Flood Control District of Maricopa County

Area Drainage Master Plan

Aguila

February 2004

Aguila

AREA DRAINAGE MASTER PLAN

February 2004

Prepared for the
Flood Control District of Maricopa County

Prepared by
HDR Engineering, Inc.

ACKNOWLEDGEMENTS

Maricopa County Board of Supervisors

District 1, Fulton Brock
District 2, Don Stapley, Chairman
District 3, Andrew Kunasek
District 4, Max Wilson
District 5, Mary Rose Wilcox

Flood Control District of Maricopa County

Michael S. Ellegood, P.E., Chief Engineer and General Manager
Valerie Swick, CFM, Project Manager

TABLE OF CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION

The Flood Control District of Maricopa County (District or the District) is charged with floodplain management and water resource responsibilities. This responsibility to the public includes efforts to prevent loss of life and reduce the potential for property damage from flooding. The District endeavors to reduce the risks of flood loss; minimize the impacts of floods on human safety, health, and welfare; and, restore and preserve the natural and beneficial values served by floodplains.

Aguila is an unincorporated farming community 76 miles northwest of Phoenix in the northwest corner of Maricopa County. The community of Aguila has experienced several significant flooding events in recent years. The community experiences flooding from three different directions: Grass Wash from the southeast, Centennial Wash from the northeast, and the Aguila Farm Channel watershed from the east, across State Route 71. The heart of the community is located in the flow path of these three major washes, so most flows that cannot be contained within the natural channels eventually inundate residential and commercial properties.

PURPOSE

The purpose of the Aguila Area Drainage Master Plan (ADMP) was to identify the flooding problem areas in the Aguila Study Area and to develop alternative solutions that could mitigate flooding. The ADMP also included Special Flood Hazard Area Zone A floodplain delineation and SFHA Zone AE (or other detailed delineation).

HYDROLOGIC ANALYSIS

A floodplain delineation was completed as part of Phase I of this study. The Hydrology Report, included in Section 4 the Technical Data Notebook, includes detailed information on the procedure, methodology, results, and discussions of the Hydrologic Analysis. The delineation identified additional areas of flood hazard within Aguila.

ALTERNATIVE FORMULATION AND ANALYSIS

The Alternative Formulation Process for the Aguila ADMP and floodplain delineation was designed to develop a range of conceptual alternatives that would help solve the flooding problems within the Study Area and meet the community's needs for public safety and flood protection.

The recommended conceptual alternatives were categorized into four decision trees. Each tree led to a series of alternatives that were discussed and discarded, left for additional research, or accepted for further analysis, based on general feedback from the District regarding funding, feasibility, and other issues.

During Alternative Formulation, the District identified three possible additional structural solutions for further analysis. In addition, modifying Eagle Eye Road at Aguila Farm Channel, either stop log gates or a lowered dip section, was analyzed as a small, local flood control solution. Non-structural solutions were researched and include: buy-out programs, flood proofing, land trades,

special district or zones and maintenance partnering.

PREFERRED ALTERNATIVE

Non-structural and unique solutions became the main focus of this study. It became clear that large, regional structural solutions would still not completely eliminate flooding potential and would be prohibitively expensive. The preferred alternative for the Aguila ADMP is a non-regional structural and public education solution. The Preferred Alternative is a combination of:

- A Flood Response Plan.
- Public Education.
- A flood delineation study that identified additional areas of flood hazard.
- Further analysis of non-structural solutions.
- Modifications to Eagle Eye Road at Aguila Farm Channel - either stop log gates or a lowered dip section.

The projected cost will be $518,800.

Implementing the Preferred Alternative will require the coordination and assistance of several agencies including the Flood Control District of Maricopa County, the County Emergency Management Department, the Maricopa County Sheriff Department, the Aguila Volunteer Fire Department, the Aguila Irrigation District, and the residents of Aguila.

PART I. INTRODUCTION

PROJECT NEED

The large contributing watershed of Centennial Wash, the Aguila Farm Channel watershed, and the Grass Wash watershed all converge at the heart of the Aguila community, creating a major threat during storm events (see Figure 1-1). Evaluation of the existing mapped drainages and additional unmapped washes was needed to develop a plan that would serve local residents, floodplain managers, developers, and all interested parties as a basis for incorporating the flood control needs of Aguila in their future projects.

PROJECT PURPOSE

The Flood Control District of Maricopa County (District or the District) is charged with floodplain management and water resource responsibilities. This responsibility to the public includes efforts to prevent loss of life and reduce the potential for property damage from flooding. The District endeavors to reduce the risks of flood loss; minimize the impacts of floods on human safety, health, and welfare; and restore and preserve the natural and beneficial values served by floodplains.

The purpose of the Aguila Area Drainage Master Plan (ADMP) was to identify the flooding problem areas and to develop cost-effective alternative solutions that would mitigate flooding in the Aguila area. The ADMP includes Special Flood Hazard Area (SFHA) Zone A (approximate methods)

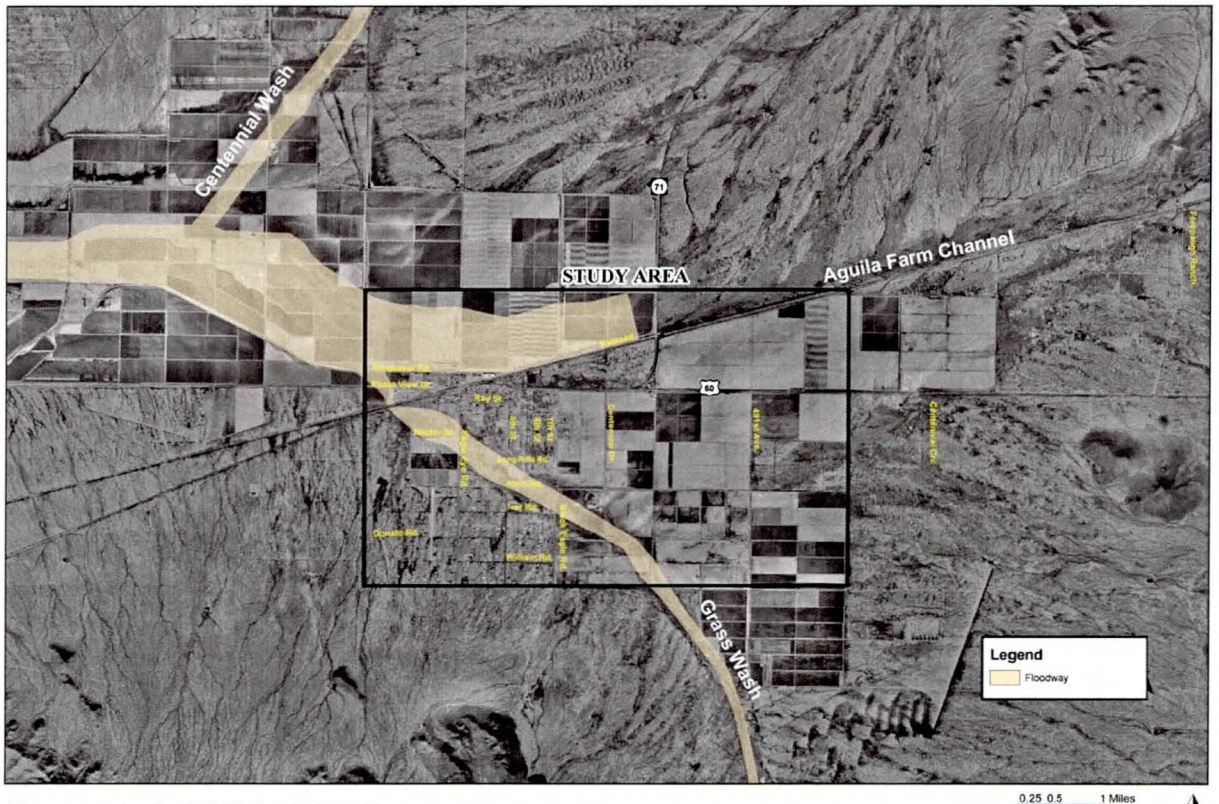


Figure 1-1: Aguila ADMP Study Area Map

floodplain delineation and SFHA Zone AE (or other detailed delineation). Topographic mapping provided by the District was supplemented by surveying to define culvert crossings, railroad elevations, and other features for use in the hydrologic and hydraulic modeling.

The Aguila ADMP had two major components: a floodplain delineation (the mapping component) and a drainage planning component (the ADMP). The purpose of the floodplain delineation component was to define Federal Emergency Management Agency (FEMA) designated special flood hazard areas, prevent hazards to life and health from flooding, reduce or eliminate flood damage to property, prevent disruption of normal activities by flooding, and regulate the use of floodprone lands by mapping out those areas that are susceptible to inundation. The ADMP component identifies flooding problems without consideration of political boundaries and develops a plan that eliminates or minimizes these problems.

The Aguila floodplain delineation:

- Identified problem areas.
- Included community involvement.
- Determined hydraulic conditions associated with a 100-year peak flood in the area.
- Mapped areas currently outside the existing FEMA floodplain.

The Aguila ADMP:

- Identified and evaluated existing regional and neighborhood drainage problems using "state-of-the-art" engineering techniques.
- Considered neighborhood character and community recreational needs.
- Evaluated archaeological, biological, and other environmental factors.
- Identified possible structural and non-structural flooding solutions to provide maximum community benefit.
- Involved the community in the development of the plan.

This study identified conceptual flood control/management alternatives for the Aguila community to reduce potential property damages and loss of life due to runoff from storm events. Concepts developed throughout this study can be implemented in combination with other projects, individually, or not at all, based on scheduling, funding, and partnering opportunities.

PROJECT OVERVIEW

The Aguila community has experienced various significant flooding events in recent years. Because of their location, the areas that suffer the most from flood damages during storm events are the residential and commercial zones.

The core of the community (on US 60 between Black Eagle Road and Eagle Eye Road) experiences flooding from three different directions: Grass Wash from the southeast, Centennial Wash from the northeast, and the Aguila Farm Channel watershed from the east across State Route 71 (SR 71). The heart of the community is located in the flow path of these three major washes, so most runoff that cannot be contained within the natural channels eventually inundates residential and commercial properties.

Other contributing factors for flood damage include changes throughout the watershed

such as modification to or obstruction of natural flow patterns upstream and lack of proper conveyance of floodwaters through the community. Many of the floodprone residences are pre-manufactured or mobile home type structures, structures built at-grade, or structures that have been built as additions to a primary structure and may not have been elevated sufficiently when originally constructed.

The scope of this ADMP was completed in two phases. Phase I included floodplain delineation, public information and coordination, hydrology, hydraulics, identification of flooding problems, and formulation of conceptual alternatives. Phase II included the analyses of alternatives, recommendations of a preferred alternative, and preparation of implementation plans for recommended concepts.

Project Location

Aguila, Arizona is an unincorporated farming community 76 miles northwest of Phoenix, in the northwest corner of Maricopa County (Figure 1-2).

The Aguila ADMP Study Area (Study Area) is generally an area bounded by Pete Road on the south, a mile west of Eagle Eye Road on the west, a mile north of US 60 on the north and a mile east of 491st Avenue on the east.

History

Beginning with the aftermath of Hurricane Nora on September 25, 1997, and followed by a series of storms on August 29 and October 21 and 27, 2000, the past six years have been very damaging for the community's infrastructure and its residents (see Figures 1-3 and 1-4). According to

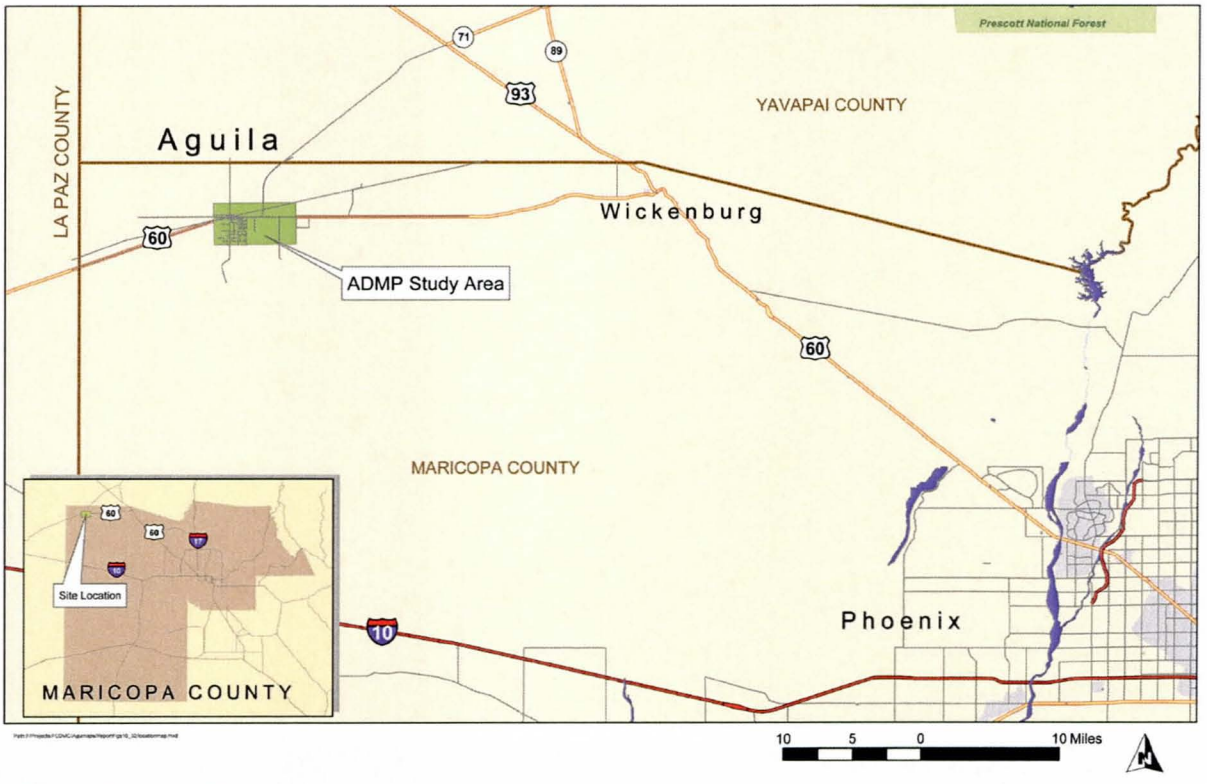


Figure 1-2: Aguila ADMP Location Map

the District, during the events of October 2000, Centennial Wash at Wenden, Arizona (downstream of Aguila) had a discharge greater than the 100-year event (FCDMC, rev. Feb. 2001). The same source rated Sols Wash (northeast of Aguila) as having had a greater than 100-year precipitation event for the 12-hour storm.

As a result of the 2000 storms, the District, through FEMA's Hazard Mitigation Grant Program, purchased and relocated six residences that were originally in the floodplain. In order to reduce or prevent repetitive losses due to floods in the future, the Aguila ADMP was initiated. This study looked at possible alternatives for flood control to protect the residents of Aguila

Figure 1-3: 1997 Storm; First Street, south of US 60

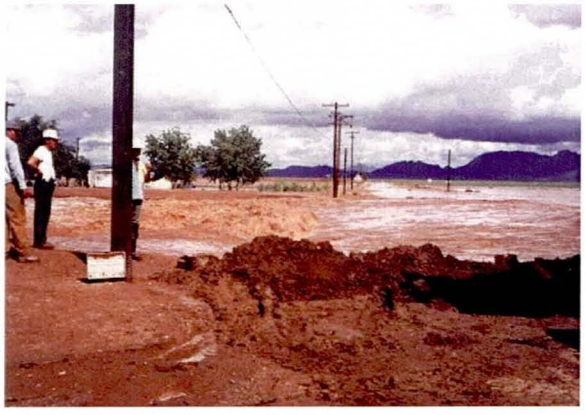


Figure 1-4: 1997 Storm; Eagle Eye Road, north of US 60

Project Authorization

This project was authorized pursuant to a contract between the District and HDR, Engineering, Inc. (HDR). The authorizing agreement is Contract FCD 2001C018, dated January 8, 2002. The District issued a notice-to-proceed to HDR, dated March 4, 2002. The completion date for Phase I (Floodplain Delineation, Alternative Formulation Phase of the ADMP) was April 2003 and for Phase II was December 2003.

Background Research and Sources

Data collection for the project consisted of compiling existing literature, media coverage, historical flooding documentation, and field reconnaissance. Existing facilities were identified and described and other analyses of the area were provided on: hydrology, land use, community, and environmental resources.

The sources of information used for this project include:

- Hydrologic Models - The District provided the HEC-1 hydrologic models used to develop the Floodplain Delineation for the Upper Centennial Wash, Grass Wash, and Aguila Farm Channel. The model output was updated to reflect the existing flooding patterns that have been observed throughout the area in recent years.
- Historic Flooding - Sources of information of historic flooding included public documentation and accounts, media coverage, weather reports (from National Weather Service and the District), and insurance claims, among others.

- Mapping Resources – HDR acquired existing topographic maps and Geographic Information Systems (GIS) imagery to create a base map of the Study Area containing topography, planimetric features, and major existing facilities. The District provided topographic mapping at a contour interval of two feet, flown on January 25, 2000.
- Floodplain Maps – Existing floodplain maps were used as a basis for the delineation updates and new delineations that were completed for the Aguila Farm Channel and other washes.
- Land Use, Planning, and Zoning Information – Land use, planning and zoning information was gathered from Maricopa County.
- Census Information – For the area of Aguila, Census information had to be obtained from 1990 and 2000 and from the Maricopa Association of Governments (MAG) 1997 Projection Data to Year 2020, prepared by Transportation Analysis Zone (TAZ). Because of the rural nature of this area, available information is not always comprehensive as with larger or incorporated towns.
- Environmental and Cultural Resource Information – The District provided environmental and cultural resources assessment reports.

Previous studies pertinent to the Aguila area were used for background information and for the hydrologic and hydraulic modeling used in the analyses. These studies include:

- *Storm Report – Summer/Autumn Storms of 2000, August 29th, October 10th, October 21st and 23rd, October 27th.* Flood Control District of Maricopa County, rev. February 1, 2001.
- *Damage Summary Report, Martori Farms, Aguila, Arizona.* Prepared for Zurich American Insurance Group. HDR Engineering, Inc., February 2001.
- *Aguila Hazard Mitigation Program Application.* Prepared for FEMA and the State of Arizona. Flood Control District of Maricopa County, December 2000.
- *Zurich American Report.* HDR Engineering, Inc., 1997.
- *Floodplain Delineation Study of Upper Centennial Wash, Grass Wash, and Aguila Farm Channel. Hydrology and Hydraulics Reports.* Prepared for the Flood Control District of Maricopa County. URS Consultants, May 1990.

PROJECT PARTICIPATION

Participation of public and private entities was a key to the success of this project. The extent to which these groups can benefit from the concepts developed is a measure of the success of the project. Therefore, the public involvement program, as well as the Alternative Formulation process, included the input of residents, government agencies, and private industries in the area.

INTERAGENCY COORDINATION

The agencies involved in the development of this project include:

- Flood Control District of Maricopa County
- Arizona Department of Transportation
- Arizona State Land Department
- Bureau of Land Management
- Maricopa County Department of Transportation
- La Paz County
- Yavapai County
- Natural Resource Conservation Service
- Aguila Irrigation District

SPECIAL INTEREST GROUPS

In addition to government groups, several private entities participated in this project due to their special interest in the Aguila area. These groups include:

- Arizona and California Railroad
- Martori Farms

PART 2. HYDROLOGY STUDY

WATERSHED DESCRIPTION

The Aguila ADMP Study Area is located in the vicinity of three major waterways: Aguila Farm Channel, Centennial Wash, and Grass Wash. Each of these major waterways has an extensive contributing watershed that extends well beyond the study limits (Figure 2-1). The steep slopes upstream and the land uses observed throughout the watersheds significantly impact the flows observed through these waterways.

The community core (on US 60 between Black Eagle Road and Eagle Eye Road) lies within, or is adjacent to, the Aguila Farm Channel floodplain. Many other homes and properties just south of the community are located in the Grass Wash floodplain or within its active floodway. North of the main community, Martori Farms lies within the Centennial Wash Floodplain.

The Aguila Farm Channel collects flows north of the Arizona and California Railroad (railroad) and conveys them westerly across Aguila into Grass Wash. Grass Wash flows northwesterly through Aguila to the confluence with Centennial Wash.

A floodplain delineation was completed as part of Phase I of this study. The Hydrology Report, included in Section 4 the Technical Data Notebook, includes detailed information on the procedure, methodology, and results

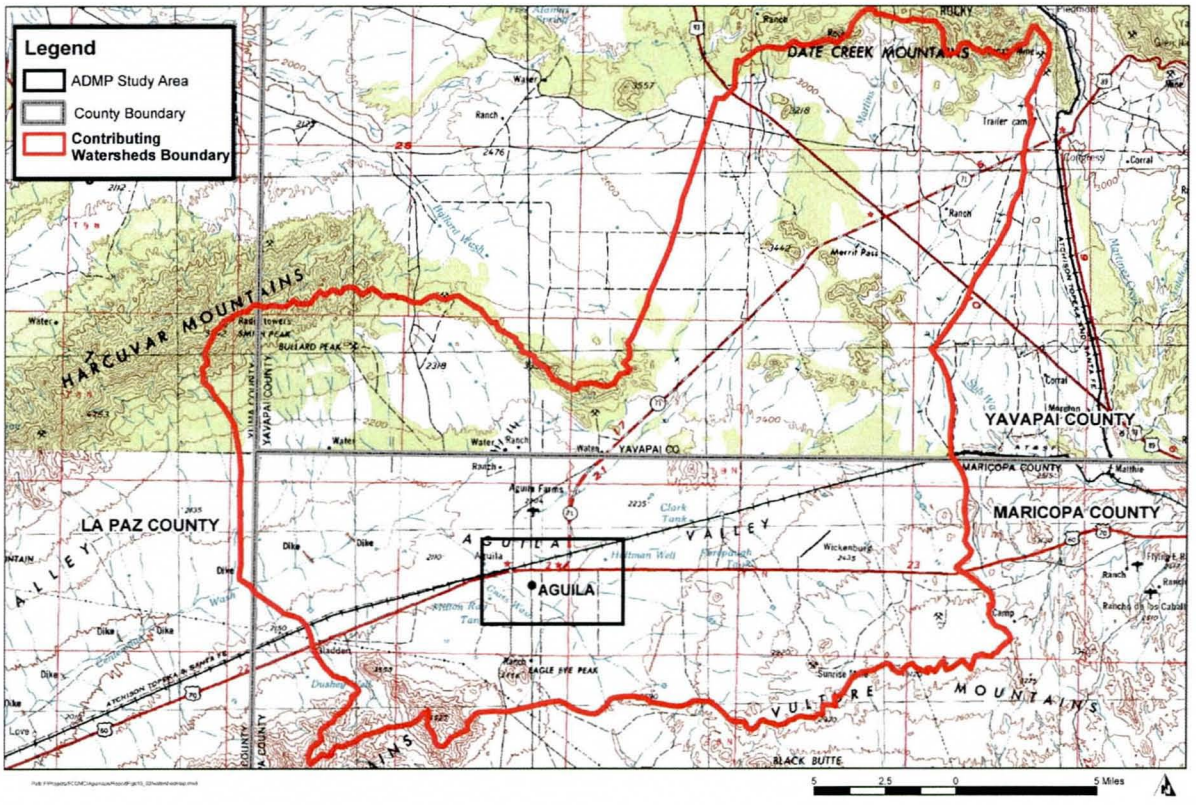


Figure 2-1: Aguila ADMP Contributing Watersheds Boundary

of the Hydrologic Analyses. Excerpts from this report are included in the following sections and in Appendix A.

DRAINAGE AREA BOUNDARIES

The current effective Flood Insurance Study (FIS) hydrologic model used a United States Geological Survey (USGS) topographic quadrangle at a scale of 1:62,500, as shown in the *Hydraulic Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash, and Aguila Farm Channel* (URS, 1990). The boundaries of the entire watershed extend into Yavapai County to the north, Effus Ranch Road to the east, the Vulture Mountains to the south, and La Paz County boundary limits to the west.

The original watershed delineation remains unchanged for this study. Subwatersheds in the original study were further subdivided to determine flows from specific locations. Regression equations were then used on the subwatersheds to develop a discharge. Subwatersheds and hydrology watershed maps are presented in Appendix A (Aguila ADMP Hydrology Report, Section 4 of the Technical Data Notebook).

EXISTING HYDROLOGIC MODEL

The existing hydrologic model for the current effective FIS is a Hydrologic Engineering Center (HEC)-1 model developed by URS Consultants in 1990 (provided by the District).

The methodology employed by this study is comprised of:

- Verifying the existing HEC-1 model.
- Updating the model where possible.
- The hydrologic model(s) selected for this project are in accordance with the District's *Consultant Guidelines*, Section 20, dated August 1, 2000.
- Topographic mapping of the area was provided by the District as noted in the Survey and Mapping Section.
- Arizona Department of Water Resources (ADWR) State Standards Attachment 1-97 (SSA 1-97) and 2-96 are employed throughout.

Research included review of the hydrology results from the existing *Hydrology Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel.*

Updating of the URS Consultants HEC-1 model involved:

- Site visit to the diversion in the watershed at Sols Wash, including an assessment of the diversion rating curve.
- Field surveys at the railroad, along SR 71, and at selected locations along US 60 where flows broke out or generated a bifurcation during the flooding of October 2000.
- Field survey and topographic mapping review to verify watershed/basin boundaries.

The following return frequencies were developed in the existing model:

- 100-year/24-hour
- 50-year/24-hour, and
- 10-year/24-hour.

The existing HEC-1 model was utilized as the backbone of this study. The original data file was analyzed with the June 1998

Flood Hydrograph Package, HEC-1, Version 4.1, developed by the United States Army Corps of Engineers in 1998. The existing effective hydrologic model produced the same results in Version 4.1 as it did in the 1990 URS Consultants report, which used Version 2. Where proposed floodplain delineations tie into existing floodplain mapping, the effective FIS discharges were used.

Hydrology for non-detailed study reaches (Zone A or numbered Zone AO) was developed using the procedures detailed in *Requirements for Floodplain and Floodway Delineation in Riverine Environments*, State Standard SSA 2-96, (ADWR, 1996).

Peak discharges for subwatersheds were reduced to a discharge-drainage area relationship developed from the verified HEC-1 model. Those discharge-drainage area relationships were compared to the regional regression equation presented in the State Standard SSA 2-96 (see Appendix A, Region 13 Equations corresponding to the Aguila area). Comparison of the two revealed the regional regression equation produces a more conservative discharge (larger), with reasonable correlation, especially in the larger watersheds (plots just above the points developed from the verified HEC-1 model). The data are presented in Appendix A.

Peak discharge for the Aguila Farm Channel was determined by taking the watershed area and utilizing the regional regression equation, similar to the non-detailed Study Area hydrology. It was increased in incremental steps downstream to match the previous mapping discharges at the tie-in point.

EXISTING FLOODING

The general flow pattern in Aguila is west, towards the Centennial Wash confluence. Excess stormwater from the northern and eastern portions of the Centennial Wash and Aguila Farm Channel watersheds flows southwest through the Aguila farms and the community into the Centennial Wash confluence with Grass Wash. Excess flows from the southern portions of the Grass Wash watershed are typically directed northwest through Aguila and the farms.

During the last major flooding events, flows overtopped the railroad, SR 71, and US 60. During the 1997 flood event, flows broke out

Figure 2-2: 1997 Storm. US 60 at Milepost 88

Figure 2-3: 1997 Storm. US 60 at SR 71

over US 60 near Milepost 88, approximately 1.5 miles east of its intersection with SR 71 (Figures 2-2 and 2-3). Aerial photographs taken after the flooding confirm the locations where flows topped the roadway and broke out to the south across US 60.

During the flood of 2000, flows broke out to the south over the railroad at its intersection with SR 71, damaging existing infrastructure (Figure 2-4). A hydraulic analysis was performed by HDR, based on the original consultant's (URS) data, to determine the kinds of impacts at the intersection of SR 71 and the railroad. The calculated 100-year discharge over the railroad near SR 71 is 4,264 cfs. For more detailed information on this model, refer to Appendix A.

Figure 2-5 shows the locations where flooding typically occurs, as identified by local residents. During the first public meeting, residents pointed out these areas and provided their personal accounts of past storms. Additional individual meetings and personal documentation (photos, videos), media coverage, and field reconnaissance confirmed the personal accounts.

Figure 2-4: 2000 Storm. Damage to railroad track

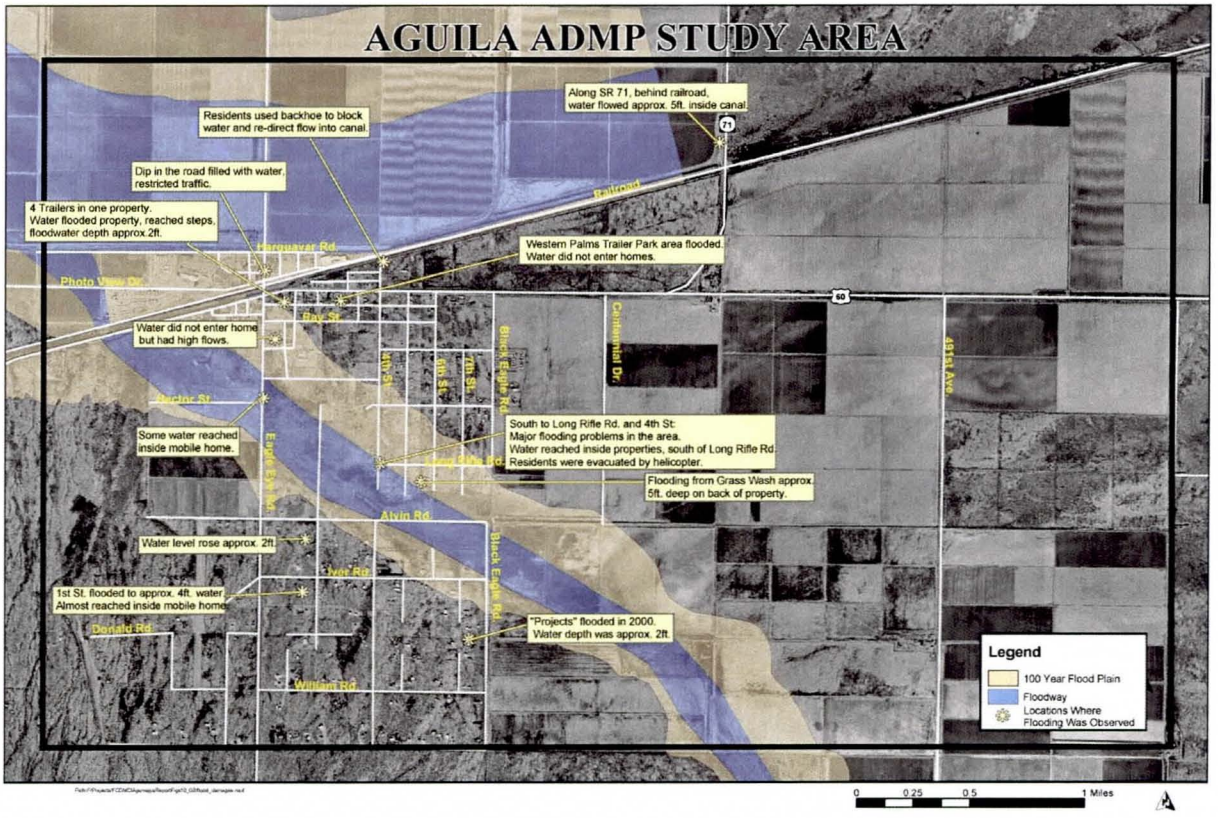


Figure 2-5: Locations where flooding typically occurs, as described by residents

Figure 2-6 depicts the flow patterns observed during the storms of 2000. Excess runoff, coming from the northeast, traveled along the north side of the railroad before overtopping it and heading south at SR 71. In addition, flows traveling on the north side of US 60 broke out at various locations, inundating properties and farms located south of the road. Water flowing along Grass Wash inundated those lands located within the active floodway. Also, the flows within Grass Wash were intercepted at various locations by berms constructed by private landowners that had tried to protect their properties from potential flood hazards. It is also speculated that a number of structures upstream that had historically provided some level of flood protection are no longer doing so. These structures include large berms and stock tanks that may have silted in over time. All these factors contributed to the flooding damages experienced by the Aguila community.

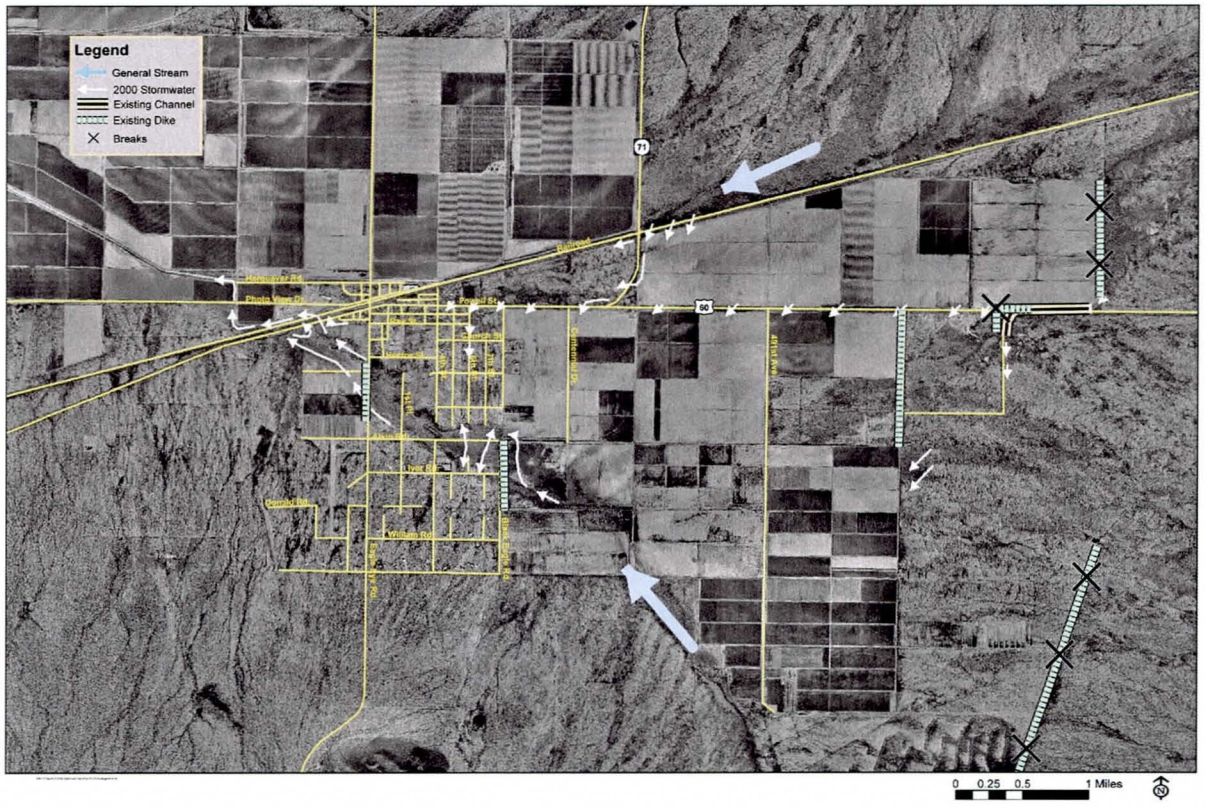


Figure 2-6: Aguila ADMP Stormwater flow diagram

PART 3. CHARACTERISTICS OF THE EXISTING CORRIDOR

DIMENSIONAL CHARACTERISTICS OF THE EXISTING CORRIDOR

Grass Wash

The defined flow area of Grass Wash within the ADMP study limits averages about 1000 feet in width. Frequently Grass Wash overtops its banks, and the designated floodplain is nearly 3000 feet in width.

Grass Wash is shallow, with no defined thalweg or incised banks. It is generally defined by a sandier soil type and increased vegetation, as compared to the overbank areas. Agricultural activities within the wash have redirected historic low flows in some cases. In other instances, attempts have been made to route the low flows away from residential lots, particularly at the airpark. These activities have proven unsuccessful during significant events.

Grass Wash	Drainage Area (square miles)	10-year (cfs)	50-year (cfs)	100-year (cfs)
At US Highway 60/70	70.6	3,340	8,660	11,100
At NW Corner of Section 25, T7N, R9W	39.9	2,430	5,950	7,500
At SE Corner of Section 25, T7N, R9W	23.9	1,720	3,900	4,870

Centennial Wash

The Centennial Wash defined limit is 1100 feet to 1200 feet in width. Within the limits of the study, Centennial Wash has been converted to agricultural use and no longer resembles its natural condition. Flows now are directed across leveled fields and within irrigation delivery ditches, causing significant destruction and siltation problems during runoff events.

Upper Centennial Wash	Drainage Area (square miles)	10-year (cfs)	50-year (cfs)	100-year (cfs)
At Maricopa/La Paz County Boundary	451.5	4,880	16,400	21,700
At SW Corner of Section 4, T7N, R9W	41.1	1,900	5,410	6,960

Aguila Farm Channel

The width of the Aguila Farm Channel varies, but the overall top width is about 90 feet. The channel conveys only a portion of the 100-year flow, and the overall floodplain width through Martori Farms is over several miles wide.

The channel is a manmade drainage way constructed by the cut-and-fill method. Material excavated from the channel bottom was used to build side levees. This is a non-engineered facility, constructed with uncompacted fill, and historically fails during significant runoff events.

Aguila Farm Channel	Drainage Area (square miles)	10-year (cfs)	50-year (cfs)	100-year (cfs)
Below Grass Wash	314.4	4,130	14,500	19,300
At Eagle Eye Road	239.6	3,620	12,700	16,900

MODAL CHARACTERISTICS

Vehicular

Major Streets

The major roads in the Aguila area are US 60 and SR 71. The center of Aguila lies near the intersection where SR 71 connects to US 60. US 60, which starts at the New Mexico border on the east side of the state and ends at Quartzsite on the California border, connects Aguila with Wickenburg and Phoenix. US 60, through Aguila, is a two-lane paved road.

State Route 71 begins at Aguila and connects to State Route 89, approximately 25 miles to the north, in the town of Congress. State Route 89 then provides access to Prescott and locations to the north. SR 71 is a two-lane paved road.

Most of the streets in Aguila are unpaved and none of them have sidewalks.

Railways

The Arizona and California Railroad passes through Aguila. The rail route begins in Cadiz, California and terminates in Wickenburg. Only freight service is provided through Wickenburg and Aguila; passenger service was withdrawn from Aguila around 1955. The original Aguila depot was built about 1905. The building was moved to Scottsdale, Arizona in the 1970s to become part of the McCormick-Stillman Railroad Park.

Non-Vehicular

Trails

Currently, there is no planned trail system or county trails in the Aguila-Wickenburg area. In the future, as part of the Maricopa County Regional Trail System being prepared by the County, the entire County will be reviewed for potential trail corridors. It is anticipated that any future trails would connect wilderness areas and other recreational amenities using wash corridors wherever possible.

Bikeways

There are no County bikeways, current or future, in the Aguila Study Area. The Maricopa County *Bicycle Transportation Plan*, adopted May 19, 1999, shows a bicycle network that connects the greater Phoenix area with Wickenburg, 25 east of Aguila. From west Phoenix, the route follows Baseline Road to its junction with the Salome Highway (approximately 335th Avenue), then northwest on the Salome Highway to its junction with 355th Avenue. The route continues north on 355th Avenue to Vulture Mine Road and then northeast into Wickenburg, where it terminates.

Summary of Modal Characteristics

Aguila reflects the typical modal characteristics of a rural community. It has one main access route, US 60, along which most of the community is situated. One rail line bypasses the community but provides only freight service. Developed bicycle and pedestrian trails are non-existent as are sidewalks.

SOCIOECONOMIC ENVIRONMENT

Regional and Local Context

Aguila is a small farming community situated in a fertile valley at an elevation of 2,160 feet. It is an important agricultural center known specifically for growing the "world's finest" cantaloupes. Aguila has several small businesses including restaurants, convenience stores, and gas stations that are dependent on the agricultural operations. Wickenburg, with a population of 5,000 people, is approximately 25 miles away. Metropolitan Phoenix is 50 miles away and offers the services and goods of a major metropolitan area.

Existing Social and Economic Environment

Aguila's distance from Phoenix has kept it, to date, as a rural community, exempt from the explosive growth of the metropolitan area. However, some non-farm development may emerge in Aguila as new and existing metropolitan residents look further out for rural or secluded communities and properties.

