Appendix C

- Technical Memorandum #3 - Conceptual Drainage Report, June 2011

HIDDEN WATERS PARKWAY NORTH
CORRIDOR FEASIBILITY STUDY
INTERSTATE 10 TO STATE ROUTE 74
CONTRACT NUMBER: 2010-054

TECHNICAL MEMORANDUM NO. 3
CONCEPTUAL DRAINAGE REPORT

Prepared For:

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Table of Contents

List of Tables

List of Figures

List of Appendices

Electronic Disc
- GIS data
- Report MS Word & PDF files
- Reference document files from FCDMC library

1.0 Introduction

The area west of the White Tank Mountains within the Hassayampa River Valley has been identified as an area where intense growth is anticipated to occur in the next 30 to 50 years. In response to this anticipated growth the Maricopa Association of Governments (MAG) completed the Interstate-10/Hasayampa Valley Transportation Framework Study (Hassayampa Framework Study) in 2007. This study identified a comprehensive roadway network to meet future traffic demands in northwest Maricopa County. Hidden Waters Parkway baseline alignment was identified in this high level planning study (Hassayampa Framework study). The Maricopa County Department of Transportation commissioned the Hidden Waters Parkway North Corridor Feasibility Study to further refine the baseline alignment as shown on the Hassayampa Framework Study. Any reference made throughout this document to the Hidden Waters Parkway baseline alignment is a reflection of the alignment as shown in the Hassayampa Framework Study with the understanding that the Preferred Alignment may differ from the baseline alignment and will be described in the Final Report.

The Hidden Waters Parkway North Corridor Feasibility Study area is located west of the Phoenix metropolitan area in Maricopa County, Arizona (Figure 1). The study area includes the northern section of the Hidden Waters Parkway, as shown on the I-10/Hassayampa Valley Transportation Framework Study (Hassayampa Framework Study), from Interstate 10 (I-10) north the future alignment of State Route 74 (SR74). The study area is approximately 28 miles long and two miles wide. Except in the area from Northern Avenue to Bell Road were the study area expands to two miles west of the alignment and from the south end of Douglas Ranch to Patton Road were the study area expands to two miles east of the alignment for a total of three miles wide in these two areas (refer to Figure 1 for graphic depiction of study area).

The purpose of this corridor feasibility study is to identify potential fatal flaws and develop an alignment alternative that meets the future traffic needs of the area. Several technical memoranda are being prepared in support of the corridor feasibility study including Technical Memorandum No. 1, Existing and Future Corridor Features, Memorandum No. 2, Environmental Overview, and Technical Memorandum No. 3 Drainage Overview.

This conceptual drainage study is being conducted in support of the Hidden Waters Parkway North Corridor Feasibility Study. The elements of this conceptual drainage study cover the baseline alignment of the Hidden Waters Parkway provided in the Hassayampa Framework Study (MAG, 2007) from Interstate 10 north to the proposed extension of the State Route 74 alignment along the base of the Vulture Mountains.

Figure 1 shows the baseline corridor alignment for Hidden Waters Parkway North. The baseline corridor runs in a north-south direction north from Interstate 10 near the 339th Avenue alignment about 28.5 miles to approximately the 301st Avenue alignment. Most of the cross draining watersheds within the corridor flow from west to east toward the Hassayampa River. The majority of offsite drainage basins are small in area with the important exception of Jackrabbit Wash which has a significant watershed, large alluvial channel, and extensive 100-year floodplain.

Offsite drainage was evaluated primarily through the review of existing hydrology reports for the area. Roadway drainage crossing specific discharges were estimated based on the results documented in existing reports. 100-year and 50-year peak discharges were determined for each crossing location for the baseline corridor alignment. Three categories of conceptual cross drainage structures (pipe culvert, box culvert, or bridge) were assigned based on the computed flow rates to pass flows across the proposed roadway corridor.

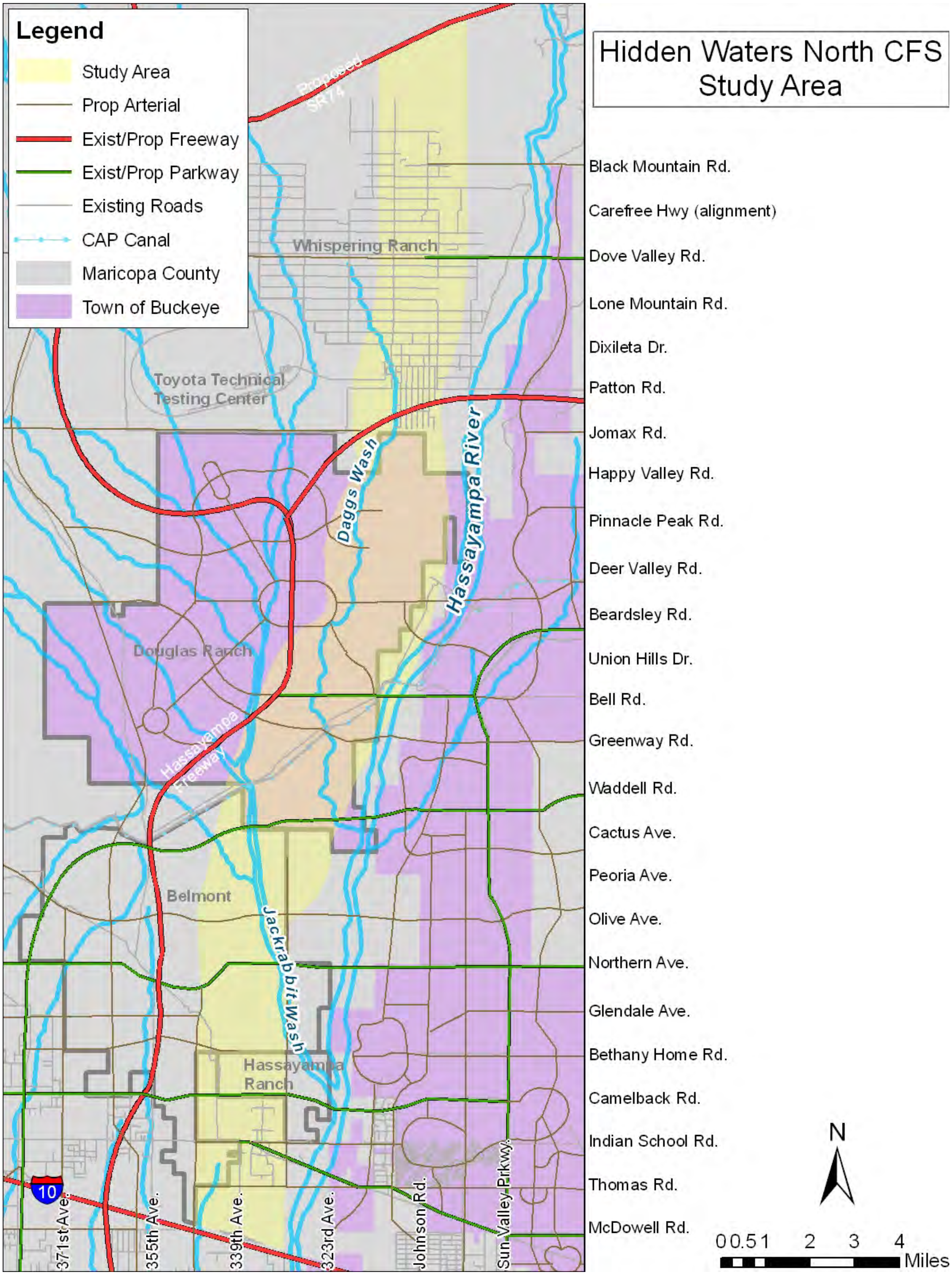

Figure 1. Hidden Waters Parkway North study area

2.0 Existing Hydrology Reports

Existing hydrology and floodplain delineation reports along the study segment were collected and reviewed. The entire area was found to have been previously studied as part of one or more floodplain delineation studies by the Flood Control District of Maricopa County (FCDMC). The pertinent studies are discussed briefly in the following sections.

Figure 2 shows a map of the FCDMC Area Drainage Master Study (ADMS) or Plan (ADMP) boundaries in the vicinity of the Hidden Waters Parkway study area. Only two of the ADMS/P areas overlap the study area. The Jackrabbit Wash ADMS area covers approximately 95 percent of the Hidden Waters Parkway study area while the Luke Wash ADMS area covers just a small portion of the southwest corner of the study area. As of April 2011, neither of these two areas have an official FCDMC ADMS performed. However, various floodplain delineation studies have been conducted in the Hidden Waters Parkway study area. Hydrology has been developed to estimate 100-year discharges and most of the large and medium size watercourses have had their 100-year floodplains delineated. However, the level of floodplain delineation detail varies by watercourse. Figure 3 shows the delineated floodplains in the area.

<u>Jackrabbit Wash Floodplain Delineation Study (FCDMC, 1991)</u>

The earliest floodplain study in the area was the Jackrabbit Wash Floodplain Delineation Study (FDS) performed for FCDMC by Burgess & Niple in 1991. This study computed 100-year 6-hour and 100-year 24-hour discharges for the Jackrabbit Wash watershed including Daggs and Star Washes. The HEC-1 computer model was used to compute discharges for the watershed. The study was performed for FCDMC using an early version of their Drainage Design Manual, Volume I – Hydrology. Many of the later delineation studies affecting the Hidden Waters Parkway study area used the 100-year discharges computed in this report including the Daggs Wash FDS (FCDMC, 1993) and the Watershed 'OO' FDS (FCDMC, 2003a).

