Kimley-Horn
and Associates, Inc.

APPENDIX 3

TECHNICAL MEMORANDUM NO. 3 – CONCEPTUAL DRAINAGE REPORT

Hidden Waters Parkway Corridor Feasibility Study – Watermelon Road to Interstate 10

Contract No.: 2008-046
Work Order No.: TT005

FINAL

Technical Memorandum No.3

Conceptual Drainage Report

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TABLE OF CONTENTS

FINAL – CONCEPTUAL DRAINAGE REPORT

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TABLE OF CONTENTS

FINAL – CONCEPTUAL DRAINAGE REPORT

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

Technical Memorandum No. 3 (TM 3), entitled *Conceptual Drainage Report*, identifies and summarizes the existing drainage conditions, features, and hydrologic characteristics within the project study area for the Hidden Waters Parkway Corridor Feasibility Study. Offsite concentration points and flow magnitudes prepared in previous studies and reports within the project study area for the 50-year and the 100-year storm events were compiled and are presented in this report. TM 3 is based on initial data gathering; a review of available existing information including previous drainage master plans and studies; roadway drainage reports; and field observations. Additional detailed information is included in the following companion documents: *Existing and Future Corridor Features* (TM 1), *Environmental Overview* (TM 2), *Development and Evaluation of Candidate Alternative Alignments* (TM 4), and *Detailed Preferred Alignment* (TM 5).

1.1 Study Background

In July 2008, the Maricopa Association of Governments (MAG) completed the *Interstate 10/Hassayampa Valley Transportation Framework Study* (known as the *Hassayampa Framework Study*), which recommended a comprehensive roadway network to meet the future traffic demands that result when the area west of the White Tank Mountains is completely developed (hereafter referred to as buildout travel demand). This long-range regional transportation network included the "Arizona Parkway" as a new facility type to supplement more traditional roadway classifications in meeting projected travel demand within the study area.

The Arizona Parkway utilizes a distinct intersection treatment that prohibits left-turns at major cross-street intersections and controls all traffic movements with simple two-phased signal control. Left-turn movements are made indirectly using directional left-turn crossovers immediately downstream of the crossroad intersection.

A north-south Arizona Parkway known as the Hidden Waters Parkway was demonstrated to be needed in the *Hassayampa Framework Study* that generally is offset about two miles to the west of the Hassayampa River. The northern portion of the Hidden Waters Parkway is proposed to cross Interstate 10 at 339^{th} Avenue (where a traffic interchange already exists) and extend southward to Old U.S. Highway 80 (Old US 80).

Similar to the *Hassayampa Framework Study*, the *Interstate 8 and Interstate 10 Hidden Valley Transportation Framework Study* (known as the *Hidden Valley Framework Study*), completed by MAG in October 2009, indicates the need for a system of Arizona Parkways to meet the future buildout travel demand for the area southwest of Interstate 10 (I-10) and north of Interstate 8 (I-8). In the *Hidden Valley Framework Study*, the need was demonstrated for the Hidden Waters Parkway identified previously in the *Hassayampa Framework Study* to extend further south, generally following the Old US 80 alignment, to Watermelon Road in Gila Bend.

In May 2009, the Maricopa County Department of Transportation (MCDOT) retained Kimley-Horn and Associates, Inc. (KHA) to conduct a corridor feasibility study for the southern portion of the Hidden Waters Parkway between Watermelon Road and I-10.

1.2 Project Study Area

The project study area for the proposed Hidden Waters Parkway is approximately 38 miles in length between Watermelon Road and I-10 and is roughly two miles wide, centered on the north-south segment of Old US 80. North of the Cactus Rose Road/Old US 80 intersection, where Old US 80 diverges to the east, the study area broadens to a four-mile wide corridor, centered on the 347th Avenue section-line alignment, extending north to the Salome Highway. North of the Salome Highway, the study area width narrows back to two miles, following the 339th Avenue alignment north to I-10. The study area covers approximately 93.9 square miles. The project study area is shown in **Figure 1**. For the purposes of this memorandum, the project study area has been broken up into three regions of similar drainage characteristics. The approximate extents of each region are described below:

- Southern Region – Watermelon Road to Old US 80 Gillespie Dam Bridge;
- Central Region – Old US 80 Gillespie Dam Bridge to Intersection of Old US 80 and Arlington School Road;
- Northern Region – Intersection of Old US 80 and Arlington School Road to I-10.

1.3 Document Purpose and Scope

The purpose of the *Conceptual Drainage Report* is to describe the existing drainage conditions and patterns in the project study area. The drainage study was limited to the collection and review of existing drainage reports, roadway drainage reports, area drainage master studies and plans, floodplain studies, and field observations of existing drainage patterns and structures included in and adjacent to the project study area. Hydrologic information from previous drainage and floodplain studies was compiled to present watershed subbasins and previously determined peak flow rates draining to the project study area. An inventory of existing drainage facilities was also prepared. This information will provide an overview of the physical features of the project study area pertaining to drainage, and will be used in the development of feasible alignment alternatives.

1.4 Design Drainage Criteria

Drainage design for the proposed parkway shall follow criteria outlined in the Drainage Policies and Standards for Maricopa County, Arizona (Maricopa County, 2007) and Chapter 4.7 of the Roadway Design Manual (MCDOT, 2004).

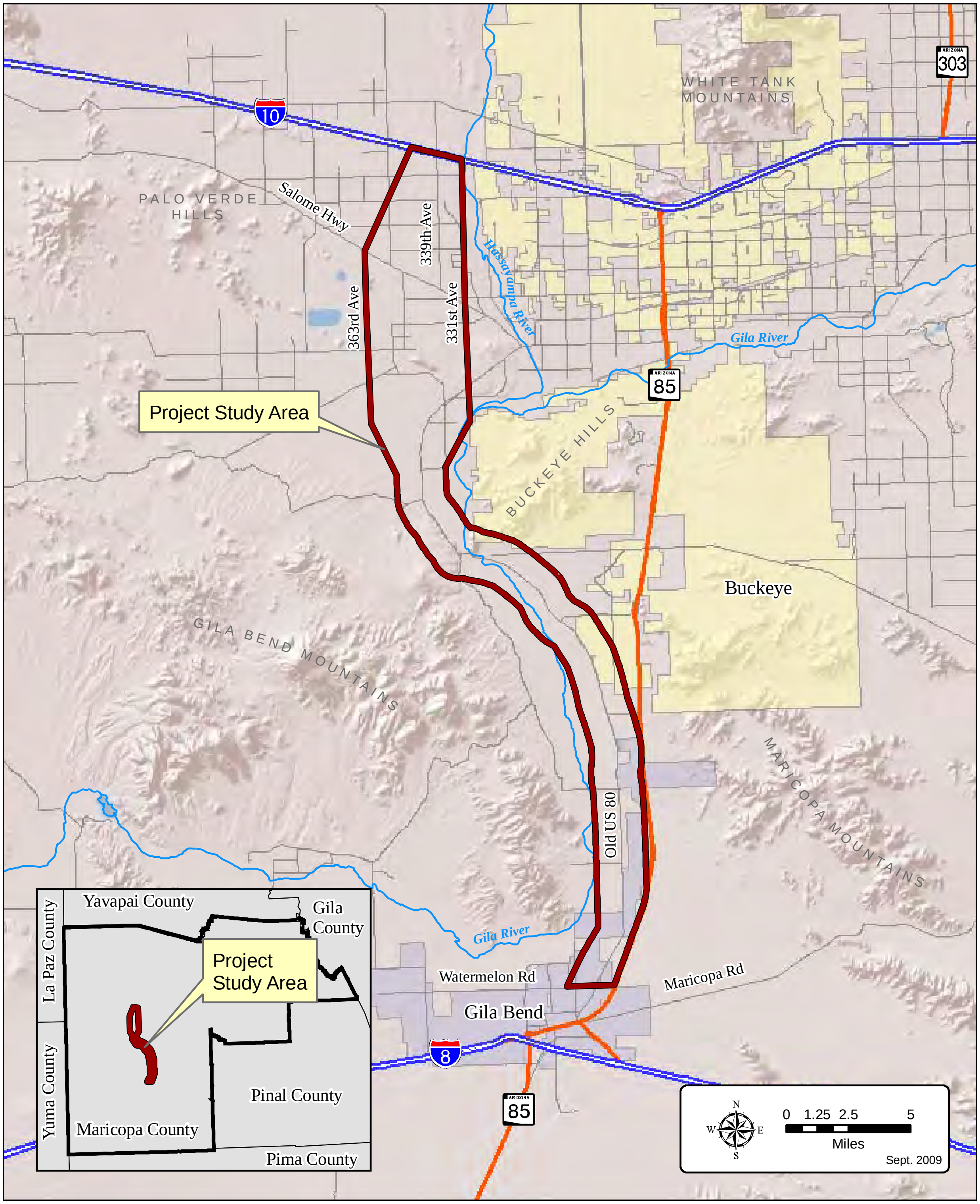

Figure 1 – Project Study Area

1.5 Drainage Studies

Several drainage studies have been prepared for the area surrounding the Hidden Waters Parkway project study area by various agencies such as the Flood Control District of Maricopa County (FCDMC) and the Arizona Department of Transportation (ADOT). A graphic depicting the vicinities of the drainage studies is provided as **Figure 2** at the end of this section. Drainage studies potentially impacting the project study area were researched and information compiled to complete the existing conditions analysis detailed in this memorandum. A summary of the most relevant drainage studies is provided in the following sections, organized by region. Floodplain and floodway delineations were based on the *Flood Insurance Study, Maricopa County, Arizona and Incorporated Areas, FIS No. 04013CV001A* (Federal Emergency Management Agency [FEMA], 2005).

1.5.1 Previous Drainage Studies - Southern Region

The following drainage studies were reviewed for study of the watersheds in the southern region of the project study area. The studies included descriptions of existing hydrology, drainage features, and existing drainage patterns.

- *Hydrology Report, Gila Bend Canal Floodplain Delineation Report, Gillespie Dam to Gila Bend (FCDMC, 1991)*

  The hydrology report presents the hydrologic methods and data used to compute the basin and subbasin discharge rates used in the hydraulic analysis and floodplain delineation portions of the Gila Bend Canal Floodplain Delineation study. The study covers the Gila Bend Canal Watershed and provides 100-year peak flow rates at each subbasin. The basin delineation and the results of the hydrologic analysis were used in this report for the southern (Gila Bend Canal Floodplain) watershed. The discharge rates and the subbasins delineations can be used, with some modifications, to determine appropriate drainage crossings for the Parkway.

- *Rainbow Wash Floodplain/Floodway Delineation Study TDN Hydraulics (FCDMC, 1994)*

  The Rainbow Wash Flood Insurance Study (FIS), which the Hydraulics Technical Data Notebook (TDN) is a part of, provides floodplain elevations in areas adjacent to Rainbow Wash and its tributary from the Gila River to upstream of SR 85. The study consists of the topographic mapping and hydraulic analysis necessary to determine 100-year flood elevations and to map regulatory floodplain boundaries for the area. The Hydraulics TDN focuses on the topographic mapping, hydraulic analysis, and floodplain delineation tasks of the Flood Insurance Study (FIS). The hydrology and basin delineation in this report updated the analysis in the *Gila Bend Canal Floodplain Delineation Report* (FCDMC, 1991), but the updated results are limited to the Rainbow Wash watershed.

- *Initial Drainage Report, SR 85, Gila Bend to I-10, Volume I and Volume II (ADOT, 1999)*

  The report evaluated the existing drainage conditions along the then two lane roadway and recommended improvements for the proposed four lane divided highway. This report was later supplemented by the design stage reports *Draft Drainage Technical Memorandum, SR 85, Gila Bend to Lewis Prison*, (ADOT 2001), the *Final Drainage Report, SR 85, MP 122.58 to 126.08 (ADOT, 2004),* and *Final Drainage Report, SR 85, MP 126.08 to 130.71, Gila Bend – Buckeye Highway* (ADOT, 2003). However, this Initial Drainage Report contains the complete hydrologic and hydraulic analyses for SR 85 and is referenced by the later reports. The hydrology in this report was derived starting with the HEC-1 analysis completed in the *Gila Bend Canal Floodplain Delineation Report* (FCDMC, 1991). 50-year and 100-year peak flow rates were calculated for the drainage crossings at SR 85.

- *Draft Drainage Technical Memorandum, SR 85, Gila Bend to Lewis Prison (ADOT, 2001)*

  This memorandum was superseded by the *Final Drainage Report, SR 85, MP 122.58 to 126.08* (ADOT, 2004) and *Final Drainage Report, SR 85, MP 126.08 to 130.71, Gila Bend – Buckeye Highway* (ADOT, 2003). The report includes more information concerning the horizontal alignment of the existing cross culverts, sedimentation, scour, and pipe corrosion. Peak flows for the 50-year storm event were estimated with HEC-1 for the report, but the Rational Method was used for small watersheds. The report includes the SR 85 corridor from Gila Bend to Lewis Prison. Some of the recommendations for drainage improvements described in this document can be utilized for the Hidden Waters Parkway, because the roadways will be nearly parallel to each other in this section.

- *Final Drainage Report, SR 85, MP 122.58 to 126.08 (ADOT, 2004) and Final Drainage Report, SR 85, MP 126.08 to 130.71, Gila Bend – Buckeye Highway (ADOT, 2003)*

  These reports discussed roadway drainage within the SR 85 corridor and discussed the preliminary design of 28 box culverts to be built during the first phase of the construction for SR 85 (from MP 122.58 to 130.71). These studies were used to update information provided in the *Initial Location/Design Concept Report, SR 85, Gila Bend to I-10*, (ADOT, 1999). The reports should be used when designing the drainage structures of the Hidden Waters Parkway as a reference for existing conditions along the section.

1.5.2 Previous Studies – Gillespie Dam and Gillespie Dam Bridge

The following drainage studies were reviewed to gather information on the Gillespie Dam and Gillespie Dam Bridge (also known as the Old US 80 Bridge). The studies include descriptions of the bridge and dam and discuss the alternatives for replacing the bridge.

- *Old US 80 Gila River Bridge, Final Design Concept Report (MCDOT, 2007)*

  The Design Concept Report is a comprehensive report that includes an in-depth steel inspection, structural analysis, traffic analysis, drainage/scour analysis, parallel seismic studies as part of the geotechnical evaluation, coating assessment, public involvement, and environmental studies for the Gillespie Dam Bridge. The Design Concept Report preceded the *Old US 80 Bridge Rehabilitation Value Engineering Final Report* (MCDOT, 2008). However, the analysis findings presented in this Design Concept Report that are relevant to the Parkway should be taken into consideration when designing the Parkway in the area of the bridge.

- *Old US 80 Bridge Rehabilitation (Gillespie Dam Bridge) Value Engineering Final Report (MCDOT, 2008)*

  The Value Engineering Report described the conclusions of a Value Engineering Workshop to evaluate the Design Concept Report to replace or improve the Gillespie Dam Bridge at the Gila River. The report describes the alternatives considered for the Gillespie Dam Bridge. DT-04 was ultimately chosen as the alternative to move forward on, which consists of a new interim low-flow crossing of the Gila River approximately 1,000 feet south of the existing bridge. The interim low-flow crossing would ultimately be replaced by an all-weather bridge crossing. The alignment of DT-04 will be the assumed alignment of the Parkway for purposes of this feasibility study.

1.5.3 Previous Drainage Studies - Central Region

The following drainage studies were reviewed for study of the watersheds in the central region of the project study area. The studies included descriptions of existing hydrology, drainage features, and existing drainage patterns.

- *Lower Centennial Wash Watershed Zone A Floodplain Delineation Study Phase 1 TDN (FCDMC, 2005a)*

  The purpose of the floodplain study was to delineate the 100-Year Zone A Floodplains for Phase I of the Lower Centennial Wash Watershed. The goal was to delineate floodplains before development occurred to improve upon floodplain management and minimize losses due to flooding. Peak flows for the 100-year, 6-hour and 100-year, 24-hour storms were calculated for the study. Subbasin delineations were also prepared for the study, and are presented in this report as the hydrology and subbasins for the watersheds in the central region of the project study area. The discharge rates and the subbasins delineations can be used, with some modification, to determine appropriate drainage crossings for the Parkway.

- *Lower Centennial Wash Watershed Zone A Floodplain Delineation Study – Low Level Geomorphic Assessment (FCDMC, 2005b)*

  The purpose of the report was to provide a Low Level Geomorphic Assessment of Lower Centennial Wash and its tributaries. The purpose of the low level geomorphic assessment was to analyze and document the landforms in the Lower Centennial Wash study area, and to identify locations where surface geomorphology may result in distributary flow. The study provided information on the existing watershed drainage features, and explained the alluvial fan nature and presence of split flows in the Lower Centennial Wash Watershed. The information presented in this report can be used for the Parkway design to better understand the existing drainage patterns and land uses.

1.5.4 Previous Drainage Studies - Northern Region

The following drainage studies were reviewed for study of the watersheds in the northern region of the project study area. The studies included descriptions of existing hydrology, drainage features, and existing drainage patterns.

- *Hydrologic Study Report for Luke Wash Watershed Zone AE Floodplain Delineation Study (FCDMC, 2008)*

  The purpose of this study was to develop detailed hydrologic models for the 100-year, 6-hour and 100-year, 24 hour events in order to delineate approximately 85 linear miles of Zone AE floodplains and floodways of Luke Wash and nearby tributaries of the Hassayampa and Gila Rivers. The study covers the Luke Wash Watershed and provides 100-year peak flow rates at each delineated subbasin. The basin delineation and the results of the hydrologic analysis were used in this report for the watersheds in the northern region of the project study area. The discharge rates and the subbasin delineations can be used, with some modification, to determine appropriate drainage crossings for the Parkway.

1.5.5 Future Drainage Study

FCDMC is initiating the *Gillespie Area Drainage Master Study* for a 140 square-mile portion of the Gillespie Watershed. This study area consists of the northern portion of the Gila Bend Canal FDS Watershed shown in **Figure 2**, from the Buckeye Hills divide near Gillespie Dam to one-half mile south of Pierpoint Road. The study is expected to begin in April 2010 and will take approximately 18 months.

The primary goals of the future study are to:

- Create updated hydrology model utilizing new 2-foot contour mapping and NOAA-14;
- Determine the impact of existing and planned development;
- Identify and prioritize watercourses for future floodplain delineation studies; and
- Establish “planning guidelines” to coordinate future drainage improvements.

