ADOBE DAM/DESERT HILLS

AREA DRAINAGE MASTER PLAN

Part 8

Phase I

Alternatives Formulation and Preliminary Analysis

Volume 2

Flood Control District of Maricopa County

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ADOBE DAM/DESERT HILLS AREA DRAINAGE MASTER PLAN

PHASE I ALTERNATIVES FORMULATION AND PRELIMINARY ANALYSIS
PART 8, VOLUME 2

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PRELIMNARY ANALYSIS

PART 8, Volume 2

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ENCLOSED DATA CD INCLUDES:

- **Digital Copy of Report in PDF Format**
- ***GIS Shapefile Coverages of Project Elements***
- **HECRAS files used in Risk Assessment**
- **Digital Copy of Phase I, Part 8, Volume 1**

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SECTION 1.1: INTRODUCTION

Residences within existing FEMA floodways were identified for the Adobe Dam / Desert Hills ADMP. Floodway residences are of particular interest because no new building or building permits would be allowed in these most hazardous areas.

These residences were identified as part of the ADMP to provide a basis for prioritization of a possible voluntary property buyout program or floodproofing program as one of the alternatives for the ADMP. Additionally, the spatial distribution of the most at-risk structures can help inform on the location of potential structural flood control measures for evaluation in the ADMP.

To assess the relative risk to floodway residences within the Adobe/Desert Hills ADMP study area, each structure was assigned a risk factor associated with the recurrence interval of first inundation of the finished floor of the structure, hydraulic considerations associated with the FEMA 100-year flow rate at the structure location, and the erosion hazard designation. The emphasis was placed on residences located within FEMA regulated floodways due to the practicality and cost associated with mitigating the hazards.

SECTION 1.2: DATA SOURCES

A number of data sources were needed to perform the risk assessment. Before presenting the risk assessment methodology the data sources are listed and some context on their origin is provided. The data sources for the analyses were:

- Elevation Certificates on file at the FCDMC

  The elevation certificates were collected via the District's GIS system. The points linked to the elevation certificate database were selected for the entire Adobe ADMP study area. The attribute table for the elevation certificates contained a link to the District database location of scanned TIF file versions of the elevation certificates. The TIF files were then located on the District system and copied to a disk for use by the ADMP team. Elevations for floodway residences with elevation certificates were taken from the certificates unless some question remained about which building the elevation corresponded to. Therefore, a few buildings were resurveyed to verify finished floor elevations for the ADMP risk assessment. Figure 1 shows the location of the elevation certificates, the floodway residences, and those surveyed for the ADMP.

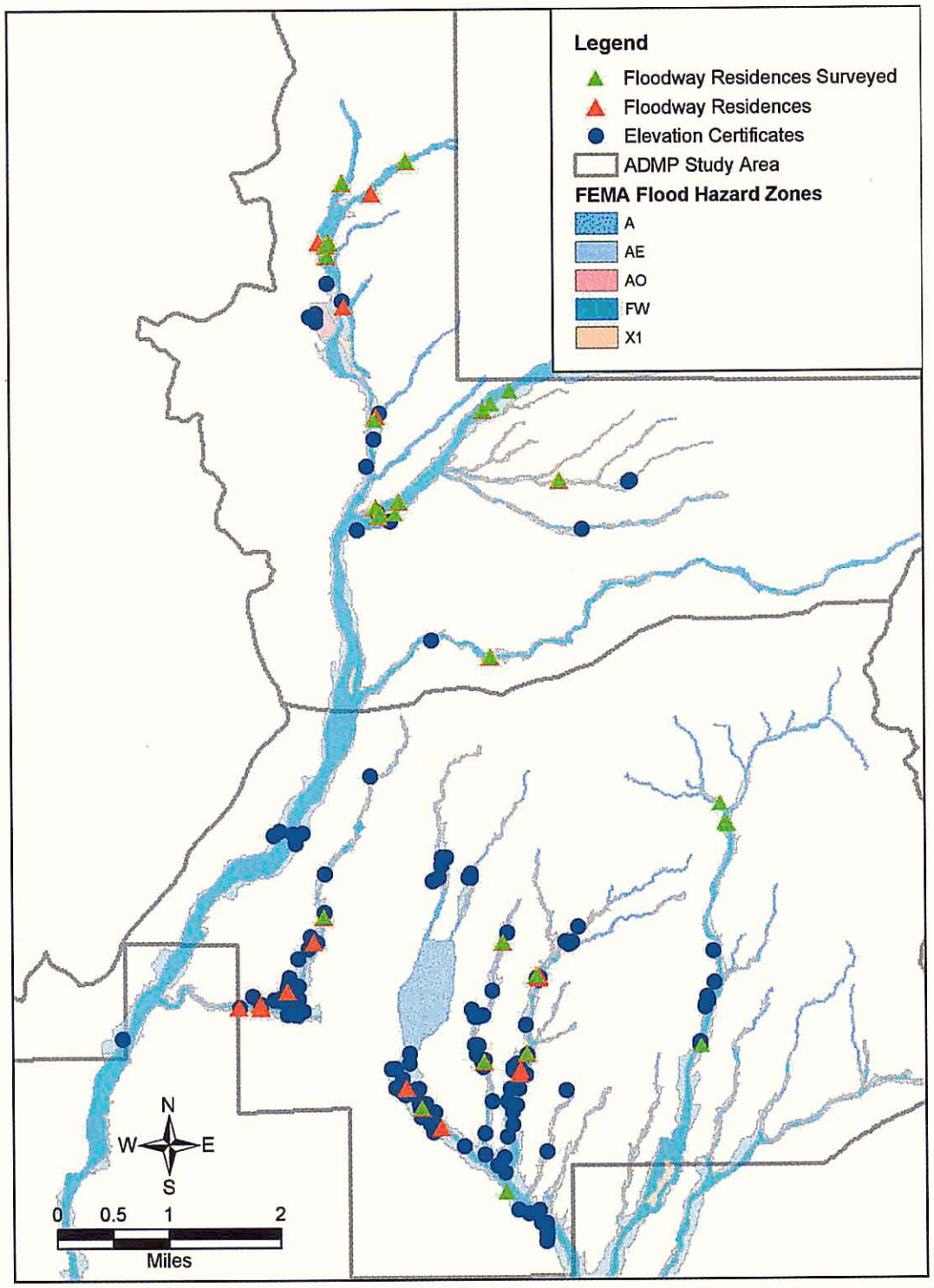


Figure 1. Elevation Certificates and Floodway Residences

- Surveys preformed by RBF Consultants for the ADMP:

  As mentioned above, floodway residences without existing elevation certificates were surveyed as part of the ADMP. Finished floor elevations for 29 structures were surveyed by RBF Consultants in August 2003. Two residents refused permission for access to perform the survey, so no elevations are available for their residences. Again, Figure 1 shows the location of the floodway residences surveyed for the ADMP.

- Existing FEMA hydraulic models:

  Figure 1 also shows the FEMA flood hazard zones for the area. The hydraulic models for those studies served as the basis for the hydraulic data used in the risk assessment. Some of the original hydraulic models were performed using HEC-2. These were imported into HECRAS for the purposes of generating the plots, rating curves, and hydraulic data for the risk assessment. The HECRAS models created from HEC-2 models were computed using the "Between every coordinate point (HEC-2)" conveyance calculation method option in HECRAS. The HECRAS model used for the Skunk Creek floodway residences not within the restudy reach (see next bullet item) were taken from the Stantec model developed for the Skunk Creek Watercourse Master Plan. Although developed from the original FDS HEC-2 models for Skunk Creek, that model used the RAS style conveyance calculation method. The discharges for the 100-year event used for the Risk Assessment were those from the effective FDS.

- Preliminary FEMA restudies for the ADMP:

  Cline Creek and Skunk Creek upstream of New River Road are currently being restudied as part of the ADMP. The preliminary hydraulic modeling results of these restudies (as of October 2003) were used to evaluate whether a residence was in the floodway and the nature of the hydraulics at any residences within the preliminary restudy floodway.

- 2002 digital aerial photos from FCDMC:

  The identification of residences in the floodway was performed by interpretation of the District's 2002 one-foot pixel digital orthophotography. These aerial photos have flight dates in Feb. 2002. The District's digital floodway limits were overlain in GIS to identify residences within the floodway.

- Parcel data collected for the ADMP from FCDMC:

  Parcel data from the Maricopa County Assessor's Office was collected in GIS format from the District in late 2002 as part of the overall ADMP data collection efforts. These data served as the basis for APN, assessed values, and owner information in the initial investigation. In October 2003 as the risk assessment was being concluded, the parcel information for the affected residences were reconfirmed and updated as necessary based on the data available on the Assessor's Office web site.

- Topographic mapping from the FEMA FDS's:

  The topographic data used in the risk assessment was the same as the data used in the Flood Delineation Studies. The dates and contour interval of these data vary by study. The contour interval was either two- or four-feet.

SECTION 1.3: METHODS

The methods employed in this analysis were essentially the same as those in the Skunk Creek Water Course Master Plan. The following is a discussion of the approach and methods as specifically applied in the Adobe ADMP. A step-by-step example of the methods used to assess and rank the risks associated with each structure are provided for Structure No. 16 on Cline Creek throughout the discussion.

The procedure was designed to:

1) Identify residences within the FEMA floodways.
2) Identify the magnitude and frequency of the flood discharge that first inundates the residence.
3) Estimate the depth and velocity of flood water at the residence during the 100-year flood.
4) Identify whether the structure is located within an erosion hazard zone.
5) From the information developed in items 1-3, establish the relative risk of each residence to the rest in the ADMP area.

1.3.1 Identification of Floodway Residences

Residences within the FEMA floodways in the ADMP area were identified by interpretation of the District's 2002 one-foot pixel digital orthographic aerial photographs. The District's digital floodway limits were overlain on the aerial photographs within the ArcView GIS software system. Judgment was used to differentiate residences from outbuildings, sheds, garages, workshops, and other non-occupied residential buildings. The size, location, and nature of the buildings seen in the aerial photographs was used to determine whether a building was to be considered a residence or not. Non-resident-type buildings were not evaluated.

In the process of identifying floodway residences, a couple of discrepancies in the digital floodway data were noted. That is, the digital floodway data showed some residences within or crossed by a floodway boundary while some other data – topographic, original work maps, etc. suggested that the digital data was somehow in error. Table 1 lists parcels where the digital floodway data suggests that the residence is in the floodway but were evaluated to not truly be located within the floodway. These residences were excluded from the risk assessment. Table 1 also provides the rationale for their exclusion from this assessment.

Table 1.

Excluded Floodway Residences

Parcel No. (APN)	Wash Name	FDS River Mile	Reason for exclusion from Risk Assessment
20220076K	Cline Creek Trib C8	81.4112	Poor digital registration to aerial photos
21170007H	Rodger Creek	1.5806	Poor digital registration to aerial photos
21174025A	Desert Hills Wash	1.71125	Residence incorrectly identified

1.3.2 Magnitude and Frequency of First Inundation of the Finished Floor

In order to calculate the magnitude and frequency of the flood discharge that first inundates the finished floor of each residence three pieces of information were needed:

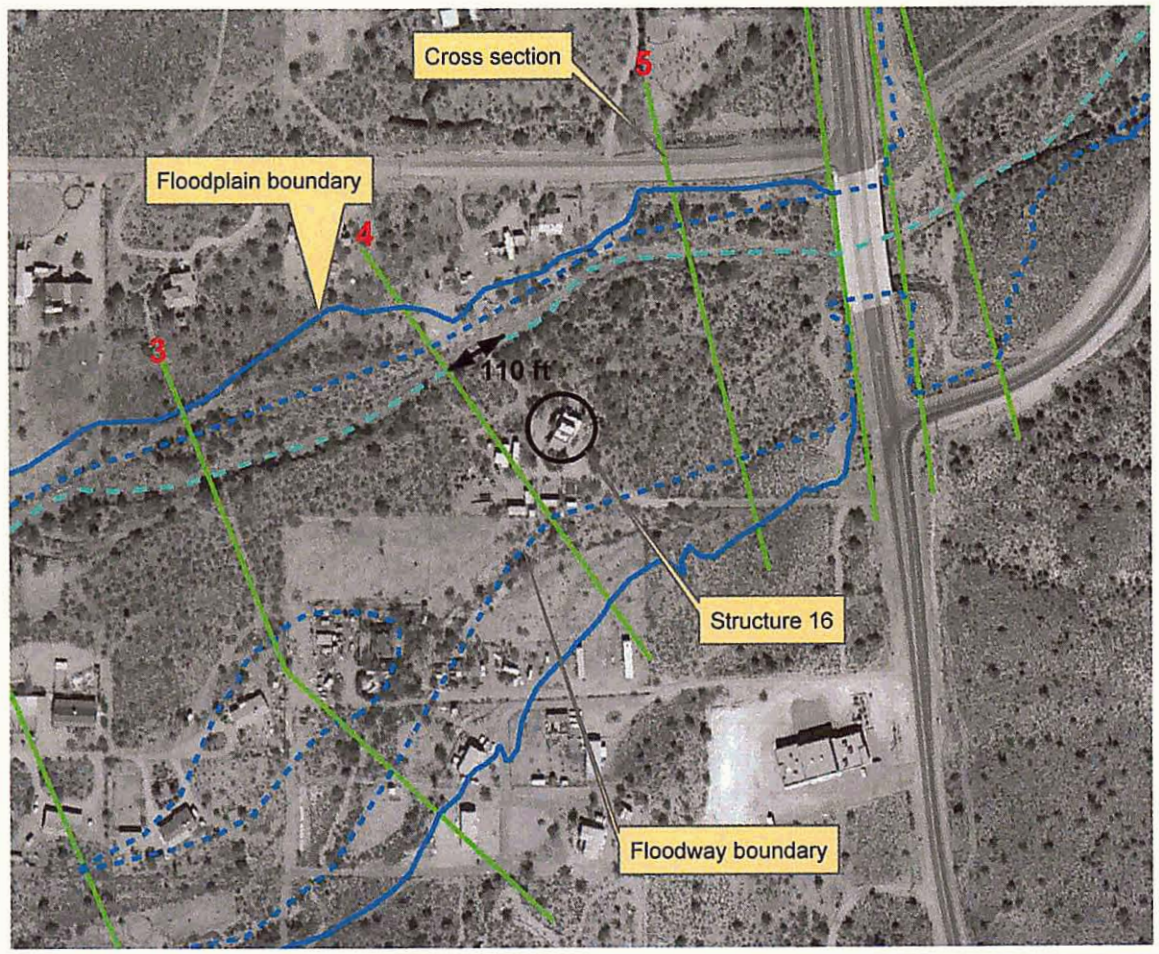
1) The finished floor elevation (FFE) of the residence.
2) The magnitude of the flood discharge of first inundation of the finished floor, called here the Q_{FFE},
3) A flood frequency relationship to estimate the frequency or recurrence interval (RI) of a particular flood discharge.

1.3.2.1 Finished Floor Elevation Determination

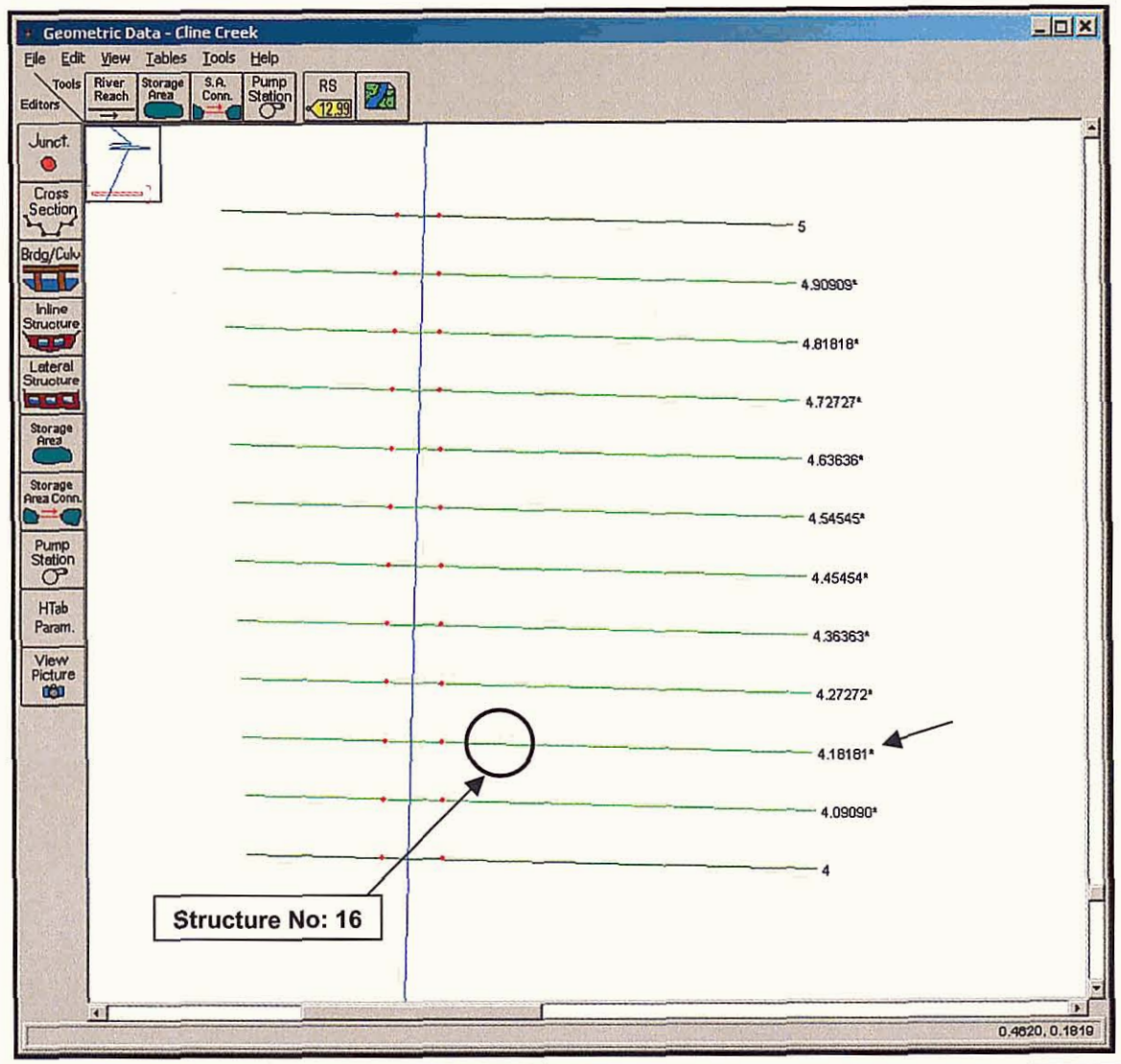
Data obtained from the District that identifies properties with Elevation Certificates on file were cross referenced with structures identified as being located within a floodway. These residences were shown previously in Figure 1. The finished floor elevations recorded on the elevation certificates were utilized to calculate the Q_{FFE} where available. Structures that did not have an elevation certificate recorded with the District were surveyed and the finished floor elevations were established (again see Figure 1).

1.3.2.2 Magnitude of the Flood Discharge at the Finished Floor Elevation (Q_{FFE})

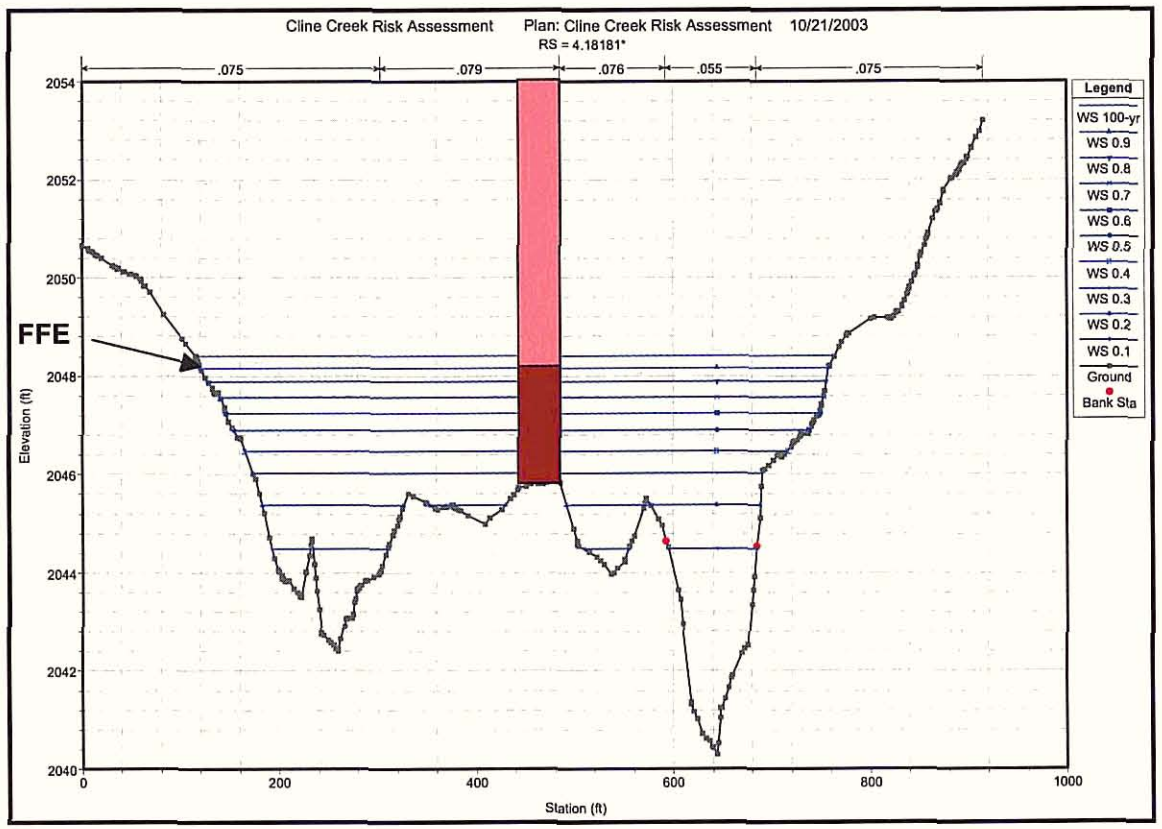
The magnitude of the flood discharge at the finished floor elevation was estimated by developing a stage-discharge relationship for a cross section at the residences. The FDS HECRAS models or converted HEC-2 models were used to compute the stage-discharge relationships. Multiple flood profiles were added to the steady-flow data sets in ten percent increments of the 100-year discharge for each reach in the models. Next, additional cross sections were added to the model in the reach where the residence was located. The HECRAS cross section interpolation module was used. An interpolation interval of 50 feet was selected. Then the cross section nearest to the floodway residence was identified. The resulting stage-discharge curve for that cross section was used to estimate the discharge at the finished floor elevation or Q_{FFE}. This process is shown for structure 16 on the following four pages.



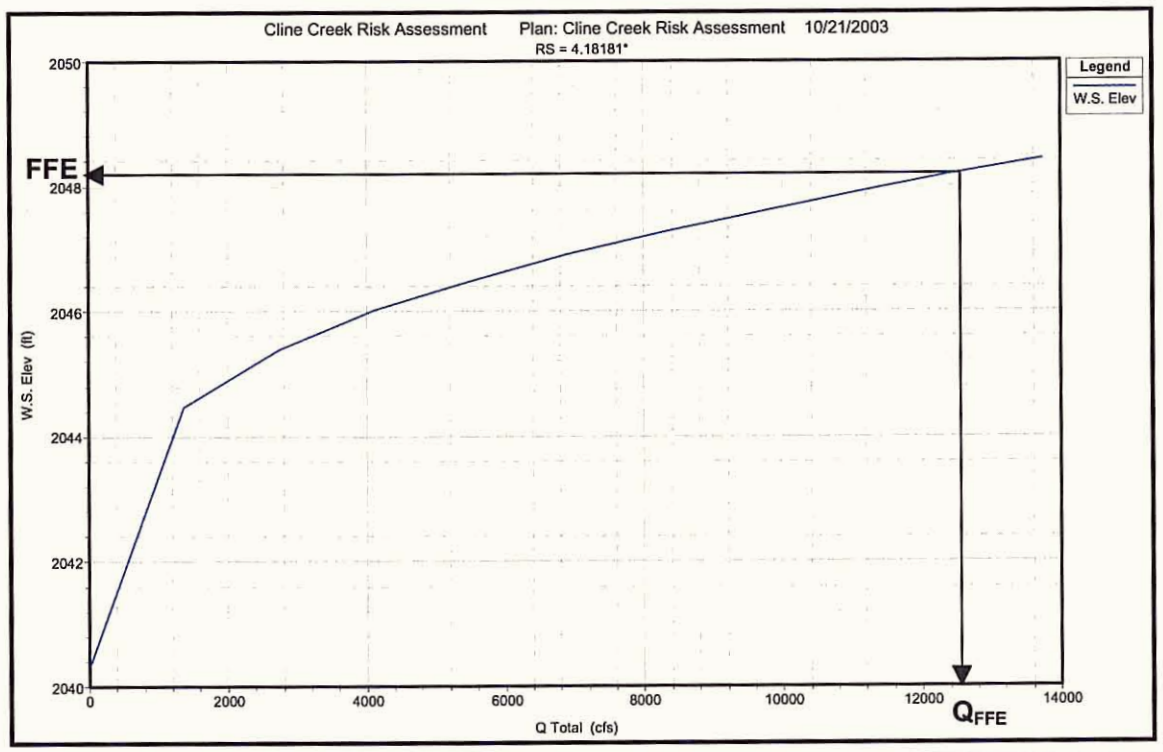
Step 1. Determine structure location along HEC-RAS reach by measuring the distance from the nearest cross-section along the thalweg. **Distance = 110 ft.**



Step 2. Use the Interpolate cross-section tool within HEC-RAS, using a standard interpolation interval of 50 ft. HEC-RAS calculates the actual distance between interpolated sections to give an even number of interpolated sections between the binding cross-sections. Choose the closest interpolated section to the structure.
Calculated Distance between sections = 46.6 ft. Closest Interpolated Section is 4.18181.



Plot of the Finished Floor Elevation at the interpolated cross section for Structure 16.
Note the shaded block in the center is the location of Structure 16.



Step 3. Find the Discharge at the Finished Floor Elevation from the stage-discharge curve at the interpolated cross section. **At FFE 2048.2, Q_{FFE} = 12,482 cfs.**

1.3.2.3 Recurrence Interval of Q_{FFE}

The recurrence interval of the flood discharge at the finished floor elevation, Q_{FFE}, was estimated using an equation developed from information in the Draft District Hydrology Manual (FCDMC, 2003). The new Manual presents standard ratios for recurrence intervals (RI) based on the 100-year flow rate. The ratios are listed in Table 2 below.

Table 2.

Recurrence Interval Ratios

Ratio	RI (in years)
0.10	2
0.35	10
1.00	100

Source: Section 6, Draft Hydrology Manual (FCDMC, 2003)

These ratios indicate that the 2-year discharge can be estimated as ten percent of the 100-year flow rate. Similarly, the 10-year flow rate can be estimated as 35 percent of the 100-year discharge. A spreadsheet was utilized to develop an equation to calculate the recurrence interval. The resulting equation is as follows:

$$RI = 118.29(\%Q_{100})^2 - 21.231(\%Q_{100}) + 2.9402$$

Where:

RI = recurrence interval in years

$\%Q_{100}$ = percentage or ratio of the 100-year flow rate

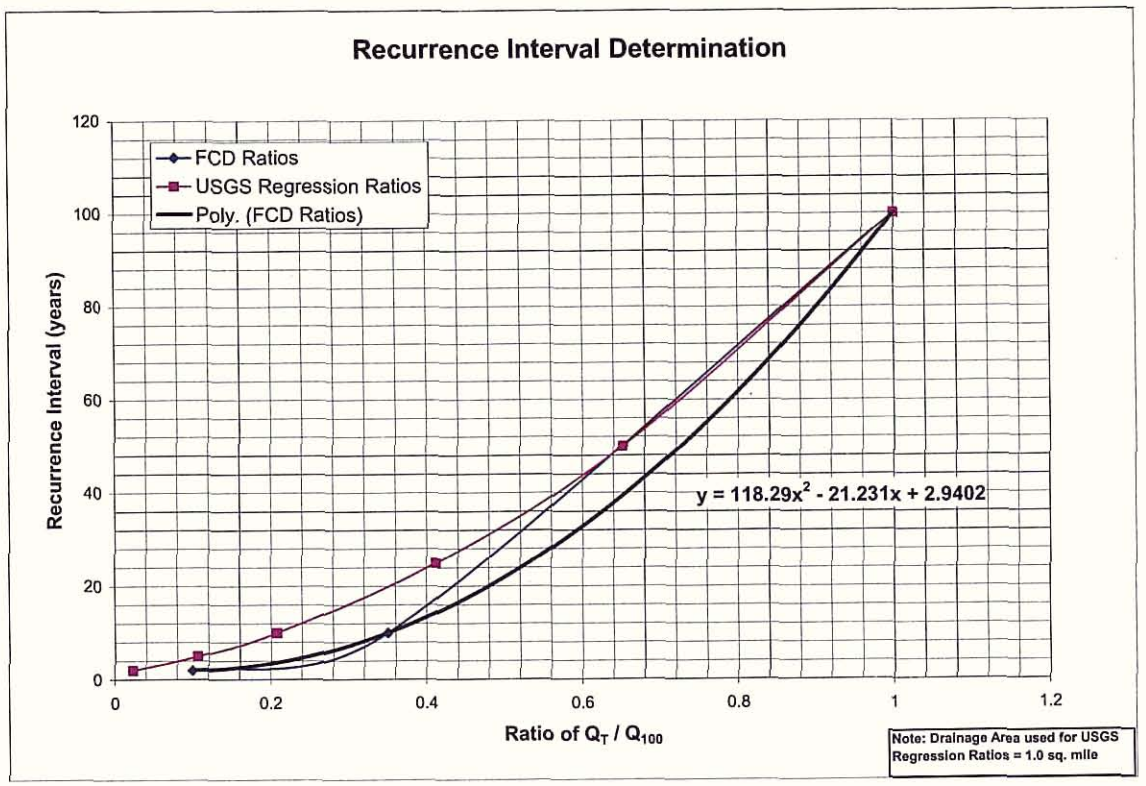


Figure 2. Recurrence Interval Curves for Risk Assessment

To evaluate the reasonableness of this equation, the USGS Regression equations (Region 12, for an average elevation of 2000 feet) for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals were plotted as percent of the 100-year flow rate verses the RI along with the trend line and the FCDMC ratios, as shown on Figure 2. The shape of the regression equation ratio line and the trend line are very similar. Therefore, the equation developed for the recurrence interval estimates for the risk assessment is considered reasonable and appropriate for application in this study.

Once the equation for the recurrence interval was developed and the flow rate for the first inundation of the finished floor, Q_{FFE}, had been computed, the corresponding recurrence interval, RI_{FFE}, could be determined. Table 3 shows the details for the calculations of the recurrence interval of the discharge of first inundation for structure 16.

Table 3. Example Recurrence Interval Calculation for Structure 16				
Parcel #:	**20221031Z**			
Structure No:	**16**			
FFE Source:	ADMP Survey			
XN 4.18181				
WSE100	2048.4			
Q Total (cfs)	W.S. Elev (ft)		Ratio Q/Q100	RI (yrs)
0	2040.3		0.0	n/a
1375	2044.5		0.1	2
2749	2045.4		0.2	3
4124	2046.0		0.3	7
5499	2046.5		0.4	13
6874	2046.9		0.5	22
8248	2047.3		0.6	33
9623	2047.6		0.7	46
10998	2047.9		0.8	62
12372	2048.2		0.9	80
13747	2048.4		1.0	100
FF_{ele} =	**2048.2**			
Q_{FFE} =	12482	RI_{FFE} =	81	

Step 4. Determine the recurrence interval for the Q_{FFE} at the interpolated cross section. **For QFFE = 12,482 cfs at 2048.2 ft, RI_{FFE} = 81 years.**

1.3.3 100-year Flood Hazard Determination

The flood hazard during the 100-year flood was evaluated from the HECRAS model results for the 100-year discharge water surface profile. The hydraulic calculations at the nearest interpolated cross section were used to evaluated the hazard for each floodway residence. Two hydraulic variables were examined: depth and velocity. The depth was determined by subtracting the computed water surface elevation from the finished floor elevation. The velocity was taken as the average overbank velocity (left or right depending on the location of the residence) for the interpolated cross section. The following HECRAS profile output table figure and Table 3 in the next section shows the results for structure 16.

Profile Output Table - RA Table

File Options Std. Tables User Tables Locations Help

HEC-RAS Plan: Cline RA River: Cline Creek Reach: reach 3 Profile: 100-yr | Reload Data

Reach	River Sta	Profile	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	Vel Left	Vel Right
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft/s)	(ft/s)
reach 3	10	100-yr	13747.00	2061.30	2071.60	2071.60	2074.05	0.011654	13.38	1333.89	372.04	0.86	2.04	4.09
reach 3	9	100-yr	13747.00	2056.78	2065.91	2065.91	2067.40	0.011268	13.41	1960.33	580.82	0.86	6.46	4.53
reach 3	8	100-yr	13747.00	2050.46	2061.81	2060.76	2062.57	0.004680	9.06	3017.82	822.33	0.56	2.62	2.97
reach 3	7	100-yr	13747.00	2051.33	2061.29	2057.41	2062.12	0.002807	7.32	1879.21	415.79	0.44		
reach 3	6.5		Bridge											
reach 3	6	100-yr	13747.00	2050.22	2056.59	2056.59	2059.25	0.016907	13.08	1050.78	197.84	0.99		
reach 3	5	100-yr	13747.00	2043.48	2053.01	2052.25	2053.83	0.010657	10.33	2353.47	613.33	0.68	4.48	5.39
reach 3	4.90909*	100-yr	13747.00	2043.13	2052.51	2051.71	2053.34	0.010671	10.28	2357.50	616.81	0.68	4.50	5.17
reach 3	4.81818*	100-yr	13747.00	2042.78	2052.01	2051.20	2052.84	0.010748	10.25	2358.96	619.87	0.68	4.51	4.96
reach 3	4.72727*	100-yr	13747.00	2042.42	2051.50	2050.73	2052.33	0.010775	10.18	2361.55	623.11	0.68	4.53	4.72
reach 3	4.63636*	100-yr	13747.00	2042.07	2051.00	2050.24	2051.83	0.010842	10.13	2362.64	626.39	0.68	4.54	4.49
reach 3	4.54545*	100-yr	13747.00	2041.72	2050.49	2049.75	2051.32	0.010866	10.06	2363.07	629.83	0.68	4.56	4.23
reach 3	4.45454*	100-yr	13747.00	2041.37	2049.98	2049.23	2050.80	0.010959	9.99	2361.74	633.09	0.69	4.58	3.97
reach 3	4.36363*	100-yr	13747.00	2041.02	2049.47	2048.66	2050.29	0.011021	9.91	2360.03	636.90	0.68	4.61	3.69
reach 3	4.27272*	100-yr	13747.00	2040.67	2048.96	2048.08	2049.77	0.011115	9.84	2355.62	640.72	0.68	4.64	3.39
reach 3	4.18181*	100-yr	13747.00	2040.31	2048.43	2047.56	2049.24	0.011323	9.80	2344.33	649.91	0.69	4.69	2.96
reach 3	4.09090*	100-yr	13747.00	2039.96	2047.88	2047.06	2048.70	0.011695	9.79	2324.32	669.36	0.69	4.76	2.41
reach 3	4	100-yr	13747.00	2039.61	2046.59	2046.45	2047.92	0.022110	12.14	1827.19	614.77	0.93	5.80	2.53
reach 3	3	100-yr	13747.00	2031.90	2040.26	2038.82	2040.78	0.010093	9.31	2656.90	841.10	0.64	3.94	5.42
reach 3	2.90909*	100-yr	13747.00	2031.30	2039.68	2038.48	2040.28	0.011619	9.99	2813.60	913.64	0.69	3.86	5.56
reach 3	2.81818*	100-yr	13747.00	2030.70	2039.07	2038.02	2039.72	0.012451	10.32	2798.75	992.51	0.71	3.83	5.48
reach 3	2.72727*	100-yr	13747.00	2030.10	2038.39	2037.52	2039.11	0.013793	10.75	2757.22	1022.34	0.75	3.83	5.42
reach 3	2.63636*	100-yr	13747.00	2029.50	2037.72	2037.49	2038.46	0.014235	10.82	2742.82	1035.59	0.76	3.88	5.16
reach 3	2.54545*	100-yr	13747.00	2028.90	2037.05	2036.84	2037.79	0.014457	10.78	2735.00	1039.48	0.77	3.93	4.83
reach 3	2.45454*	100-yr	13747.00	2028.30	2036.37	2036.17	2037.11	0.014684	10.73	2726.56	1044.32	0.77	3.97	4.47
reach 3	2.36363*	100-yr	13747.00	2027.70	2035.67	2035.46	2036.42	0.015073	10.71	2708.82	1050.65	0.78	4.03	4.09

Total flow in cross section

Step 5. Collect WSE and appropriate overbank velocity at the interpolated cross section. **For Q100 = 13,747 cfs, W.S. Elev. 100 = 2048.4 ft, Velocity Left Overbank = 4.7 ft/s.**

1.3.4 Personal Hazard Factor

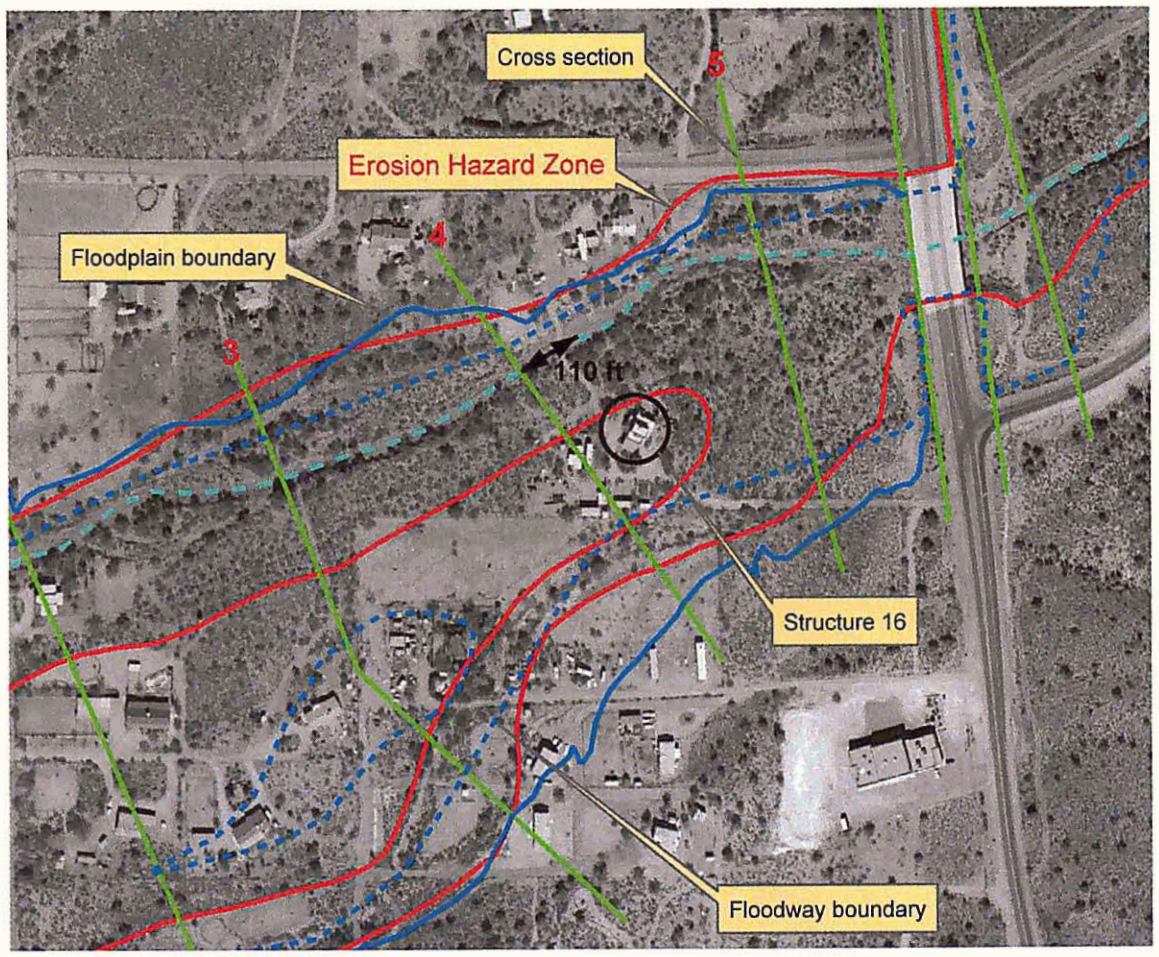
A Personal Hazard Factor (PHF) representing the relationship between depth of flow and velocity at the structure during the 100-year flood peak was computed for each structure following the methodology used in the Skunk Creek Watercourse Master Plan. Flow depths and velocities were determined with HECRAS from the corresponding cross-section output data. The PHF was calculated by multiplying the depth (water surface elevation of the 100-year flood minus the finished floor elevation) times the square of the velocity. A value greater than 18 means there is sufficient depth and velocity of flow to sweep a person off their feet. The PHF threshold of 18 is based on depth/velocity relationships developed by the Bureau of Reclamation (USBR, 1988) and refined by Pima County (Pima County, 1999).

Table 4. Example Personal Hazard Factor Calculation for Structure 16				
100-yr Water Surface Elevation	**Finished Floor Elevation (FFE)**	**Delta Δ 100-yr WSE - FFE (feet)**	**100-year Overbank Flow Velocity (v) (fps)**	**100-year Personal Hazard Factor (PHF) ($\Delta \times v^2$)**
2048.4	2048.2	0.2	4.7	4

Step 6. Use the $WSEL_{100}$, FFE, and the over bank velocity to calculate the PHF for the structure.
For D = 0.2 and V = 4.7, PHF = 4.

1.3.5 Erosion Hazard

Erosion hazards at each structure were considered in this analysis. The erosion hazards in the study area were delineated as part of the ADMP or previous study. Structures were given a *yes* or *no* label, based on whether the structure lies within an identified erosion hazard area. The presence of an identified erosion hazard was used in the final ranking of associated risks. An example for structure 16 is provided in the following figure.



Step 7. Determine if the structure lies within the Erosion Hazard Boundary.
Structure 16 lies outside the Erosion Hazard Boundary.

1.3.6 Ranking Hazardous Structures

Structures were ranked by greatest to least overall risk in this analysis using essentially the same methods employed in the Skunk Creek Water Course Master Plan (Tetra Tech, 2001). Structures were sorted by the recurrence interval of the first inundation, RI_{FFE}, then by the Personal Hazard Factor, PHF, by the presence or absence of an erosion hazard, and finally by the depth below or above the 100-year water surface elevation. Structure 16 ranked number 12 of the 41 residences analyzed.

SECTION 1.4: RESULTS

Figures 3 and 4 and Table 4 present the results of the risk assessment of floodway residences in the Adobe ADMP study area. The results show that 16 of the 41 structures in the floodway are inundated by the 100-year flood. Two structures are inundated by the 10-year flood and five structures are inundated by the 20-year flood. Figure 3 shows where each residence lies on the Bureau of Reclamation's depth-velocity flood danger level relationship for houses built on foundations (USBR, 1988). Note that only one residence, structure 29, falls in the Judgement Zone. The remainder all fall within the Low Danger Zone as defined by the Bureau.

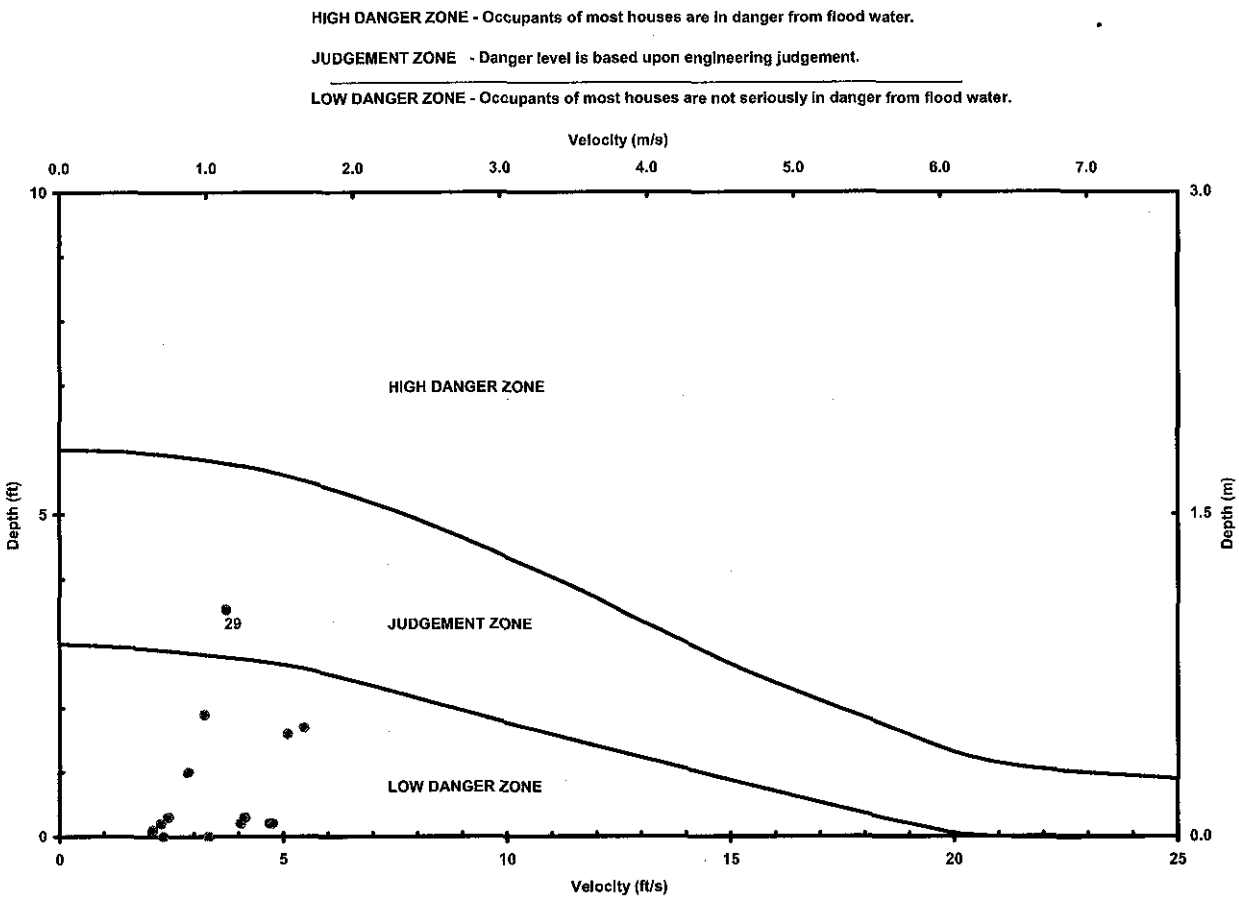


Figure 3. USBR Depth-Velocity Flood Danger Level Relationship For Houses Built On Foundations

Figure 4 shows the locations of each of the floodway structures and the recurrence interval of first inundation of each structure. The map can also be used to cross reference with the other details provided in Table 4 and Appendix B. Note that the floodway residences are spread throughout the study area within hydrologically separate watersheds.

The stage-discharge plots, (interpolated) cross section plots, and recurrence interval estimates for each floodway residence are included in Appendix B. The HECRAS models used to compute the hydraulics for the risk assessment are provided on an accompanying CD-ROM.

SECTION 1.5: LIMITATIONS OF THE RISK ASSESSMENT

The risk assessment analysis is limited to structures that fall within 100-year FEMA floodways. There are other structures within the ADMP boundary at risk that lie within the floodway fringe that are not addressed in this assessment. The relative risks at those structures were not evaluated in this assessment. However, a similar approach could be used.

In addition, the accuracy of the analysis is limited by a number of possible error sources including the following:

- Contour mapping errors:
  The contour interval of the FDS mapping is either two-feet or four-feet. Such mapping has an inherent vertical error of plus or minus half a contour interval. Therefore, the calculated water surface elevation at any residence could be 1 to 2 feet higher or lower than computed.
- Use of HECRAS models converted from original HEC-2 models
  The converted HECRAS models do not always perfectly duplicated the 100-year water surface elevations computed by the HEC-2 models. Therefore, the 100-year water surface elevation reported in the summary table may not be identical to the BFE shown on the FDS work maps or previous elevation certificates.
- Limitations associated with using interpolated cross sections
  Interpolated cross sections are just that, interpolated. That is, they do not necessary represent the true shape of the cross section at that location. They are estimated based on the shapes of the upstream and downstream cross sections. Also, the addition of cross sections to a model can also result in slightly different computed water surface elevation as compared to the original FDS models.

- Flood frequency relationship errors

  The flood frequency relationship used to estimate the recurrence interval of the Q_{FFE} was developed from the standard District relationship. Moreover, the same relationship was used for every location. This is an approximation. In reality, the flood frequency relationship for each watershed will vary somewhat depending on elevation, aspect, geology, and land cover.
- Use of preliminary floodplain restudy results

  The RAS model results for Upper Skunk Creek and Cline Creek are preliminary as of the date of this report. While preliminary District review has already been performed, additional review by the District and FEMA remains. Some changes to the specific hydraulic results therefore could occur in the future affecting the PHF and rankings of this risk assessment.

SECTION 1.6: SUMMARY AND CONCLUSIONS

Residences in the regulatory floodways in the Adobe ADMP area were identified. The relative flood risk at each residence was evaluated based on a procedure developed for the Skunk Creek Watercourse Master Plan. The evaluation is based on how often a residence is flooded and the depth and velocity of flood water during the 100-year event. The presence of erosion hazards was also included in the evaluation.

The results found 41 residences in the study area within the floodway and ranked their relative risk from 1 to 41. These results provide data for evaluation of the flood hazard mitigation alternatives as part of the ADMP.

Table 4.
Estimated Flow Rate and Recurrence Interval at Finished Floor Elevations
(sorted by 16, 19, 20, 13 respectively)

Structure No.	Wash Name	APN	FFE Source	Survey Date	RA RAS Model 100-yr Water Surface Elevation	Finished Floor Elevation (FFE)	RA RAS 100-yr WSE - FFE (feet) (11)-(10)	FEMA Q_{100} (cfs)	Discharge of First Inundation, $Q_{FFE\ (cfs)}$	Approx. R.I. of FFE (years)	Approx. Chance Of Flooding at FFE	RA RAS 100-year Overbank Flow Velocity (fps)	100-year Personal Hazard Factor $(12)*(17)^2$	In an Erosion Hazard Zone?	Rank	Year Built
(1)	(2)	(3)	(4)	(5)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
29	Desert Hills	21174091	ADMP survey	Aug. 2003	1756.5	1753.0	-3.5	10259	996	2	50.0%	3.7	49	yes	1	N/A
10	Cline Creek	20220017L	ADMP survey	Aug. 2003	2135.8	2134.2	-1.6	10883	3053	6	16.7%	5.1	41	yes	2	1981
3	Apache	21164029	ADMP survey	Aug. 2003	1989.7	1987.8	-1.9	7187	2618	11	9.1%	3.2	20	yes	3	N/A
2	Desert Hills	21152012B	ADMP survey	Aug. 2003	1812.6	1811.6	-1.0	3669	1437	13	7.7%	2.9	8	yes	4	1987
17	Rodger Creek	21170001P	ADMP survey	Aug. 2003	2027.6	2025.9	-1.7	6170	2551	14	7.1%	5.5	51	yes	5	1981
47	Skunk Tank	21151003C	EC-00819	11/14/1997	1787.1	1786.8	-0.3	4240	3331	59	1.7%	4.2	5	yes	6	2000
48	Skunk Tank	21151003D	EC-00811	11/14/1997	1787.1	1786.8	-0.3	4240	3331	59	1.7%	4.1	5	yes	7	1999
46	Skunk Tank	21151056M	EC-00808	11/14/1997	1818.3	1818.1	-0.2	2210	1711	64	1.6%	4.1	3	yes	8	1996
35	Desert Hills	21168053F	EC-00833	10/19/1992	1838.6	1838.3	-0.3	2692	2231	67	1.5%	2.4	2	yes	9	1993
34	Desert Hills	21168053F	EC-00832	10/19/1992	1839.1	1838.8	-0.3	2692	2342	74	1.4%	2.5	2	yes	10	
5	Desert Lake	21153046H	ADMP survey	Aug. 2003	1793.1	1793.0	-0.1	3406	3013	77	1.3%	2.1	0	yes	11	1945
16	Cline Creek	20221031Z	ADMP survey	Aug. 2003	2048.4	2048.2	-0.2	13747	12482	81	1.2%	4.7	4	no	12	1982
41	Skunk Tank	21151002F	EC-00810	11/14/1997	1781.0	1780.8	-0.2	4340	3975	83	1.2%	4.8	5	yes	13	1985
36	Desert Hills	21168053F	EC-00834	10/19/1992	1839.3	1839.1	-0.2	2692	2465	83	1.2%	2.3	1	yes	14	
37	Desert Lake	21153065A	EC-00845	10/19/1992	1797.8	1797.8	0.0	3406	3292	93	1.1%	2.3	0	yes	15	1988
15	Skunk Trib 10B*	20221148	ADMP survey	Aug. 2003	2055.0	2055.0	0.0	9700	9700	100	1.0%	3.3	0	yes	16	N/A
20	Cline Creek	20221036L	ADMP survey	Aug. 2003	2034.4	2034.5	0.1	13747	n/a	n/a	n/a	4.0	0	no	17	1990
40	Skunk Tank	21151053D	EC-00807	11/14/1997	1798.1	1798.4	0.3	2440	n/a	n/a	n/a	3.3	0	yes	18	1960
4	Apache	21164029	ADMP survey	Aug. 2003	1988.0	1988.4	0.4	7187	n/a	n/a	n/a	3.1	0	yes	19	
14	Kings Well Wash (Trib 6B)	20209013K	ADMP survey	Aug. 2003	2149.0	2149.4	0.4	921	n/a	n/a	n/a	1.5	0	yes	20	1980
24	Cline Creek	20221036F	ADMP survey	Aug. 2003	2032.6	2033.2	0.6	13747	n/a	n/a	n/a	4.8	0	no	21	1970
32	Apache	21167063	EC-00831	10/19/1992	1864.1	1864.8	0.7	7187	n/a	n/a	n/a	3.8	0	yes	22	N/A
42	Skunk Trib 10B*	20221147A	EC-00262	11/13/1998	2056.2	2057.0	0.8	9700	n/a	n/a	n/a	2.8	0	yes	23	1999
8	Cline Creek	20220450	ADMP survey	Aug. 2003	2144.8	2145.7	0.9	10883	n/a	n/a	n/a	4.0	0	yes	24	N/A
18	Upper Skunk	20209006J	ADMP survey	Aug. 2003	2195.2	2196.1	0.9	4899	n/a	n/a	n/a	4.6	0	yes	25	1979
39	East Fork Desert Lake	21152047F	EC-00734	1/17/2001	1807.0	1808.0	1.0	933	n/a	n/a	n/a	1.5	0	yes	26	1997
44	Desert Hills	21152031C	EC-00839	10/19/1992	1805.7	1806.8	1.1	4143	n/a	n/a	n/a	3.0	0	no	27	1990
26	Skunk Tank	21150038K	ADMP survey	Aug. 2003	1827.2	1828.5	1.3	2110	n/a	n/a	n/a	3.9	0	yes	28	1998
27	Desert Lake	21153058B	ADMP survey	Aug. 2003	1787.5	1788.8	1.3	3406	n/a	n/a	n/a	2.3	0	yes	29	1942
45	Desert Hills	21152030B	EC-00838	10/19/1992	1806.9	1808.3	1.4	4143	n/a	n/a	n/a	2.7	0	no	30	1993
23	Cline Creek	20221036M	ADMP survey	Aug. 2003	2032.6	2034.4	1.8	13747	n/a	n/a	n/a	4.8	0	yes	31	1994
28	East Fork Desert Lake	21168007D	ADMP survey	Aug. 2003	1852.5	1854.4	1.9	692	n/a	n/a	n/a	1.9	0	yes	32	1997
9	Cline Creek	20220453	ADMP survey	Aug. 2003	2163.6	2165.7	2.1	10883	n/a	n/a	n/a	5.0	0	yes	33	N/A
13	Kings Well Wash (Trib 6B)	20209031D	ADMP survey	Aug. 2003	2157.4	2159.6	2.2	921	n/a	n/a	n/a	n/a	0	yes	34	1993
7	Kings Well Wash (Trib 6B)	20208005K	ADMP survey	Aug. 2003	2250.5	2252.9	2.4	3169	n/a	n/a	n/a	6.4	0	yes	35	N/A
11	Cline Trib C6	20220040K	ADMP survey	Aug. 2003	2187.4	2189.9	2.5	1430	n/a	n/a	n/a	5.2	0	yes	36	1983
30	Apache Wash West Fork	21164015	ADMP survey	Aug. 2003	2001.1	2003.8	2.7	2191	n/a	n/a	n/a	4.2	0	yes	37	N/A
12	Kings Well Wash (Trib 6B)	20209031C	ADMP survey	Aug. 2003	2155.3	2159.3	4.0	921	n/a	n/a	n/a	n/a	0	yes	38	N/A
22	Skunk Trib 10A*	20216004D	ADMP survey	Aug. 2003	2119.1	2123.1	4.0	7800	n/a	n/a	n/a	4.2	0	yes	39	N/A
21	Upper Skunk	20209013G	not surveyed		2159.1			7840				4.1	0	yes	40	N/A
19	Kings Well Wash (Trib 6B)	20208007F	not surveyed		2210.2			3169				1.3	0	no	41	1987
	* = in FW of trib, but hydraulic data from Skunk Creek				Elevations in Red Font are in NAVD 1988. All others in NGVD 1929.											

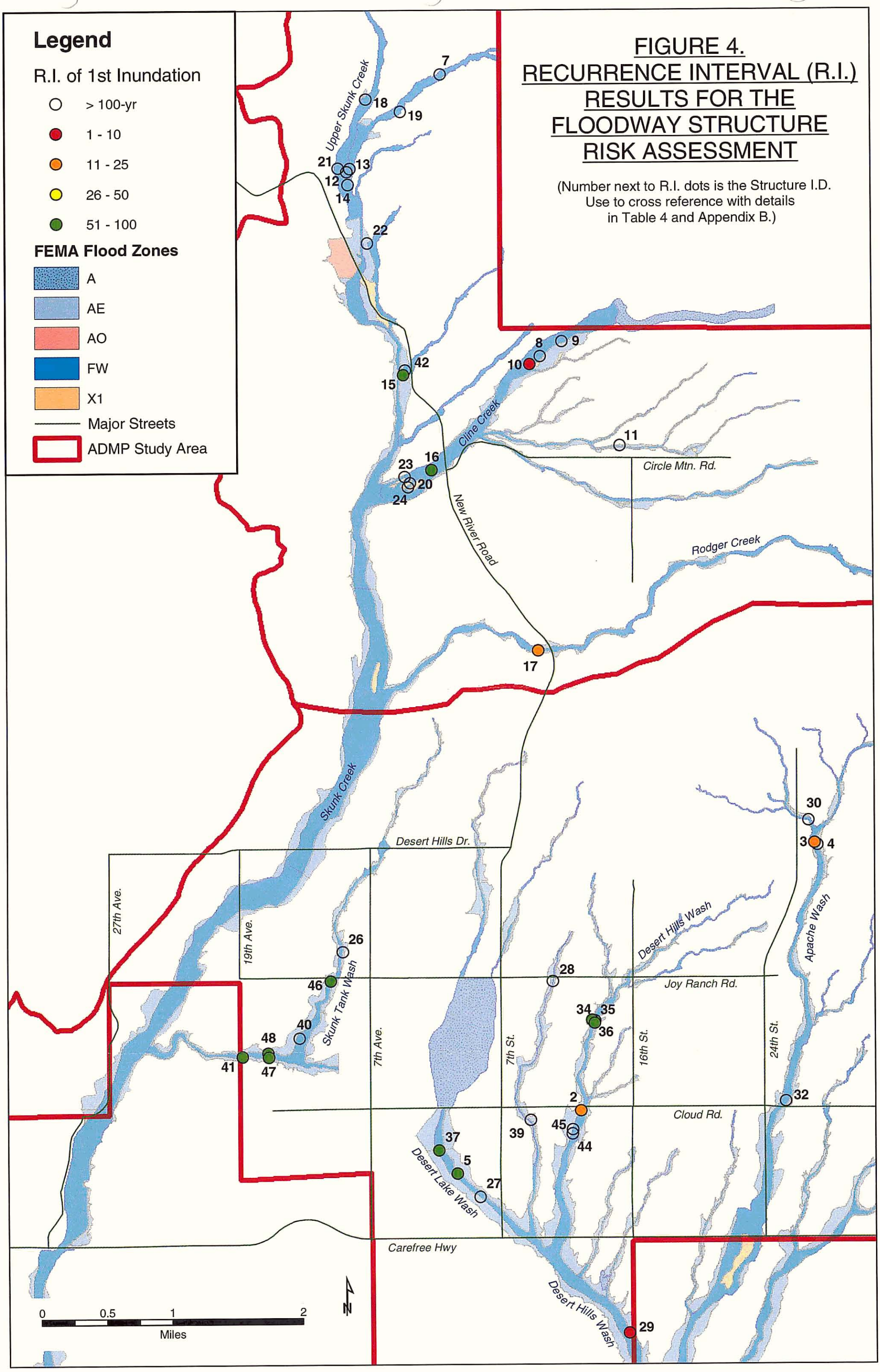


FIGURE 4.
RECURRENCE INTERVAL (R.I.) RESULTS FOR THE FLOODWAY STRUCTURE RISK ASSESSMENT

(Number next to R.I. dots is the Structure I.D. Use to cross reference with details in Table 4 and Appendix B.)

Appendix A

Bibliography

FCDMC, 2003, draft Drainage Design Manual, Volume I, Hydrology, draft revisions to the 1995 edition.

Pima County Flood Control District, 1999, Floodplain and Erosion Hazard Management Ordinance, Ordinance 1999-FC-1 § 1 (part) 1999; Ordinance 1988-FC-2 Article 1, 1988.

Tetra Tech, Inc., 2001, Skunk Creek / Sonoran Wash Watercourse Master Plan, Attachment 11, performed under contract with FCDMC, Phoenix, Arizona.

USBR, 1988, Downstream Hazard Classification Guidelines, ACER Technical Memo. No. 11, Denver, CO.

Appendix B

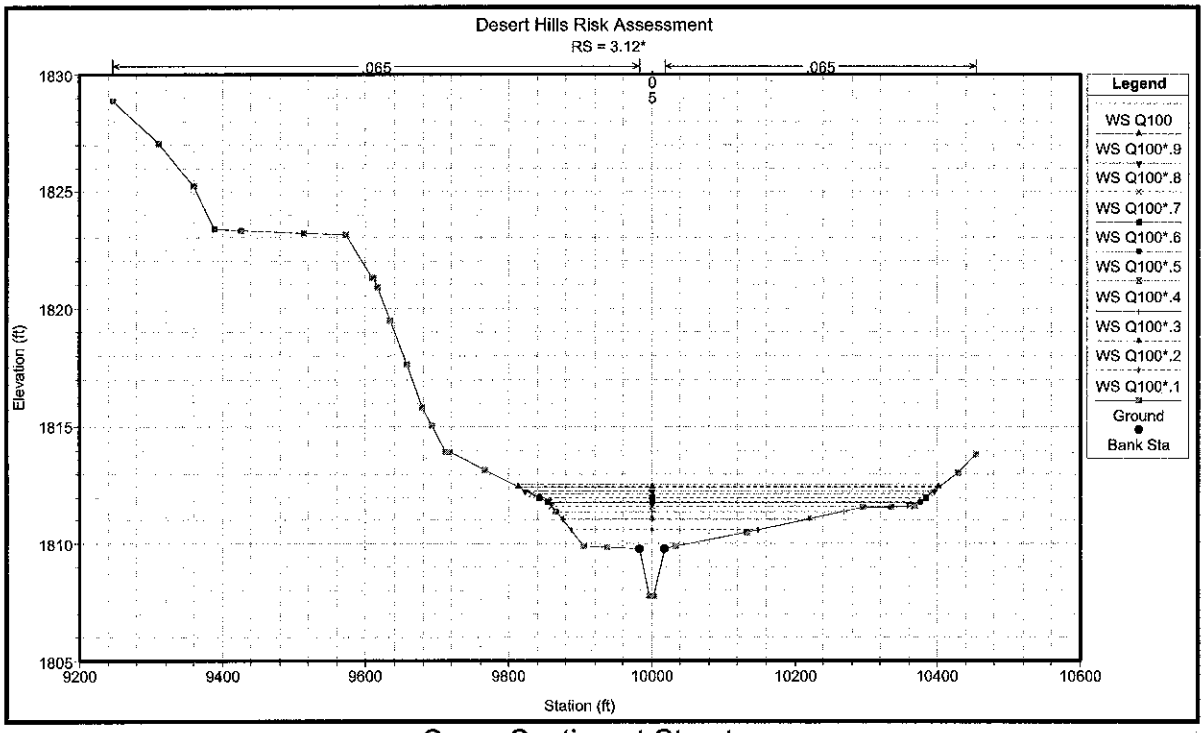
Stage-Discharge Plots

Cross section Plots

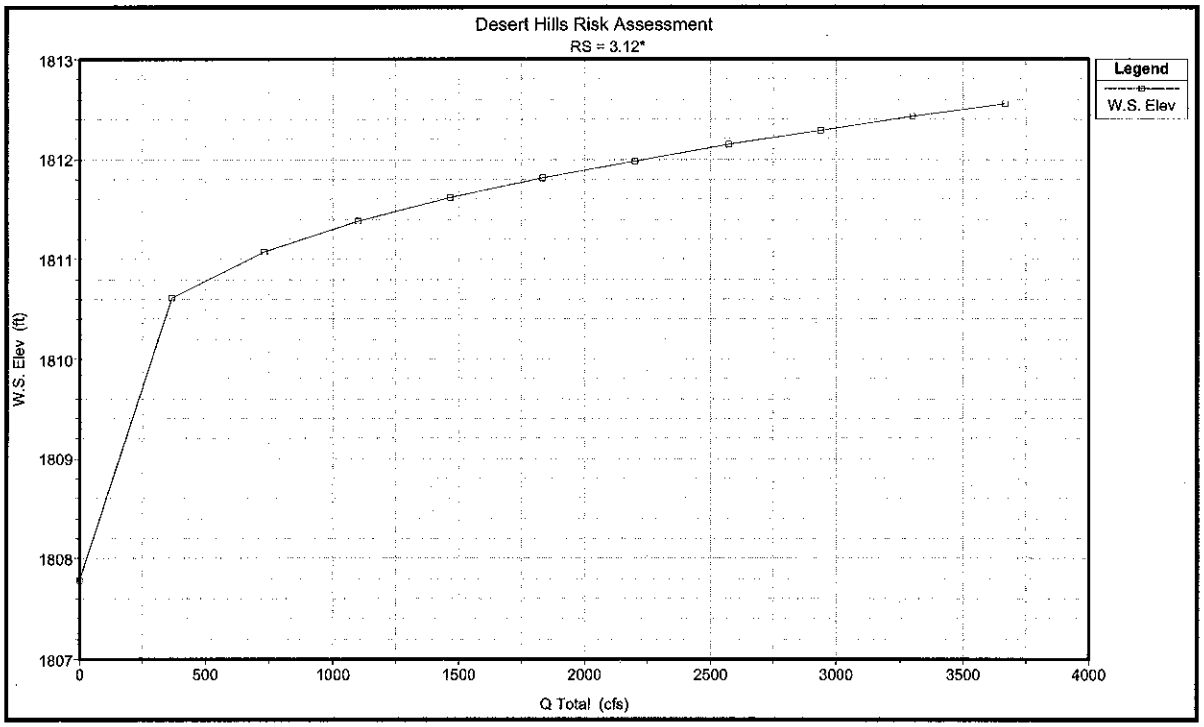
Recurrence Interval Calculations

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 2



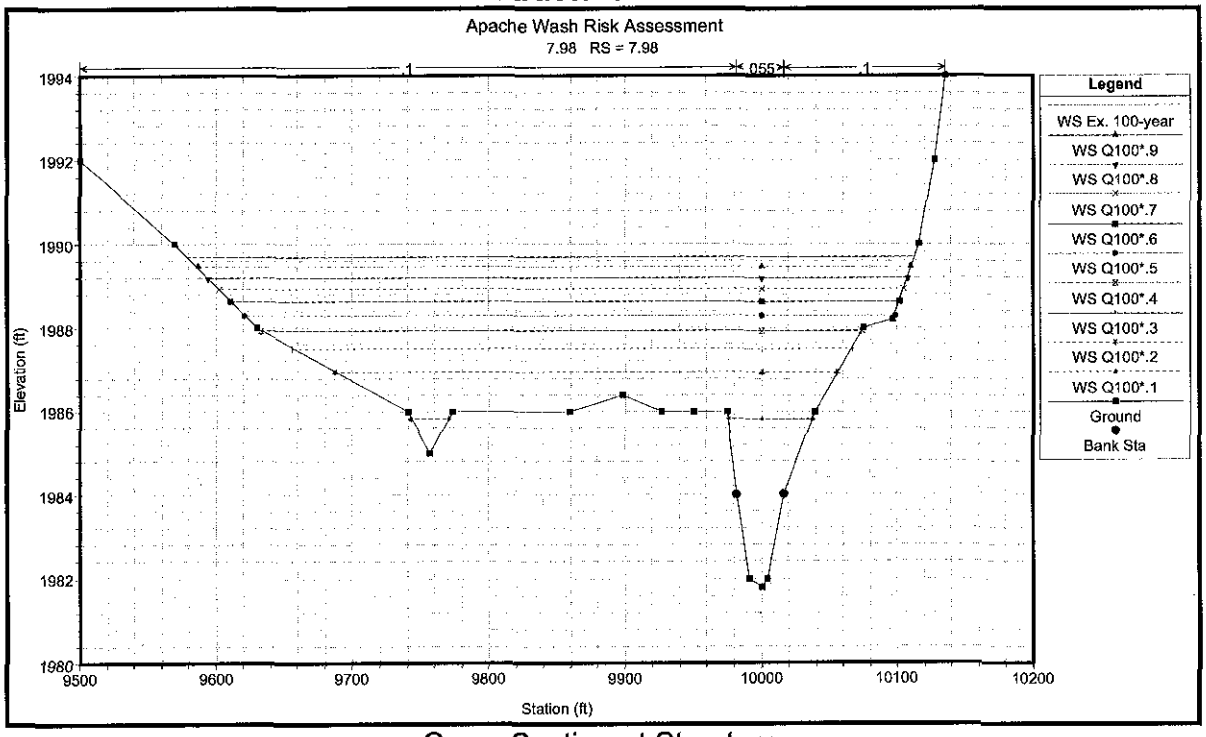
Cross Section at Structure



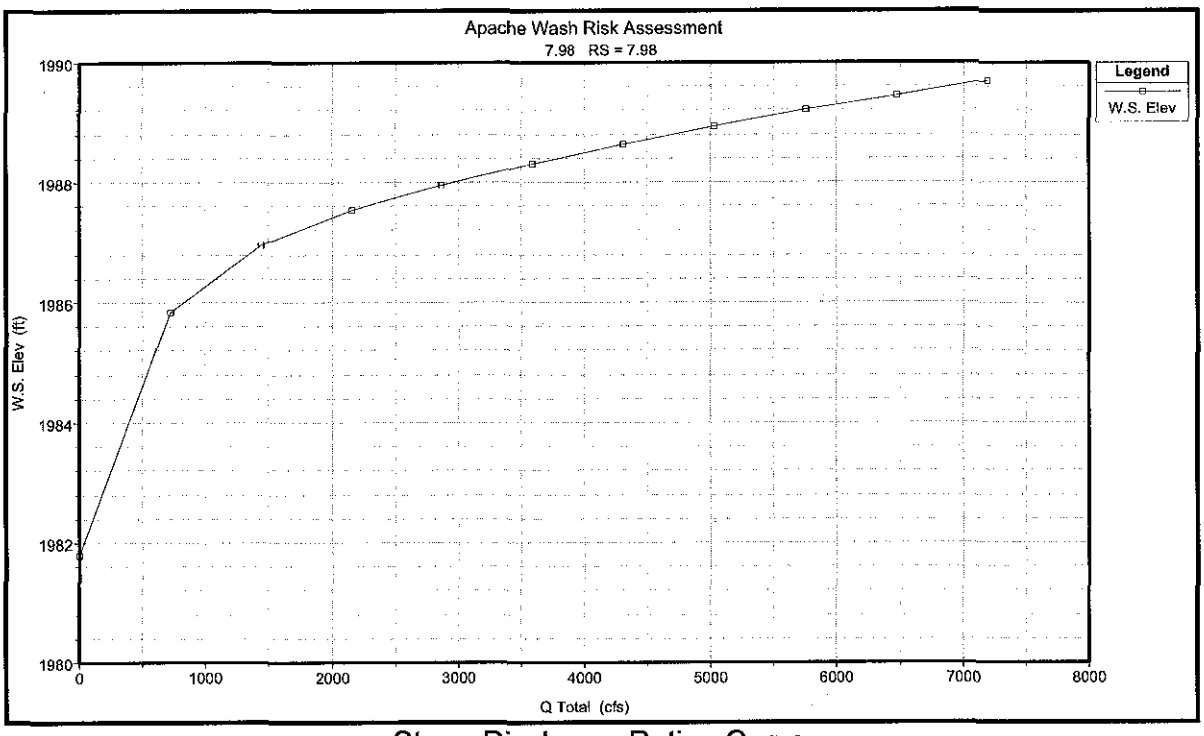
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 3



