Interpolated Cross Section
** Starting Water Surface Elevation = 1017.1

Pocket Between
11X17

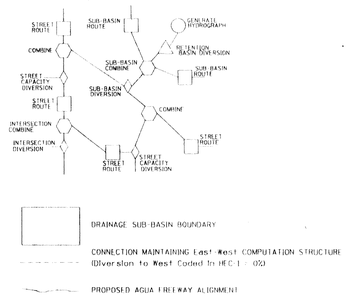
Plate
J1 & EX3

MATCH EXISTING
MARYVALE ADMS REPORT



MATCH EXISTING
MARYVALE ADMS REPORT

LEGEND

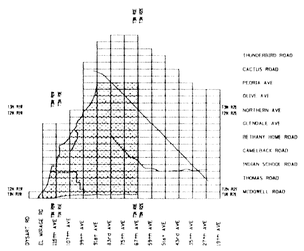


DRAINAGE SUB-BASIN BOUNDARY

CONNECTION MAINTAINING East/West COMPUTATION STRUCTURE
(Diversion to West Coded In HEC1 - 02)

PROPOSED AGUA FREEWAY ALIGNMENT

INDEX MAP



0 1 2 3

SCALE , in Miles

ARIZONA DEPARTMENT OF TRANSPORTATION

HEC-1 SCHEMATIC

Wood, Patel & Associates Inc
1550 East Missouri, Suite 203
Phoenix, Arizona 85014 (602) 234-1344