<u>Daggs Wash Floodplain Delineation Study (FCDMC, 1993)</u>

The Daggs Wash Floodplain Delineation Study used the 100-year discharge estimates from the Jackrabbit Wash FDS to perform HEC-2 floodplain delineation modeling for Daggs Wash. About 13 miles of the Daggs Wash floodplain were delineated beginning at the Hassayampa River and continuing upstream across the CAP Canal to the Peak View Road alignment. The delineation included a floodway determination for most of the study reach to a point about one mile south of Patton Road.

<u>Approximate Zone A Floodplain Delineation Study of Watershed 'OO' (FCDMC, 2003a)</u>

JE Fuller/Hydrology & Geomorphology, Inc. conducted an extensive Zone A, or approximate, floodplain delineation study of numerous small watercourses within the Jackrabbit Wash watershed and a number of adjacent, small Hassayampa River tributaries for FCDMC. Discharges were computed based on regional equations derived from the Jackrabbit Wash FDS (FCDMC, 1991) model results. Equations were based on physiographically similar areas and drainage area size. Floodplain delineations were performed using HEC-RAS and the 2001 countywide ten-foot contour mapping.

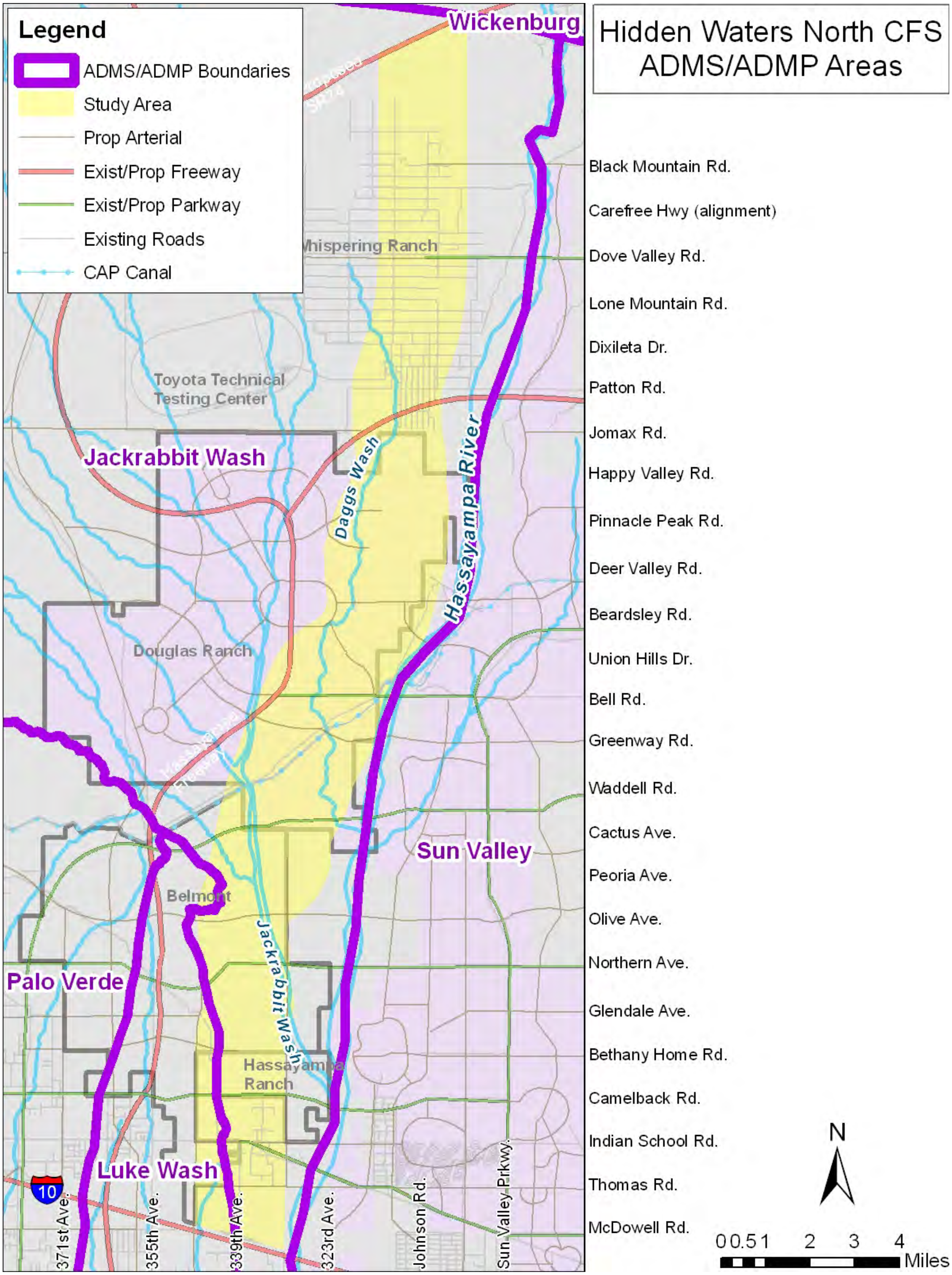

Figure 2. County ADMS/ADMP boundaries

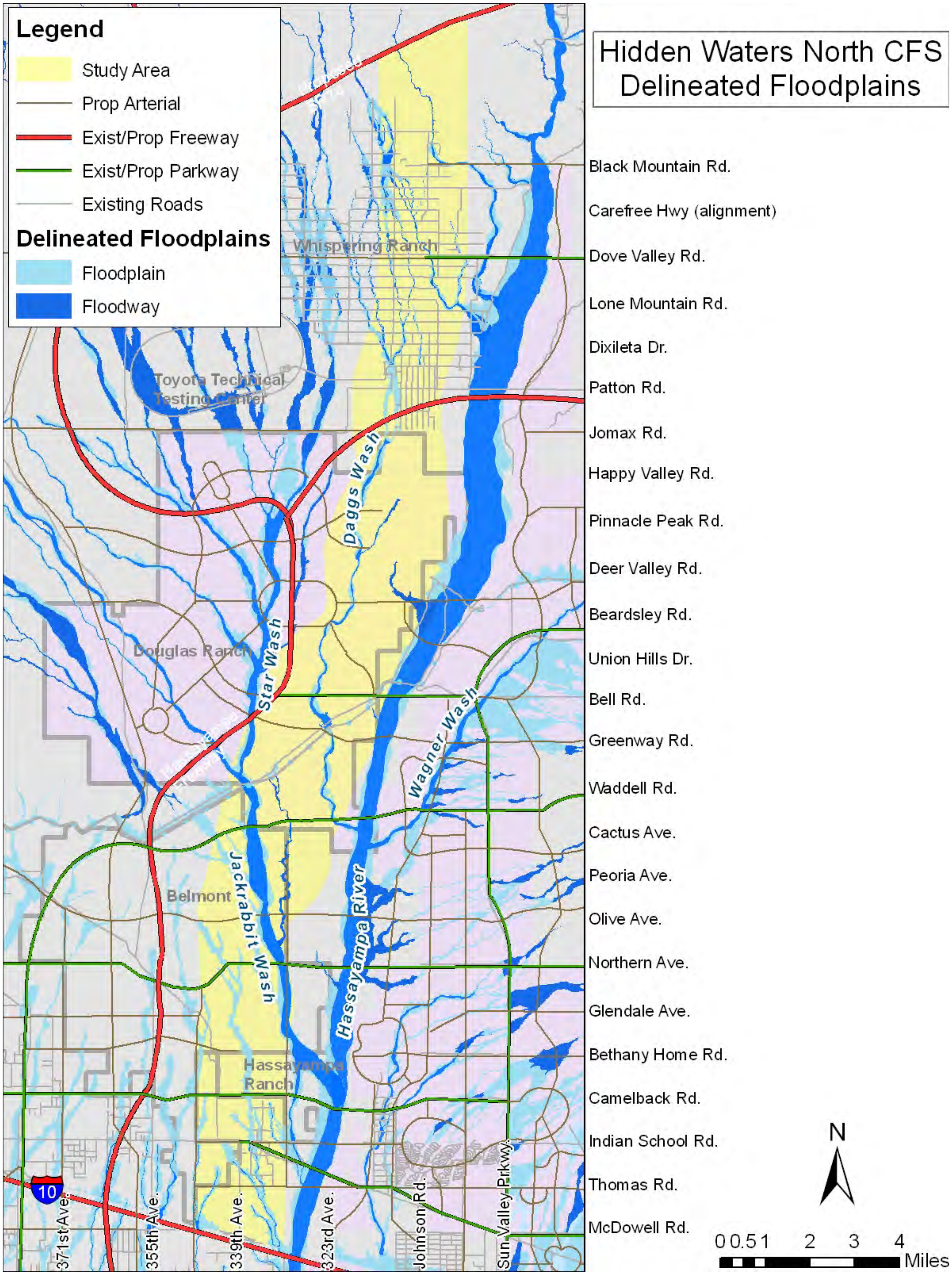

Figure 3. Delineated floodplains in study area

Upper Daggs/Star Wash Zone AE FDS (FCDMC, 2008b)
In the Upper Daggs/Star Wash Zone AE Floodplain Delineation Study, 75 miles of the approximate Zone A floodplains delineated as part of the Watershed 'OO' study were upgraded to detailed Zone AE delineates. Base flood elevations to establish the AE zones were computed using HEC-RAS. Floodways were also delineated. The reaches included numerous upper watershed tributaries of Daggs and Star Washes as well as a few small tributaries draining directly to the Hassayampa River.

