Skunk Creek
Watercourse Master Plan

# EXECUTIVE SUMMARY

Flood Control District of Maricopa County



AUGUST 2001

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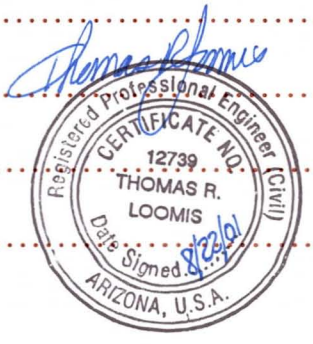

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# List of Acronyms and Abbreviations

| | |
|---|---|
| ADMP | Area Drainage Master Plan |
| ADMS | Area Drainage Master Study |
| ADWR | Arizona Department of Water Resources |
| AGFD | Arizona Game and Fish Department |
| ALERT | Automated Local Evaluation in Real Time |
| API | Arizona Preserve Initiative |
| ARS | Arizona Revised Statute |
| BLM | Bureau of Land Management |
| BOR | Bureau of Reclamation |
| CAP Canal | Central Arizona Project Canal |
| COE | US Army Corps of Engineers |
| COP | City of Phoenix |
| District | Flood Control District of Maricopa County |
| EAS | Emergency Alert System |
| FEMA | Federal Emergency Management Agency |
| FLO-2D | FLO-2D computer program for two-dimensional hydraulic modeling |
| FWS | Flood Warning System |
| GIS | Geographic Information System |
| GLO | General Land Office |
| HEC | Hydrologic Engineering Center |
| MSL | Mean Sea Level |
| MSP | Flood Control District of Maricopa County Meteorological Services Program |
| NWR | NOAA Weather Radio |
| NWS | National Weather Service |
| QPF | Quantitative Precipitation Forecast |
| RTIMP | Percent impervious area of a watershed |
| Study Team | Flood Control District of Maricopa County, City of Phoenix, Tetra Tech, Inc., Stantec Consulting Inc., JE Fuller Hydrology & Geomorphology Inc., Logan Simpson Design Inc. |
| T & E Species | Threatened and Endangered Species |
| WCMP | Skunk Creek Watercourse Master Plan |

# Acknowledgements

The individuals with Maricopa County, the City of Phoenix, the Arizona State Land Department, and the consultant team listed below have worked together to prepare this watercourse master plan. These are the people who formed the steering committee for the study. They have contributed not only their professional expertise, but their shared belief that planning for the safety and welfare of future generations is an important aspect of performing our professional roles today. Finally, this long-range planning tool would not be a reality without the support of the Maricopa County Board of Supervisors. Thanks to all of you for your contributions to the creation of this plan.

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# Preface

Providing a safe floodplain environment for residents is the primary goal and responsibility of the Flood Control District of Maricopa County (District). To that end, the District, along with the City of Phoenix, has developed a floodplain management plan for Skunk Creek and Sonoran Wash. Implementation of this plan will protect existing and future residents, and permit appropriate uses of floodplain areas, while allowing both watercourses to function naturally.

This study has determined that the floodplains of these watercourses are highly prone to the dangers of flooding, bank erosion, and sedimentation. The primary purpose of the plan is to provide public safety, and the District recognizes that there are many methods through which this purpose can be achieved. It is the intent, in preparing the Watercourse Master Plan, to not only protect residents from the hazards of a 100-year flood, but also to investigate the feasibility of preserving physical, cultural, and biological resources and the ability of the watercourses to function naturally.

If land is to be protected in its natural state, it must first be determined that the land has qualities worth preserving. The riparian habitat along Skunk Creek and Sonoran Wash offer Maricopa County's native plants and animals opportunities for survival that are limited and diminishing in other regions of the Valley. Mesquite bosques, palo verde trees, and saguaros flourish within the watercourse area as well as Harris hawks, foxes, and Sonoran Desert tortoise. The area provides a travel corridor for many wildlife species as well. The desert watercourses with their dense ribbons of desert hackberry, palo verde, and mesquite trees along the banks create a distinct visual character. Land of this character has value that warrants consideration for preservation. The study findings show that preservation also results in an increased level of public safety, and a reduction in public expenditures.

Flood control is a challenge in the Skunk Creek and Sonoran Wash area. However, beyond the hazards of flooding, the study area is subject to significant erosion hazards and sedimentation problems. This means that not only could homes built within these watercourses be filled with water in the event of a 100-year flood, but homes adjacent to the banks could become victims of erosion as the soil they sit on crumbles and moves downstream during floods. Soil erosion and deposition could cause channel movement putting existing and future homes in jeopardy and requiring extensive public investments to protect them. Historically, floodplain management throughout the county has not studied the shifts in watercourses due to these factors. Changes in Arizona law have established regulations for developing watercourse master plans to address these issues.

Research findings illustrate that in the last 50 years Skunk Creek and Sonoran Wash have been subject to bank erosion and lateral movement. Large floods have moved the main channel of Skunk Creek by more than 400 feet in some areas, while during an average year, the creek will move less than a foot. To address these hazards, the District developed four watercourse management alternatives:

- a full-structural solution which maximizes developable area within the floodplain but necessitates extensive construction of levees and bank protection;
- a stakeholders solution which maximizes developable area, in accordance with proposed development plans for the areas downstream of the Carefree Highway, but necessitates extensive construction of levees, channelization and bank protection;
- a low-impact structural solution that allows limited developable land within the floodplain but reserves the minimum area necessary for the natural function of the watercourse; and
- a nonstructural solution which reserves the maximum area needed for the natural function of the watercourse.

Based on pubic safety, economic impacts, and social and environmental criteria, the recommended management plan for the watercourse is the Low-Impact Structural Alternative, as described on pages 36-46 of this document. This alternative is the most successful for meeting the goals of the study.

For more information on this study, please contact Marilyn DeRosa or Doug Williams of the Flood Control District of Maricopa County at (602) 506-1501.

# 1 Introduction

The Flood Control District of Maricopa County (District) teamed with the City of Phoenix (COP) to develop the Skunk Creek Watercourse Master Plan (WCMP) for Skunk Creek, and its tributary Sonoran Wash. A watercourse master plan is a comprehensive floodplain management plan based on hydrologic and hydraulic analyses, lateral migration potential, future land use development, and environmental considerations. Historically, floodplain management within the COP and Maricopa County has not considered bank erosion, the potential long-term lateral movement of a watercourse over time, or future growth patterns within a watershed. The State of Arizona recently established Arizona Revised Statute (ARS) 48-3609.01 that enables local flood control agencies to identify sensitive watercourses for inclusive floodplain management through a process of watercourse master planning. The authority for the preparation of this study and the management of the Skunk Creek and Sonoran Wash watercourses is established in ARS 48-3609.1 and the Floodplain Regulations for Maricopa County (Flood Control District of Maricopa County, 2000).

The District contracted with Tetra Tech, Inc. who assembled a highly qualified team of subconsultants to assist in the preparation of the WCMP in conjunction with District and COP staff (Study Team). Tetra Tech, Inc. managed the project, performed the hydrologic modeling, assisted with hydraulic and erosion analyses, identified and analyzed the management alternatives, and prepared the WCMP report. Tetra Tech, Inc. contracted with the firm of Stantec Consulting Inc. to perform most of the hydraulic and sediment transport modeling, JE/Fuller Hydrology & Geomorphology, Inc. to perform the lateral stability analyses, and Logan Simpson Design Inc. to perform biological reconnaissance, delineate Waters of the United States, manage the public involvement process, and prepare final graphics.

The study area, shown in Figures 1 and 2, includes Skunk Creek from the Central Arizona Project Canal (CAP Canal) to about 2,200 feet north of the Skunk Creek crossing of New River Road. The study covers a length of about 13.2 stream miles of Skunk Creek, starting at the CAP Canal and extending upstream. The study area also includes Sonoran Wash, a tributary watercourse that joins Skunk Creek approximately 0.5 miles downstream of the CAP Canal, and has a study length of about 3.3 stream miles. The study area is generally defined as a 500-foot perimeter beyond the known 100-year floodplain of these watercourses, as determined by the Federal Emergency Management Agency (FEMA). Both Skunk Creek and Sonoran Wash have significant desert riparian vegetation. The potential exists for bank *erosion* and lateral migration of their *channel* banks to occur over time, particularly if vegetation along the banks is removed or disturbed by natural or human activities.

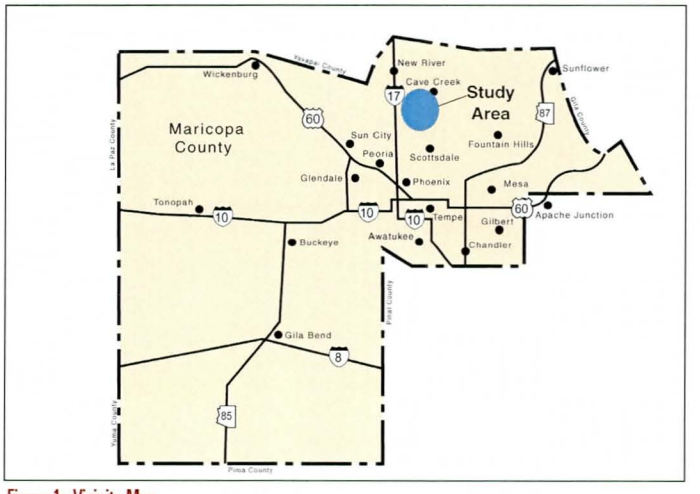


Figure 1: Vicinity Map

The study was divided into two phases to accommodate a request by the COP to fast track the area south of the Carefree Highway. Phase 1 consists of the study area between the CAP Canal and the Carefree Highway, including Sonoran Wash, and Phase 2 covers the study area north of the Carefree Highway. Phase 1 lies within the area covered by the COP North Black Canyon Corridor Plan, adopted by the Phoenix City Council in July 1999. This report describes the master plan purpose and goals, the watercourse characteristics, and the watercourse management plan alternatives and recommendations.

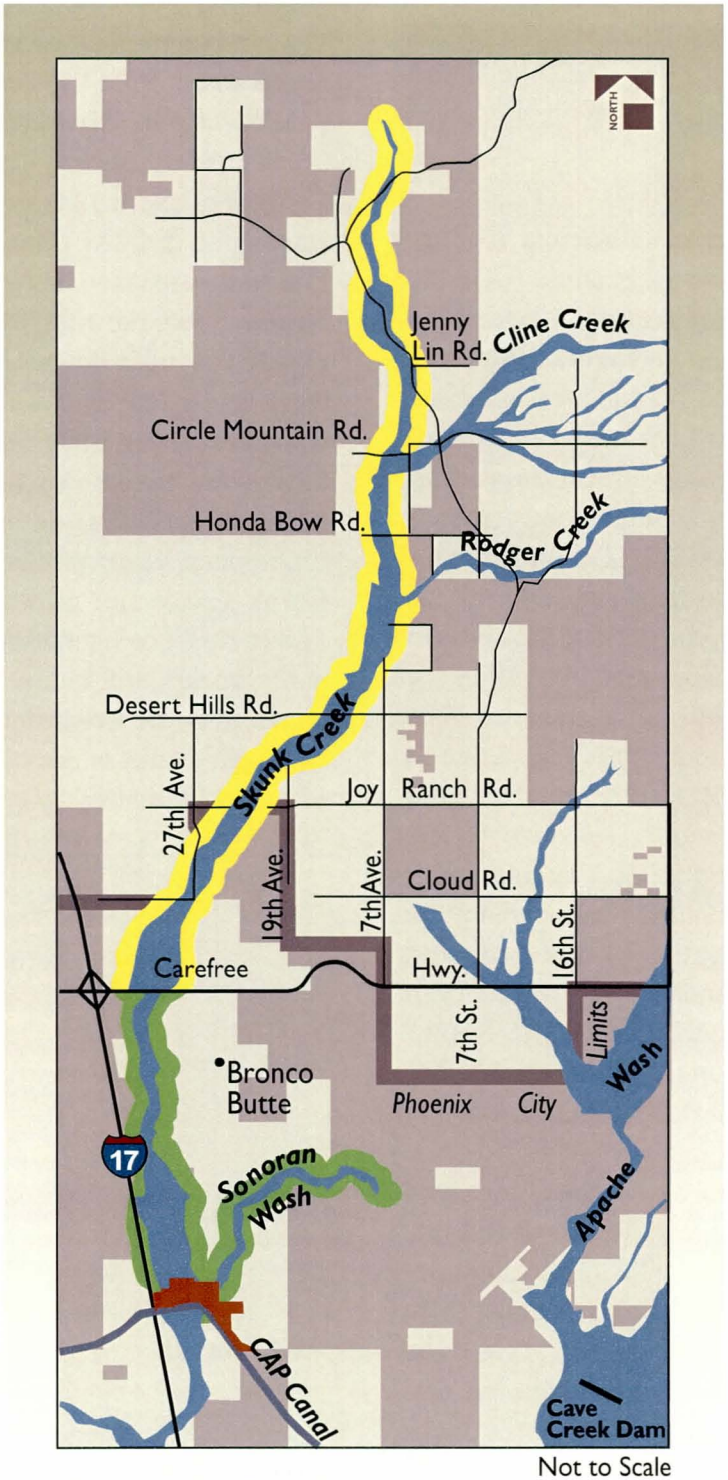



**Figure 2. Study Area**



2

Many terms used in this report have definitions specific to the purpose of this study. There are also technical terms used that require definition. These terms are italicized in red, and defined in the glossary. The titles of documents and reports referenced herein are underlined.

Skunk Creek

# 2 Master Plan Purpose and Goals

Much of the relatively undeveloped lands located within the study area have not been identified for preservation, and therefore face development pressure in the near future. In recent years, there has been increasing controversy surrounding the future of desert *watercourses* such as Skunk Creek and Sonoran Wash. This controversy centers on the continuance of traditional development practices and trends versus increasing support for maintaining open space corridors. Traditionally, as development takes place, bank stabilization, levees, and basins have been constructed to control flooding. These structural alternatives are costly, destroy natural *watercourse* corridors, and create negative impacts upstream and downstream. Because public safety and welfare are affected, these negative impacts are usually addressed using public funds. Opportunities for implementation of a long-term floodplain management plan that minimize expenditures of public funds diminish as development increases.

The purpose of the WCMP is to examine the benefits, opportunities, and weaknesses of various flood control solutions, including nonstructural, structural, and a combination of structural and nonstructural measures, and to recommend a management plan. This includes examining the *watercourses* as components of the overall watershed system. The primary goals of the WCMP are:

- Protect existing and future residents from the 100-year flood event and potential damages associated with *channel erosion* and lateral migration of the watercourse.
- Consider structural, nonstructural and a combination of structural and nonstructural alternatives.
- Minimize future expenditures of public funds for flood control and emergency management.
- Consider multiple-use opportunities for floodplain areas.
- Develop a *watercourse* management plan that generates widespread support and is implementable.

Sonoran Wash

# 3 Public Involvement Program

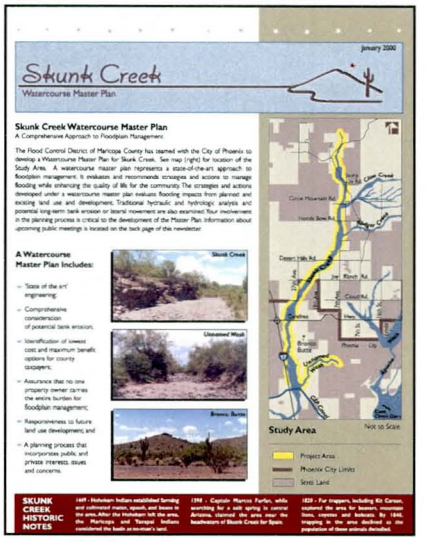
Public involvement was an integrated component in the development of the WCMP. A Public Involvement Plan was developed to outline the goals of the public involvement program, describe the types and formats of public meetings and presentations, and identify the various outreach techniques and methods. The goals of the Public Involvement Plan were to:

- ★ Inform the community of the study.
- ★ Enhance understanding of the alternatives through timely and effective distribution of information.
- ★ Obtain input from all potentially affected interests, including citizens, agencies, developers, and special interest groups, regarding issues and concerns.
- ★ Coordinate this study effort with Federal, State, County, and local agencies.

In order to inform and provide the public with the opportunity to furnish input, there have been numerous outreach components to the study process. Such components included: public meetings, newsletters, information provided in the District's existing website, community meetings, a Stakeholders Task Force and individual meetings with local property owners. Notices for the public meetings were published in the Foothills Sentinel, Scottsdale Tribune, and the Arizona Republic newspapers.

## A. Phase 1 Public Involvement

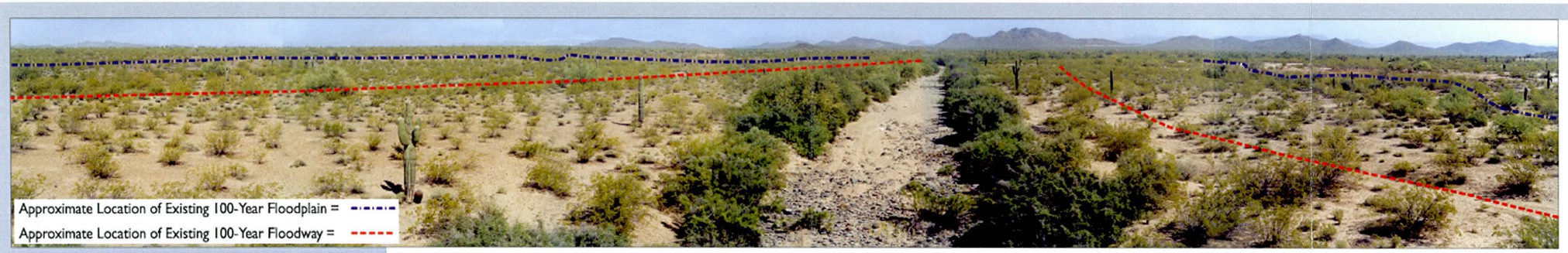
An initial newsletter was developed in January of 2000 and distributed to property owners within the study area as well as to affected agencies. The newsletter introduced the study, identified the study area, established a study schedule, and announced the first public workshop. A mail-back card was included in the newsletter for people who wanted to receive information on the WCMP. The first public meeting was held on January 27, 2000 at the Desert Mountain Middle School in Phoenix. A brief presentation was made introducing the study and the Study Team members. Participants were asked to provide their input on issues and concerns about flooding problems.



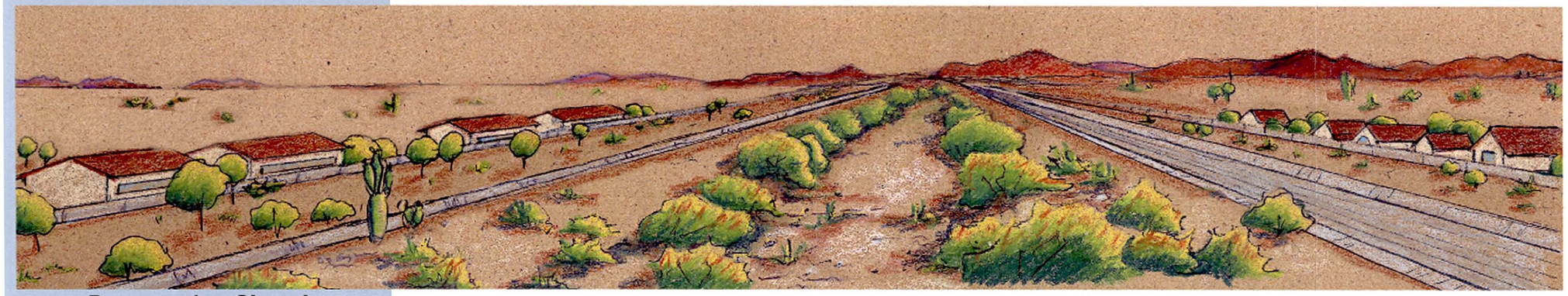

January 2000 Newsletter

The second public meeting was held on May 16, 2000 at the Paradise Valley Community Center in Phoenix. The meeting was facilitated by the COP staff as part of their continuing North Black Canyon Corridor planning process. Five proposed floodplain management alternatives were presented at the open house as part of a joint presentation by COP and the Study Team staff. An example of one of the exhibits illustrating the alternatives is shown on Figure 3. Participants were asked to provide comments on the proposed alternatives.

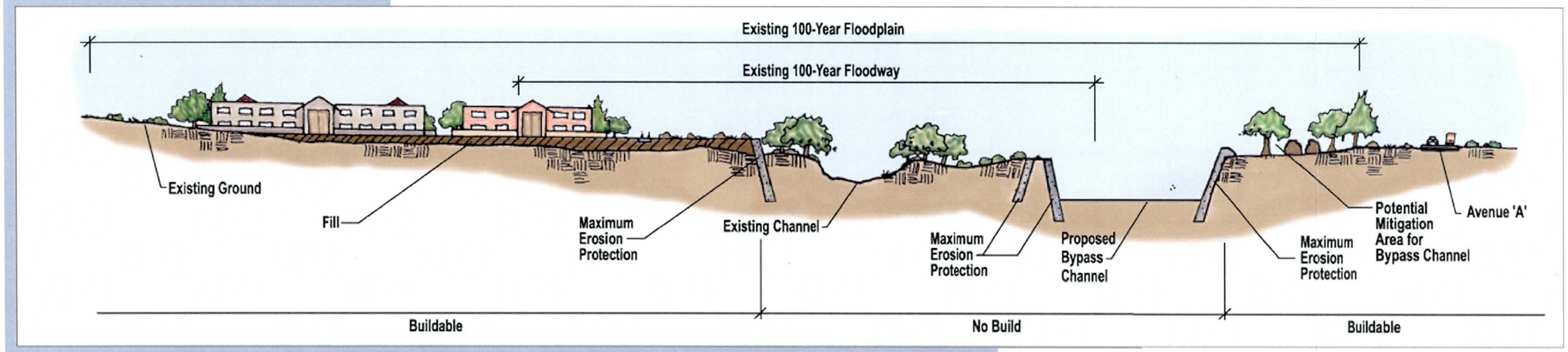
Property owners in the Phase 1 area were invited to participate in a Stakeholders Task Force (Task Force). The purpose of the Task Force was to provide input and to be informed of the Study Team's progress. Five Task Force meetings were held in addition to one-on-one meetings with individual property owners. This process culminated in a workshop conducted by the Study Team with the interested




## North View



## Perspective Sketch




## Section

Sonoran Wash Main Stem-Stakeholders Alternative

Figure 3. Main Stem-Alternative 2 (Stakeholders)

property owners and stakeholders on March 20, 2000. As a result of the workshop, a consensus was reached on the approach to be utilized for floodplain management of the Phase 1 study area.

In addition to the public and stakeholders meetings, presentations and progress updates were made periodically to several entities, including the COP North Gateway Village Planning Committee, the Planning Commission, the City Council Natural Resources subcommittee, and the Parks, Recreation, and Library Board. Periodic presentations were also made to the COP North Gateway Village Planning Committee in Phase 2 of the study.

## B. Phase 2 Public Involvement

A special public workshop was held on December 14, 2000 at the Desert Valley Baptist Church in New River at the request of the property owners to discuss the WCMP and local drainage problems. Meeting announcement letters were sent to each property owner in the project area. At this meeting, there was a brief presentation by the Study Team followed by a small group interaction session with Study Team members to assist the participants with their questions.

Another public meeting was held on February 15, 2001 at the Desert Mountain Middle School in Phoenix that focused on the Phase 2 study area. At this meeting, a handout was distributed to the public providing a summary of the three proposed floodplain management alternatives. The Study Team made a brief presentation that outlined the major components to each of the alternatives. The public gave their input regarding the initial alternatives, their preferences, and any recommendations they may have for other alternatives.

February 15, 2001 Open House

The final public meeting was held on June 28, 2001 at the Desert Mountain Middle School in Phoenix. Flyers were mailed to local homeowners and previous workshop attendees. At this meeting, a handout was distributed to the public that outlined the recommended floodplain management alternative. This public meeting was held in an open house format and Study Team members were available to receive input from the public regarding the recommended alternative. Information was also provided on the flood warning system being proposed as part of the planning initiative.

June 28, 2001 Open House

The results of the technical analyses show existing residences are located in the *FEMA 100-year floodway*. These residences were constructed prior to the adoption of the existing *FEMA 100-year floodway* in 1997. The location of these residences is an area very hazardous to public safety, both from a flood and *erosion* standpoint. The District sent letters to the owners of the identified properties requesting that each property owner contact the District to schedule a meeting regarding the floodplain status of their property. Six (6) property owners responded and individual meetings were held at the property in question. Property owners expressed the desire to

have the District establish a flood warning/notification system for the area as soon as possible, and most favored a voluntary acquisition program for existing residences located within the *FEMA 100-year floodway*. It was made clear to each property owner that an acquisition program would require approval by the Maricopa County Board of Supervisors, and several years for funding. Follow-up meetings were held with several property owners at their request, and with some of their neighbors. Time was also spent with interested property owners at each public meeting. The District sent letters, including the handout materials, to the property owners that did not respond to prior notices.

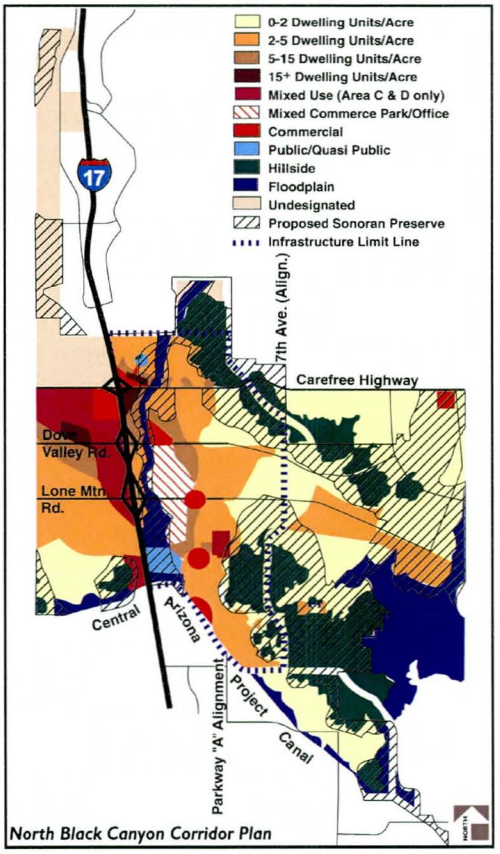
# 4 Watercourse General Characteristics

The study area is located within the COP and unincorporated areas of the northern portion of Maricopa County (County). The small rural community of New River is located at the north end of the study area, with the Anthem, Dynamite Mountain Ranch, and Tramonto residential communities lying to the west of Skunk Creek. Lands within the study area are primarily privately owned with some land owned by the Arizona State Land Department (ASLD) and the Bureau of Reclamation (BOR). Minor elevation differences within the study area provide panoramic views of mountainous and mesa landforms, undeveloped desert areas, and rural development. The desert *watercourses* within the study area are generally undisturbed, with the desert riparian vegetation adjacent to the *watercourse channel* intact. The regional and local planning strategies that affect the WCMP study area, and the physical characteristics of the study *watercourses*, are described in the following sections.

Skunk Creek North of Carefree Highway Bridge

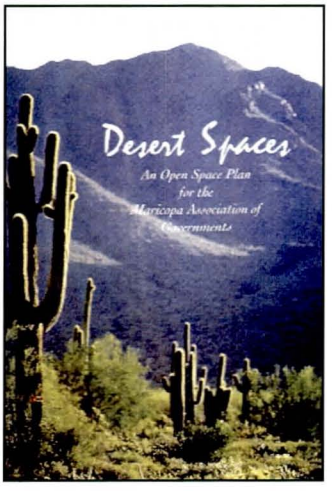
## A. Regional and Local Planning Strategies

There are several planning documents that provide recommendations regarding land use and development characteristics for the build-out of the planning study area. These documents include Maricopa County's New River Area Plan, the COP's North Black Canyon Corridor Plan and Sonoran Desert Preserve Plan, and Maricopa Association of Governments' (MAG) Desert Spaces plan. In addition, the County and COP adopted the Carefree Highway Scenic Corridor Study.




North Black Canyon Corridor Plan

The New River Land Use Plan was first adopted November 5, 1990 and updated in 1999. The adoption of the Eye to the Future 2020, Maricopa County Comprehensive Plan in October 1997 required the update of all area plans. The updated New River Area Plan was adopted April 7, 1999. The purpose of the plan is to promote high quality living and community development, while preserving a variety of lifestyles and the Sonoran Desert. Portions of the study area north of the COP corporate boundary are addressed in the New River Area Plan and are primarily designated as open space. The North Black Canyon Corridor Concept Plan was adopted in the fall of 1997 by the COP City Council. The concept plan proposed the development of a regional employment center and residential areas integrated with the surrounding desert environment. As a result of this concept plan a General Plan amendment (GPA-NG-1-97-1-2) regarding revised land use and General Plan text was proposed and approved. The entire portion of the study area addressed in Phase 1 of the WCMP is regulated by the COP and is covered by the North Black Canyon Corridor Plan.



Desert Spaces Cover

The Carefree Highway Scenic Corridor Study was completed in March of 1997 and adopted by the Maricopa County Board of Supervisors on May 14, 1997. The plan was created by a Technical Advisory Committee, which included representatives from the State of Arizona, Maricopa County, and local municipalities. The plan provides recommended policies to balance the retention of scenic qualities with the provision of safe and efficient traffic flow and the reality of development. Skunk Creek and the associated WCMP study area intersect the Carefree Highway and nearby hillsides that are addressed in the Carefree Highway Scenic Corridor Study.

The MAG Regional Council adopted the Desert Spaces plan for the 9,200 square mile region of Maricopa County in 1995. The intent of this plan is to provide a non-regulatory framework directed toward establishing a regional open-space network by defining regionally significant mountains, rivers, *watercourses*, and upland desert. The Desert Spaces plan identified Skunk Creek as having outstanding open-space values. The WCMP study area is within the areas defined in Desert Spaces as Environmentally Sensitive Development Areas (ESDA). Development in these areas should be limited to designs that retain the integrity of regionally and locally significant natural features, wildlife habitats, scenic resources, and cultural resources. Rivers and washes of regional significance within ESDA areas should be managed to retain their natural character and public access to them.

Utilizing the 1993 Desert Preserve Preliminary Plan and the 1995 Desert Spaces plan, the Sonoran Preserve Master Plan was approved by the Phoenix City Council in 1998. The residents of the COP approved by an 80% vote in May of 2000 to pursue acquisition of approximately 20,000 acres of lands held by the ASLD that were identified in the 1998 Sonoran Desert Preserve Plan. The purpose of this plan is to accommodate quality growth and


Skunk Creek within Sonoran Desert Preserve

preservation of the Sonoran Desert. The stated goals of the plan were not only to preserve significant portions of the Sonoran Desert, but also to preserve the natural hydrologic processes. These goals can be accomplished by preserving the floodway, the definable 100-year floodplain, and buffers wide enough to allow for the natural meandering of the watercourse over time. Several areas within and adjacent to the WCMP study area are recommended for preservation under the Sonoran Desert Preserve Plan.

The Sonoran Preserve Master Plan evolved through an extensive four-year public involvement process. This reflects the nationwide trend towards promoting nonstructural approaches and ecosystem preservation, as witnessed by the removal of flood control structures in many parts of the country. Federal agencies such as the U.S. Army Corps of Engineers (COE) and the BOR have, in recent years, significantly changed their focus from hard engineering solutions to include nonstructural alternatives, preservation of natural hydrologic functions, and ecosystem restoration.

Arizona Upland Vegetation

## B. Watercourse Characteristics

Skunk Creek is a moderately large *ephemeral watercourse* that originates in the New River Mountains, northeast of the unincorporated rural community of New River. Skunk Creek flows southward from the New River Mountains, across the Little Deer Valley and northern Phoenix, and into the Adobe Dam impoundment area. Prior to the construction of Adobe Dam in 1982, Skunk Creek flowed freely through the Little Deer Valley, around the edge of the Hedgpeth Hills (where the dam is now located), and then southwest across Deer Valley in northern Glendale toward its confluence with New River. Between the study area and Adobe Dam, Skunk Creek is now controlled through most of that *reach* by levees or channelization. The reach of Skunk Creek downstream of Interstate 17 (I-17) is heavily developed with residential and commercial land uses and a major landfill. This downstream reach is also very susceptible to flooding breakouts where the structural drainage features have limited freeboard in excess of the design discharge. The potential for flooding breakouts is particularly true upstream of Pinnacle Peak Road at 35th Avenue where a small increase in the existing 100-year peak discharge can cause Skunk Creek to overtop its banks and flood adjacent neighborhoods. This is important because management methods for the WCMP affect public safety in these areas.

Sonoran Wash is a small *ephemeral watercourse* that originates in the Union Hills east of Skunk Creek. Sonoran Wash flows westerly out of the Union Hills and then south around the hills, across the CAP Canal, and joins Skunk Creek about 0.5 miles south of the CAP Canal. Sonoran Wash is a relatively intact natural watercourse that has heavily vegetated banks for most of the entire study area.

Skunk Creek Downstream of Adobe Dam

Sonoran Wash Sandy Reach

The Skunk Creek watershed for the study area is about 50.3 square miles at the CAP Canal and encompasses portions of the COP, unincorporated Maricopa County, and the Tonto National Forest. Much of the watershed is comprised of undeveloped desert mountain terrain or desert upland foothills with low-density suburban ranch development. Higher density commercial, industrial, and residential development is planned or under construction in the southern portion of the study area, especially within the COP. Construction of the 1,100-acre Tramonto development between Cloud Road and the Carefree Highway is currently underway, with numerous other large developments in the planning phases in the Phase 1 portion of the study area. The Del Webb Anthem development extends into the study area between Desert Hills Drive and Rockaway Hills Road, although the portions along Skunk Creek have yet to be constructed. The Sonoran Wash watershed is about 13.4 square miles, and is also expected to experience rapid urbanization. The total length of the study area is 13.2 miles for Skunk Creek, and 16.5 miles when Sonoran Wash is included.

