Casas Adobes Wash Technical Data Notebook

Prepared for:
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

Prepared by:
Dave Stewart, EIT, Civil Engineering Assistant
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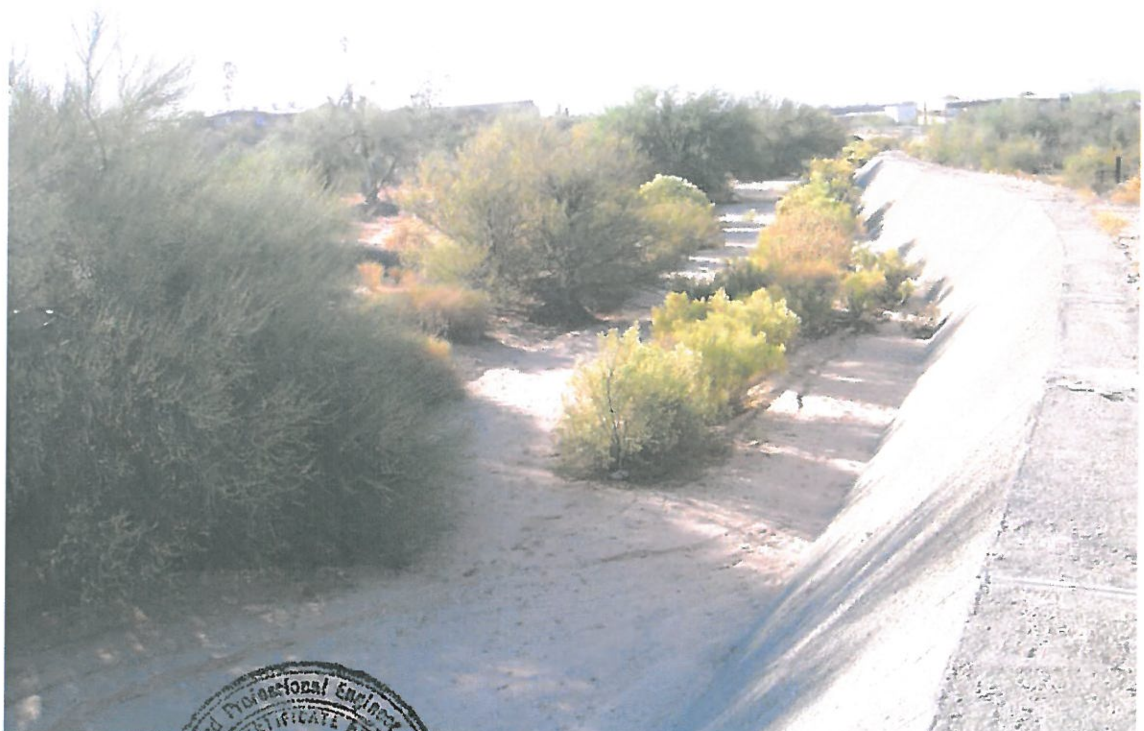
October 2011



Approved by

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Director
Pima County Regional Flood Control District
97 E Congress Street
Tucson Arizona, 85701

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Section 1 Introduction

1.1 Purpose

This Technical Data notebook (TDN) has been prepared for the Casas Adobes Wash (CSA) located in Pima County, Arizona (Figure 1.1). The objective of the TDN is to provide discharges and floodplain limits along the CSA using better topographic, hydrologic, and hydraulic data.

This TDN was prepared in accordance with the "Instructions for Organizing and Submitting Technical Documentation for Flood Studies" prepared by the Arizona Department of Water Resources, Flood Mitigation Section (Arizona State Standard, SSA 1-97) and FEMA Guidelines. This is a local study and has not been submitted to FEMA.

1.2 Project Authority

The State of Arizona has delegated the responsibility to each county flood control district to adopt floodplain regulations designed to promote the public health, safety and general welfare of its citizenry as provided under the Arizona Revised Statutes, Title 48, Chapter 21, Article 1, Sections 48-3601 through 3627. More specifically, A.R.S. 3609 directs county flood control districts to adopt floodplain regulations that:

> A. Regulate all development of land, construction of residential, commercial or industrial structures or uses of any kind which may divert, retard or obstruct flood water and threaten public health or safety or the general welfare; and
> B. Establish minimum flood protection elevations and flood damage prevention requirements for uses, structures and facilities which are vulnerable to flood damage; and
> C. Comply with state and local land use plans and ordinances, if any.
> In conformance with A.R.S. 3609, this ordinance provides for protection of the public health safety and welfare by regulation of flood and erosion hazard areas to control flood hazards and prevent repetitive loss from flood damage.
> D. The flood hazard areas of Pima County are subject to periodic inundation which may result in loss of life and property, create health and safety hazards, disrupt commerce and governmental services, require extraordinary public expenditures for flood protection and relief, and impair the tax base, all of which adversely affect the public health, safety, and general welfare.
> E. These flood losses are caused by the cumulative effect of obstructions in areas of special flood hazards which increase flood heights, flow velocities, and cause flood and erosion damage. Uses that are inadequately flood-proofed, elevated, or otherwise protected from flood damage, also contribute to the flood loss. (Ord. 2005 FC-2 § 2 (part), 2005).

Section 16 of the Pima County Ordinance describes the provisions for floodplain regulation in Pima County.

This study has been prepared by the Pima County Regional Flood Control District (RFCD):

Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

The project was prepared by:

Dave Stewart, EIT, Civil Engineering Assistant
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The Casas Adobes (CSA) study area is located within Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) panels 04019C1680L, 1660L, and 1667L. The FEMA-designated "Zone A" flood-hazard area is specified for the length of the Casas Adobes wash from upstream of the W. Sunset Rd. bridge to downstream of W. Orange Grove Rd (Figure 1.2). A Letter of Map Revision with effective date of April 10, 2001 displayed updated topographic information along the CSA from approximately 420 feet north of Sunset Rd. to approximately 1200 ft South of Orange Grove Rd. The objective of this TDN is to provide discharges and floodplain limits along the CSA using updated topographic data, hydrologic modeling, and hydraulic modeling.

The detailed study reach for the Casas Adobes Wash (CSA) is from the W. River Rd. Bridge at the downstream boundary to N. Oracle Rd at the upstream end. The CSA enters the study reach from the northeast and a tributary to the CSA converges in Section 10 of Township 13 South, Range 13 East, Pima County, Arizona (Figure 1.2). A levee has been constructed on the west bank of the CSA south of the confluence, and the channel is lined immediately upstream of the Sunset Rd. Bridge to the CSA outlet at the Rillito River (Section 15, Township, 13 South, Range 13 East).

1.4 Hydrologic and Hydraulic Methods

A hydrologic analysis was performed to determine the 100-year return period discharge at concentration points along the CSA using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) and PC-HYDRO for the tributary. The hydraulic analysis was performed to delineate floodplain limits along the study reach of the CSA using the Hydrologic Engineering Center's River Analysis System (HEC-RAS)

(USACE 2002) and FLO2D models in the upstream distributary flow areas. A box culvert is located at the CSA crossing with W. Orange Grove Rd, and bridges are located at W. Sunset Rd and W. River Rd. Storm drains are located at the W. Ina Rd. crossing that have an outlet downstream of the N. Oracle Rd. crossing, where the hydraulic study begins. The attenuation of the peak discharge from culverts and bridges was not included in the calculation of the discharge to provide a conservative estimate.

1.5 Acknowledgments

This study relied on assistance of RFCD staff, who were integral to the development of the models and maps.

1.6 Study Results

The CSA was divided into 25 sub-basins, and discharges were calculated at significant confluences for floodplain mapping (Fig. 1.2). The estimated discharges are 1474.0 cfs for the main reach at Las Lomitas Rd. (CP A) with an area of 1.42 mi^2, a discharge of 1133.0 cfs for the tributary at La Lomitas Rd. (CP B) with an area of 0.518 mi^2, a discharge of 1987.2 cfs for the confluence with the Rillito (CP C) with an area of 2.22 mi^2, a discharge of 1363.3 cfs for the main reach at La Canada Rd. (CP D) with a drainage area of 1.06 mi^2, and a discharge of 479.0 cfs for the tributary at La Canada Rd. (CP E) with a drainage area of 0.15 mi^2.

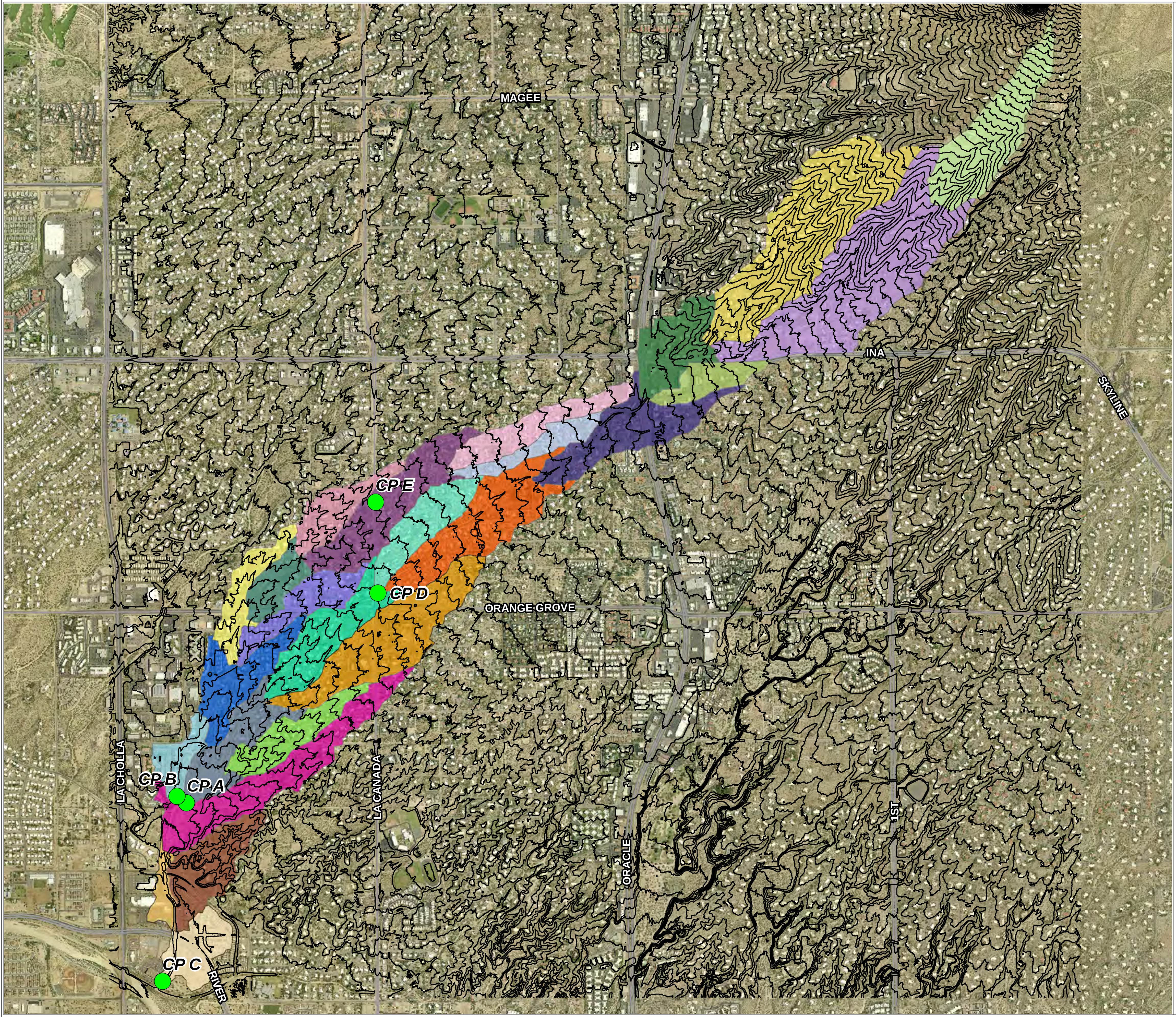


Figure 1.1
Watershed Map
Casas Adobe Wash

Discharge Point

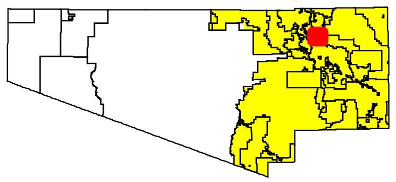
Contour 10 ft.

Subbasin

- CSAA001
- CSAA002
- CSAA003
- CSAA004
- CSAA005
- CSAA006
- CSAA007
- CSAA008
- CSAA009
- CSAA010
- CSAA011
- CSAA012
- CSAB001
- CSAB002
- CSAB003
- CSAB004
- CSAB005
- CSAB006
- CSAB007
- CSAB008
- CSAB009
- CSAC001
- CSAC002
- CSAC003
- CSAC004

Aerial : 2010 Pictometry
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:5,250,000

The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Regional Flood Control Department makes no claims regarding the accuracy of the information depicted herein.

This product is subject to the Department of Transportation Technical Services Division's Use Restriction Agreement.