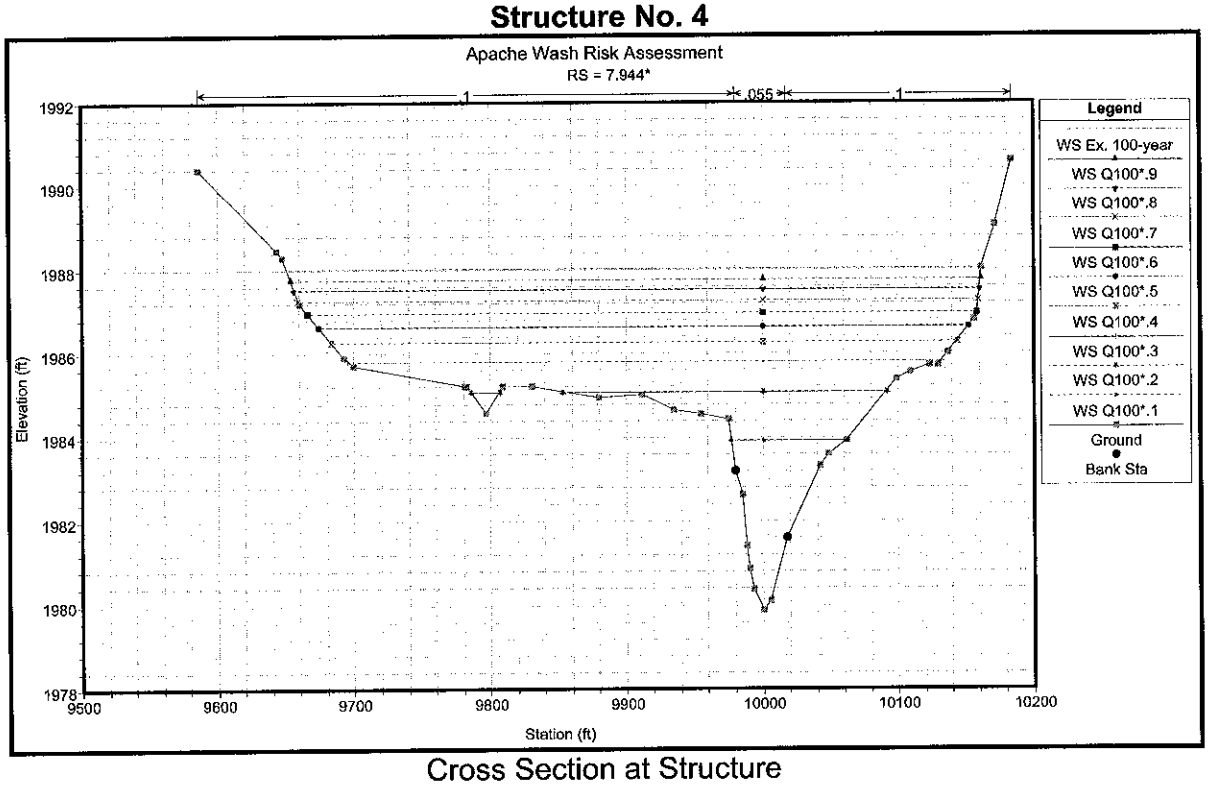
Cross Section at Structure



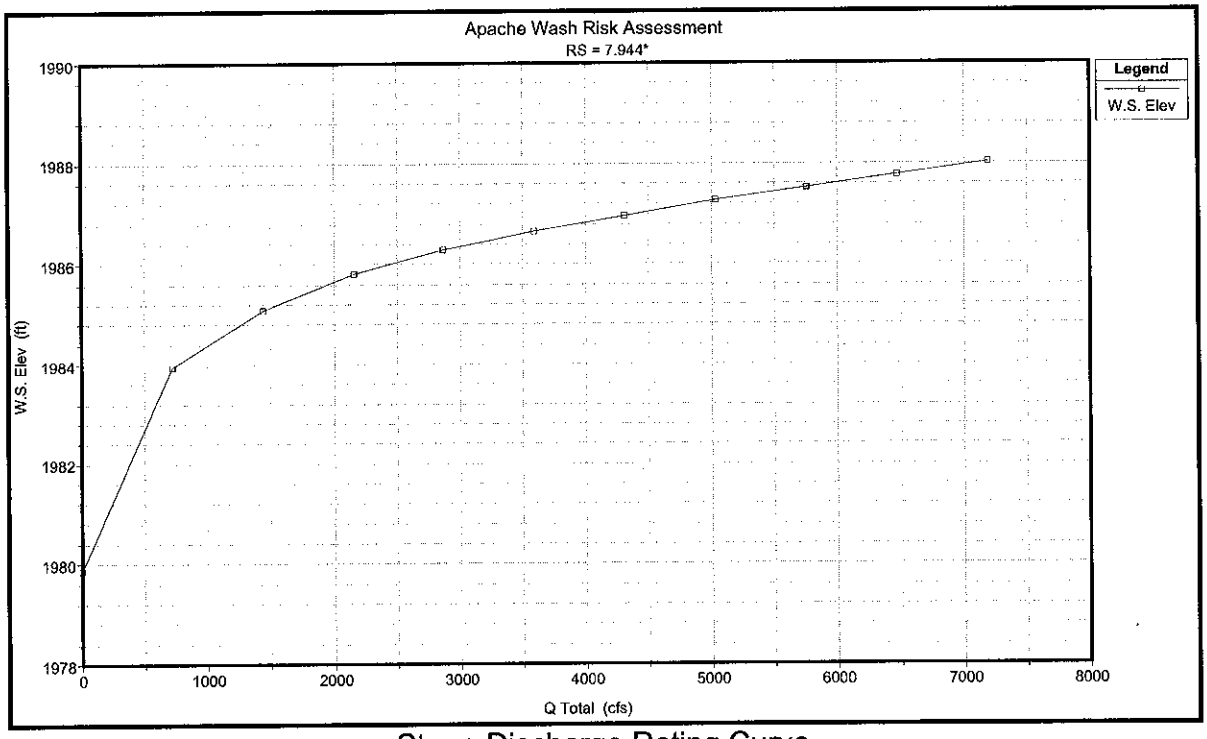
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 4



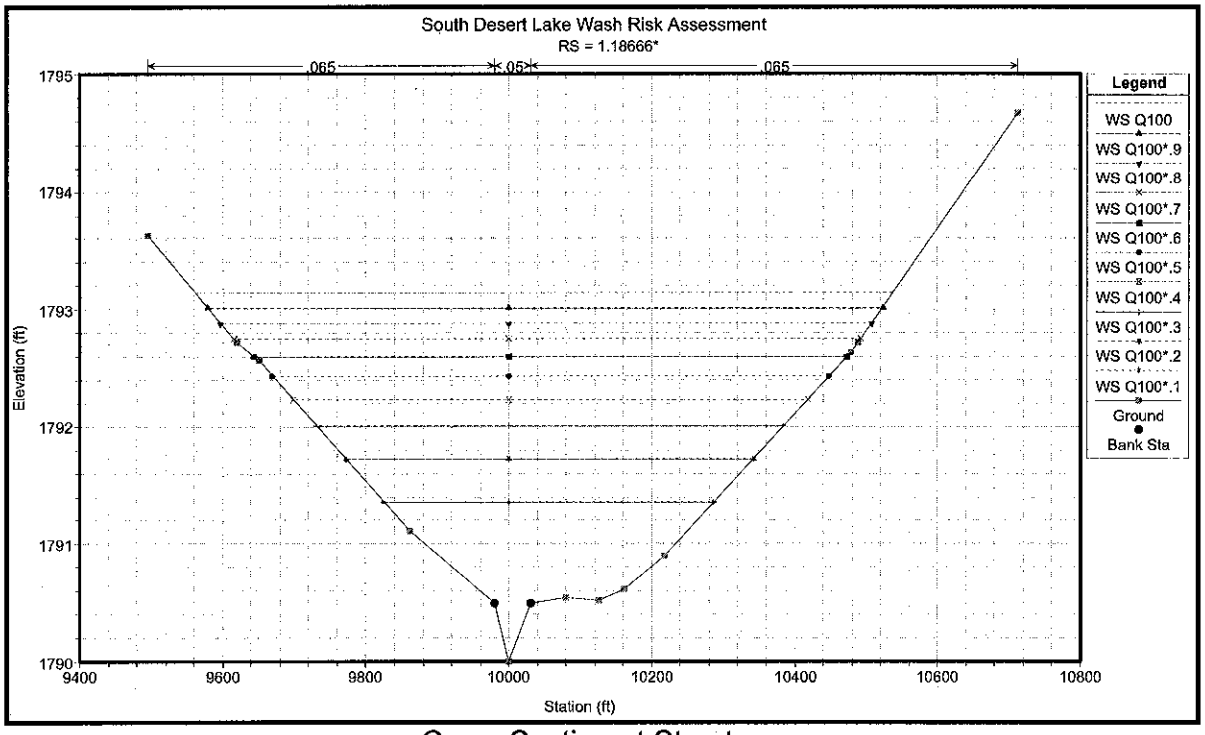
Cross Section at Structure



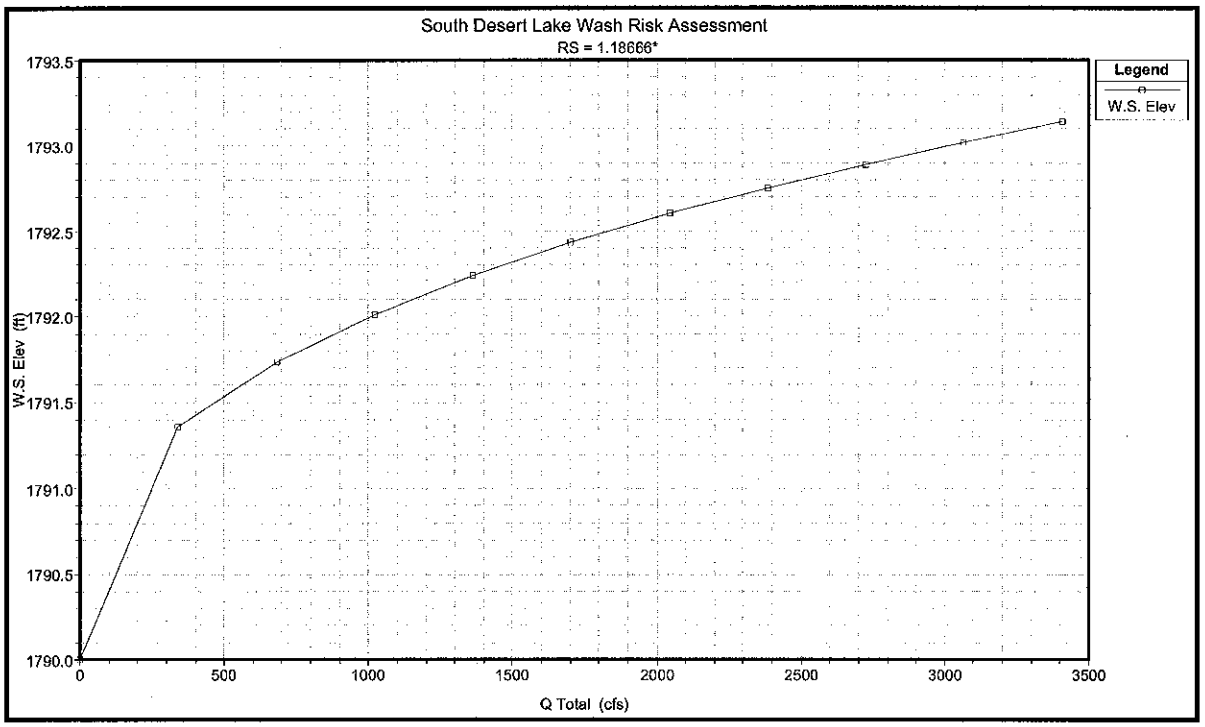
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 5



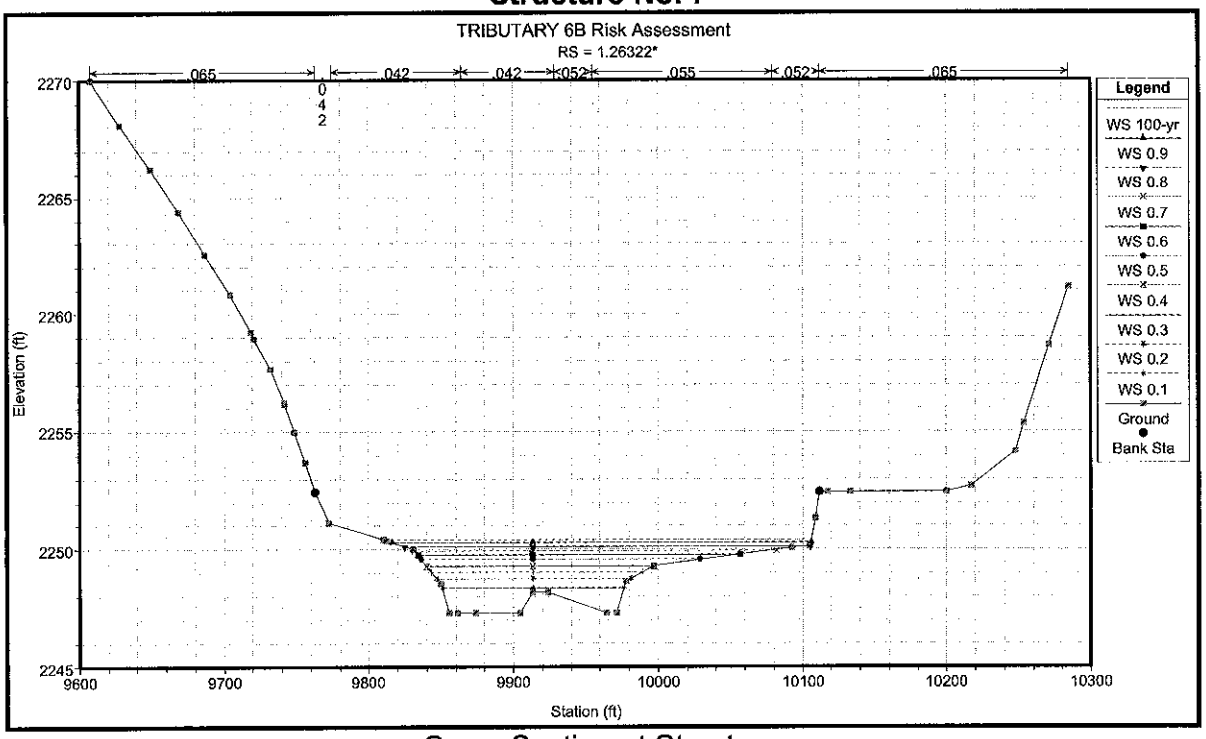
Cross Section at Structure



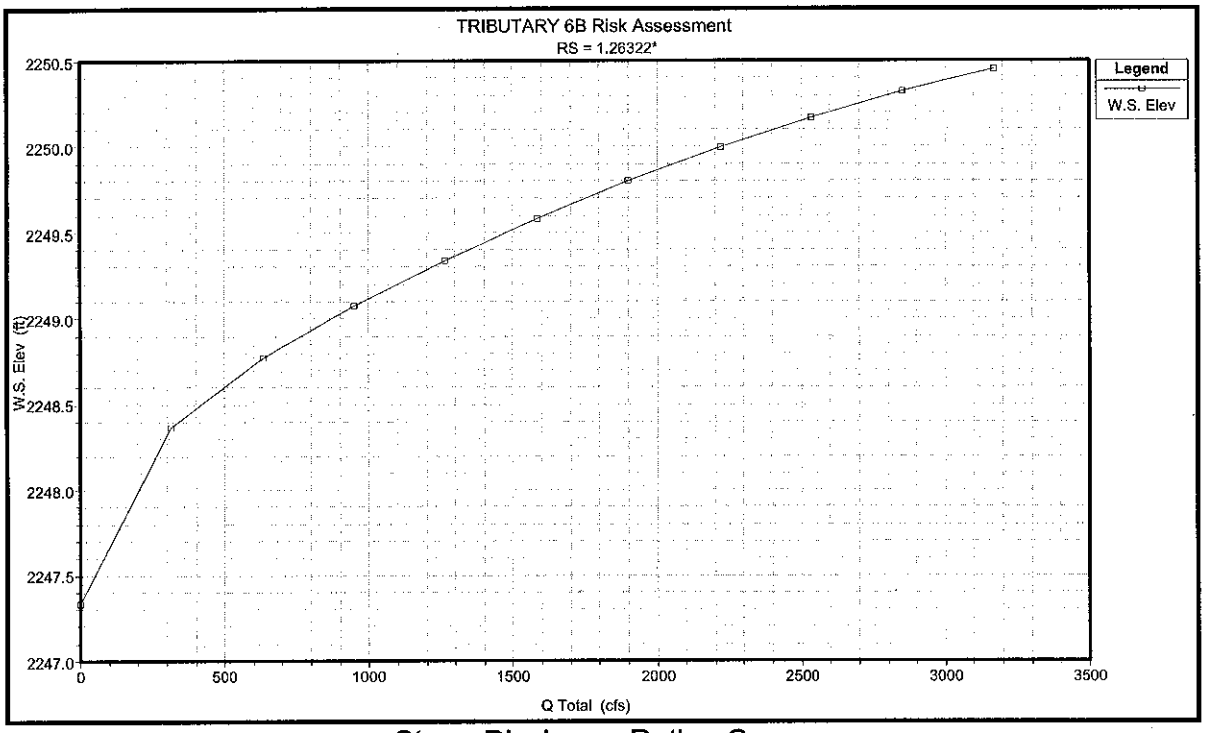
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 7



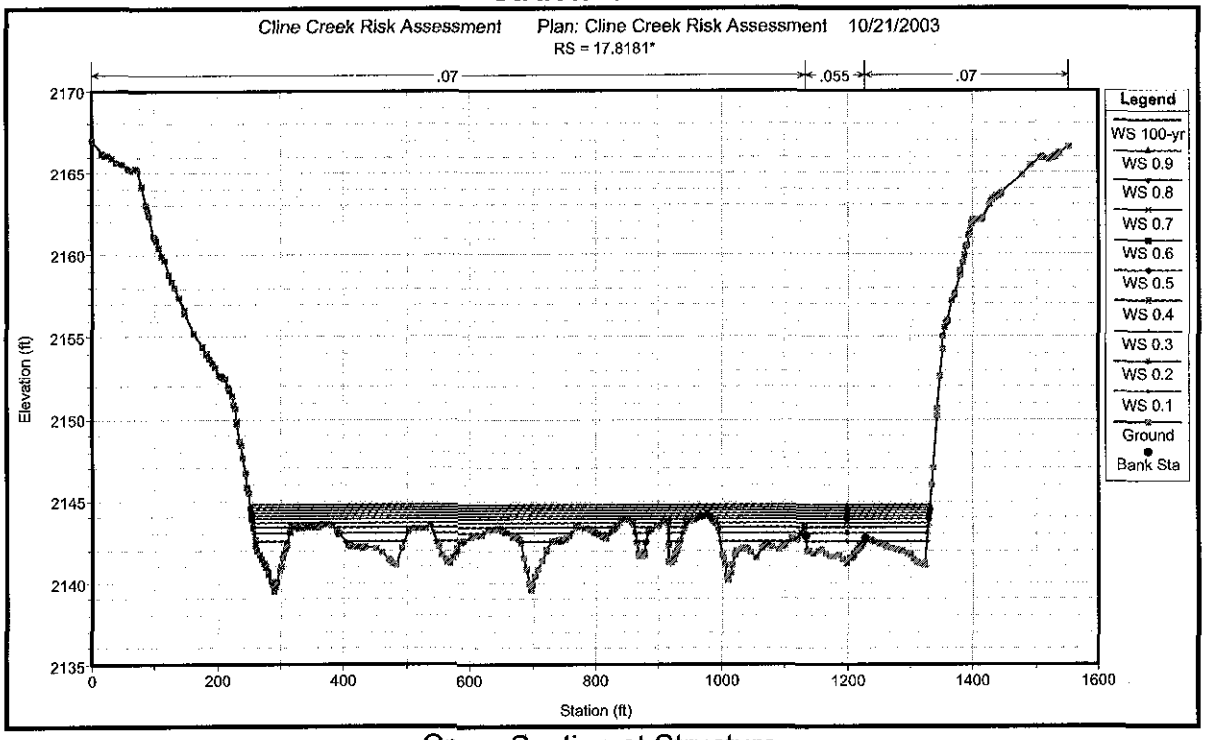
Cross Section at Structure



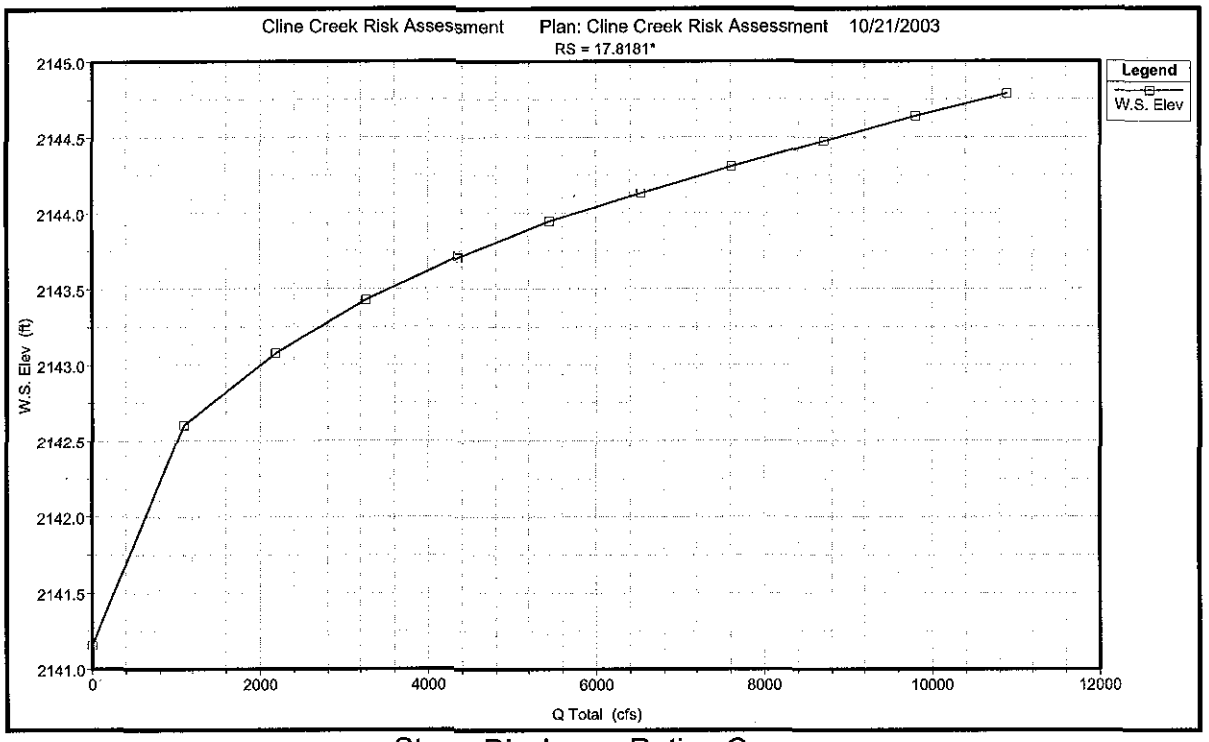
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 8



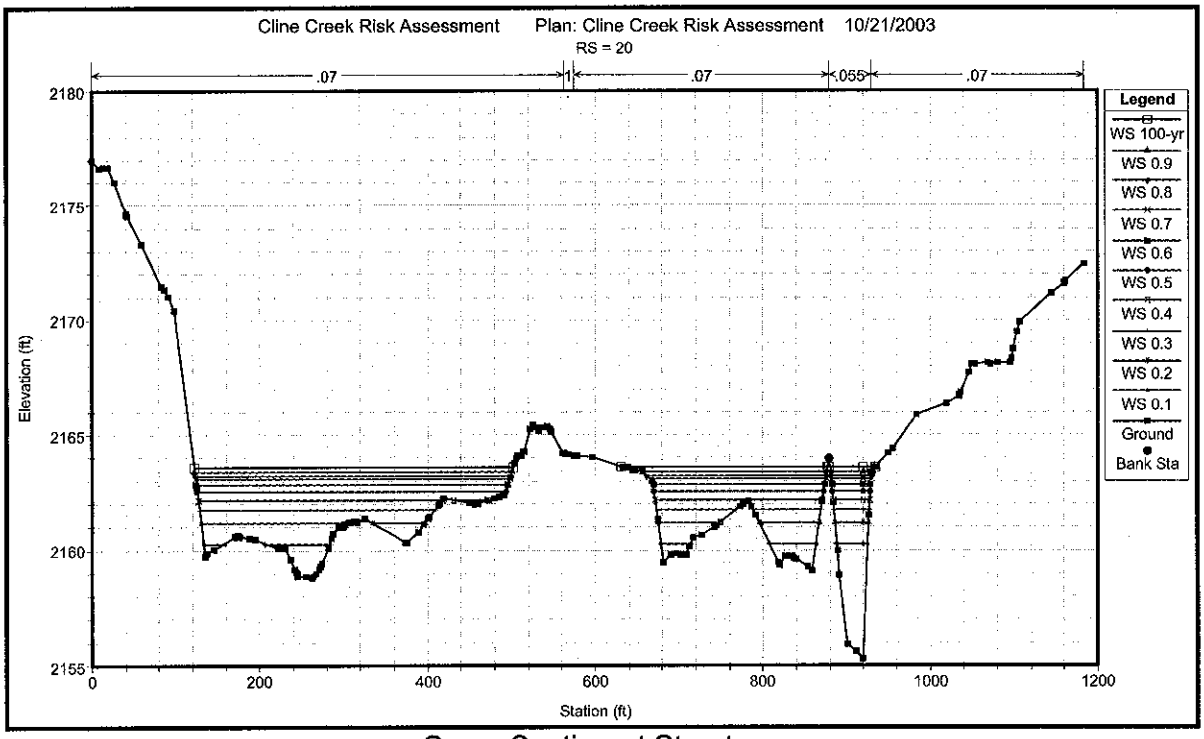
Cross Section at Structure



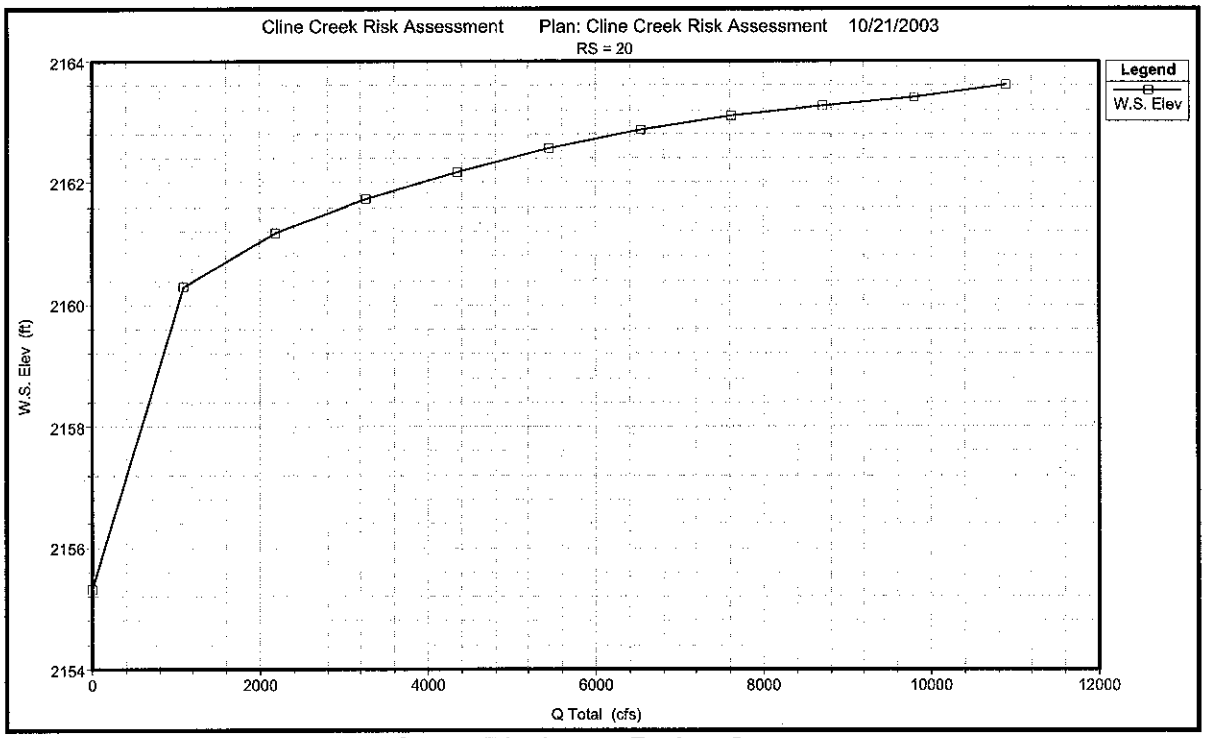
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 9



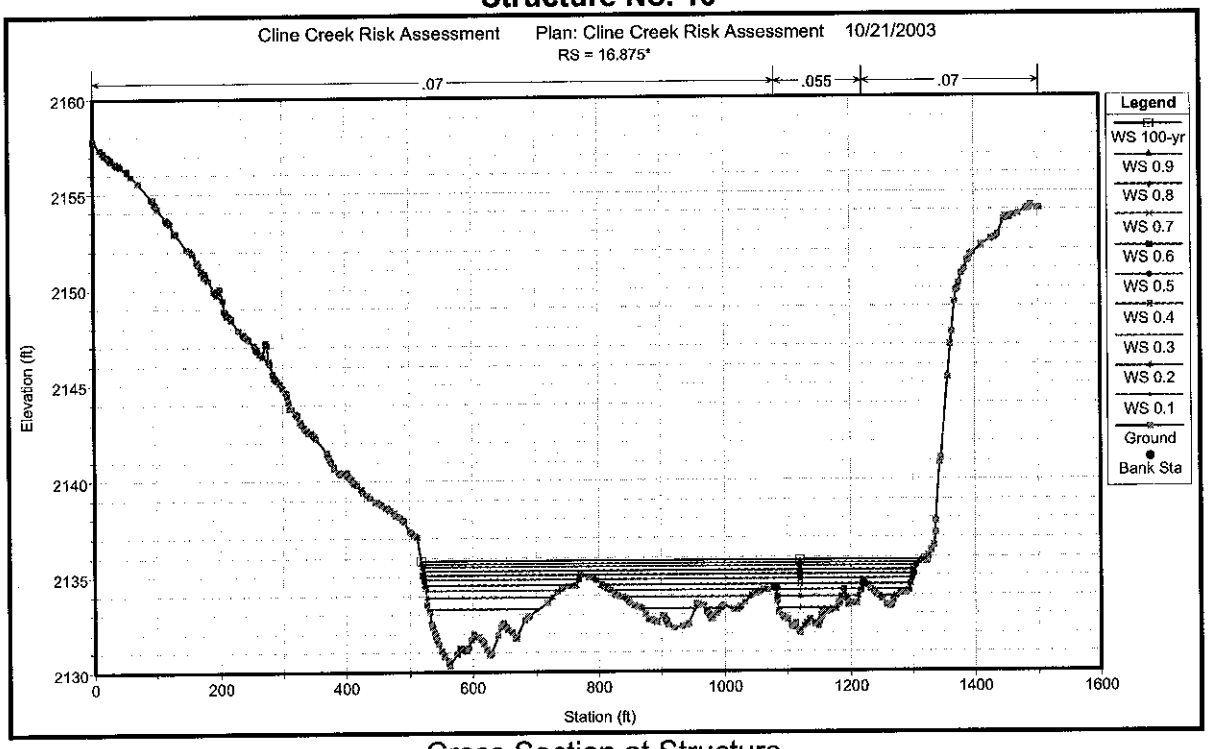
Cross Section at Structure



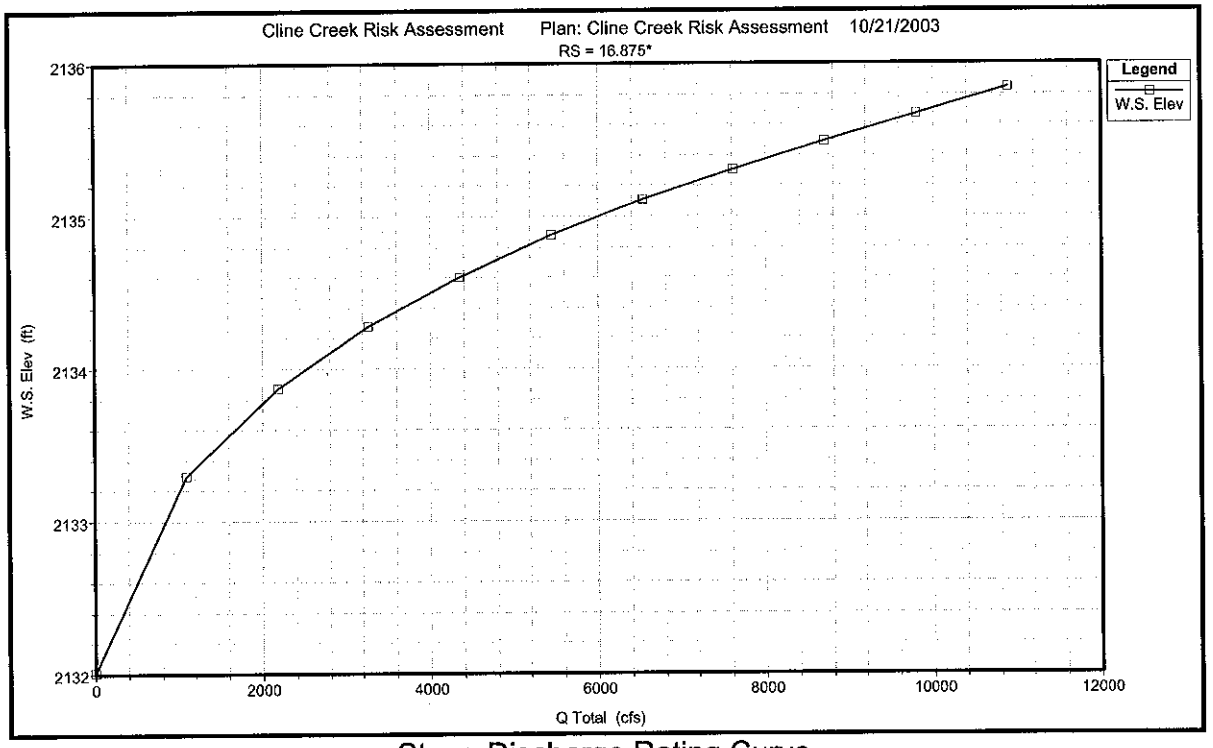
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 10



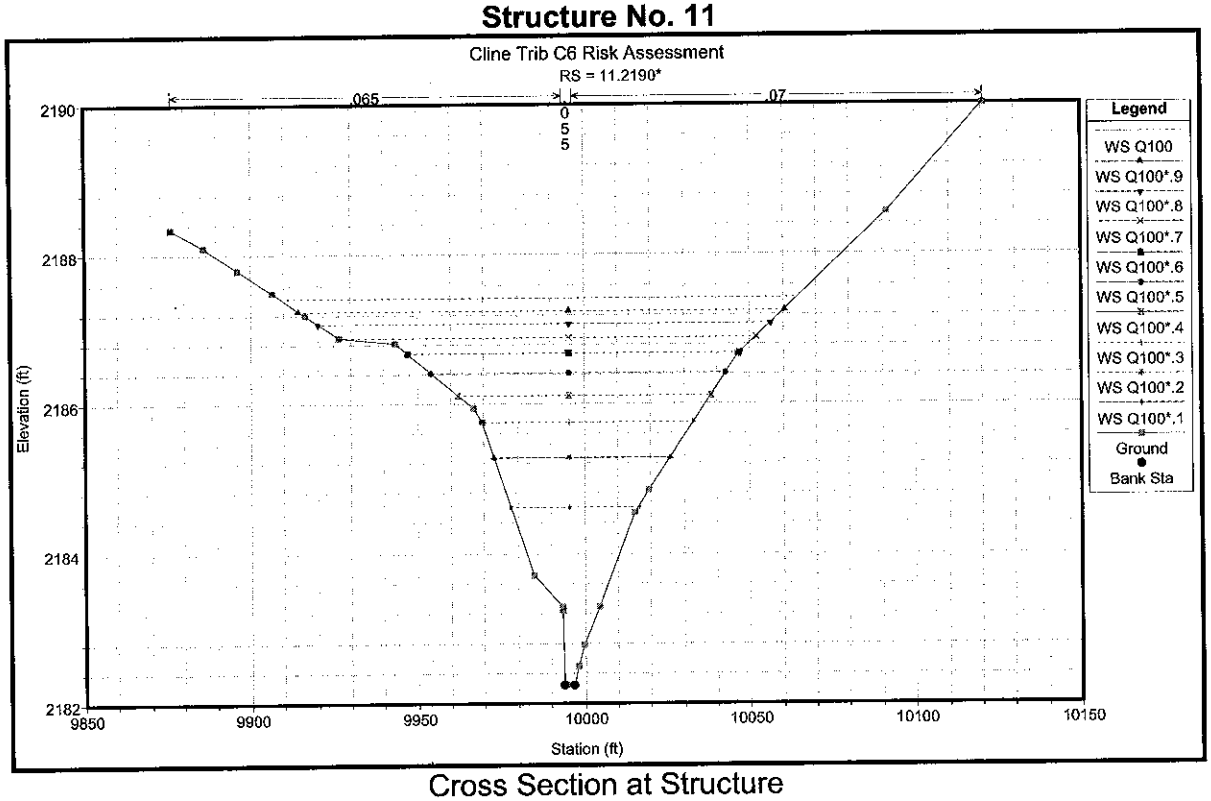
Cross Section at Structure



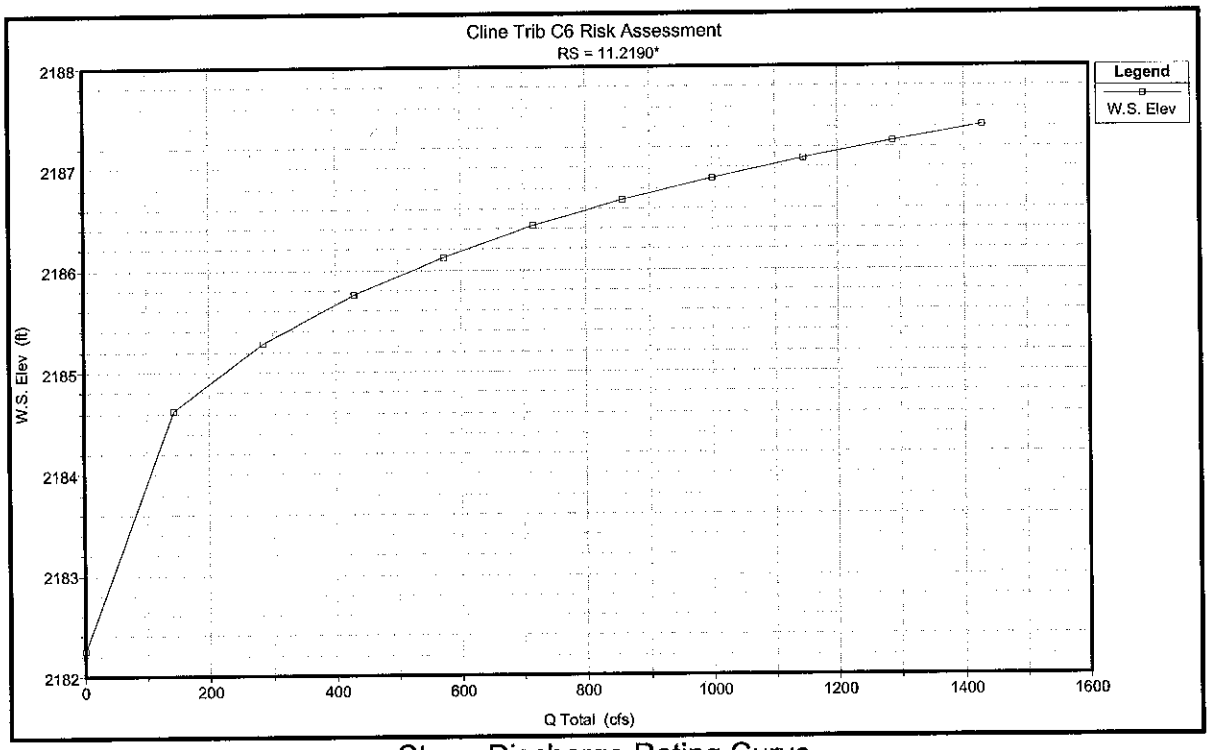
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 11



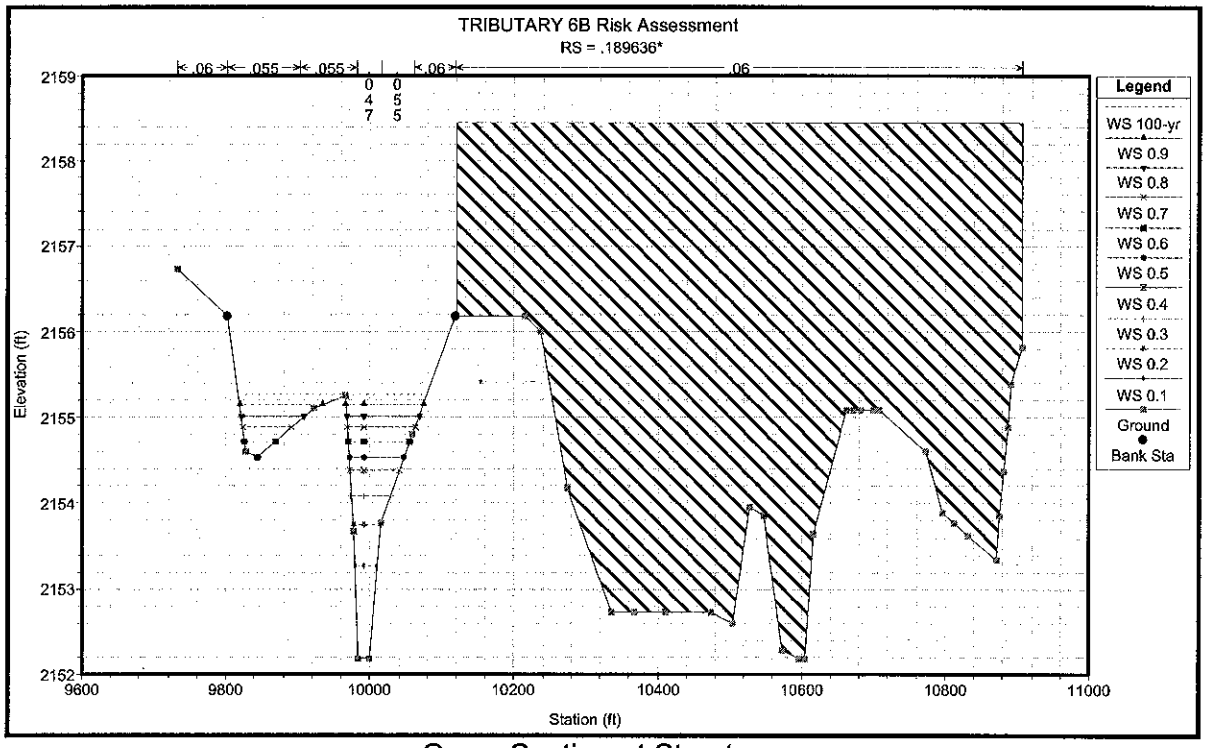
Cross Section at Structure



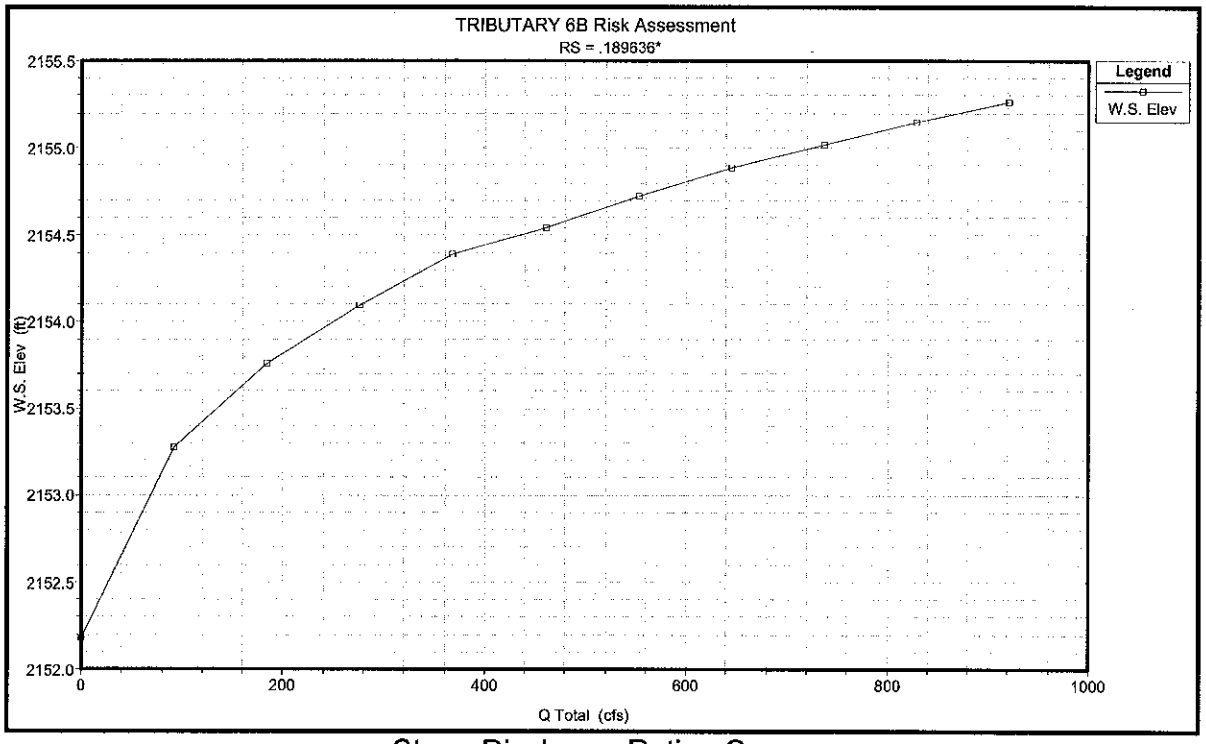
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 12



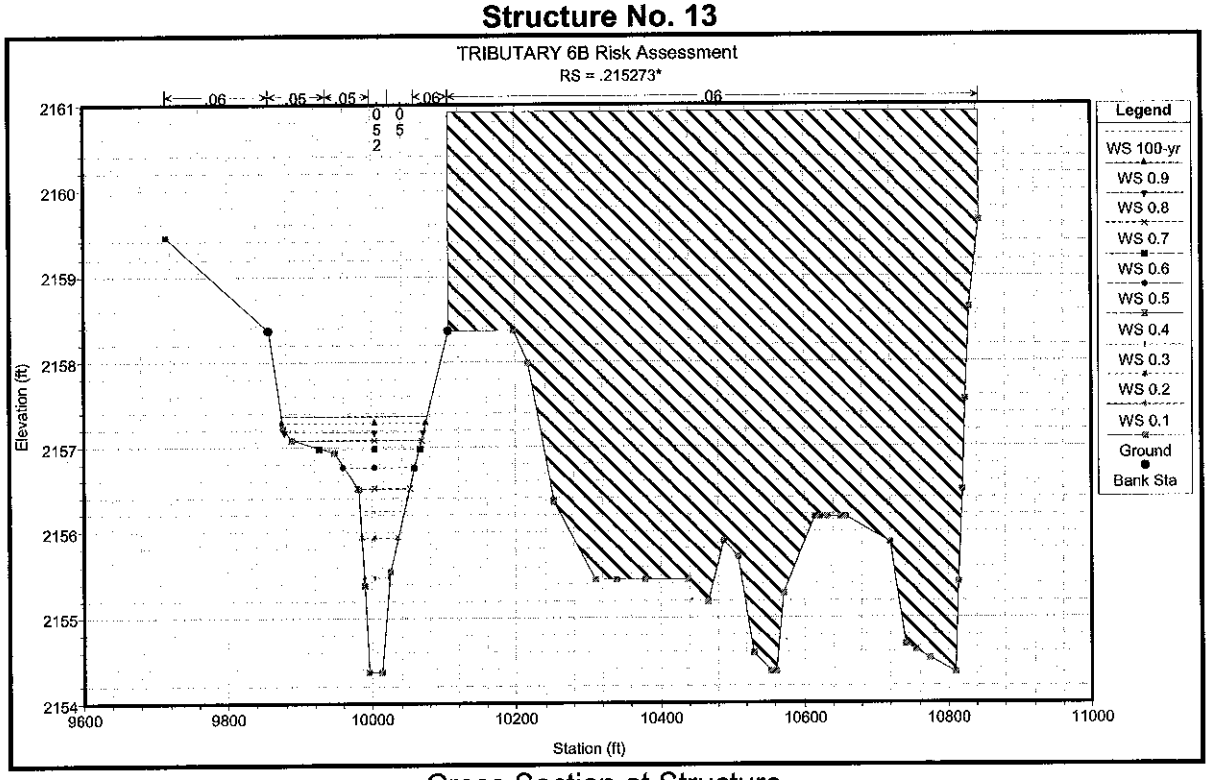
Cross Section at Structure



Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 13



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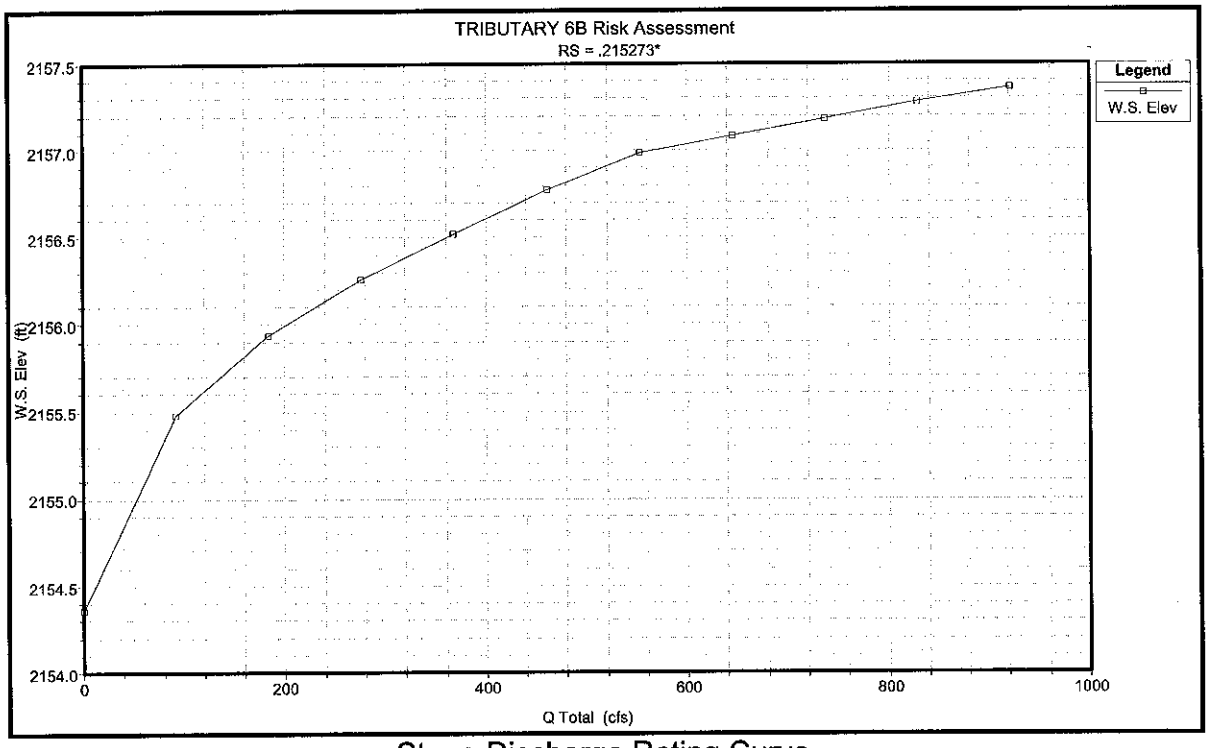
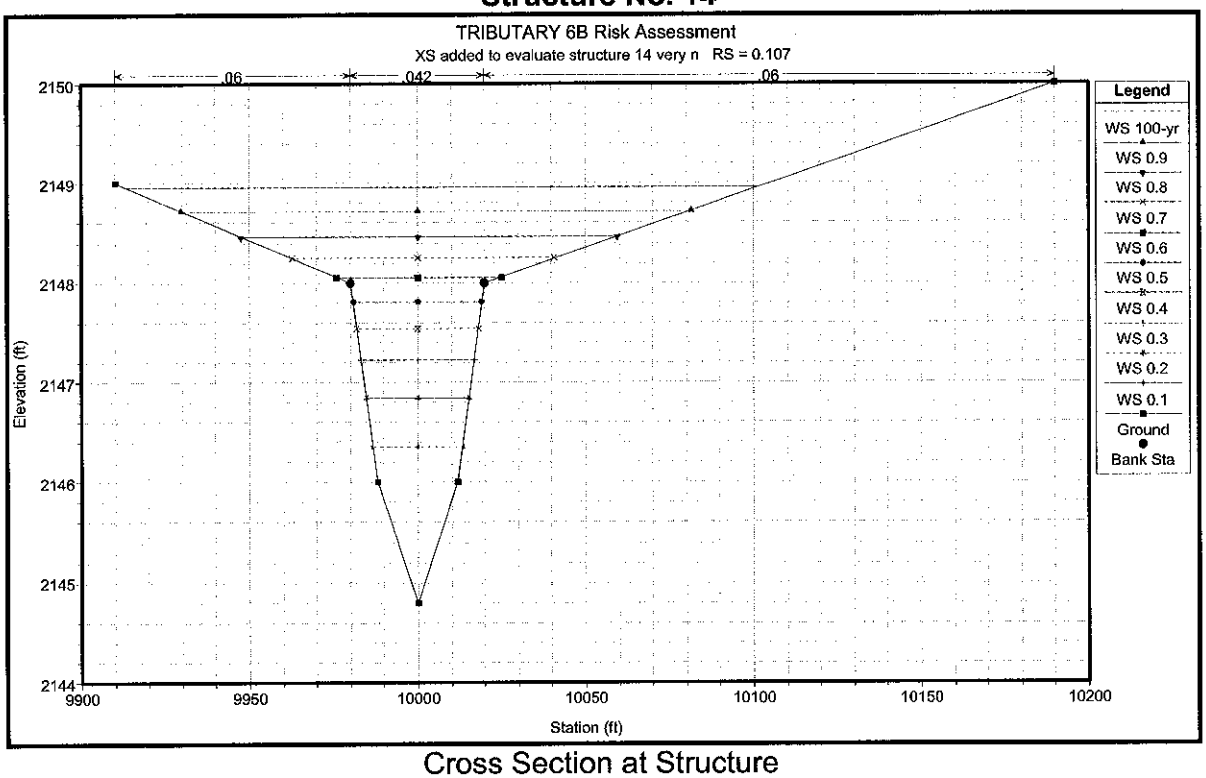


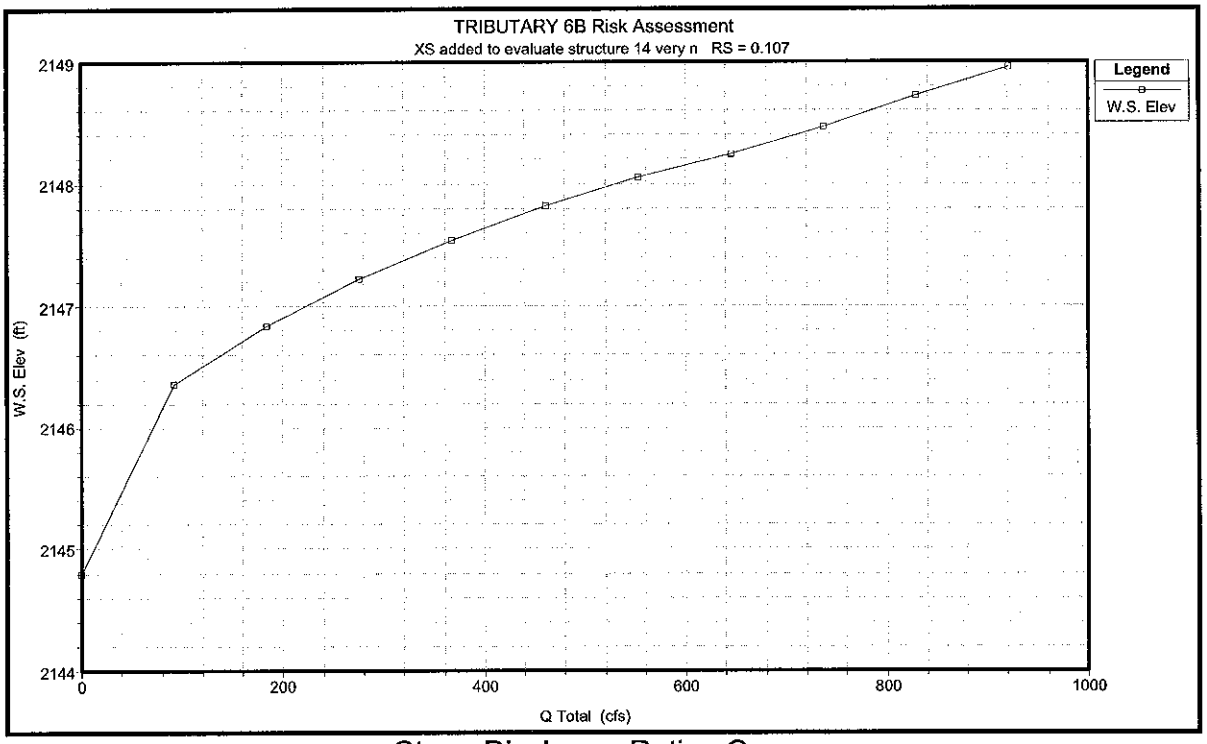
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 14



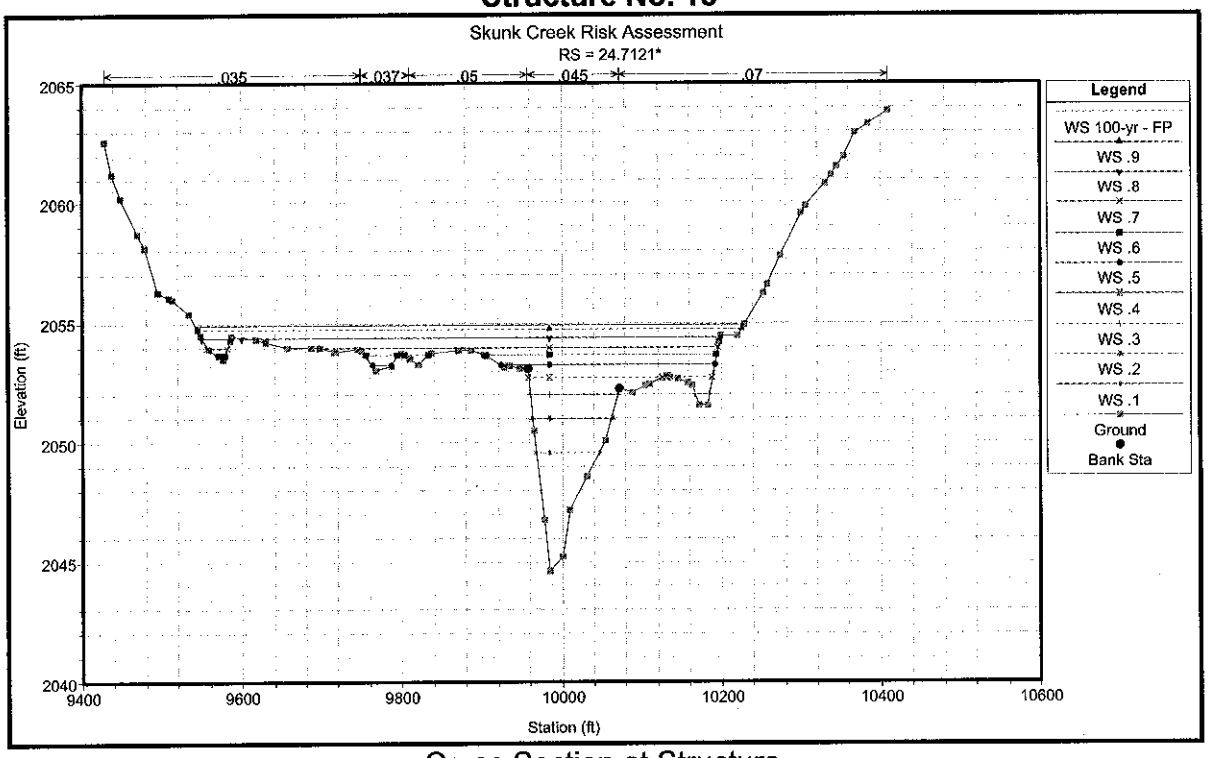
Cross Section at Structure



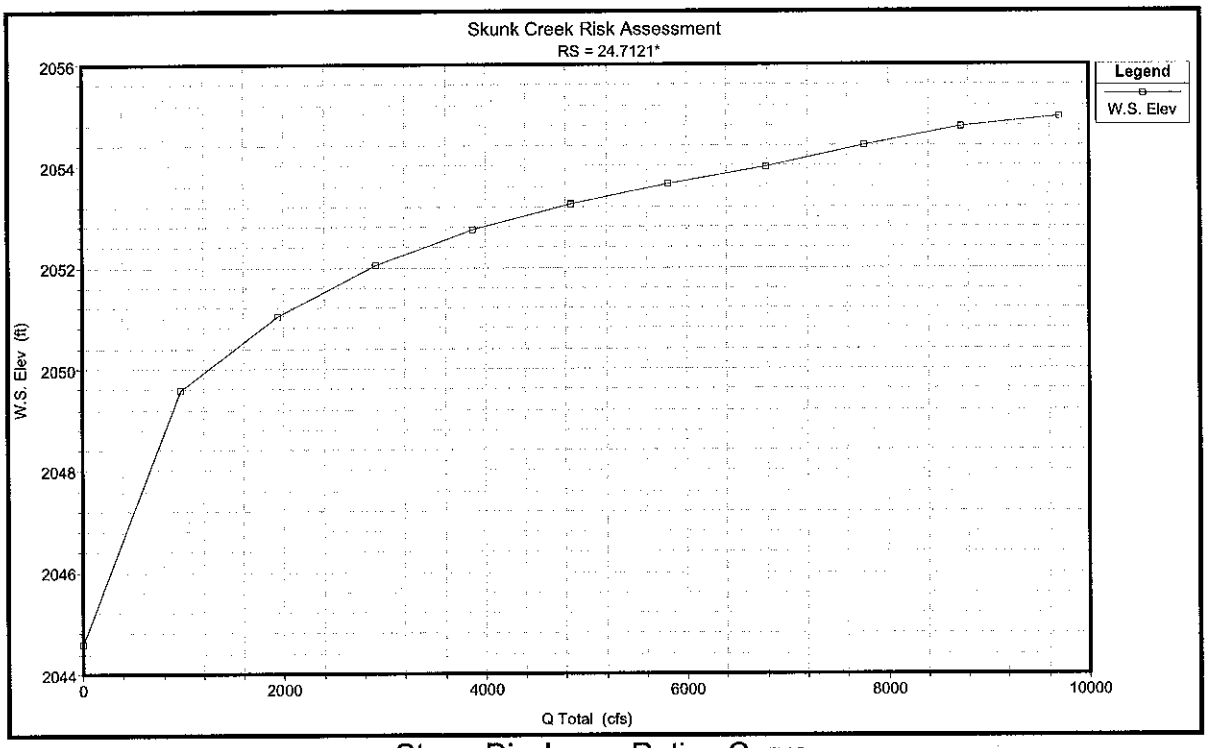
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 15



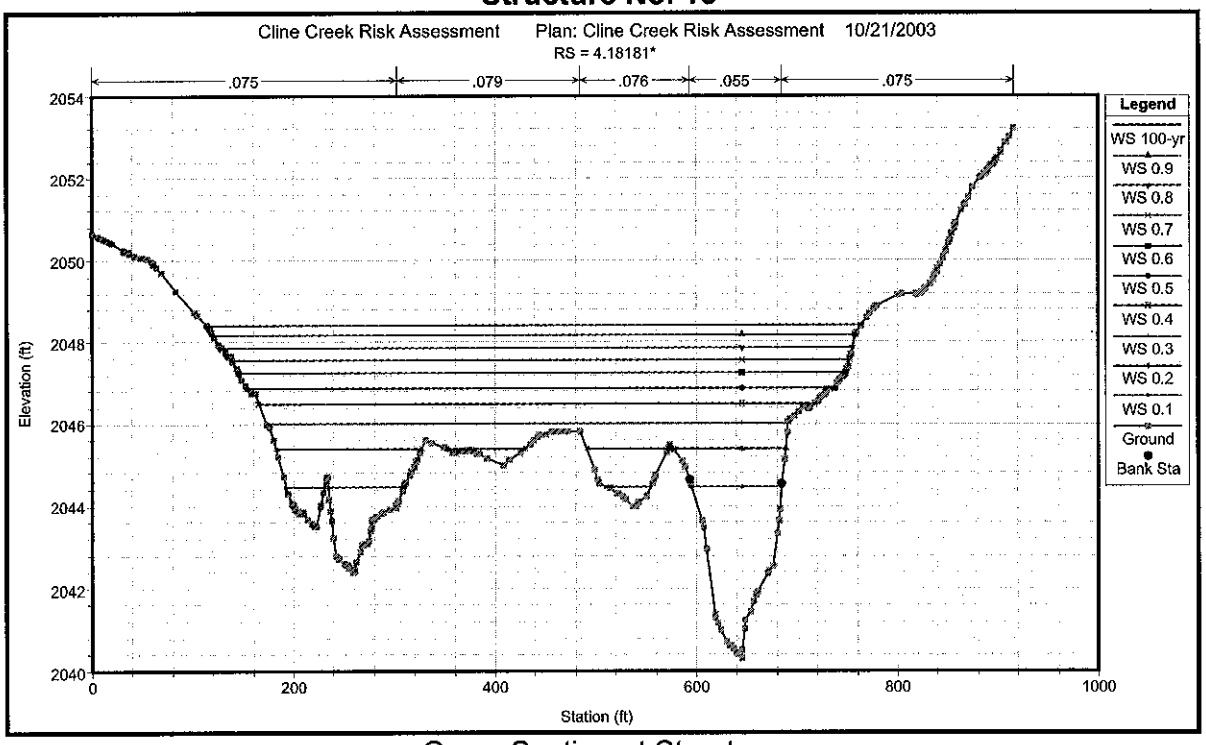
Cross Section at Structure



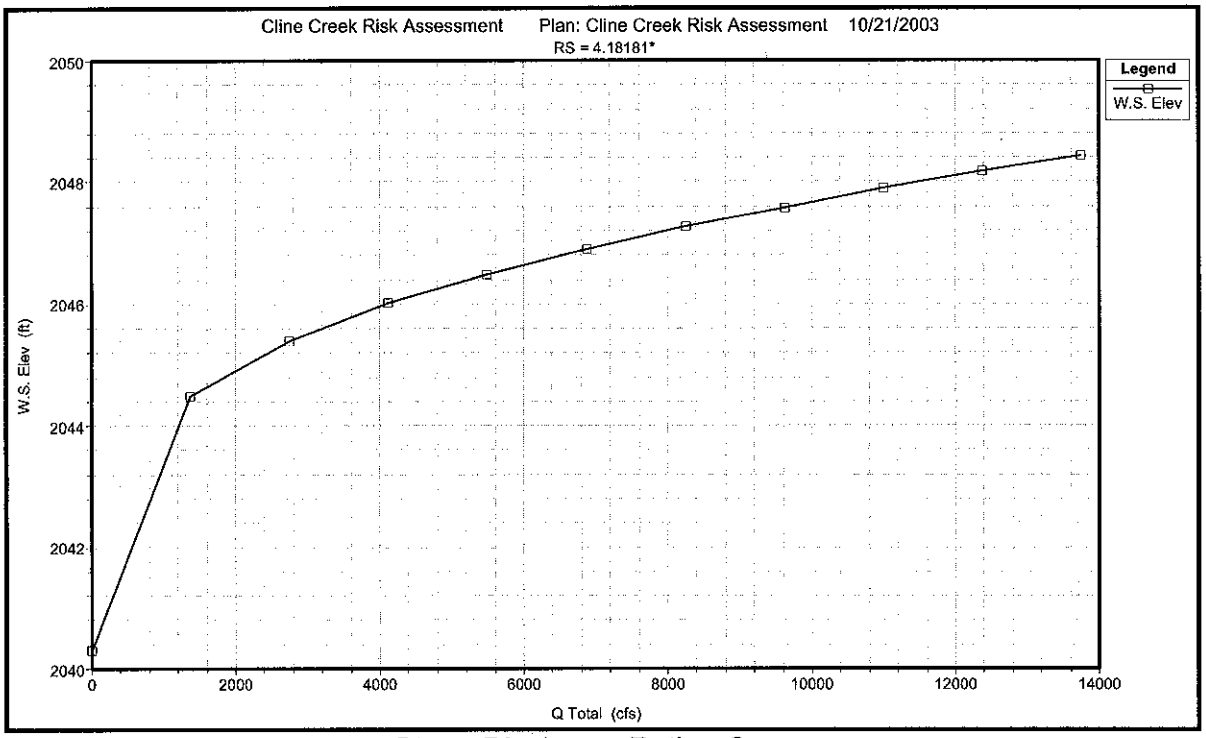
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 16



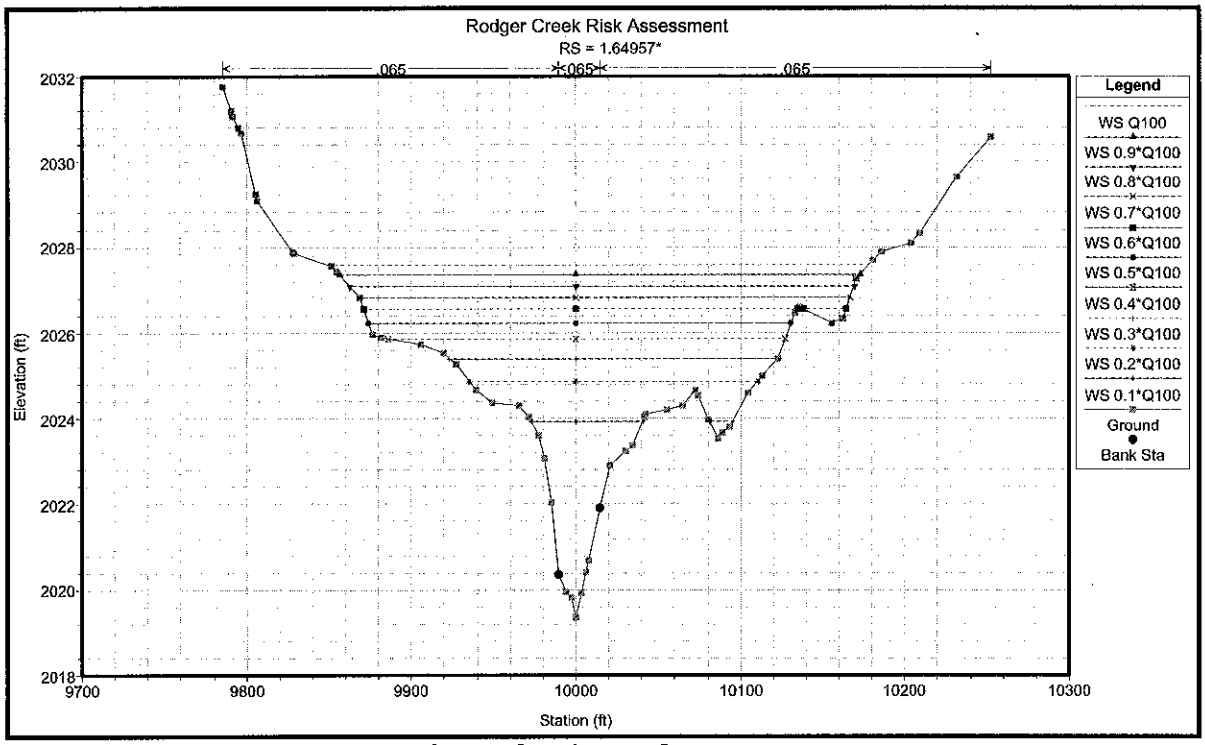
Cross Section at Structure



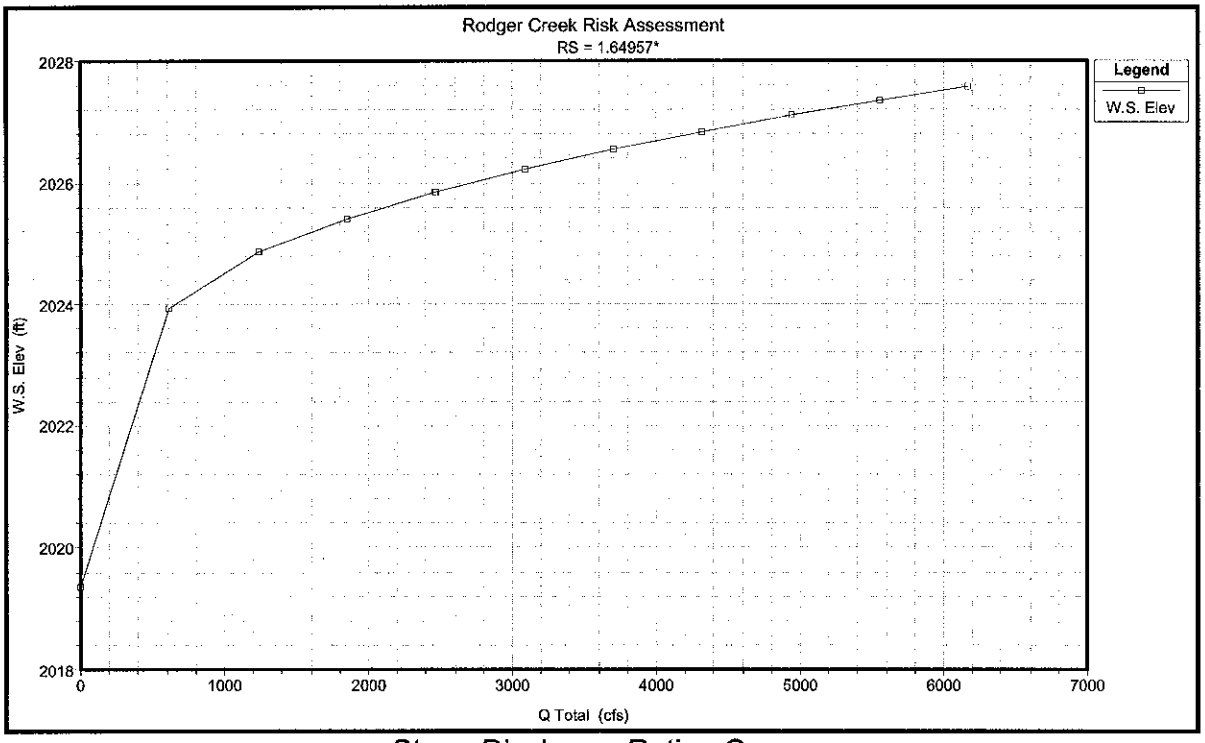
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 17



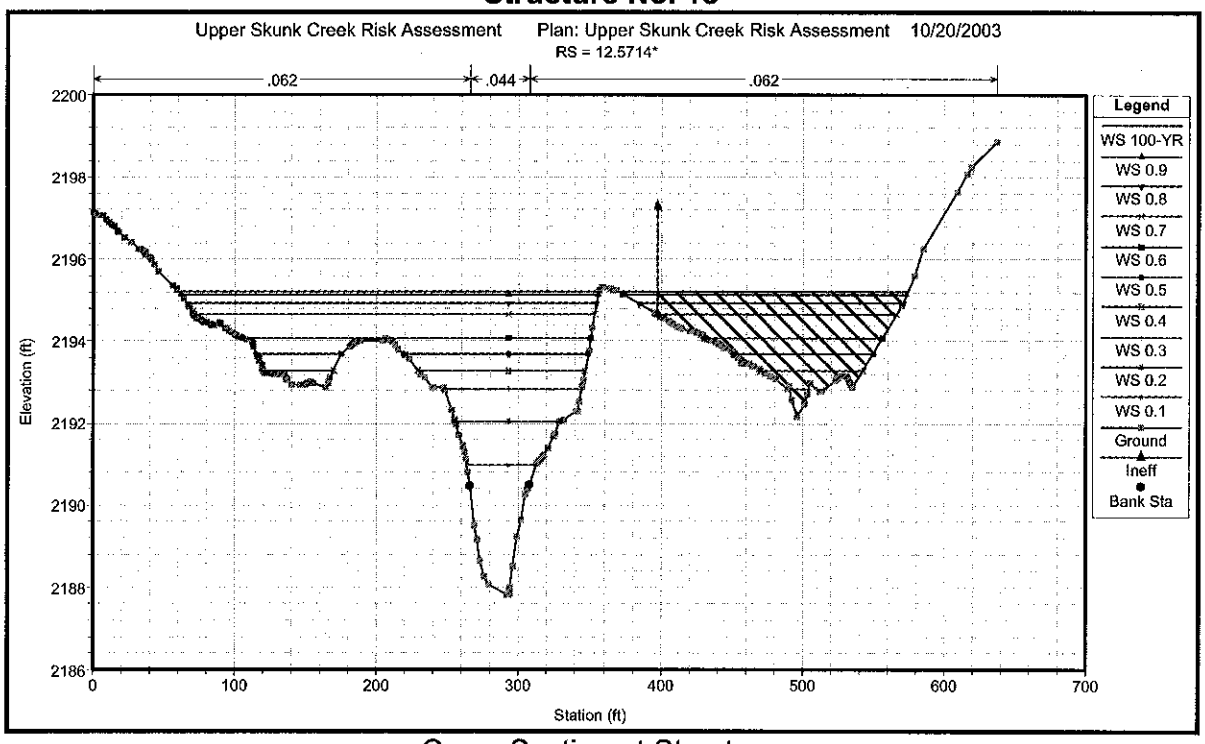
Cross Section at Structure



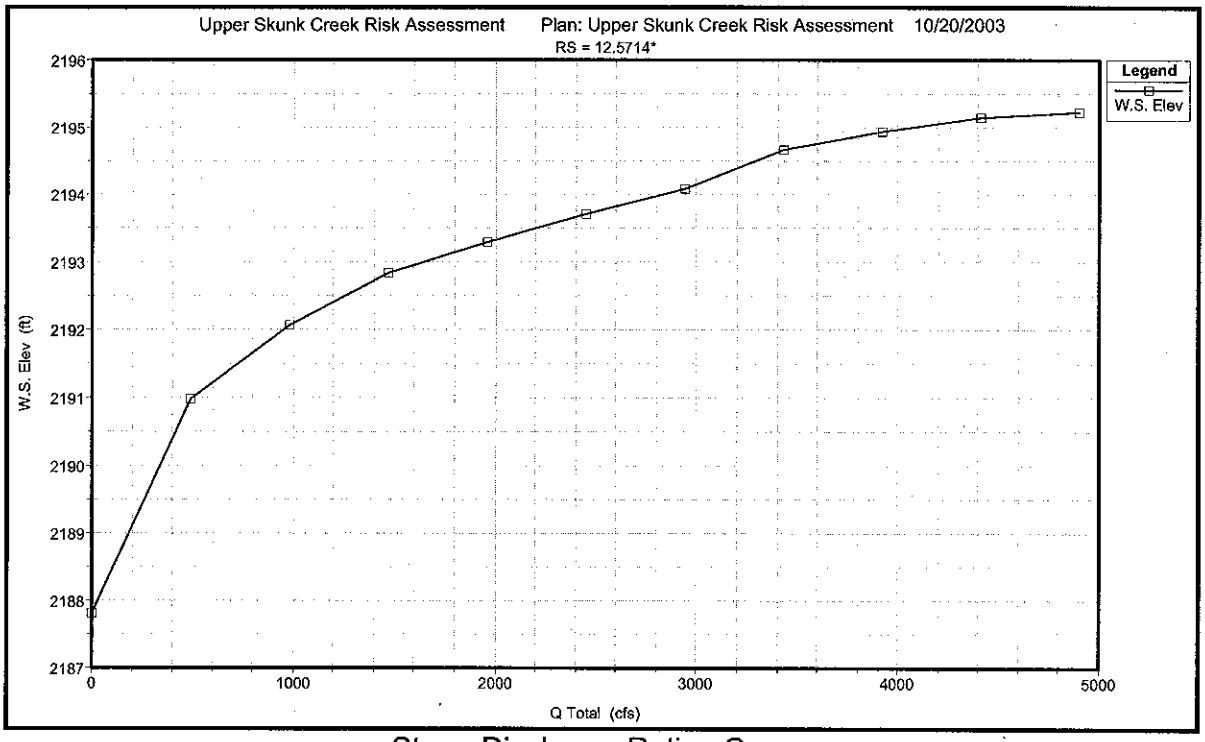
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 18



