SCANNED

# BUCKEYE/SUN VALLEY AREA DRAINAGE MASTER STUDY

CONTRACT FCD 2002C027

# VOLUME I: MASTER DOCUMENT SUMMARY

JUNE 2006

PREPARED FOR

Flood Control District of Maricopa County

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# 1.0 INTRODUCTION

The Flood Control District of Maricopa County (District) contracted with PBS&J to perform the Buckeye/Sun Valley Area Drainage Master Study (ADMS). The study area encompasses approximately 280 square miles and is divided into four (4) distinct hydrologic regions.

The Buckeye/Sun Valley ADMS work product is comprised of eight volumes in eleven bound notebooks and three independent reports as follows:

1. Volume I — Master Document Summary, June 2006
2. Volume II-A — Data Collection Report, August 2005
3. Volume II-B — Surveying Report, August 2005
4. Volume III — Area 1 Hydrology, July 2006
5. Volume IV-A — Area 2 Floodplain Delineation Federal Emergency Management Association (FEMA) Submittal, March 2006
6. Volume IV-B — Area 2 Hydrology, Hydraulics and Floodplain Delineation, February 2006
7. Volume V-A — Area 3 Hydrology, February 2006
8. Volume V-B — Area 3 Hydraulics, July 2005
9. Volume VI — Sediment Transport Studies, August 2005
    - Erosion Hazard Setbacks (Ayres and Associates), August 2005
    - Sediment Yield Analysis (Ayres and Associates), August 2005
10. Volume VII — Geomorphology Studies (Ayres and Associates), August 2005
11. Volume VIII — Supporting Documents, July 2006
    - Area 4 Summary Report (Ayres and Associates), February 2005
    - Preliminary Engineering Subsidence Report, June 2004
    - Alluvial Fan Development Technical Memorandum, July 2006
    - Stakeholder Involvement Plan, April 2006
    - Public Involvement Plan, September 2005
    - Project Administration Report, September 2005
12. Interim Guidelines for Development Report (EPG), February 2006
13. Area 1 Agricultural Analysis Report (Entellus), July 2005
14. Probable Maximum Flood (PMF) Report of Flood Retarding Basins (prepared for ADWR), March 2005

# 2.0 PROJECT AUTHORIZATION

Notice to proceed for this study was issued in June 2003 by the District. The District Contract Number for this project is 2002C027.

# 3.0 PROJECT PURPOSE & GOALS

The purpose of the Buckeye/Sun Valley ADMS is to quantify the extent of drainage, flooding, and erosion problems, sources, and hazards in the Buckeye/Sun Valley area. Arizona Revised Statutes Title 48, Chapter 21, requires the Board of Directors to identify flood control problems and prepare plans which, when implemented, will eliminate or

minimize flooding problems.

The major goals and objectives of the project include:

1. Identify drainage, flooding, and erosion hazards within the project area.
2. Develop a preliminary plan (Interim Guidelines for Development) that area floodplain managers, municipalities, and developers will use as a basis for storm drainage management.

To obtain the goals and objectives of the project, the work undertaken included public and stakeholder coordination, survey, identification of drainage problems, hydrology, hydraulics, sedimentation and geomorphic studies, sediment yield analyses for the Buckeye Structures, subsidence evaluation, environmental and visual resources overviews, and development of preliminary alternative solutions.

## 4.0 PROJECT PARTICIPATION

Project participation included interagency coordination, coordination with special interest groups and preparation of a Stakeholder Involvement Plan (SIG) and a Public Involvement Plan (PIP). Major stakeholders included:

- Flood Control District of Maricopa County
- Town of Buckeye
- Maricopa County Department of Planning and Development (MCP&D)
- Maricopa County Department of Transportation (MCDOT)
- Maricopa County Parks Department
- Roosevelt Irrigation District (RID)
- Buckeye Irrigation District (BID)
- Arizona Department of Transportation (ADOT)
- Arizona Department of Water Resources
- Arizona State Land Department
- Arizona Game & Fish Department (AGFD)
- Bureau of Land Management (BLM)
- United States Military
- Arizona Public Service Company (APS), and
- Salt River Project.

Volume VIII of the ADMS includes the SIP and PIP developed as part of the study.

## 5.0 PROJECT LOCATION

The project area for the Buckeye/Sun Valley ADMS is shown in Figure 1. The watershed is generally bounded by Gates Road to the north, the White Tank Mountains and approximately the Dean Road alignment to the east, the Gila River to the south, and the Hassayampa River to the west.

The Buckeye/Sun Valley watershed is subdivided into four hydrologically distinct areas

as described below:

1. Area 1 - Buckeye: South of I-10 , east of the Hassayampa River and north of the Gila River (includes the Town of Buckeye)
2. Area 2 - Hassayampa: Tributary area to the Hassayampa River south of the Buckeye Structures
3. Area 3 - Buckeye Structures: North of I-10
4. Area 4 - North Sun Valley: Tributary area to the Hassayampa River north of I-10

These areas are described in more detail below.