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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

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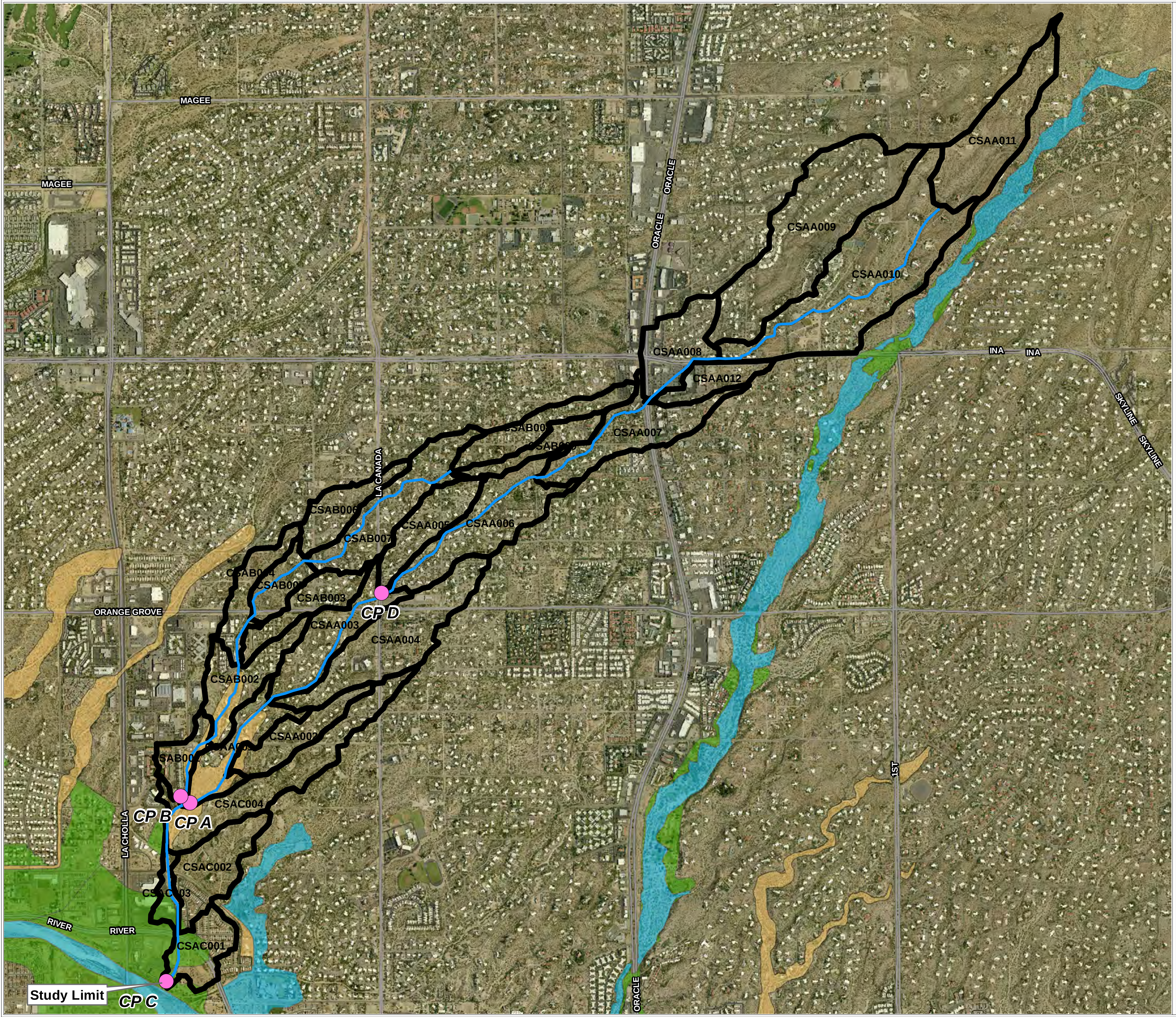
Figure 1.2
Study Limit
Casas Adobe Wash



Discharge Points

River

Subbasin Boundary

Existing FEMA Floodplain

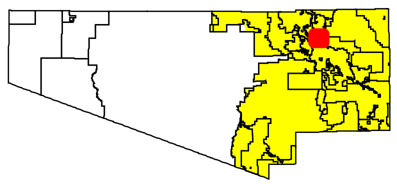
ZONE A

ZONE AE

ZONE X - SHADED

Aerial : 2010 Pictometry

Pima County Index Map



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Pima County Regional Flood Control District

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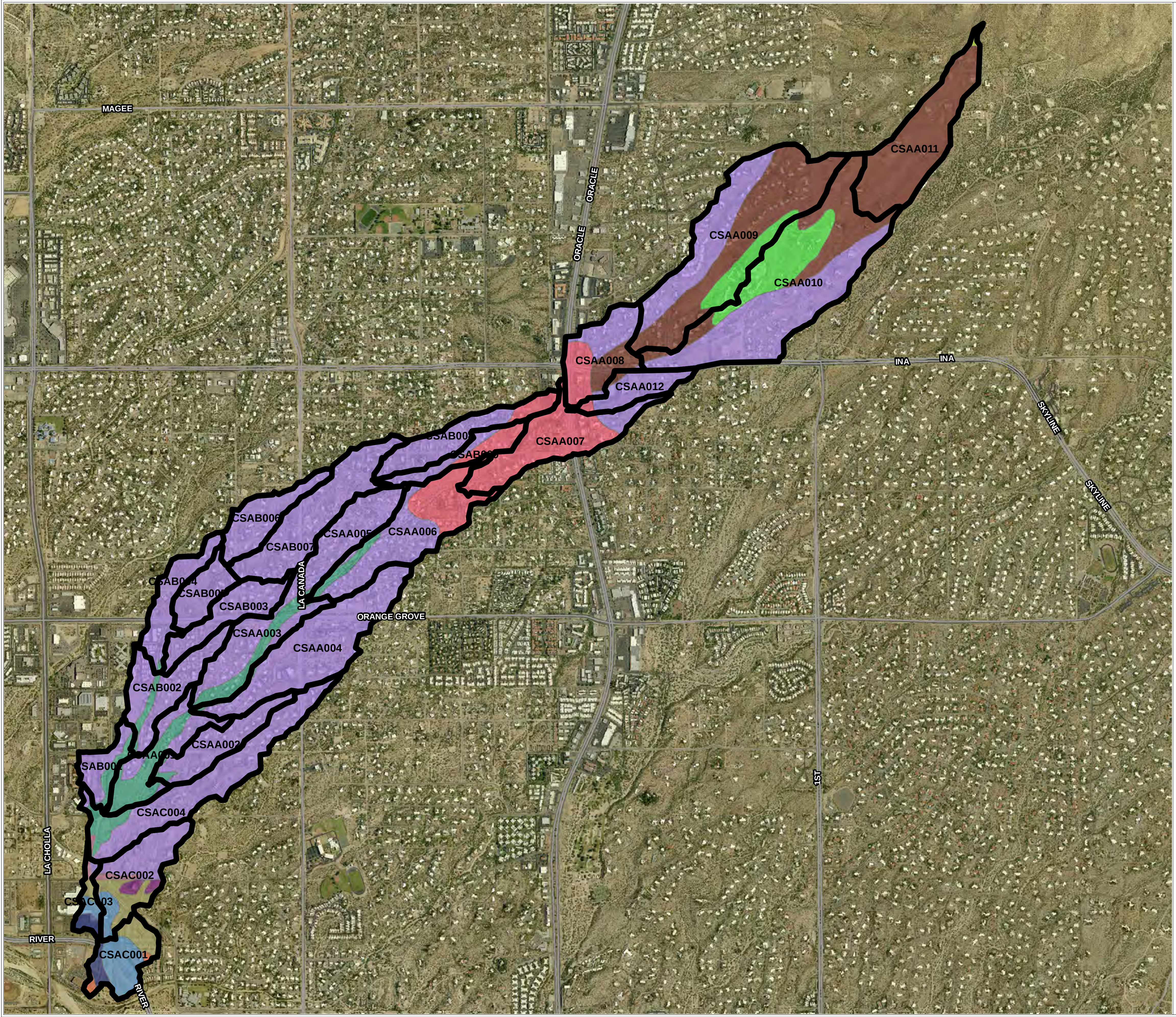
Figure 1.3
Soil Classification
Casas Adobe Wash



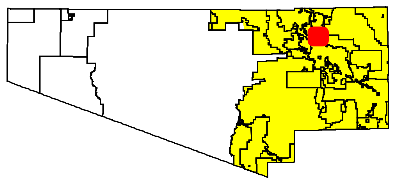
Subbasin

Soil Classification

- Soil Group: A (100%), ARIZO-RIVERWASH COMPLEX, 0 TO 3 PERCENT SLOPES
- Soil Group: A (100%), RIVERWASH
- Soil Group: A (100%), VINTON SANDY LOAM
- Soil Group: A (53%) B (47%), VINTON-ANTHONY SANDY LOAMS
- Soil Group: B (100%),
- Soil Group: B (100%), ANTHONY FINE SANDY LOAM, 0 TO 3 PERCENT SLOPES
- Soil Group: B (100%), ANTHONY GRAVELLY SANDY LOAM,1 TO 3 PERCENT SLOPES
- Soil Group: B (100%), GILA LOAM, 0 TO 1 PERCENT SLOPES
- Soil Group: B (100%), GILA SANDY LOAM
- Soil Group: B (100%), GRABE LOAM
- Soil Group: B (100%), PINALENO-STAGECOACH COMPLEX, 5 TO 16 PERCENT SLOPES
- Soil Group: B (50%) C (50%), PALOS VERDES-SAHUARITA COMPLEX, 2 TO 8 PERCENT SLOPES
- Soil Group: B (82%) C (18%), PINALENO-STAGECOACH-PALOS VERDES COMPLEX, 10 TO 35 PERCENT SLOPES
- Soil Group: C (100%), ROUGH BROKEN LAND-PALOS VERDES COMPLEX, 0 TO 60 PERCENT SLOPES
- Soil Group: C (50%), D (50%)
- Soil Group: C (53%) D (47%), PALOS VERDES-JAYNES COMPLEX, 2 TO 8 PERCENT SLOPES

Aerial : 2008 Pima Association of Governments

Pima County Index Map



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Section 2 FEMA Forms

2.1 Study Documentation Abstract for FEMA submittals

2.1.1 Date Study Accepted: This study has not been submitted to FEMA.

2.1.2 Study Contractor:

Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

Prepared by Dave Stewart, EIT, Civil Engineering Assistant.

2.1.3 Local Technical Reviewer:

Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

2.1.4 Reach Description

A segment of the CSA study reach is located within a FEMA-designated “Zone A” flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1660L and 1667L (February 8, 1999). The detailed study reach of the CSA begins immediately downstream of N. Oracle Rd. and ends at the W. River Rd. bridge.

The study reach of the CSA is primarily a sand channel with desert brush in the channel and in the overbanks areas.

2.1.5 USGS Quad Sheets

Not available for this study

2.1.6 Unique Conditions and Problems

None.

2.1.7 Coordination of Peak Discharges

The 100-year regulatory discharge rates at the concentration points along the study reach were computed using HEC-HMS and PC-Hydro for CP B and E. The HEC-HMS discharges assumed no base flow in the watersheds and no transmission losses within the reaches. All reaches were modeled with HEC-RAS. The discharge rates were acceptable per Evan Canfield, Pima County Regional Flood Control District Project manager.

2.2 FEMA Forms

This is a local study and no FEMA forms are included in this TDN.

Section 3 Survey and Mapping Information

3.1 Field Survey Information

A box culvert is located at the Casas Adobes Wash crossing at W. Orange Grove Rd, and bridges are located at W. Sunset Rd and W. River Rd. Storm drains are located at the W. Ina Rd. crossing that have an outlet at the N Oracle Rd. crossing. A dip crossing is located at N. La Canada Rd.

3.2 Mapping

The topographic data was obtained using GeoRas and ArcGIS. A triangular Irregular Network (TIN) derived from 2008 Light Detection and Ranging (LiDAR) data was used for the analysis.

The following data was used in this TDN;

Projection = State Plane, Arizona Central Zone
Datum = NAD83 HARN
Units = International Feet
North American Vertical Datum of 1988 (NAVD, 1988)
The contour interval of the topographic map is 2 feet.

Section 4 Hydrology

4.1 Method Description

The 100-year peak discharges at CSA concentration points with drainage area greater than 1 mi^2 (CP A, C, D) were calculated using the Hydrologic Engineering Center's

Hydrologic Modeling System, (HEC-HMS) version 3.1.0, and the peak discharges at concentration points with drainages areas less than 1 mi2 (CP B and E) were found using PC-Hydro. The HEC-HMS model parameters for rainfall, topography, soil, vegetation, and channel characteristics were determined according to the Pima County Regional Flood Control District Technical Policy 018 (Tech-018). Tech-018 is included in Appendix A.

The HEC-HMS and PC-Hydro models are included in Appendix D.

4.2 Parameter Estimation

4.2.1 Drainage Area

As mentioned in 3.2, topographic data was derived from a TIN created from 2008 LiDAR data. ArcGIS was used to delineate the sub-basins. The watershed map is shown in Figure 1.1.

4.2.2 Watershed Work Map

ArcGIS was used to determine drainage areas from 2008 LiDAR data in Figure 1.1. Sub-basins were delineated for the hydrologic analysis at CP A, C, and D in HEC-HMS, and for the hydrologic analysis at CP B and CP E in PC-Hydro.

4.2.3 Gage Data

No gage data were used in this TDN.

4.2.4 Statistical Parameters

No statistical parameters were used in this TDN.

4.2.5 Precipitation

According to Tech-018, the design storm should be used that produces the higher discharge between the 100-yr 3-hour SCS Type II distribution and the 100-yr 24-hr SCS Type I distribution. The 100-yr 3-hour SCS Type II distribution was found to produce the higher discharge on the CSA.