As part of the study process, Skunk Creek and Sonoran Wash are divided into segments with similar characteristics, called reaches. The reaches are defined based on landscape character, including vegetation, landforms, land use, and special features, and the geomorphologic and hydraulic considerations of each watercourse. Figures 4, 5 and 6 are examples of a typical reach for Sonoran Wash, Skunk Creek Phase 1 and Skunk Creek Phase 2, respectively, that illustrate the unique characteristics of both *watercourses*. Similar figures were created for all the WCMP study reaches. The floodplain management alternatives developed for the WCMP are based on numerous analyses conducted on these reaches.

# 5 Watercourse Environmental Characteristics

A general environmental overview of the study area was prepared, specifically identifying the visual characteristics, biological and cultural resources, land use, and recreation opportunities based on existing information and reconnaissance-level field investigation. The environmental characteristics were then summarized in terms of their influence on the planning process and used in the evaluation of floodplain management alternatives.

## A. Visual Analysis

The existing visual resources of the study area, which are described below, are based on readily accessible viewpoints within the study area. These viewpoints include major road crossings, the Carefree Highway and New River Bridges, and notable landforms such as Bronco Butte and Union Hills. Visual resources of

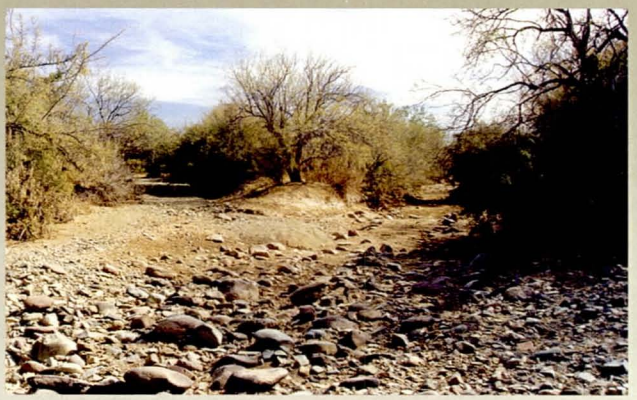
Bronco Butte

**Land Use/ Land Form**

- Undeveloped land use with mining operations adjacent to watercourse
- Relatively flat, uniform terrain transitioning to foothills of Union Hills

**Special Features**

- Gravel mining operation
- Desert riparian habitat
- Union Hills



**Channel**

- Multiple Channels
- Bottom cover includes sandy cobble surfaces
- Bank height varies

**Vegetation**

- Moderately desertscrub upland and riparian vegetation

July 1999 Aerial Photograph

**Phase I Key Map:**

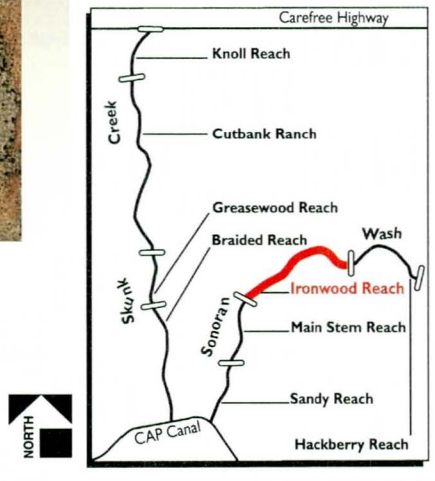



**Figure 4. Sonoran Wash - Ironwood Reach Landscape Character**

**Land Use/ Land Form**

- Undeveloped land use

**Special Features**

- Bronco Butte
- Interstate 17
- High, cobbled embankments

**Channel**

- Channel width varies
- Bottom cover includes sandy cobble surfaces
- High bank height

**Vegetation**

- Sparse, creosote bush upland
- Open riparian vegetation

July 1999 Aerial Photograph

**Phase I Key Map:**

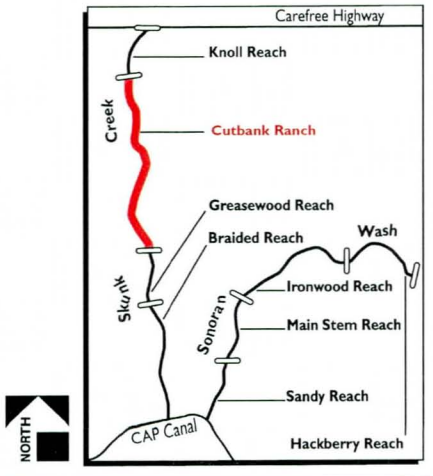
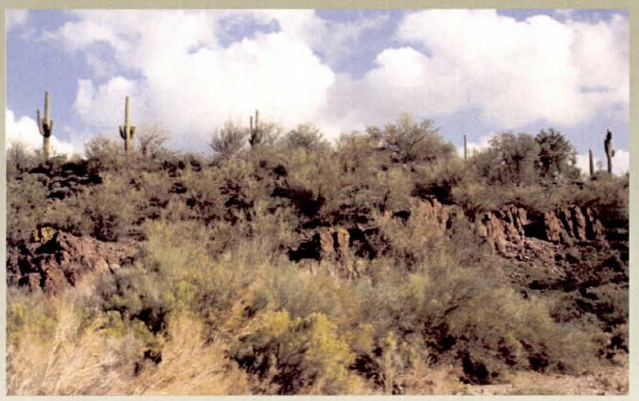



**Figure 5. Skunk Creek - Cutbank Reach Landscape Character**



**Land Use/ Land Form**

- Low density rural residential
- Rolling terrain

**Special Features**

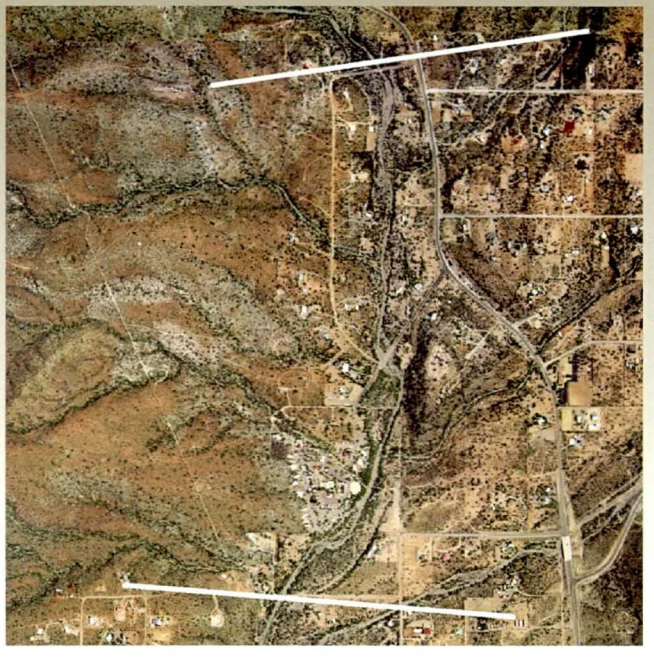
- Prominent view of Daisy Mountain
- Rock outcrops
- High density of saguaro cacti
- Scattered residences

**Channel**

- Cobble bottom channel
- High banks
- Channel width varies

**Vegetation**

- Dense desert riparian and upland vegetation



July 1999 Aerial Photograph

**Phase 2 Key Map:**

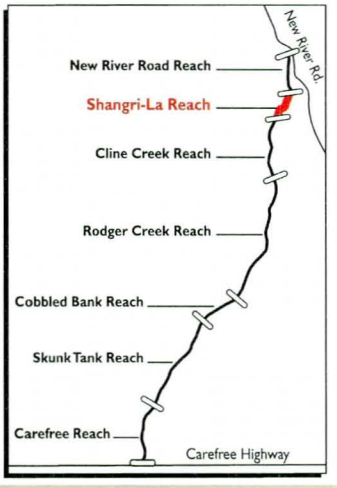



**Figure 6. Skunk Creek - Shangri La Reach Landscape Character**

the study area are evaluated in terms of the existing conditions of the landscape. The visual analysis includes an identification of distinct features, areas of high and low scenic quality, and location of major viewpoints. Distinct features are those features in the landscape that make a memorable impression such as Skunk Tank and the cliff formations in the portion of Skunk Creek Wash near Honda Bow Road. Scenic quality, or attractiveness, is based on the human perception of the inherent beauty of visual elements such as landform (mesas, valleys, and mountains), waterform (lakes, rivers, and drainages), vegetation, and built forms within the landscape. The visual analysis for Phase 1, shown graphically in Figure 7, presents the existing visual conditions of the landscape within the study area. The existing visual conditions of the landscape for Phase 2 are illustrated in Figures 8 and 9.

## B. Biological and Cultural Resources

The purpose of the biological investigation was to identify current vegetative conditions in the study area and the potential existence of federally listed and proposed threatened and endangered species (T&E species), designated critical habitat for T&E species, and Wildlife of Special Concern in Arizona (WSCA) as described by the Arizona Game & Fish Department (AGFD). The cultural resource evaluation relied on existing survey reports from the various state and local agencies to provide an overview of the cultural resources within the study area. Special status species or intensive pedestrian surveys were not conducted.

High Habitat Value along Skunk Creek

The study area was evaluated in terms of its relative *habitat values* and types. *Habitat value* refers to the suitability of the landscape for wildlife. Relative *habitat values* were determined for the study area and were assigned as high, medium and low. The *habitat values* within the study area are shown graphically on Figure 10 for Phase 1, and Figures 11 and 12 for Phase 2. These values reflect the overall suitability of the landscape for a diversity of wildlife species. Habitat type categorizes the landscape in terms of landforms.

An overview of the Upper Skunk Creek area catalogued 22 previously documented archaeological sites and numerous isolated artifacts. The overview was based on existing records from the State Historic Preservation Office, Arizona State Museum, Arizona State University, the Bureau of Land Management (BLM) office in Phoenix, and review of previous archaeological reports for this area (studies extending from the 1910s to the 1990s). Approximately 35 percent of the study area has been covered by previous archaeological survey. The general location of cultural sites that affect the WCMP are shown on Figure 10 for Phase 1, and Figures 11 and 12 for Phase 2.

## C. Land Use and Recreation

The existing land use and existing and planned recreation facilities were inventoried for the study area. Land use is a representation of existing occupation and/or a physical use of land. Land uses in the study area were determined by using recent aerial photography, City and County existing land use maps and a 1995 existing land use Geographic Information System (GIS) coverage, created by MAG.

Land in the Phase 1 portion of the WCMP falls under the jurisdiction of the COP. Private holders, BOR, and the ASLD own the land in the study area. Current land use is undeveloped land, range, and mining. In the COP's General Plan, planned land uses include mixed-use/commerce park, residential of varying density, public, commercial, and

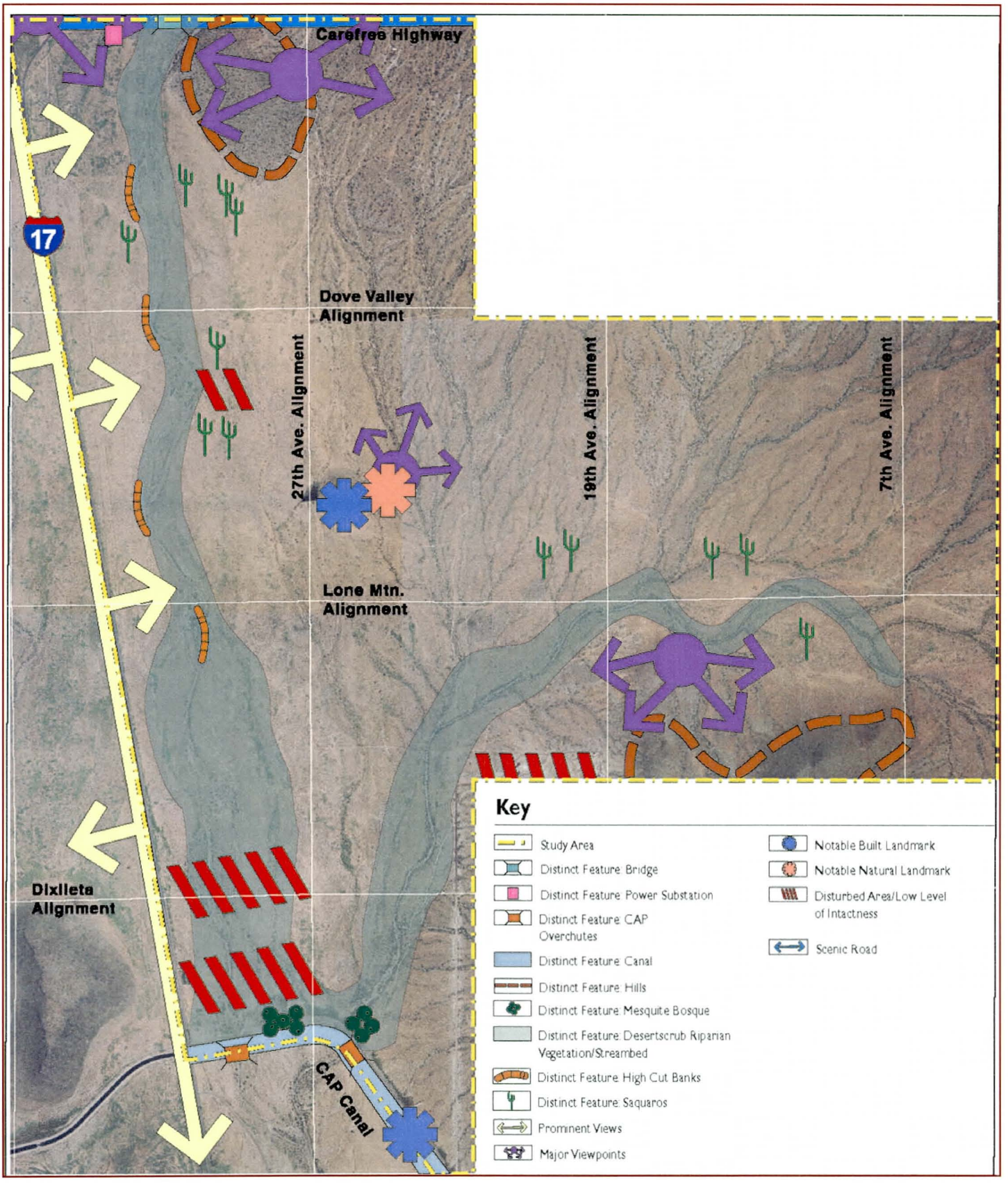



**Figure 7. Phase 1 Visual Analysis**

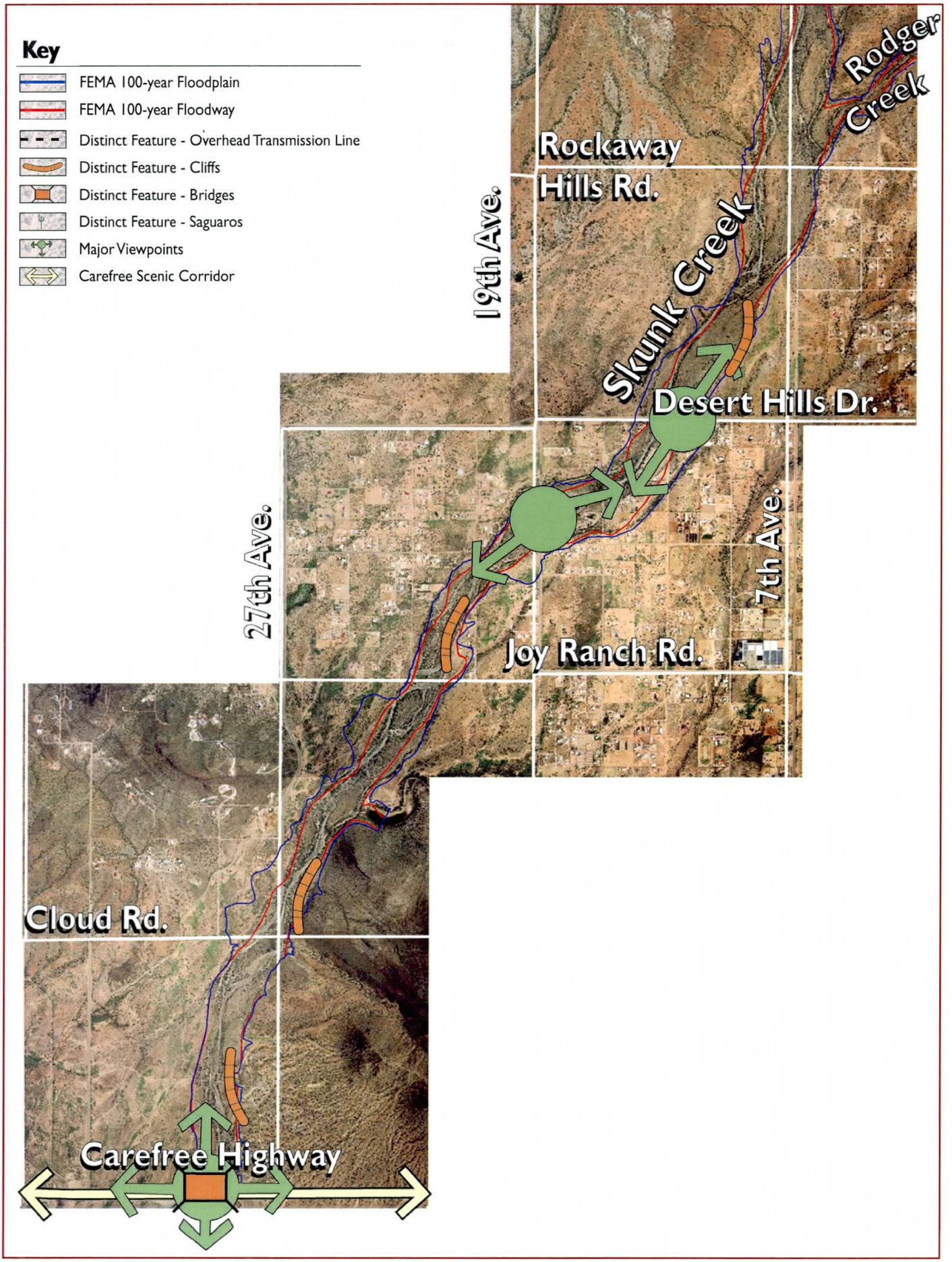



**Figure 8. Phase 2 Visual Analysis (South Half)**

**Key**

- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Distinct Feature - Overhead Transmission Line
- Distinct Feature - Cliffs
- Distinct Feature - Bridges
- Distinct Feature - Saguaros
- Major Viewpoints

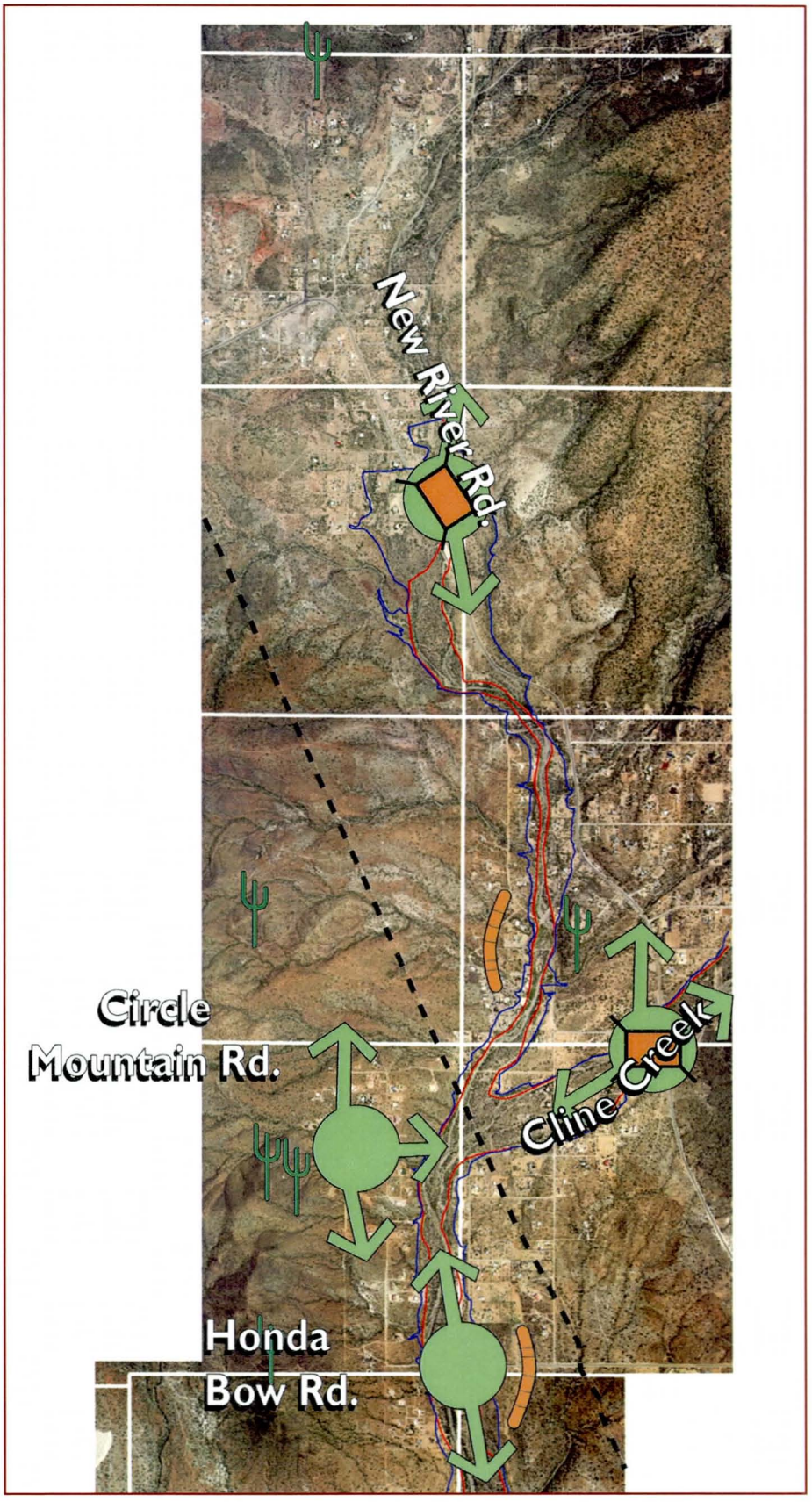



**Figure 9. Phase 2 Visual Analysis (North Half)**

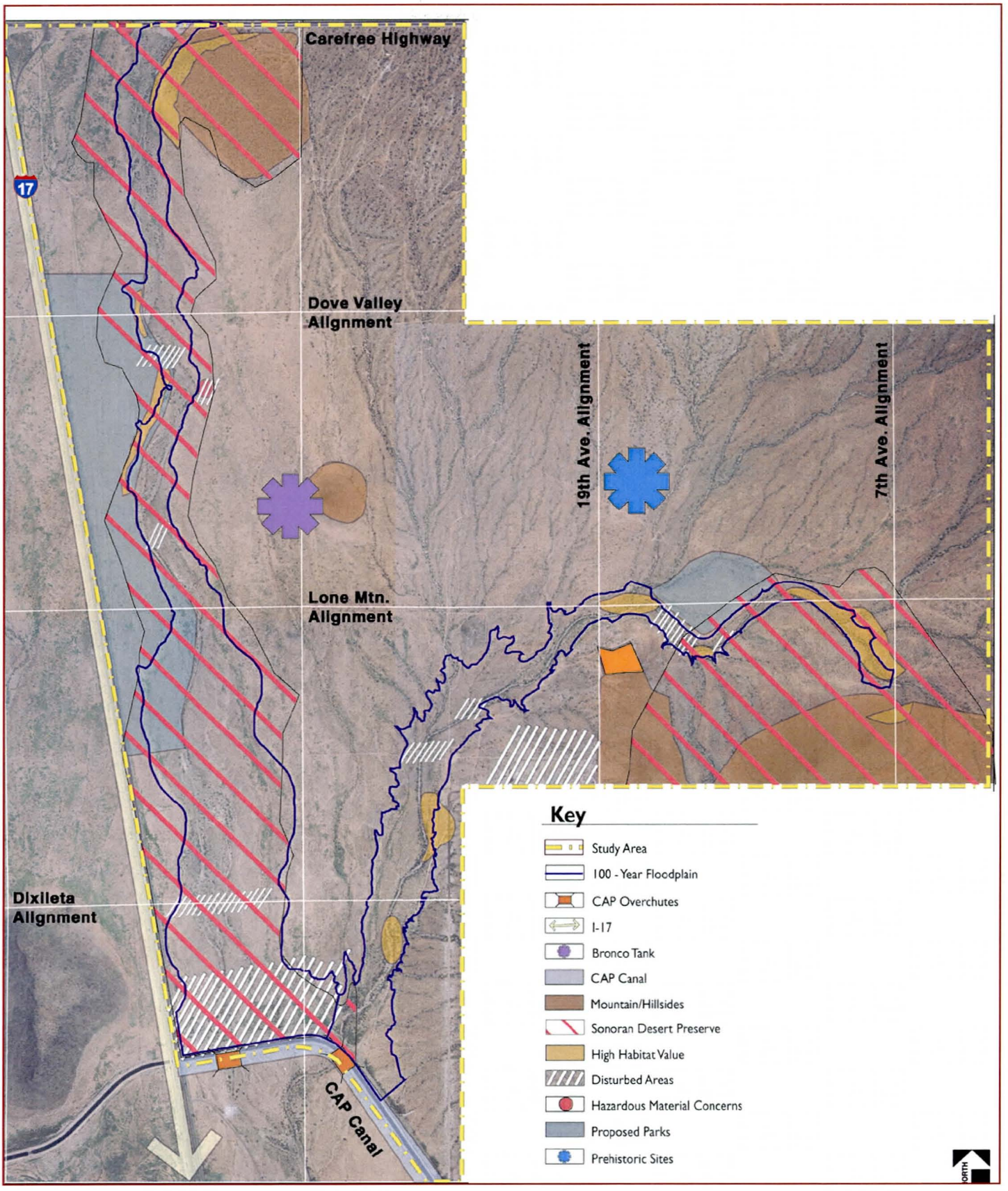



**Figure 10. Phase 1 Biological and Cultural Features**

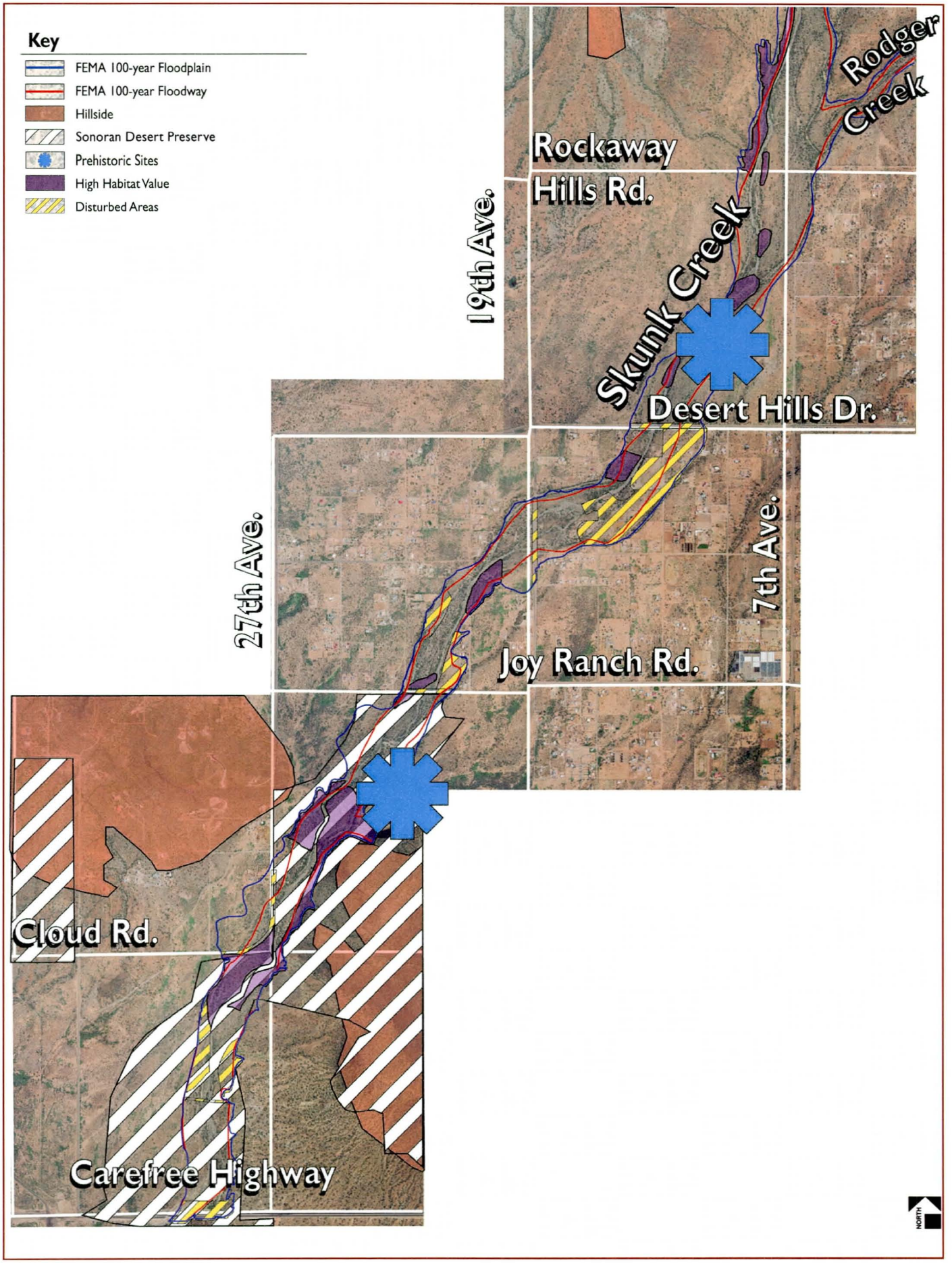



Figure 11. Phase 2 Biological and Cultural Features (South Half)

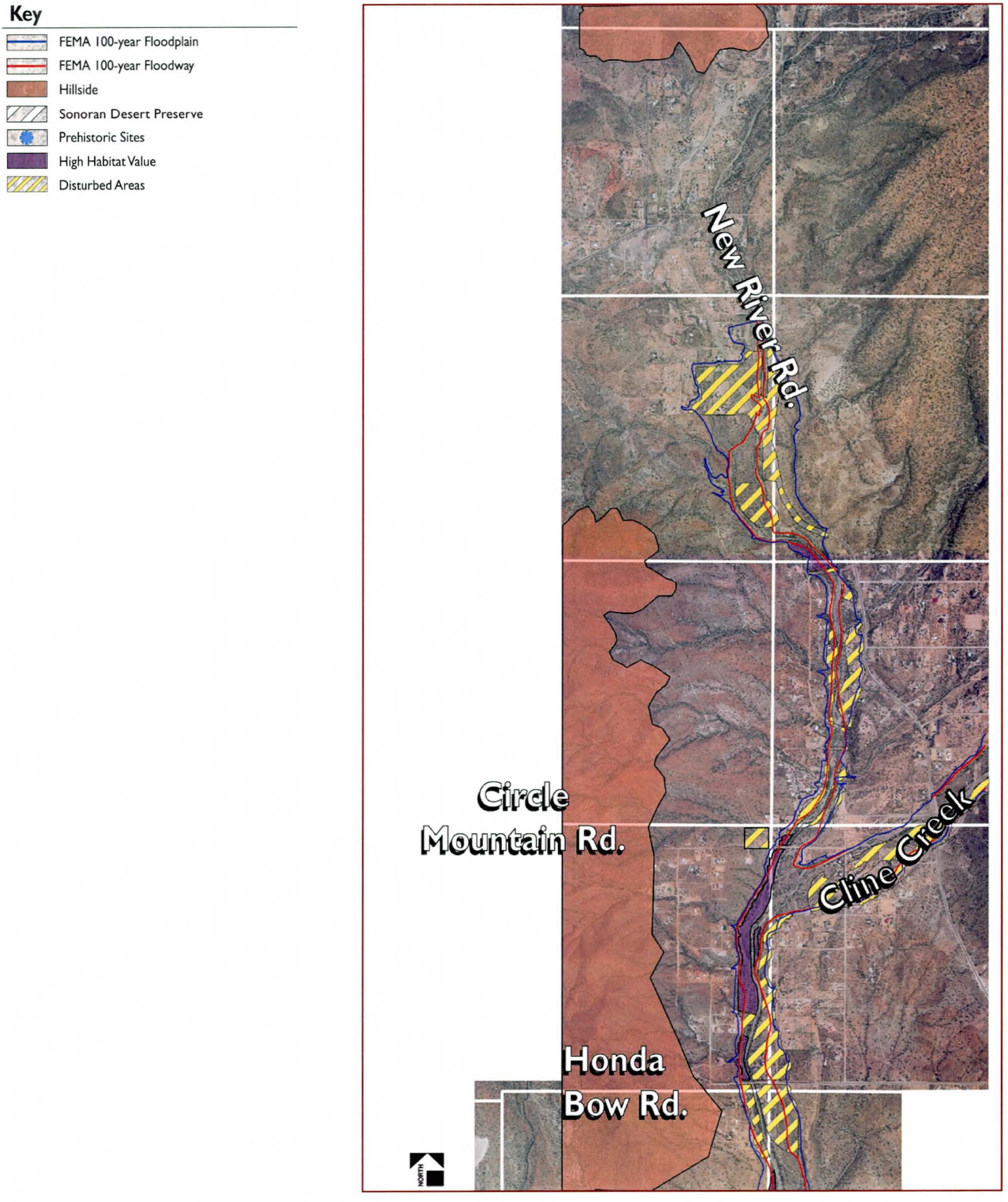
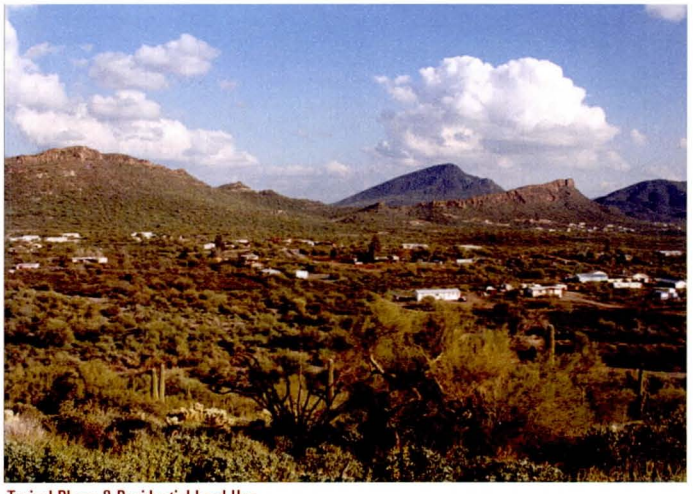



**Figure 12. Phase 2 Biological and Cultural Features (North Half)**

floodplain. Areas within the floodplain of Skunk Creek are included in areas slated for the Sonoran Desert Preserve as part of the Arizona Preserve Initiative (API). Those lands owned by the ASLD will be purchased with part of the bond funding provided for the plan; and private parcels will be purchased with other funds. Funding for the purchase of private lands will be provided in part by a bond that provides the COP Parks, Recreation and Library Department with five million dollars over five years.