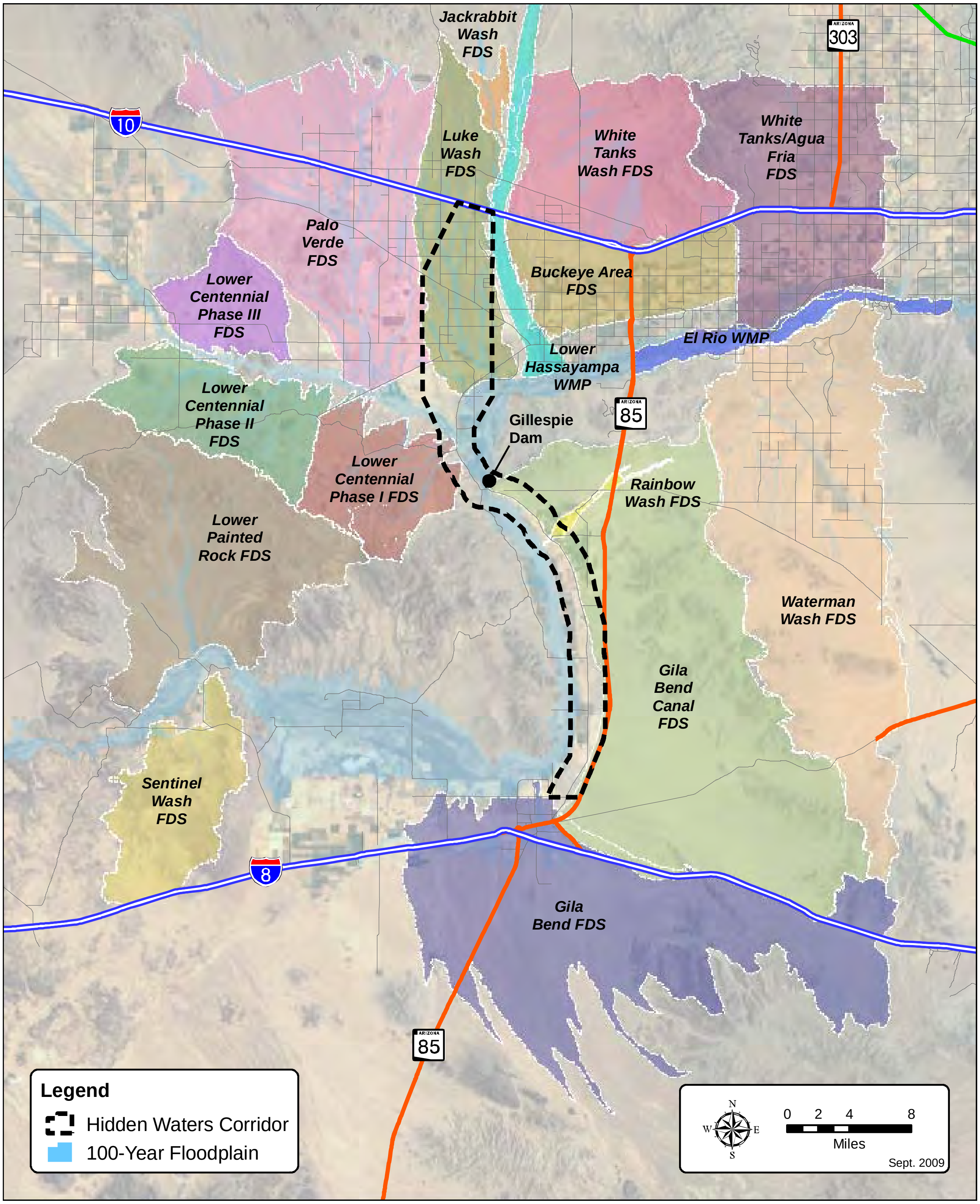

Figure 2 – Area Drainage Studies

2. EXISTING LAND USE

Exhibit 1A and **Exhibit 1B** in **Appendix TM3-1** provide photographs taken during a field review of the project study area land uses and their associated typical drainage features. The existing land use within the project study area is primarily agriculture and vacant land; however, a few residential, commercial, and industrial land uses also exist within the area. Some portions of the project study area contain parts of the Gila River. The land use features discussed below should be considered when developing Parkway alignment alternatives and when designing drainage conveyance structures during final design. Where existing drainage structures and residential, commercial, and industrial land uses exist within the project study area, care should be taken during final design to not increase flooding or ponding upstream and downstream of proposed drainage structures.

In the southern region, State Road 85 (SR 85) runs along the east side of the project study area, paralleling the project study area until approximately the intersection of SR 85 and Woods Road. Land use in this area is predominantly agriculture, including a large dairy farm with sludge ponds located within the project corridor between Watermelon Road and Fornes Road. The Gila Bend Canal flows along the eastern boundary of the project study area from Gillespie Dam to the south end of the project. The canal is elevated and hydraulically separates the project area from lands east of the Corridor.

The Old US 80 Bridge is located approximately 500 feet downstream of Gillespie Dam. The bridge is a 9-span steel truss bridge that spans the Gila River. Gillespie Dam has been breached but still acts as a dominant control on the Gila River and the subsequent land uses that result from the water impoundment. The land use in the central region is mostly agricultural lands on the east side of Old US 80, and undeveloped desert lands on the west side of Old US 80. Much of this land is located within the broad Gila River floodplain. The Arlington Canal runs within the project study area, along the east side of Old US 80 from 331^{st} Avenue to West Desert Rose Road. The Arlington Canal then crosses Old US 80 and runs along the west side of Old US 80 from West Desert Rose Road to just north of Agua Caliente Road. The Arlington Canal then crosses Old US 80 again and runs along the east side of the road to Gillespie Dam.

In the northern region, much of the land is undeveloped desert featuring numerous regulatory floodplains. The project study area crosses the Union Pacific Railroad (UPRR) approximately 2000 feet south of Elliot Road. Low-density residential areas are located within the project study area between Elliot Road and I-10. More detailed land use observations for the northern region can be found in the recently completed *Luke Wash Watershed Zone AE Floodplain Delineation Study (FCDMC, 2008).*

3. EXISTING WATERSHED FEATURES

The Hidden Waters Parkway project study area lies within the Sonoran Desert region of the Basin and Range geographic province. The region is characterized by alluvial fan, terrace, and basin floor deposits surrounded by rugged, low- to high-relief mountain ranges that include a variety of granitic rocks and volcanic rocks. The area is drained by numerous washes that flow towards the Gila River. Dry washes in the project study area flow only in response to rainfall events, and may overtop during heavy rainfall events. Flooding is more likely to occur during the monsoon season lasting from July through September, but may also occur during the winter storms from December through February (Maricopa County, 2007).

The watersheds contributing offsite flows to Hidden Waters Parkway may be addressed by dividing the drainage patterns into three drainage regions within the project study area. These regions are:

- **Southern Region: Drainage south of the Gila River –** The project study area in this region is generally oriented parallel to the Gila River but perpendicular to the offsite drainage patterns. Offsite flows come from watersheds to the east of the project study area and flow west to the river, which is a very similar situation that exists along SR 85 in this area. Drainage impacting Hidden Waters will be alluvial fan and distributary in nature, subject to flash flooding and high sediment loading. The drainage region south of the Gila River may be described as associated with the Gila Bend Canal watershed and Rainbow Wash. The Gila Bend Canal watershed borders the east side of the project study area. This watershed originates in the Maricopa and Buckeye Hills Mountains and flows west towards the Gila Bend Canal and SR 85.
- **Central Region: Gila River Crossing –** The Gila River provides a separate and distinct riverine challenge for a crossing for the Parkway. A bridged crossing of the river will need to consider high flood flows, a fairly wide floodplain, FEMA floodplain impacts, and long-term river bed elevation changes and local scour countermeasures. The central drainage region may be described as associated with the Lower Centennial Wash (tributary of the Gila River) and the Gila River. The Lower Centennial Wash watershed originates in the Gila Bend Mountains and flows east towards the Gila River.
- **Northern Region: Drainage north of the Gila River –** The project study area in this region is generally oriented parallel to the Luke Wash drainage. Luke Wash is a large regional drainage tributary system to the Gila River. The wash is typical of ephemeral desert washes subject to flash flooding and high sediment transport. The project study area crosses Luke Wash and its finger tributaries many times. Drainage facilities for the Parkway will need to accommodate sediment-laden flood flows. The Parkway embankment and earthen diversions may serve to direct and control flows within the project study area. The Luke Wash watershed, which makes up the northern region of the project study area, flows south from the Central Arizona Project (CAP) Canal, is conveyed under I-10 and Salome Highway, and discharges to the Gila River.

3.1 Southern Region: Drainage South of the Gila River

3.1.1 Gila Bend Canal Watershed

Flow south of the Gila River in the Gila Bend Canal watershed occurs in wide, shallow sheet-flow patterns with numerous small braided stable washes and one major wash. The Rainbow Wash floodplain is also included in this watershed. Flow is conveyed west across SR 85 to the Gila Bend Canal by box culverts, pipes, and a bridge at Rainbow Wash. Dikes and ditches have been constructed at some locations to collect and direct both the sheet and the smaller wash flows to the appropriate culvert (ADOT, 1999).

The Gila River and floodplain in this area parallel the western side of the southern region project study area for most of the region. The river and floodplain cross into the southern region project study area about 5.2 miles south of Gillespie Dam. The Gila River floodplain in this area is approximately 1.7 miles wide, with roughly 0.6 miles of floodplain width within the project study area.

In the Gila Bend Canal Floodplain Delineation Report (FCDMC, 1991) the watershed subbasins were defined by starting the delineation from 11 siphon spillways and the lift station spillway along the Canal. Minor features, including small culverts passing under or into the Canal, and significant ponding areas, also were considered in forming major subbasin divides at the downstream boundary of the watershed. The combined drainage area is approximately 297 square miles. Within the watershed, 18 subbasins were defined and delineated.

Subbasins north of Rainbow Wash are relatively small (mostly less than a square mile). These northern areas are hilly with rock outcrops. The southern soils are sandy loam and loamy sand. Vegetation is sparse and consists of desert brush.

Subbasins south of the Gila River and south of Rainbow Wash are mostly undeveloped desert, range, or mountainous. Half of the watershed (to the east) is designated as the North and South Maricopa Mountains Wilderness Area. A residential development one mile south of Woods Road abuts the east bank of the Gila Bend Canal inside the project study area. Agricultural fields occupy the land adjacent to SR 85. The Maricopa Mountains are mostly granite, while the other soils are gravelly and coarse textured. Vegetation density varies.

In general, the downhill slopes are towards the west and south and reach a maximum of about 15 percent in the Maricopa Mountains and Buckeye Hills along the eastern and northern boundaries of the watershed. Slopes generally decrease moving west towards the Gila Bend Canal. Flatter slopes of 1 percent or less prevail in the western and southern portions of the watershed. Much of the Little Rainbow Valley has slopes in the range of 1 percent to 5 percent. Agricultural areas have been graded by landowners to slopes that are essentially flat.

Much of the watershed is drained by small channels which tend to converge and diverge in a braided network. There are a few well-defined channels and three major washes: Rainbow Wash (in the Little Rainbow Valley), Margie's Cove Wash, and Butterfield Wash. These washes, particularly Rainbow Wash, form significant channels of large capacity as they approach SR 85 and the Gila Bend Canal. In other basins, channels continue to be braided and distributary even as they pass to the west of SR 85, arriving at the Gila Bend Canal berm and cross-drainage structures in many distinct flow paths. In agricultural areas, landowners have constructed a system of drainage ways to convey storm flow around crop land and provide tailwater drainage.

Parkway Drainage Considerations: Currently, no structures exist in the area to convey or control the Gila River through this approximately 5.2 mile stretch of land below the Gillespie Dam. Consideration to avoid impacting the Gila River floodplain as much as possible should be given during the alignment alternatives analysis for the Parkway. The embankment along the Gila Bend Canal will control drainage patterns along the east side of the project study area, so drainage crossings structures will ultimately need to be designed in conjunction with the canal overshoot locations.

Because SR 85 parallels Old US 80 in this area, several considerations should be made based on information from the SR 85 Gila Bend to Lewis Prison Drainage Technical Memorandum (ADOT, 2001). Sedimentation will most likely be a problem, as it is currently a problem for SR 85 in this area. Culverts along SR 85 were set below the flow line of the wash, and this has created a foot of more sediment accumulation in the culverts. Care should be taken to set the proposed Parkway culvert inverts at the flow line of the wash to avoid the problems that the SR 85 culverts encounter. Inspectors have also noted corrosion in the corrugated metal pipes along the SR 85 corridor. Soil conditions seem to be corrosive in the area between SR 85 Mile Post (MP) 123 and MP 126; therefore, corrosion-resistant culvert materials for the Parkway should be chosen with soil properties in mind. The ADOT document also suggested using ditches and berms where possible to allow culverts to function as a group, making it more difficult to clog any single culvert.

3.1.2 Rainbow Wash Watershed

The Rainbow Wash watershed is included in the Gila Bend Canal Floodplain Watershed, but was studied separately by FCDMC in 1994. The watershed is typical of desert basins of the arid southwest. The northern limits of the watershed lie within the Buckeye Hills. Rainbow Wash flows through Little Rainbow Valley and discharges into the Gila River about 3.5 miles downstream of the Gillespie Dam. The Rainbow Wash floodplain and the Gila River floodplain have a confluence approximately 4.7 miles downstream of the Gillespie Dam Bridge. The 100-year peak discharge at the confluence with the Gila Bend Canal is 11,568 cfs (FEMA, 2005).

Vegetation within the watershed consists of creosote bush, palo verde, mesquite, cacti, and acacias. Agricultural land consisting of active and inactive cotton fields are located adjacent to Rainbow Wash downstream of SR 85. There is little development within the floodplain.

Floods are characterized by flows which rise and recede quickly. Flows in Rainbow Wash appear to result in substantial transport of sediment as well as cause some bank erosion. Minor scouring occurs along the channel bottom just downstream of SR 85 over the main stem of Rainbow Wash (FCDMC, 1994). Based on observations from the field visit, a bridge once existing along the east side of Old US 80 at Rainbow Wash – only the north abutment is still present, so further research into the fate of this bridge is recommended during final design of the Parkway.

Parkway Drainage Considerations: The Rainbow Wash floodplain is approximately 600 feet wide at the point where the floodplain enters the project study area. A bridge or other large drainage structure will likely need to be considered if an alignment is selected that crosses Rainbow Wash in this area. Impacts to the Rainbow Wash floodplain and floodway should be considered and may necessitate a detailed floodway study.

3.2 Central Region: Gila River Crossing

The Lower Centennial Wash Watershed is approximately 53.5 square miles of mainly undeveloped upland desert. The confluence of Lower Centennial Wash and the Gila River occurs near Desert Rose Road in the center of the project study area. The watershed is bounded at its far upstream end by mountains and on the north and west by a segment of the UPRR, Centennial Wash, and the Gila River. The watershed incorporates areas of riverine flooding, sheet flooding in areas of alluvial plains, alluvial fan deposition, and stable areas that are underlain by pediments and relict fans. Although sheet flooding may occur in these areas, it does not result in either deposition of widespread erosion. The Lower Centennial Wash watershed contains areas of low-density residential, open space, and agriculture land uses. The runoff from the watershed ultimately discharges to the Gila River (FCDMC, 2005b).

The Gila River floodplain covers the eastern half of this region of the project study area. The 100-year peak discharge of the Gila River at Gillespie Dam is 235,000 cubic feet per second (cfs). The 100-year water surface of the Gila River at the dam is approximately 11 feet, and the 100-year water surface of the Gila River at the ground just upstream of the dam is 16 feet. The Gila River floodplain at Gillespie Dam is approximately 1,750 feet wide, and the Gila River floodplain at Desert Rose Road, just upstream of the confluence with Lower Centennial Wash, is 9,100 feet wide (2,700 feet within the project study area). The depth of flow in this area is 23.5 feet.

Parkway Drainage Considerations: The alluvial fans and distributary flow characteristics in the watershed should be considered during the hydrologic analysis for proposed drainage structures along the Parkway in this region. Sediment deposition will probably not be as much of a concern in this section as it is in the southern and northern sections because the area is considered stable. The Parkway is assumed to cross the Gila River at the new crossing location identified by MCDOT approximately 1,000 feet south of the existing Old US 80 Bridge. The Parkway will also need to cross Lower Centennial Wash if the Parkway follows a similar alignment to Old US 80.

3.3 Northern Region: Drainage North of the Gila River

The Luke Wash Watershed is located in the western part of Maricopa County, roughly from the 371st Avenue alignment east to the Hassayampa River, and from the Gila River north to the CAP Canal. The watershed has a total area of approximately 75 square miles. The watershed is primarily natural undeveloped desert with portions of agricultural farmland and urban development. Most of the agricultural farmland and urban developments are located within the southern portion of the watershed (south of I-10).

Elevations range from approximately 1,360 feet near the CAP Canal to approximately 800 feet near the northern edge of the Gila River. Surface runoff is generally from north to south through a network of ephemeral sand-bed washes. These washes eventually drain into the Gila River with a few directly tributary to the Hassayampa River. The general slope of the watershed is 0.55 percent. Vegetation through the study reaches includes trees, cacti and various shrubs.

Dickey Wash and Phillips Wash combine approximately 3 miles south of I-10 and become Luke Wash. Luke Wash is the main wash that runs into the Gila River. A major tributary (to the west of Luke Wash) joins Luke Wash just south of the UPRR.

The study area has a wide variety of channel and overbank characteristics, varying from well defined sand-bed and bedrock channels with a majority of the estimated 100-year flow expected to be contained within the defined channel banks, to shallow distributary reaches with very limited channel conveyance capacity. Split flow can occur as side weir or distributary conditions. Stormwater runoff occurs in the study area only in response to significant rainfall events (FCDMC, 2008).

Parkway Drainage Considerations: Drainage structures, such as bridges or culverts, will need to be considered for any Parkway alignments that cross Luke Wash and its tributaries. During the alignment alternatives analysis for the Parkway, consideration should be given to making the least impact on FEMA floodplains. Hydrologic analysis for the proposed culverts along the Parkway should be developed during final design to consider split flows and the distributary nature of the watershed. Upstream ponding and downstream inundation should be analyzed so that property owners are not affected by increased flooding. Sediment and erosion control should also be considered during the design of the proposed drainage system.

3.4 Soils

According to the United States Department of Agricultural (USDA) Natural Resource Conservation Service's soils website, the major soil types within the study area are Gunsight-Rillito-Chuckawalla (approximately 63 percent of the study area), Gilman-Lagunita-Indio (approximately 16 percent of the study area), Carrizo-Brios-Antho (approximately 11 percent of the study area), Denure (approximately 9 percent of the study area) and Quilotosa-Vaiva-Rock Outcrop (approximately 1 percent of the study area). **Table 1** lists the characteristics of the soil types and **Figure 3** indicates where the soils are located in the study area. These soil types are typically considered suitable for the construction of roadways on top of them.

Table 1 – Soil Type Characteristics

Soil Type	Typical Location	Depth to Restrictive Layer	Drainage Comments
Gunsight-Rillito-Chuckwalla	Alluvial fans at 0-10% slopes	More than 80 inches	Well drained to somewhat excessively drained, with a moderately high to high water transmission rate, which makes runoff from this soil type very slow or almost negligible.
Gilman-Lagunita-Indio	Floodplains at 0-1% slopes	More than 80 inches	Well to excessively drained, with a moderately high to very high water transmission rate - this makes runoff from this soil type almost negligible.
Carrizo-Brios-Antho	Floodplains at 0-1% slopes	More than 80 inches	Excessively drained with a high water transmission rate, which makes runoff from this soil type almost negligible.
Denure	Fan terraces at 1-3% slopes	More than 80 inches	Somewhat excessively drained with a moderately high to high water transmission rate, which makes runoff from this soil type very slow and almost negligible.
Quilotosa-Vaiva-Rock Outcrop Complex	Mountains at 15-55% slopes	More than 80 inches	Somewhat excessively drained with a very low to low water transmission rate, which creates a high potential for stormwater runoff.