## 5.1 Area 1 - Buckeye Area

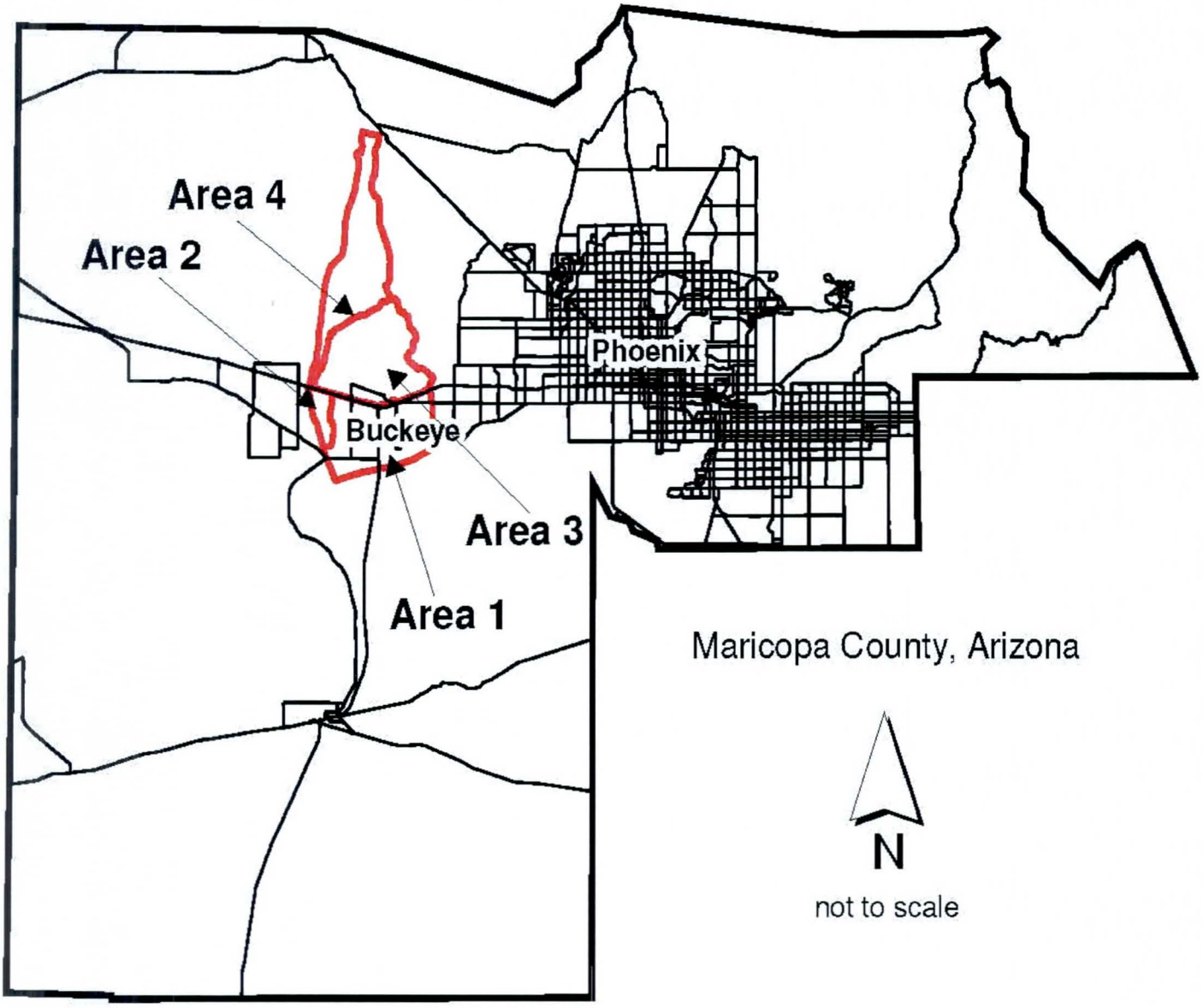
This subwatershed is south of the Buckeye Flood Retarding Structures (FRSs) and extends to the Gila River. This subwatershed is approximately 85 square miles in areal extent. Five major structures in the subwatershed impact drainage, and these include:

1. I-10 Freeway
2. State Route 85
3. Union Pacific Railroad (UPRR)
4. Roosevelt Irrigation District (RID) Canal, and
5. Buckeye Irrigation District (BIC) Canal.

These structures greatly influence the collection and movement of floodwater within the watershed. In addition, the Town of Buckeye business center is located within the lower portion of the watershed.

The predominant land use is irrigated agriculture. Within the farmed areas there is a highly developed irrigation network consisting of major canals, laterals, and sub-laterals. The land use is anticipated to be changing to residential in the future. Runoff generally flows in a north to south direction toward the Gila River. Due to the agricultural areas, few natural drainageways exist.