The NOAA Atlas 14, upper 90% confidence interval precipitation frequency estimate values (NOAA 14 rainfall) were used to determine point 3-hour rainfall depth for the

CSA watershed. The point rainfall depth for the 3-hour storm was obtained, based on the coordinates of the centroid of the watershed. Area reduction factor was applied to watersheds larger than 1 square mile as noted in Tech-018. The 3-hour rainfall depth for the CSA watershed is 3.17 inches. The area reduction factors are 0.946, 0.938, and 0.970 for CP A, C and D respectively.

4.2.6 Physical Parameters

The physical parameters for the sub-basins and reaches of the HEC-HMS model are summarized in Tables 1 and 2. As mentioned in 4.1, all the methods and parameters were determined based on Tech-018. Table 1 summarizes the method used for a HEC-HMS analysis.

Table 4.1 Methods used for a HEC-HMS analysis

	Selected Method
Rainfall Depth	NOAA 14, upper 90% Confidence Interval
Rainfall Distribution	3-hr SCS Type II Storm
Rainfall Loss	SCS Curve number
Time of Concentration	SCS Segmental Method
Transform	SCS Unit Hydrograph
Routing	Modified-Puls

The SCS Curve Number (CN) method was utilized as a rainfall loss method in the HEC-HMS model. The CN was determined using the Curve Number tables and Hydrologic Soils Group maps associated with the PC Hydro User Guide (Arroyo Engineering, 2007). The CN was not adjusted for rainfall intensity or antecedent moisture conditions. The SCS Unit Hydrograph method was used as a transform method. Impervious cover was determined using the 2008 PAG aerial photographs. The combination of the kinematic wave time of concentration method and the U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (Tc) calculation (USDA-NRCS, 1986) was used to determine Tc, based on the recommendation on Tech-018. The Tc was calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow. The Tc for sheet flow was estimated using the kinematic wave equation. Manning’s roughness coefficient for sheet flow was obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986). The detail of the Tc calculation is included in Appendix D.

Table 4.2. Physical Parameters for Sub-Basins

Sub-basin	Area (mi^2)	CN	Initial Abstraction (in)	Imp%	Lag time (min)
A1	0.068	86.1	0.249	22.1%	10.12
A2	0.059	89.0	0.182	26.9%	15.50
A3	0.085	87.4	0.211	26.3%	10.04
A4	0.145	89.3	0.178	26.4%	18.17
A5	0.065	89.3	0.170	30.0%	13.53
A6	0.126	87.3	0.217	24.8%	12.92
A7	0.101	86.1	0.225	29.5%	15.72
A8	0.076	86.5	0.172	44.5%	10.33
A9	0.249	85.2	0.256	24.9%	13.35
A10	0.276	86.5	0.258	16.9%	14.70
A11	0.126	83.1	0.383	5.0%	11.59
A12	0.040	88.7	0.146	43.4%	11.84
B1	0.035	87.3	0.186	35.5%	6.78
B2	0.074	88.8	0.177	30.1%	10.81
B3	0.056	89.4	0.163	32.0%	16.49
B4	0.049	89.3	0.162	33.3%	9.34
B5	0.039	89.4	0.198	16.7%	9.38
B6	0.052	89.4	0.187	21.3%	12.53
B7	0.111	89.4	0.171	28.5%	19.88
B8	0.064	88.6	0.175	32.3%	16.81
B9	0.039	87.5	0.204	28.3%	17.45
C1	0.055	83.0	0.293	26.4%	15.45
C2	0.080	86.7	0.276	9.4%	11.94
C3	0.020	83.5	0.373	5.0%	5.46
C4	0.130	88.6	0.200	22.5%	24.68

Runoff from sub-basins was routed using the Modified-Puls method. A storage discharge table for the channel routing was developed using the cross sections and slopes in HEC-RAS. The number of subreaches was calculated using the following method:

$$V_{ave} = \frac{L}{T} \text{..................} eq.1$$

$$V_w = 1.5 * V_{ave} \text{.........} eq.2$$

$$K = \frac{L}{V_w} \text{..................} eq.3$$

Therefore,

$$K = \frac{T}{1.5} \text{..................} eq.4$$

$$N = \frac{K}{\Delta t} \text{.................} eq.5$$

where V_{ave} is average flow velocity, L is reach length, T is average travel time, V_w is the wave celerity (a conversion factor of 1.5 is used for natural channels), K is hydrograph travel time, Δt is the time interval for computations in the model, and N is the number of steps in the routing. Eq.4 was obtained from Eq.1, 2, and 3.

Table 4.3. Physical Parameters for Reaches

Sub-basin	Number of subreaches
RCSA001	12
RCSA002	7
RCSA003	5
RCSA004	8
RCSA005	5
RCSA006	6
RCSA007	4
RCSA008	3
RCSA009	8
RCSA010	14
RCSA011	7
RCSA012	4
RCSA013	5
RCSA014	4

4.3 Problems Encountered During the Study

4.3.1 Special Problems and Solutions

There were no problems with the hydrologic modeling.

4.3.2 Modeling Warning and Error Messages

The time interval of the rainfall data used in this study is 5 minutes, while the simulation time interval is 1 minute. The HEC-HMS model interpolated the 5-minute time interval of the rainfall data to 1-minute time interval.

Warnings were produced in the HEC-HMS model stating that each hyetograph gage with 5 minute interval was interpolated to a simulation time interval of 1 minute.;

4.4 Calibration

No calibration was conducted in this study.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

The 100-year peak discharges at the concentration points along the CSA were determined using the HEC-HMS model. The results are summarized in Tables 4 and 5.

Table 4.4 Summary of sub-basin discharges.

Sub-basin	Area (mi^2)	Rainfall Depth (in)	Runoff Depth (in)	Peak Discharge (cfs)
A1	0.068	3.17	2.05	175.9
A2	0.059	3.17	2.29	136.0
A3	0.085	3.17	2.18	231.7
A4	0.145	3.17	2.31	307.8
A5	0.065	3.17	2.34	163.8
A6	0.126	3.17	2.16	304.0
A7	0.101	3.17	2.13	217.1
A8	0.076	3.17	2.33	218.5
A9	0.249	3.17	2.02	556.1
A10	0.276	3.17	2.02	584.6
A11	0.127	3.17	1.65	248.9
A12	0.040	3.17	2.44	110.9
B1	0.035	3.17	2.27	113.3
B2	0.074	3.17	2.31	205.2
B3	0.057	3.17	2.37	129.9
B4	0.049	3.17	2.37	147.7
B5	0.039	3.17	2.23	111.6
B6	0.052	3.17	2.09	123.8
B7	0.111	3.17	2.34	225.1
B8	0.064	3.17	2.32	142.2
B9	0.039	3.17	2.21	80.4
C1	0.055	3.17	1.64	91.9
C2	0.080	3.17	1.92	178.9
C3	0.020	3.17	1.68	51.3
C4	0.130	3.17	2.22	216.8

Table 4.5. Summary of 100-yr Peak Discharge Values

Concentration Point		Area	100-yr Peak Discharge	Runoff Volume	Time of Peak
Name	Location	(mi^2)	(cfs)	(in)	(min)
CP A	Main Reach at Las Lomitas	1.42	1474.0	1.99	134
CP B*	Tributary at Las Lomitas	0.52	1133.0		
CP C	At the Rillito	2.22	1987.2	1.95	142
CP D	Main Reach at N. La Canada Rd.	1.06	1363.3	1.98	122
CP E*	Tributary at La Canada Rd.	0.15	479.0		

*Runoff volumes are not directly calculated in PC-Hydro.

4.5.2 Verification results

The 100-yr peak discharge was compared with discharges estimated from the USGS Regression Equation 13 (RRE13) (Thomas et al., 1997) (Table 4.8). The comparison shows that the modeled 100-yr peak discharge is slightly lower than the RRE13 discharge for CP A and CP C, possibly due to the attenuation effects along the main reach. The modeled 100-yr discharge is higher than the RRE13 discharge at CP B, CP D, CP E which may be attributed to the steep slopes and shorter lengths of those reaches and the use of the more conservative PC-Hydro estimate for CP B and CP E.

Table 4.8. Comparison of peak discharge with regional regression equations.

Concentration Point		Area	100-yr Peak Discharge	USGS RRE13 Qp
Name	Location	(mi^2)	(cfs)	(cfs)
CP A	Main Reach at Las Lomitas	1.42	1474.0	1581.0
CP B	Tributary at Las Lomitas	0.52	1133.0	796.6
CP C	At the Rillito	2.22	1987.2	2092.5
CP D	Main Reach at N. La Canada Rd.	1.06	1363.3	1307.9
CP E	Tributary at La Canada Rd.	0.15	479.0	297.3

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the CSA wash was performed using FLO-2D, Hec-Ras, Version 4.0 (HEC-RAS), and HEC-GeoRAS Version 4.1.1.

2008 LiDAR data was used to create a Triangular Irregular Network (TIN) for the detailed study area of the CSA wash. The locations of the stream centerline, cross-sections, and banks of the CSA wash were determined using ArcGIS and 2008 PAG aerial photos. The physical attributes of the wash were digitized in ArcGIS using the HEC-GeoRAS extension and then exported to HEC-RAS to create geospatially referenced geometric data (cross sections, and reach lengths). Other parameters for the steady-state analysis, such as Manning's n-values, culvert data, expansion and contraction coefficients, boundary condition, and ineffective flow areas were manually input into HEC-RAS. The hydraulic data obtained from HEC-RAS were then imported into HEC-GeoRAS to delineate a floodplain in the study area.

The hydraulic analysis was performed for the study area that includes an area currently mapped as FEMA Zone A. Steady flow analysis was performed to determine 100-year water surface elevations in the study area by using HEC-RAS. As described above, geometric data for HEC-RAS including the stream centerline, cross-sections, river banks, and culverts were obtained using HEC-GeoRAS. The HEC-RAS data and shape files (contour lines, flowpath, cross section lines, concentration points, sub-basins, and floodplain limit) from the analysis are included on the CD.

The downstream boundary condition was assumed to be critical depth for the HEC-RAS model. Using a normal depth downstream boundary condition was found to have no effect on results above the Sunset Rd. bridge, and therefore the critical depth boundary condition is justified.

The reaches upstream of CP A and CP B were found to flow over bank and leave the channel, and therefore FLO-2D was used for those areas. The reaches of the Casas Adobes wash were split into three areas for FLO-2D models which are displayed in Figure 5.1. The HEC-HMS hydrographs from the downstream concentration point were used as the inflow at the upstream boundary of each FLO-2D model. The hydrographs from CP A and B were entered at the top of FLO-2D Area 2, while CP D and E were used at the top of FLO-2D Area 1, and the hydrograph for CP D was used at the top of FLO-2D Area 3 (which results in a breakout flow path that connects to the tributary in Area 1). A base floodplain Manning's n value of 0.045 was used in the FLO-2D models and then calibrated based on the roughness adjustments made by the FLO-2D software. Houses were removed from the effective flow area by using the area reduction factors in FLO-2D. The FLO-2D models are included in Appendix E.

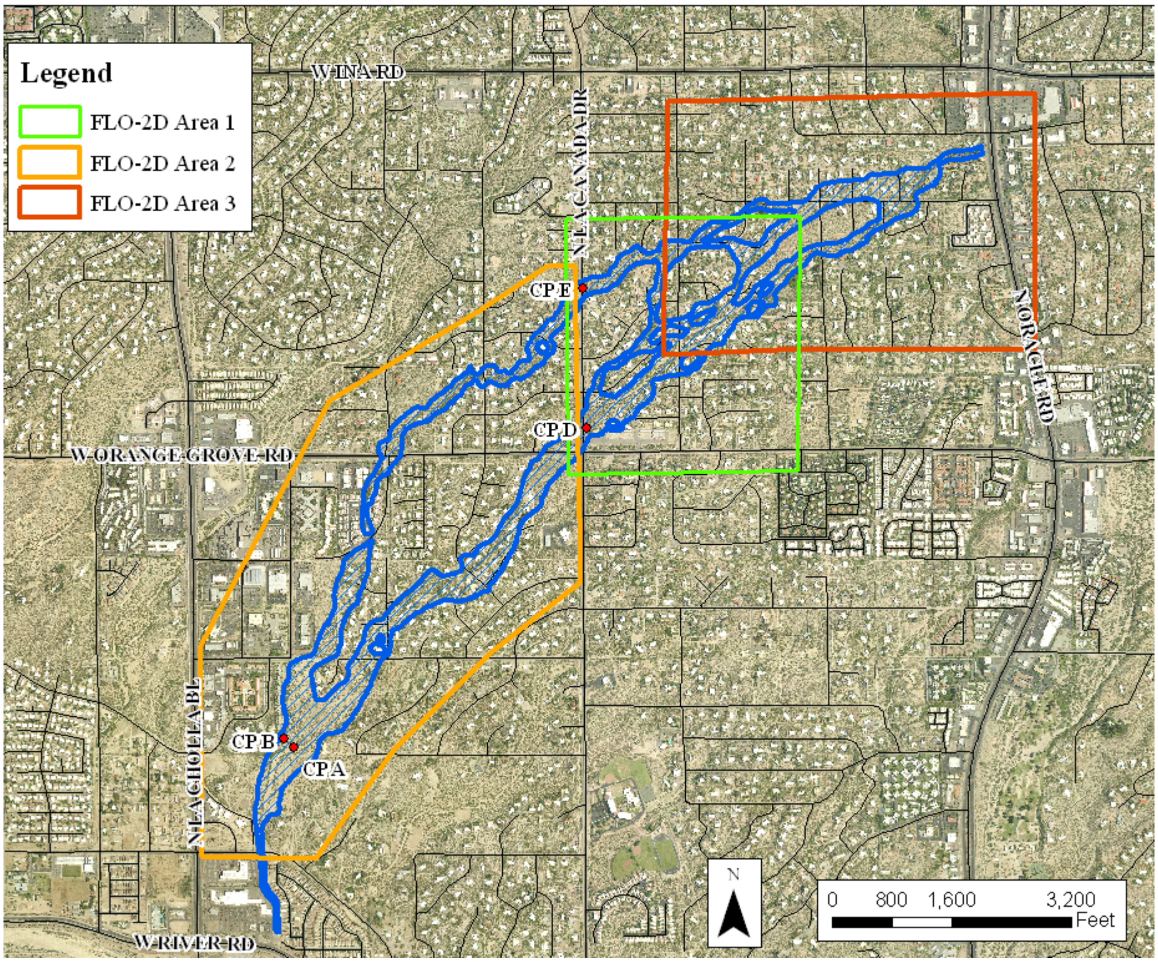


Figure 5.1. The study areas for the three FLO-2D models.