Source: United States Department of Agricultural (USDA) Natural Resource Conservation Service's soils website (http://websoilsurvey.nrcs.usda.gov, accessed June 29, 2009)

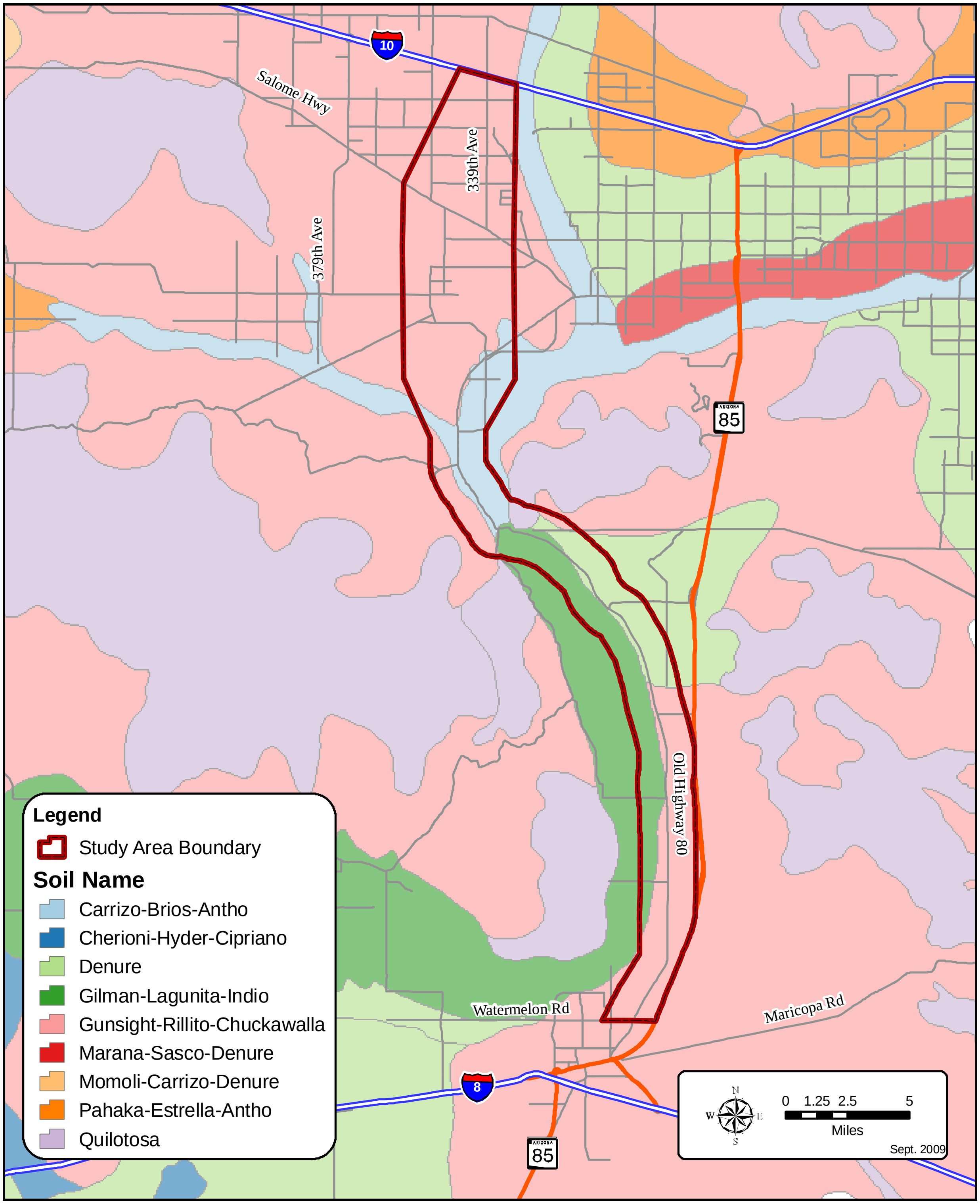

Figure 3 – Soils

3.5 Regulatory Floodplains

Several FEMA floodplains are included in the watersheds that drain through the Hidden Waters Parkway project study area. These floodplains ultimately discharge to the Gila River within the project study area. **Figure 4** provides a graphic of the 100-year floodplain areas and also displays the Flood Insurance Rate Map (FIRM) panels containing the effective floodplain mapping. Both FEMA effective and FCDMC (typically pending FEMA approval) floodplain limits are shown on this exhibit. Floodplain encroachment will be a limiting factor for the Parkway alignment alternatives. Detailed floodway analysis and coordination with FCDMC and FEMA may be necessary where floodplain encroachments occur.

3.6 Potentially Impacted Drainage Structures

Drainage structures that could be impacted by the Hidden Waters Parkway are structures along SR 85, Gila Bend Canal siphons, proposed Gillespie Dam Bridge Alternative DT-4, UPRR bridges, and culverts along I-10. Gillespie Dam could also be impacted by proposed alignment alternatives.

3.6.1 Structures along SR 85

Approximately 49 cross-culverts exist between the Milepost 121.3 and Milepost 133.8 (Woods Road) on SR 85 according to the SR 85 Corridor Study, Gila Bend to I-10 Proposed Drainage Plan (ADOT, 1999). These culverts could potentially be impacted by the proposed Hidden Waters Parkway, and should be considered during final design of the Parkway.

3.6.2 Structures along I-10 and the UPRR

There are several box culverts and drainage pipes along I-10 and railroad bridges along the UPRR that drain the Luke Wash Watershed. These should be considered during final design of the Parkway. **Exhibit 2A** in **Appendix TM3-2** is provided to show crossing structure locations and calculations for I-10 and the UPRR that may be impacted by the proposed Parkway.

3.6.3 Gila Bend Canal Siphons

Eleven siphon spillways and a lift station spillway exist along the Gila Bend Canal that could be impacted by the proposed Hidden Waters Parkway. The siphon locations are included in the Gila Bend Canal Floodplain Delineation Study HEC-1 Schematic provided as **Exhibit 2B** in **Appendix TM3-2**. These siphon locations should be considered during final design of the Parkway.

3.6.4 Gillespie Dam Bridge

The existing Gillespie Dam Bridge is a 9-span steel truss bridge that spans the Gila River. The bridge is located approximately 500 feet downstream of the Gillespie Dam. The foundations for the bridge are spread footings supported on igneous bedrock from about 15 feet to over 40 feet below the river bed. The spread footings are about 10 feet wide and 33 feet in length (MCDOT, 2007b).

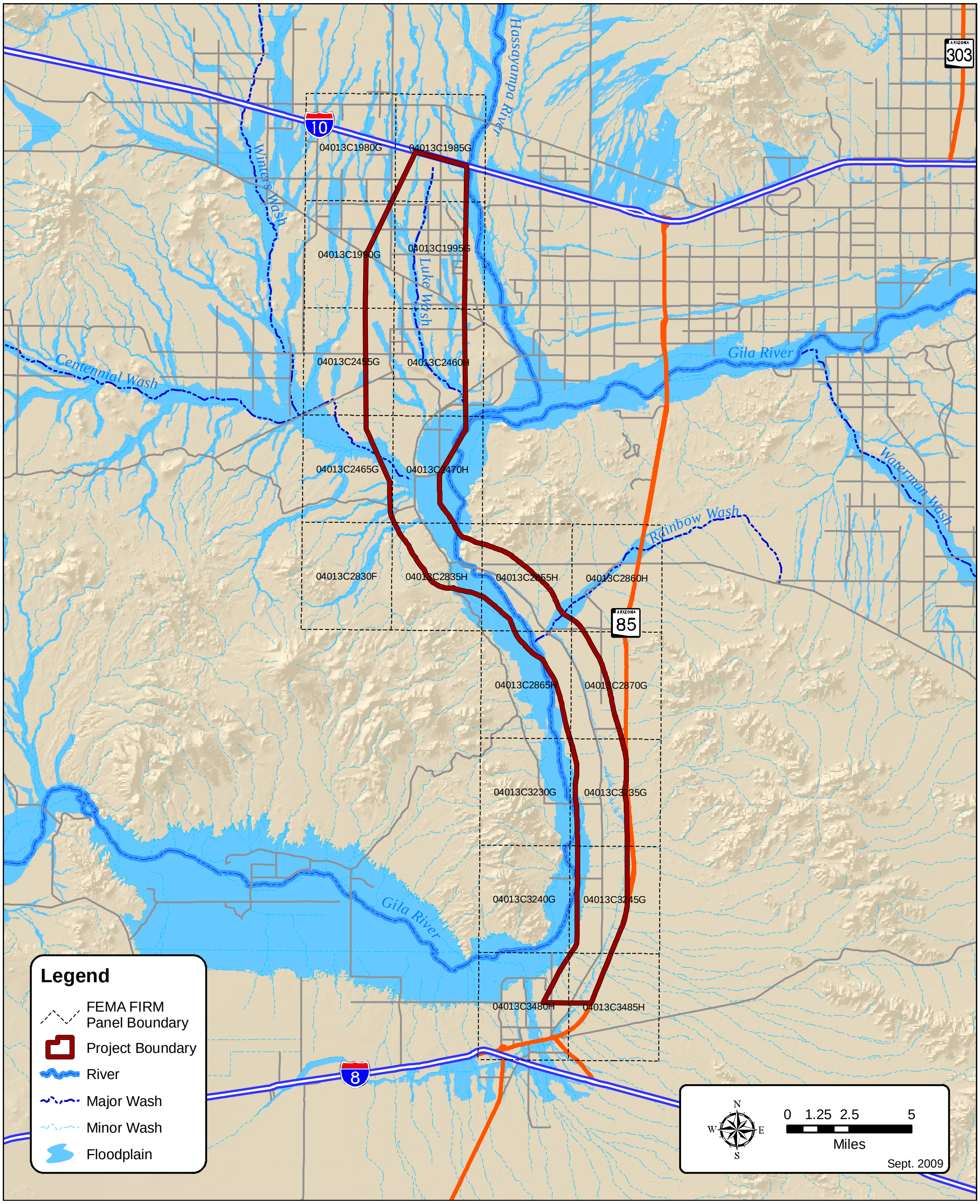

Figure 4 – Floodplains

In January 1993, a major flood occurred that resulted in the overtopping and subsequent failure of Gillespie Dam. The size of the flood was not recorded due to equipment failure. However, an estimated flow of 200,000 cfs based upon a high water mark recorded on USGS equipment was determined. This corresponds to approximately a 65-year flood (Wikipedia, 2009). The collapse of the dam concentrated flows on the easternmost portion of the bridge. This caused scouring of the east bridge abutment and two of the piers. A repair project was undertaken for three of the piers at the east end of the bridge in late 1995. The repair addressed cracks in some piers and provided a curtain wall around the upstream and the sides of several piers.

Alternatives have been proposed by MCDOT to rebuild the Gillespie Dam Bridge. The currently preferred alternative, DT-04, includes constructing a new interim low-flow crossing roadway outside of the bridge ponding area to allow the existing bridge to be converted to a pedestrian crossing or one-way bridge. The new roadway would become a two-lane full service roadway at completion. A new 60-foot single span bridge would allow for conveyance of minor river flows across the lowest point of the Gila River (MCDOT, 2008). An all-weather, 1,800-foot long, 14-span bridge has been proposed to ultimately replace the interim low-flow crossing. For purposes of this study, it is assumed that the Parkway will utilize the same alignment as the proposed new bridge. Sketches of the proposed bridge alignment and roadway are provided as **Exhibit 2C** in **Appendix TM3-2**.

3.6.5 Gillespie Dam

Gillespie Dam is a privately-owned irrigation water diversion dam located on the Gila River near the midpoint of the Hidden Waters Parkway project study area. It is a multiple-arch concrete dam on a 2-foot thick concrete slab with piling below pier walls and with concrete sheet piling as cut off walls near the upstream and downstream edges of the slab. Diversion structures at the east and west ends of the dam were constructed and include sluice gates. The west diversion structure has been inactivated and its function replaced by a gated opening in the third arch from the west end that releases impounded stream-flow to the 4-foot deep water cushion impounded by a concrete weir. A 30-inch diameter corrugated metal pipe has been installed, with inlet submerged below the water cushion, to divert irrigation water to the Enterprise Canal. The transition length of the Gila Bend Canal has been rehabilitated from the diversion gates to the newly lined canal.

Gila River surface water has been diverted for agricultural irrigation at Gillespie Dam since its construction in 1921. Two principal canals, the Enterprise Canal and the Gila Bend Canal, transport the diverted water for many miles and have provided a basis for the development of large acreages of cropland and pasture. These canal routes have permitted development of many wells located adjacent to the canals to supplement surface water supply by pumping groundwater. Any modifications to Gillespie Dam must account for the maintenance of adequate diversion capability in the foreseeable future (FCDMC, 1981).

In 1993, the dam was overtopped by an approximately 65-year flood and failed. The flood caused extensive scouring at the Gillespie Dam Bridge. The dam has not been repaired since the flood, and a small earthen embankment exists to direct water into nearby canals.

3.7 Sedimentation

The alluvial fan and distributary flow characteristics of the watersheds carry significant amounts of sediment during storm events. Sedimentation could impact the drainage facilities and hydraulic structures within the project study area, and may result in erosion and scour at the structures. The level of sedimentation, scour, and erosion expected to occur at proposed drainage structures would be typical the drainage issues commonly experienced along SR 85 and I-10. Sediment deposition, scour, and erosion should be considered during the final design of the Parkway.

3.8 Geology

The land surrounding the project study area is characterized by alluvial fans and basin floor deposits. Mountain ranges surround the area, and these ranges include a wide variety of granitic and volcanic rocks. The areas bordered by the Palo Verde Hills to the northwest and the Signal Mountain and Woolsey Peak Wilderness Areas to the south are generally composed of lava, tuff, and fine grained intrusive rock. The east side of the project study area, bordered by the Maricopa Mountains and the Buckeye Hills are generally composed of granitic rock. The eastern portions of the Woolsey Peak Wilderness Area are also composed of granitic rock (Maricopa County, 2007). A map depicting flood hazards based on soil type, surficial geology, and 100-year floodplains is provided as **Figure 5.**

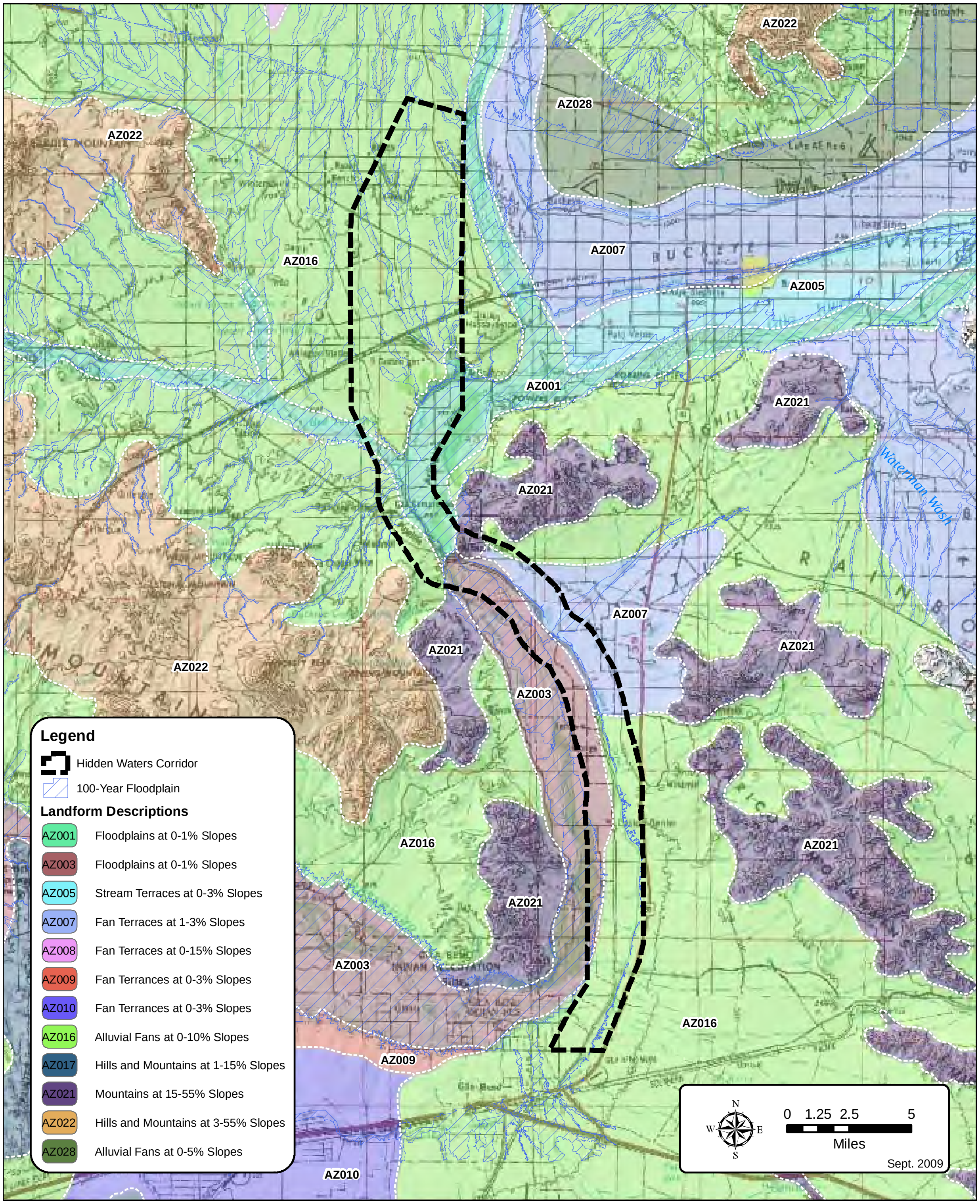

Figure 5 – Flood Hazards Map

4. EXISTING HYDROLOGY

Existing hydrology data for the Hidden Waters Parkway project study area watershed was summarized from the following studies.

- Hydrology Report, Gila Bend Canal Floodplain Delineation Report, Gillespie Dam to Gila Bend (FCDMC, 1991)
- Rainbow Wash Floodplain/Floodway Delineation Study (FCDMC, 1994)
- Lower Centennial Wash Watershed Zone A Floodplain Delineation Study, Phase I TDN (FCDMC 2005a)
- Hydrologic Study Report for Luke Wash Zone AE Floodplain Delineation Study (FCDMC, 2008)

A summary of the hydrologic resources is provided in **Table 2**. A map depicting the subbasin drainage areas, concentration points, and flow paths is provided as **Exhibit 3A** in **Appendix TM3-3.** The storm event discharges at concentration points for the 50-year and 100-year storm events are provided as **Exhibit 3B** in **Appendix TM3-3**. As shown in these tables, the highest concentrated flows are expected in the southern and central regions. Washes in these parts of the Corridor typically originate in nearby mountains and flow perpendicular to the proposed parkway, requiring crossing structures. Flows in the northern region are smaller but more numerous, and typically flow parallel to the Corridor. Careful selection of an alignment could reduce the need for drainage structures in the northern region.