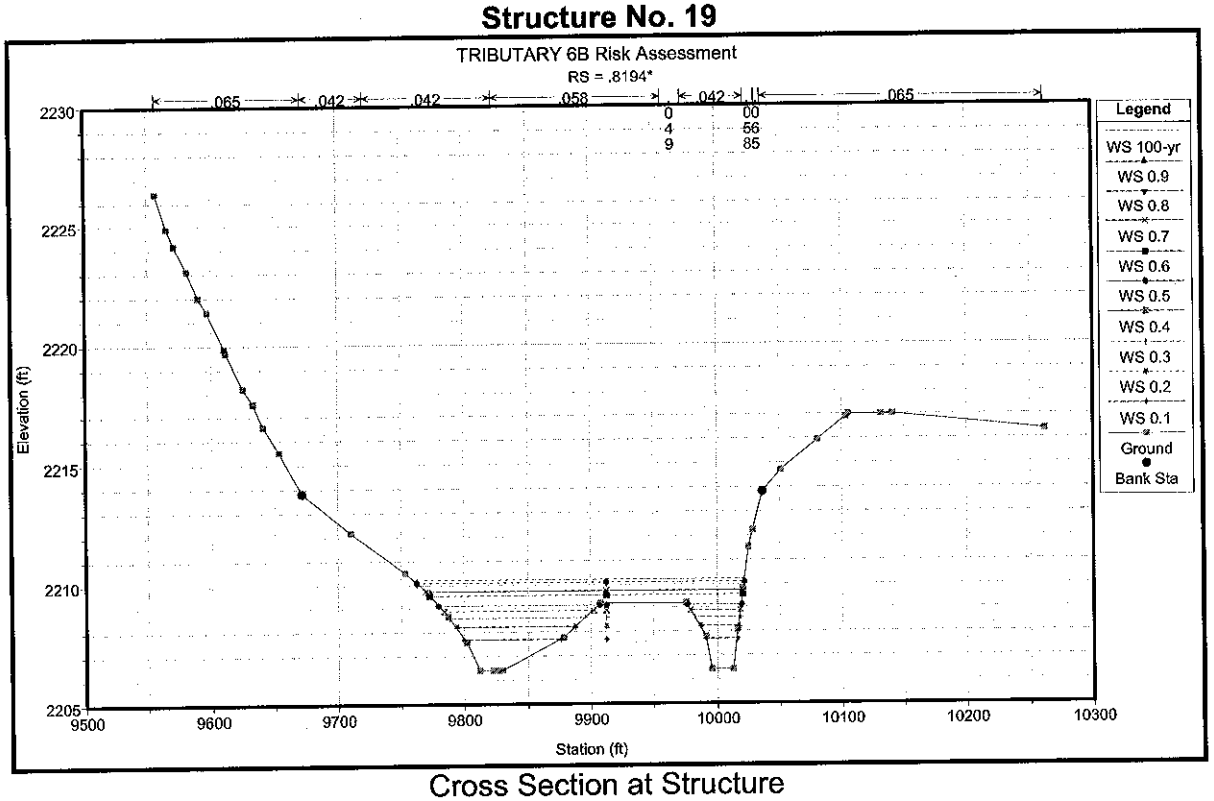
Cross Section at Structure



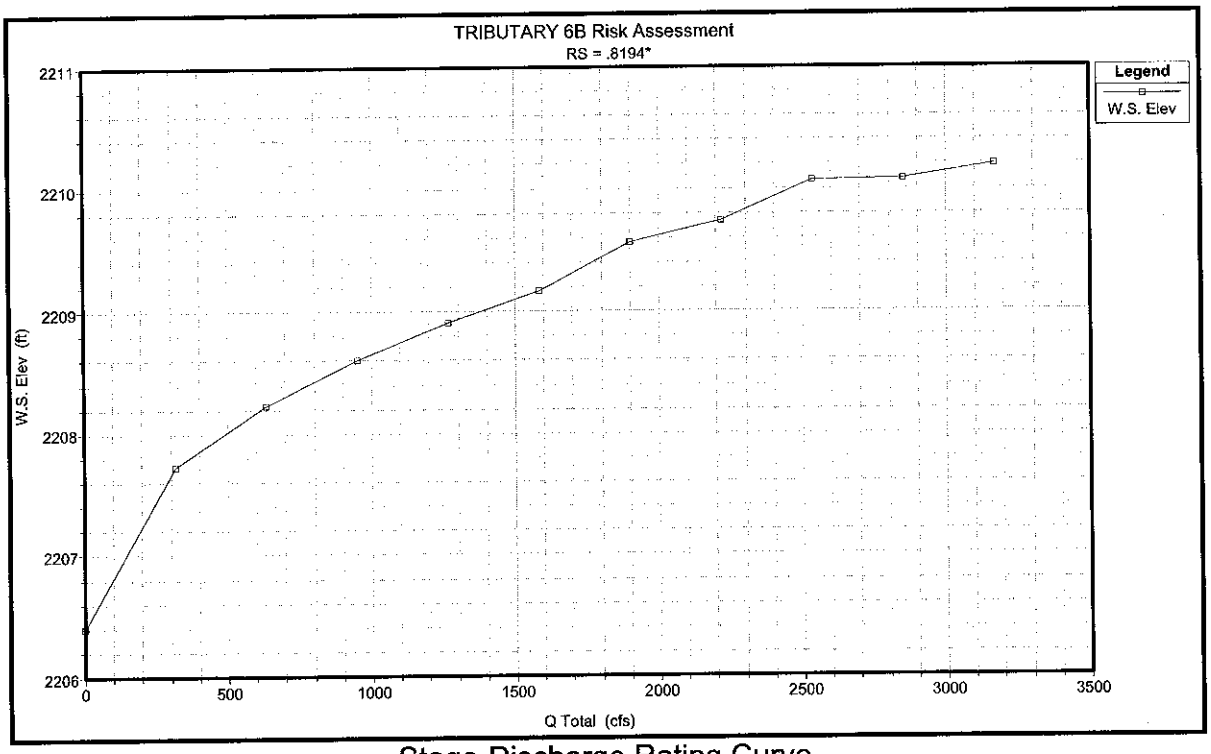
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 19



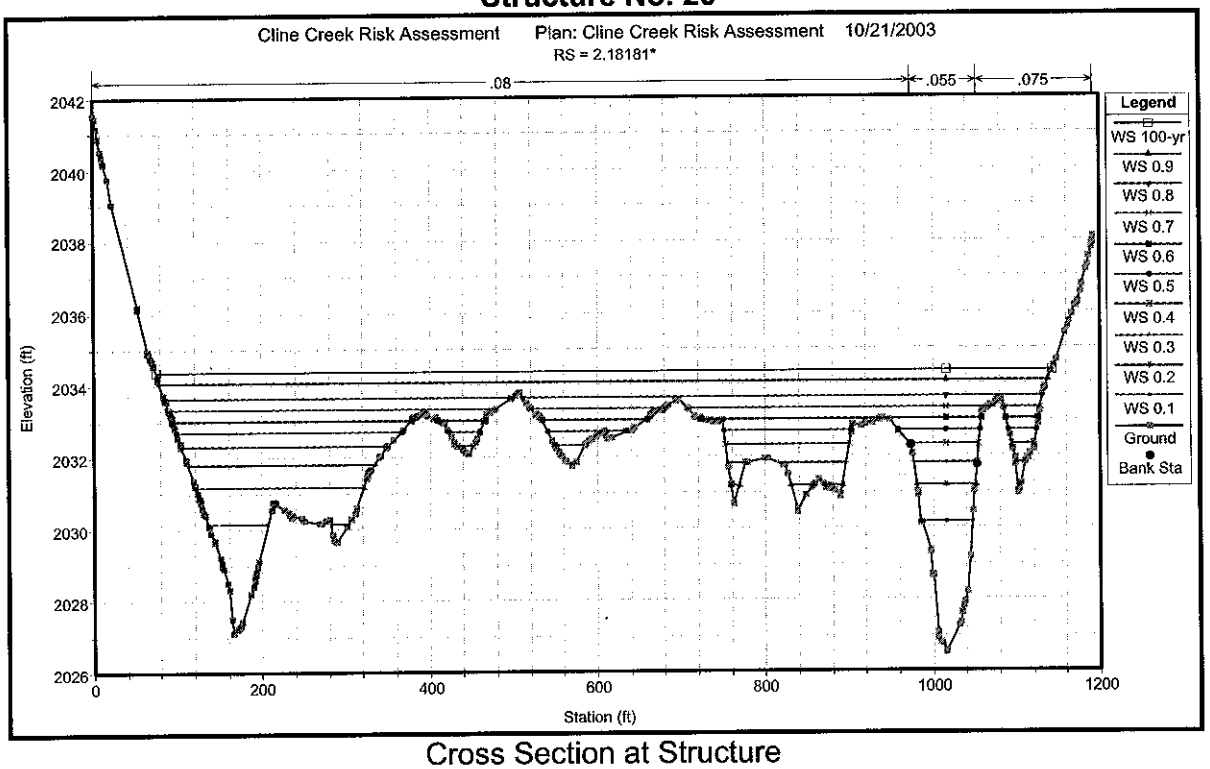
Cross Section at Structure



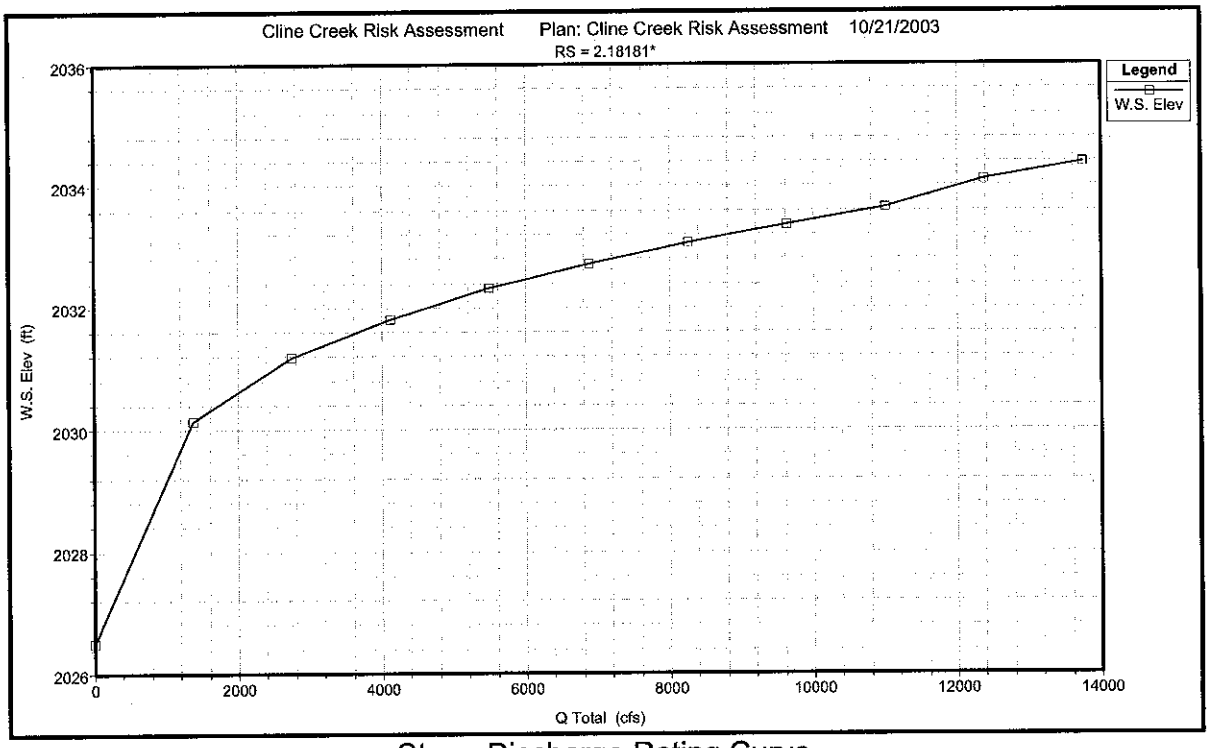
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 20



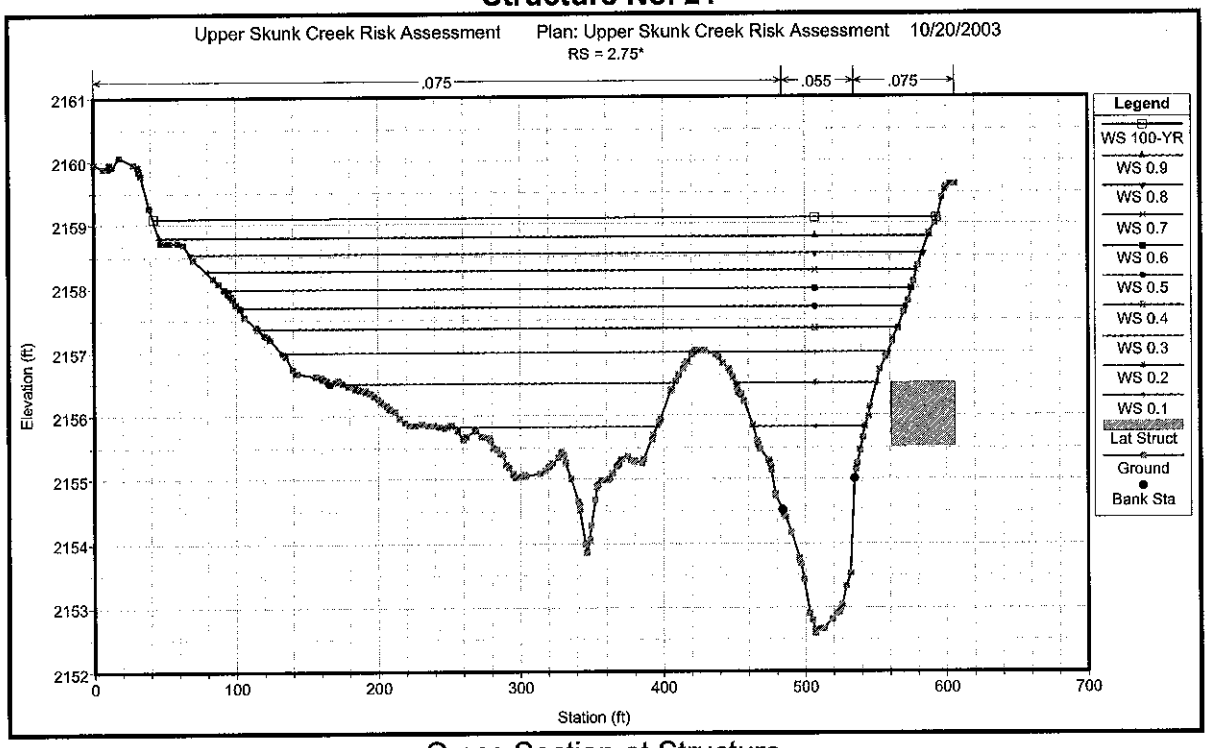
Cross Section at Structure



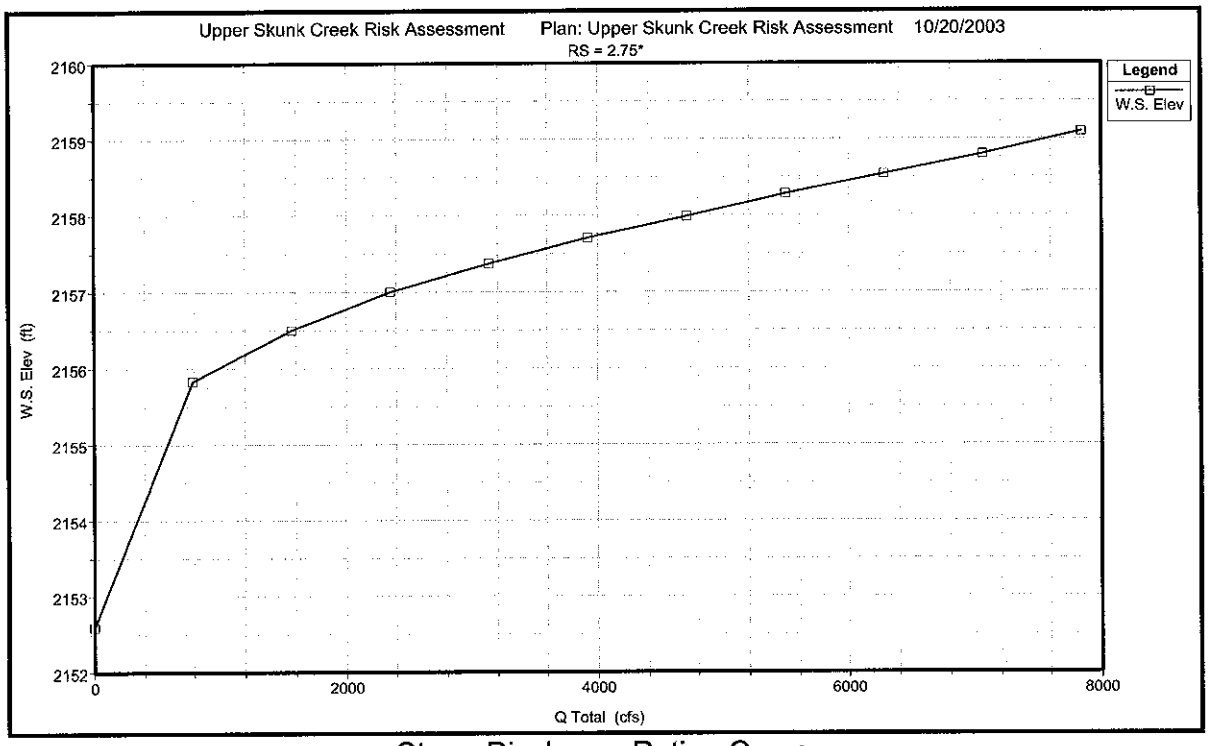
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 21



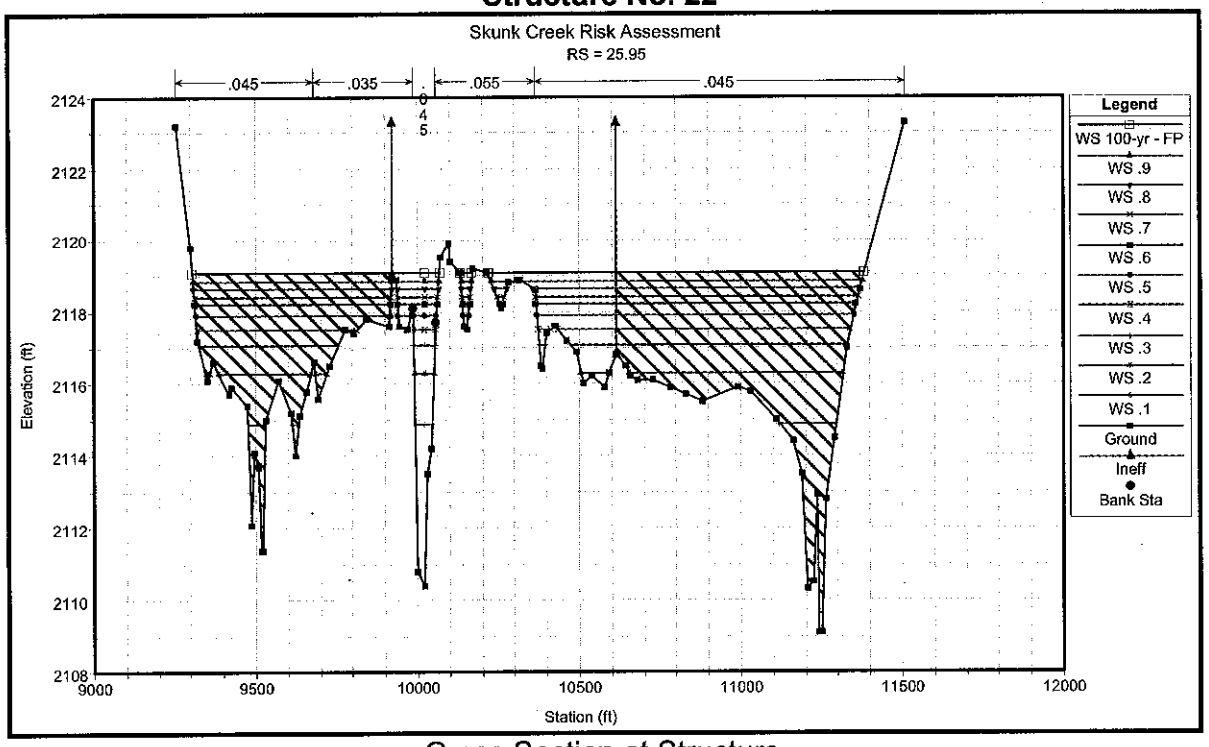
Cross Section at Structure



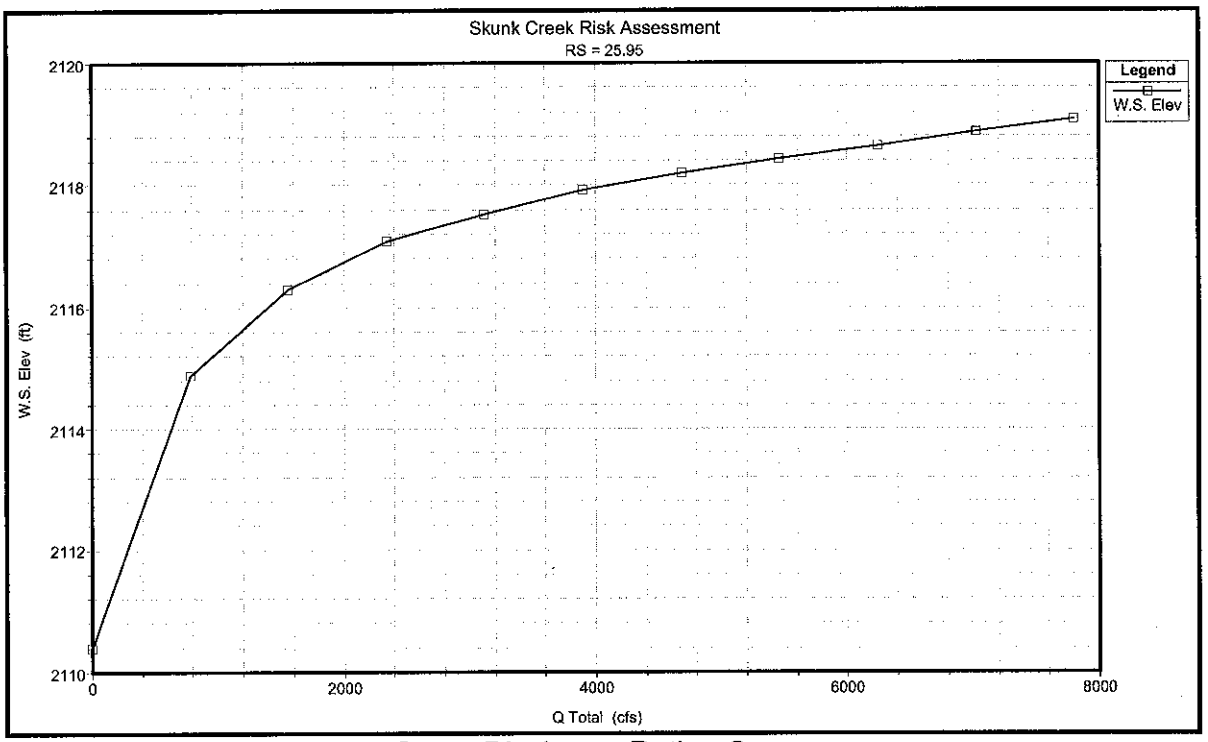
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 22



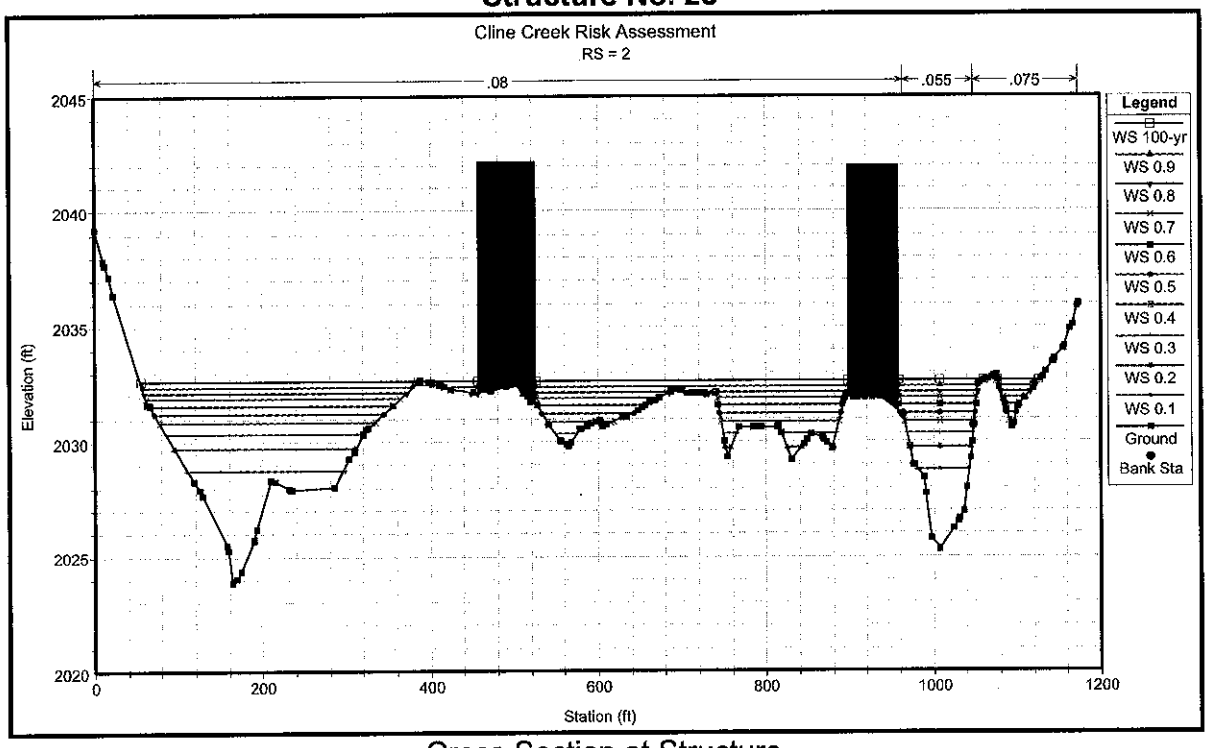
Cross Section at Structure



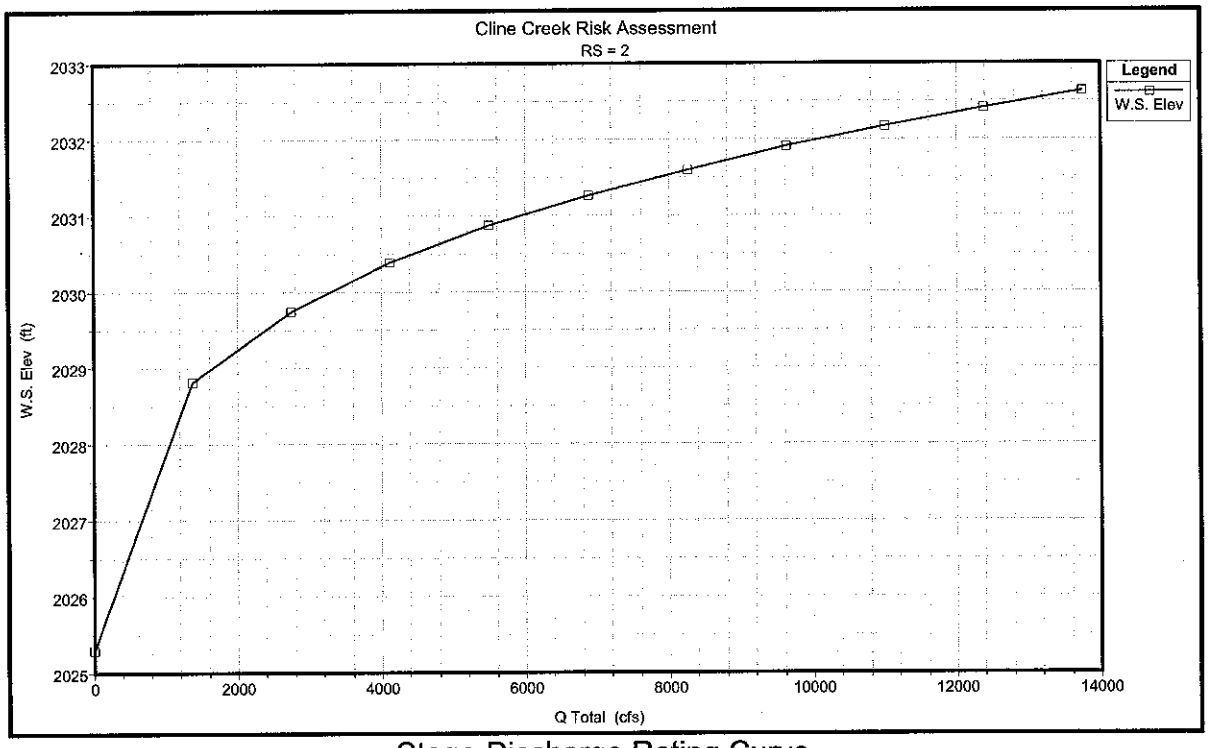
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 23



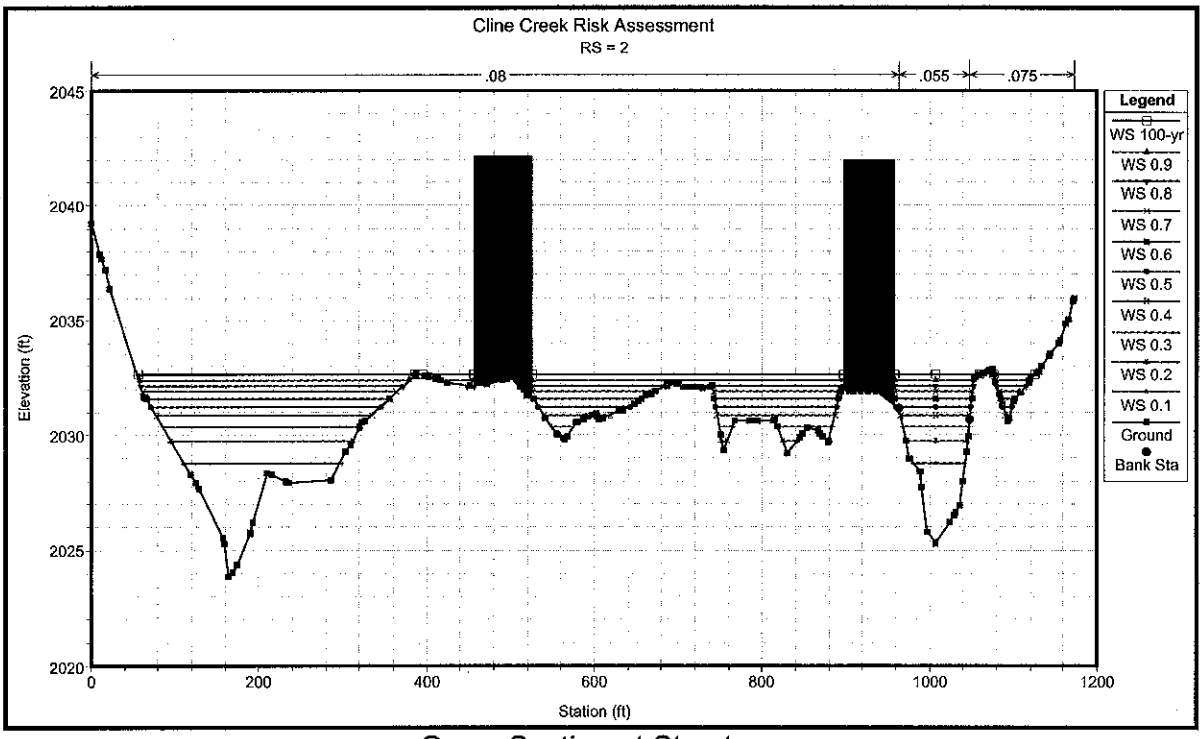
Cross Section at Structure



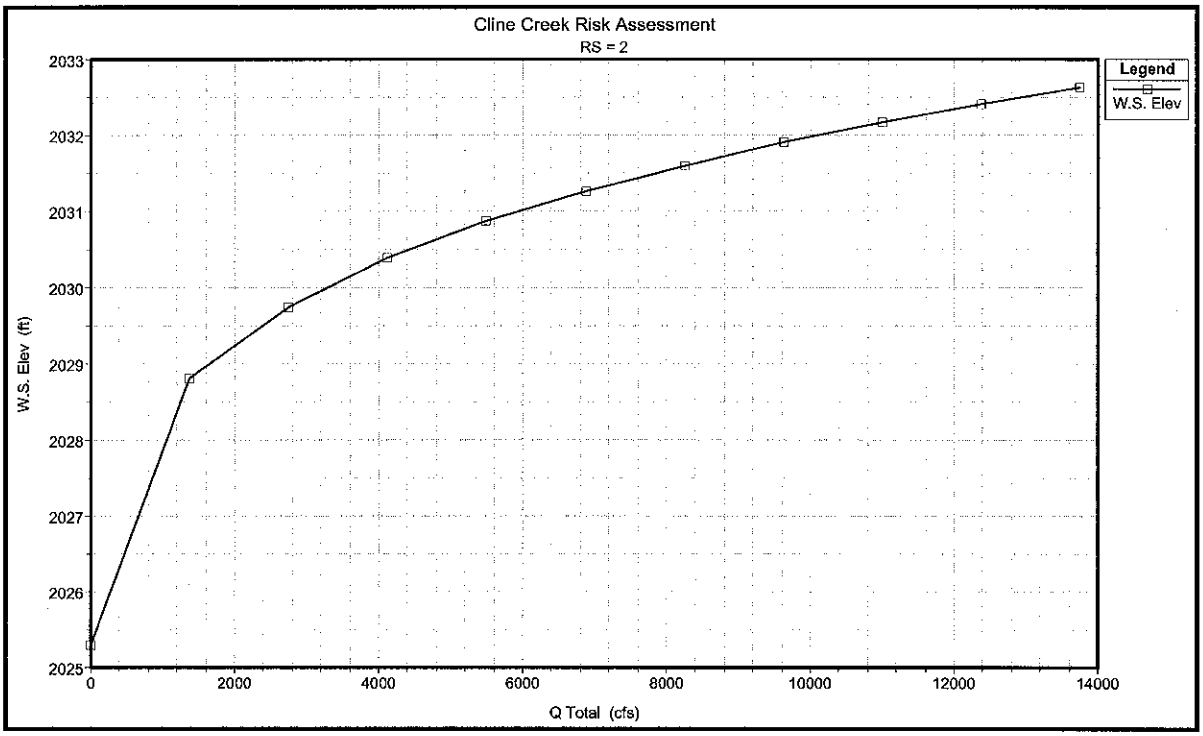
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 24



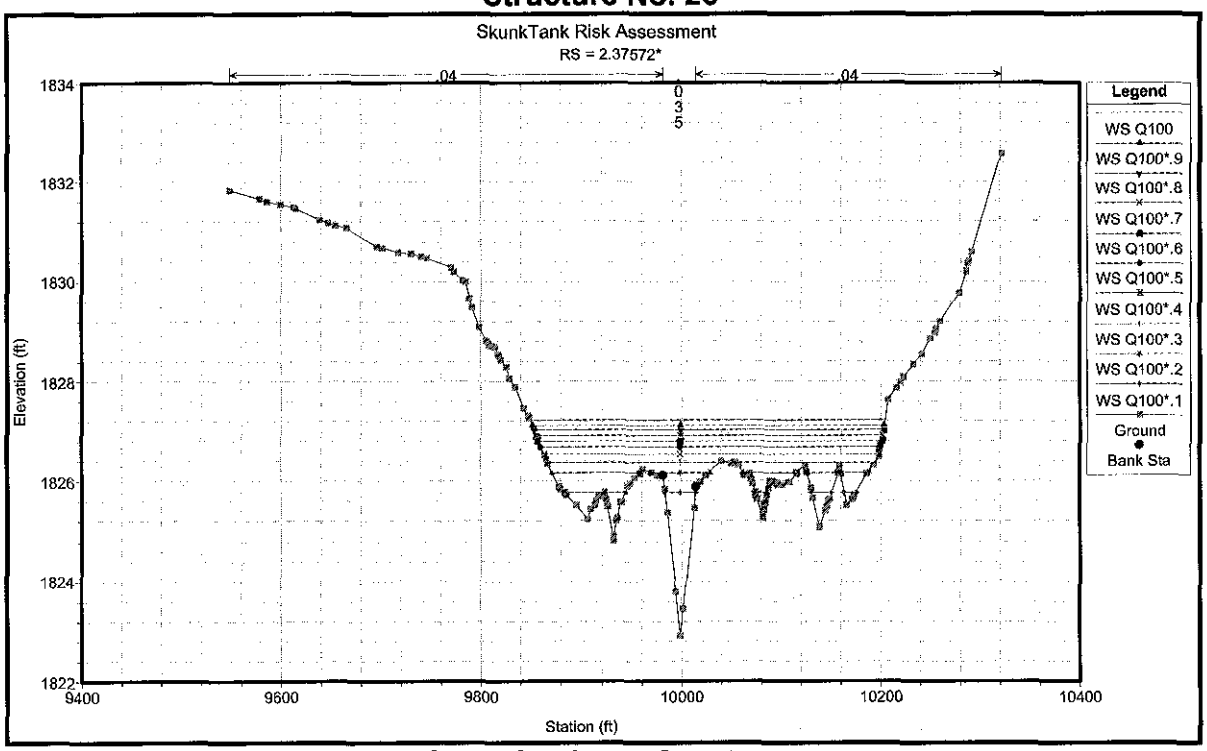
Cross Section at Structure



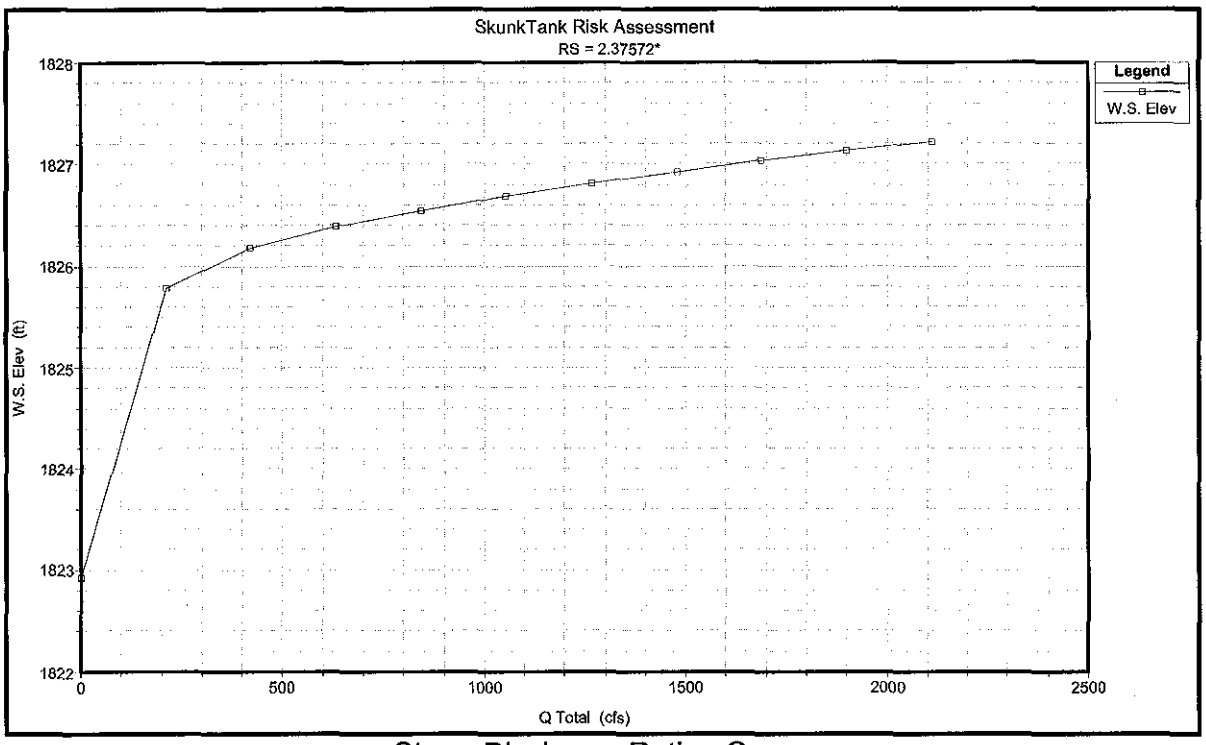
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 26



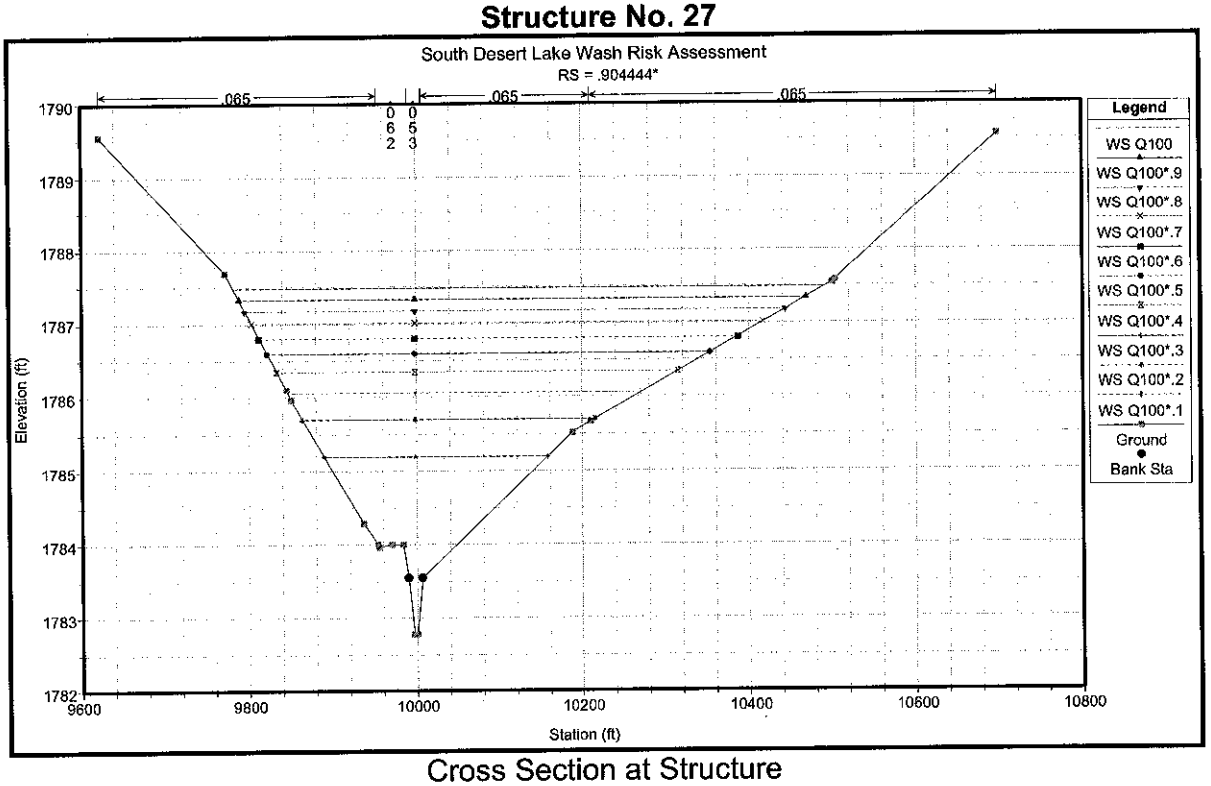
Cross Section at Structure



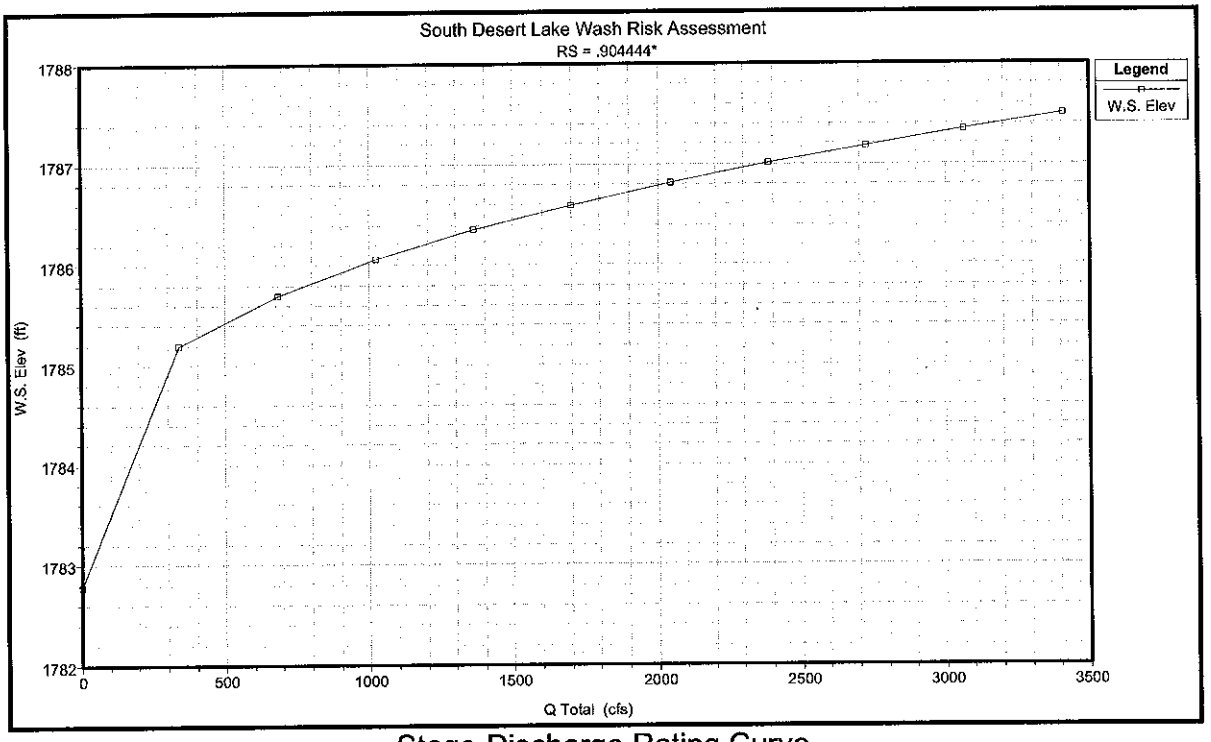
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 27



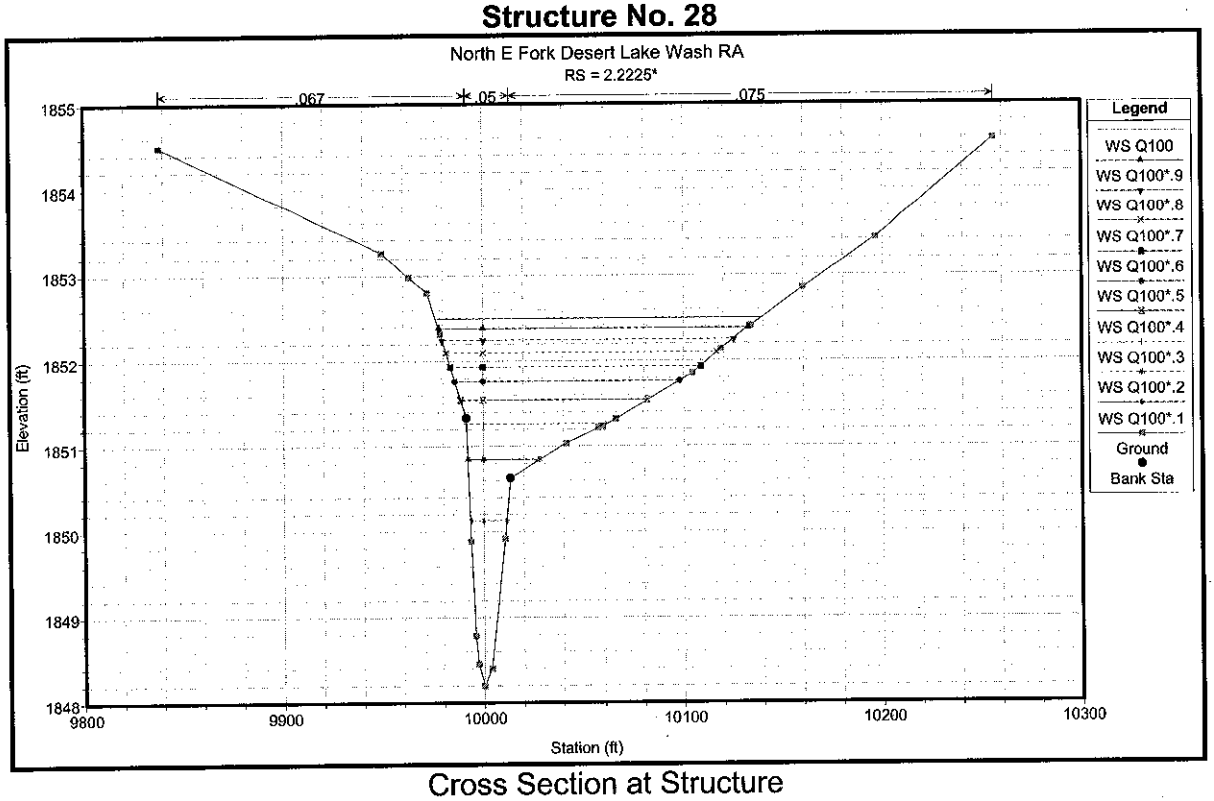
Cross Section at Structure



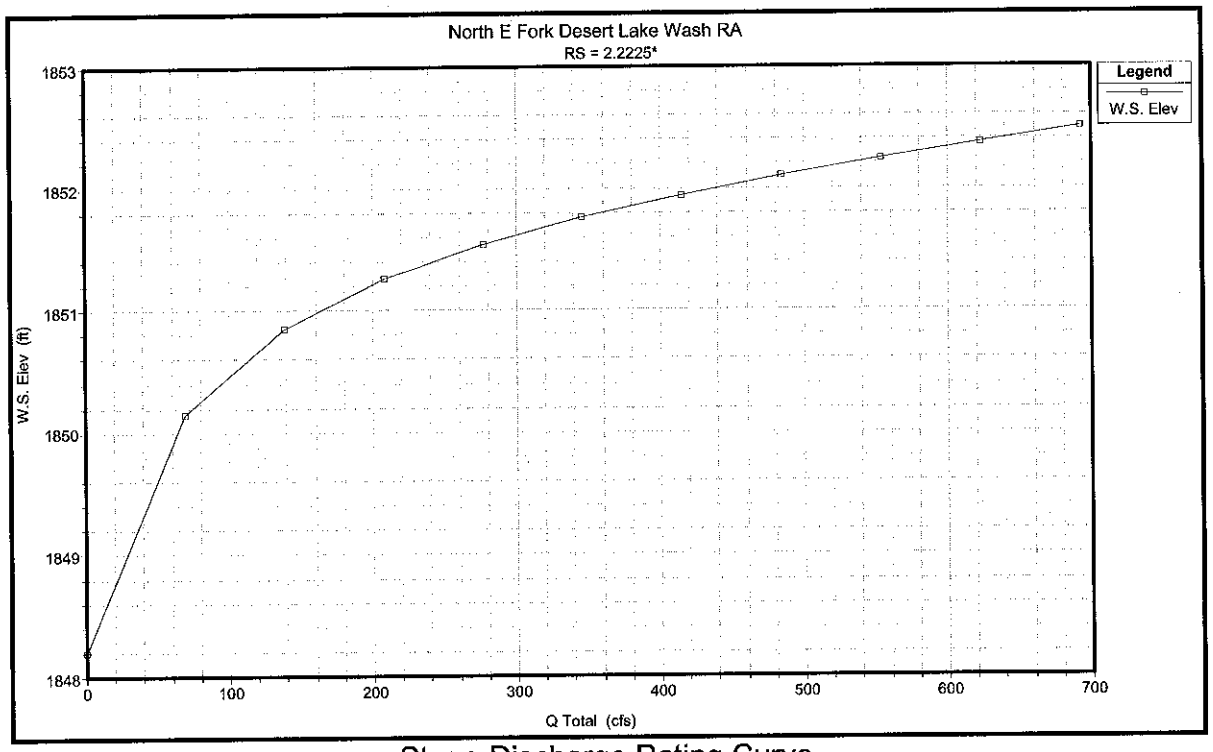
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 28



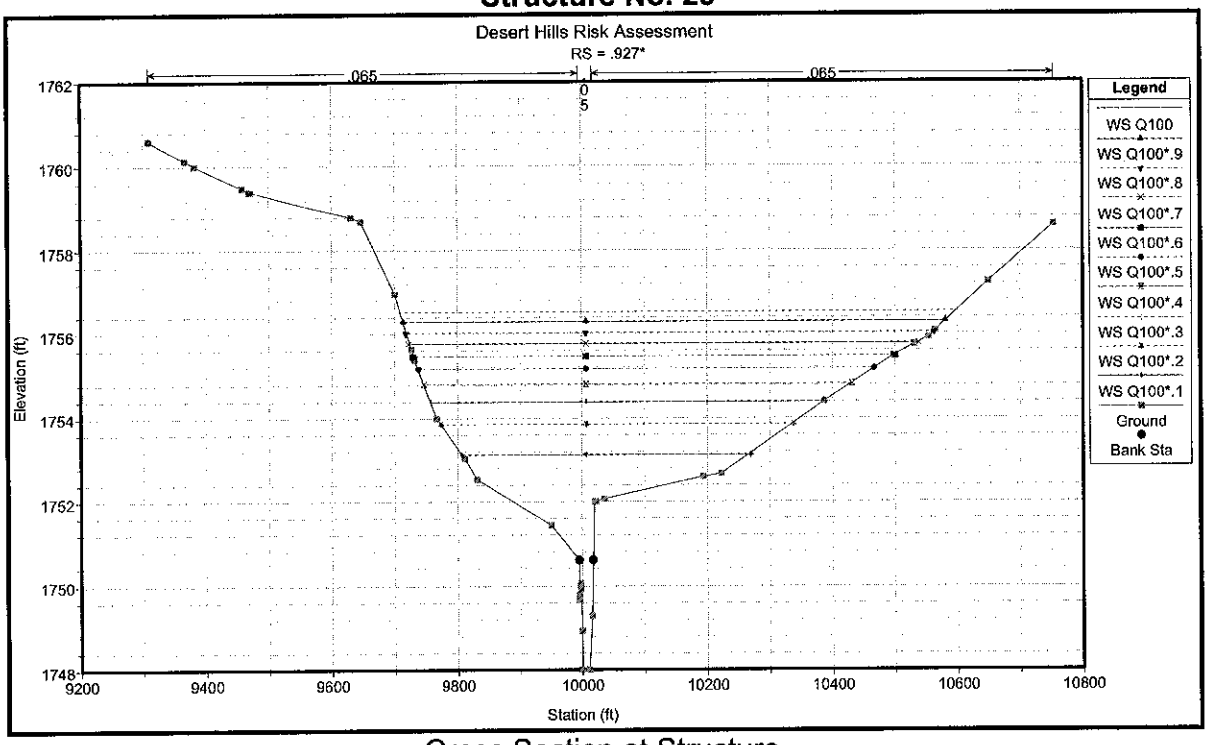
Cross Section at Structure



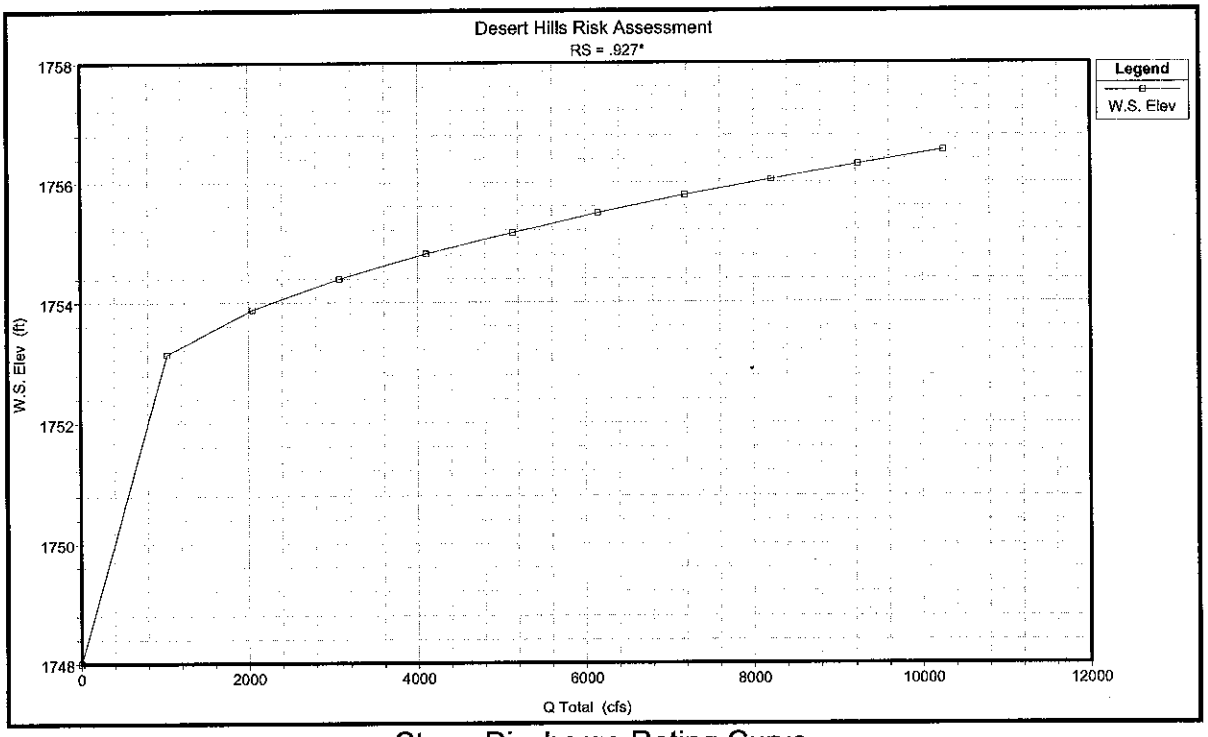
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 29



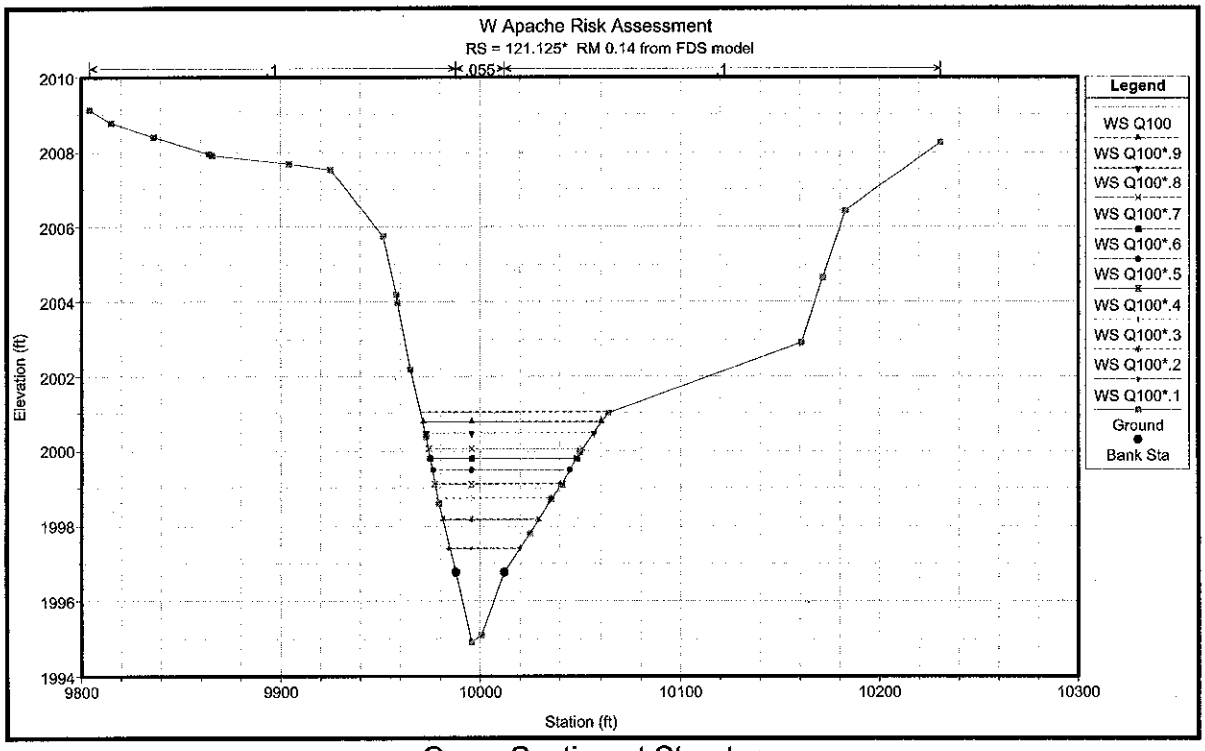
Cross Section at Structure



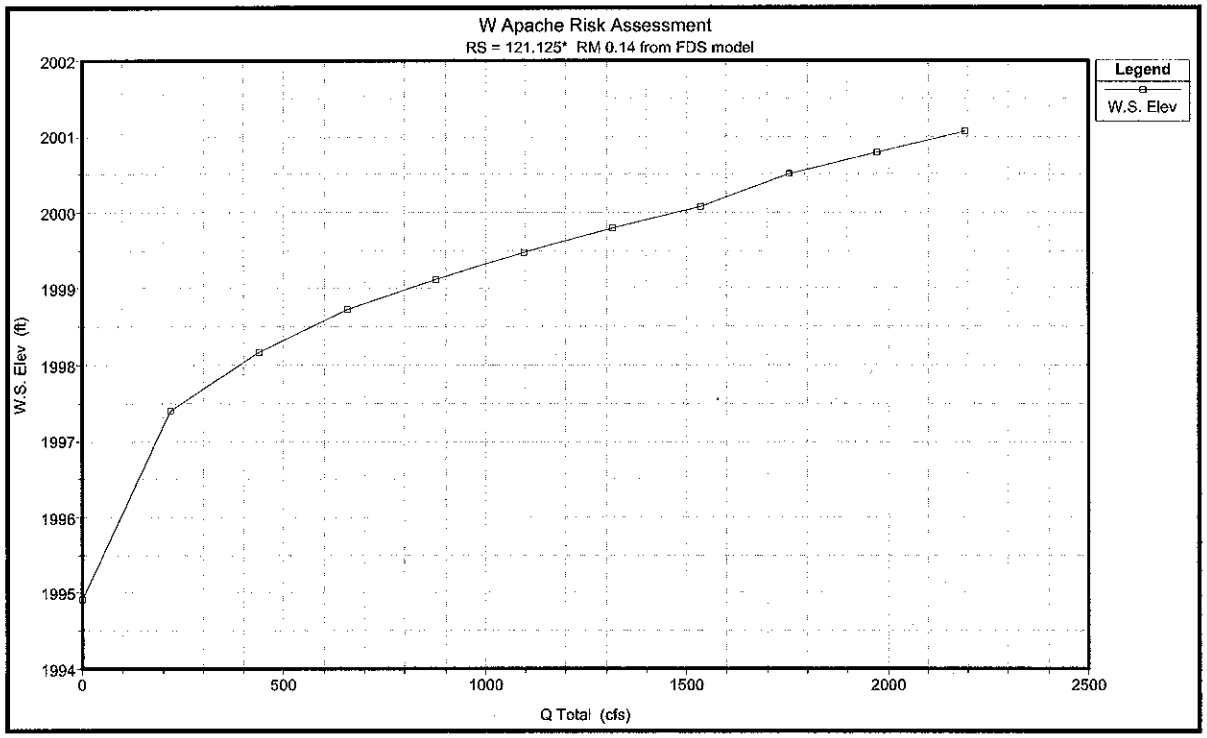
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 30



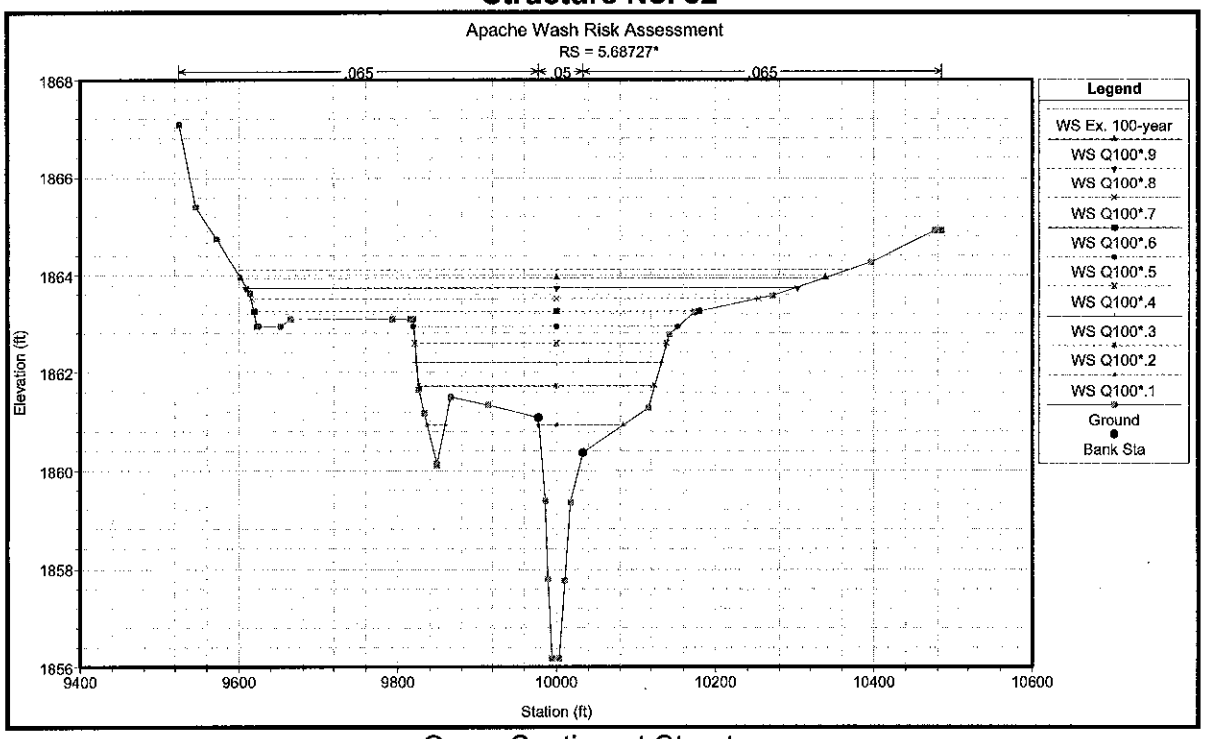
Cross Section at Structure



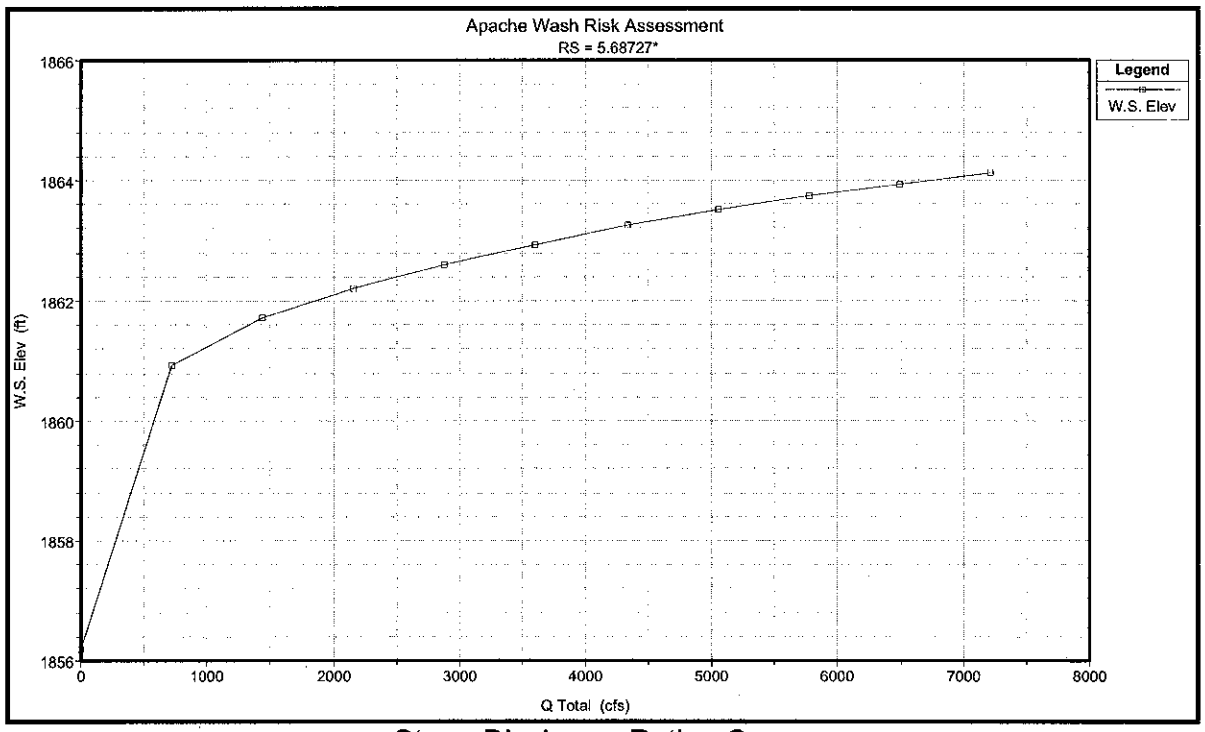
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 32



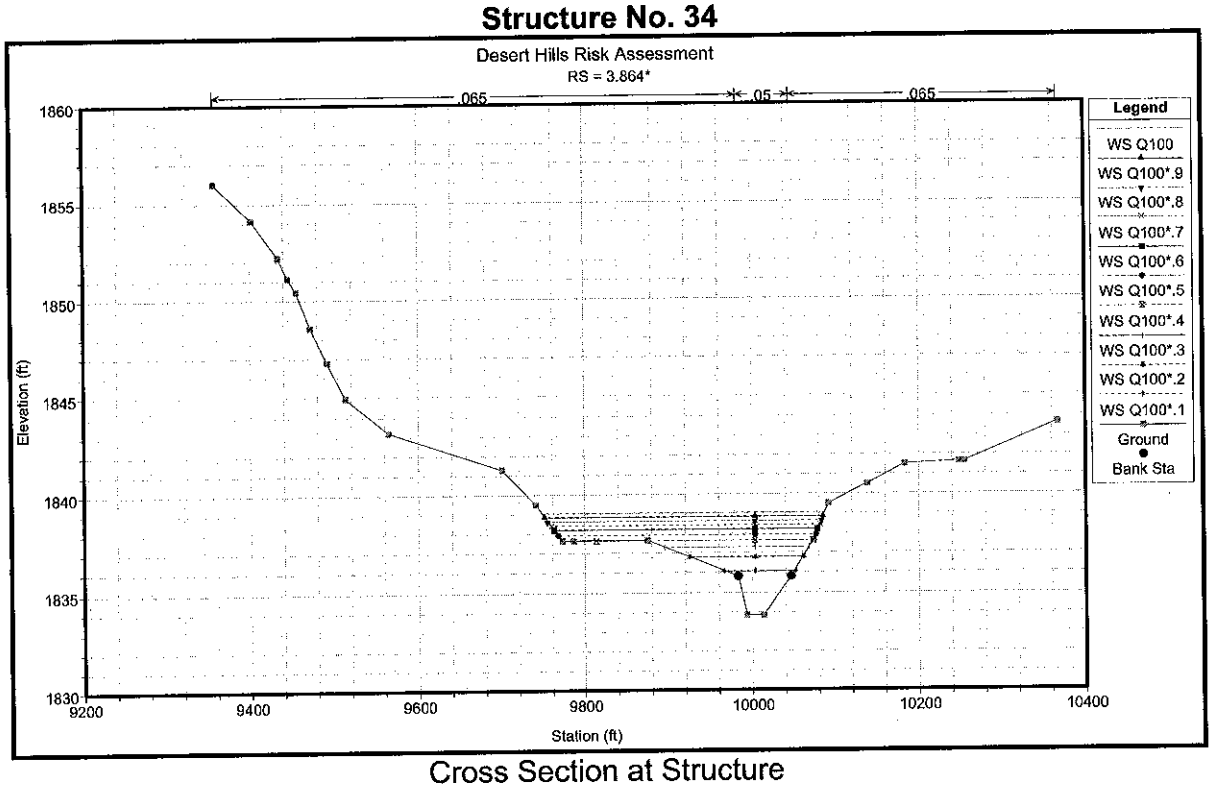
Cross Section at Structure



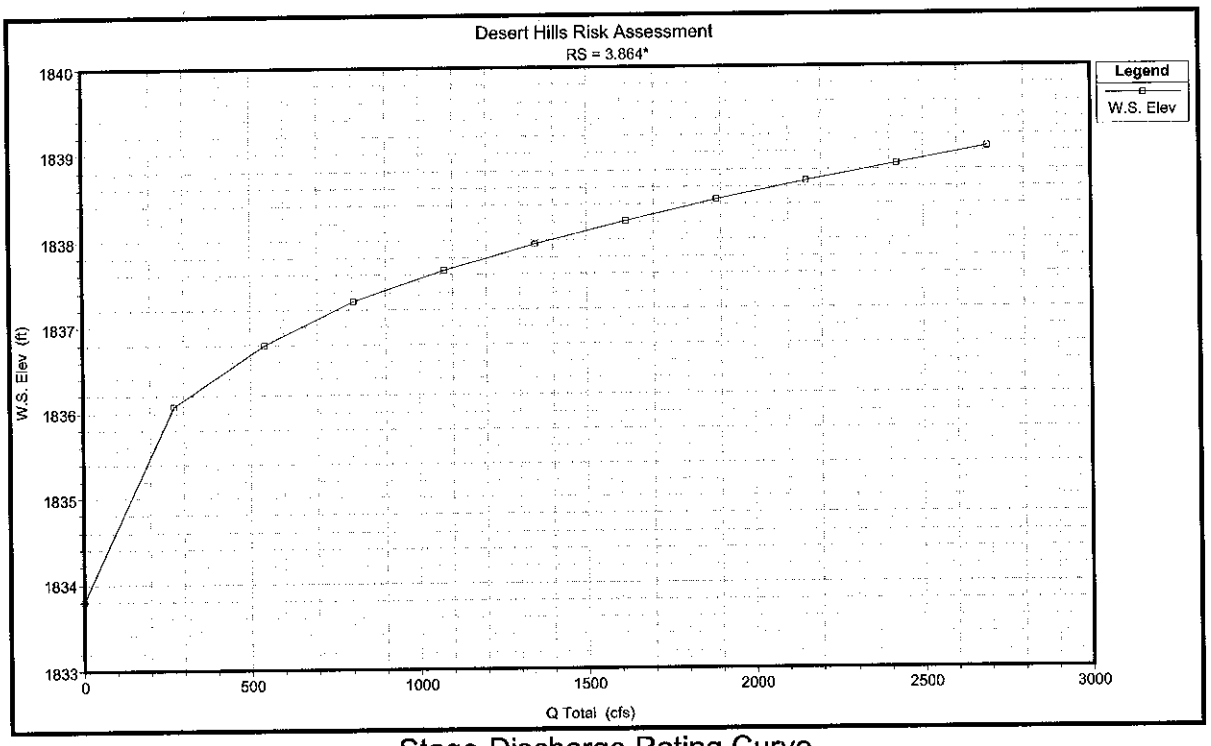
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 34