Zone A – Floodplain Delineation of Watershed 'PP' Luke Wash (FCDMC, 2003b)
Entellus delineated approximately 90 miles of watercourses within the Luke Wash drainage basin and another 20 miles of small Hassayampa River tributaries as part of this study. Approximate methods were used to estimate floodplain boundaries. The 100-year discharges were calculated using an area-runoff relationship derived from HEC-1 analyses performed as part of the Luke Wash Flood Insurance Study (FCDMC, 1992). Floodplain hydraulics were computed using Manning's equation for individual cross sections.

Luke Wash Watershed Zone AE Floodplain Delineation Study (FCDMC, 2009)
This 2009 study developed new HEC-1 modeling of 100-year 24-hour and 100-year 6-hour rainfall events for the Luke Wash watershed area. The results were used to update and redelineate about 90 miles of floodplains using detailed methods. Zone AE floodplains were delineated using HEC-RAS. Floodway delineations were also performed. This study provides the most recent drainage-related information for much of the study corridor south of Jackrabbit Wash.

Electronic versions of these reports are included on the electronic disc accompanying this memorandum. They are also available through the FCDMC Library. The FCDMC Library call numbers for each reference are provided in the reference list with this memo.

Earth Fissures

Significant groundwater withdrawal can cause an area to experience subsidence (lowering) of the ground surface. In some areas of Arizona, land subsidence has occurred at different rates. The result can be large, deep cracks in the earth's surface. These cracks, or earth fissures, create a significant hazard to constructed features including roadways. Earth fissures also intercept surface runoff which in turn increases their size.

The Arizona Department of Water Resources (ADWR) has conducted satellite monitoring of subsidence throughout the state. Figure 4 shows a map of active land subsidence area in the vicinity of the Hidden Waters Parkway North study area. Note that none of the identified areas are within close proximity of the study area.

Depth to Groundwater

Figure 5 shows a map of groundwater wells located in the study area and vicinity. The data are taken from the ADWR well database. Also shown in Figure 5 is the depth to groundwater reported in the well database. Not all wells have depth to water data. Stations without depth data are symbolized in yellow triangles. For the wells with depth data, a contour map was made in GIS of the depth to groundwater. The results highlight that groundwater is shallowest in areas near to the large watercourses – namely the Hassayampa River and Jackrabbit Wash.

Figure 4. ADWR active land subsidence areas map

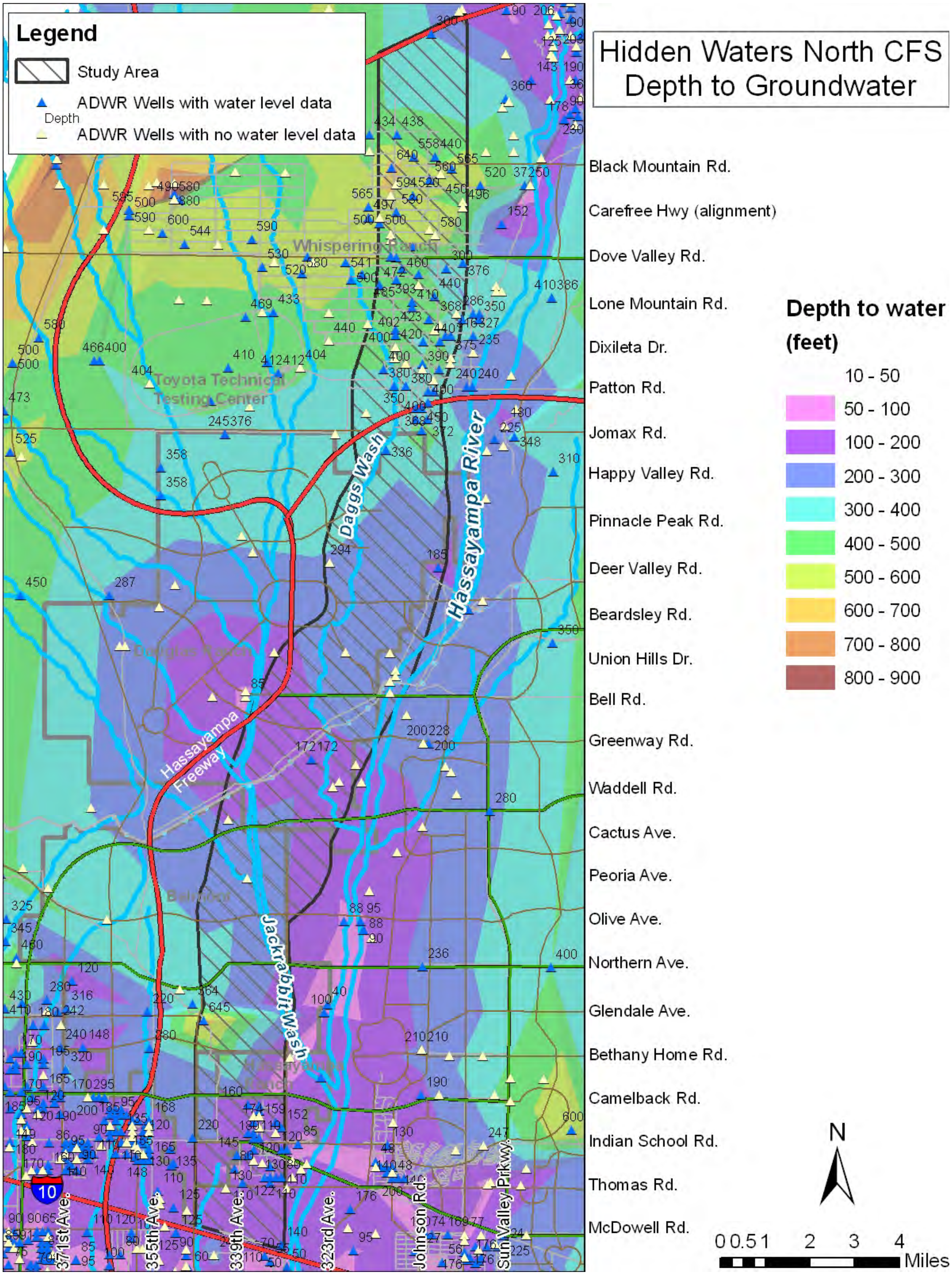

Figure 5. ADWR wells and depth to groundwater

3.0 Past Drainage Problems

Past drainage problems along the study corridor were investigated by contacting appropriate personnel from agencies with responsibilities in the area. Because most of the corridor length is undeveloped and without access, no significant drainage-related issues were noted by personnel contacted.

A large flood did occur on Jackrabbit Wash and its tributaries in October 2000. The flood event in the study area was possibly in excess of the 100-year regulatory discharge. Extensive documentation of the flooding extents and impacts of that event are summarized in AZGS Open-file Report OFR02-06. A copy of this report is provided electronically with this memorandum.

4.0 Existing Drainage Facilities

The study area currently has very little in the way of developed drainage facilities. In the far southern portion of the study area there are a few small diameter culverts along 339th Avenue and several more along Indian School Road (Figure 6). However, the remainder of the study area has very few roadways. Any of the other roadway drainage crossings are at-grade, so-called, dip-crossings that allow offsite runoff to pass over the top of the road surface.