Typical Phase 2 Desidential Land Use

Land use within the Phase 2 study area is primarily composed of vacant or undeveloped parcels and scattered low-density residential areas. Land within the study area is owned by either private ventures or held in State Trust. The majority of the study area falls under the jurisdiction of Maricopa County. A smaller portion on the southern end of the study area is under the jurisdiction of the COP.

Areas within the jurisdiction of the COP are described in the COP's General Plan (December 1999) as hillside, water, residential (2-5 du/ac), several areas of higher density residential (10+ du/ac), and commercial uses. Additionally, areas along Skunk Creek and on the hillsides east of the Tramonto development are designated as parts of the proposed Sonoran Desert Preserve.

Areas under the jurisdiction of Maricopa County are addressed in the New River Area Plan part of the Maricopa County 2020 Eye to the Future Comprehensive Plan. Planned land uses in the study area include rural residential (0-1.0 du/ac), large lot residential (1.0-2.0 du/ac), Development Master Planned communities (2.56 du/ac), and open space. The southern edge of the project is located in the Carefree Highway Scenic Corridor.

Future COP District Park Site

Planned recreation in the Phase 1 study area is covered in the North Black Canyon Corridor Plan prepared by the COP. In the plan, recreation uses include the Sonoran Desert Preserve, developed parks, and trails. A district park is proposed south of the Dove Valley Road alignment. The Sonoran Desert Preserve encompasses over 20,000 acres of hillside, washes and open desert. Skunk Creek is one of the major *watercourses* included in the Sonoran Desert Preserve. Three future access points, including parking, trails, picnicking, outdoor recreation and visitor services, will be located near the current study area. Additionally eight secondary access points with parking areas will be located near the study area. Bronco Butte serves as a landmark and waypoint. A trail from the planned commercial areas to the butte is anticipated.

Currently there are no proposed or planned active recreation sites or parks within the Phase 2 study area. The potential for passive recreation opportunities are extensive as the area is relatively undeveloped. Adjacent to the Maricopa County New River Planning Area are four established trail systems. The BLM operates the Emory Henderson Trail to the west of the New River Planning area. In the south,

the COP has a developed system of trails. An existing trail system is at Cave Creek Park, located east of the study area. Additionally the Tonto National Forest operates a trail system to the north. Trails and public access were identified in the New River Area Plan. A citizens group in 1998 identified trails that were widely used by equestrians, hikers, and recreational vehicles, as well as wildlife. A developed trail system would provide travel for both citizens and wildlife, and preserve the equestrian lifestyle of the area. In addition, a developed trail system in the New River area would also provide the opportunity to link together the already developed surrounding trail systems.

Typical Desert Riparian Vegetation along Skunk Creek

## D. Planning Influences

The planning influences shown on Figure 13 for Phase 1, and Figures 14 and 15 for Phase 2, illustrate the primary factors that should be considered during the development of floodplain management alternatives. The proposed Sonoran Desert Preserve lands would limit development and its associated infrastructure requirements immediately adjacent to and through the *watercourses* in the southern portion of the study area. Opportunities to incorporate multi-use trails along the *watercourses* in accordance with Maricopa County's New River Area Plan, the COP's General Plan, and Sonoran Desert Preserve goals should be considered, and minimally not excluded, from any proposed flood control facilities. In addition, any flood control facilities visible from any road crossing or overlook should be designed to minimize visual contrast with the surround landscape in terms of color, scale and texture. Preservation areas include the proposed Sonoran Desert Preserve lands, and areas of high habitat, inherent scenic quality, and cultural resource (both historic and prehistoric) value. Areas are also noted where the landscape would benefit from restoration of disturbed vegetation and/or landforms.

# 6 Watercourse Technical Characteristics

Detailed technical analyses were performed as a basis for development of the WCMP. Existing watershed and *watercourse conditions* were compared with anticipated future watershed and *watercourse conditions* for the purpose of planning, not just for build-out in the watershed, but for the transition between existing and future conditions. The technical analyses performed are based on key assumptions regarding the management of the watershed. Successful implementation of the WCMP is therefore contingent upon management of the watershed in accordance with those assumptions.

The District plans to coordinate with communities in the WCMP study area to implement the appropriate watershed planning components. This is done as a part of the District's Area Drainage Master Study (ADMS) and Area Drainage Master Plan (ADMP) processes. An ADMP is planned for the Skunk Creek watershed upstream of Adobe Dam to address the watershed issues. The key assumptions made for this study regarding management of the watershed are that land managers will:

- Implement the COP and Maricopa County's 100-year, 2-hour retention ordinance requirement for zoning classifications with densities greater than 1 unit per acre.
- Preserve the natural *watercourse* system wherever possible. An ADMP for the watershed

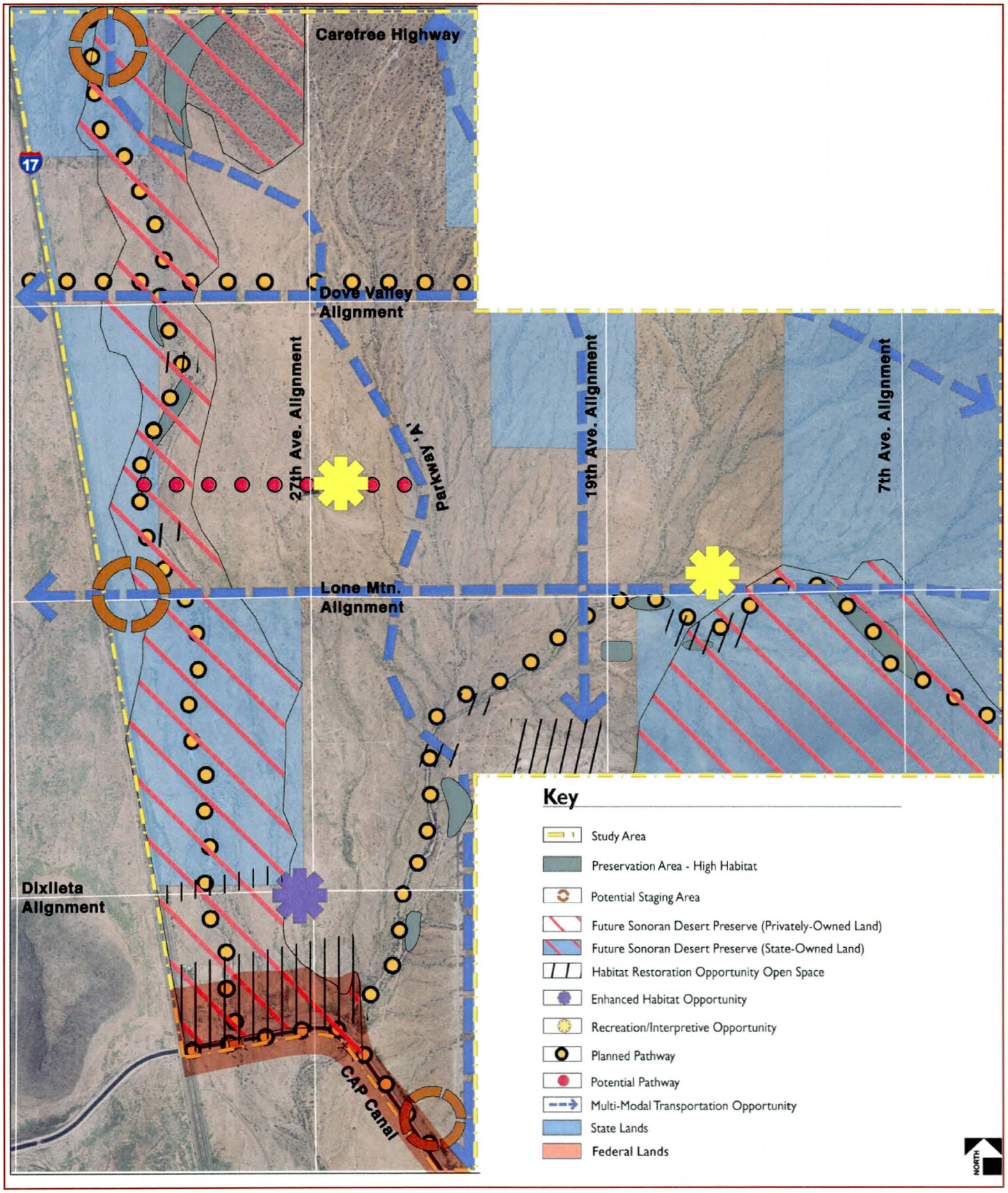



**Figure 13. Phase 1 Planning Influences**

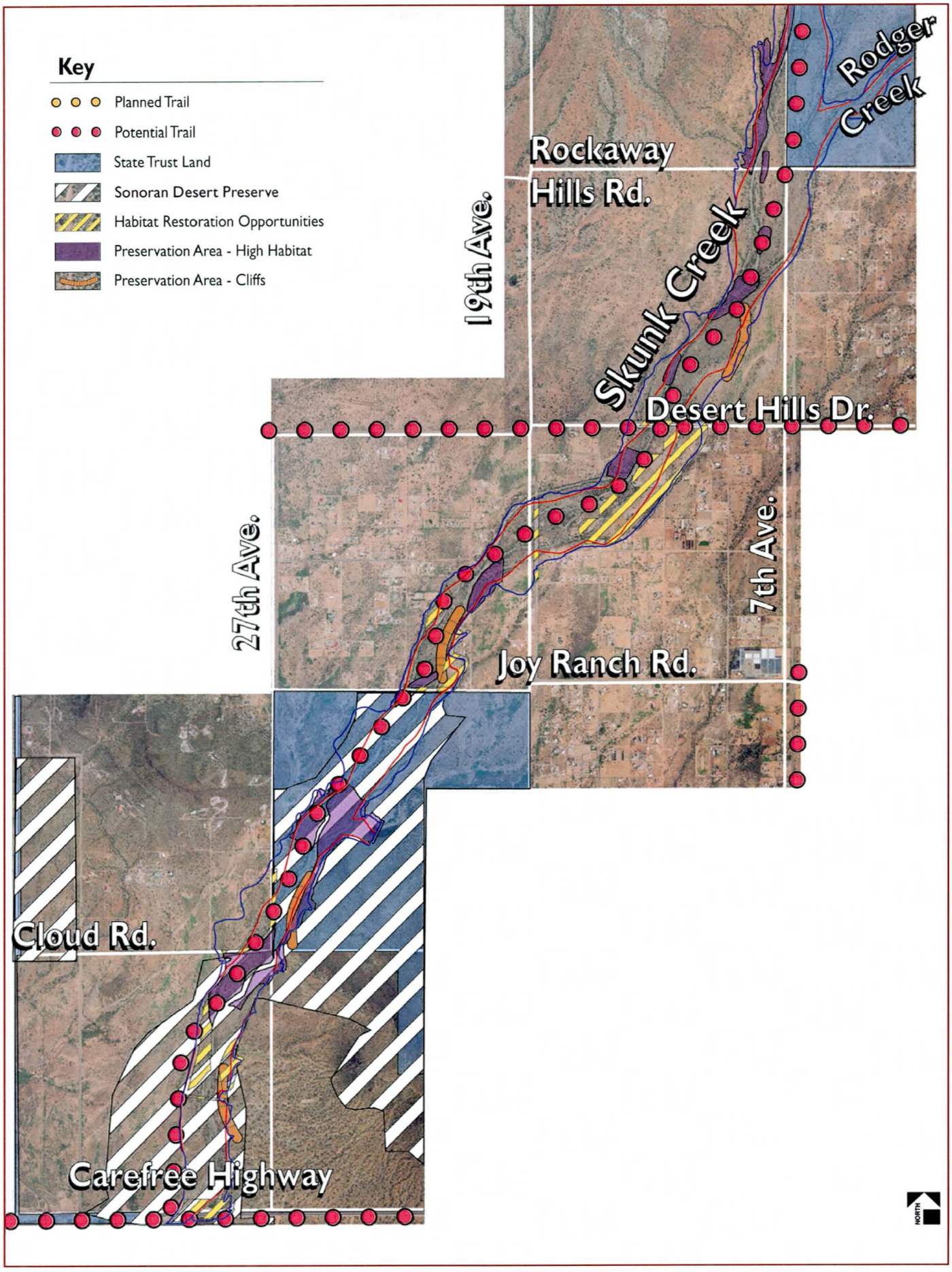



Figure 14. Phase 2 Planning Influences (South Half)

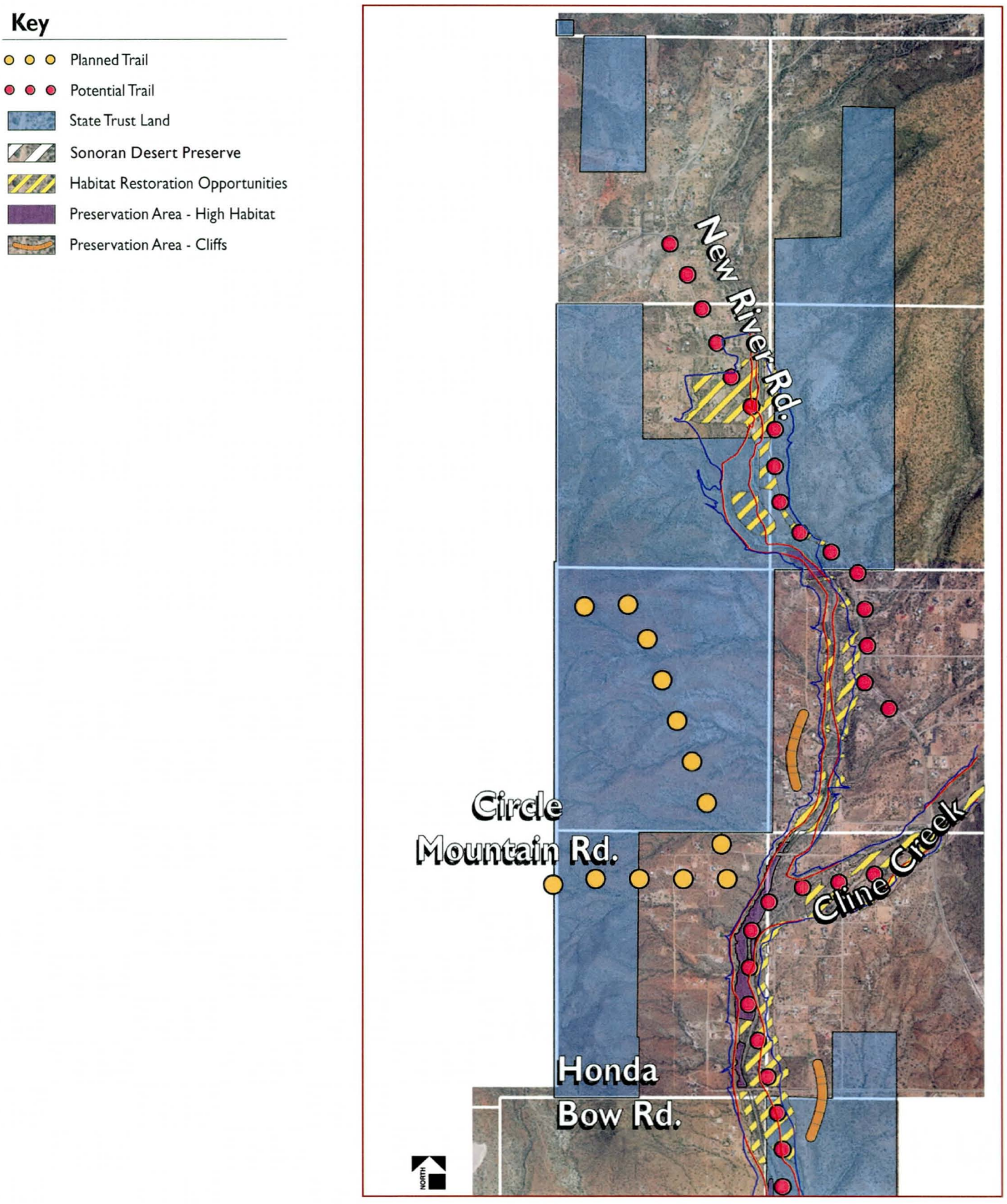



**Figure 15. Phase 2 Planning Influences (North Half)**

should quantify the *watercourses* to be preserved. If channelization or floodplain encroachment becomes necessary, travel times through the watershed should match existing natural conditions as closely as possible.

- Sediment loads in the natural *watercourse* system should not increase or decrease significantly as a result of development or other human disturbances in the watershed. Where significant changes may result, appropriate mitigation measures must be implemented to maintain long-term *watercourse* stability.

- Maintain peak discharges for the 2-year, 10-year and *100-year storms* at or below the future watershed condition levels estimated in the WCMP.

- Maintain the release of future condition runoff volumes to the *watercourses* from the 2-year, 10-year and *100-year storms* as close as possible to the WCMP estimated existing watershed condition runoff volumes. This approach is necessary to help meet the goal of minimizing changes to *sediment yield*, and to support natural riparian vegetation along the *watercourses*.

- Implement the North Black Canyon Corridor Plan and the MAG 1995 General Land Use Plan for the watershed.

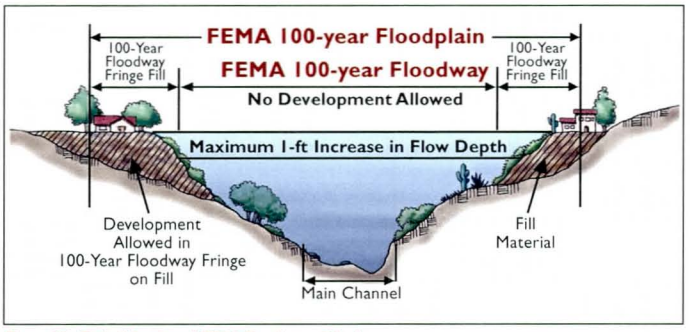


Figure 16: Typical Section of FEMA Regulatory Criteria

The WCMP considers the natural processes of *erosion*, *sedimentation* and *channel* migration. These processes are major safety concerns that current FEMA regulations, as illustrated in Figure 16, do not adequately address. The *channel* bottom may erode or fill as a result of flooding. If it erodes, *channel* banks may become unstable and collapse. If the *channel* bottom fills through *sedimentation*, the floodplain can widen, potentially damaging property and structures and endangering lives. Therefore, the WCMP must consider the natural movement of the *watercourse*. In addition, *watercourses* need a riparian corridor in which to function naturally. Because the *watercourse* constantly changes over time, as shown in Figure 17, the WCMP incorporates a riparian corridor to help protect adjacent property from the impacts of these natural processes. Understanding *erosion*, *sedimentation*, and *channel* migration and identifying appropriate methods to analyze these processes are critical to creating viable alternatives for managing the *watercourses*. Technical considerations relating to this understanding are described in following sections.

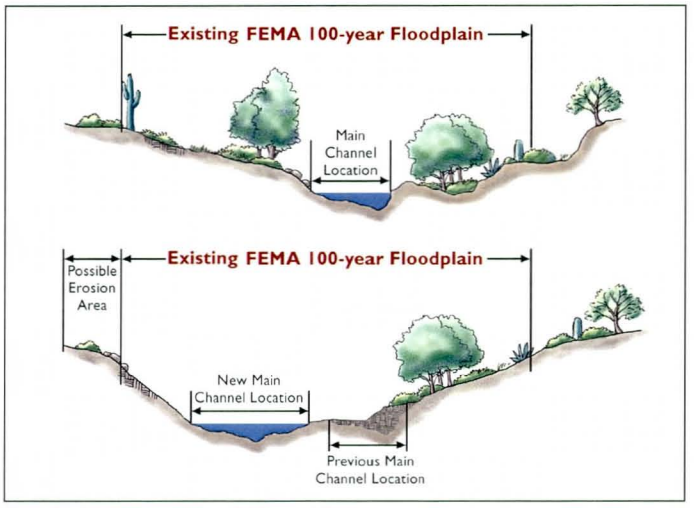


Figure 17: Cross Section of Potential Channel Migration

## A. Hydrology

*Hydrology* is a very important consideration because it is used to define the link between the watershed and the *watercourse*. The other technical considerations such as *hydraulics*, sediment transport modeling and lateral migration analyses are applied specifically to the *watercourse*. Those considerations rely on input from hydrology to define how the *watercourse* will respond to changes occurring in the watershed. The hydrologic analyses con-

ducted as a part of this study include hydrology for existing and future *watershed conditions* for the 2-, 10- and 100-year *recurrence interval* storms for Skunk Creek and Sonoran Wash. The hydrology models are used for testing the alternative *watercourse* management plans to determine their effects on public safety. This is done by testing for *cumulative impacts*. The hydrology models are also used to estimate the available time for warning residents residing within the *FEMA 100-year floodway* and floodplain of an impending flood. Refer to Figure 18 for a map illustrating the watersheds of Skunk Creek and Sonoran Wash.

Skunk Creek Overchute at CAP Canal

## B. Hydraulics, Erosion and Sedimentation

Hydraulics, *erosion* and *sedimentation* information are needed for understanding the physical aspects of how *watercourses* function in the study area. Hydraulic and *sedimentation* models were created and then used as two of the engineering techniques for estimating the potential for *lateral channel migration* as well as for other purposes. The models were also used to test the *watercourse* management alternatives.

*Computer models* developed for the current FEMA 100-year floodplain delineation study were used as a basis for hydraulic modeling of the study *watercourses*. The FEMA computer models were adjusted for the purposes of this study, and then modified to simulate estimated future watershed conditions. The results of these computer models were used to provide base input data for the sediment transport models, as well as to identify water surface elevations, provide hydraulic data for *scour* computations and potential lateral migration analyses, and provide a baseline for testing management alternatives.

During the development of the hydraulic modeling for the WCMP, it was found that a breakout occurs at the CAP Canal and I-17. The breakout results from a backwater caused by limited hydraulic capacity of the Skunk Creek and Sonoran Wash overchutes at the CAP Canal. This breakout results in stormwater being diverted west over I-17, and the CAP Canal overchutes being overwhelmed by discharges from floods more frequent than the 100-year event. This breakout has the potential to flood existing residences that were previously thought safe, and residences currently under construction. The overwhelming of the overchutes could result in failure of the CAP Canal embankments. The estimated peak discharge over I-17 during the *100-year storm* is 6,400 cfs, or about 23 percent of the total flow in Skunk Creek. The estimated average flow depth over I-17 during the 100-year event is 2.5 feet.

A breakout situation was also identified near the north limit of the study area upstream of the New River Road Bridge. The breakout peak flow rate over the west bank during the 100-year flood is estimated to range from 4,000 cfs to 4,500 cfs; over one-half of the total peak flow rate of 7,800 cfs. This breakout threatens several existing residences in the area.

*Erosion* and *sedimentation* analyses were performed for the Skunk Creek and Sonoran Wash *watercourses*. The components of the *erosion* and *sedimentation* analyses include estimating *erosion* or *sedimentation* in the *watercourses* during floods, and estimating the potential impacts of *erosion* and *sedimentation* on the structural components proposed for the WCMP alternatives. These components include existing and proposed structures, such as bank protection, *channel* grade-control structures, and bridges.

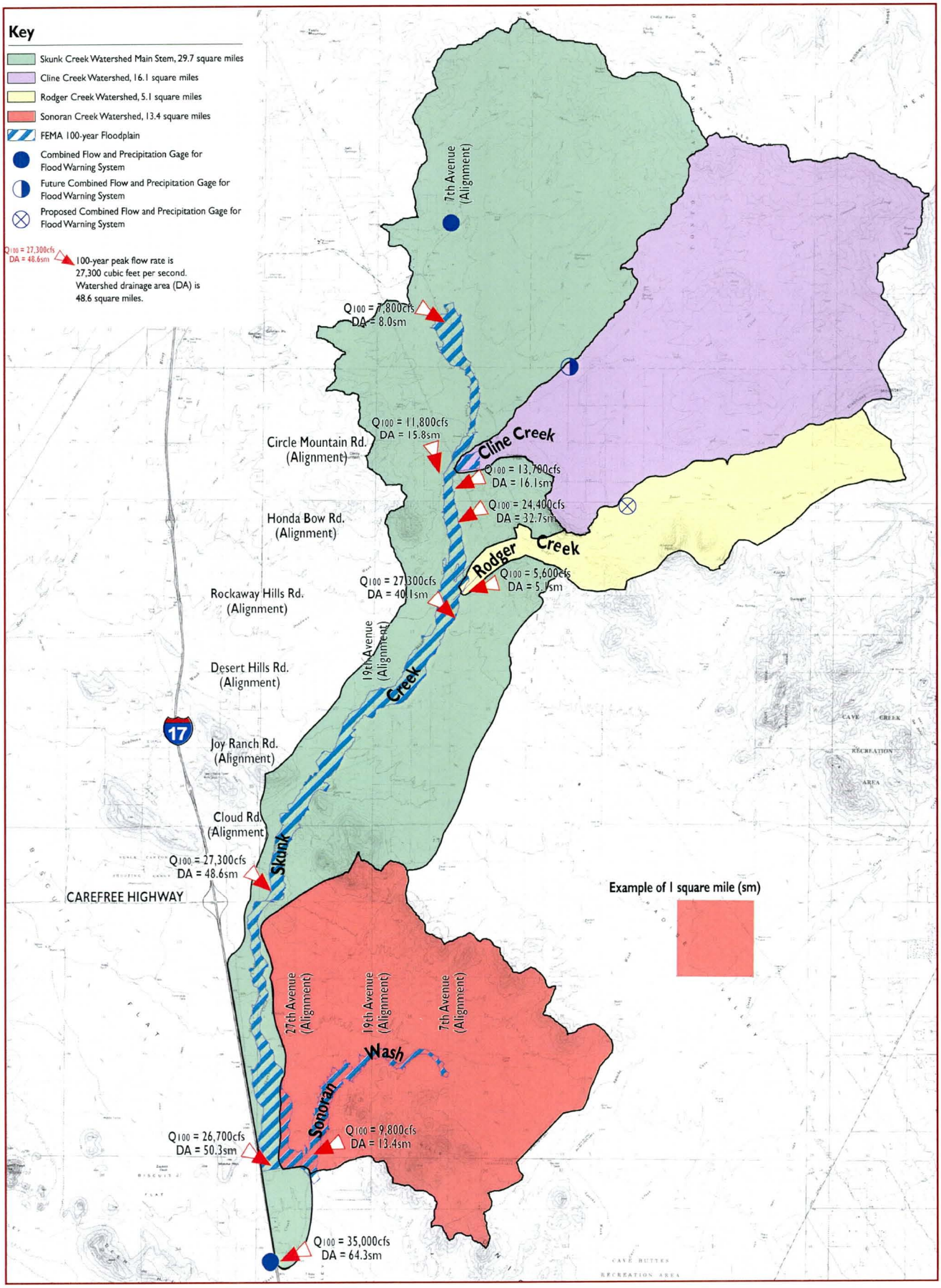
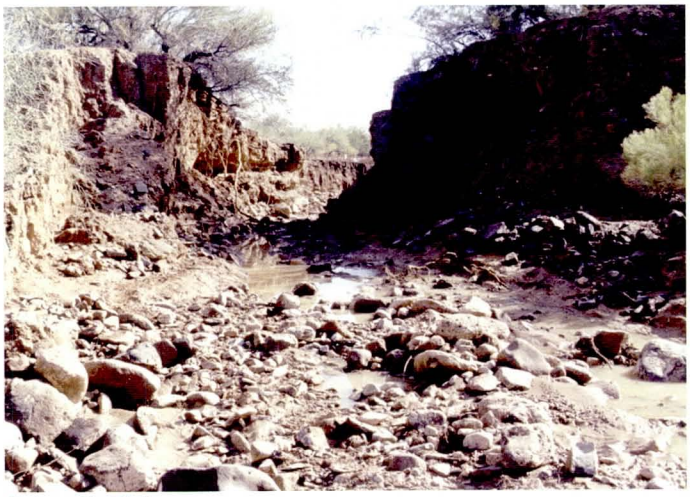



**Figure 18. Watershed Map**

Eroding Bank in Skunk Creek

The U.S. Army Corps of Engineers HEC-6 *computer model* was used to estimate the *erosion* and *sedimentation* trends and magnitudes of the study *watercourses* for the 10- and 100-year floods for Skunk Creek, and the 25- and 100-year floods for Sonoran Wash. The HEC-6 models address *channel* bed vertical movement. *Main channel erosion* and *channel* migration were interpreted from those results. Review of the modeling results provides insight into the range of general scour or deposition that can be expected to occur during a single flood, in individual reaches of each *watercourse*. Results of the computer modeling analysis indicate that Skunk Creek could experience general scour as much as 2 feet, or deposition of up to 4 feet during a major flood such as a 100-year event. The results for Sonoran Wash indicate general scour could be as much as 1 foot and deposition as much as 1 foot, during a 100-year flood. The *erosion* and *sedimentation* analyses also included scour analysis computations. *Scour* computations were used to determine the maximum potential scour and, hence, the depth for designing the structural components of the various WCMP alternative management plans considered.



Erosion at Skunk Tank

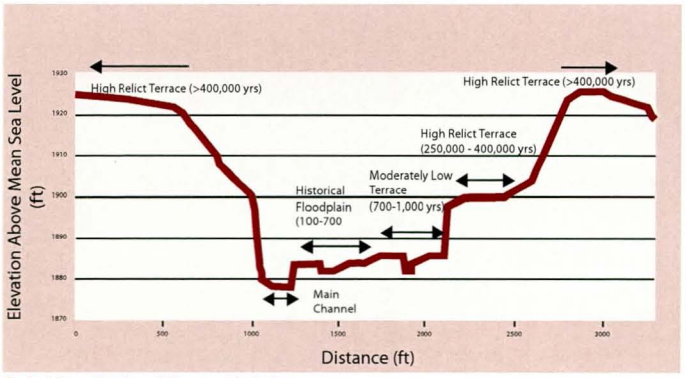
## C. Lateral Stability Analysis

The potential for lateral *channel* migration was extensively evaluated for the Skunk Creek and Sonoran Wash *watercourses*. The components for this evaluation included a review of the study area characteristics, historical analyses, geomorphic analyses, and engineering analyses. The results of the lateral stability analyses were used to delineate *erosion* hazard zones.

The stability of the Skunk Creek and Sonoran Wash systems is directly affected by several characteristics of the study area. Understanding the watershed characteristics, regional geologic setting, hydrologic inputs, and stream classification is fundamental for explaining past stream behavior, for predicting future river processes, and for selecting appropriate tools for analysis of the stream behavior. These fundamental data represent the most important independent variables that control lateral migration.

A basic assumption of any geologic analysis is that "understanding the past, as preserved in the geologic record, is the key to understanding the future" (NRC, 1996). In the case of the WCMP historic analyses, this means that to predict the potential future lateral migration, past river behavior must be thoroughly understood. Historical information illustrates the types of *channel* changes that have occurred in the study area during the past, and suggests the types of *channel* change that can be expected in the future. The data sources used to obtain this understanding included published summaries of the archaeological record, published descriptions of regional geology, historical maps and aerial photographs, *channel* descriptions from historical General Land Office (GLO) surveys, and field evidence of past *channel* and floodplain changes.

The geomorphic analyses used in this study evaluate the topography of the *watercourses* and the adjacent terrain in order to estimate past and future *channel* movement. These estimates were then used to define the land area subject to *erosion* and required by the *watercourse* to preserve its natural function. The three basic geomorphic analyses undertaken were application of field assessment techniques, preparation of geomorphic mapping, and application of geomorphic assessment techniques.



Typical Cross Section of Geomorphic Surfaces

The geomorphic analysis techniques employed used field observations, interpretation of the surface geology, and application of empirical and theoretical data to evaluate the lateral stability of Skunk Creek and Sonoran Wash. Field observations made in the study area indicate that the study reaches are subject to lateral *erosion*, *channel avulsions*, scour, and have experienced some historical *channel degradation*. Evidence of human impacts is minimal. Observations made along Sonoran Wash indicate that it is more laterally stable than Skunk Creek. Field data suggest that the frequency of *channel avulsions* on Skunk Creek is greater than on Sonoran Wash.