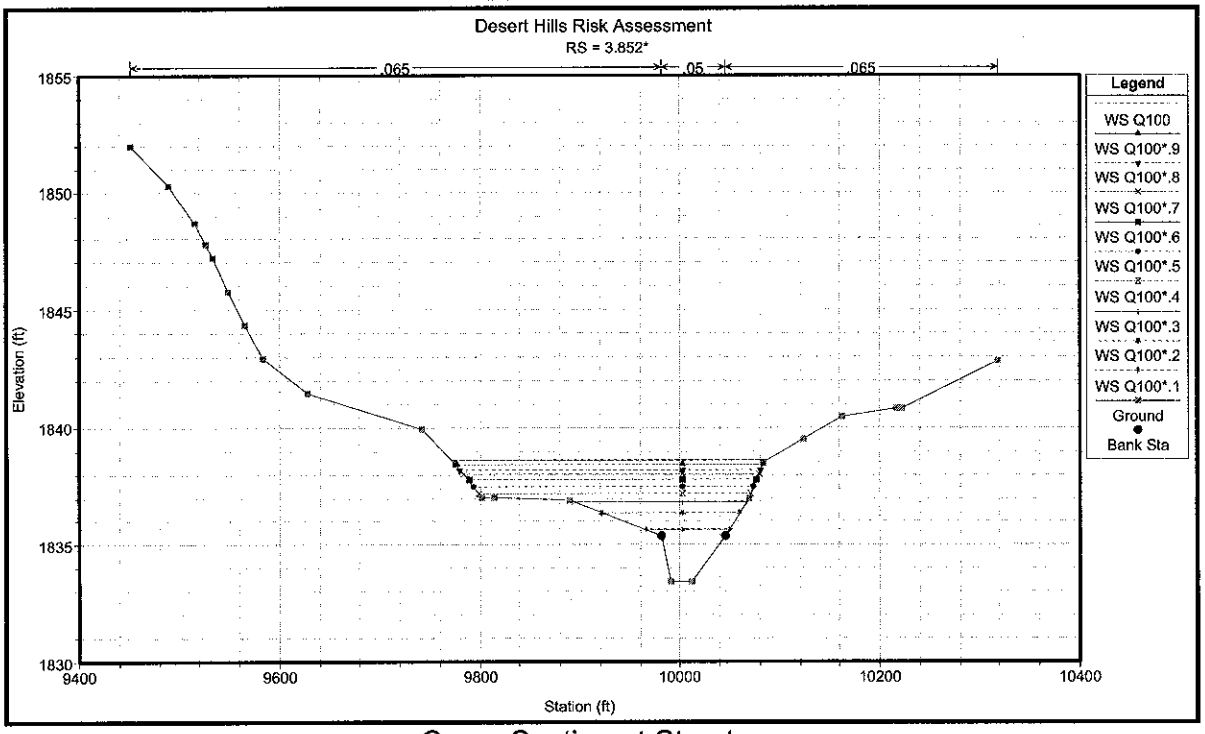
Cross Section at Structure



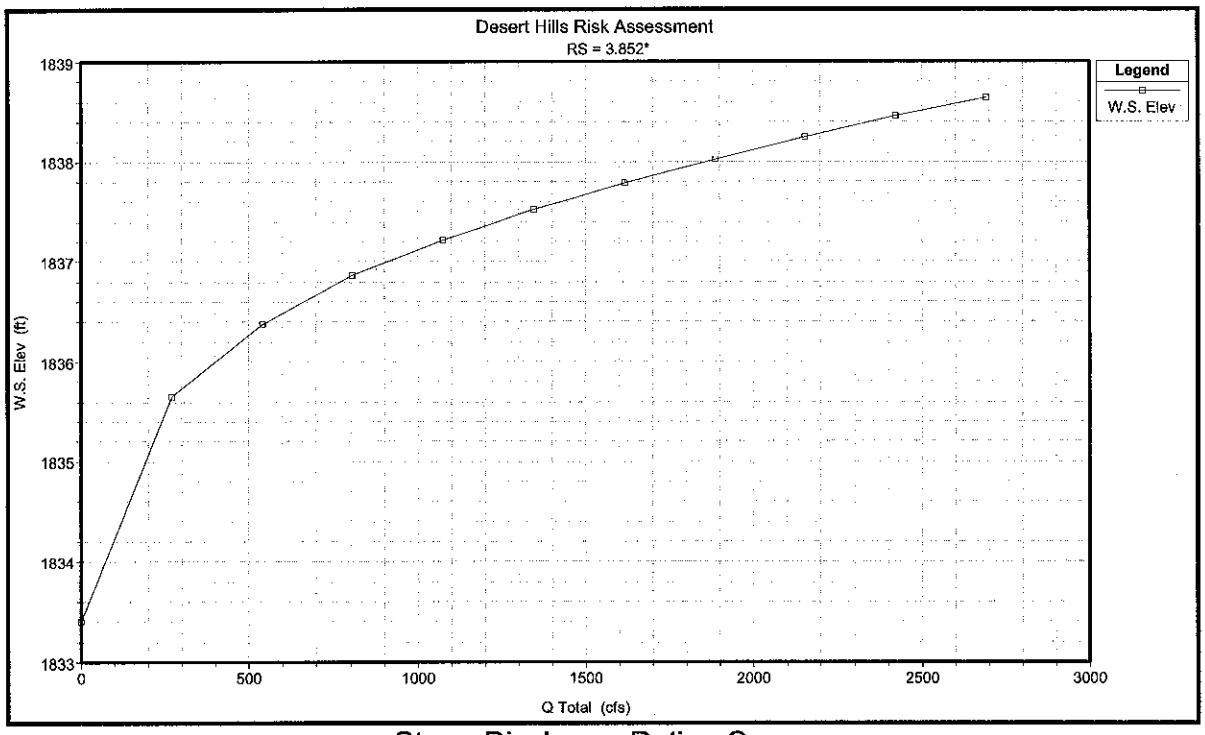
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 35



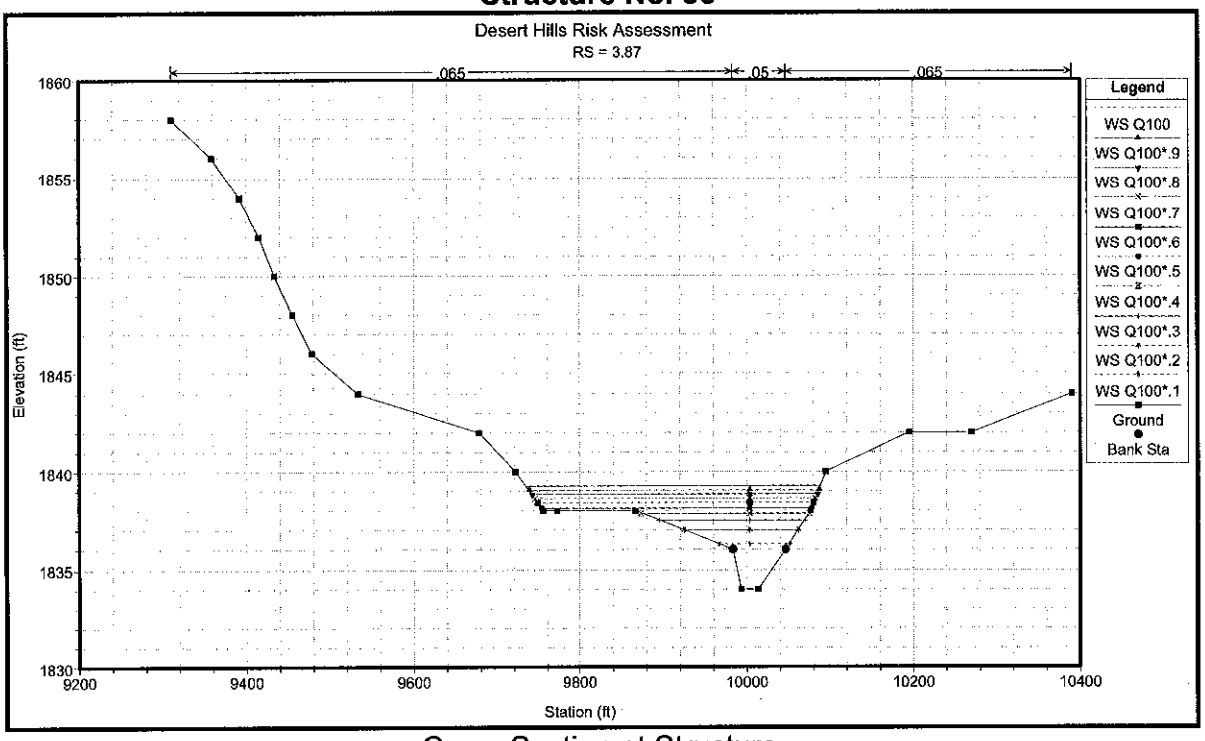
Cross-Section at Structure



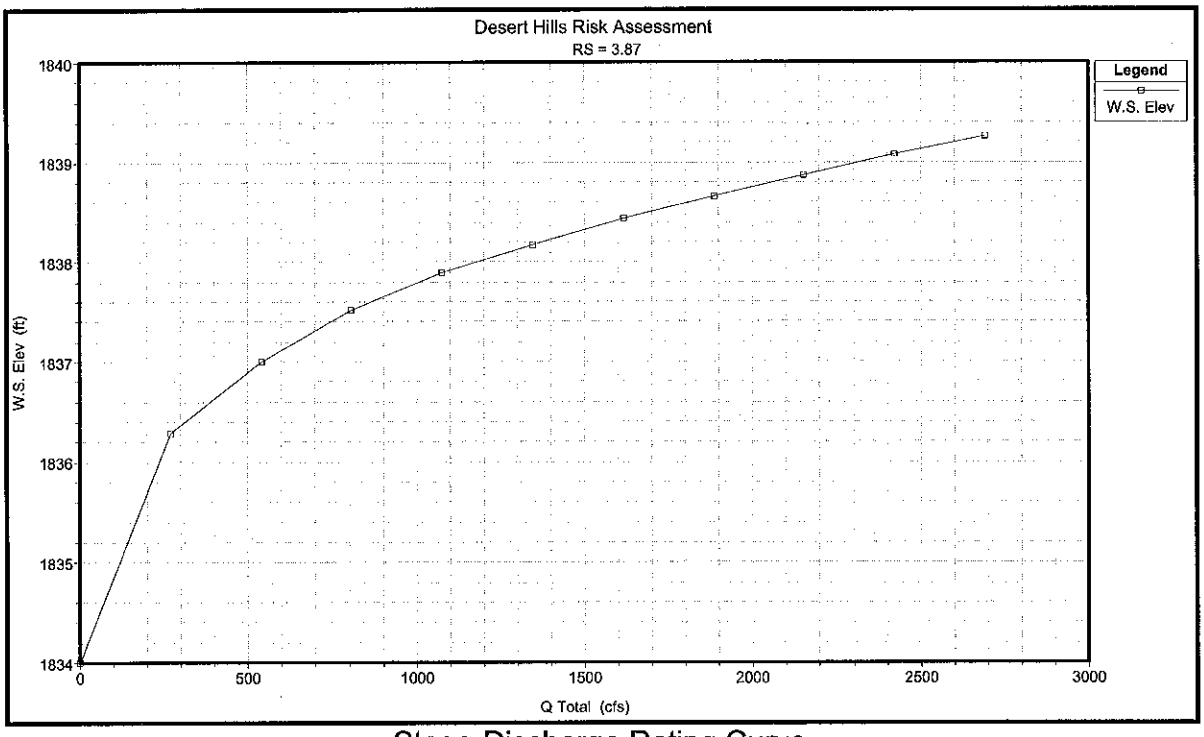
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 36



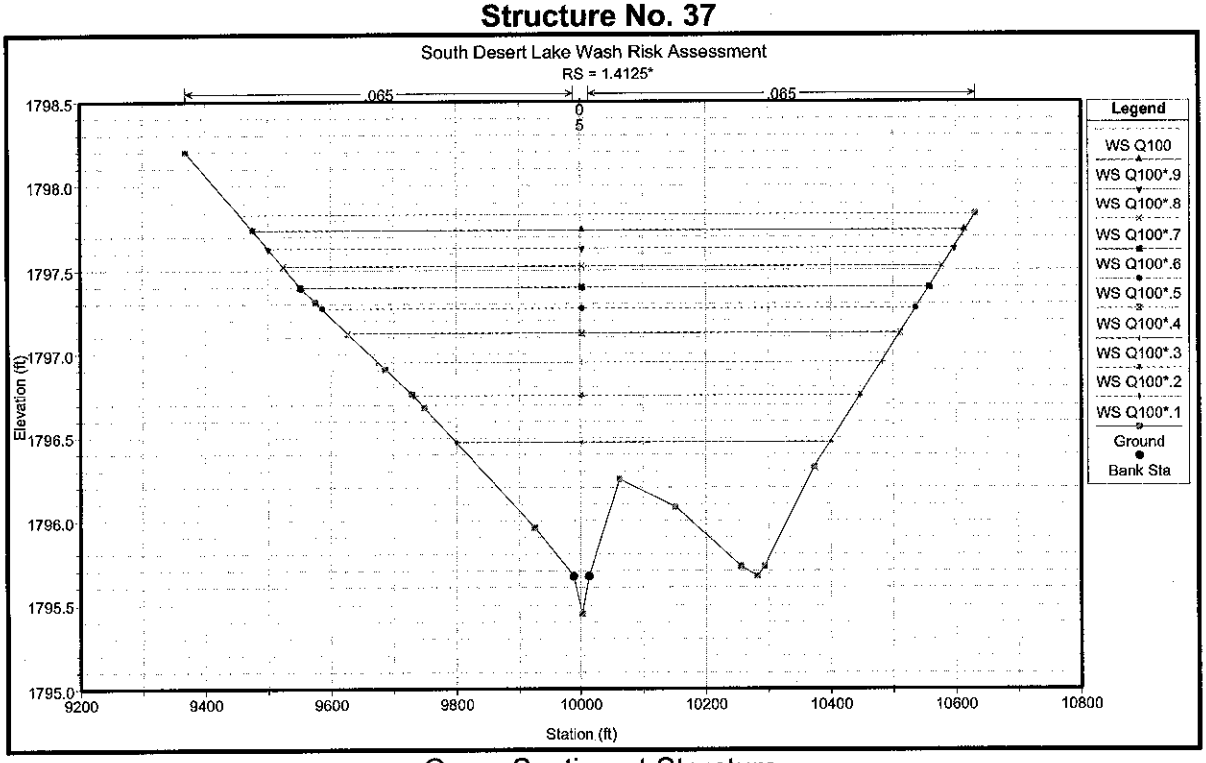
Cross Section at Structure



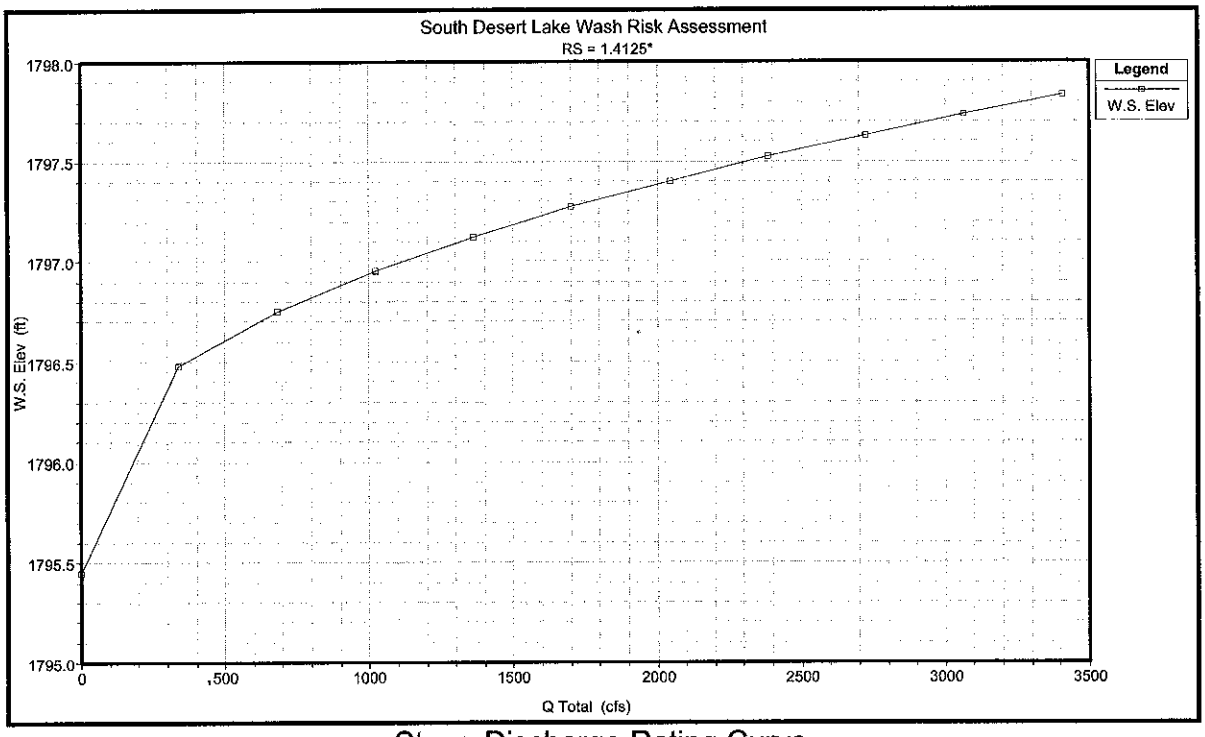
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 37



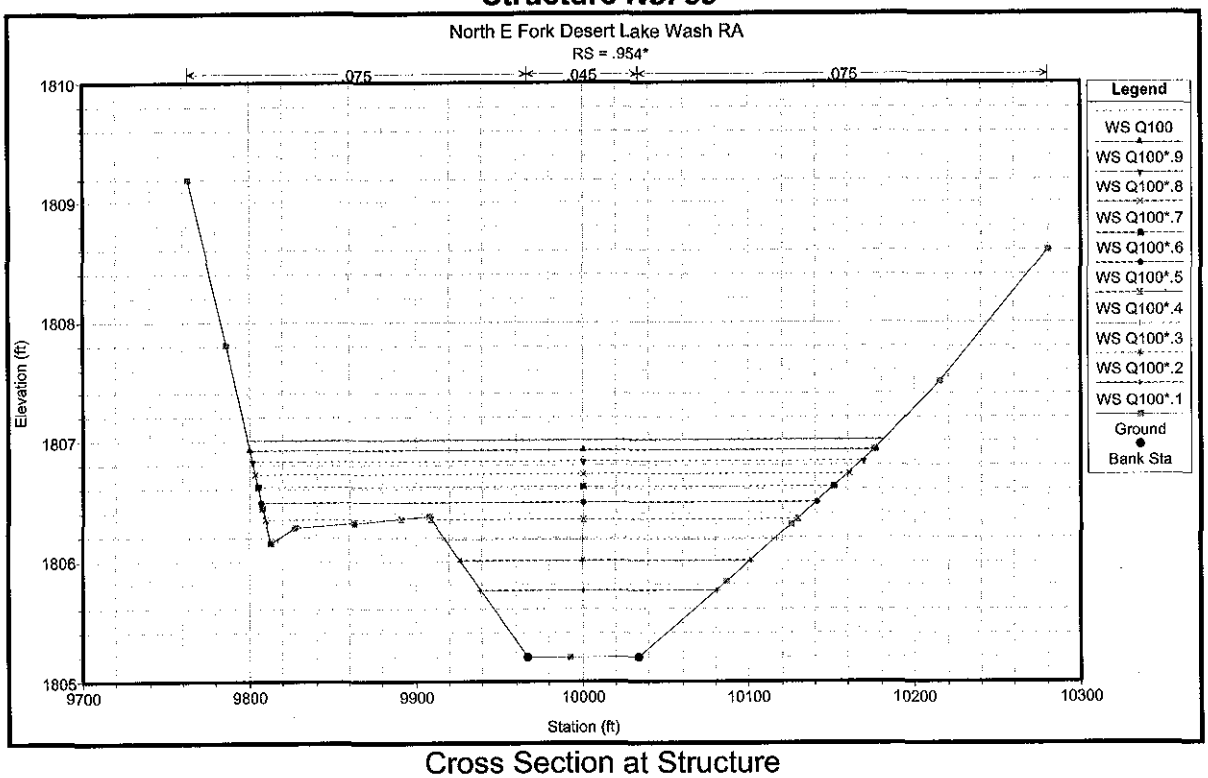
Cross Section at Structure



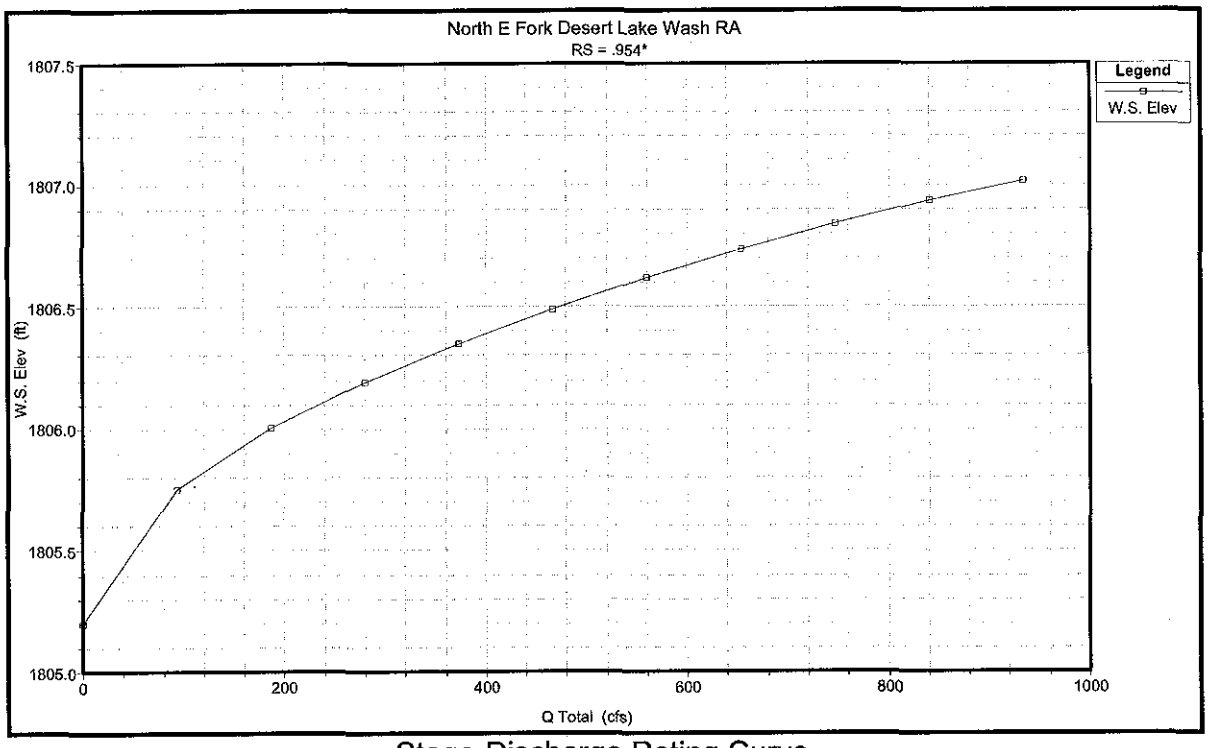
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 39



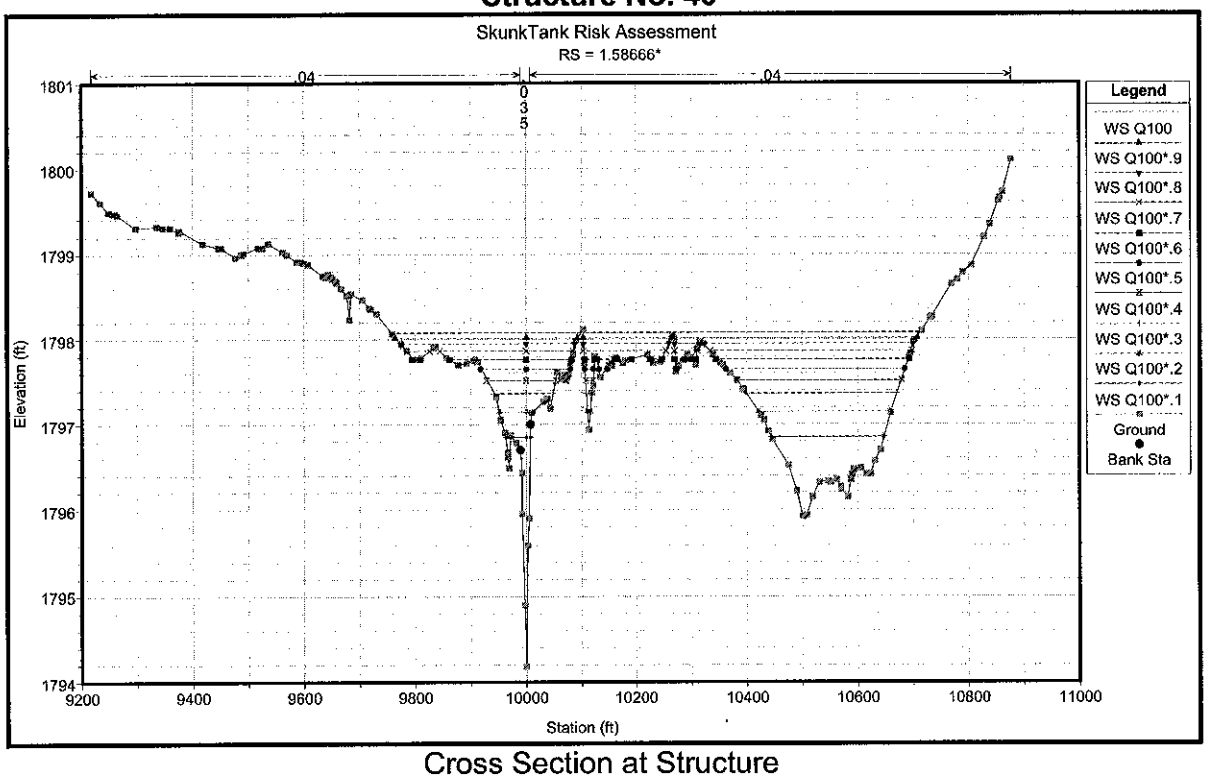
Cross Section at Structure



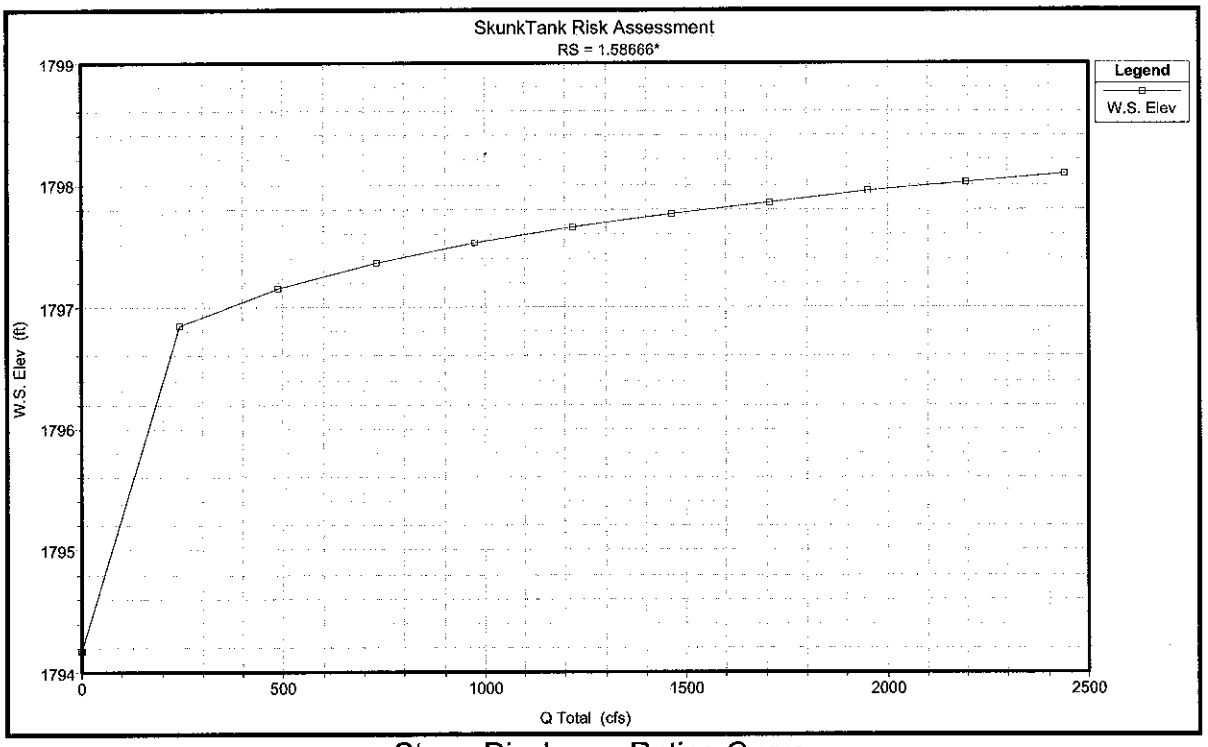
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 40



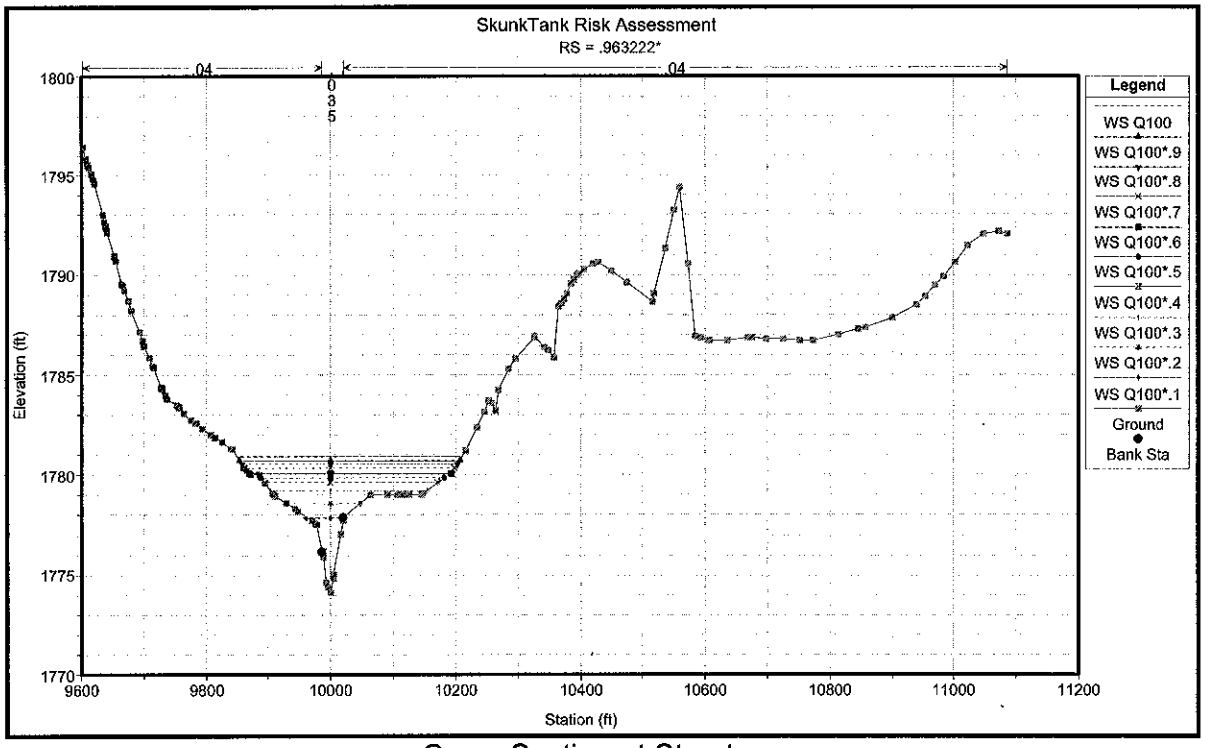
Cross Section at Structure



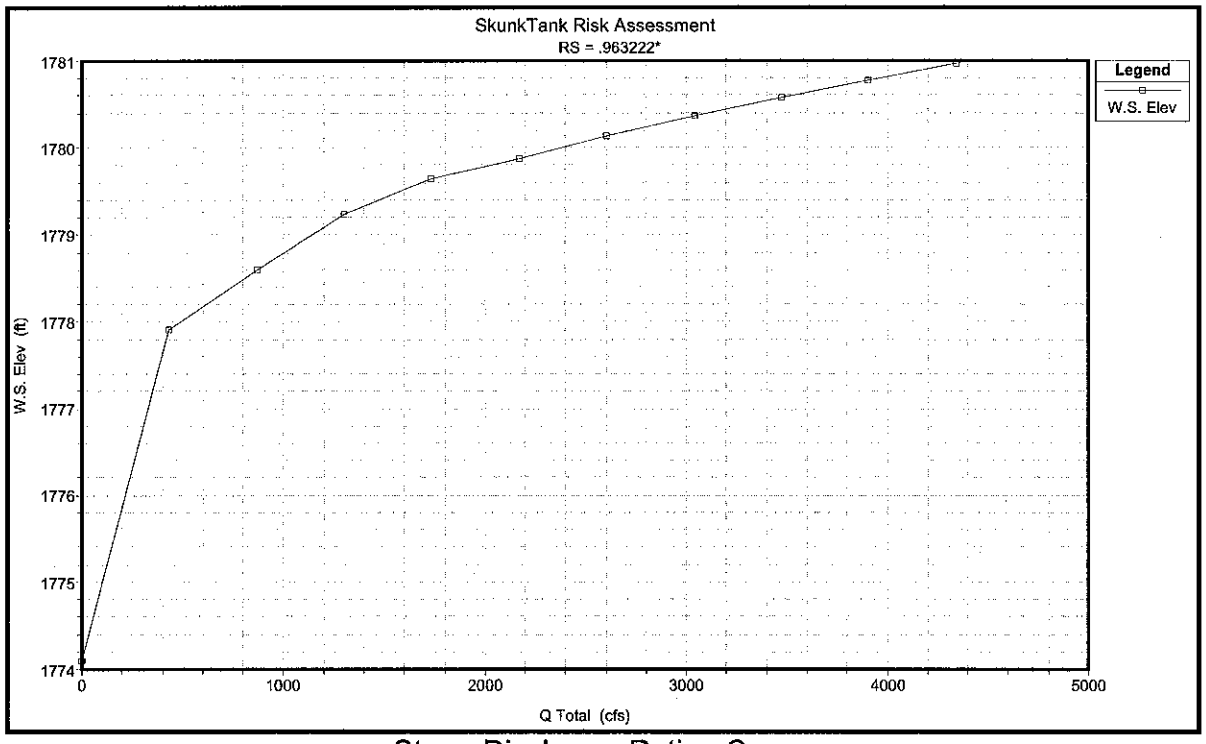
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 41



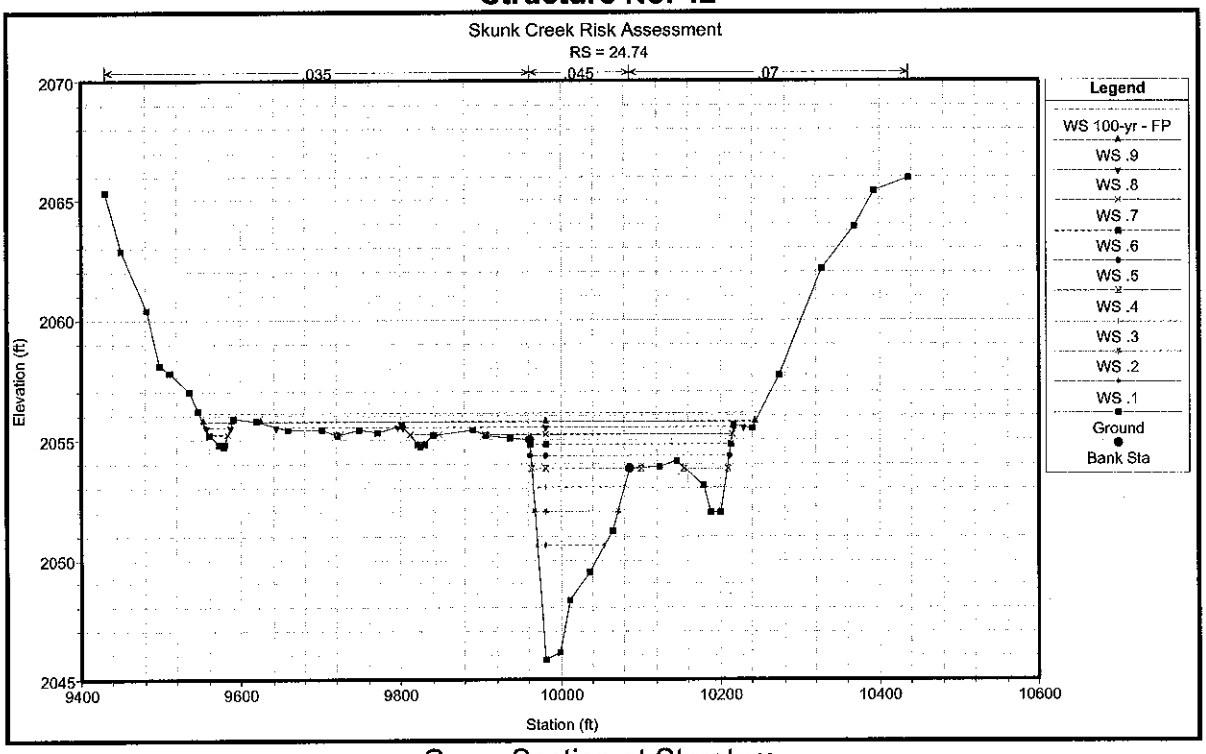
Cross Section at Structure



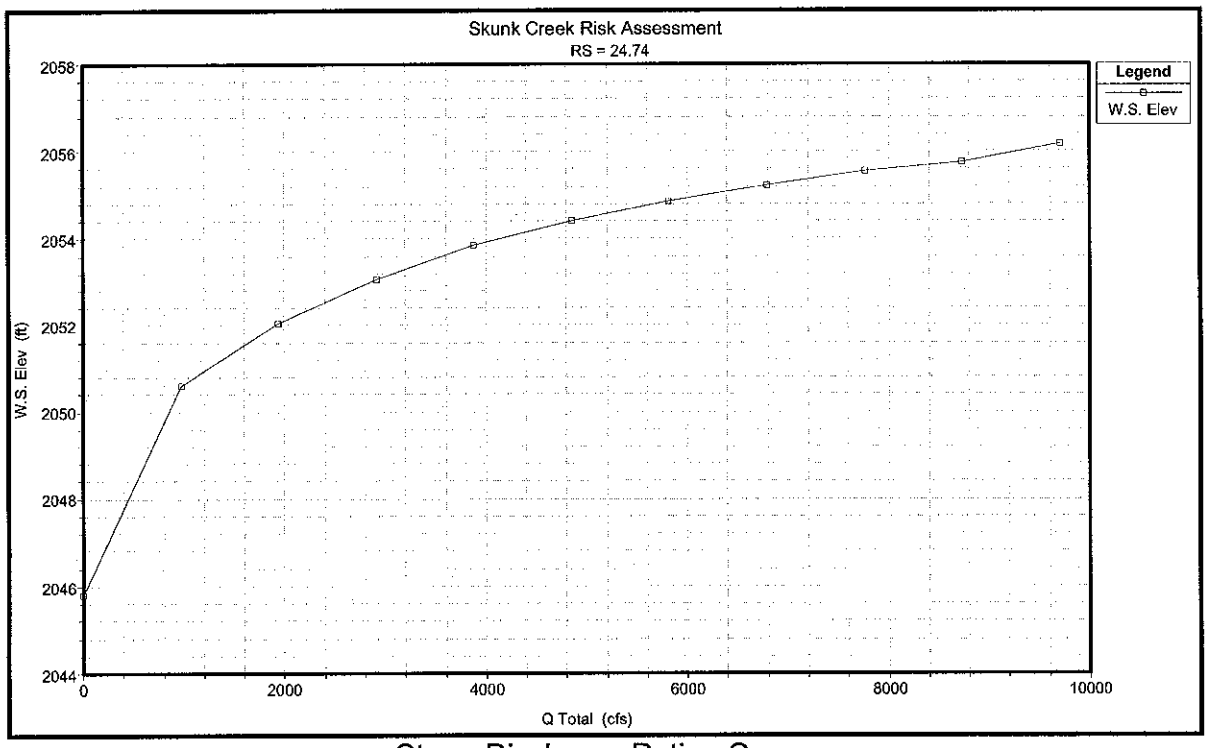
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 42



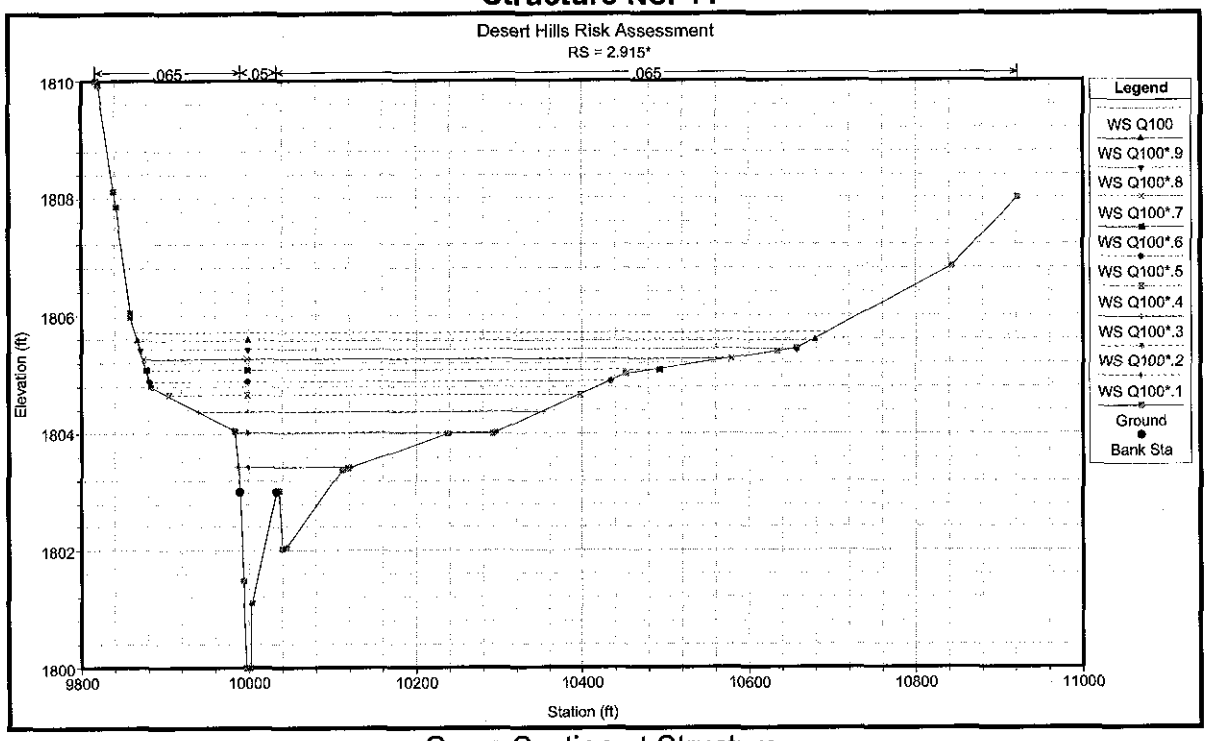
Cross Section at Structure



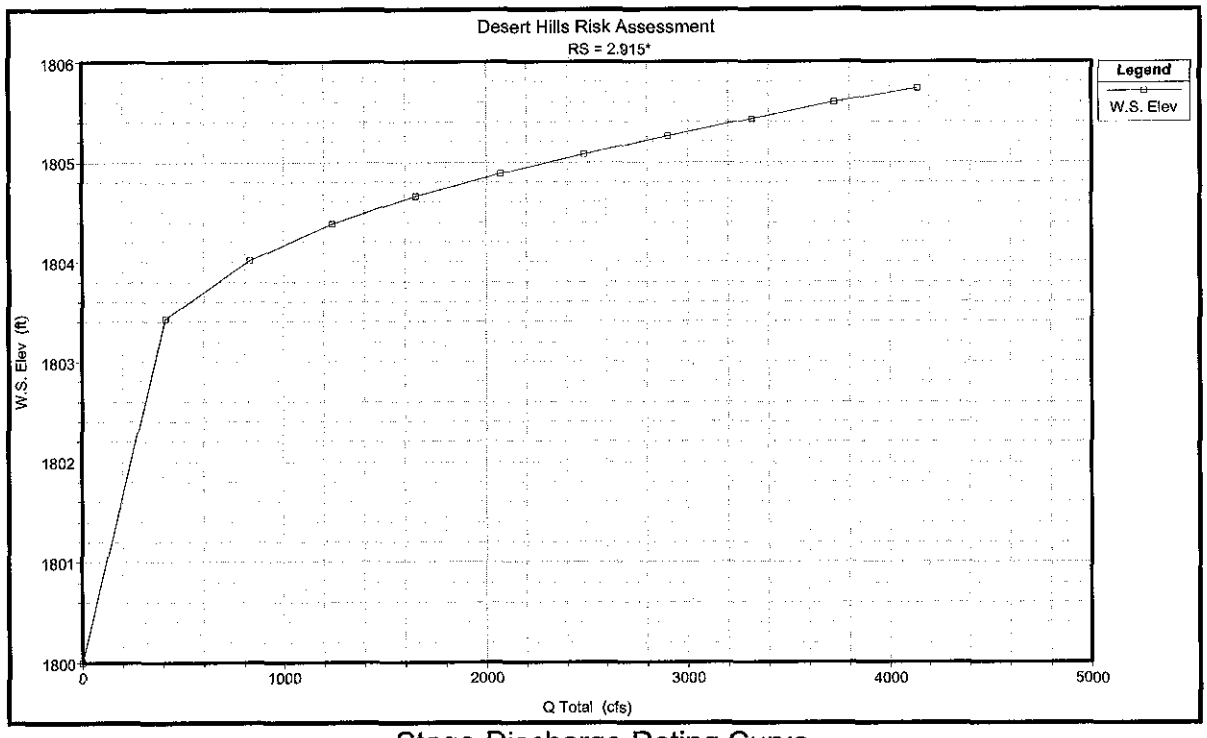
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 44



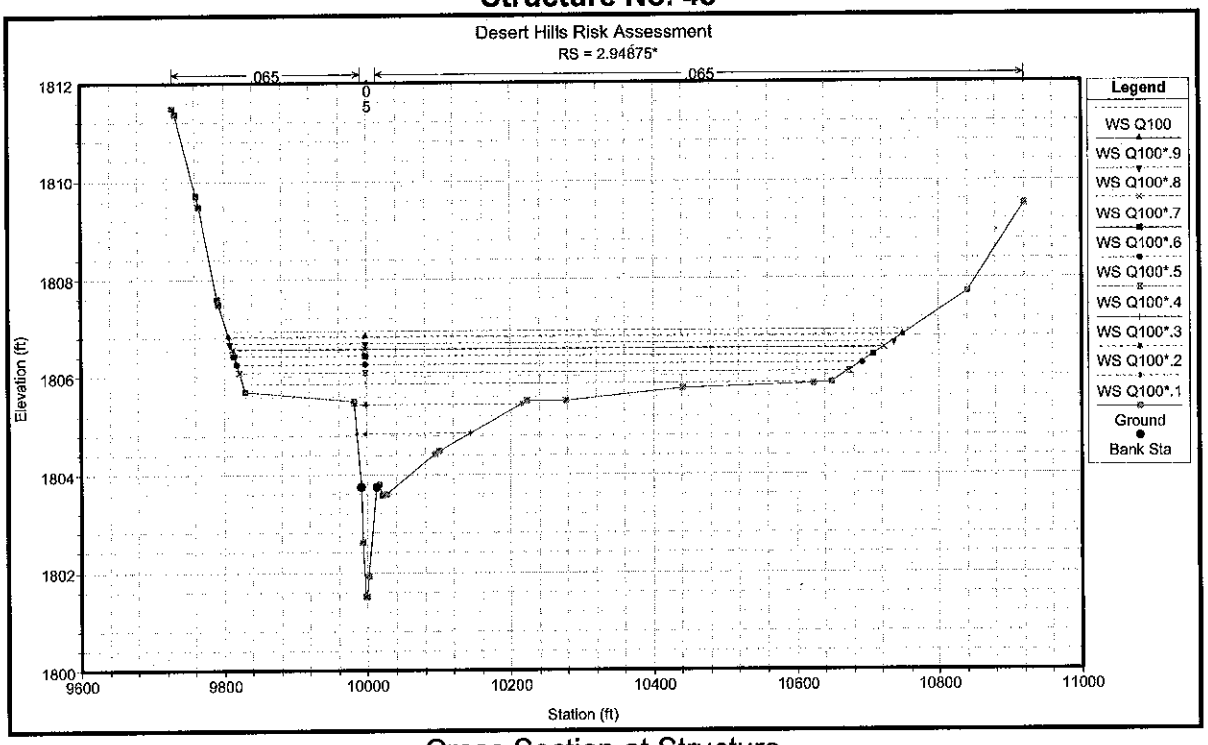
Cross Section at Structure



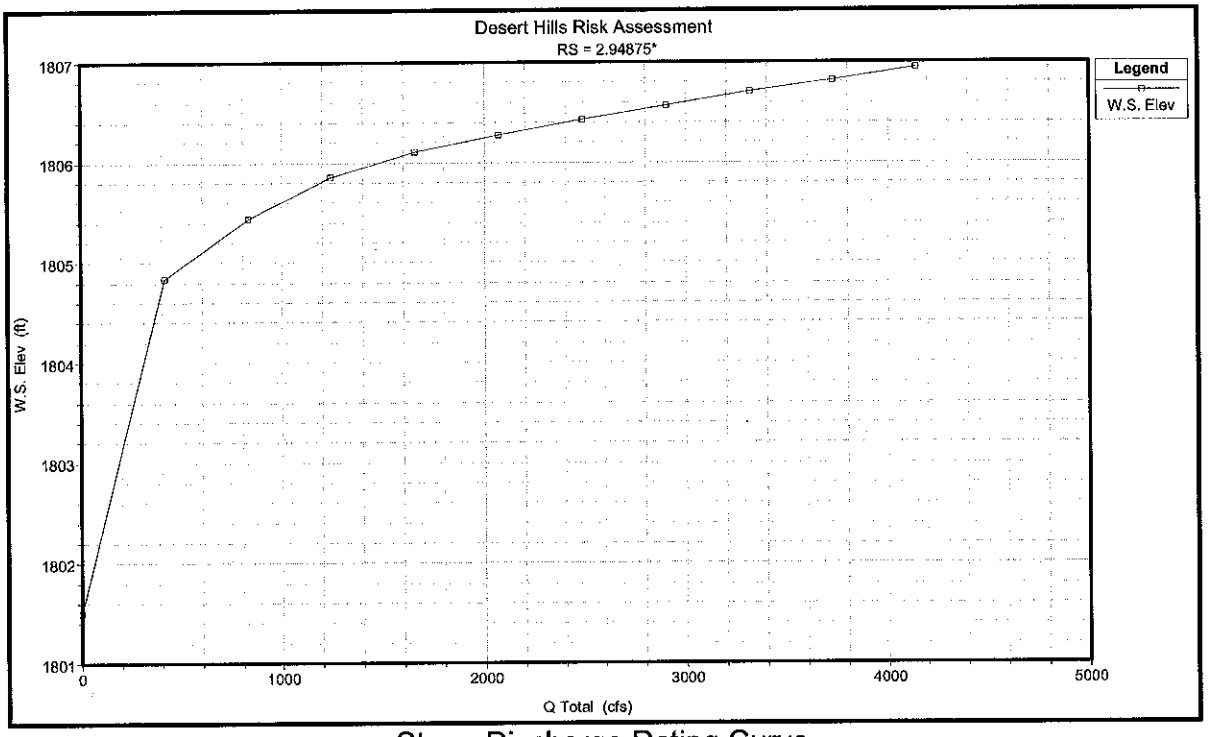
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 45



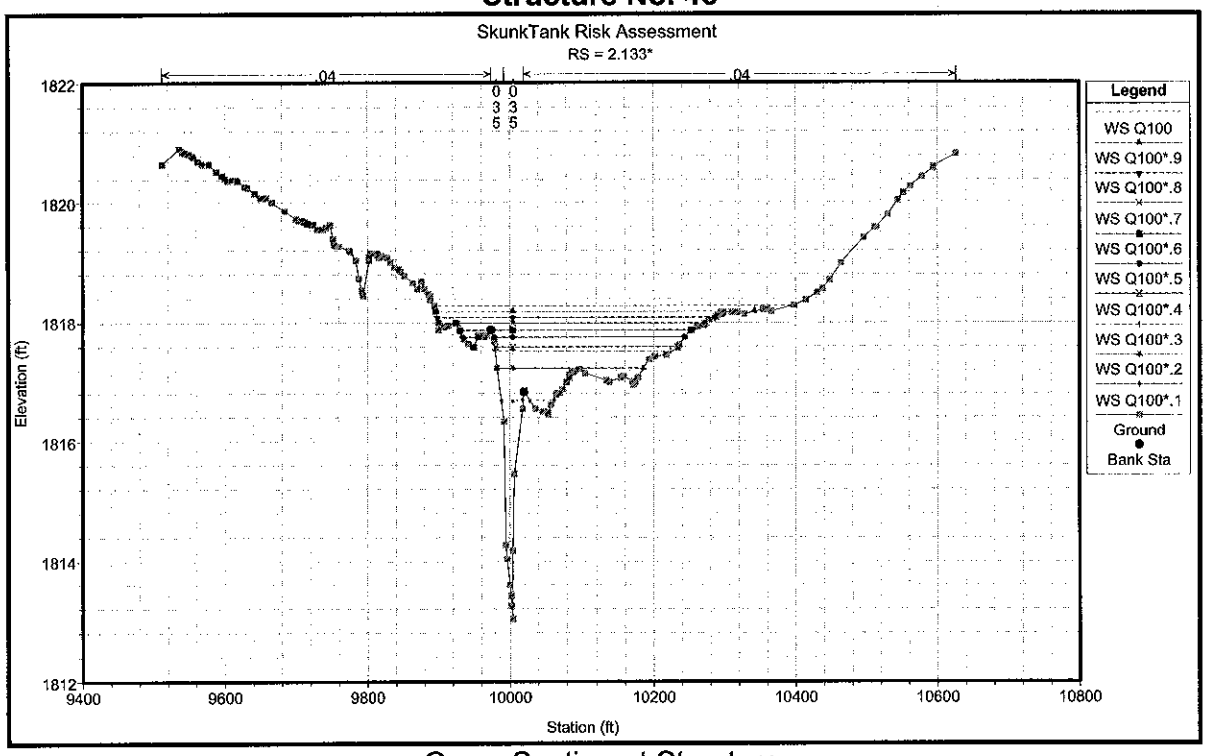
Cross Section at Structure



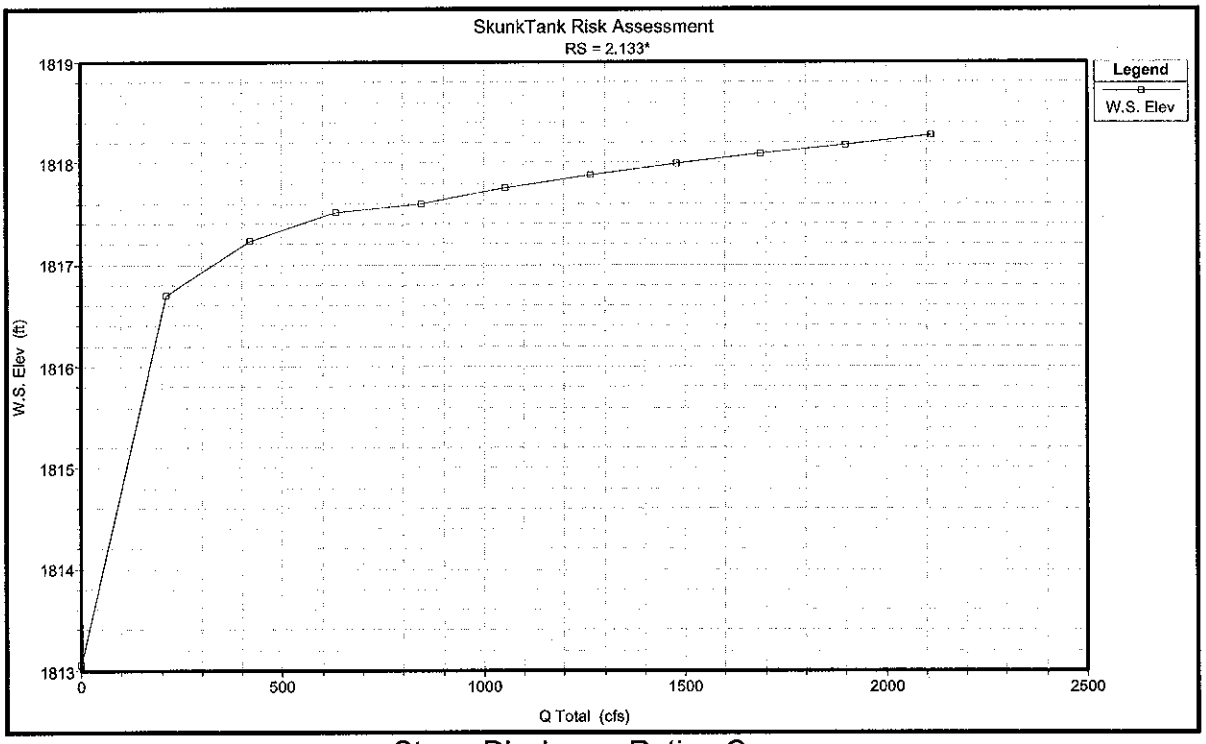
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 46



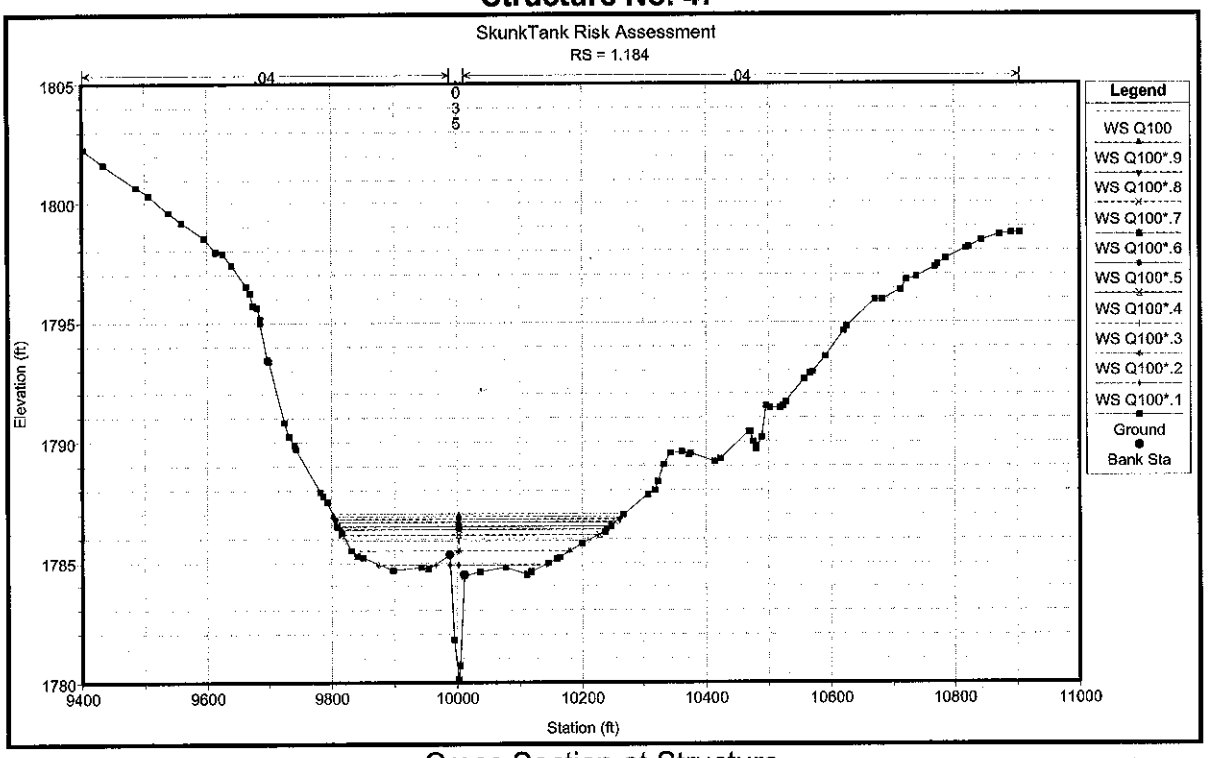
Cross Section at Structure



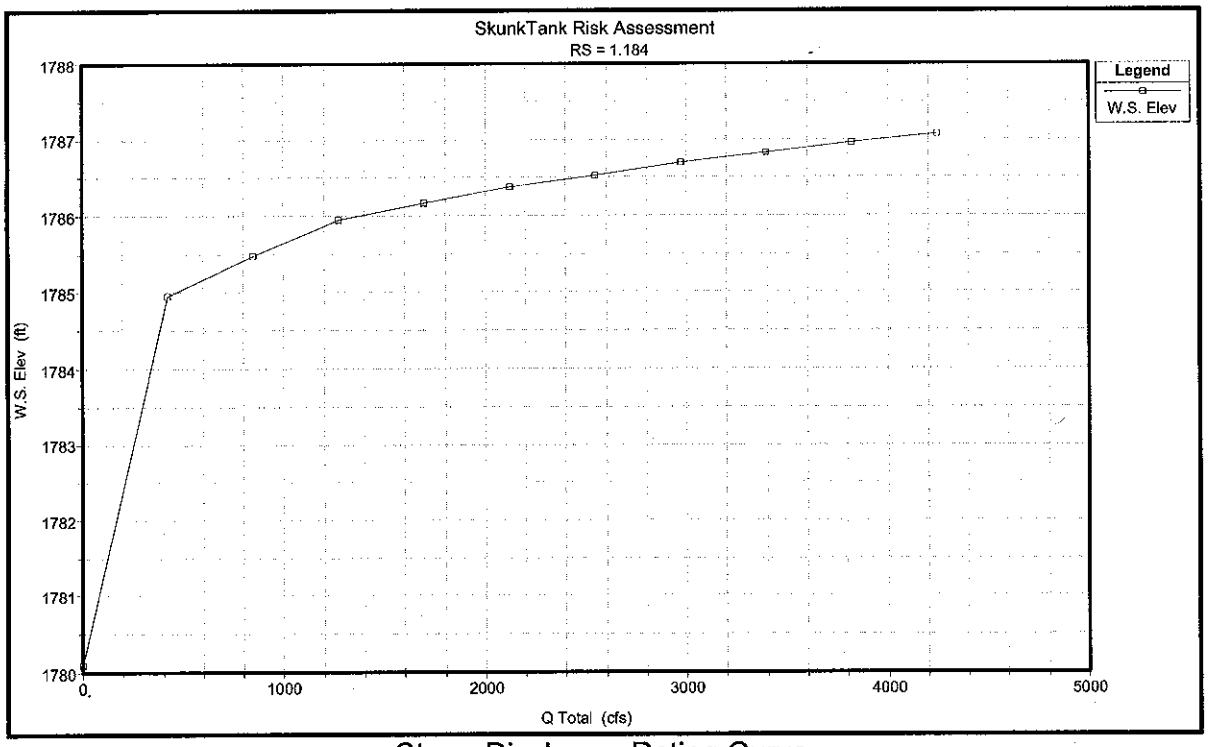
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 47



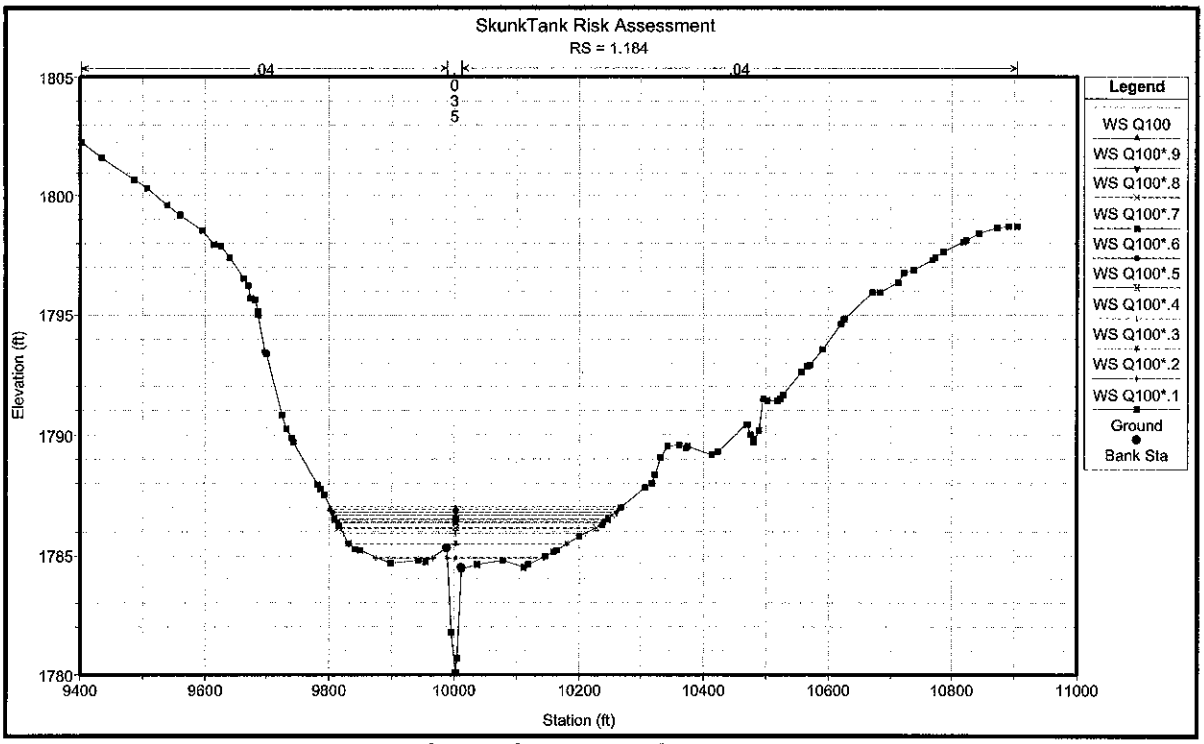
Cross Section at Structure



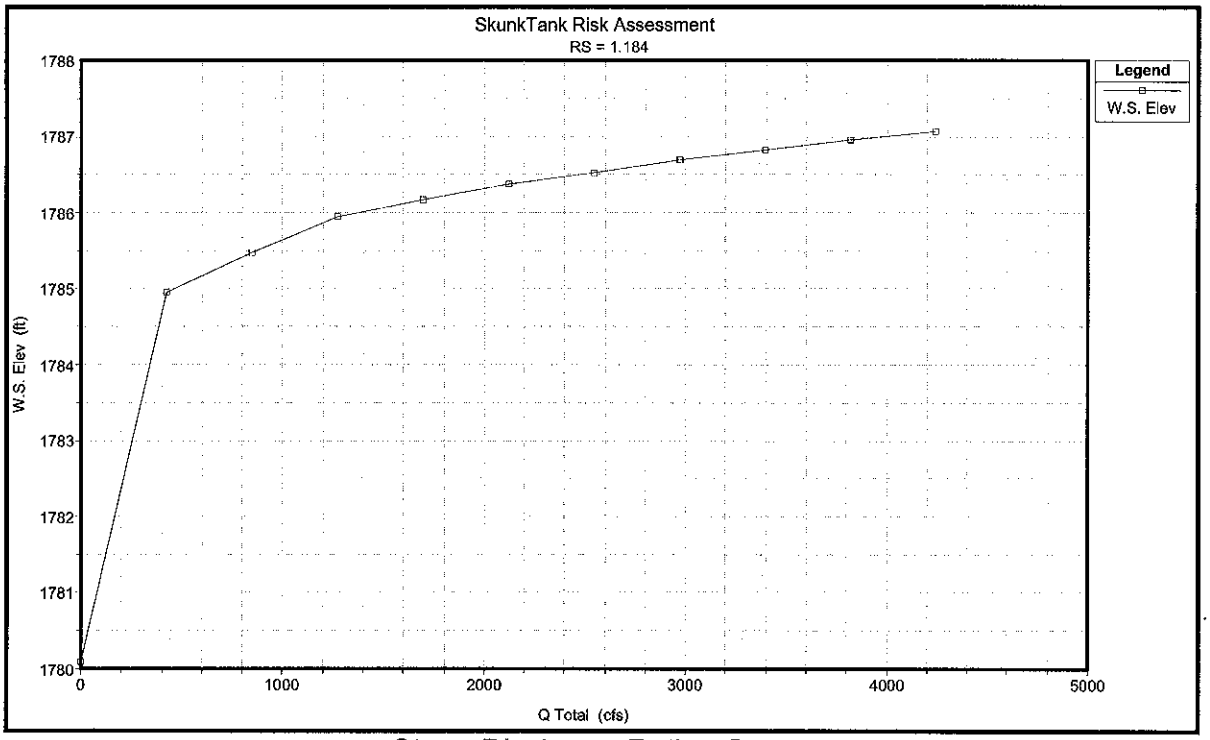
Stage-Discharge Rating Curve

Adobe / Desert Hills ADMP - Risk Assessment
Cross Sections and Stage Discharge Curves

Structure No. 48



Cross Section at Structure



Stage-Discharge Rating Curve

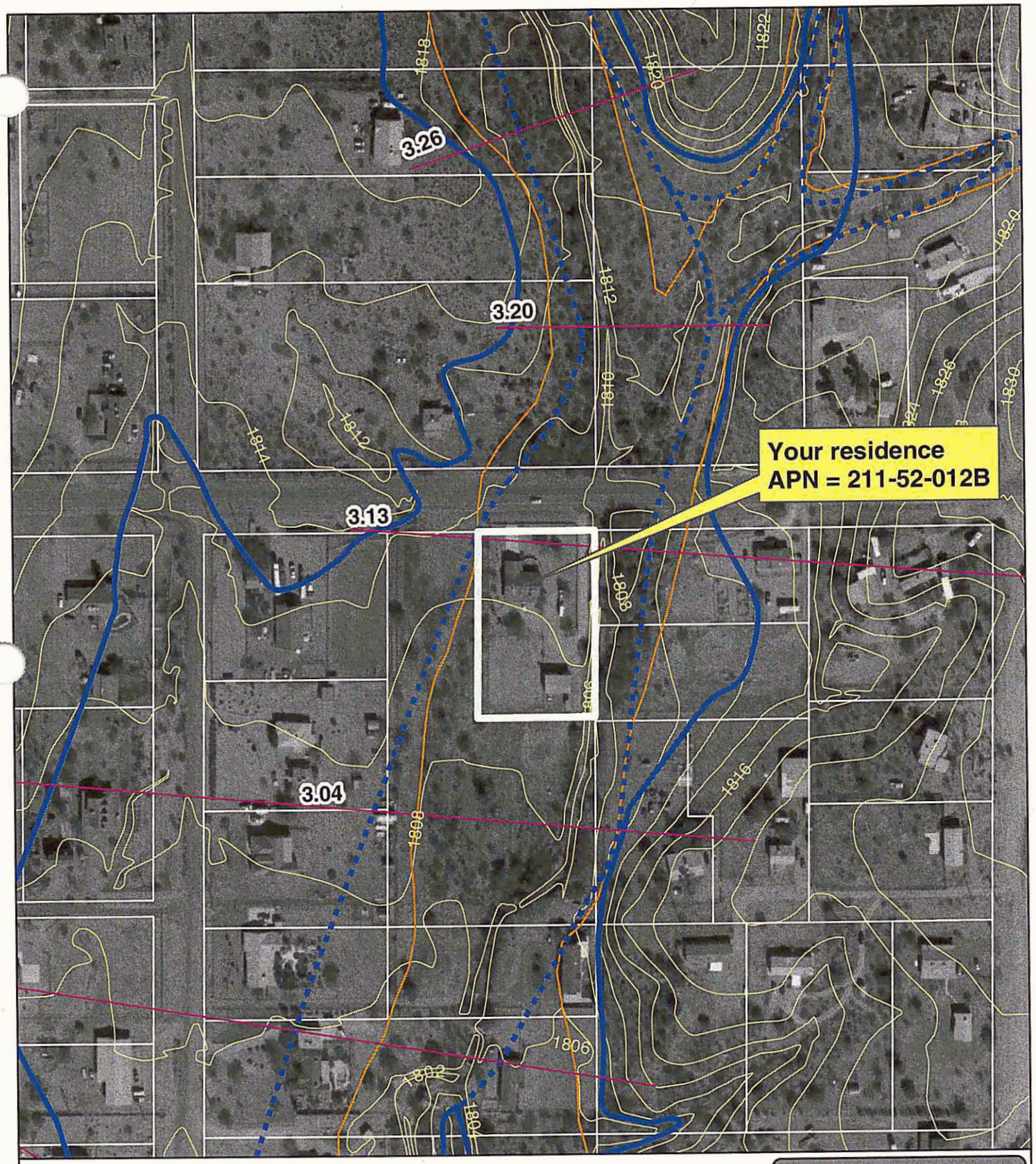


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 3,669 cfs
100-yr Water Surface Elevation = 1812.6 ft
Finished Floor Elevation = 1811.6 ft
Depth = 1.0 ft below 100-yr Water Surface Elevation
Velocity = 2.9 ft/s
Approximate Chance of Flooding in Any Given Year = 7.7 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