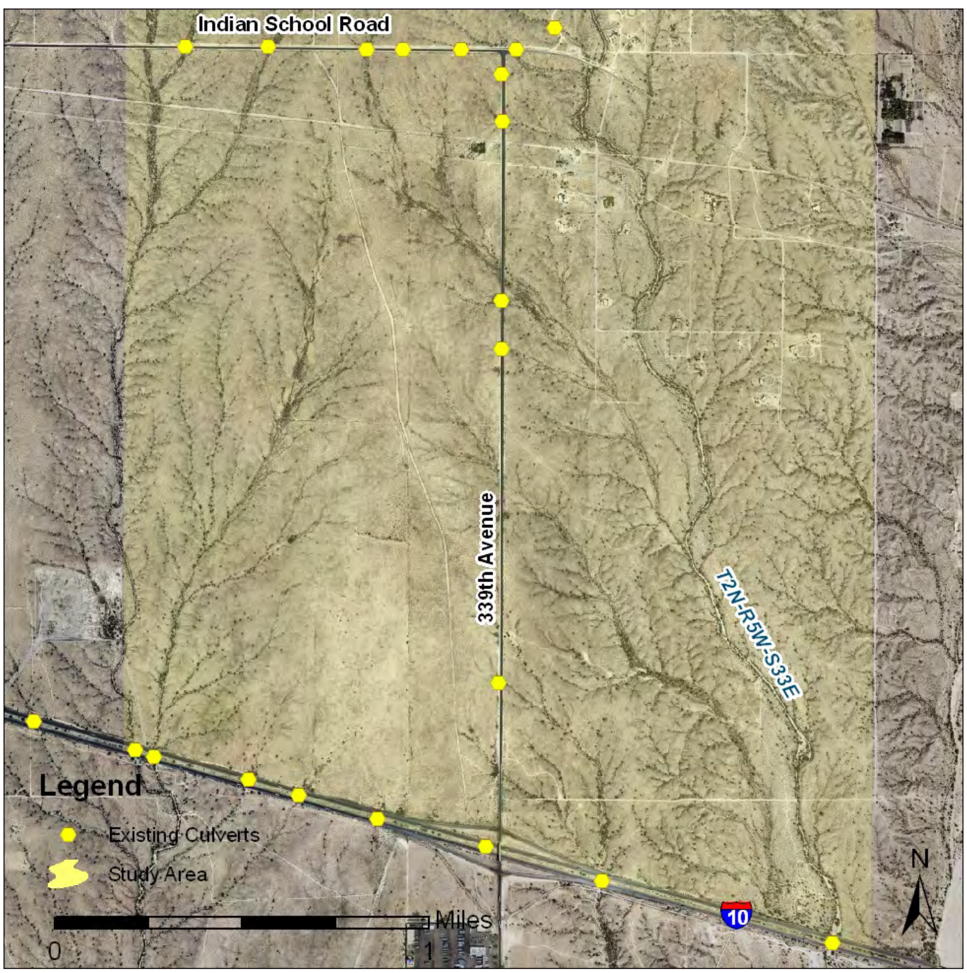

Figure 6. Existing culverts in south portion of study area

The other major drainage facilities in the area are associated with the Central Arizona Project (CAP) Canal. The baseline alignment passes over the Reach 7 of the Hayden-Rhodes Aqueduct of the CAP Canal within the study area. There are two major drainage crossings of the CAP Canal within the study area – Jackrabbit Wash and Daggs Wash. In addition, there are two pipe overchute crossings and three small culvert crossings of the canal within the study area. The Jackrabbit Wash crossing is an approximately 1,450 foot long siphon passing beneath Jackrabbit Wash. Daggs Wash crosses the canal in a 47.3-foot wide concrete flume. Table 1 shows a listing of the CAP drainage crossings of Reach 7 within the study area. Figure 7 shows the location of these CAP drainage crossings. PDFs of the original US Bureau of Reclamation hydrology documents are also provide on the electronic disc accompanying this report.

Table 1. CAP Canal Drainage Crossings in Study Area

Drainage Crossing	Hayden-Rhodes Reach 7 Station	Facility Description
Jackrabbit Wash	366+78	1450-foot siphon
Wash T3-R5-S33	393+00	1 – 66-inch pipe overchute
Wash T3-R5-S33	402+50	1 – 66-inch pipe overchute
Daggs Wash	485+00	47.33-foot flume
Wash T3-R5-S01	544+25	2 – 36-inch pipe culverts
unnamed wash	561+50	1 – 30-inch pipe culvert
unnamed wash	571+50	1 – 30-inch pipe culvert

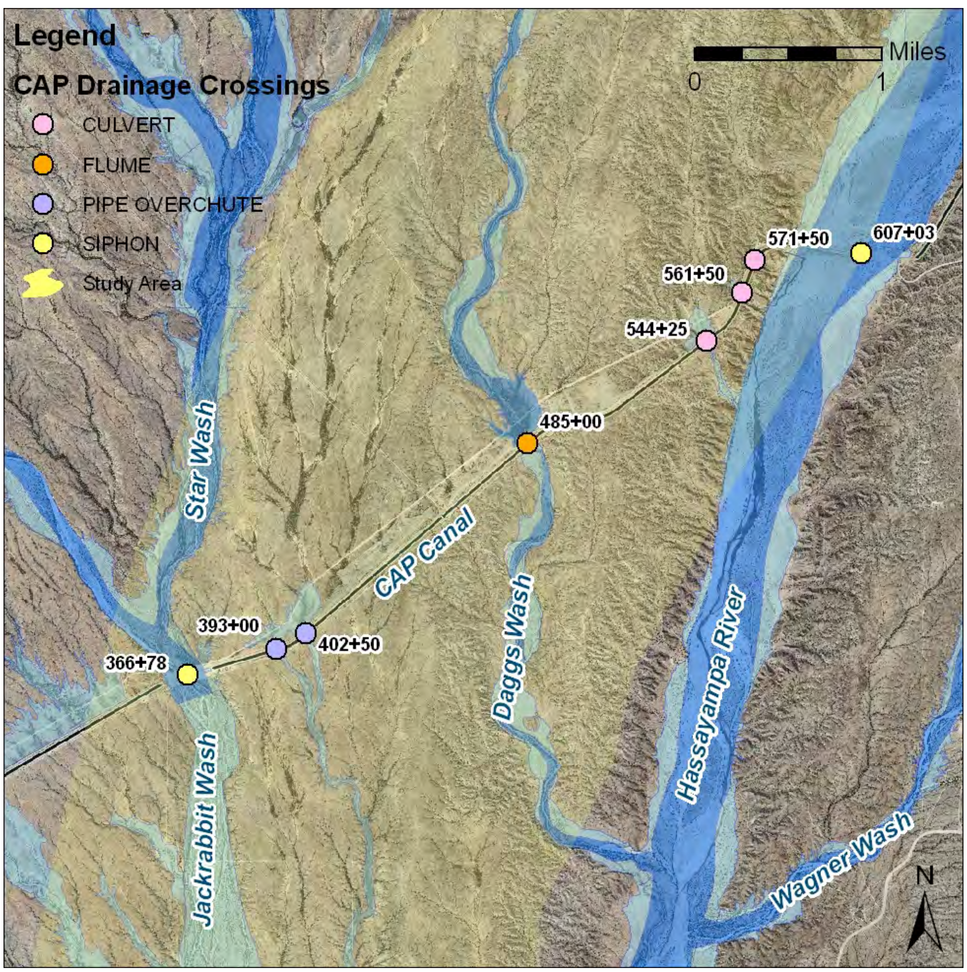

Figure 7. CAP drainage crossings in study area

5.0 Existing Concentration Points

Based on the review of the existing reports and hydrologic modeling in the area, it was determined that reasonable estimates of all the potential roadway drainage crossings for the baseline alignment could be made using the data in those reports. The approach and results of those estimates are presented in the following sections.

Hydrology

The first step in determining estimated offsite flood discharges along the baseline corridor (per the Hassayampa Framework Study) was to identify drainage crossing locations. Roadway drainage crossing locations were identified based on examination of high resolution digital aerial photographs, topographic maps, and delineated floodplains in the study area. Next, drainage basin delineations and HEC-1 modeling results from existing hydrology studies in the area were reviewed and interpreted. Finally, those watersheds were subdivided in order to compute the drainage area contributing to each of the identified crossing locations. Discharges were then estimated based on a ratio of the computed area and the area and discharge reported in the most recent existing hydrology study.

Eighty-four roadway drainage crossing locations were identified for the baseline alignment of the Hidden Waters Parkway as shown in the Hassayampa-Hidden Valley Framework Study. The 100-year and 50-year discharges were computed for each drainage crossing location. The 50-year discharge was estimated as 67 percent of the computed 100-year discharge based on examination of the USGS Jackrabbit Wash gaging station data reported in Pope & others (1998).

Results

Figure 8 shows the 84 locations of the roadway drainage crossings identified for the baseline alignment. The existing conditions estimated discharge results for those roadway drainage crossings are presented in Table 2. These are considered the best estimate of the current condition 50- and 100-year runoff peak discharges for the drainage areas impacting the baseline corridor alignment for Hidden Waters Parkway. Table 2 also includes the hydrology study source from which each discharge estimate was taken or computed. A more detailed table of data on the discharge determination for each crossing is provided in the appendix to this memorandum.

GIS shapefiles of the roadway drainage crossing locations and the attributes shown in Table 2 are provided on the electronic disc accompanying this report.