Socioeconomic information in this section is from the 1990 and 2000 US Census and from the Maricopa Association of Governments (MAG) 1997 Projection Data to Year 2020, prepared by Transportation Analysis Zone (TAZ). Since Aguila is not identified as a place under Census designation, Census data at the Block and Block Group level was determined by the extents of the Study Area. There are 245 Blocks within the Study Area. Some of the Blocks extend beyond the Study Area boundary but, based on aerial review, the additional area is virtually unpopulated. Some information is only available at the Block Group level. Again, the majority of the Block Group is in the Study Area and those parts outside the Study Area are relatively unpopulated. Since the Aguila area is mostly undeveloped, the TAZ encompasses the area north to the County line and south of US 60 to Interstate 10 (I-10), the County line, and the Hassayampa River. Consequently, the projections for the Aguila area are generally reflective of trends occurring in the larger planning area in localities closer to Wickenburg, Buckeye, or I-10.

Population

The Aguila area population is estimated at 1,122 people. This estimate is based upon 2000 Census Block data (see Figure 3-1).

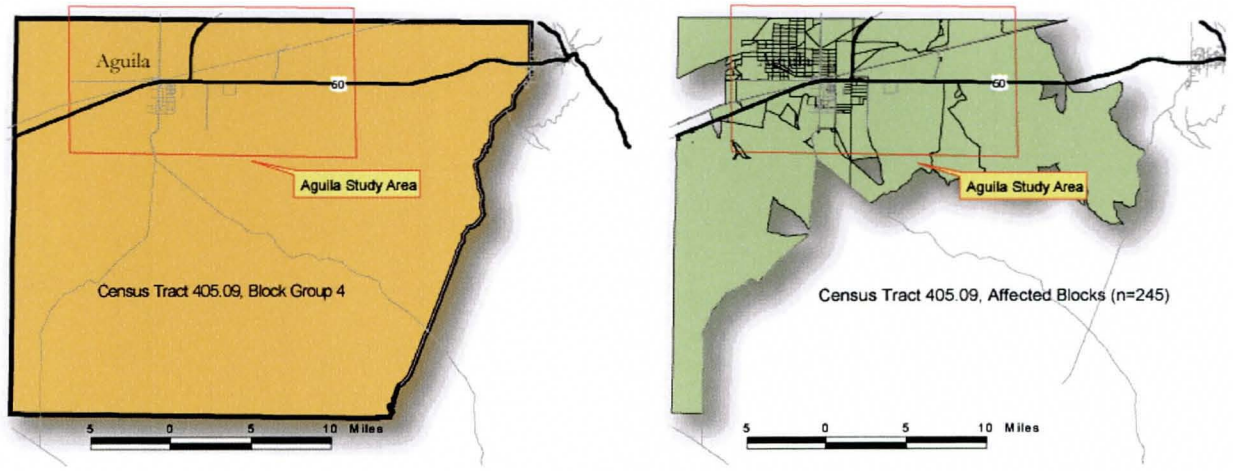


Figure 3-1: Comparison of the area of the Census Group and Census Blocks used in the Aguila Area sociodemographic analysis.

Income

The average median family income for the Study Area is $35,699, about 69% of the Maricopa County average of $51,827. The Study Area median family income is approximately 11% less than that of Wickenburg, which is $40,051.

Low Income Populations are those whose median household income is at or below the Department of Health and Human Services poverty guidelines[1]. The percentage of people in poverty in the Aguila area is 16.0%, compared to an average of 11.6% for Maricopa County. These figures are based upon 2000 Census Block Group data (see Figure 3-1).

Ethnicity

For the purposes of this study, minority populations are defined as American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic Origin; or Hispanic[2].

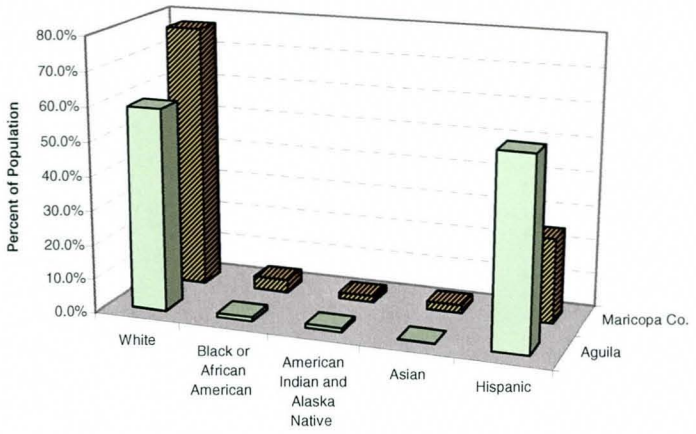


Figure 3-2: Ethnicity

The minority population of the Aguila area is 58.1%, which is approximately 44% higher than Maricopa County (32.6% minority). The majority of Aguila's population (55.6%) is Hispanic (see Figure 3-2). These figures are based upon 2000 Census Block Group data (see Figure 3-1).

[1] Federal Highway Administration. 1998. Directive 6640.23, "FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations". U.S. Department of Transportation, Federal Highway Administration, December 2, 1998.

[2] Federal Highway Administration. 1998. Directive 6640.23, "FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations". U.S. Department of Transportation, Federal Highway Administration, December 2, 1998.

Age Distribution

The Study Area has a larger youth population and a larger population of residents over 50 years of age as compared to Maricopa County. The Study Area is approximately 35% under 18 years of age, 34% between 18 and 49, and 31% over the age of 50 (see Figure 3-3). Maricopa County is 27% under the age of 18, 48% between 18 and 49, and 25% over the age of 50. The large number of residents over 50 years of age may reflect that Aguila is viewed as a retirement destination.

Population Trends

Based on the 2002 Draft MAG Projections, the population of the Aguila Study Area is expected to grow by 79%, or 996 people (see Table 3-1).

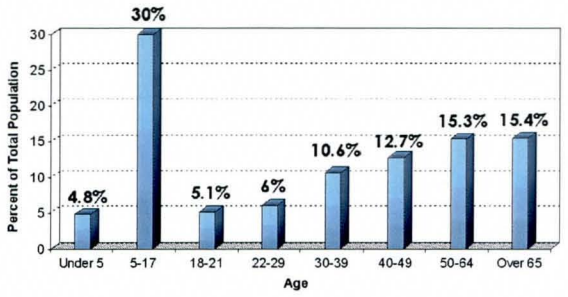
Housing

Based upon a windscreen survey, the housing stock in Aguila is generally low to medium quality. Only 50% of the housing stock is owner occupied. Of the remaining 50%, half are rented and half are vacant, many of the latter in deteriorating condition. There are high-end homes in the development of Eagle Roost Airpark, south of Aguila. The development started thirty years ago selling "air ranches". The lots are a minimum of five acres and include horse properties and runway access. The 116 lots have sold out and approximately 76 homes have been built.

The number of total housing units is projected to increase by 72%, or 394 units by 2020 (see Table 3-2).

Employment Growth

By 2020, employment in the Study Area is expected to grow 35% (see Table 3-3). The bulk of the employment growth is attributed to jobs in the warehousing, public, or agricultural sectors (see Figure 3-4).



Source: Census 2000 Data (by Census Block for Aguila Study Area)

Figure 3-3: Aguila Age of Population

Table 3-1: Aguila Population Projections

Aguila Population Projections			
Year	**2000**	**2010**	**2020**
Population*	1,265	1,319	2,261
Percent Change		4.3%	71%

MAG 2002 Projection Data to Year 2040, prepared by TAZ Zones 2047 and 2042. TAZ Zones do not correspond exactly with Census units.

Table 3-2: Aguila Housing Unit Projections

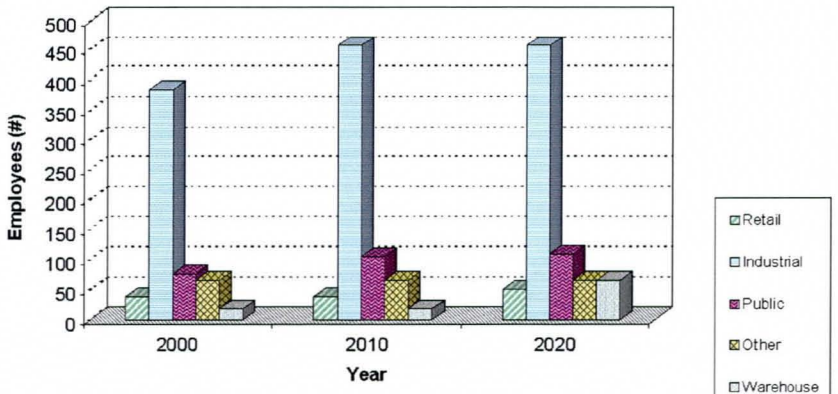
Aguila Housing Unit Projections			
Year	**2000**	**2010**	**2020**
Housing Units	545	545	939
Percent Change		0%	72%

MAG 2002 Projection Data to Year 2040, prepared by TAZ Zones 2047 and 2042

Table 3-3: Aguila Employment Projections

Aguila Employment Projections			
Year	**2000**	**2010**	**2020**
Employees	593	686	798
Percent Change		16%	16%

MAG 2002 Projection Data to Year 2040, prepared by TAZ Zones 1610 and 1611



Source: Maricopa Association of Governments Draft 2020 Projections for TAZ 2047 and 2042

Figure 3-4: Aguila Employment 2000-2020

Title VI Environmental Justice Assessment

Overview

The District has identified concentrations of disadvantaged communities in the Aguila area (relative to Maricopa County averages) for the purposes of conducting an Environmental Justice analysis of the Aguila ADMP. The intent of Environmental Justice is to ensure that minority and low-income communities are included in the planning process, and to ensure that these *communities of concern* may benefit equally from any recommendations without shouldering a disproportionate share of any associated burdens.

Background

Environmental Justice is a planning consideration based on Title VI of the 1964 Civil Rights Act and Executive Order 12898 of 1994 titled Federal Actions to Address Environmental Justice in Minority and Low-Income Populations.

While the environmental justice movement has focused on the impacts of toxins and transportation project impacts, it has devoted much less attention to the broader array of environmental issues that affect the welfare of low-income and minority communities. These include risk from natural hazards (such as flooding), access to open space, recreational opportunities, and livability. As the designated agency for regional flood control planning in Maricopa County, it is the District's intent to recognize the significance of flood control planning on the continued quality of life of all County residents.

The purpose of this assessment is to establish whether the impact of the proposed action(s) would have a "disproportionately high and adverse effect" on the communities of concern. If the proposed action is deemed to have a disproportionately high and adverse impact, mitigative actions should be incorporated as part of the proposed action. For example, in the course of acquisition of residential property to remove structures from the floodplain pursuant to Section 404 of the Stafford Act, it appears that the properties

represent the least expensive real estate in the area and are likely owned by a lower income population than the homes located outside the floodplain. If the proposed acquisition appears to have a disproportionately high and adverse effect on a minority and/or low-income population because replacement housing is scarce, relocation assistance might be recommended as a mitigative action.

Communities of Concern

Communities of concern include minority and low-income communities, as identified in Title VI of the 1964 Civil Rights Act and Executive Order 12898.

In determining communities of concern, the Census data for the Aguila area was compared to the County mean for both minority and low-income populations. Communities of concern are identified as those tracts where the identified group represents a percentage of the population greater than that of the County mean.

The Aguila area is higher than the County average for both the percentage of minorities and people living in poverty (refer to Socioeconomic Environment). A review of the Census Block data for the area indicated that there are clusters of 100% minority groups within the area; however, poverty data are unavailable for units of analysis smaller than the block group.

Public Involvement Program

An important tenet of environmental justice is that no individual be excluded from participation in a program on the basis of race or income. Public involvement plays an important role in the District's approach to environmental justice.

The District continues to build upon its Public Involvement, Information, and Education Programs to reach out and inform County residents of the public safety issues pertaining to storm water flooding. The District uses the Area Drainage Master Studies and Plans program to assess and recommend solutions for the hazards and problems by watershed due to the County's large area. These studies give a more localized view of issues and solutions to flooding problems and allow citizen participation. To encourage citizen participation in the Aguila ADMP process a number of events were held and other outreach efforts were conducted.

Events/Outreach

To encourage participation from the entire community, the public involvement program was designed to reach both Spanish and English-speaking residents. All written materials – newsletters, flyers, posters, website (see Figure 3-5), letters, and communications were bilingual, ensuring that public concerns and ideas from the entire community were integrated into the process.

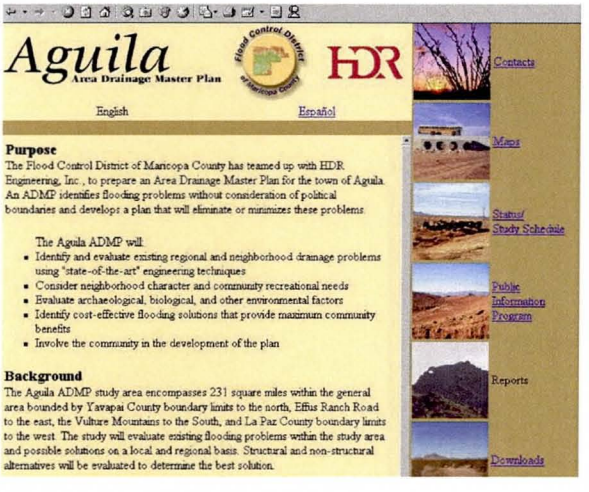


Figure 3-5: Aguila ADMP Website

Recognizing the large Hispanic population in the Study Area, the first public event for the project was held at the weekly Aguila farmer's market along US 60 on May 21, 2002. The open-air market is a popular event for area residents to socialize and purchase locally grown fruits and vegetables. Seven representatives of the District, including three Spanish speakers, staffed the District's booth. A departure from the typical open house format, this event is illustrative of the District's effort to reach out to the community.

The Aguila ADMP Open House Meeting was held Thursday, April 24, 2003, from 4:00 to 7:00 p.m. at Aguila Elementary School. In June of 2002, follow-up meetings were held with five of the attendees from the April 24th Open House. Of the five people, two spoke only Spanish and the District provided translators for the meeting. Their comments were recorded and information considered in the determination of the recommended actions.

In addition to the newsletter and one mailing, all of the postings and information provided were prepared in both English and Spanish (see Figure 3-6). The Aguila ADMP website included project information in both English and Spanish as well (refer to www.fcd.maricopa.gov/Projects/aguilaADMP).

Impact of the Recommended Action on Environmental Justice

Phase I of the Aguila ADMP identified several structural alternatives that were eventually ruled out as being prohibitively expensive, given the value and number of structures protected. Instead, the recommended alternative is to identify small individual projects to address flooding problems. This action would result in all of the existing structures identified as having a flooding problem to be individually protected.

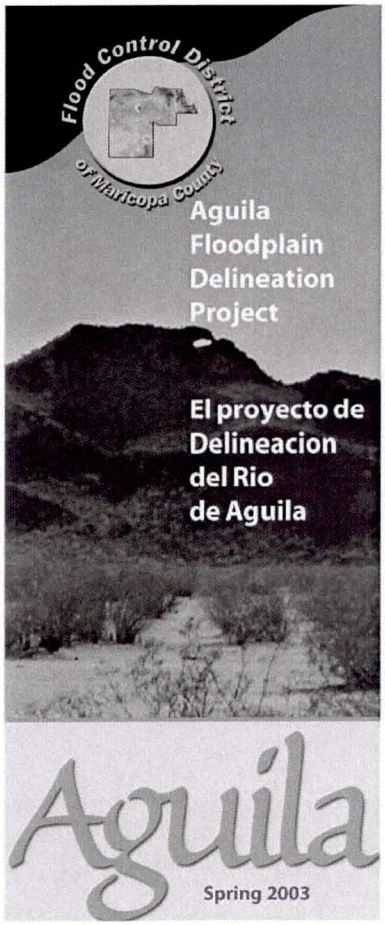


Figure 3-6: Flyer Cover

To this end, all structures within the existing floodplain were identified from aerial images. Structural flood control solutions were developed to protect all of the identified structures. The recommended action does not distinguish between low value or higher value residences; all residences subject to flooding are addressed.

Summary

The District's effort to incorporate environmental justice into floodplain management planning is an ongoing effort. Reaching out to disadvantaged communities and assessing their needs and interests is paramount to ensuring the continued quality of life of all residents in the County.

The public involvement plan of the Aguila ADMP demonstrates the District's effort in engaging communities that are traditionally difficult to reach. Going to the community, as was the case with a booth at the Aguila farmer's market, and the follow-up meetings held with representative stakeholders, provides an effective venue for public involvement efforts.

All of the structures within the existing floodplain were identified and structural solutions for flood protection recommended. The recommended protection of all structures, regardless of the residence's value, is demonstrative of environmental equity. Modifications to the floodplain through the Aguila Floodplain Delineation Project will require revisiting aerial images of the area to identify if any additional structures may be at risk of flooding and require structural protection as well.

Jurisdiction and Ownership

Aguila is not a self-governing town. It falls under the jurisdiction of Maricopa County

Ownership within the Study Area is predominantly privately held land. There is some State-held land at the east end of the Study Area.

Zoning

Zoning and permitting falls under the jurisdiction of Maricopa County. Almost 100% of the land in the Study Area is zoned Rural 190 or Rural 43. The uses allowed in Rural 190 are farm and non-farm residential, farms, recreation, and institutional uses. The minimum lot size is 190,000 square feet. The principal purpose of Rural 43 is to conserve and protect farms and other open land uses, foster orderly growth in rural and agricultural areas, and prevent urban and agricultural land use conflicts. The minimum lot area in Rural 43 is one acre. The remaining zoning categories together are only .01% of the Study Area and include the zoning categories of Industrial 1 and 2, Commercial 2 and 3, and Residential 2, 4 and 5.

Land Use

Predominant land uses in Aguila include agriculture, low to very low-density residential development, and neighborhood service retail. The core of the Aguila community is centralized on US 60. The highest concentration of businesses and homes occurs within a short distance of the highway. The remaining Study Area is composed of increasingly scattered homes intermingled with 5 to 40 acre parcels. The Eagle Roost Airpark subdivision, located on the southern edge of the community, is the only master planned development in the Aguila area. It includes large lot homes on five acre and larger parcels with direct access to the runway. The current land use pattern in Aguila should continue as long as agriculture remains the predominant land use in the area. There are no rezoning or development projects on file for Aguila at this time.

As the Wickenburg area continues to grow, the Aguila area may experience moderate development. The lack of sewer services makes suburban style development (more

than one dwelling per acre) unlikely in the foreseeable future. However, continued low-density residential development is likely to continue at a moderate pace as Wickenburg and the Phoenix metropolitan area continue to grow.

Plans

As described below, planning for the Study Area falls under the jurisdiction of Maricopa County and is covered in the Maricopa County *Eye to the Future 2020 Comprehensive Plan*. Aguila is also included in the MAG *Land Use Plan 1995*. There is no Area Plan for Aguila or any specific plans regarding trails or parks and open space.

Eye to the Future 2020: The *Eye to the Future* plan designates Aguila as an Established Community surrounded by Rural Development Area. As described in the plan, the intent of the Established Community designation is to "recognize these areas and ensure their character and lifestyle are respected. These areas are characterized by existing patterns of development. These are guided and/or regulated by land use plans, community plans, improvement districts, or traditional zoning ordinances". It also states in the plan that "residents of these areas have stressed the importance of preserving the character of their communities. To achieve this, historic development patterns will continue".

A Rural Development Area (RDA) is "typically vacant land or rural in character with minimal, if any, infrastructure or public services. Residential development will be allowed at a very low density, generally not to exceed one house per five acres". The purpose of the RDA is to "preserve the opportunity for low density rural living as a lifestyle choice". "While the primary land uses of the RDA are residential and agricultural, other compatible public and private non-residential uses may be located within these areas. Appropriate uses could include: agricultural support services, ranching, hunting clubs, recreational areas, dude ranches, RV parks, churches, home-based businesses, and small scale cottage industries".

MAG Land Use Plan 1995: The *MAG Land Use Plan 1995* shows 99% of the land in the Study Area in the Rural category. This corresponds to the areas that are now under agricultural production with housing scattered throughout. Nearer to central Aguila, the major land use category is Large Lot Residential at .2% of the Study Area. There are small sections designated as Neighborhood Retail Center (.04%) and as Educational (.01%).

Summary of Socioeconomic Environment

Aguila is a rural, agricultural community of predominantly low-income families. The population has a higher percentage of minorities than Maricopa County and a higher percentage of youths and elderly persons than the County. This is an area with low home values, with only half the homes being owned. The other half are rentals or vacant.

The public outreach program was geared toward a bilingual community. All materials were provided in English and Spanish and translators were available at all public meetings. Operating a booth at the local farmer's market was one way to reach residents that might not otherwise attend a formal meeting.

PHYSICAL AND NATURAL ENVIRONMENT

Topography

The Study Area is located within the Basin and Range province of Arizona. This is an area characterized by linear mountain ranges that trend mostly in a north-south or northwest-southeast direction. As the mountain ranges have eroded, the material has been carried to the valleys, filling in the basins and leaving broad expanses of relatively flat land between the ranges.

The Study Area lies within one of these flat basins. The elevation across the Study Area ranges from 2,230 feet to 2,190 feet in about four miles. The mountain ranges surrounding the basin are the Vulture Mountains to the southeast and the Harquahala Mountains to the southwest.

Environmental Resources

The District conducted an environmental overview of the Study Area. For more detailed information, refer to the *Environmental Overview of the Aguila Area Drainage Master Plan*, dated June 2002.

Biotic Communities, Wildlife, and Sensitive Species and Habitat

A biological resources reconnaissance survey was completed in April 2002 that included vegetation, wildlife, and sensitive habitat. The vegetation type was assessed and plant and wildlife species were observed and recorded. For Phase I of the ADMP, an extensive plant and wildlife survey was not necessary. Lists of potentially occurring plants, mammals, birds, and herpetoperfauna are presented in the appendix of the *Overview*. Further detailed surveys or assessments might have been required in later phases of the planning process if disturbance would occur in areas that had special habitat or could have provided appropriate habitat for species of special concern.

The *Environmental Overview* identified four vegetation communities: Lower Colorado River Valley Subdivision, Xeroriparian Habitat, Residential Development, and Agricultural Lands. The report notes that much of the native vegetation throughout the Study Area has been altered or completely removed by human activities. What does remain as native is the Lower Colorado River Valley Subdivision with distinct washes of the Xeroriparian vegetation.

A formal wildlife survey was not completed as part of the overview. During the short field survey of vegetation, wildlife sightings were noted and included numerous species of birds, a rattlesnake, and a desert cottontail.

The *Environmental Overview* studied the potential for threatened and endangered species. Of the thirteen species listed for Maricopa County, it was determined that none of them have suitable habitat in the Study Area. The Arizona Game and Fish Department (AGFD) was contacted by the biologist. According to the AGFD, the Sonoran desert tortoise, a federally listed Species of Concern, has been documented in the Study Area. Guidelines for reducing impacts to the tortoises, prepared by the AGFD, should be used on any future projects.

Hazardous Materials

Other environmental concerns in the area include leaking underground storage tanks

and solid waste handling facilities. Based on the District's *Environmental Overview for the Aguila Area Drainage Master Plan*, June 2002, "One leaking underground storage tank (LUST) was located in the Study Area (see Figure 3-7). The facility name is Phoenix-Agro Invest located at 51040 West Valley Road. (ADEQ LUST #5057.01, Facility ID #0-003796). The leak was reported on March 22, 1999. According to the Arizona Department of Environmental Quality (ADEQ), this LUST case is a priority level 2 and has not yet been closed. If a proposed project is located within ½ mile of this facility, the LUST file should be reviewed by District personnel to determine the effect the LUST site has on the proposed project" (Flood Control District of Maricopa County, 2002).

Three solid waste sites were listed in the *Environmental Overview*. One appears to be incorrectly listed, one is located somewhere on the Martori Farm and the third is the closed Maricopa County Municipal Solid Waste Landfill. Siting a proposed project through or near these two known solid waste facilities should be avoided. The Aguila Dumpsite, located outside of the Study Area, should also be avoided by any future projects.

Cultural and Archaeological Resources

Scientific Archaeological Services completed a cultural resource assessment under contract with the District in February 2002. The findings of the assessment indicate that six cultural resource surveys have been completed within the Study Area. Five of

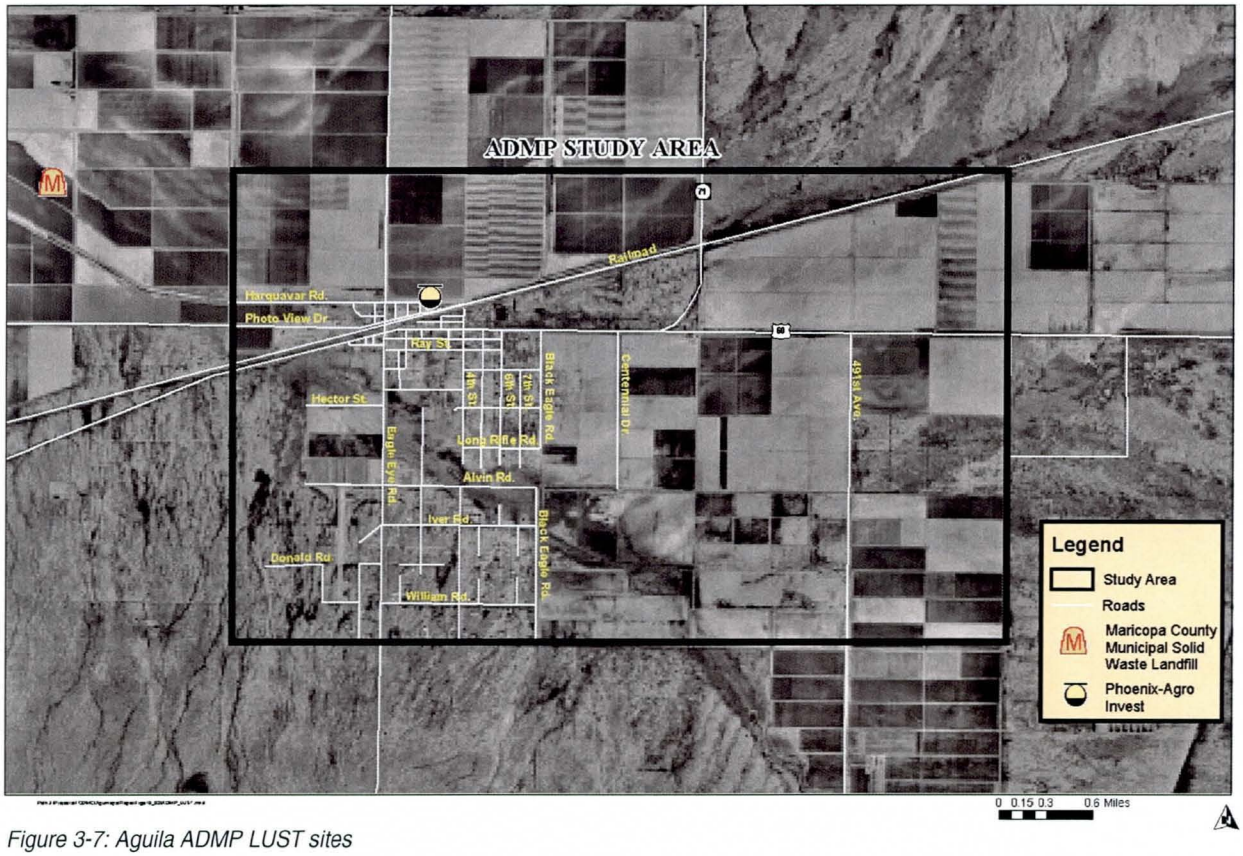


Figure 3-7: Aguila ADMP LUST sites

these were intensive surveys encompassing less than 1% of the Study Area. Thirty-one cultural sites were recorded, all of which are late historic sites that date from 1903 to 1928. The overview states that these sites represent five major patterns of activity: 1) railroad transportation, 2) telegraph communication, 3) local commerce, 4) highway transportation, and 5) residential life.

Only eleven of these sites may still exist and warrant future consideration. It is recommended that if any of the recommended alternatives impact one of these sites, the District should evaluate potential impact on these resources. It is also recommended that the District conduct an intensive survey in any areas where proposed projects will be constructed since less than 1% of the Study Area has ever been intensively examined.

For detailed information on the cultural sites mentioned in this section, refer to "*A Cultural Resource Survey of the Aguila Archaeological Research Locale of Northwestern Maricopa County, Arizona*", prepared and submitted by James B. Rodgers, Scientific Archaeological Services, March 13, 2002.

SUMMARY OF THE EXISTING CORRIDOR

Aguila is located in the vicinity of three major waterways: Aguila Farm Channel, Centennial Wash, and Grass Wash. Centennial and Grass Washes are broad shallow channels with hard to define banks. Aguila Farm Channel is a man-made drainage way constructed by the cut-and-fill method. Material excavated from the channel bottom was used to build side levees. This is a non-engineered facility, constructed with uncompacted fill, and historically fails during significant runoff events.

Aguila reflects the typical modal characteristics of a rural community. It has one main access route, US 60. One rail line bypasses the community and provides only freight service. Developed bicycle and pedestrian trails are non-existent as are sidewalks.

The population of Aguila is lower income, predominantly Hispanic with a higher percentage of younger and older residents than Maricopa County as a whole. Land use is low to very low density and the housing stock is low to medium quality.

Due to the low income and minority characteristics of the population, Aguila is considered a community of concern under Title VI Environmental Justice. It was determined that this population will not carry a disproportionate share of the burden. The recommended action does not distinguish between low value and higher value residences; all residences subject to flooding are addressed. In addition, a public outreach program was conducted in both English and Spanish to reach as many residents as possible.

Physically, Aguila is located in an agricultural area. Little to no natural vegetation exists except along washes. One leaking underground storage tank was identified as hazardous and should be monitored. Only 1% of the Study Area has been intensely surveyed for cultural resources; this too should be monitored in the future.

PART 4. ALTERNATIVE FORMULATION

ALTERNATIVE FORMULATION PROCESS

The Alternative Formulation Process for the Aguila ADMP and floodplain delineation was designed to develop a range of conceptual alternatives that would help solve the flooding problems within the Study Area and meet the community's needs for public safety and flood protection.

The goal of this process was to provide the District with the necessary information to determine the direction of the Aguila project, specifically whether to continue on to Phase II. The process began July 9, 2002 and was conducted in four stages:

1. Scoping.
2. Individual meetings.
3. Alternative formulation meeting.
4. Review and direction from the District.

During the scoping stage, the Aguila team defined the Alternative Formulation Process, identified and contacted key stakeholders, and coordinated individual meetings.

The individual stakeholder meetings provided interested parties the opportunity to meet with the Aguila team in an open setting where they could comfortably provide their input on possible alternatives. The individual approach was recommended because some of the stakeholders have outstanding issues relating to the potential outcomes that might inhibit their participation in a group setting. The District, as well as HDR, also met individually to develop their own conceptual alternative.

The alternative formulation meeting was a structured brainstorming session where the conceptual alternatives were presented to the District Project Manager and other individuals identified by the Project Manager. This meeting included three components:

1. An overview of the Study Area hydrology and hydraulics, environmental resources, and public/community interests identified to date.
2. Presentation of the conceptual alternatives suggested by the stakeholders.
3. Evaluation of the conceptual alternatives to determine if they would be fully analyzed in Phase II.

INDIVIDUAL STAKEHOLDER MEETINGS

Individual stakeholder meetings were held with the following groups:

- Public
- Arizona State Land Department
- Arizona Department of Transportation
- Arizona and California Railroad
- Martori Farms
- La Paz County
- Yavapai County
- Maricopa County Department of Transportation
- Natural Resource Conservation Service
- Flood Control District of Maricopa County
- HDR Engineering, Inc.

ALTERNATIVE FORMULATION WORKSHOP

On August 15, 2002, following all of the individual stakeholder meetings, a workshop was conducted to discuss potentially feasible alternatives. The District and HDR personnel attended the workshop.

The concepts suggested by the different stakeholders were discussed. The recommended concepts were categorized into four decision trees (see Figures 4-1 through 4-10). Each tree led to a series of alternatives that were discarded, left for additional research, or accepted for further analysis, based on general feedback from the District regarding funding, feasibility, and other issues.

For presentation purposes during the alternative formulation workshop, the options listed in the sidebars in the decision trees were left for later discussion. The decision trees present conceptual options that could be implemented in a number of ways. For example, containing and directing a channel at a road crossing may be achieved by the construction of a culvert, a dip in the road, or a bridge. These detailed options were not selected at the level of analysis performed during the workshop. Rather, a reality check based on feasibility, construction, and implementation was considered for the main option, which in the aforementioned example would be whether or not to contain flows at a crossing. If an option was considered to be infeasible, the branch of the tree was eliminated. The summary tables (Tables 4-1 through 4-4) provide a quick reference of the discussion surrounding each decision tree.

Decision Trees 1 and 2 represent the general flooding areas in terms of location (flooding due to Centennial Wash and Grass Wash, respectively). Decision Trees 3 and 4 represent options that can be implemented solely or in combination with any of the options discussed in the first two decision trees.

Decision Tree 1 evaluates flooding due to Centennial Wash (Figure 4-1). The main concern with the flows within the Centennial Wash watershed is the farmland. Most of the land flooded in this area is privately owned farmland. Opportunities for partnerships exist with these private landowners. The improvement of existing infrastructure, such as channels and ditches, can be considered as a possible alternative, along with the implementation of a maintenance program in coordination with local farmers.

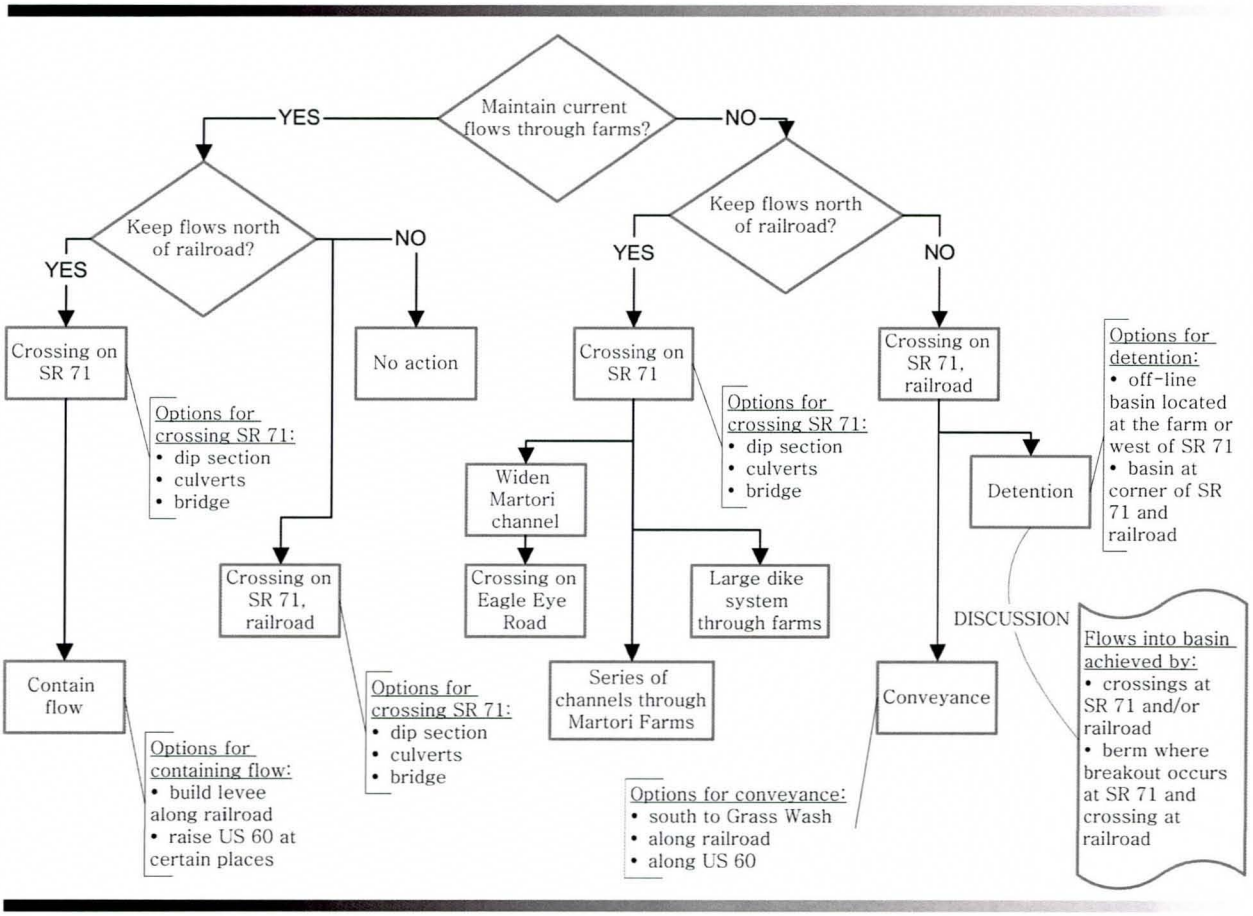


Figure 4-1: Decision Tree 1. Flows on the north (Centennial Wash floodplain through the farms)

The discussion of Decision Tree 1 began with the consideration of present flow patterns that currently flood existing farmland. If the current flow patterns are maintained, they will overtop the railroad. If the excess flows are managed, they can be directed south of the railroad or they can be contained north of the railroad. In order to contain these flows north of the railroad, a crossing at SR 71 would be necessary. All of the options represented in this branch were deemed potentially feasible (see Figure 4-2).

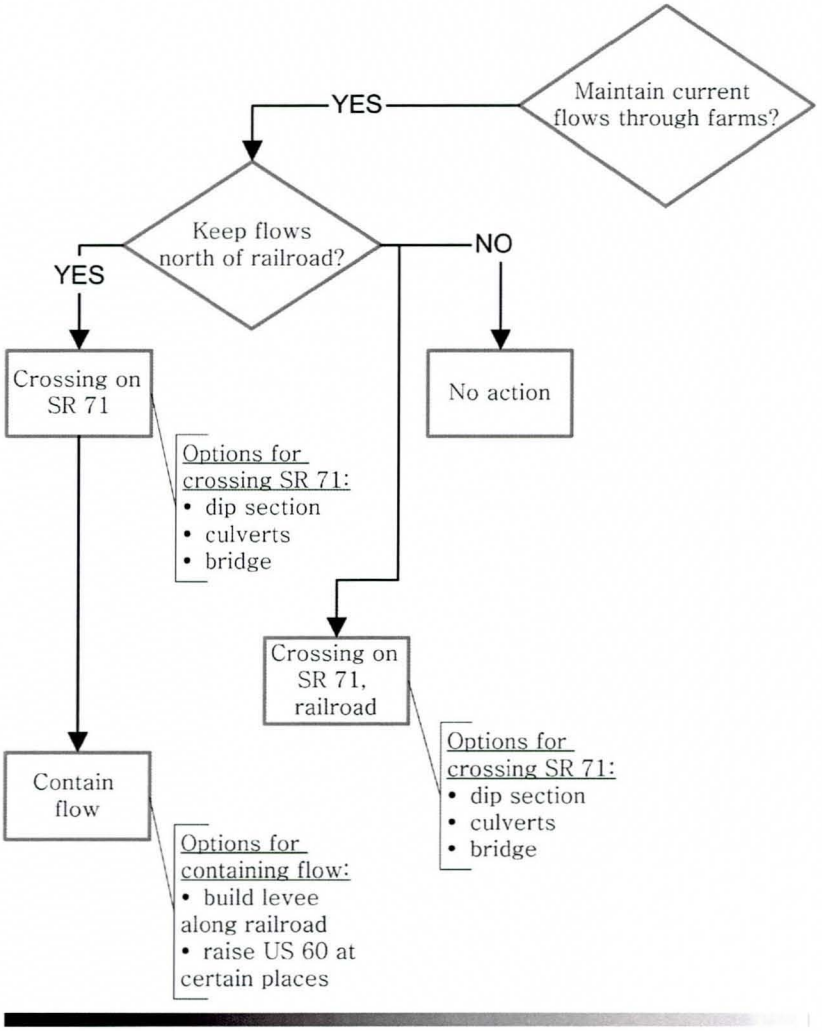


Figure 4-2: Decision Tree 1: Maintain existing flow pattern through the farms

Again, if the existing flow pattern is managed, the option to keep the flows north of the railroad arises. As was decided before, either route is potentially feasible. If the flows are kept on the north side of the railroad, a crossing at SR 71 would be necessary and those flows would need to be managed so that they are either contained and/or directed away from the existing farms. This can be achieved with various options that are considered potentially feasible (see Figure 4-3). The only infeasible option (depicted with a gray box) was the construction of a large dike system north of the farms.