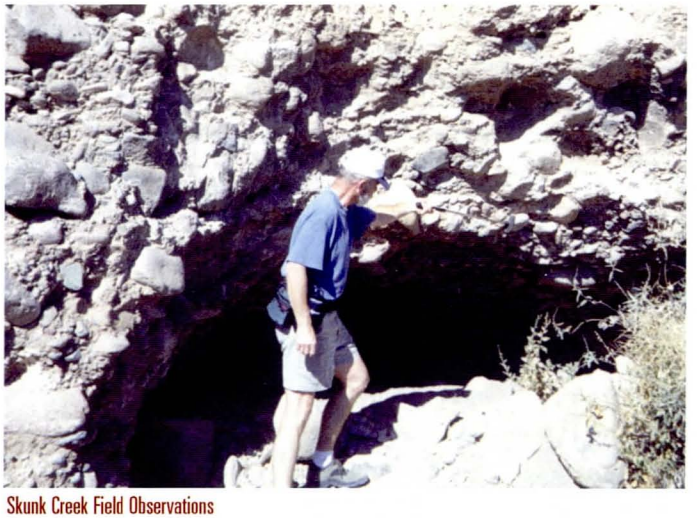
The engineering approaches used for lateral stability assessment were focused on estimating the potential for, and magnitude of, future bank *erosion*. The approaches used were based on the following: hydraulic data, sediment data, and engineering methodologies. The specific engineering methodologies used to assess lateral stability indicate that Skunk Creek and Sonoran Wash are subject to bank *erosion* during floods and both *watercourses* will experience scour and slope adjustments over time.

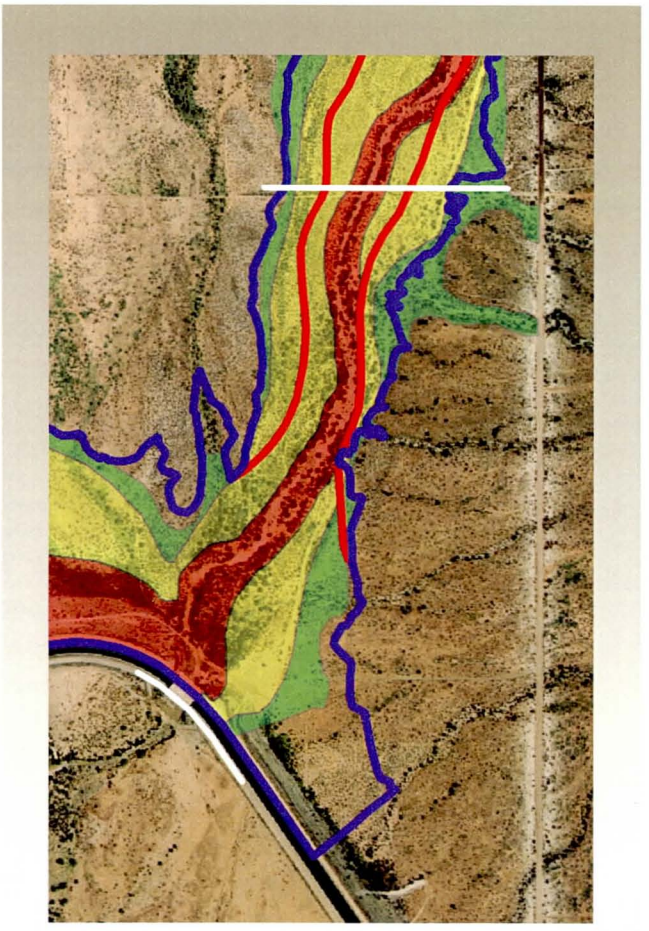
## D. Erosion Hazard Zones

The results of the hydrology, hydraulics, *erosion*, *sedimentation* and lateral stability analyses indicate that there is a potential public safety hazard resulting from *erosion* and *channel* migration in the study *watercourses*. Therefore, three *erosion* hazard zones were developed to help prepare the *watercourse* management alternatives. The severe *erosion*, lateral migration and long-term *erosion* hazard zones are shown on Figures 19 through 33 and are described below:

***Severe Erosion Hazard Zone***. The Severe *Erosion* Hazard Zone is comprised of the active *watercourse channels* and adjacent areas likely to be eroded during a single major event, such as the 100-year flood. The Severe *Erosion* Hazard Zone is also comprised of the area likely to be removed if the bank angle were to be reduced to the *natural angle of repose*.

***Lateral Migration Erosion Hazard Zone***. The Lateral Migration *Erosion* Hazard Zone consists of the area adjacent to the main *channel* likely to be eroded by a "typical" series of floods over a 60-year planning period, plus the *erosion* that could be caused by a single major event such as the 100-year flood. The Lateral Migration *Erosion* Hazard Zone


Skunk Creek Field Observations



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long-Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

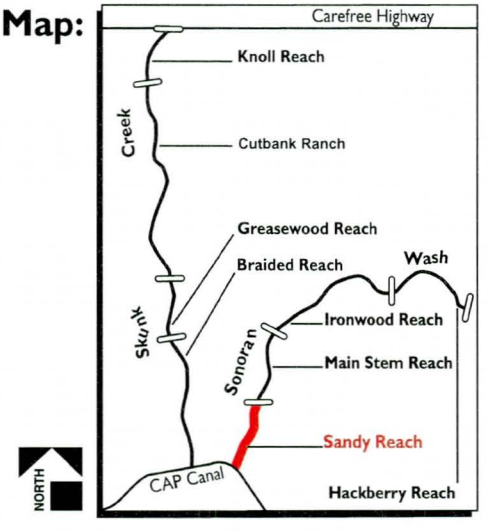
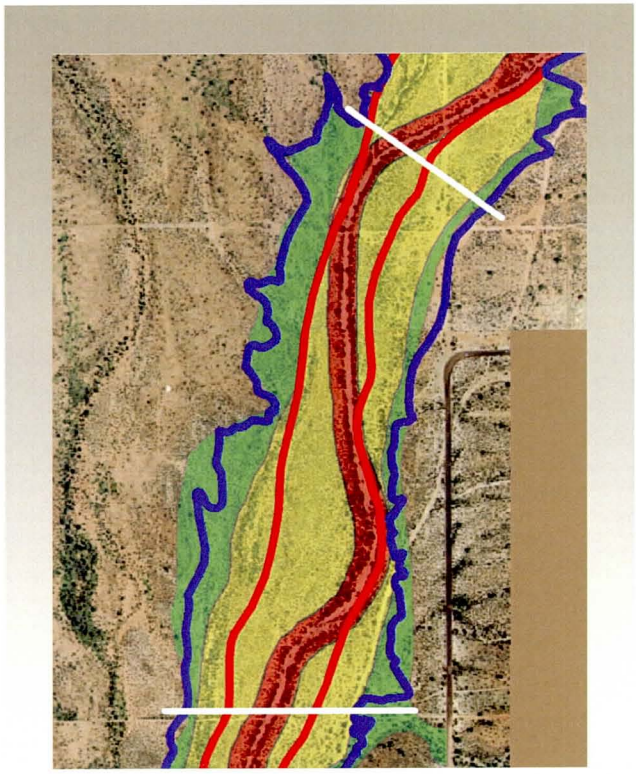



**Figure 19. Sonoran Wash - Sandy Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 1 Key Map:**

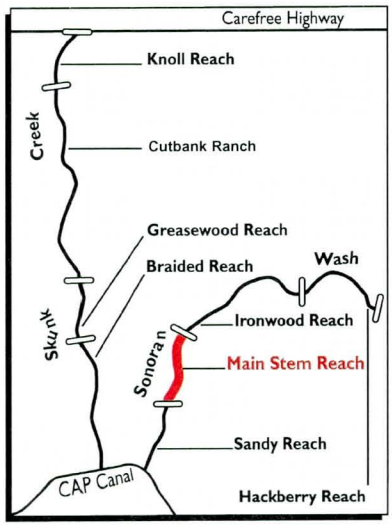
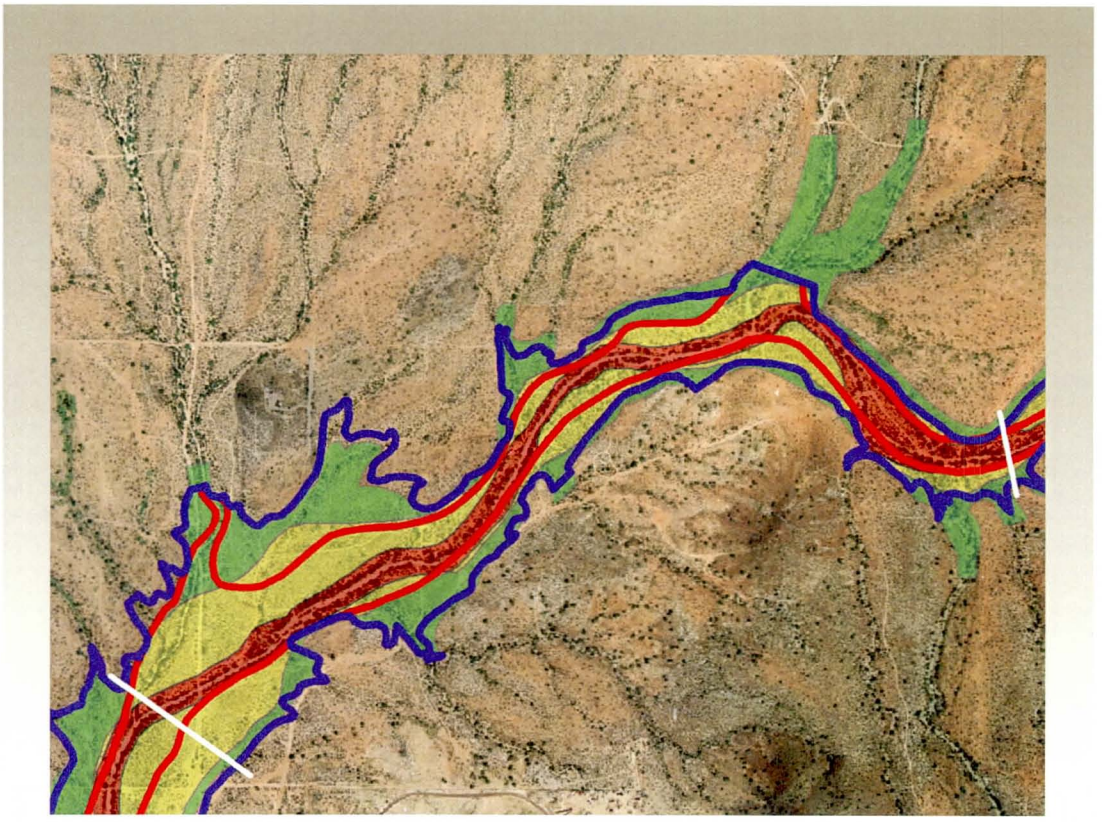



**Figure 20. Sonoran Wash - Main Stem Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

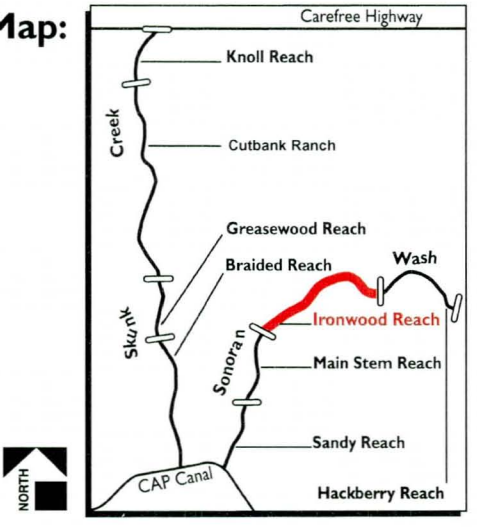
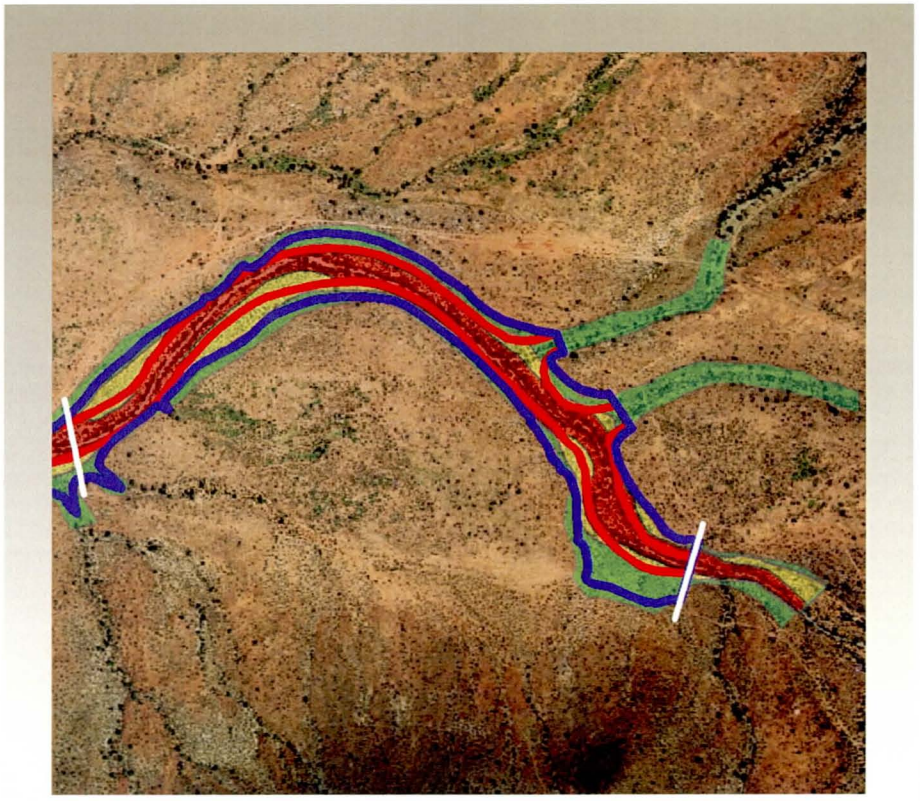



**Figure 21. Sonoran Wash - Ironwood Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

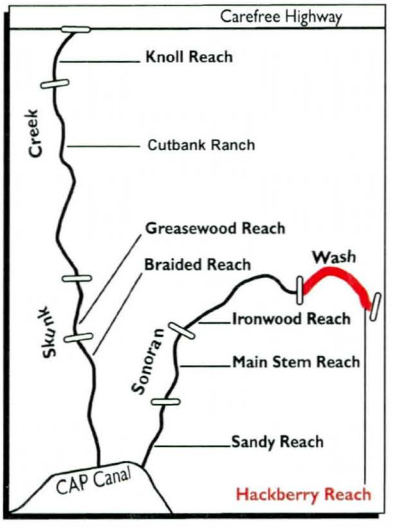
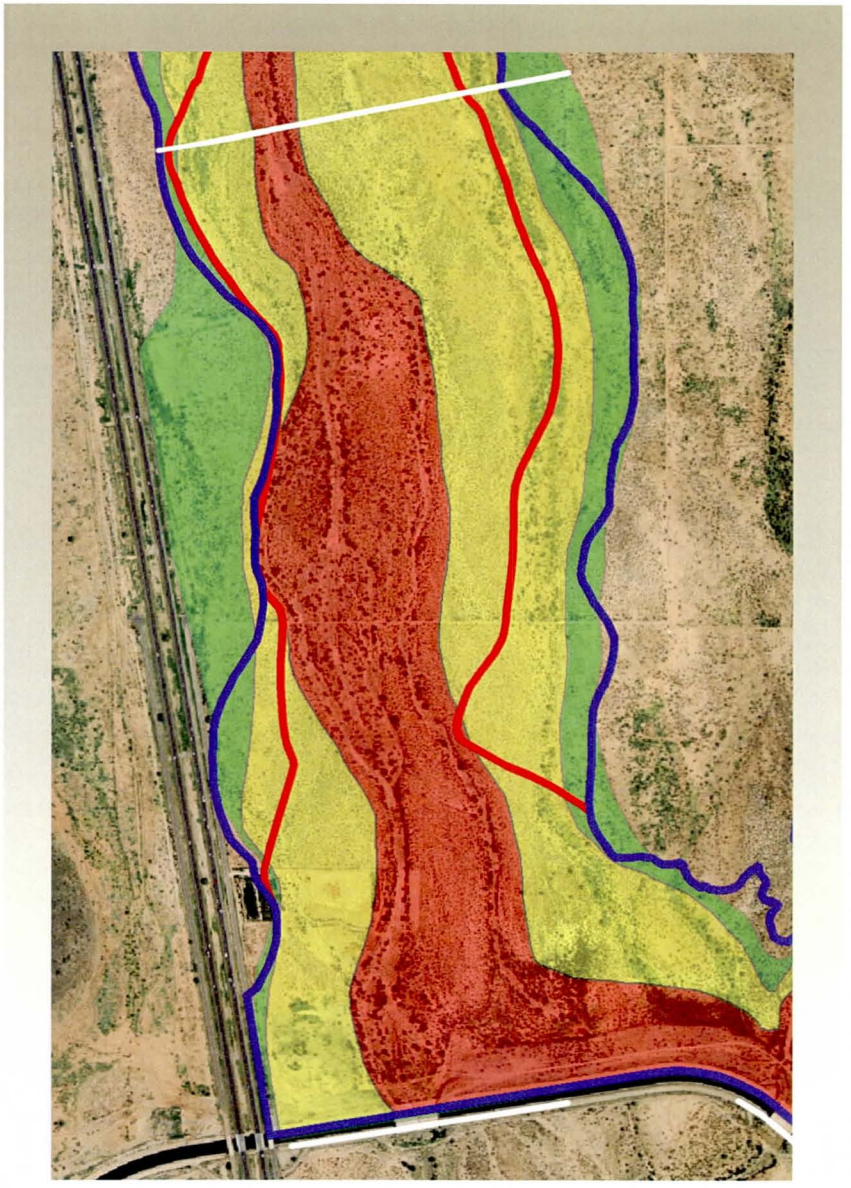



**Figure 22. Sonoran Wash - Hackberry Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

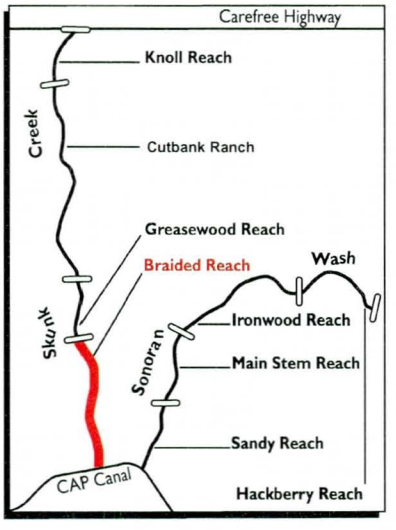
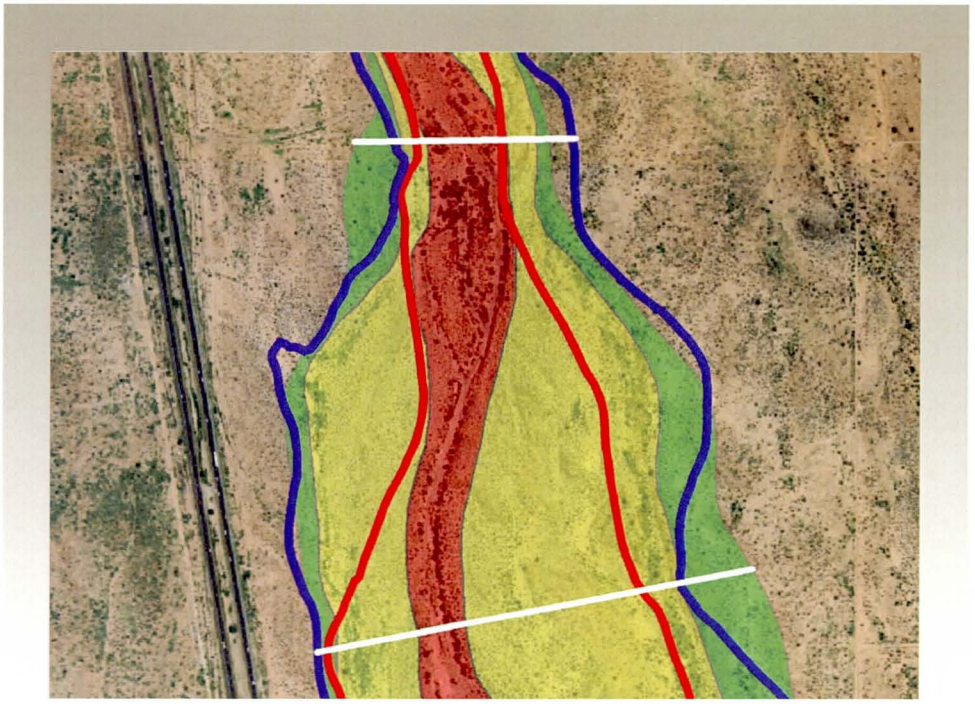



**Figure 23. Skunk Creek - Braided Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

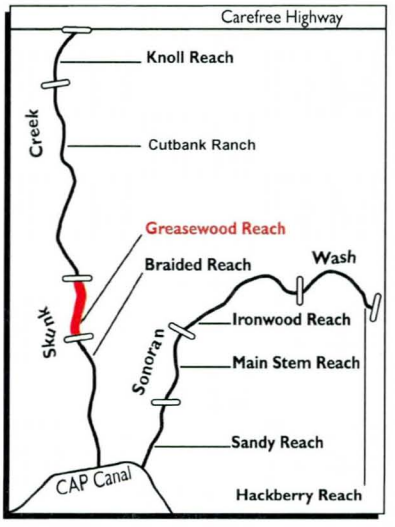
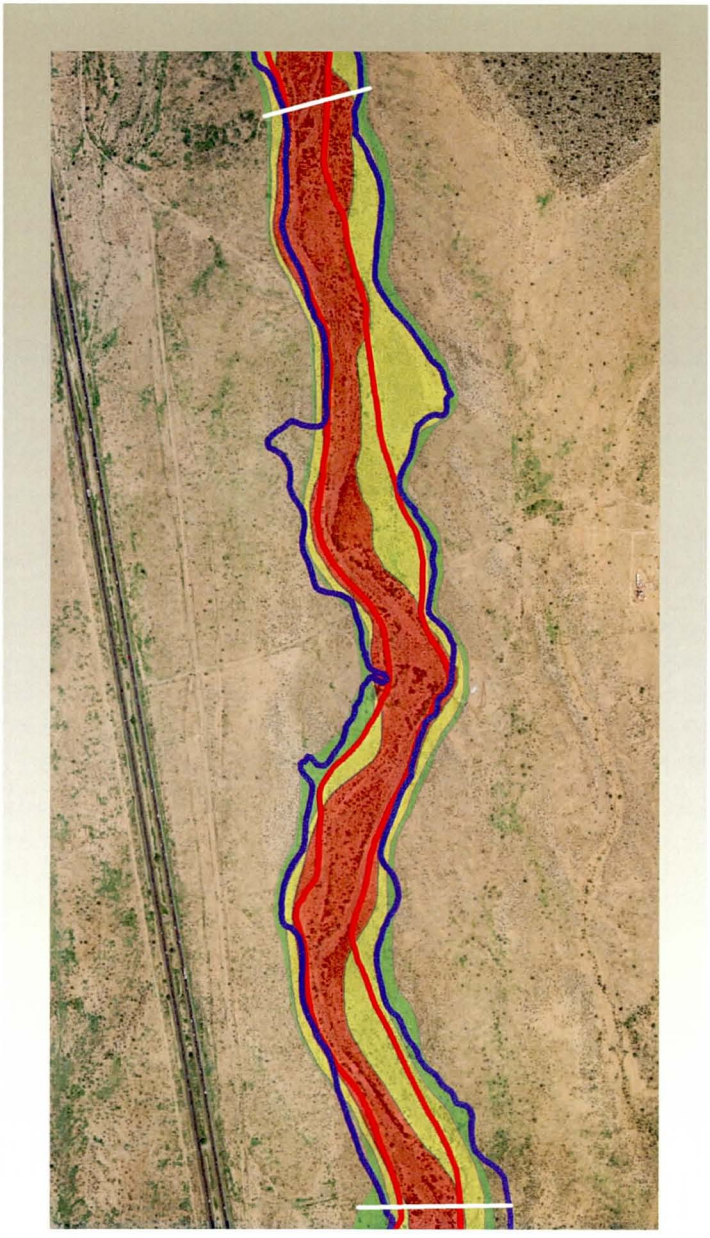



**Figure 24. Skunk Creek - Greasewood Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

## Phase I Key Map:

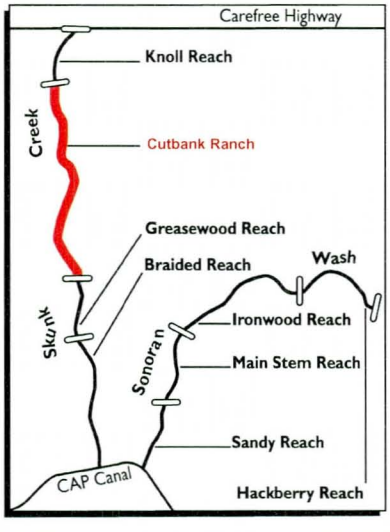
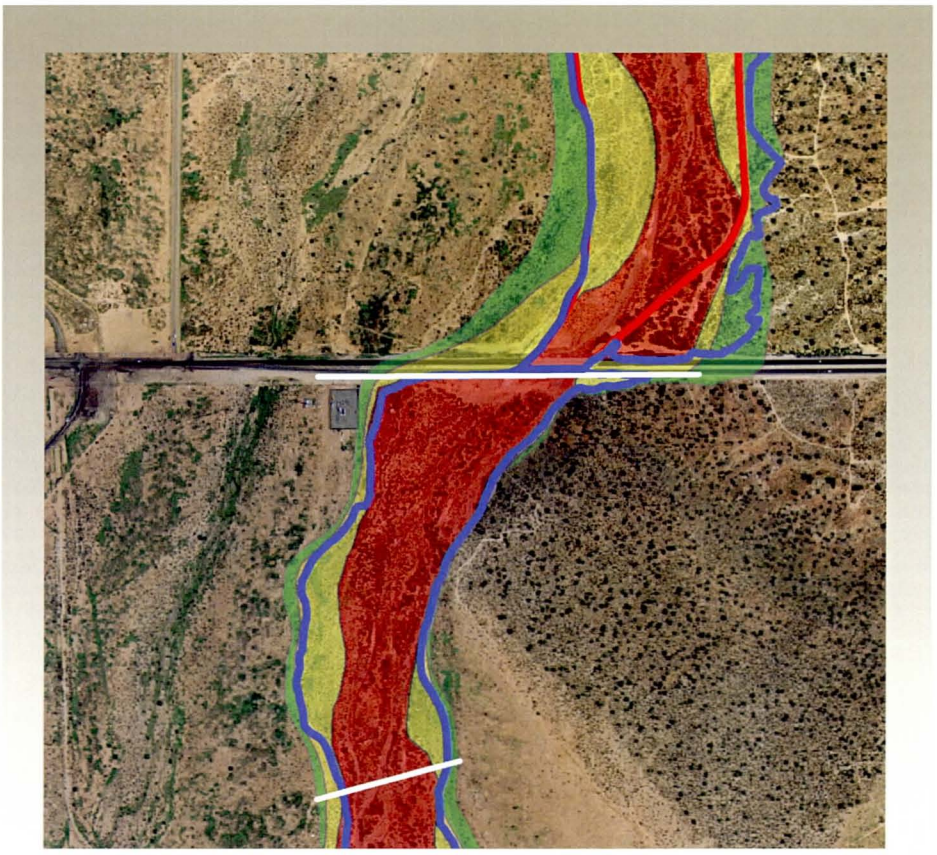



**Figure 25. Skunk Creek - Cutbank Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase I Key Map:**

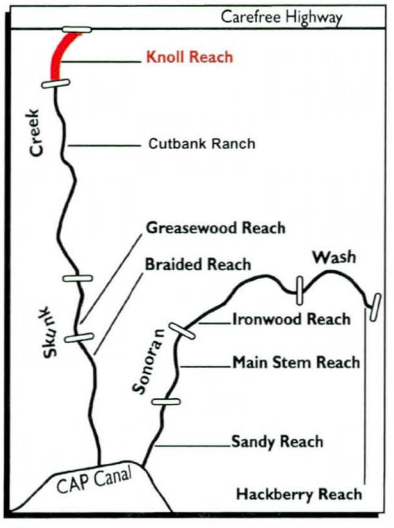
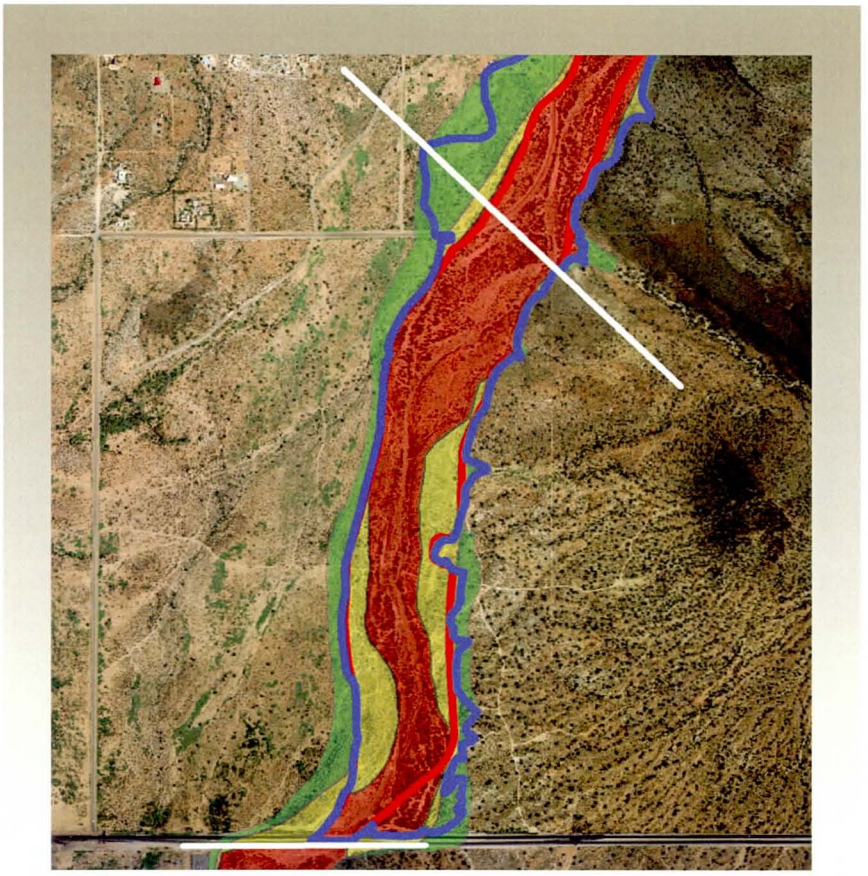



**Figure 26. Skunk Creek - Knoll Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

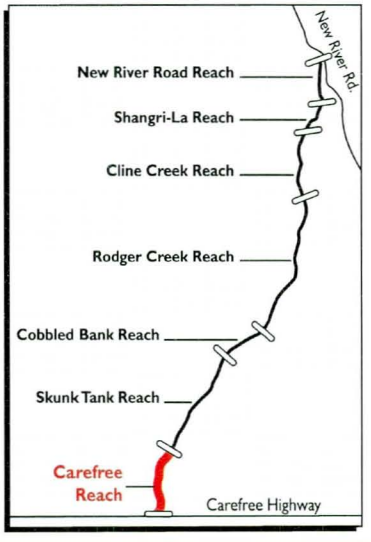
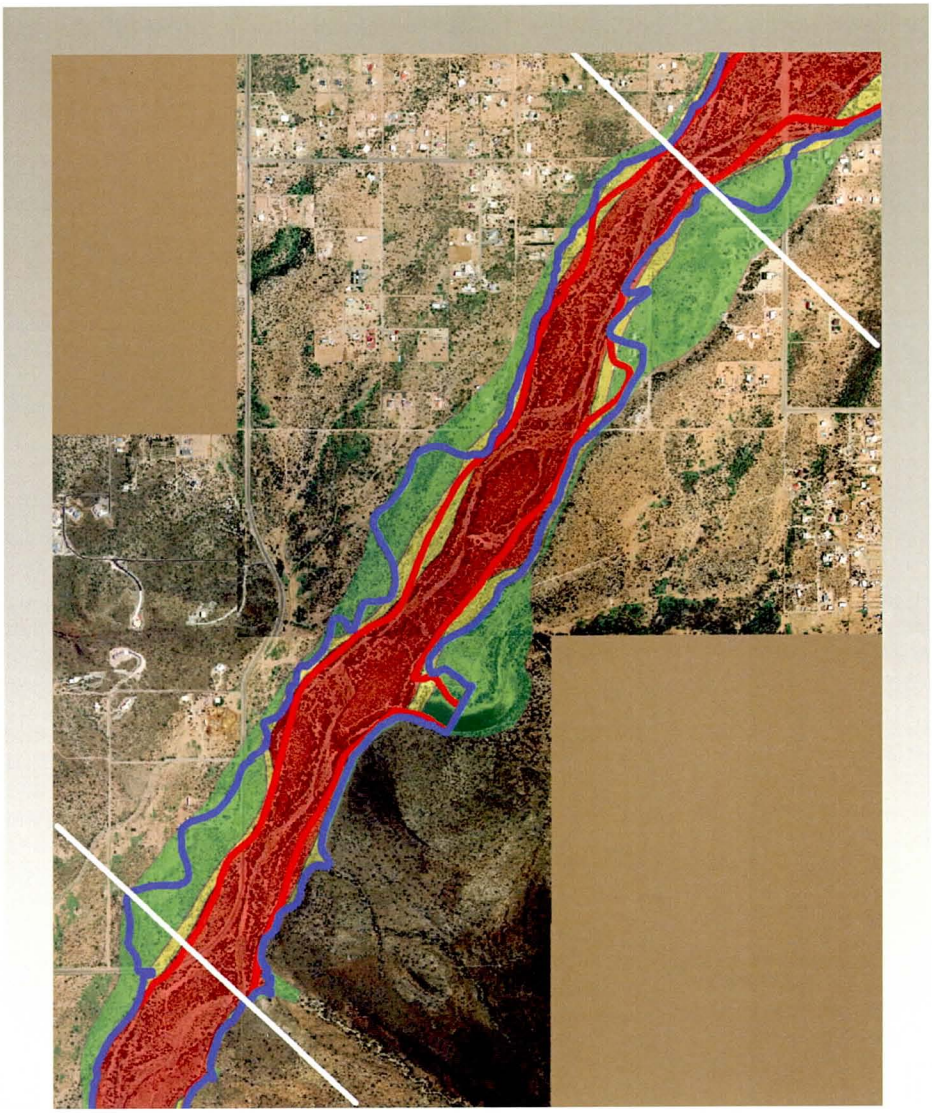