**Figure 1**
**Location Map**



### 5.2 Area 2 - Hassayampa Area

This subwatershed is west of the Buckeye Area and drains directly to the Hassayampa River. The watershed area covers approximately 12 square miles. The predominant land use in this area is natural desert with washes that are incised with steep slopes. Additionally, the north part of the watershed area has been diverted by the Buckeye FRS #1. The future land use in this area is anticipated to be developed into large lot residential property.

### 5.3 Area 3 - Buckeye Structures Area

Area 3 is bounded on the south by I-10 or Buckeye FRSs and is located between the White Tank Mountains and the Hassayampa River. This subwatershed begins on the west side of the White Tank Mountains and covers approximately 92 square miles. The runoff generally flows in a south to southwest direction toward three flood retarding structures (FRS) that were built by the Soil Conservation Service in the 1970's. These structures were designed to protect I-10 and agricultural lands in Area 1 during a 100-year frequency runoff event. Outflow from these structures drains west toward the Hassayampa River.

Currently, this subwatershed is primarily natural desert, although there are several residential developments within Area 3. Additionally, alluvial fans have been identified that emanate from the White Tank Mountains. A number of master planned communities are planned within this area in the near future.

### 5.4 Area 4 - North Sun Valley Area

This subwatershed contains the area to the north of the Buckeye Structures Area (Area 3) and is approximately 91 square miles. This area is mostly natural desert with two major structures that are within the area: the Sun Valley Parkway and the Central Arizona Project (CAP) Canal. The predominant land use is natural desert. There are a number of master planned communities being proposed throughout most of this area.

## 6.0 PROJECT OVERVIEW

The Buckeye/Sun Valley Project Area has been experiencing rapid and extensive growth over the last several years with projections of continued development and growth over the next 20 years.

There are four categories of land ownership within the study area: federal, state, county, and private. The percentage of land owned by each entity is:

1. 69% Private,
2. 19% State,
3. 10% Federal, and
4. 2% Maricopa County.

State lands include two AGFD units and State Trust Lands. State Trust Lands abutting

the western edge of the White Tank Mountain Regional Park (WTMRP) have been proposed for conveyance to the park as part of the Arizona Preserve Initiative (total of 5,742 acres). Federal lands include the Bureau of Land Management (BLM) and the Arizona National Guard.

Local jurisdictions within the study area include the Town of Buckeye and unincorporated Maricopa County (see jurisdiction map). The percentage of land under each jurisdiction is:

1. 43% Town of Buckeye, and
2. 56% unincorporated Maricopa County.

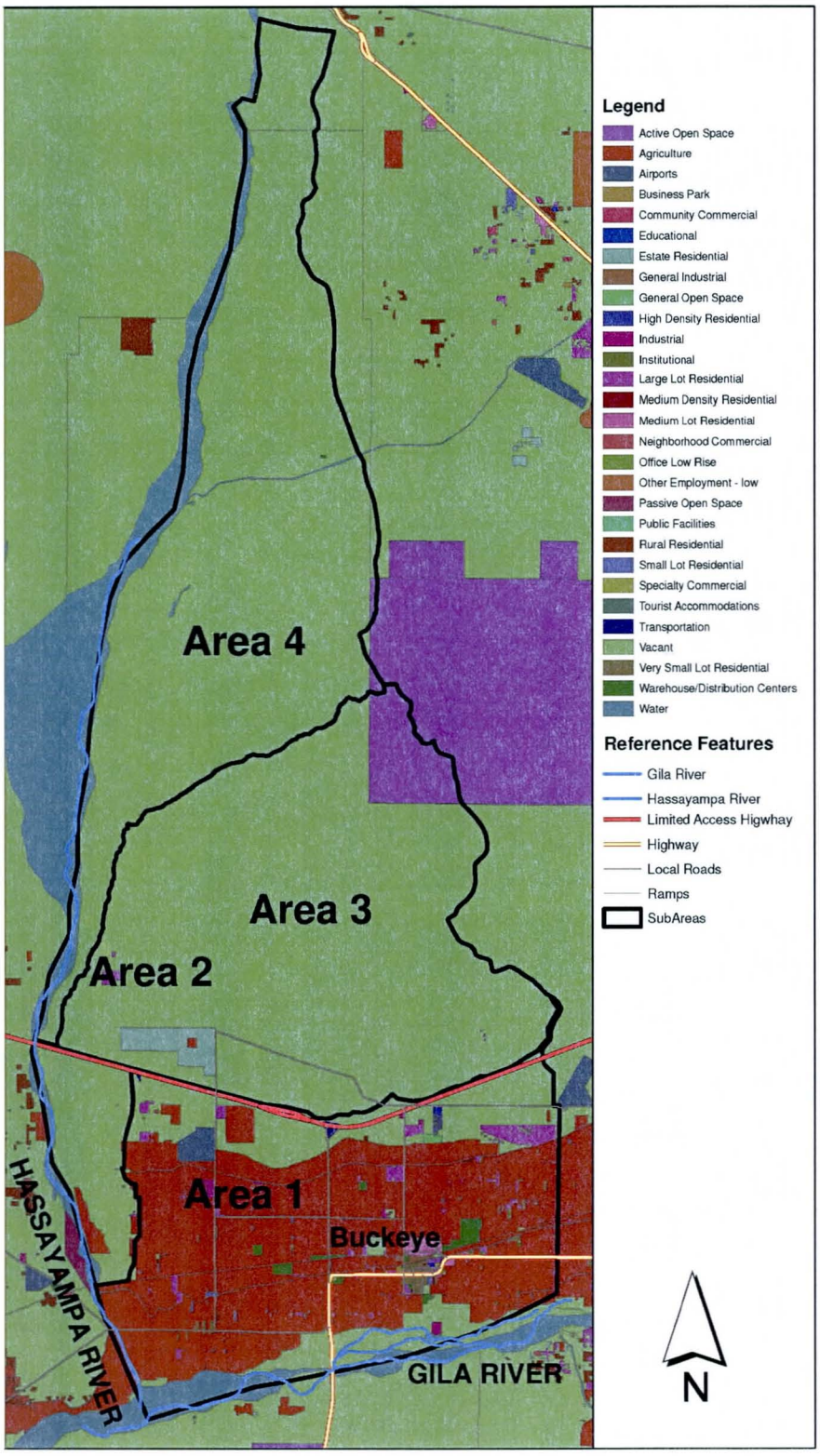
Existing land use in the study area consists generally of undeveloped desert land to the north of I-10 and agricultural lands to the south of I-10. The Buckeye area (Area 1) contains most of the existing agricultural and developed areas, including downtown Buckeye. Other land uses include open space, military use, transportation, rural/estate residential, medium-density residential, industrial, commercial, mining, grazing, public/quasi-public, and water. Figure 2 includes the existing land use within the study area per MAG 2000 that was reconciled with the Town of Buckeye land use data.