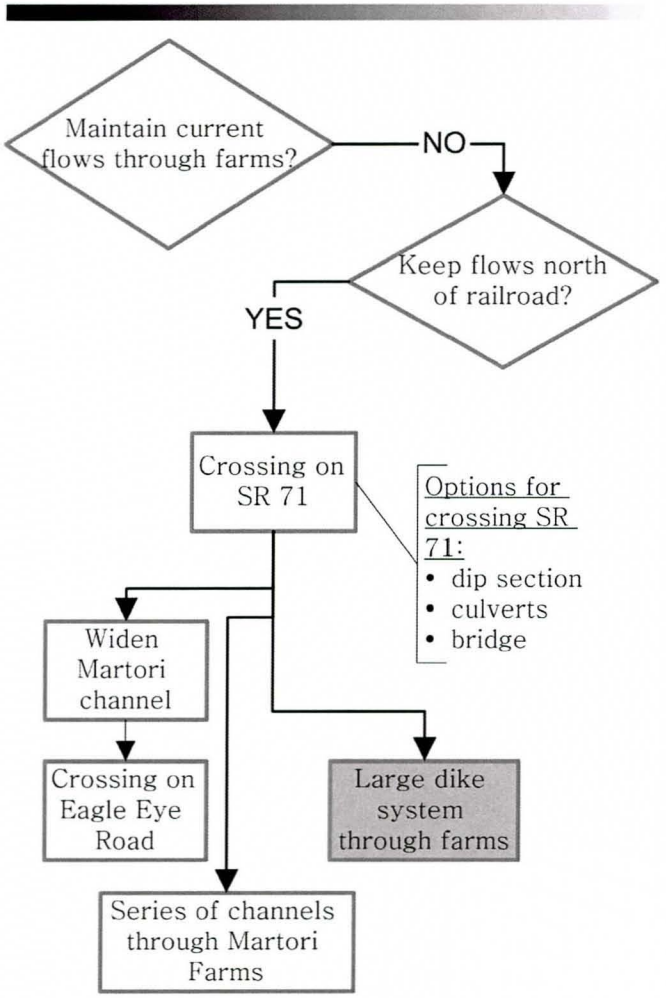


Figure 4-3: Decision Tree 1. Do not maintain existing flow patterns through the farms and keep flows north of railroad

On the other hand, if the flows head south of SR 71, there are two options for their management (Figure 4-4). They can be conveyed or detained. The alternatives for either of these options were considered potentially feasible. Additional evaluation using hydrologic analysis was performed for an off-line basin option to determine its feasibility. The additional analysis was used to determine if it is economically feasible to construct a basin large enough to prevent the flood damage associated with an uncontrolled discharge over the railroad.

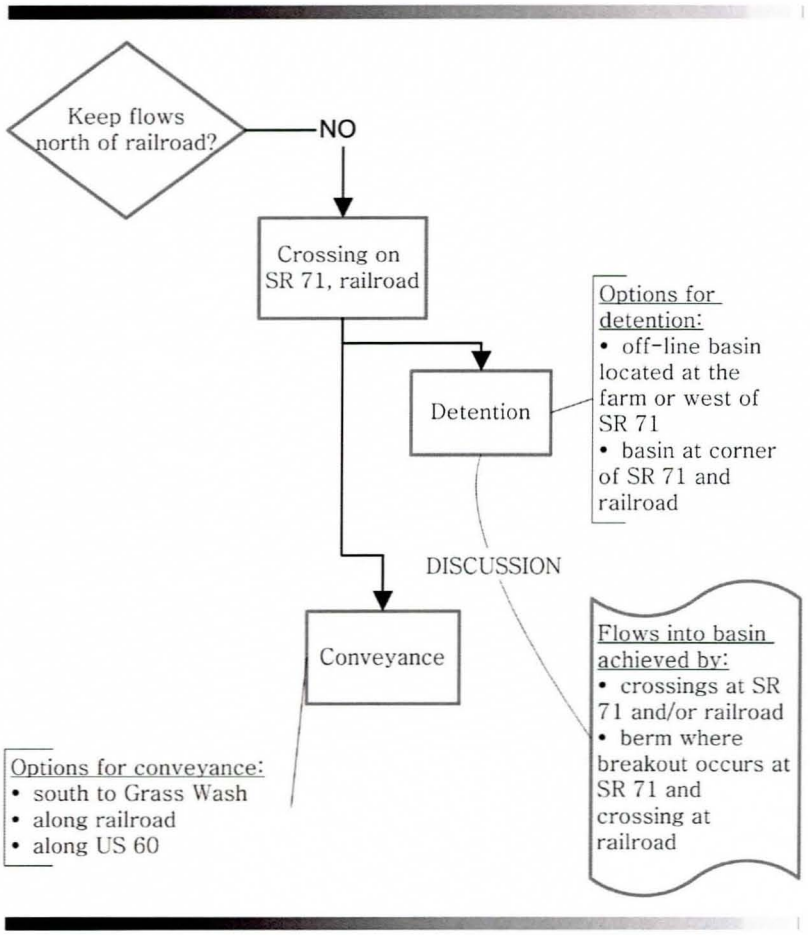


Figure 4-4: Decision Tree 1. Do not maintain existing flow pattern through the farms and do not keep flows north of railroad

The following table summarizes the discussion of Decision Tree 1:

Table 4-1: Summary of Decision Tree 1

Decision Tree 1: Flows on the north (Centennial Wash floodplain through the farms)		
Feasible Alternatives	**Alternatives for Further Analysis**	**Infeasible Alternatives**
• Crossing on SR 71 (dip, culvert, etc.)	• Off-line detention basin south of railroad:	• Large dike system north of farms
• Crossing on Eagle Eye Road (dip)		
• Widen Martori channel	Hydrologic analysis would have to be performed to determine feasibility. Specifically, is it economical to construct a basin large enough to contain the hydrograph peak, preventing damage associated with an uncontrolled discharge over the railroad?	
• Series of channels through Martori Farms		
• Diversion dikes through Martori Farms		
• Conveyance of flows: south to Grass Wash, along US 60, or along railroad		

Decision Tree 2 (Figure 4-5) focuses on the flooding problems in the Grass Wash watershed. The main concern is whether or not to take action in this area.

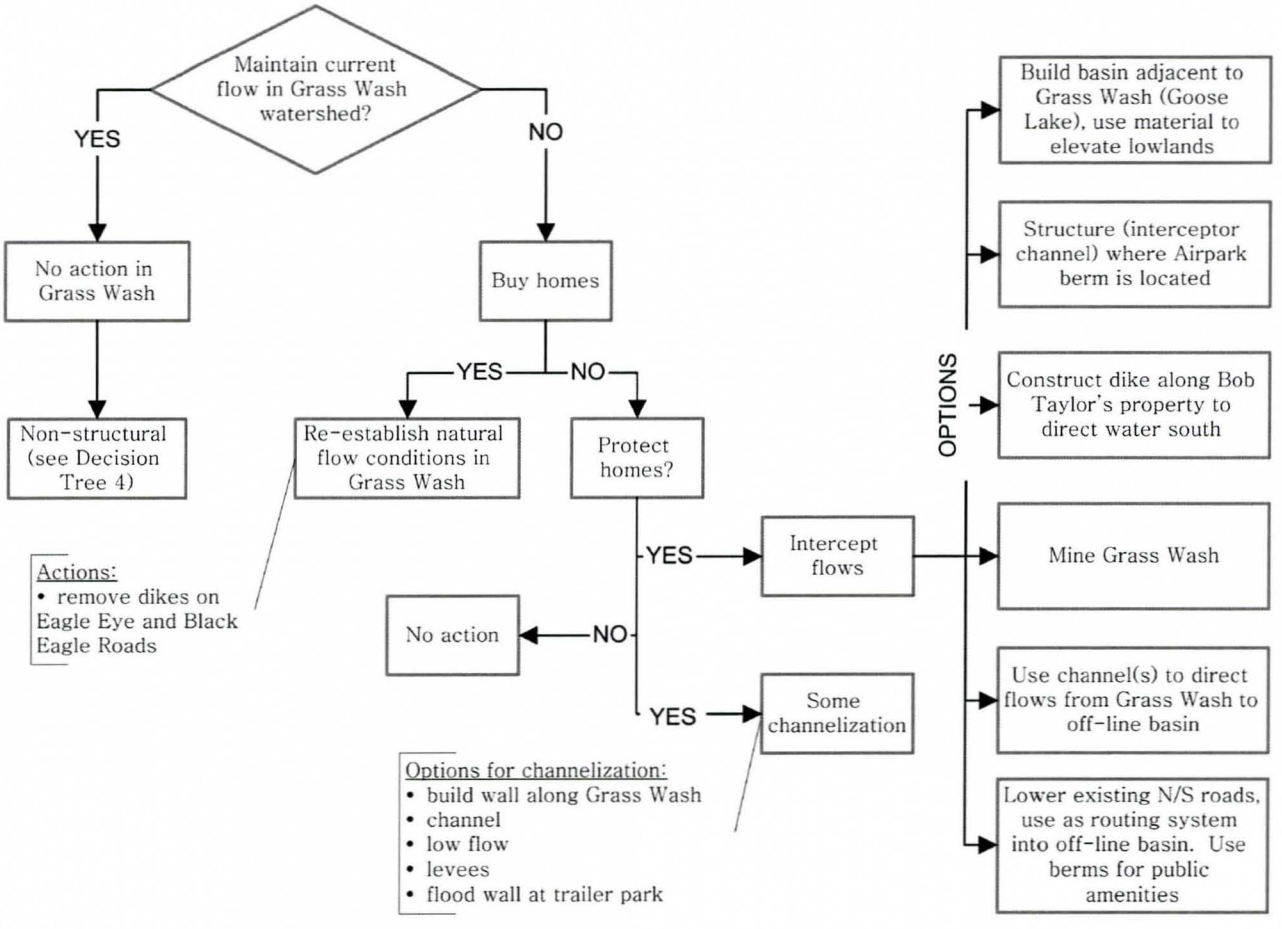


Figure 4-5: Decision Tree 2. Flows on the south (Grass Wash floodplain)

If the flows are left as they are, a "no action" alternative may be considered (Figure 4-6). In this case, the potential flood damage within the Grass Wash watershed was documented, and no further action was taken.

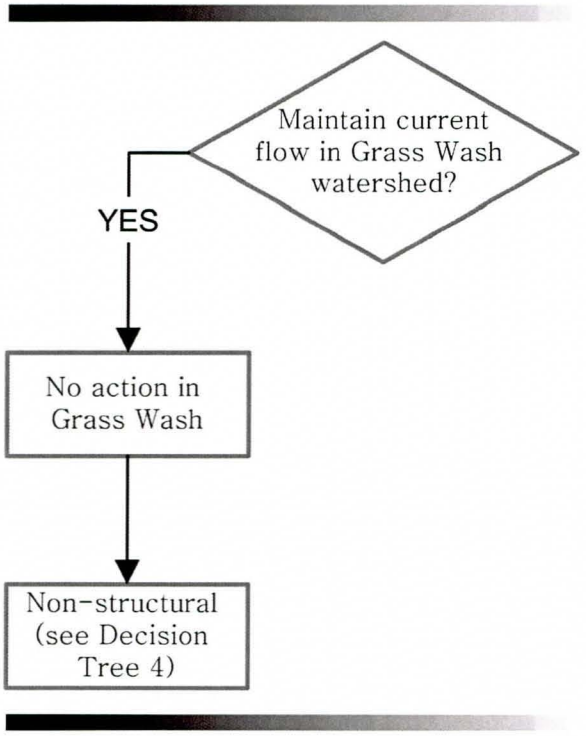


Figure 4-6: Decision Tree 2. Maintain current flow in Grass Wash

In addition, other non-structural alternatives can be considered without affecting the existing flows. The existing properties located within the floodway or floodplain may benefit from non-structural solutions even if a "no-build" solution is taken. Individual properties may benefit from flood proofing, education, and possible buy-out programs.

If the flows of Grass Wash were to be managed, not allowing them to follow their existing course, and in order to protect the homes located in the floodplain, the question of purchasing the homes comes up. Based on previous experience with the Aguila Hazard Mitigation Program, the purchasing of all homes located in the floodplain was considered infeasible. If homes are not purchased, a decision must be made of whether or not to protect these homes. It is evident that if they are not protected, no action would be necessary. Conversely, if the homes are to be protected, there are various ways to achieve this by intercepting the flows or partially channelizing them.

Another option of clearing excess vegetation along Grass Wash was suggested. This, along with establishing a low-flow channel, may provide some protection in the wide, flat floodway.

For the interception of flows, various options were considered infeasible. Constructing a basin to re-establish Goose Lake, constructing an interceptor channel at the Airpark, and constructing a dike along the existing farmland were all eliminated. The first two options were not economically feasible and the third option only provided protection to privately owned farmland, which is not in accordance with the District's goals and objectives. Mining Grass Wash and lowering existing north/southbound roads to intercept flows and direct them into a basin were also eliminated from further consideration (Figure 4-7), all noted in gray.

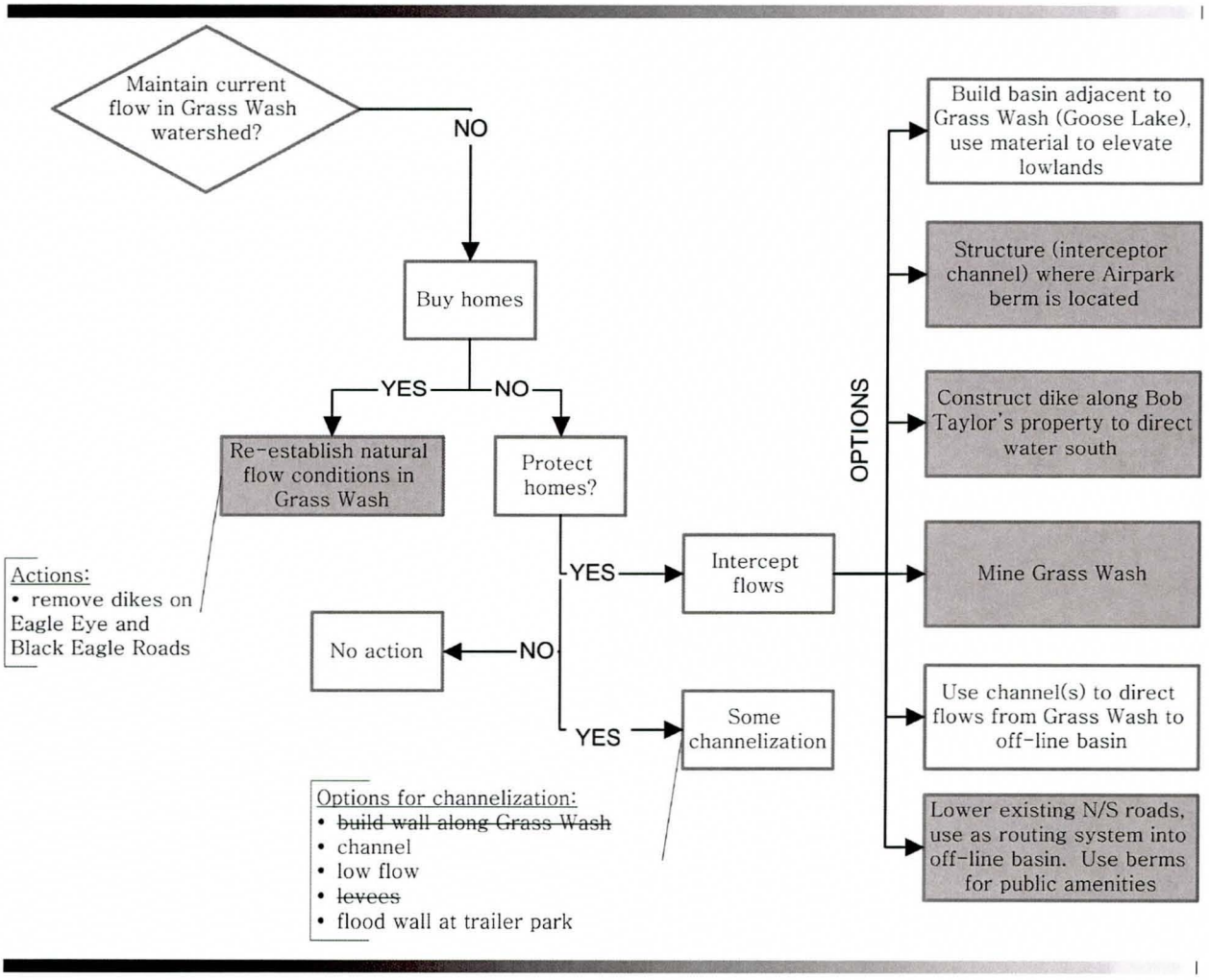


Figure 4-7: Decision Tree 2. Do not maintain current flow pattern in Grass Wash

Table 4-2 summarizes the discussion for Decision Tree 2:

Table 4-2: Summary of Decision Tree 2

Decision Tree 2: Flows on the south (Grass Wash floodplain)		
Feasible Alternatives	**Alternatives for Further Analysis**	**Infeasible Alternatives**
• No action in Grass Wash, document and quantify flood damage.	• Clear excess vegetation in Grass Wash. Sensitivity analysis of the hydrologic model is required to determine whether this concept would result in any meaningful flood control benefits.	• Re-establish natural flow through Grass Wash (eliminating dikes, relocating all properties within the floodplain).
• Some channelization: build channel, build low-flow channel, floodwall/levee at the trailer park.	• Construct detention basin in Grass Wash and conveyance facilities into the basin. Hydrologic analysis would have to be performed to determine feasibility. Specifically, is it economical to construct a basin large enough to contain the hydrograph peak, preventing damage associated with an uncontrolled discharge over the railroad?	• Re-establish Goose Lake. • Construct dike along Bob Taylor's property to direct flows south, protect agricultural fields. • Mine Grass Wash. • Lower existing north/south roads, use a routing system into off-line basin.

Decision Tree 3 focused on exploring alternatives upstream and downstream throughout the watershed (see Figure 4-8). There are a number of stock tanks and other structures believed to provide some degree of flood protection, even though they were not originally designed for this purpose. These structures include berms, levees, and dikes (e.g. spreader dikes). Many of these structures are old and have silted in with time. They currently do not function to the capacity they once had (as none were designed to engineering standards), decreasing the amount of detention they once provided. The effect of these structures on excess runoff resulting from a 100-year storm was evaluated in order to determine the feasibility of reconstructing these structures.

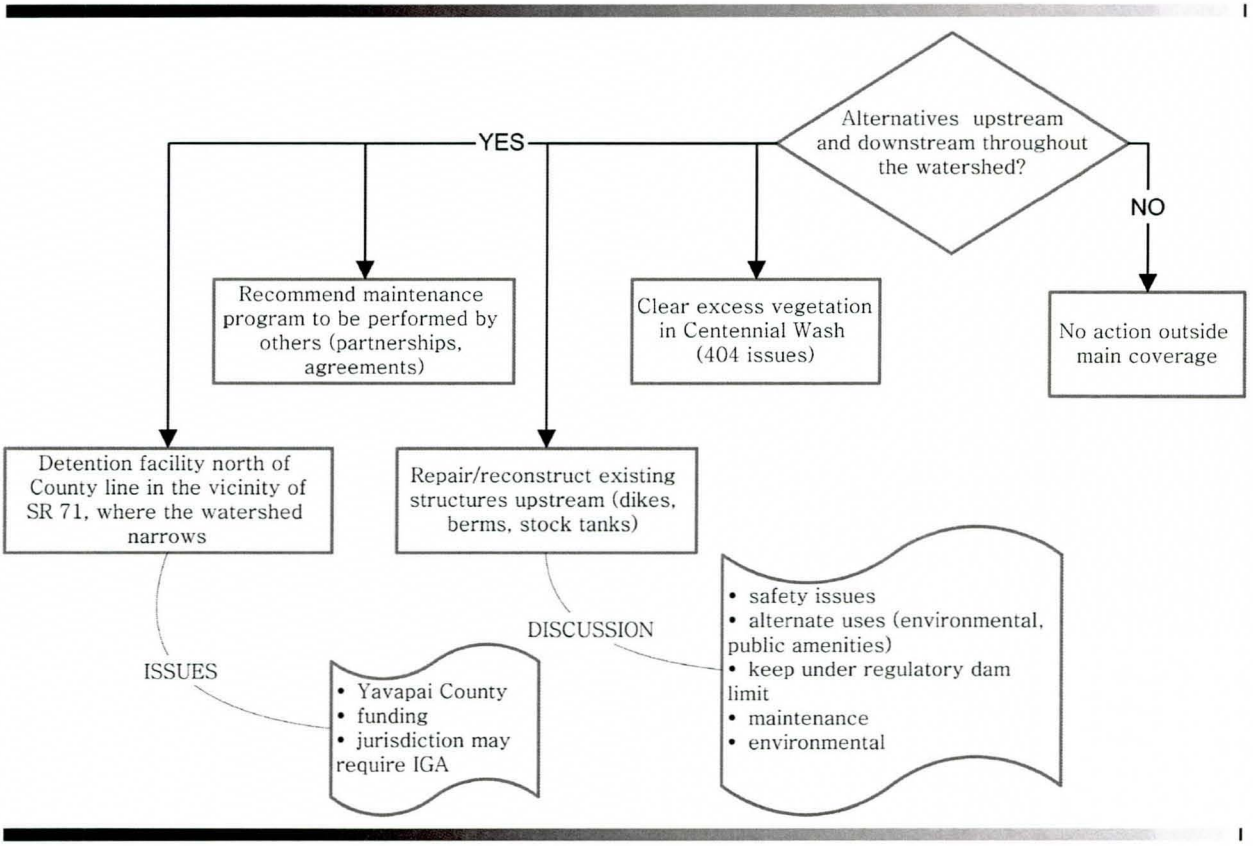


Figure 4-8: Decision Tree 3. Explore alternatives upstream and downstream throughout the watershed

If options upstream and downstream throughout the watershed are considered, there are various alternatives that can be explored. The options of constructing a detention facility north of the Maricopa County line and clearing vegetation in Centennial Wash were eliminated (see Figure 4-9).

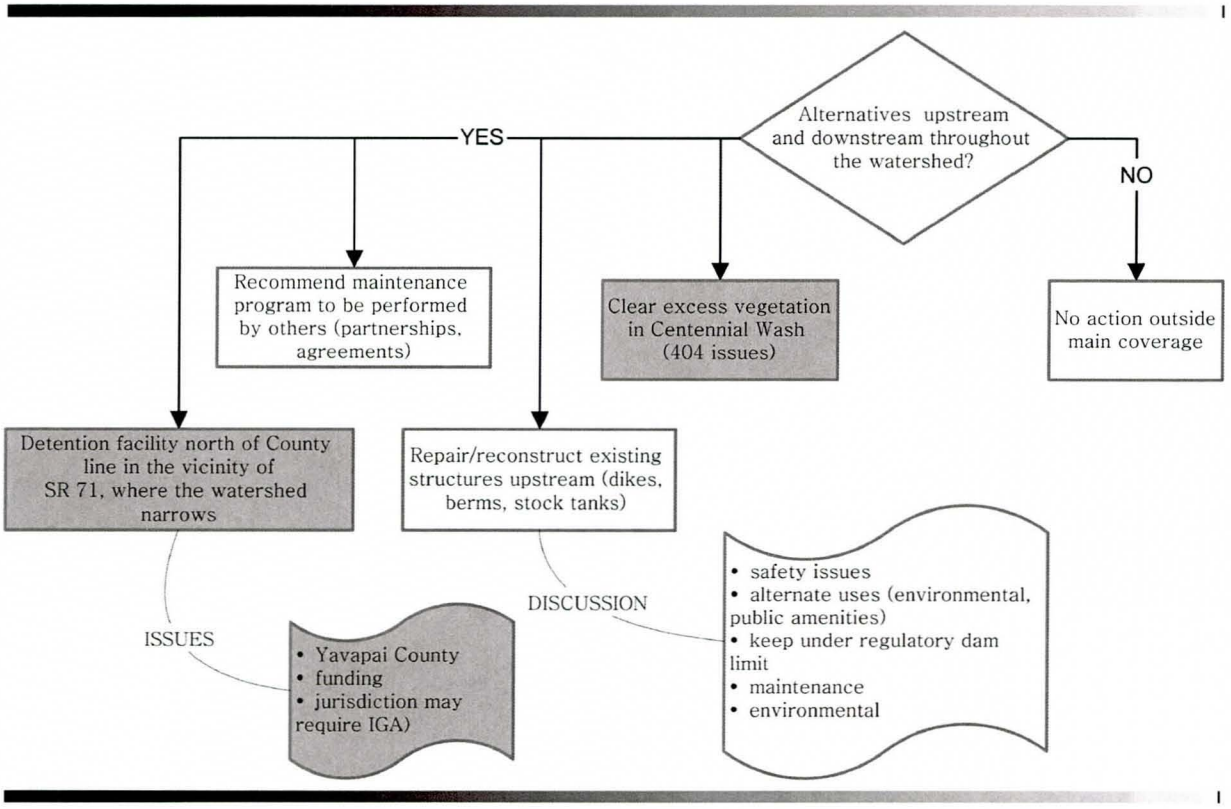


Figure 4-9: Decision Tree 3. Explore alternatives upstream and downstream throughout the watershed

Table 4-3 summarizes the discussion for Decision Tree 3:

Table 4-3: Summary of Decision Tree 3

Decision Tree 3: Explore Alternatives Upstream and Downstream Throughout the Watershed		
Feasible Alternatives	**Alternatives for Further Analysis**	**Infeasible Alternatives**
	• Repair/reconstruct existing structures upstream. Additional hydrologic modeling of the watershed is required to quantify the effect that restoring these features located on State and BLM lands would have on downstream flood control.	• Clear excess vegetation in Centennial Wash. • Detention facility north of existing County line in the vicinity of SR 71 (where watershed narrows).

Decision Tree 4 (Figure 4-10) focused on non-structural alternatives. These options can be implemented alone or in combination with any of the options discussed earlier.

Additional analysis was performed to determine the cost-effectiveness of flood proofing in the Study Area. Single-home flood proofing may be an option that can be considered for this area but the value of the existing properties may not warrant costly flood proofing measures. The results of the additional analysis were used to determine if this option was carried on to Phase II.

For land swaps and ventures, two of the three options were eliminated. These were relocating homes and/or farmland and using City of Phoenix land located in La Paz County for a land swap. For the options mentioned in relocation, there were no truly feasible alternatives.

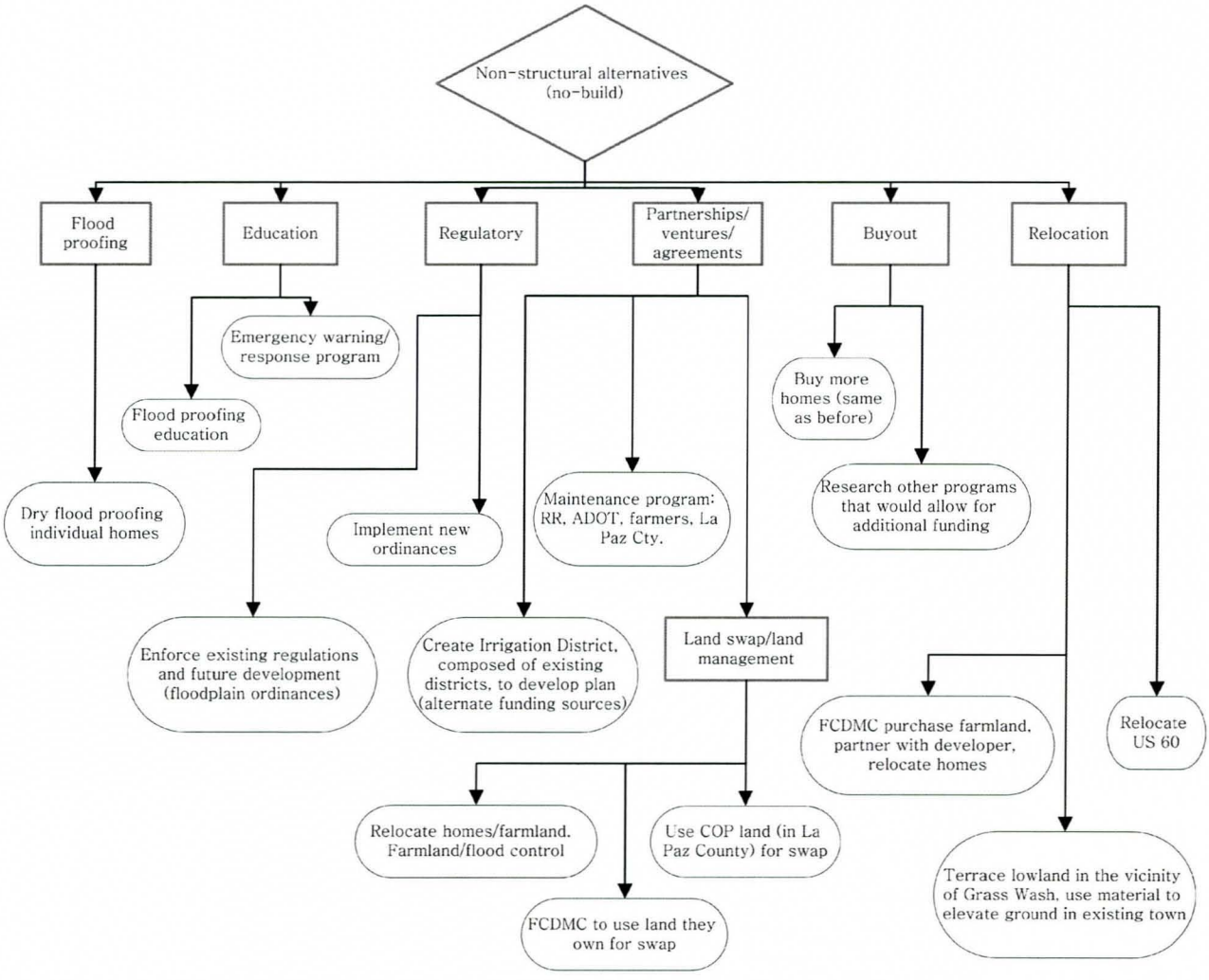


Figure 4-10: Decision Tree 4. Non-structural alternatives

The following table (Table 4-4) summarizes this discussion:

Table 4-4: Summary of Decision Tree 4

Decision Tree 4: Non-Structural Alternatives		
Feasible Alternatives	**Alternatives for Further Analysis**	**Infeasible Alternatives**
• Education. Provide community with information on flood proofing, emergency response, etc.	• Flood proofing. Cost/Benefit analyses should be performed to determine level of flood proofing for individual residences that may economically compete with other alternatives.	• Relocate all properties within floodway/floodplain.
• Rules for development.	• Implement maintenance program by partnering with others.	• Relocate US 60.
• Enforcement.		• FCDMC to purchase land, partner with a developer to relocate homes – only possible with public entities.
• Create FCD composed of various entities.		• Relocate/Reconstruct. Terrace lowland areas, use material to elevate existing community.
• FCDMC to use land they own for possible land swaps, on a limited basis.		
• Explore additional buy-out programs.		

Some of the alternatives provide other benefits in addition to flood control. Improvements to existing infrastructure, such as the road crossings at SR 71 and Eagle Eye Road, whether they are dip sections, culverts, or other solutions, could provide safer roads for drivers and pedestrians. Some channelization of Grass Wash, by constructing a floodwall or levee, may provide more controlled access to natural areas, thereby protecting wildlife and preventing public safety concerns such as open spaces being used for off-roading.

Developing a flood warning/response program can help the community work together during other types of hazards.

However, implementation of some of the alternatives discussed would not be cost-effective. The quantifiable value of existing properties in Aguila and related infrastructure may be much less than the cost of flood control. This is why non-structural and unique solutions became the main focus of this study.

PART 5. ALTERNATIVES

ALTERNATIVE ANALYSIS

During Alternative Formulation and subsequently by the District, the following alternatives were identified for further analysis:

1. Repair/reconstruct existing structures upstream.
2. Clear excess vegetation in Grass or Centennial Washes.
3. Off-line detention basin south of railroad.
4. Construct detention basin in Grass Wash and conveyance facilities into the basin.
5. Flood proofing.
6. Implement maintenance program by partnering with others.

Studies for alternatives 1 through 4 were completed and the reports are provided in Appendix B. Items 1 through 4 either proved to not serve any substantial benefit or were prohibitively expensive. Items 5 and 6 (discussed later in this section), both non-structural solutions, were considered potentially feasible and additional research was undertaken.

The District also identified four possible additional structural solutions for further analysis. Schematic or concept designs for these three scenarios were analyzed. They were: 1) replace the culverts at SR 71 north of US 60 with a bridge large enough to convey the 100-year flow under the roadway; 2) a 100-year capacity channel downstream of SR 71 through the farming area; 3) replacement of the highway bridge and railroad trestle at US 60 on Grass Wash to convey the 100-year event with limited backwater, and 4) modifications on Eagle Eye Road at Aguila Farm Channel. An additional alternative was considered – a combination of numbers 1 and 2, as number 1 did not work alone due to the difficulties with backwater associated with the proposed SR 71 bridge. This option is discussed under both alternatives 1 and 2.

These alternatives were analyzed to determine the engineering feasibility and approximate costs. The effects of these alternatives were evaluated within the approved hydraulic model(s). These facilities were also assessed for potential impact of future flooding on structures, public infrastructure, and transportation corridors.

The evaluation included a revision of the hydraulic model to determine the extent of the potential floodplain based on conditions changed through implementation of each alternative.

Costs were estimated for major project components to include design, major construction items, utility relocation, land and right-of-way acquisition, contingencies, engineering, and legal, and estimates of operation and maintenance costs.

1. Bridge Replacement at SR 71 North of US 60

The purpose of the evaluation of the bridge replacement at SR 71, north of US 60, was to determine the approximate bridge opening that would allow the 100-year, 24-hour storm event to pass underneath the bridge. The existing hydrology and hydraulics for this area were developed

under Phase I of the Aguila ADMP. The geometry of the existing area was modified in the HEC-RAS model to develop various conceptual designs that would have a sufficient bridge opening to allow the conveyance of 100-year, 24-hour storm event.

The methodology for this alternative was to vary the HEC-RAS geometry of the four existing 7-foot diameter culverts and vary the bridge openings and analyze the effects on the water surface elevation at the bridge. Results of this analysis are presented in Appendix C, Calculations for Structural Alternatives. The only alternative that had any visible effect on the water surface elevation was a bridge with a 500-foot by 10 foot bridge opening. However, this is with a water surface elevation downstream based on existing conditions. With revising the downstream water surface elevation by incorporating a 100-foot bottom width channel (see analysis of the Aguila Farm Channel), a bridge that spans a 125-foot by 10-foot bridge opening would be large enough to convey the 100-year storm.

In summary, the bridge replacement at SR 71, with a 125-foot bridge section wide enough to convey the 100-year storm, would drop the water surface elevation at the bridge, only if a channel downstream of SR 71 was constructed to lower the downstream water surface elevation. A new bridge would require improvements to the Aguila Farm Channel to function correctly. The bridge work alone would cost approximately $1,137,000.

The impacts of constructing a bridge large enough to convey the 100-year event at SR 71 within the Aguila Farm Channel are: 1) breakout over the railroad would not occur; 2) conveyance through the bridge would increase, thereby reducing any backwater effect upstream; 3) reduce overbank storage (reduced ponding would allow floodwaters to move faster through the area); and 4) potentially increase erosion. However, only replacing a bridge is not an option. Combining the bridge replacement alternative with a channel downstream would produce the desired results.

2. Aguila Farm Channel Downstream of SR 71

This analysis utilized the effective FIS HEC-2 model for Aguila Farm Channel, converted to the currently approved hydraulic model HEC-RAS. Results of this analysis are presented in Appendix C, Calculations for Structural Alternatives.

The analysis evaluated the channel downstream of SR 71, through the farming area, and determined a channel that would convey the 100-year, 24-hour storm event. URS Consultants completed the existing hydrology and hydraulics calculations for this area in May of 1990 and these models were used to develop this alternative. The HEC-2 model of the existing area was used and imported into HEC-RAS in order to develop various conceptual designs for the channel that would allow the 100-year, 24-hour storm event to be conveyed.

The goal of the development of the channel was to reduce the surface area covered by the floodwaters and reduce backwater effects upstream at SR 71.

Three channel scenarios were developed at 100-, 200-, and 300-foot bottom widths. However, all resulted in some backwater effects downstream. The first scenario was a 100-foot wide earth-lined channel within

the same alignment of the existing channel. This design contained the 100-year storm, but backwater effects downstream still existed at the confluence with Centennial Wash. The second scenario was a channel that had a fixed bottom width of 200 feet within the same alignment. This proved to hold the 100-year storm, but backwater effects downstream still existed at the confluence with Centennial Wash. The third scenario was a channel that had a bottom width of 300 feet, but backwater effects downstream still existed at the confluence with Centennial Wash. A summary of this analysis is located in Appendix C, Calculations for Structural Alternatives.

A combined scenario used a combination of analyses based on the results of the analysis of the bridge replacement at SR 71 and the analysis of a channel through the farming area. The approach was to combine the 125-foot bridge opening at SR 71 and the channel through the Aguila Farm Channel with the varying bottom width to see the effects of the backwater and if it reduced the water surface elevation at the bridge. This alternative had a minimal effect on the water surface elevation, but did reduce the water surface elevation at the bridge.

In summary, a 100-foot channel at 6 to 1 side slopes would convey the 100-year event, reduce overbank storage, and reduce backwater affects upstream. However, backwater effects from Centennial Wash downstream would reduce the channel capacity at the downstream end. Combining alternatives for Centennial Wash, Aguila Farm Channel, and the bridge replacement at SR 71 reduce the water surface elevation and overbank storage through this area.

The impacts of a 100-year capacity channel downstream of SR71 through the farming area are: 1) conveyance through this area would increase, thereby reducing any backwater affect upstream (this would remove a portion of the farm from the floodplain); 2) reduce overbank storage (reduced ponding would allow floodwaters to move faster through the area); and 3) potentially increase erosion. Flow increases due to reduced time of concentration caused by increased velocities are small compared with the magnitude of the 100-year flow. The five miles of channel alone would cost approximately $2,300,000, assuming no real estate acquisition and minimal environmental permitting.

3. Bridge Replacement and Railroad Trestle at US 60

Evaluation of this alternative was accomplished by using the effective FIS HEC-2 model for Grass Wash, converted to the currently accepted hydraulic model HEC-RAS. Replacement of the highway bridge and railroad trestle at US 60 on Grass Wash to convey the 100-year event with limited backwater was evaluated by a series of iterations within the HEC-RAS modeling.

URS Consultants developed the existing hydrology and hydraulics for this area in May of 1990. The HEC-2 model of the existing area was imported into HEC-RAS in order to develop various conceptual designs for bridges that would have a sufficient bridge opening to convey the 100-year, 24-hour storm event without floodwaters overtopping the bridge, which is the case now. When the HEC-2 model was imported into HEC-RAS. The cross-sections up-stream and downstream and the bridge cross-sections were corrected to reflect the

existing topography based on maps and drawings on file.

The methodology for this alternative is similar to the analysis for the bridge replacement at SR 71, varying the HEC-RAS geometry of the bridge and railroad trestle in order to develop various bridge sections and analyze the effects on the water surface elevation at the bridge. These data are presented in Appendix C, Calculations for Structural Alternatives. A bridge with a 500-foot opening and railroad trestle with an opening of 600 feet significantly reduces the water surface elevation. However, there are still backwater effects upstream of the US 60 bridge due to the flow rate conveyed and the backwater from the Aguila Farm Channel. Floodplain widths were not substantially reduced.

Cost for replacement of both bridges is estimated at $3,700,000.

The impacts of replacing the highway bridge and railroad trestle at US 60 on Grass Wash to convey the 100-year event with limited backwater impacts are: 1) conveyance through this area would increase, thereby reducing any backwater effect upstream; 2) reduce overbank storage (reduced ponding would allow floodwaters to move faster through the area); and 3) potentially increase erosion. Flow increases due to increased travel time caused by increased velocities are small compared with the magnitude of the 100-year flow. Increasing the bridge opening and railroad trestle had significant effect on lowering the water surface elevation but there were still some backwater effects from the Aguila Farm Channel and the lack of slope in Grass Wash.

4. Eagle Eye Road at Aguila Farm Channel

The District requested that HDR assess the potential placement of stop log gates, or alternatively lowering the dip section, on Eagle Eye Road at the Aguila Farm Channel. A Technical Memorandum addressing this is included in Appendix B of this report. The study reviewed the effects of either 4-foot high stop log gates or lowering the dip section by 4 feet. The respective costs are $18,000 or $93,000 for construction only. If gates are installed, they will require the additional cost of periodic testing and maintenance in the future. While there are some issues regarding final design, these alternatives are considered feasible and are included in the Recommended Plan.

NON-STRUCTURAL SOLUTIONS

Numerous non-structural solutions were identified and of those, the following solutions were further evaluated:

- Public Education
- Flood Response Plan
- But-Out Program
- Flood Proofing
- Land Trades
- Special Districts or Zones

The first two items, Public Education and a Flood Response Plan, are not true non-structural solutions. They don't prevent flooding and the associated structural and contents damages that can occur. However, they can possibly decrease the risk of injury or loss of life.

Flood Response Plan

A flood response plan (FRP) was prepared by HDR Engineering, Inc. for the District. The plan focuses on three washes:

Centennial Wash, Grass Wash, and Aguila Farm Channel. The primary goal of the FRP is to provide the opportunity for local, county, state and federal agencies that perform flood related activities in the Aguila area to perform their activities in a pro-active mode.

The plan covers the elements of Flood Threat Assessment, Prediction/Detection Criteria, Communication Flow, and Preparedness Levels of Green, Orange, and Red.