**Figure 27. Skunk Creek - Carefree Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

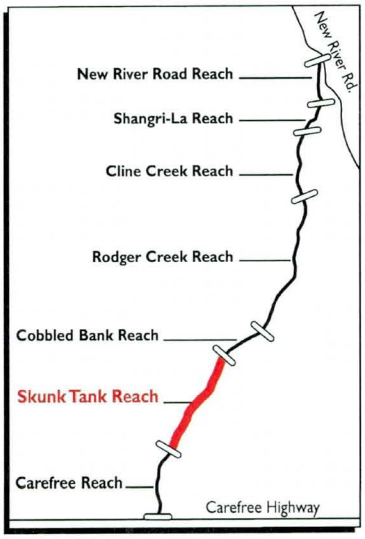
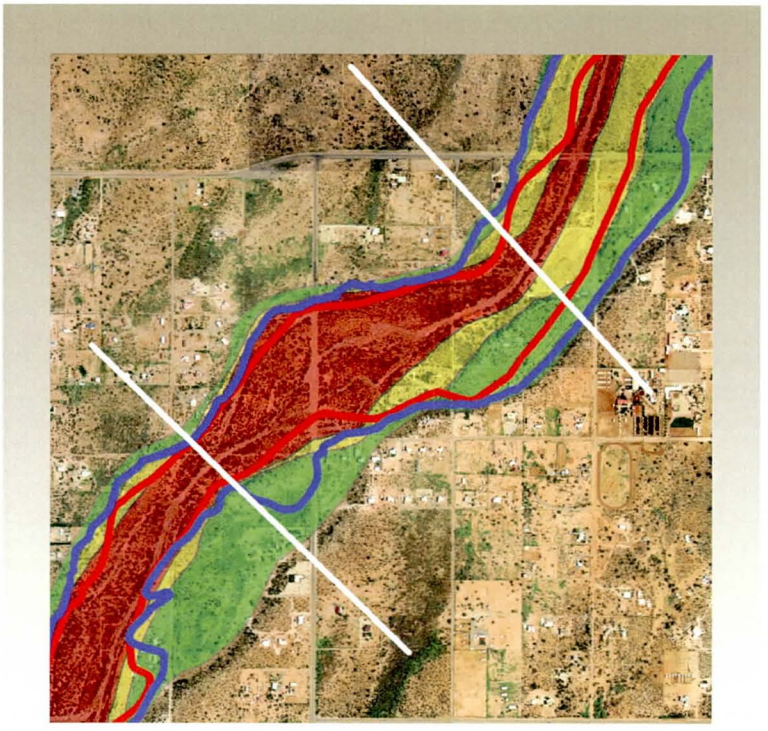



**Figure 28. Skunk Creek - Skunk Tank Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

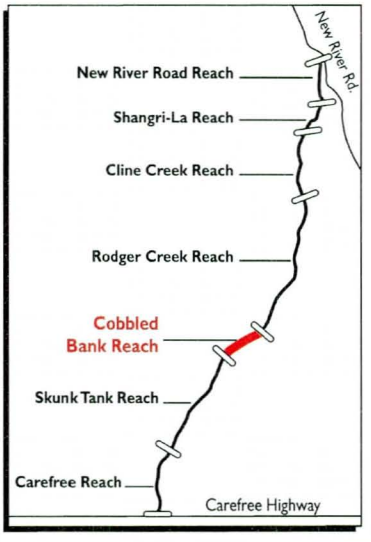
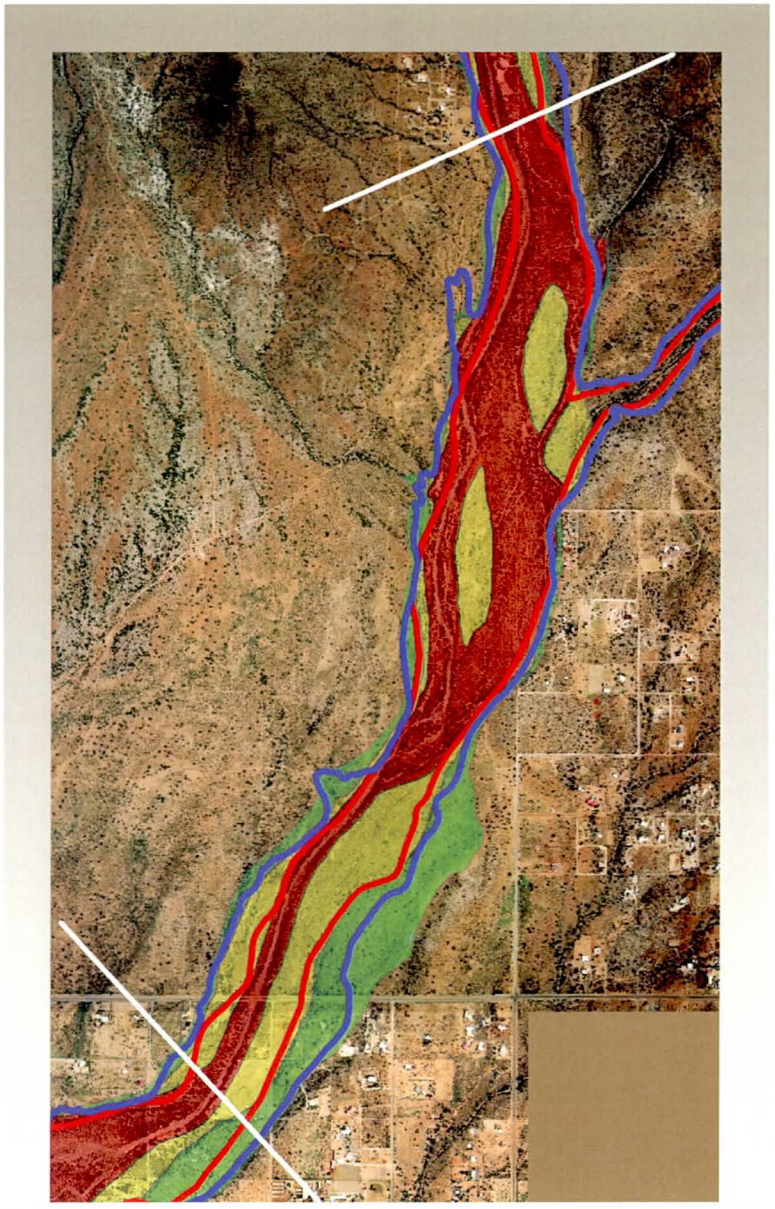



**Figure 29. Skunk Creek - Cobbled Bank Reach Erosion Hazard Zones**

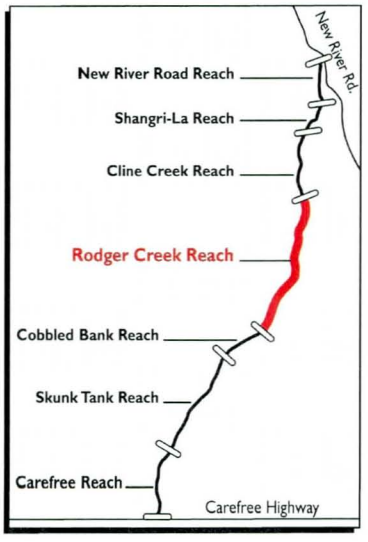


July 1999 Aerial Photograph

## Key

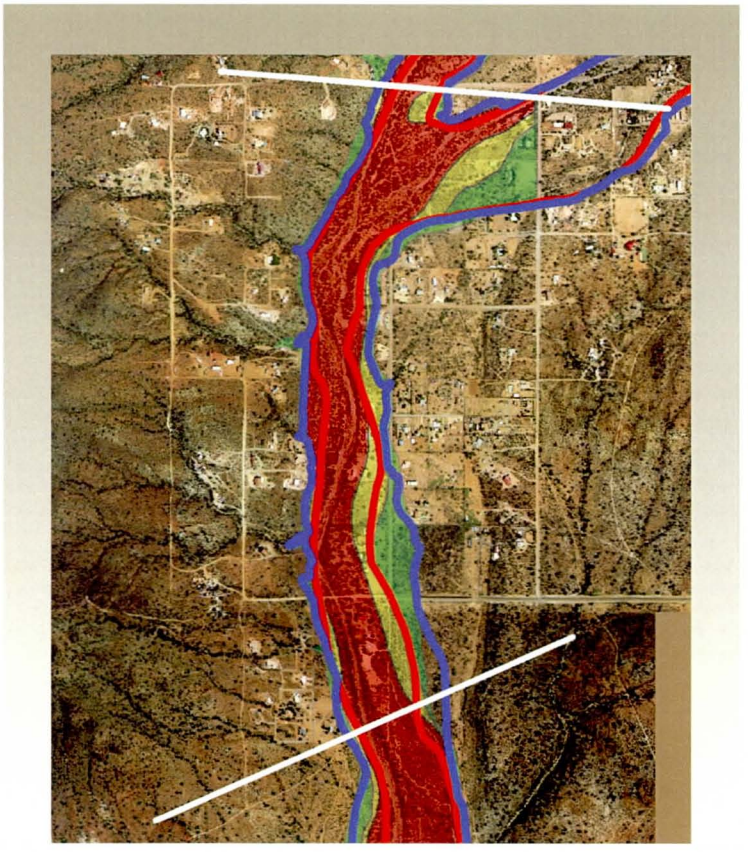
- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**




NORTH

**Figure 30. Skunk Creek – Rodger Creek Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

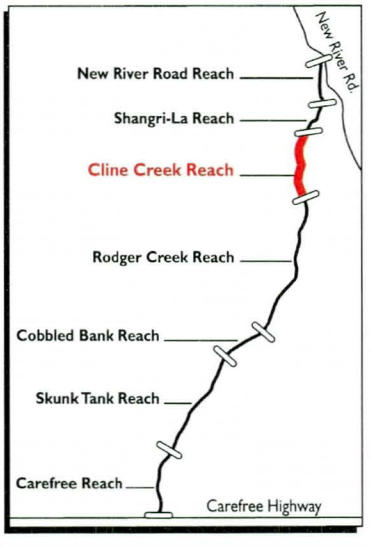
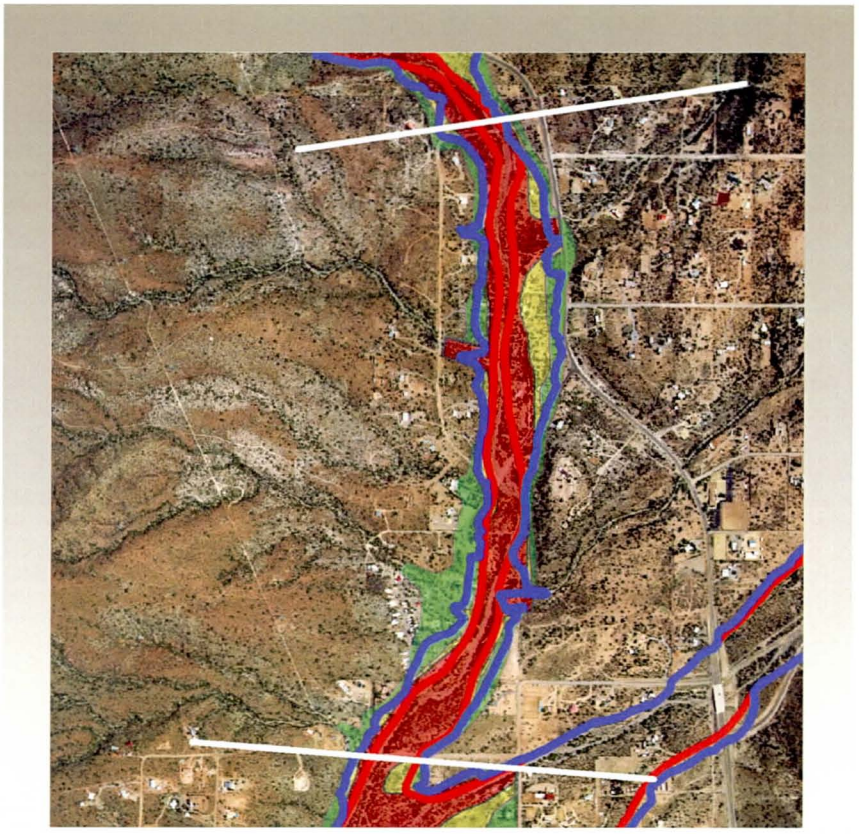



**Figure 31. Skunk Creek - Cline Creek Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

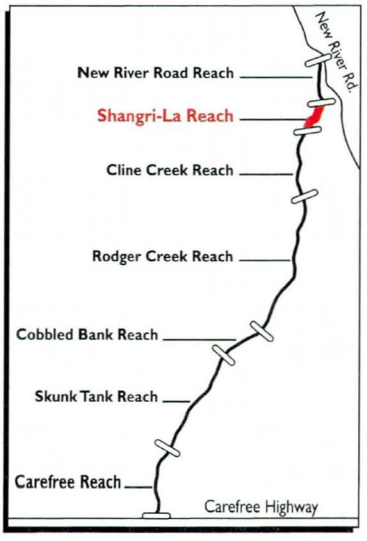
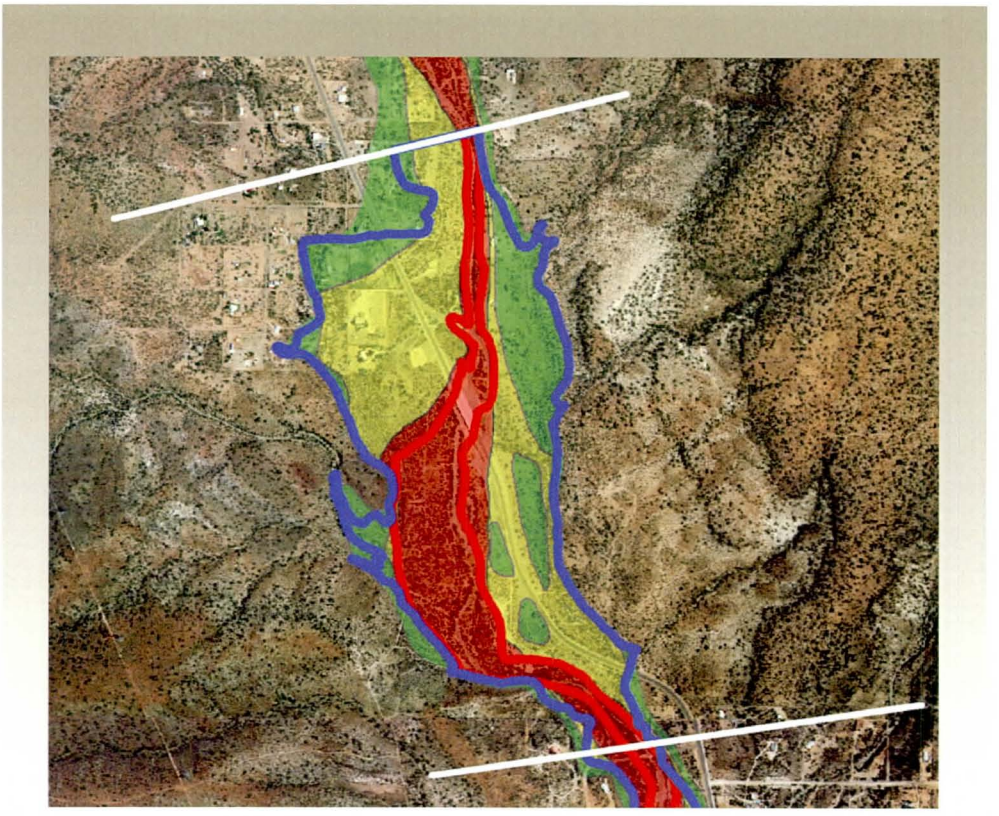



**Figure 32. Skunk Creek – Shangri La Reach Erosion Hazard Zones**



July 1999 Aerial Photograph

## Key

- Severe Erosion Hazard Zone
- Lateral Migration Erosion Hazard Zone
- Long Term Erosion Hazard Zone
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Reach Boundary

**Phase 2 Key Map:**

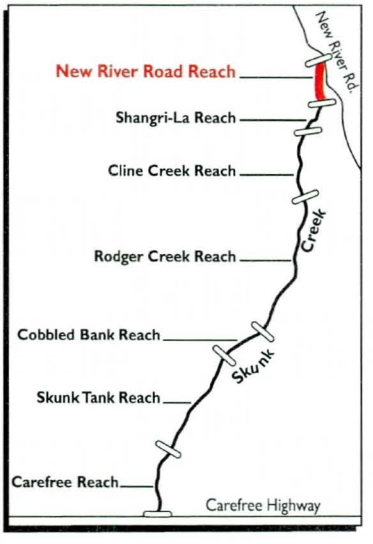



**Figure 33. Skunk Creek - New River Road Reach Erosion Hazard Zones**

also includes the natural *channel* movement due to geomorphic processes such as meander migration or *channel avulsion*.

The limits of the Lateral Migration *Erosion* Hazard Zone were widened in reaches where the field assessment indicated a high potential for future *erosion*, where evidence of ongoing *erosion* was observed, and in reaches where accelerated *erosion* was expected due to *channel* bends or over-steep banks. In general, the Lateral Migration *Erosion* Hazard Zone included areas outside, but adjacent to, the active *channels* of Skunk Creek and Sonoran Wash.

***Long-Term Erosion Hazard Zone***. The Long-Term *Erosion* Hazard Zone consists of the area defined by geologic evidence of *channel* movement over the past 60- to 1,000-years, and represents expected or potential *channel* movement over the same period in the future. Portions of areas mapped as older geomorphic surfaces, but adjacent to active *channels* and floodplains, were generally included in the Long-Term *Erosion* Hazard Zone.

Sank Creek Road-Closure at Desert Hills Drive

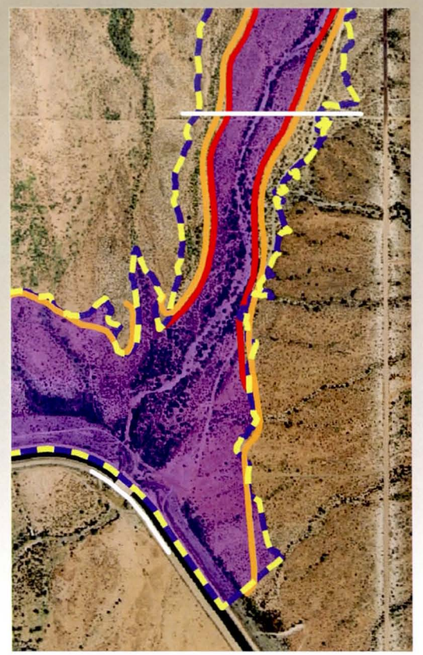
# 7 Alternatives Development and Evaluation

The purpose of the alternatives analysis is to formulate and evaluate a range of plans for providing flood and *erosion* control, determine the costs and benefits of each, identify opportunities for nonstructural solutions, and to recommend a preferred *watercourse* management alternative for regulating the study *watercourses*. It is anticipated that some structural control measures may be necessary in a nonstructural solution; however, the objective is to minimize their use. Full-structural and nonstructural alternatives for flood control management are developed and evaluated to meet the goals of the WCMP. For the purposes of this study, a structural measure is one that includes construction of flood protection facilities and/or maintenance activities that result in ground disturbance. Structural solutions include engineered bank protection, channelization, grade-controls, and bio-remediation or bio-engineering such as re-vegetation activities.

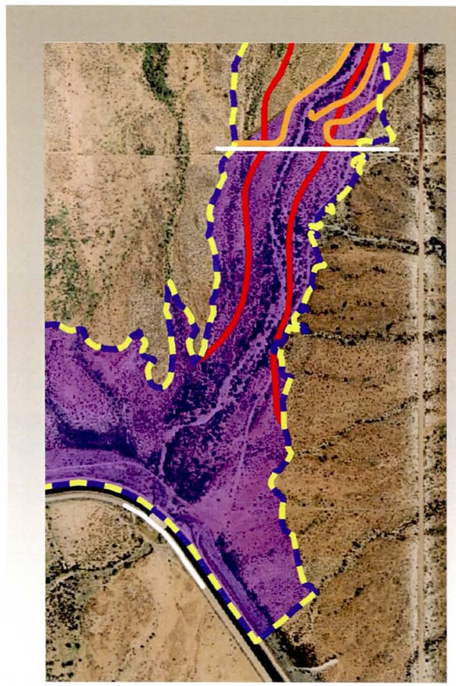
Limits of allowable encroachment within the regulatory area of each *watercourse* in the study area were defined for each alternative. The type and extent of structural features needed to allow the proposed encroachment were then identified. *Scour* analyses were conducted on the necessary structural features to determine design parameters. Conceptual designs were developed with the structural quantities, costs, benefits, and habitat impacts defined. Criteria and procedures were developed to evaluate the alternatives, and recommendations for implementation are made accordingly. The proposed *non-encroachment area* limits are shown by reach for each alternative on Figures 34 through 48. Typical sections for the alternatives are shown on Figures 49 and 50.

## A. Phase 1 and Phase 2 Full-Structural Alternative

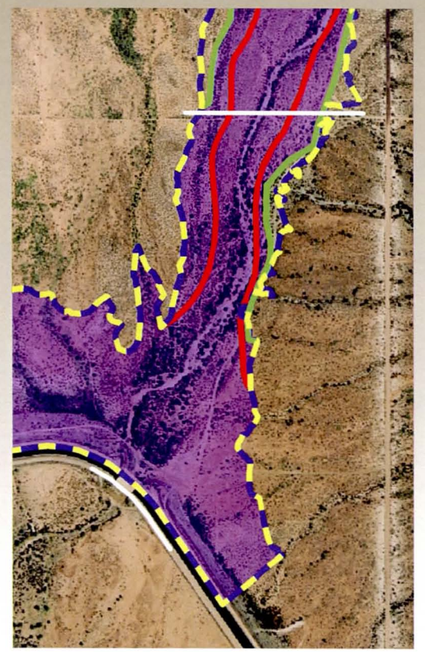
The Full-Structural Alternative reflects the traditional approach to floodplain management that allows encroachment to the regulatory floodway, as defined



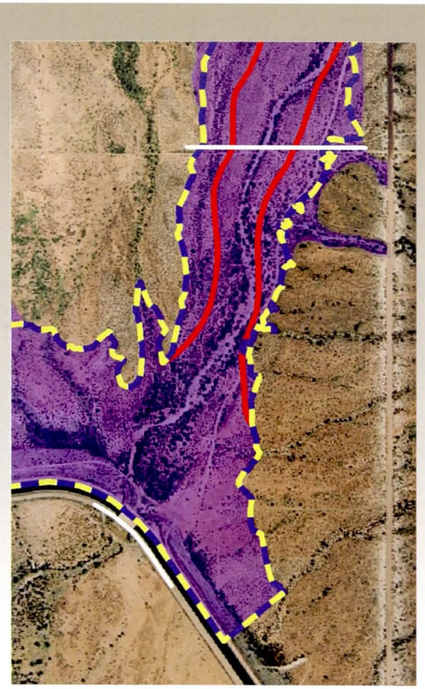
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

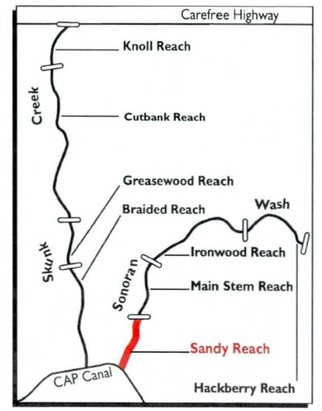


Nonstructural Alternative

## Key

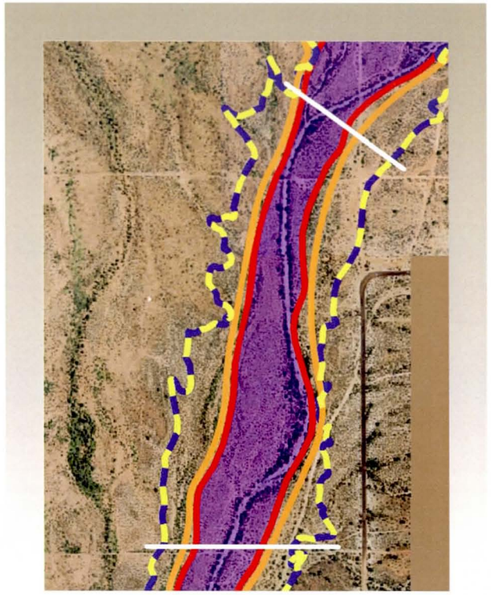
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase I Key Map:**

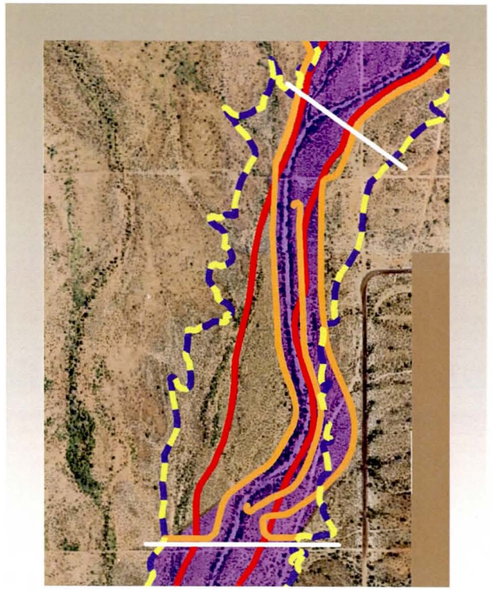



Note: All aerial photographs taken in July 1999

**Figure 34. Sonoran Wash - Sandy Reach Alternatives (Phase 1)**



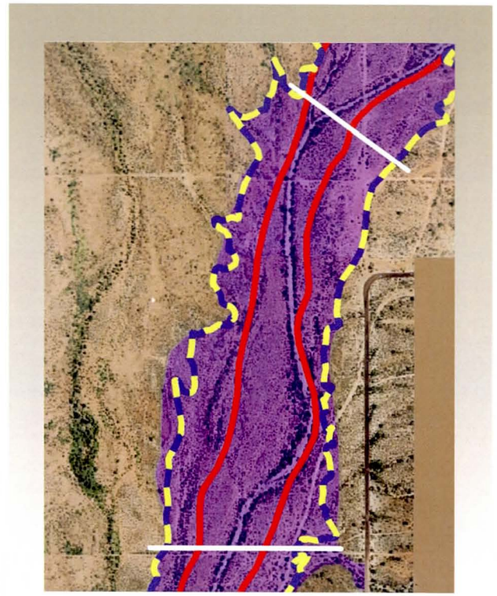
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

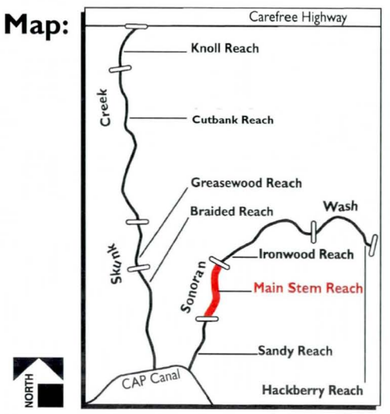


Nonstructural Alternative

## Key

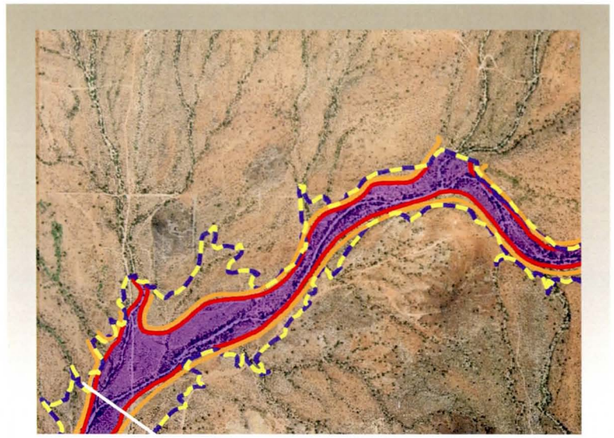
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 1 Key Map:**

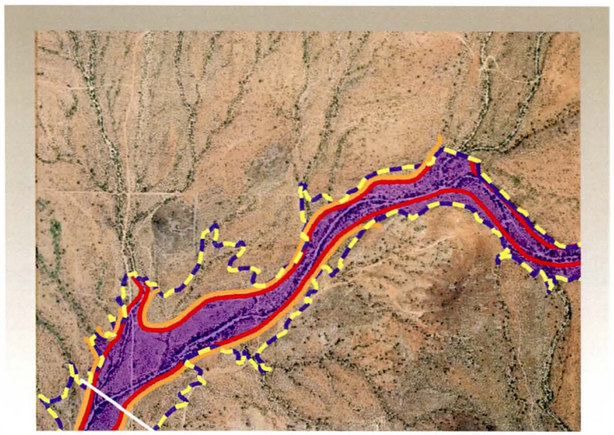



Note: All aerial photographs taken in July 1999

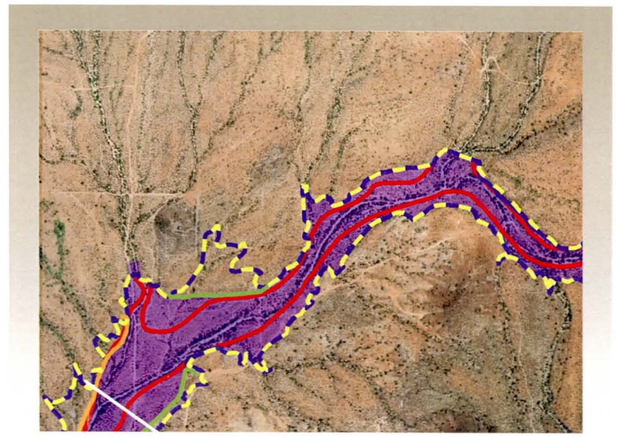
**Figure 35. Sonoran Wash - Main Stem Reach Alternatives (Phase 1)**



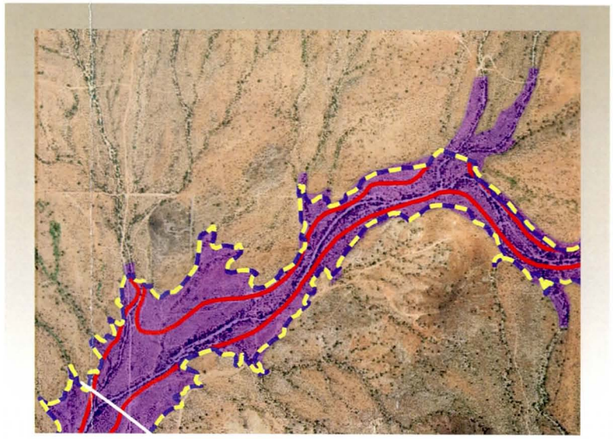
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

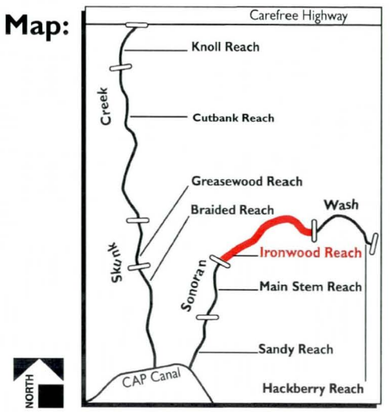


Nonstructural Alternative

## Key

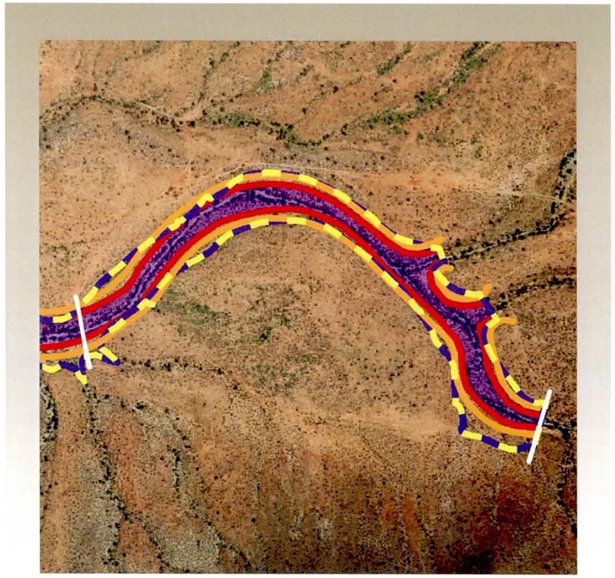
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 1 Key Map:**