The predominant future land use, as projected by various planning documents for the area, is anticipated to be large-lot residential and neighborhood commercial. A number of large master-planned developments have already been approved, and several more are pending. As part of the Maricopa Association of Governments' (MAG) *Desert Spaces Plan*, large areas of open space are recommended for environmentally sensitive development. Other projected future land uses in the study area include mixed use, commercial, transportation, mining, military, public/quasi-public, and water. Figure 3 shows the future land uses in the Buckeye/Sun Valley study area per MAG 2000.

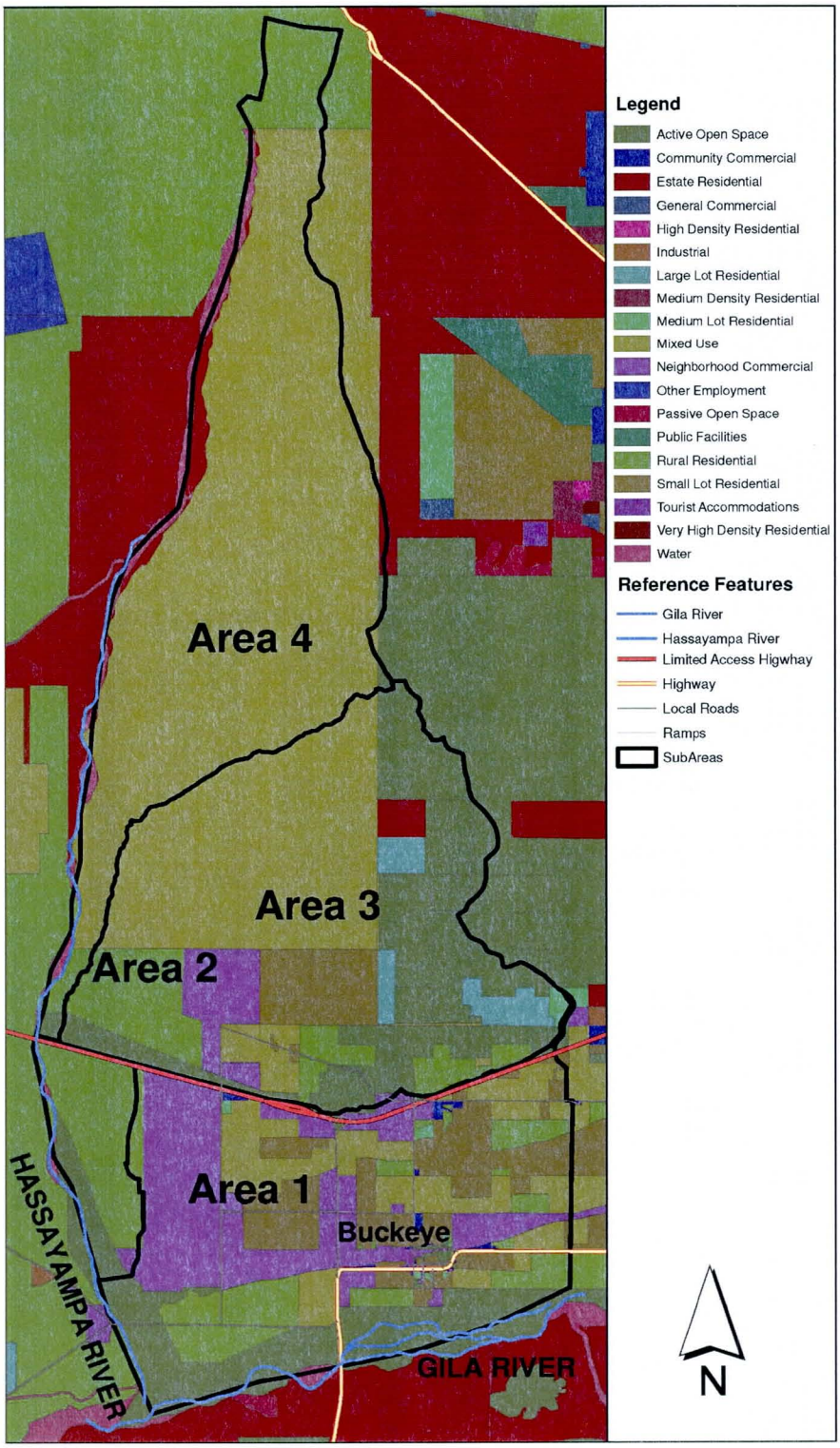
The Town of Buckeye had a population of 13,030 persons in 2003. According to local records, population within the area increased approximately 18 percent from April 1, 2000 to July 1, 2002. This growth rate is expected to continue over the next 20 years.