The cost of the FRP was $98,000.00. This cost includes preparing the plan and presenting it to the public. The FRP is a pivotal element of the Recommended Plan.

Public Education

A public education plan was developed and is a part of the Recommended Plan. It centers on providing information to Aguila residents on several topics, including but not limited to: the FRP and flood insurance options.

The FRP (described above) was presented to the residents and stakeholders on September 9, 2003. The County will continue to educate the residents regarding alerts and actions to take in the event of an actual or predicted flood. Other ongoing education could include providing information to farm workers at the Martori Farms Tuesday morning tailgate safety meetings. Also in the future, the Emergency Response Lead staff will hold meetings (ideally twice a year, in the spring and fall). Personnel from Martori Farms, the school, the library and the Volunteer Fire Department will be invited. The County will educate any new personnel on the elements of the FRP and update attendees with any new information.

On November 5, 2003, another public meeting was held to present the Area Drainage Master Plan. At this meeting pamphlets and fliers were provided to the residents describing flood insurance options available through FEMA. All eligible residents were encouraged to purchase insurance.

The future public education plan costs include primarily personnel hours on the part of the County Emergency Response Lead and its staff. Preparation and meeting time, twice a year, would be approximately 48 hours at approximately $100 per hour for a total of $4,800 per year. FEMA pamphlets and fliers are available at no cost from the government and would be distributed as well.

Buy-Out Program

For structures that experience repetitive flooding, one type of flood mitigation approach is the permanent removal of the structure from the floodprone area. As described below, there are two types of funding programs available in Maricopa County that could be pursued for the Aguila area.

Local Buy-Out Program

In 1995, the District's Board of Directors authorized the Alternative Flood Control Works Program, which provided limited funding for non-structural flood mitigation, including purchasing and removing residences from the floodplain. The program was recently renamed the Floodprone Properties Acquisition Program FCD 95-01A (see Appendix D) and was modified to provide better definition of

program criteria and selection processes. Participation in the program is voluntary, is limited to inhabited residential properties, and includes several eligibility criteria.

There are a number of properties in Aguila that could be evaluated for eligibility in the program. It is noted that after the October 2000 flood, a number of properties in Aguila were offered buy-out assistance, but most declined. It is believed that the primary reason for the low participation was reluctance of the homeowners to move from the area.

Federal Buy-Out Programs

There are three federal buy-out programs available that are administered by the Arizona Department of Emergency Management (ADEM).

The National Pre-Disaster Mitigation Program has $150 million available with a primary goal of reducing repetitive losses. Of the $150 million, nearly $14 million has been set aside for states to develop Hazard Mitigation Plans. It is noted that the funds are available nationwide, so Aguila would be competing for funds against numerous applicants across the country. Funding requirements are typically 75% federal and 25% non-federal; however, for small rural communities such as Aguila, the cost share would be 90/10. Participation in this program is contingent on having first developed a Hazard Mitigation Plan, an effort that is being administered by ADEM.

The Flood Mitigation Assistance Program offers assistance to properties whose communities participate in the National Flood Insurance Program (NFIP) and that have experienced repetitive losses or substantial damage (greater than 50%) in one or more floods. Maricopa County participates in the NFIP program so Aguila residents would be eligible. However, participation is limited to properties that carry flood insurance.

The Hazard Mitigation Grant Program makes funding available to selected applicants after a disaster has been declared. An example of this application of the Hazard Mitigation Grant Program was the relocation of Winkelman Flats in southeastern Arizona after the 1993 floods. However, if funds are granted, they become available to the entire state, not just the areas that experienced the particular disaster. Further, funding is limited to 7.5% of the total (public and private) damages incurred.

The primary advantage to a buy-out program is the permanent elimination of future flood threat to participating structures. Additionally, the program is expected to be less expensive than a major storm drainage infrastructure that would be needed to provide equivalent protection if structural solutions were pursued.

A primary disadvantage of a buy-out program is the issue of future property management. If the District purchases property in remote areas such as Aguila, periodic property maintenance requires a disproportionately large resource allocation. In particular, problems have arisen in other areas where vacant land has been used locally as an illegal landfill. Additionally, there are several considerations that would diminish the effectiveness of a buy-out program, including:

- Residents are typically reluctant to move, as demonstrated after the October 2000 flood. Unfortunately, the overall program effectiveness would be minimal

unless most or all of the floodprone residents participate.

- Funding from existing local and federal programs is very limited, and program restrictions, particularly at the federal level, may preclude buy-outs in Aguila.
- Unless participants relocate to non-floodprone areas, the problems are simply transferred, not solved. The District has an aggressive program to map floodplains in the county, but currently less than 20% are mapped. Therefore, care must be taken to ensure that program participants do not relocate to other floodprone areas.

A possible estimate of costs to implement a Buy-Out Program at the local (non-federal) level is presented in Table 5-1. Housing values used to develop unit cost data are included in Appendix B, Flood Proofing Techniques. In developing the costs, the following conditions were assumed:

- Participation is expected to be low.
- Buy-Out is a last resort if flood proofing is not viable.
- Many homes would be ineligible because 1) they don't have a valid building permit or 2) they have been previously damaged by flooding.
- The average home value ($41,516) was calculated as an average of home values in Aguila considered under the flood proofing scenario.
- The number of homes was calculated as a percentage (50%) of the total homes that are in the current and newly delineated flood zones based on the percent of homes within the floodplain that were flooded previously (50% of 48 existing and 316 new delineated area).
- The homes were assumed to be split evenly between mobile and pre-manufactured construction based on a similar ratio of homes within the existing floodplain.
- Type of home construction considered for buy-out was assumed to be 50% mobile homes and the remainder split between pre-manufactured and single-family homes.
- Costs do not include the future management of purchased properties.

Table 5-1: Buy-Out Program Cost

Buy-out Program Cost		
Type of Construction	**Number of Units**	**Unit Buy-out Cost (based on estimated current home value)**
Mobile	91	$4,000
Pre-Manufactured	46	$25,000
Single-Family	45	$70,000

Because of the serious concern over the District being able to adequately maintain acquired properties, and due to the unlikelihood of program participation by the local residents, a buy-out program was not considered further for inclusion in the recommended plan.

Flood Proofing Options

In Appendix B, Flood Proofing Techniques is a report summarizing research into various flood proofing methods used nationally. The predominant methods include:

- Dry Flood proofing
- Wet flood proofing
- Elevation of structures (on fill or structural members)
- Perimeter Flood walls (with or without closures)

These methods were then evaluated specifically for suitability in the Aguila area and are summarized below.

Dry Flood Proofing
Dry flood proofing consists of sealing a structure's walls with impermeable sealants or barriers. Windows and doors are also protected, either by constructing them of impermeable material or by placing temporary barriers over them prior to flooding. Dry flood proofing has several constraints that make it an unsuitable option for Aguila. It is not suitable for flash flood areas because significant time is required if barriers need to be put in place. A special problem exists from the force of floodwaters due to a sudden breach of the Aguila Farm Channel. Dry flood proofing is also unsuitable in flood conditions greater than three feet because of hydrostatic pressure concerns. Additionally, the type and condition of structures would pre-empt dry flood proofing for many structures in Aguila because this technique cannot be used on wood frame houses and, in any case, the structure must be in good or excellent condition.

Wet Flood Proofing
Wet flood proofing consists of protecting part of a structure's contents while allowing it to flood inside and out. Wet flood proofing is considered unsuitable in flash flood situations because it requires intensive preparation prior to flooding such as covering outlets and covering, removing, or elevating portions of the structure's contents. Wet flood proofing is also unsuitable unless the structure is in good or excellent condition. Additionally, only a portion of the contents would be protected.

Elevation on Fill
Elevation on fill involves temporarily removing the structure, installing an elevated earth or other structural foundation above the base flood elevation (BFE), and replacing the structure. It is generally the most desirable approach because it is accepted by the Federal Emergency Management Agency (FEMA) as a first step in reclassifying a property within the flood fringe to remove its special flood hazard designation. A successful application for reclassification would remove the property from the floodplain and eliminate the requirement to purchase flood insurance for properties that hold federally insured mortgages. Additionally, it does not require human action during a flood to ensure that it protects as intended. However, removal and replacement of the structure dictate that the structure be in good to excellent condition.

Perimeter Floodwalls (No Closures)
Perimeter floodwalls can be constructed with the top of wall above the base floor elevation (BFE) around structures with or without closures. Without closures, driveways and sidewalks would have to be constructed with gentle slopes to allow automobile and pedestrian access and egress. At some locations, this scenario may not be possible because of space or configuration constraints on the property. However, floodwalls without closures are much preferred because they require no human action.

Perimeter Floodwalls (With Closures)
Perimeter floodwalls can be constructed with removable closures that require placement prior to a flood. Floodwalls with closures are not recommended because they require human action and advance warning. This type of flood proofing for most

structures in Aguila is not considered reliable for several reasons. First, the migratory nature of the population mandates intensive and repetitive public education. Second, the timing of a flood has a significant impact on the success of putting closures in place. For example, if a major storm occurs during the day while residents are away at work, the structures would not be flood proofed. If a major storm occurs at night, residents may be caught unawares and not be able to install the closures in time.

Additionally, even if a storm occurs when residents are awake and at home, regional climatic conditions produce flashy, sometimes unpredictable flooding. Therefore, a storm could develop suddenly and local residents may not have adequate notice to put closures in place. Another complication is that Aguila is subject to flooding by three major conveyances, including breakouts at any number of locations along the Aguila Farm Channel's non-engineered levees. In particular, flooding from a breakout of the Aguila Farm Channel could be catastrophic in nature (sudden and with large volumes of floodwater) and leave little reaction time.

As summarized in Table 5-2, most flood proofing techniques are considered unsuitable based on factors such as predominant type of home construction, typical condition of structures, and anticipated flood characteristics. However, elevation on fill and construction of perimeter flood walls without closures have been identified as potentially viable approaches.

*Table 5-2: Evaluation of Flood Proofing Methods**

Flood Proofing Methods for the Aguila Area

Method	Description	Suitability/Unsuitability Factors
Elevation on Fill	Walls, doors, and windows of structure are sealed with impermeable sealants or barriers.	• May result in reclassification of structure from flood zone • Does not require special preparation prior to flood • Unsuitable for structures in fair to poor condition
Flood Walls (no closure)	Wall is constructed above the BFE around the structure. Driveways and sidewalks are constructed with sloped access/egress.	• Sloped driveways and sidewalks may not be possible on all lots due to space or configuration limitations.
Flood Walls (with closure)	Wall is constructed above the BFE around the structure. Driveways and sidewalks are constructed at the adjacent grade. Barriers or closures are stored onsite and are put in place prior to flooding.	• Unsuitable Sloped driveways and sidewalks may not be possible on all lots due to space or configuration limitations.
Elevation on Structural Members	Structure is elevated on walls, piers, columns, or piles	• Unsuitable for structures in fair to poor condition
Dry Flood Proofing	Walls, doors, and windows of structure are sealed with impermeable sealants or barriers.	• Unsuitable for flooding depths >3 feet • Unsuitable for flash flood conditions • Unsuitable for wood frame construction • Unsuitable for structures in fair to poor condition
Wet Flood Proofing	Structure is allowed to flood inside and outside. Contents are enclosed in plastic, removed, or elevated prior to flooding.	• Unsuitable for flash flood conditions • Unsuitable for wood frame construction • Unsuitable for structures in fair to poor condition • Requires intensive preparation prior to flooding for activities such as covering outlets and enclosing, removing, or elevating contents.

Based on the publication "Flood Proofing, How to Evaluate Your Options", USACE National Flood Proofing Committee, July 1993.

Flood Proofing Program

Based on the evaluation of flood proofing methods and previously identified combination options, a program was developed for consideration by the District with the following options available to individual property owners:

- Elevation of entire structure on fill.
- Construction of a floodwall with no closure around the structure.
- Combined techniques for hybrid projects where the base mobile home structure is elevated on fill and a floodwall surrounds add-on structures.

These techniques could be used as a basis for a flood proofing program similar in concept to the District's existing Floodprone Properties Acquisition Program. The District could subsidize the cost of flood proofing qualifying homes in lieu of constructing large-scale structural drainage improvements. Qualifying criteria for participation in the program could include:

- Participation would be voluntary and would require formal application for assistance.
- Construction must be performed by a licensed, bonded contractor.
- The District could consider funding a portion of construction only (e.g., 75%); the owner would be responsible for the remaining portion.
- Flood proofing using any of the approved methods would be limited to a maximum rise in elevation of fill or flood wall of three feet. Therefore, in order to keep finished floors one foot above the BFE, only homes that are two feet or less below the BFE would qualify.
- Properties not able to meet the flood proofing criteria would be directed to consider applying for assistance under the Floodprone Properties Acquisition Program or other identified federal buy-out programs.
- An owner may choose to use a non-approved flood proofing method, but would bear 100% of the cost.

A description of the proposed techniques is provided below.

Elevation on Fill

Elevation on fill could be used for stand-alone structures such as single-family detached houses or mobile homes with no attached structures. It is noted that this option would be available only to structures able to withstand temporary removal and replacement. For example, this technique could not be used for a single-family detached home in poor condition.

Perimeter Floodwalls (No Closures)

Perimeter floodwalls could be constructed without closures if the property configuration would allow elevated driveways and sidewalks. Additionally, this technique could potentially be an option as a common perimeter wall for a group of homes such as the Fairhaven RV Park.

Elevation on Fill and Perimeter Floodwalls

A number of mobile homes have attached structures and they may benefit from combining the elevation and floodwall techniques. The mobile home portion could be elevated and the attached structure could be enclosed by a floodwall. As with the elevation-only scenario, the condition of the existing structure(s) dictates the applicability of this technique.

An estimate of unit costs to implement a Flood Proofing Program is presented in Table 5-3. Development of unit costs is

included in Appendix B, Flood Proofing Techniques. In developing the costs, the following conditions were assumed:

- Any structure with potential flood depths greater than two feet would not be eligible for flood proofing.
- Construction costs only were included in the estimate. However, an additional 20% of construction costs was included to cover any design work needed.

Applying participation assumptions similar to the buy-out program, the ultimate flood proof program costs would be:

Table 5-3: Flood Proofing Costs

Flood Proofing Program Cost		
Type of Construction	**Number of Units**	**Unit Flood Proof Cost**
Mobile	91	$18,000
Pre-Manufactured	46	$17,000
Single-Family	45	$22,000

It is noted that flood proofing for many houses would not be would not be viable due to the poor condition of the structure. Additionally, a number of houses could not accommodate the configuration of a passive floodwall on the property. As a result, participation in a flood proofing program is expected to be very small. Therefore, this option was not considered further.

Land Trades

The viability of implementing voluntary land trades with homeowners who live in flood susceptible areas was researched. It was found that the trading of land between a private citizen and a government agency, for the benefit of the general public, has a precedent in Arizona. Legislative, funding, and logistic obstacles to the implementation of a land trade program are identified below.

The District has initiated "voluntary property acquisition" programs in the past. Under these programs, the District offers to purchase the homes and property of people living in high hazard flood areas, in particular floodways. The District also provides relocation assistance. A land trade would require a value for value trade based on an estimate from an independent appraiser.

An important part of the process of designing and constructing a flood control project involves acquiring the land. The District Lands Division is responsible for property acquisition, property management, and titles and rights-of-way. In addition to the appraisal and acquisition of the property, the District also maintains the property until construction begins - keeping it secure and free from hazard, issuing use permits, and making decisions for the best use of the property. Homes that are acquired are often leased or rented until it is time to demolish them for construction.

Under the "Eminent Domain" provision, the District must pay the property owner 'just compensation' for their home and property. 'Just compensation' is normally based on the appraised value. If an agreement cannot be reached between the parties on the amount, then the court decides (condemnation procedures). In addition to paying 'just compensation,' the District also pays relocation assistance and must relocate the property owner to another home that is decent, sanitary, and safe, as well as a comparable replacement dwelling.

Land trades as a method of removing individuals from the floodplain is not recommended because: 1) it would be a circuitous and complicated process; 2) the District would be burdened by properties in remote locations that require maintenance and monitoring; and 3) it requires the acquisition of land to trade.

The direct approach of acquiring floodprone properties is preferred. This has been done on Skunk Creek with limited success. The District has instituted policies consistent with FEMA's guidelines on floodprone land acquisition.

Special District or Zone

The option of creating a Zone with project(s) of special benefit to that Zone is within the enabling legislation for County Flood Control Districts. This includes authority for constructing and maintaining flood control improvements. Legislative authority allowing the formation of Zones within the District can be found in ARS §48-3604.A:

> "The board may divide the area of jurisdiction into two or more zones, the boundaries of which shall be described in a resolution adopted at a hearing held pursuant to subsection C."

The purpose of the Zone concept is to have those who are to benefit from an improvement pay for and maintain those improvements. Should a structural facility be required, those who receive the direct benefits from the facility (e.g., reduced structural flooding, improved access, etc.) would pay for its construction. The Zone concept has been employed in Yuma County where it was of benefit to each property in the Zone and it established a separate tax levee.

Obstacles to the creation of such a Zone are legal (limited experience with Zones), political (limited experience with Zones), and financial (assessed value of the area may not support large public infrastructure projects).

Other special taxing districts include:

Agricultural Improvement District
ARS §48-2337.A.1, Chapter 17. "For the storage, regulation, control, development and distribution of water for the irrigation of lands within the district, for the use, control and disposal of drainage water within the district or for flood control purposes."

Drainage and Flood Protection Districts
ARS §48-2601, Chapter 18. "When five or more holders of title or evidence of title to agricultural lands which are susceptible of drainage by the same general system of works desire to provide for the drainage of such lands, they may propose the organization of a drainage district under the provisions of this chapter. When organized, the district shall have the powers, rights and duties conferred by law upon such drainage districts."

ARS §48-2664.B. "The board, its agents and employees may enter upon any land to make surveys and may locate necessary drainage works and lines for any canals, sluices, water-gates, sites and embankments, and the necessary branches thereof on any land which is deemed suitable for such location."

Flood Prevention Districts
ARS §48-2811.A. "When five or more holders of title or evidence of title to improved lands which are subject to overflow or washing, or menaced or threatened by the normal flow, flood or overflow waters of any natural watercourse, stream, canyon or wash, whether perennial, intermittent or flood, which can be protected or relieved from such overflow or menace by the same general system of works, desire to provide for the protection of such lands there from, they may propose the organization of a flood protection district in the manner provided by this chapter for the organization of drainage districts."

Irrigation and Water Conservation Districts, ARS §48-2901, Chapter 19. "All irrigation districts organized under the laws of this state are declared to be municipal corporations for all purposes. Under the laws of this state affecting or relating to irrigation districts such irrigation districts shall be deemed municipal corporations in the construction and application thereof.

ARS §48-2978.5. "Construct, acquire or purchase canals, ditches, reservoirs, reservoir sites, water, water rights, rights-of-way or other property deemed necessary for the use of the district."

The Aguila Irrigation District is located in and around the community of Aguila. The Aguila Irrigation District owns no facilities and a consolidated distribution system does not exist. Irrigation is from groundwater and all wells and ditches are privately owned. The Aguila Irrigation District primarily sells power. The Aguila Irrigation District is located in the same drainage basin as the McMullen Valley Water Conservation District.

Any one of the special districts noted here or a Zone under ARS Title 48 could provide drainage and flood control facility construction and maintenance. Utilization of the existing irrigation district combined with maintenance partnering is a viable option for local improvements and maintenance operations.

Maintenance Partnering

A list of agencies and interests, public and private, with interests in the Study Area was compiled during the development of the ADMP. These agencies and interests were contacted about maintenance requirements for existing and proposed flood control features in the area and their willingness to participate in a maintenance agreement.

Maintenance partnering is not a common government choice due to liability and budgetary constraints. Clark County, Nevada has adopted an Operations and Maintenance Manual to establish performance standards and guidelines for the maintenance of flood control facilities. Each of the separate entities in Clark County is provided funds by the Clark County Regional Flood Control District (CCRFCD) to maintain the regional flood control facilities within their respective jurisdictions. The CCRFCD worked with the entities to develop Maintenance Work Plans and Budgets. However, this model does not work for Maricopa County because of the drastically different funding mechanisms and enabling legislation.

The District does have Intergovernmental Agreements with entities for maintenance and operation of flood control facilities. This mechanism may prove effective if combined with one of the special districts.

There are few direct costs associated with creating a special district combined with initiating maintenance partnering. There would be labor needed from County employees and partnering companies, and legal fees to set up the agreements.

ESTIMATE OF COSTS

The estimated costs for the non-structural solutions are summarized in the table below.

Table 5-4: Estimate of Non-structural Costs

Non-structural Solution Costs	
Solution	**Cost**
Flood Response Plan	$98,000
Public Education	$4,800 per year
Buy-Outs	$4,664,000
Flood Proofing	$3,410,000
Special District Creation and Maintenance Partnering	$unknown
TOTAL	$8,176,800

OPERATION AND MAINTENANCE

These non-structural solutions do not have the typical operation and maintenance costs similar to structural solutions. Upcoming items might include:

- Updating the FRP as future flood events provide additional flood data.
- Future education events regarding the FRP.
- Further detailed floodplain delineation as development increases.

PART 6. RECOMMENDED PLAN

PREFERRED ALTERNATIVE

The preferred alternative for the Aguila ADMP is primarily a non-structural solution. Through Alternative Formulation and Development, numerous regional structural solutions were identified, analyzed and eliminated. The best solution appears to be public education, including the FRP, and small, local flood control structures.

The features of the preferred alternative include:

- Implement the FRP.
- Implement an education program to inform residents of their flood insurance options and where to obtain further information and assistance.
- Further analyze non-structural solutions.
- A Zone A flood delineation we prepared to further identify those areas considered at high flood risk.
- Eagle Eye Road at Aguila Farm Channel – stop log gates or dip section.

Costs

The approximate cost to implement all of the recommended solutions is $518,800, itemized in Table 6-1.

Table 6-1: Estimate of Non-structural Costs

Non-structural Solution Costs	
Solution	**Cost**
Flood Response Plan	$98,000
Public Education	$4,800 per year
Further Analyze Non-structural Solutions	to be determined
Flood Delineation	$323,000
Eagle Eye Road at Aguila Farm Channel – stop log gates or lowered dip section	$18,000 or $93,000
TOTAL	$518,800

Engineering

As there are no structural solutions, there are no specific engineering design criteria.

Environmental

There will be no direct environmental impacts from these non-structural solutions. The leaking storage tank previously identified will need to be monitored and the District must review any solution involving an area within ½ mile of the tank. All efforts to minimize disproportionately high and adverse impacts to the low-income and minority populations in Aguila must be a priority.

Implementing the Preferred Alternative will require the coordination and assistance of several agencies including the District, the County Emergency Management Department, the County Sheriff, the Aguila Volunteer Fire Department, the Aguila Irrigation District and the residents of Aguila.

Timing

The FRP, initial public education, and the flood delineation were completed with this ADMP. Further analysis of the solution for Eagle Eye Road at Aguila Farm Channel and other non-structural solutions will continue.

Summary

This project benefits Aguila residents by:

- Decreasing property loss during future storm events.
- Preparing residents and emergency managers to respond quickly and efficiently to future storm events.

PART 7. IMPLEMENTATION PLAN

IMPLEMENTATION

Much of the plan has been implemented to date as part of the ADMP. A Zone A floodplain delineation was completed that identified further areas of higher flood risk. As development increases in Aguila, further detailed delineations may be implemented. Also completed is the FRP. However, there will be a continuing education program to keep residents informed and updated on the flood response process. Public education has begun with education on the FRP and the disbursement of pamphlets and fliers regarding FEMA flood insurance.

Further analysis of other non-structural solutions will be ongoing as will further analysis for a solution on Eagle Eye Road at Aguila Farm Channel.

FUNDING SOURCES

The Aguila ADMP is unlike any other ADMP that has been prepared. Aguila has no funding partners or cost-sharing partners. Implementation costs will have to come from District funds.

An exception may be the suggested improvement of Eagle Eye Road at Aguila Farm Channel. Eagle Eye Road is a Maricopa County Department of Transportation roadway and the cost of a dip section at this location may possibly to shared with that agency.

PRIORITY OF FEATURES TO BE IMPLEMENTED

Table 7-1 list action items in order of priority with suggested time frames of completion.

Table 7-1: Action Items

Action Priorities			
Project	**Within 1 year**	**1 to 5 years**	**5+ years**
Analyze solution for Eagle Eye Road at Aguila Farm Channel		X	
Implement FRP	X		
Public Education	X	X	X
Further analyze non-structural solutions		X	

REFERENCES

1. Arizona Department of Water Resources, Flood Mitigation Section. *Requirements for Flood Study Technical Documentation - State Standard 1-97.* November 1997.

2. Arizona Department of Water Resources, Flood Mitigation Section. *Delineation of Riverine Floodplains and Floodways in Arizona - State Standard Attachment 2-96.* July 1996.

3. Clark County Regional Flood Control District. *Maintenance Work Program and Fulfilling Environmental Regulations.* http://www.ccrfcd.org/details.htm.

4. Clark County Regional Flood Control District. *Partnering with the Federal Government.* http://www.ccrfcd.org/coe.htm.

5. Council of Environmental Quality, *Environmental Justice: Guidance under the National Environmental Policy Act, Executive Office of the President, December 1997.* Environmental Protection Agency, web site available at: http://www.epa.gov/compliance/environmentaljustice/index.html.

6. Entellus. *Zone A - Floodplain Delineation of Watershed "PP" Luke Wash.* Prepared for the Flood Control District of Maricopa County. FCD Contract No. 99-03, October 2000.

7. Federal Emergency Management Agency 37 (FEMA 37). *Flood Insurance Study - Guidelines and Specifications for Study Contractors.* March 1993.

8. Federal Emergency Management Agency. *Managing Floodplain* Development *in Approximate Zone A Areas.* April 1995.

9. Federal Emergency Management Agency, Flood Insurance Rate Map Numbers: 04013C-0135E, -0155F, -0160F, -0165F, -0170F, 0190F. July 19, 2001.

10. Federal Emergency Management Agency. *Environmental Policy Memo #1, Categorical Exclusion (CATEX) of Projects Involving the Acquisition of Damaged Properties; and Implementation of E.O. 12898 Concerning Environmental Justice.* FEMA, Washington, D.C. April 18, 1994.

11. Federal Highway Administration, *FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* December 2, 1998.

12. Federal Highway Administration. 1998. Directive 6640.23. *FHWA Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* U.S. Department of Transportation, Federal Highway Administration. December 2, 1998.

13. Flood Control District of Maricopa County. *Comprehensive Plan 2002.* 2002.

14. Flood Control District of Maricopa County. *Consultant Guidelines.* 2002.

15. Flood Control District of Maricopa County. Waters, Stephen, E. Jim Perfrement and David E. Gardner. *Storm*

Report Summer/Autumn Storms of 2000 August 29th, October 10th, October 21st - 23rd, October 27th. December 2000. Rev. February 2001.

16. Flood Control District of Maricopa County. *Aguila Hazard Mitigation Program Application*. Prepared for FEMA and the State of Arizona. December 2000.

17. Flood Control District of Maricopa County. http://www.fcd.maricopa.gov/Services/LandManagement.asp.

18. HDR Engineering, Inc. *Damage Summary Report, Martori Farms, Aguila, Arizona*. Prepared for Zurich American Insurance Group. February 2001.

19. HDR Engineering, Inc. *Zurich American Report*. HDR Engineering, Inc., 1997.

20. Maricopa Association of Governments. *Land Use Plan*. ArcView Shapefiles. 1995.

21. Maricopa County. *County Zoning Map*. ArcView Shapefiles. 2002.

22. Maricopa Association of Governments. Traffic Analysis Zones. *Projection Data to Year 2020*. ArcView Shapefiles. 1997.

23. Sansone, Michael. Eagle Roost Airpark. Telephone Interview. October 21, 2002.

24. State of Arizona. Arizona Revised Statutes Title 45 & 48.

25. United States Department of Commerce. U. S. Census Bureau. *Census 2000 Summary Files*. http://www.census.gov. October 10, 2002.

26. United States. Executive Order 12898. *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. February 11, 1994, 59 Federal Register at 7630.

27. URS Consultants, Inc. *Hydraulic Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel*. Prepared for Flood Control District of Maricopa County. FCD Contract No. 88-54. May 1990.

28. URS Consultants. *Floodplain Delineation Study of Upper Centennial Wash, Grass Wash, and Aguila Farm Channel. Hydrology and Hydraulics Reports*. Prepared for the Flood Control District of Maricopa County. May 1990.

LIST OF SUPPLEMENTAL DOCUMENTS

Technical Data Notebook, prepared by HDR Engineering, Inc., 2003.

A Cultural Resource Survey of the Aguila Archaeological Research Locale of Northwestern Maricopa County, Arizona", prepared and submitted by James B. Rodgers, Scientific Archaeological Services, March 13, 2002.

Environmental Overview for the Aguila Area Drainage Master Plan, prepared by the Flood Control District of Maricopa County, June 2002.

Aguila, Arizona Flood Response Plan, prepared by HDR Engineering, Inc., 2003.

APPENDICES

APPENDIX A

Aguila ADMP Hydrology Report, Section 4 of the Technical Data Notebook

APPENDIX B - SUPPLEMENTARY STUDIES

1. Rehabilitation and Repair of Upstream Diversion Dikes and Stock Watering Tanks
2. Clearing of Excess Vegetation in Centennial Wash
3. Detention Storage
4. Flood Proofing Techniques
5. Alternative Eagle Eye Road at Aguila Farm Channel

APPENDIX C – CALCULATIONS FOR STRUCTURAL ALTERNATIVES

APPENDIX D – FLOODPRONE PROPERTIES ACQUISITION PROGRAM

APPENDIX A – AGUILA ADMP HYDROLOGY REPORT, SECTION 4 OF THE TECHNICAL DATA NOTEBOOK

AGUILA ADMP HYDROLOGIC REPORT
SECTION 4 OF THE TECHNICAL DATA NOTEBOOK

Introduction

Section 4 of the Technical Data Notebook contains the findings of the hydrologic study and has been prepared in accordance with *ADWR State Standards* Attachment 1-97 (SSA 1-97). This report is organized as specified by the *Aguila Area Drainage Master Plan, Scope of Work*, following the SSA 1-97 format.

Aguila, Arizona is an unincorporated farming community 76 miles northwest of Phoenix. It is enjoying limited growth in residential development on mostly 5-40 acre ranches. The nearest shopping and medical facilities are 25 miles east in Wickenburg. North of the community, Martori Farm lies within the Centennial Wash floodplain. Aguila has suffered severe damage following recent flooding events starting with the aftermath of Hurricane Nora on September 25, 1997, and then by back-to-back storms on August 29 and October 21 and 27, 2000. Centennial Wash at Wenden had a discharge greater than the 100-year event. The Flood Control District of Maricopa County (FCDMC) rated Sols Wash (northeast of Aguila) as having had a greater than 100-year precipitation event for the 12-hour storm. The source of recent flooding has been from three different directions, Grass Wash on the southeast, Centennial Wash on the northeast, and Aguila Farm Channel watershed from the east across SR 71.

Study Location

The study area is generally bounded by Yavapai County on the north, Vulture Mountains on the south, and La Paz County on the west, and extends to the approximate alignment of Effus Ranch Road to the east. The total area is approximately 231 square miles.

Section 4: Hydrology

4.1 Method Description

4.1.1 Wash Naming Convention

The naming convention for the washes was determined using township, range, and section of the downstream end of the wash:

- T#-R#-S#$
  # = number
  $= suffix (A, B, C, & D)

If more than one wash is in a section, a suffix was used to distinguish between the washes. These washes were also labeled counter clockwise beginning with the southern most wash. For example, the downstream end of the wash in Township 7, Range 8, Section 10 the naming convention dictates it be labeled T7-R8-S10.

If the downstream end of various washes occurs in the same section (Township 7, Range 8, and Section 1) the naming convention is, labeling counterclockwise, T7-R8-S1A, T7-R8-S1B, T7-R8-S1C, T7-R8-S1D, T7-R8-S1E, and T7-R8-S1F.

FIGURE 4-1
WASH NAME MAP

4.1.2 Existing/Verified Hydrologic Model

The existing hydrologic model for the currently effective Flood Insurance Study (FIS) is a Hydrologic Engineering Center (HEC) -1 model developed by URS Consultants in 1990.

The methodology employed by this study comprised of:

- Verifying the existing HEC-1.
- Updating the model where possible.
- The Hydrologic Model(s) selected for this project are in accordance with the *District's Consultant Guidelines*, Section 20, dated August 1, 2000.
- Topographic mapping of the area was provided by the District as noted in the Survey and Mapping Section.
- *ADWR State Standards* Attachment 1-97 (SSA 1-97) and 2-96 are employed throughout .

HDR Engineering researched, and became familiar with existing hydrologic and hydraulic studies and models. Research included review of the hydrology results from the existing Hydrology Report for *Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel.*

Updating of the URS HEC-1 model involved:

- Site visits to the diversion in the watershed at Sols Wash, including an assessment of the diversion-rating curve.
- Field surveys at the railroad, along SR 71, and at selected locations along US 60 where flows broke out or generated a bifurcation during the flooding of October 2000.
- Field survey and topographic mapping review to verify watershed/basin boundaries.

The following return frequencies were developed in the existing model:

- 100-year/24-hour,
- 50-year/24-hour, and
- 10-year/24-hour

The existing HEC-1 model was utilized as the backbone of this study. The original data file was analyzed with the June 1998 Flood Hydrograph Package, HEC-1, Version 4.1 design by the Unites States Army Corps of Engineers (USACOE) in 1998. The existing effective hydrologic model produced the same results in Version 4.1 as it did in the 1990 URS Consultants report, which was Version 2. Where proposed floodplain delineations tie into existing floodplain mapping, the effective FIS discharges are used.

4.1.2.1 Hydrologic Model For Approximate Zone A Study

Hydrology for non-detailed study reaches (Zone A or numbered Zone AO) was developed using the procedures detailed in *Requirement for Floodplain and Floodway Delineation in Riverine Environments*, State Standard 2-96, (ADWR, 1996).

Peak discharges for subwatersheds were reduced to a discharge-drainage area relationship developed from the verified HEC-1 model. Those discharge-drainage area relationships were compared to the regional regression equation presented in the State Standard SSA 2-96 (Table G-6, Region 13 Equations corresponding to the Aguila area). Comparison of the two revealed the regional regression equation produces a more conservative discharge, with reasonable correlation, especially in the larger watersheds (plots just above the points developed from the verified HEC-1 model). This data is presented in Section 4.5.1.

Table G-6. Region 13 Equations

Recurrence Interval	Equation	Average Standard Error (%)
2	$Q = 10^{(6.38-4.29\ A^{(-0.06)})}$	57
5	$Q = 10^{(5.78-3.31\ A^{(-0.08)})}$	40
10	$Q = 10^{(5.68-3.02\ A^{(-0.09)})}$	37
25	$Q = 10^{(5.64-2.78\ A^{(-0.10)})}$	39
50	$Q = 10^{(5.57-2.59\ A^{(-0.11)})}$	43
100	$Q = 10^{(5.52-2.42\ A^{(-0.12)})}$	48

Q = discharge, cfs
A = drainage area, sq. miles

Figure 4-2
Equation From SSA 2-96

4.1.2.2 Detailed Study Area Hydrologic Model

Detail mapping begins at approximately six miles upstream of the existing mapping for Aguila Farm Channel corresponding to Concentration Point I in the original HEC-1. The discharge for Concentration Point I was determined by taking the watershed area and utilizing the regional regression equation, similar to the non-detailed study area hydrology. The discharge was increased in incremental steps downstream to match the previous mapping discharges at the tie in point.

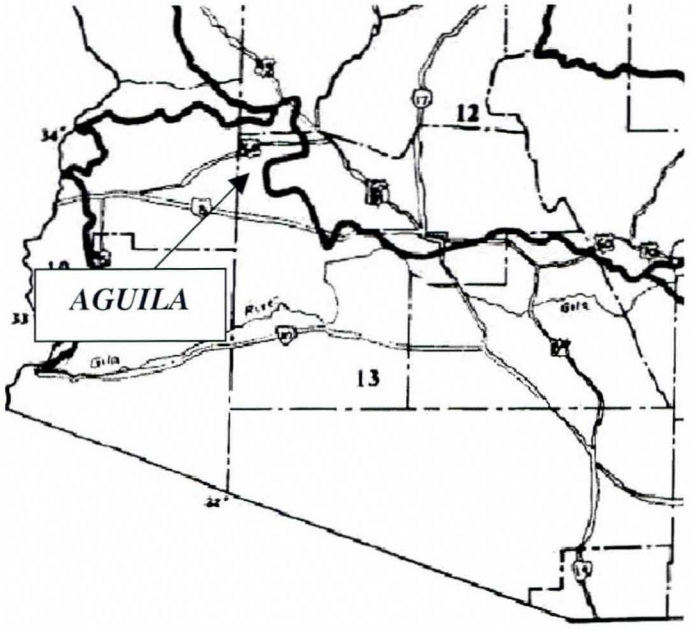


Figure 4-3
Equation Areas From SSA 2-96

4.2 Parameter Estimation

4.2.1 Drainage Area Boundaries

The currently effective FIS hydrologic model used a United States Geological Survey (USGS) topographic quadrangle at a scale of 1:62,500 as shown in the URS Consultants Hydraulic *Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel*, May 1990. The boundaries of the entire watershed extend into Yavapai County to the north, the Harquahala Mountains to the south and the Vulture Mountains to the east.

The original watershed delineation remains unchanged for this report. Subwatersheds within the original study were further subdivided to determine flows for specific locations. The regression equations where then used on the subwatersheds to develop a discharge. Subwatersheds are presented in Section 4.2.2, and hydrology watershed maps are included in **Appendix D.3**

4.2.2 Watershed Work Maps

4.2.2.1 Methodology

The watershed work maps were created using URS Consultants, Inc. "Watershed Sub-basin Boundary Map". This map was used as a guide to help re-delineate the subbasins digitally. In order to re-delineate the watershed, USGS quadrangle maps were imported into ArcView Graphical Information Systems (GIS) 3.2, and the URS's watersheds digitally recreated. ArcView 3.2 allows focusing on a particular area to assure the

delineations are appropriate. Once the subbasins were recreated digitally, further subdivision of the subwatersheds was performed to determine the watershed areas that will be used for the Regional Regression Equation producing a discharge for the specific subarea.

4.2.2.2 Watershed Labeling Protocol

The Aguila Area Drainage Master Plan (ADMP) labeling protocol utilized the URS labeling scheme. This is intended to minimize confusion between the new subwatersheds and existing subbasin watershed delineations. If more than one subwatershed in a subbasin was created, the labeling convention utilized identifying the watersheds with the same subbasin ID followed with a suffix A & B. The following table shows the naming convention used compared to URS Consultant's names and the washes that are associated with the subwatersheds. The naming convention for the washes is detailed in Section 4.1.1

Table 4-1
Watershed Labels

URS Consultant's Subbasin ID	HDR Engineering Subwatershed ID	Wash Names
5B	5B-A	T7-R9-S25E
5B	5B-B	T7-R9-S25E
6	6A	T7-R8-S30
6	6B	T7-R8-S30
6	6C	T7-R8-S30
7B	7B-A	T7-R9-S25C
7B	7B-B	T7-R9-S25C
7B	7B-C	T7-R9-S25D
9	9A	T7-R9-S25A
9	9B	T7-R9-S25B
9	9C	T7-R9-S25A
10	10A	T7-R9-S25A
12	12A	T7-R9-S22
104	104A	T7-R8-S1A
104	104B	T7-R8-S1B
104	104C	T7-R8-S1C
105	105A	T7-R8-S1E
105	105B	T7-R8-S1E
105	105C	T7-R8-S1D
105	105D	T7-R8-S1C
107	107A	T7-R8-S1F
108	108A	T7-R8-S2

112	112A	T7-R8-S10

Table 4-1 (continued)
Watershed Labels

URS Consultant's Subbasin ID	HDR Engineering Subwatershed ID	Wash Names
112	112B	T7-R8-S9
112	112C	T7-R8-S18
112	112D	T7-R8-S7
112	112E	T7-R9-S12
112	112F	T7-R9-S12
203	203A	T7-R9-S4
204	204A	T7-R9-S17
204	204B	T7-R9-S17
206	206A	T7-R10-S13
206	206B	T7-R10-S13

In cases where two or more watersheds fall within one subbasin the labeling scheme begins from the southern most watershed and continues counter clockwise i.e. 104A, 104B & 104C. **Figure 4-1** depicts how the labeling scheme was organized for the entire study area. **Appendix D** presents each subwatershed delineation utilized in the Aguila ADMP.

4.2.3 Gage Data

Included in **Appendix D** is the *Storm Report - Summer/Autumn Storms of 2000 August 29th, October 10th, October 21st-23rd, October 27th*. This presents information on selected rainfall, runoff, and graphical and statistical data from the storm events of August 29, October 10, October 21-23 and October 27, 2000. The majority of the data presented was collected by the District's Automated Local Evaluation Real Time (ALERT) System, with contributions from the Phoenix National Weather Service (NWS) Forecast Office and the USGS surface-water data collection program.