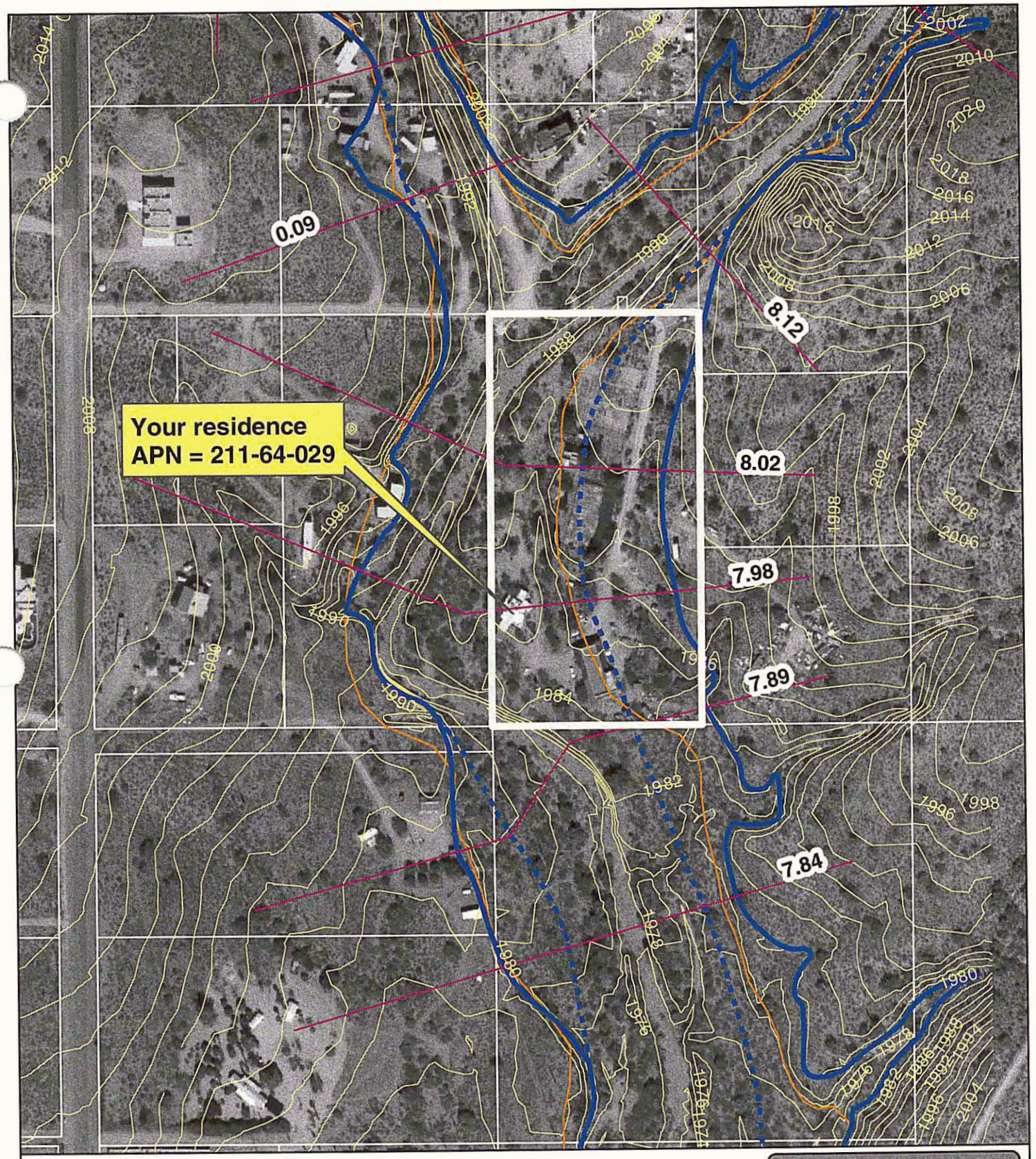


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 7,187 cfs
100-yr Water Surface Elevation = 1989.7 ft
Finished Floor Elevation = 1987.8 ft
Depth = 1.9 ft below 100-yr Water Surface Elevation
Velocity = 3.2 ft/s
Approximate Chance of Flooding
in Any Given Year = 9.1%

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

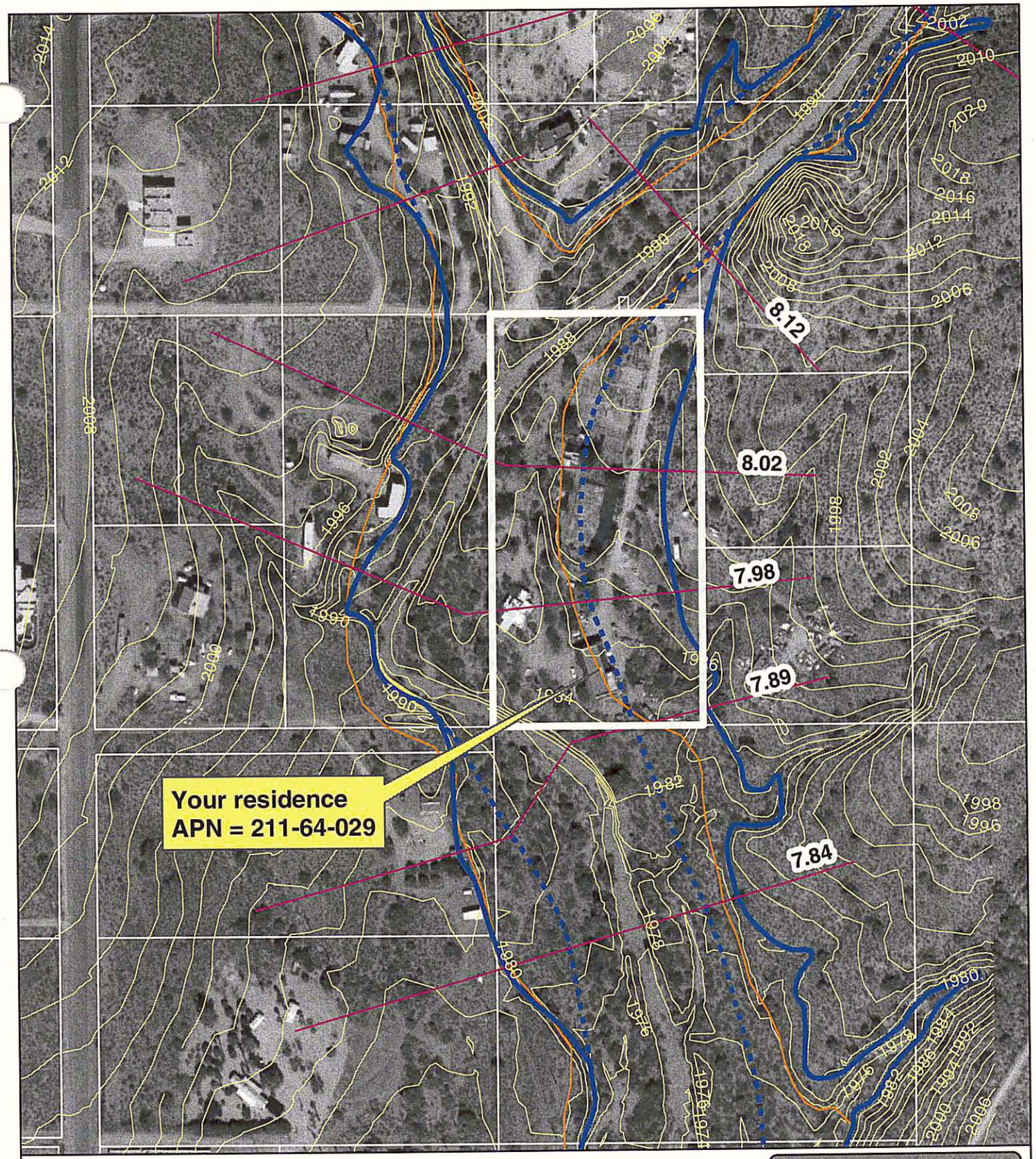


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 7,187 cfs
100-yr Water Surface Elevation = 1988.0 ft
Finished Floor Elevation = 1988.4 ft
Depth = 0.4 ft above 100-yr Water Surface Elevation
Velocity = 3.1 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

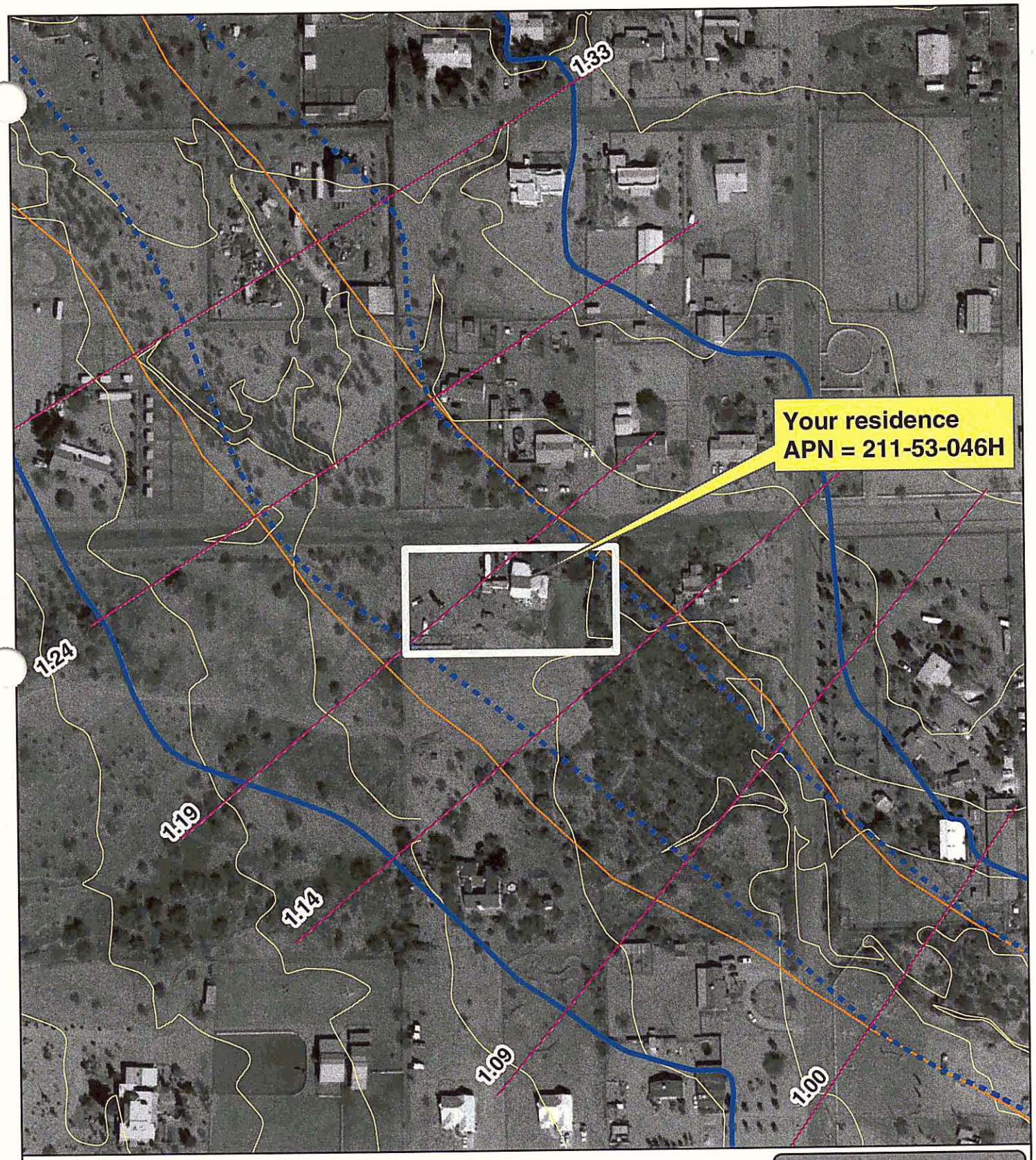


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 3,406 cfs
100-yr Water Surface Elevation = 1,793.1 ft
Finished Floor Elevation = 1,793.0 ft
Depth = 0.1 ft below 100-yr Water Surface Elevation
Velocity = 2.1 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.3 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

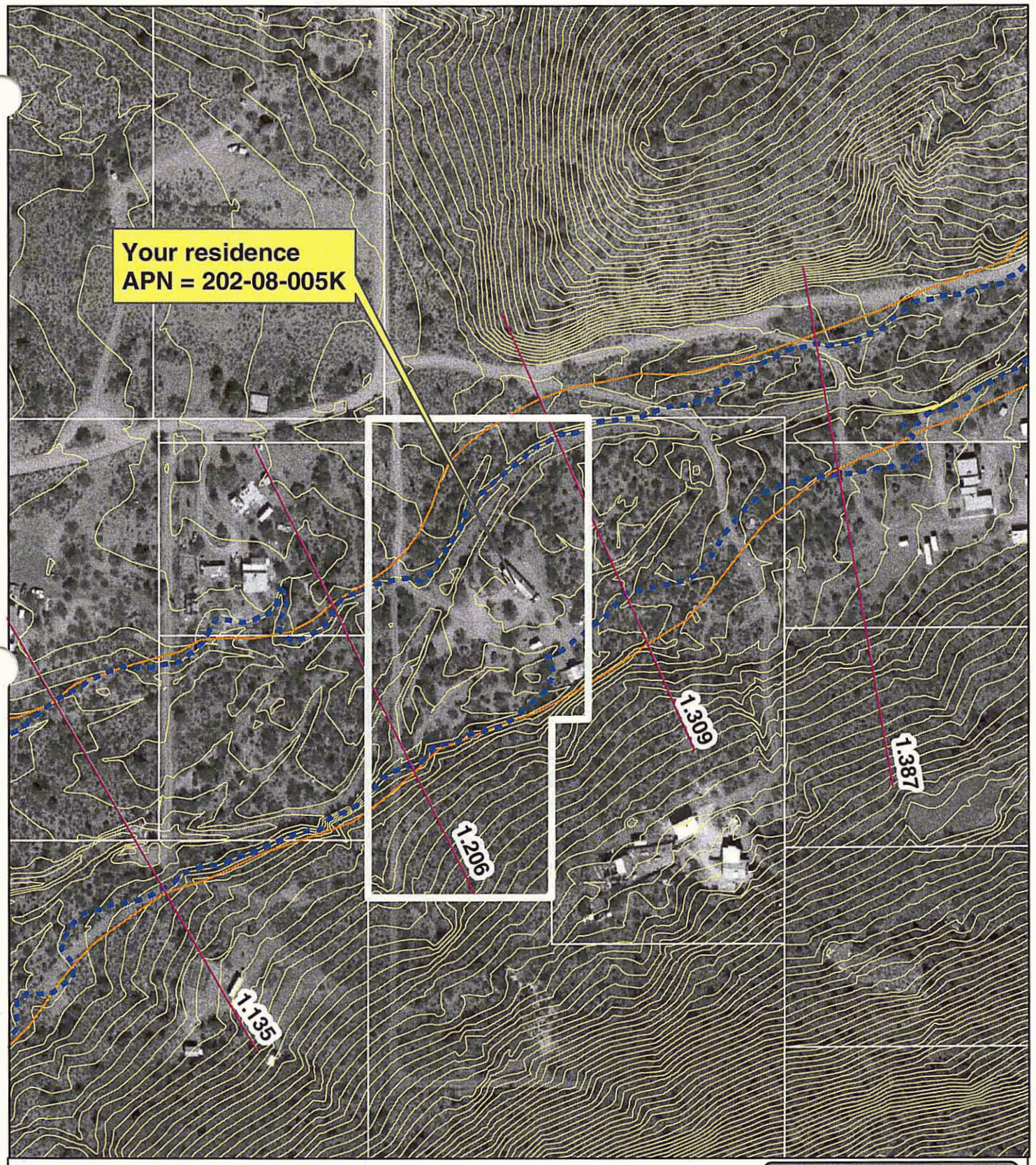


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 3,169 cfs
100-yr Water Surface Elevation = 2250.5 ft
Finished Floor Elevation = 2252.9 ft
Depth = 2.4 ft above 100-yr Water Surface Elevation
Velocity = 6.4 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 10,883 cfs
100-yr Water Surface Elevation = 2,144.8 ft
Finished Floor Elevation = 2,145.7 ft
Depth = 0.9 ft above 100-yr Water Surface Elevation
Velocity = 4.0 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

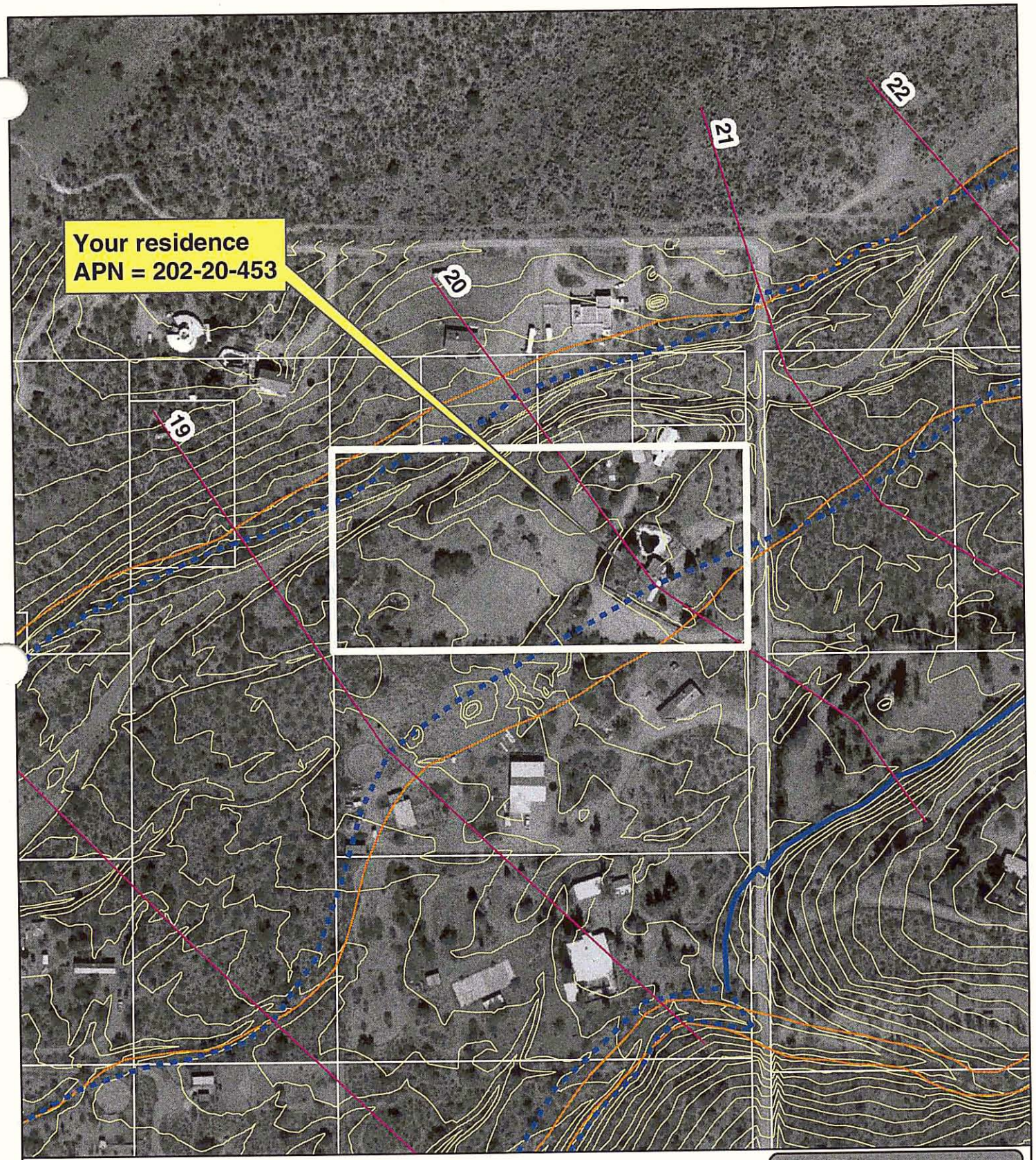


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 10,883 cfs
100-yr Water Surface Elevation = 2163.6 ft
Finished Floor Elevation = 2165.7 ft
Depth = 2.1 ft above 100-yr Water Surface Elevation
Velocity = 5.0 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

100-year Floodplain
Floodway
Erosion Hazard Zones
Cross-sections
Topography
Assessor's Parcel Boundary

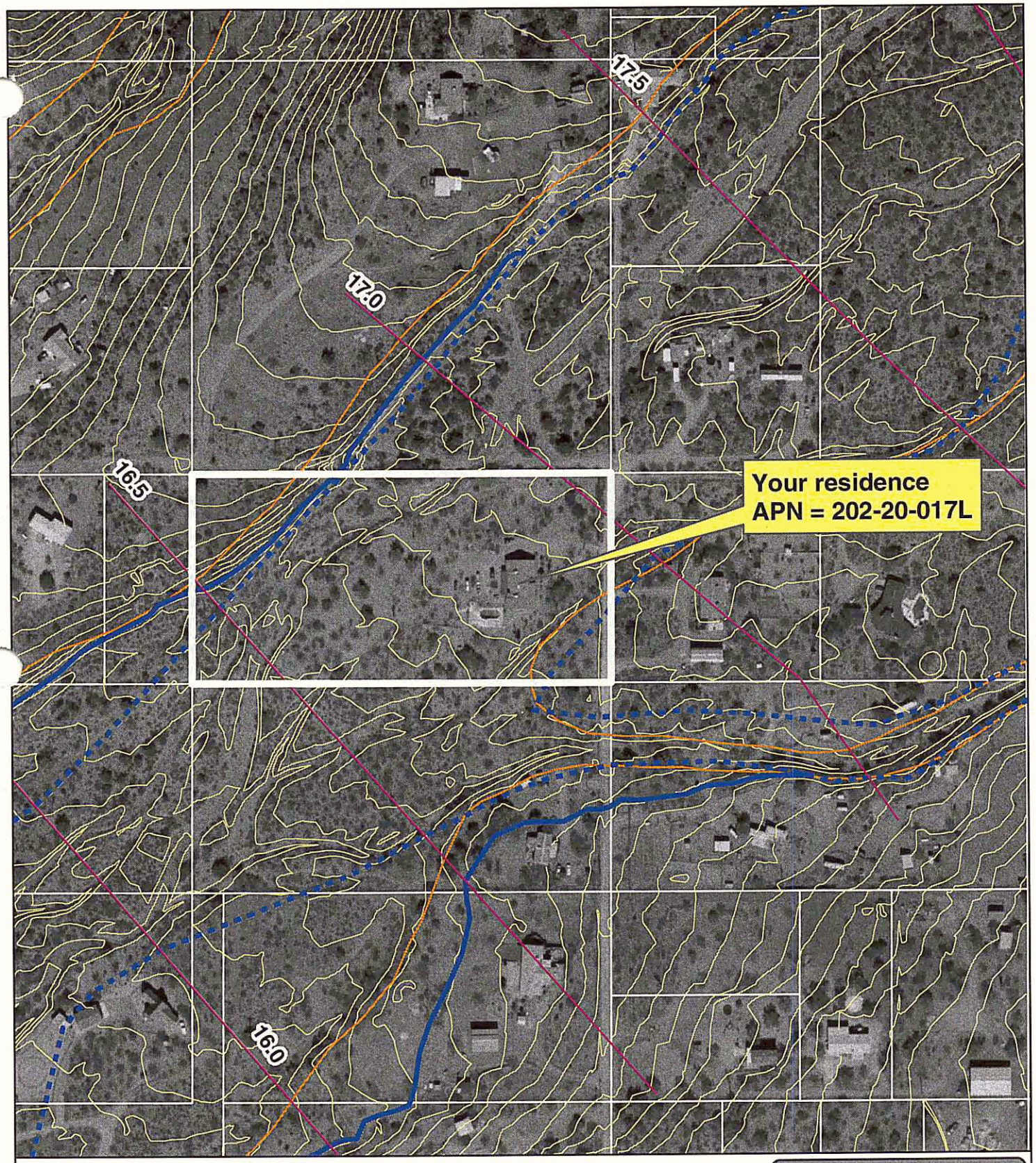


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 10,833 cfs
100-yr Water Surface Elevation = 2,135.8 ft
Finished Floor Elevation = 2,134.2 ft
Depth = 1.6 ft below 100-yr Water Surface Elevation
Velocity = 5.1 ft/s
Approximate Chance of Flooding
in Any Given Year = 16.7 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

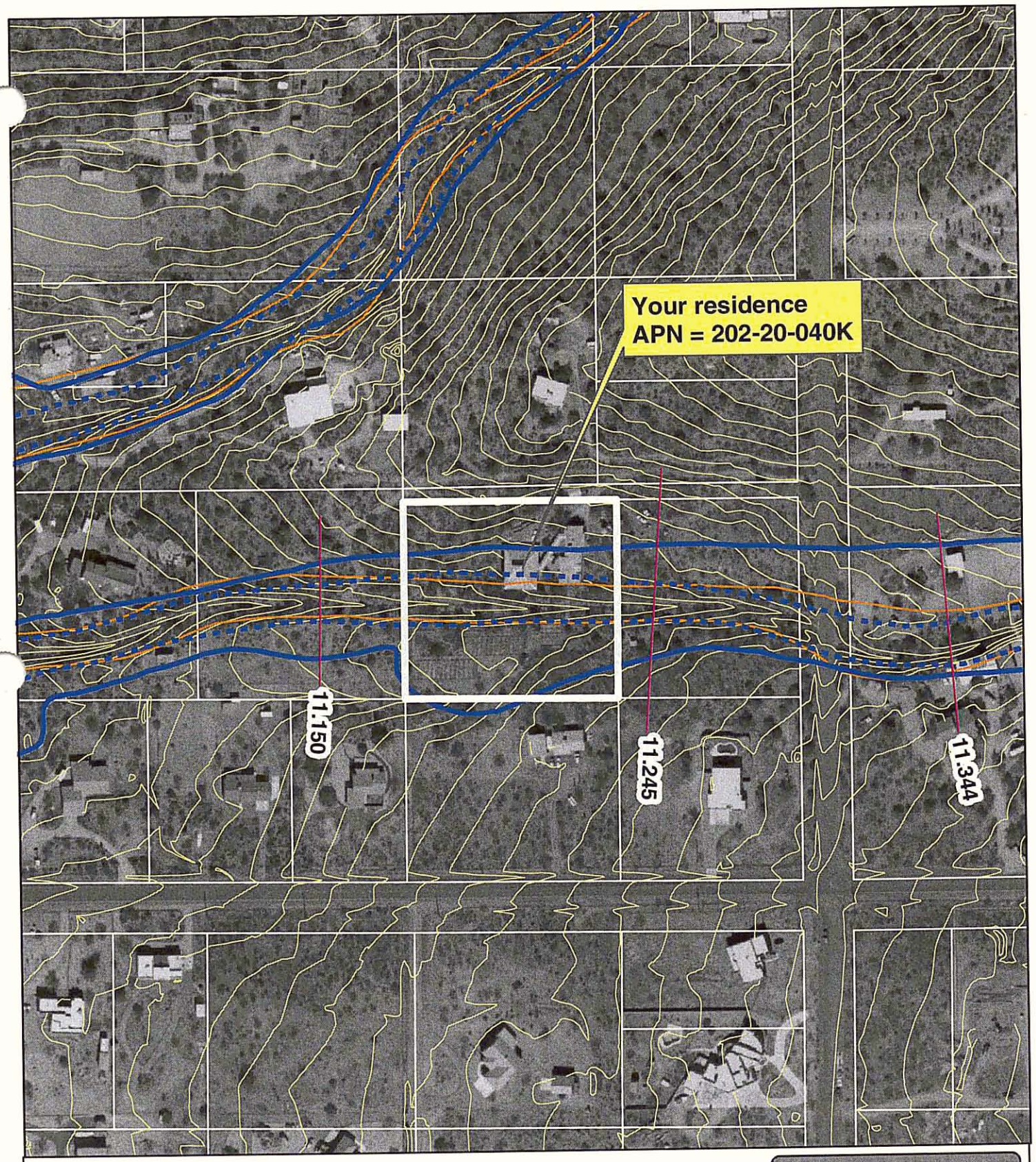


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 1,430 cfs
100-yr Water Surface Elevation = 2187.4 ft
Finished Floor Elevation = 2189.9 ft
Depth = 2.5 ft above 100-yr Water Surface Elevation
Velocity = 5.2 ft/s
Approximate Chance of Flooding in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

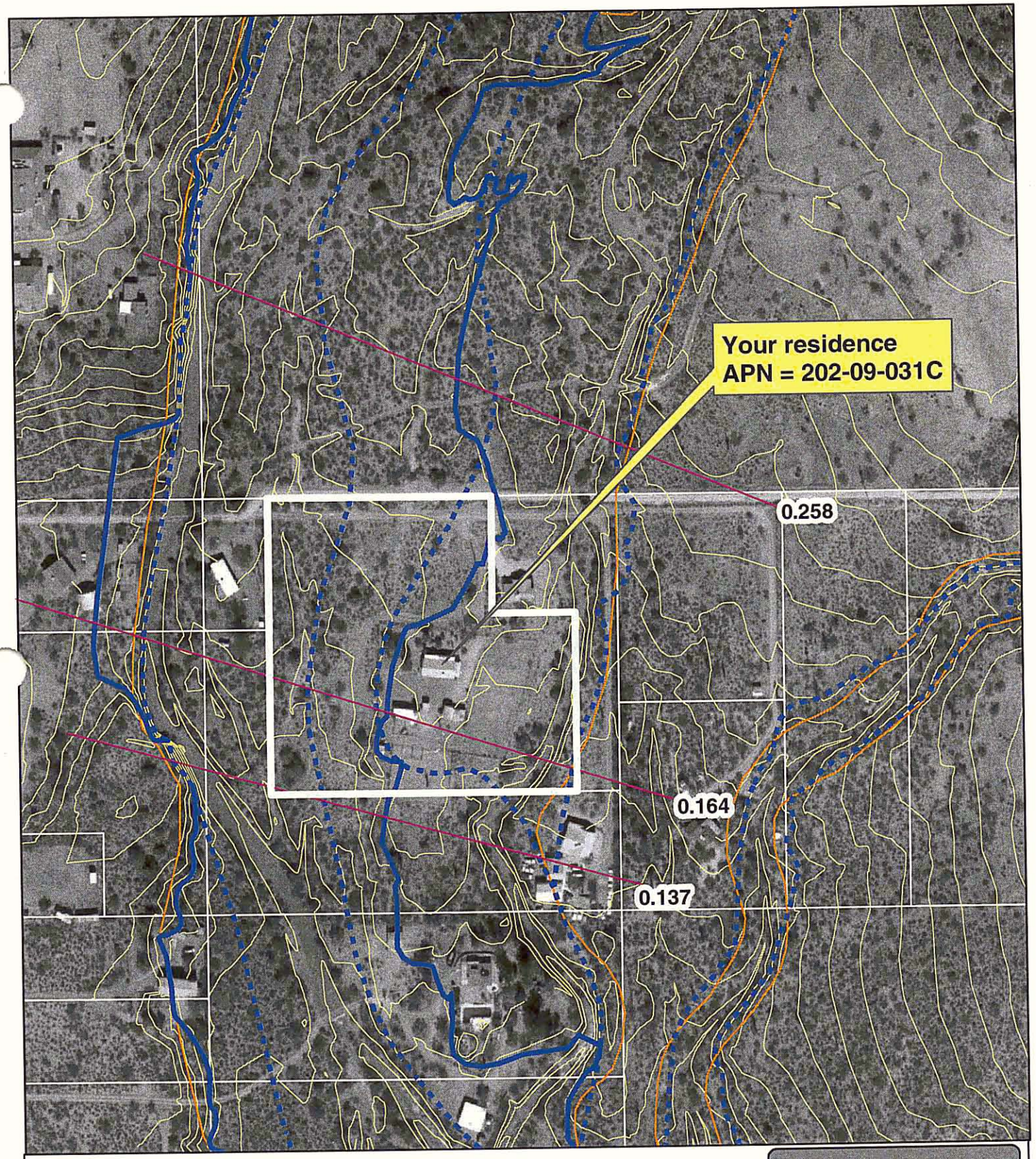


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 921 cfs
100-yr Water Surface Elevation = 2155.3 ft
Finished Floor Elevation = 2159.3 ft
Depth = 4.0 ft above 100-yr Water Surface Elevation
Velocity = n/a
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

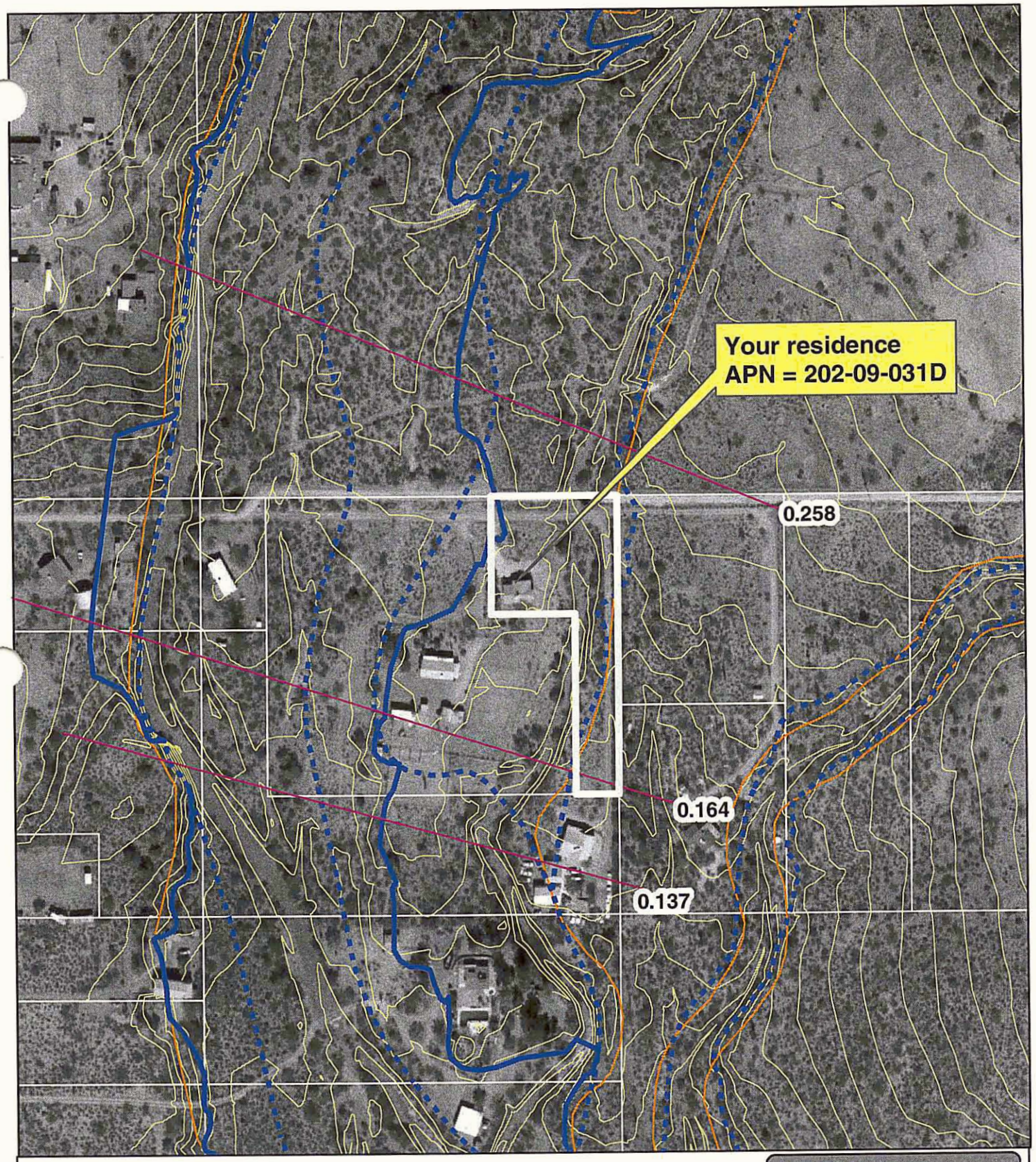


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 921 cfs
100-yr Water Surface Elevation = 2157.4 ft
Finished Floor Elevation = 2159.6 ft
Depth = 2.2 ft above 100-yr Water Surface Elevation
Velocity = n/a ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

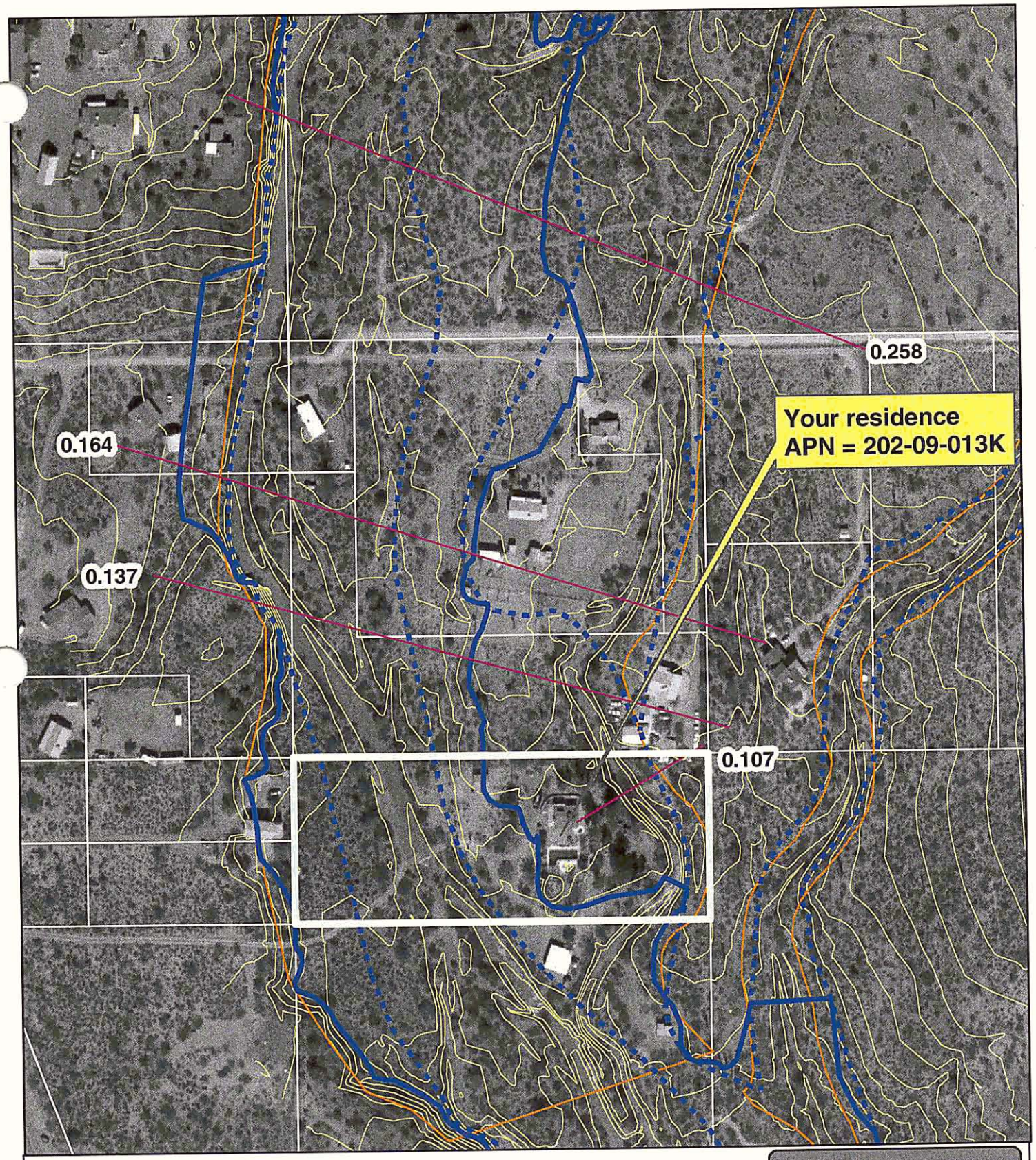


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 921 cfs
100-yr Water Surface Elevation = 2149.0 ft
Finished Floor Elevation = 2149.4 ft
Depth = 0.4 ft above 100-yr Water Surface Elevation
Velocity = 1.5 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

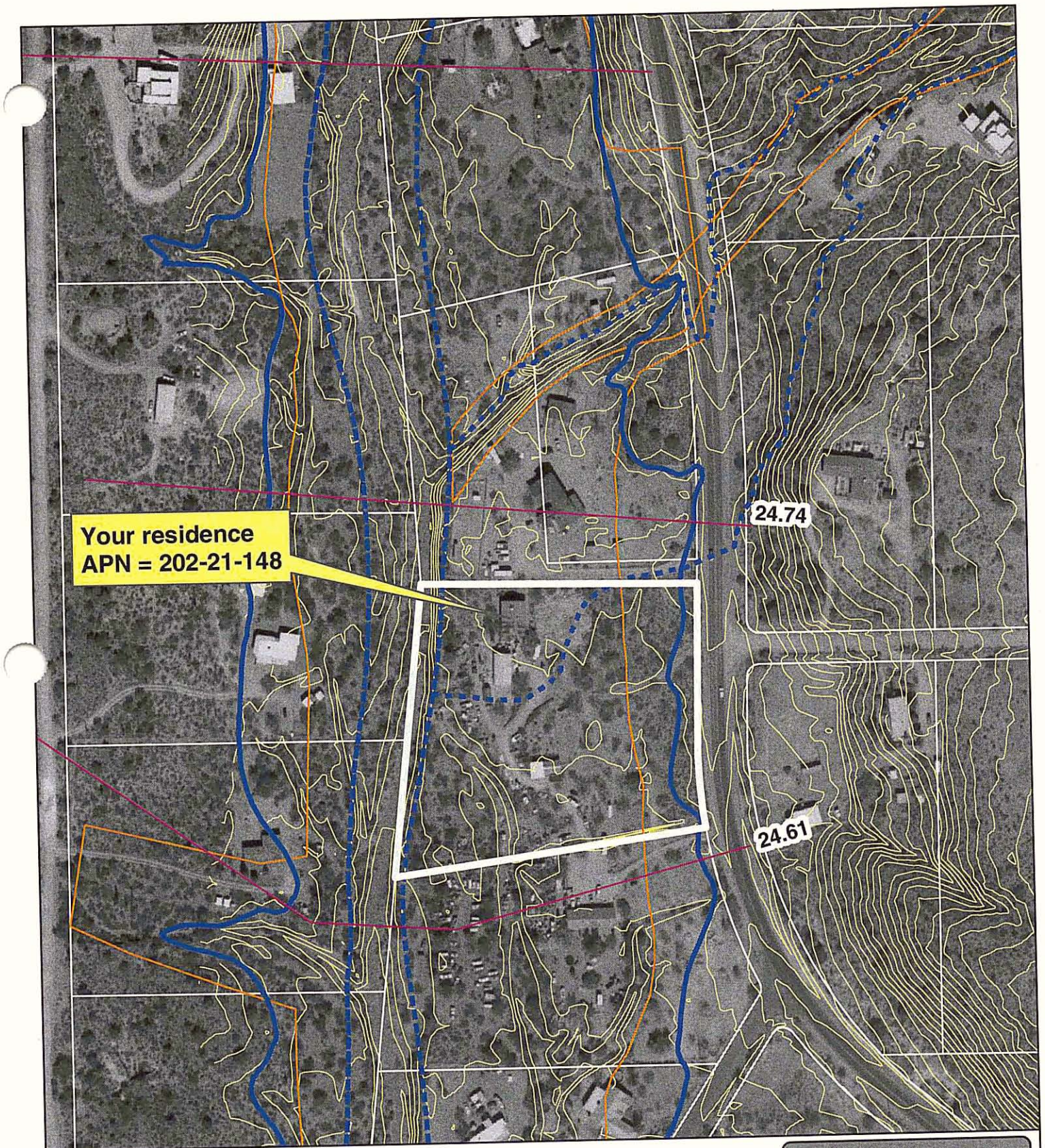


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 9,700 cfs
100-yr Water Surface Elevation = 2,055.0 ft
Finished Floor Elevation = 2,055.0 ft
Depth = 0.0 ft (at 100-yr Water Surface Elevation)
Velocity = 3.3 ft/s
Approximate Chance of Flooding
in Any Given Year = 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

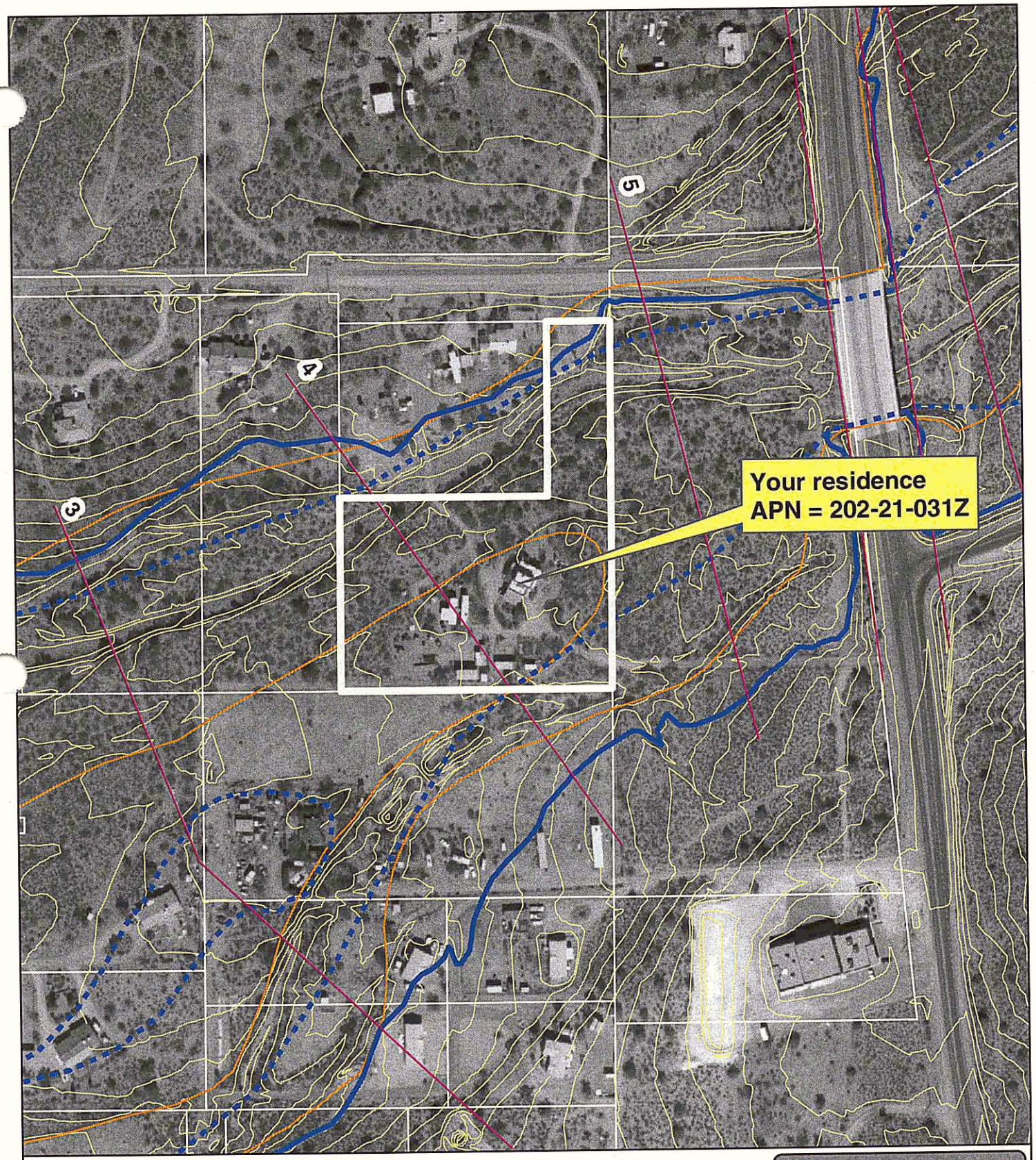


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 13,747 cfs
100-yr Water Surface Elevation = 2,048.4 ft
Finished Floor Elevation = 2,048.2 ft
Depth = 0.2 ft below 100-yr Water Surface Elevation
Velocity = 4.7 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.2 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

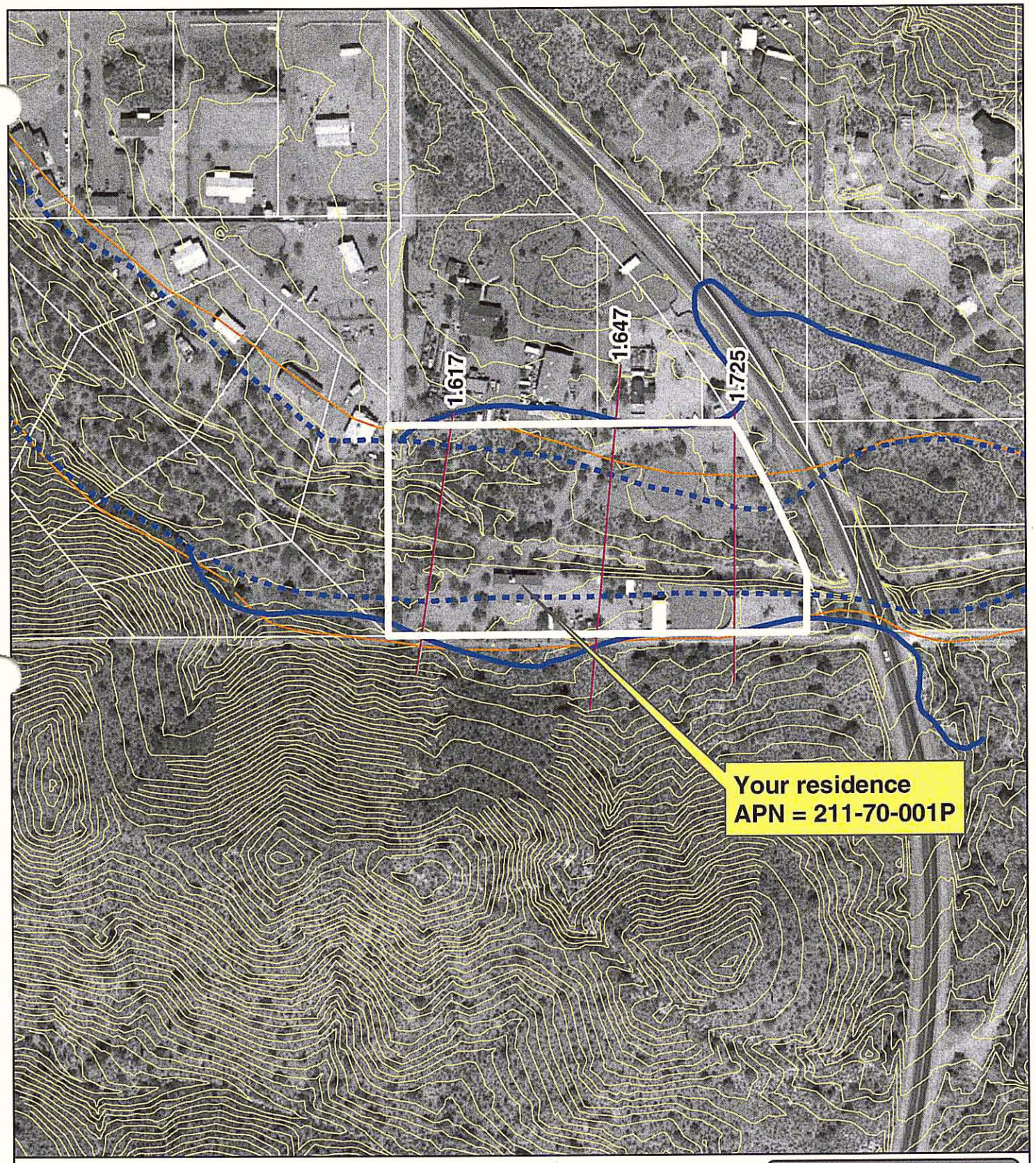


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 6,170 cfs
100-yr Water Surface Elevation = 2,027.6 ft
Finished Floor Elevation = 2,025.9 ft
Depth = 1.7 ft below 100-year Water Surface Elevation
Velocity = 5.5 ft/s
Approximate Chance of Flooding
in Any Given Year = 7.1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,900 cfs
100-yr Water Surface Elevation = 2195.2 ft
Finished Floor Elevation = 2196.1 ft
Depth = 0.9 ft above 100-yr Water Surface Elevation
Velocity = 4.6 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

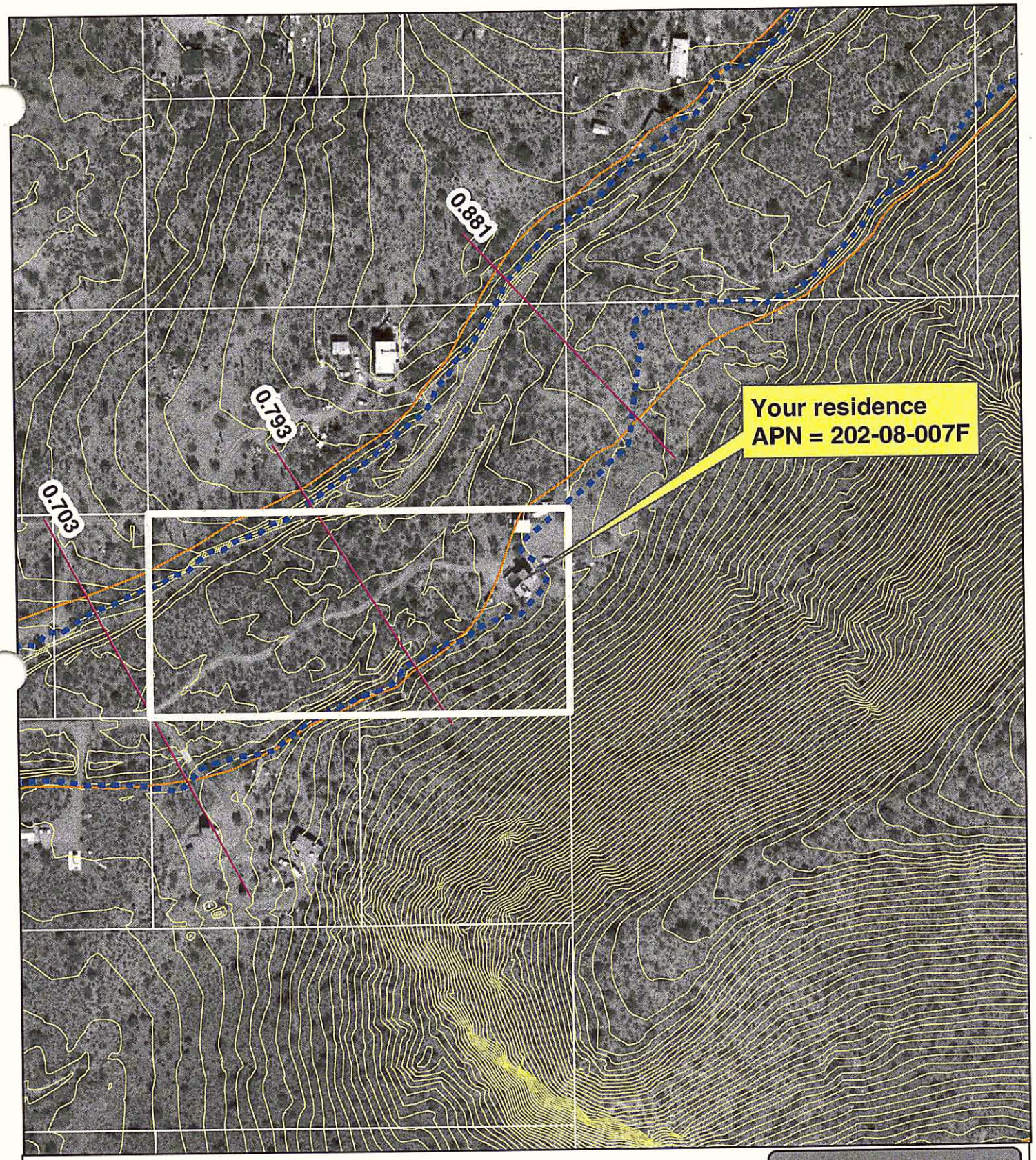


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 3,169 cfs
100-yr Water Surface Elevation = 2210.2 ft
Finished Floor Elevation = not surveyed
Depth = undetermined
Velocity = 1.3 ft/s
Approximate Chance of Flooding in Any Given Year = undetermined

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

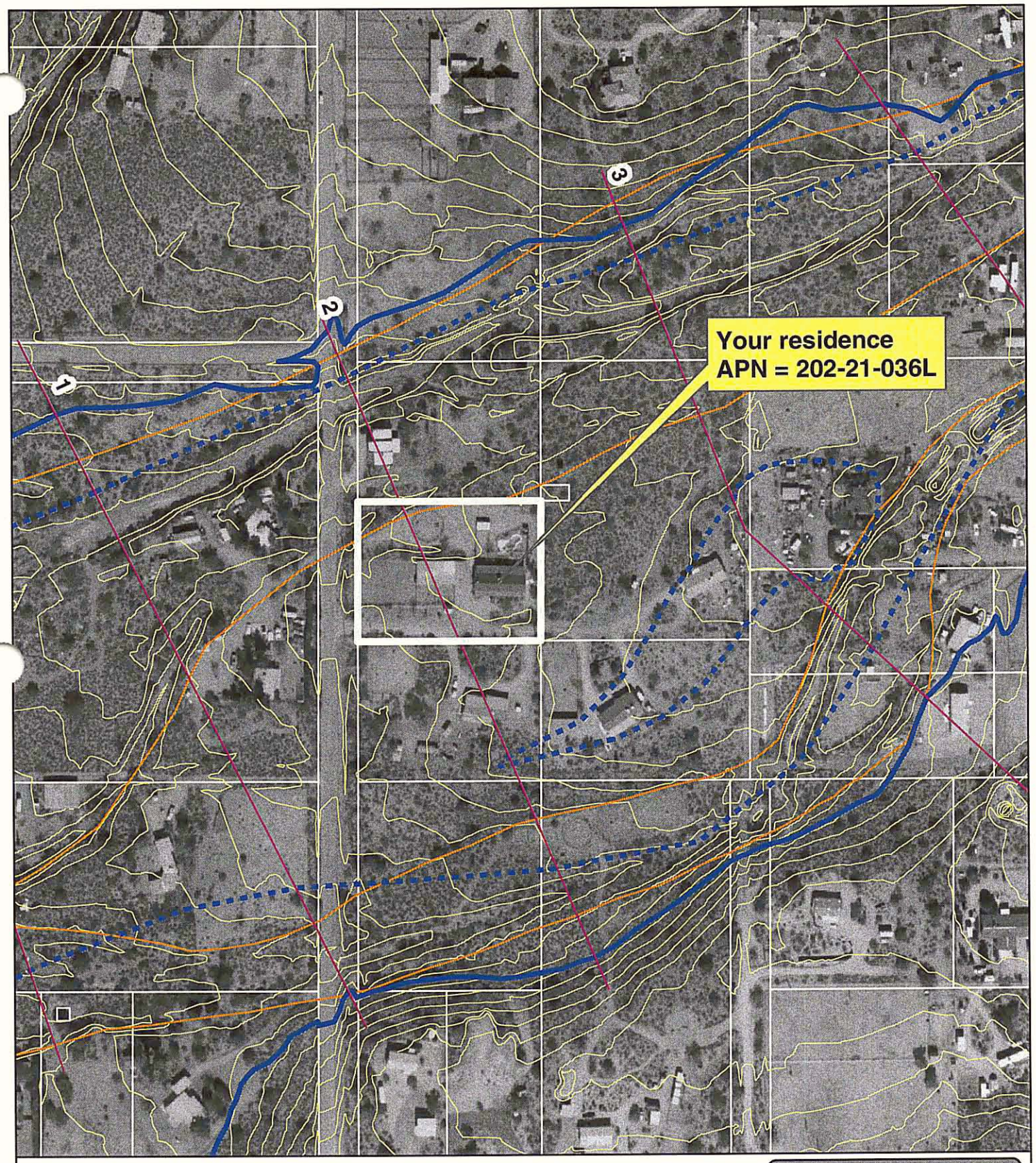


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 13,747 cfs
100-yr Water Surface Elevation = 2,034.4 ft
Finished Floor Elevation = 2,034.5 ft
Depth = 0.1 ft above 100-yr Water Surface Elevation
Velocity = 4.0 ft/s
Approximate Chance of Flooding
in Any Given Year < 1%

100-year Floodplain
Floodway
Erosion Hazard Zones
Cross-sections
Topography
Assessor's Parcel Boundary

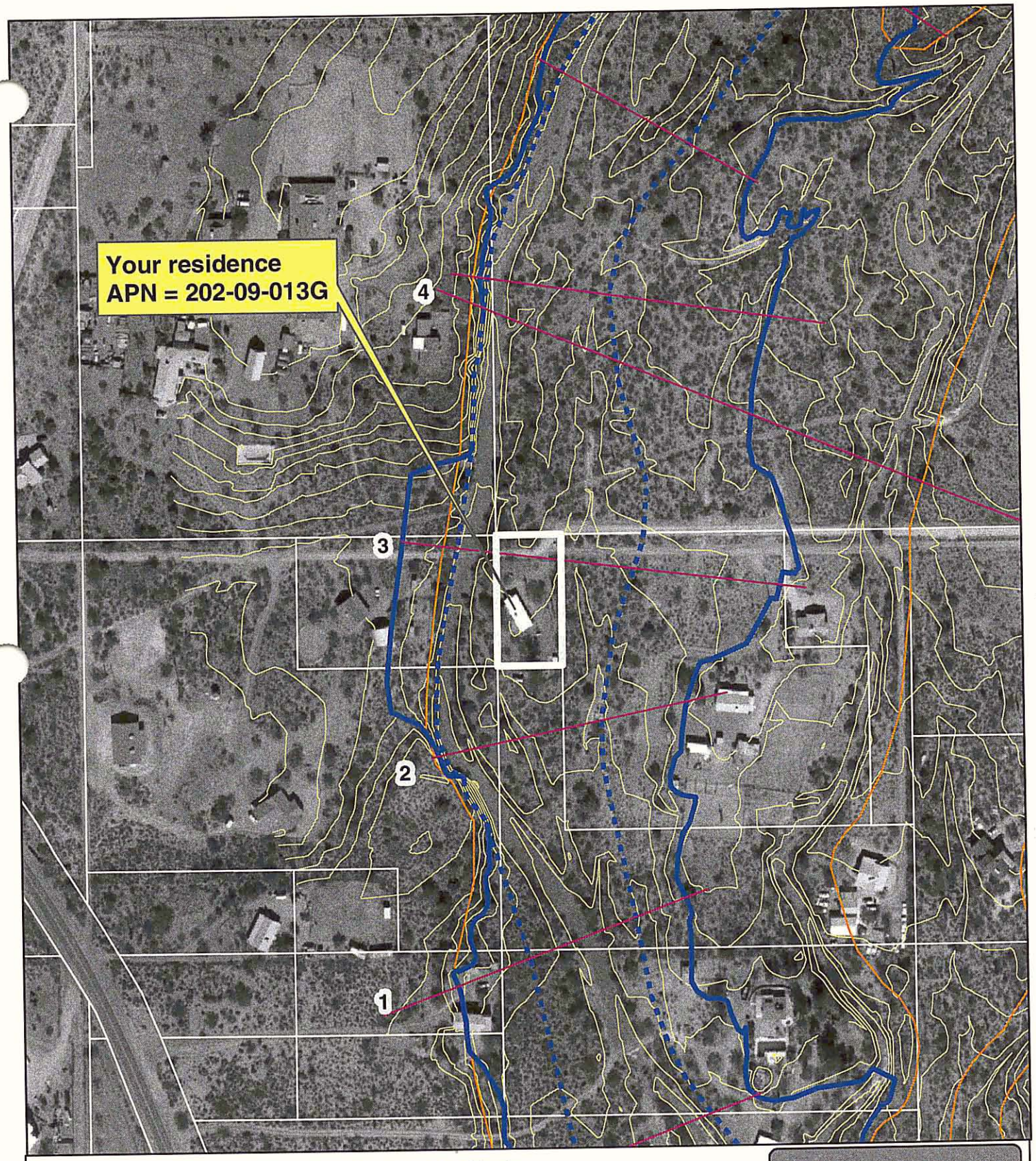


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 7,840 cfs
100-yr Water Surface Elevation = 2159.1 ft
Finished Floor Elevation = not surveyed
Depth = undetermined
Velocity = 4.1 ft/s
Approximate Chance of Flooding
in Any Given Year = undetermined

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

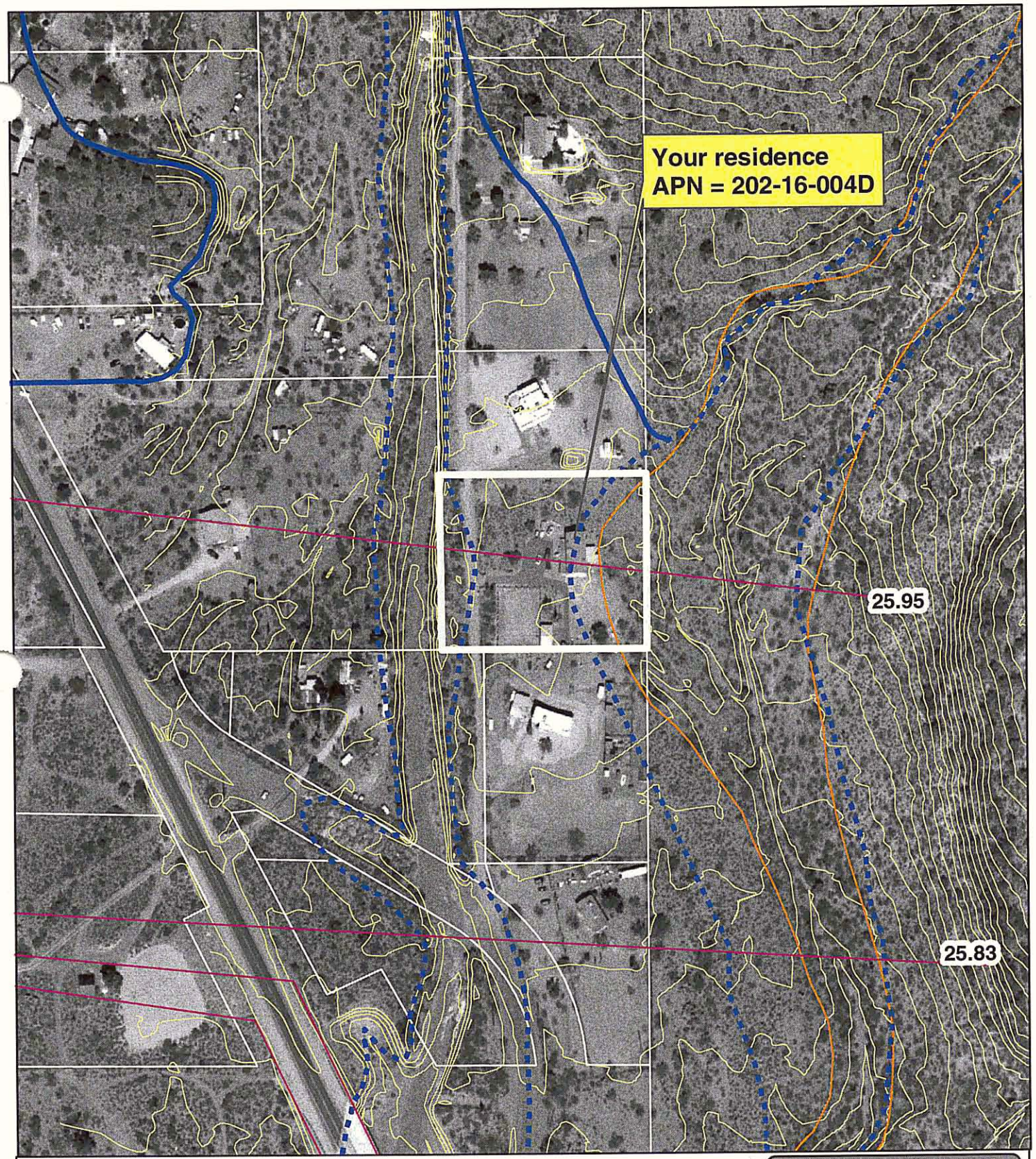


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 7,800 cfs (978 cfs)
100-yr Water Surface Elevation = 2119.1 ft (2115.7 ft)
Finished Floor Elevation = 2123.1 ft
Depth = 4.0 ft above 100-yr Water Surface Elevation
Velocity = 4.2 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

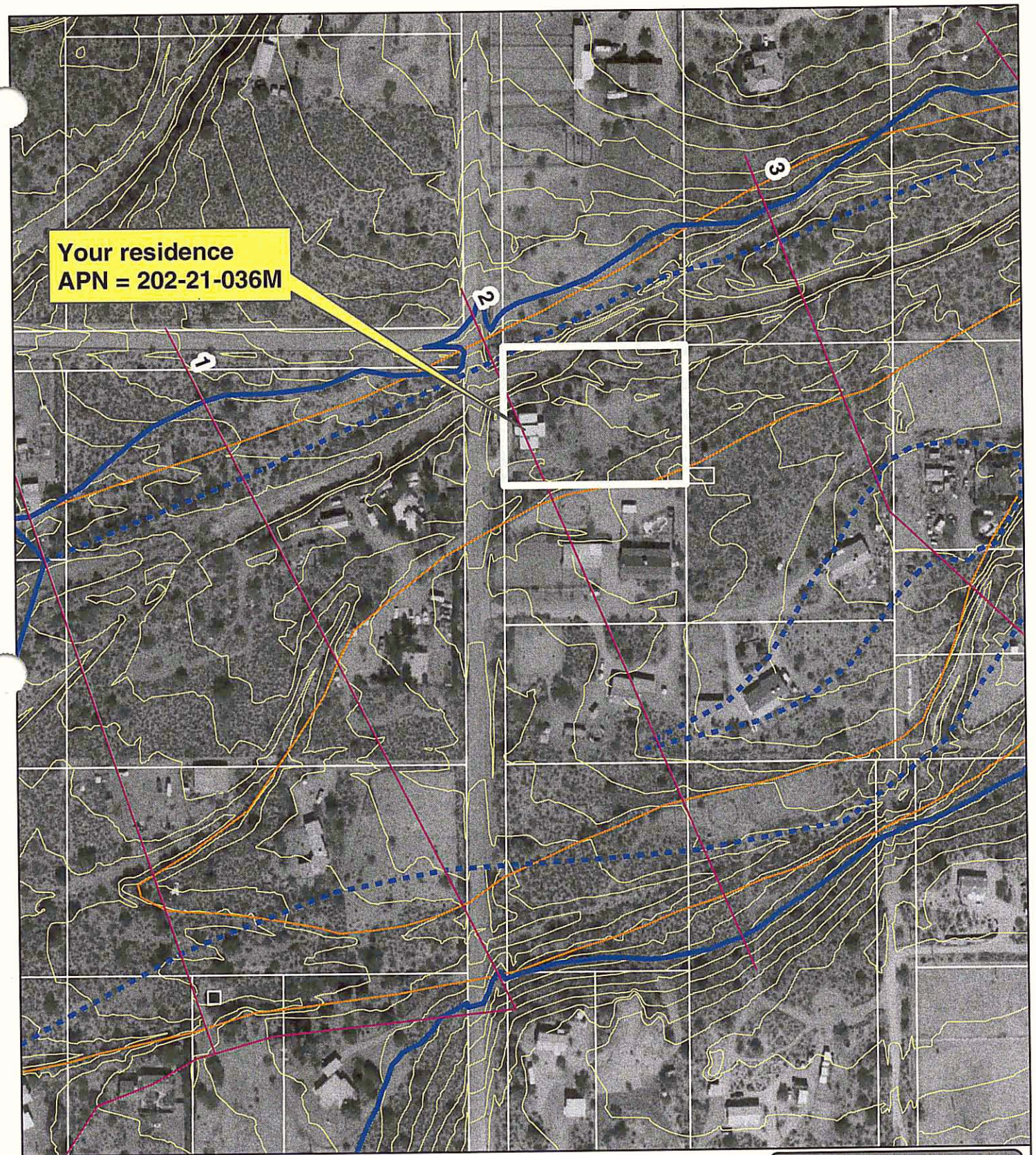


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 13,747 cfs
100-yr Water Surface Elevation = 2032.6 ft
Finished Floor Elevation = 2034.4 ft
Depth = 1.8 ft above 100-yr Water Surface Elevation
Velocity = 4.8 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 13,747 cfs
100-yr Water Surface Elevation = 2,032.6 ft
Finished Floor Elevation = 2,033.2 ft
Depth = 0.6 ft above 100-yr Water Surface Elevation
Velocity = 4.8 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

100-year Floodplain
Floodway
Erosion Hazard Zones
Cross-sections
Topography
Assessor's Parcel Boundary

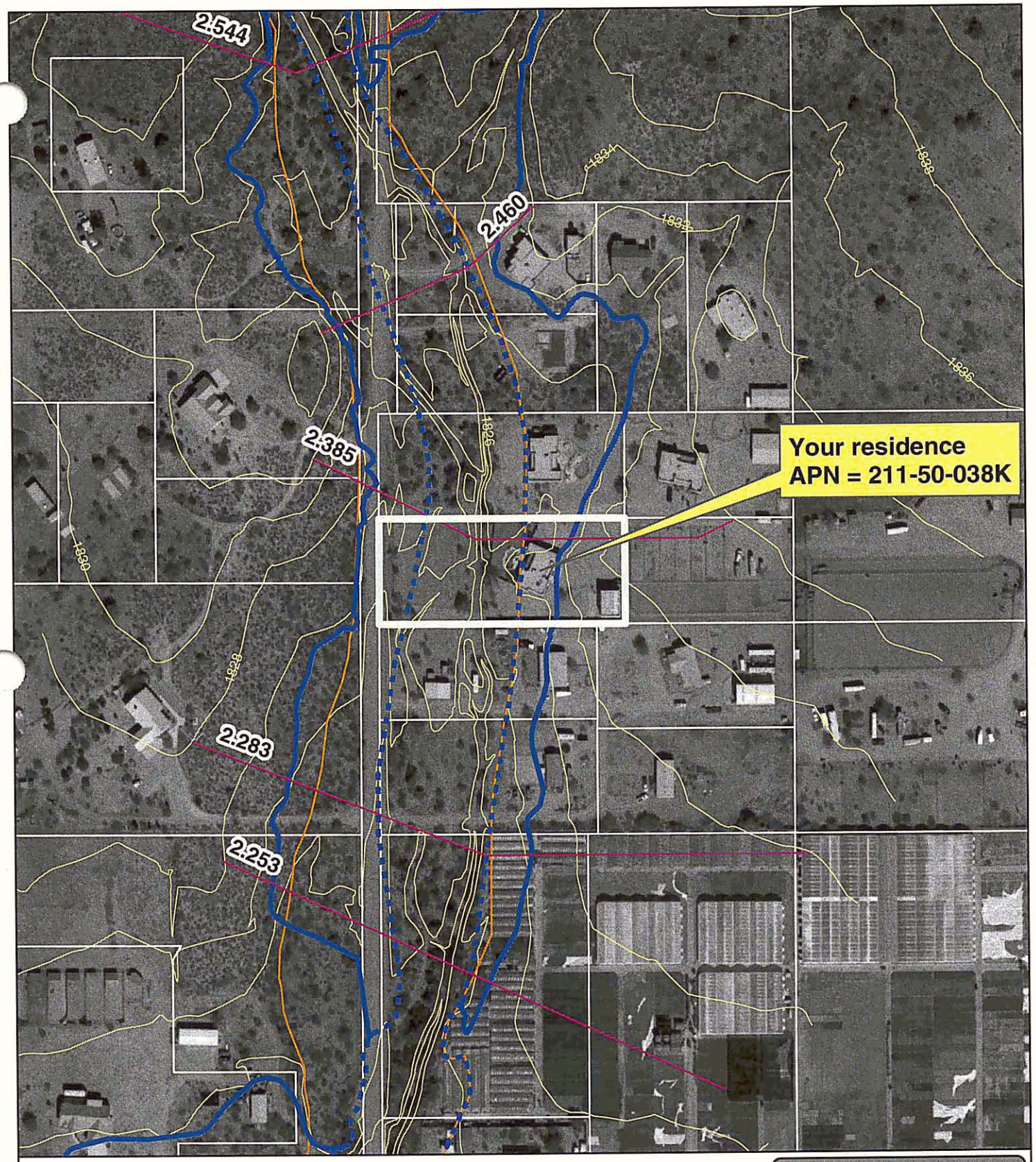


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 2,110 cfs
100-yr Water Surface Elevation = 1,827.2 ft
Finished Floor Elevation = 1,828.5 ft
Depth = 1.3 ft above 100-yr Water Surface Elevation
Velocity = 3.9 ft/s
Approximate Chance of Flooding in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