Existing population density is low in most of the study area, with less than 15 people per square mile. Nearly all of the current population resides south of I-10 in the Buckeye area, although there is an area north of I-10 on the western side of the study area with a population density of 50-300 people per square mile. The greatest population density is found in downtown Buckeye, where density exceeds 1,500 people per square mile.

# Figure 2
# Existing Land Use



# Figure 3
# Future Land Use



## 7.0 HISTORY OF FLOODING

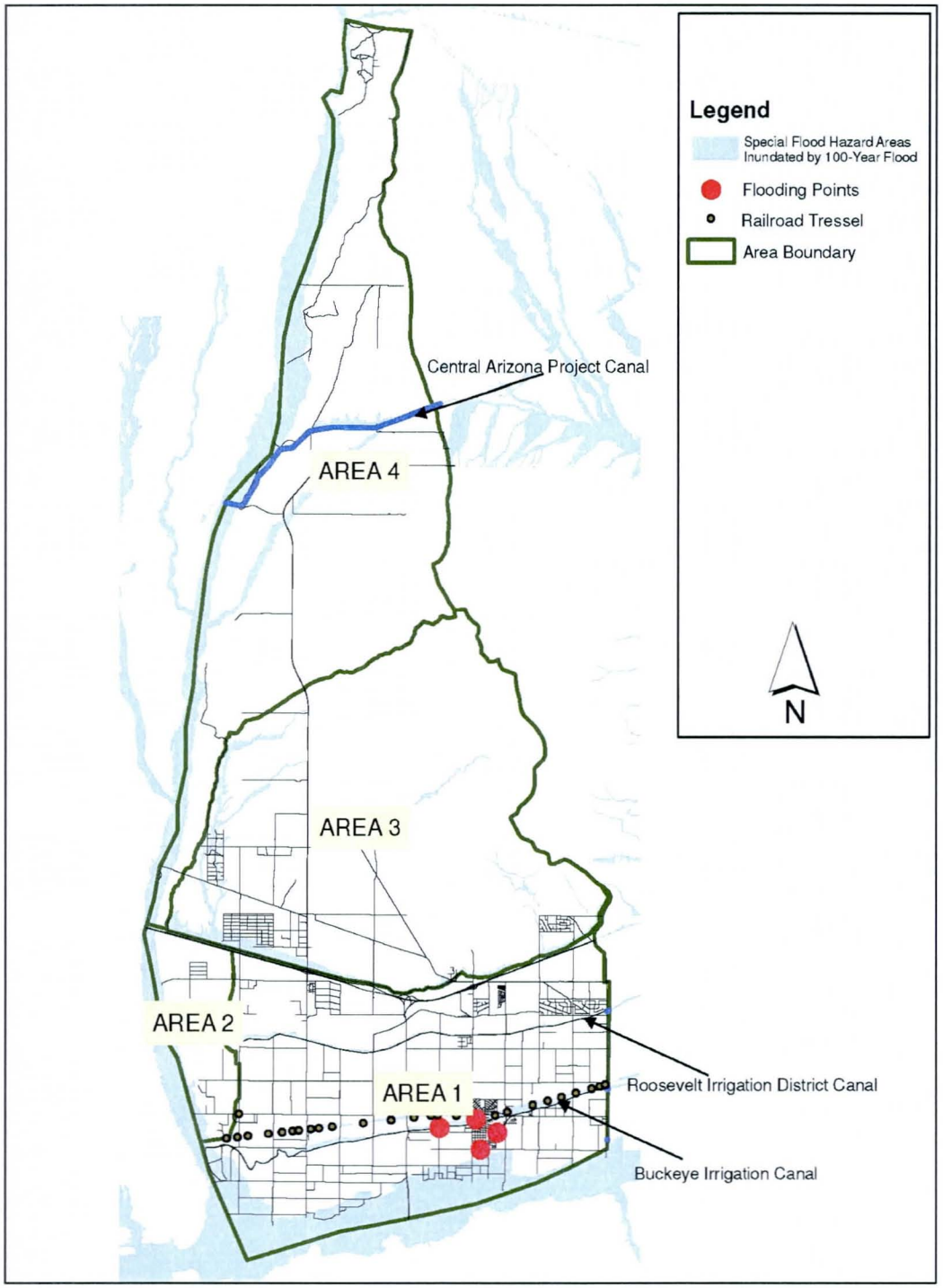
The Buckeye/Sun Valley ADMS study area is sparsely populated, with most of the existing homes and businesses located south of I-10 and clustered around Maricopa County Route 85 (MC85). Because the existing population density is primarily concentrated in the existing downtown Buckeye area, that is where flooding and drainage problems have been identified. An informational brochure and questionnaire to all property owners in the Buckeye and Sun Valley areas were mailed and assisted in identifying existing flooding problems.