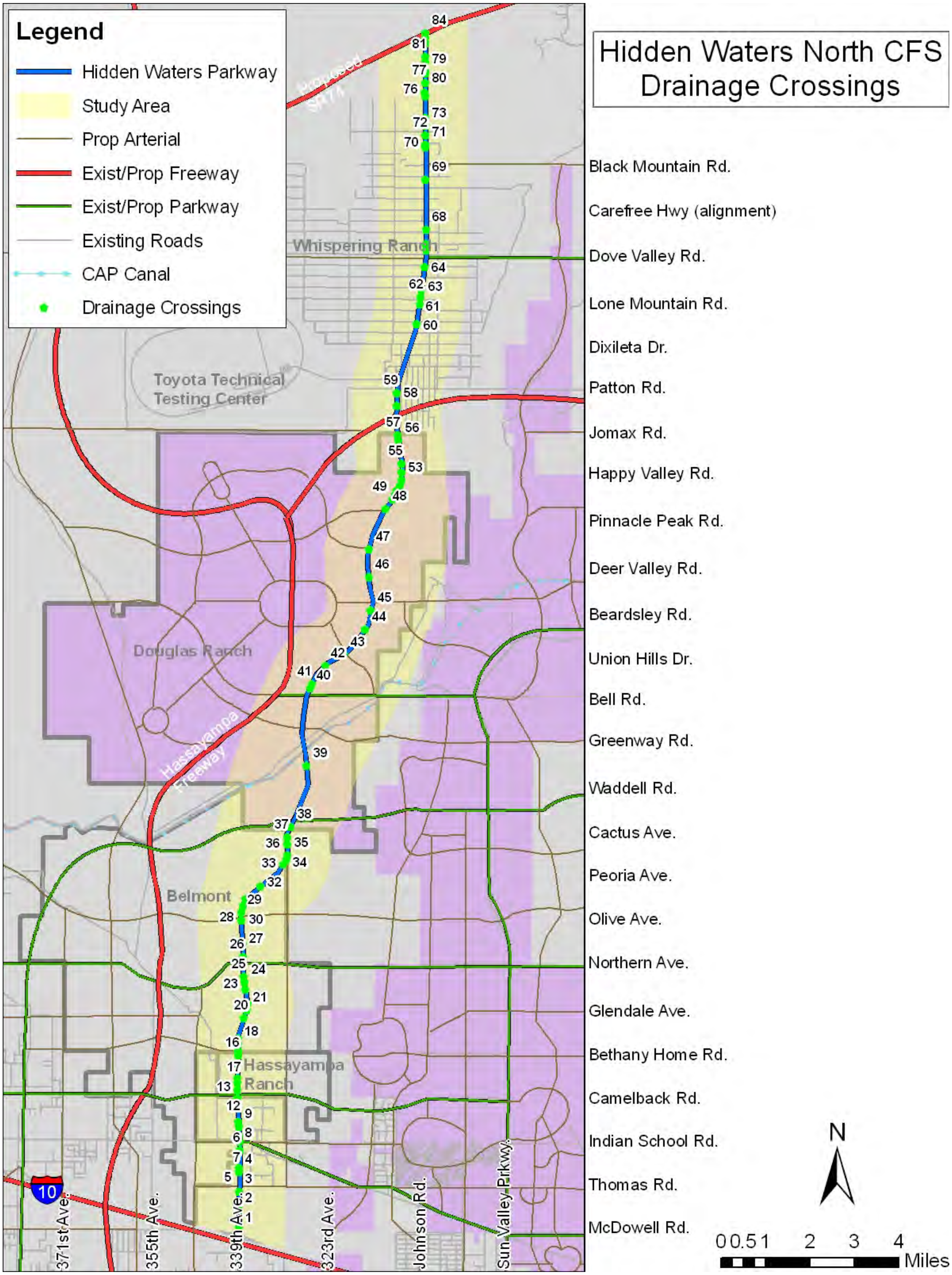

Figure 8. Roadway drainage crossings for baseline corridor alignment

Table 2. Estimated Roadway Drainage Crossing Types & Discharges – Baseline Alignment

Id	Crossing Type	Area (sq.mi.)	Area (acres)	Peak Discharge (cfs) 100-yr	Peak Discharge (cfs) 50-yr	Source
1	pipe	0.046	29.5	64	43	Luke Wash Watershed Zone AE FDS (FCD 2007C020)
2	pipe	0.031	19.9	43	29	
3	pipe	0.127	81.0	150	100	
4	pipe	0.060	38.2	73	49	
5	box	0.223	142.7	344	230	
6	pipe	0.018	11.3	27	18	
7	pipe	0.048	31.0	72	48	
8	pipe	0.038	24.1	57	38	
9	pipe	0.019	12.1	19	13	
10	box	0.384	245.6	382	256	
11	pipe	0.026	16.7	32	21	
12	pipe	0.026	17.0	23	15	
13	pipe	0.026	16.8	23	15	
14	pipe	0.169	108.1	150	100	
15	pipe	0.109	69.7	97	65	
16	pipe	0.014	8.8	12	8	
17	pipe	0.019	12.1	17	11	
18	pipe	0.015	9.7	14	9	
19	box	2.765	1769.4	1700	1139	Watershed 'PP' Luke Wash FDS
20	pipe	0.131	84.0	118	79	Luke Wash Watershed Zone AE FDS (FCD 2007C020)
21	pipe	0.015	9.7	14	9	
22	pipe	0.077	49.2	70	47	
23	pipe	0.048	30.6	53	36	
24	pipe	0.019	12.3	25	17	
25	pipe	0.049	31.1	64	43	
26	box	0.127	81.3	175	117	
27	pipe	0.038	24.3	52	35	
28	pipe	0.033	21.0	92	62	Watershed 'PP' Luke Wash FDS (FCD 99-03)
29	pipe	0.033	20.8	92	62	
30	pipe	0.055	35.4	128	86	
31	box	0.262	167.9	361	242	
32	bridge	357.081	228532.0	33600	22512	Jackrabbit Wash FDS (FCD 90-05)
33	box	3.999	2559.1	1200	804	Watershed 'OO' Approx. FDS (FCD 2000C019)
34	box	3.633	2325.0	1200	804	
35	box	3.525	2256.0	1200	804	
36	box	3.483	2229.2	600	402	
37	pipe	0.091	58.0	66	44	Jackrabbit Wash FDS
38	box	3.258	2085.4	600	402	Watershed 'OO' Approx. FDS
39	pipe	0.048	30.9	27	18	Jackrabbit Wash FDS (FCD 90-05)
40	pipe	0.084	53.8	44	29	
41	box	0.415	265.5	216	145	
42	box	22.579	14450.7	4555	3052	Daggs Wash FDS
43	box	0.415	265.6	216	145	Jackrabbit Wash FDS
44	pipe	0.069	43.9	122	82	

Table 2. Estimated Roadway Drainage Crossing Types & Discharges – Baseline Alignment (Continued)

Id	Crossing Type	Area (sq.mi.)	Area (acres)	Peak Discharge (cfs) 100-yr	Peak Discharge (cfs) 50-yr	Source
45	pipe	0.080	51.1	142	95	assume same unit Q as xing 44
46	pipe	0.118	75.7	125	84	Watershed 'OO' Approx. FDS (FCD 2000C019)
47	box	1.327	849.2	1400	938	
48	pipe	0.026	16.6	33	22	
49	pipe	0.015	9.8	19	13	
50	pipe	0.011	6.7	14	9	
51	pipe	0.022	13.9	28	19	
52	pipe	0.021	13.6	27	18	
53	pipe	0.028	17.7	36	24	
54	pipe	0.025	11.5	23	15	
55	pipe	0.018	11.5	23	15	
56	pipe	0.036	22.9	22	15	Jackrabbit Wash FDS (FCD 90-05)
57	box	2.383	1524.9	1470	985	
58	box	13.170	8429.1	1585	1062	Daggs Wash FDS (FCD 92-08)
59	box	13.106	8387.7	1585	1062	
60	box	0.109	69.7	300	201	Upper Daggs/Star Wash Zone AE FDS (FCD 2006C006)
61	box	0.096	61.2	229	153	
62	box	0.074	47.2	192	129	
63	pipe	0.046	29.3	138	92	
64	pipe	0.031	19.7	105	70	
65	box	3.072	1965.8	3900	2613	
66	box	3.060	1958.1	3900	2613	
67	box	3.054	1954.5	3900	2613	
68	pipe	0.045	28.8	136	91	
69	box	0.062	39.5	170	114	
70	box	0.352	225.2	562	377	
71	box	0.481	308.0	697	467	
72	pipe	0.034	21.7	112	75	
73	pipe	0.026	16.6	93	62	
74	box	0.161	102.8	328	220	
75	box	2.329	1490.8	2300	1541	Watershed 'OO' Approx. FDS
76	pipe	0.042	26.7	130	87	Upper Daggs/Star Wash Zone AE FDS (FCD 2006C006)
77	box	0.063	40.6	172	115	
78	box	0.838	536.2	1022	685	
79	box	0.133	85.2	288	193	
80	pipe	0.044	27.9	134	90	
81	pipe	0.034	21.8	112	75	
82	pipe	0.030	19.2	103	69	
83	pipe	0.012	7.9	55	37	
84	box	0.062	39.5	170	114	

Geomorphic Hazards

The scope for TM #3 also requests investigation of geomorphic hazards in the study area based on existing studies. Watercourse-specific erosion hazard zone delineations have also been performed for within the study area for Jackrabbit Wash and the lower Hassayampa River as part of the Lower Hassayampa River Watercourse Master Plan, Phase I (FCDMC, 2007a). The resulting zones are shown in Figure 9. Three levels of hazard were identified and delineated for the Hassayampa River – severe erosion hazard, lateral migration erosion hazard, and long-term erosion hazard zones. Only one zone was delineated for Jackrabbit Wash approximately equivalent to the lateral migration erosion hazard zone. The bases for the delineations are described in the Final River Behavior Report, Volume 5 of the Lower Hassayampa River Watercourse Master Plan, Phase I.

One of the key factors in the erosion hazard delineation is the age of the alluvial deposits. Figure 10 shows a map of surficial geologic mapping units in the study area as delineated by the Arizona Geological Survey (AZGS) on their 1:100,000 scale maps. The majority of units affecting the study area are Quaternary alluvial deposits. That is, they are unconsolidated or loosely consolidated sedimentary deposits from streams and alluvial fans laid down and modified over the past 2.6 million years. In general, the younger the age of an alluvial deposit, the greater the geomorphic hazard associated with flooding and erosion. In Figure 10, the young units are labeled Qy and Qyc. Note that the only young units within the study area are located along the larger watercourses. If the mapping were at a larger scale (i.e. zoomed in further), the smaller washes and drainages would also show up as younger Qy and Qyc units. Higher resolution 7.5 minute quadrangle 1:24,000 scale mapping has been performed by AZGS and is provided electronically as PDF on the disc accompanying this memorandum.