The floodplain studies listed above only calculated the 100-year discharge for each subbasin. However, a 50-year discharge was provided for concentration points along SR 85 in the SR 85 Initial Drainage Report (ADOT, 1999). A local regression equation was derived from the SR 85 Initial Drainage Report results and applied to the other project study area subbasins to calculate preliminary 50-year discharges. This regression analysis is shown as **Exhibit 3C** in **Appendix TM-3.**

4.1 Gila Bend Canal Floodplain Watershed – Southern Region

The Gila Bend Canal Floodplain watershed was modeled using the U.S. Army Corps of Engineers HEC-1 computer program. The models were formulated to compute flows arriving at the Gila Bend Canal at 18 concentration points. Subbasins were delineated using United States Geological Survey (USGS) 7.5 minute topographic maps. Basin boundaries were traced upstream starting from the spillway siphons or ponding areas. The delineation proceeded eastward of SR 85 and the UPRR to the watershed divide.

The 100-year, 6-hour and 24-hour precipitation events were derived from National Oceanic and Atmospheric Administration (NOAA) II rainfall depths. The time distribution was based on FCDMC design procedures for the 6-hour storm and the SCS Type II distribution for the 24-hour storm. Runoff rates from individual subbasins were determined by application of Green and Ampt precipitation loss procedures. Flows were generated using unit hydrographs based on either the FCDMC standard procedures for the 6-hour storm or the Phoenix Valley S-hydrograph method for the 24-hour storm.

Subbasins flows were combined and routed as appropriate for the flow pattern in each subbasin. Normal depth routing procedures were used. Transmission losses in channel flow due to infiltration were included in all routings. Flows were assumed to be able to split and jump across basin or subbasin divides at five locations in the watershed. Each of these locations was represented as a diversion in the HEC-1 model (FCDMC, 1999).

Table 2 – Summary of Offsite Hydrology Resources

Study	Drainage Area (mi^2)	Study Reach Length (mi)	Rainfall	Hydrology Methodology	Topography	Year of Study
Gila Bend Canal Floodplain Delineation Study Gillespie Dam to Gila Bend	297	23	NOAA 6-hr, 24-hr	HEC-1 Green and Ampt Clark, S-graph UH	7.5' quad maps	1991
Rainbow Wash FIS Gila River through S.R. 85	50	11?	NOAA 6-hr, 24-hr	Modified GB Canal HEC-1	aerial survey	1994
Lower Centennial Wash Watershed Zone A Floodplain Delineation Study Phase I	53.5	80.5	NOAA 2 6-hr, 24-hr	HEC-1, Local Regression	10-ft DEM	2005
Luke Wash Zone AE Floodplain Delineation Study	90	85	NOAA 14 6-hr, 24-hr	HEC-1 Green and Ampt S-graph UH	2-ft contours 800-1360 ft elevations	2008

4.2 Lower Centennial Wash Watershed – Central Region

Peak flows for the Lower Centennial Wash watershed were determined for the 100-year, 6-hour and 24-hour storms using HEC-1 software. Subbasin delineation was performed with the aid of the Watershed Modeling System (WMS), version 7.0, using a digital elevation model (DEM) produced from digital orthophotos. The HEC-1 model parameters were determined using WMS. The FCDMC provided a DEM that contained data points on 10-foot grid elements. WMS analyzed the DEM, SCS soils data, and land use data in order to create a HEC-1 model based on the FCDMC's criteria.

NOAA Atlas II was used to obtain the 100-year, 6-hour and 24-hour point precipitation values for the HEC-1 model. The Green and Ampt precipitation loss procedures were used to determine runoff rates based on the FCDMC guidelines. The Phoenix Mountain S-Graph was used to obtain the unit hydrographs for the watershed because the total drainage area is greater than 10 square miles.

Eleven reaches required channel routing. Normal depth routing was performed in HEC-1 for these reaches. There were two locations within the watershed along the UPRR where the runoff could back up at trestles, causing a need to perform reservoir storage routing. Reservoir storage routing was not performed due to its nature of being a Zone A Delineation Study, and the large area of the trestles compared to the contributing watershed (FCDMC, 2005a).

4.3 Luke Wash Watershed – Northern Region

The 100-year, 6-hour and 24-hour storm events were modeled for the Luke Wash watershed using HEC-1 software, in conjunction with methods and procedures described by FCDMC. WMS software was used to develop the preliminary subbasin boundary delineations. Drainage Design Management System for Windows software (DDMSW) was utilized to prepare the input parameters for the HEC-1 models. ArcGIS was applied to transfer databases available from FCDMC to prepare parameters for modeling purposes.

NOAA 14 rainfall data was used to estimate the design rainfall depth for this study. The FCDMC 6-hour local storm distribution for 6-hour model and SCS Type II precipitation distribution for the 24-hour model were used for the HEC-1 rainfall distributions. The Green and Ampt Method was utilized for the estimation of rainfall losses. The S-Graph method was used for the development of unit hydrographs.

Normal depth channel routing methodology was utilized in the hydrologic model to route surface runoff through subbasins. An 8-point composite channel cross-section was developed to represent typical wash cross-section conveyance using 2-foot contour mapping. The longitudinal slopes were estimated based on general existing wash slopes and Manning's "n" values were based on field reconnaissance estimates.

Storage routing along I-10 and the UPRR were modeled using the Modified Puls reservoir routing option of HEC-1. The storage-elevation discharge relationship curves for storage facilities were developed using 2-foot contour mapping, as-built plans, and survey data. Initial rating curves were developed using Dodson software. The HEC-1 models were executed to obtain preliminary 100-year peak flows. HEC-RAS models were developed for the study washes and preliminary floodplains were delineated to evaluate if lateral flows occur along I-10 and the UPRR. The lateral flow conditions were further verified by field reconnaissance. Hydrologic models and storage routing curves were revised to represent the lateral flow (multiple washes merged flow) conditions. The final storage routing curves were developed using HEC-RAS models for the study washes. The rating curves for non-study washes were refined with Dodson software.

Surface runoff from the subbasins has the potential to concentrate at more than one point. It was assumed that the concentration point was located at the hydrologic low point of the subbasin. A potential split flow from Jackrabbit Wash was identified to one of the study washes. The FCDMC provided both hydrologic and hydraulic models for the Jackrabbit Wash. A rating curve was developed using the HEC-RAS models for Jackrabbit Wash to determine the diverted flow. The diverted flow hydrograph was coded into the 100-year, 24-hour HEC-1 model. There was no split flow for the 100-year, 6-hour storm model (FCDMC, 2008).

5. SUMMARY AND CONCLUSIONS

The purpose of the Conceptual Drainage Report is to describe the existing drainage conditions and patterns, including peak flows, for the Hidden Waters Parkway project study area. The findings of this memorandum can help determine the best alignment for the proposed Parkway. Drainage structures and features in and around the project study area have been identified and should be considered during the design of the future Parkway. Peak flows reported in this memorandum have been compiled for planning purposes only. Discharges should be evaluated based on FCDMC drainage criteria during final design of the Parkway.

The impacts of crossing the Gila River and the numerous washes discussed in this memorandum should be considered when developing and evaluating potential Parkway alignment alternatives. Alignment considerations will need to include the structures (such as bridges and box culverts) that may be necessary to include in the Parkway design to convey flood flows under the proposed Parkway. Floodplain impacts and the potential need for detailed floodway studies should also be considered where applicable.

The watersheds are often comprised of alluvial fans. Hydrologic analyses considered for proposed drainage structures along the Parkway alignment will need to accommodate the split flows that occur due to the alluvial fans in the watersheds in which the Parkwayalignment may be located. Sedimentation should also be taken into account when designing the proposed drainage structures. Adequate erosion control and correct placement of structures to minimize sedimentation will be necessary for the proposed drainage structures to convey flows properly throughout the service life of these structures.

The proposed Parkway may cause increased ponding and inundation in the area. The watershed is mostly undeveloped desert, but there are a few residential, industrial, and agricultural developments, especially along the Gila River. Increased inundation and ponding on developed land should be avoided where feasible. Care should be taken not to adversely affect the functions of the Arlington Canal, Enterprise Canal, Gila Bend Canal, Gillespie Dam Bridge, Gillespie Dam, and culverts along SR 85 and I-10 during the drainage design for the Parkway.

In summary, the following issues should be considered during the alignment alternatives analysis. A "major" issue to be considered is the placement of bridges over the washes and the Gila River. Several crossings of washes will most likely be required, and bridges may be necessary at all of these crossings. Cost considerations for possible bridges, and the upstream and downstream impacts of a bridge crossing, should be part of the alignment alternatives analysis. FEMA and FCDMC collaboration will likely be a "moderate" issue to consider during the alignment alternatives analysis and the drainage design. Impacts to the floodplains could lead to detailed floodway studies, and such impacts probably cannot be completely avoided within the project study area. Floodway studies may need FEMA and FCDMC approvals. The time, effort, and collaboration to obtain these approvals will need to be considered during the alignment alternatives analysis. A "minor" issue to be considered during final design of the Parkway is possible sedimentation. Drainage systems will need to account for the sediment deposition that will most likely occur within the project study area.

6. REFERENCES

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APPENDIX TM3-1
FIELD DOCUMENTATION

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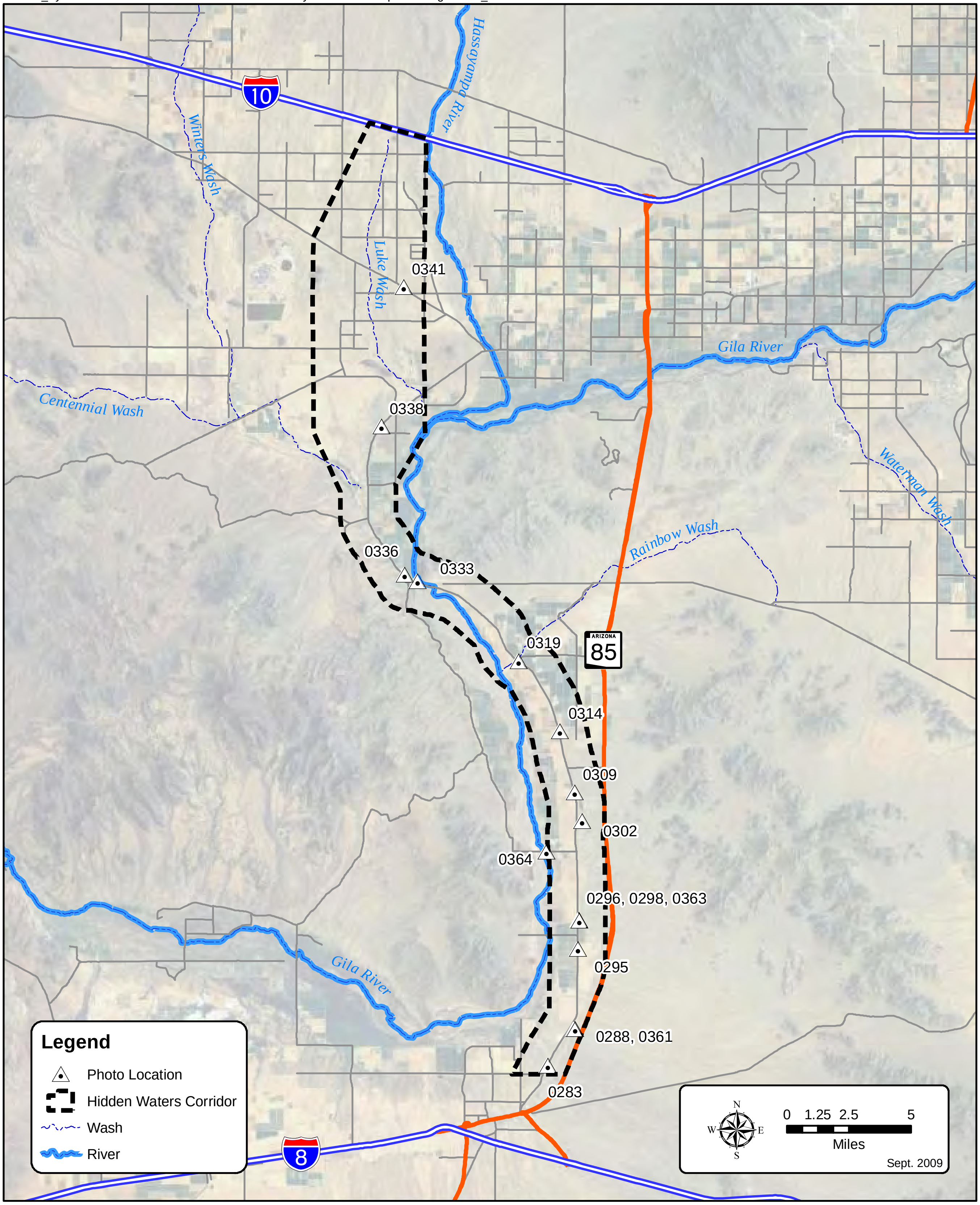


Kimley-Horn and Associates, Inc.

Hidden Waters Parkway Maricopa County, Arizona	Field photos taken: August 5, 2009

Exhibit 1A: Drainage Photo Locations

Photo 0288: Downstream section and erosion at Gila Bend Canal...

Photo 0296: Constructed earthen channel towards Gila River

EXHIBIT 1B. DRAINAGE FIELD PHOTOS

Photo 0283: Downstream side of Old US 80 at-grade crossing

Photo 0295: At-grade wash crossing of Old US 80

Photo 0302: Overflow overshoot of Gila Bend Canal

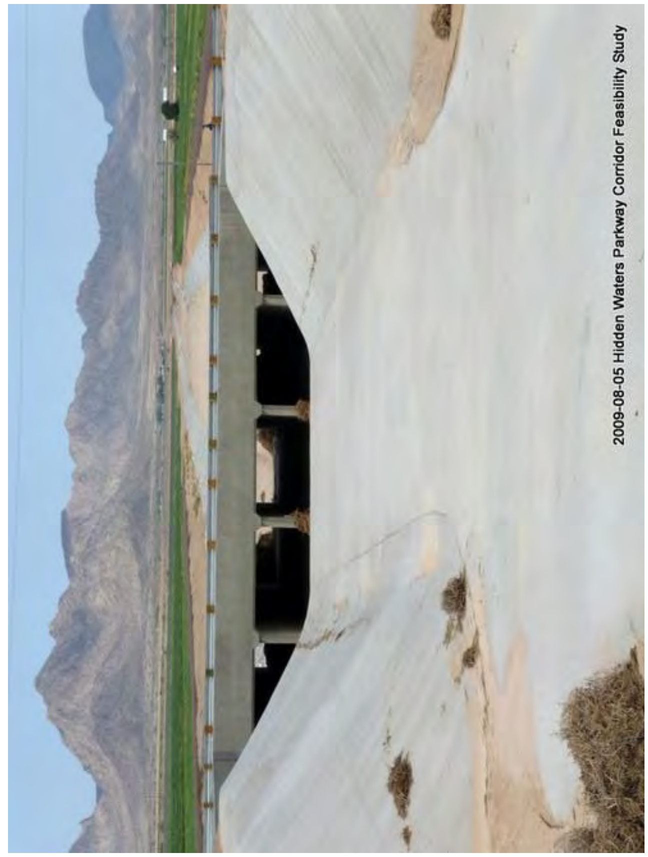


Photo 0314: New Box Culverts Crossing of Old US 80 at Layton Wash

EXHIBIT 1B. DRAINAGE FIELD PHOTOS

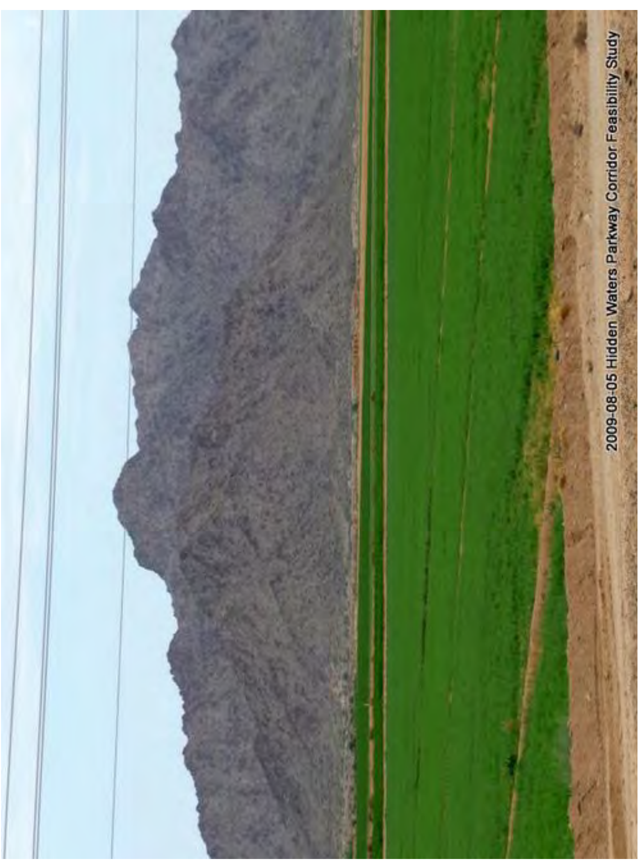


Photo 0298: Typical agricultural land use in Gila River valley

Photo 0309: Typical roadway section of Old US 80

Photo 0333: Looking upstream at Gillespie Dam breach

Photo 0338: Overgrown box culvert entrance along Old US 80

EXHIBIT 1B. DRAINAGE FIELD PHOTOS

Photo 0319: Looking downstream at former bridge and Old US 80...

Photo 0336: Looking downstream at Gillespie Dam and Old US 80...