USGS gage data from Tiger Wash near Aguila (USGS Gage Number 09517280) and gage data from a tributary to Centennial Wash near Wenden (USGS Number 09517200) were utilized to verify the regression equation results presented in the next section of this report.

4.2.4 Statistical Parameters

Available USGS data from Tiger Wash near Aguila (USGS Gage Number 09517280) and from a tributary to Centennial Wash near Wenden (USGS Number 09517200) were analyzed in HEC-FFA, Version 3.0. This program performs a log-Pearson Type III analysis. Data and results are presented in ***Appendix D****. Results of the computed probability for these two watersheds are depicted on* ***Figure 4-12*** *in Section 4.5.2.2.*

4.2.5 Precipitation

The existing hydrologic modeling included precipitation information as detailed in the 1990 URS Consultants report. Rainfall depth values and depth-area reduction factors are consistent with the drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology.

4.2.6 Physical Parameters

Watershed parameters have not changed significantly since the original model was developed. The only conceivable change would be residential and/or commercial development, which has been very limited and impacts a small portion of the lower watershed. Refer to URS Consultants, Inc., *Hydrologic Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel*, May 1990.

4.3 Problems Encountered During the Study

4.3.1 Special Problems and Solutions

Verification of existing hydrologic model used in the effective FIS was undertaken as previously noted. Correlation of results between the model versions has previously been discussed. Specific components requiring special attention are addressed below:

4.3.1.1 Diversion to Sols Wash at Subbasin 100

Verification of the assumptions that were utilized in the existing hydrology included: 1) a qualitative assessment of the 50% split of subwatershed 100 between Sols Wash watershed and Aguila Farm Channel watershed; and 2) quantitative sensitivity analysis by removing the divert card from the HEC-1 model. This split takes place at a stock tank constructed of uncompacted earth embankment. The findings include:

- Examination of the USGS Quadrangle for the area reveals the stock tank is located at a site that can direct flow to either Sols Wash or the Aguila Farm Channel as depicted in Figure 4-4.
- Inspection of the site reveals low flows are directed towards Aguila Farm Channel. This appears to be a historic diversion that has been in place for a long time. During a runoff event, the stock tank will fill with several feet of water before flows flank the embankment on its west side, and continue into a wash system towards Aguila.

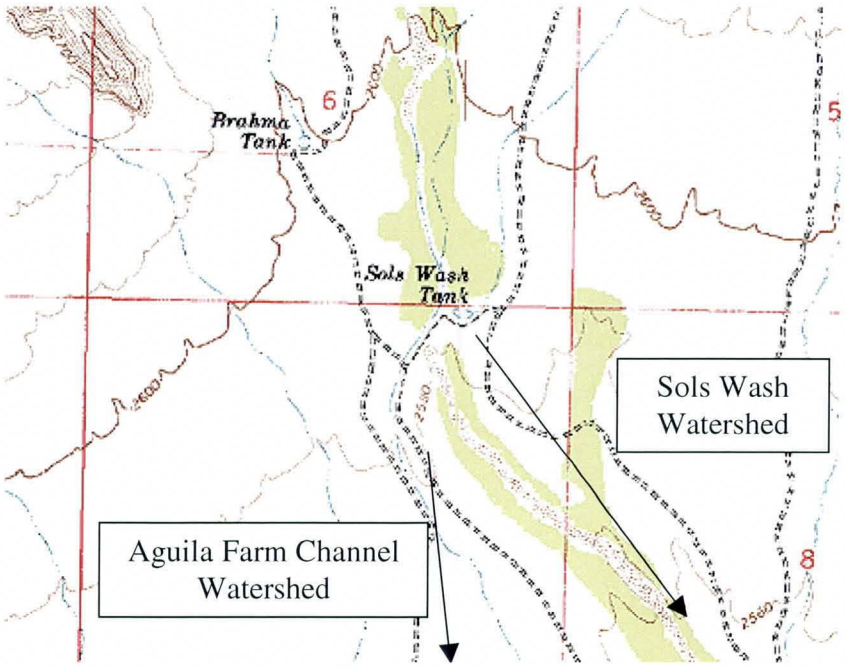


Figure 4-4
Sols Wash Tank

- Inspection of the site also reveals areas where the embankment has been breached on its east side, where flows would have been directed towards Sols Wash. These areas are depicted in Figure 4-5.

Figure 4-5
Repaired Breach in Stock Tank

- The stock tank is located 18 miles upstream from SR 71.

The original assumptions in the hydrology for the effective FIS remain valid. High flows into the stock tank flank the structure on the west and the east sides, splitting flows between Sols Wash watershed and Aguila Farm Channel watershed. A 50% split is reasonable considering the distributory flow pattern in place near the stock tank.

Regardless of the exact flow split, the 18 miles of natural channel between the stock tank and SR 71 attenuates much of the flow generated by subbasin 100. This is evident by removing the divert card from the HEC-1 (causing 100% of subbasin 100 to be directed toward Aguila), which causes only a 0.2% increase in discharge at SR 71.

4.3.1.2 Flow Paths of Watercourse Systems

Several areas where the exact flow paths of watercourses were not clear have been inspected. In each case, such as where flows combine at Concentration Point I (CP I), the existing model reflected field conditions such as depicted in **Figure 4-6.**

Figure 4-6
Near C.P. I Northerly Flow Under The Rail Road Tracks

4.3.1.3 Break-out over US 60

During the 1997 flood event, flows broke out over U.S. 60 near milepost 88, approximately 1.5 miles east of the intersection of SR 71. This is documented in **Figures 4-7 and 4-8.** The general slope of the land in this area is towards the west-southwest.

Aerial photographs taken after the flooding confirm the locations were flows topped the roadway and broke out to the south across U.S. 60.

Figure 4-7
U.S. 60 At M.P. 88 September 26, 1997

Figure 4-8
U.S. 60 at SR 71 September 26, 1997

4.3.1.4 Break-out over Railroad Tracks at SR 71

During the flood of 2000, flows broke out to the south over the railroad tracks at the intersection with SR 71. The main purpose of this hydraulic analysis was to determine the amount of water that breached the intersection of SR 71 and railroad tracks using existing flood elevations and survey data. Existing information from URS Consultants, Inc. was used to develop the model. The model was extended three cross-sections at the downstream end using URS's data.

A split-flow analysis was performed using HEC GeoRas where water flowed over the railroad tracks and SR 71. Because of the overflow at the railroad tracks, an increase of flow was considered in the downstream reach and modified in an existing HEC-1 model. The overview of the results, methodology and assumptions modeled follows.

The hydraulic computations performed were one-dimensional steady flow calculations. The results that will be discussed are the lateral weir discharge, culvert, and weir overflow of the roadway. The existing railroad track along the channel is considered to be the lateral weir. The 100-year discharge over the railroads tracks near SR 71 is 4,264 cfs. The existing four 84" diameter pipes handle a total flow of 432.8 cfs each totaling 1,731 cfs during the 100-year discharge. A total 11,190 cfs flows as weir flow over the roadway during the 100-year discharge.

In order to develop the HEC-RAS Model, a HEC-GeoRas extension specifically designed to process geospatial data for use with the HEC-RAS is used. HEC-GeoRas is an extension for use with ArcView GIS 3.2, a general purpose Geographic Information System software program. The HEC-GeoRas extension allows us to create a HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM). The DTM is imported into ArcView GIS 3.2 and data sets (ArcView shape files) are created for use in HEC-RAS. HEC-GeoRas also enables viewing the exported results from HEC-RAS in ArcView GIS 3.2.

The process in developing the HEC-RAS Model is as follows:

- Import the existing digital terrain model (created by CEI) into ArcView GIS 3.2
- Format the DTM into a TIN format using HEC-GeoRas
- Create a series of line themes are created to develop the geometric data. The following line themes were created using HEC-GeoRas:
    - Stream Centerline
    - Flow Path Centerline
    - Main Channel Banks (Left & Right Overbank)
    - Cross Section Cut Lines (Spaced 500 ft maximum)
- Generate the RAS GIS import file using HEC-GeoRas

Once the model has been created with corresponding geometric data the HEC-RAS model is ready for hydraulic analysis by performing the following:

- Import the GIS import file into HEC-RAS
    - Input flow data & Manning's "n" values

  - Perform the hydraulic analysis
- Export the HEC-RAS results back into ArcView GIS 3.2

Figure 4-9 shows the process used in order to obtain a detailed floodplain analysis.

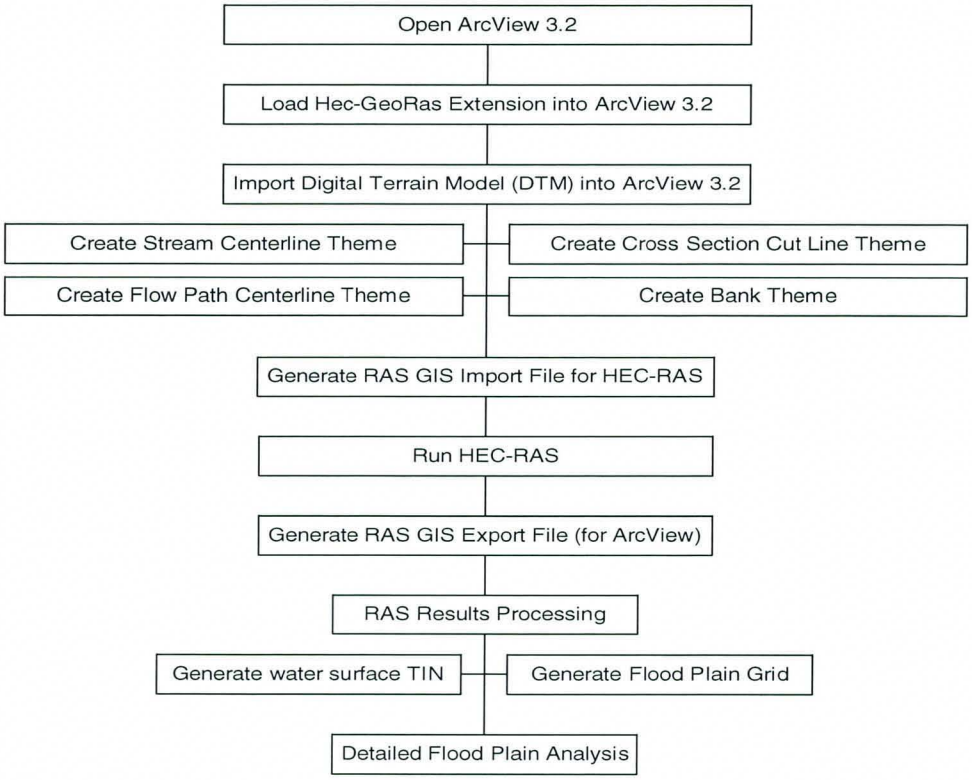


Figure 4-9
Process Flow Diagram

In order to proceed with the hydraulic analysis, assumptions were made in the following items:

- Ineffective Flow
- Left & Right Overbanks
- Cross Sections & Downstream Water Surface Elevation
- Contraction and Expansion Losses
- Culvert Location

The ineffective flow option from HEC-RAS was utilized to define areas of the cross sections that contain water that is not actively being conveyed. Once the water surface exceeds the established elevations set for ineffective flow, that specific area is no longer considered effective. The elevations for this model were established using the railroad tracks along the channel. An example of an ineffective flow area is shown in Figure 4-10.

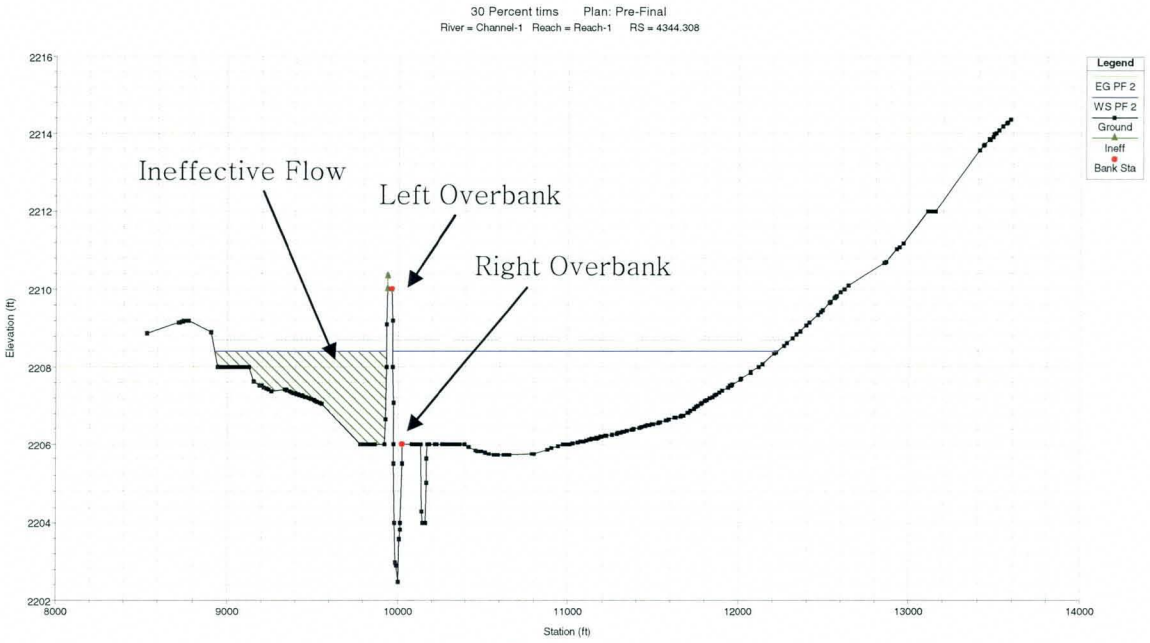


Figure 4-10
Stream Cross Section

The left overbank was established along the railroad tracks, and the right overbank was established at the point in the main channel that still conveys flow, as can be seen in Figure 4-10.

An elevation was referenced from a cross section developed from URS Consultants, Inc. on the *Flood Delineation Study of Upper Centennial Wash, Grash Wash and Aguila Farm Channel*. Three cross sections were used from sheet 15 of 23 and used as the downstream end of HDR's study. There is a water surface elevation associated with each cross section. Since a different datum was used in URS's study, this elevation was adjusted using Corpscon, Version 5.0. Corpscon is a program created by the U.S. Army Topographic Center (TEC) to convert coordinates between different datums. This program adjusted the elevation of 2193.07 to 2195.32, which is used in the HEC-RAS program as the downstream known elevation. The cross section associated with this elevation is 11.189 from URS's study.

The coefficients applied between cross sections in this HEC-RAS model were assumed to be gradual transitions. The coefficients used for this type of transition were 0.1 for the contraction and 0.3 for the expansion.

The only revision to the URS hydrologic model required placing a divert card at intersection of SR 71 and the railroad tracks, and subsequently routing this flow to Concentration Point F (via R13). The effective FIS begins just downstream of SR 71 with an estimated 100-year discharge of 16,900 cfs. The 100-year event at this location is expected to produce a breakout to the south (over the railroad tracks) of 4264 cfs. A

curve was developed based on a multiple profile HEC-RAS run to obtain breakout flows for lesser flows in the Aguila Farm Channel.

Table 4-2 Break–Out Flows		
Main Channel (DI) (cfs)	Break-Out (DQ) (cfs)	Comments
0	0	
2120	0	Break-Out Begins
4000	700	
8000	1702	
12000	2789	
16900	4264	100-year flow

Flow is routed in routing reach RDK to the downstream end of Subbasin 13 where hydrographs are combined, ultimately reaching concentration point F under US 60. These flows quickly attenuate, and due to the delay timing of the breakout peak discharge add little to the peak discharge at US 60. The most significant affect of this breakout is along the flow path prior to combining with Grass Wash. The 100-year flow at the downstream end of Subbasin 13 is estimated at 5991 cfs (includes break-out) compared to the previous estimate of 1349 cfs (without break-out).

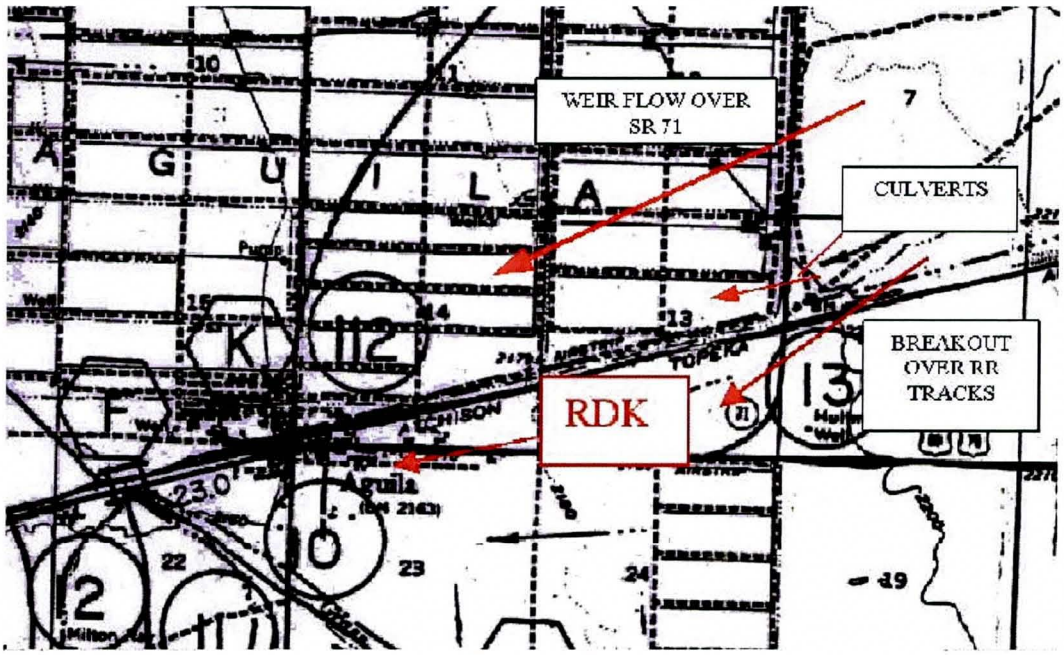


Figure 4-11
Break-Out Schematic

4.3.2 Modeling Warning and Error Messages

Routing reach R1 had the following error message when the original URS HEC-1 was executed:

"WARNING. POSSIBLE INSTABILITIES IN THE MUSKINGUM ROUTING FOR REACH 1. ADJUST NSTPS AND/OR COMPUTATION INTERVAL TO MEET CRITERIA IN USER MANUAL."

A direct run of the existing HEC-1 model resulted in the above error message for Reach 1. The Muskingum flood routing method computes flow through a reach. Derived from the continuity equation, this method calculates the outflow through a stream reach in a step-wise manner. Each step, or sub-reach (NSTPS), is dependent on the computational time interval (NMIN) and the velocity through the reach. The calculation is repeated iteratively throughout the reach to obtain the overall outflow.

HEC-1 input for Muskingum routing method includes the following:

- NSTPS (computational interval)
- AMSKK (travel time through the reach, calculated from the velocity and reach length)
- X (Muskingum constant)
- NSTPS (number of sub-reaches)

"To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2(1-X)} \leq \frac{AMSKK}{NSTPSxNMIN} \leq \frac{1}{2X}$$

Source: (US Army Corps of Engineers, Hydrologic Engineering Center, June 1998)

Appendix D presents the calculation sheet for the Muskingum Routing Method values. From the existing HEC-1 model, the AMSKK for Reach R1 was 0.07, which corresponds to a reach length of 1042 ft. From this value, an NSTPS of 0.43 is calculated. HEC-1 requires NSTPS to be an integer. Rounding up to a value of 1 would require an NSTPS greater than 0.5. Back-calculation yields a reach length of 1450 ft for an NSTPS of 0.6 and an AMSKK of 0.10.

The reach length for Reach 1 was increased to 1450 ft and the HEC-1 model was run with the corresponding values (AMSKK = 0.1, NSTPS = 0.6). No error messages were generated. The output indicated a combined peak flow at R1 of 1701 cfs at 12.83 hours whereas the original model indicated a peak flow of 1687 cfs at 12.83 hours. This represents a 0.8% change, which is negligible.

The existing HEC-1 input and output file based on the original values by URS was utilized without modifying the input file as this warning was demonstrated have little affect.

4.4 Calibration

No quantitative calibration was attempted other than the data presented under verification of results with the HEC-FFA analysis. Qualitative assessments included verification of watershed flow paths as previously described.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

Table 4-3 contains the 100 year discharge, both total and per square mile, for the existing HEC-1 and the computed regression equations.

Table 4-3
Comparison of URS HEC-1 Results and USGS Regression Models

Concentration Point	Area (sq-mi)	URS HEC-1		USGS Regression Models	
		100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi	100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi
SUB1	3.48	1701	489	2731	785
SUB2A	5.21	2267	435	3426	658
SUB2B	6.98	1645	236	4011	575
A	15.67	3547	226	6034	385
SUB3	3.63	1205	332	2798	771
SUB4	4.59	1180	257	3195	696
B	23.88	4873	204	7351	308
SUB5A	2.01	1591	792	1970	980
SUB5B	5.44	1681	309	3508	645
SUB6	8.57	1454	170	4466	521
C	39.90	7495	188	9228	231
SUB7A	2.25	1231	547	2111	938
SUB7B	4.95	1649	333	3331	673
D	7.19	1668	232	4075	567
SUB8	2.13	923	433	2041	958
SUB9	5.34	1449	271	3473	650
E	14.67	3616	246	5845	398
SUB10	6.34	1168	184	3811	601
SUB11	3.12	1352	433	2564	822
SUB12	2.59	1046	404	2297	887

Table 4-3 (continued)
Comparison of URS HEC-1 Results and USGS Regression Models

Concentration Point	Area (sq-mi)	URS HEC-1		USGS Regression Models	
		100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi	100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi
SUB13	3.92	1349	344	2923	746
F	70.55	11060	157	11692	166
SUB100	58.27	6549	112	10819	186
50% Diversion of SUB 100	29.14	3275	112*	8042	276
SUB101	9.37	1868	199	4676	499
SUB102	5.25	1544	294	3441	655
G	43.75	3618	83	9599	219
SUB103	13.66	2322	170	5645	413
SUB104	28.20	3993	142	7925	281
SUB105	19.80	3525	178	6741	340
SUB106	5.75	2247	391	3616	629
SUB107	10.92	3206	294	5053	463
H	16.66	3202	192	6213	373
I	122.06	11061	91	14466	119
SUB108	2.68	1331	497	2344	875
SUB109	49.05	5682	116	10073	205
SUB110	18.84	2979	158	6586	350
SUB111	2.41	1073	445	2200	913
J	70.29	7221	103	11675	166
SUB112	15.40	2674	174	5983	389
K	210.43	16866	80	17635	84
SUB200	4.24	1486	350	3056	721
SUB201	14.68	3505	239	5846	398
SUB202	14.98	2288	153	5904	394
SUB203	11.41	2026	178	5165	453
L	326.29	20345	62	20496	63
SUB204	12.76	2158	169	5460	428
SUB205	25.65	3825	149	7594	296
M	364.70	21136	58	21267	58

SUB206	8.83	1966	223	4536	514

Table 4-3 (continued)
Comparison of URS HEC-1 Results and USGS Regression Models

Concentration Point	Area (sq-mi)	URS HEC-1		USGS Regression Models	
		100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi	100-year Discharge (cfs)	100-year Discharge (cfs) per sq-mi
SUB207	7.49	1592	213	4163	556
SUB208	12.62	2143	170	5430	430
N	393.63	21364	54	21806	55
SUB209	11.82	1871	158	5257	445
SUB210	16.93	2701	160	6261	370
O	422.39	21730	51	22312	53

* Diversion of 50% of the flow at SUB100 does not correspond to the logarithmic regression equation – presently here only for information.

Table 4-4 shows the differences in peak discharges obtained by the URS HEC-1 model and the USGS regression equations.

Table 4-4
Aguila Farm Channel Discharge

Concentration Point I - Located at Upstream End of Detailed Study Area	Area (sq-mi)	URS HEC-1		USGS Regression Models	
		100-year Discharge (cfs)	100-yearDischarge (cfs) per square mi	100-year Discharge (cfs)	100-year Discharge (cfs) per square mi
10-yr	122.1	2751	23	5253	43
50-yr	122.1	8509	70	11051	90
100-yr	122.1	11061	91	14472	119

* The USGS Regression Models were utilized at the upstream end to the detailed floodplain study.

Table 4-5 shows the wash names with the associated subbasin and subwatershed. The table includes the area and 100 yr discharge from the wash.

Table 4-5
Aguila ADMP Discharges

Wash Name	URS Subbasin Name	Aguila ADMP Subwatershed	Area (sq-mi)	10-yr Discharge (cfs)	50-yr Discharge (cfs)	100-yr Discharge (cfs)
	5B		5.44	1222	2632	3508
T7-R9-S25E		5B-A	2.63	816	1743	2318
T7-R9-S25E		5B-B	5.95	1282	2763	3683
	6		8.57	1552	3350	4466
T7-R8-S30		6A	1.57	603	1275	1689
T7-R8-S30		6B	4.78	1139	2452	3268
T7-R8-S30		6C	5.96	1283	2765	3687
	7B		4.95	1161	2499	3331
T7-R9-S25C		7B-A	3.32	931	1996	2658
T7-R9-S25C		7B-B	4.79	1141	2455	3271
T7-R9-S25D		7B-C	1.67	625	1325	1756
	9		5.34	1210	2605	3473
T7-R9-S25A		9A	1.15	499	1046	1381
T7-R9-S25B		9B	1.81	656	1392	1846
T7-R9-S25A		9C	4.41	1090	2345	3124
	10		6.34	1326	2859	3811
T7-R9-S25A		10A	18.67	2288	4931	6558
	12		2.59	809	1728	2297
T7-R9-S22		12A	1.12	491	1028	1357
	104		28.20	2779	5973	7925
T7-R8-S1A		104A	4.82	1144	2463	3283
T7-R8-S1B		104B	2.96	873	1868	2486
T7-R8-S1C		104C	27.04	2726	5860	7777
	105		19.80	2353	5071	6741
T7-R8-S1E		105A	1.37	555	1170	1548
T7-R8-S1E		105B	60.66	3916	8340	10999
T7-R8-S1D		105C	1.64	619	1310	1736
T7-R8-S1C		105D	27.60	2752	5915	7849
	107		10.92	1756	3792	5053
T7-R8-S1F		107A	12.12	1851	3996	5322
	108		2.68	825	1763	2344

Table 4-5 (continued)
Aguila ADMP Discharges

Wash Name	URS Subbasin Name	Aguila ADMP Subwatershed	Area (sq-mi)	10-yr Discharge (cfs)	50-yr Discharge (cfs)	100-yr Discharge (cfs)
T7-R8-S2		108A	1.00	457	955	1259
	112		15.40	2084	4495	5983
T7-R8-S10		112A	1.07	477	998	1317
T7-R8-S9		112B	3.13	901	1930	2568
T7-R8-S18		112C	2.01	698	1484	1970
T7-R8-S7		112D	1.00	457	955	1259
T7-R9-S12		112E	71.30	4198	8917	11742
T7-R9-S12		112F	72.39	4225	8972	11814
	203		11.41	1796	3877	5165
T7-R9-S4		203A	4.02	1036	2226	2966
	204		12.76	1899	4099	5460
T7-R9-S17		204A	1.60	610	1290	1709
T7-R9-S17		204B	8.47	1543	3330	4439
	206		8.83	1576	3403	4536
T7-R10-S13		206A	1.94	684	1452	1927
T7-R10-S13		206B	4.45	1096	2356	3140

4.5.2 Verification of Results

4.5.2.1 Tie to Effective FIS Hydrology

Centennial Wash, the Aguila Farm Channel and Grass Wash have Federal Emergency Management Agency (FEMA) accepted peak discharges as depicted in the Flood Insurance Study for Maricopa County, Arizona. These discharges are based upon the hydrology developed in 1990 by URS Consultants for a physical map revision. At all locations where the study ties into the effective FIS, the FIS discharges are utilized and shown in Table 4-6.

Table 4-6 FIS Hydrology				
Flooding Source	Drainage Area (square miles)	10-year (cfs)	50-year (cfs)	100-year (cfs)
Aguila Farm Channel				
Below Grass Wash	314.4	4,130	14,500	19,300
At Eagle Eye Road	239.6	3,620	12,700	16,900
Upper Centennial Wash				
At Maricopa/La Paz County Boundary	451.5	4,880	16,400	21,700
At SW corner of Section 4, T7N, R9W	41.1	1,900	5,410	6,960
North Branch Centennial Wash				6,960
Grass Wash				
At US Highway 60/70	70.6	3,340	8,660	11,100
At NW Corner of Section 25, T7N, R9W	39.9	2,430	5,950	7,500
At SE Corner of Section 25, T7N, R9W	23.9	1,720	3,900	4,870

4.5.2.2 HEC-FFA Comparison with Data

As previously noted, Tiger Wash near Aguila (USGS Gage Number 09517280) and a tributary to Centennial Wash near Wenden (USGS Number 09517200) were analyzed in HEC-FFA, Version 3.0. This program performs a log-Pearson Type III analyses. Data and results are presented in Appendix D. Results of the computed probability for these two watersheds are depicted compared with the HEC-1 data for this study and the Regional Regression Equation for the Aguila area. **Figure 4-12** illustrates the HEC-1, regression equations, HEC FFA and the Power HEC-1 flow versus area results.

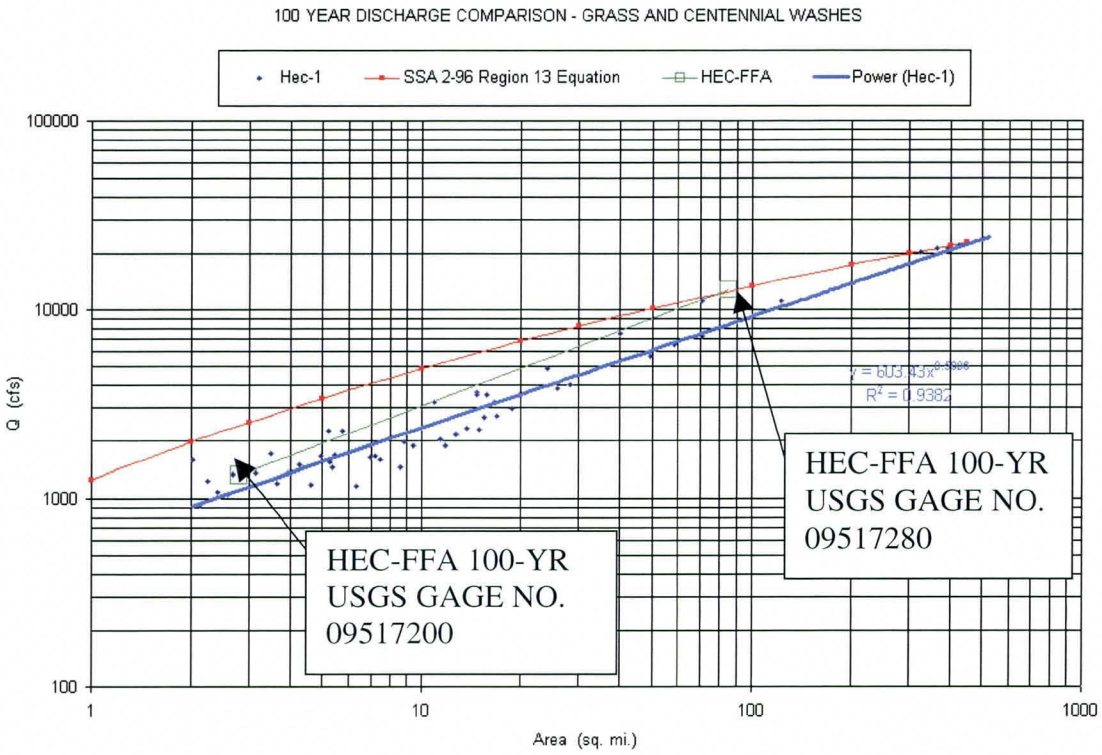


Figure 4-12
100 Year Discharge Comparison

4.5.2.3 Predicted vs. Observed Storm Events

There have been several large storm events since the effective model was prepared by URS model and accepted by FEMA. The most significant events were hurricane NORA (1997) and storms of 2000. Both events caused wide spread flooding in the southwestern Arizona including the Aguila area. Flows in the Aguila Farm Channel were not measured during these events and the only reference to the Aguila area in the *Storm Report – Summer/Autumn Storms of 2000, August 29th, October 10th, October 21st-23rd, October 27th* (FCDMC, Feb 2001) notes the failure of the railroad bed near SR 71 during the event. During the 2000 floods, a 100-year event was estimated at Wenden, downstream from Aguila in La Paz County.

The most significant difference between the previously predicted response floodplain and the actual events is the breakout over the railroad tracks. Observed flows that entered the community of Aguila directly from the east, came from areas that are not currently mapped in the floodplain.

Without gage data at Aguila, and limited rainfall data no calibration of the model could be conducted as has been previously investigated by the Flood Control District.

4.6 References

Arizona Department of Water Resources, *Instructions for Organizing and Submitting Technical Documentation for Flood Studies, 1997, State Standard Attachment 1-97*, November 1997.

Arizona Department of Water Resources, *Requirement for Floodplain and Floodway Delineation in Riverine Environments, State Standard Attachment 2-96*, July 1996.

Federal Emergency Management Agency, *Flood Insurance Study Maricopa County, Arizona and Incorporated Areas Volume 1 of 12*, September 30, 1995.

Flood Control District of Maricopa County, *Storm Report - Summer/Autumn Storms of 2000, August 29th, October 10th, October 21st-23rd, October 27th*, February 1, 2001.

Flood Control District of Maricopa County, *District's Consultant Guidelines, Section 20*, August 1, 2000.

Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Volume I, Hydrology*, 1992.

URS Consultants, Inc., *Hydraulic Report for Floodplain Delineation Study of Upper Centennial Wash, Grass Wash and Aguila Farm Channel*, May 1990.

U.S. Army Corps of Engineers, *HEC-1 Flood Hydrograph Package, Version 4.1*, Hydrologic Engineering Center, 1998.

U.S. Army Corps of Engineers, *HEC-FFA Flood Frequency Analysis, Version 3.0*, Hydrologic Engineering Center, May 1992.

U.S. Geologic Survey, *Centennial Wash Gage Number 09517200*, http://waterdata.usgs.gov/az/nwis/inventory/?site_no=09517200.

U.S. Geological Survey, *Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona*, April 1991

U.S. Geological Survey, *Tiger Wash Gage Number 09517280*, http://waterdata.usgs.gov/az/nwis/inventory/?site_no=09517280.

U.S. Geological Survey, *Quadrangles: Aguila AZ, Black Butte AZ, Congress AZ, Congress SW AZ, Date Creek Ranch AZ, Date Creek Ranch NE AZ, Date Creek Ranch SE AZ, Date Creek Ranch SW AZ, Flores AZ, Forepaugh Peak AZ, Gladden AZ, Harquahala Mountain AZ, O'Neill Pass AZ, Outlaw Hill AZ, Smith Peak AZ, Tiger Well AZ, Wildcat Well, AZ.*

Wiley and Sons, Inc, Soil and Water Conservation Engineering, Fourth Edition, 1993

Appendix D: Hydrologic Analysis Supporting Documentation

D.1 Flow Splits and Diversions Data

D.2 Hydrologic Calculations

D.3 Hydrology Watershed Maps

APPENDIX B – SUPPLEMENTARY STUDIES

REHABILITATION AND REPAIR OF UPSTREAM DIVERSION DIKES AND STOCK WATERING TANKS

A common occurrence across much of Arizona, particularly in western Maricopa County, is the presence of numerous small facilities constructed for the purpose of capturing and diverting storm water runoff as a watering source for livestock. While not constructed with the intention of providing any real flood control benefit, it is generally thought that these stock ponds have provided incidental flood protection, at least during minor events. These structures are usually not engineered facilities and receive little, if any, regular maintenance.

The purpose of this study is to quantify the extent, if any, to which these types of structures may actually be providing a level of flood protection from a 100-year event and to investigate whether the cost of restoring, rehabilitating or enhancing these structures may provide a reasonable return in terms of flood protection benefits.

A total of 66 of these locations have been identified within the Aguila ADMP watershed area. These structures were identified from the USGS Quadrangle maps and other available topographic information for the area. Some of the identified tanks are named on the USGS maps. The stock tanks vary in size, configuration, and condition and are distributed throughout the entire watershed. Some of these locations include multiple structure arrangements. To evaluate flood control benefits, four typical structures have been selected that represent the range of conditions and types present at the 66 sites. The four sites in order of investigation are:

1. Sols Wash Tank – Located in T8N, R6W, in Section 6. This large tank is located in subbasin 100 and lies about 16.9 miles northeast of Aguila in Yavapai County.

2. Fishery Diversion Dike – This levee system lies upstream of an abandoned fish farm east of Aguila. The northeast corner starts in T7N, R8W in Section 27 (watershed subbasin 6) and runs diagonally through Section 34 ending at T6N, R8W, Section 4. A series of downstream check dams lie in T6N, R8W Sections 4 and 5. This system is located in subbasins 1 and 2B.

3. Centennial Wash Levees – A series of low earthen levees in the main channel of Centennial Wash starts in the northeast corner of T8N, R9W, Section 27 and runs southwest. These levees are located in subbasin 201.

4. West Stock Tank – An unnamed stock tank west of Aguila lies in T7N, R10W, Section 25. This tank is located in subbasin 206.

Members of the project team visited the four typical sites on November 22, 2002, and existing conditions at each site were noted. The results of the field investigation were used to evaluate the flood retarding potential of the remaining sites in the Aguila ADMP watershed area.

Sols Wash Tank

This stock watering pond is actively used and appears to receive some level of regular maintenance. The embankment height varies from zero to a maximum of about 9.4 feet. The embankment length is approximately 1,930 feet. Judging by aerial photographs and contour mapping, the impoundment area appears to be about 22 acres. It seems reasonable to conclude that this structure could fall under the classification of a jurisdictional dam according to Arizona Department of Water Resources (ADWR) criteria. Specifically, the total impoundment volume could possibly exceed 50 acre-feet. An actual determination as to whether Sols Wash Tank qualifies as an ADWR jurisdictional structure has not been made.

The slope of the downstream embankment face is approximately 1:1 and the upstream face varies, but is approximately 4½:1. A dirt road along the top of the embankment is approximately 16 feet wide. The earthen embankment was placed using native material from upstream of the structure, thereby creating a permanent pond area below natural grade. This area was filled with water during the time of observation and the overall depth was not determined. A District rainfall recording station (Centennial Divide, #7135) is located at the eastern edge of the embankment.

The embankment was found to be intact; however, there was evidence on the downstream face of minor and sporadic gulleying. During a series of severe rainfall events in late 2000, equivalent to a 60-year to 100-year storm, the embankment was overtopped along the eastern edge. This location was obvious during the field investigation and repair work was evident. There are no inhabited structures immediately downstream of the embankment.

Sols Wash Tank downstream face

This particular structure is significant in that it serves to divide flows from the upper watershed area to either Centennial Wash or Sols Wash, depending on certain ponding levels. Initial flows in excess of the storage capacity flow west to Centennial Wash in what is essentially a principal spillway. Overtopping flows, or flows in excess of the principal spillway capacity, contribute to Sols Wash. The current hydrology model for the Aguila Floodplain Delineation Study assumes a 50%-50% split for the flows.

Recommendation

The HEC-1 model for the Aguila Floodplain Delineation study that shows the 50%-50% split was modified to include the entire area contributing to Centennial Wash. Because the tank is located so far upstream of Aguila (18 miles upstream of SR 71), the impact to the 100-year flow rate was negligible. This was shown by removing the divert card from the HEC-1 model, which causes only a 0.2% increase in discharge at SR 71. Therefore, no improvements or modifications to the tank are recommended, as the benefit to Aguila would be minor. It is recommended that further investigation of the tank be performed to determine if it qualifies as a jurisdictional dam according to ADWR criteria.

Fishery Diversion Dike

This structure is an earthen dike approximately 1¾ miles long and 5 feet high. There is no storm water impoundment area associated with the dike; rather, storm water is directed to the south, away from an abandoned fish hatchery towards a series of check dams. The check dams are configured to retain small amounts of water, which serve to enhance vegetation, particularly mesquite and low ground cover. The mesquite and water is then available for grazing cattle. While the check structures appear to be intact, the diversion dike has completely failed in several locations and failure in at least three other locations appears imminent.

Downstream properties closest to the dike are natural desert areas owned by the BLM. Farther downstream are cultivated fields that are either privately owned or leased State Land. The owner of these fields has indicated that over time, flooding has become more frequent because of the breaches in the dike. Ultimately, flows contribute to Grass Wash as they approach Aguila.

Breach in fishery dike

Although there are fences that prevent vehicular access to the top of the dike, the top width of 10 to 12 feet would allow for a maintenance road. The slope of both the upstream and downstream faces is about 3½:1.

The check structures downstream of the diversion dike have a narrower top width, preventing vehicular access. Side slopes vary from 2:1 to 3:1. The earthen berms seem to have been constructed from material excavated from the downstream side of each dam. This has created pools downstream of the dams, which enhance habitat.