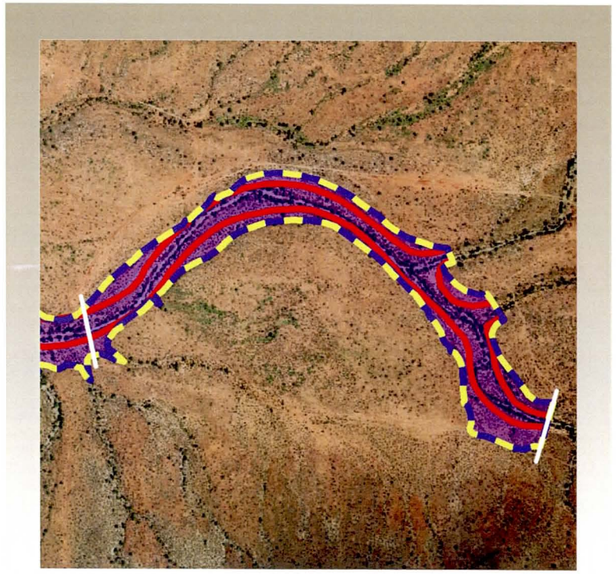



Note: All aerial photographs taken in July 1999

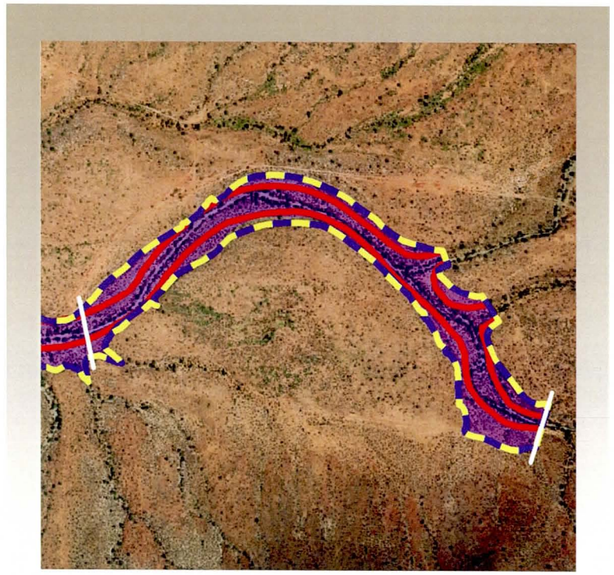
**Figure 36. Sonoran Wash - Ironwood Reach Alternatives (Phase 1)**



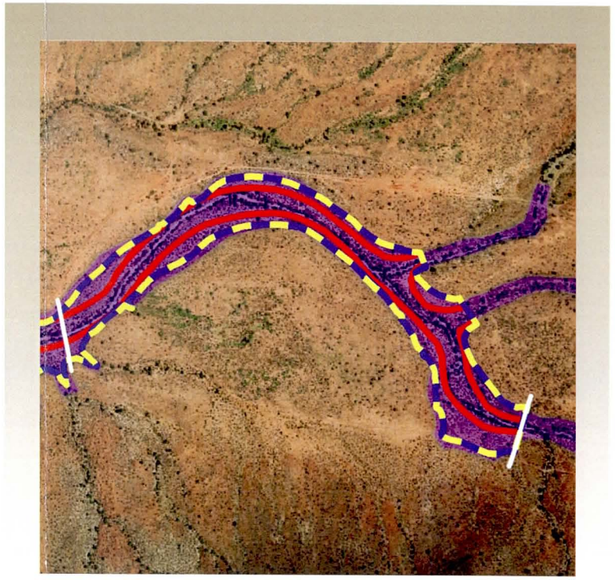
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

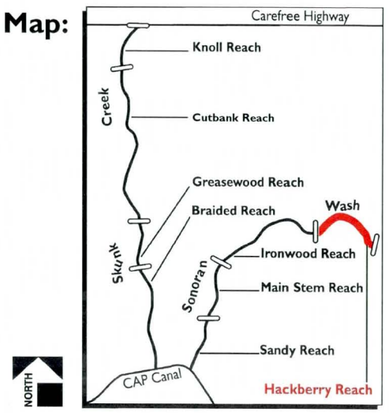


Nonstructural Alternative

## Key

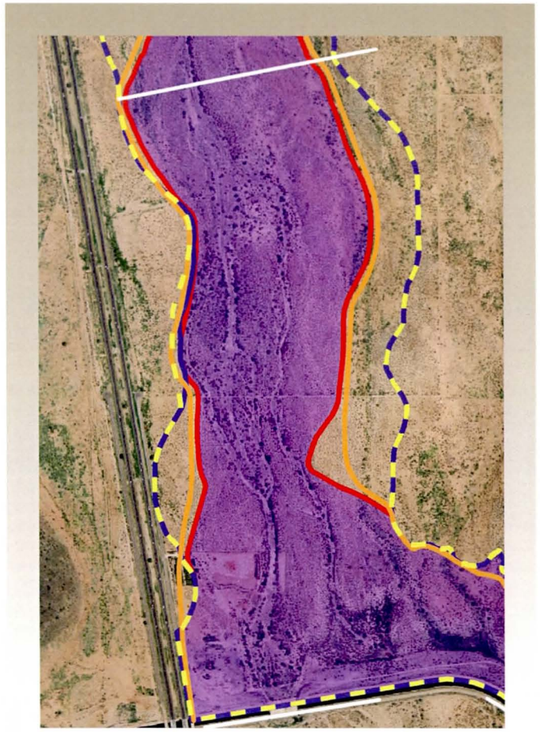
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

**Phase 1 Key Map:**

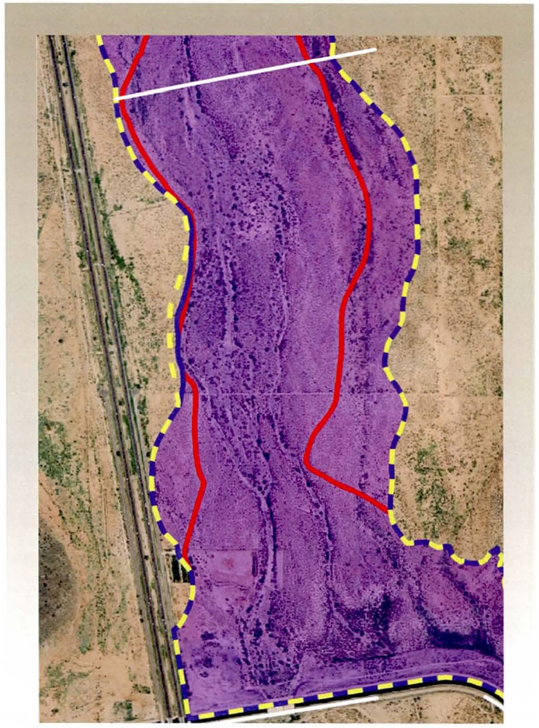



Note: All aerial photographs taken in July 1999

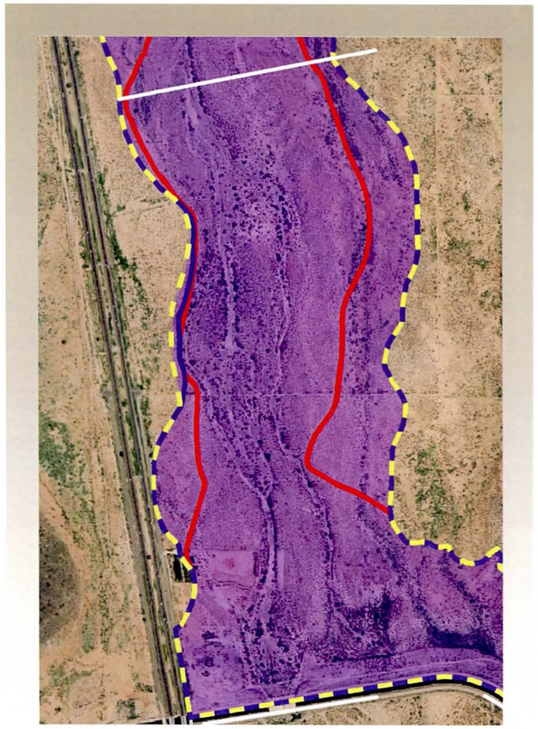
**Figure 37. Sonoran Wash - Hackberry Reach Alternatives (Phase 1)**



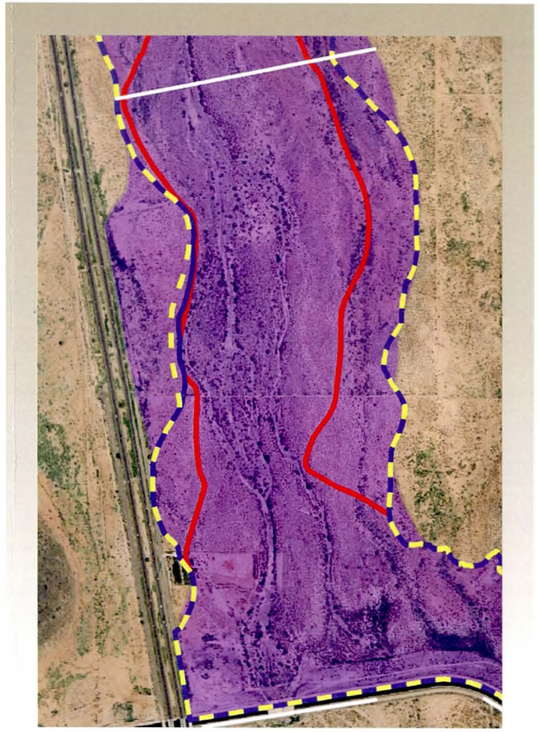
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

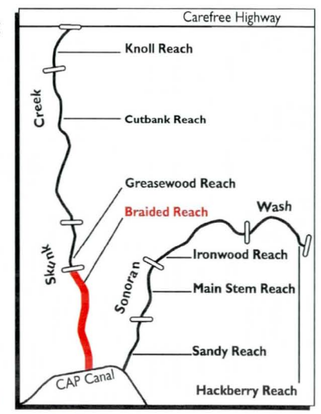


Nonstructural Alternative

## Key

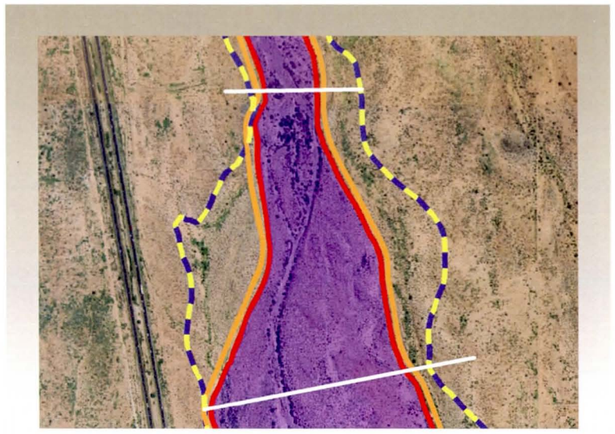
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

**Phase I Key Map:**

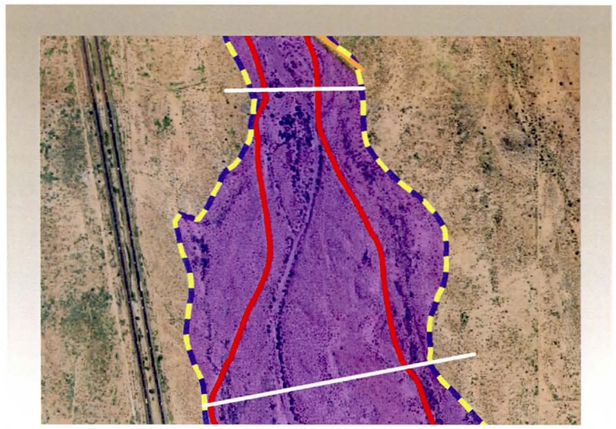



Note: All aerial photographs taken in July 1999

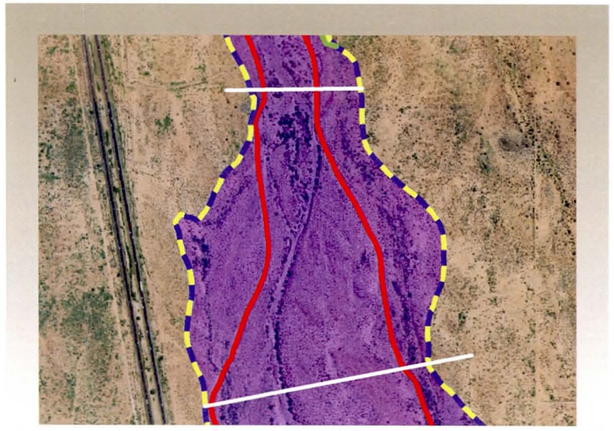
**Figure 38. Skunk Creek - Braided Reach Alternatives (Phase 1)**



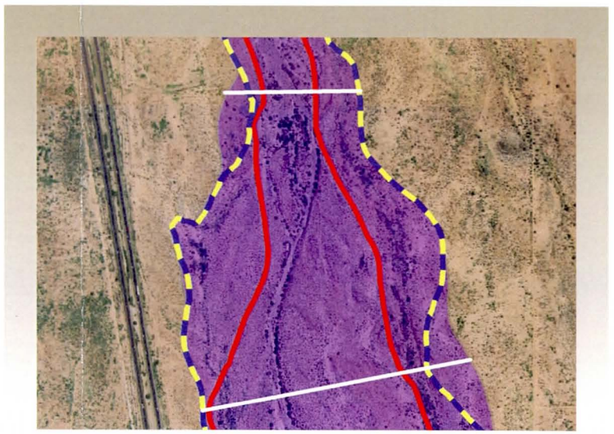
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

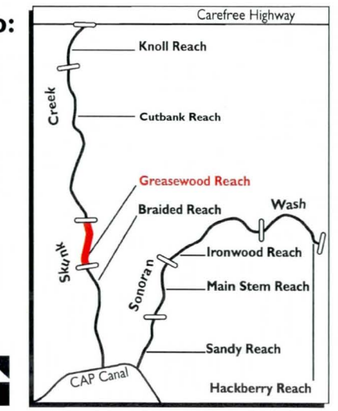


Nonstructural Alternative

## Key

- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

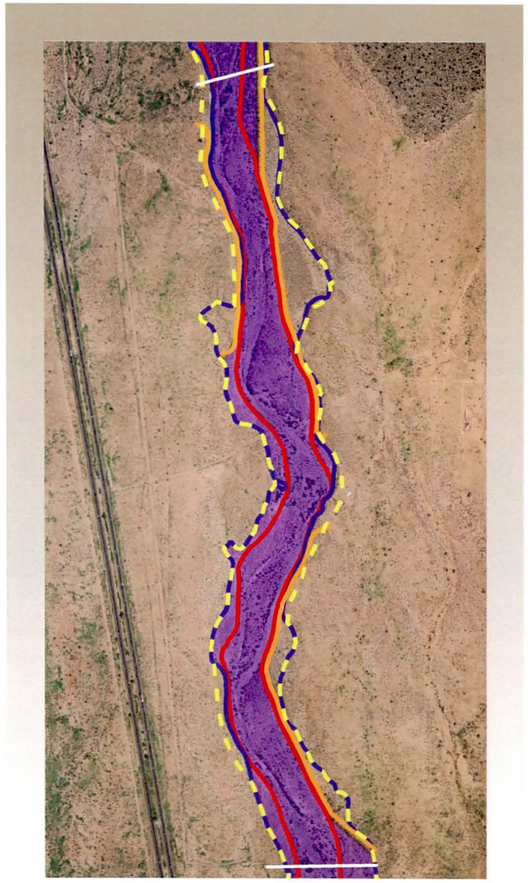
**Phase 1 Key Map:**



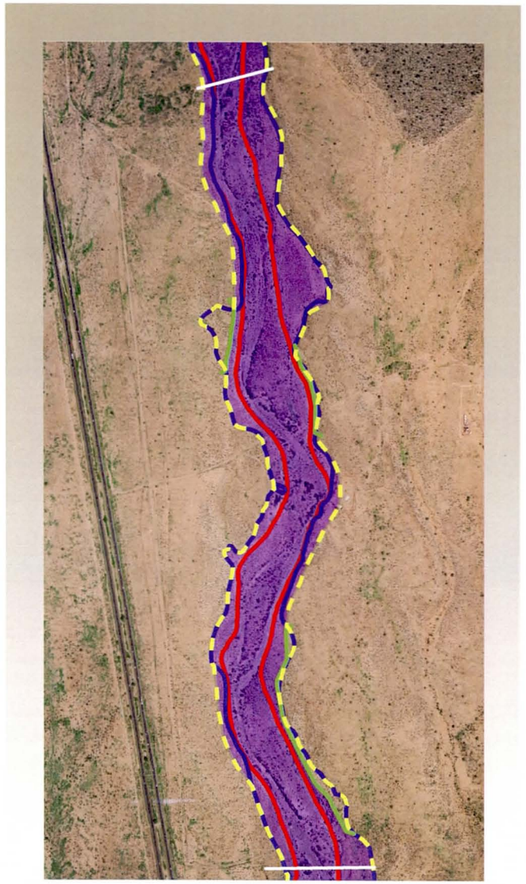

Note: All aerial photographs taken in July 1999

**Figure 39. Skunk Creek - Greasewood Reach Alternatives (Phase 1)**

Full-Structural Alternative



Stakeholders Alternative



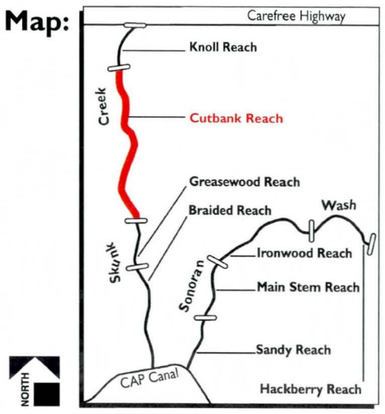
Team Alternative

Nonstructural Alternative

## Key

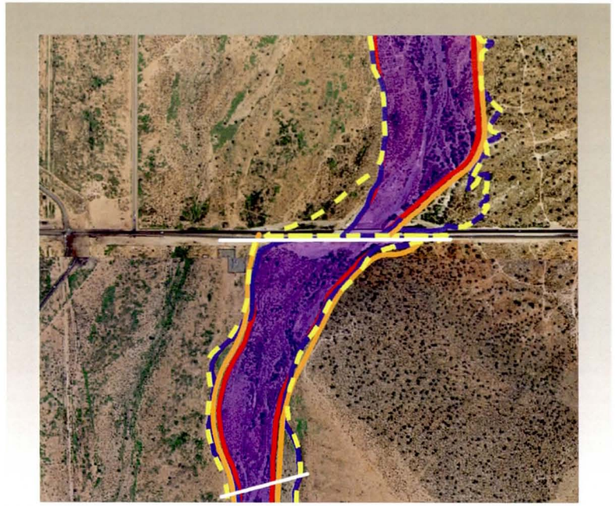
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 1 Key Map:**

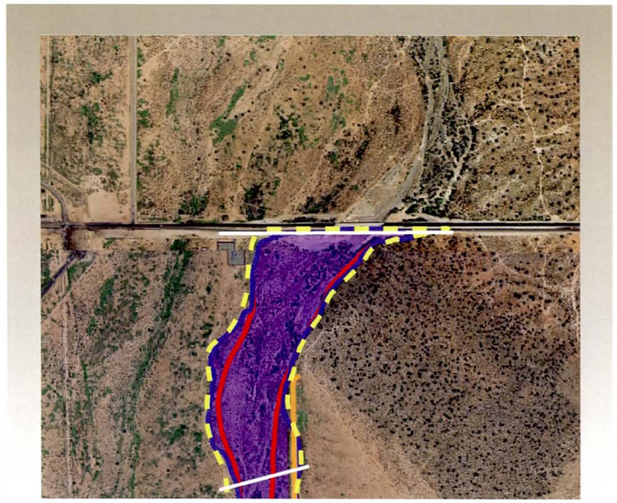



Note: All aerial photographs taken in July 1999

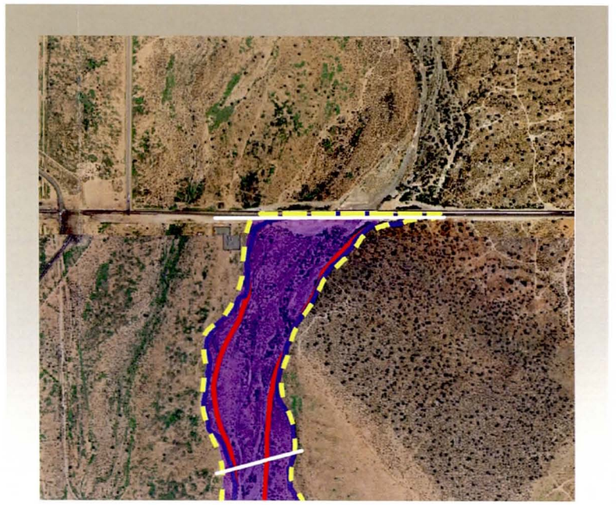
**Figure 40. Skunk Creek - Cutbank Reach Alternatives (Phase 1)**



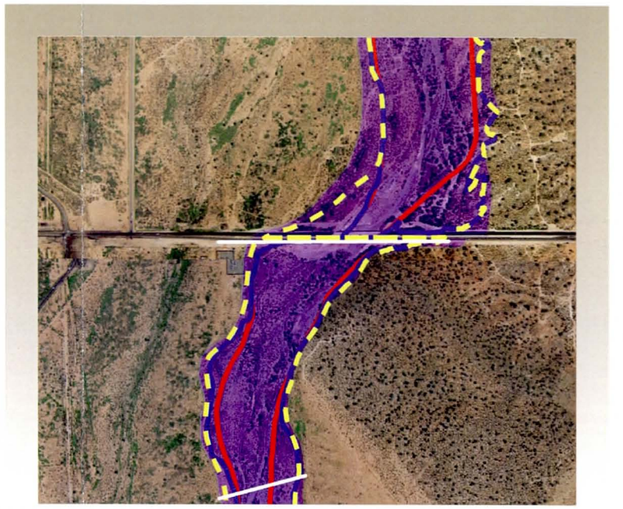
Full-Structural Alternative



Stakeholders Alternative



Team Alternative

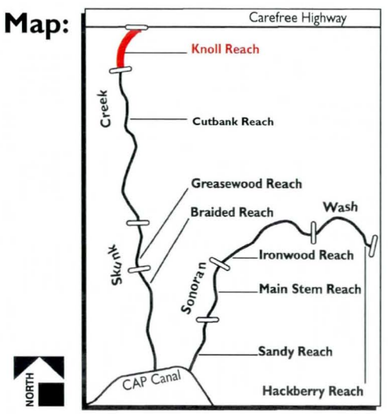


Nonstructural Alternative

## Key

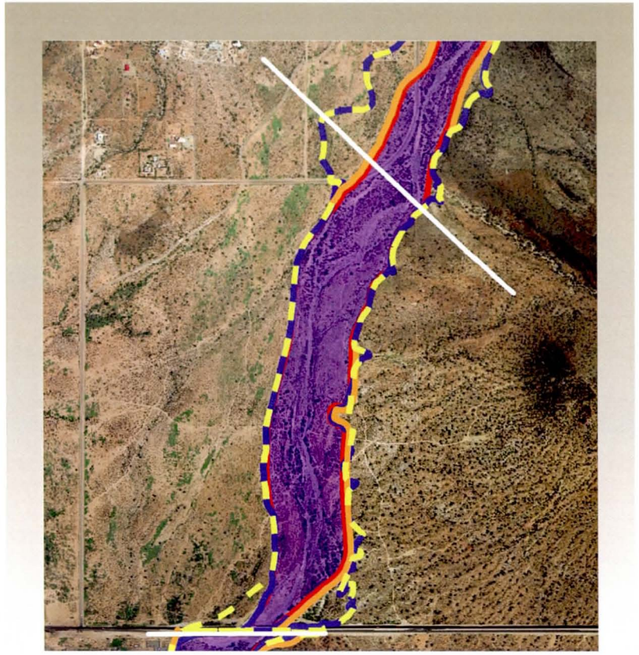
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

**Phase 1 Key Map:**

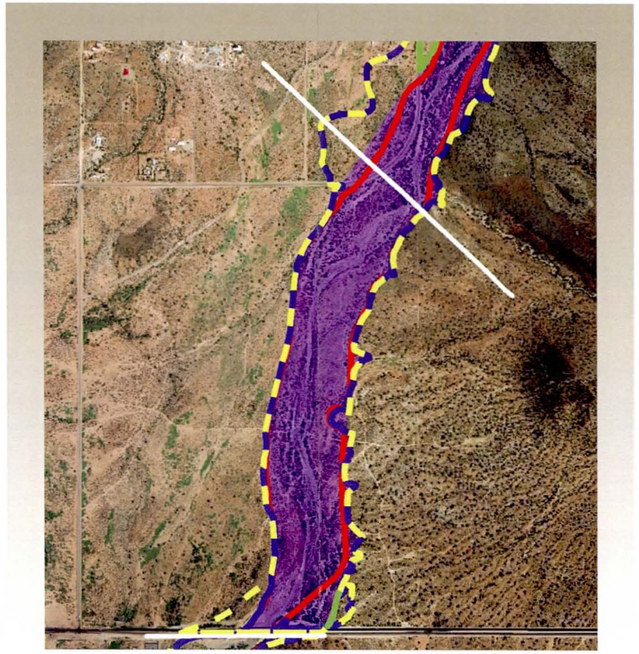



Note: All aerial photographs taken in July 1999

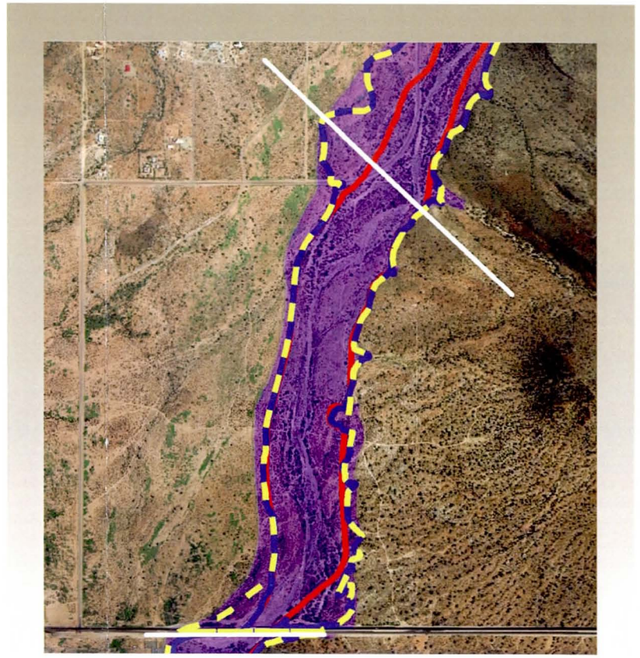
**Figure 41. Skunk Creek - Knoll Reach Alternatives (Phase 1)**



Full-Structural Alternative



Low-Impact Structural Alternative

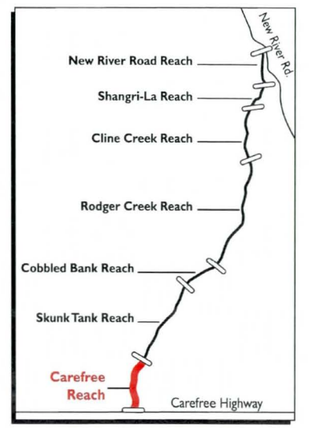


Nonstructural Alternative

## Key

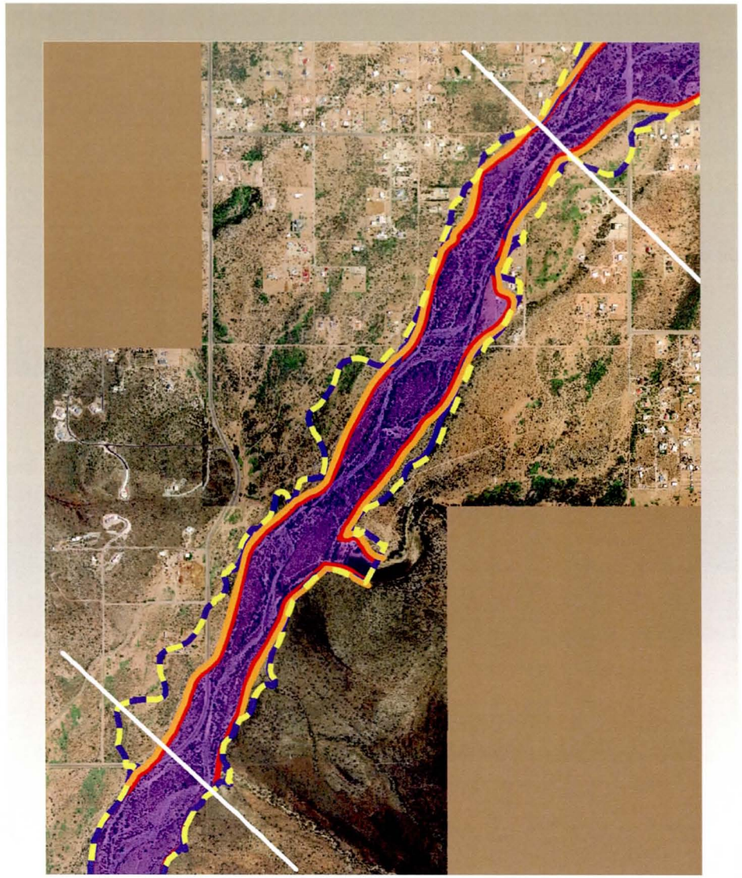
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

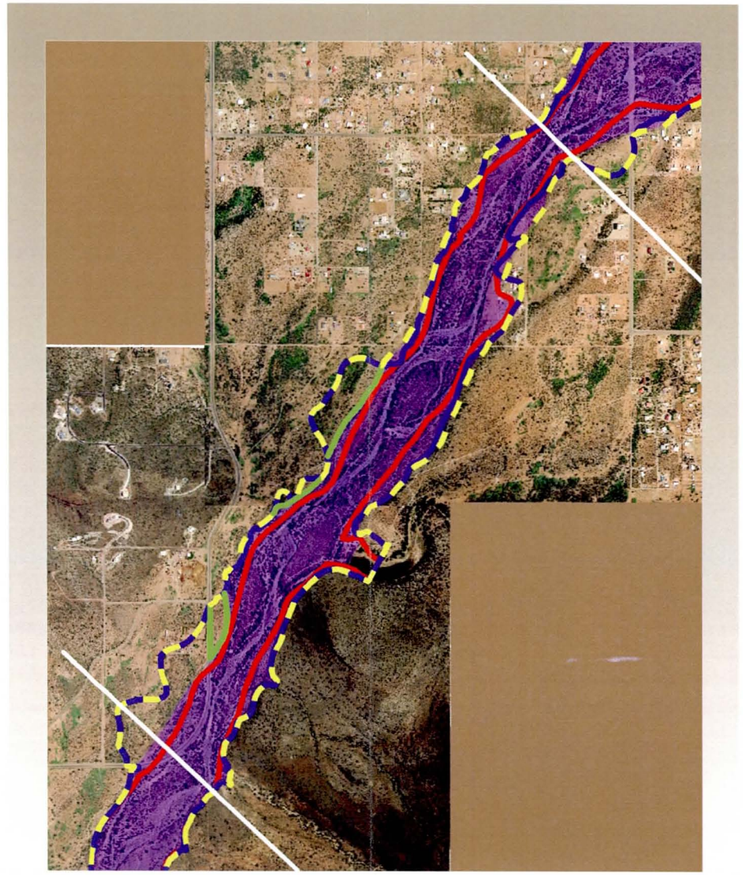



Note: All aerial photographs taken in July 1999

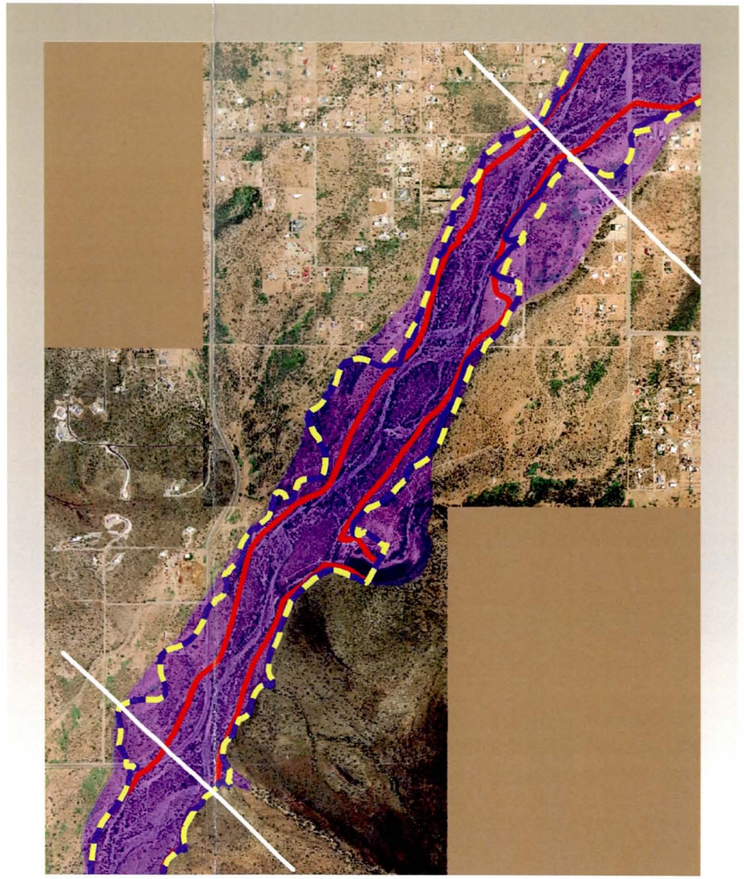
**Figure 42. Skunk Creek - Carefree Reach Alternatives (Phase 2)**



Full-Structural Alternative



Low-Impact Structural Alternative

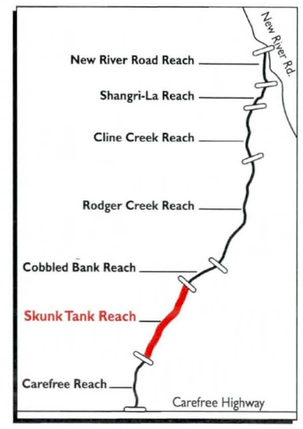


Nonstructural Alternative

## Key

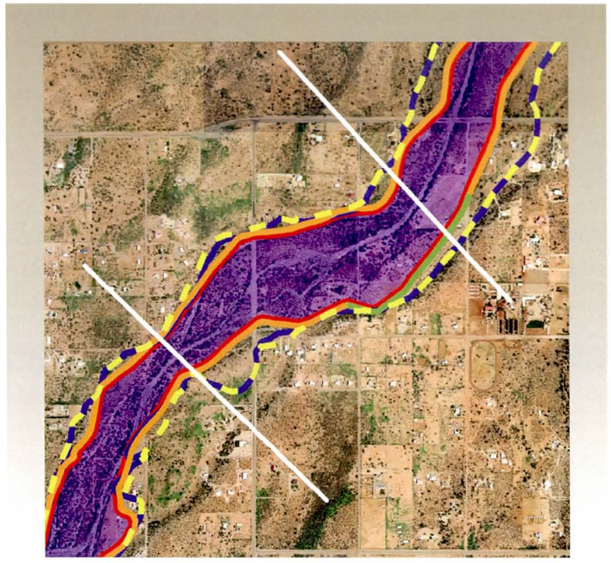
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