Frequent flooding areas identified are as follows:

- Ponding near the rodeo grounds is caused by stormwater ponding upstream of Miller Road and the BID Canal. Existing drains that continue south on 4th Street have inadequate capacity. The problem area is bounded by the Southern Pacific Railroad (SPRR) and the BID Canal between Miller and Apache Road.
- Ponding near the city park is caused by ponding upstream of MC 85 and 9th Street. Floodwater overtops MC85 and continues south along 9th Street, causing additional ponding problems near the wastewater treatment plant south of Beloat Road. The area is located at the intersection of MC 85 and 9th Street, and continues south on 9th Street.
- Irrigation ditch on the south side of Beloat Road is used as a storm drain and the ditch runs east to west between Norton Road and Miller Road. Flood water overtops into the agricultural field south of Beloat Road. The area is located at the intersection of Beloat Road and 4th Street.
- Floodwater overtops the BID Canal near the intersection of MC 85 and Rooks Road from ponding north of the canal. The area is located at the intersection of Rooks Road and the BID Canal.

Figure 4 shows the existing major flooding sources within the study area.

# Figure 4
# Existing Flooding Sources



The District has also logged complaints for the Buckeye/Sun Valley ADMS study area (see Volume II-A, Data Collection Report). All of the logged complaints were related to modifications of drainage patterns made by property owners, such as construction of drainage swales or fences which diverted flows onto a neighboring property. Most of the modifications did not receive permits from the District, and regulatory staff has worked to bring the majority of offending property owners into compliance. Many of these areas are designated as regulated floodplains, and any new developments in these areas would require a Letter of Map Revision (LOMR) to have the area in question removed from the floodplain.

# 8.0 EXISTING DRAINAGE FACILITIES

Existing drainage facilities include the Buckeye FRS 1, 2, and 3, located upstream of I-10. The structures were designed as a system to protect I-10 and portions of the Buckeye watershed. The system includes three separate dams, each with principal and emergency spillways. Other than the Structures, storm drains and culverts were installed on major infrastructure such as the Southern Pacific Railroad (SPRR), Sun Valley Parkway, and I-10. Volume II-A, Data Collection Report, includes a tabulation of all existing drainage facilities; Volume II-B, Surveying, includes details on the drainage facilities surveyed during the course of the study.

## 8.1 Existing Infrastructure

Existing major transportation corridors within the Buckeye/Sun Valley ADMS study area include I-10, SR-85, MC85, the Sun Valley Parkway, and the SPRR. The CAP Canal crosses Area 4 north of the Sun Valley Parkway As previously noted, there are two private irrigation canals: the RID and the BID Canals which traverse Area 1.

## 8.2 Major Utilities

Major utilities in the Buckeye/Sun Valley ADMS study area include a 96-inch reclaimed water pipeline from the 91st Avenue Wastewater Treatment Plant to the Palo Verde Nuclear Generating Station. Also known as the ANPP pipeline, this is the sole coolant water supply for the power plant. There is also a large petroleum pipeline owned by El Paso Natural Gas, which crosses Area 1 south of the SPRR. Several major electric transmission lines cross through Areas 3 and 4.

Available mapping data was compiled initially and is included in the Data Collection Report (Volume II-A). Maps developed as part of the study include the boundaries of the study area, known flooding problems, land ownership, and existing and future land uses.

Existing infrastructure and major utilities within the study area were identified and were integrated into the hydrologic and hydraulic studies for each sub-watershed.