Breach shows typical cross section of dike

Typical check dam downstream of dike

Vegetation is extremely thick in these areas. The integrity of the check dam system seems to be intact.

Recommendation

Because the original purpose of the diversion dike, to protect the fishery, is no longer necessary, and because the check dams receive sufficient water to sustain plant life, there is no reason to believe that the property owners will repair the diversion dike. The flood protection originally afforded to the agricultural properties, although not insignificant, was incidental. Repairing the diversion dike would restore this limited flood protection to the agricultural properties, but not remove inhabited residential structures from the floodplain. Therefore, repair of the dike is not recommended.

Centennial Wash Levees

This series of small check structures and levees located on the main branch of the Centennial Wash are very short in height with no appreciable pool area. The structure located furthest downstream is only 2.3 feet tall. Multiple breaches and areas of overtopping are present at nearly every location. In at least one location, flows tend to bypass around both ends of the structure.

Construction is of loosely compacted fill with a rounded top and gently sloping upstream and downstream faces. Structures are generally void of any vegetation.

It appears that these types of structures were probably built to protect farm fields by retarding minor flows, probably in the 2-year to 5-year range. Being uncompacted and not regularly maintained (as evidenced by failures appearing in the aerial photographs), they probably serve little or no real flood control purpose, certainly not above a 5-year frequency event.

Recommendation

This type of structure should be ignored for the 100-year storm, having no flood control benefit. An alternative that includes rehabilitating these structures would not provide any significant level of flood protection.

Typical Centennial Wash levee

Numerous breaches in the levee system

Pool level in the stock tank

West Stock Tank

This is an actively used and maintained stock pond. The embankment is quite a bit higher than is necessary to contain the pool area. This may be because the pond is regularly dredged and sediment material is laid on the downstream face and embankment top. Mature and healthy vegetation in the pond area indicates that water is probably present year around.

Although the embankment is quite high, the associated storage volume is actually very small, probably only several acre-feet. The structure was not intended to have any flood control benefit and in fact does not serve to provide even incidental protection to any inhabited structures downstream of the spillway.

Recommendation

Any improvements to this type of structure to provide flood control would not be beneficial.

CLEARING OF EXCESS VEGETATION IN CENTENNIAL WASH

A sensitivity analysis of the hydrologic model was performed to determine whether clearing vegetation in Centennial Wash or Grass Wash would provide meaningful flood control benefits. Vegetation clearing within existing channels includes regular maintenance to remove excess vegetation and debris by mowing, grading, and/or cutting.

Channel clearing and maintenance operations reduce the obstructions in the drainage system. The reduction in vegetative density and channel obstructions reduces the Manning's n value, thereby increasing channel velocities.

Methodology

The concept was evaluated by varying the travel velocity component within the Muskingum Routing method used for reach routing in the hydrologic model. The HEC-1 model was prepared using a constant travel velocity of four feet per second (fps). This value was varied to present a range representative of a cleared channel. The cost to perform and maintain a channel clearing project and associated maintenance was compared against the flood control benefits of such a program.

The analysis included:

- Varying the velocity (3.0 fps, 3.5 fps, 4.5 fps, 5.0 fps, and 5.5 fps) and recalculating the routing parameters (the attached spreadsheets show calculations for each velocity; the existing model assumes a constant 4.0 fps).
- Running the model with revised parameters (see the Technical Data Notebook for the output for each run).
- Comparing the results of peak discharge at several strategic locations, such as at US 60, SR 71, and most downstream points.
- Summarizing the results in a report/technical memorandum.

The following table compares peak discharge (Q) and time to peak at various strategic locations:

Table 1: Discharge at various locations for different velocities

Velocity (fps)	Station (concentration point)					
	SR 71 (K)		US 60 and Railroad (F)		Downstream (O)	
	Q	time to peak (hrs)	Q	time to peak (hrs)	Q	time to peak (hrs)
3	8863	15.83	15421	18.83	18574	21.5
3.5	9929	15.33	17016	17.83	22563	20
4	**10427**	15	**16866**	18	**21730**	19
4.5	11439	14.83	17725	17.33	24584	18.83
5	12178	14.83	18124	17.17	26401	18
5.5	12557	14.67	18652	17	28377	17.67

The locations selected represent strategic locations that have been identified throughout the Study Area. Concentration point K represents where SR 71 intersects US 60. This takes into account the Aguila Farm Channel. Concentration point F is located at the railroad and US 60. It includes the flows from Grass Wash. The point furthest downstream, O, is on Centennial Wash.

As expected, at higher velocities the peak discharge is higher and the time to peak is shorter. Channel clearing would actually increase the flood potential because a higher channel velocity would cause more flooding to occur in the community. A maintenance program that would keep the existing channels clear of vegetation and debris would create this effect. If the system were left as is, there would be no change in the existing flooding condition.

Assuming a channel width of 100 feet and a linear stretch of ten miles, the area of channel is about 120 acres. Based on this analysis, the conclusion is:

- At a unit cost of $3,000 per acre, a clearing effort of the downstream portion of Centennial Wash was estimated at $360,000. The total for this effort does not seem to provide any flood control benefit to Aguila and could actually increase the flood potential.

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 3 fps
Time steps = 10 min.
Muskingum weighting 0.2

Number of minutes in computational interval (NMIN) = 10 minutes 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (velocity fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{AMSKK \times 60}{NSTPS \times NMIN} <= \frac{1}{2X}$$

Calculate Values:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X
R1	1042	0.096	1	0.2
R2A	23437	2.170	13	0.2
RA	7031	0.651	4	0.2
RB	6771	0.627	4	0.2
R5A	21875	2.025	12	0.2
RC	10417	0.965	6	0.2
R7A	28385	2.628	16	0.2
RD	7552	0.699	4	0.2
R8	4687	0.434	3	0.2
RE	28125	2.604	16	0.2
R13	3906	0.362	2	0.2
RF	14063	1.302	8	0.2
R100	26042	2.411	14	0.2
RG	35417	3.279	20	0.2
R103	17708	1.640	10	0.2
R106	28125	2.604	16	0.2
RH	1823	0.169	1	0.2
RI	40625	3.762	23	0.2
R108	29427	2.725	16	0.2
R109	14062	1.302	8	0.2
RJ	30729	2.845	17	0.2
RK	15625	1.447	9	0.2
R201	13542	1.254	8	0.2
RL	14323	1.326	8	0.2
RM	14063	1.302	8	0.2
R206	6771	0.627	4	0.2
RN	10677	0.989	6	0.2

Check:

AMSKK x 60 / NSTPS x NMIN	1 / 2 (1-X)	1 / 2X
0.58	0.625	2.5
1.00	0.625	2.5
0.98	0.625	2.5
0.94	0.625	2.5
1.01	0.625	2.5
0.96	0.625	2.5
0.99	0.625	2.5
1.05	0.625	2.5
0.87	0.625	2.5
0.98	0.625	2.5
1.09	0.625	2.5
0.98	0.625	2.5
1.03	0.625	2.5
0.98	0.625	2.5
0.98	0.625	2.5
0.98	0.625	2.5
1.01	0.625	2.5
0.98	0.625	2.5
1.02	0.625	2.5
0.98	0.625	2.5
1.00	0.625	2.5
0.96	0.625	2.5
0.94	0.625	2.5
0.99	0.625	2.5
0.98	0.625	2.5
0.94	0.625	2.5
0.99	0.625	2.5

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 3.5 fps
Time steps = 10 min.
Muskingum weighting 0.2

Number of minutes in computational interval (NMIN) = 10 minutes 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (velocity fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{AMSKK \times 60}{NSTPS \times NMIN} <= \frac{1}{2X}$$

Calculate Values:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X
R1	1042	0.083	1	0.2
R2A	23437	1.860	11	0.2
RA	7031	0.558	3	0.2
RB	6771	0.537	3	0.2
R5A	21875	1.736	10	0.2
RC	10417	0.827	5	0.2
R7A	28385	2.253	14	0.2
RD	7552	0.599	4	0.2
R8	4687	0.372	2	0.2
RE	28125	2.232	13	0.2
R13	3906	0.310	2	0.2
RF	14063	1.116	7	0.2
R100	26042	2.067	12	0.2
RG	35417	2.811	17	0.2
R103	17708	1.405	8	0.2
R106	28125	2.232	13	0.2
RH	1823	0.145	1	0.2
RI	40625	3.224	19	0.2
R108	29427	2.335	14	0.2
R109	14062	1.116	7	0.2
RJ	30729	2.439	15	0.2
RK	15625	1.240	7	0.2
R201	13542	1.075	6	0.2
RL	14323	1.137	7	0.2
RM	14063	1.116	7	0.2
R206	6771	0.537	3	0.2
RN	10677	0.847	5	0.2

Check:

AMSKK x 60 / NSTPS x NMI	1 / 2 (1-X)	1 / 2X
0.50	0.625	2.5
1.01	0.625	2.5
1.12	0.625	2.5
1.07	0.625	2.5
1.04	0.625	2.5
0.99	0.625	2.5
0.97	0.625	2.5
0.90	0.625	2.5
1.12	0.625	2.5
1.03	0.625	2.5
0.93	0.625	2.5
0.96	0.625	2.5
1.03	0.625	2.5
0.99	0.625	2.5
1.05	0.625	2.5
1.03	0.625	2.5
0.87	0.625	2.5
1.02	0.625	2.5
1.00	0.625	2.5
0.96	0.625	2.5
0.98	0.625	2.5
1.06	0.625	2.5
1.07	0.625	2.5
0.97	0.625	2.5
0.96	0.625	2.5
1.07	0.625	2.5
1.02	0.625	2.5

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 4 fps
Time steps = 10 min.
Muskingum weighting factor (X) = 0.2

Number of minutes in computational interval (NMIN) = 10 minutes = 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (4fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{\text{AMSKK} \times 60}{\text{NSTPS} \times \text{NMIN}} <= \frac{1}{2X}$$

Calculate Values:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X
R1	1042	0.072	1	0.2
R2A	23437	1.628	10	0.2
RA	7031	0.488	3	0.2
RB	6771	0.470	3	0.2
R5A	21875	1.519	9	0.2
RC	10417	0.723	4	0.2
R7A	28385	1.971	12	0.2
RD	7552	0.524	3	0.2
R8	4687	0.325	2	0.2
RE	28125	1.953	12	0.2
R13	3906	0.271	2	0.2
RF	14063	0.977	6	0.2
R100	26042	1.808	11	0.2
RG	35417	2.460	15	0.2
R103	17708	1.230	7	0.2
R106	28125	1.953	12	0.2
RH	1823	0.127	1	0.2
RI	40625	2.821	17	0.2
R108	29427	2.044	12	0.2
R109	14062	0.977	6	0.2
RJ	30729	2.134	13	0.2
RK	15625	1.085	7	0.2
R201	13542	0.940	6	0.2
RL	14323	0.995	6	0.2
RM	14063	0.977	6	0.2
R206	6771	0.470	3	0.2
RN	10677	0.741	4	0.2

Check:

$\frac{\text{AMSKK} \times 60}{\text{NSTPS} \times \text{NMIN}}$	$\frac{1}{2\,(1-X)}$	$\frac{1}{2X}$
0.43	0.625	2.5
0.98	0.625	2.5
0.98	0.625	2.5
0.94	0.625	2.5
1.01	0.625	2.5
1.09	0.625	2.5
0.99	0.625	2.5
1.05	0.625	2.5
0.98	0.625	2.5
0.98	0.625	2.5
0.81	0.625	2.5
0.98	0.625	2.5
0.99	0.625	2.5
0.98	0.625	2.5
1.05	0.625	2.5
0.98	0.625	2.5
0.76	0.625	2.5
1.00	0.625	2.5
1.02	0.625	2.5
0.98	0.625	2.5
0.98	0.625	2.5
0.93	0.625	2.5
0.94	0.625	2.5
0.99	0.625	2.5
0.98	0.625	2.5
0.94	0.625	2.5
1.11	0.625	2.5

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 4.5 fps
Time steps = 10 min.
Muskingum weighting 0.2

Number of minutes in computational interval (NMIN) = 10 minutes 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (velocity fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{AMSKK \times 60}{NSTPS \times NMIN} <= \frac{1}{2X}$$

Calculate Values:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X
R1	1042	0.064	1	0.2
R2A	23437	1.447	9	0.2
RA	7031	0.434	3	0.2
RB	6771	0.418	3	0.2
R5A	21875	1.350	8	0.2
RC	10417	0.643	4	0.2
R7A	28385	1.752	11	0.2
RD	7552	0.466	3	0.2
R8	4687	0.289	2	0.2
RE	28125	1.736	10	0.2
R13	3906	0.241	1	0.2
RF	14063	0.868	5	0.2
R100	26042	1.608	10	0.2
RG	35417	2.186	13	0.2
R103	17708	1.093	7	0.2
R106	28125	1.736	10	0.2
RH	1823	0.113	1	0.2
RI	40625	2.508	15	0.2
R108	29427	1.816	11	0.2
R109	14062	0.868	5	0.2
RJ	30729	1.897	11	0.2
RK	15625	0.965	6	0.2
R201	13542	0.836	5	0.2
RL	14323	0.884	5	0.2
RM	14063	0.868	5	0.2
R206	6771	0.418	3	0.2
RN	10677	0.659	4	0.2

Check:

AMSKK x 60 / NSTPS x NM	1 / 2 (1-X)	1 / 2X
0.39	0.625	2.5
0.96	0.625	2.5
0.87	0.625	2.5
0.84	0.625	2.5
1.01	0.625	2.5
0.96	0.625	2.5
0.96	0.625	2.5
0.93	0.625	2.5
0.87	0.625	2.5
1.04	0.625	2.5
1.45	0.625	2.5
1.04	0.625	2.5
0.96	0.625	2.5
1.01	0.625	2.5
0.94	0.625	2.5
1.04	0.625	2.5
0.68	0.625	2.5
1.00	0.625	2.5
0.99	0.625	2.5
1.04	0.625	2.5
1.03	0.625	2.5
0.96	0.625	2.5
1.00	0.625	2.5
1.06	0.625	2.5
1.04	0.625	2.5
0.84	0.625	2.5
0.99	0.625	2.5

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 5 fps
Time steps = 10 min.
Muskingum weighting 0.2

Number of minutes in computational interval (NMIN) = 10 minutes 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (velocity fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{AMSKK \times 60}{NSTPS \times NMIN} <= \frac{1}{2X}$$

Calculate Values:

Check:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X	AMSKK x 60 / NSTPS x NM	1 / 2 (1-X)	1 / 2X
R1	1042	0.058	1	0.2	0.35	0.625	2.5
R2A	23437	1.302	8	0.2	0.98	0.625	2.5
RA	7031	0.391	2	0.2	1.17	0.625	2.5
RB	6771	0.376	2	0.2	1.13	0.625	2.5
R5A	21875	1.215	7	0.2	1.04	0.625	2.5
RC	10417	0.579	3	0.2	1.16	0.625	2.5
R7A	28385	1.577	9	0.2	1.05	0.625	2.5
RD	7552	0.420	3	0.2	0.84	0.625	2.5
R8	4687	0.260	2	0.2	0.78	0.625	2.5
RE	28125	1.563	9	0.2	1.04	0.625	2.5
R13	3906	0.217	1	0.2	1.30	0.625	2.5
RF	14063	0.781	5	0.2	0.94	0.625	2.5
R100	26042	1.447	9	0.2	0.96	0.625	2.5
RG	35417	1.968	12	0.2	0.98	0.625	2.5
R103	17708	0.984	6	0.2	0.98	0.625	2.5
R106	28125	1.563	9	0.2	1.04	0.625	2.5
RH	1823	0.101	1	0.2	0.61	0.625	2.5
RI	40625	2.257	14	0.2	0.97	0.625	2.5
R108	29427	1.635	10	0.2	0.98	0.625	2.5
R109	14062	0.781	5	0.2	0.94	0.625	2.5
RJ	30729	1.707	10	0.2	1.02	0.625	2.5
RK	15625	0.868	5	0.2	1.04	0.625	2.5
R201	13542	0.752	5	0.2	0.90	0.625	2.5
RL	14323	0.796	5	0.2	0.95	0.625	2.5
RM	14063	0.781	5	0.2	0.94	0.625	2.5
R206	6771	0.376	2	0.2	1.13	0.625	2.5
RN	10677	0.593	4	0.2	0.89	0.625	2.5

File	clear veg centennial.xls	Job No.	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	MP	Date	11/18/2002
Subject	Muskingam Routing Summary	Checked		Date	
Task	Clear Excess Vegetation at Centennial Wash (Phase II Lite)	Sheet		Of	

Assume: Avg. travel velocity = 5.5 fps
Time steps = 10 min.
Muskingum weighting 0.2

Number of minutes in computational interval (NMIN) = 10 minutes 0.17 hr.

Muskingum K (AMSKK) = Reach Length (ft.) / (velocity fps X 3600 sec/hr)

Number of subreaches (integer NSTPS) = K(hr.) x (60 min/hr) / dt

NOTE: "To insure computational stability and the accuracy of the computed hydrograph, the routing reach should be chosen so that":

$$\frac{1}{2\,(1-X)} <= \frac{\text{AMSKK} \times 60}{\text{NSTPS} \times \text{NMIN}} <= \frac{1}{2X}$$

Calculate Values:

Reach ID	Reach Length (ft.)	AMSKK (hr.)	NSTPS (hr.)	X
R1	1042	0.053	1	0.2
R2A	23437	1.184	7	0.2
RA	7031	0.355	2	0.2
RB	6771	0.342	2	0.2
R5A	21875	1.105	7	0.2
RC	10417	0.526	3	0.2
R7A	28385	1.434	9	0.2
RD	7552	0.381	2	0.2
R8	4687	0.237	1	0.2
RE	28125	1.420	9	0.2
R13	3906	0.197	1	0.2
RF	14063	0.710	4	0.2
R100	26042	1.315	8	0.2
RG	35417	1.789	11	0.2
R103	17708	0.894	5	0.2
R106	28125	1.420	9	0.2
RH	1823	0.092	1	0.2
RI	40625	2.052	12	0.2
R108	29427	1.486	9	0.2
R109	14062	0.710	4	0.2
RJ	30729	1.552	9	0.2
RK	15625	0.789	5	0.2
R201	13542	0.684	4	0.2
RL	14323	0.723	4	0.2
RM	14063	0.710	4	0.2
R206	6771	0.342	2	0.2
RN	10677	0.539	3	0.2

Check:

AMSKK x 60 / NSTPS x NM	1 / 2 (1-X)	1 / 2X
0.32	0.625	2.5
1.01	0.625	2.5
1.07	0.625	2.5
1.03	0.625	2.5
0.95	0.625	2.5
1.05	0.625	2.5
0.96	0.625	2.5
1.14	0.625	2.5
1.42	0.625	2.5
0.95	0.625	2.5
1.18	0.625	2.5
1.07	0.625	2.5
0.99	0.625	2.5
0.98	0.625	2.5
1.07	0.625	2.5
0.95	0.625	2.5
0.55	0.625	2.5
1.03	0.625	2.5
0.99	0.625	2.5
1.07	0.625	2.5
1.03	0.625	2.5
0.95	0.625	2.5
1.03	0.625	2.5
1.09	0.625	2.5
1.07	0.625	2.5
1.03	0.625	2.5
1.08	0.625	2.5

Compare Q at various locations

Station:						
Velocity (fps) in	US 60 & RR (F)		US 71 (K)		Downstream (O)	
Centennial Wash	Q	time of peak	Q	time of peak	Q	time of peak
3	15421	18.83	8863	15.83	18574	21.5
3.5	17016	17.83	9929	15.33	22563	20
4	**16866**	18	**10427**	15	**21730**	19
4.5	17725	17.33	11439	14.83	24584	18.83
5	18124	17.17	12178	14.83	26401	18
5.5	18652	17	12557	14.67	28377	17.67

DETENTION STORAGE

Background

A traditional way of reducing flood damage is to intercept and reduce the peak discharge (flow) that reaches a location. Floodwater storage works by either retaining the flow, thereby releasing a very small discharge, or by reducing the flow by attenuating the hydrograph (reducing the flow with little change in its total volume). Attenuation of the hydrograph is accomplished by providing enough volume in a basin such that inflow must spread out and fill the basin before leaving.

Two floodwater storage structural alternatives were suggested for further analysis at the August 15, 2002 workshop. They were:

1. Detention Basin Near SR 71 and the railroad: Flood flows associated with this breakout have flooded the community. Flood flows arriving from the east contribute to flood flows directly from Grass Wash. The breakout floods areas within both Zone A and X. A basin to contain or attenuate the flows at this location would reduce flooding that the community has experienced.
2. Detention Basin on Grass Wash Upstream of Aguila: Flows that enter the community from the southeast flood areas associated with the Zone A. A basin to intercept and attenuate flows at this location would reduce flooding directly attributed to Grass Wash.

A hydrologic analysis was performed to determine the feasibility of constructing an off-line storage basin near the intersection of SR 71 and the railroad, and of constructing an on-line storage basin along Grass Wash. Specifically, the questions to be answered are "Is it economical to construct a basin large enough to contain the hydrograph peak, preventing damage associated with an uncontrolled discharge over the railroad?" and, "Is it economical to construct a basin along Grass Wash to prevent flooding in the Grass Wash floodplain upstream of US 60?"

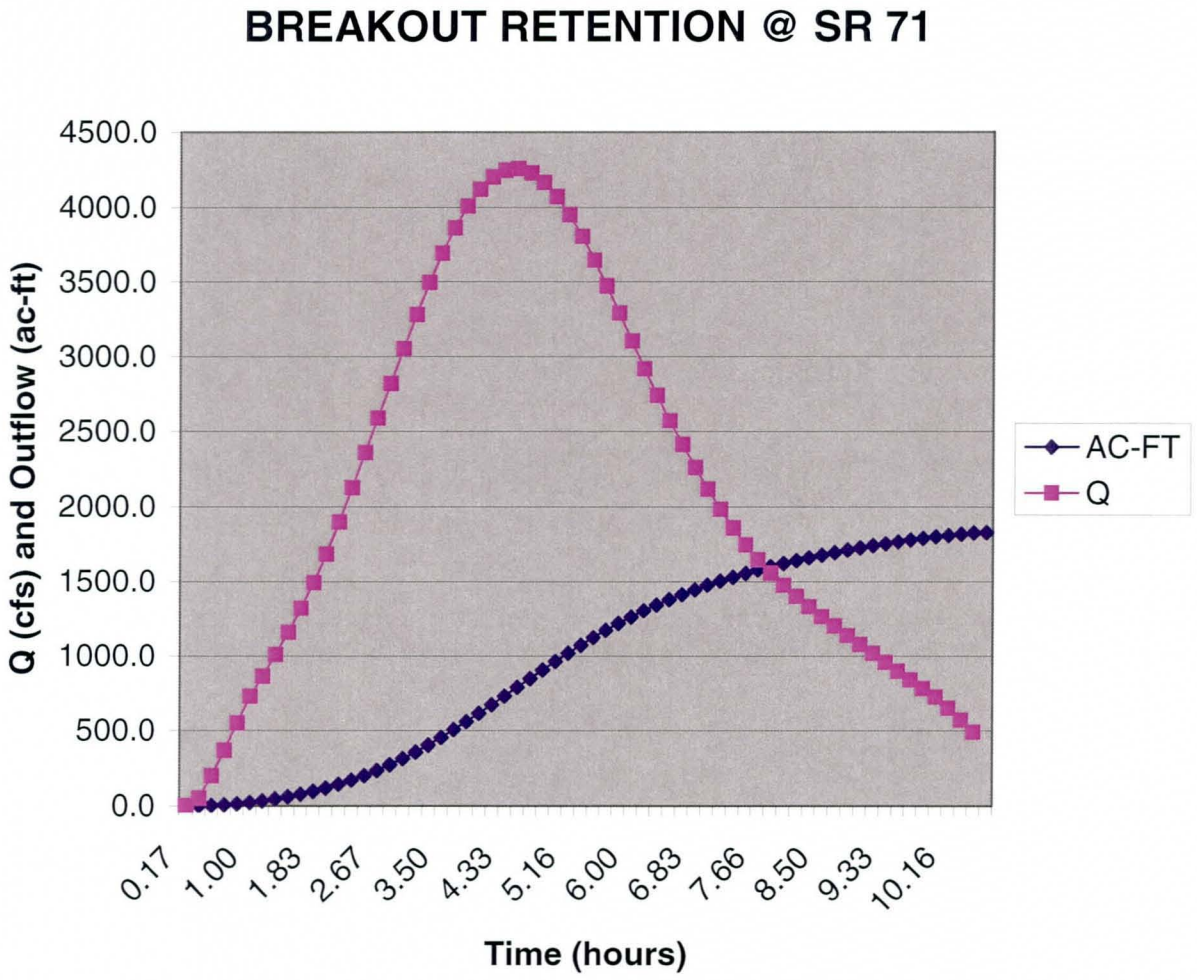
Modeling detention storage at several locations, with several sizes of basins, was performed using HEC-1. Costs for basin construction were estimated based on recent historical construction data. The hydraulic effects were analyzed qualitatively.

Detention Basin Near SR 71 and the Railroad

This section develops the required information to answer "Is it economical to construct a basin to contain the diverted hydrograph peak, preventing damage associated with an uncontrolled discharge over the railroad?" A basin here would act as if the railroad was the inflow (inlet) of an off-line detention basin. The off-line basin would serve essentially as a retention basin for breakout flows. Because the existing floodplain mapping found on the effective Flood Insurance Rate Map (FIRM) does not account for this breakout, the floodplain in Aguila would be as presently depicted (Grass Wash floodplain only). Flooding downstream of the breakout is in

sheet flow until it reaches Grass Wash. A non-destructive discharge would have to be very low due to the lack of channels and already undersized facilities associated with Grass Wash.

Flows from the breakout are the inflow into the basin (the URS Consultants model did not account for the breakout; therefore mapping would stay the same), and the volume of the diverted hydrograph computed in the Aguila ADMP is the volume of storage required. Taking the breakout hydrograph from the approved hydrology model, the only analysis required was volume verses depth/area and associated costs.



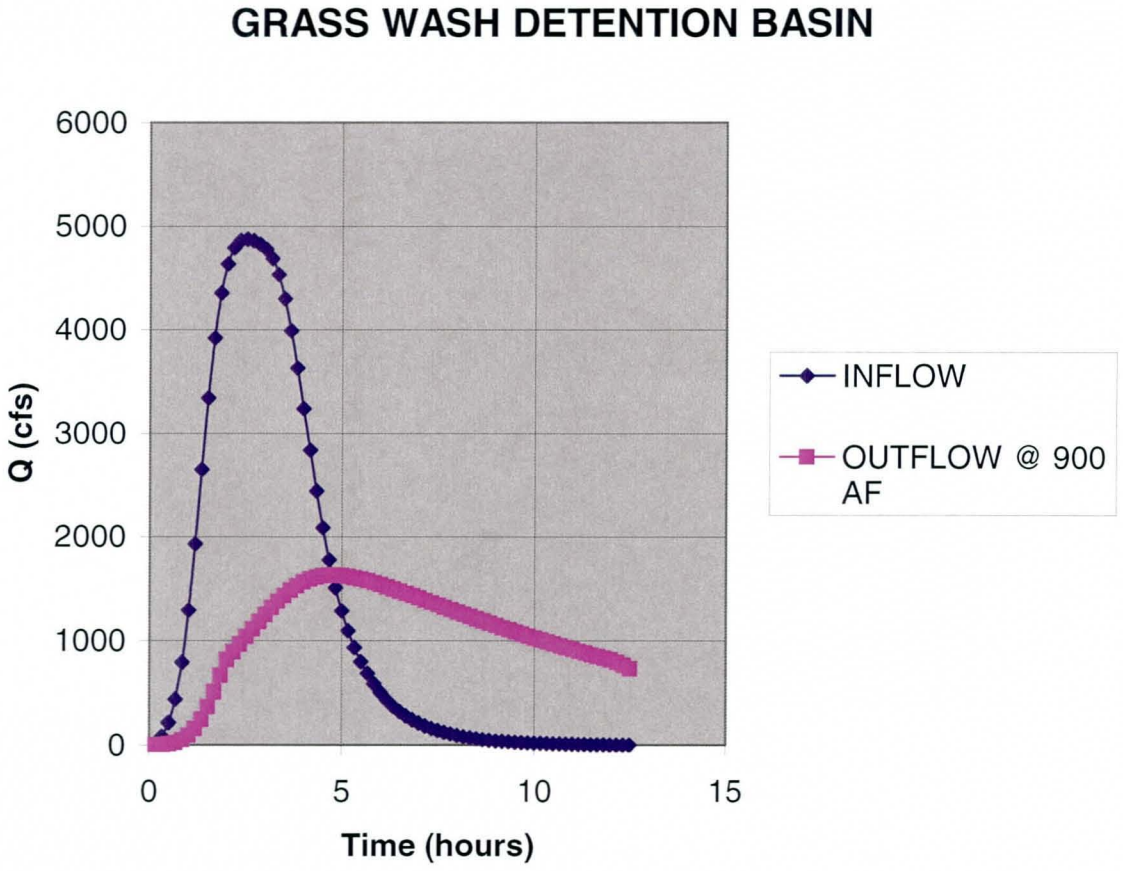
A basin at this location is estimated to cost in excess of $11,000,000. The costs associated with long term maintenance, multi-use, or access related components were not computed. The actual

basin size would be larger than the computed floodwater storage volume to accommodate side slopes and any maintenance ramps that might be required.

The benefit of a basin at this location would be the elimination of flooding due to the breakout of flow from Aguila Farm Channel upstream of SR 71 into the Grass Wash Watershed. These flows would be intercepted and would reduce damages associated with flooding coming from the east into Aguila. However, flooding from other sources would continue, such as Grass Wash and the Grass Wash tributaries east of Aguila.

Detention Basin on Grass Wash Upstream of Aguila

This section develops the required information to answer "Is it economical to construct a basin along Grass Wash to prevent flooding in the Grass Wash floodplain upstream of US 60?" A proposed basin located just upstream of "Goose Lake", in a wide floodprone and flat area, was analyzed. This location was chosen because it is upstream of housing, has floodprone areas associated with Grass Wash, and is at a concentration point in the model (Concentration Point B representing the start of routing reach RB).



The process of sizing a proposed basin consisted of:

- The inflow hydrograph is from the hydrology model at C.P.B.
- A safe discharge (outflow) was assumed to be the 10-year discharge.
- Developed stage/storage/outflow relationship for on-line basin at routing reach RB.
- Prepared storage routing data for HEC-1, using RS, SV, and SQ records (RS = using reservoir routing, SV= storage volume, and SQ= outflow Q).
- Outflow hydrographs were developed for the basin, taking several iterations.
- Locations were identified in the "diagram" or schematic prior to placement into the model.
- Comment cards where added for all changes and additions.
- Analysis of the watershed and its subbasins compiled and compared to existing conditions (spreadsheet/graph was prepared depicting basin volume verses outflow, basin depth verses size, basin size verses cost).

A basin at this location is estimated to cost in excess of $5,000,000. The costs associated with long term maintenance, multi-use, or access related components were not computed. The basin size would be larger than the computed floodwater storage volume to accommodate side slopes and any maintenance ramps that might be required.

The benefit of a basin at this location would be the reduction of flooding due to Grass Wash. Flows from Grass Wash and its tributaries at this location would be intercepted and would reduce damages. Flooding problems would persist where more frequent discharges cause flooding (e.g., where finished floor elevations are at-grade, allowing entry of floodwaters during frequent events); tributaries to Grass Wash cause flooding downstream from the proposed basin site, or there is a breakout from Aguila Farm Channel.

Recommendations

The focus of the analysis is on the merits of an alternative to be carried forward for further development. These two alternative basin locations were analyzed independently with the intent of resolving specific flooding conditions. The basin at SR 71 was analyzed in an effort to find a solution to recent flooding in areas in, and out of, the federally mapped floodplain. The basin on Grass Wash was analyzed in an effort to find a solution to flooding experienced in currently mapped floodplains within Aguila. Construction of a single basin would only resolve finite flooding problems in an area with flooding sources from numerous directions. Integrated solutions to the flooding problem would require the construction of both basins at a cost of over $16,000,000. Based on this analysis the conclusion are:

- The detention basin option(s) are hydraulically feasible.
- The cost to construct the basin alternative is cost prohibitive and therefore was not further considered.

File	Detention Basin At Break-out Over Tracks	Job No 07162084-044	No. 1

Computation

HDR

Project	Aguila ADMP	Computed	TDM	Date	11/26/2002
Subject	Hydrograph and Proposed Retention Basin	Checked		Date	
Task	Compute Area of Basin	Sheet		Of	

Assume:

Break-out would be contained within basin near RR tracks
Outflow would be minimal due to severe flooding
Volume within 24-hr Model will be used (discharge at end of 24-hrs disregarded)
Assumed basin size does not include maintenance and multi-use components

Number of minutes in computational interva 10 min. = 0.17 hr.

Hydrograph Volume in Acre Feet (DIVK from FCD100XX.OUT) = 1827 AC-FT

Depth ft	Size acre	Land Cost $10,000.00 per acre	Earth Work $3.00 cy
2	914	$9,135,123.97	$8,842,617.30
3	609	$6,090,082.64	"
4	457	$4,567,561.98	"
5	365	$3,654,049.59	"
6	305	$3,045,041.32	"
7	261	$2,610,035.42	"
8	228	$2,283,780.99	"
9	203	$2,030,027.55	"
10	183	$1,827,024.79	"

Ranges from	$17,977,741.26
to	$10,669,642.09

File	Detention Basin At C.P. B	Job No	07162084-044	No.	1

Computation

HDR

Project	Aguila ADMP	Computed	TDM	Date	11/26/2002
Subject	Hydrograph and Proposed Detention Basin - Grass Wash @ B	Checked		Date	
Task	Compute Area of Basin and Costs	Sheet		Of	

Assume:

Volume within 24-hr Model will be used (discharge at end of 24-hrs disregarded)
Assumed basin size does not include maintenance and multi-use components
Base Model: URS Model modified with break-out over the RR tracks at SR 71

Number of minutes in computational interva 10 min. = 0.17 hr.

Discharge from FCD10XX.DAT @ Routing Reach RB = 1696 cfs
Discharge from FCD100XX.DAT @ Routing Reach RB = 4844 cfs
Hydrograph Volume in Acre Feet to Obtain 10-yr Q 900 AC-FT
(GR-DET.DAT modified for reservoir at B w/ 100-yr Q)

Depth ft	Size acre	Land Cost $10,000.00 per acre	Earth Work $3.00 cy
2	450	$4,500,000.00	$4,355,910.00
3	300	$3,000,000.00	"
4	225	$2,250,000.00	"
5	180	$1,800,000.00	"
6	150	$1,500,000.00	"
7	129	$1,285,714.29	"
8	113	$1,125,000.00	"
9	100	$1,000,000.00	"
10	90	$900,000.00	"

Ranges from	$8,855,910.00
to	$5,255,910.00

100-yr Impact downstream

	Existing	W/ Basin	
Reach RB	4844	1628	Proposed Basin
C.P. C	7495	4150	Goose Lake
C.P. F	11346	8222	US 60
C.P. O	20898	19417	End of Study Hydrology

FLOOD PROOFING TECHNIQUES

Background

"Flood proofing is any combination of structural changes and/or adjustments incorporated in the design and/or construction and alteration of individual buildings, structures, or properties, primarily for the reduction of flood damages" (USACE, 2002). There are various methods of flood proofing including: elevation, wet flood proofing, relocation, dry flood proofing, levees and floodwalls, and demolition.

Flood proofing or retrofitting methods can be combined into two major categories: active and passive methods (FEMA, 1998). Active methods require human intervention while passive methods do not. Hence, active methods require some prior warning of the flood, as well as someone being present in the home in order to be implemented. These methods range from openings on a floodwall that may need to be opened and/or closed, to raising all house contents onto platforms, in the case of wet flood proofing.

In 2000, the Flood Control District of Maricopa County completed a Hazard Mitigation Grant Program in Aguila in which six properties were bought. This option combined two techniques of flood proofing: relocation and demolition. The residents relocated to an alternate location and the structures were demolished. The land has since been dedicated for open space.

Since the techniques of relocation and demolition have been addressed previously, this assessment concentrates on other techniques for flood proofing and their applicability to Aguila. Elevation is one of the most common and effective forms of flood proofing. This technique can be applied by raising the home (the new structure or extended foundation) onto continuous walls, columns, piers, posts, or pilings. Other techniques for elevation include moving the home onto a second story and abandoning the first floor or raising the floor within the house. Elevating an existing structure may be inefficient if the home is older or is not in good condition. In addition, it is very costly when compared on a per unit basis.

According to the Aguila Hazard Mitigation Grant Program, the homes in danger of flooding ranged from $4,000 to $75,000, with a distinct classification between mobile homes (average $4,000), single-family manufactured homes (between $20,000 and $25,000), and single-family homes (between $60,000 and $75,000). Mobile homes are relatively easy to elevate at lower costs but the vast majority are attached to slab-on-grade additions that generally cost about $47 per square foot to elevate. For a slab-on-grade addition averaging 625 square feet (25 feet by 25 feet), this amounts to over $29,000, plus additional cost to elevate the mobile home (typically higher than the value of the home).

Wet flood proofing is a method of protecting the building and its contents while allowing it to flood. This method can be incorporated in design and construction using materials that will not undergo as much structural damage. Allowing the building to flood balances the hydrostatic

forces, minimizing the probability of breakage to walls and floors. When buildings are already in place, most of the effort focuses on protecting the contents of the home by elevating or covering appliances, furniture, etc.

Dry flood proofing is a method that uses sealants, membranes, and impermeable materials to protect walls and cover openings around buildings. Shields are used to cover doors, windows, vents, and other openings. This method is generally recommended for buildings constructed of reinforced concrete, concrete block, or brick veneer on a wood frame. The typical cost for dry flood proofing varies from $1.10 to $3.30 per square foot of wall covered, plus the cost of valves, pumps, shields, etc.

Levees and floodwalls protect properties by intercepting flows. Levees are typically constructed of compacted earth and are large in scale. They are usually built parallel to a river or stream. Floodwalls can be constructed at smaller scales to provide protection to individual homes or certain openings such as doors. Floodwalls are constructed of concrete or masonry. Their cost can range from $85 per linear foot for a wall two feet above ground level to $124 per linear foot for a wall four feet above ground level. In addition, other components necessary for this method include sump pumps and closures that can amount to $1,500. Therefore, for a typical 1,000 square foot structure, a floodwall system can range anywhere from $10,000 to over $20,000.

Flood Proofing Analysis for Aguila ADMP Study Area

For the Aguila ADMP Study Area, a flood proofing method that combines floodwalls and dry flood proofing would provide the necessary protection to the homes while keeping capital costs down.

Elevation certificates were prepared for the Aguila ADMP Study Area. The following table (Table 1) summarizes the findings of the information gathered:

Table 1: Number of Properties Flooded

Flooding occurs at a depth of:	Structures Where Bottom Floor Floods
Total number of properties flooded	48
0-6"	48
>6"	37
>1'	28
>1.5'	23
>2'	17
>2.5'	14
>3'	11
Average flooding depth (ft)	1.91

The total number of properties below the base flood elevation is 80. Of those, 48 properties had structures that suffered flooding (bottom floor). The average water depth from a base flood inside the structural property was 1.9 feet.

Based on the generic depth-damage relationships developed by FEMA (2000), for a one-story home with no basement, for a two-foot depth of water, the average damage to a structure can be quantified as 32% of the property value. In terms of contents of the home, the damage can be estimated at a mean of 17.9% of the home value.

For a 1,000 square foot home, the cost of flood proofing using a floodwall system with sump pump, closures can range from $20,000 to over $60,000. Figure 1 shows the cost of flood proofing a home for the various levels of flooding. As shown, there is significant increase in cost when protecting a home for a flood elevation higher than 1.5 feet. Allowing one foot of freeboard, the floodwall height corresponding to 1.5 feet protection is 2.5 feet.