In the northernmost portion of the study area there are also some older bedrock and talus (hillslope) deposits associated with the Vulture Mountains. Geomorphic hazards in this area would be related to hillslope processes such as landslides and rockfalls.

The AZGS mapping and digital data are provided on the electronic disc accompanying this memorandum.

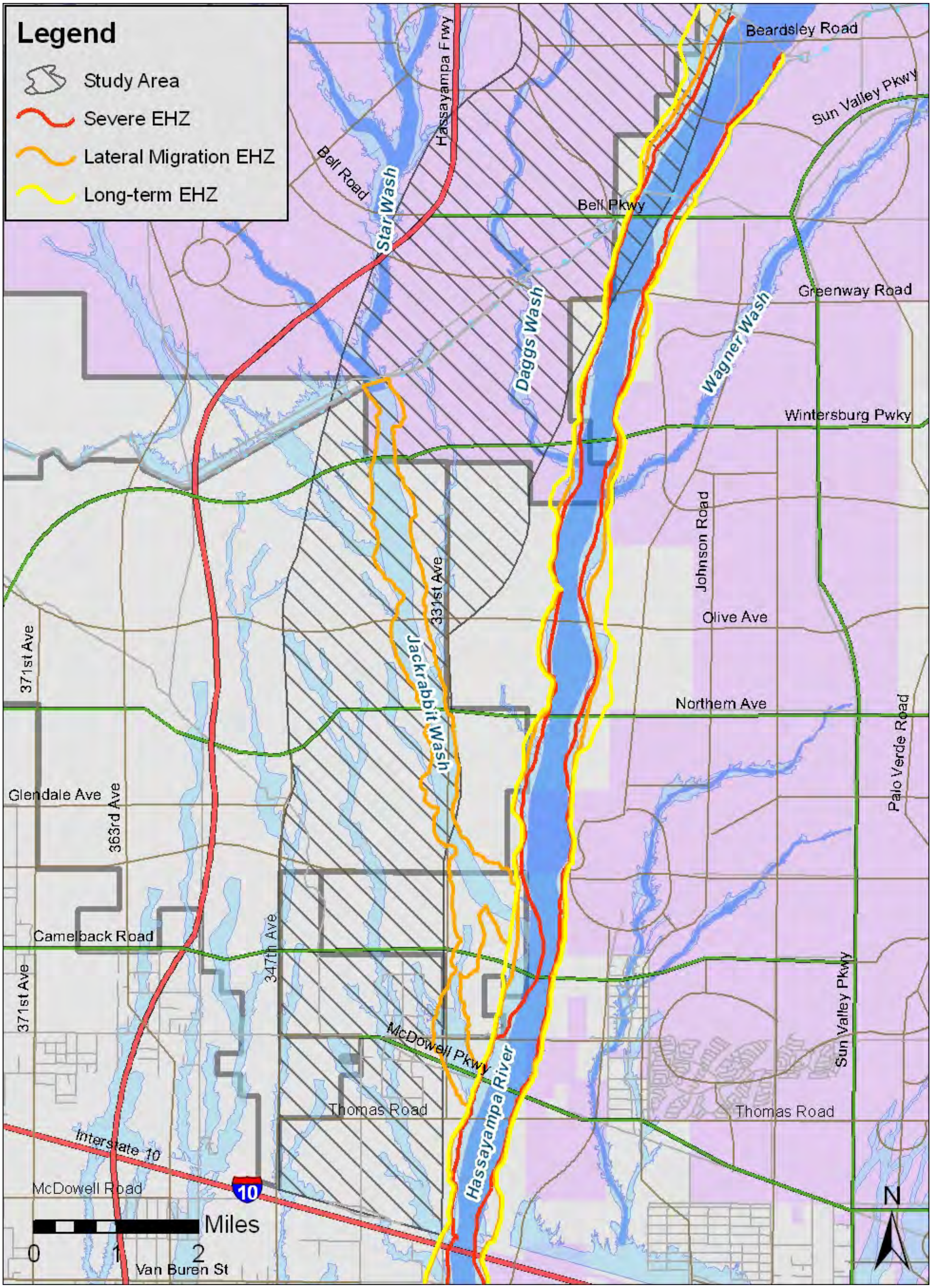

Figure 9. Erosion Hazard Zones from Lower Hassayampa River Watercourse Master Plan (FCDMC, 2007a)

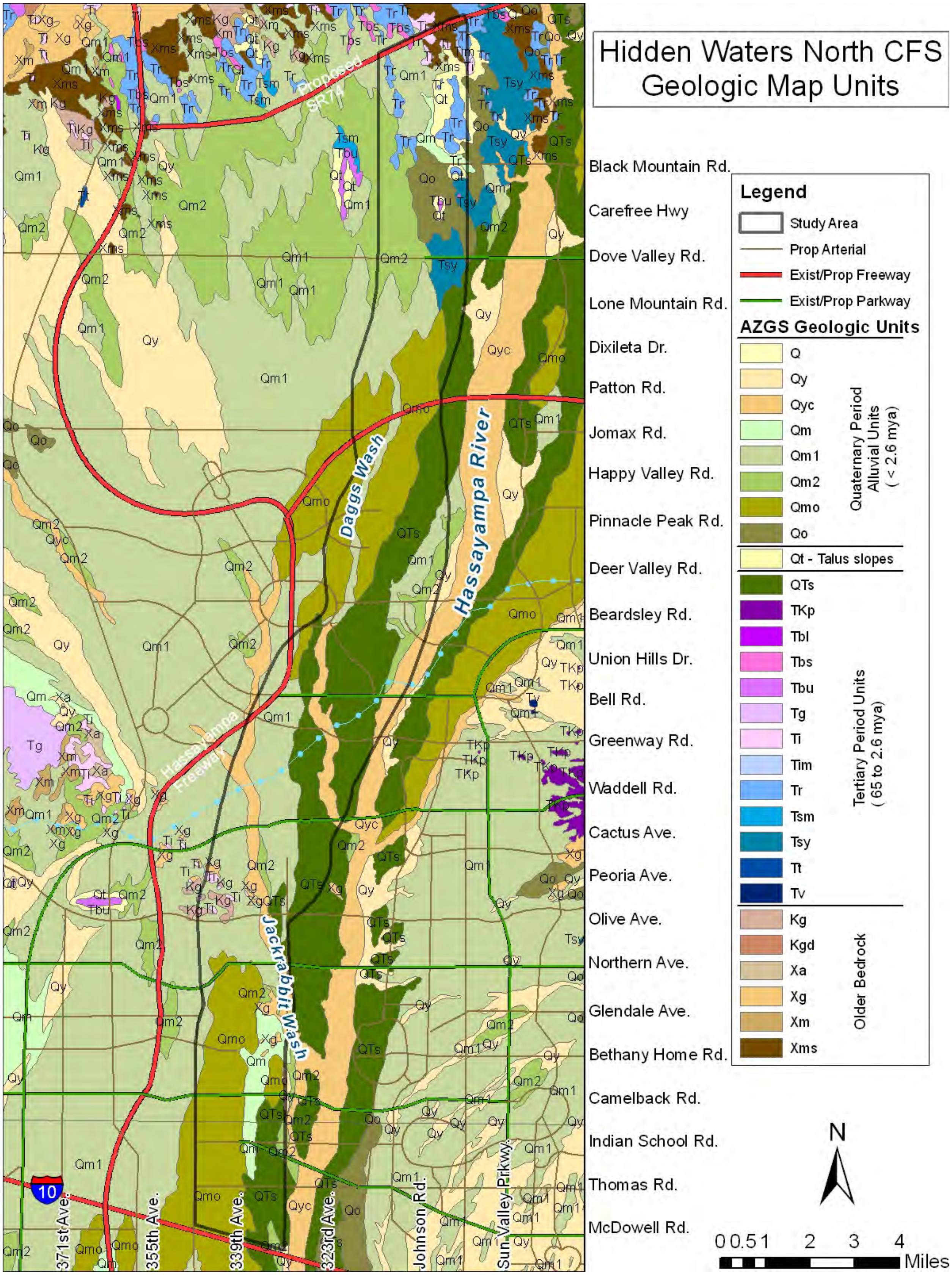

Figure 10. Arizona Geological Survey Geologic Units

6.0 Potential Drainage-Related Issue Segments

Based on examination and evaluation of the existing drainage-related reports and data for the study area, potential drainage-related issues were identified for the baseline corridor alignment. Figure 11 shows an overview of eight segments of the baseline corridor alignment that were identified as locations with drainage-related issues that pose possible opportunities or constraints to placement of Hidden Waters Parkway along the proposed baseline corridor alignment. Table 3 shows a list of the issue segments and a brief description of the constraint and possible opportunities related to each issue. In each case a potential cost savings to the ultimate corridor construction is identified relative to drainage-related crossing facilities. All other factors being equal, conceptual alignments other than the baseline alignment could reduce the number or size of roadway drainage crossings at most of these locations.

GIS shapefiles of the issue reaches are provided on the electronic disc accompanying this memorandum.