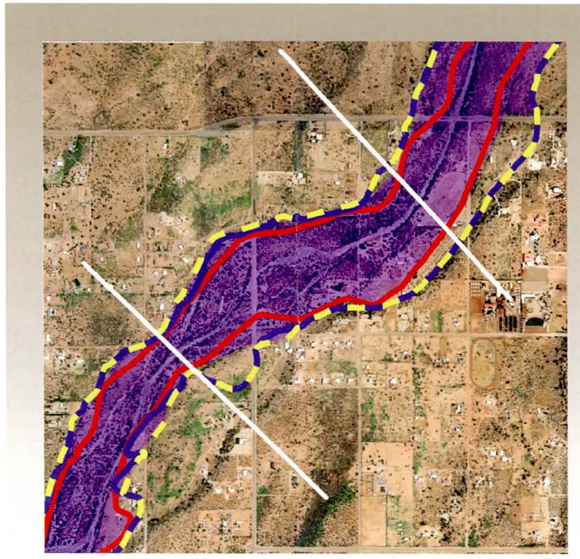



Note: All aerial photographs taken in July 1999

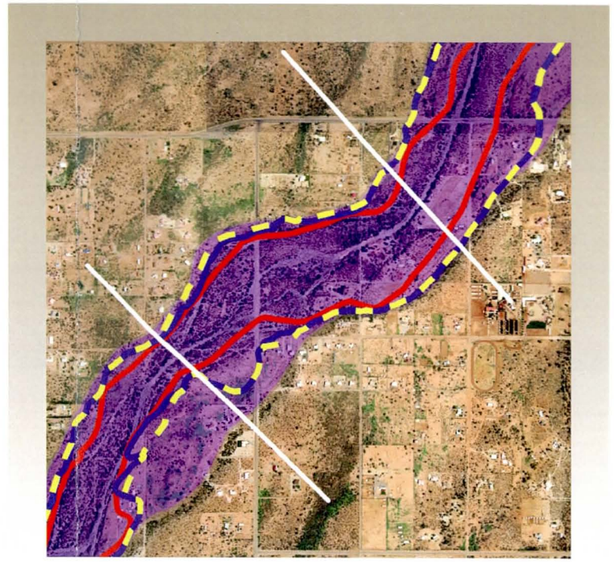
Figure 43. Skunk Creek - Skunk Tank Reach Alternatives (Phase 2)



Full-Structural Alternative



Low-Impact Structural Alternative

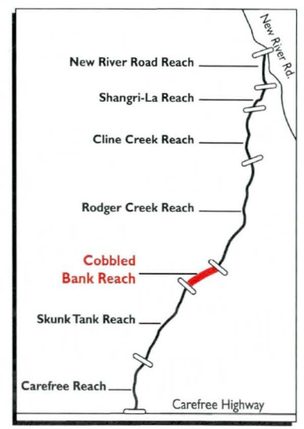


Nonstructural Alternative

## Key

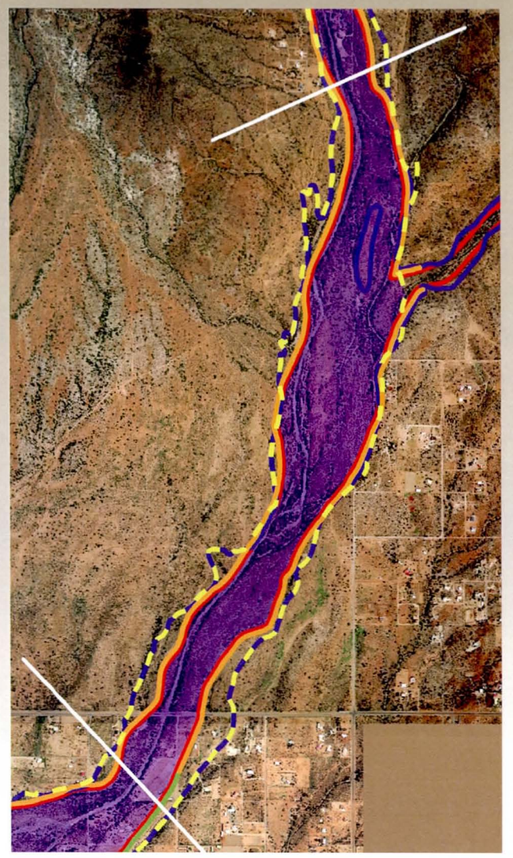
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

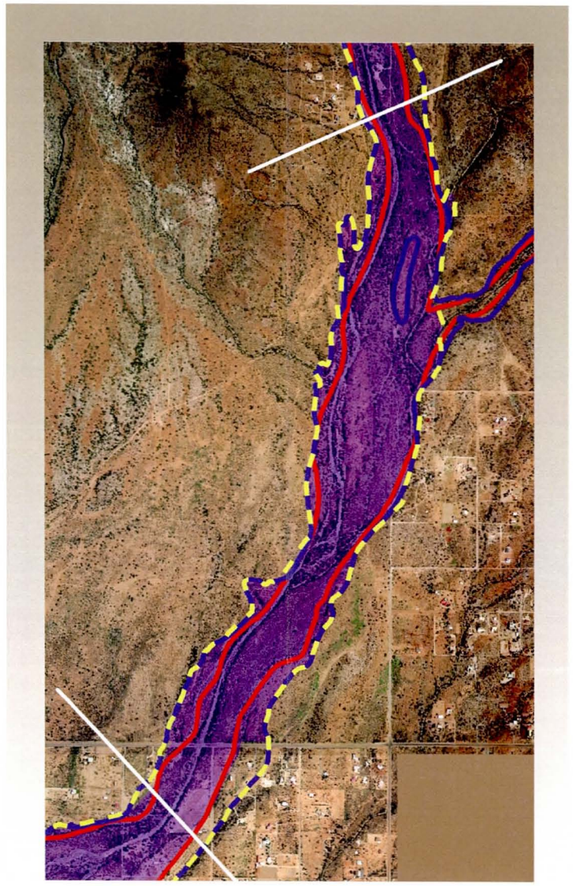



Note: All aerial photographs taken in July 1999

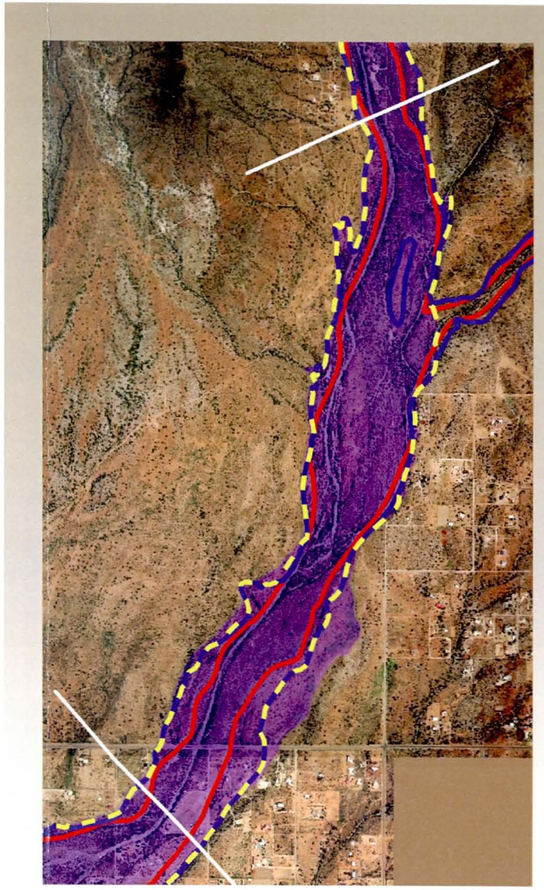
**Figure 44. Skunk Creek - Cobbled Bank Reach Alternatives (Phase 2)**



Full-Structural Alternative



Low-Impact Structural Alternative

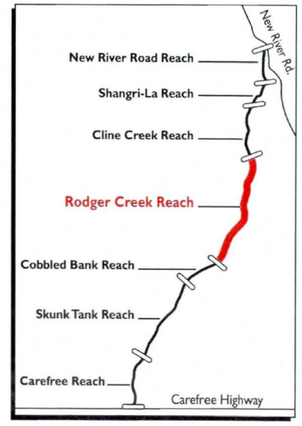


Nonstructural Alternative

## Key

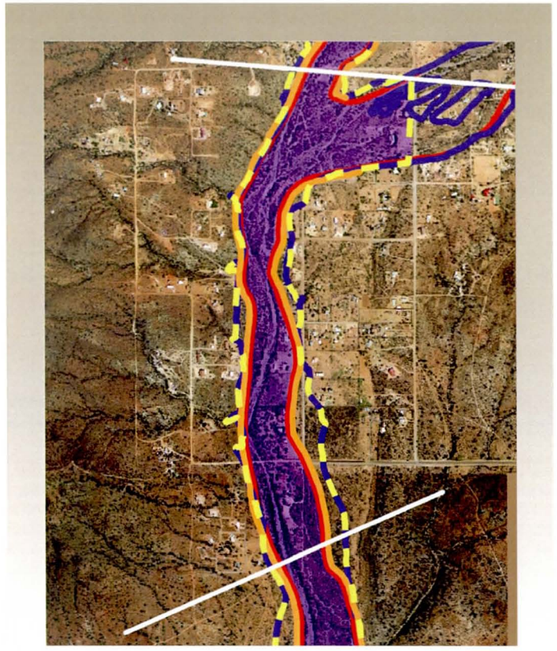
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Minimum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

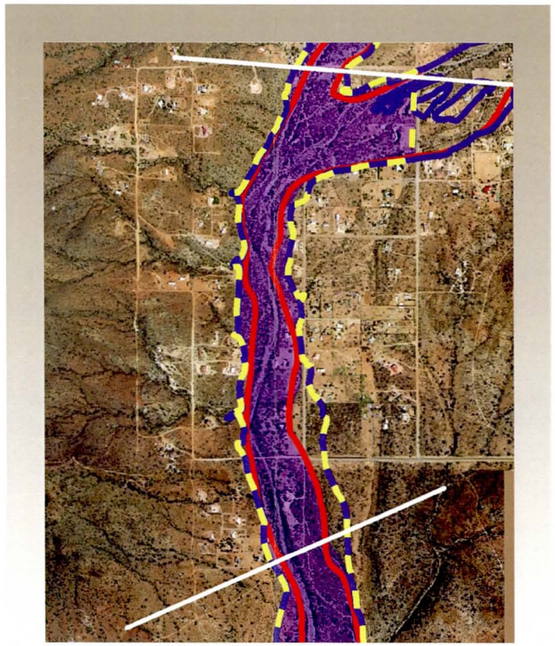



Note: All aerial photographs taken in July 1999

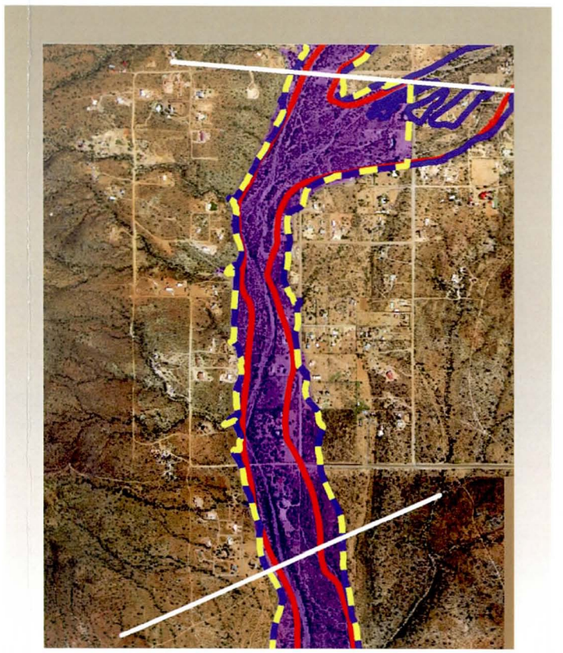
Figure 45. Skunk Creek - Rodger Creek Reach Alternatives (Phase 2)



Full-Structural Alternative



Low-Impact Structural Alternative

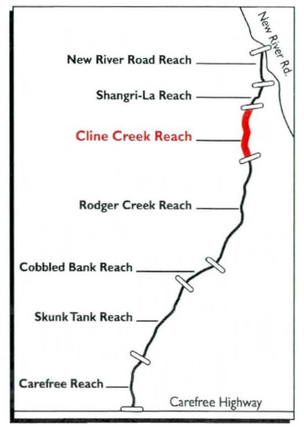


Nonstructural Alternative

## Key

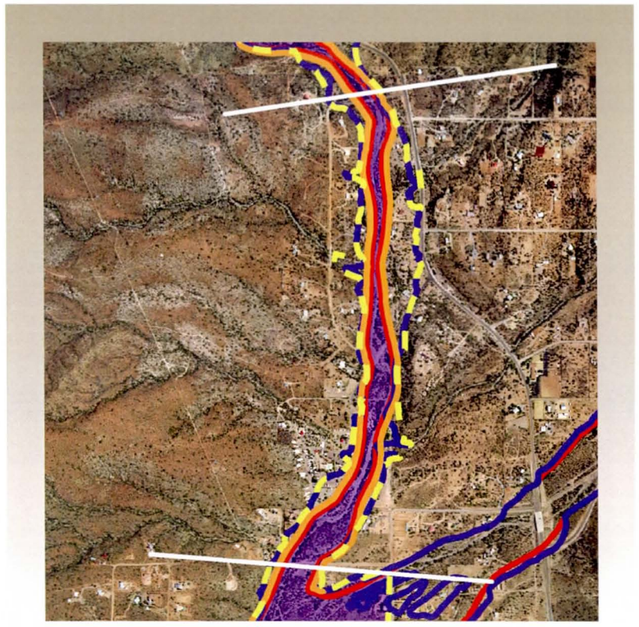
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

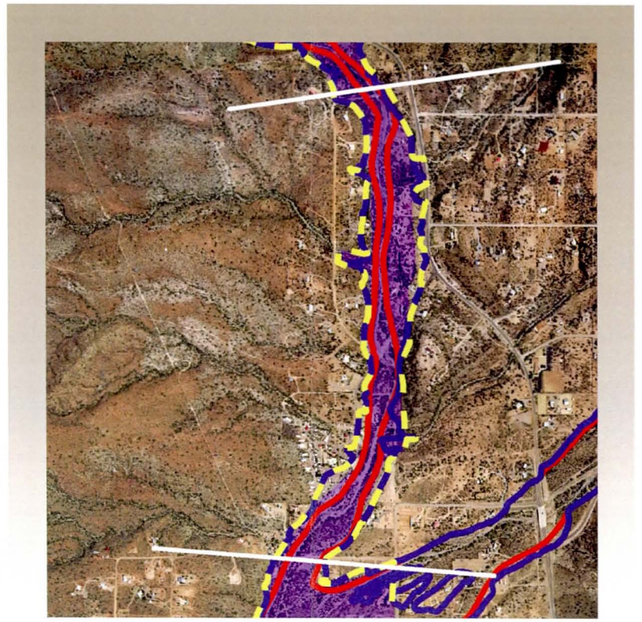



Note: All aerial photographs taken in July 1999

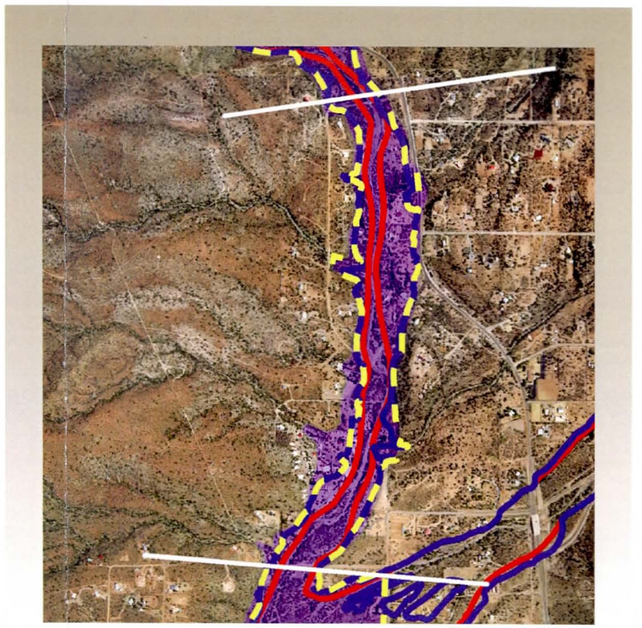
**Figure 46. Skunk Creek - Cline Creek Reach Alternatives (Phase 2)**



Full-Structural Alternative



Low-Impact Structural Alternative

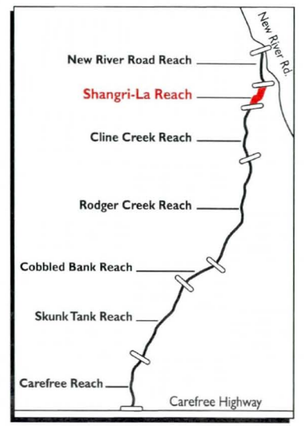


Nonstructural Alternative

## Key

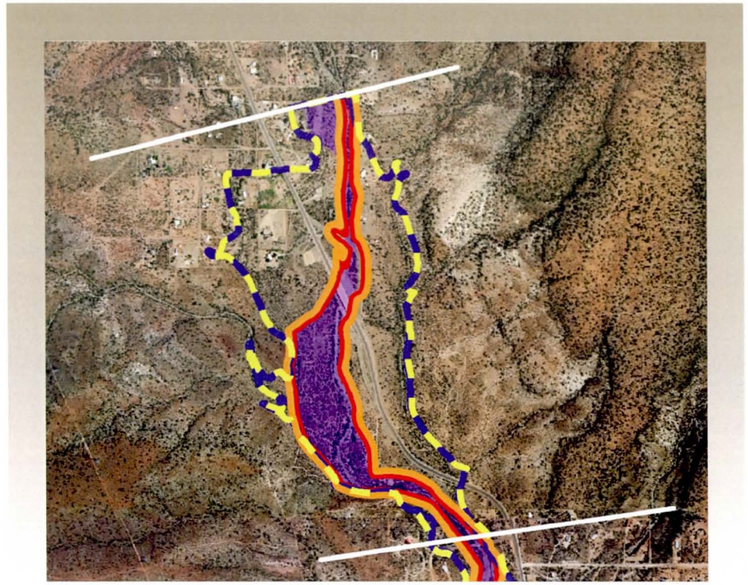
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

**Phase 2 Key Map:**

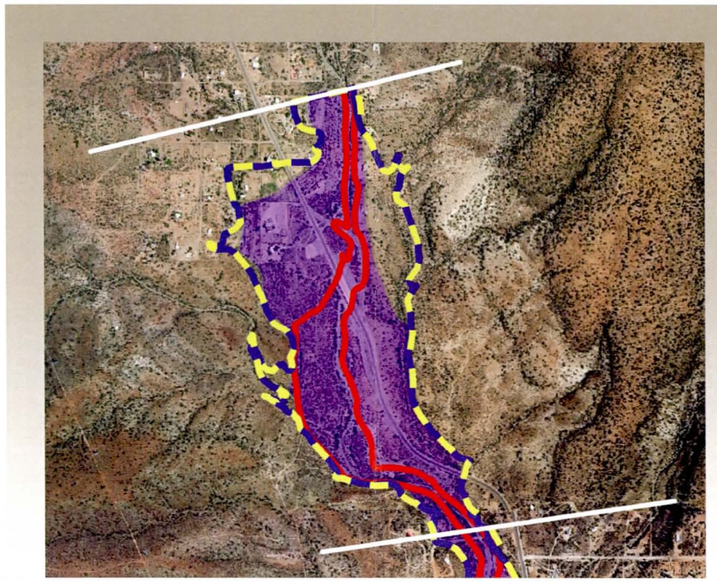



Note: All aerial photographs taken in July 1999

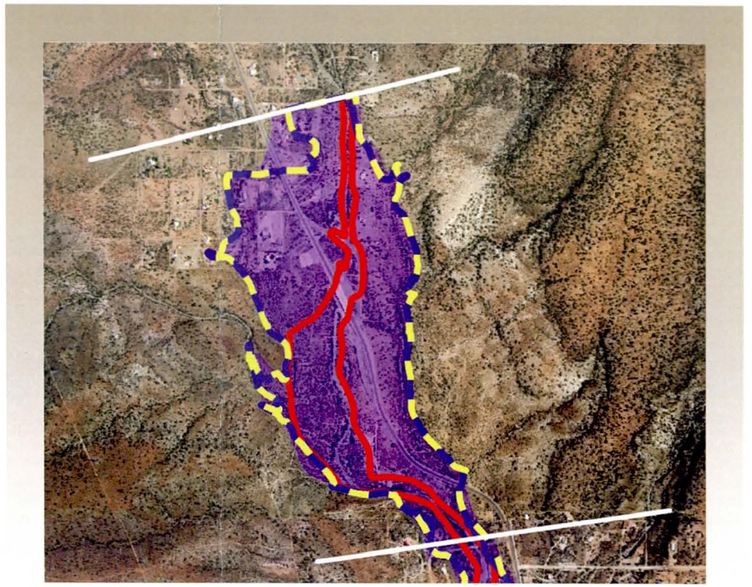
**Figure 47. Skunk Creek - Shangri La Reach Alternatives (Phase 2)**



Full-Structural Alternative



Low-Impact Structural Alternative

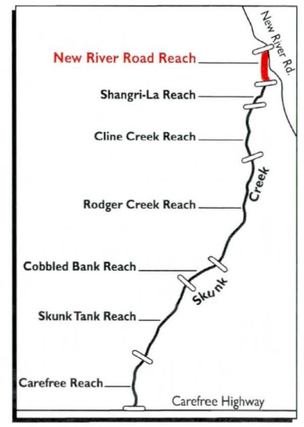


Nonstructural Alternative

## Key

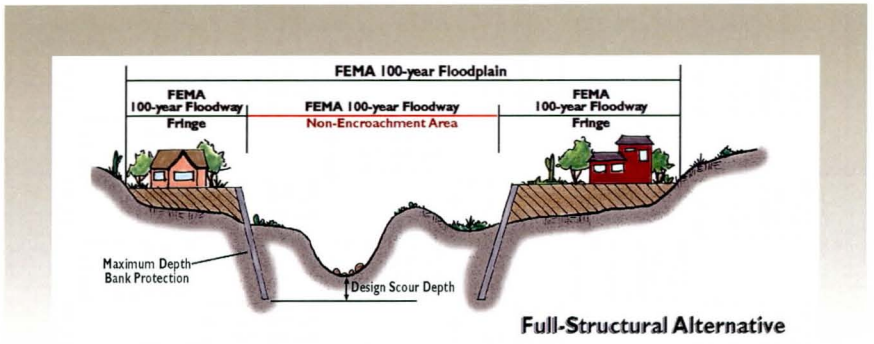
- Non-encroachment Area
- FEMA 100-year Floodplain
- FEMA 100-year Floodway
- Regulatory Line
- Maximum Depth Bank Protection
- Reach Boundary

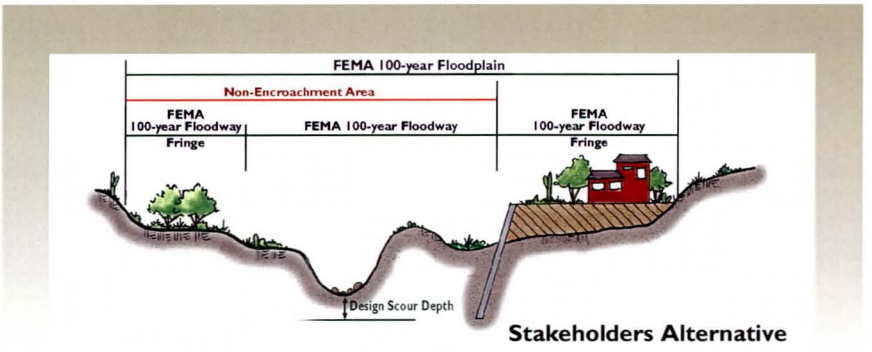
**Phase 2 Key Map:**

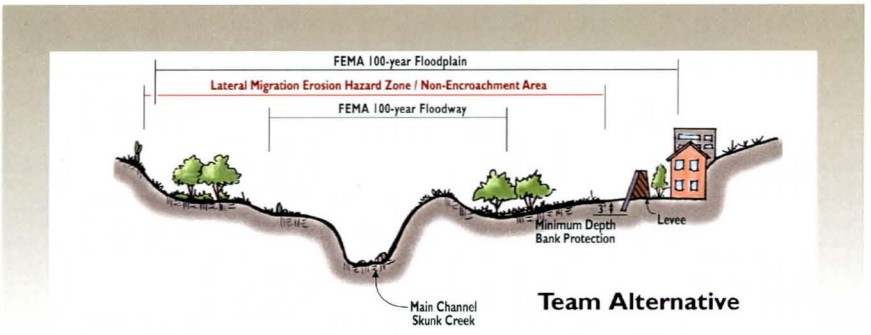



Note: All aerial photographs taken in July 1999

Figure 48. Skunk Creek - New River Road Reach Alternatives (Phase 2)



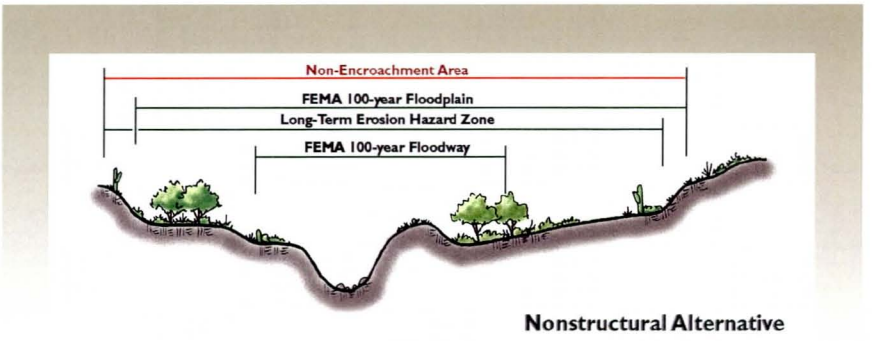




**Figure 49. Typical Cross Sections for Phase 1 Alternatives**



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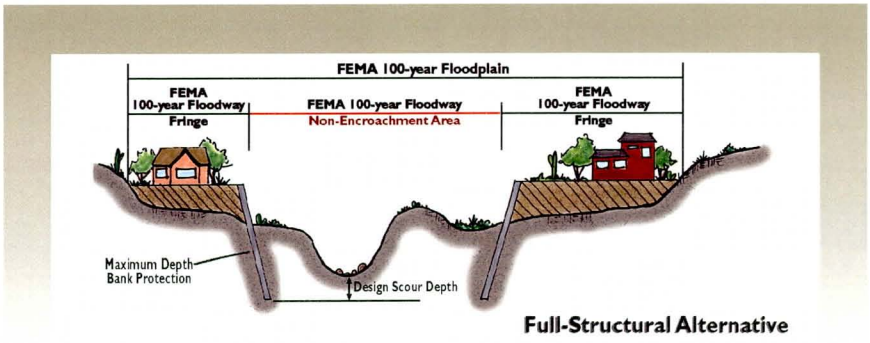
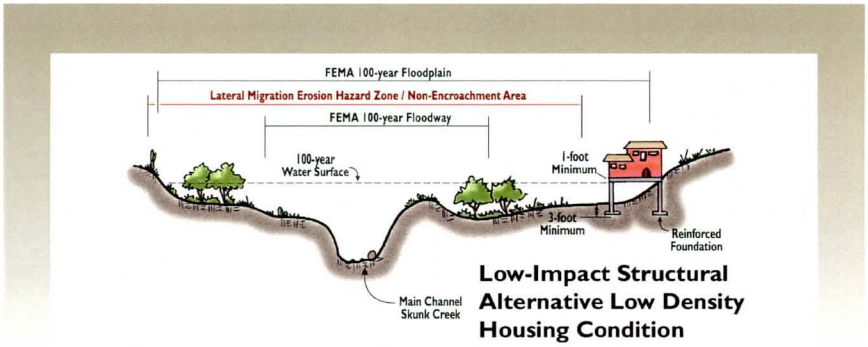
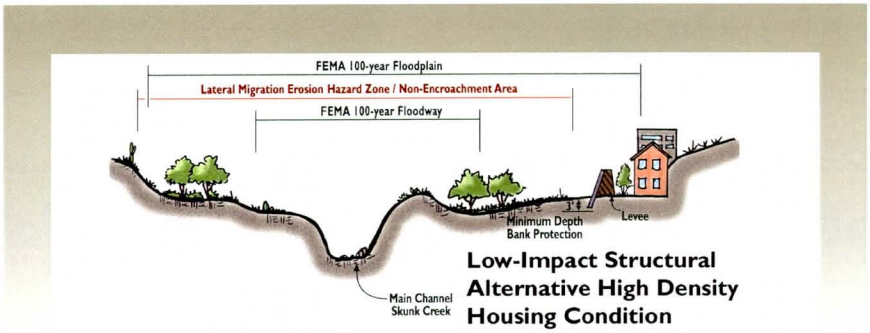


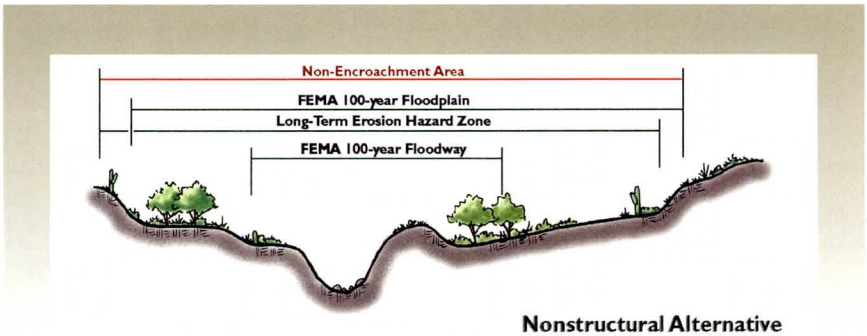

**Full-Structural Alternative**




**Low-Impact Structural Alternative Low Density Housing Condition**




**Low-Impact Structural Alternative High Density Housing Condition**




**Nonstructural Alternative**

## Figure 50. Typical Cross Sections for Phase 2 Alternatives

Example of Full-Structural Alternative

Skunk Creek North of Honda Bow Road

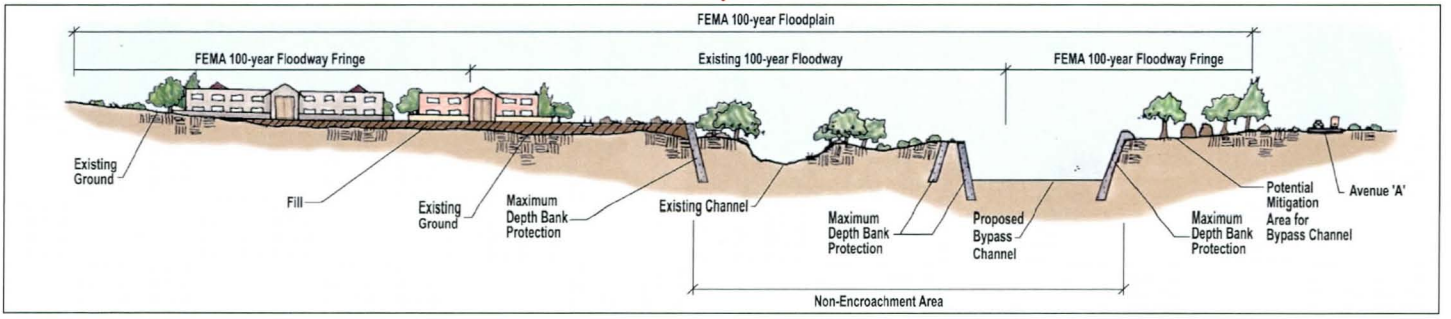
by the FEMA. Unless the current floodway limit is modified through the appropriate regulatory process, it represents the maximum allowable encroachment into the floodplain and provides the maximum amount of land for development.

The primary advantage of the Full-Structural Alternative is that it maximizes the amount of land available for development in the current *FEMA 100-year floodway fringe* area. The primary disadvantages are that it does so at a high construction cost, and risk to the public because of the resulting higher velocity of water moving through the *watercourse*, excessive *cumulative impacts*, and the potential for structural failure. Also, the finished product typically would have an unnatural appearance and function, and result in significant disturbance of riparian habitat and cultural features.

## B. Phase 1 Stakeholders Alternative

The Phase 1 Stakeholders Alternative was included to evaluate the development plans of private landowners and the impact of those plans on the stability of Skunk Creek and Sonoran Wash. This alternative was not defined for Phase 2 because there are no high-density developments proposed for Phase 2, other than Tramonto and Anthem. The Stakeholders Alternative contains encroachments into the *FEMA 100-year floodway fringe*, encroachment into the *FEMA 100-year floodway* of Sonoran Wash (requiring channelization), and areas that were left in their natural state.

The advantages of the Stakeholder Alternative are that it accounts for the current development plans of the local landowners, allows the impacts of those plans to be quantified and compared to the other alternatives in the study, and provides a vehicle for informing the local land owners about the study and future development restrictions. The primary disadvantages are that it does so at a high construction cost, and risk to the public because of the resulting higher velocity of water moving through the *watercourse*, excessive cumulative impacts, and the potential for structural failure. The finished product typically would have an unnatural appearance and function, particularly in the channelized reach of




Stakeholders Alternative Sonoran Wash Main Stem Reach

Sonoran Wash, and result in significant disturbance of riparian habitat and cultural features.