5.2 Work Study Maps

The work study maps are included as Exhibits.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

The Manning's n values were assigned based on USGS publications on roughness coefficients for Southern Arizona (Phillips and Tadayon, 2006). A Manning's n value of 0.045 was assigned for the channel and 0.055 was assigned for the overbank due to scattered desert brush. In FLO-2D, the n values were calibrated based on the roughness adjustment performed by the FLO-2D software.

5.3.2 Expansion and Contraction Coefficients

The channel of the Casas Adobes Wash is assumed to have gradual transitions and default expansion and contraction coefficients of 0.3 and 0.1 were used respectively.

5.4 Cross-Section Description

HEC-RAS Cross sections were created using GeoRAS at changes in channel geometry from the 2008 LiDAR data. The cross-section lines were drawn to be perpendicular to flow paths in Geo-RAS and ArcGIS. Cross sections were not created for FLO-2D.

5.5 Modeling Consideration

5.5.1 Hydraulic Jump and Drop Analysis

No hydraulic jump or drop was shown in the analysis of this study.

5.5.2. Bridges and Culverts

The Sunset Rd. bridge was modeled at the downstream end of the study area using the "As-built" plans for the Casas Adobes wash levee at Riverside Crossing (Environmental Engineering Consultants, Inc. 12/18/98) included in Appendix C. The bridge at Sunset Rd. consists of four 12' x 8' cells.

5.5.3 Levees and Dikes

The Riverside Crossings Levee is located on the west bank of the CSA wash from immediately upstream of W. Sunset Rd. up to Las Lomitas Rd and was accredited by FEMA on July 24, 2009 (Appendix B). The 2008 LiDAR data were used for the levee features in HEC-RAS cross sections. “As-built” plans for the CSA levee (12/18/98) are included in Appendix C.

5.5.4 Island and Flow Splits

FLO-2D was used for the reaches of the Casas Adobes wash where significant flow splits and breakouts were found.

5.5.5 Ineffective Flow Areas

Ineffective flow areas were defined in HECRAS for areas of cross sections that were not hydraulically connected until the water surface elevation exceeded a topographic feature. Ineffective flow areas were set as permanent for large areas not connected to the channel that would otherwise cause instability in the model when the water surface elevation exceeded the ineffective flow elevation.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Problems Encountered

5.7.1 Special Problems and Solutions

There are no special problems in the study limit.

5.7.2 Model Warnings and Errors

The FEMA guidelines state that it is required to run hydraulic models for the subcritical flow condition. Since areas of the CSA wash have steep slopes and a lined channel, the flow regime of the CSA is expected to exhibit critical flow at some locations. The HEC-RAS modeling produced some warnings stating “During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer.” The program defaulted to critical depth at several HEC-RAS cross-sections along the lower reach of the CSA. Most of the warnings force a critical solution which is reasonable for these steep watercourses. A summary of errors is available in Appendix E.

The warnings stating that “The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations”, “The energy loss was greater than 1.0 ft (0.3 m) between the current and previous cross section. This may indicate the need for additional cross sections”, and “The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections” are produced at some locations in the Casas Adobes HECRAS study reach. These warning messages were expected due to the steep slopes of the CSA wash. All the warning messages in the HEC-RAS modeling are included in Appendix E.

5.8 Calibration

The FLO-2D models for the Casas Adobes wash were calibrated for roughness to improve model stability and speed. The TIME.OUT and ROUGH.OUT files were reviewed and the cells causing increases in time steps were replaced with the higher roughness values.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The Casas Adobes wash 100-yr floodplain is shown in Exhibit 1, Sheets 1 through 3. The HEC-RAS model of the CSA is included in Appendix E.

The lower reach of the CSA (from CP A and B down to CP C) is considered a confined wash at some locations and additional floodplain restrictions may apply. The ratio of the average width of the 100-yr floodplain to the 25-yr floodplain was found to be 1.22 for the lowest reach (lower than the 1.25 criterion), and at some locations the overbanks are higher than 1.5 times the 100-yr flow depth. The CSA is not considered a confined wash in the reaches above CP A and B.

5.9.2 Verification of Results

The floodplain limit obtained by this study was compared to the current FEMA floodplain limit. The proposed floodplain approximately follows the existing floodplain limit; however, this study extends further north and covers both the tributary as well as the main reach. The results within in the current FEMA floodplain suggest that the proposed floodplain limit is reasonable based on the new topographic data of the Casas Adobes Wash.

Section 6 Erosion and Sediment Transport

No erosion and sediment transport study was conducted in this study.

Section 7 Draft FIS Report Data

7.1 Summary of Discharges

Table 7. Summary of Discharges

Concentration Point		Area	100-yr Peak Discharge
Name	Location	(mi^2)	(cfs)
CP A	Main Reach at Las Lomitas	1.42	**1474.0**
CP B	Tributary at Las Lomitas	0.52	**1133.0**
CP C	At the Rillito	2.22	**1987.2**
CP D	Main Reach at N. La Canada Rd.	1.06	**1363.3**
CP E	Tributary at La Canada Rd.	0.15	**479.0**

7.2 Floodway Data

Not applicable.

7.3 Annotated Flood Insurance Rate Map

Not applicable.

7.4 Flood Profiles

Flood profiles are included in Appendix E.

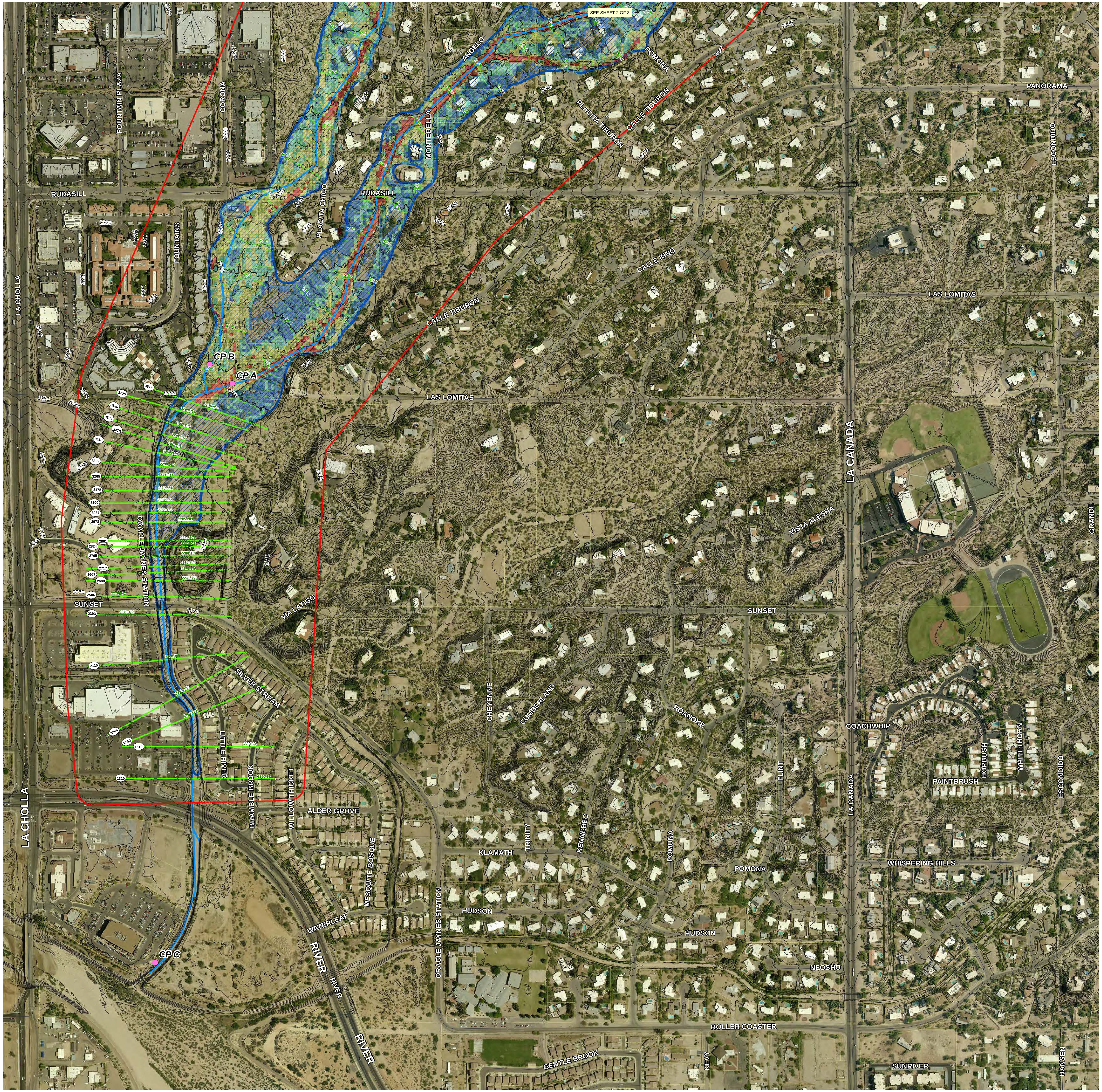


Exhibit 1
100-year Floodplain with cross sections Casas Adobes Wash
Sheet 1 of 3

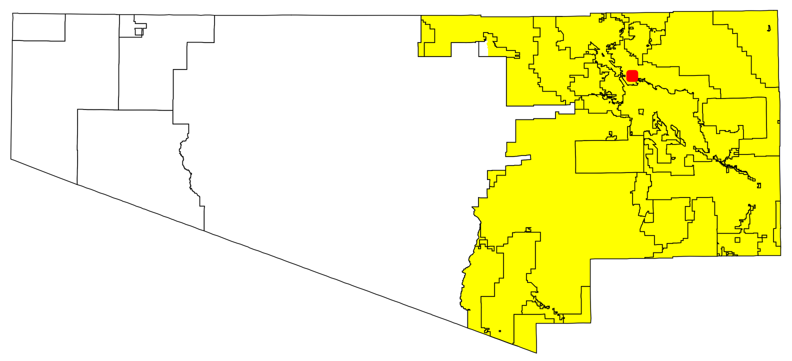
- Discharge Points
- 2008 Contour 2ft
- Contour10ft
- CasasAdobes BFE Contours 1ft
- CasasAdobes BFE Contours 5ft
- Cross Sections
- River
- Study Area
- Casas Adobe 100-yr Floodplain
- Shallow Flooding Zone

Casas Adobes FLO2D Floodplain BFE FlowDepth

- =>0.200
- =>0.500
- =>1.000
- =>2.000

Aerial : 2010 Landiscor Aerial Imagery
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Department of Transportation Technical Services Division makes no claims regarding the accuracy of the information depicted herein.