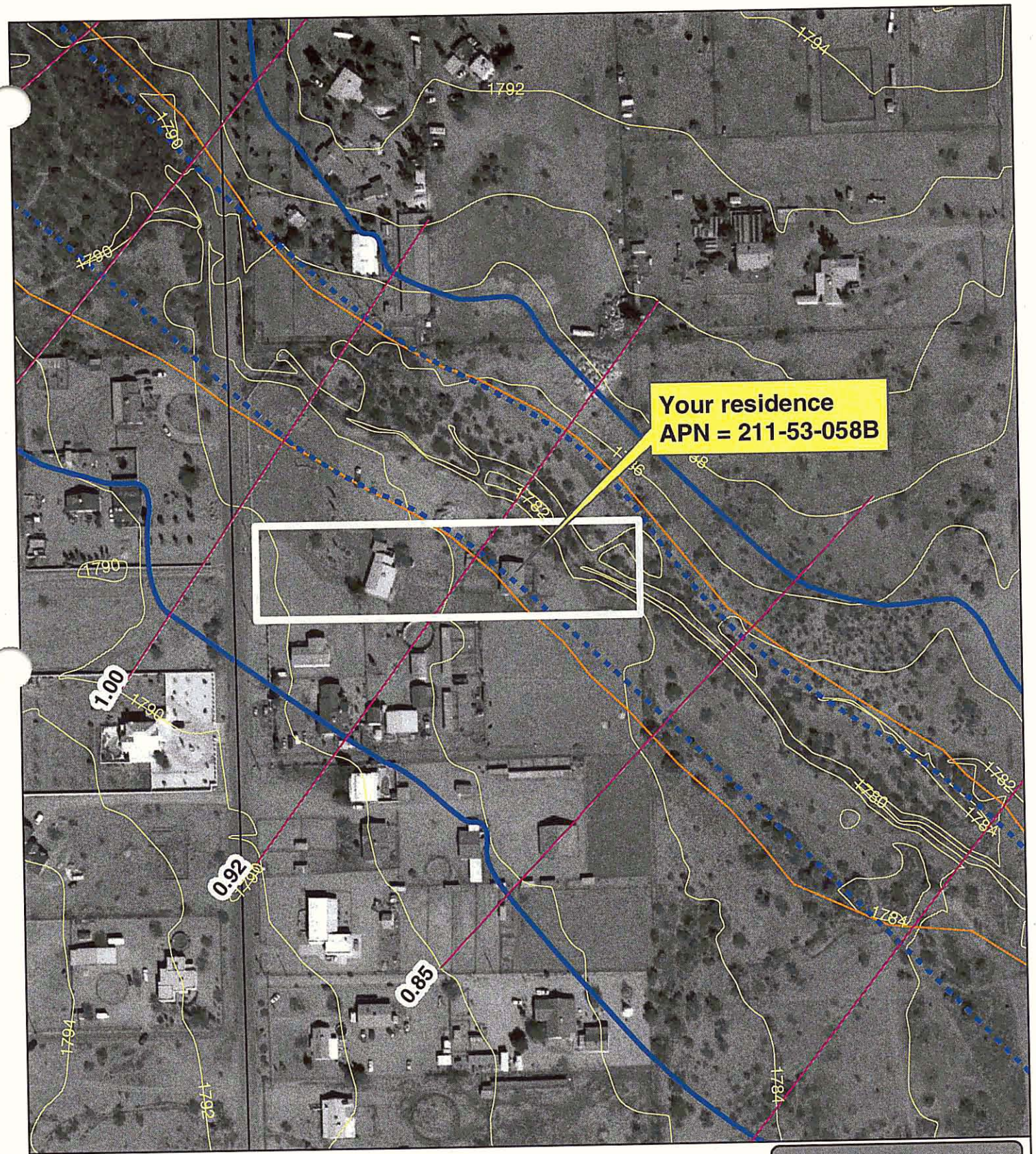


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 3,406 cfs
100-yr Water Surface Elevation = 1787.5 ft
Finished Floor Elevation = 1788.8 ft
Depth = 1.3 ft above 100-yr Water Surface Elevation
Velocity = 2.3 ft/s
Approximate Chance of Flooding in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

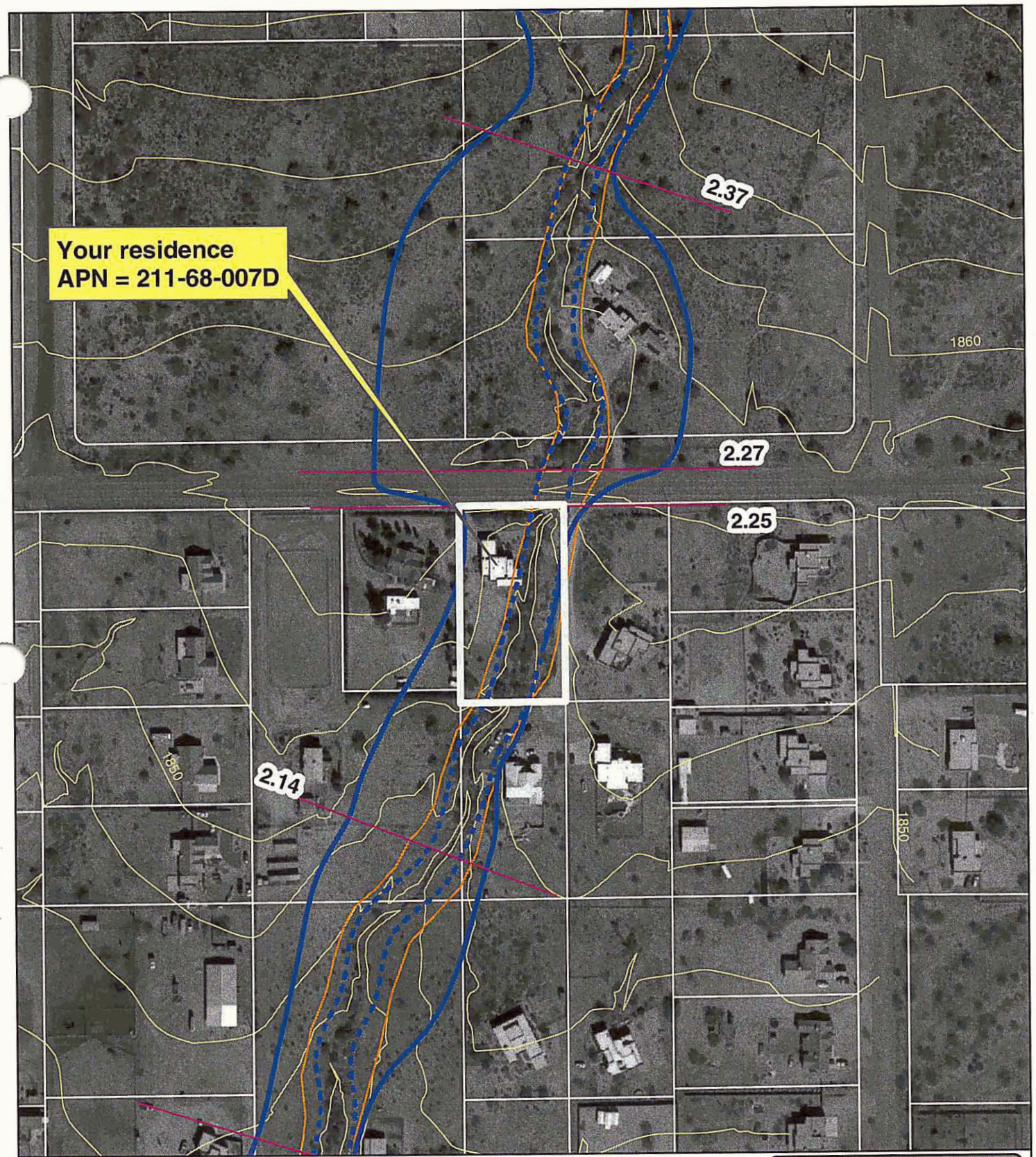


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 692 cfs
100-yr Water Surface Elevation = 1852.5 ft
Finished Floor Elevation = 1854.4 ft
Depth = 1.9 ft above 100-yr Water Surface Elevation
Velocity = 1.9 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

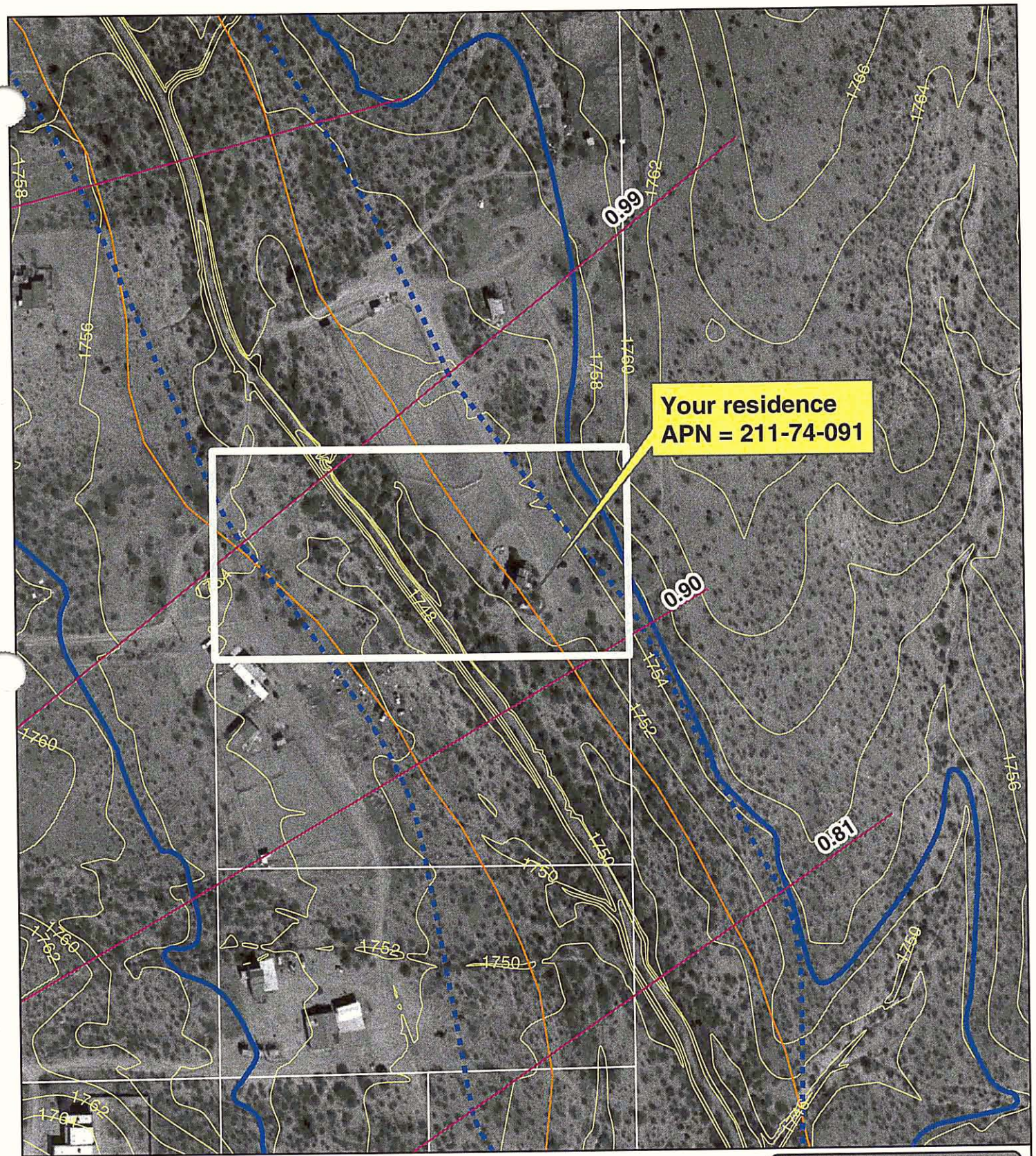


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 10,259 cfs
100-yr Water Surface Elevation = 1756.5 ft
Finished Floor Elevation = 1753.0 ft
Depth = 3.5 ft below 100-yr Water Surface Elevation
Velocity = 3.7 ft/s
Approximate Chance of Flooding
in Any Given Year = 50 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

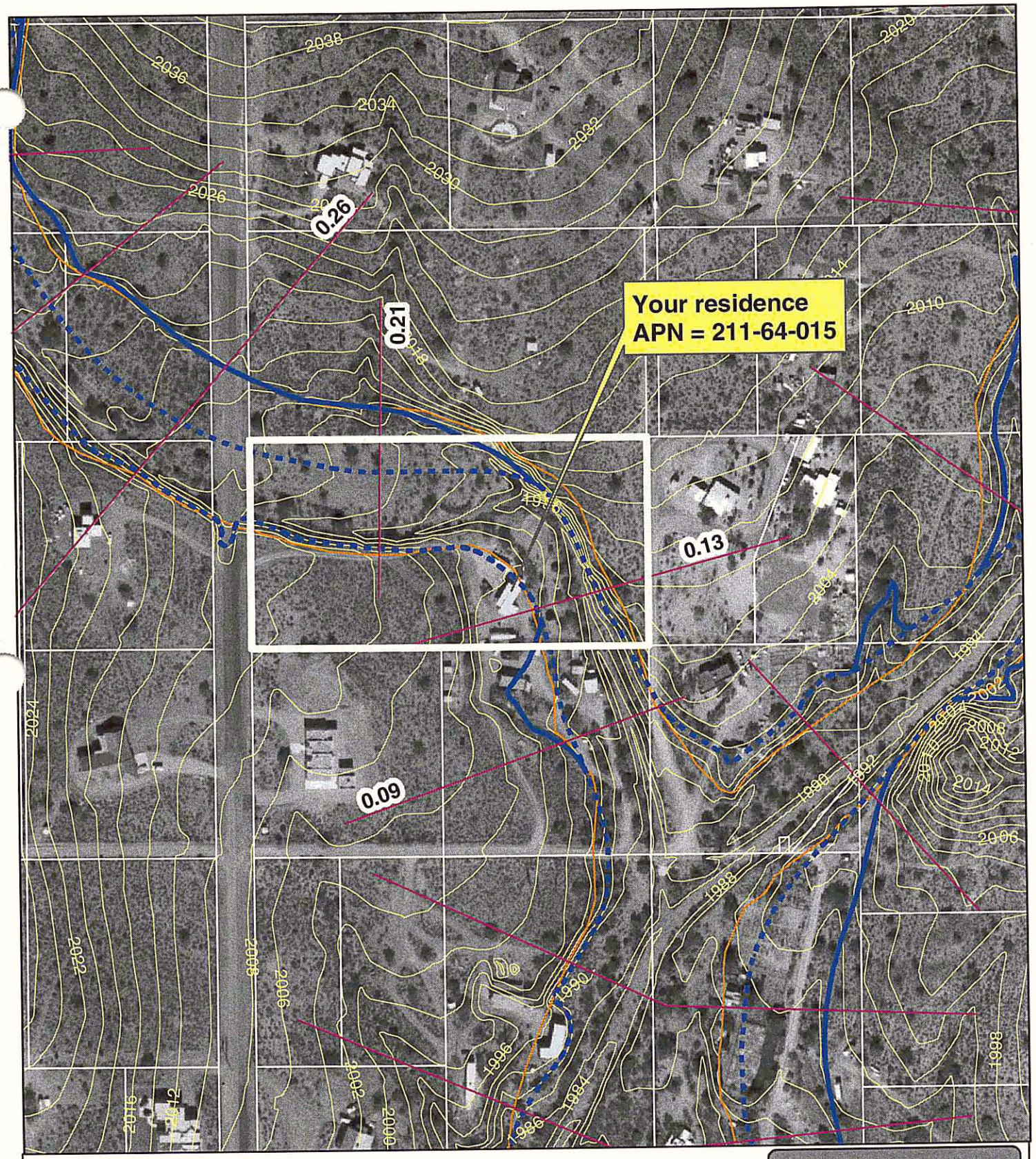


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 2,191 cfs
100-yr Water Surface Elevation = 2001.1 ft
Finished Floor Elevation = 2003.8 ft
Depth = 2.7 ft above 100-yr Water Surface Elevation
Velocity = 4.2 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

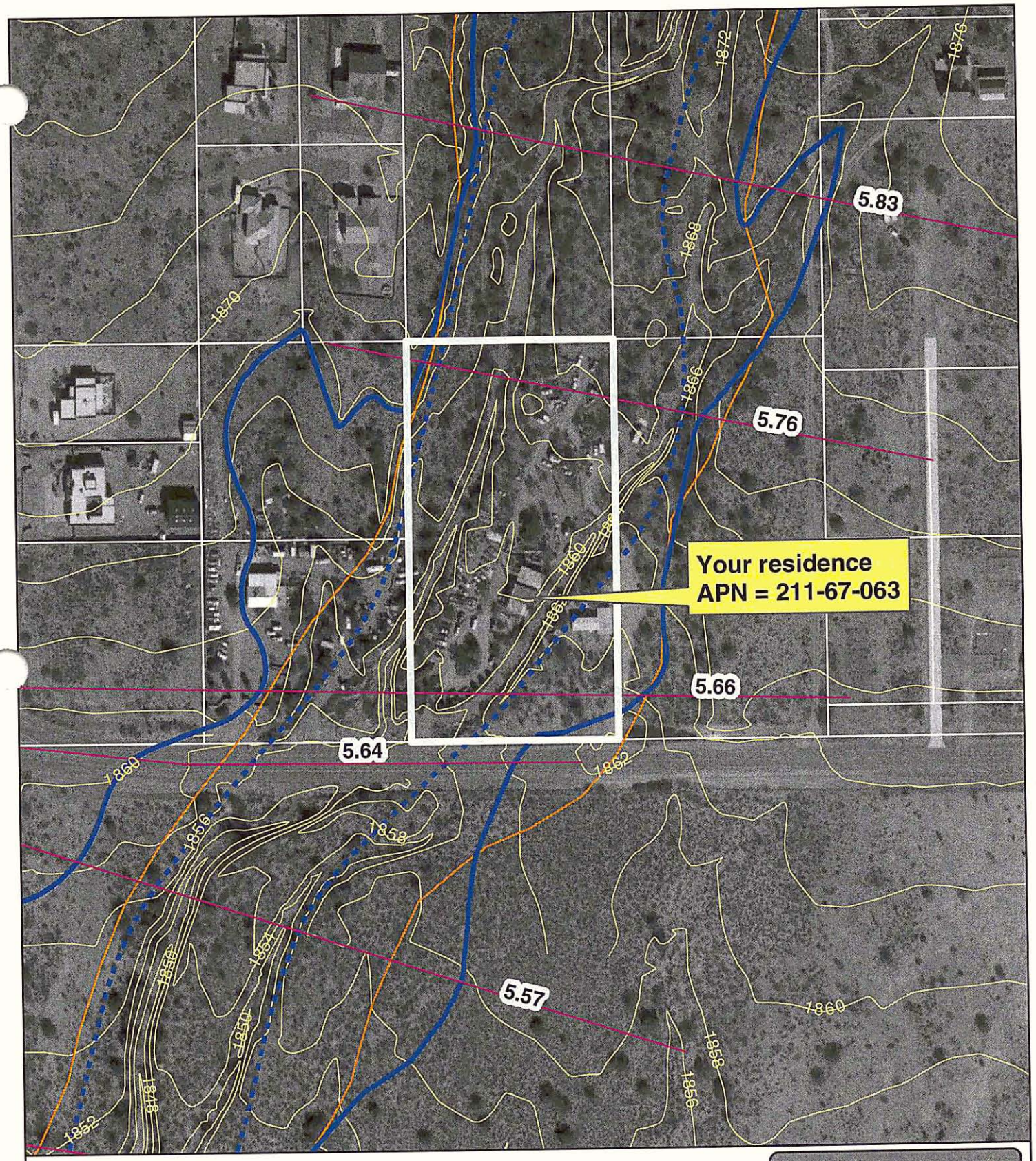


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 7,187 cfs
100-yr Water Surface Elevation = 1864.1 ft
Finished Floor Elevation = 1864.8 ft
Depth = 0.7 ft above 100-yr Water Surface Elevation
Velocity = 3.8 ft/s
Approximate Chance of Flooding
in Any Given Year < 1%

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

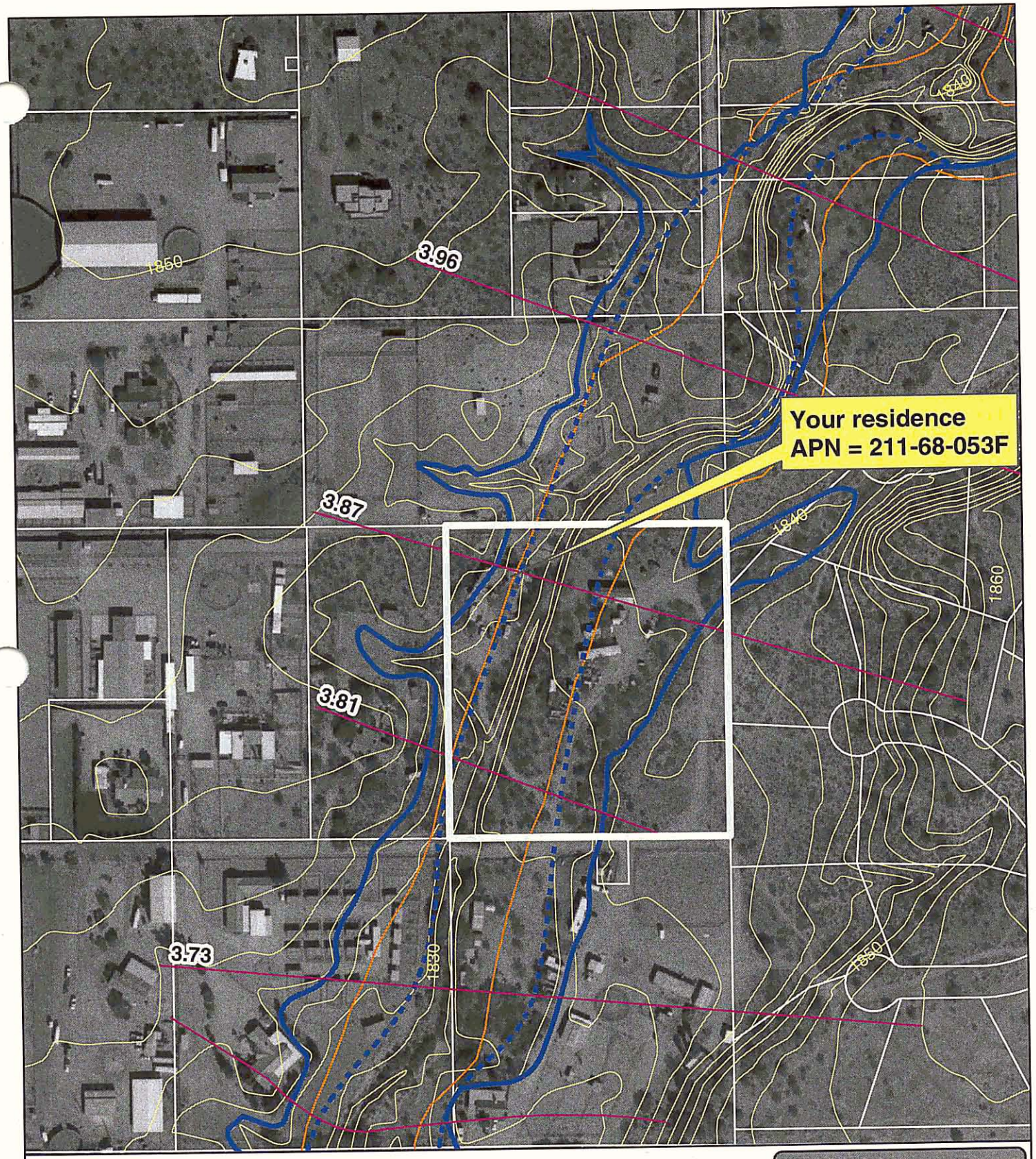


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 2,692 cfs
100-yr Water Surface Elevation = 1,839.1 ft
Finished Floor Elevation = 1,838.8 ft
Depth = 0.3 ft below 100-yr Water Surface Elevation
Velocity = 2.5 ft/s
Approximate Chance of Flooding in Any Given Year = 1.4 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

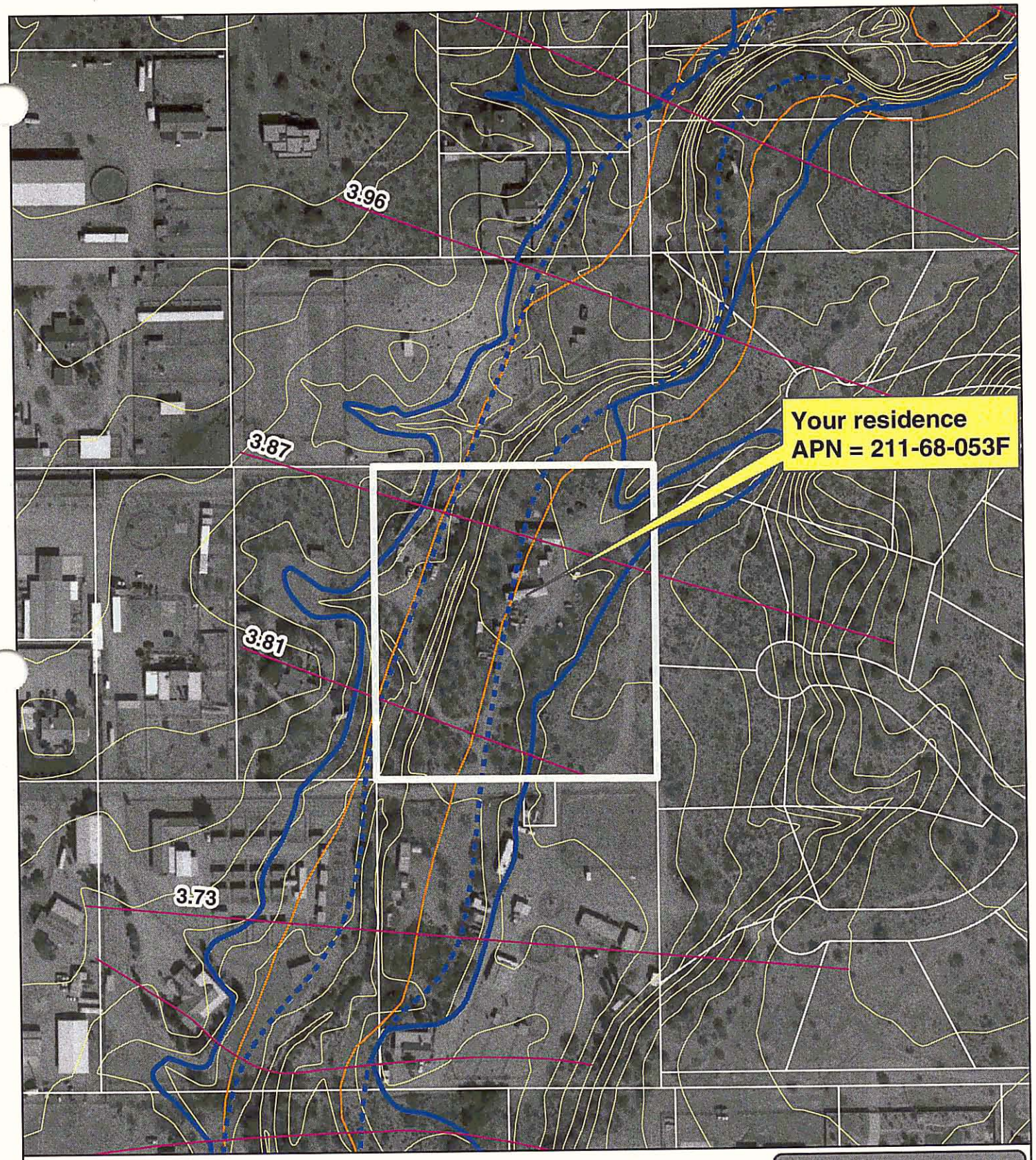


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 2,692 cfs
100-yr Water Surface Elevation = 1,838.6 ft
Finished Floor Elevation = 1,838.3 ft
Depth = 0.3 ft below 100-yr Water Surface Elevation
Velocity = 2.4 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.5 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

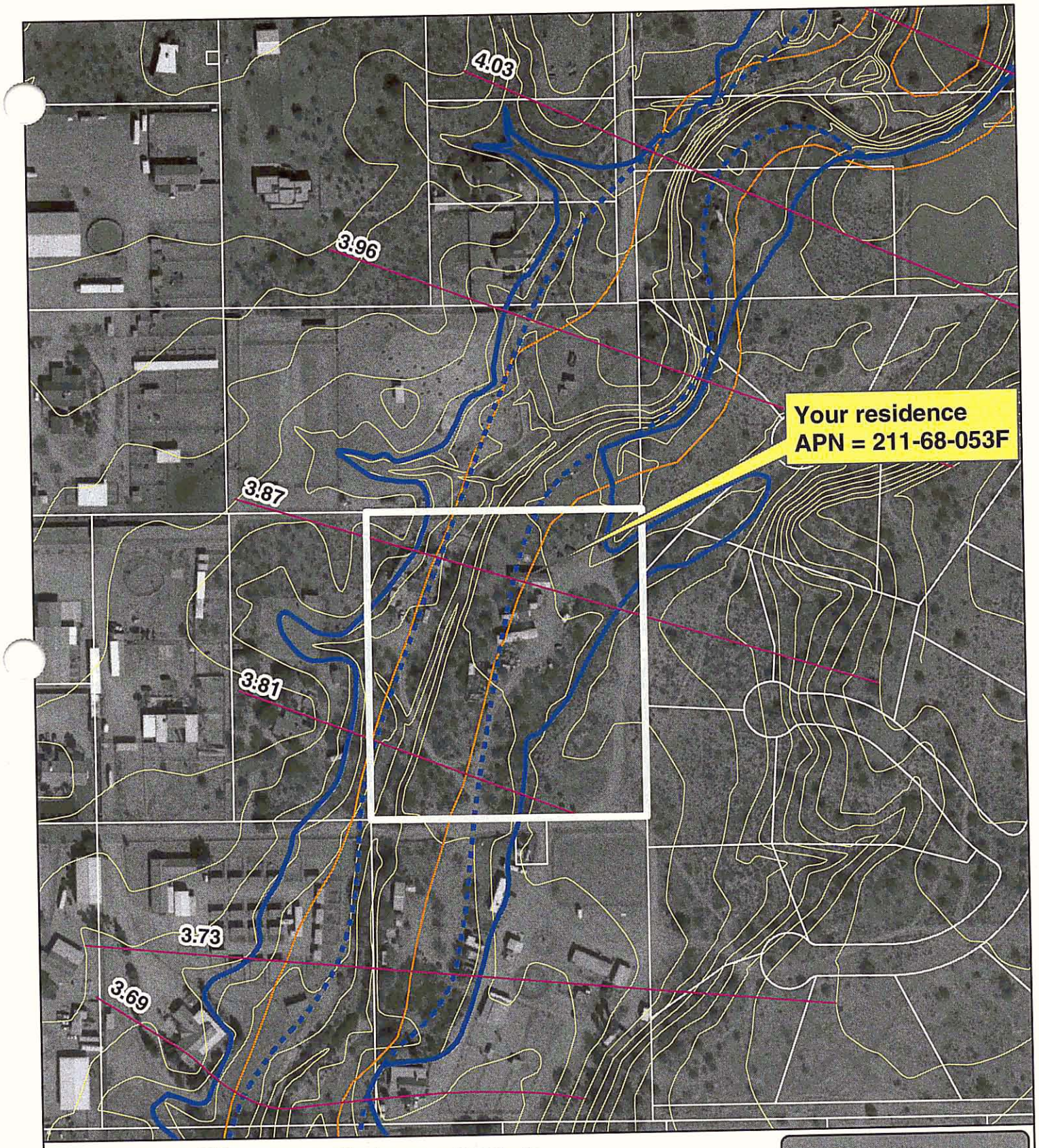


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 2,692 cfs
100-yr Water Surface Elevation = 1,839.3 ft
Finished Floor Elevation = 1,839.1 ft
Depth = 0.2 ft below 100-yr Water Surface Elevation
Velocity = 2.3 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.2 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

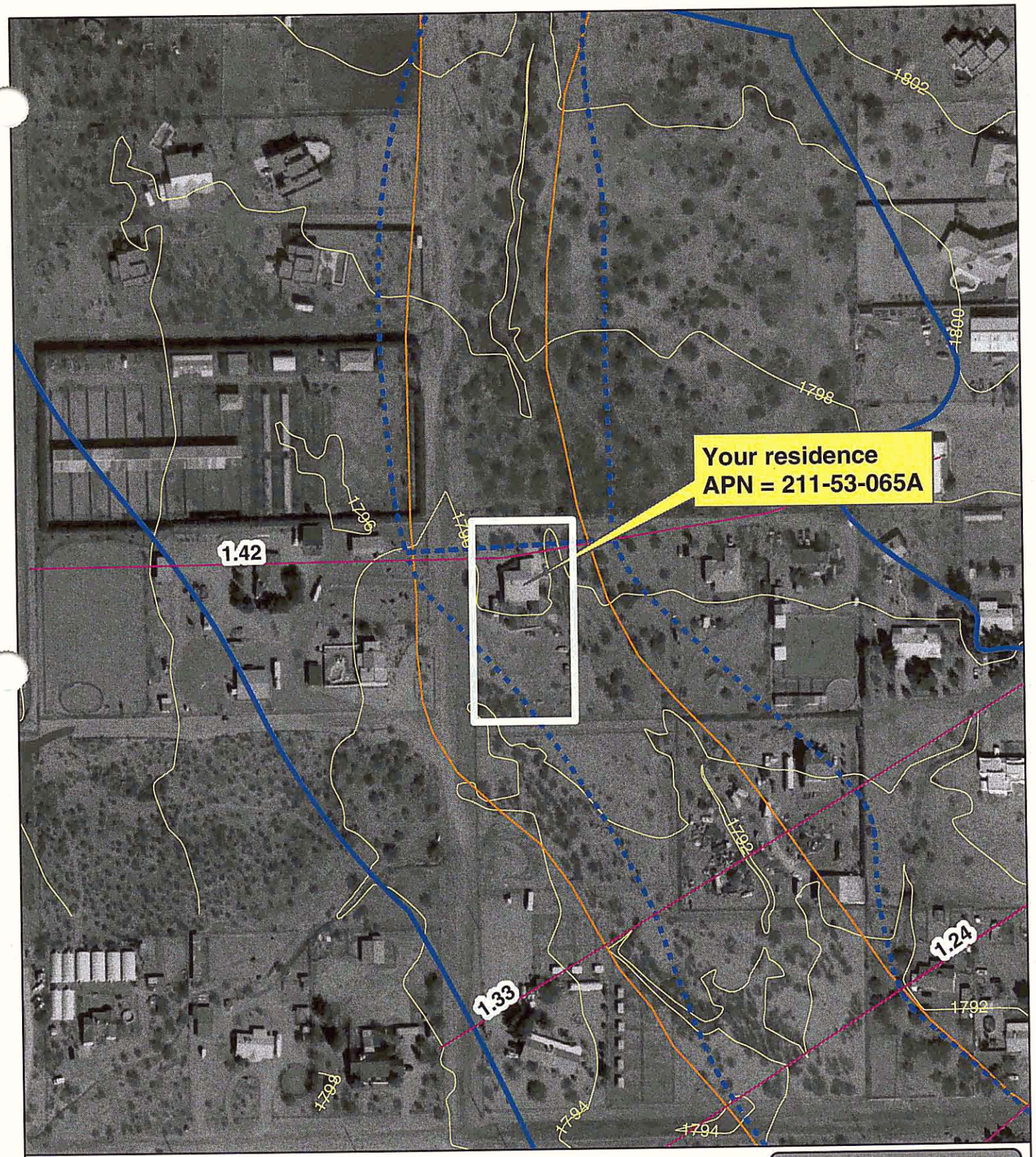


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 3,406 cfs
100-yr Water Surface Elevation = 1797.8 ft
Finished Floor Elevation = 1797.8 ft
Depth = 0 ft (at 100-yr Water Surface Elevation)
Velocity = 2.3 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

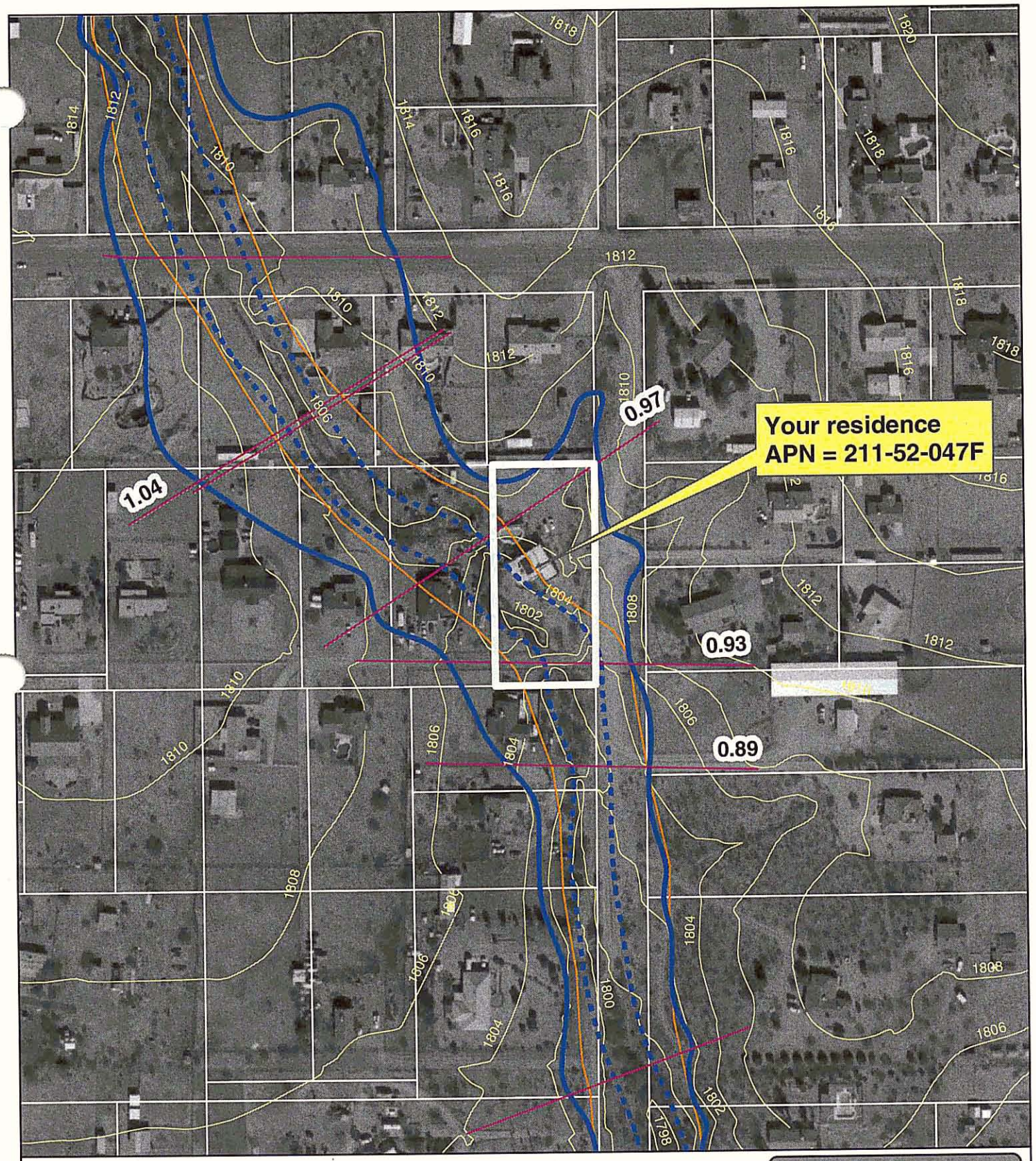


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 933 cfs
100-yr Water Surface Elevation = 1807.0 ft
Finished Floor Elevation = 1808.0 ft
Depth = 1.0 ft above 100-yr Water Surface Elevation
Velocity = 1.5 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

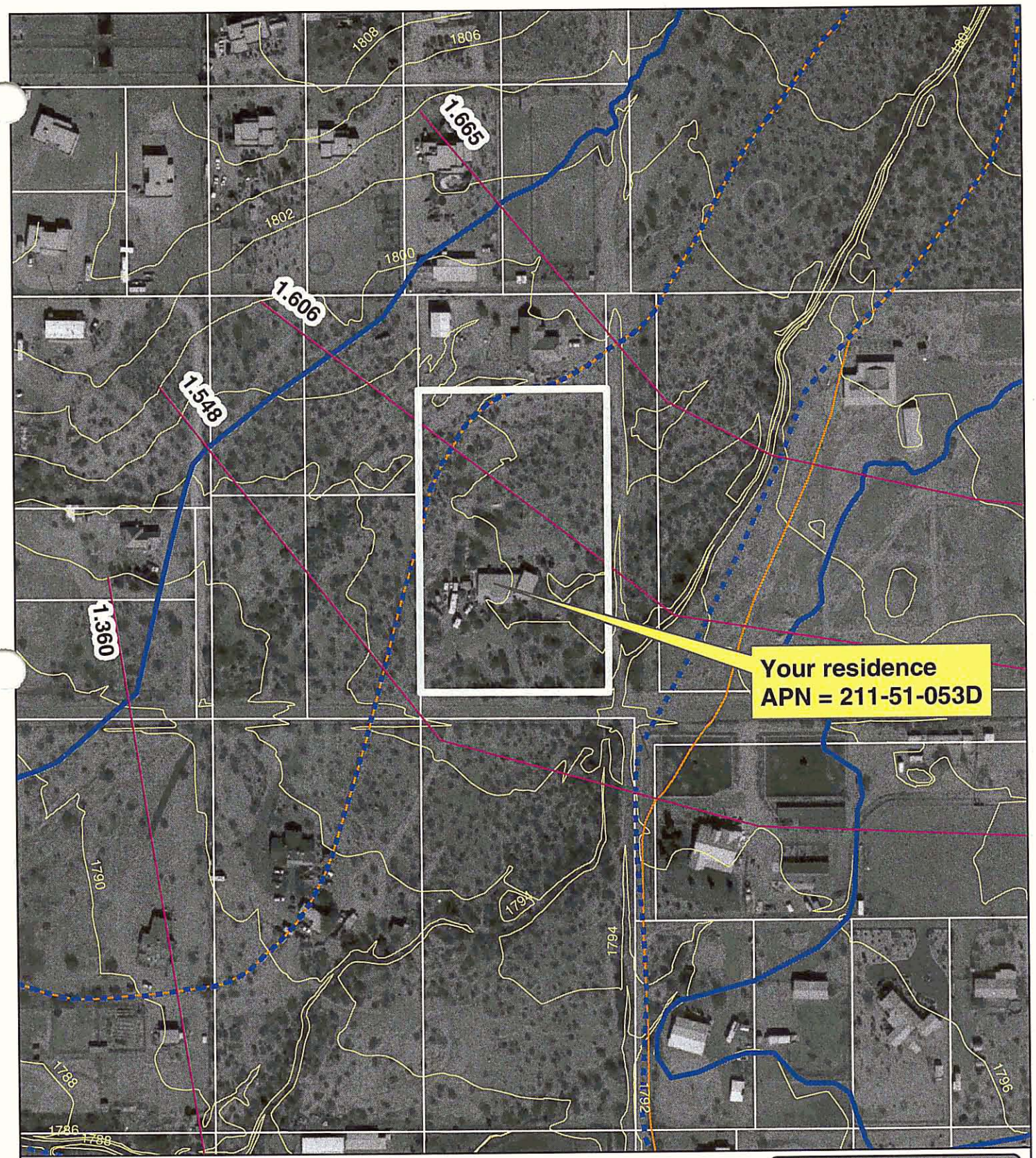


Photo date: February 2002

N

0 50 100 200

Feet

100-yr Discharge = 2,440 cfs
100-yr Water Surface Elevation = 1,798.1 ft
Finished Floor Elevation = 1,798.4 ft
Depth = 0.3 ft above 100-yr Water Surface Elevation
Velocity = 3.3 ft/s
Approximate Chance of Flooding in Any Given Year < 1%

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

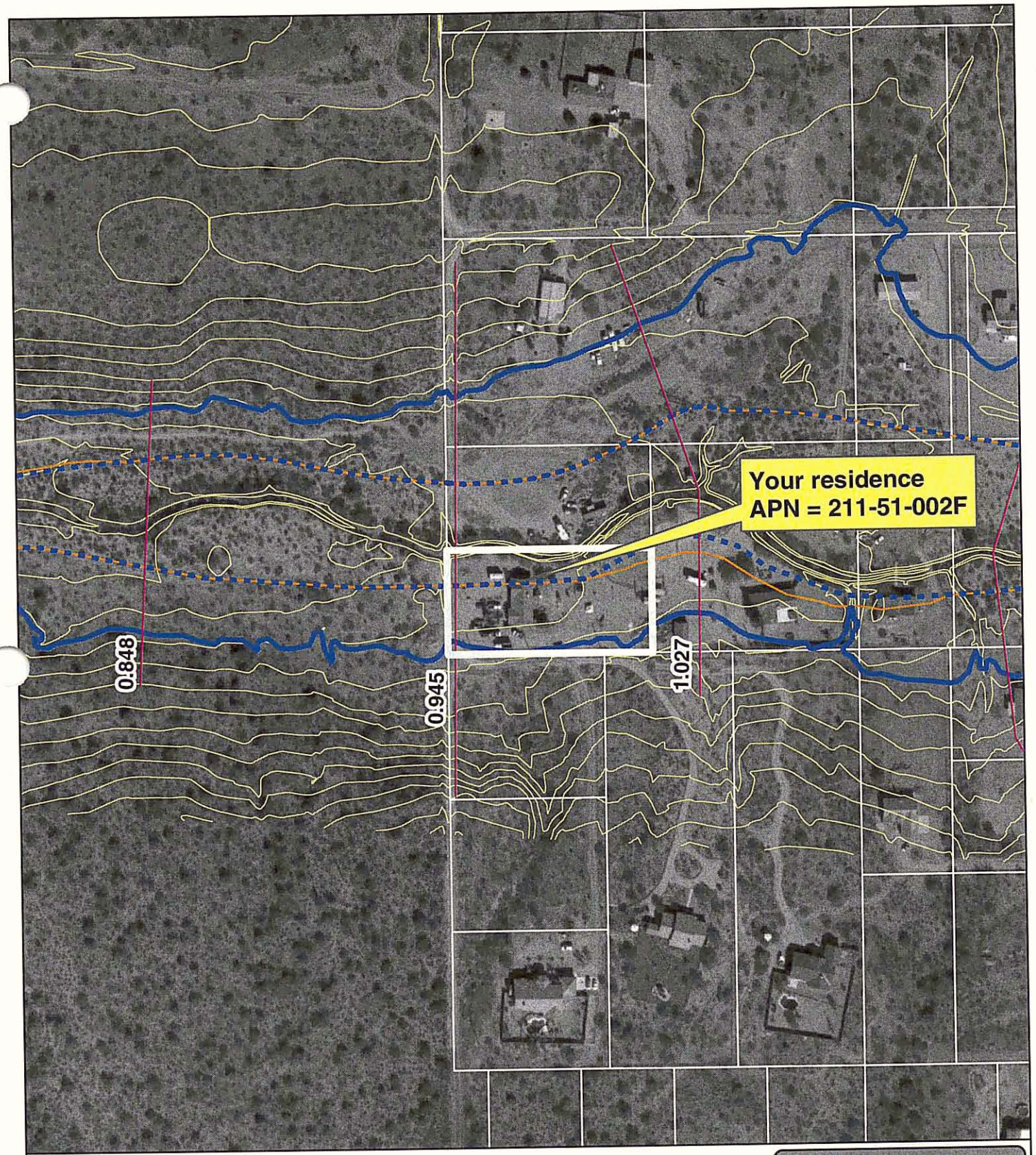


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,340 cfs
100-yr Water Surface Elevation = 1,781.0 ft
Finished Floor Elevation = 1,780.8 ft
Depth = 0.2 ft below 100-yr Water Surface Elevation
Velocity = 4.8 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.2 %

100-year Floodplain
Floodway
Erosion Hazard Zones
Cross-sections
Topography
Assessor's Parcel Boundary

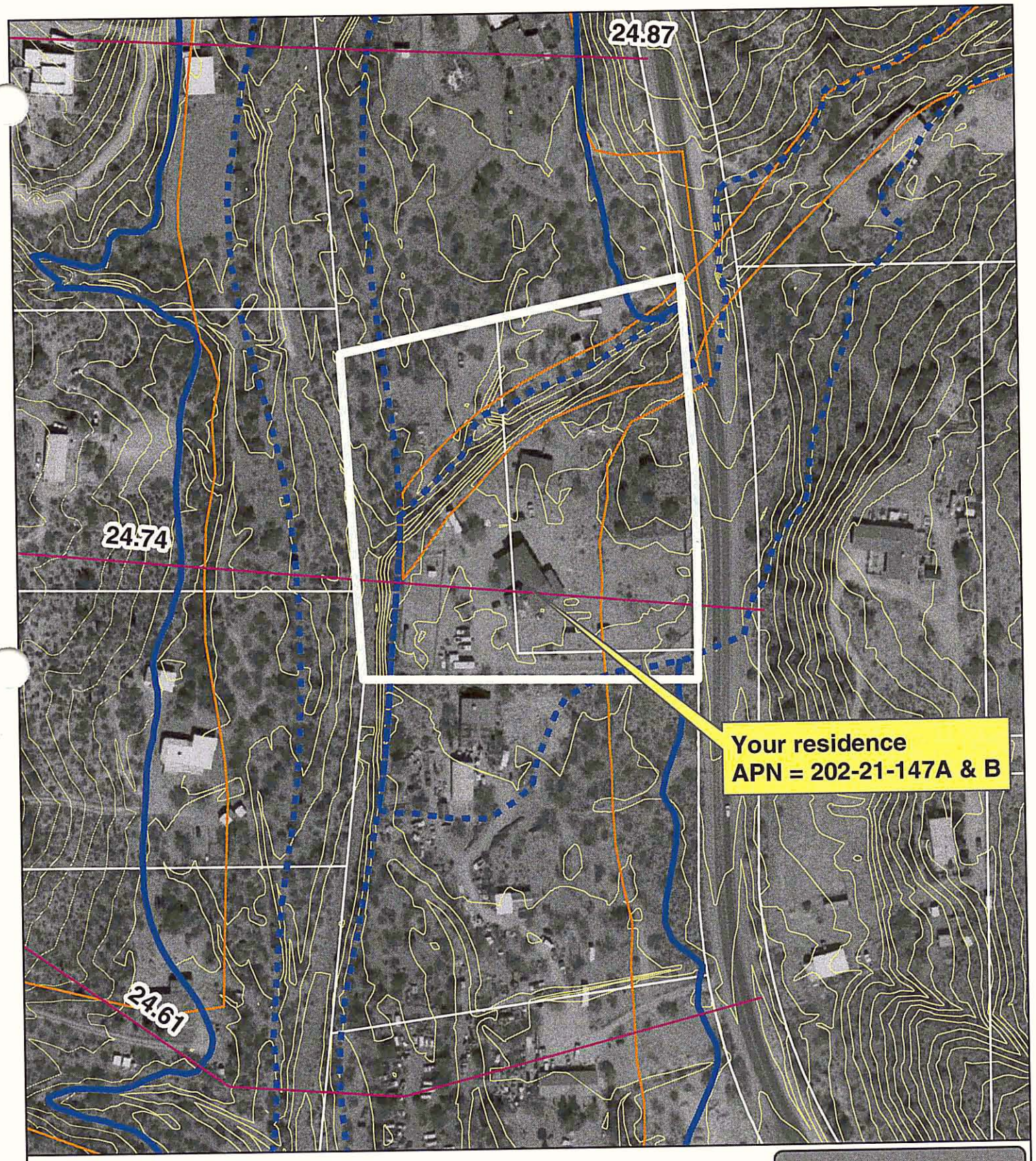


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 9,700 cfs
100-yr Water Surface Elevation = 2,056.2 ft
Finished Floor Elevation = 2,057.0 ft
Depth = 0.8 ft above 100-yr Water Surface Elevation
Velocity = 2.8 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

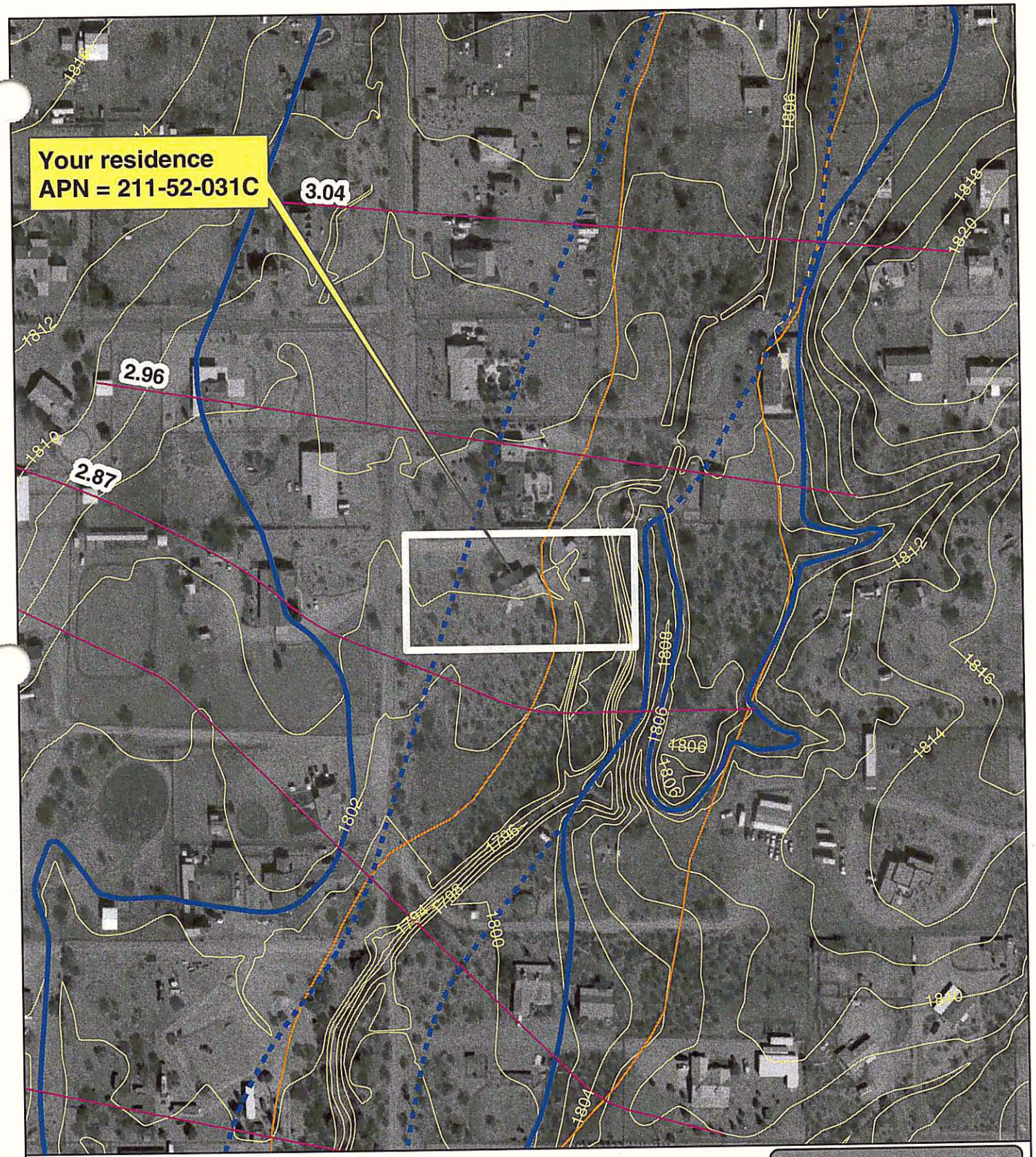


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,143 cfs
100-yr Water Surface Elevation = 1805.7 ft
Finished Floor Elevation = 1806.8 ft
Depth = 1.1 ft above 100-yr Water Surface Elevation
Velocity = 3.0 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

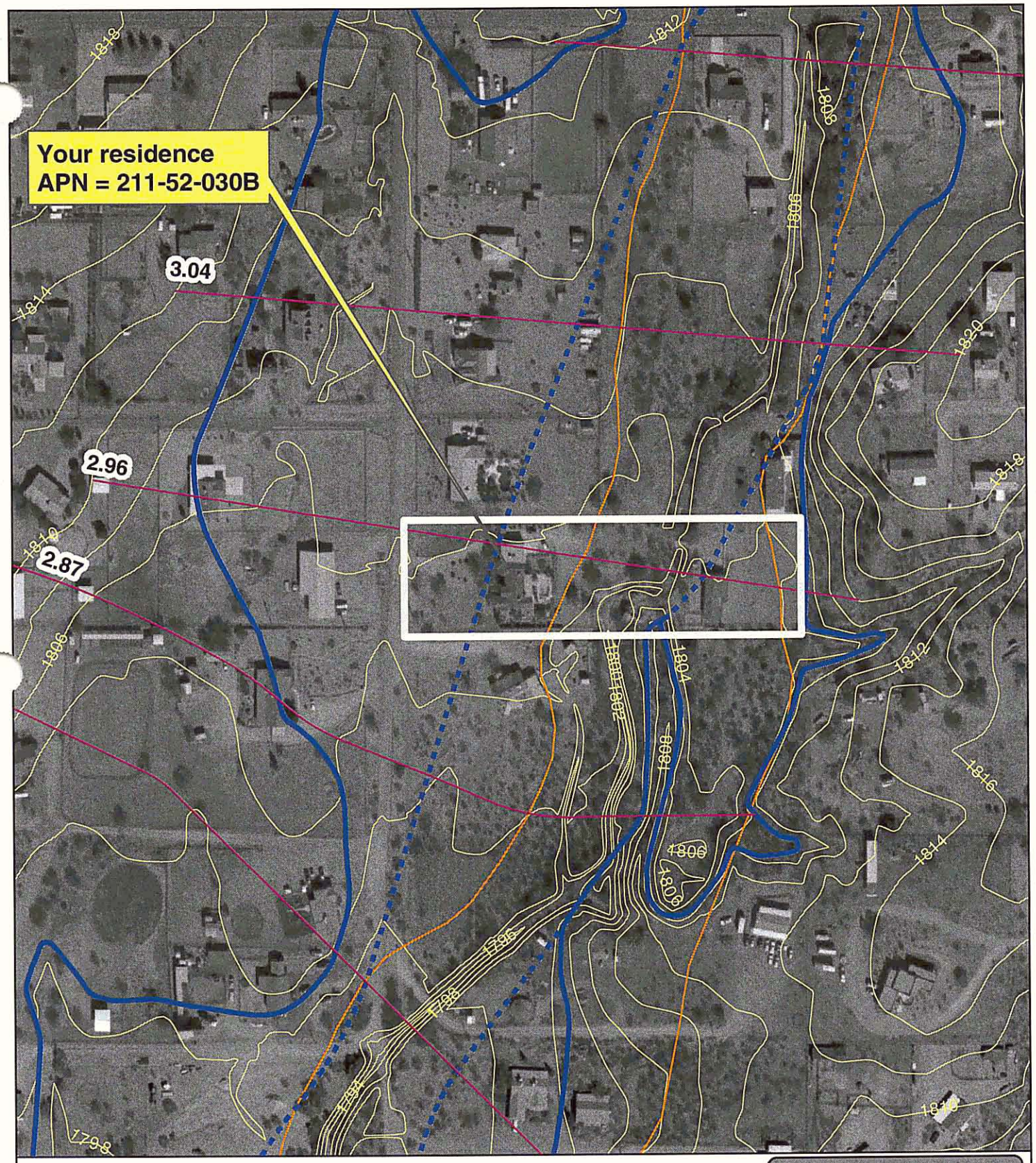


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,143 cfs
100-yr Water Surface Elevation = 1806.9 ft
Finished Floor Elevation = 1808.3 ft
Depth = 1.4 ft above 100-yr Water Surface Elevation
Velocity = 2.7 ft/s
Approximate Chance of Flooding
in Any Given Year < 1 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

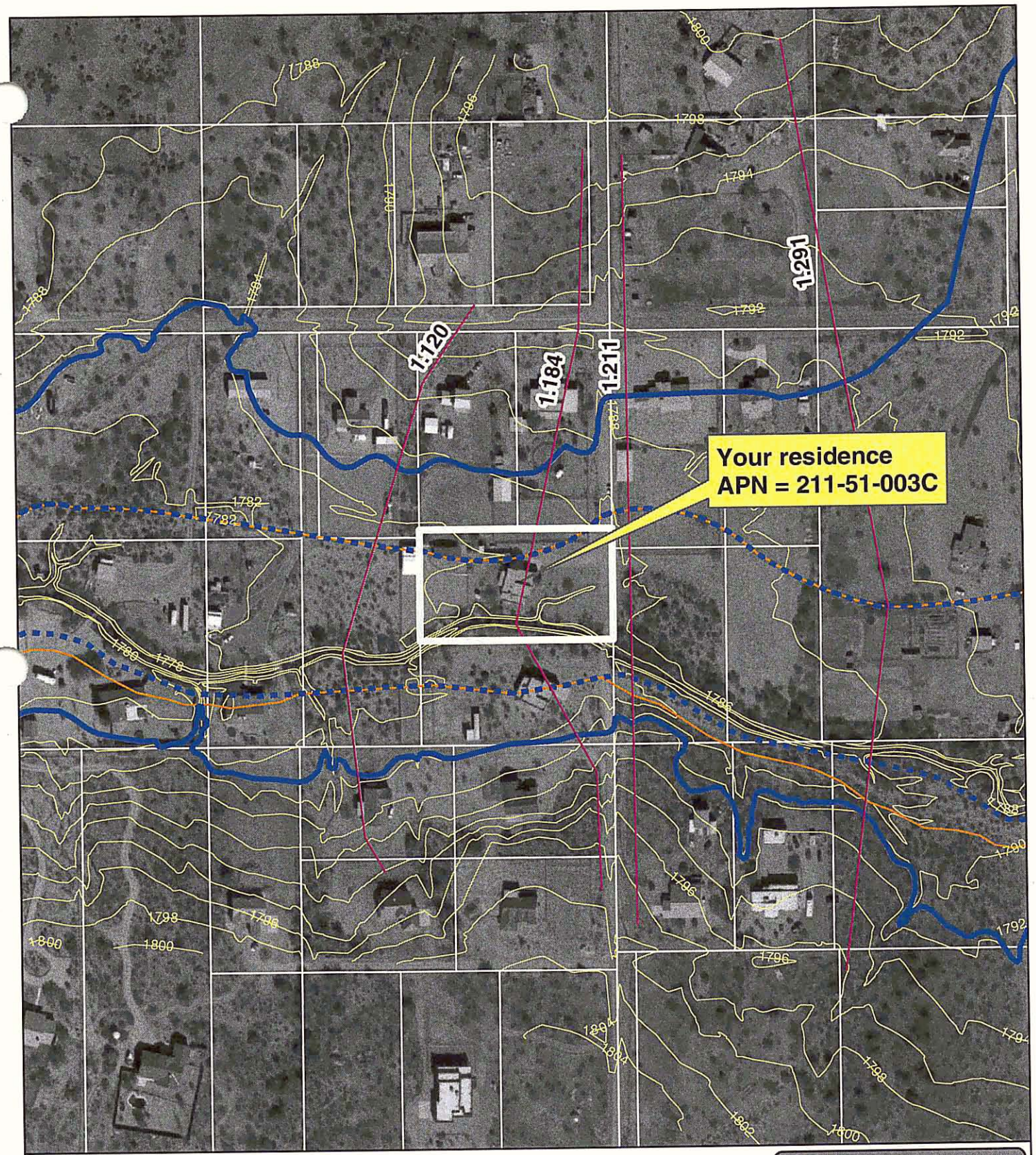


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,240 cfs
100-yr Water Surface Elevation = 1,787.1 ft
Finished Floor Elevation = 1,786.8 ft
Depth = 0.3 ft below 100-yr Water Surface Elevation
Velocity = 4.2 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.7 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

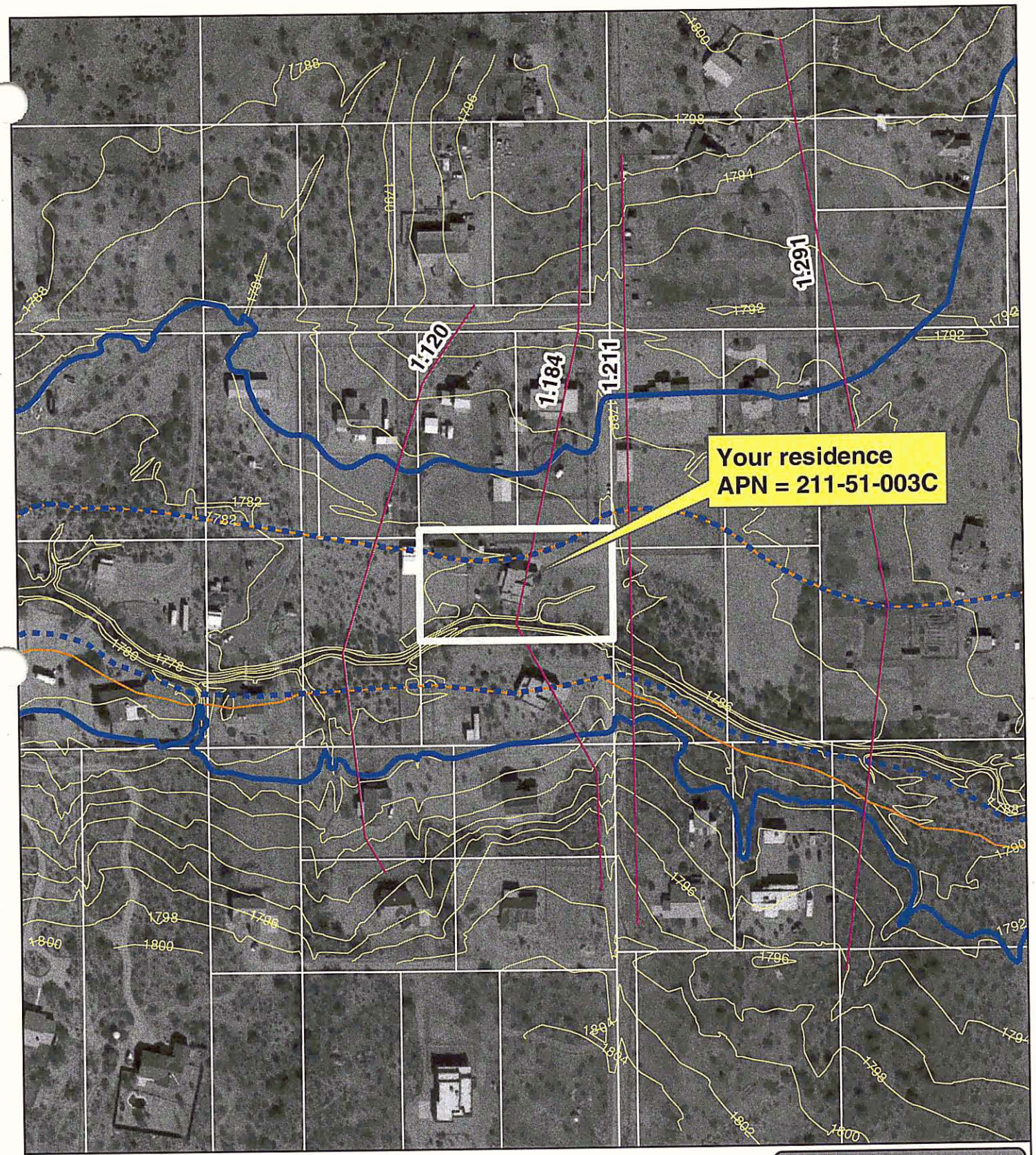


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,240 cfs
100-yr Water Surface Elevation = 1,787.1 ft
Finished Floor Elevation = 1,786.8 ft
Depth = 0.3 ft below 100-yr Water Surface Elevation
Velocity = 4.2 ft/s
Approximate Chance of Flooding
in Any Given Year = 1.7 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

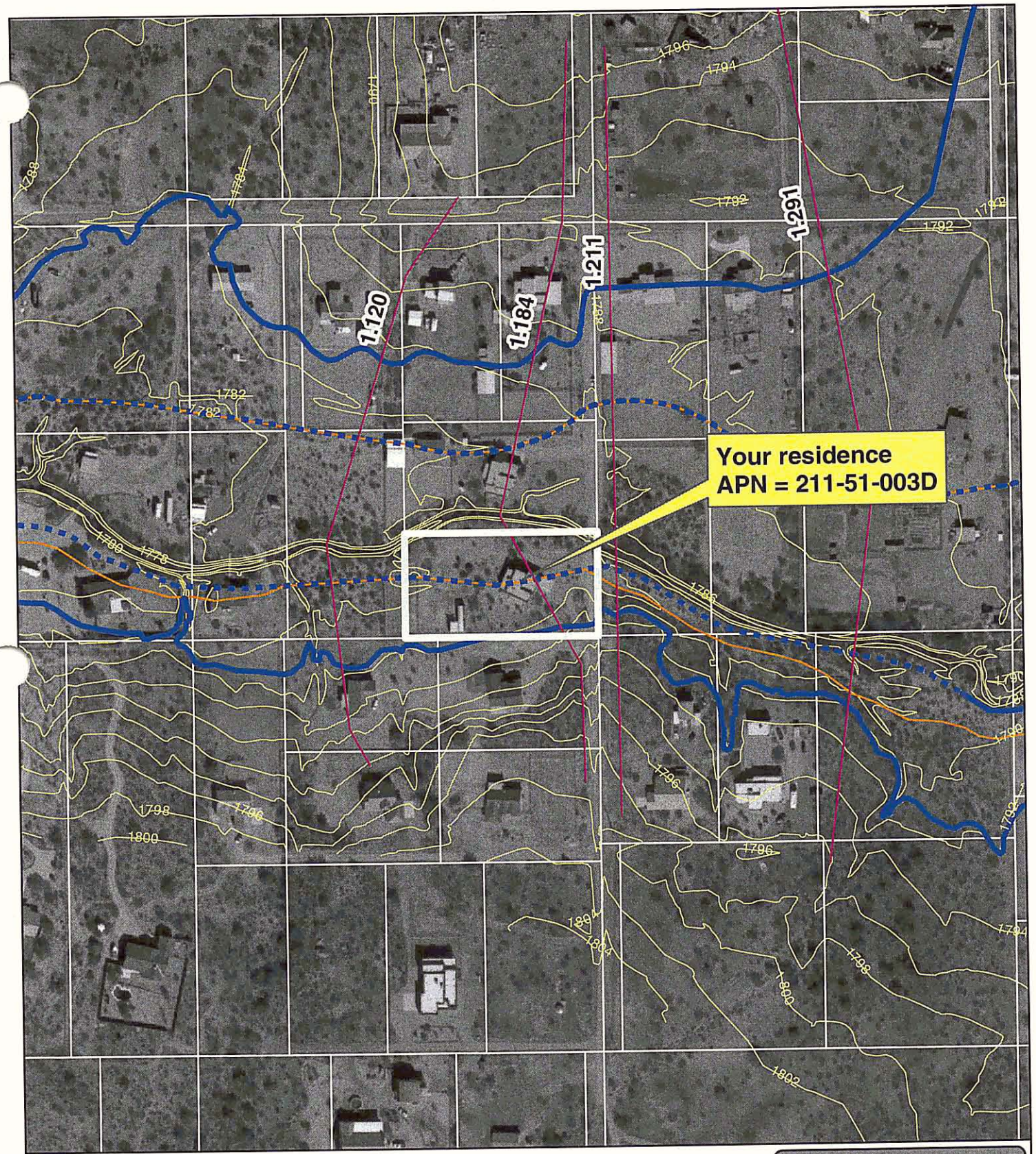


Photo date: February 2002

N

0 50 100 200
Feet

100-yr Discharge = 4,240 cfs
100-yr Water Surface Elevation = 1,787.1 ft
Finished Floor Elevation = 1,786.8 ft
Depth = 0.3 ft below 100-yr Water Surface Elevation
Velocity = 4.1 ft/s
Approximate Chance of Flooding in Any Given Year = 1.7 %

- 100-year Floodplain
- Floodway
- Erosion Hazard Zones
- Cross-sections
- Topography
- Assessor's Parcel Boundary

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21152012B**
Structure No: **2**
FFE Source: ADMP Survey
XN 3.12
W.S. Elev 1812.6

Q Total (cfs)	W.S. Elev (ft)
0	1807.8
367	1810.6
734	1811.1
1101	1811.4
1468	1811.6
1835	1811.8
2201	1812.0
2568	1812.1
2935	1812.3
3302	1812.4
3669	1812.6

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1811.6**

Q_{FFE} = 1437 RI_{FFE} = 13

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21164029**
Structure No: **3**
FFE Source: ADMP Survey
XN 7.98
W.S. Elev 1989.7

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1981.8	0	n/a
719	1985.8	0.1	2
1437	1987.0	0.2	3
2156	1987.5	0.3	7
2875	1988.0	0.4	13
3594	1988.3	0.5	22
4312	1988.6	0.6	33
5031	1988.9	0.7	46
5750	1989.2	0.8	62
6468	1989.5	0.9	80
7187	1989.7	1	100

FF_{ele} = **1987.8**

Q_{FFE} = 2618 RI_{FFE} = 11

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21164029**
Structure No: **4**
FFE Source: ADMP Survey
XN 7.944
W.S. Elev 1988.0

Q Total (cfs)	W.S. Elev (ft)
0	1979.9
719	1983.9
1437	1985.1
2156	1985.8
2875	1986.3
3594	1986.6
4312	1987.0
5031	1987.3
5750	1987.5
6468	1987.8
7187	1988.0

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1988.4**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21153046H**
Structure No: **5**
FFE Source: ADMP Survey
XN 1.18666
W.S. Elev 1793.1

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1790.0	0	n/a
341	1791.4	0.1	2
681	1791.7	0.2	3
1022	1792.0	0.3	7
1362	1792.2	0.4	13
1703	1792.4	0.5	22
2044	1792.6	0.6	33
2384	1792.8	0.7	46
2725	1792.9	0.8	62
3065	1793.0	0.9	80
3406	1793.1	1	100

FF_{ele} = **1793.0**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 3013 RI_{FFE} = 77

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20208005K**
StructureNo: **7**
FFE Source: ADMP Survey
XN 1.26322
W.S. Elev 2250.5

Q Total (cfs)	W.S. Elev (ft)
0	2247.3
317	2248.4
634	2248.8
951	2249.1
1268	2249.3
1585	2249.6
1901	2249.8
2218	2250.0
2535	2250.2
2852	2250.3
3169	2250.5

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2252.9**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20220450**
Structure No: **8**
FFE Source: ADMP Survey
XN 17.8181
W.S. Elev 2144.8

Q Total (cfs)	W.S. Elev (ft)
0	2141.2
1088	2142.6
2177	2143.1
3265	2143.4
4353	2143.7
5442	2143.9
6530	2144.1
7618	2144.3
8706	2144.5
9795	2144.6
10883	2144.8

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2145.7**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20220453**
Structure No: **9**
FFE Source: ADMP Survey
XN 20
W.S. Elev 2163.6

Q Total (cfs)	W.S. Elev (ft)
0	2160.3
1088	2160.3
2177	2161.2
3265	2161.7
4353	2162.2
5442	2162.6
6530	2162.9
7618	2163.1
8706	2163.3
9795	2163.4
10883	2163.6

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2165.7**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20220017L**
Structure No: **10**
FFE Source: *ADMP Survey*
XN 16.875
W.S. Elev 2135.8

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2132.0	0	n/a
1088	2133	0.1	2
2177	2134	0.2	3
3265	2134	0.3	7
4353	2135	0.4	13
5442	2135	0.5	22
6530	2135	0.6	33
7618	2135	0.7	46
8706	2135	0.8	62
9795	2136	0.9	80
10883	2136	1	100

FF_{ele} = **2134.2**

Q_{FFE} = 3053 RI_{FFE} = 6

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20220040K**
Structure Np: **11**
FFE Source: ADMP Survey
XN 11.2190
W.S. Elev 2187.4

Q Total (cfs)	W.S. Elev (ft)
0	2182.3
143	2184.6
286	2185.3
429	2185.8
572	2186.1
715	2186.4
858	2186.7
1001	2186.9
1144	2187.1
1287	2187.3
1430	2187.4

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2189.9**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20209031C**
Structure No: **12**
FFE Source: ADMP Survey
XN 0.189636
W.S. Elev 2155.3

Q Total (cfs)	W.S. Elev (ft)
0	2149.8
92	2153.3
184	2153.8
276	2154.1
368	2154.4
461	2154.6
553	2154.7
645	2154.9
737	2155.0
829	2155.2
921	2155.3

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2159.3**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = *n/a* RI_{FFE} = *n/a*

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20209031D**
Structure No: **13**
FFE Source: ADMP Survey
XN 0.215273
W.S. Elev 2157.4

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2153.1	0	n/a
92	2155.5	0.1	2
184	2155.9	0.2	3
276	2156.3	0.3	7
368	2156.5	0.4	13
461	2156.8	0.5	22
553	2157.0	0.6	33
645	2157.1	0.7	46
737	2157.2	0.8	62
829	2157.3	0.9	80
921	2157.4	1	100

FF_{ele} = **2159.6**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20209013K**
Structure No: **14**
FFE Source: ADMP Survey
XN 0.107
W.S. Elev 2149.0

Q Total (cfs)	W.S. Elev (ft)
0	2144.6
92	2146.4
184	2146.8
276	2147.2
368	2147.5
461	2147.8
553	2148.1
645	2148.3
737	2148.5
829	2148.7
921	2149.0

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2149.4**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = *n/a* RI_{FFE} = *n/a*

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221148**
Structure No: **15**
FFE Source: ADMP Survey
XN 24.7121*
W.S. Elev 2055.0

Q Total (cfs)	W.S. Elev (ft)
0	2044.6
970	2049.6
1940	2051.0
2910	2052.0
3880	2052.7
4850	2053.3
5820	2053.7
6790	2054.0
7760	2054.4
8730	2054.8
9700	2055.0

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2055.0**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

* = Hydraulic data from Skunk Creek though residence in floodway of Trib 10B.