Photo 0361: Looking north at Gila Bend Canal overshoot

Photo 0364: At-grade crossing of Gila River at Pierpoint Road

EXHIBIT 1B. DRAINAGE FIELD PHOTOS

Photo 0341: Typical roadway section looking north at 339th Avenue

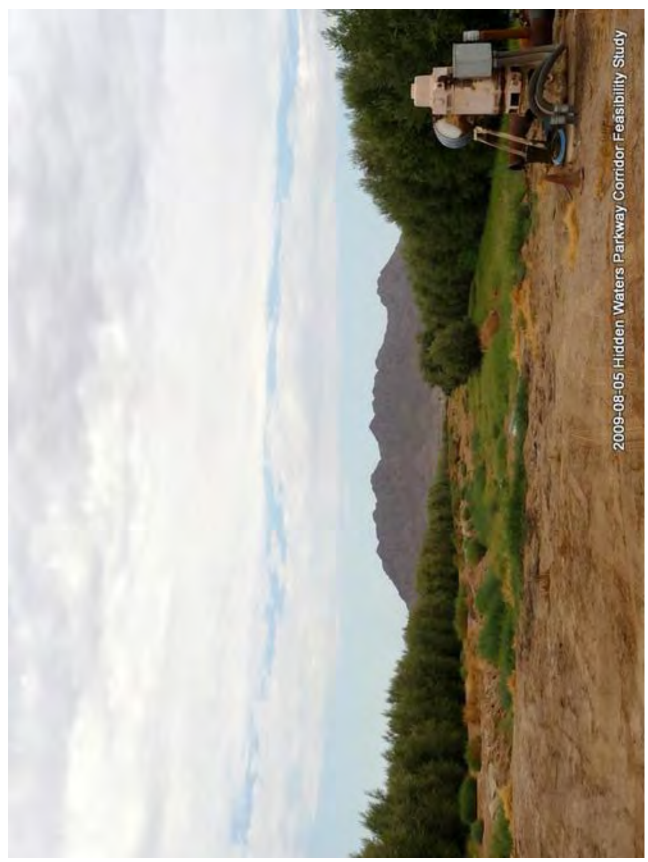
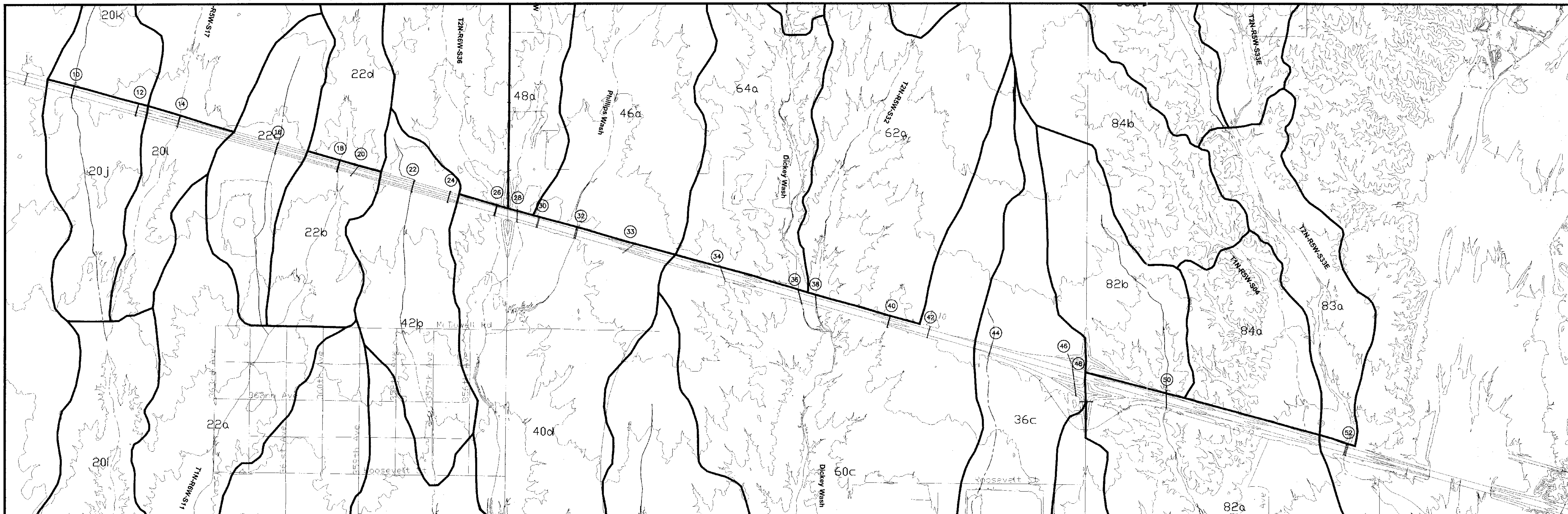


Photo 0363: Looking west through olive tree plantation

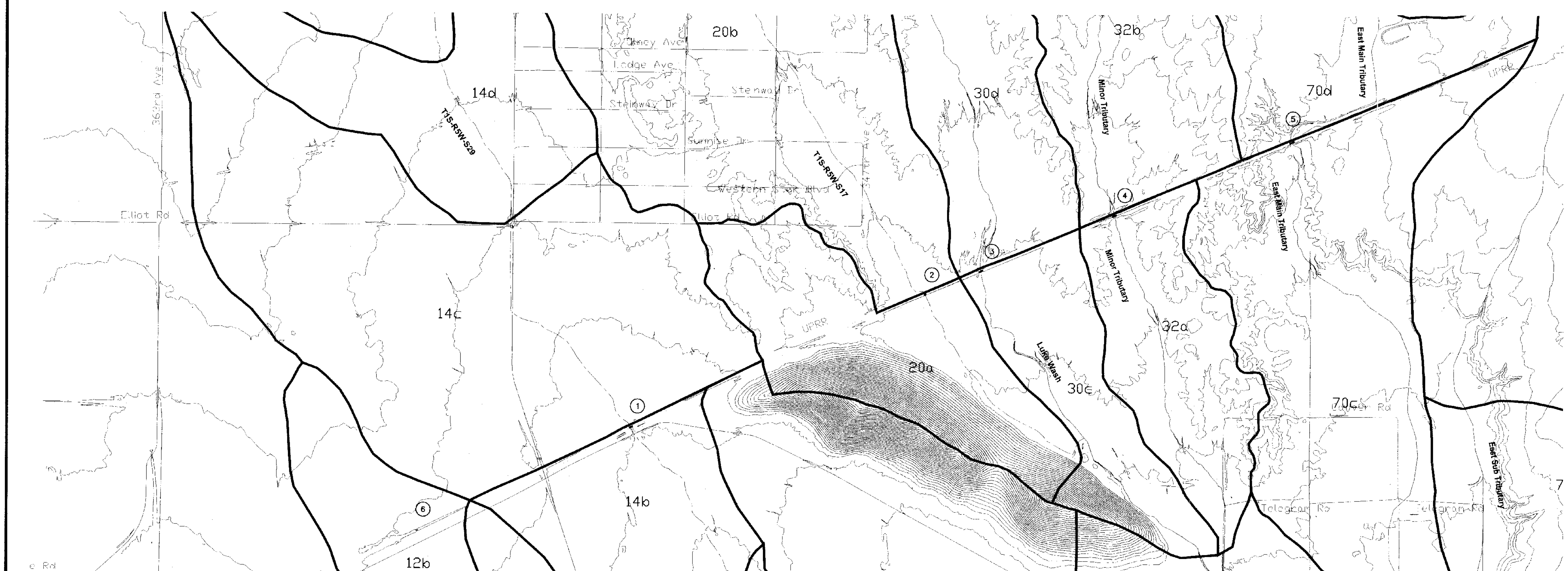
Kimley-Horn and Associates, Inc.

APPENDIX TM3-2

POTENTIALLY IMPACTED DRAINAGE STRUCTURES



I-10 Culverts



UPRR Bridges

SCALE: 1" = 800' FEET
CONTOUR INTERVAL = 2 FEET

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LUKE WASH WATERSHED FDS

CROSSING STRUCTURE LOCATIONS
FOR NO DIKE CONDITIONS

FCD 2007C020
JULY 2008

EXHIBIT
D4.2b

WOOD/PATEL

LAND DEVELOPMENT • WATER RESOURCES
TRANSPORTATION / TRAFFIC
WATER / WASTEWATER • SURVEYING
CONSTRUCTION MANAGEMENT

(602) 335-8500

ID 36

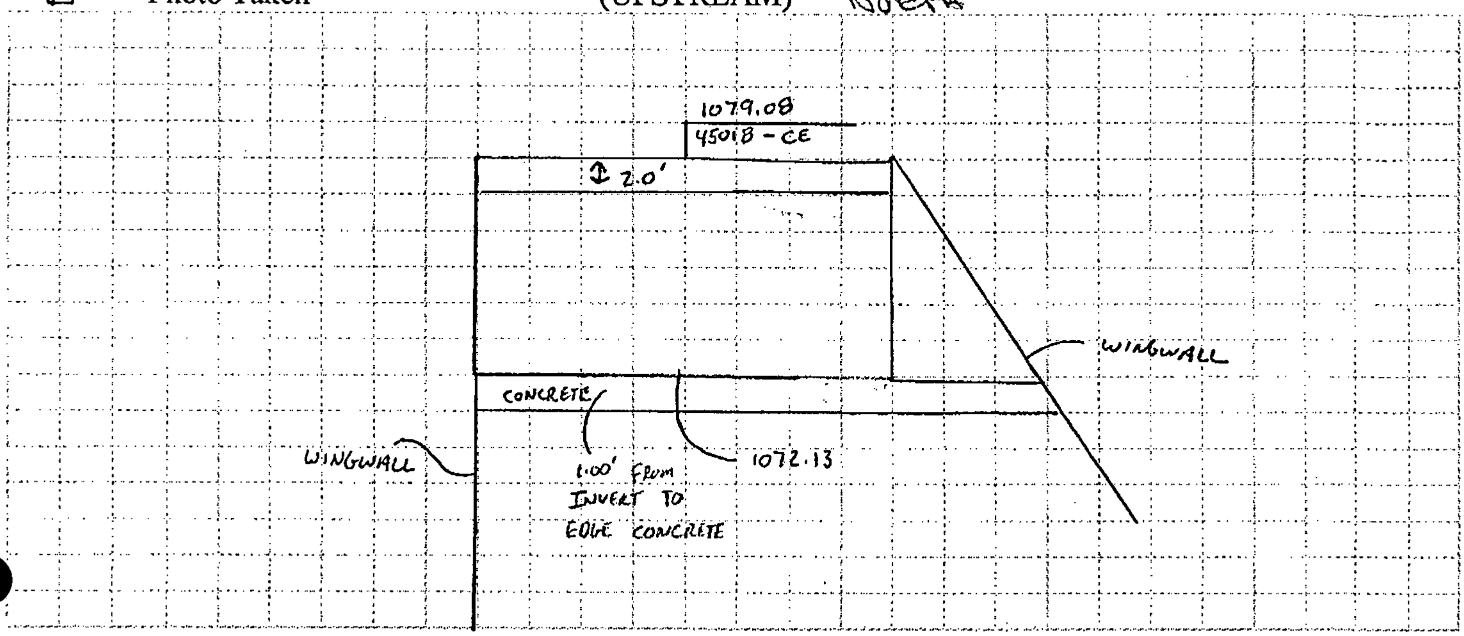
FCDMC Contract 2007C020
Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: BOX CULVERT 10' x 5'   Date: 1-22-2008

File Name: LUKE WASH

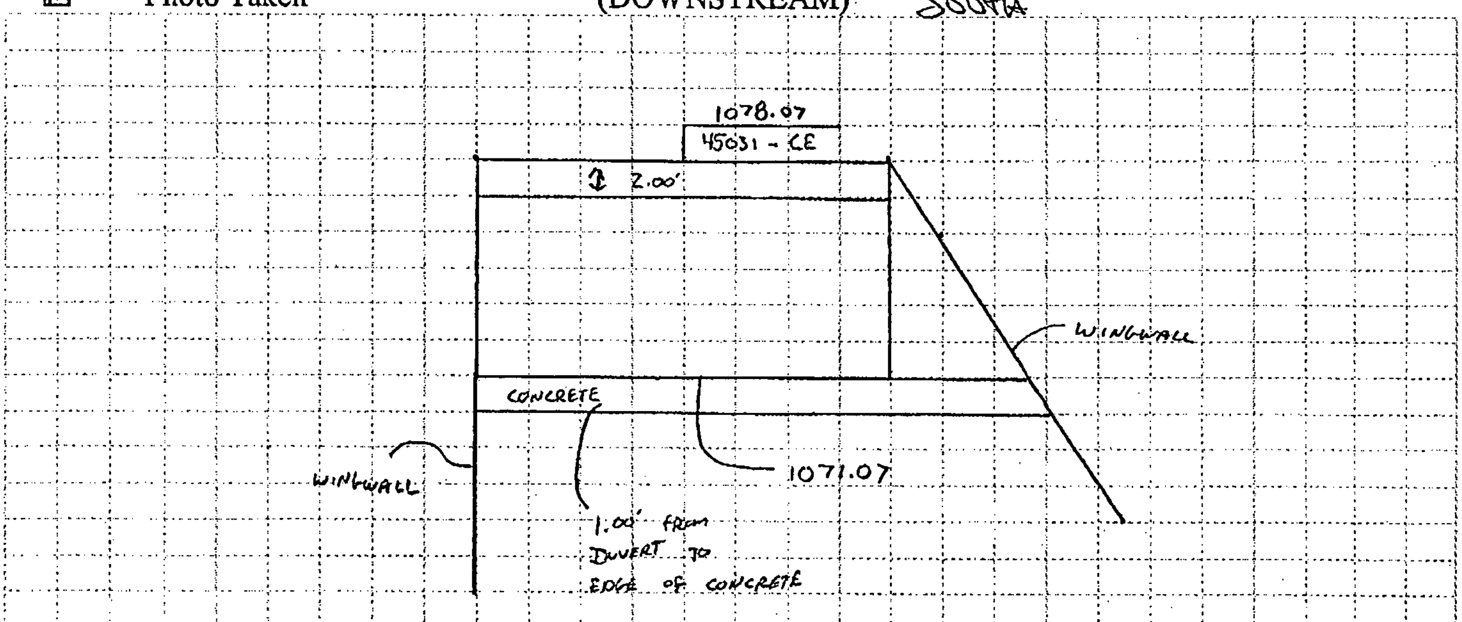
Description Name: I-10 STA. 5402+36   Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure GOOD

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure GOOD

FCDMC Contract 2007C020
Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: 72" CMP

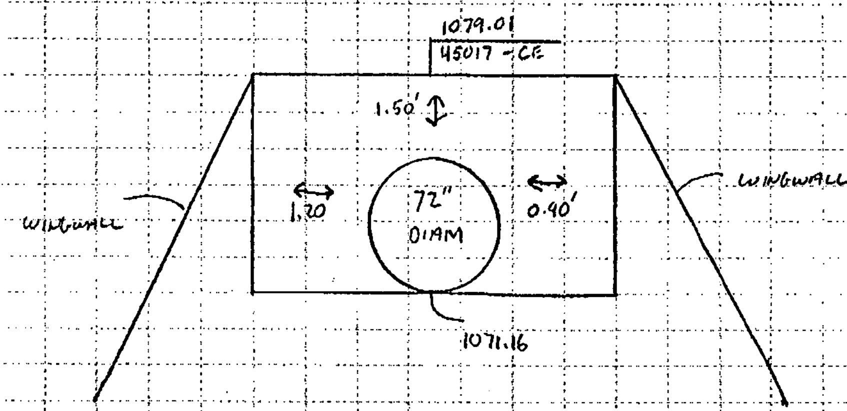
Date: 1-22-2008

File Name: LUKE WASH

Description Name: I-10 STA. 5405+30

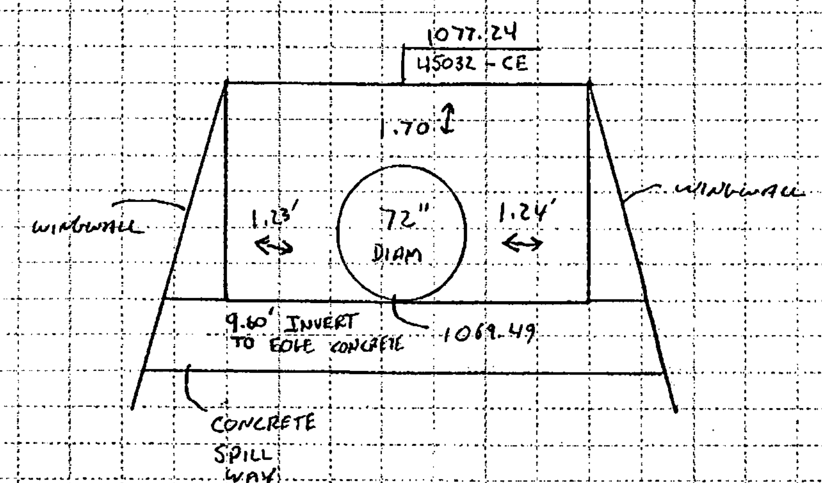
Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure GOOD

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure GOOD

HIDDEN WATERS PARKWAY CORRIDOR STUDY

EXHIBIT 2A

FCDMC Contract 2007C020

Task - Luke Wash Watershed Zone AE Floodplain Delineation Study

Structure Detail Worksheet

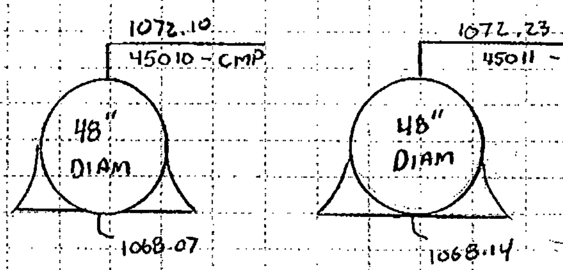
Wood/Patel Project #073087

Type of Structure: 48" CMP   Date: 1-21-2008

File Name: LUKE WASH

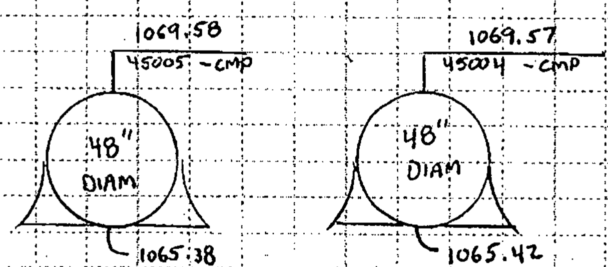
Description Name: I-10 STA. 5470 + 80   Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure GOOD

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure GOOD

E2-15

ID 52

FCDMC Contract 2007C020

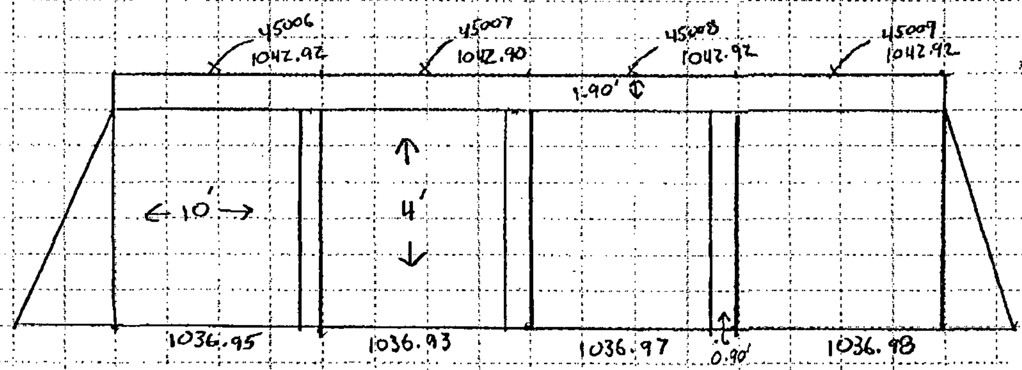
Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: BOX CULVERT Date: 1-21-2008