# 9.0 EVALUATIONS UNDERTAKEN

Hydrologic and hydraulic evaluations as well as stream stability and geomorphology studies were undertaken for various portions of the study area, excluding Area 1.

Volumes III through V of the ADMS provide a detailed description of the evaluations undertaken. A summary of the results of these evaluations is included below. Volumes VI and VII provide a summary of the sediment transport and geomorphic evaluations undertaken.

Previous hydrologic and hydraulic studies related to this study were reviewed and discussed. The studies that could be used as a basis for hydrology in the Buckeye/Sun Valley ADMS were identified. The studies were reviewed in sufficient detail to provide a basis for determining whether updating elements of those studies is feasible and adequate for the purposes of this project.

## 9.1 Area 1

The hydrologic analysis for Area 1 is summarized in Volume III of the ADMS. There are no expected sediment transport or geomorphologic issues within this subwatershed. Special conditions that exist are associated with the primarily agricultural nature of this subwatershed. The flat agricultural fields greatly influence the existing and future runoff rates and volumes in this area. More information on the hydrologic aspects of the existing agricultural lands can be found in the Agricultural Study Report (Entellus, 2005).

### 9.1.1 Hydrology

The hydrologic models for Area 1 were updated for both the existing and future conditions scenarios. Specifically, this study updates the most current hydrologic study that exists for the area (McLaughlin Kmetty Engineers, Ltd., 1992). The updated hydrology can be used to determine existing and future drainage problems and assist in developing alternatives to mitigate those identified problems.

The Buckeye Structures upstream of Area 1 were designed to provide protection from storms up to the one percent exceedance level. However, any emergency spillway discharges from FRS No. 1 or No. 2 flow south through the Town of Buckeye toward the Gila River. The FRSs were evaluated as part of this study in relation to ADWR dam safety requirements and the results were provided separately to ADWR.

Two major irrigation canals exist in Area 1 and these canals greatly influence the hydrologic and hydraulic characteristics of the sub-basin. The RID canal supplies irrigation water to the agricultural fields to the north of the RID and areas to the south that are between the RID and the BID Canal. The RID is built along a terrace with an unpaved access road adjacent to each bank. The canal is concrete lined with approximately one foot of earthen freeboard. Turnouts, irrigation pump stations and storage tailwater ponds occur along its length. Irrigation return flow and storm runoff are directed to the RID Canal through rundown structures along its north bank at numerous locations that are generally adjacent to the north-south roads. The overflow gates are closed during normal operation, but can be opened to drain the canal for maintenance or if excess water is threatening overtopping.

The BID Canal supplies water to the agricultural fields south of the BID and some of the fields to the north that are between the BID and RID. The construction of the BID is

similar to the RID. However, irrigation return flow rundown structures do not occur in the BID as they do in the RID.

Peak runoff rates and volumes for Area 1 were obtained using the 1998 revision of HEC-1 (version 4.1) embedded in WMS 7.0. Peak existing overflows from the RID range from approximately 200 to 750 cubic feet per second (cfs) and peak overflows from the BID range from approximately 100 to 600 cfs. Unit runoff rates for existing conditions range from 74 to 1,942 cfs/square mile and average approximately 640 cfs/square mile.

### 9.1.2 Hydraulics

Hydraulic evaluations for Area 1 were not evaluated as there are no defined flow paths within the area. However, several areas where the existing canals would overtop and spill during extreme runoff events have been estimated.

## 9.2 Area 2

The hydrology and hydraulics for Area 2 are summarized in Volume IV of the ADMS report. Geomorphology and erosion hazards are summarized in Volume VI and VII, respectively of the ADMS.