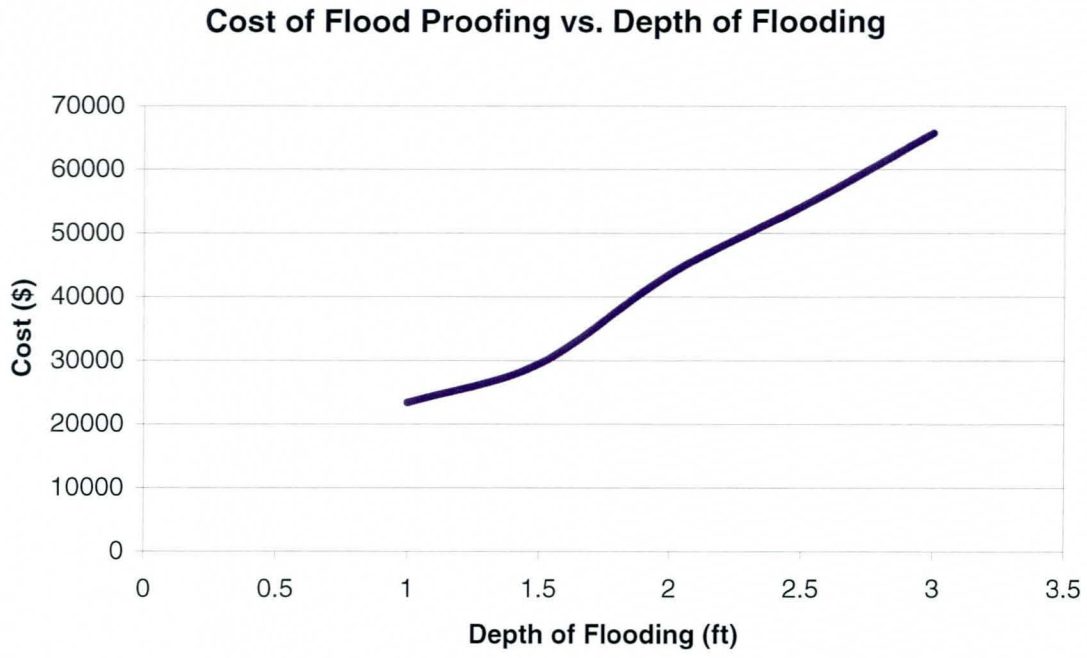


Figure 1: Typical cost of flood proofing vs. depth of flood

These estimates were for 1,000 square foot homes. According to the elevation surveys, of the 48 homes that lie within the base flood elevation, 25 are mobile homes, or about 50%. A more detailed assessment of these properties will be made in order to better estimate the cost of constructing a floodwall for this area. This represents the homes in Fairhaven RV Park, which are located within the Grass Wash floodplain. These particular properties can be protected using a combination of elevation and floodwalls. The mobile home can be easily elevated while the additions can be protected with the use of floodwalls. The cost of protecting the add-ons

with floodwalls reduces the cost significantly compared to elevating. Assuming a 20-foot by 20-foot slab-on-grade addition, the cost of a four-foot wall is approximately $10,000.

These general cost data were compared with recent cost estimates developed by the District for its potential flood proofing activities in the Wittmann area. Four pre-manufactured homes are being considered for elevation on 3-foot stem walls after recent flooding. The District has estimated that the flood proofing costs would be approximately $12,500 per structure. Using this estimate with an additional 15% due to the more remote location and 20% to cover any required analysis or design, the unit cost per structure would be about $17,000 for a pre-manufactured home. It was assumed that a mobile home with attached slab-on-grade structure could be elevated for approximately half the cost, but would need an additional flood wall for the add-on structure of $10,000. Elevation of a single-family home would be more expensive than pre-manufactured; therefore, the unit cost was increased by 30%, or $22,000.

A combination of techniques, along with an established early warning system, would provide the community with options to their flooding concerns. Early warning and response would also provide the community with education and direction in the event of large storm events.

File	Finished Floor.xls	Job No.	07162084-044	No.	1

Computation

Project	Aguila ADMP	Computed	MP	Date	11/11/2002
Subject	Flood Proofing Costs Summary	Checked	DWB	Date	12/13/2002
Task	Homes in Existing Floodplain Only	Sheet		Of	

Depth of Flooding at Finished Floor	# of Single Family Homes	Cost per House	Total Cost
X < 1.0'	15	14,819	222,285
1.0' < X < 1.5'	5	29,413	147,065
1.5' < X < 2.0'	2	43,534	87,068
2.0' < X < 2.5'	1	54,113	54,113
2.5' < X < 3.0'	0	65,699	-
3.0' < X	0	65,699	-
	23		510,531

# of Mobile Homes	Cost to Elevate Mobile Home	Cost for Floodwall	Total Cost
25	5000	11,420	410,500

Cost of Flood Proofing in Existing Floodplain 921,031

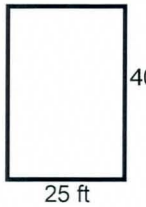
Job No. 07162-084-044	No.

Computation

HDR

Project	Aguila ADMP	Comp MP	Date 12/3/2002
Subject	Phase II Lite	Checked	Date
Task	Flood Proofing - Cost Estimate	Sheet	Of

Assume:
Typical Home, 1000 square feet

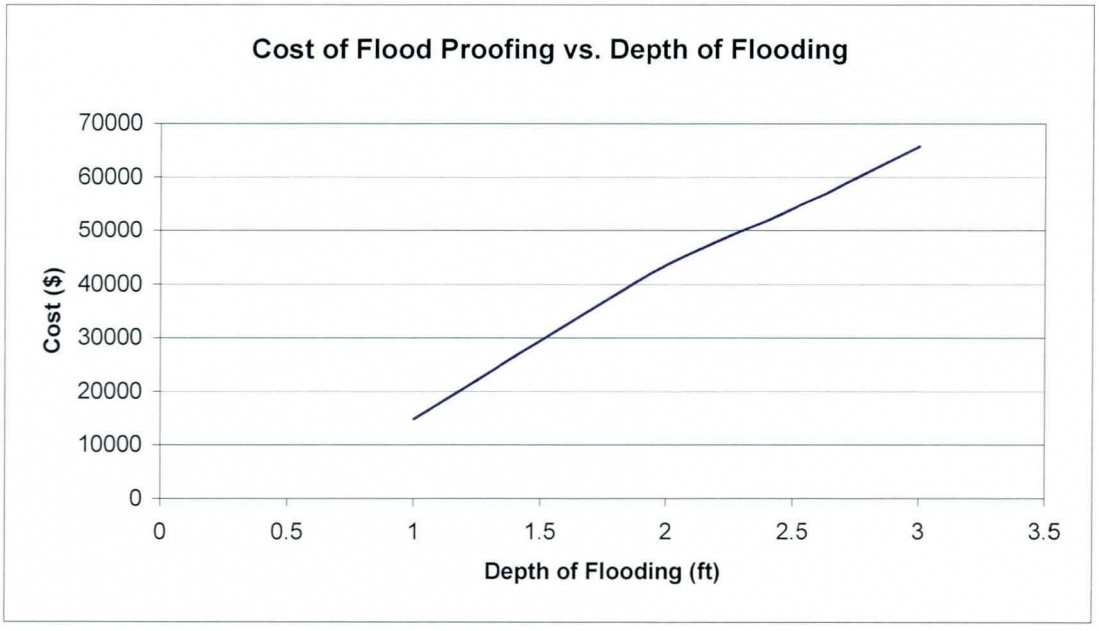


Total Length = 130 ft
Cost = 130 X Unit Cost
Total Cost = Cost + Sump Pump + Closures + Dry Flood Proofing

Flood proofing method is floodwall with sump pump, closures, and some dry flood proofing membrane or sealant

Number of closures = 3

Depth of Flooding (ft)	Freboard	Unit Cost	Sump Pump	Closures	Total Cost
1	1	85	1000	219	14819
1.5	1	86.75	1000	219	29413
2	1	108.5	1000	219	43534
2.5	1	116.25	1000	219	54113
3	1	124	1000	219	65699



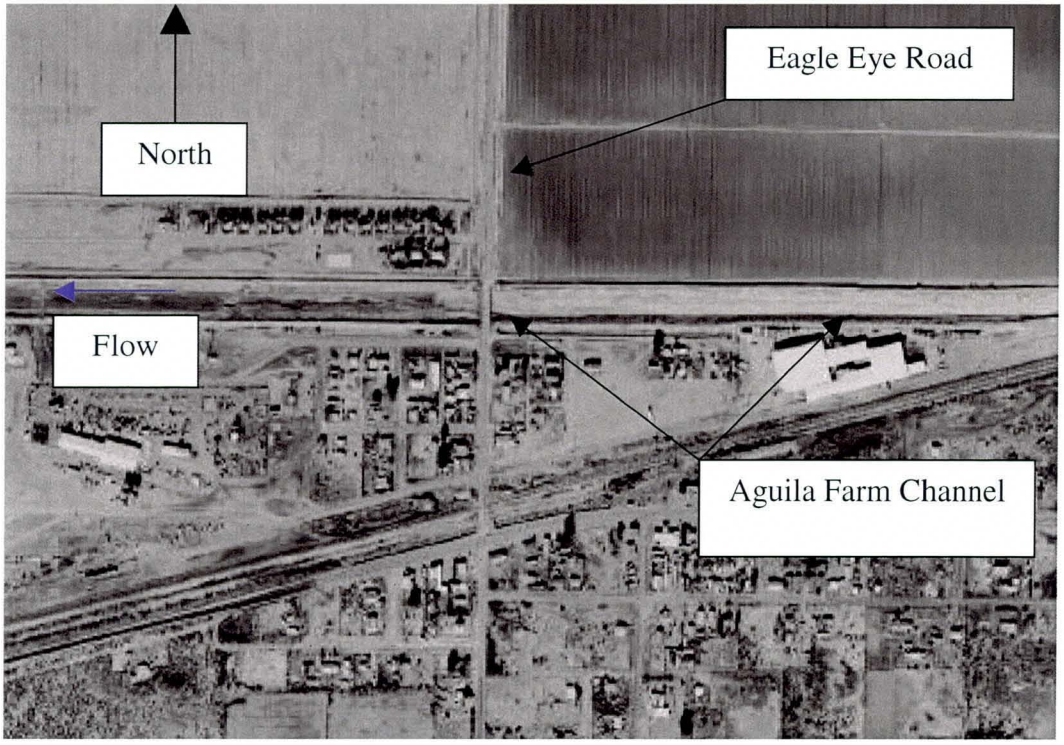
ALTERNATIVES EAGLE EYE ROAD AT AGUILA FARM CHANNEL

TECHNICAL MEMORANDUM
HYDRAULIC CAPACITY AND COSTS
EAGLE EYE ROAD AT AGUILA FARM CHANNEL
ALTERNATIVE: 1) GATES; AND 2) LOWERING THE DIP SECTION

This Technical Memorandum documents the assessment HDR Engineering, Inc. performed regarding the potential placement of Gates, or alternatively lowering the dip section at Eagle Eye Road at the Aguila Farm Channel.

Location

Aguila, Arizona is an unincorporated farming community 76 miles northwest of Phoenix. Martori Farm lies within the Centennial Wash floodplain. Aguila has suffered severe damage following recent flooding events starting with the aftermath of Hurricane Nora on September 25, 1997, and then by back-to-back storms on August 29 and October 21 and 27, 2000.



Methodology

Four cross sections were cut in HEC-GeoRAS using the most current topographic data for the Aguila ADMP. Two cross-sections downstream (at 500 and 1000 feet down stream) of Eagle Eye Road, one down the centerline and one 500 feet upstream.

The centerline cross section was analyzed with the following scenarios:

- Existing Conditions,
- 4 foot high stop log gates on the north side of the Aguila Farm Channel,
- Lowering the dip section by 4 feet.

Once preliminary hydraulics was performed, costs were developed for the proposed improvements as compared in Table 1. Larger flows in the Aguila Farm Channel will breakout at Eagle Eye Road and flow north and west through the adjacent farmland.

Table 1

Comparison of Alternatives
Eagle Eye Road at Aguila Farm Channel

Alternative	Channel Capacity At Breakout (CFS)	Cost
Existing Conditions	1000	$ 0
4' Stop Logs	4000	$ 18,000
Lower Dip By 4'	1500	$ 93,000

Several issues that would affect final design are:

- The existing levee is uncompacted earth placed without benefit of an engineered design.
- Placement of gates would require human intervention to close the roadway and place the stop logs.
- Costs associated with right-of-way, long term maintenance, and legal were not computed.
- Backwater from large events inundate this area thereby limiting channel capacity which forces flow into the overbank areas.
- Gates are more hydraulically effective because backwater conditions limit capacity of a dip section.

EAGLE EYE ROAD AT AGUILA FARM CHANNEL

		Unit	Unit Cost	Quantity	Cost	
4' Stop Logs						
	Abutment		$1,800.00	2	$3,600.00	
	Stop Logs 4' high by 65'		$4,800.00	1	$4,800.00	
	Center Peir		$900.00	1	$900.00	
	Asphalt Repair		$1,000.00	1	$1,000.00	
	Foundation		$3,600.00	1	$3,600.00	
	Contingency/Eng./CM	@ 30%			$4,170.00	
			Total Cost		$18,070.00	
			Both Sides of Roadway			$36,140.00
Lower Dip By 4'						
	Excavation	CY	$5.00	3,274	$16,370.00	
	Relocate Utilities	LS	$2,000.00	1	$2,000.00	
	Asphalt Removal/Replacement	SY	$88.00	600	$52,800.00	
	Contingency/Eng./CM	@ 30%			$21,351.00	
					Total Cost	$92,521.00

APPENDIX C – CALCULATIONS FOR STRUCTURAL ALTERNATIVES

Bridge Replacement at SR 71 north of US 60

HEC-RAS Plan: Plan 01 River: Aguila Farm Chan Reach: Reach-1 Profile: PF 1

Reach	River Sta	Existing W.S. Elevation w/ 4 - 7' dia circular culverts (ft)	Estimated W.S w/ proposed bridge opening at 45x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 125x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 500x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 500x10 feet (ft) with change in downstream backwater effects
Reach-1	17.641	2310.46	2310.46	2310.46	2310.46	2310.46
Reach-1	17.547	2308.34	2308.34	2308.34	2308.34	2308.34
Reach-1	17.449	2305.55	2305.54	2305.54	2305.54	2305.54
Reach-1	17.357	2303.65	2303.65	2303.65	2303.65	2303.65
Reach-1	17.259	2302.16	2302.16	2302.16	2302.16	2302.16
Reach-1	17.161	2300.55	2300.55	2300.55	2300.55	2300.55
Reach-1	17.066	2298.82	2298.82	2298.82	2298.82	2298.82
Reach-1	16.972	2296.84	2296.84	2296.84	2296.84	2296.84
Reach-1	16.876	2295.45	2295.45	2295.45	2295.45	2295.45
Reach-1	16.781	2294.42	2294.42	2294.42	2294.42	2294.42
Reach-1	16.682	2293.03	2293.03	2293.03	2293.03	2293.03
Reach-1	16.59	2291.33	2291.33	2291.33	2291.33	2291.33
Reach-1	16.498	2289.63	2289.63	2289.63	2289.63	2289.63
Reach-1	16.403	2288.25	2288.25	2288.25	2288.25	2288.25
Reach-1	16.307	2286.43	2286.43	2286.43	2286.43	2286.43
Reach-1	16.21	2284.62	2284.62	2284.62	2284.62	2284.62
Reach-1	16.117	2282.61	2282.61	2282.61	2282.61	2282.61
Reach-1	16.021	2281.23	2281.22	2281.22	2281.22	2281.22
Reach-1	15.924	2278.40	2278.40	2278.40	2278.40	2278.40
Reach-1	15.828	2277.07	2277.07	2277.07	2277.07	2277.07
Reach-1	15.736	2275.59	2275.59	2275.59	2275.59	2275.59
Reach-1	15.642	2273.82	2273.82	2273.82	2273.82	2273.82
Reach-1	15.547	2272.03	2272.03	2272.03	2272.03	2272.03
Reach-1	15.448	2270.22	2270.23	2270.23	2270.23	2270.23
Reach-1	15.358	2268.14	2268.14	2268.14	2268.14	2268.14
Reach-1	15.265	2266.15	2266.15	2266.15	2266.15	2266.15
Reach-1	15.166	2264.52	2264.51	2264.51	2264.51	2264.51
Reach-1	15.074	2262.73	2262.72	2262.72	2262.72	2262.72
Reach-1	14.976	2261.01	2261.01	2261.01	2261.01	2261.01
Reach-1	14.884	2259.48	2259.48	2259.48	2259.48	2259.48
Reach-1	14.787	2258.12	2258.12	2258.12	2258.12	2258.12
Reach-1	14.689	2256.66	2256.66	2256.66	2256.66	2256.66
Reach-1	14.596	2254.52	2254.52	2254.52	2254.52	2254.52
Reach-1	14.498	2252.62	2252.62	2252.62	2252.62	2252.62
Reach-1	14.402	2251.13	2251.13	2251.13	2251.13	2251.13
Reach-1	14.3	2248.99	2248.99	2248.99	2248.99	2248.99
Reach-1	14.202	2247.12	2247.12	2247.12	2247.12	2247.12
Reach-1	14.114	2245.78	2245.77	2245.77	2245.77	2245.77
Reach-1	14.013	2244.12	2244.12	2244.12	2244.12	2244.12
Reach-1	13.913	2242.67	2242.67	2242.67	2242.67	2242.67
Reach-1	13.822	2240.56	2240.56	2240.56	2240.56	2240.56
Reach-1	13.726	2239.08	2239.08	2239.08	2239.08	2239.08
Reach-1	13.629	2237.57	2237.57	2237.57	2237.57	2237.57
Reach-1	13.534	2236.02	2236.02	2236.02	2236.02	2236.02
Reach-1	13.438	2235.00	2234.99	2234.99	2234.99	2234.99
Reach-1	13.345	2233.32	2233.32	2233.32	2233.32	2233.32

Bridge Replacement at SR 71 north of US 60

Reach	River Sta	Existing W.S. Elevation w/ 4 - 7' dia circular culverts (ft)	Estimated W.S w/ proposed bridge opening at 45x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 125x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 500x10 feet (ft)	Estimated W.S w/ proposed bridge opening at 500x10 feet (ft) with change in downstream backwater effects
Reach-1	13.25	2231.74	2231.74	2231.74	2231.74	2231.74
Reach-1	13.155	2230.11	2230.11	2230.11	2230.11	2230.11
Reach-1	13.059	2228.37	2228.36	2228.36	2228.36	2228.36
Reach-1	12.961	2226.86	2226.86	2226.86	2226.86	2226.86
Reach-1	12.87	2225.17	2225.17	2225.17	2225.17	2225.17
Reach-1	12.775	2223.40	2223.40	2223.40	2223.40	2223.40
Reach-1	12.68	2221.71	2221.71	2221.71	2221.71	2221.71
Reach-1	12.585	2220.05	2220.04	2220.04	2220.04	2220.04
Reach-1	12.491	2217.91	2217.91	2217.91	2217.91	2217.91
Reach-1	12.395	2216.28	2216.28	2216.28	2216.28	2216.28
Reach-1	12.3	2214.22	2214.22	2214.21	2214.22	2214.22
Reach-1	12.206	2211.38	2211.38	2211.38	2211.38	2211.38
Reach-1	12.105	2209.78	2209.78	2209.78	2209.78	2209.78
Reach-1	12.01	2208.36	2208.35	2208.36	2208.35	2208.35
Reach-1	11.912	2206.97	2206.99	2206.91	2207.04	2207.04
Reach-1	11.815	2206.28	2206.34	2206.03	2205.16	2205.16
Reach-1	11.713	2206.21	2206.27	2205.95	2203.93	2203.93
Reach-1	11.621	2206.15	2206.22	2205.88	2202.36	2202.36
Reach-1	11.579	2206.02	2206.10	2205.77	2202.97	2202.97
Reach-1	11.571	**Bridge deck elevation is at 2204.90**				
Reach-1	11.541	2203.19	2203.19	2203.13	2202.50	2202.50
Reach-1	11.523	2200.75	2200.75	2200.75	2200.75	2200.75
Reach-1	11.468	2199.49	2199.49	2199.49	2199.49	2199.49
Reach-1	11.378	2198.75	2198.75	2198.75	2198.75	2197.79

Bridge Replacement at SR 71 north of US 60

Item No.	Description	Alt. 1: Estimated Quantity	Alt. 2: Estimated Quantity	Alt. 3: Estimated Quantity	Unit	Unit Cost	Alt. 1: proposed bridge opening at 45x10 feet (ft)	Alt. 2: proposed bridge opening at 125x10 feet (ft)	Alt. 3: proposed bridge opening at 500x10 feet (ft)
1	Mobilization	1	1	1	LS	$ 200,000	$ 200,000	$ 200,000	$ 200,000
2	Removal of Existing Structures	1	1	1	LS	$ 250,000	$ 250,000	$ 250,000	$ 250,000
3	Clearing and Grubbing	193	262	331	AC	$ 5.00	$ 964	$ 1,309	$ 1,653
4	Removal of Asphaltic Concrete Pavement	1,481	1,481	1,481	SY	$ 1.00	$ 1,481	$ 1,481	$ 1,481
5	Roadway Excavation	3,375	9,375	37,500	CY	$ 2.35	$ 7,931	$ 22,031	$ 88,125
7	Survey & Layout	1	1	1	LS	$ 10,000.00	$ 10,000	$ 10,000	$ 10,000
8	Bridge	1	1	1	LS	varies	$ 165,383	$ 311,483	$ 984,692
9	Aggregate Base	467	1,296	5,185	CY	$ 16.00	$ 7,472	$ 20,736	$ 82,960
10	Survey & Layout	1	1	1	LS	$ 25,000	$ 25,000	$ 25,000	$ 25,000
						Subtotal:	$ 668,231	$ 842,040	$ 1,643,911
						Engineering (15%):	$ 100,235	$ 126,306	$ 246,587
						Construction Contignecy (20%):	$ 133,646	$ 168,408	$ 328,782
						Total:	**$ 902,112**	**$ 1,136,754**	**$ 2,219,280**

Aguila Farm Channel Downstream of SR 71

		Length of Channel	6:1 Sideslopes @ 15' depth	100' Bw	200' Bw	300' Bw	500' Bw
		30,000	180	100	200	300	500
					Areas (sf)		
				8,400,000	11,400,000	14,400,000	20,400,000
					Areas (sy)		
				933,333	1,266,667	1,600,000	2,266,667
					Areas (ac)		
				193	262	331	468
	thickness (in)	thickness (yd)					
Aggregate Base	8	0.074074074					
	thickness (ft)						
	0.667						
	thickness (in)	thickness (yd)					
Topsoil	4	0.037037037					
	thickness (ft)						
	0.333						

Aguila Farm Channel Downstream of SR 71

HEC-RAS Plan: Alt10: 9.5 River: RIVER-1 Reach: Reach-1 Profile: PF 3

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	11.378	PF 3	16900	2174	2184.22		2185.85	0.002993	10.25	1649.58	222.7	0.66
Reach-1	11.28	PF 3	16900	2172.46	2182.68		2184.31	0.003001	10.26	1647.92	222.6	0.66
Reach-1	11.189	PF 3	16900	2171.02	2181.24		2182.87	0.003003	10.26	1647.59	222.58	0.66
Reach-1	11.094	PF 3	16900	2169.5	2179.72		2181.35	0.002994	10.25	1649.45	222.68	0.66
Reach-1	10.998	PF 3	16900	2167.99	2178.21		2179.84	0.003001	10.26	1647.98	222.6	0.66
Reach-1	10.903	PF 3	16900	2166.49	2176.71		2178.34	0.003003	10.26	1647.64	222.58	0.66
Reach-1	10.808	PF 3	16900	2164.97	2175.19		2176.82	0.002993	10.25	1649.5	222.68	0.66
Reach-1	10.714	PF 3	16900	2163.49	2173.71		2175.34	0.003	10.25	1648.2	222.61	0.66
Reach-1	10.621	PF 3	16900	2162.02	2172.24		2173.87	0.003	10.25	1648.2	222.61	0.66
Reach-1	10.525	PF 3	16900	2160.49	2170.71		2172.34	0.003	10.25	1648.15	222.61	0.66
Reach-1	10.43	PF 3	16900	2158.99	2169.21		2170.84	0.003001	10.26	1647.98	222.6	0.66
Reach-1	10.337	PF 3	16900	2157.52	2167.74		2169.37	0.003003	10.26	1647.65	222.58	0.66
Reach-1	10.241	PF 3	16900	2156	2166.22		2167.85	0.002993	10.25	1649.5	222.68	0.66
Reach-1	10.15	PF 3	16900	2154.55	2164.77		2166.4	0.003001	10.26	1647.98	222.6	0.66
Reach-1	10.055	PF 3	16900	2153.05	2163.27		2164.9	0.003002	10.26	1647.7	222.59	0.66
Reach-1	9.965	PF 3	16900	2151.62	2161.84		2163.47	0.002993	10.25	1649.51	222.68	0.66
Reach-1	9.871	PF 3	16900	2150.14	2160.36		2161.99	0.003	10.25	1648.2	222.61	0.66
Reach-1	9.773	PF 3	16900	2148.58	2158.8		2160.43	0.003001	10.25	1648.04	222.61	0.66
Reach-1	9.682	PF 3	16900	2147.14	2157.36		2158.99	0.003002	10.26	1647.76	222.59	0.66
Reach-1	9.589	PF 3	16900	2145.67	2155.88		2157.52	0.003006	10.26	1647.1	222.55	0.66
Reach-1	9.444	PF 3	16900	2143.37	2153.59		2155.22	0.003	10.25	1648.14	222.61	0.66
Reach-1	9.349	PF 3	16900	2141.87	2152.09		2153.72	0.003	10.25	1648.15	222.61	0.66
Reach-1	9.258	PF 3	16900	2140.43	2150.65		2152.28	0.003	10.25	1648.2	222.61	0.66
Reach-1	9.164	PF 3	16900	2138.93	2149.15		2150.78	0.003	10.25	1648.2	222.61	0.66
Reach-1	9.071	PF 3	16900	2137.46	2147.68		2149.31	0.003	10.25	1648.25	222.62	0.66
Reach-1	8.974	PF 3	16900	2135.93	2146.15		2147.78	0.002999	10.25	1648.29	222.62	0.66
Reach-1	8.865	PF 3	16900	2134.19	2144.41		2146.04	0.002998	10.25	1648.57	222.63	0.66
Reach-1	8.749	PF 3	16900	2132.36	2142.58		2144.21	0.002994	10.25	1649.39	222.68	0.66
Reach-1	8.631	PF 3	16900	2130.49	2140.71		2142.34	0.003001	10.25	1647.99	222.6	0.66
Reach-1	8.508	PF 3	16900	2128.54	2138.75		2140.39	0.003005	10.26	1647.11	222.55	0.66
Reach-1	8.399	PF 3	16900	2126.81	2137.03		2138.66	0.003	10.25	1648.25	222.61	0.66
Reach-1	8.3	PF 3	16900	2125.25	2135.47		2137.1	0.002999	10.25	1648.37	222.63	0.66
Reach-1	8.196	PF 3	16900	2123.6	2133.82		2135.45	0.002998	10.25	1648.63	222.64	0.66
Reach-1	8.097	PF 3	16900	2122.04	2132.26		2133.89	0.002995	10.25	1649.23	222.67	0.66
Reach-1	8	PF 3	16900	2120.5	2130.71		2132.35	0.003004	10.26	1647.37	222.56	0.66
Reach-1	7.9	PF 3	16900	2118.92	2129.14		2130.77	0.002995	10.25	1649.25	222.67	0.66
Reach-1	7.805	PF 3	16900	2117.41	2127.63		2129.26	0.003004	10.26	1647.43	222.56	0.66
Reach-1	7.711	PF 3	16900	2115.92	2126.14		2127.77	0.002995	10.25	1649.2	222.67	0.66
Reach-1	7.617	PF 3	16900	2114.44	2124.65		2126.29	0.003005	10.26	1647.13	222.55	0.66
Reach-1	7.522	PF 3	16900	2112.92	2123.14		2124.77	0.002999	10.25	1648.47	222.63	0.66
Reach-1	7.427	PF 3	16900	2111.42	2121.64		2123.27	0.002997	10.25	1648.83	222.64	0.66
Reach-1	7.313	PF 3	16900	2109.62	2119.85		2121.48	0.00299	10.24	1650.3	222.74	0.66
Reach-1	7.225	PF 3	16900	2108.23	2118.46		2120.09	0.002991	10.24	1649.91	222.7	0.66
Reach-1	7.085	PF 3	16900	2106.01	2116.26		2117.88	0.002961	10.21	1655.84	223.02	0.66
Reach-1	6.958	PF 3	16900	2104	2114.33		2115.92	0.002875	10.1	1673.36	223.96	0.65
Reach-1	6.831	PF 3	16900	2101.99	2112.55		2114.04	0.002639	9.79	1725.49	226.73	0.63
Reach-1	6.736	PF 3	16900	2100.47	2111.4		2112.76	0.002308	9.33	1810.54	231.21	0.59
Reach-1	6.608	PF 3	16900	2098.45	2110.25		2111.34	0.001711	8.38	2015.87	241.62	0.51
Reach-1	6.489	PF 3	16900	2096.56	2109.55		2110.38	0.001171	7.31	2311.5	255.87	0.43
Reach-1	6.418	PF 3	16900	2095.43	2109.26		2109.95	0.000912	6.68	2530.84	265.96	0.38
Reach-1	6.258	PF 3	21700	2092.9	2108.31		2109.14	0.000972	7.32	2965.45	284.89	0.4
Reach-1	6.143	PF 3	21700	2091.08	2107.96		2108.6	0.000669	6.38	3398.84	302.61	0.34
Reach-1	6.005	PF 3	21700	2088.89	2107.72		2108.16	0.000413	5.33	4584.3	1693.7	0.27
Reach-1	5.911	PF 3	21700	2087.42	2107.66	2096.75	2107.95	0.000273	4.48	7058.6	3929.57	0.37

Aguila Farm Channel Downstream of SR 71

HEC-RAS Plan: 9.12.03 (c) River: RIVER-1 Reach: Reach-1 Profile: PF 3

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach-1	11.378	PF 3	16900	2174	2182.08	2182.08	2185.16	0.001377	14.08	1199.96	196.98	1.01
Reach-1	11.28	PF 3	16900	2172.46	2180.54	2180.54	2183.62	0.001377	14.08	1199.98	196.98	1.01
Reach-1	11.189	PF 3	16900	2171.02	2179.1	2179.1	2182.18	0.001377	14.08	1200.03	196.98	1.01
Reach-1	11.094	PF 3	16900	2169.5	2177.58	2177.58	2180.66	0.001378	14.09	1199.73	196.96	1.01
Reach-1	10.998	PF 3	16900	2167.99	2176.07	2176.07	2179.15	0.001377	14.08	1199.98	196.97	1.01
Reach-1	10.903	PF 3	16900	2166.49	2174.57	2174.57	2177.65	0.001378	14.09	1199.68	196.96	1.01
Reach-1	10.808	PF 3	16900	2164.97	2173.05	2173.05	2176.13	0.001377	14.08	1199.93	196.97	1.01
Reach-1	10.714	PF 3	16900	2163.49	2171.57	2171.57	2174.65	0.001377	14.08	1199.98	196.98	1.01
Reach-1	10.621	PF 3	16900	2162.02	2170.1	2170.1	2173.18	0.001378	14.09	1199.68	196.96	1.01
Reach-1	10.525	PF 3	16900	2160.49	2168.57	2168.57	2171.65	0.001377	14.08	1199.93	196.97	1.01
Reach-1	10.43	PF 3	16900	2158.99	2167.07	2167.07	2170.15	0.001377	14.08	1199.98	196.98	1.01
Reach-1	10.337	PF 3	16900	2157.52	2165.6	2165.6	2168.68	0.001378	14.09	1199.68	196.96	1.01
Reach-1	10.241	PF 3	16900	2156	2164.08	2164.08	2167.16	0.001377	14.08	1199.93	196.97	1.01
Reach-1	10.15	PF 3	16900	2154.55	2162.63	2162.63	2165.71	0.001377	14.08	1199.98	196.98	1.01
Reach-1	10.055	PF 3	16900	2153.05	2161.13	2161.13	2164.21	0.001377	14.08	1200.03	196.98	1.01
Reach-1	9.965	PF 3	16900	2151.62	2159.7	2159.7	2162.78	0.001378	14.09	1199.74	196.96	1.01
Reach-1	9.871	PF 3	16900	2150.14	2158.22	2158.22	2161.3	0.001377	14.08	1199.97	196.98	1.01
Reach-1	9.773	PF 3	16900	2148.58	2156.66	2156.66	2159.74	0.001378	14.09	1199.68	196.96	1.01
Reach-1	9.682	PF 3	16900	2147.14	2155.22	2155.22	2158.3	0.001377	14.08	1199.93	196.97	1.01
Reach-1	9.589	PF 3	16900	2145.67	2153.75	2153.75	2156.83	0.001377	14.08	1199.96	196.97	1.01
Reach-1	9.444	PF 3	16900	2143.37	2151.45	2151.45	2154.53	0.001377	14.08	1200.03	196.98	1.01
Reach-1	9.349	PF 3	16900	2141.87	2149.95	2149.95	2153.03	0.001378	14.09	1199.74	196.96	1.01
Reach-1	9.258	PF 3	16900	2140.43	2148.51	2148.51	2151.59	0.001377	14.08	1199.98	196.98	1.01
Reach-1	9.164	PF 3	16900	2138.93	2147.01	2147.01	2150.09	0.001378	14.09	1199.68	196.96	1.01
Reach-1	9.071	PF 3	16900	2137.46	2145.54	2145.54	2148.62	0.001377	14.08	1199.93	196.97	1.01
Reach-1	8.974	PF 3	16900	2135.93	2144.01	2144.01	2147.09	0.001377	14.08	1199.97	196.98	1.01
Reach-1	8.865	PF 3	16900	2134.19	2142.27	2142.27	2145.35	0.001377	14.08	1200.01	196.98	1.01
Reach-1	8.749	PF 3	16900	2132.36	2140.44	2140.44	2143.52	0.001378	14.09	1199.74	196.96	1.01
Reach-1	8.631	PF 3	16900	2130.49	2138.57	2138.57	2141.65	0.001377	14.08	1199.98	196.98	1.01
Reach-1	8.508	PF 3	16900	2128.54	2136.62	2136.62	2139.7	0.001378	14.09	1199.69	196.96	1.01
Reach-1	8.399	PF 3	16900	2126.81	2134.89	2134.89	2137.97	0.001377	14.08	1199.93	196.97	1.01
Reach-1	8.3	PF 3	16900	2125.25	2133.33	2133.33	2136.41	0.001377	14.08	1199.98	196.98	1.01
Reach-1	8.196	PF 3	16900	2123.6	2131.68	2131.68	2134.76	0.001377	14.08	1200.02	196.98	1.01
Reach-1	8.097	PF 3	16900	2122.04	2130.12	2130.12	2133.2	0.001377	14.08	1200.07	196.98	1.01
Reach-1	8	PF 3	16900	2120.5	2128.58	2128.58	2131.66	0.001378	14.09	1199.75	196.96	1.01
Reach-1	7.9	PF 3	16900	2118.92	2127	2127	2130.08	0.001376	14.08	1200.38	197	1.01
Reach-1	7.805	PF 3	16900	2117.41	2125.49	2125.49	2128.57	0.001376	14.08	1200.18	196.98	1.01
Reach-1	7.711	PF 3	16900	2115.92	2124	2124	2127.08	0.001379	14.09	1199.24	196.93	1.01
Reach-1	7.617	PF 3	16900	2114.44	2122.52	2122.52	2125.6	0.001377	14.08	1200.04	196.98	1.01
Reach-1	7.522	PF 3	16900	2112.92	2121	2121	2124.08	0.001377	14.08	1200.1	196.99	1.01
Reach-1	7.427	PF 3	16900	2111.42	2119.5	2119.5	2122.58	0.001378	14.09	1199.77	196.96	1.01
Reach-1	7.313	PF 3	16900	2109.62	2117.7	2117.7	2120.78	0.001377	14.08	1199.98	196.97	1.01
Reach-1	7.225	PF 3	16900	2108.23	2116.31	2116.31	2119.39	0.001377	14.08	1200.1	196.99	1.01
Reach-1	7.085	PF 3	16900	2106.01	2114.09	2114.09	2117.17	0.001376	14.08	1200.09	196.98	1.01
Reach-1	6.958	PF 3	16900	2104	2112.08	2112.08	2115.16	0.001378	14.09	1199.5	196.95	1.01
Reach-1	6.831	PF 3	16900	2101.99	2110.07	2110.07	2113.15	0.001379	14.09	1199.23	196.94	1.01
Reach-1	6.736	PF 3	16900	2100.47	2108.55	2108.55	2111.63	0.001377	14.08	1199.98	196.98	1.01
Reach-1	6.608	PF 3	16900	2098.45	2107.01	2106.53	2109.65	0.001106	13.03	1296.56	202.78	0.91
Reach-1	6.489	PF 3	16900	2096.56	2107.5		2108.85	0.000432	9.32	1813.11	231.34	0.59
Reach-1	6.418	PF 3	16900	2095.43	2107.62		2108.62	0.000283	8.01	2111.16	246.31	0.48
Reach-1	6.258	PF 3	21700	2092.9	2107.41		2108.4	0.000233	7.99	2714.48	274.14	0.45
Reach-1	6.143	PF 3	21700	2091.08	2107.52		2108.2	0.00014	6.65	3264.82	297.25	0.35
Reach-1	6.005	PF 3	21700	2088.89	2107.6		2108.06	0.000081	5.44	4393.25	1483.39	0.27
Reach-1	5.911	PF 3	21700	2087.42	2107.66	2096.75	2107.99	0.000055	4.65	7058.6	3929.57	0.39

Aguila Farm Channel Downstream of SR 71

Reach	River Sta	Earth-Lined		Concrete-Lined	
		W.S. Elev (ft)	Vel Chnl (ft/s)	W.S. Elev (ft)	Vel Chnl (ft/s)
Reach-1	11.378	2184.22	10.25	2182.08	14.08
Reach-1	11.28	2182.68	10.26	2180.54	14.08
Reach-1	11.189	2181.24	10.26	2179.10	14.08
Reach-1	11.094	2179.72	10.25	2177.58	14.09
Reach-1	10.998	2178.21	10.26	2176.07	14.08
Reach-1	10.903	2176.71	10.26	2174.57	14.09
Reach-1	10.808	2175.19	10.25	2173.05	14.08
Reach-1	10.714	2173.71	10.25	2171.57	14.08
Reach-1	10.621	2172.24	10.25	2170.10	14.09
Reach-1	10.525	2170.71	10.25	2168.57	14.08
Reach-1	10.43	2169.21	10.26	2167.07	14.08
Reach-1	10.337	2167.74	10.26	2165.60	14.09
Reach-1	10.241	2166.22	10.25	2164.08	14.08
Reach-1	10.15	2164.77	10.26	2162.63	14.08
Reach-1	10.055	2163.27	10.26	2161.13	14.08
Reach-1	9.965	2161.84	10.25	2159.70	14.09
Reach-1	9.871	2160.36	10.25	2158.22	14.08
Reach-1	9.773	2158.80	10.25	2156.66	14.09
Reach-1	9.682	2157.36	10.26	2155.22	14.08
Reach-1	9.589	2155.88	10.26	2153.75	14.08
Reach-1	9.444	2153.59	10.25	2151.45	14.08
Reach-1	9.349	2152.09	10.25	2149.95	14.09
Reach-1	9.258	2150.65	10.25	2148.51	14.08
Reach-1	9.164	2149.15	10.25	2147.01	14.09
Reach-1	9.071	2147.68	10.25	2145.54	14.08
Reach-1	8.974	2146.15	10.25	2144.01	14.08
Reach-1	8.865	2144.41	10.25	2142.27	14.08
Reach-1	8.749	2142.58	10.25	2140.44	14.09
Reach-1	8.631	2140.71	10.25	2138.57	14.08
Reach-1	8.508	2138.75	10.26	2136.62	14.09
Reach-1	8.399	2137.03	10.25	2134.89	14.08
Reach-1	8.3	2135.47	10.25	2133.33	14.08
Reach-1	8.196	2133.82	10.25	2131.68	14.08
Reach-1	8.097	2132.26	10.25	2130.12	14.08
Reach-1	8	2130.71	10.26	2128.58	14.09
Reach-1	7.9	2129.14	10.25	2127.00	14.08
Reach-1	7.805	2127.63	10.26	2125.49	14.08
Reach-1	7.711	2126.14	10.25	2124.00	14.09
Reach-1	7.617	2124.65	10.26	2122.52	14.08
Reach-1	7.522	2123.14	10.25	2121.00	14.08
Reach-1	7.427	2121.64	10.25	2119.50	14.09
Reach-1	7.313	2119.85	10.24	2117.70	14.08
Reach-1	7.225	2118.46	10.24	2116.31	14.08
Reach-1	7.085	2116.26	10.21	2114.09	14.08
Reach-1	6.958	2114.33	10.10	2112.08	14.09
Reach-1	6.831	2112.55	9.79	2110.07	14.09
Reach-1	6.736	2111.40	9.33	2108.55	14.08
Reach-1	6.608	2110.25	8.38	2107.01	13.03
Reach-1	6.489	2109.55	7.31	2107.50	9.32
Reach-1	6.418	2109.26	6.68	2107.62	8.01
Reach-1	6.258	2108.31	7.32	2107.41	7.99
Reach-1	6.143	2107.96	6.38	2107.52	6.65
Reach-1	6.005	2107.72	5.33	2107.60	5.44
Reach-1	5.911	2107.66	4.48	2107.66	4.65