File Name: LUKE WASH

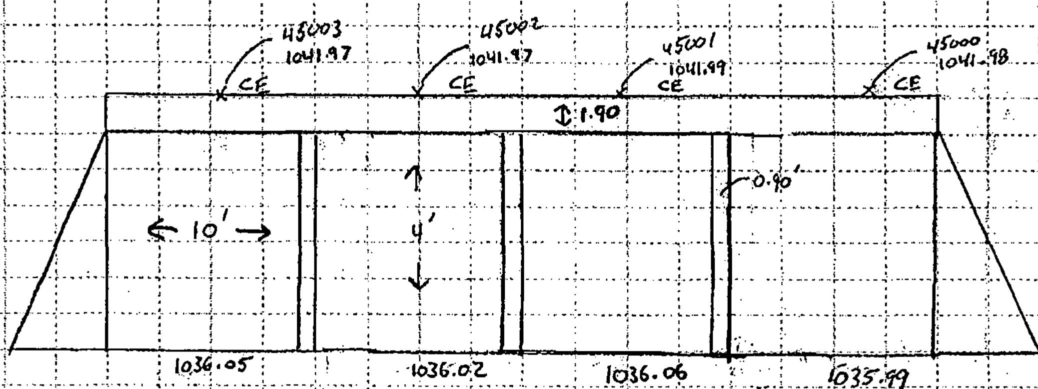
Description Name: T-10 STA. 5504 +40 Party Chief: JEFF LAWIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure GOOD

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure GOOD

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UPR 1

FCDMC Contract 2007C020

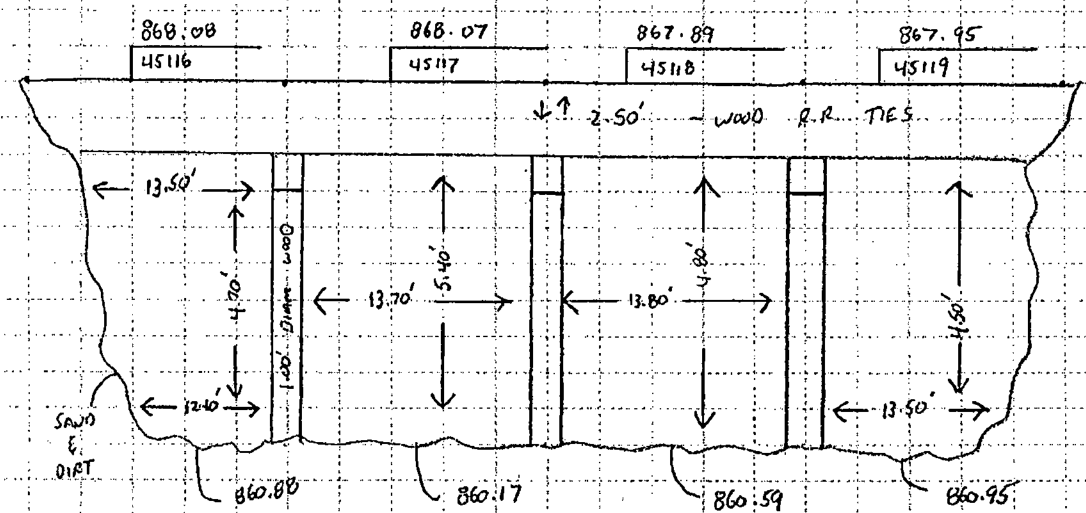
Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: WOOD BRIDGE Date: 2-4-2008

File Name: LUKE WASH

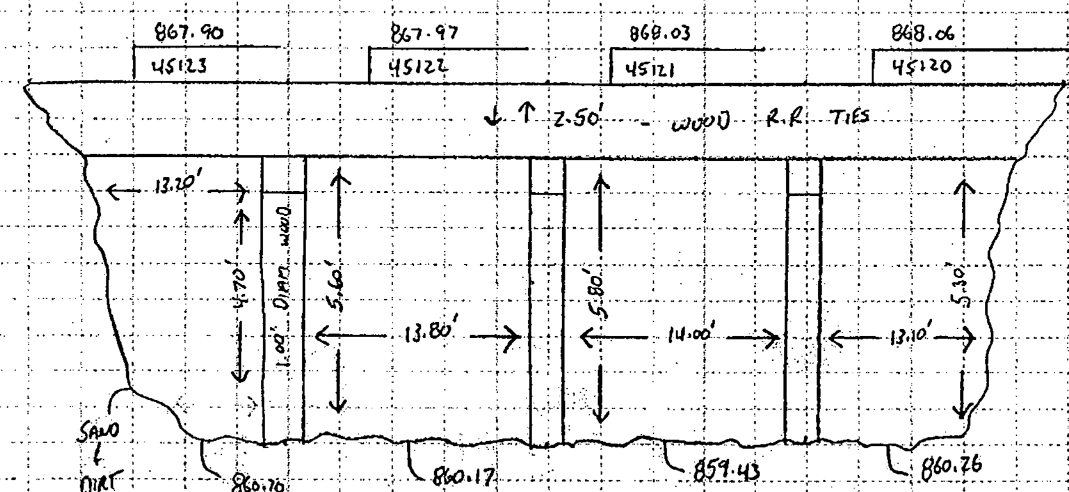
Description Name: UPR BRIDGE # 1 Party Chief: JEFF LAWIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure OK

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure OK

E2-17

UPR 2

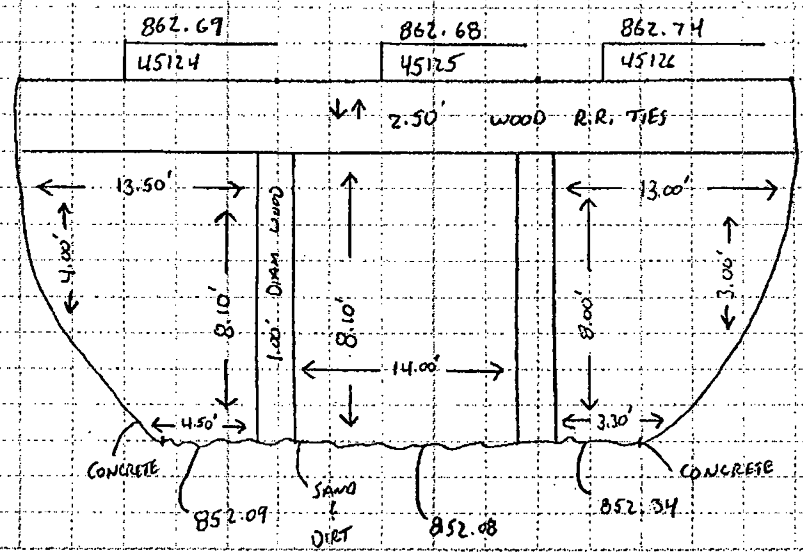
FCDMC Contract 2007C020
Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: WOOD BRIDGE Date: 7-4-2008

File Name: LUKE WASH

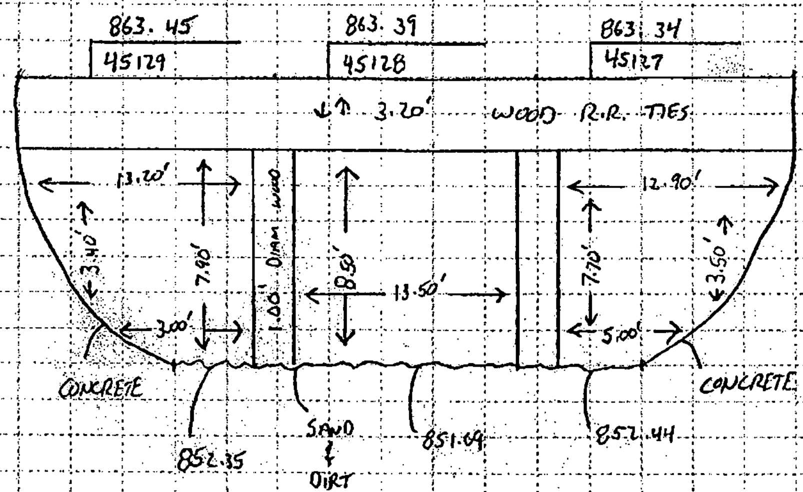
Description Name: UPR BRIDGE # 2 Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure OK

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure OK

UPR 3

FCDMC Contract 2007C020

Task - Luke Wash Watershed Zone AE Floodplain Delineation Study

Structure Detail Worksheet

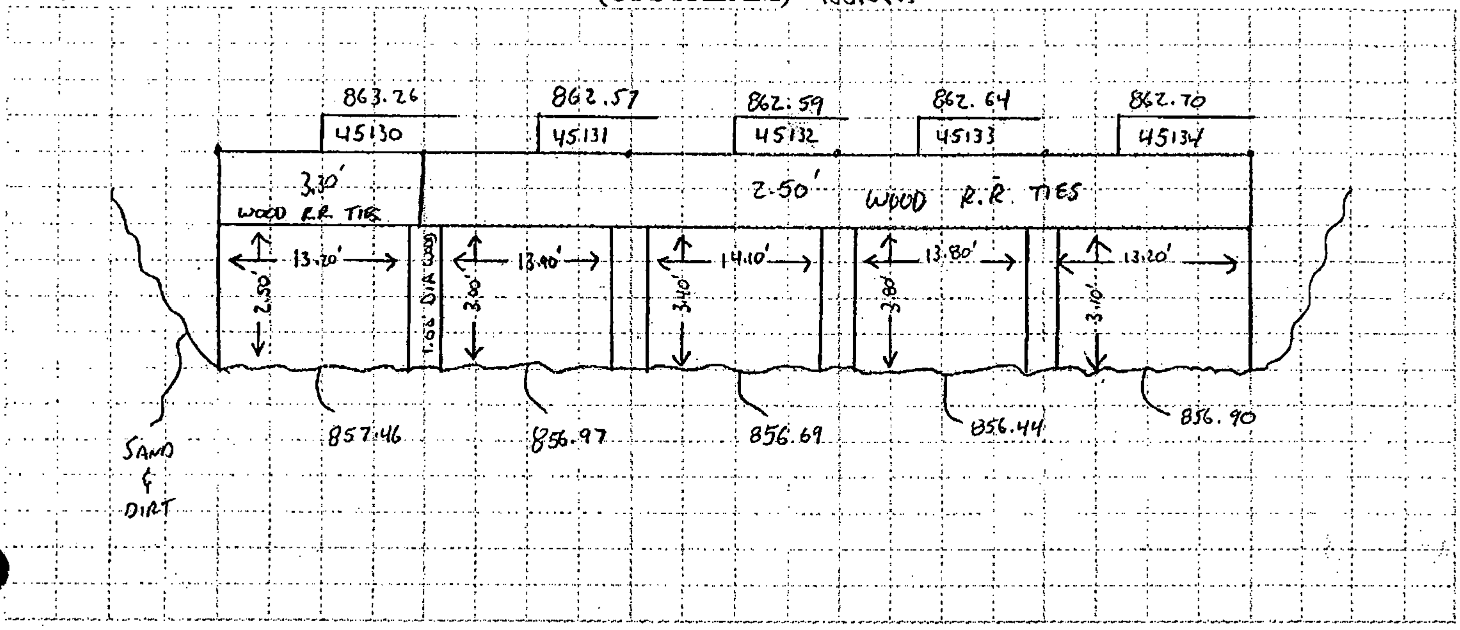
Wood/Patel Project #073087

Type of Structure: WOOD BRIDGE Date: 2-4-2008

File Name: LUKE WASH

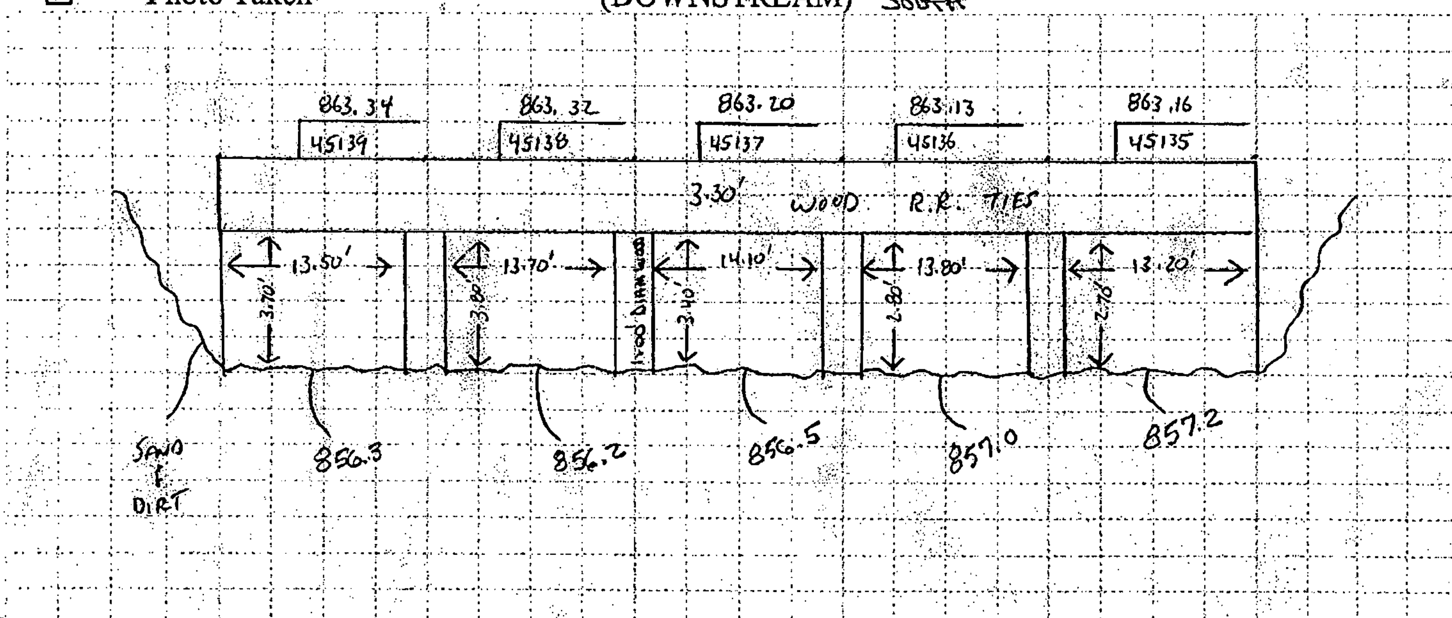
Description Name: UPR # 3 Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure ok

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure ok

E2-19

UPR 4

HIDDEN WATERS PARKWAY CORRIDOR STUDY

FCDMC Contract 2007C020

EXHIBIT 2A

Task - Luke Wash Watershed Zone AE Floodplain Delineation Study
Structure Detail Worksheet
Wood/Patel Project #073087

Type of Structure: WOOD BRIDGE

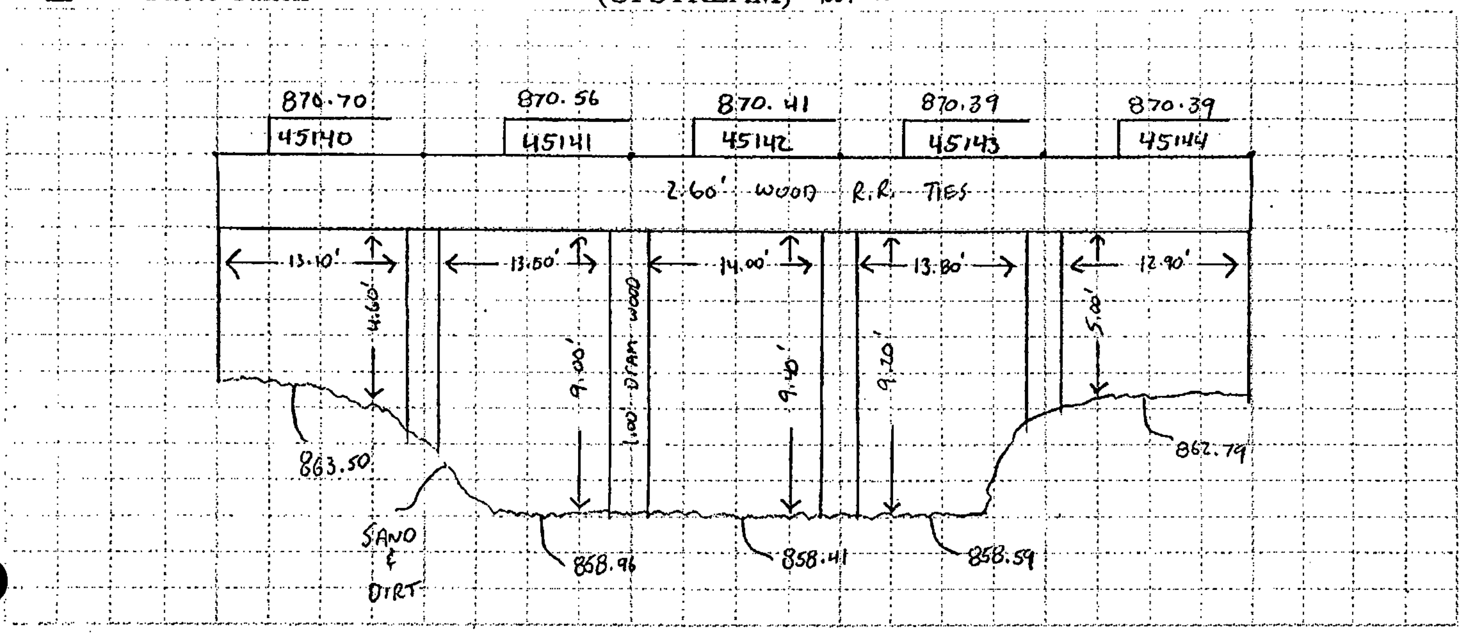
Date: 2-4-2008

File Name: LUKE WASH

Description Name: UPR # 4

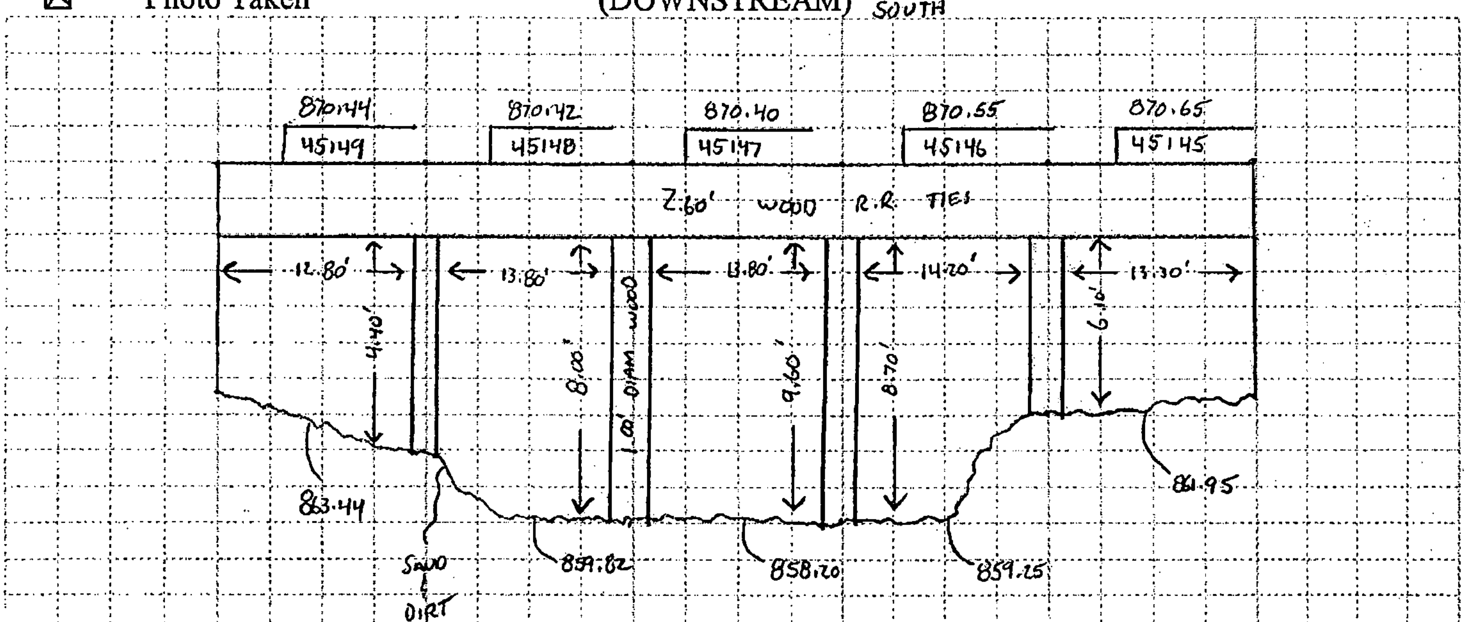
Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure OK