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Pima County Regional Flood Control District

N

0 100 200 400 Feet

Pima County Regional FLOOD CONTROL DISTRICT

THE SEAL OF PIMA COUNTY ARIZONA

Pima County Regional Flood Control
97 East Congress Street - 3rd Floor
Tucson, Arizona 85701-1207
(520)243-1800 - FAX (520)243-1821
http://www.rfcd.pima.gov

10/2011

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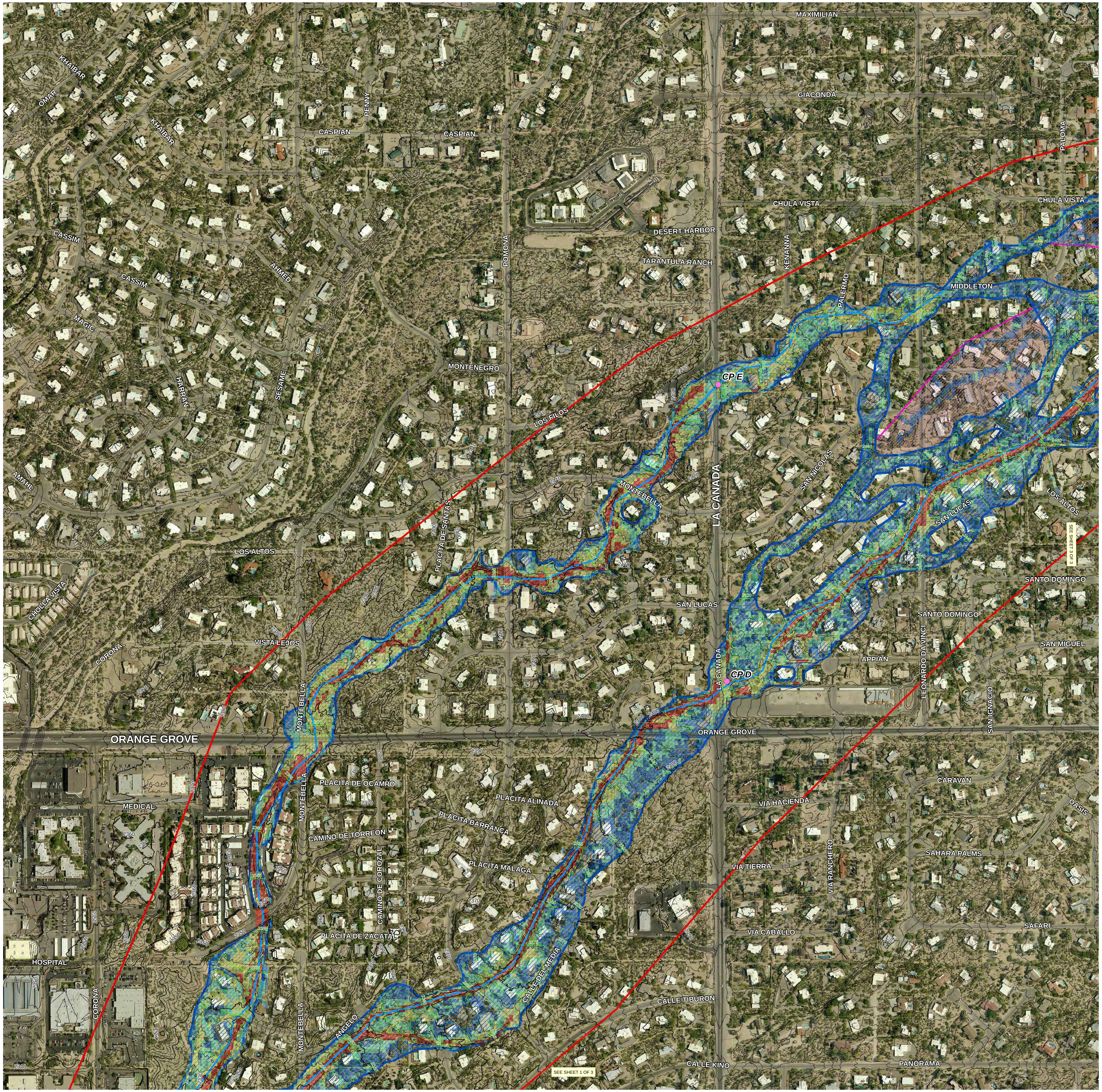


Exhibit 1
100-year Floodplain with cross sections Casas Adobes Wash
Sheet 2 of 3

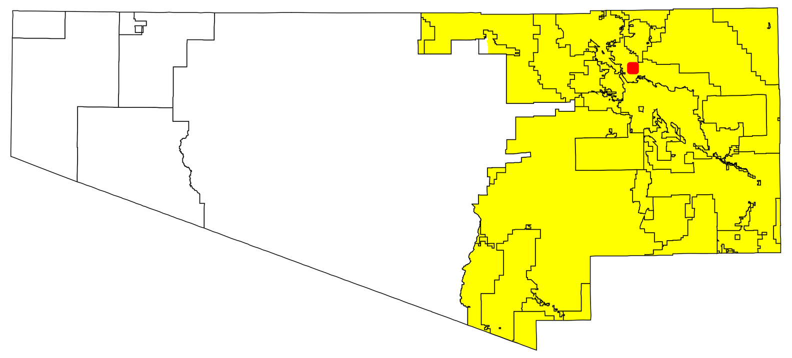
- Discharge Points
- 2008 Contour 2ft
- Contour10ft
- CasasAdobes BFE Contours 1ft
- CasasAdobes BFE Contours 5ft
- Cross Sections
- River
- Study Area
- Casas Adobe 100-yr Floodplain
- Shallow Flooding Zone

Casas Adobes FLO2D Floodplain BFE FlowDepth

- =>0.200
- =>0.500
- =>1.000
- =>2.000

Aerial : 2010 Landiscor Aerial Imagery
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



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10/2011

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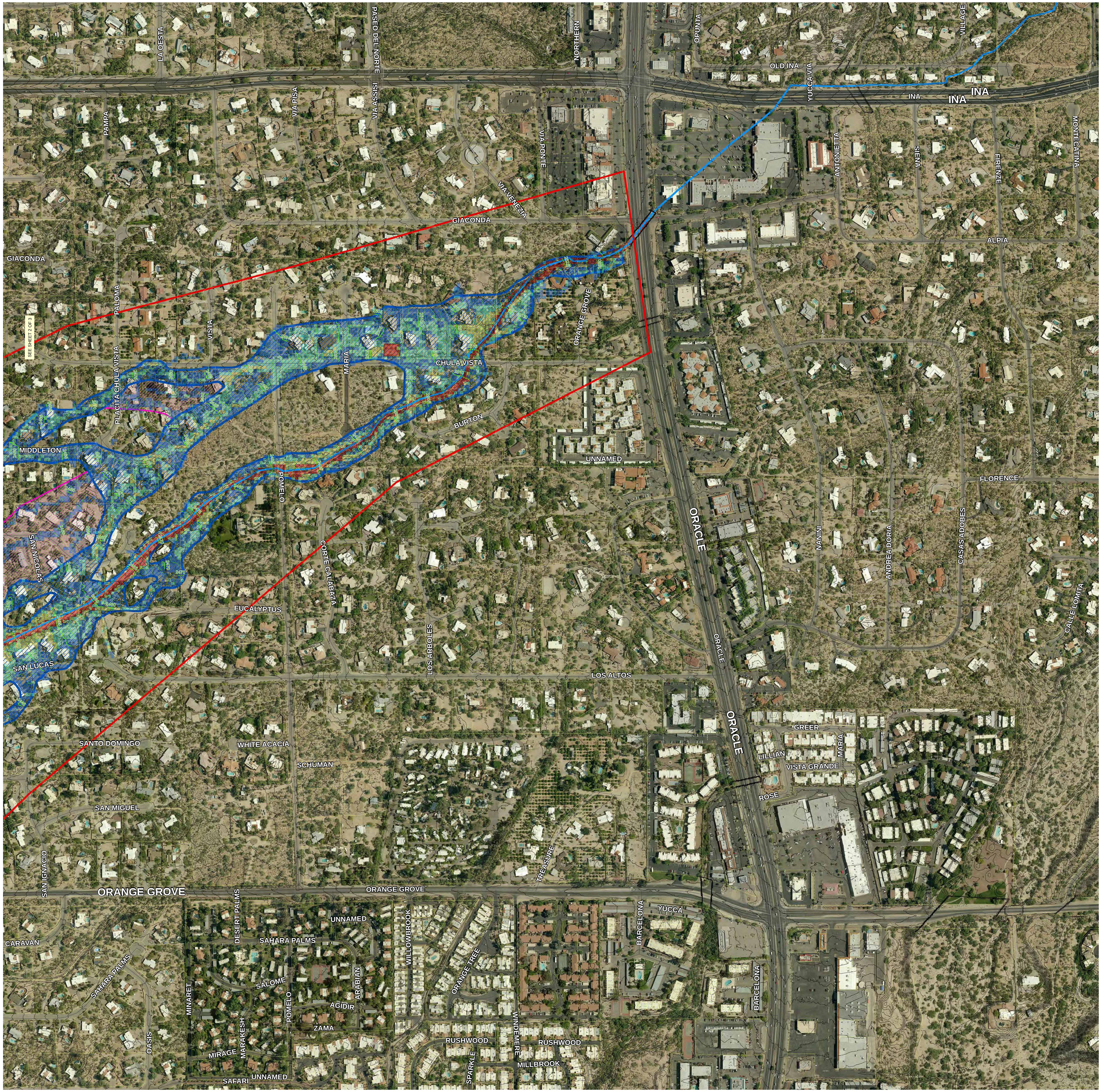
Exhibit 1
100-year Floodplain with cross sections Casas Adobes Wash Sheet 3 of 3



- Discharge Points
- 2008 Contour 2ft
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- CasasAdobes BFE Contours 1ft
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Casas Adobes FLO2D Floodplain BFE FlowDepth

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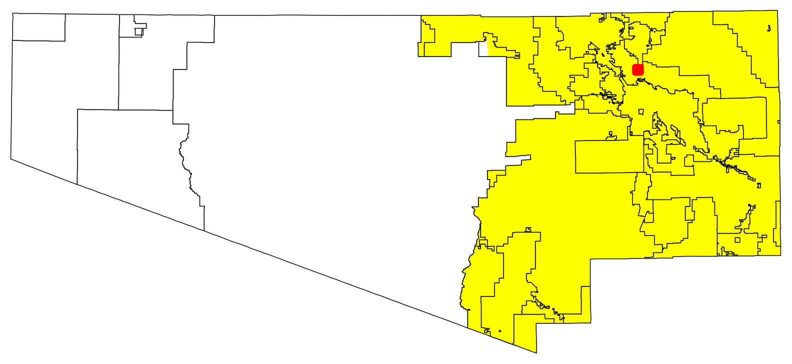
Aerial : 2010 Landiscor Aerial Imagery
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Department of Transportation Technical Services Division makes no claims regarding the accuracy of the information depicted herein.

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10/2011

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A.1 Data Collection Summary

Aldridge, B. and J. Garrett. 1973. Roughness Coefficients for Stream Channels in Arizona. US Department of the Interior Geological Survey. Tucson, AZ.

Arizona Department of Water Resources, Flood Mitigation Section
“Requirements for Flood Study Technical Documentation” SS1-97, November 1997

National Weather Service. 1984. Depth-Area Ratios in the Semi-Arid Southwest United States, NOAA Technical Memorandum NWS Hydro-40

Phillips, J., and S. Tadayon. 2006. Selection of Manning’s roughness coefficient for natural and constructed vegetated and non-vegetated channels, and vegetation maintenance plan guidelines for vegetated channels in central Arizona: U.S. Geological Survey Scientific Investigations Report 2006–5108, 41 p.

Phillips, J., and T. Ingersoll. 1998. Verification of Roughness Coefficients for Selected Natural and Constructed Stream Channels in Arizona. U.S. Geological Survey Professional Paper 1584.

Pima County Regional Flood Control District
“Pima County Mapguide Map”, 2008

U.S. Army Corps of Engineers (COE). 2001. HEC-RAS, River Analysis System, Hydraulic
Reference Manual, CPD-69, Hydraulic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers (COE). 2003. Geospatial Hydrologic Modeling Extension HEC-GeoHMS, (v 1.1) CPD-77, Hydraulic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers (COE). 2006. HEC-HMS, Hydrologic Modeling System User’s Manual, (v. 3.1.0) CPD-74A, Hydraulic Engineering Center, Davis, CA.

U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Washington, DC.

A 2. Referenced Documents

Eychaner, J.H., 1984. Estimation of magnitude and frequency of floods in Pima County, Arizona, with comparisons of alternative methods: U.S. Geological Survey Water-Resources Investigations Report 84-4142, 69 p.

Haan, C.T., Barfield, B.J., Hayes, J.C. 1994. Design Hydrology and Sedimentology for Small Catchments, Academic Press.

Thomas, B.E., H.W. Hjalmarson, and S.D. Waltemeyer. 1997. Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States. USGS Water Supply Paper 2433. 195 p.

U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1986. Urban Hydrology for Small Watersheds, Technical Release 55. Washington, DC.