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221031Z**
Structure No: **16**
FFE Source: ADMP Survey
XN 4.18181
W.S. Elev 2048.4

Q Total (cfs)	W.S. Elev (ft)
0	2040.3
1375	2044.5
2749	2045.4
4124	2046.0
5499	2046.5
6874	2046.9
8248	2047.3
9623	2047.6
10998	2047.9
12372	2048.2
13747	2048.4

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2048.2**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 12482 RI_{FFE} = 81

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Cline Creek

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20209006J**
Structure No: **18**
FFE Source: ADMP Survey
XN 12.5714
W.S. Elev 2195.2

Q Total (cfs)	W.S. Elev (ft)
0	2187.8
490	2191.0
980	2192.1
1470	2192.8
1960	2193.3
2450	2193.7
2939	2194.1
3429	2194.7
3919	2194.9
4409	2195.1
4899	2195.2

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2196.1**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Parcel #: **20208007F**
Structure: 19
EC#:
XN 0.8194
W.S. Elev 2210.2

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2206.4	0	n/a
317	2207.7	0.1	2
634	2208.2	0.2	3
951	2208.6	0.3	7
1268	2208.9	0.4	13
1585	2209.2	0.5	22
1901	2209.6	0.6	33
2218	2209.7	0.7	46
2535	2210.1	0.8	62
2852	2210.1	0.9	80
3169	2210.2	1	100

FF_{ele} = **ACCESS DENIED**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221036L**
Structure No: **20**
FFE Source: ADMP Survey
XN 2.18181
W.S. Elev 2034.4

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2026.5	0	n/a
1375	2030.2	0.1	2
2749	2031.2	0.2	3
4124	2031.8	0.3	7
5499	2032.3	0.4	13
6874	2032.7	0.5	22
8248	2033.1	0.6	33
9623	2033.4	0.7	46
10998	2033.7	0.8	62
12372	2034.1	0.9	80
13747	2034.4	1	100

FF_{ele} = **2034.5**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine QFEE and RIFEE

Parcel #: **20209013G**
Structure: **21**
EC#:
XN 2.75
W.S. Elev 2159.1

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2152.6	0	n/a
784	2155.8	0.1	2
1568	2156.5	0.2	3
2352	2157.0	0.3	7
3136	2157.4	0.4	13
3920	2157.7	0.5	22
4704	2158.0	0.6	33
5488	2158.3	0.7	46
6272	2158.6	0.8	62
7056	2158.8	0.9	80
7840	2159.1	1	100

FF_{ele} = **ACCESS DENIED**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20216004D**
Structure No: **22**
FFE Source: ADMP Survey
XN 25.95*
W.S. Elev 2119.1

Q Total (cfs)	W.S. Elev (ft)
0	2110.4
780	2115.0
1560	2116.4
2340	2117.2
3120	2117.6
3900	2117.9
4680	2118.2
5460	2118.4
6240	2118.7
7020	2118.9
7800	2119.1

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2123.1**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = *n/a* RI_{FFE} = *n/a*

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

* = Hydraulic data from Skunk Creek though residence in floodway of Trib 10A.

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221036M**
Structure No: **23**
FFE Source: ADMP Survey
XN 2.0
W.S. Elev 2032.6

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	2025.3	0	n/a
1375	2028.8	0.1	2
2749	2029.7	0.2	3
4124	2030.4	0.3	7
5499	2030.9	0.4	13
6874	2031.3	0.5	22
8248	2031.6	0.6	33
9623	2031.9	0.7	46
10998	2032.2	0.8	62
12372	2032.4	0.9	80
13747	2032.6	1	100

FF_{ele} = **2034.4**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221036F**
Structure No: **24**
FFE Source: ADMP Survey
XN 2
W.S. Elev 2032.6

Q Total (cfs)	W.S. Elev (ft)
0	2025.3
1375	2028.8
2749	2029.7
4124	2030.4
5499	2030.9
6874	2031.3
8248	2031.6
9623	2031.9
10998	2032.2
12372	2032.4
13747	2032.6

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2033.2**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21150038K**
Structure No: **26**
FFE Source: ADMP Survey
XN 2.37572
W.S. Elev 1827.2

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1822.9	0	n/a
211	1825.8	0.1	2
422	1826.2	0.2	3
633	1826.4	0.3	7
844	1826.6	0.4	13
1055	1826.7	0.5	22
1266	1826.8	0.6	33
1477	1826.9	0.7	46
1688	1827.0	0.8	62
1899	1827.1	0.9	80
2110	1827.2	1	100

FF_{ele} = **1828.5**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21153058B**
Structure No: **27**
FFE Source: ADMP Survey
XN .904444
W.S. Elev 1787.5

Q Total (cfs)	W.S. Elev (ft)
0	1782.8
341	1785.2
681	1785.7
1022	1786.1
1362	1786.4
1703	1786.6
2044	1786.8
2384	1787.0
2725	1787.2
3065	1787.3
3406	1787.5

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1788.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21168007D**
Structure No: **28**
FFE Source: ADMP Survey
XN 2.2225
W.S. Elev 1852.5

Q Total (cfs)	W.S. Elev (ft)
0	1848.2
69	1850.2
138	1850.9
208	1851.3
277	1851.5
346	1851.8
415	1851.9
484	1852.1
554	1852.2
623	1852.4
692	1852.5

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1854.4**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21174047E**
Structure No: **29**
FFE Source: ADMP Survey
XN .927
W.S. Elev 1756.5

Q Total (cfs)	W.S. Elev (ft)
0	1748.0
1026	1753.2
2052	1753.9
3078	1754.4
4104	1754.8
5130	1755.2
6155	1755.5
7181	1755.8
8207	1756.1
9233	1756.3
10259	1756.5

ratio	RI
0	0
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1753.0**

Q_{FFE} = 996 RI_{FFE} = 2

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21164015**
Structure No: **30**
FFE Source: ADMP Survey
XN 121.125 (RM 0.14)
W.S. Elev 2001.1

Q Total (cfs)	W.S. Elev (ft)
0	1994.9
219	1997.4
438	1998.2
657	1998.7
876	1999.1
1096	1999.5
1315	1999.8
1534	2000.1
1753	2000.5
1972	2000.8
2191	2001.1

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2003.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: 21167063
Structure No: **32**
FFE Source: EC-00831
XN 5.68727
W.S. Elev **1864.1**

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1856.2	0	n/a
721	1860.9	0.1	2
1443	1861.7	0.2	3
2164	1862.2	0.3	7
2885	1862.6	0.4	13
3607	1862.9	0.5	22
4328	1863.3	0.6	33
5049	1863.5	0.7	46
5770	1863.7	0.8	62
6492	1863.9	0.9	80
7213	1864.1	1	100

FF_{ele} = **1864.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21168053F**
Structure No: **34**
FFE Source: EC-00832
XN 3.864
W.S. Elev 1839.1

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1833.8	0	n/a
269	1836.1	0.1	2
538	1836.8	0.2	3
808	1837.3	0.3	7
1077	1837.7	0.4	13
1346	1838.0	0.5	22
1615	1838.2	0.6	33
1884	1838.5	0.7	46
2154	1838.7	0.8	62
2423	1838.9	0.9	80
2692	1839.1	1	100

FF_{ele} = **1838.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 2342 RI_{FFE} = 74

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21168053F**
Structure No: **35**
FFE Source: EC-00833
XN 3.852
W.S. Elev 1838.6

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1833.4	0	n/a
269	1835.7	0.1	2
538	1836.4	0.2	3
808	1836.9	0.3	7
1077	1837.2	0.4	13
1346	1837.5	0.5	22
1615	1837.8	0.6	33
1884	1838.0	0.7	46
2154	1838.2	0.8	62
2423	1838.5	0.9	80
2692	1838.6	1	100

FF_{ele} = **1838.3**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 2231 RI_{FFE} = 67

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21168053F**
Structure No: **36**
FFE Source: EC-00834
XN 3.87
W.S. Elev 1839.3

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1834.0	0	n/a
269	1836.3	0.1	2
538	1837.0	0.2	3
808	1837.5	0.3	7
1077	1837.9	0.4	13
1346	1838.2	0.5	22
1615	1838.4	0.6	33
1884	1838.7	0.7	46
2154	1838.9	0.8	62
2423	1839.1	0.9	80
2692	1839.3	1	100

FF_{ele} = **1839.1**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 2465 RI_{FFE} = 83

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21153065A**
Structure No: **37**
FFE Source: EC-00845
XN 1.4125
W.S. Elev 1797.8

Q Total (cfs)	W.S. Elev (ft)
0	1795.4
341	1796.5
681	1796.8
1022	1797.0
1362	1797.1
1703	1797.3
2044	1797.4
2384	1797.5
2725	1797.6
3065	1797.7
3406	1797.8

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1797.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 3292 RI_{FFE} = 93

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21152047F**
Structure No: **39**
FFE Source: EC-00734
XN .954
W.S. Elev 1807.0

Q Total (cfs)	W.S. Elev (ft)
0	1805.2
93	1805.8
187	1806.0
280	1806.2
373	1806.4
467	1806.5
560	1806.6
653	1806.7
746	1806.8
840	1806.9
933	1807.0

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1808.0**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21151053D**
Structure No: **40**
FFE Source: ADMP Survey
XN 1.58666
W.S. Elev 1798.1

Q Total (cfs)	W.S. Elev (ft)
0	1794.2
244	1796.9
488	1797.2
732	1797.4
976	1797.5
1220	1797.7
1464	1797.8
1708	1797.9
1952	1797.9
2196	1798.0
2440	1798.1

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1798.4**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21151002F**
Structure No: **41**
FFE Source: ADMP Survey
XN 0.963222
W.S. Elev 1781.0

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1774.1	0	n/a
434	1777.9	0.1	2
868	1778.6	0.2	3
1302	1779.2	0.3	7
1736	1779.6	0.4	13
2170	1779.9	0.5	22
2604	1780.1	0.6	33
3038	1780.4	0.7	46
3472	1780.6	0.8	62
3906	1780.8	0.9	80
4340	1781.0	1	100

FF_{ele} = **1780.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 3975 RI_{FFE} = 83

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **20221147A**
Structure No: **42**
FFE Source: ADMP Survey
XN 24.74*
W.S. Elev 2056.2

Q Total (cfs)	W.S. Elev (ft)
0	2045.8
970	2050.6
1940	2052.0
2910	2053.1
3880	2053.8
4850	2054.4
5820	2054.9
6790	2055.2
7760	2055.6
8730	2055.8
9700	2056.2

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **2057.0**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

* = Hydraulic data from Skunk Creek though residence in floodway of Trib 10B.

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine QFEE and RIFEE

Parcel #: **21152031C**
Structure No: **44**
FFE Source: EC-00839
XN 2.915
W.S. Elev 1805.7

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1800.0	0	n/a
414	1803.4	0.1	2
829	1804.0	0.2	3
1243	1804.4	0.3	7
1657	1804.7	0.4	13
2072	1804.9	0.5	22
2486	1805.1	0.6	33
2900	1805.3	0.7	46
3314	1805.4	0.8	62
3729	1805.6	0.9	80
4143	1805.7	1	100

FF_{ele} = **1806.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = *n/a* RI_{FFE} = *n/a*

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21152030B**
Structure No: **45**
FFE Source: EC-00838
XN 2.94875
W.S. Elev 1806.9

Q Total (cfs)	W.S. Elev (ft)
0	1801.5
414	1804.8
829	1805.4
1243	1805.9
1657	1806.1
2072	1806.3
2486	1806.4
2900	1806.6
3314	1806.7
3729	1806.8
4143	1806.9

ratio	RI
0	n/a
0.1	2
0.2	3
0.3	7
0.4	13
0.5	22
0.6	33
0.7	46
0.8	62
0.9	80
1	100

FF_{ele} = **1808.3**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = n/a RI_{FFE} = n/a

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21151056M**
Structure No: **46**
FFE Source: ADMP Survey
XN 2.133
W.S. Elev 1818.3

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1813.1	0	n/a
211	1817	0.1	2
422	1817	0.2	3
633	1818	0.3	7
844	1818	0.4	13
1055	1818	0.5	22
1266	1818	0.6	33
1477	1818	0.7	46
1688	1818	0.8	62
1899	1818	0.9	80
2110	1818	1	100

FF_{ele} = **1818.1**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 1711 RI_{FFE} = 64

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21151003C**
Structure No: **47**
FFE Source: ADMP Survey
XN 1.184
W.S. Elev 1787.1

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1780.1	0	n/a
424	1785.0	0.1	2
848	1785.5	0.2	3
1272	1786.0	0.3	7
1696	1786.2	0.4	13
2120	1786.4	0.5	22
2544	1786.5	0.6	33
2968	1786.7	0.7	46
3392	1786.8	0.8	62
3816	1787.0	0.9	80
4240	1787.1	1	100

FF_{ele} = **1786.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 3331 RI_{FFE} = 59

$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$

Adobe/Desert Hill ADMP Risk Assessment

Rating Table from HEC-RAS to Determine Q_{FFE} and RI_{FFE}

Parcel #: **21151003D**
Structure No: **48**
FFE Source: ADMP Survey
XN 1.184
W.S. Elev 1787.1

Q Total (cfs)	W.S. Elev (ft)	ratio	RI
0	1780.1	0	n/a
424	1785.0	0.1	2
848	1785.5	0.2	3
1272	1786.0	0.3	7
1696	1786.2	0.4	13
2120	1786.4	0.5	22
2544	1786.5	0.6	33
2968	1786.7	0.7	46
3392	1786.8	0.8	62
3816	1787.0	0.9	80
4240	1787.1	1	100

FF_{ele} = **1786.8**

Q_{FFE} = n/a RI_{FFE} = n/a

Q_{FFE} = 3331 RI_{FFE} = 59

$$RI = 118.29(ratio^2) - 21.231(ratio) + 2.9402$$

PRELIMNARY ANALYSIS
PART 8, Volume 2, Section 2
EVALUATION OF FLOODPROOFING FOR FLOODWAY RESIDENCES

Registered Professional Engineer (Civil) CERTIFICATE NO. 35895 TED W. LEHMAN Date Signed 6-17-09 ARIZONA U.S.A.

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ENCLOSED DATA CD INCLUDES:

- **Digital Copy of Report in PDF Format**

SECTION 2.1: INTRODUCTION

This section of the ADMP report briefly describes the methods, sources of data, and results of the analysis of floodproofing options and their associated costs for residences identified within the FEMA floodways in the Adobe Dam / Desert Hills ADMP (Adobe ADMP) study area.

2.1.1 Methods and Data Sources

Residences in the FEMA floodways within the Adobe ADMP study area have been previously identified as part of the ADMP Risk Assessment. In addition, the Risk Assessment provided information about the minimum finished floor elevation (FFE) of these residences relative to the Base Flood Elevation (BFE). Finally, the Risk Assessment also computed a Personal Hazard Factor (PHF) for each residence. The PHF is the product of the depth of flow at the structure and the square of the flow velocity.

Floodproofing options were taken from FEMA publication *Homeowner's Guide to Retrofitting, FEMA 312* (FEMA, 1998). Four floodproofing options were evaluated, including elevation, dry floodproofing, levees and floodwalls. Excerpts from *FEMA 312* describing each of these floodproofing options, and their advantages and disadvantages, are provided for reference. The FEMA report gives unit costs in 1998 dollars for each floodproofing option. The 1998 dollars were converted to 2003 dollars using a factor of 1.28 which is the cost assuming 5% inflation each year.

For each floodproofing option, all buildings were assumed to be slab-on-grade type construction and 2000 square feet in area. Each perimeter length used for the levee and floodwall options was assumed to be 250 ft.

Buyout costs were estimated from the Maricopa County Assessor's Office data collected as part of the ADMP. The Total Assessed Value (TAV) was converted to an approximate buyout cost using a factor of 1.25.

2.1.2 Results

Table 1 below summarizes the results of this analysis. The resolution of the analysis and the cost estimates is comparable to those reflected in the full structural alternative for Phase I of the ADMP.

The following points clarify the estimated costs summarized in Table 1 and/or provide items for consideration in assessing the feasibility of floodproofing for floodway residences:

- Floodproofing of floodway residences does not remove them from the floodway.
- Public safety concerns are not eliminated. *FEMA 312* recommends residents leave their floodway residences during flooding events even if floodproofing measures are in place.
- Building permits and/or floodplain use permits are required for construction of floodproofing measures.
- Elevation of residences or construction of floodproofing barriers around floodway homes (i.e., levees and floodwalls) may constitute obstructions to flow that potentially result in undesirable hydraulic impacts in adjacent upstream and downstream watercourse reaches. These negative impacts could include increased floodway encroachment resulting in increased water surface elevation, increased flow velocities, and/or increased erosion potential. This does not apply to the dry floodproofing method.
- The costs associated with temporarily housing floodway residents and their possessions during construction activities to elevate their homes are not included in Table 1 cost estimates.
- There are costs associated with the operation and maintenance of dry floodproofing, levees, and floodwalls that are not reflected in the Table 1 estimates. These methods also require active participation on the part of the floodway residents to implement the measure (e.g., close floodwall gate) or to maintain the integrity of the floodproofing measure in order to meet the intended purpose. This does not apply to elevation of floodway residences.

Figure 1 and Table 2 show a comparison of buyout costs of floodway residences versus the full structural measures. Note that only 8 of the 41 floodway residences are affected by the full structural measures. These costs can also be compared to the floodproofing costs presented in Table 1. Note that the cost to adequately elevate all floodway residences to at least one foot above the Base

Flood Elevation is about half of the estimated buyout costs. By comparison the full structural alternatives that would help 8 of the 41 floodway residences are estimated at two and a half to three times the buyout costs for all 41 floodway residences.

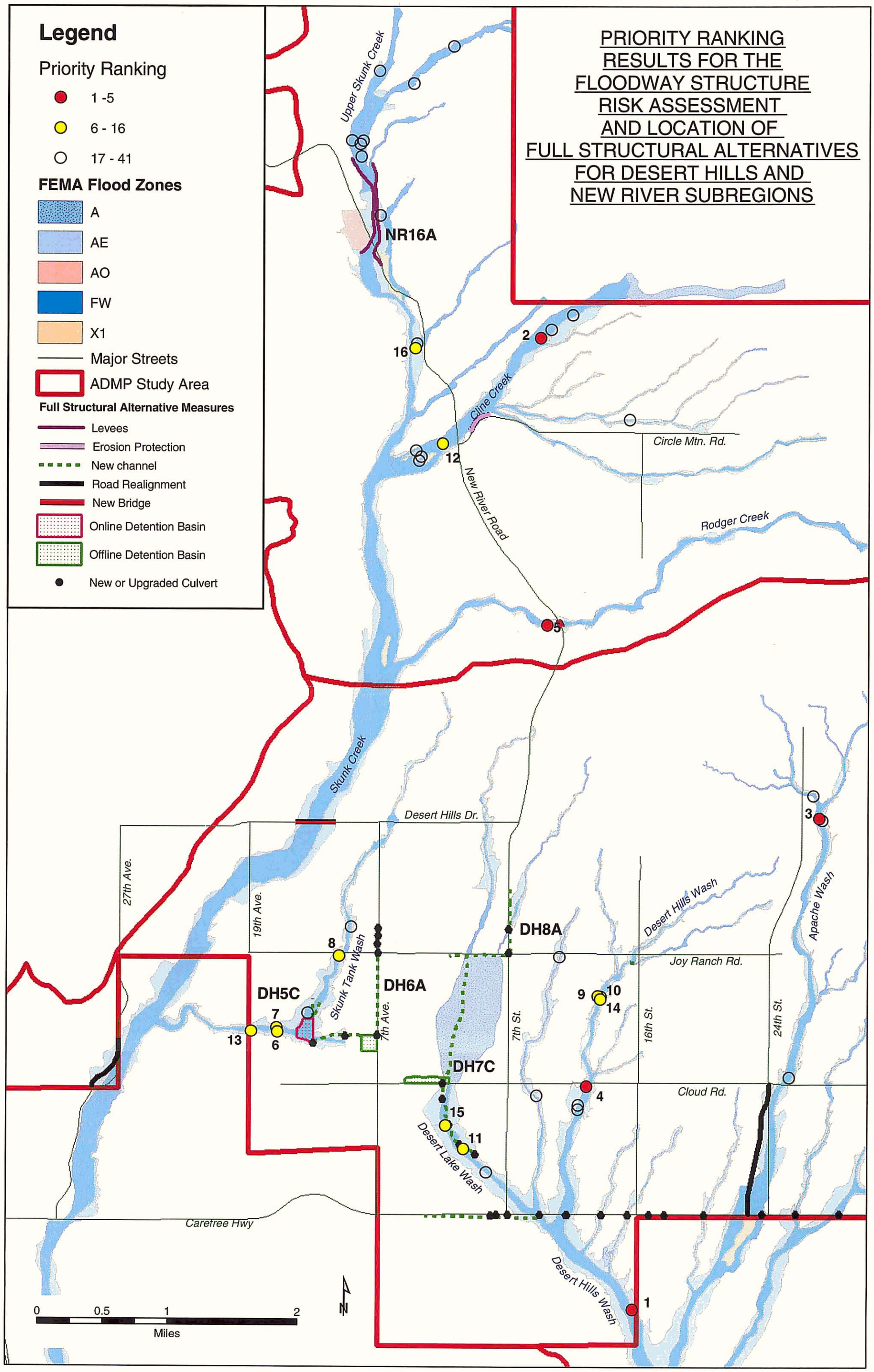
Table 1. Estimated Flood Proofing Costs for Floodway Residences in Adobe Dam/Desert Hills ADMP Study Area

				Levee		Floodwall		
		Elevate	Dry Floodproof	2 ft	4 ft	2 ft	4 ft	Buyout
	Unit Cost [1]	$ 120,000	$ 19,000	$ 20,000	$ 32,000	$ 35,000	$ 48,000	(TAV*1.25)
Group	**No. of Residences**							
PHF > 15 [2]	4	$ 480,000	$ 76,000	$ 80,000	$ 128,000	$ 140,000	$ 192,000	$ 746,156
Depth >= 1.0 ft below BFE	4	$ 480,000	$ 76,000	$ 80,000	$ 128,000	$ 140,000	$ 192,000	$ 915,531
Depth = 0 - 1 ft below BFE	12	$ 1,440,000	$ 228,000	$ 240,000	$ 384,000	$ 420,000	$ 576,000	$ 1,262,161
FFE 1-0 ft above BFE	10	$ 1,200,000	$ 190,000	$ 200,000	$ 320,000	$ 350,000	$ 480,000	$ 1,769,620
FFE more than 1 ft above BFE	13	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,167,235
Survey Denied	2	$ 240,000	$ 38,000	$ 40,000	$ 64,000	$ 70,000	$ 96,000	$ 241,004
Total	**41**	**$ 3,360,000**	**$ 532,000**	**$ 560,000**	**$ 896,000**	**$ 980,000**	**$ 1,344,000**	**$ 6,355,551**

Footnotes:

[1]Unit costs based on *FEMA 312* using an assumed 2,000 sq. ft. building with slab-on-grade construction and a perimeter of 250 linear feet for the levee and floodwall options.

[2]Personal Hazard Factor (PHF) is the product of the depth of flow at the structure and the square of the flow velocity.


PRIORITY RANKING RESULTS FOR THE FLOODWAY STRUCTURE RISK ASSESSMENT AND LOCATION OF FULL STRUCTURAL ALTERNATIVES FOR DESERT HILLS AND NEW RIVER SUBREGIONS
Legend
Priority Ranking
1 -5
6 - 16
17 - 41
FEMA Flood Zones
A
AE
AO
FW
X1
Major Streets
ADMP Study Area
Full Structural Alternative Measures
Levees
Erosion Protection
New channel
Road Realignment
New Bridge
Online Detention Basin
Offline Detention Basin
New or Upgraded Culvert
Upper Skunk Creek
NR16A
16
2
Cline Creek
Circle Mtn. Rd.
12
New River Road
Rodger Creek
5
Skunk Creek
Desert Hills Dr.
3
27th Ave.
19th Ave.
8
Skunk Tank Wash
DH8A
Desert Hills Wash
Apache Wash
Joy Ranch Rd.
DH5C
DH6A
7th Ave.
7th St.
16th St.
24th St.
9
10
14
7
13
6
DH7C
4
Cloud Rd.
15
11
Desert Lake Wash
Caretree Hwy
Desert Hills Wash
1
0
0.5
1
2
Miles
N

Structural Measure Costs with Ranked Floodway Residence Buyout Costs for Adobe ADMP Study Area

Structural Measure Location (ID)	Estimated Structure Cost	Residence Ranking Number	Total Assessed Value (TAV)	Estimated Buyout Cost (TAV *1.25)
Ranked Floodway Residences Impacted by ADMP Structural Measures				
Desert Lake Wash (DH7C, DH8A)	$3,610,000	5, 27, 37	$328,000	$410,000
Skunk Tank Wash (DH6A, DH5C)	$7,880,000	6, 7, 13, 18	$495,500	$619,375
Upper Skunk Creek (NR16A)	$4,000,000 - $6,000,000	22	$40,649	$50,811
Total	**$15,490,000 - $17,490,000**			**$1,080,186**
Ranked Floodway Residences NOT Impacted by ADMP Structural Measures				
N/A	N/A	1-4, 8-12, 14-17, 19-21, 23-26, 28-36, 38-41	$4,220,292	$5,275,365
Total	**$0**			**$5,275,365**
Total Floodway Residence Buyout Cost				**$6,355,551**

Appendix A

Excerpts from FEMA 312

An Overview of the Retrofitting Methods

Introduction

This guide describes six retrofitting methods that you should consider as you think about how to protect your house from flooding:

ELEVATION – Raising your house so that the lowest floor is above the flood level. You can do this in one of four ways.

WET FLOODPROOFING – Making uninhabited portions of your house resistant to flood damage and allowing water to enter during flooding.

RELOCATION – Moving your house out of the floodplain to higher ground where it will not be exposed to flooding.

DRY FLOODPROOFING – Sealing your house to prevent flood waters from entering.

LEVEES AND FLOODWALLS – Building a floodwall or levee around your house to hold back flood water.

DEMOLITION– Tearing down your damaged house and either rebuilding properly on the same property or buying or building a house elsewhere.

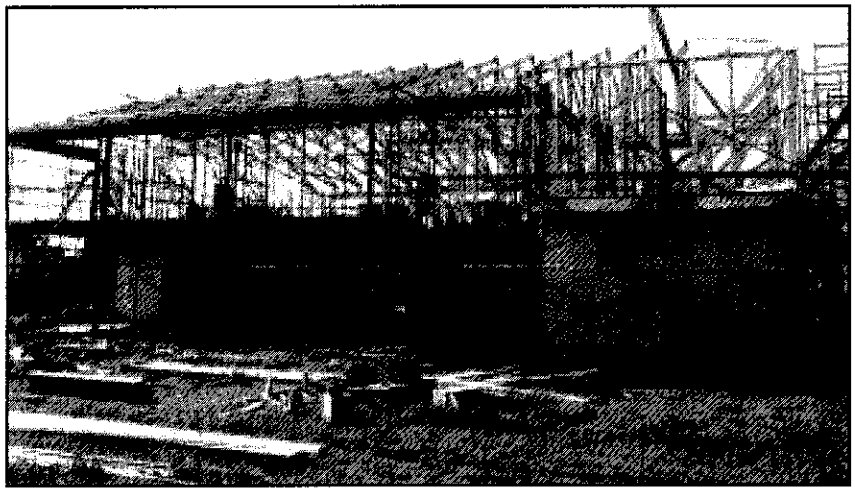


Figure 3-6
The owner of this floodprone house in south Florida decided to build a new frame second story on top of his masonry first story. The new second story is well above the BFE.

Table 3.1

ADVANTAGES AND DISADVANTAGES OF ELEVATION

ADVANTAGES	DISADVANTAGES
• **Elevation to or above the BFE allows a substantially damaged or substantially improved house to be brought into compliance with your community's floodplain management ordinance or law.** • Elevation reduces the flood risk to the house and its contents. • Except where a lower floor is used for storage, elevation eliminates the need to move vulnerable contents to areas above the water level during flooding. • Elevation often reduces flood insurance premiums. • Elevation techniques are well-known, and qualified contractors are often readily available. • Elevation does not require the additional land that may be needed for the construction of floodwalls or levees. • Elevation reduces the physical, financial, and emotional strain that accompanies floods.	• Cost may be prohibitive. • The appearance of the house may be adversely affected. • Access to the house may be adversely affected. • The house must not be occupied during a flood. • Unless special measures are taken, elevation is not appropriate in areas with high-velocity flows, waves, fast-moving ice or debris flow, or erosion. • Additional costs are likely if the house must be brought into compliance with current code requirements for plumbing, electrical, and energy systems. • Potential wind and earthquake loads must be considered.

WARNING

Because dry floodproofing requires human intervention, you must be willing and able to install all flood shields and carry out all other activities required for the successful operation of the dry floodproofing system. As a result, not only must you be physically capable of carrying out these activities, you must be home or able to go home in time to do so before flood waters arrive.

Table 3.7

ADVANTAGES AND DISADVANTAGES OF DRY FLOODPROOFING

ADVANTAGES	DISADVANTAGES
• Dry floodproofing reduces the flood risk to the house and its contents. • Dry floodproofing may be less costly than other retrofitting methods. • Dry floodproofing does not require the additional land that may be needed for levees and floodwalls (discussed later in this chapter). • Dry floodproofing reduces the physical, financial, and emotional strain that accompanies floods.	• **Dry floodproofing may not be used to bring a substantially damaged or substantially improved house into compliance with your community's floodplain management ordinance or law.** • Ongoing maintenance is required. • Flood insurance premiums are not reduced for residential structures. • Installing temporary protective measures, such as flood shields, requires human intervention and adequate warning time. • If the protective measures fail or the FPE is exceeded, the effect on the house will be the same as if there were no protection at all. • If design loads are exceeded, walls may collapse, floors may buckle, and the house may even float, potentially resulting in more damage than if the house were allowed to flood. • The house must not be occupied during a flood. • Flood shields may not be aesthetically pleasing. • Damage to the exterior of the house and other property may not be reduced. • Shields and sealants may leak, which could result to damage to the house and its contents. • Dry floodproofing does nothing to minimize the potential damage from high-velocity flood flow and wave action.

ADVANTAGES AND DISADVANTAGES OF LEVEES AND FLOODWALLS

Table 3.9

ADVANTAGES	DISADVANTAGES
• The house and the area around it will be protected from inundation, and no significant changes to the house will be required. • Flood waters cannot reach the house or other structures in the protected area and therefore will not cause damage through inundation, hydrodynamic pressure, erosion, scour, or debris impact. • The house can be occupied during construction of levees and floodwalls. • Levees and floodwalls reduce the flood risk to the house and its contents. • Levees and floodwalls reduce the physical, financial, and emotional strain that accompanies flood events.	• **Levees and floodwalls may not be used to bring a substantially damaged or substantially improved house into compliance with your community's floodplain management ordinance or law.** • Cost may be prohibitive. • Periodic maintenance is required. • Human intervention and adequate warning time are required to close any openings in a levee or floodwall. • If a levee or floodwall fails or is overtopped by flood waters, the effect on the house will be the same as if there were no protection at all. • An interior drainage system must be provided. • Local drainage can be affected, possibly creating or worsening flood problems for others. • The house must not be occupied during a flood. • Access to the house may be restricted. • Levees and floodwalls do not reduce flood insurance rates. • Floodplain management requirements may make levees and floodwalls violations of codes and/or regulations. • A large area may be required for construction, especially for levees. • Hydrostatic pressure on below-ground portions of a house may still be a problem, so levees and floodwalls are not good retrofitting methods for houses with basements.

Demolition (Chapter 7)

Demolition, as a retrofitting method, is tearing down a damaged house and either rebuilding properly somewhere on the same property or moving to a house on other property, outside the regulatory floodplain. This retrofitting method may be the most practical of all those described in this guide when a house has sustained extensive damage, especially severe structural damage.

Whether you rebuild or move, you must tear down your damaged house and then restore the site. Site restoration usually involves filling in a basement, grading, and landscaping. As a result, you will probably need the services of a demolition contractor. The contractor will disconnect and cap all utility lines at the site and then raze the house with a bulldozer or other heavy equipment. If you decide to rebuild on the old site or somewhere else on the same property, your construction contractor may be able to do the demolition and site restoration work as part of the house construction.

Remember, all demolition, construction, and site restoration work must be done according to the regulatory requirements of your community. Permits may be required for all or part of this work. If you decide to rebuild on the site of your old house, you must rebuild properly, which means ensuring that the lowest floor of your new house is at or above the FPE. You can do this by elevating your new house on an extended foundation as described in the *Elevation* section in this chapter or on compacted fill dirt. If your property includes an alternative building site outside the regulatory floodplain, a better approach is to build on that site, where you can use standard construction practices, including the construction of a basement. Remember, if you rebuild on the existing site, within the regulatory floodplain, your community's floodplain management ordinance or law will not allow your new house to have a basement (as defined by the NFIP regulations).

The advantages and disadvantages of demolition vary depending on which of the following three options you choose:

1. rebuilding on the existing site
2. rebuilding on an alternative, flood-free site elsewhere on your existing property
3. moving to a house on other property, outside the regulatory floodplain

The advantages and disadvantages of option 1 are same as those listed in Table 3.1 for the elevation method (see page 43). The advantages and disadvantages of options 2 and 3 are the same as those listed in Table 3.5 for the relocation method (see page 51), with the following exceptions: If you choose option 2, you will avoid the need to buy new property and dispose of your existing property.

If you decide to demolish your damaged house and rebuild somewhere on your existing property (option 1 or 2 above), your costs will be those for tearing down the damaged house, building the new house, reconnecting utility lines, and restoring the site around the new house. If you decide to move to a house outside the regulatory floodplain (option 3), your costs will be those for tearing down the damaged house, buying or building a house elsewhere, capping and abandoning the old utility lines, and restoring the old site.

The cost of tearing a house down, which is not a complex or difficult job, will be almost entirely for the disposal of the resulting debris. This cost can vary widely depending on the amount of debris, whether it can be buried at the demolition site or must be hauled to a licensed disposal site, and whether a dumping fee is required at the disposal site. The major costs associated with the demolition method will be for building or buying a house and will therefore depend on how and where you build or on the type of house you buy. Be sure to get a complete cost estimate before you begin a demolition project.

NOTE

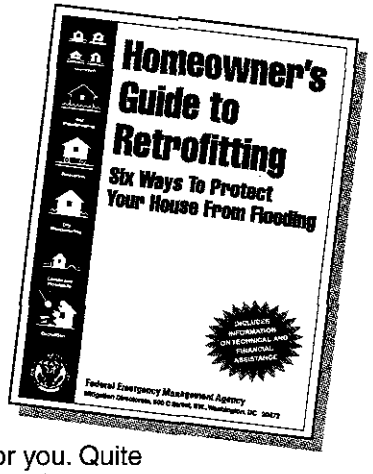
As discussed in *Financial Assistance for Retrofitting* in Chapter 2, the cost of demolishing a substantially damaged house may be an eligible flood insurance claim under ICC coverage.

Summary

To protect your house from flooding, you may be able to use one or more of the retrofitting methods described in this chapter. However, as noted in this chapter, some retrofitting methods are probably inappropriate for your house, and some may not be allowed by your state or community. Also, if the substantial damage and substantial improvement requirements do not apply to your house, you may be faced with decisions about the level of protection you are willing to pay for and the level of risk you are willing to accept.

Chapter 4 will help you decide on a method. Then, depending on your decision, you can move on to Chapter 5, 6, or 7 for a detailed look at your preferred method.

Who The Guide Is For



As a homeowner, you need clear information about the options that are available to reduce flood damage to your home – and straightforward guidance on selecting the option that is best for you. Quite often this is a difficult task. The publication described here is for readers who have little or no knowledge of flood protection methods or building construction techniques.

You should take action to avoid repetitive flood damage to your house. First, you need to know what damage-reduction methods are available, the degree to which they work, how much they cost, and whether they meet your needs. All of these questions are answered by the guide. In addition, the guide explains how the degree of flood risk varies from one location to another. By knowing the basic questions to ask, you are guided towards the investment in retrofitting that is appropriate for you.

You can download FEMA 312, or parts of it, from FEMA's web site –
http://www.fema.gov/mit/rfit/

Some retrofitting techniques may not be used in certain circumstances under state or local laws, ordinances, or regulations.

Want To Learn More?

Homeowner's Guide to Retrofitting: Six Ways To Protect Your House From Flooding is FEMA publication 312.
Call 1-800-737-8669 to get a copy of this important guide. For copies of other FEMA publications, including those listed below, call 1-800-480-2520.

Related Publications

- **FEMA 55**
  Coastal Construction Manual
- **FEMA 257**
  Mitigation of Flood and Erosion Damage
- **FEMA 102**
  Floodproofing Non-Residential Structures

Recommended for Architects and Engineers —

- **FEMA 259**
  Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings

State and local representatives of emergency management, emergency services, floodplain management, building code, and planning and zoning agencies may have copies of FEMA 312 for immediate distribution.

Elevation

Wet Floodproofing

Relocation

Dry Floodproofing

Levees and Floodwalls

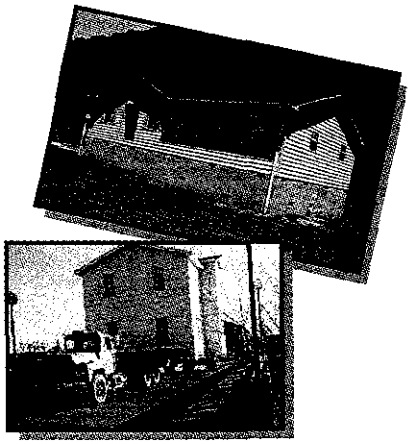
Demolition

PROJECT IMPACT

FEMA-L235

Homeowner's Guide to Retrofitting

Six Ways To Protect Your House From Flooding



Federal Emergency Management Agency
Mitigation Directorate
Washington, DC 20472
www.fema.gov

What Is "Retrofitting"?

Retrofitting means making changes to an existing building to protect it from flooding or other hazards such as high winds and earthquakes. FEMA publication 312, ***Homeowner's Guide to Retrofitting:*** *Six Ways To Protect Your House From Flooding*, provides information that will help you decide whether your house is a candidate for retrofitting.

The guide helps by describing six retrofitting methods that protect your house from flooding.

Elevation is raising your house so that the lowest floor is above the flood level. This is the most common way to avoid flood damage.

Wet floodproofing makes uninhabited parts of your house resistant to flood damage when water is allowed to enter during flooding.

Relocation means moving your house to higher ground where the exposure to flooding is eliminated altogether.

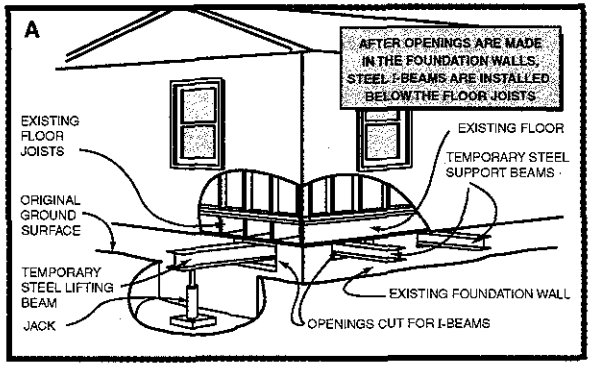
Dry floodproofing is sealing your house to prevent flood waters from entering.

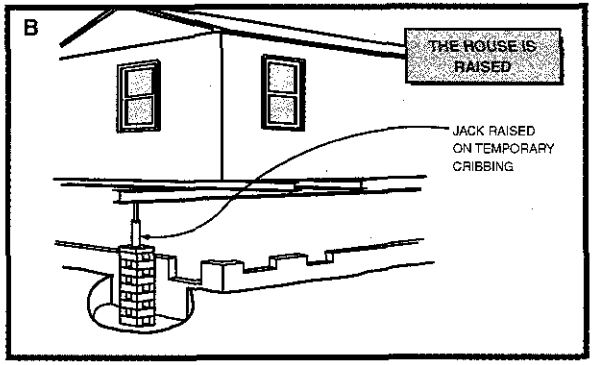
Levee and floodwall protection means constructing barriers to prevent flood waters from entering your house.

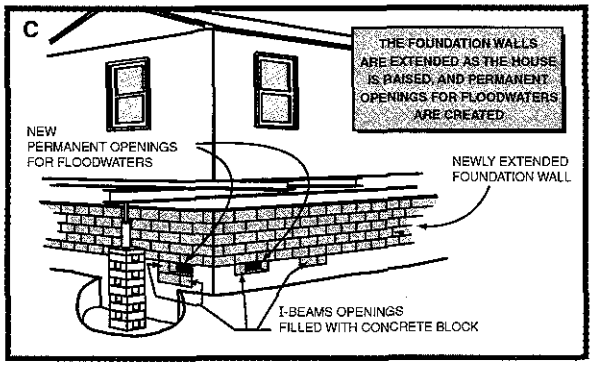
Demolition means razing your house and rebuilding properly on the same property or buying a house elsewhere.

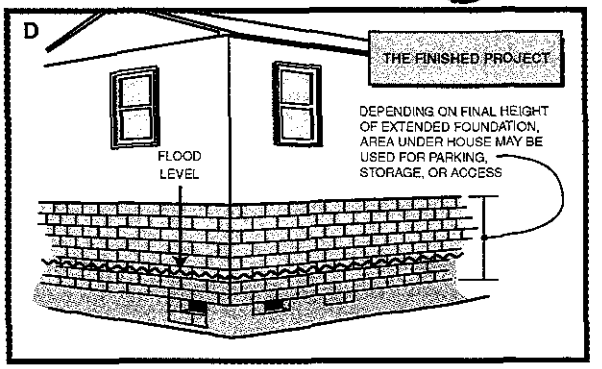
The guide uses photographs and illustrations to help explain how each of the six retrofitting methods works.

For example, this series of figures from the guide shows how a house on a basement or crawlspace foundation can be elevated above the flood level on extended foundation walls.









The Next Step

Whether or not your house has been damaged by flooding, contact your local floodplain administrator or building official before retrofitting. This contact is the critical next step in reducing your potential flood losses. Local officials know the retrofitting methods that meet state and local government requirements.

Financial Assistance

The guide provides information on government and non-government financial assistance that can help homeowners with retrofitting projects. Financial assistance means loans, grants, and insurance payments. The assistance goes to individual property owners, communities, and states.

For example, under FEMA's National Flood Insurance Program, a policy holder may qualify for Increased Cost of Compliance (ICC) coverage. If your house is substantially damaged by flooding, ICC coverage may help pay for some types of retrofitting. Other programs, such as the Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program are designed to help financially. The guide describes many government and non-government programs, and it explains how you might qualify for assistance.

Draft

INTERIM RULES OF DEVELOPMENT for INDIVIDUAL SINGLE-FAMILY LOTS

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SECTION 3.1: INTRODUCTION

3.1.1 Overview

Rules of Development are a work product of an Area Drainage Master Plan (ADMP). This plan is based on an Area Drainage Master Study (ADMS) which develops hydrology for a watershed, identifies potential flood prone areas and drainage problems, and identifies alternatives for solving these problems. There are 48 identified study areas within the jurisdiction of the Flood Control District of Maricopa County (FCDMC). To date there have been 32 studies completed, and the remainder are projected to be completed by 2010. See Figure 1.1.1 for the general boundaries of all 48 study areas.

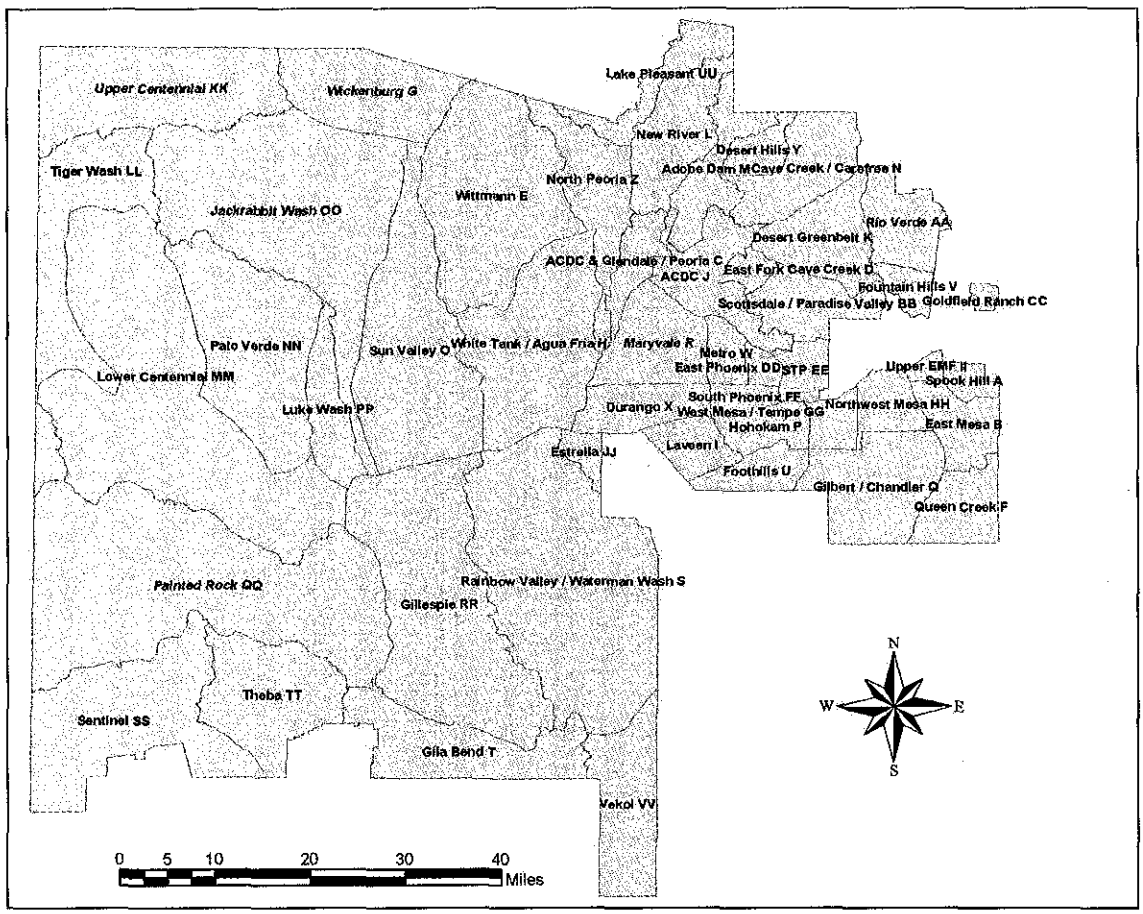

Figure 1.1.1
Maricopa County Drainage Study Areas

The ADMP takes the information from the ADMS and analyzes the alternatives to reach a preferred solution. The solutions proposed are both structural (such as levees, basins, culverts and channels) and non-structural (such as rules of development, flood warning system, and property acquisition) in nature.

The Adobe Dam/Desert Hills study area is located in the north central portion of the Phoenix metropolitan area. See Figure 1.1.2 below. The southern half of the study area lies predominantly within the incorporated limits of the City of Phoenix. The Town of Cave Creek covers a small area in the northeastern portion of the study area. The majority of the northern portion of the study area is unincorporated Maricopa County.

Counties lack the regulatory authority to manage lot splits. As a result, these types of land division are exempt from subdivision and/or other improvement requirements. Although impacts from lot split development may appear relatively insignificant when viewed on the individual lot basis, frequently the cumulative impact of such external impacts is much more significant. Counties have greater ability to review residential subdivisions, multi-family, industrial and commercial projects to address potential impacts on adjacent properties. Cities have the authority to review and require compliance with development standards for the above projects, as well as individual lots.

In reviewing these issues, it became apparent that rules of development would have the most positive affect on single-family development on individual lots within the unincorporated areas of Maricopa County. Therefore, the analysis of the types of potential regulations, as well as the review process proposed, was done with a specific focus on the nature of single-family development on individual lots. In addition to developing the technical standards for the rules of development, Section 2.2.5 of the scope of work requires that "(T)he CONSULTANT shall develop possible methods to implement the Guidelines within the County." Therefore, an implementation strategy has also been developed for these specific rules of development.

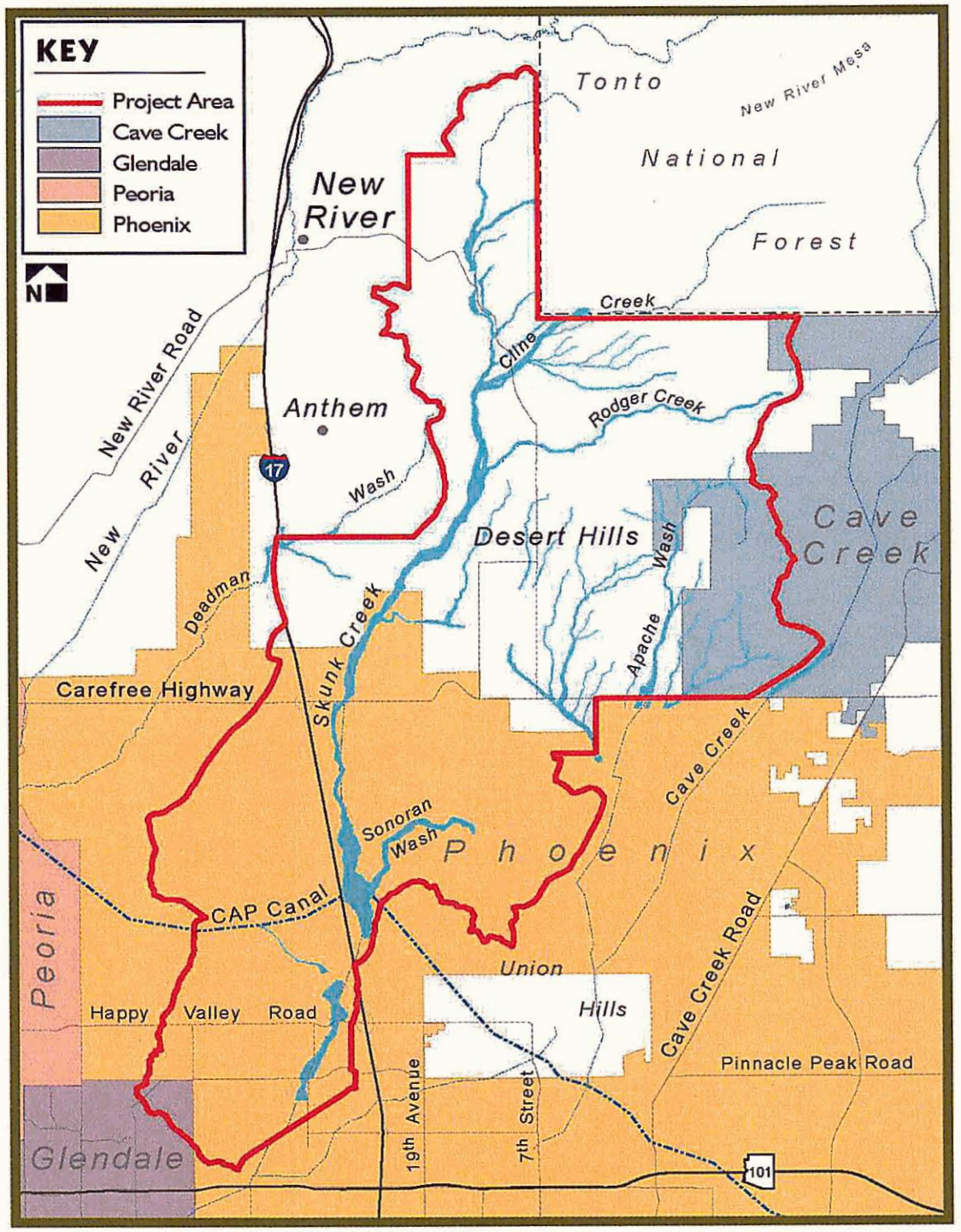

Figure 1.1.2 Adobe Dam/Desert Hills Study Area

3.1.2 Statutory Basis

Governmental entities are limited in their powers to those the State has expressly granted them. The Arizona Revised Statutes describe these powers and duties. The Statutes are divided into Titles (or chapters) that address the various governmental entities in Arizona. Title 11 addresses county authority to regulate. Special Districts, such as the Flood Control District, are addressed in Title 48. Specific applicable citations from the Statutes are given below.

Figure 1.2.1 depicts the approximate boundaries or areas of limitation for the respective statutory authorities. Title 48 authorities apply to 100-year flood areas regulated by the National Flood Insurance Program (NFIP) and Arizona Department of Water Resources. Title 11 authorities regulate drainage concerns in areas outside of the regulatory 100-year floodplain. In practice, Title 11 authorities sometimes overlap into the Title 48 area.

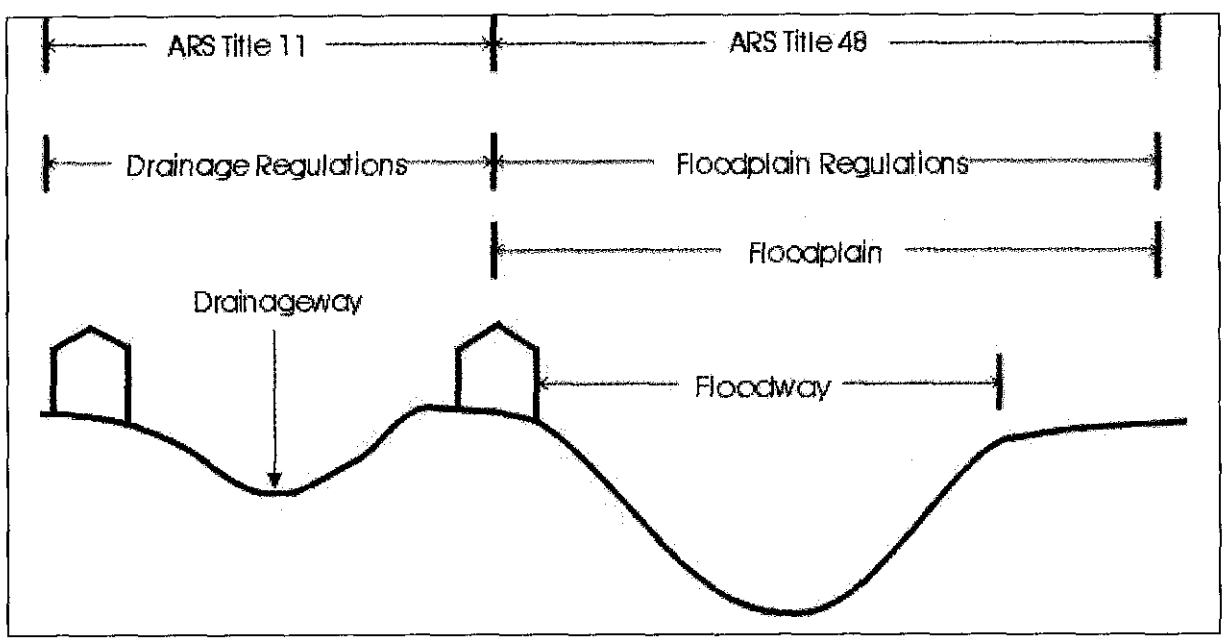

Figure 1.2.1 Statute Applicability

Section 3.1.2.1 summarizes State Statutes, while Section 3.1.2.2 summarizes Maricopa County ordinance authorized under Title 11. Section 3.1.2.3 summarizes Flood Control District of Maricopa County ordinance authorized under Title 48. The underlined sections within the statutes highlight language that relates to development guidelines and rules of development. These statutes and ordinances are provided as references to facilitate a better understanding of the opportunities and limitations associated with rules of development.

3.1.2.1 Arizona Revised Statutes

State statutes specifically pertaining to "Rules of Development" include the following:

ARS 11-251.36. Subject to the prohibitions, restrictions and limitations as set forth in section 11-830, adopt and enforce standards for excavation, landfill and grading to prevent unnecessary loss from erosion, flooding and landslides.

ARS 48-2664.D. The Board may adopt equitable by-laws, rules and regulations and perform all acts necessary to carry out the purposes of this chapter.

ARS 48-3609.B. Except as provided in section 48-3610, the board shall adopt and enforce regulations governing floodplains and floodplain management in its area of jurisdiction which shall include the following:

1. Regulations for all development of land, construction of residential, commercial or industrial structures or uses of any kind which may divert, retard or obstruct floodwater and threaten public health or safety or the general welfare.

ARS 48-3609.01.A. If a district organized pursuant to this chapter has completed a watercourse master plan which includes one or more watercourses, and if the plan has been adopted by the board or by any other jurisdiction in that river or drainage system, then the board and the governing body of each jurisdiction may adopt and shall enforce uniform rules for the river or drainage system within the jurisdiction using criteria that meet or exceed criteria adopted by the director of water resources pursuant to section 48-3605, subsection A.

3.1.2.2 Drainage Regulations

The Drainage Regulations for Maricopa County, dated 1994, provides specific guidance for rules of development associated with Area Drainage Master Studies.

Article III. Definitions

3. Area Drainage Master Study – a study to develop stormwater hydrology for a watershed, to define drainage systems, identify potential flood hazard areas, drainage problems and recommend solutions and standards for sound floodplain and stormwater management. The ADMS identifies alternative solutions to a given flooding or drainage

problem. An Area Drainage Master Plan (ADMP) identifies the preferred alternative. An ADMP, unique to the subject watershed provides minimum criteria and standards (for flood control and drainage) for land use and development.

Article XI. Area Drainage Master Study

Section 1101. Adoption

Whenever an Area Drainage Master Study authorized under this regulation has been completed, such plan including uniform rules for development may be submitted to the Board of Supervisors for adoption as an Area Drainage Master Plan. If adopted by the Board of Supervisors, the District shall enforce the Area Drainage Master Plan under this Regulation.

3.1.2.3 Floodplain Regulations

The Maricopa County Flood Control District Board of Directors has adopted floodplain regulations as required by State Statute. In the current regulations, dated 1993, further basis is found for "Rules of Development" in the following sections:

Article III. Definitions

Section 301.

6. Area Drainage Master Study (ADMS): A study to develop hydrology for a watershed, to define watercourses, identify potential flood problem areas, drainage problems and recommend solutions and standards for sound floodplain and stormwater management. The ADMS will identify alternative solutions to a given flooding or drainage problem. An Area Drainage Master Plan (ADMP) identifies the preferred alternative. An ADMP, unique to the subject watershed provides minimum criteria and standards (for flood control and drainage) for land use and development.

Article VIII. Flood Hazard Boundaries

Section 803. Other Flood Hazard Boundaries

Whenever the District determines through a flood hazard study, watercourse master plan or other flood related study authorized by the Board that a flood related hazard exists due to such factors as high-velocity flows, erosion, sediment transport, deposition, unstable soil conditions or land subsidence, the Floodplain Administrator shall designate such hazard

areas on the Flood Control Management Maps for Maricopa County and shall establish technical criteria and enforce rules and regulations for subsequent development that meet or exceed criteria adopted by the Director, State Department of Water Resources and when appropriate such studies may be forwarded to the Federal Emergency Management Agency.

Article XIV. Other Flood Hazard Zones

Section 1402. Flood Hazard Development Standards

1. Standards adopted for development contained in a Watercourse Master Plan, Area Drainage Master Plan or other hydrologically oriented master plan shall be consistent with sound floodplain management practices and this Regulation.

6. The standards, provisions, criteria and requirements for development in flood hazard zones imposed by an authorized master plan shall meet or exceed the requirements of this Regulation.

3.1.3 Rules of Development Objectives

The Adobe Dam/ Desert Hills ADMP identifies flooding and erosion hazards in the New River and Desert Hills areas and recommends measures to mitigate those hazards. Both structural and non-structural measures are component parts of the recommended alternative plans for addressing drainage and flooding problems. The Rules of Development are one of the non-structural components of the alternative plans. The general objectives of the Rules of Development include the following:

General Objectives

- Enhance public safety by guiding development in the watershed to protect current and future residents from the effects of flooding.
- Reduce adverse drainage impacts due to development in the watershed by guiding activities of new residents so that current runoff to Skunk Creek is maintained at current conditions and downstream neighbors are not negatively impacted.
- Guide future development in a manner consistent with the recommended alternative plan of the Adobe ADMP.

The following specific objectives were established to guide the development of the recommended criteria as presented herein and their means of implementation:

Specific Objectives

- Use existing aerial photography, topographic data, and parcel database resources to the maximum extent possible.

- Use available resources and the work products of the ADMP, including floodplain delineations, geomorphic evaluation, and identification of drainage problems, to determine the level of review required for each application.

- Provide the consumer with as much upfront information as possible about the process and permit requirements to minimize cost and time investments for all parties.

- Provide a simplified review procedure for parcels not impacted by drainage issues.

- Provide a means for flexibility in the review process so that drainage permit applicants may proceed with lot development incorporating drainage features that do not explicitly meet the Rules of Development criteria provided they are designed and sealed by a registered professional engineer, and reviewed and approved by the District.

- Develop criteria consistent and compatible with existing statutes, ordinances, and regulations.

- Develop criteria that have been tested against the actual environmental and development conditions within the study area.

- Limit the criteria to those necessary to address watershed specific problems not adequately covered by existing Floodplain and/or Drainage Regulations.

Both the criteria and the means of implementation comprising the proposed Rules of Development for the Adobe Dam/Desert Hills ADMP are consistent with the general and specific objectives set forth above.

3.1.4 Summary & Conclusions

A careful analysis of area development trends and regulatory options was conducted to identify specific issues that were not addressed by the existing drainage and floodplain regulations. It became apparent that single-family development on individual lots within unincorporated areas was the one category with insufficient standards to address the cumulative impacts of this type of development.

This analysis documented the existing practices and procedures and carefully integrated a unique toolkit and implementation strategy to address individual single-family lot development. By

maximizing resources, both technical and personnel, a significant percentage of reviews may be simplified. An option is also available for individuals to obtain approval for variations to the regulations if a higher degree of drainage analysis is provided in order to justify the proposed change(s). By providing this degree of flexibility within a clearly documented and easily applied process, both the public and FCDMC staff will benefit from these proposed rules of development.

SECTION 3.2: TOOLKIT

3.2.1 Overview

A number of tools or criteria were evaluated for application to single-lot development in the Adobe Dam / Desert Hills ADMP study area. The tools were evaluated based on their hydrologic efficacy, long-term viability, and their potential for implementation. Seven types of tools or criteria relating to single-family, individual lot development were examined:

- Drainageways
- (Erosion Hazard) Setbacks
- Finished Floor Elevations
- Disturbance Envelopes
- Culverts, Driveways, & Roads
- Walls, Fences, & Berms
- Retention

Each criterion is discussed in the following sections. Recommendations are made for selection of specific measures or requirements for each tool or criteria for the ADMP.

3.2.2 Drainageways

The primary use of the drainageways will be as a routing tool to quickly assess parcels requesting a permit for development. This function is discussed further under the implementation discussion in Section 3.3. It should be recognized that many of these drainageways may potentially carry 50 cfs or more during the 100-year event. Article IV of the *Floodplain Regulations for*

Maricopa County states that "The Regulation is applicable to all lands located within a delineated floodplain and watercourses or contributing watersheds that have flows greater than 50 cfs during a 100-year flood event which are within the area of jurisdiction of the Flood Control District of Maricopa County." As such, they would be subject to the Floodplain Regulations.

Drainageways were delineated based on examination of available topography and interpretation of 2002 orthographic aerial photographs. Drainageways include all observable washes, swales or other drainage features as indicated by their physical, biological (vegetation), or topographic characteristics. Drainageways were delineated for all areas outside of the City of Phoenix and the Cave Creek Recreation Area.

The delineated drainageways were used to identify existing parcels crossed by these drainageways. In addition, a second set of parcels were identified that lie within a 150-foot influence area of any delineated drainageway. The parcels crossed by drainageways, or within their influence area, were selected using ArcView GIS 8.2.

The 150-foot width of the influence area was determined based on a 160-acre drainage area (the limit of State Standard 2-96 for floodplain delineation (Title 48)). A discharge of 500 cfs (2000 cfs/ square mile * 0.25) (also State Standard) with an assumed depth of 1 foot, a width of 250 feet, and a velocity of 2 ft/s, gives 125 feet from center. Therefore, a 150-foot distance was selected as a "conservative" measurement for use in identifying parcels that might be influenced by or potentially have an effect on the drainageways, and therefore require additional drainage and/or floodplain review.

3.2.3 Erosion Hazard Setbacks

An erosion hazard setback shall be identified for any parcel crossed by or adjacent to "a delineated floodplain and watercourses or contributing watersheds that have flows greater than 50 cfs during a 100-year flood event." All of the existing FEMA floodplain delineations and those being conducted as part of the ADMP have or will have a detailed erosion hazard zone identified for them. Any drainageway that carries more than 50 cfs in the 100-year flood event (i.e. subject to the Floodplain Regulation) will also need to have an erosion hazard setback assessment prior to development. The erosion setback shall be determined using the District's draft *Riverine Erosion Hazard Delineation and Development Guidelines*. These guidelines describe a three level approach. Generally, additional information and analysis are required to demonstrate a required setback distance

closer to the drainageway or floodplain without erosion protection measures. A minimum setback of 15 ft or 2 times the bank height, whichever is greater, is required per the draft erosion hazard guidelines. Structural measures for erosion hazard mitigation are also presented in the guidelines.

3.2.4 Minimum Floor Elevation

The District already has minimum criteria for minimum finished floor elevations for all construction. All new buildings shall have a minimum finished floor elevation no less than 1 foot above the natural adjacent grade. Within a (delineated) floodplain the minimum finished floor shall be set 1 foot above the regulatory flood elevation. The Regulatory Flood Elevation is defined within the Floodplain Regulations as "(T)he elevation which is one foot above the base flood elevation for a watercourse. Where a floodway has been delineated, the base flood elevation is the higher of either the natural or encroached water surface elevation of the 100-year flow." No change to the minimum finished floor elevation criterion is recommended for the Adobe Dam/Desert Hills ADMP rules of development. This existing minimum finished floor elevation criteria should continue to be enforced in the Adobe Dam/Desert Hills ADMP study area.

3.2.5 Disturbance Envelope

A disturbance envelope is a contiguous spatial limit on a lot which may be altered from its natural state as part of the development of the lot. The rationale for the disturbance envelope is that the removal of vegetation and other disturbance of the natural ground results in an adverse impact on storm water runoff from the lot. Namely, rainfall is no longer intercepted by the native plants and consequently becomes runoff. In addition, plant roots and other biological activity associated with the plant increase the rate at which rainfall soaks into the soil. The combined result is an increase in both the magnitude and frequency of runoff from the disturbed area. Another consequence of the disturbance of the natural areas is a disruption and elimination of habitat for native desert species.

Hydrologic modeling of the effects of single lot development of very low density development on one acre or larger lots shows that any disturbance of the natural ground and removal of vegetation results in an adverse impact to storm water runoff. Total conversion of a 160-acre watershed from natural desert to residential land use with complete removal of vegetation results in nearly a 200% increase in the runoff magnitude generated by a 2-year rainfall event and a 50% increase in the runoff from a 100-year event. The reduction in these adverse impacts is approximately proportional to the amount of disturbed area. Therefore, a maximum disturbance area of 50%

including all improvements is recommended. Improvements include landscaping with permanent irrigation, impervious ground cover and/or barriers that preclude infiltration, retention, cleared and grubbed areas (such as horse corrals), and all roof-bearing structures. While this will not fully mitigate the adverse effects of development, it will reduce those effects appreciably.

Temporary disturbances in excess of the final disturbance envelope will be allowed for utility installation, temporary construction access, stockpiling, etc. Revegetation of the temporarily disturbed areas must be demonstrated before final approval of the development.

Figure 2.5.1 shows examples of disturbance envelopes for some existing lots in the Desert Hills area. Table 2.5.1 shows the gross lot area, the disturbed area, and the coverage of the lot by roof top or paved surfaces.

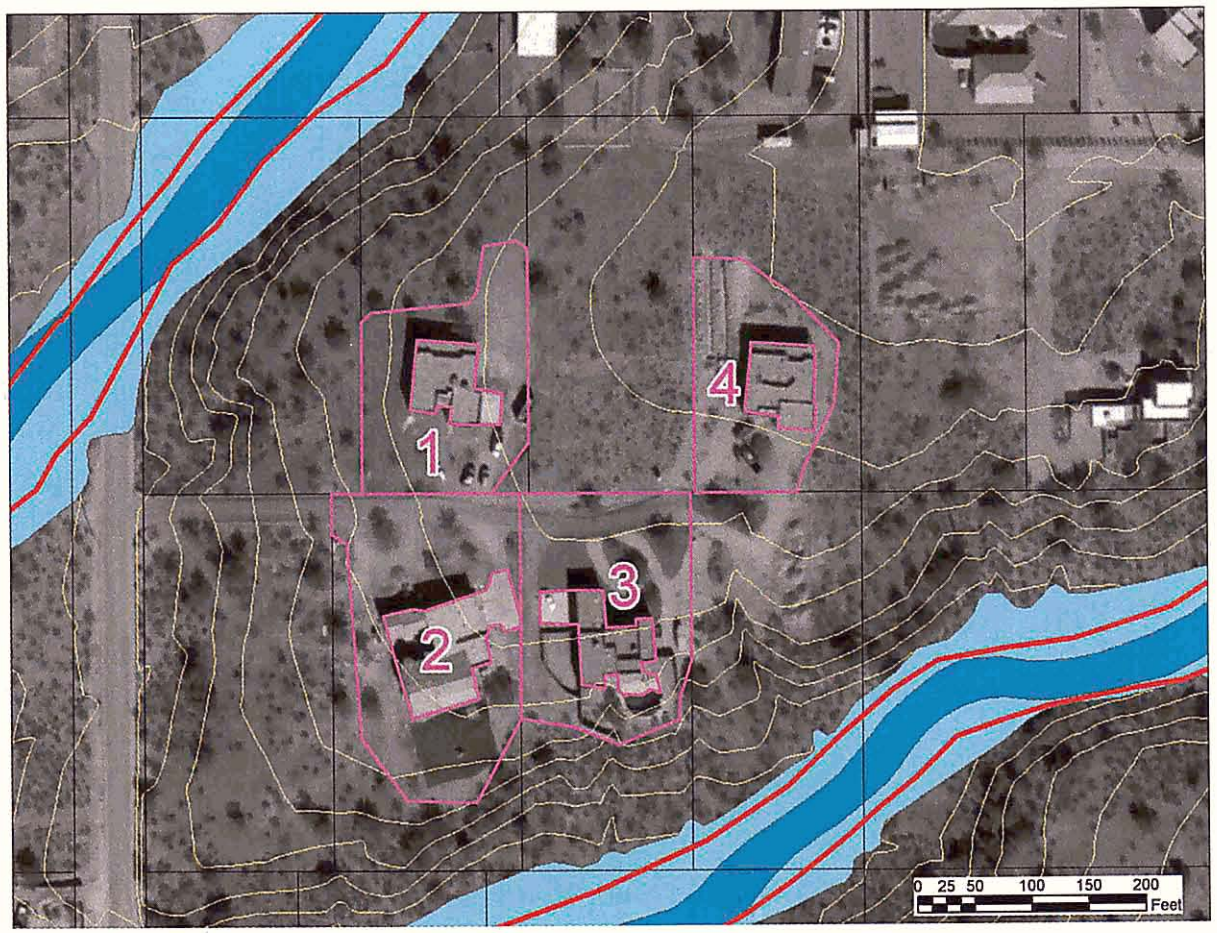

Figure 2.5.1 Example Lots with Disturbance Envelopes

"Courtyard" fences are considered acceptable immediately upslope or downslope of the residence. A "courtyard" fence is considered any fence (open-type or otherwise) or wall that surrounds an area immediately adjacent to a residential structure and is limited laterally to no more than 15 feet from the building walls in the direction perpendicular to flow (i.e. parallel to the topographic contours). The "courtyard" fence or wall may extend as far as desired if it projects from an exterior wall of the residential structure in the upslope or downslope direction parallel to flow (i.e. perpendicular to the topographic contours), see Figure 2.7.1., below.

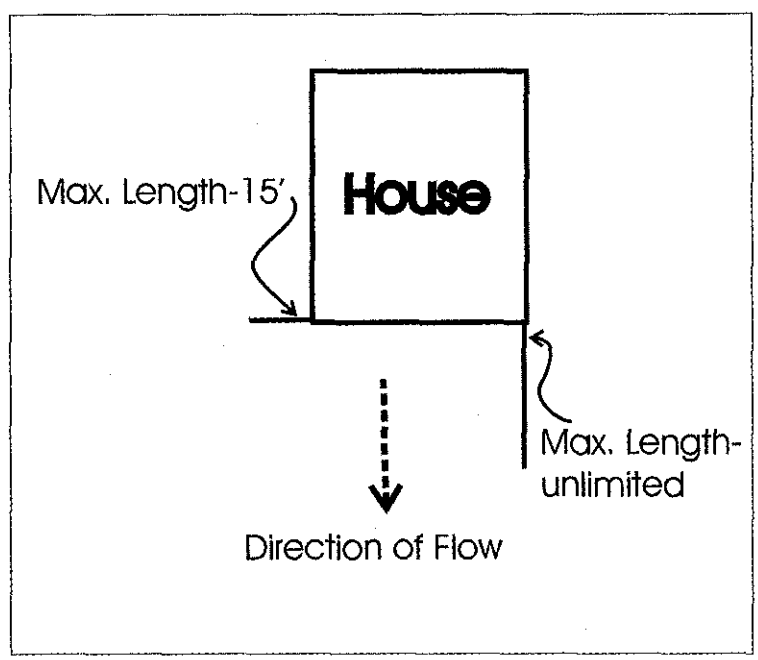

Figure 2.7.1 Courtyard Walls

Closed fences, walls, or perimeter berms are not allowed without a demonstration that no adverse impact on neighboring properties results from the construction of the proposed fence, wall, or berm. That is, it can be demonstrated to the satisfaction of the Drainage Administrator that there is no increase in peak discharge, flow depth, or velocity or flow diversion as the result of the proposed improvement(s).

3.2.8 Retention

Although concern has been raised about the long-term assurance of single-lot retention facilities, retention may be the most effective tool available to mitigate adverse hydrologic impacts

from development. Additionally, retention may have possible complementary benefits with respect to requirements of the Clean Water Act.

Some possible criteria for retention volume for single-lot development are listed below:

- Current retention requirement for commercial, industrial, multi-family residential and subdivisions (i.e. 100-yr 2-hr which equals about 2.75" in the Desert Hills area)
- 100-yr 2-hr pre vs. post development
- Retention of runoff from biggest "typical" storms
- Retention related to runoff based on the maximum lot coverage per zoning
- Future development increases in runoff volume from hypothetical basin analyses using HEC-1

An evaluation of these criteria was conducted and is provided in detail in Appendix A.

Table 2.8.1 summarizes the possible retention criteria, the parameters associated with the estimation of the retention volumes, and the calculated retention volume for the minimum size lot in each of three zoning categories (i.e., R-43, R-70, and R-190). The recommended retention volume approach is the Maximum Lot Coverage approach. The recommended retention volume to be retained is for the 100-year 2-hour rainfall. Note that the recommended retention volume of 1,500 cu.ft. / ac is about 28% of the volume that would be required for a similar zoning in a subdivision.