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure OK

E2-20

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UPR 5

FCDMC Contract 2007C020

Task - Luke Wash Watershed Zone AE Floodplain Delineation Study

Structure Detail Worksheet

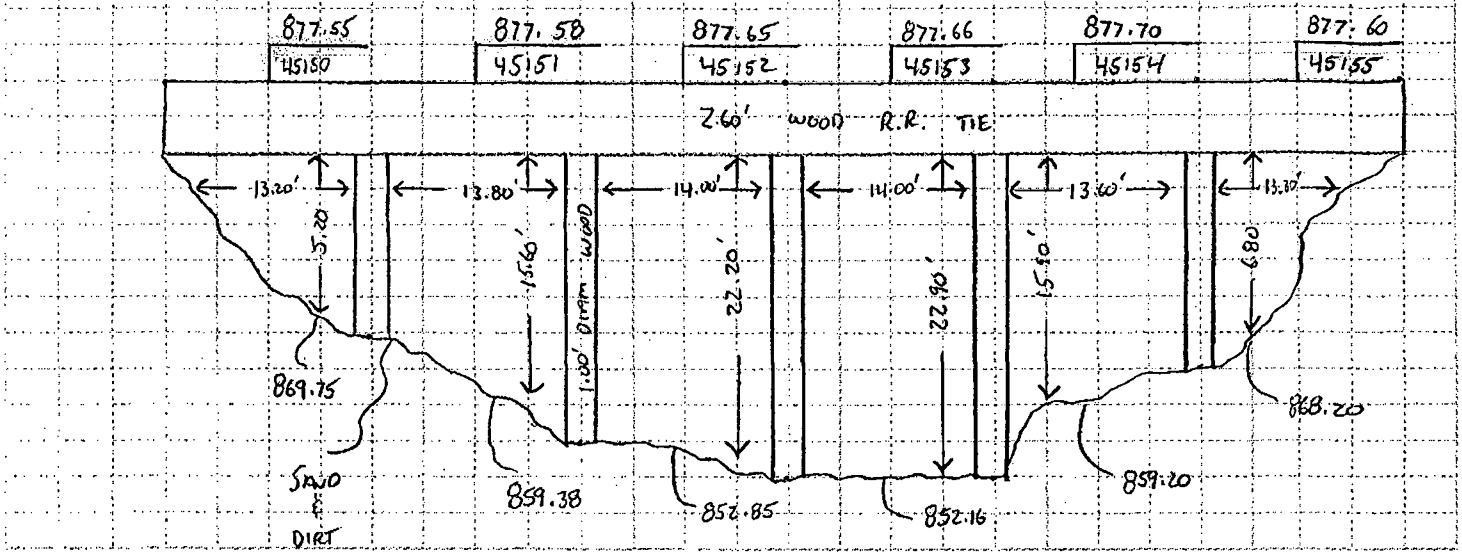
Wood/Patel Project #073087

Type of Structure: WOOD BRIDGE Date: 2-4-2008

File Name: LUKE WASH

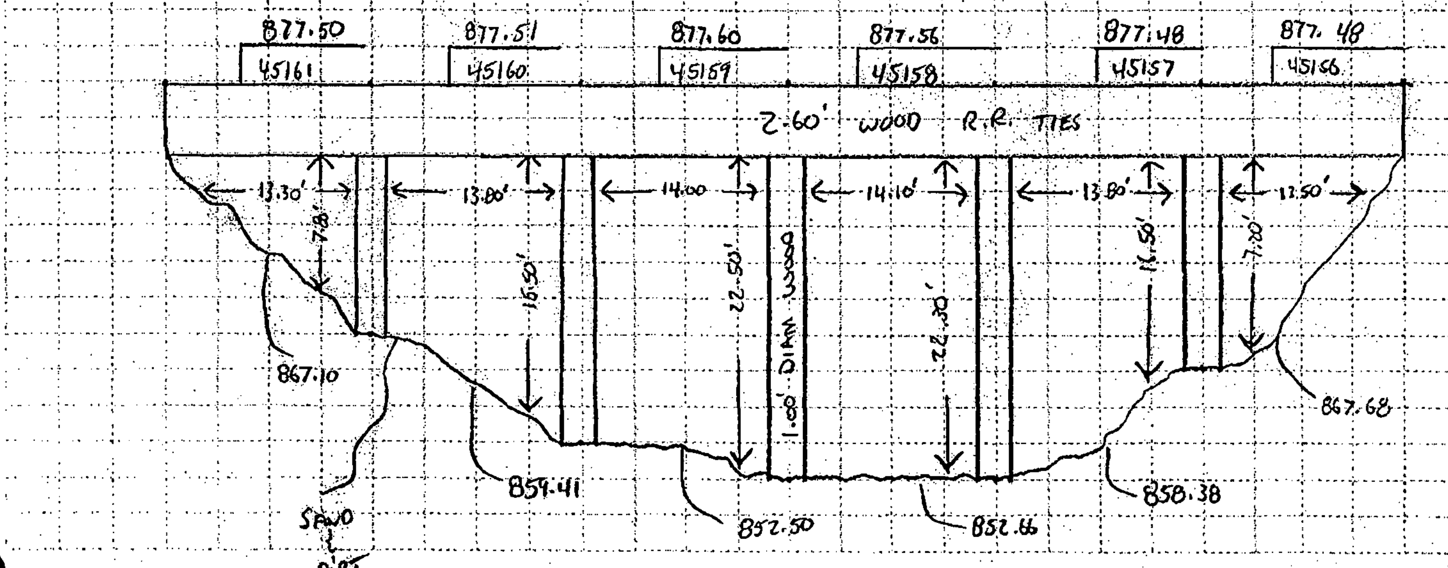
Description Name: UPR BRIDGE # 5 Party Chief: JEFF LALLIER

☒ Photo Taken (UPSTREAM) NORTH



General Condition of Structure OK

☒ Photo Taken (DOWNSTREAM) SOUTH



General Condition of Structure OK

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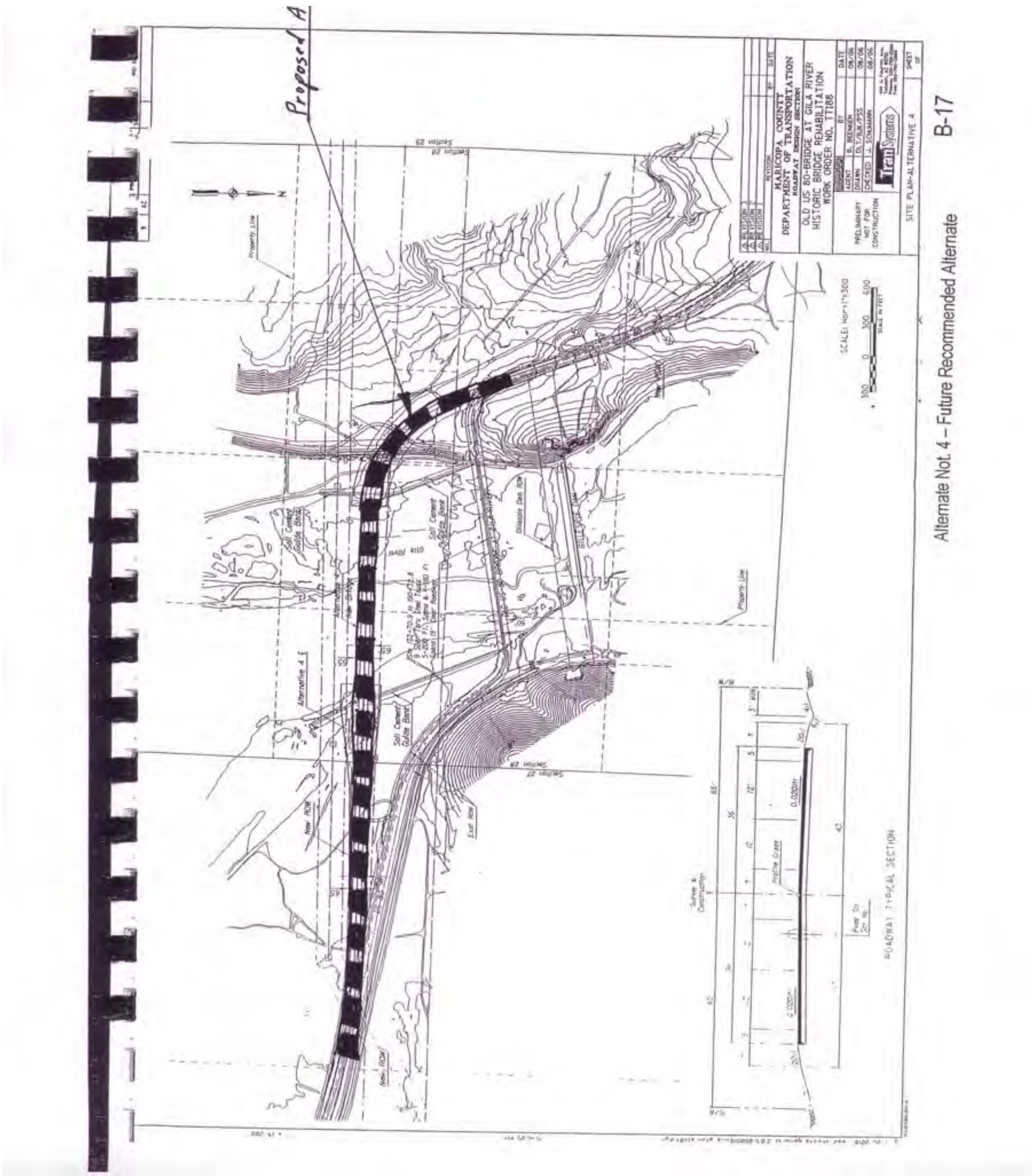
SCALE: 1"-5000'
SIPHON 1 (GILLESPIE)
SIPHON 2 (RUSSEL BADLEY)
SIPHON 3 (RAINBOW)
SIPHON 4 (LAYTON)
LIFT STATION (PALOMA)
SIPHON 5
SIPHON 6 (STIEL #2)
SIPHON 7 (TILLEY 1)
SIPHON 8 (TILLEY 2)
SIPHON 9 (THE NECK)
SIPHON 10 (BUTTERFIELD)
SIPHON 11 (GETZWILLER)
SIPHON 12
GILLESPIE DAM
GILA BEND
LEGEND
STUDY AREA BOUNDRY
MAJOR DRAINAGE BASIN BOUNDRY
MAJOR BASIN
HYDROGRAPH CALCULATION FOR SUBBASIN 8.2
DIVERSION CALCULATION TO SIMULATE FLOW SPLIT
COMBINE HYDROGRAPH OPERATION
HYDROGRAPH ROUTING OPERATION
DIRECTION OF FLOW
FIGURE 3
HEC-1 MODEL SCHEMATIC
GILA BEND CANAL FLOODPLAIN DELINEATION STUDY
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
Donohue ENGINEERS ARCHITECTS SCIENTISTS
Date 8/91

VALUE ANALYSIS PROPOSAL DT-04
Old US 80 Bridge
Gillespie Dam Bridge

May 2008

PROPOSAL DESCRIPTION:	New interim roadway, at-grade, located 1200' +/- downstream of existing bridge

SKETCH OF BASELINE ASSUMPTION

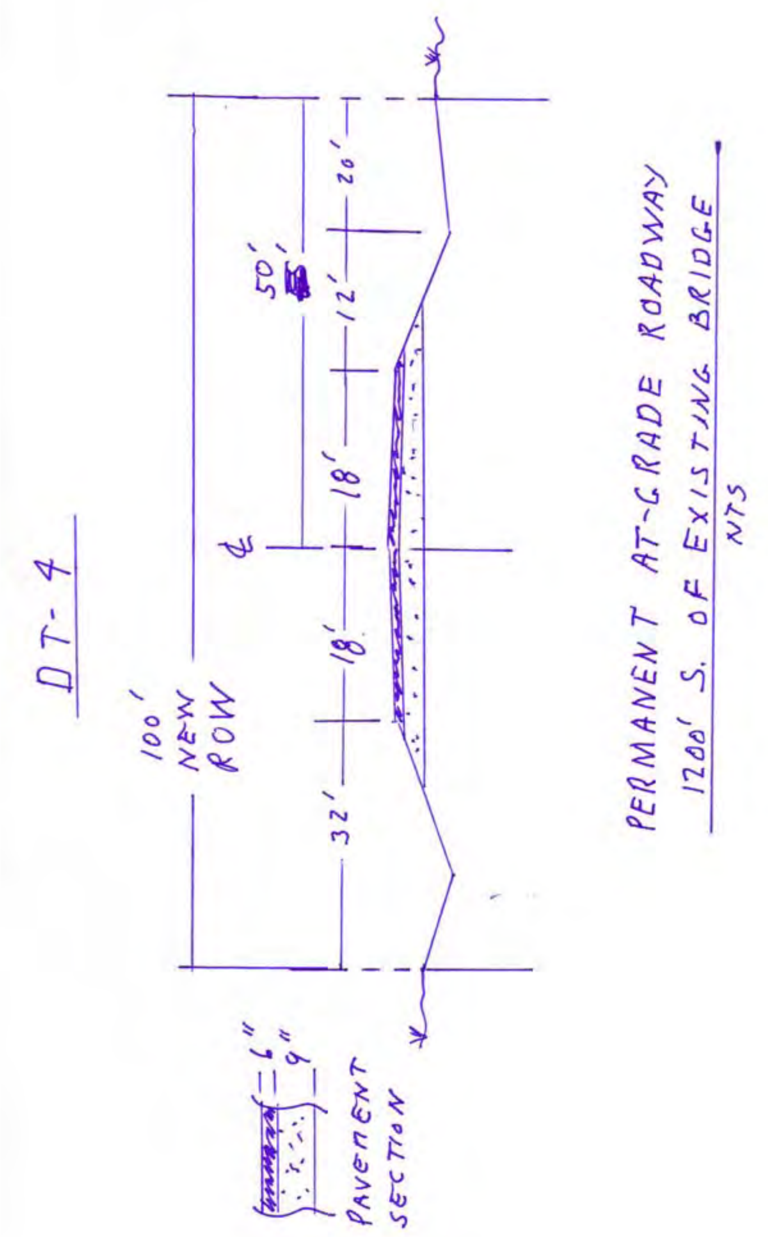


VALUE ANALYSIS PROPOSAL DT-04
Old US 80 Bridge
Gillespie Dam Bridge

May 2008

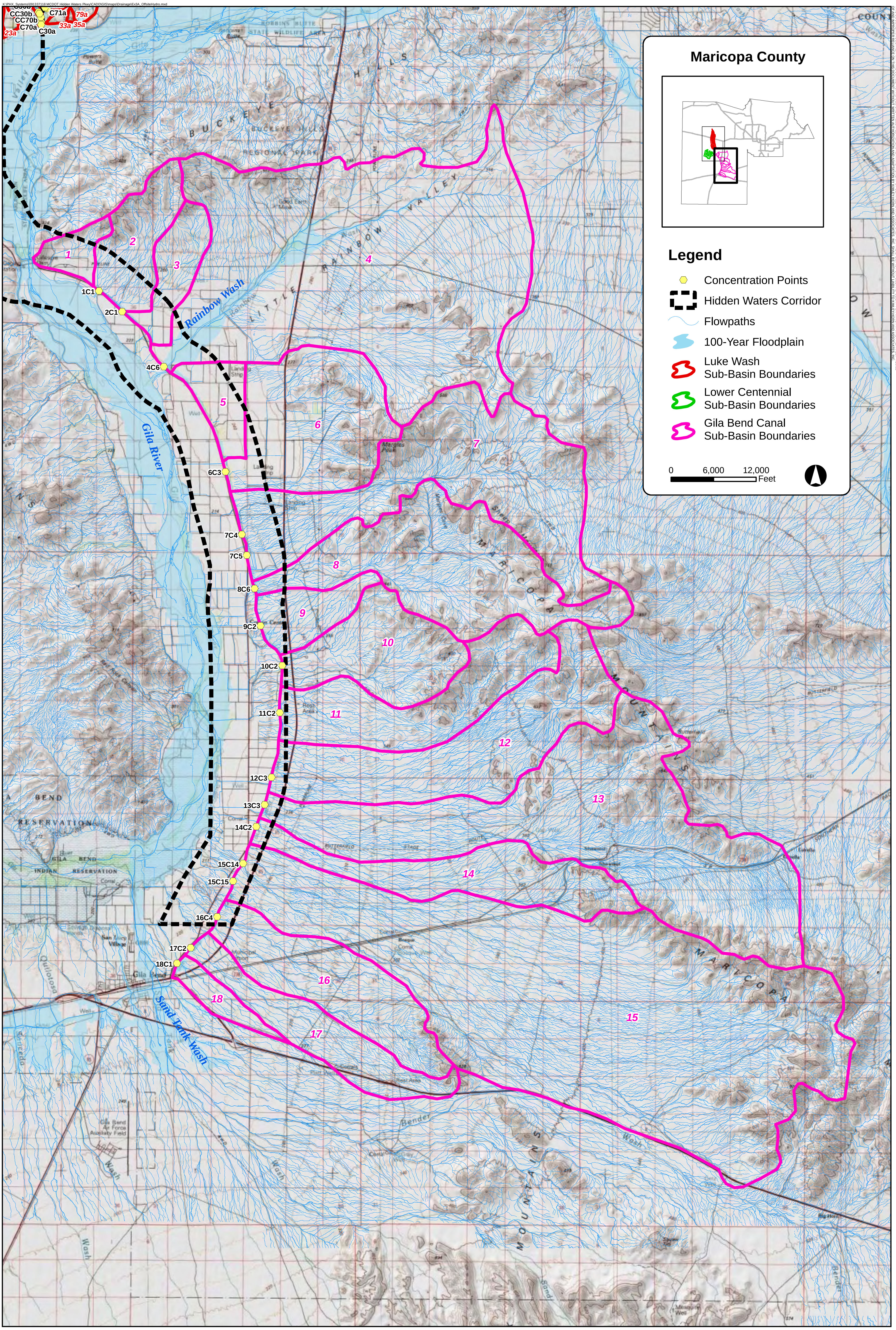
PROPOSAL DESCRIPTION:	New interim roadway, at-grade, located 1200' +/- downstream of existing bridge