Appendix B General Documentation and Correspondence

Appendix C: Survey Field Notes

IMPROVEMENT PLANS

FOR

CASAS ADOBES WASH

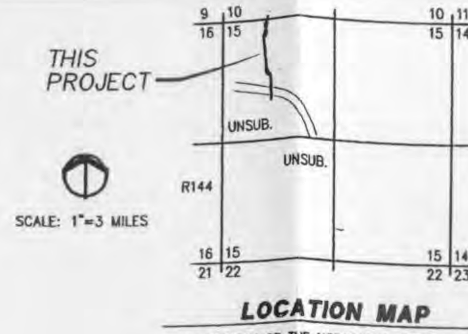
PIMA COUNTY, ARIZONA

GENERAL GRADING & PAVING NOTES

1. ALL MATERIALS AND WORKMANSHIP ARE TO BE IN ACCORDANCE WITH PIMA COUNTY/CITY OF TUCSON STANDARD SPECIFICATIONS FOR PUBLIC IMPROVEMENTS (PC/COT SSPI), EDITION OF 1994, EXCEPT AS MODIFIED HEREBY.
2. ALL CONSTRUCTION AND TESTING METHODS SHALL BE IN CONFORMANCE WITH PC/COT SSPI, EDITION OF 1994, EXCEPT AS MODIFIED HEREBY.
3. EXCAVATION AND BACKFILL FOR STRUCTURES SHALL CONFORM TO PC/COT SSPI, SECTION 203-5.
4. ALL CONCRETE SHALL CONFORM TO PC/COT SSPI, SECTION 1006, CLASS S, 3,000 PSI COMPRESSIVE STRENGTH AT 28 DAYS, UNLESS OTHERWISE SPECIFIED.
5. A STAMPED SET OF APPROVED PLANS SHALL BE KEPT IN AN EASILY ACCESSIBLE LOCATION ON THE JOB SITE AT ALL TIMES OR DURING CONSTRUCTION.
6. CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION REGULATIONS.
7. CONTRACTOR SHALL CALL BLUE STAKE (745-2211) TO VERIFY LOCATION OF ALL UTILITIES PRIOR TO COMMENCEMENT OF CONSTRUCTION.
8. CONTRACTOR SHALL OBTAIN ALL PERMITS REQUIRED BY GOVERNMENTAL AGENCIES.
9. UPON COMMENCEMENT OF WORK, TRAFFIC CONTROL DEVICES SHALL BE POSTED AND MAINTAINED BY THE CONTRACTOR UNTIL SUCH TIME AS THE WORK IS COMPLETED. ALL WARNING SIGNS, BARRICADES, ETC., SHALL BE IN ACCORDANCE WITH THE MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES ADOPTED BY THE STATE OF ARIZONA PURSUANT TO A.R.S. 28-650.
10. ALL STATIONING SHOWN ON PLAN AND PROFILE IS ALONG CONSTRUCTION CENTERLINE UNLESS OTHERWISE NOTED.
11. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE CARE AND MAINTENANCE OF EXISTING IMPROVEMENTS AND VEGETATION IN THE WORK AREA. PAVEMENT, CURBS, AND ANY OTHER OBSTRUCTIONS DAMAGED DURING CONSTRUCTION ARE TO BE REPLACED BY THE CONTRACTOR. ANY UNDERGROUND PIPES, STRUCTURES, OR OBSTRUCTIONS NOT SHOWN ON THESE PLANS SHALL BE MOVED, ALTERED, OR REPAIRED BY THE CONTRACTOR WHEN ENCOUNTERED, AS DIRECTED BY THE ENGINEER, AND IS A DEFINITE PART OF THIS PROJECT.
12. THE CONTRACTOR SHALL GIVE FORTY-EIGHT (48) HOURS NOTICE WHEN HE SHALL REQUIRE THE SERVICES OF THE ENGINEER OR ANY OTHER PERSON PROPERLY AUTHORIZED FOR SUCH PURPOSE FOR LAYING OUT ANY PORTION OF THE WORK. HE SHALL ALSO DIG ALL STAKE HOLES NECESSARY TO GIVE LINE AND LEVELS AND SHALL PROVIDE ASSISTANCE CALLED FOR BY THE ENGINEER OR HIS ASSISTANTS UPON ANY PART OF THE WORK WHENEVER SO REQUESTED, AND SHALL PRESERVE ALL STAKES SET FOR THE LINES, LEVELS OR MEASUREMENTS OF THE WORK IN THEIR PROPER PLACES UNTIL AUTHORIZED TO REMOVE THEM BY THE ENGINEERS. ANY EXPENSE INCURRED IN REPLACING ANY STAKES WHICH THE CONTRACTOR OR HIS SUBORDINATES MAY HAVE FAILED TO PRESERVE SHALL BE CHARGED TO THE CONTRACTOR.
13. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO FURNISH, HAUL AND APPLY ALL WATER REQUIRED FOR COMPACTION AND FOR THE CONTROL OF DUST FROM CONSTRUCTION ACTIVITY. THE COST THEREOF IS TO BE INCLUDED IN THE CONSTRUCTION PRICE.
14. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO FULLY COMPLY WITH U.S. EPA STORMWATER DISCHARGE PERMIT.
15. THE SOILS ENGINEER SHALL OBSERVE, INSPECT AND TEST ALL CONSTRUCTION OPERATIONS, INCLUDING BUT NOT LIMITED TO: CLEARING, GRUBBING, SUBGRADE PREPARATION, STRUCTURAL, TRENCH EXCAVATION AND BACKFILL, MATERIAL TESTING, TOGETHER WITH PLACEMENT OF FILL. SAID ENGINEER SHALL CERTIFY IN WRITING, THAT ALL SOILS OPERATIONS AND MATERIALS USED FOR THIS DEVELOPMENT WERE PERFORMED IN ACCORDANCE WITH THE RECOMMENDATIONS AS SET FORTH IN THE GEOTECHNICAL INVESTIGATION OF RECORD AND ARE IN CONFORMANCE WITH THE ACCEPTED PLANS AND SPECIFICATIONS.
16. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE BENCHMARK AND COMPARE THE SITE CONDITIONS WITH THE PLANS AND SHALL NOTIFY THE ENGINEER OF ANY DISCREPANCIES OBSERVED. SHOULD ANY BENCHMARK, GRADE OR DESIGN INDICATED ON THE PLANS BE SUSPECT, THE ENGINEER SHALL BE NOTIFIED OF SAID BENCHMARK, GRADE OR DESIGN PROBLEM AT LEAST TWENTY-FOUR HOURS BEFORE CONSTRUCTION IS SCHEDULED TO BEGIN ON THE AFFECTED AREA.
17. BASIS OF BEARING: THE WEST LINE OF THE NW 1/4 OF SECTION 15, ACCORDING TO AN UNRECORDED SURVEY PREPARED BY THE WLB GROUP JOB NO. 183159-A-002-1000 DATED 12-8-94, BEARING BEING N00°50'14"W.
18. BASIS OF ELEVATION: FOUND PK NAIL AND ALUMINUM TAG "USCE" RR92-91, STATION 36+53.44, 23.46' LT. ALONG EL CAMINO DE LA TIERRA. SAID ELEVATION =- 2234.04', PER RILLITO RIVER BANK PROTECTION, CAMINO DE LA TIERRA TO SHANNON ROAD, W.O. #4FRPEG.

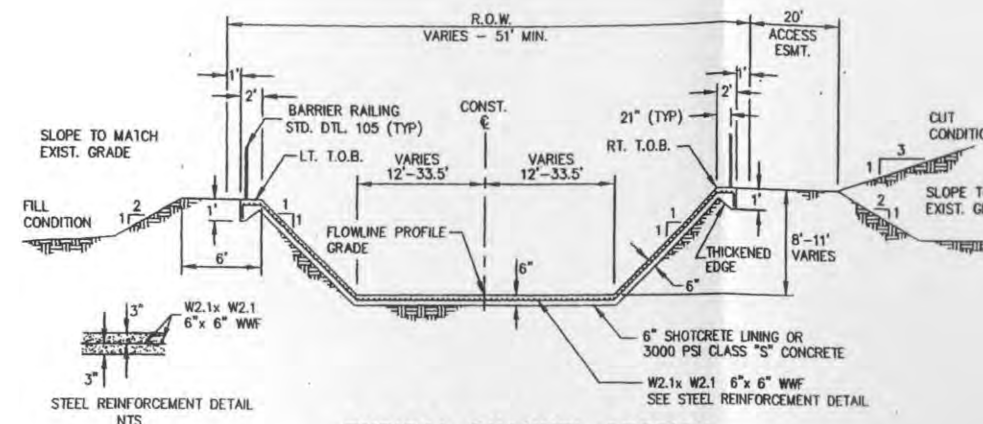
LINE DATA TABLE		
LINE	LENGTH	BEARING
L1	62.47	N44°14'14"W
L2	74.26	S12°30'20"W
L3	17.93	S55°09'02"W
L4	141.33	N07°20'56"E
L5	74.52	N68°37'51"E
L6	63.96	N84°48'04"E
L7	55.01	N89°59'48"E
L8	83.32	S72°12'33"E

CURVE DATA TABLE					
CURVE	LENGTH	RADIUS	CHORD	TANGENT	DELTA
C1	178.01	235.00	173.78	93.52	43°24'00"
C2	153.30	225.00	150.36	79.76	39°02'18"
C3	165.15	460.00	164.27	83.48	20°34'15"
C4	64.79	241.50	64.60	32.59	15°22'20"
C5	42.52	158.50	42.40	21.39	15°22'20"
C6	107.92	145.00	105.45	56.60	42°38'42"
C7	11.54	5.00	9.14	11.28	132°11'54"
C8	5.35	5.00	5.10	2.96	61°16'55"
C9	10.81	5.00	8.82	9.38	123°52'29"
C10	23.57	75.88	23.47	11.88	17°47'39"
C11	303.53	800.00	301.71	153.61	21°44'18"
C12	55.20	460.00	55.17	27.63	06°52'32"
C13	109.95	460.00	109.69	55.24	13°41'44"



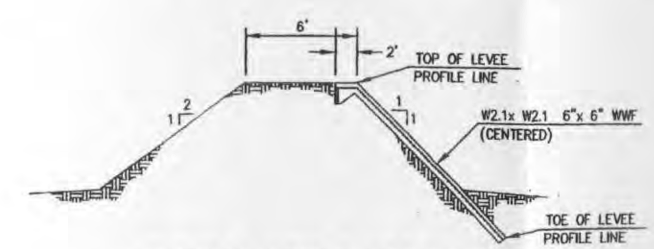
LOCATION MAP

A PORTION OF THE NORTHWEST QUARTER OF SECTION 15, TOWNSHIP 13 SOUTH, RANGE 13 EAST, G.&S.R.B.&M., PIMA COUNTY, ARIZONA



TYPICAL CHANNEL SECTION

CASAS ADOBES WASH, CONCRETE LINED — N.T.S.
STA. 50+75.00 TO STA. 67+16.72



TYPICAL LEVEE SECTION

STA. 65+77.53 TO STA. 76+98.37 — N.T.S.

SITE PLAN

SCALE: 1" = 200'

OWNER/DEVELOPER

RIVER AT LA CHOLLA, LLC
2200 EAST RIVER ROAD, SUITE 115
TUCSON, ARIZONA 85718
(520) 577-0200
CONTACT: MARK WEINBERG

LEGEND

- PROPOSED CONCRETE
- PROPOSED BARRIER RAILING
- PROPOSED RIP RAP
- EXISTING RIP RAP

APPROVALS

[signature]
PIMA COUNTY DEPT. OF TRANSPORTATION

1-20-99
DATE

4554 B
~~[illegible]~~

DWG: P:\98054\CAD\WASH\WASHPP1.DWG
XREF: P:\98054\CAD\WASH\XREF\WASHBASE.DWG

EEC JOB No. 98054.02

Two working days before you dig CALL FOR THE BLUE STAKES
745-2211
Blue Stake Center CALL COLLECT

REV.	DATE	DESCRIPTION	CK. BY

CASAS ADOBES WASH FOR RIVERSIDE CROSSING

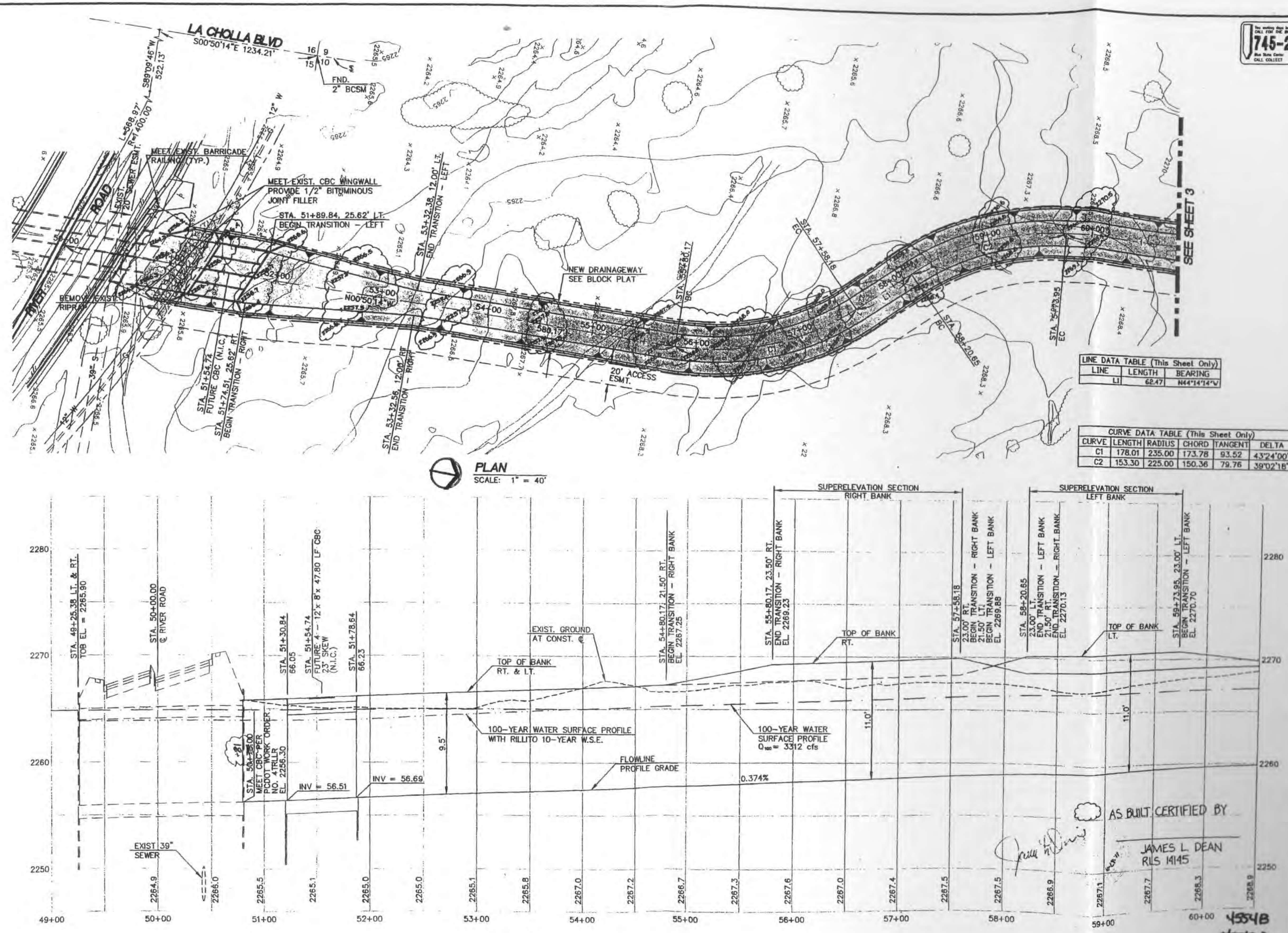
SHEET TITLE: COVER SHEET
PROJECT TITLE: CASAS ADOBES WASH

EEC
ENVIRONMENTAL ENGINEERING CONSULTANTS, INC.
4625 E. FT. LOWELL RD. SUITE 200
TUCSON, ARIZONA 85712 520-321-4625

13800 R. CRAIG ALLISON ARIZONA, U.S.A.

DESIGN BY:	RCA
DRAWN BY:	WHW
CHK'D BY:	RCA
DATE:	12/18/98
SCALE:	AS NOTED
SHEET	1 of 5
PLAN No.	—

P1202_004_QM_S0001



LINE DATA TABLE (This Sheet Only)		
LINE	LENGTH	BEARING
L1	62.47	N44°14'14"W

CURVE DATA TABLE (This Sheet Only)					
CURVE	LENGTH	RADIUS	CHORD	TANGENT	DELTA
C1	178.01	235.00	173.78	93.52	43°24'00"
C2	153.30	225.00	150.36	79.76	39°02'18"