Table 2.8.1. Summary of Possible Retention Criteria for Adobe ADMP

	R-43		R-70		R-190		Desert
C factor (100-yr)	0.53		0.50		0.41		0.38
Pre vs. Post C factor (100-yr) (ΔC100)	0.15		0.12		0.03		
C factor (10-yr)	0.42		0.40		0.33		0.30
Pre vs. Post C factor (10-yr) (ΔC10)	0.12		0.10		0.03		
Lot Area (sq.ft.) (A)	43560		70000		190000		
Max Lot Coverage (%)	15%		10%		5%		

	R-43		R-70		R-190	
	Biggest "Typical Storm"	100-yr 2-hr	Biggest "Typical Storm"	100-yr 2-hr	Biggest "Typical Storm"	100-yr 2-hr
Storm Depth (inches)	2.2	2.75	2.2	2.75	2.2	2.75
Storm Depth (D) (feet)	0.183	0.229	0.183	0.229	0.183	0.229
	Retention Volume (cu. ft.)					
All Runoff Retained (D x A x C)	3354	5287 [1]	5133	8021 [1]	11495	17852 [1]
Pre vs Post (D x A x ΔC)	958	1497	1283	1925	1045	1306
Max. Lot Coverage (D x A x % Cover)	1198	1497	1283	1604	1742	2177
HEC-1	1089	1089	1750	1750	4750	4750

Shaded cells are the recommended retention volumes for a minimum sized lot in each zoning type.
[1] This is equivalent to the current retention requirements for subdivisions

Lot disturbance in excess of the 50% value recommended can be allowed by providing for additional retention in direct proportion to the increased disturbance. The retention area is considered part of the disturbed area. Figure 2.5.1 (see Section 3.2.5) and Table 2.8.2 show examples of disturbed areas and proposed retention volumes for some example lots in the Desert Hills area.

Table 2.5.1 Summary of Example Lots with Disturbance Envelopes

Parcel Id (1)	Disturbed Area (2)	3.2.5.1.1 Impervious Area (3)	Total Parcel Area (4)	Percent of Parcel (5)
	(sq.ft)	(sq.ft)	(sq.ft)	%
1	25302		48180	53%
1		4214	48180	9%
2	37220		54450	68%
2		8207	54450	15%
3	30631		49500	62%
3		5239	49500	11%
4	21225		48180	44%
4		4021	48180	8%

The data for these example lots show that three of the four lots exceed the proposed 50% disturbance envelope. The "impervious area" [column (3)] relates to the maximum lot coverage discussed under retention in Section 3.2.9, and is included in the disturbed area [column (2)].

3.2.6 Culverts, Driveways, Roads

Dip crossings are preferred to culvert crossings for access on driveways and local streets. Arterial streets should be designed in accordance with existing County criteria. However in addition to the design levels prescribed in those criteria, all culverts or bridged crossings should be designed to minimize disruption of sediment transport continuity upstream and downstream of the crossing. Crossings that mimic the natural channel's depth and width within the reach being crossed will be most successful. Lowering of local channel bottom elevations is also discouraged. Roadways shall be designed so as not to divert flows.

3.2.7 Walls, Fences, Berms

Perimeter fences shall be limited to open-type fencing (pipe rail, barb wire, etc.) for lots within drainageway influence areas or within the inundation limits of the 100-year flood along a drainageway or floodplain. Chain link or chicken wire does not constitute open-type fencing. In order to be considered "open-type" fencing, the openings must be a minimum of 8 inches in diameter. For lots not in a drainageway influence area or 100-year floodplain, solid perimeter fences that comply with current Maricopa County development standards are permitted.

Table 2.8.2 Retention Requirement Statistics for Example Lots in Desert Hills Area (Continuation of Table 2.5.1)				
Parcel ID (see Fig. 2.5.1)	**"Required" Retention (1500 cu.ft./ac)**	**Additional "Required" Retention (for disturbance > 50%)**	**Total "Required" Retention**	**Retention Area assumed 1.5 ft deep (Total / 1.5)**
	(cu.ft.)	(cu.ft.)	(cu.ft.)	(sq.ft)
1	1656	42	1698	1132
2	1872	344	2215	1477
3	1702	202	1904	1269
4	1656	0	1656	1104

The location and configuration of retention areas shall be shown on the site plan. In general, the same criteria and guidelines for retention facilities outlined in the Drainage Design Manual, Volume II should be followed. In particular, the location of basins shall meet the following objectives:

- Retention areas shall be located such that they effectively capture runoff from the impervious surfaces on the lot.
- Retention areas do not have to be located in a single basin; multiple retention areas are allowed.
- Retention areas shall not be placed in a regulatory floodplain or otherwise such that off-site runoff is intercepted in the retention area. The regulatory floodplain includes delineated floodplains and watercourses that have flows greater than 50 cfs during a 100-year flood.
- Approval of site suitability (with respect to percolation rates) for a standard septic system will constitute site suitability for retention.
- Retention areas may be landscaped (with appropriate types of vegetation).

3.2.9 Summary and Recommendations

Table 2.9.1 summarizes the recommended tools and measures for the Rules of Development for the Adobe ADMP.

Table 2.9.1 Summary of Rules of Development Criteria for Adobe ADMP

Tool	Measure	Source/Basis
Erosion Hazard Setback	▪ Function of discharge ▪ Minimum 15 ft or 2 times bank height (whichever is greater)	Riverine Erosion Hazard Delineation and Development Guidelines
Minimum Floor Elevation	▪ 1 ft above highest adjacent natural ground ▪ 1 ft above regulatory base flood	▪ Drainage Regulations ▪ Floodplain Regulations
Disturbance Envelope	50% of lot; additional allowed with increased retention	Consistent with current zoning regulatory environment
Culverts, driveways, roads	▪ Prefer dips ▪ Maintain sediment transport continuity ▪ Prevent base level lowering ▪ Do not divert flow	▪ Drainage Design Manual Volume II ▪ Drainage Regulations
Walls, Fences, Berms	Open-type fencing & Courtyard fencing allowed	Floodplain Regulations
Retention	2.75" x max cover for zoning (in sq.ft.) x lot size (in sq.ft) = retention volume required	▪ 100-yr 2-hr ▪ Drainage Design Manual Volume II

Drainage impacts of single-lot development need to be addressed in order to prevent unnecessary damages and public expenditures in the future. It is therefore recommended that lots crossed or within a 150-ft buffer of a drainageway be scrutinized closely by reviewers at the District and that the following criteria be applied to their development.

1) All single-lot development in the Desert Hills and New River/Cline Creek portions of the ADMP shall henceforth be required to provide the minimum retention as indicated in these Rules of Development.

2) Minimum floor elevation criteria from the Drainage Regulations and the Floodplain Regulations should continue to be enforced.

3) Also, the other components of the Floodplain Regulation with respect to floodplain encroachment and erosion hazard setbacks should continue to be enforced.

4) Development will be limited to a 50% disturbance envelope on the lot unless retention volume in excess of the minimum is provided.

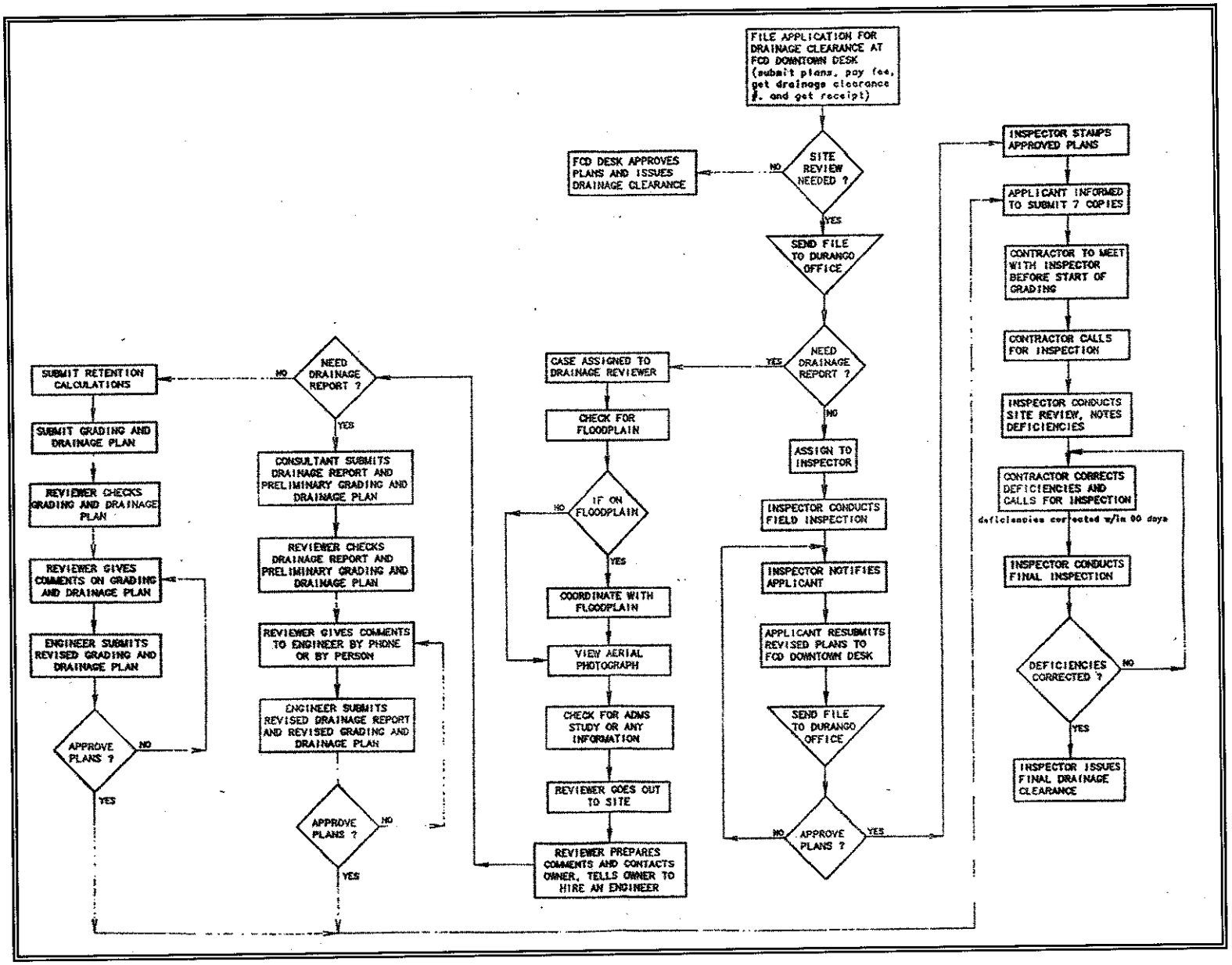

Figure 3.1.1 Current Drainage Review Process

An attempt to incorporate a certain degree of automation to the permit process at the "One Stop Shop" in the County Planning and Development Department has been initiated and in time may create opportunities for streamlining. In addition, the completion of 32 area studies and ready access to the information developed through these studies via GIS, has given FCDMC staff additional tools to perform their functions.

3.3.2 Proposed Implementation Strategy

The implementation strategy proposed to address single-family development on individual lots was created to make use of the information currently available on the County's GIS database. It also assigns tasks to staff in a fashion that optimizes the relationship between fiscal impacts and degree of professional staff review required. By assigning technicians to conduct a preliminary review or routing of the applications, the more highly trained staff can be available to review the more complex or technically challenging applications.

This process results in a simplified review for properties determined to have fewer potential drainage or flooding impacts. Properties not located within a jurisdictional floodplain or within the influence area of an identified drainageway influence area are not required to prepare a full drainage report and can be assigned to an engineering technician for a simplified drainage review. This determination is only made for properties within a completed ADMP because of the degree of hydrologic and hydraulic analyses that have already been conducted. It should be noted that such a determination can be overruled by a FCDMC Professional Engineer based on field observations and professional judgment.

The checklist shown in Table 3.2.1 is intended to show the questions that would be asked by a reviewer when a new drainage clearance application is submitted. By following this checklist the application would be routed to the appropriate staff person commensurate with the level of review required.

Table 3.2.1 Proposed Checklist for Drainage Clearance Applications for Single-Family Development on Individual Lots	
Y or N	Is application complete? If NO, return to applicant.
Y or N	Is subject property located within the Adobe Dam/Desert Hills ADMP study area? If YES, check for FEMA Floodplain and drainageway influence area map.
Y or N	Is subject property located within a FEMA Floodplain? If YES, applicant requires a Floodplain Use Permit. Route application to Floodplain Division.
Y or N	Is subject property impacted by a drainageway influence area? If YES, an Engineer must review application to determine whether a drainage report is required.
Y or N	Is subject property NOT impacted by a drainageway influence area and application is in compliance with Drainage Regulations and Rules of Development? If YES, application is eligible for simplified site plan review.
Y or N	If Drainage Report is required, is it complete? If YES, Engineer reviews report. If NO, Engineer returns report to applicant for revisions.
Y or N	Is Drainage Report approved? If YES, Engineer forwards application to Inspection Division. If NO, Engineer returns to applicant for revisions.

3.3.3 Application

The graphic shown in Figure 3.3.1 helps demonstrate how the rules of development would be applied. Colored and numbered boxes represent parcels with various circumstances that will receive a different level of review.

5) Dip crossings for road and driveways, open type fencing, and courtyard fencing will be approved without a drainage report.

Any variations from these minimum criteria will require engineering analyses that demonstrate to the satisfaction of the Drainage or Floodplain Administrator that no adverse impact to adjacent properties results from the requested variations, and that the proposed improvements will themselves be free of inundation from the 100-year flood event and protected against erosion.

SECTION 3.3: IMPLEMENTATION

3.3.1 Drainage Review Process

The process chart shown in Figure 3.1.1 was provided by the Regulatory Division of the Flood Control District of Maricopa County (FCDMC). In order to develop a clearer understanding of the various steps in this process and the interrelationship of the various divisions that each plays a role, a number of interviews were conducted with FCDMC staff. Staff involved with the initial intake of the permit at the "One Stop Shop" and those that review the drainage applications provided an overview of their role in the current process (See Figure 3.1.1), and provided suggestions for improvement.

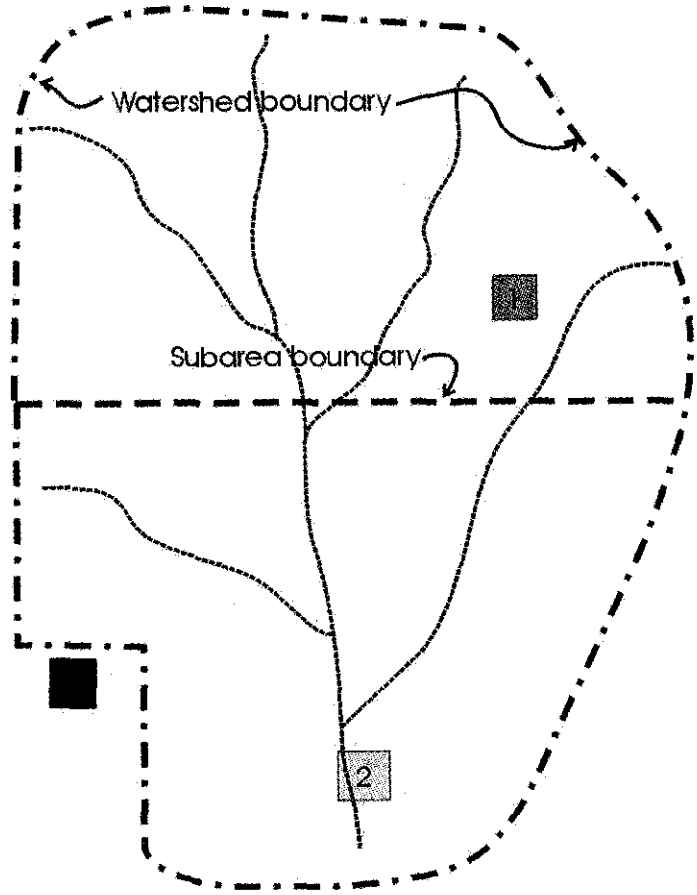

Figure 3.3.1 Process Application

3.3.3.1 Type 1 Parcels

Designated on Figure 3.3.1 by the green box labeled with number 1, Type 1 parcels are located within the study area of an ADMP, but not within the influence area of a drainageway. Rather, than having to prepare a full drainage report, if the applicant can show compliance with the rules of development (e.g. retention, disturbance area, erosion hazard setback), they will be eligible for a simplified review.

3.3.3.2 Type 2 Parcels

The yellow box labeled with a number 2 represents a Type 2 parcel also located within the boundaries of an ADMP. However, unlike a Type1 parcel, it is within the influence area of a delineated drainageway. Therefore, the applicant is required to complete a drainage report to accompany the drainage clearance application. A Professional Engineer in the Regulatory Division will determine what elements must be included in the report, and will also decide whether the report

contains all of the required information before the review is initiated. In order to assist the Professional Engineer with his review of drainage reports, Best Management Practices (BMPs) are available as a reference in the *Sedimentation Engineering and Geomorphic Analysis Report* for the Adobe Dam/Desert Hills ADMP.

In order to assist the Engineer in determining whether a drainage report is required, some criteria have been developed. These criteria include the following:

- Non-compliance with the drainage ordinance and rules of development
- Location within an Erosion Hazard Zone
- Modification of a drainageway by the proposed development
- Observation of field conditions
- Professional judgment of the Engineer

Any proposed deviation from the drainage ordinance (including these rules of development) would trigger an engineering analysis that demonstrates to the satisfaction of the Drainage or Floodplain Administrator that no adverse impact to adjacent properties results, and that the proposed improvements will themselves be free of inundation from the 100-year flood event and protected against erosion.

In both examples, once the required approvals have been obtained the building plans are stamped approved and an inspection may be scheduled. An inspector may note deficiencies while conducting the inspection. In that case, the applicant is informed of the necessary corrections and told to call for re-inspection once they have been made. After the inspector is satisfied that the development is in compliance with the approved plans, a final drainage clearance is issued.

This description of the implementation strategy was based on the assumption that neither the Type 1 parcel nor the Type 2 parcel was located within a FEMA floodplain. If this was the case, then a Floodplain Use Permit would be obtained, and a drainage report would have to be submitted along with that application. Conditions of approval for the Floodplain Use Permit issued by the Floodplain Management Division would be forwarded to the Regulatory Division who would then complete the overall drainage review for the property.

3.3.3.3 Type 3 Parcels

The red boxed labeled number 3 represents a Type 3 parcel located outside of a completed ADMP. In that instance, the drainage clearance application would be processed according to current procedures.

3.3.4 Evaluation

Figure 3.4.1 and Table 3.4.1 document the results of a GIS query used to analyze the potential impact of the proposed implementation strategy in the Desert Hills and New River/Cline Creek subareas. It shows that 2,630 parcels (45%) would fall into the Type 1 category (green box) and be eligible for a simplified plan review. There are 975 parcels where a drainageway intersects the property and 714 within a 150-foot influence area, equaling 1,689 parcels (29%) that would be classified as Type 2 parcels (yellow box), with a presumption that a full drainage report would be required. A floodplain or floodway impacts another 1,571 parcels (27%), which requires the preparation of a complete drainage report and obtaining a Floodplain Use Permit.

By applying the recommended triage approach in the proposed implementation strategy, 45% of the parcels within the study area would be able to receive a drainage clearance in a shorter period of time due to the simplified plan review.

If this approach is adopted for properties located within the Adobe Dam/Desert Hills ADMP, the check list should be made part of a public information process and included in permit handouts, on the District website, and in community newsletters. Many of the concerns heard from residents during various public meetings were in regard to the degree of uncertainty they feel about the current process. Providing documentation and making the public aware will facilitate their advance preparation when they make a development application to the County.

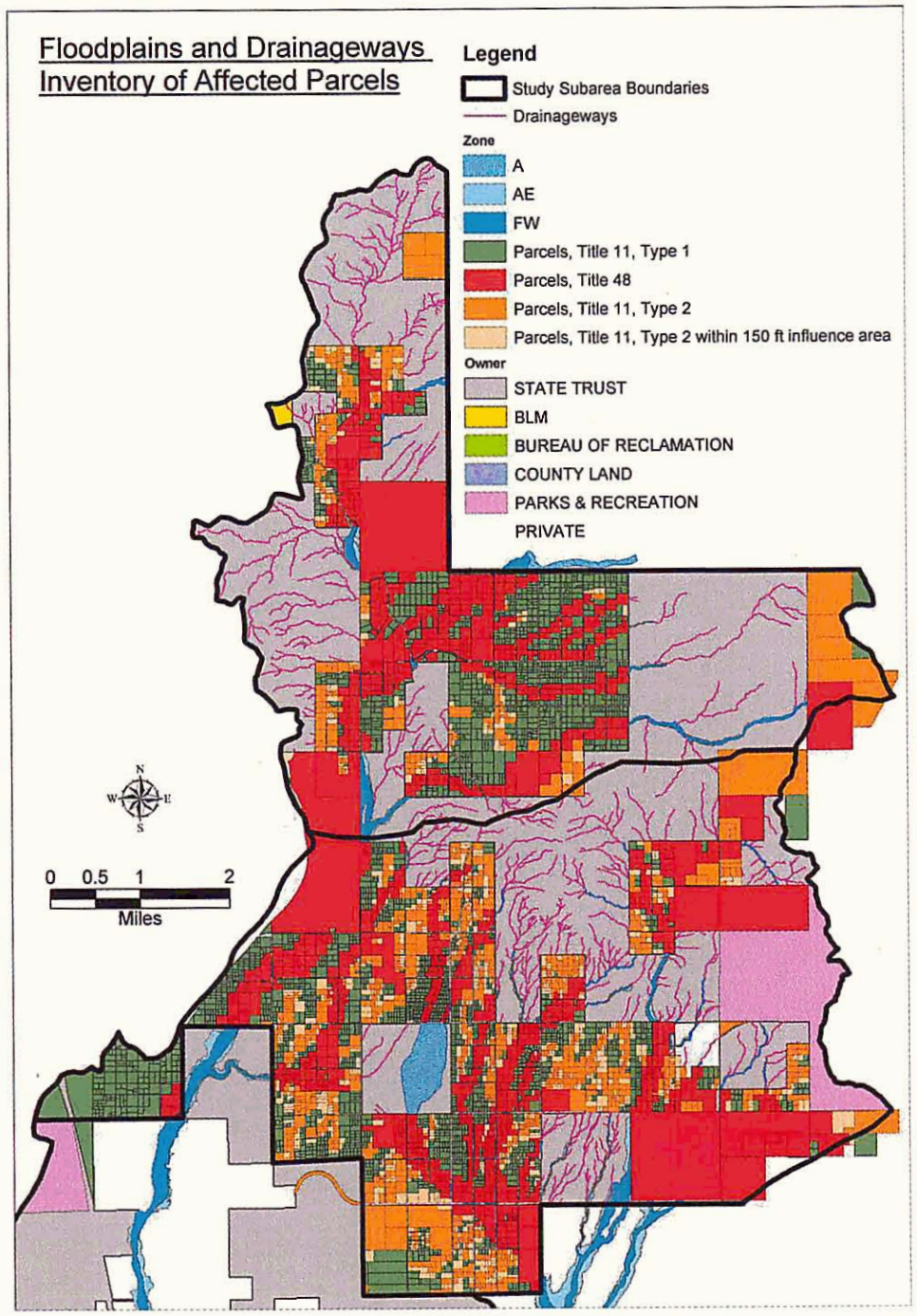

Figure 3.4.1 Parcels Affected by Drainageways

Table 3.4.1 Summary of Parcels Affected by Drainageways

Adobe Dam / Desert Hills ADMP - New River/Cline Creek & Desert Hills Subareas		
Category	No. Parcels	Percent
Parcels, Title 11, Type 1	2630	45%
Parcels, Title 11, Type 2	975	17%
Parcels, Title 11, Type 2 within 150 ft influence area	714	12%
Parcels, Title 48	1571	27%
Total	5890	100%

Miles of Drainageways in NR-CC/DH	218.5	miles

	Area (sq. miles)	Percent of NR/DH Area
Area assuming 300' wide	12.4	23%
ASLD in NR-CC/DH	24.6	45%
NR/Cline + Desert Hills Area	54.3	100%

	Area (sq. mi.)	Percent of Study Area
Total Study Area (excluding USFS)	95.7	100%
State Land	45.6	48%
NR-CC/DH Area	54.3	57%

SECTION 3.4: CONCLUSION

The combination of the toolkit and the proposed implementation strategy are intended to provide a mechanism to manage the potential cumulative impacts to drainage and flooding caused by single-family development on individual lots within incorporated Maricopa County. The toolkit is based upon customary regulations that have been successfully implemented in numerous jurisdictions within Maricopa County. Specifically, the retention regulations are the result of the application of an accepted methodology to the unique conditions found within the Adobe Dam/Desert Hills ADMP.

By making minor modifications to the current process in order to take full advantage of previous investment in the form of area drainage master studies and plans, these changes will also benefit the public by making efficient use of County resources and creating the opportunity for many to obtain their drainage clearance approvals in a more timely manner. Also, making the method for obtaining a drainage clearance and the associated requirements more visible to the public will eliminate some of the uncertainty regarding the review of their drainage clearance application.

Appendix A

Technical Support for Retention Requirements

100-yr 2-hour Retention Approach

Currently all commercial, industrial, multi-family residential and subdivision developments are required to retain the 100-year 2-hour runoff volume as described in the Drainage Design Manual. In the Desert Hills portion of the ADMP area, the 100-year 2-hour point rainfall is about 2.75 inches. For a single-lot one acre type development this would equate to a requirement for about 5,290 cu. ft. of retention volume.

100-yr 2-hour Pre- vs. Post-Development Approach

Another consideration for a retention requirement might be to require single-lot developers to retain the difference in runoff volume from the pre- to post-development runoff conditions. Some examples are shown below:

- Assume C=0.53 vs. C=0.38 (Table 3.2 – new Manual); delta C = 0.15 * 2.75" = 0.41" = 1,488 cu.ft./ac
- Assume C=0.7 vs. C=0.4 (more conservative); delta C = 0.30 * 2.75 = 0.82" = 2,977 cu.ft./ac

Biggest "Typical" Storm Approach

Examination of the Carefree, Arizona maximum daily precipitation gage data (see Figure 2.8.1 below) shows that consideration of a rainfall of somewhere around 2.2 inches would capture most of the biggest "typical" rainfall events. These data are from a nearly 40-year period record. This level of 2.2" matches almost exactly the 10-year 6-hour point rainfall statistics from NOAA Atlas II (Table A.1). If the 10-year event is representative of the "channel forming discharge," then mitigation of adverse hydrologic impacts at this level should minimize the adverse geomorphologic effects as well.

Applying the same C factor logic from the 100-year 2-hour discussion above:

- 2.2" * 0.15 = 0.33" → 0.33"/12" = 0.0275 ft * 43,560 sq.ft = 1,198 cu.ft/ac
- 2.2"* 0.30 = 0.66" → 0.66"/12" = 0.055 ft * 43,560 sq.ft = 2,396 cu.ft/ac

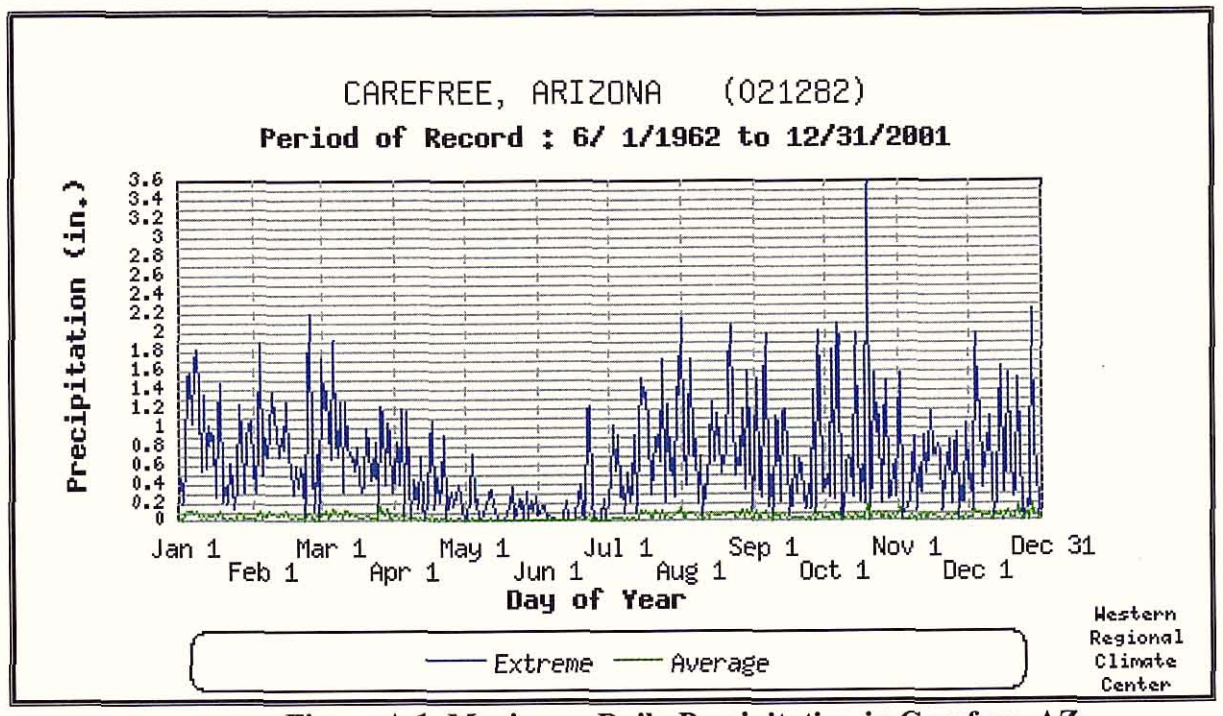

Figure A.1 Maximum Daily Precipitation in Carefree, AZ

Table A.1 Rainfall Statistics for Desert Hills Area

*** P R E F R E O U T P U T D A T A ***

PRECIPITATION FREQUENCY VALUES FOR Desert Hills Area Hydrology
POINT VALUES
RETURN PERIOD

DURATION	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR	
5-MIN	.37	.45	.51	.59	.66	.73	.88	5-MIN
10-MIN	.56	.68	.78	.91	1.01	1.11	1.35	10-MIN
15-MIN	.68	.85	.98	1.15	1.29	1.43	1.74	15-MIN
30-MIN	.89	1.14	1.31	1.56	1.75	1.94	2.37	30-MIN
1-HR	1.09	1.41	1.63	1.94	2.18	2.42	2.97	1-HR
2-HR	1.21	1.58	1.83	2.19	2.46	2.74	3.37	2-HR
3-HR	1.29	1.69	1.97	2.35	2.65	2.95	3.64	3-HR
6-HR	1.45	1.91	2.22	2.67	3.01	3.35	4.14	6-HR
12-HR	1.63	2.17	2.55	3.07	3.47	3.88	4.80	12-HR
24-HR	1.80	2.44	2.87	3.47	3.94	4.40	5.47	24-HR

Maximum Lot Coverage Approach

Another way of looking at retention would be to consider just the impervious surfaces added to a lot. Impervious surfaces generate runoff during all but the most minimal rainfall events. The hydrologic impact of impervious surfaces is therefore more profound on the more frequent events.

Mitigation of runoff from impervious surfaces would reduce the impacts of development on the magnitude and frequency of storm water runoff.

Looking at a range of possible impervious surface coverage single lot development yields the following potential retention volume criteria:

The maximum lot coverage by zoning is 15% for R-43. Therefore, 43,560 sq. ft * 0.15 = 6534 sq.ft of potential impervious surfaces. Again, the biggest "typical" storm is 2.2" or 0.183 ft and the 100-year 2-hour rainfall is 2.75" or 0.23 ft. The 100-year 6-hour point rainfall is 3.35" for the Desert Hills area, or 3.35"/12" = 0.28 ft.

So, some possible retention volumes for these three storms would be:

<u>For R-43 (maximum lot coverage = 15%):</u>

- 6534 * 0.183 = 1196 cu. ft. retention (per acre) — Biggest "typical" storm
- Or, 6534 * 0.230 = 1497 cu. ft retention (per acre) — 100-year 2-hour
- Or, 6534 * 0.280 =1824 cu. ft retention (per acre) — 100-year 6-hour

<u>For R-70 (maximum lot coverage = 10%):</u>

- 70000 * 0.1 = 7000 sq.ft * 0.183 = 1281 cu.ft — Biggest "typical" storm
- 70000 * 0.1 = 7000 sq.ft * 0.23 = 1610 cu.ft — 100-year 2-hour
- 70000 * 0.1 = 7000 sq.ft * 0.28 = 1960 cu.ft — 100-year 6-hour

<u>For R-190 (maximum lot coverage = 5%):</u>

- 190000*0.05 = 9500 sq. ft * 0.183 = 1739 cu. ft — Biggest "typical" storm
- 190000*0.05 = 9500 sq. ft * 0.23 = 2185 cu. ft — 100-year 2-hour
- 190000*0.05 = 9500 sq. ft * 0.28 = 2660 cu. ft — 100-year 6-hour

Hypothetical Subbasin HEC-1 Model Approach

Analysis of a hypothetical subbasin using HEC-1 shows an increase in runoff volume due to future development of about 0.30" for all return periods. Therefore, 0.30"/12 * 43560 = 1089 cu. ft / ac. This is approximately the same result via a different argument as the pre-versus post- C-factor approach for the "biggest typical storm". The result is also substantially similar to the 15% coverage

argument for the "biggest typical storm". The 0.30" hypothetical subbasin result yields 1,750 cu.ft for R-70 and 4,750 cu.ft for R-190.

Appendix B

References

Arizona Department of Water Resources, State Standards for Floodplain Management

SS1-97, Requirement for Flood Study Technical Documentation
Sets technical documentation standards for Flood Studies that are to be submitted to ADWR or FEMA.

SS2-96, Requirement for Floodplain and Floodway Delineation in Riverine Environments
Provides methodologies for estimating 100-year peak discharges, delineating 100-year floodplain limits, and determining administrative floodway boundaries for riverine floodplains in Arizona.

SS3-94, State Standard for Supercritical Flow (Floodway Modeling)
Provides guidelines to be used when modeling floodways for supercritical or near-critical flow conditions in Arizona.

SS4-95 State Standard for Identification of and Development within Sheet Flow Areas
Details minimum floodplain management standards for identification of and development within sheet flooding areas in Arizona.

SS5-96 State Standard for Watercourse System Sediment Balance
Provides guidelines for identification of and development within erosion hazard areas, watercourses with a net sediment deficit, and watercourses with a net sediment surplus. Individual guidelines for: Lateral Migration Setback Allowance, Channel Degradation Estimation, and River Stability Impacts associated with Sand and Gravel Mining.

SS6-96 State Standard for Development of Individual Residential Lots within Floodprone
Areas
Site Plan Checklist, Typical Plan and Cross-Section requirements for Individual residential lots within floodprone areas.

SS7-98 State Standard for Watercourse Bank Stabilization
Provides minimum design standards for several bank stabilization techniques.

SS8-99 State Standard for Stormwater Detention/Retention
Provides minimum criteria for sizing Detention and/or Retention facilities.

SS9-02 State Standard for Floodplain Hydraulic Modeling

Provides guidance on mathematical modeling of hydraulic processes in watercourses and floodplains.

Arizona Revised Statutes, Title 11

Arizona Revised Statues, Title 48

FCDMC, 2003, Drainage Design Manual, Volume I, Hydrology, draft dated January 9, 2003.

FCDMC, 1995, Drainage Design Manual, Volume I, Hydrology, revised January 1, 1995.

FCDMC, 1996, Drainage Design Manual, Volume II, Hydraulics

FCDMC, 1986, Floodplain Regulations for Maricopa County, as revised 11/1/2000

FCDMC, 1988, The Drainage Regulation for Maricopa County, as revised 12/14/1994

PRELIMNARY ANALYSIS

PART 8, Volume 2, Section 4

ROADWAY DRAINAGE CROSSINGS PASSABILITY

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Appendix A: Roadway Drainage Crossing Hydrologic and Hydraulic Details

ENCLOSED DATA CD INCLUDES:

- Digital Copy of Report in PDF Format
- GIS Shapefile Coverages of Project Elements

SECTION 4.1: PASSABILITY OF ROADWAY DRAINAGE CROSSINGS

4.1.1 Determination of the Recurrence Interval of 0.5 foot Depth Overtopping

Roadway crossings of drainages were identified from examination of maps, aerial photographs, field observations, and existing hydraulic models. Only primary arterial roadway crossings were included in the level of service determination. Figure 1 shows the roadways considered in the analysis and the other roadways in the study area. These are the same streets considered in the Flood Response Plan (FRP) being developed as part of Phase II of the ADMP.

Hydraulic models from existing floodplain delineation studies were used where available to determine the degree of overtopping of roadways. Flood depth and velocity were taken from the HEC-2 or HECRAS model output files. In addition, the discharge rates flowing under and over the roadway were recorded as shown in the model output. Where no floodplain delineation hydraulic model was available or the crossing was not reflected in the FDS model, HY8 depictions of the crossings were developed. The data for the HY8 models were taken from existing topographic maps, interpretation of aerial photographs, and field data collected as part of the ADMP structure inventory.

In addition to the hydraulic performance at the crossings for the 100-year flood, discharge values from available hydrologic models were recorded for the 2-year and 10-year discharges. These data were used to assist in the determination of the approximate frequency of the maximum safe passable discharge at each crossing.

Based on previous work and convention for passability used previously by Maricopa County, a crossing was deemed passable if the maximum flow depth was less than 0.5 ft during the 100-year flow. For crossings with depths greater than 0.5 ft at the 100-year flow, the recurrence interval of the 0.5 foot overtopping discharge was determined for the flow rate in the culvert and/or over the crossing structure at 0.5 feet depth. The discharge rate that at 0.5 depth over the crossing (including the culvert flows, if any) was compared to the flood frequency at the crossing as indicated by the 100-year FDS discharge, the available 10-year and 2-year discharges and the synthetic frequency curve developed for the floodway residences risk assessment (see Part 8, Volume 2, Section 1).

4.1.2 Results

Table 1 and Figure 2 show the summary of the results of the determination of the recurrence interval of the 0.5 foot overtopping discharge for the primary arterial roadways in the study area upstream of the CAP. What these data show is that access to or from almost anywhere in this part of the study area is limited during even the most frequent flood events. Although 100-year capacity is provided at many crossings, a larger number of critical locations would be hazardous to vehicular traffic.

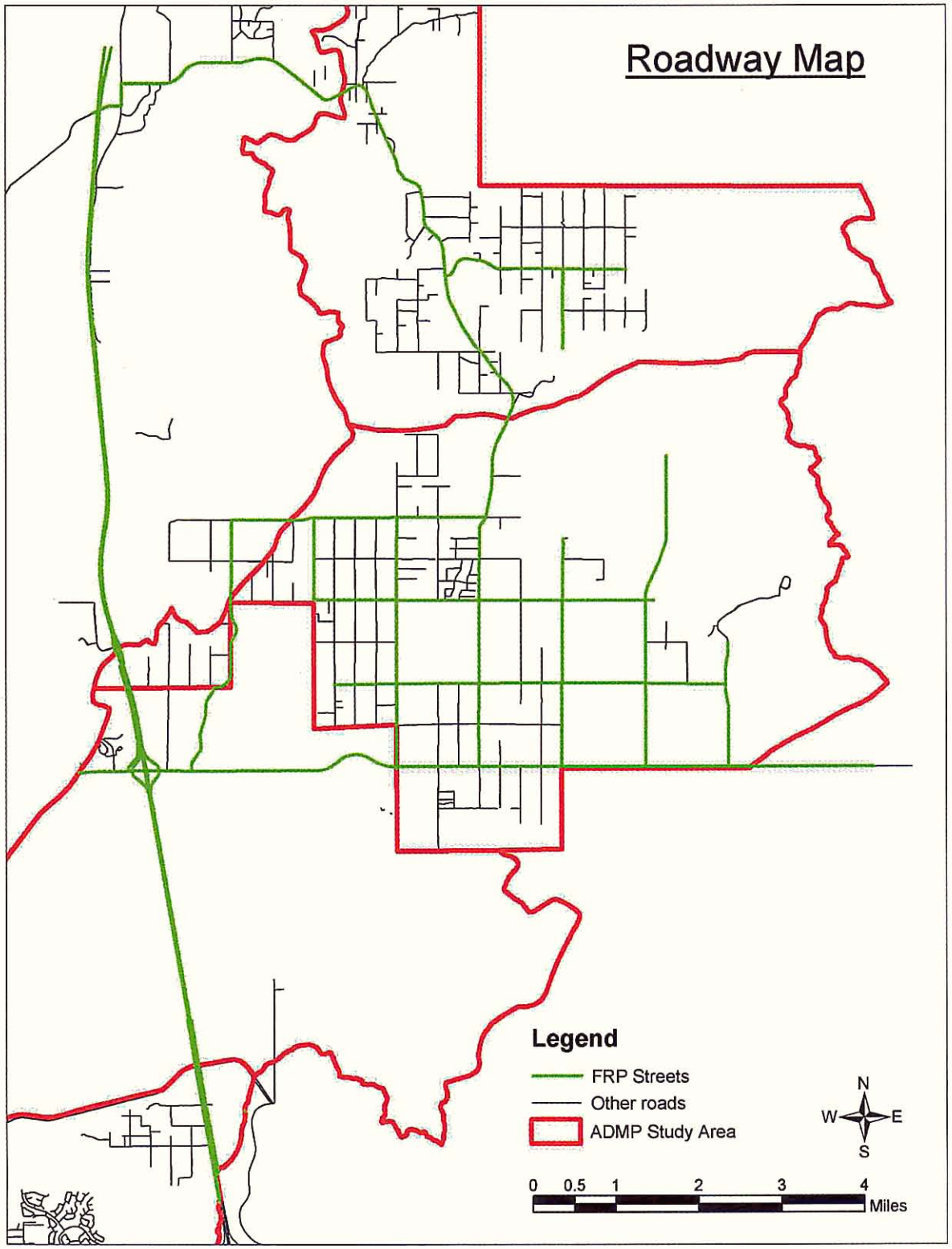

Figure 1. Streets in the ADMP Area

Table 1. Recurrence Interval of 0.5 foot Inundation of Arterial Roadway Crossings

Stream Name	Street Name	# of Barrels	Structure Description	Structure Material	Q2	Q10	Q100	OT Depth	OT Velocity	Q100 in Pipe	Q at 0.5 ft OT	R.I. of 0.5 ft OT
Cline Wash Tributary C8	16th Street	1	n/a	Ashpalt	228	800	2280	5.0	11.3	N/A	100	1
Desert Hills Wash	16th Street	1	n/a	Dirt	117	411	1787	6.9	2.0	N/A	50	1
Desert Hills Wash Tributary 1	16th Street	2	24"	CMP	39	160	417	0.7	1.6	164	300	49
Desert Hills Wash Tributary 2	16th Street	2	48"	Spiral CMP	39	157	437	1.3	2.3	162	145	9
Desert Hills Wash Tributary 3	16th Street	2	48"	CMP	48	169	532	1.0	1.1	210	275	24
Desert Hills Wash Tributary 4	16th Street	1	3' x 2'	CMP	33	116	330	0.5	2.0	30	330	100
Desert Hills Wash Tributary 6	16th Street	1	48"	Spiral CMP	38	180	430	1.2	3.0	124	160	11
unnamed	16th Street	2	2'	CMP	4	12	35	0.2	1.1	8	0	> 100
unnamed	16th Street	2	2'	CMP	4	12	35	0.2	1.1	8	0	> 100
Skunk Creek	19th Avenue	1	dip	Asphalt	4900	14000	26500	7.0	9.0	N/A	400	1
Apache Wash	24th Street	2	2.5'x5'	elliptical concrete pipe	515	1943	7213	2.0	7.0	200	2600	11
West Fork Apache Wash	26th Street	2	5'	CMP	180	690	2191	1.8	3.8	360	555	5
Paradise Wash Trib	32nd Street	1	3'	CMP	3	11	30	0.0	0.0	> 40	0	> 100
Ranieri Tank Wash	32nd Street	9	2.5' to 6' diameter	CMPs	207	726	2074	0.2	1.0	2000	0	> 100
Paradise Wash	32nd Street/Cloud Road	2	8' x 6'	Box	224	852	1701	-5.5	0.0	1701	0	> 100
Skunk Tank Wash	7th Ave	2	5'	CMP	157	550	1570	1.5	2.4	413	400	5
unnamed	7th Ave	0	Paved dip	Paved dip	15	28	70	0.6	1.2	N/A	70	10
Desert Lake Wash	7th Street	6	12' x 6.5'	RCBC	341	1192	3406	0.5	1.7	3200	3400	100
Desert Lake Wash Trib 2	7th Street	1	N/A	N/A	112	430	1330	1.3	2.1	N/A	110	2
Apache Wash	Carefree Highway	3	5' x 7'	Box	505	1748	7213	2.0	4.3	1486	2000	6
Apache Wash tributary 1	Carefree Highway	2	4'x10'	RCBC	67	232	641	-3.7	0.0	641	0	> 100
Desert Hills Wash	Carefree Highway	3	10'x5' (approx. 60 dg skew)	RCBC	243	928	4143	2.4	2.2	1420	2700	39
Desert Hills Wash Tributary 1	Carefree Highway	2	10'x5'	RCBC	39	160	417	-4.0	0.0	417	0	> 100
Desert Hills Wash Tributary 2	Carefree Highway	5	4.5'x6.5'	CMPA	46	155	562	-4.0	0.0	562	0	> 100
Desert Lake Wash	Carefree Highway	4	12' x 6.5'	RCBC	137	674	4772	1.8	4.8	1872	2000	15
Paradise Wash	Carefree Highway	4	8' x 8'	Box	256	1300	4179	1.0	3.0	2200	2800	42
Paradise Wash West Branch	Carefree Highway	3	5'x10'	RCBC	136	523	1023	1.0	2.1	455	600	31
Skunk Creek	Carefree Highway	1	4-Pier Bridge (9'3" high to bridge bottom)	Concrete	4872	13837	27283	-1.0	0.0	27300	0	> 100
unnamed	Carefree Highway	1	2.5'	CMP	17	60	172	0.0	0.0		0	undetermined
unnamed	Carefree Highway	1	2'	CMP	3	9	25	0.0	0.0		0	undetermined
unnamed	Carefree Highway	1	2.5'	CMP	12	42	120	0.0	0.0		0	undetermined
unnamed	Carefree Highway	2	2.5'	CMP	8	27	76	0.0	0.0		0	undetermined
unnamed	Carefree Highway	1	2'	CMP	5	18	50	0.0	0.0		0	undetermined
unnamed	Carefree Highway	2	5'	CMP	7	26	73	0.0	0.0		0	undetermined
unnamed	Carefree Highway	2	3.5'	CMP	43	151	432	0.5	2.5	60	383	77
unnamed	Carefree Highway	3	3' x 2'	CMP	7	25	71	0.0	0.0	15	0	> 100
unnamed	Carefree Highway	4	1'	CMP	5	63	233	0.4	3.6	35	0	> 100
unnamed	Carefree Highway	2	2'	CMP	26	91	260	0.0	0.0	58	0	> 100
unnamed	Carefree Highway	2	2'	CMP	5	17	49	0.1	0.5	45	0	> 100
unnamed	Carefree Highway	2	5'	CMP	4	13	38	0.0	0.0	> 40	0	> 100
unnamed	Carefree Highway	1	3.5'	CMP	0	20	852	0.8	2.6	30	450	50
unnamed trib of Desert Hills Wash	Carefree Highway	0			9	31	89	0.0	0.0		0	undetermined
Cline Wash Tributary C8	Circle Mountain Road	1	2 cell arch (est. 24' x 6')	Steel	228	780	2280	0.3	1.4	2220	0	> 100
Apache Wash	Cloud Road	0	Paved dip	Paved dip	515	1943	7213	5.2	5.2	N/A	100	1

Notes: OT = Overtopping; R.I. = Recurrence Interval

FIGURE 2

ADOBE DAM/ DESERT HILLS ADMP

RECURRENCE INTERVAL (R.I.) FOR 0.5 FT ROADWAY INUNDATION OF EXISTING DRAINAGE CROSSINGS

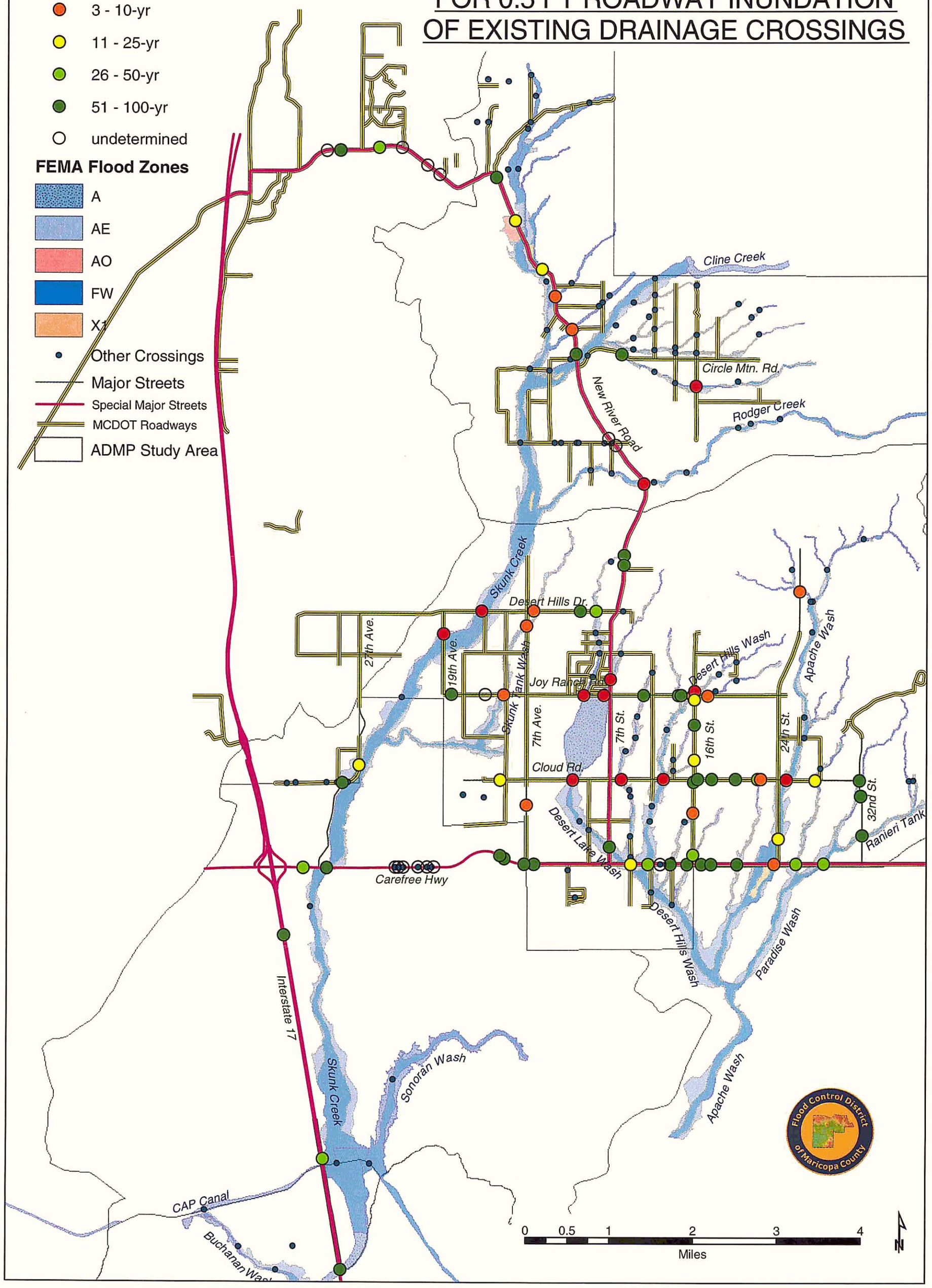

Table 1. Recurrence Interval of 0.5 foot Inundation of Arterial Roadway Crossings

Stream Name	Street Name	# of Barrels	Structure Description	Structure Material	Q2	Q10	Q100	OT Depth	OT Velocity	Q100 in Pipe	Q at 0.5 ft OT	R.I. of 0.5 ft OT
Apache Wash Trib 1	Cloud Road	2	5'	CMP	54	190	543	0.7	1.3	233	330	34
Apache Wash Trib 1	Cloud Road	1	3'	CMP	54	190	543	0.7	1.3	54	120	4
Desert Hills Wash	Cloud Road	1	n/a	Concrete	260	1006	3669	4.8	7.0	N/A	50	1
Desert Hills Wash Trib 2	Cloud Road	2	2'	CMP	20	72	205	0.3	1.6	43	0	> 100
Desert Hills Wash Tributary 1	Cloud Road	3	24"	Spiral CMP	17	60	171	0.2	1.3	69	0	> 100
Desert Lake Wash	Cloud Road	1	n/a	Concrete	148	519	1484	3.0	2.6	N/A	100	1
East Fork Desert Lake Wash	Cloud Road	1	n/a	Concrete	93	327	933	4.8	1.7	N/A	50	1
Paradise Wash West Branch	Cloud Road	1	6'	CMP	101	377	798	1.5	2.6	188	295	11
unnamed	Cloud Road	3	2.5' x 2'	CMP	59	187	585	0.8	2.0	60	227	13
unnamed	Cloud Road	1	3' x 2'	ECMP	33	114	325	0.5	2.2	42	325	100
unnamed	Cloud Road	1	6' x 4'	Box	92	153	327	0.2	1.0	270	0	> 100
unnamed trib of Skunk Tank Wash	Cloud Road	0			27	93	266	0.0	0.0		0	undetermined
Skunk Creek	Cloud Road/27th Ave	3	6'	CMP	4900	13800	27300	2.8	3.5	N/A	10500	12
Desert Lake Wash	Desert Hills Drive	6	3-4' x 3.2', 2-4.5'x3.3'	CMPA & CMP	110	410	992	0.9	2.8	339	640	38
Skunk Creek	Desert Hills Drive	1	n/a	Asphalt	4900	14000	26500	10.0	12.0	N/A	100	1
Skunk Tank Wash	Desert Hills Drive	2	5'	CMP	142	497	1420	1.5	1.5	410	420	7
unnamed	Desert Hills Drive	1	2.5' x 2'	CMP	11	37	105	0.3	1.2	35	0	> 100
Skunk Creek	I-17	1	8-barrel box	Concrete	5400	14800	28700	0.0	0.0	28700	0	> 100
Skunk Creek	I-17	0	none	n/a	0	0	6000	2.5	0.0	N/A	0	50
unnamed	I-17	2	10' x 5'	Box	46	160	720	0.0	0.0	720	0	> 100
Desert Hills Wash Trib 5	Jor Ranch Road	2	48"	CMP	82	286	782	0.6	2.6	250	600	56
Desert Lake Wash	Jor Ranch Road	1	n/a	Concrete	92	320	915	1.0	2.0	N/A	50	1
Desert Hills Wash	Joy Ranch Road	3	2-48", 1-5'	Spiral CMP	117	411	1787	1.7	3.2	445	530	7
Desert Hills Wash Tributary 6	Joy Ranch Road	1	48"	Spiral CMP	38	180	430	1.9	2.6	98	105	5
Desert Lake Wash Tributary 2	Joy Ranch Road	4	n/a	Concrete	52	182	520	0.8	1.8	N/A	50	2
East Fork Desert Lake Wash	Joy Ranch Road	2	48"	CMP	53	176	692	0.5	2.5	209	640	84
Skunk Tank Wash	Joy Ranch Road	3	5'	CMP	211	740	2110	2.2	1.8	285	420	3
Trib to Desert Hills Wash Trib 5	Joy Ranch Road	1	3'	CMP	82	286	782	0.6	2.6	37	600	56
Desert Lake Wash	New River Road	1	6'	CMP	92	321	645	0.5	2.2	386	635	97
Rodger Creek	New River Road	2	8'	CMP	1699	3310	6500	3.2	1.9	1300	1250	1
Skunk Creek	New River Road	0	bridge	Concrete	1463	4063	7840	2.2	5.1	3000	3000	12
Skunk Creek Tributary 10A	New River Road	2	5' projecting inlet on skew	CMP	187	529	1215	0.8	2.3	364	630	24
Skunk Creek Tributary 12	New River Road	2	5'	CMP	499	1230	2255	2.5	4.3	302	470	4
Skunk Creek Tributary10B	New River Road	2	5' projecting inlet on skew	CMP	182	640	1820	2.7	4.7	388	475	5
unnamed	New River Road	1	4'	CMP	13	45	129	0.1	1.2	92	0	> 100
unnamed	New River Road	4	4'	Concrete	179	365	622	0.2	0.4	592	0	> 100
unnamed	New River Road	1	2'	CMP	2150	6975	13750	0.0	0.0	13750	0	> 100
unnamed	New River Road	0			48	167	478	0.0	0.0		0	undetermined
unnamed	New River Road	0			12	41	117	0.0	0.0		0	undetermined
	New River Road	2	10' x 5'	RCB	228	797	2277	1.0	3.5	1300	1600	46
	New River Road	3	12' x 5.5'	RCB	407	1424	4070	0.8	3.2	2550	3310	64
	New River Road	0			430	1500	4310	0.0	0.0		0	undetermined
	New River Road	0			53	186	531	0.0	0.0		0	undetermined
	New River Road	0			9	33	93	0.0	0.0		0	undetermined
	New River Road	0			88	308	880	0.0	0.0		0	undetermined

Notes: OT = Overtopping; R.I. = Recurrence Interval

Appendix A

Roadway Drainage Crossing Hydrologic and Hydraulic Details

Sources of Hydrologic and Hydraulic Data for Roadway Drainage Crossing Analysis and Results

Struct_ID	Stream Name	Street Name	# of Barrels	Structure Description	Structure Material	Source of Hydrologic Data	Q2	Q10	Q100	KK_ID	Source of Hydraulic Data	OT Depth	OT Velocity	Q100 in Pipe	Q at 0.5 ft OT	R.I. of 0.5 ft OT
jef0139	Cline Wash Tributary C8	16th Street	1	n/a	Ashpalt	FDS workmaps; FCD ratios	228	800	2280	C-8	RA RAS clinec8.prj (impassable below 2-yr)	5.0	11.3	N/A	100	1
jef0175	Desert Hills Wash	16th Street	1	n/a	Dirt	FDS; DH#6e.out	117	411	1787	C109C	J.J. dthl.out HEC-2 RM 4.48	6.9	2.0	N/A	50	1
jef0152	Desert Hills Wash Tributary 1	16th Street	2	24"	CMP	FDS; DH#6e.out	39	160	417	C138	Stanley dthl-t1.prj RM 0.66	0.7	1.6	164	300	49
jef0149	Desert Hills Wash Tributary 2	16th Street	2	48"	Spiral CMP	FDS; DH#6e.out	39	157	437	C132	Stanley dthl-t2.prj RM 1.12	1.3	2.3	162	145	9
jef0169	Desert Hills Wash Tributary 3	16th Street	2	48"	CMP	FDS; DH#6e.out	48	169	532	S119	Stanley dthl-t3.prj RM 0.46	1.0	1.1	210	275	24
brd0174	Desert Hills Wash Tributary 4	16th Street	1	3' x 2'	CMP	Stanley FDS; FCD ratios	33	116	330	N/A	HY8 brd0174.inp	0.5	2.0	30	330	100
jef0179	Desert Hills Wash Tributary 6	16th Street	1	48"	Spiral CMP	FDS; DH#6e.out	38	180	430	C115	Stanley dthl-t6.prj RM 0.06	1.2	3.0	124	160	11
brd0167	unnamed	16th Street	2	2'	CMP	DH#6e.out	4	12	35	22 ac. of S121	HY8 S121_1.inp	0.2	1.1	8	0	> 100
brd0166	unnamed	16th Street	2	2'	CMP	DH#6e.out	4	12	35	22 ac. of S121	HY8 S121_1.inp	0.2	1.1	8	0	> 100
brd0104	Skunk Creek	19th Avenue	1	dip	Asphalt	SCWMP - SCE100.OH1	4900	14000	26500	S16C	SCWMP RAS RM 20.08	7.0	9.0	N/A	400	1
brd0199	Apache Wash	24th Street	2	2.5'x5'	elliptical concrete pipe	FDS; DH#6e.out	515	1943	7213	C221	apache1.prj from CC CMP RM 4.96	2.0	7.0	200	2600	11
brd0130	West Fork Apache Wash	26th Street	2	5'	CMP	FDS; DH#6e.out	180	690	2191	C214	HY8 WBAWAT26.inp	1.8	3.8	360	555	5
brd0171	Paradise Wash Trib	32nd Street	1	3'	CMP	13.1 ac of S304 in DH#6e.out	3	11	30	S304	HY8 S304_1	0.0	0.0	> 40	0	> 100
brd0196	Ranieri Tank Wash	32nd Street	9	2.5' to 6' diameter	CMPs	DH#6e.out	207	726	2074	RR310	RR310 and HY8 for SE-SQ curve	0.2	1.0	2000	0	> 100
brd0193	Paradise Wash	32nd Street/Cloud Road	2	8' x 6'	Box	FDS; DH#6e.out	224	852	1701	C303	J.J. HEC-2 file PARADFCD.DAT (SC betw 3.149-3.177)	-5.5	0.0	1701	0	> 100
brd0165	Skunk Tank Wash	7th Ave	2	5'	CMP	MKE FDS; FCD Ratios	157	550	1570	N/A	STW_FW1Y.OH2	1.5	2.4	413	400	5
	unnamed	7th Ave	0	Paved dip	Paved dip	Estimated from DHA FLO-2D Grid 9638	15	28	70	FLO2D	FLO-2D Grid cell 9638	0.6	1.2	N/A	70	10
jef0118	Desert Lake Wash	7th Street	6	12' x 6.5'	RCBC	FDS; FCD Ratios	341	1192	3406	N/A	HY8 7th_st.inp	0.5	1.7	3200	3400	100
	Desert Lake Wash Trib 2	7th Street	1	N/A	N/A	FDS; DH#6e.out	112	430	1330	C104	FLO2D grid 3328	1.3	2.1	N/A	110	2
brd0198	Apache Wash	Carefree Highway	3	5' x 7'	Box	FDS; DH#6e.out	505	1748	7213	C222	J.J. apache.dat HEC-2 (Q100 = 5739; 1474 in w chl)	2.0	4.3	1486	2000	6
jef0154	Apache Wash tributary 1	Carefree Highway	2	4'x10'	RCBC	FDS; DH#6e.out	67	232	641	C226	Stanley apch-t1.prj; RM 0.73	-3.7	0.0	641	0	> 100
jef0141	Desert Hills Wash	Carefree Highway	3	10'x5' (approx. 60 dg skew)	RCBC	FDS; DH#6e.out	243	928	4143	C127L	J.J.dthl.out in HEC-2 RM 2.005	2.4	2.2	1420	2700	39
jef0144	Desert Hills Wash Tributary 1	Carefree Highway	2	10'x5'	RCBC	FDS; DH#6e.out	39	160	417	C138	Stanley dthl-t1.prj RM 0.53, under	-4.0	0.0	417	0	> 100
jef0143	Desert Hills Wash Tributary 2	Carefree Highway	5	4.5'x6.5'	CMPA	FDS; DH#6e.out	46	155	562	C133	Stanley dthl-t2.prj RM 0.4	-4.0	0.0	562	0	> 100
jef0117	Desert Lake Wash	Carefree Highway	4	12' x 6.5'	RCBC	FDS; DH#6e.out	137	674	4772	FLO2D	J.J. jona.out HEC2 RM 0.22	1.8	4.8	1872	2000	15
brd0197	Paradise Wash	Carefree Highway	4	8' x 8'	Box	FDS; DH#6e.out	256	1300	4179	C314	FDS work map plot shows about 1 ft over road	1.0	3.0	2200	2800	42
jef0156	Paradise Wash West Branch	Carefree Highway	3	5'x10'	RCBC	FDS; DH#6e.out	136	523	1023	C317	J.J. prdwst.out HEC-2 RM 0.345	1.0	2.1	455	600	31
tjn0116	Skunk Creek	Carefree Highway	1	4-Pier Bridge (9'3" high to bridge bottom)	Concrete	SC#e.OH1	4872	13837	27283	S22C	SC_FEMA.prj from SCWMP	-1.0	0.0	27300	0	> 100
brd0184	unnamed	Carefree Highway	1	2.5'	CMP	4 cfs/ac * 43 ac; FCD ratios	17	60	172	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0183	unnamed	Carefree Highway	1	2'	CMP	4 cfs/ac * 6.3 ac; FCD ratios	3	9	25	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0182	unnamed	Carefree Highway	1	2.5'	CMP	4 cfs/ac * 29.8 ac; FCD ratios	12	42	120	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0181	unnamed	Carefree Highway	2	2.5'	CMP	4 cfs/ac * 19.0 ac; FCD ratios	8	27	76	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0180	unnamed	Carefree Highway	1	2'	CMP	4 cfs/ac * 12.4 ac; FCD ratios	5	18	50	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0179	unnamed	Carefree Highway	2	5'	CMP	4 cfs/ac * 18.3 ac; FCD ratios	7	26	73	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0176	unnamed	Carefree Highway	2	3.5'	CMP	DH#6e.out	43	151	432	S140	HY8 S140	0.5	2.5	60	383	77
brd0175	unnamed	Carefree Highway	3	3' x 2'	CMP	26.1 ac of S140 in DH#6e.out	7	25	71	S140	HY8 S140_E	0.0	0.0	15	0	> 100
brd0200	unnamed	Carefree Highway	4	1'	CMP	DH#6e.out	5	63	233	C153	HY8 brd0200.inp	0.4	3.6	35	0	> 100
brd0201	unnamed	Carefree Highway	2	2'	CMP	DH#6e.out; HY8 D152.inp	26	91	260	D152	HY8 D152.inp; Q > pipe flows E along CFH not over	0.0	0.0	58	0	> 100
brd0202	unnamed	Carefree Highway	2	2'	CMP	DH#6e.OUT	5	17	49	S151	HY8 brd0202.inp	0.1	0.5	45	0	> 100
brd0203	unnamed	Carefree Highway	2	5'	CMP	DH#6e.OUT	4	13	38	S150	HY8 brd0203.inp	0.0	0.0	> 40	0	> 100
brd0204	unnamed	Carefree Highway	1	3.5'	CMP	BF FDS	0	20	852	RR17	HY8 C170.INP	0.8	2.6	30	450	50
twl0100	unnamed trib of Desert Hills Wash	Carefree Highway	0			DH#6.OUT	9	31	89	S130	Undetermined possibly no culvert here	0.0	0.0		0	Undetermined
jef0138	Cline Wash Tributary C8	Circle Mountain Road	1	2 cell arch (est. 24' x 6')	Steel	FDS workmaps; FCD ratios	228	780	2280	C-8	HY8 tc8atcm.inp	0.3	1.4	2220	0	> 100
brd0189	Apache Wash	Cloud Road	0			FDS; DH#6e.out	515	1943	7213	C221	J.J. apache.out HEC-2 RM 5.64	5.2	5.2	N/A	100	1
brd0169	Apache Wash Trib 1	Cloud Road	2	5'	CMP	DH#6e.out	54	190	543	S225	HY8 file s225w	0.7	1.3	233	330	34
brd0170	Apache Wash Trib 1	Cloud Road	1	3'	CMP	DH#6e.out	54	190	543	S225	HY8 file s225e	0.7	1.3	54	120	4
jef0172	Desert Hills Wash	Cloud Road	1	n/a	Concrete	FDS; DH#6e.out	260	1006	3669	C116	J.J. dthl.out RM 3.13	4.8	7.0	N/A	50	1
brd0168	Desert Hills Wash Trib 2	Cloud Road	2	2'	CMP	DH#6e.out	20	72	205	S131	HY8 s131.inp	0.3	1.6	43	0	> 100
jef0148	Desert Hills Wash Tributary 1	Cloud Road	3	24"	Spiral CMP	DH#6e.out	17	60	171	S137	HY8 file s137.inp	0.2	1.3	69	0	> 100
jef0121	Desert Lake Wash	Cloud Road	1	n/a	Concrete	FDS; FCD Ratios	148	519	1484	N/A	Stanley dslk-so.prj RM 1.76	3.0	2.6	N/A	100	1
jef0157	East Fork Desert Lake Wash	Cloud Road	1	n/a	Concrete	FDS; FCD Ratios	93	327	933	N/A	Stanley dslk-ef.prj RM 1.1	4.8	1.7	N/A	50	1
jef0155	Paradise Wash West Branch	Cloud Road	1	6'	CMP	FDS: DH#6e.out	101	377	798	C316	Stanley Parads-WF.prj RM 1.48	1.5	2.6	188	295	11
brd0161	unnamed	Cloud Road	3	2.5' x 2'	CMP	Region 12 Reg. Eq.; FCD Ratios	59	187	585	N/A	HY8 brd0161.inp	0.8	2.0	60	227	13
brd0164	unnamed	Cloud Road	1	3' x 2'	ECMP	Reg. 12 Reg Eq; FCD ratios	33	114	325	N/A	HY8 brd0164.inp	0.5	2.2	42	325	100
brd0154	unnamed	Cloud Road	1	6' x 4'	Box	Tramanto MDP	92	153	327	Basin G	HY8 brd0154.inp	0.2	1.0	270	0	> 100
twl007	unnamed trib of Skunk Tank Wash	Cloud Road	0			Region 12 Reg. Eq.; FCD Ratios	27	93	266	N/A	Undetermined	0.0	0.0		0	Undetermined
brd0101	Skunk Creek	Cloud Road/27th Ave	3	6'	CMP	SC#E.OH1	4900	13800	27300	S21C2	SCWMP Att 11 (road in F/P)	2.8	3.5	N/A	10500	12
jef0130	Desert Lake Wash	Desert Hills Drive	6	3-4' x 3.2', 2-4.5'x3.3'	CMPA & CMP	FDS; DH#6e.out	110	410	992	C101	Stanley dslk.prj RM 3.985	0.9	2.8	339	640	38
brd0105	Skunk Creek	Desert Hills Drive	1	n/a	Asphalt	SCWMP - SCE100.OH1	4900	14000	26500	S16C	SCWMP RAS RM 20.77	10.0	12.0	N/A	100	1
brd0153	Skunk Tank Wash	Desert Hills Drive	2	5'	CMP	MKE FDS; FCD Ratios	142	497	1420	N/A	STW_FW1Y.OH2	1.5	1.5	410	420	7
brd0152	unnamed	Desert Hills Drive	1	2.5' x 2'	CMP	DH#6.OUT	11	37	105	S500	HY8 brd152.inp	0.3	1.2	35	0	> 100
tjn0100	Skunk Creek	I-17	1	8-barrel box	Concrete	SCWMP - SCE100.OH1	5400	14800	28700	S24C	Tetra Tech FLO-2D	0.0	0.0	28700	0	> 100
twl000	Skunk Creek	I-17	0	none	n/a	TetraTech FLO-2D	0	0	6000	N/A	TetraTech FLO-2D	2.5	0.0	N/A	0	50
brd0185	unnamed	I-17	2	10' x 5'	Box	BF#6e.out	46	160	720	B18C	Biscuit Flat FDS	0.0	0.0	720	0	> 100
jef0162	Desert Hills Wash Trib 5	Jor Ranch Road	2	48"	CMP	FDS; dh#6e.out	82	286	782	S109	Stanley dthl-t5.prj RM 0.21 (with brd0172)	0.6	2.6	250	600	56
jef0125	Desert Lake Wash	Joy Ranch	1	n/a	Concrete	FDS; FCD Ratios	92	320	915	N/A	FLO-2D grid 4079	1.0	2.0	N/A	50	1
jef0174	Desert Hills Wash	Joy Ranch Road	3	2-48", 1-5'	Spiral CMP	FDS; DH#6e.out	117	411	1787	C109C	J.J. dthl.out HEC-2 RM 4.4	1.7	3.2	445	530	7
jef0178	Desert Hills Wash Tributary 6	Joy Ranch Road	1	48"	Spiral CMP	FDS; DH#6e.out	38	180	430	C115	Stanley dthl-t6.prj RM 0.22	1.9	2.6	98	105	5
jef0142	Desert Lake Wash Tributary 2	Joy Ranch Road	4	n/a	Concrete	FDS; FCD Ratios	52	182	520		FLO-2D grid 4091	0.8	1.8	N/A	50	2
jef0164	East Fork Desert Lake Wash	Joy Ranch Road	2	48"	CMP	FDS; DH#6e.out	53	176	692	C106	Stanley dslk-ef.prj RM 2.26	0.5	2.5	209	640	84
brd0162	Skunk Tank Wash	Joy Ranch Road	3	5'	CMP	MKE FDS; FCD Ratios	211	740	2110	N/A	STW_FW1Y.OH2	2.2	1.8	285	420	3

Sources of Hydrologic and Hydraulic Data for Roadway Drainage Crossing Analysis and Results

Struct_ID	Stream Name	Street Name	# of Barrels	Structure Description	Structure Material	Source of Hydrologic Data	Q2	Q10	Q100	KK_ID	Source of Hydraulic Data	OT Depth	OT Velocity	Q100 in Pipe	Q at 0.5 ft OT	R.I. of 0.5 ft OT
brd0172	Trib to Desert Hills Wash Trib 5	Joy Ranch Road	1	3'	CMP	FDS; dh#6e.out	82	286	782	S109	Stanley dthl-t5.prj RM 0.21 (with jef0162)	0.6	2.6	37	600	56
jef0132	Desert Lake Wash	New River Road	1	6'	CMP	FDS; DH#6e.out	92	321	645	S100	Stanley dslk.prj RM 4.96	0.5	2.2	386	635	97
brd0118	Rodger Creek	New River Road	2	8'	CMP	FDS; SC#e.OH1	1699	3310	6500	CO-2	Rodger Creek FDS	3.2	1.9	1300	1250	1
	Skunk Creek	New River Road	0			SC#E.OH1	1463	4063	7840	S6C	SCWMP Att 11	2.2	5.1	3000	3000	12
jef0140	Skunk Creek Tributary 10A	New River Road	2	5' projecting inlet on skew	CMP	520 ac of S-10, SC#E.Oh1	187	529	1215	S-10	HY8 T10AatNR.inp	0.8	2.3	364	630	24
jef0145	Skunk Creek Tributary 12	New River Road	2	5'	CMP	SLA work maps; SC#E.OH1	499	1230	2255	S-12	HY8 T12ATNR.inp	2.5	4.3	302	470	4
brd0099	Skunk Creek Tributary10B	New River Road	2	5' projecting inlet on skew	CMP	SLA workmaps and ADMP ratios	182	640	1820		HY8 T10BATNR.inp; WEIR T10BatNR.OUT	2.7	4.7	388	475	5
brd0149	unnamed	New River Road	1	4'	CMP	37.7 ac of S101, DH#6e.dat	13	45	129	S101	HY8 S101_1	0.1	1.2	92	0	> 100
brd0138	unnamed	New River Road	4	4'	Concrete	252 ac of S-7 in SC#E.OH1	179	365	622	S-7	HY8 TWOFSC.INP	0.2	0.4	592	0	> 100
brd0141	unnamed	New River Road	1	2'	CMP	SC#E.out	2150	6975	13750	CCO-5	new FDS shows all flow under NR Rd bridge	0.0	0.0	13750	0	> 100
twl005	unnamed	New River Road	0			Region 12 Reg. Eq.; FCD Ratios	48	167	478	N/A	Undetermined	0.0	0.0		0	Undetermined
twl006	unnamed	New River Road	0			Region 12 Reg. Eq.; FCD Ratios	12	41	117	N/A	Undetermined	0.0	0.0		0	Undetermined
mjk0100		New River Road	2	10' x 5'	RCB	Region 12 Reg. Eq.; FCD ratios	228	797	2277	N/A	HY8 MJK0100.inp	1.0	3.5	1300	1600	46
mjk0101		New River Road	3	12' x 5.5'	RCB	Region 12 Reg. Eq.; FCD ratios	407	1424	4070	N/A	HY8 MJK0101.inp	0.8	3.2	2550	3310	64
twl001		New River Road	0			Region 12 Reg. Eq.; FCD Ratios	430	1500	4310	N/A	Undetermined	0.0	0.0		0	Undetermined
twl004		New River Road	0			Region 12 Reg. Eq.; FCD Ratios	53	186	531	N/A	Undetermined	0.0	0.0		0	Undetermined
twl003		New River Road	0			Region 12 Reg. Eq.; FCD Ratios	9	33	93	N/A	Undetermined	0.0	0.0		0	Undetermined
twl002		New River Road	0			Region 12 Reg. Eq.; FCD Ratios	88	308	880	N/A	Undetermined	0.0	0.0		0	Undetermined