Table 3. Drainage-related issue segments

ID	Issues and Opportunities
1	numerous small wash crossing could be avoided by shifting potential parkway alignments to the ridgeline
2	segment aligned within a long stretch of wash
3	very wide bridge crossing could be avoided by shifting potential parkway alignments
4	multiple roadway drainage crossings could easily be avoided shifting potential parkway alignments to ridgeline
5	numerous small wash crossing could be avoided by shifting potential parkway alignments to the ridgeline
6	segment through complex braided floodplain area
7	opportunity to reduce the number of required wash crossings by shifting potential parkway alignments to the ridgeline
8	opportunity to reduce the number of required wash crossings by shifting potential parkway alignments to the ridgeline

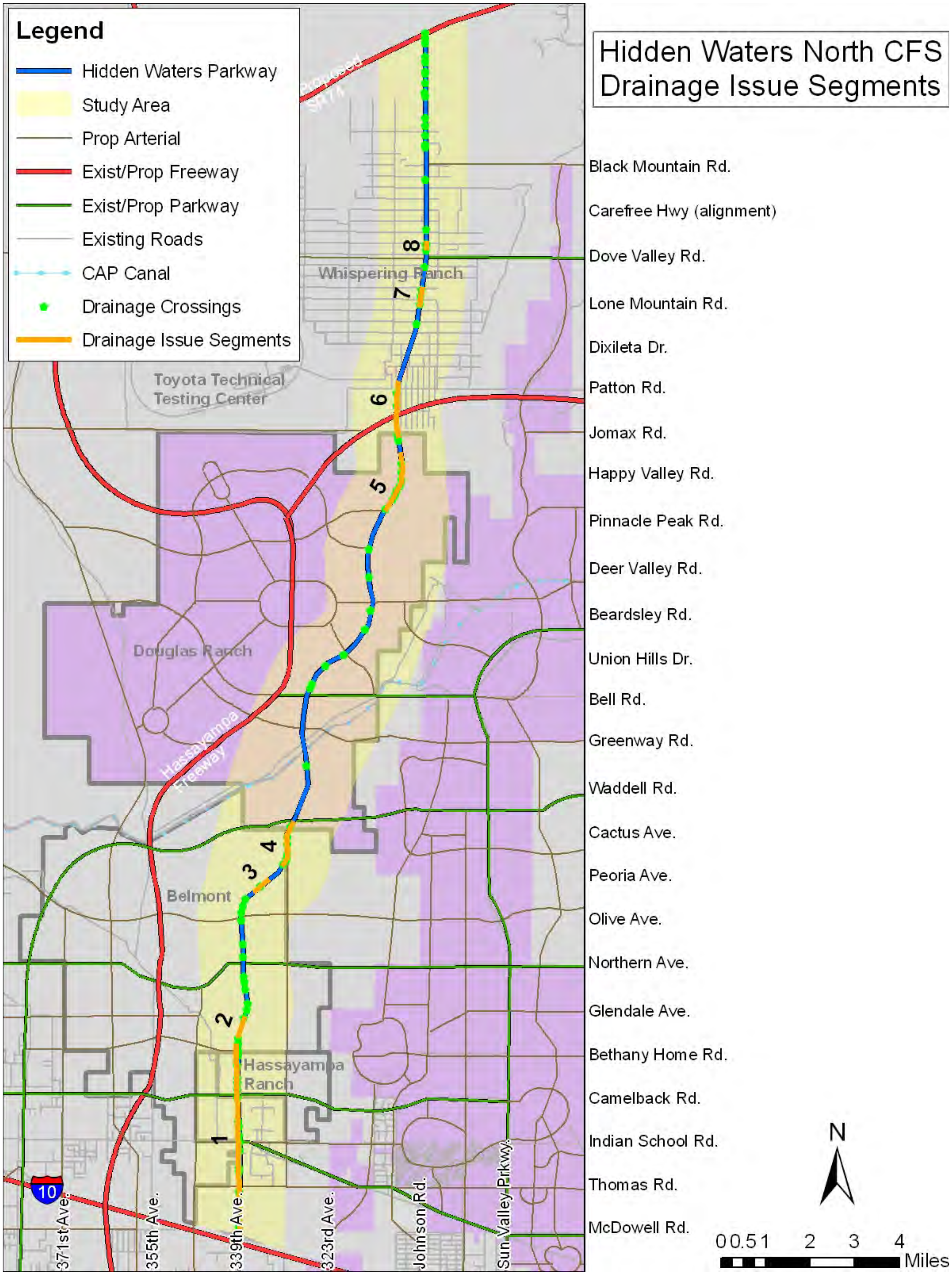

Figure 11. Drainage-related issue segments of baseline corridor alignment

7.0 Conclusions

Existing drainage reports and plans in the area were collected and reviewed. The 100-year and 50-year offsite discharges were developed for concentration points along the baseline alignment from Interstate 10 to the proposed State Route 74 alignment. Classifications of conceptual cross drainage structures for the baseline alignment were assigned based on the estimated discharges. This analysis will serve as a basis for comparison with alignment alternatives and ultimately aid the selection of a recommended alignment for the Hidden Waters Parkway North.

All of the potential drainage constraints within the study area may be mitigated through additional engineering and construction efforts. As noted in Section 6, each identified constraint represents a cost saving opportunity that may be realized with minor adjustments to the conceptual parkway alignments. Therefore, the conclusion of the Drainage Overview is that no fatal flaws, based upon drainage issues, occur within the study area.