AS BUILT CERTIFIED BY
JAMES L. DEAN
RLS 14145

745-2211

CASAS ADOBES WASH FOR RIVERSIDE CROSSING

CHANNEL PLAN/PROFILE

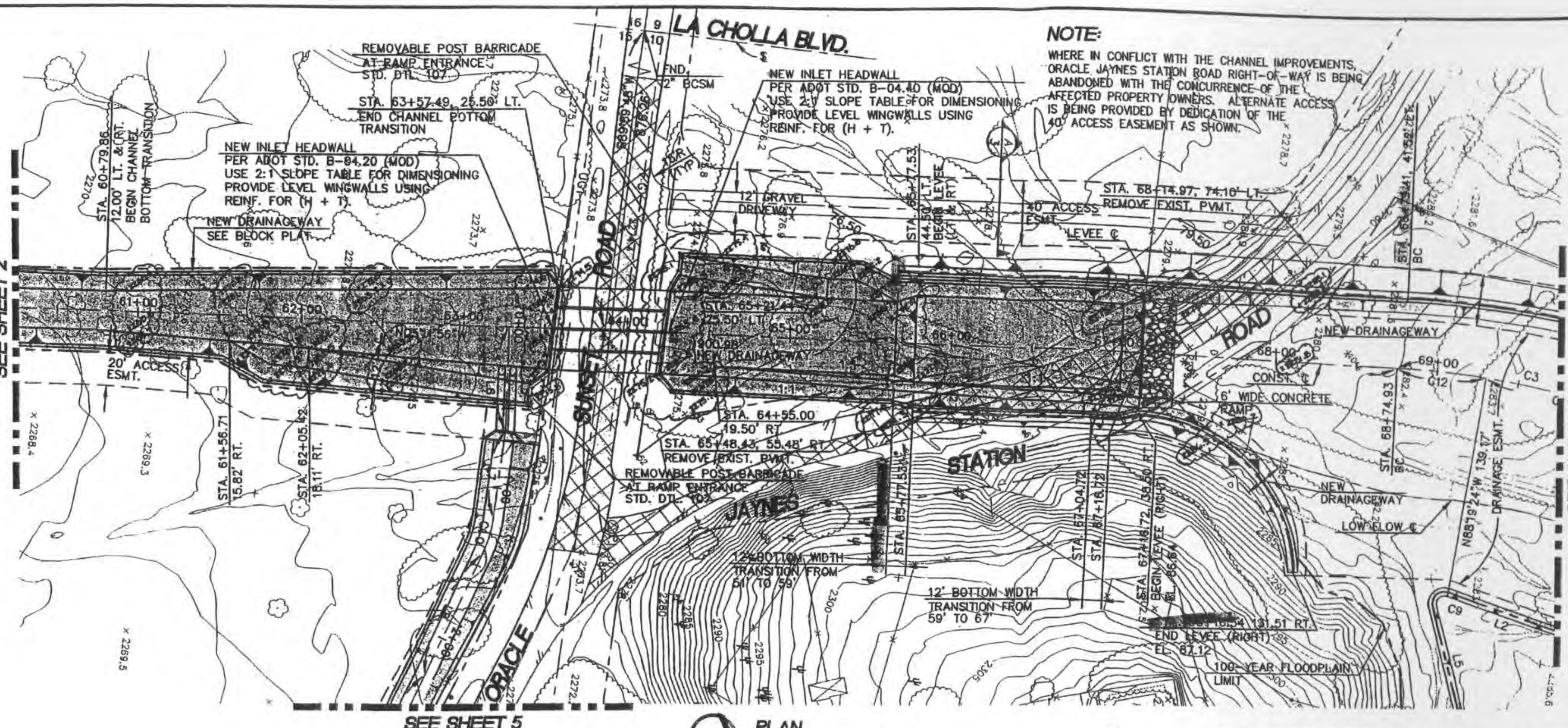
CASAS ADOBES WASH

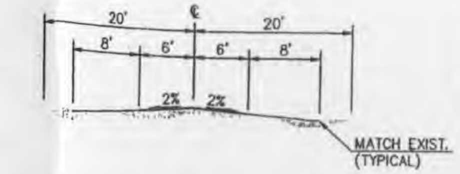
EEC
ENVIRONMENTAL ENGINEERING CONSULTANTS, INC.

SHEET 2 of 5

4554B

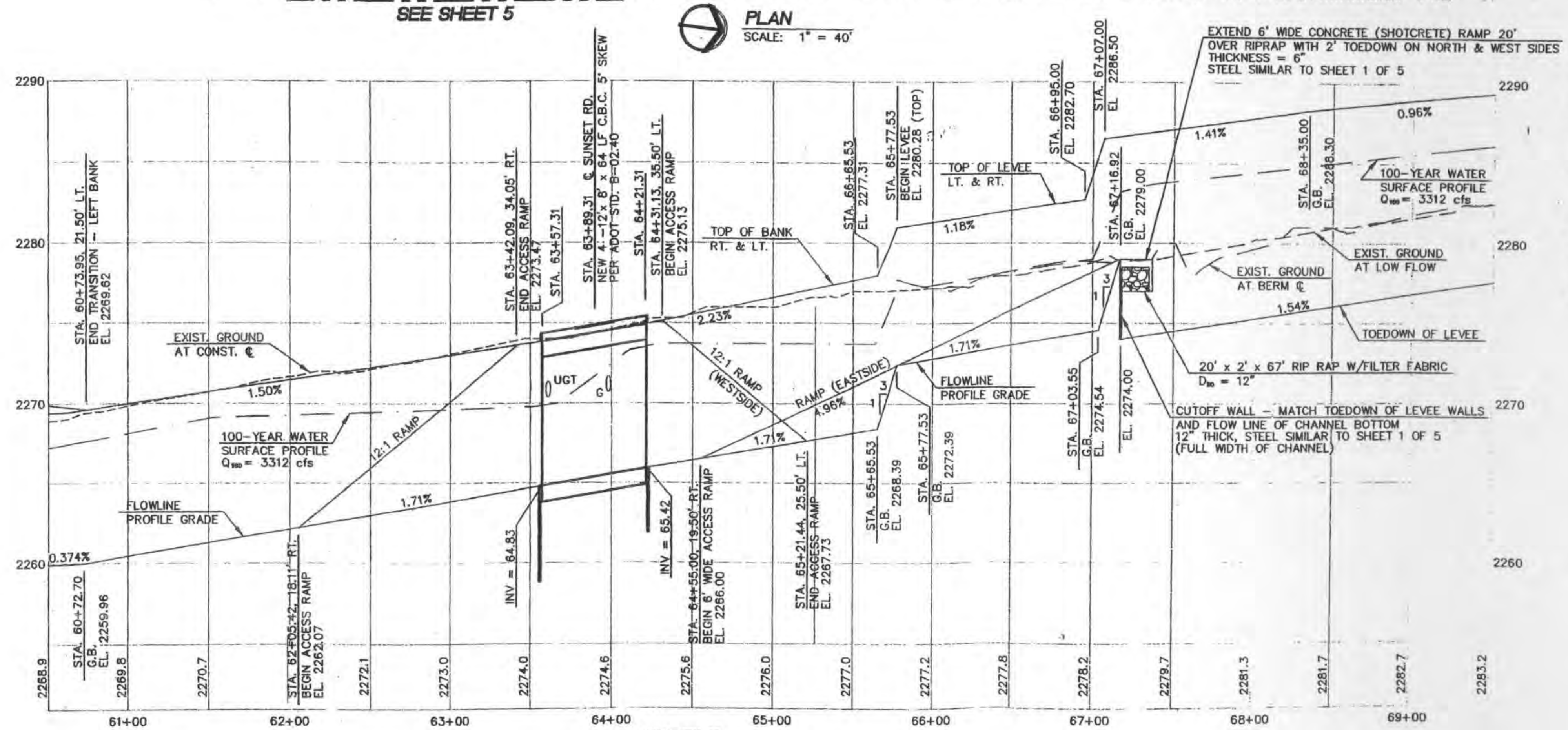
EEC JOB No. 98054.02





CROSS SECTION A-A

12' GRAVEL DRIVEWAY N.T.S.



PROFILE
SCALE: HORIZ: 1"=40'
VERT: 1"= 4'

LINE DATA TABLE (This Sheet Only)		
LINE	LENGTH	BEARING
L2	74.26	S12°30'20"W
L5	74.52	N68°37'51"E
L6	63.96	N84°48'04"E
L7	55.01	N89°59'48"E
L8	83.32	S72°12'33"E

CURVE DATA TABLE (This Sheet Only)					
CURVE	LENGTH	RADIUS	CHORD	TANGENT	DELTA
C3	165.15	460.00	164.27	83.48	20°34'15"
C9	10.81	5.00	8.82	9.38	123°52'29"
C10	23.57	75.88	23.47	11.88	17°47'39"
C12	55.20	460.00	55.17	27.63	06°52'32"