Aguila Farm Channel Downstream of SR 71

HEC-RAS Plan: Imported Pla River: RIVER-1 Reach: Reach-1 Profile: PF 1								
			Existing		Proposed 100' bottom width trapedzoidal channel, 15' deep		Proposed 300' bottom width trapedzoidal channel, 15' deep	
Reach	River Sta	Profile	W.S. Elev (ft)	Converted Datum Elev. (ft)	W.S. Elev (ft)	Converted Datum Elev. (ft)	W.S. Elev (ft)	Converted Datum Elev. (ft)
Reach-1	11.378	PF 1	2196.64	2198.89	2184.22	2186.47	2178.00	2180.25
Reach-1	11.28	PF 1	2194.81	2197.06	2182.68	2184.93	2176.23	2178.48
Reach-1	11.189	PF 1	2192.77	2195.02	2181.24	2186.47	2174.37	2176.62
Reach-1	11.094	PF 1	2190.26	2192.51	2179.72	2184.93	2171.68	2173.93
Reach-1	10.998	PF 1	2188.26	2190.51	2178.21	2183.49	2169.17	2171.42
Reach-1	10.903	PF 1	2186.09	2188.34	2176.71	2181.97	2166.64	2168.89
Reach-1	10.808	PF 1	2183.98	2186.23	2175.19	2180.46	2164.22	2166.47
Reach-1	10.714	PF 1	2182.00	2184.25	2173.71	2178.96	2161.49	2163.74
Reach-1	10.621	PF 1	2180.22	2182.47	2172.24	2177.44	2159.24	2161.49
Reach-1	10.525	PF 1	2178.48	2180.73	2170.71	2175.96	2156.93	2159.18
Reach-1	10.43	PF 1	2176.51	2178.76	2169.21	2174.49	2153.65	2155.90
Reach-1	10.337	PF 1	2175.28	2177.53	2167.74	2172.96	2152.05	2154.30
Reach-1	10.241	PF 1	2174.05	2176.30	2166.22	2171.46	2148.7	2150.95
Reach-1	10.15	PF 1	2173.00	2175.25	2164.77	2169.99	2145.76	2148.01
Reach-1	10.055	PF 1	2171.46	2173.71	2163.27	2168.47	2144.37	2146.62
Reach-1	9.965	PF 1	2169.57	2171.82	2161.84	2167.02	2141.88	2144.13
Reach-1	9.871	PF 1	2168.09	2170.34	2160.36	2165.52	2139.41	2141.66
Reach-1	9.773	PF 1	2166.16	2168.41	2158.8	2164.09	2136.81	2139.06
Reach-1	9.682	PF 1	2164.76	2167.01	2157.36	2162.61	2134.41	2136.66
Reach-1	9.589	PF 1	2162.92	2165.17	2155.88	2161.05	2131.95	2134.20
Reach-1	9.444	PF 1	2160.17	2162.42	2153.59	2159.61	2128.13	2130.38
Reach-1	9.349	PF 1	2159.13	2161.38	2152.09	2158.13	2125.63	2127.88
Reach-1	9.258	PF 1	2157.97	2160.22	2150.65	2155.84	2123.23	2125.48
Reach-1	9.164	PF 1	2156.22	2158.47	2149.15	2154.34	2120.73	2122.98
Reach-1	9.071	PF 1	2154.55	2156.80	2147.68	2152.90	2118.29	2120.54
Reach-1	8.974	PF 1	2153.13	2155.38	2146.15	2151.40	2115.71	2117.96
Reach-1	8.865	PF 1	2152.03	2154.28	2144.41	2149.93	2112.91	2115.16
Reach-1	8.749	PF 1	2151.05	2153.30	2142.58	2148.40	2109.64	2111.89
Reach-1	8.631	PF 1	2149.86	2152.11	2140.71	2146.66	2108.14	2110.39
Reach-1	8.508	PF 1	2148.24	2150.49	2138.75	2144.83	2107.83	2110.08

Aguila Farm Channel Downstream of SR 71

			Existing		Proposed 100' bottom width trapedzoidal channel, 15' deep		Proposed 300' bottom width trapedzoidal channel, 15' deep	
Reach	River Sta	Profile	W.S. Elev (ft)	Converted Datum Elev. (ft)	W.S. Elev (ft)	Converted Datum Elev. (ft)	W.S. Elev (ft)	Converted Datum Elev. (ft)
Reach-1	8.399	PF 1	2146.90	2149.15	2137.03	2142.96	2107.74	2109.99
Reach-1	8.3	PF 1	2145.35	2147.60	2135.47	2141.00	2107.7	2109.95
Reach-1	8.196	PF 1	2143.84	2146.09	2133.82	2139.28	2107.69	2109.94
Reach-1	8.097	PF 1	2142.23	2144.48	2132.26	2137.72	2107.68	2109.93
Reach-1	8	PF 1	2140.25	2142.50	2130.71	2136.07	2107.67	2109.92
Reach-1	7.9	PF 1	2138.93	2141.18	2129.14	2134.51	2107.67	2109.92
Reach-1	7.805	PF 1	2137.38	2139.63	2127.63	2132.96	2107.67	2109.92
Reach-1	7.711	PF 1	2135.89	2138.14	2126.14	2131.39	2107.67	2109.92
Reach-1	7.617	PF 1	2134.12	2136.37	2124.65	2129.88	2107.66	2109.91
Reach-1	7.522	PF 1	2132.62	2134.87	2123.14	2128.39	2107.66	2109.91
Reach-1	7.427	PF 1	2131.13	2133.38	2121.64	2126.90	2107.66	2109.91
Reach-1	7.313	PF 1	2129.21	2131.46	2119.85	2125.39	2107.66	2109.91
Reach-1	7.225	PF 1	2127.58	2129.83	2118.46	2123.89	2107.66	2109.91
Reach-1	7.085	PF 1	2126.61	2128.86	2116.26	2122.10	2107.66	2109.91
Reach-1	6.958	PF 1	2125.46	2127.71	2114.33	2120.71	2107.66	2109.91
Reach-1	6.831	PF 1	2123.93	2126.18	2112.55	2118.51	2107.66	2109.91
Reach-1	6.736	PF 1	2122.58	2124.83	2111.4	2116.58	2107.66	2109.91
Reach-1	6.608	PF 1	2121.27	2123.52	2110.25	2114.80	2107.66	2109.91
Reach-1	6.489	PF 1	2120.14	2122.39	2109.55	2113.65	2107.66	2109.91
Reach-1	6.418	PF 1	2119.28	2121.53	2109.26	2112.50	2107.66	2109.91
Reach-1	6.258	PF 1	2116.20	2118.45	2108.31	2111.80	2107.66	2109.91
Reach-1	6.143	PF 1	2113.42	2115.67	2107.96	2111.51	2107.66	2109.91
Reach-1	6.005	PF 1	2109.97	2112.22	2107.72	2110.56	2107.66	2109.91
Reach-1	5.911	PF 1	2108.80	2111.05	2107.66	2110.21	2107.66	2109.91

Aguila Farm Channel Downstream of SR 71

5 Miles of Earth Lined Channel											
Item No.	Description	Alt. 1: Estimated Quantity	Alt. 2: Estimated Quantity	Alt. 3: Estimated Quantity	Alt. 4: Estimated Quantity	Unit	Unit Cost	Alt. 1: Proposed 100' bottom width trapedzoidal channel, 15' deep	Alt. 2: Proposed 200' bottom width trapedzoidal channel, 15' deep	Alt. 3: Proposed 300' bottom width trapedzoidal channel, 15' deep	Alt. 4: Proposed 500' bottom width trapedzoidal channel, 15' deep
1	Mobilization	1	1	1	1	LS	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
2	Clearing and Grubbing	193	262	331	468	AC	$ 800.00	$ 154,400	$ 209,600	$ 264,800	$ 374,400
3	Channel Excavation	321,281	642,562	963,843	1,606,405	CY	$ 3.00	$ 963,843	$ 1,927,686	$ 2,891,529	$ 4,819,215
4	Hydroseeding	193	262	331	468	AC	$ 3.00	$ 579	$ 786	$ 993	$ 1,404
5	Survey & Layout	1	1	1	1	LS	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
6	Topsoil	34,568	46,914	59,259	83,951	CY	$ 10.00	$ 345,679	$ 469,136	$ 592,593	$ 839,506
							Subtotal:	$ 1,689,501	$ 2,832,208	$ 3,974,915	$ 6,259,525
							Engineering (15%):	$ 253,425	$ 424,831	$ 596,237	$ 938,929
							Construction Contignecy (20%):	$ 337,900	$ 566,442	$ 794,983	$ 1,251,905
							Total:	**$ 2,280,826**	**$ 3,823,481**	**$ 5,366,135**	**$ 8,450,359**

Note: This estimate does not include environmental permitting, land acquition and other realestate costs.

Bridge Replacement and Railroad Trestle at US 60

HEC-RAS Plan: 7.29.03 River: RIVER-1 Reach: Reach-1 Profile: PF 3

Reach	River Sta	Existing W.S. Elev (ft)	W.S. Elev (ft) at 300 ft opening	W.S. Elev (ft) at 400 ft opening	W.S. Elev (ft) at 500 ft opening
Reach-1	5.6850	2210.58	2210.58	2210.58	2210.58
Reach-1	5.5920	2209.79	2209.79	2209.79	2209.79
Reach-1	5.4930	2208.83	2208.83	2208.83	2208.83
Reach-1	5.4000	2207.95	2207.95	2207.95	2207.95
Reach-1	5.3040	2207.01	2207.01	2207.01	2207.01
Reach-1	5.2110	2205.67	2205.67	2205.67	2205.67
Reach-1	5.1170	2203.90	2203.90	2203.90	2203.90
Reach-1	5.0250	2203.02	2203.02	2203.02	2203.02
Reach-1	4.9280	2202.19	2202.19	2202.19	2202.19
Reach-1	4.8330	2201.32	2201.32	2201.32	2201.32
Reach-1	4.7400	2200.53	2200.53	2200.53	2200.53
Reach-1	4.6470	2199.82	2199.82	2199.82	2199.82
Reach-1	4.5520	2199.16	2199.16	2199.16	2199.16
Reach-1	4.4550	2198.49	2198.49	2198.49	2198.49
Reach-1	4.3620	2197.79	2197.79	2197.79	2197.79
Reach-1	4.2700	2196.94	2196.94	2196.94	2196.94
Reach-1	4.1780	2196.04	2196.04	2196.04	2196.04
Reach-1	4.0810	2195.19	2195.19	2195.19	2195.19
Reach-1	3.9880	2194.02	2194.02	2194.02	2194.02
Reach-1	3.8930	2192.54	2192.54	2192.54	2192.54
Reach-1	3.7980	2191.06	2191.06	2191.06	2191.06
Reach-1	3.7060	2189.94	2189.94	2189.94	2189.94
Reach-1	3.6110	2188.69	2188.69	2188.69	2188.69
Reach-1	3.5160	2187.08	2187.08	2187.08	2187.08
Reach-1	3.4210	2185.94	2185.94	2185.94	2185.94
Reach-1	3.3280	2185.04	2185.04	2185.04	2185.04
Reach-1	3.2340	2184.18	2184.18	2184.18	2184.18
Reach-1	3.1370	2183.44	2183.44	2183.44	2183.44
Reach-1	3.0440	2182.73	2182.73	2182.73	2182.73
Reach-1	2.9500	2182.02	2182.02	2182.02	2182.02
Reach-1	2.8530	2181.55	2181.55	2181.55	2181.55
Reach-1	2.7590	2180.99	2180.99	2180.99	2180.99
Reach-1	2.6660	2180.31	2180.31	2180.31	2180.31
Reach-1	2.5700	2179.82	2179.82	2179.82	2179.82
Reach-1	2.4780	2179.10	2179.10	2179.10	2179.10
Reach-1	2.3840	2178.18	2178.18	2178.18	2178.18
Reach-1	2.2910	2177.11	2177.11	2177.11	2177.11
Reach-1	2.1960	2176.12	2176.12	2176.12	2176.12
Reach-1	2.1030	2175.02	2175.02	2175.02	2175.02
Reach-1	2.0080	2174.39	2174.39	2174.39	2174.39
Reach-1	1.9140	2173.53	2173.53	2173.53	2173.53
Reach-1	1.8220	2172.75	2172.75	2172.75	2172.75
Reach-1	1.7250	2172.13	2172.13	2172.13	2172.13
Reach-1	1.6310	2171.43	2171.43	2171.43	2171.43
Reach-1	1.5390	2170.50	2170.50	2170.50	2170.50
Reach-1	1.4430	2169.60	2169.60	2169.60	2169.60
Reach-1	1.3500	2168.70	2168.70	2168.70	2168.70
Reach-1	1.2560	2167.88	2167.88	2167.88	2167.88
Reach-1	1.1610	2167.20	2167.20	2167.20	2167.20
Reach-1	1.0680	2166.42	2166.42	2166.42	2166.42
Reach-1	0.9740	2165.48	2165.48	2165.48	2165.48
Reach-1	0.8800	2164.62	2164.62	2164.62	2164.62
Reach-1	0.7860	2163.18	2163.18	2163.18	2163.18
Reach-1	0.6940	2161.52	2161.52	2161.52	2161.52
Reach-1	0.6000	2160.48	2160.47	2160.47	2160.47
Reach-1	0.5050	2160.05	2160.05	2160.04	2160.04
Reach-1	0.4110	2159.77	2159.76	2159.75	2159.75
Reach-1	0.3170	2159.45	2159.44	2159.43	2159.43
Reach-1	0.2230	2159.04	2159.01	2159.00	2159.00
Reach-1	0.1320	2158.71	2158.67	2158.66	2158.65
Reach-1	0.0370	2156.68	2156.54	2156.47	2156.43
Reach-1	0.0325	US-60 Bridge			
Reach-1	0.0280	2156.27	2156.27	2156.27	2156.27
Reach-1	0.0040	2156.55	2156.55	2156.55	2156.55
Reach-1	0.0025	Railroad Bridge			
Reach-1	0.0010	2153.34	2153.34	2153.34	2153.34

Bridge Replacement and Railroad Trestle at US 60

HEC-RAS Plan: 7.29.03 River: RIVER-1 Reach: Reach-1 Profile: PF 3

Reach	River Sta	Existing W.S. Elev (ft)	Revised existing W.S. Elev (ft)*	W.S. Elev (ft) at 300 ft @ US 60; 400 ft at RR (revised)	W.S. Elev (ft) at 400 ft @ US 60; 500 ft at RR (revised)	W.S. Elev (ft) at 500 ft @ US 60; 600 ft at RR (revised)
Reach-1	5.6850	2210.58	2210.58	2210.58	2210.58	2210.58
Reach-1	5.5920	2209.79	2209.79	2209.79	2209.79	2209.79
Reach-1	5.4930	2208.83	2208.83	2208.83	2208.83	2208.83
Reach-1	5.4000	2207.95	2207.95	2207.95	2207.95	2207.95
Reach-1	5.3040	2207.01	2207.01	2207.01	2207.01	2207.01
Reach-1	5.2110	2205.67	2205.67	2205.67	2205.67	2205.67
Reach-1	5.1170	2203.90	2203.90	2203.90	2203.90	2203.90
Reach-1	5.0250	2203.02	2203.02	2203.02	2203.02	2203.02
Reach-1	4.9280	2202.19	2202.19	2202.19	2202.19	2202.19
Reach-1	4.8330	2201.32	2201.32	2201.32	2201.32	2201.32
Reach-1	4.7400	2200.53	2200.53	2200.53	2200.53	2200.53
Reach-1	4.6470	2199.82	2199.82	2199.82	2199.82	2199.82
Reach-1	4.5520	2199.16	2199.16	2199.16	2199.16	2199.16
Reach-1	4.4550	2198.49	2198.49	2198.49	2198.49	2198.49
Reach-1	4.3620	2197.79	2197.79	2197.79	2197.79	2197.79
Reach-1	4.2700	2196.94	2196.94	2196.94	2196.94	2196.94
Reach-1	4.1780	2196.04	2196.04	2196.04	2196.04	2196.04
Reach-1	4.0810	2195.19	2195.19	2195.19	2195.19	2195.19
Reach-1	3.9880	2194.02	2194.02	2194.02	2194.02	2194.02
Reach-1	3.8930	2192.54	2192.54	2192.54	2192.54	2192.54
Reach-1	3.7980	2191.06	2191.06	2191.06	2191.06	2191.06
Reach-1	3.7060	2189.94	2189.94	2189.94	2189.94	2189.94
Reach-1	3.6110	2188.69	2188.69	2188.69	2188.69	2188.69
Reach-1	3.5160	2187.08	2187.08	2187.08	2187.08	2187.08
Reach-1	3.4210	2185.94	2185.94	2185.94	2185.94	2185.94
Reach-1	3.3280	2185.04	2185.04	2185.04	2185.04	2185.04
Reach-1	3.2340	2184.18	2184.18	2184.18	2184.18	2184.18
Reach-1	3.1370	2183.44	2183.44	2183.44	2183.44	2183.44
Reach-1	3.0440	2182.73	2182.73	2182.73	2182.73	2182.73
Reach-1	2.9500	2182.02	2182.02	2182.02	2182.02	2182.02
Reach-1	2.8530	2181.55	2181.55	2181.55	2181.55	2181.55
Reach-1	2.7590	2180.99	2180.99	2180.99	2180.99	2180.99

Bridge Replacement and Railroad Trestle at US 60

Reach	River Sta	Existing W.S. Elev (ft)	Revised existing W.S. Elev (ft)*	W.S. Elev (ft) at 300 ft @ US 60; 400 ft at RR (revised)	W.S. Elev (ft) at 400 ft @ US 60; 500 ft at RR (revised)	W.S. Elev (ft) at 500 ft @ US 60; 600 ft at RR (revised)
Reach-1	2.6660	2180.31	2180.31	2180.31	2180.31	2180.31
Reach-1	2.5700	2179.82	2179.82	2179.82	2179.82	2179.82
Reach-1	2.4780	2179.10	2179.10	2179.10	2179.10	2179.10
Reach-1	2.3840	2178.18	2178.18	2178.18	2178.18	2178.18
Reach-1	2.2910	2177.11	2177.11	2177.11	2177.11	2177.11
Reach-1	2.1960	2176.12	2176.12	2176.12	2176.12	2176.12
Reach-1	2.1030	2175.02	2175.02	2175.02	2175.02	2175.02
Reach-1	2.0080	2174.39	2174.39	2174.39	2174.39	2174.39
Reach-1	1.9140	2173.53	2173.53	2173.53	2173.53	2173.53
Reach-1	1.8220	2172.75	2172.75	2172.75	2172.75	2172.75
Reach-1	1.7250	2172.13	2172.13	2172.13	2172.13	2172.13
Reach-1	1.6310	2171.43	2171.43	2171.43	2171.43	2171.43
Reach-1	1.5390	2170.50	2170.50	2170.50	2170.50	2170.50
Reach-1	1.4430	2169.60	2169.60	2169.60	2169.60	2169.60
Reach-1	1.3500	2168.70	2168.70	2168.70	2168.70	2168.70
Reach-1	1.2560	2167.88	2167.88	2167.88	2167.88	2167.88
Reach-1	1.1610	2167.20	2167.20	2167.20	2167.20	2167.20
Reach-1	1.0680	2166.42	2166.42	2166.42	2166.42	2166.42
Reach-1	0.9740	2165.48	2165.48	2165.48	2165.48	2165.48
Reach-1	0.8800	2164.62	2164.62	2164.62	2164.62	2164.62
Reach-1	0.7860	2163.18	2163.15	2163.18	2163.18	2163.18
Reach-1	0.6940	2161.52	2161.57	2161.52	2161.52	2161.52
Reach-1	**0.6000**	2160.48	2160.92	2160.42	2160.41	2160.41
Reach-1	**0.5050**	2160.05	2160.73	2159.95	2159.91	2159.91
Reach-1	**0.4110**	2159.77	2160.60	2159.60	2159.55	2159.55
Reach-1	**0.3170**	2159.45	2160.48	2159.21	2159.11	2159.12
Reach-1	**0.2230**	2159.04	2160.34	2158.58	2158.34	2158.36
Reach-1	**0.1320**	2158.71	2160.23	2157.97	2157.01	2156.67
Reach-1	**0.0370**	2156.68	2159.35	2156.78	2155.13	2154.66
Reach-1	0.0325	**US-60 Bridge (low cord @ 2158.40)**				
Reach-1	0.0280	2156.27	2157.39	2156.78	2155.13	2154.66
Reach-1	0.0040	2156.55	2157.49	2156.23	2154.18	2153.78
Reach-1	0.0025	**Railroad Bridge**				
Reach-1	0.0010	2153.34	2152.98	2152.63	2152.63	2152.63

* The revised water surface elevation is from a correction of URS' existing HEC-2 model, which the upstream cross-section and brdige cross sections of the US60 and

Bridge Replacement and Railroad Trestle at US 60

	Unit Cost	Unit	Quantity Alt 1	Alt 2	Alt 3	US60 Bridge 300' x 35'	400' x 35'	500' x 35'
Structural Excavation	$ 20.00	CY	80	85	90	$ 1,600	$ 1,700	$ 1,800
Sturctural Backfill	$ 30.00	CY	122	132	142	$ 3,660	$ 3,960	$ 4,260
Class S Concrete (3000 PSI)	$ 300.00	CY	250	260	310	$ 75,000	$ 78,000	$ 93,000
Class S Concrete (4000 PSI)	$ 400.00	CY	510	560	610	$ 204,000	$ 224,000	$ 244,000
48" Drilled Shaft	$ 200.00	LF	600	650	700	$ 120,000	$ 130,000	$ 140,000
Rebar	$ 0.50	LB	178000	182000	188365	$ 89,000	$ 91,000	$ 94,183
Bridge Joint Deck Assembly	$ 390.00	LF	95	100	105	$ 37,050	$ 39,000	$ 40,950
F-Shaped Barrier	$ 100.00	LF	910	960	1,060	$ 91,000	$ 96,000	$ 106,000
Approach Slab	$ 10.00	SF	900	950	1,050	$ 9,000	$ 9,500	$ 10,500
Precast girders	$ 125.00	LF	1000	1500	2,000	$ 125,000	$ 187,500	$ 250,000
Removal of AC	$ 75.00	SY	300	400	500	$ 22,500	$ 30,000	$ 37,500
					Total	**$ 755,310**	**$ 860,660**	**$ 984,693**

	Unit Cost	Unit	Alt 1	Alt 2	Alt 3	RR Tressel 400' x 35'	500' x 35'	600' x 35'
Structural Excavation	$ 20.00	CY	80	85	90	$ 1,600	$ 1,700	$ 1,800
Sturctural Backfill	$ 30.00	CY	122	132	142	$ 3,660	$ 3,960	$ 4,260
Class S Concrete (3000 PSI)	$ 300.00	CY	250	260	310	$ 75,000	$ 78,000	$ 93,000
Class S Concrete (4000 PSI)	$ 400.00	CY	510	560	610	$ 204,000	$ 224,000	$ 244,000
48" Drilled Shaft	$ 200.00	LF	600	650	700	$ 120,000	$ 130,000	$ 140,000
Rebar	$ 0.50	LB	178000	182000	188365	$ 89,000	$ 91,000	$ 94,183
Bridge Joint Deck Assembly	$ 390.00	LF	100	105	110	$ 39,000	$ 40,950	$ 42,900
Tracks & Accessories	$ 150.00	LF	800	1,000	1,200	$ 120,000	$ 150,000	$ 180,000
Railroad Ties	$ 50.00	LF	800	1,000	1,200	$ 40,000	$ 50,000	$ 60,000
F-Shaped Barrier	$ 100.00	LF	960	1,060	1,150	$ 96,000	$ 106,000	$ 115,000
Approach Slab	$ 10.00	SF	950	1,050	1,150	$ 9,500	$ 10,500	$ 11,500
Precast girders	$ 125.00	LF	1500	2,000	2,100	$ 187,500	$ 250,000	$ 262,500
					Total	**$ 985,260**	**$ 1,136,110**	**$ 1,249,143**

Bridge Replacement and Railroad Trestle at US 60

Item No.	Description	Alt. 1: Estimated Quantity	Alt. 2: Estimated Quantity	Alt. 3: Estimated Quantity	Unit	Unit Cost	Alt. 1: proposed bridge opening at 300 ft @ US 60; 400 ft at RR	Alt. 2: proposed bridge opening at at 400 ft @ US 60; 500 ft at RR	Alt. 3: proposed bridge opening at 500 ft @ US 60; 600 ft at RR
1	Mobilization	1	1	1	LS	$ 200,000	$ 200,000	$ 200,000	$ 200,000
2	Removal of Existing Structures	1	1	1	LS	$ 250,000	$ 250,000	$ 250,000	$ 250,000
3	Clearing and Grubbing	3	3	3	AC	$ 90.00	$ 270	$ 270	$ 270
4	Removal of Asphaltic Concrete Pavement	300	400	500	SY	$ 75.00	$ 22,500	$ 30,000	$ 37,500
5	Roadway Excavation	300	400	500	CY	$ 20.00	$ 6,000	$ 8,000	$ 10,000
7	Survey & Layout	1	1	1	LS	$ 10,000.00	$ 10,000	$ 10,000	$ 10,000
8	Bridge AT US60	11	1	1	LS	Varies	$ 755,310	$ 860,660	$ 984,693
9	RR Tressel	1	1	1	LS	Varies	$ 985,260	$ 1,136,110	$ 1,249,143
11	Survey & Layout	1	1	1	LS	$ 25,000	$ 25,000	$ 25,000	$ 25,000
						Subtotal:	$ 2,254,340	$ 2,520,040	$ 2,766,605
						Engineering (15%):	$ 338,151	$ 378,006	$ 414,991
						Construction Contigney (20%):	$ 450,868	$ 504,008	$ 553,321
						Total:	**$ 3,043,359**	**$ 3,402,054**	**$ 3,734,917**

APPENDIX D – FLOODPRONE PROPERTIES ACQUISITION PROGRAM

Resolution FCD 95-01A
Floodprone Properties Acquisition Program
(Amendment to the Alternative Flood Control Works Program, Resolution FCD 95-01)

Policy Statement

The Flood Control District of Maricopa County (District) promotes protection of the public from the dangers of flooding through a variety of flood management projects and programs. The District promotes allowing the floodplain to serve in its natural function whenever possible. To reduce the occurrence of repetitive loss to property and to protect the public, the District has worked with property owners on projects to remove them from harm's way. To facilitate this effort, the District developed a proactive "Alternative Flood Control Works Program" (Resolution FCD 95-01) to provide limited District funding for voluntary non-structural mitigation measures.

Building on recent experience, District staff worked to revise and update the "Alternative Flood Control Works Program," and amend it with the *Floodprone Properties Acquisition Program,* as described herein. As an amendment to the "Alternative Flood Control Works Program," the *Floodprone Properties Acquisition Program* will continue to be a voluntary acquisition and relocation program with uniform guidelines and available annual funding, implemented to remove properties from floodprone areas. The District's power of eminent domain will not be invoked for acquisitions completed under this Program; the Program is completely voluntary. Acquired properties may serve a dual purpose as community open space in addition to handling floodwaters.

Purpose

The *Floodprone Properties Acquisition Program* builds on previous program efforts to provide another mechanism through which the District can achieve its mission of protecting the public from hazards due to flooding. Through implementation of the Program, the District will continue to allow limited funding for voluntary property acquisition to assist residents of floodprone properties where large-scale structural or non-structural CIP projects are considered infeasible.

Background

Less than 18 percent of the estimated 9,800 miles of stream corridor in Maricopa County have been mapped with regulatory floodplains and floodways. In many of the mapped areas, development took place prior to the floodplain mapping. As floodplains were delineated, many residents learned that their homes were within a regulatory floodplain. A recent analysis of the mapped floodplains and floodways shows over 22,000 homes or businesses in the 100-year floodplain, with more than 400 of these in an identified floodway. These homes are at a higher risk for flooding than those outside the floodplain and, when the floodplain is active, the presence of these structures in the floodplain can create adverse impacts to adjacent homeowners.

The District has undertaken a program to identify all of the floodplains within Maricopa County by 2010 using approximate methods. Over the next several years, as more lineal miles of regulatory floodplains are identified, the number of homes or businesses in the 100-year floodplain could significantly increase.

Prior to 1995, the District was not authorized to set aside funds annually to acquire properties in floodprone areas to protect the public from flooding hazards. District staff identified the need for a consistent, proactive program for addressing properties in these floodprone areas.

In February 1994, the Flood Control Advisory Board approved staff's recommendations for the FY 1994/1995 Prioritization Procedure. Included was a recommendation to develop a program that addressed alternative flood mitigation measures at localized sites that were subject to, or had high potential for, repetitive flood damage. Generally these sites, due to their localized nature, do not score well using the prioritization matrix, since potential structural solutions are not cost-effective for the limited number of homes affected. However, non-structural solutions such as property or easement acquisition may prove cost effective.

The "Alternative Flood Control Works Program" (Resolution FCD 95-01) was developed to fulfill this need. The Program was approved by the Board of Directors in September 1995, to act as a supplement to the District's *Procedure for Identifying and Prioritizing Potential Five-Year Capital Improvement Program (CIP) Projects*, which serves as the preferred method for developing funding priorities in the *General Policies Concerning the Allocation of Fiscal Resources to Accomplish the District's Functions and Responsibilities*.

The *Floodprone Properties Acquisition Program* as described herein (Resolution FCD 95-01A), will amend the previous program and will continue to act as a supplement to the District's Prioritization Procedure.

Goals

The goals of the Floodprone Properties Acquisition Program are:

- To reduce the risk of injury, death, and property damage due to flooding by providing flood hazard remediation in the form of voluntary acquisition and relocation.
- To establish program criteria, guidelines, and funding for acquisition of properties in delineated floodplains.
- To identify all properties located in floodprone areas in Maricopa County that pose a threat to personal and public safety, and to identify similar properties in all future District studies.
- To encourage local jurisdictions to consider the removal of residents from floodprone areas through the *Floodprone Properties Acquisition Program*, and to allow negotiation of intergovernmental agreements (IGA's) with local jurisdictions for property acquisition under the Program.

The *Floodprone Properties Acquisition Program* is a voluntary program that will increase the District's and the District's client communities, economic, technical and administrative flexibility while improving beneficial floodplain characteristics. The Program is not intended to facilitate urban renewal or Community Development Block Grant projects or to allow non-structural, stand-alone CIP projects to bypass the requirements of the *Procedure for Identifying and Prioritizing Potential Five-Year CIP Projects.*

For some of the District's client communities, potential reductions in flood insurance premiums may be available through the National Flood Insurance Program's (NFIP) Community Rating System (CRS) program, which credits the acquisition of structures as a sound floodplain management method.

The Program will avoid conflicts with existing regulatory programs. For example, ARS Section §48-3609 requires that nonconforming buildings or structures in a regulatory floodplain that are not used for 12 months or more, or are destroyed to the extend of 50 percent of its value, must come into compliance with the floodplain regulations before further use is authorized. Structures falling under this regulation would not be eligible for acquisition by the District, but they may be eligible for federal funding through provisions of the NFIP.

Benefits

- Direct public safety benefit by providing flood mitigation for people living in floodprone areas.
- Direct and indirect economic benefits from reduced flood losses.
- Avoidance of costs of structural flood control projects.
- Reduced public costs for disaster assistance and emergency relief.
- Reduced public costs of emergency operations during flood disasters.
- Moderation of flood flows by allowing floodplains to function more naturally (reducing flow velocities, flow depths, and flood peaks).
- Protection of flora and fauna by providing and preserving natural open space and maintaining and preserving natural floodplain habitats.
- Providing multiple-use recreational opportunities (developed and facilitated by others).
- Water quality enhancement by reducing downstream turbidity.
- Increasing infiltration in the natural channels enhancing groundwater recharge.

Authority

The District has the authority to acquire properties under Arizona Revised Statutes Section 48-3603.

Funding

Funding for the *Floodprone Properties Acquisition Program* will be established annually as part of the District's CIP project prioritization process and included in the District's annual budget approval process. The funding level will be based on an assessment of requests received, funding availability, and relative priority of other CIP projects.

Qualifying Criteria

The following list describes the Program's qualifying criteria. A property must meet one or more of the following descriptions to be further evaluated using the established prioritization criteria.

Property with an inhabited residential structure located in a delineated 100-year floodway, or floodplain if no floodway designation exists, and built prior to such designation.

Property with an inhabited residential structure within a delineated 100-year floodplain that has experienced documented flood damage.

An "inhabited residential structure" is defined as a house, townhouse, condominium, apartment complex of four units or less, manufactured home, or mobile home designed to be used with a permanent structure, that is used principally for residence, and that is actually occupied by the owner or a tenant as a residence.

The resident must also show a valid building permit for the residential structure, except in those cases where the structure predates any city, town, or county building permit requirements, or the current owner is not the person that constructed the building. In the latter instance, the current owner must have lived in the home for at least one year.

Any property or structure that will benefit from a proposed future CIP drainage or flood control project is not eligible for this Program. Nonconforming residences in a regulatory floodplain that have not been used for 12 months or more or are destroyed to the extent of 50 percent or more of their value will not be eligible for acquisition under this Program. Proposed projects will be submitted to the *Floodprone Properties Acquisition Program* Evaluation Committee and may be made at any time. The Top-Ranked properties will then be submitted by the Evaluation Committee to the annual CIP Prioritization Procedure process.

A set of Program Guidelines (see Attachment 1, this document) follow this Policy Statement and have been developed to establish the program implementation strategy, the prioritization methodology, a property management approach, and land costs and relocation procedures. With the approval of the Chief Engineer and General Manager of the Flood Control District, the Program Guidelines may be updated as required.

Attachment 1

Floodprone Properties Acquisition Program Guidelines

Program Implementation

The following steps, which are illustrated in Figure 1, outline the tasks necessary to implement the *Floodprone Properties Acquisition Program*. Any property considered for acquisition under this Program must first be evaluated for eligibility, and subsequently be ranked using the prioritization criteria. Program implementation (from submittal of proposed properties to initiation of acquisition process) requires approximately 12 months to complete, and includes the following steps:

1. Floodprone areas are identified by District staff and/or local, state or federal agencies, and acquisition proposals for floodprone properties are submitted for evaluation to the *Floodprone Properties Acquisition Program* Evaluation Committee. Proposals for projects within the unincorporated County may be submitted by District staff, or directly to the District by the requesting resident. Proposals for projects within incorporated areas should be requested through the appropriate jurisdiction. Project proposals can be made at any time during the year.

2. The *Floodprone Properties Acquisition Program* Evaluation Committee determines if the proposed properties meet the eligibility requirements of the Program (i.e., location of property with respect to delineated floodway or floodplain; year delineation was completed vs. year residence was constructed; flood damage history of residence; if flood damaged, degree of damage and whether residence has been habitable during previous 12 months).

3. If proposed properties meet the initial eligibility criteria, District staff will determine whether the property is located within an area benefited by a possible future CIP project. If so, the property is ineligible for acquisition under the *Floodprone Properties Acquisition Program.*

4. The Floodprone *Properties Acquisition Program*'s Prioritization Criteria (as described below) are applied to the eligible properties by the Evaluation Committee, and the eligible properties are assigned a numerical ranking.

5. The proposed CIP budget for the upcoming fiscal year, including funding for the *Floodprone Properties Acquisition Program,* is presented to the Board of Directors for their approval.

6. Once the CIP budget is approved by the Board of Directors, and ranking for the eligible properties has been completed by the Evaluation Committee, the "top-ranked" properties are identified dependent upon the approved CIP budget and other factors.

7. District staff initiates acquisition of the top-ranked properties by following the guidelines for the Floodprone Properties Acquisition Program, as set forth herein. The acquisition process begins with title searches and appraisals of the top-ranked properties, followed by acquisition offers, opening of escrow accounts, relocation of residents, closing of escrow accounts, demolition of property improvements, and ongoing maintenance or disposition of the property. This step will generally take six to 12 months to complete.

8. Eligible properties not identified as top-ranked during a budget cycle, and therefore not acquired during a given fiscal year, can be reconsidered during the subsequent budget cycle. District staff, the resident, or the appropriate jurisdiction will be required to confirm continued interest in the Program by re-submitting the request to the Evaluation Committee. The proposed property will then be evaluated along with all other requests, without preference or prejudice.

Prioritization

Once it is established through the qualifying criteria that a property is eligible for the *Floodprone Properties Acquisition Program,* an evaluation will be completed to assist in prioritizing the requests. If the data necessary to complete the prioritization are not available, staff will work to develop approximate data to assist in the ranking. A discussion of the prioritization factors and the maximum number of points available for each factor follows.

Severity of Hazard

Severity of Hazard = $\leq$ 25 points

The hazard analysis uses several variables to calculate a Hazard Ranking Factor (HRF). Variables include a Personal Hazard Factor (PHF) related to the depth and velocity of flow, a residence's chance of flooding, the residence's location with respect to erosion hazard zones, and a residence's Emergency Response Time (ERT). For the purposes of this Program, the HRF is used to evaluate relative risks and is calculated using the following formula:

A x B x C x D = HRF, where;

A = PHF = the square of the overbank flow velocity (feet/second) times the flow depth (measured in feet at the residences finished floor) during the 100-year flood peak stage. A PHF of 18 or more is generally considered to be highly hazardous.

B = The estimated percent chance that, during any given year, floodwaters will enter the residence or flow under a manufactured residence.

C = Location in erosion hazard zone. When a detailed erosion hazard analysis is available, a residence should be assigned a factor of three (3) if located in a Severe Erosion Hazard Zone; a factor of two (2) if located in a Lateral Migration Erosion Hazard Zone; and a factor of one (1) if located in a Long-Term Erosion Hazard Zone. If a detailed

erosion hazard analysis is not available, but a residence is in a State of Arizona or District designated Erosion Hazard Zone, a factor of two (2) should be assigned. If the residence is clearly outside any observable erosion hazard area, a factor of one (1) should be assigned.

D = ERT = the calculated time between the most intense precipitation on the watershed and when the modeled flow reaches hazardous levels at the effected residences. This time interval is the time available to affect a coordinated flood warning and response. A residence should be assigned a factor of five (5) when the ERT is one hour or less; a factor of four (4) when the ERT is between one and three hours; a factor of three (3) when the ERT is between three and six hours; a factor of two (2) when the ERT is between six and 12 hours; and a factor of one (1) when the ERT is more than 12 hours.

Location of Residence

Delineated 100-year floodway	= ≤ 20 points
Delineated 100-year floodplain fringe	= ≤ 10 points

Project is eligible for points from only one of these categories. To qualify the residence must have been constructed prior to the area drainage regulations, or the floodplain delineation.

Economic Benefit

Damage potential vs. property value	= ≤ 10 points
Cost for acquisition	= ≤ 10 points
Priority of the local jurisdiction	= ≤ 10 points
Local cost sharing	= ≤ 10 points
Potential for CRS credits	= ≤ 5 points

Project is eligible to receive points from all these categories. Proposals for projects within incorporated areas must be requested through the appropriate jurisdiction.

Potential Impacts to Adjacent Properties

Potential for reuse	= ≤ 5 points
Potential neighborhood impacts	= ≤ 5 points

Project is eligible to receive points from both these categories. Evaluation must take into account the potential for reuse of the property as open space, for recreation, environmental mitigation, etc. In addition, impacts to surrounding neighbors must be considered including dislocation, reduced security, effects to property values, etc.

Property Management

The District will determine the appropriate disposition of any acquired properties in unincorporated Maricopa County. Per the terms of any applicable IGA or other agreement, the District and its cost-sharing partners will determine the appropriate disposition of any acquired properties in an incorporated municipality. In general, the District will remove any standing structures and subsequently dispose of the properties or require the properties be maintained and managed as open space.

Land Costs and Relocation

The Program is available for single family or multi-family residences, including houses, townhouses, condominiums, apartment complexes of four units or less, manufactured homes, or mobile homes designed to be used with a permanent structure, that are used principally for residences, and that are actually occupied by the owner or a tenant as residences, including the associated lot, up to 10 acres in size. The Program is not available to commercial properties. Vacant parcels and attached properties such as agricultural and/or ranching lands do not qualify for the Program and are not eligible.

The value of the properties less then or equal to one acre in size, will be determined *without* consideration of the flood hazard encumbrance. If, however, the total acreage of the parcel exceeds one acre, then the acquisition cost will be a function of two elements:

The value of one acre (+/-), including the residence and ancillary out-buildings (i.e., garage, shed, barn, corral, etc.), will be based on fair market value, *without* consideration of the flood hazard encumbrance.

1. The value of the remaining real property (that property within the same parcel, but outside the one acre area of improvements) will also be based on fair market value, and be established by comparable sales or by estimating the value, *with* consideration of the flood hazard encumbrance.

2. These two values will be combined to determine the total acquisition cost. The owner can choose to accept an offer on the residential site alone, or both the residential site and remainder property. The District will provide the appraisal(s) at the time of making the offer (ARS §12-1116). All appraisals will be conducted by a licensed appraiser and reviewed and approved by District staff. Offers will be good for 45 days.

Acquisitions may also provide relocation assistance as determined by the District's Volunteer Sales Assistance Program.

Figure 1: Floodprone Properties Acquisition Program Implementation
(Cycle Requires Approximately 12 Months to Complete)