SKETCH OF PROPOSED ALTERNATIVE



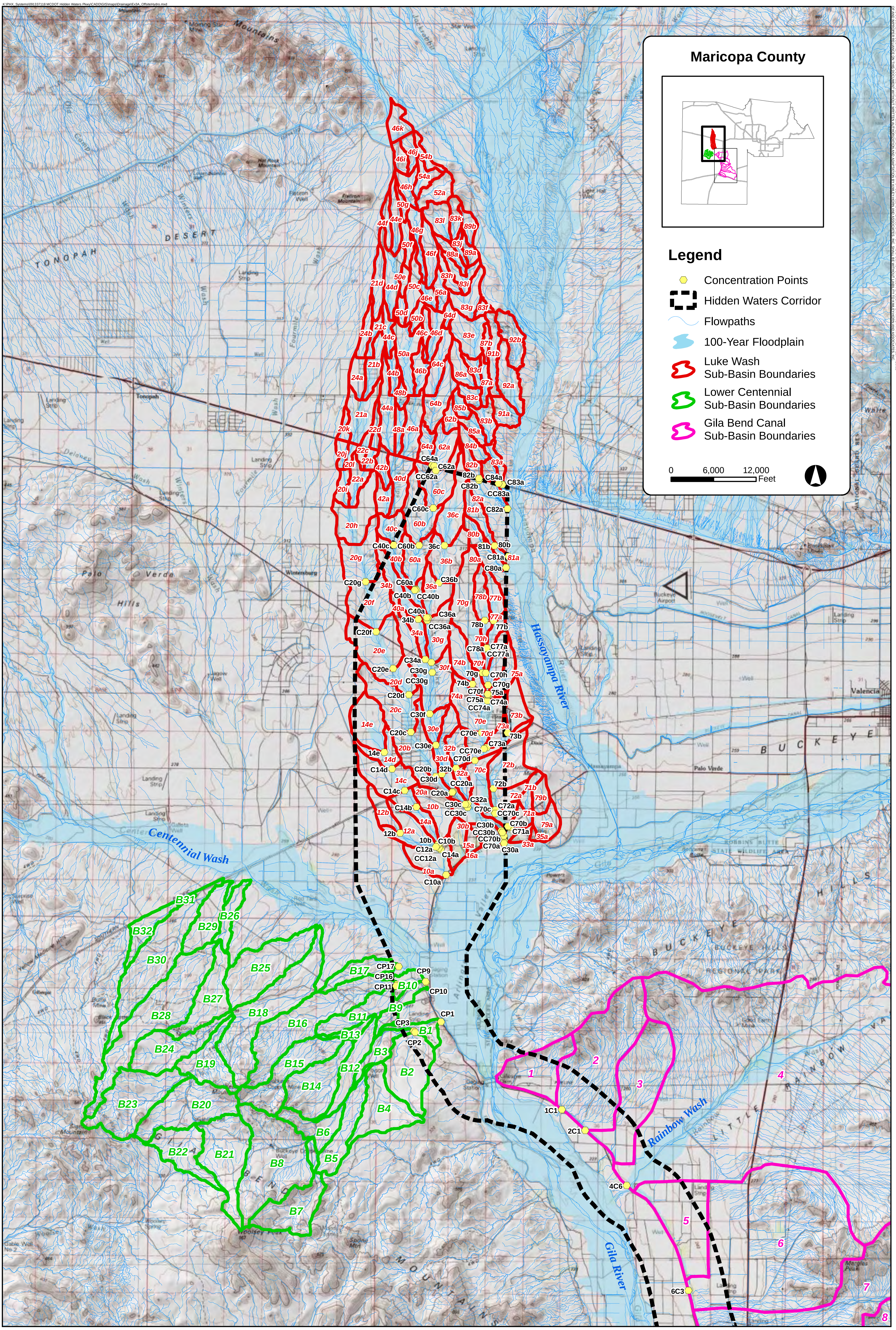
APPENDIX TM3-3

SUPPORTING HYDROLOGIC DOCUMENTATION



PROJECT NO. 091337118	HIDDEN WATERS PARKWAY	SCALE(H): 1"= 12,000'	Kimley-Horn and Associates, Inc.
DRAWING NAME EX3A_OFFSITEHYDRO	CORRIDOR FEASIBILITY STUDY	SCALE(V): NONE	© 2009 KIMLEY-HORN AND ASSOCIATES, INC.
SHEET 1 OF 2	EXHIBIT 3A. OFFSITE HYDROLOGY WORKMAP	DESIGNED BY: BML	Engineering, Planning and Environmental Consultants
		DRAWN BY: JAG	7878 North 16th Street, Suite 300
		CHECKED BY: RAE	Phoenix, Arizona 85020 (602) 944-5500
		DATE: 09/11/09	

K:\PHX_Systems\091337118 MCDOT Hidden Waters Pkwy\CADD\GIS\maps\Drainage\Ex3A_OffsiteHydro.mxd



PROJECT NO. 091337118	DRAWING NAME EX3A_OFFSITEHYDRO	SHEET 2 OF 2

HIDDEN WATERS PARKWAY
CORRIDOR FEASIBILITY STUDY
EXHIBIT 3A. OFFSITE HYDROLOGY WORKMAP

SCALE(H): 1"= 12,000'
SCALE(V): NONE
DESIGNED BY: BML
DRAWN BY: JAG
CHECKED BY: RAE
DATE: 09/11/09

Kimley-Horn and Associates, Inc.

Engineering, Planning and Environmental Consultants

7878 North 16th Street, Suite 300
Phoenix, Arizona 85020 (602) 944-5500

Gila Bend Canal FDS (1991)
Hydrology Results
EXHIBIT 3B

Conc. Point	Drainage Area (mi^2)	Q_{50} * (cfs)	Q_{100} (cfs)	Storm Duration	Notes
1C1	7.31	2,173	2,876	6-HR	
300	3.78	1,819	2,403	6-HR	
4C6	50.49	8,671	11,565	24-HR	Rainbow Wash FIS Q100=11,568 cfs (SLA 1994)
500	3.17	1,218	1,599	24-HR	
6C3	13.74	3,984	5,297	24-HR	
7C4	22.51	2,157	2,854	24-HR	
7C5	0.64	1,306	1,717	6-HR	
8C6	18.39	4,073	5,417	24-HR	
9C2	3.51	1,224	1,607	6-HR	
10C2	9.41	3,675	4,885	24-HR	
11C2	11.43	2,024	2,676	24-HR	
12C3	18.22	2,084	2,757	24-HR	
13C3	36.41	2,513	3,330	24-HR	
14C2	10.2	1,430	1,882	24-HR	
15C14	65.15	3,740	4,971	24-HR	
15C15	1.36	653	843	6-HR	
16C4	11.54	1,989	2,630	6-HR	
17C2	7.59	1,814	2,396	6-HR	
18C1	1.85	993	1,298	6-HR	

Notes: * From local regression, $Q_{50} = 0.7478 * Q_{100} + 22.41$

Gila Bend Canal FDS (1991)
Hydrology Results
EXHIBIT 3B

Conc. Point	Drainage Area (mi^2)	Q_{50} * (cfs)	Q_{100} (cfs)	q (csm)	Storm Duration	Notes
CP1	12.98	4,263	5,671	437	24-HR	
CP2	12.54	4,393	5,845	466	24-HR	
CP3	10.55	4,325	5,754	545	24-HR	
CP9	0.52	489	624	1,200	6-HR	
CP10	10.08	4,253	5,658	561	24-HR	Does not include flow split from B5
CP11	6.30	3,332	4,426	703	24-HR	Does not include flow split from B5
CP16	9.73	4,470	5,947	611	24-HR	
CP17	0.75	618	796	1,061	6-HR	

Notes: * From local regression, $Q_{50} = 0.7478 * Q_{100} + 22.41$

Gila Bend Canal FDS (1991)
Hydrology Results
EXHIBIT 3B

Conc. Point	Drainage Area (mi^2)	Q_{50} * (cfs)	Q_{100} (cfs)	q (csm)	Time to Peak (hr)	Max Flow Model
C70a	54.17	2,966	3937	73	15.67	EC24NODK
C30b	42.91	2,444	3238	75	16.75	EC24NODK
C73a	1.11	502	641	577	5.00	EC06DIKE
C60c	3.87	1,021	1336	345	12.75	EC24NODK
C82a	1.42	632	815	574	4.58	EC06NODK
C83a	6.74	1,008	1318	196	14.17	EC24DIKE
CC83a	7.31	1,020	1334	182	14.17	EC24DIKE
75a	0.46	363	455	989	4.58	EC06NODK
C10b	5.46	1,471	1937	355	12.92	EC24NODK
10b	0.86	562	721	838	4.58	EC06NODK
C82b	0.83	459	584	704	4.67	EC06NODK
C74a	0.97	433	549	566	4.92	EC06NODK
CC30g	24.96	1,923	2541	102	14.50	EC24NODK
C10a	6.30	1,434	1887	300	13.42	EC24NODK
CC30c	42.41	2,465	3266	77	16.08	EC24NODK
C32a	0.76	440	559	736	4.75	EC06NODK
C30c	41.64	2,465	3266	78	16.08	EC24NODK
CC12a	4.61	1,250	1642	356	5.17	EC06NODK
C14a	3.33	945	1234	371	5.50	EC06NODK
C12a	1.28	711	921	720	4.83	EC06NODK
12b	0.45	420	532	1182	4.50	EC06NODK
C14b	2.96	980	1281	433	5.00	EC06NODK
C14c	2.70	1,007	1316	487	4.75	EC06NODK
C14d	1.61	789	1025	637	4.75	EC06NODK
73b	0.61	490	625	1025	4.50	EC06NODK
C70e	6.44	1,255	1648	256	13.50	EC24NODK
C20c	12.13	927	1209	100	13.83	EC24DIKE
CC74a	5.07	1,236	1623	320	13.08	EC24NODK
C75a	4.09	1,038	1358	332	5.33	EC06NODK
C70f	3.63	1,004	1312	361	5.42	EC06NODK
C20f	8.55	850	1107	129	14.00	EC24DIKE
C20g	7.21	874	1139	158	13.08	EC24DIKE
C36b	2.14	698	904	422	4.67	EC06NODK
C60a	5.75	1,149	1507	262	13.58	EC24NODK
CC40b	19.95	1,700	2244	112	15.75	EC24NODK
C40b	14.20	1,573	2074	146	16.00	EC24NODK
C60b	4.98	1,197	1571	315	13.08	EC24NODK
C40c	13.79	1,598	2107	153	15.58	EC24NODK
C64a	1.99	629	811	408	5.00	EC06NODK

Gila Bend Canal FDS (1991)
Hydrology Results
EXHIBIT 3B

Conc. Point	Drainage Area (mi^2)	Q_{50} * (cfs)	Q_{100} (cfs)	q (csm)	Time to Peak (hr)	Max Flow Model
C62a	0.83	514	657	792	4.50	EC06NODK
CC62a	2.83	793	1031	364	4.83	EC06NODK
82b	0.26	298	368	1415	4.33	EC06NODK
C84a	0.57	308	382	670	4.58	EC06NODK
36c	1.09	547	702	644	4.75	EC06NODK
80b	0.28	325	404	1443	4.33	EC06NODK
81b	0.51	393	495	971	4.50	EC06NODK
C81a	0.59	370	465	788	4.67	EC06NODK
C80a	0.62	484	617	995	4.50	EC06NODK
77b	0.44	421	533	1211	4.42	EC06NODK
78b	0.48	458	582	1213	4.42	EC06NODK
34b	0.63	378	476	756	4.67	EC06NODK
CC36a	23.04	1,879	2483	108	14.00	EC24NODK
C36a	2.82	803	1044	370	4.83	EC06NODK
C40a	20.22	1,695	2237	111	16.08	EC24NODK
CC77a	1.32	656	847	642	4.83	EC06NODK
C77a	0.69	382	481	697	4.75	EC06NODK
C78a	0.63	388	489	776	4.83	EC06NODK
74b	0.67	481	613	915	4.50	EC06NODK
C70g	3.24	1,047	1370	423	5.08	EC06NODK
70g	1.63	629	811	498	5.00	EC06NODK
C30g	23.89	1,850	2444	102	14.58	EC24NODK
C34a	1.08	363	455	421	5.42	EC06DIKE
C20d	10.71	901	1175	110	13.17	EC24DIKE
C30f	26.74	1,896	2505	94	15.00	EC24NODK
CC20a	41.40	2,472	3276	79	15.83	EC24NODK
C20a	41.40	2,423	3210	78	16.33	EC24UPRR
72b	1.05	709	918	874	4.42	EC06DIKE
C30a	54.21	2,966	3937	73	15.67	EC24NODK
CC70b	54.07	2,973	3946	73	15.50	EC24NODK
CC30b	53.52	2,973	3946	74	15.50	EC24NODK
C71a	0.55	289	357	649	4.25	EC06NODK
C70b	10.61	1,439	1895	179	14.50	EC24NODK
C70c	8.78	1,404	1847	210	14.33	EC24DIKE
C72a	1.49	628	810	544	4.75	EC06DIKE
CC70c	10.27	1,454	1915	186	14.25	EC24DIKE
C20b	13.27	894	1165	88	14.75	EC24I-10
C30d	27.75	1,866	2465	89	15.75	EC24NODK
32b	0.48	520	665	1385	4.33	EC06NODK

Gila Bend Canal FDS (1991)
Hydrology Results
EXHIBIT 3B

Conc. Point	Drainage Area (mi^2)	Q_{50} * (cfs)	Q_{100} (cfs)	q (csm)	Time to Peak (hr)	Max Flow Model
C70d	8.04	1,437	1892	235	13.58	EC24DIKE
CC70e	7.56	1,444	1901	251	13.42	EC24DIKE
C20e	10.09	923	1204	119	13.00	EC24NODK
C30e	27.14	1,880	2484	92	15.42	EC24NODK
14e	1.10	722	936	851	4.50	EC06NODK
C70h	1.61	606	780	484	5.17	EC06NODK

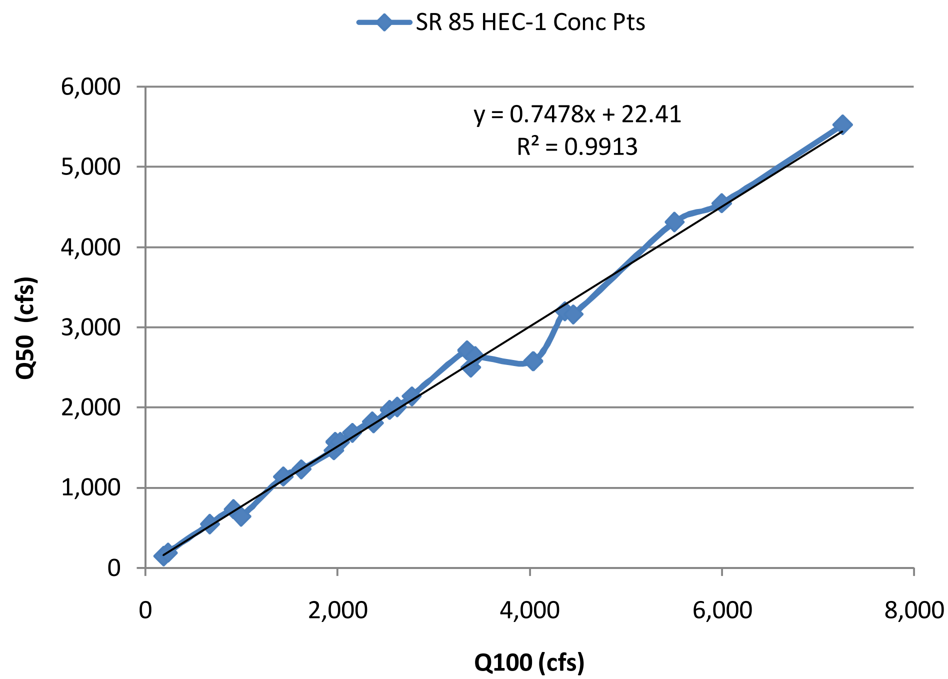
Notes: * From local regression, $Q_{50} = 0.7478 * Q_{100} + 22.41$

EXHIBIT 3C. Derivation of Local Q50 vs Q100 Regression Equation

SR 85 Initial Drainage Report (1999) Flow Comparisons

Conc. Point	Analysis Method	Drainage Area (mi^2)	Q_{100} (cfs)	Q_{50} (cfs)	Storm Duration	Q_{50}/Q_{100}
10.2-A2	HEC-1	0.30	186	148		0.80
7.5-H	HEC-1	0.34	231	189		0.82
405	HEC-1	0.53	668	545	6-HR	0.82
15.20	HEC-1	1.09	914	733	6-HR	0.80
16C2	HEC-1	5.97	994	639	6-HR	0.64
1801	HEC-1	1.64	1,431	1,138	6-HR	0.80
408	HEC-1	6.47	1,619	1,229	6-HR	0.76
15C12	HEC-1	27.40	1,957	1,465	24-HR	0.75
9C1	HEC-1	4.83	1,973	1,571	6-HR	0.80
14C1	HEC-1	9.92	2,021	1,570	24-HR	0.78
404	HEC-1	3.87	2,149	1,685	6-HR	0.78
603	HEC-1	2.28	2,356	1,824	6-HR	0.77
16C3	HEC-1	5.05	2,371	1,803	6-HR	0.76
601	HEC-1	3.68	2,539	1,970	6-HR	0.78
1701	HEC-1	7.09	2,614	2,007	24-HR	0.77
411	HEC-1	6.03	2,767	2,139	6-HR	0.77
606	HEC-1	3.64	3,345	2,712	6-HR	0.81
13C2	HEC-1	36.11	3,383	2,498	24-HR	0.74
12C2	HEC-1	17.61	3,427	2,636	24-HR	0.77
15C13	HEC-1	37.41	4,032	2,576	24-HR	0.64
CD5	HEC-1	20.41	4,360	3,200	24-HR	0.73
11C1	HEC-1	10.84	4,451	3,159	24-HR	0.71
10C1	HEC-1	9.12	5,503	4,311	24-HR	0.78
8C5	HEC-1	4.76	5,994	4,544	24-HR	0.76
4C2	HEC-1	16.93	7,252	5,523	24-HR	0.76
AVERAGE						0.76

For studies with Q100 values but no Q50 results, recommend regression:
$Q_{50} = 0.7478 * Q_{100} + 22.41$ (cfs)



Check against Precipitation Comparisons

Storm Duration (hrs)	50-Yr Precipitation (in)	100-Yr Precipitation (in)	P_{50}/P_{100}	Study
6	3.10	3.45	0.90	SR 85 Initial Drainage Report
24	3.70	4.20	0.88	SR 85 Initial Drainage Report
6	2.57	2.91	0.88	Luke Wash FDS
24	3.26	3.69	0.88	Luke Wash FDS