8.0 References

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APPENDIX

Roadway Drainage Crossing Estimated Discharges
Baseline Corridor Alignment

	Crossing	Area		Peak Discharge (cfs)				Model	Model Area	Model Q100	Model		
Id	Type	(sq.mi.)	(acres)	100-yr	50-yr	Source	Contract	ID	(sq.mi.)	(cfs)	Rainfall Event	Major Basin	Notes
1	pipe culvert	0.046	29.5	64	43	Luke Wash FDS	FCD2007C020	82b	0.265	368	100-yr 6-hr	Luke Wash	ratio of subbasin 82b
2	pipe culvert	0.031	19.9	43	29	Luke Wash FDS	FCD2007C020	82b	0.265	368	100-yr 6-hr	Luke Wash	ratio of subbasin 82b
3	pipe culvert	0.127	81.0	150	100	Luke Wash FDS	FCD2007C020	84b	0.347	411	100-yr 6-hr	Luke Wash	ratio of subbasin 84b
4	pipe culvert	0.060	38.2	73	49	Luke Wash FDS	FCD2007C020	85a	0.315	382	100-yr 6-hr	Luke Wash	ratio of subbasin 85a
5	box culvert	0.223	142.7	344	230	Luke Wash FDS	FCD2007C020	85b	0.237	344	100-yr 6-hr	Luke Wash	100-yr 6-hr CP 85b
6	pipe culvert	0.018	11.3	27	18	Luke Wash FDS	FCD2007C020	83c	0.278	416	100-yr 6-hr	Luke Wash	ratio of subbasin 83c
7	pipe culvert	0.048	31.0	72	48	Luke Wash FDS	FCD2007C020	83c	0.278	416	100-yr 6-hr	Luke Wash	ratio of subbasin 83c
8	pipe culvert	0.038	24.1	57	38	Luke Wash FDS	FCD2007C020	83c	0.278	416	100-yr 6-hr	Luke Wash	ratio of subbasin 83c
9	pipe culvert	0.019	12.1	19	13	Luke Wash FDS	FCD2007C020	86a	0.479	476	100-yr 6-hr	Luke Wash	ratio of subbasin 86a
10	box culvert	0.384	245.6	382	256	Luke Wash FDS	FCD2007C020	86a	0.479	476	100-yr 6-hr	Luke Wash	ratio of subbasin 86a
11	pipe culvert	0.026	16.7	32	21	Luke Wash FDS	FCD2007C020	83d	0.230	282	100-yr 6-hr	Luke Wash	ratio of subbasin 83d
12	pipe culvert	0.026	17.0	23	15	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
13	pipe culvert	0.026	16.8	23	15	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
14	pipe culvert	0.169	108.1	150	100	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
15	pipe culvert	0.109	69.7	97	65	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
16	pipe culvert	0.014	8.8	12	8	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
17	pipe culvert	0.019	12.1	17	11	Luke Wash FDS	FCD2007C020	83e	0.837	743	100-yr 6-hr	Luke Wash	ratio of subbasin 83e
18	pipe culvert	0.015	9.7	14	9	Luke Wash FDS	FCD2007C020	83g	0.619	559	100-yr 6-hr	Luke Wash	ratio of subbasin 83g
19	box culvert	2.765	1769.4	1700	1139	Watershed 'PP' Luke Wash FDS	FCD99-03	XS280	0.000	1700	Sheet 32	Luke Wash	Sheet 32 XS280 Wash T2N-R5W-S33E
20	pipe culvert	0.131	84.0	118	79	Luke Wash FDS	FCD2007C020	83g	0.619	559	100-yr 6-hr	Luke Wash	ratio of subbasin 83g
21	pipe culvert	0.015	9.7	14	9	Luke Wash FDS	FCD2007C020	83g	0.619	559	100-yr 6-hr	Luke Wash	ratio of subbasin 83g
22	pipe culvert	0.077	49.2	70	47	Luke Wash FDS	FCD2007C020	83g	0.619	559	100-yr 6-hr	Luke Wash	ratio of subbasin 83g
23	pipe culvert	0.048	30.6	53	36	Luke Wash FDS	FCD2007C020	83i	0.404	444	100-yr 6-hr	Luke Wash	ratio of subbasin 83i
24	pipe culvert	0.019	12.3	25	17	Luke Wash FDS	FCD2007C020	89a	0.215	279	100-yr 6-hr	Luke Wash	ratio of subbasin 89a
25	pipe culvert	0.049	31.1	64	43	Luke Wash FDS	FCD2007C020	89a	0.215	279	100-yr 6-hr	Luke Wash	ratio of subbasin 89a
26	box culvert	0.127	81.3	175	117	Luke Wash FDS	FCD2007C020	89b	0.283	389	100-yr 6-hr	Luke Wash	ratio of subbasin 89b
27	pipe culvert	0.038	24.3	52	35	Luke Wash FDS	FCD2007C020	89b	0.283	389	100-yr 6-hr	Luke Wash	ratio of subbasin 89b
28	pipe culvert	0.033	21.0	92	62	Watershed 'PP' Luke Wash FDS	FCD99-03	101	0.989	870	Fig 2A	Jackrabbit Wash	ratio of subbasin 101
29	pipe culvert	0.033	20.8	92	62	Watershed 'PP' Luke Wash FDS	FCD99-03	101	0.989	870	Fig 2A	Jackrabbit Wash	ratio of subbasin 101
30	pipe culvert	0.055	35.4	128	86	Watershed 'PP' Luke Wash FDS	FCD99-03	100	0.440	510	Fig 2A	Jackrabbit Wash	ratio of subbasin 100
31	box culvert	0.262	167.9	361	242	Watershed 'PP' Luke Wash FDS	FCD99-03	100	0.440	510	Fig 2A	Jackrabbit Wash	ratio of subbasin 100; T3N-R5W-S28S
32	bridge	357.081	228532.0	33600	22512	Jackrabbit Wash FDS	FCD90-05	C94	363.130	33554	100-yr 24-hr	Jackrabbit Wash	Jackrabbit Wash; CP C94
33	box culvert	3.999	2559.1	1200	804	Watershed 'OO' Approx. FDS	FCD2000C019	XS300	0.000	1200	Sheet 46B XS 300	Jackrabbit Wash	Sheet 46B XS 300
34	box culvert	3.633	2325.0	1200	804	Watershed 'OO' Approx. FDS	FCD2000C019	XS300	0.000	1200	Sheet 46B XS 300	Jackrabbit Wash	Sheet 46B XS 300
35	box culvert	3.525	2256.0	1200	804	Watershed 'OO' Approx. FDS	FCD2000C019	XS300	0.000	1200	Sheet 46B XS 300	Jackrabbit Wash	Sheet 46B XS 300
36	box culvert	3.483	2229.2	600	402	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.000	600	Sheet 46A XS 400	Jackrabbit Wash	Sheet 46A XS 400
37	pipe culvert	0.091	58.0	66	44	Jackrabbit Wash FDS	FCD90-05	15B	2.080	1517	100-yr 24-hr	Jackrabbit Wash	ratio of subbasin 15B
38	box culvert	3.258	2085.4	600	402	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.000	600	Sheet 46A XS 400	Jackrabbit Wash	Sheet 46A XS 400
39	pipe culvert	0.048	30.9	27	18	Jackrabbit Wash FDS	FCD90-05	16B	1.940	1080	100-yr 24-hr	Daggs Wash	ratio of subbasin 16B
40	pipe culvert	0.084	53.8	44	29	Jackrabbit Wash FDS	FCD90-05	12E	7.540	3916	100-yr 24-hr	Daggs Wash	ratio of subbasin 12E
41	box culvert	0.415	265.5	216	145	Jackrabbit Wash FDS	FCD90-05	12E	7.540	3916	100-yr 24-hr	Daggs Wash	ratio of subbasin 12E
42	box culvert	22.579	14450.7	4555	3052	Daggs Wash FDS HEC-2	FCD92-08	CP90I	26.140	4957	100-yr 24-hr	Daggs Wash	Daggs Wash; between RM 4.918 and 5.207; CP 90I d/s at CAP
43	box culvert	0.415	265.6	216	145	Jackrabbit Wash FDS	FCD90-05	12E	7.540	3916	100-yr 24-hr	Daggs Wash	ratio of subbasin 12E
44	pipe culvert	0.069	43.9	122	82	Jackrabbit Wash FDS	FCD90-05	13A	0.900	1596	100-yr 6-hr	Hassayampa River	ratio of subbasin 13A
45	pipe culvert	0.080	51.1	142	95	assume same unit Q as xing 44						Hassayampa River	assume same unit Q as xing 44
46	pipe culvert	0.118	75.7	125	84	Watershed 'OO' Approx. FDS	FCD2000C019	XS100	0.610		ratio of xing 47	Daggs Wash	ratio of Q for xing 47
47	box culvert	1.327	849.2	1400	938	Watershed 'OO' Approx. FDS	FCD2000C019	XS100			Sheet 44 XS100	Daggs Wash	Sheet 44, XS 100
48	pipe culvert	0.026	16.6	33	22	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
49	pipe culvert	0.015	9.8	19	13	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
50	pipe culvert	0.011	6.7	14	9	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
51	pipe culvert	0.022	13.9	28	19	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
52	pipe culvert	0.021	13.6	27	18	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
53	pipe culvert	0.028	17.7	36	24	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
54	pipe culvert	0.025	11.5	23	15	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
55	pipe culvert	0.018	11.5	23	15	Watershed 'OO' Approx. FDS	FCD2000C019	XS400	0.780	1000	Sheet 44 XS400	Daggs Wash	Ratio of Q for XS 400 on Sheet 44
56	pipe culvert	0.036	22.9	22	15	Jackrabbit Wash FDS	FCD90-05	12D	5.290	3263	100-yr 24-hr	Daggs Wash	Daggs Wash
57	box culvert	2.383	1524.9	1470	985	Jackrabbit Wash FDS	FCD90-05	12D	5.290	3263	100-yr 24-hr	Daggs Wash	Daggs Wash

Roadway Drainage Crossing Estimated Discharges
Baseline Corridor Alignment

Id	Type	(sq.mi.)	(acres)	100-yr	50-yr	Source	Contract	ID	(sq.mi.)	(cfs)	Rainfall Event	Major Basin	Notes
58	box culvert	13.170	8429.1	1585	1062	Daggs Wash FDS	FCD92-08				East Breakout	Daggs Wash	Daggs Wash; between RM 11.577 and 11.882
59	box culvert	13.106	8387.7	1585	1062	Daggs Wash FDS	FCD92-08				East Breakout	Daggs Wash	Daggs Wash; between RM 11.882 and 12.268
60	box culvert	0.109	69.7	300	201	Upper Daggs Star Wash FDS	FCD2006C008	1.785			RM 1.785	Daggs Wash	Wash T5-R4-S30 shown on Sheet 25 near RM 1.785
61	box culvert	0.096	61.2	229	153	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Daggs Wash	Q100=1154.7*SQMI^0.6889 (Table 4.2)
62	box culvert	0.074	47.2	192	129	Upper Daggs Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Daggs Wash	Q100=1154.7*SQMI^0.6889 (Table 4.2)
63	pipe culvert	0.046	29.3	138	92	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Daggs Wash	Q100=1154.7*SQMI^0.6889 (Table 4.2)
64	pipe culvert	0.031	19.7	105	70	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
65	box culvert	3.072	1965.8	3900	2613	Upper Daggs/Star Wash FDS	FCD2006C008				Sheet 23	Hassayampa River	Sheet 23, betw RM 3,664 and 3.909, T5-R4-S20A
66	box culvert	3.060	1958.1	3900	2613	Upper Daggs/Star Wash FDS	FCD2006C008				Sheet 23	Hassayampa River	Sheet 23, betw RM 3,664 and 3.909, T5-R4-S20A
67	box culvert	3.054	1954.5	3900	2613	Upper Daggs/Star Wash FDS	FCD2006C008				Sheet 23	Hassayampa River	Sheet 23, betw RM 3,664 and 3.909, T5-R4-S20A
68	pipe culvert	0.045	28.8	136	91	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
69	box culvert	0.062	39.5	170	114	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
70	box culvert	0.352	225.2	562	377	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
71	box culvert	0.481	308.0	697	467	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
72	pipe culvert	0.034	21.7	112	75	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
73	pipe culvert	0.026	16.6	93	62	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
74	box culvert	0.161	102.8	328	220	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
75	box culvert	2.329	1490.8	2300	1541	Watershed 'OO' Approx. FDS	FCD2000C019	XS1300		2300	Wash T5-R4-S21	Hassayampa River	Sheet 40, XS 1300, Wash T5-R4-S21
76	pipe culvert	0.042	26.7	130	87	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
77	box culvert	0.063	40.6	172	115	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
78	box culvert	0.838	536.2	1022	685	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
79	box culvert	0.133	85.2	288	193	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
80	pipe culvert	0.044	27.9	134	90	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
81	pipe culvert	0.034	21.8	112	75	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
82	pipe culvert	0.030	19.2	103	69	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
83	pipe culvert	0.012	7.9	55	37	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)
84	box culvert	0.062	39.5	170	114	Upper Daggs/Star Wash FDS	FCD2006C008				Table 4.2 JRW<1	Hassayampa River	Q100=1154.7*SQMI^0.6889 (Table 4.2)