## C. Phase 1 Team Alternative and Phase 2 Low-Impact Structural Alternative

The Team and Low-Impact Structural Alternatives contain both encroachments into the *FEMA 100-year floodway* fringe and areas that are left in their natural state. For this alternative, the extent of encroachment is controlled through the implementation of a regulatory setback distance. The setback distance was generally based on engineering and geomorphic estimates of the lateral migration potential, as defined by the limits of the Lateral Migration *Erosion* Hazard Zone. The proposed setback distance defines the *non-encroachment area* limits for this alternative.

The advantages and disadvantages of this alternative lie in the fact that it is a compromise solution that neither maximizes the amount of developable land, nor the amount of undisturbed, natural area along the *watercourse*. The alternative defines the minimum area the *watercourses* need to function naturally over a 60-year period. A significant advantage is that this alternative does not produce significant *cumulative impacts* within a reach or upstream or downstream of the study limits.

## D. Phase 1 and Phase 2 Nonstructural Alternative

As the name implies, the Nonstructural Alternative contains no structural features in the *FEMA 100-year floodplain*. This alternative effectively leaves the study *watercourses* in their natural (albeit existing) state and controls the allowable encroachment for development through the implementation of a regulatory setback distance. The setback distance is based on engineering and geomorphic estimates of the long-term lateral migration potential, as defined by the limits of the Long-Term *Erosion* Hazard Zone.

The primary advantage of the Nonstructural Alternative when compared to the other alternatives is that it provides the highest level of public safety, the maintenance costs are minimum, and it effectively leaves the *watercourse* corridors in their natural state. The primary disadvantage is that it minimized the amount of land available for development and is expensive to implement.

## E. Evaluation of Alternatives

The evaluation of the proposed *watercourse* management alternatives was accomplished by measuring how successful each alternative is at achieving the goals of the WCMP by applying criteria that are indicators that the goals are met. The evaluation of the management alternatives was based on three, weighted criterion - Public Safety and Economic Impacts, both weighted a two 2, and Social/Environmental Impacts, weighted a 1. The weighting factor represents the "relative importance" of each criterion in the evaluation process. The criteria and weighting factors were developed through application of a value engineering process, with consensus reached among the Study Team members. The evaluation criteria and weights of importance are listed in Table 1.

Each of the three evaluation criterion are made up of several elements. The elements provide a means of measuring the effectiveness of the alternative being evaluated, relative to the WCMP goals. For each alternative, the effectiveness is quantified by assigning a rating factor of one (1) to five (5) to each element, with five being the most effective.

Because traditional floodplain management policy allows encroachment to the *FEMA 100-year floodway* limit, the Full-Structural Alternative was selected as a standard to which all other alternatives were compared. A benchmark rating was then assigned to the Full-Structural Alternative, and the other three alternatives were typically measured against the Full-Structural Alternative and rated accordingly. The scores were averaged then multiplied by the criterion weight to determine the criterion score. Finally,

| Table 1<br>Criteria and Weighting Factors for Evaluation of Watercourse Management Alternatives | | |
|---|---|---|
| **Evaluation Criteria (1)** | **Weighting Factor (0-10) (2)** | **Maximum Possible Score[1] (3)** |
| Public safety | 2 | 10 |
| Economic | 2 | 10 |
| Social and environmental | 1 | 5 |
| **Maximum Possible Score for an Alternative:** | | **25** |

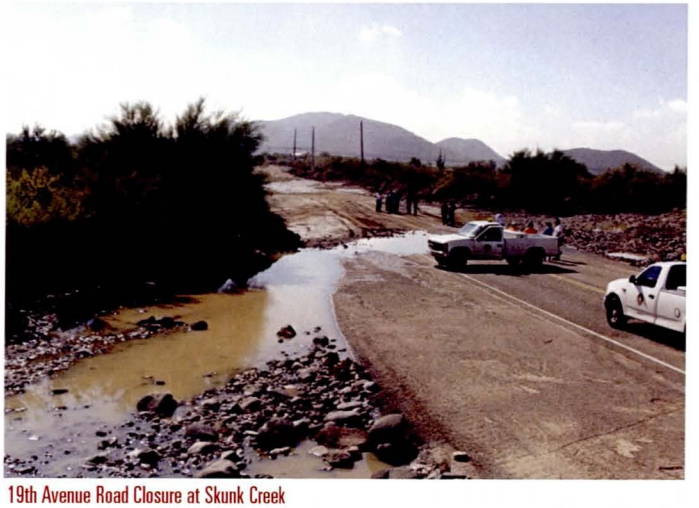
[1] Maximum Possible Score = Weighting Factor x Rating Factor of 5

the three criterion scores were added to provide the total alternative score. The highest total score possible for an alternative was 25. The basis for each criterion is discussed below.

## 1. Public Safety Criteria

The public safety criterion was based on evaluating the threat for loss of human life and possible damage to residences and property resulting from implementation of a given alternative. This criterion is an indicator of how well the proposed management alternative will succeed in reducing or eliminating life threatening, or potentially life threatening, flood and *erosion* related hazards, as well as reducing the potential for flood and *erosion* related damage to public and private properties. This criterion is also an indicator of how well the proposed management alternative will succeed in achieving overall public safety.

The evaluation of the public safety criterion was based on the effectiveness of each alternative in satisfying ten (10) elements. The elements are cumulative encroachment impacts, localized *erosion* impacts, hydrologic modeling uncertainty, hydraulic modeling uncertainty, development opportunity, risk of failure, flood events greater than design, flood events less than design, emergency response, and incidental use. The elements account for various types of risk, hazards, and impacts associated with development encroaching into natural *watercourses*. All the elements under the public safety criterion were assumed to have equal importance. A rating of 5 means the alternative was found most effective at meeting public safety concerns. A rating of 1 means the alternative was found least effective at meeting public safety concerns.



19th Avenue Road Closure at Skunk Creek

Great Horned Owl at Skunk Creek

## 2. Social/Environmental Criteria

The evaluation of the Social/Environmental criterion was based on the effectiveness of each alternative in satisfying six (6) elements. The elements are community acceptance, complexity of environmental permitting, impact on wildlife habitat, visual resource and aesthetic compatibility, multi-use opportunities, and impact on cultural resources. By consensus of the consultant team and representatives of the District, each element was of equal importance.

## 3. Economic Criteria

The evaluation of the economic criterion was based on the effectiveness of each alternative in satisfying two (2) elements; implementation and maintenance costs. Again, by consensus of the consultant team and representatives of the District, each element was of equal importance.

## F. Summary of Results and Recommended Management Alternatives

The scoring results for each Phase 1 alternative are summarized for Skunk Creek and Sonoran Wash in Table 2. The scoring results for each Phase 2 alternative are summarized for Skunk Creek in Table 3.

The recommended management plan for Phase 1 of the Skunk Creek WCMP is the Team Alternative. The Team Alternative achieved a total score of 39.8,

**Table 2**

**Phase 1 Summary of Alternative Scoring for Skunk Creek and Sonoran Wash**

| Evaluation Criteria (1) | Weighting Factor (2) | Full-Structural | | Stakeholders | | Team | | Nonstructural | |
|---|---|---|---|---|---|---|---|---|---|
| | | Rating (3) | Score[1] (4) | Rating (5) | Score[1] (6) | Rating (7) | Score[1] (8) | Rating (9) | Score[1] (10) |
| **Skunk Creek Phase 1** | | | | | | | | | |
| Public safety | 2 | 2.5 | 5.0 | 3.4 | 6.8 | 4.0 | 8.0 | 4.8 | 9.6 |
| Economic | 2 | 3.5 | 7.0 | 4.0 | 8.0 | 4.0 | 8.0 | 3.0 | 6.0 |
| Social and environmental | 1 | 2.2 | 2.2 | 3.4 | 3.4 | 4.0 | 4.0 | 4.2 | 4.2 |
| **Total Scores for Skunk Creek Phase 1:** | --- | --- | **14.2** | --- | **18.2** | --- | **20.0** | --- | **19.8** |
| **Sonoran Wash** | | | | | | | | | |
| Public safety | 2 | 2.1 | 4.2 | 2.9 | 5.8 | 3.9 | 7.8 | 4.8 | 9.6 |
| Economic | 2 | 3.0 | 6.0 | 3.5 | 7.0 | 4.0 | 8.0 | 3.0 | 6.0 |
| Social and environmental | 1 | 2.0 | 2.0 | 3.2 | 3.2 | 4.0 | 4.0 | 4.2 | 4.2 |
| **Total Scores for Sonoran Wash System:** | --- | --- | **12.2** | --- | **16.0** | --- | **19.8** | --- | **19.8** |
| **Watercourse Master Plan, Phase 1** | | | | | | | | | |
| Public safety | --- | --- | 9.2 | --- | 12.6 | --- | 15.8 | --- | 19.2 |
| Economic | --- | --- | 13.0 | --- | 15.0 | --- | 16.0 | --- | 12.0 |
| Social and environmental | --- | --- | 4.2 | --- | 6.6 | --- | 8.0 | --- | 8.4 |
| **Watercourse Master Plan Total Scores :** | --- | --- | **26.4** | --- | **34.2** | --- | **39.8** | --- | **39.6** |

[1] Score = Weighting Factor x Rating Factor

**Table 3**

**Phase 2 Summary of Alternative Scoring for Skunk Creek**

| Evaluation Criteria (1) | Weighting Factor (2) | Full-Structural | | Low-Impact | | Nonstructural | |
|---|---|---|---|---|---|---|---|
| | | Rating (3) | Score[1] (4) | Rating (5) | Score[1] (6) | Rating (7) | Score[1] (8) |
| **Skunk Creek Phase 2** | | | | | | | |
| Public Safety Criterion | 2 | 2.4 | 4.8 | 3.8 | 7.6 | 4.8 | 9.6 |
| Economic Criterion | 2 | 2.5 | 5.0 | 4.5 | 9.0 | 3.0 | 6.0 |
| Social and Environmental Criterion | 1 | 2.0 | 2.0 | 3.7 | 3.7 | 4.3 | 4.3 |
| **Total Scores for Skunk Creek Phase 2:** | --- | --- | 11.8 | --- | **20.3** | --- | **19.9** |

[1] Score = Weighting Factor x Rating Factor

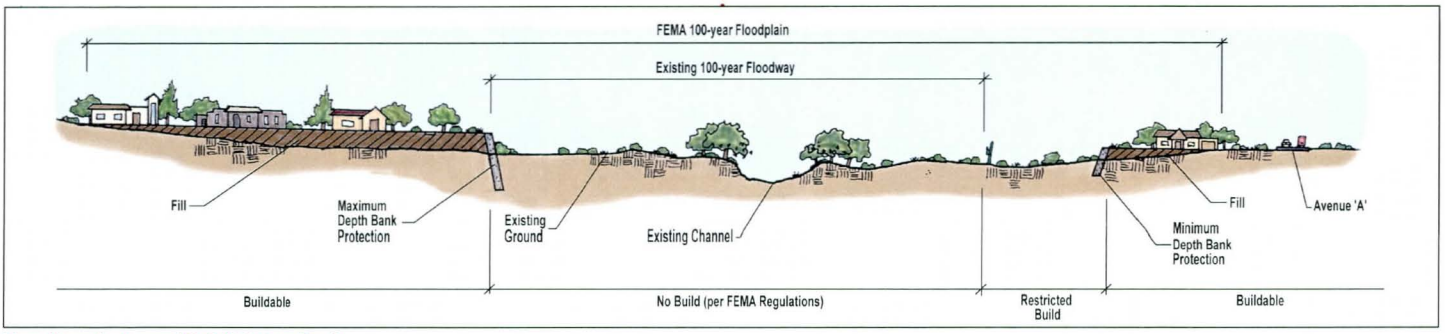
as compared to scores of 26.4, 34.2, and 39.6 for the Full-Structural, Stakeholders, and Nonstructural Alternatives, respectively. This alternative achieved a total score of 20 and 19.8 out of a possible 25 points for Skunk Creek and Sonoran Wash, respectively. Although the margin is small over the Nonstructural Alternative, the Team Alternative was most successful at meeting the WCMP goals. Key factors that supported the selection of the Team Alternative are that it allows use of private land within the FEMA 100-year floodplain without compromising public safety and it also met the goals of the Sonoran Preserve Master Plan, and the North Black Canyon Corridor Plan. Selection of this alternative was also consistent with the alternatives analysis conducted by the COP.

Sonoran Wash

A significant amount of State land within the *non-encroachment area* of the Team Alternative is within the land slated for purchase under the API. However, the API designation does not guarantee preservation. The API designation is only good for a maximum of 7 years. After that time frame, the ASLD is free to place the land on the open market for development. If sold, the ASLD must sell the land at market value. It is, therefore, recommended that the State land within the *non-encroachment area* of the Team Alternative be designated a high priority for acquisition under the API. Successful implementation of the Team Alternative is contingent upon the acquisition, or if land acquisition is not feasible, the regulatory control of the *non-encroachment area* through such methods as zoning and density transfers. Regulatory control of the *non-encroachment area* on private land must be accomplished through such methods as zoning and density transfers.

The recommended management plan for Phase 2 of the Skunk Creek WCMP is the Low-Impact Structural Alternative. The Low-Impact Structural Alternative achieved a total score of 20.3, as compared to scores of 11.8 and 19.9 for the Full-Structural and Nonstructural Alternatives, respectively. Although the margin is small over the Nonstructural Alternative, the Low-Impact Structural Alternative was the most successful at meeting the WCMP goals. A key factor supporting the selection of the Team Alternative for Phase 2 of the study was the flexibility afforded to private

Skunk Creek

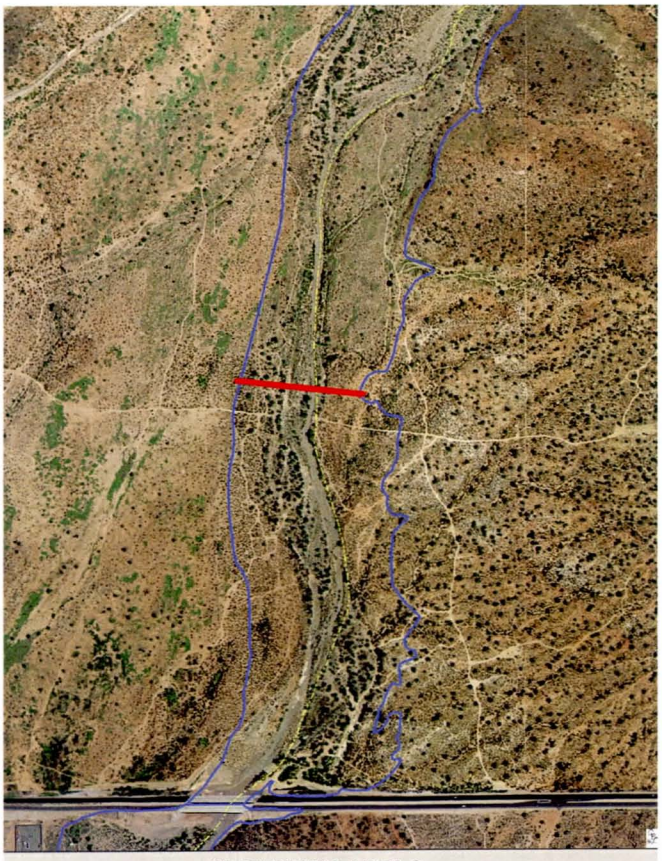



Team Alternative Sonoran Wash Main Stem Reach

landowners to reclaim land from the *FEMA 100-year floodplain*, while minimizing adverse impacts on the environment and the threat to public safety. Approximately 74 percent of the land in Phase 2 is privately owned.

## 8 Monitoring and Maintenance Plan

The Monitoring and Maintenance Plan for the WCMP was developed for the purpose of providing a recommendation for a systematic approach for monitoring and maintaining Skunk Creek and Sonoran Wash in a manner that will attempt to preserve *watercourse* stability and design functionality for a minimum 60-year time period. The primary objective for development of the plan was to formulate simple protocols that, if adopted by the District, should be easily accomplished and completed on an ordinary basis as well as an extraordinary basis, with minimal, straightforward field application. The Monitoring and Maintenance Plan for the WCMP consists of short-term monitoring criteria, long-term monitoring criteria, and maintenance criteria. The plan defines specific locations in the study area for monitoring, and establishes thresholds to trigger short-term monitoring and regular inspection periods for long-term monitoring. Maintenance activities are triggered by the results of the monitoring program. The monitoring plan is also intended for development of an historical database that can be used by the District for verification and adjustment of the lateral stability analysis procedures. The District may also elect to use the database for future *watercourse* research activities.




Typical Monitoring Cross Section Location

## 9 Implementation

The recommended Implementation Plan was developed to provide guidance for the District to implement the WCMP. The primary objectives for development of the Implementation Plan are to identify strategies for regulatory enforcement of the recommended *non-encroachment area*, provide guidance on appropriate uses for that area, and to identify allowable variances that may be granted for protection of personal property rights without jeopardizing public safety. The criteria identified for regulations may be more stringent than that currently recommended by the Arizona Department of Water Resources.

Existing Residence in FEMA 100-year Floodway and Severe Erosion Hazard Zone

**Table 4**

**Prioritization for Residence Acquisition in High-Hazard Areas**

| Tag ID (1) | Assessors Parcel Number (2) | Rec. Buy-Out Priority (3) | Parcel Area acres (4) | Year Built (5) | Hazard Assess. Done On (6) | In F/W (7) | In Sev EHZ (8) | In LM EHZ (9) | Erosion Hazard Multiplier[1] (10) | Approx. Chance of Flooding[2] (11) | Personal Hazard Factor[3] (12) | Response Time Factor[4] (13) | Hazard Ranking Value (10)*(11)*(12)*(13) (14) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 211-22-002B | 1 | 2.5 | 1985 | House | Y | Y | | 3 | 20.0%[5] | 76 | 5 | 22800.0 |
| 847 | 202-21-169 | 2 | 4.5 | 1988 | House | Y | Y | | 3 | 20.0% | 52 | 5 | 15600.0 |
| 62 | 211-50-022 | 3 | 9.6 | n/a | Mobile 3 | Y | | | 1 | 20.0% | 59 | 5 | 5900.0 |
| 579 | 202-21-008T | 4 | 36.4 | n/a | Mobile | N | Y | | 3 | 16.7% | 22 | 5 | 5511.0 |
| 6 | 211-22-002J | 5 | 3 | 1981 | Mobile | Y | Y | | 3 | 6.3% | 35 | 5 | 3281.3 |
| 104 | 211-50-037C | 6 | 5.2 | 1980[6] | Mobile | Y | | Y | 2 | 8.3% | 36 | 5 | 3000.0 |
| 84 | 211-50-016J | 7 | 6.5 | n/a | Mobile 1 | Y | | | 1 | 9.1% | 54 | 5 | 2454.5 |
| 616 | 202-21-024B | 8 | 4.5 | 1976 | House | Y | | Y | 2 | 7.7% | 31 | 5 | 2384.6 |
| 826 | 202-21-150 | 9 | 3.9 | 1996 | Mobile | N | Y | | 3 | 7.7% | 13 | 5 | 1501.5 |
| 584 | 202-21-013M | 10 | 9.4 | 1970 | House | N | Y | | 3 | 2.4% | 21 | 5 | 750.0 |
| 585 | 202-21-013R | 11 | 9.2 | 1976 | House | Y | | Y | 2 | 2.9% | 15 | 5 | 441.2 |
| 634 | 202-21-031C | 12 | 8.7 | n/a | House | Y | | | 1 | 2.5% | 34 | 5 | 425.0 |
| 929 | 211-50-016H | 13 | 2.5 | n/a | Mobile | Y | Y | | 3 | 1.4% | 5 | 5 | 105.6 |
| 647 | 202-21-032A | 14 | 4.7 | 1976 | House | Y | | | 1 | 1.1% | 5 | 5 | 27.5 |
| 639 | 202-21-031Q | 15 | 2.7 | 1960 | House | Y | Y | | 3 | 1.0% | 0 | 5 | 0.0 |
| 148 | 203-32-006 | 16 | 10.2 | n/a | Mobile | N | Y | | 3 | <1.0% | 0 | 5 | 0.0 |

[1] "1" for outside Severe and Lateral Migration EHZ's, "2" for within Lateral Migration EHZ, and "3" for within Severe EHZ.

[2] Represents the percent chance of flood water entering a house, or flowing under a mobile, in any given year.

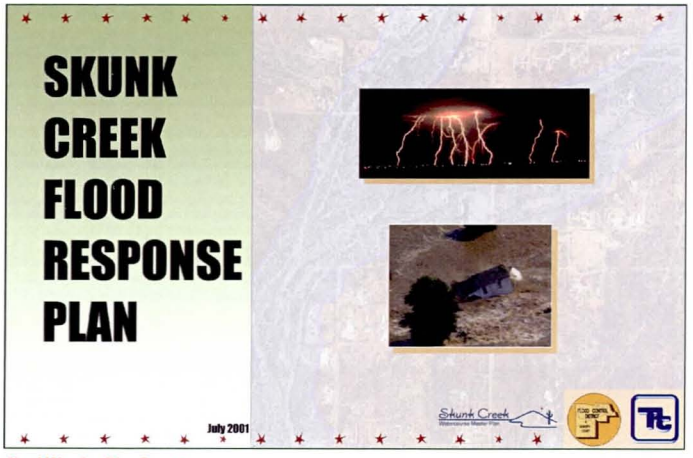
[3] Represents flow depth times velocity squared at the residence during the 100-year flood.

[4] Accounts for personal safety related to time between the most intense precipitation and the time for flood peaks to reach the residence. "1" for > than 12 hours, "2" for > 6 to 12 hours, "3" for 3 to 6 hours, "4" for 1 to 3 hours, "5" for <1 hour.

[5] 20.0% Estimates are based on a field survey of actual finished floor elevations.

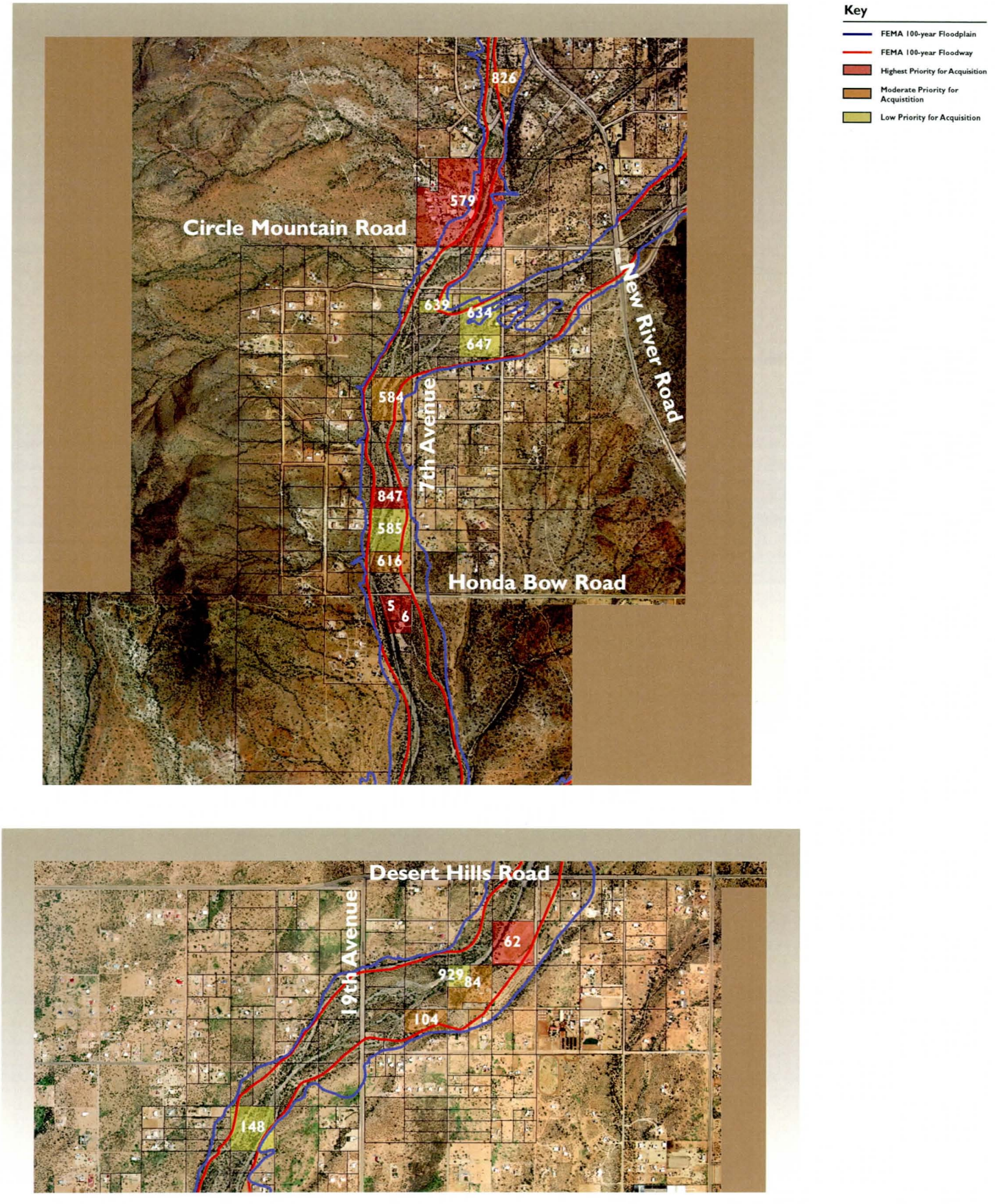
[6] 1980 is the year the house was constructed. The year the mobile was set is unknown.

A second component of the Implementation Plan, which is highly recommended, is consideration of a flood warning plan and establishment of an interim flood warning system for the existing residences located in the *FEMA 100-year floodway* and the severe *erosion* hazard zone. A third component is definition of an acquisition program for existing residences located within the high hazard areas, and a recommendation of priorities for acquisition of residences and/or property. The recommended priority for acquiring the existing residences is shown in Table 4. The location of those properties is shown on Figure 51. A fourth component is the identification of problems within the study area that require more detailed analysis than the WCMP scope of work allows. These problem areas may be studied in more detail as a part of the future Adobe Dam Area Drainage Master Plan, or through other future studies. The final component of the proposed implementation plan provides recommendations for establishing a monitoring and maintenance program.




Flood Warning Plan Report

Skunk Creek




July 1999 Aerial Photograph

**Figure 51. Location of Parcels Recommended for Inclusion in the Acquisition Program**

# 10 Glossary

***100-year Storm.*** A storm with a 100-year recurrence interval. The 100-year storm for the study area results from 5.0-inches of precipitation within a 24-hour period. The 2-year and 10-year storms result from a 24-hour precipitation of 2.3-inches and 3.4-inches, respectively.

***Avulsion.*** An avulsion occurs when the main channel relocates to another part of the floodplain during a flood. This movement may occur suddenly as a result of a single large storm, although a series of floods over a long period of time may also contribute to the avulsive process.

***Channel.*** For the purpose of this study, a channel is defined as the portion of a cross section of a watercourse that carries stormwater. A channel is characterized by its bed and banks. The channel bed is made up of sand, gravel and/or cobbles. The channel banks may be heavily vegetated or have exposed soils. A watercourse cross section can have multiple channels. These channels may vary in elevation in relation to each other.

***Computer Models.*** Computer models are used in this study to simulate natural functions for existing watershed and watercourse conditions, and to predict future watershed and watercourse conditions. The following computer models are used in this study:

Hydrology: US Army Corps of Engineers HEC-1 program.
Hydraulics: US Army Corps of Engineers HEC-2 and HEC-RAS programs.
Sediment Transport: US Army Corps of Engineers HEC-6 program.

***Cumulative Impacts.*** For the purpose of this study, cumulative impacts are a decrease in public safety, or an increase in cost to the public, within, upstream or downstream of the WCMP study area, resulting from implementation of a proposed management alternative. The key indicator for determining the existence of cumulative impacts is an increase in peak discharge resulting from floodplain encroachment. A change in peak discharge, increasing in the downstream direction as a result of floodplain encroachment, typically results in increases in flow depth and velocity, and adversely affects the sedimentation and erosion characteristics of the watercourse. These effects can jeopardize existing structural flood control improvements or result in increased damage to property. Cumulative impacts have the effect of increasing the cost of floodplain management to the public.

***Degradation.*** Degradation is the progressive lowering, over time, of the channel bed in a reach due to erosion.

***Ephemeral Watercourse.*** An ephemeral watercourse is one in which runoff occurs only in direct response to precipitation. An ephemeral watercourse does not have water flowing in it year round.

***Erosion.*** For the purpose of this study, erosion is defined as the natural process of flowing water removing soil, sand, gravel, or cobbles within a watercourse. Erosion has the effect of changing the watercourse geometry and increasing conveyance capacity. Erosion occurs naturally along all watercourses, but can be accelerated by human activities such as removal of bank vegetation, sand and gravel mining, or urbanization.

***FEMA 100-year Floodplain.*** The FEMA 100-year floodplain is defined by FEMA as an area that is flooded by a 100-year recurrence interval storm. The area so defined is based on existing watershed and watercourse conditions at the time of the study. It does not include the effects, over time, of erosion and sedimentation in the watercourse.

***FEMA 100-year Floodway.*** The FEMA 100-year floodway is defined by FEMA as an area that is reserved for conveyance of floodwaters, in which buildings or other obstructions are not allowed. The

FEMA 100-year floodway limits are established by determining the amount of fill that can be placed in the 100-year floodplain without increasing the 100-year depth of flow by more than 1 foot.

***FEMA 100-year Floodway Fringe.*** The FEMA 100-year floodway fringe is defined by FEMA as the area inside the FEMA 100-year floodplain and outside the FEMA 100-year floodway. According to FEMA regulations, buildings or other obstructions to flow can be constructed in the FEMA 100-year floodway fringe provided the structures used for human habitation are raised above the BFE.

***Habitat Value.*** Habitat value refers to the suitability of the landscape for wildlife. Relative habitat values were determined for the study area and were assigned as high, medium, and low.

***Hydraulics.*** For the purposes of this project, hydraulics is defined as the study of the ability of the watercourse to carry storm water. The hydraulic models are used to estimate the depth, width, velocity, energy, and travel time of flow through the study area.

***Hydrology.*** For the purposes of this project, hydrology is defined as the study of surface water runoff from the contributing watersheds. The hydrology models are used to estimate watershed runoff volumes and peak flow rates in relation to time during storm events, for both existing and future conditions.

***Lateral Channel Migration.*** For the purpose of this study, lateral channel migration is defined as the movement of a channel within its floodplain through the processes of bank erosion or channel avulsions. Bank erosion is a natural process whereby soil material is removed from the channel banks during floods.

***Main Channel.*** The main channel is defined as a channel that is continuous throughout the watercourse and carries the most flow.

***Natural Angle of Repose.*** The maximum angle of slope that can be maintained by the soil material in a channel bank.

***Non-Encroachment Area.*** For the purpose of this study, a non-encroachment area is the area within a watercourse management alternative where floodplain encroachment is not allowed. The uses permitted within the non-encroachment area are:

- Drainage and stormwater conveyance, in an undisturbed desert state.
- Open-space, unimproved (undisturbed desert with native landscape enhancements/restoration permitted).
- Open-space, improved (limited to passive and active recreational activities including hiking/riding trails and similar activities within a desert landscape).
- Homes or other structures may be constructed within this area, outside the FEMA 100-year Floodway, provided the structure and its foundation is designed to withstand the forces which may be imposed upon it by floodwaters, erosion, sedimentation and channel migration, to the satisfaction of the District. It must also be proven that the structure or structures will not result in cumulative impacts, or negatively impact adjacent properties. The design must be prepared and sealed by a professional civil or structural engineer licensed to practice within the State of Arizona.

***Reach.*** For the purpose of this study, a reach is defined as a portion of a watercourse in which watercourse characteristics are similar throughout the reach. Reaches can be defined based on hydrologic, hydraulic or geomorphologic similarities, or on similarities in biologic, visual, or landscape characteristics.

***Recurrence Interval.*** A recurrence interval storm or flood is defined as a storm or flood that has a specific probability of occurring within any given

year. For example, the 100-year recurrence interval storm or flood has a 1 % probability of being equaled or exceeded in any given year. The other two recurrence interval storms or floods considered in this study are the 2-year (50 % probability) and 10-year (10 % probability).

***Scour.*** For the purpose of this study, scour is defined as a lowering of the channel bed by erosion. Scour occurs at natural or man-made obstructions to flow, or at channel banks. Examples of natural obstructions are trees in the channel, or constrictions in the channel. Man-made obstructions include bridge piers and grade-control structures.

***Sediment Yield.*** Sediment yield is the amount of soil (mainly silt, sand and some gravel) that erodes from the watershed and enters the watercourse system.

***Sedimentation.*** For the purpose of this study, sedimentation is defined as the natural process of flowing water depositing soil, sand, gravel and cobbles in the watercourse or on the floodplain. Deposition in the main channel has the effect of changing the shape and dimensions of the channel and decreasing its conveyance capacity.

***Watercourse.*** For the purpose of this study, a watercourse is defined as the entire length of a wash to be studied, including the width necessary for the watercourse to function naturally. This includes the watercourse channels, over-bank floodplains, and the area the watercourse has occupied in recent geologic time (<10,000 years).

***Watercourse Conditions.*** The watercourse conditions used in hydraulic modeling are the main channel geometry (i.e., depth, width and slope) and its floodplain (areas outside the main channel that carry water), and roughness (resistance to flow). The main channel and floodplain makeup the watercourse cross section.

***Watershed Conditions.*** A watershed is the land contributing area that collects rainfall and directs it to a watercourse. The primary watershed conditions used in hydrologic modeling are the percentage of contributing area that is impervious to rainfall, the vegetative cover, soil characteristics relating to the ability to absorb and store.

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