AS BUILT CERTIFIED BY
JAMES L. DEAN
RLS 14145

4554B
~~4113D~~

DWG: P:\98054\CAD\WASH\WASHPP3.DWG
XREFS: P:\98054\CAD\WASH\XREF\WASHBASE.DWG
P:\98054\CAD\SURVEY\TOPO.DWG

EEC JOB No. 98054.02

745-2211
Blue Stake Center CALL COLLECT

REV.	DATE	DESCRIPTION	BY	CK. BY
A		ADD SPOT ELEVATIONS		ULD

CASAS ADOBES WASH FOR RIVERSIDE CROSSING

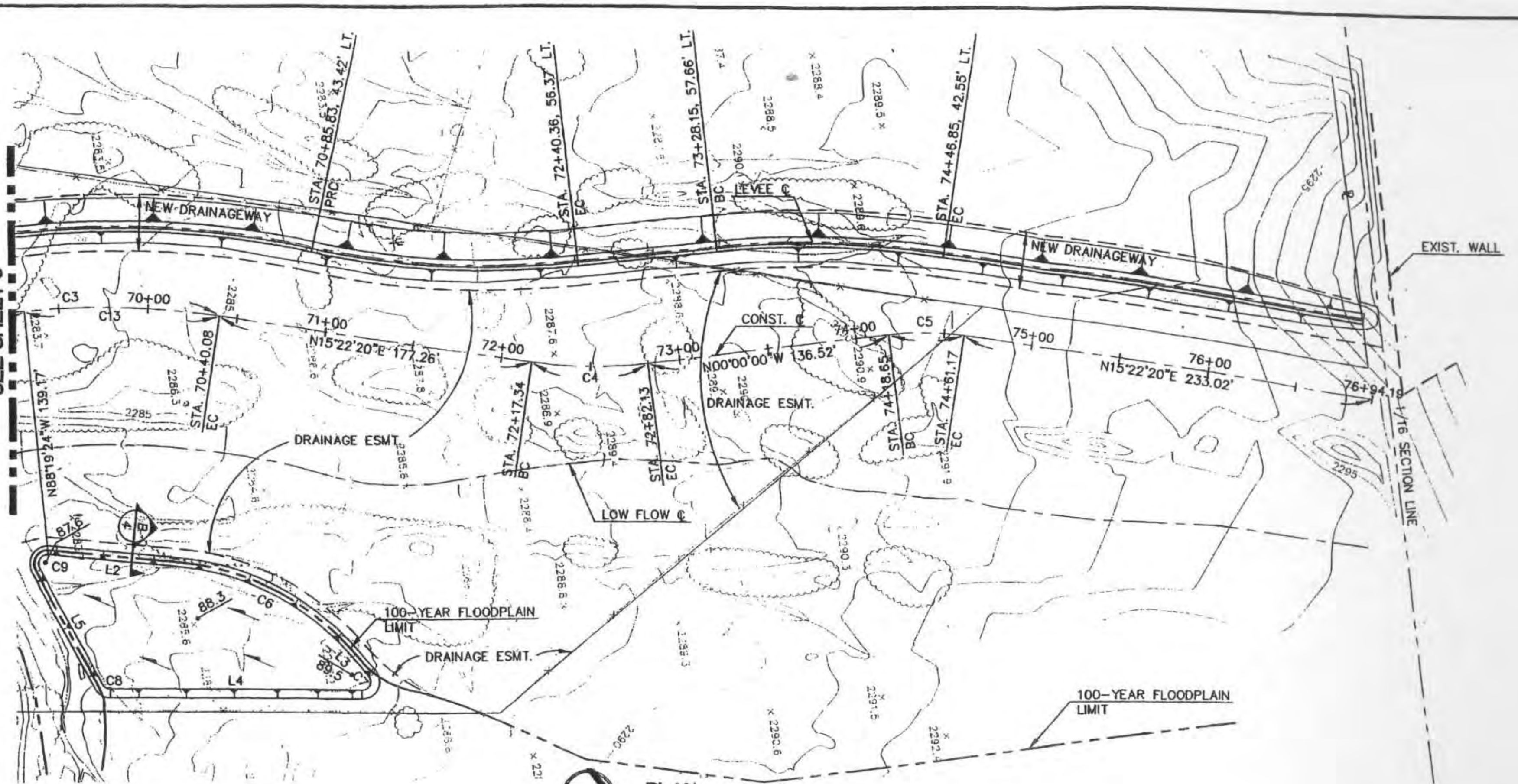
SHEET TITLE: CHANNEL PLAN/PROFILE
PROJECT TITLE: CASAS ADOBES WASH

EEC
ENVIRONMENTAL ENGINEERING CONSULTANTS, INC.
4626 E. FT. LOWELL RD. SUITE 200
TUCSON, ARIZONA 85712 520-321-4625

13800 R. CRAIG ALLISON ARIZONA, U.S.A.

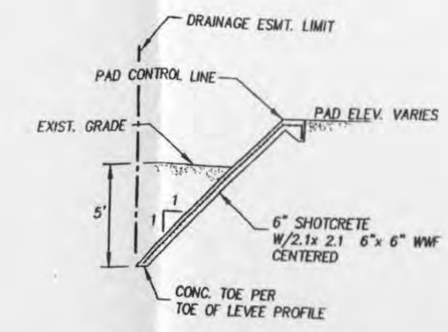
DESIGN BY:	RCA
DRAWN BY:	MHW
CHK'D BY:	RCA
DATE:	12/18/98
SCALE:	AS NOTED
SHEET	3 of 5
PLAN No.	—

P1293_Add_Om_S443



PLAN

SCALE: 1" = 40'

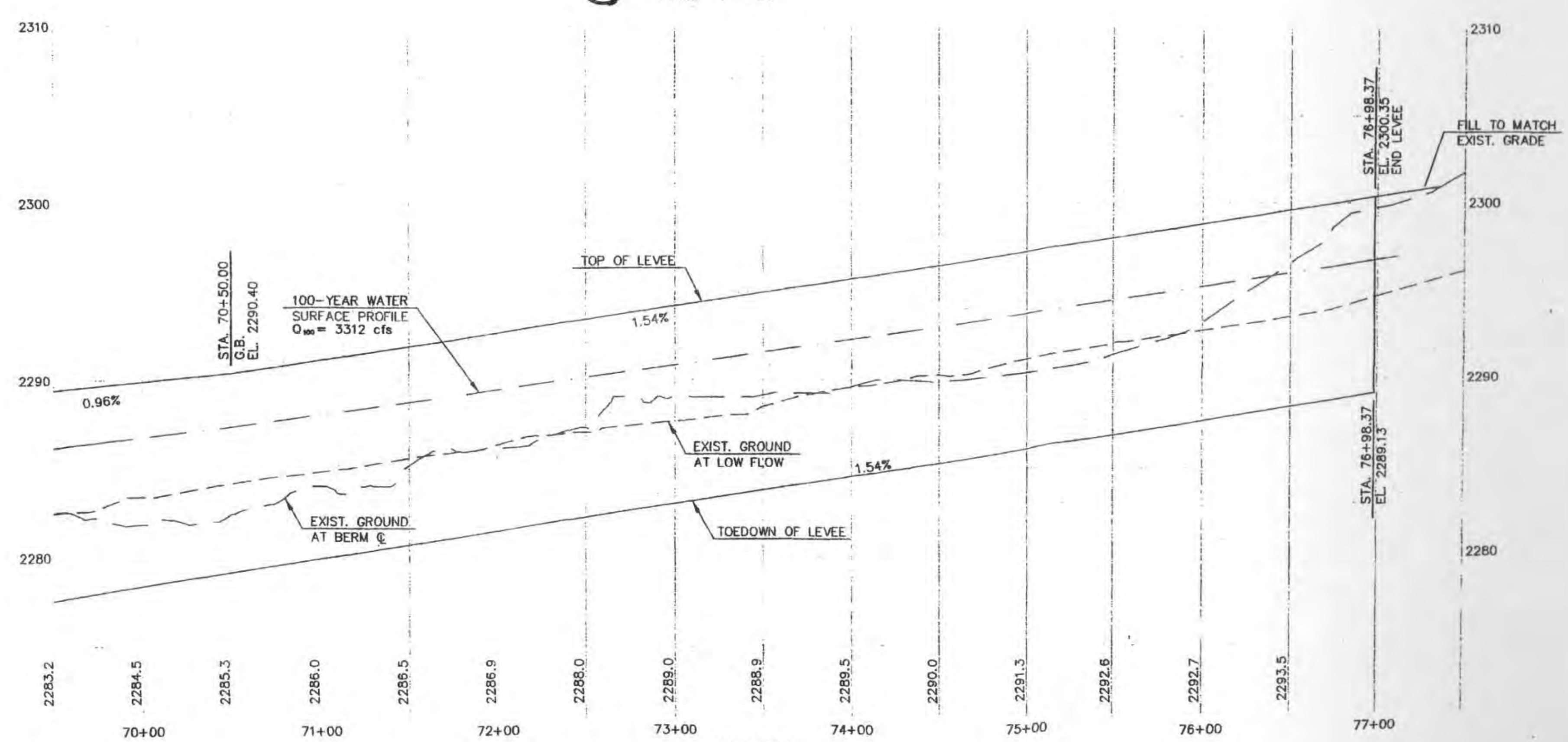


CROSS SECTION B-B

N.T.S.

LINE DATA TABLE (This Sheet Only)		
LINE	LENGTH	BEARING
L2	74.26	S12°30'20"W
L3	17.93	S55°09'02"W
L4	141.33	N07°20'56"E
L5	74.52	N68°37'51"E

CURVE DATA TABLE (This Sheet Only)					
CURVE	LENGTH	RADIUS	CHORD	TANGENT	DELTA
C3	165.15	460.00	164.27	83.48	20°34'15"
C4	64.79	241.50	64.60	32.59	15°22'20"
C5	42.52	158.50	42.40	21.39	15°22'20"
C6	107.92	145.00	105.45	56.60	42°38'42"
C7	11.54	5.00	9.14	11.28	132°11'54"
C8	5.35	5.00	5.10	2.96	61°16'55"
C9	10.81	5.00	8.82	9.38	123°52'29"
C13	109.95	460.00	109.69	55.24	13°41'44"



PROFILE

SCALE: HORIZ: 1"=40'
VERT: 1"= 4'

DWG: P:\98054\CAD\WASH\WASHPP4.DWG
XREFS: P:\98054\CAD\WASH\XREF\WASHBASE.DWG
P:\98054\CAD\SURVEY\TOPO.DWG

EEC JOB No. 98054.02

4554B

Two working days before you dig CALL FOR THE BLUE STAKES 745-2211 Blue Stake Center CALL COLLECT

REV.	DATE	DESCRIPTION	CK. BY

CASAS ADOBES WASH FOR RIVERSIDE CROSSING

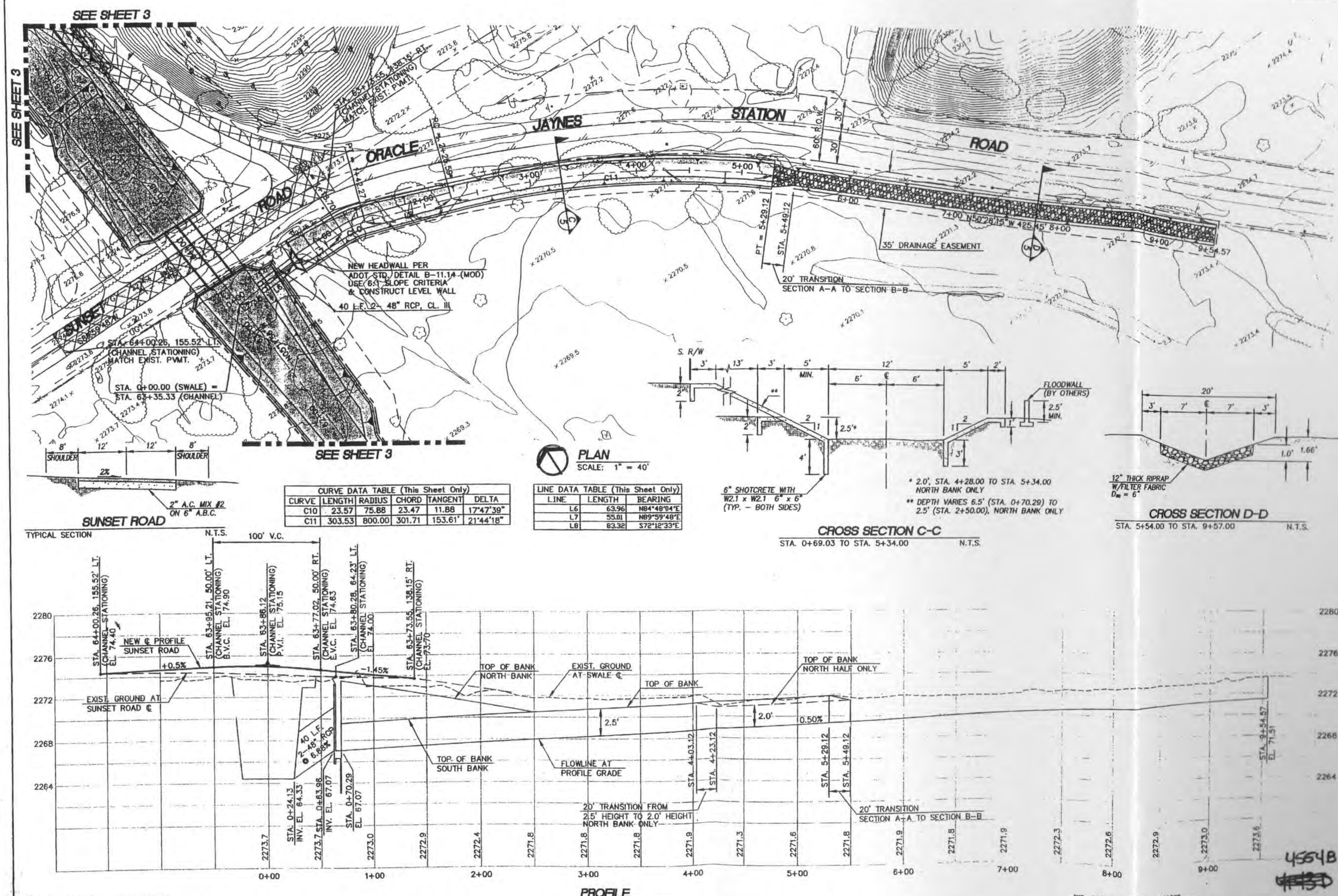
SHEET TITLE: LEVEE PLAN & PROFILE

PROJECT TITLE: CASAS ADOBES WASH

EEC
ENVIRONMENTAL ENGINEERING CONSULTANTS, INC.
4625 E. FT. LOWELL RD. SUITE 200
TUCSON, ARIZONA 85712 520-321-4625

13900 R. CRAIG ALLISON ARIZONA, U.S.A.

DESIGN BY:	RCA
DRAWN BY:	WHW
CHK'D BY:	RCA
DATE:	12/18/98
SCALE:	AS NOTED
SHEET	4 of 5
PLAN No.	—



CURVE DATA TABLE (This Sheet Only)					
CURVE	LENGTH	RADIUS	CHORD	TANGENT	DELTA
C10	23.57	75.88	23.47	11.88	17°47'39"
C11	303.53	800.00	301.71	153.61'	21°44'18"

LINE DATA TABLE (This Sheet Only)		
LINE	LENGTH	BEARING
L6	63.96	N84°48'04"E
L7	55.01	N89°59'48"E
L8	83.32	S72°12'33"E

745-2211
CALL COLLECT

REV. | DATE | DESCRIPTION | CK. BY

CASAS ADOBES WASH FOR RIVERSIDE CROSSING

SHEET TITLE: SUNSET ROAD PLAN/PROFILE

PROJECT TITLE: CASAS ADOBES WASH

EEC
ENVIRONMENTAL ENGINEERING CONSULTANTS, INC.
4625 E. FT. LOWELL RD. SUITE 200
TUCSON, ARIZONA 85712 520-321-4625

DESIGN BY: RCA
DRAWN BY: WHB
CHK'D BY: RCA
DATE: 12/18/98
SCALE: AS NOTED
SHEET 5 of 5

EEC JOB No. 98054.02

4554B

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Appendix D: Hydrology

Supporting documentation is included as digital data on the CD.

Appendix E: Hydraulics

Supporting documentation is included as digital data on the CD.

Appendix F: Erosion and Sediment Transport Analysis Supporting Documentation

None