DRAWN BY: dlp

JOB NO: 1527L&M

EXHIBIT A

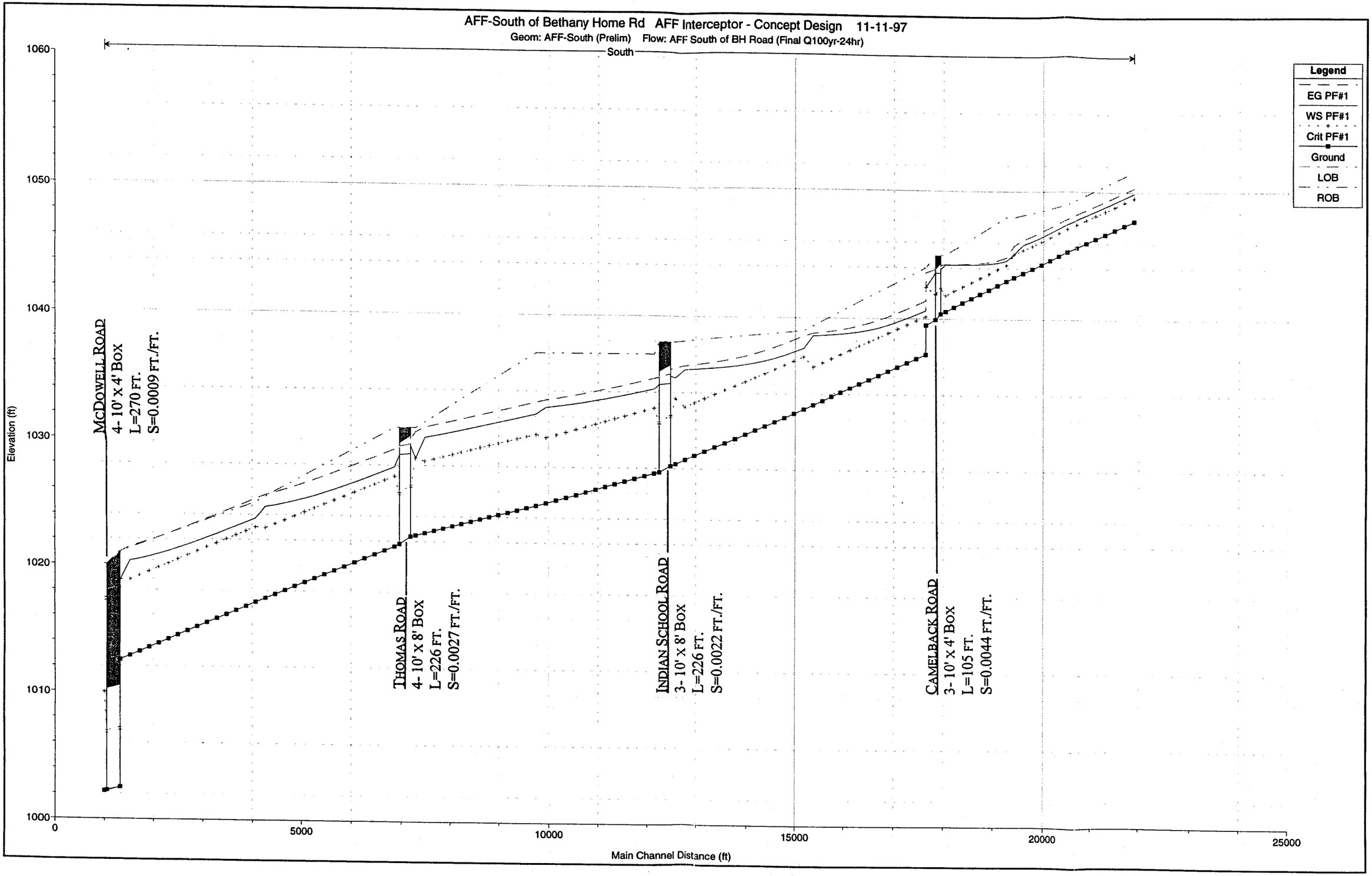
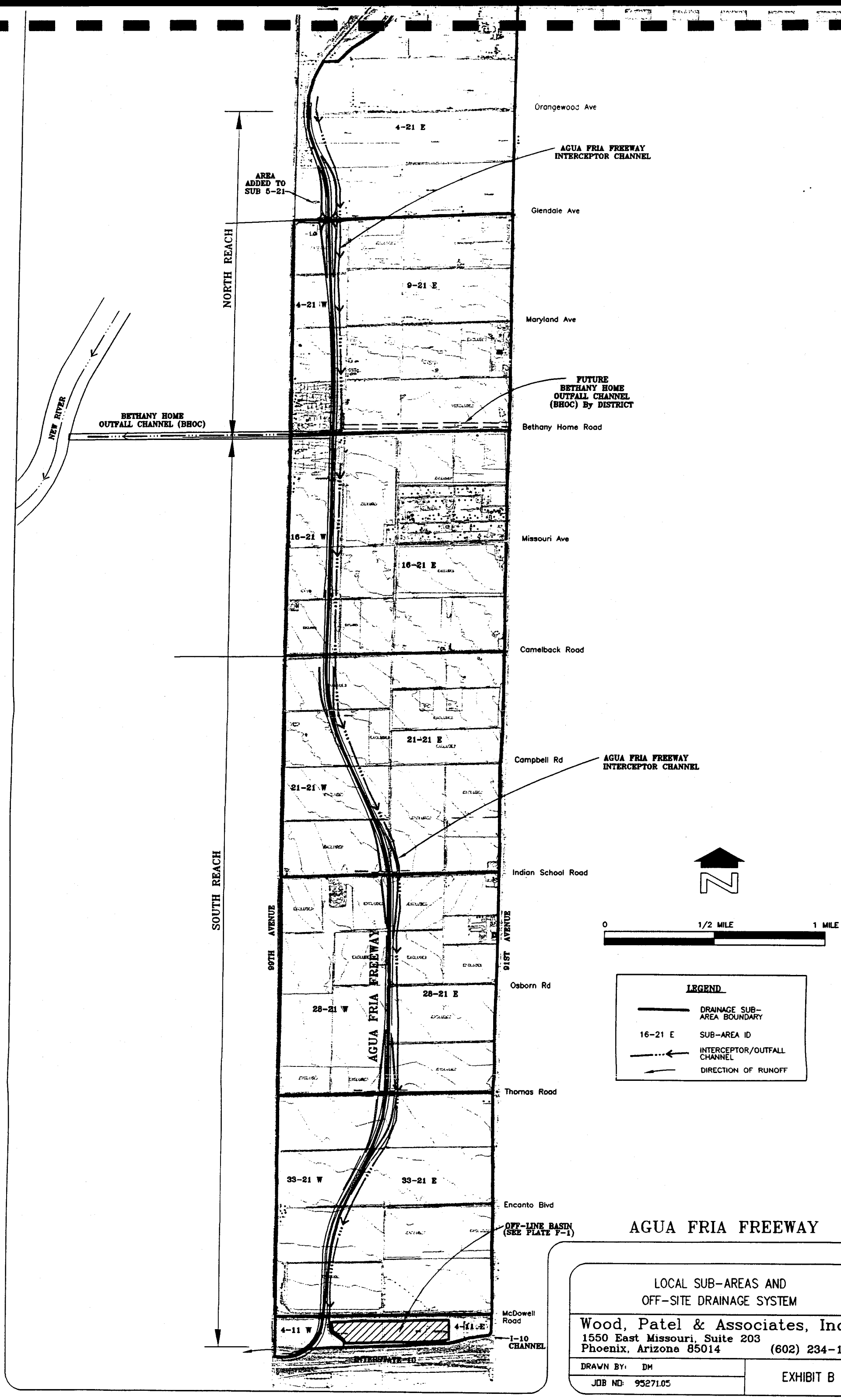


PLATE J1
AGUA FRIA FREEWAY INTERCEPTOR CHANNEL
SOUTH REACH



AGUA FRIA FREEWAY

LOCAL SUB-AREAS AND OFF-SITE DRAINAGE SYSTEM

Wood, Patel & Associates, Inc.
1550 East Missouri, Suite 203
Phoenix, Arizona 85014 (602) 234-1344

DRAWN BY: DM
JOB NO: 95271.05

EXHIBIT B