### 9.2.1 Hydrology

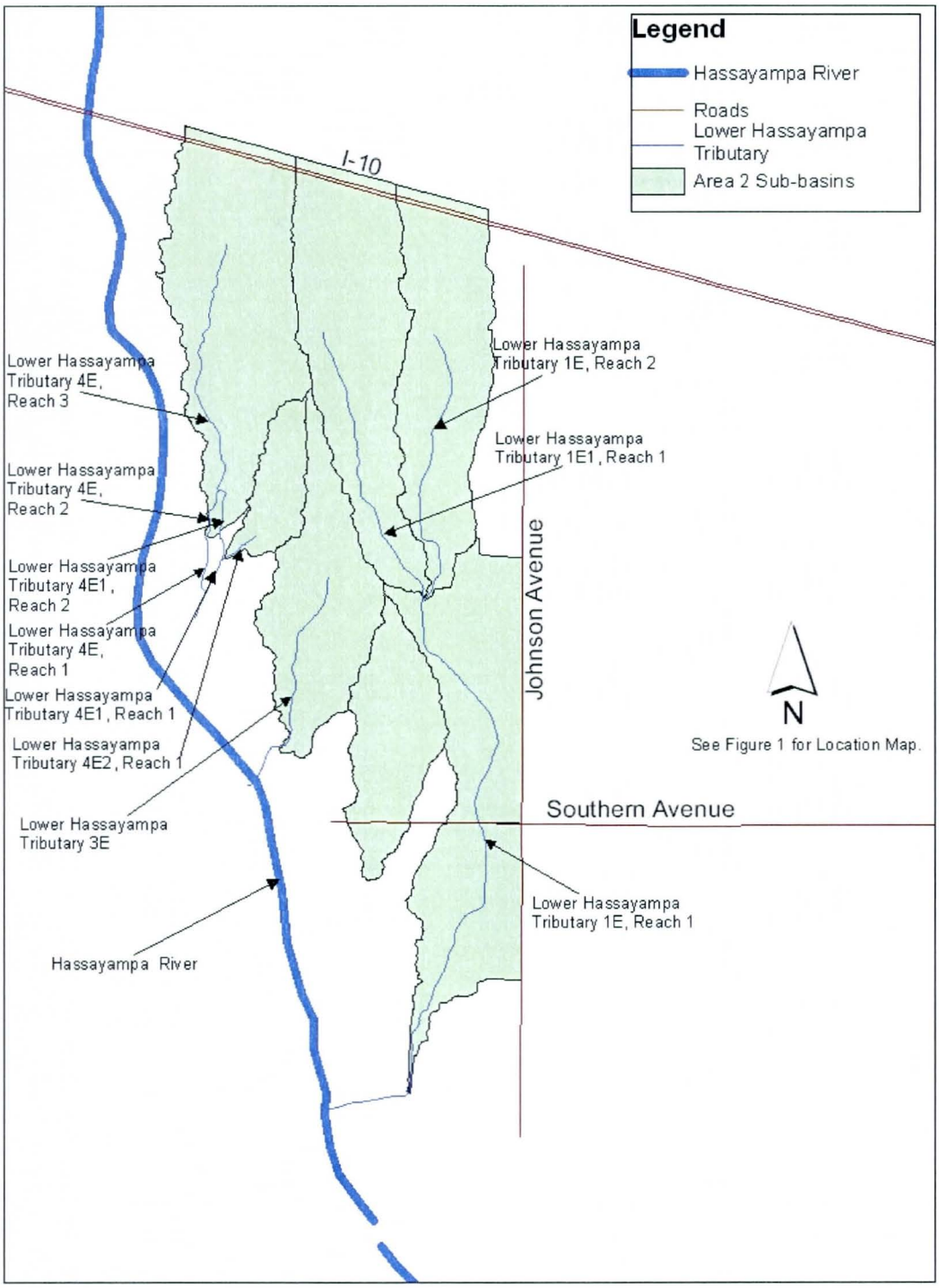
The hydrology for Area 2 was developed utilizing the U. S. Army Corps of Engineers HEC-1 (May 1998) computer program embedded in WMS 7.0 (January 2003). The HEC-1 model parameters were determined using the methods described in the District's Hydrology Manual (Sabol et al, 1995). Both the 6-hour duration and the 24-hour duration rainfall depths were evaluated for the 2-, 10-, 50-, and 100-year frequency events. The results of the hydrologic evaluations indicated that the 6-hour duration rainfall depths and distributions generated generally larger peak runoff rates and volumes. The future condition hydrologic analysis indicates an increase in runoff volume of approximately 13%. The future on-site retention volume requirement is intended to handle the 100-year, 2-hour peak discharge.

### 9.2.2 Hydraulics

Hydraulic evaluations for several flood prone tributaries to the Hassayampa River were undertaken as part of the evaluations. The hydraulics of these tributaries were evaluated utilizing the U. S. Army Corps of Engineers HEC-RAS computer program. Six reaches were evaluated and delineated for the 100-year frequency event. Figure 5 shows the Area 2 Lower Hassayampa Tributaries. These reaches included:

1. Lower Hassayampa Tributary 1E,
2. Lower Hassayampa Tributary 1E1
3. Lower Hassayampa Tributary 3E,
4. Lower Hassayampa Tributary 4E,
5. Lower Hassayampa Tributary 4E1, and
6. Lower Hassayampa Tributary 4E2.

# Figure 5
# Area 2 Lower Hassayampa Tributaries



These reaches are intended to become federally regulated floodplains under the National Flood Insurance Program (NFIP) directed by FEMA. Hydraulic parameters were estimated based on a site review, standard engineering practices, and guidelines outlined by the District. Peak discharges used in the hydraulic modeling were based on the peak discharges determined from the existing conditions hydrologic evaluation. For more details refer to Volumes IV-A and IV-A.

### 9.2.3 Sediment Transport Studies

Sediment transport studies within Area 2 included an evaluation of the recommended erosion hazards setbacks for selected major drainageways and an evaluation of the geomorphic characteristics and stability of existing natural drainageways.

*Erosion Hazards Setbacks*

Erosion hazard setbacks for watercourses within Areas 2 and 3 that have existing FEMA Flood Insurance Study (FIS) floodplain delineations were determined as part of the evaluations. Hydraulic and hydrologic data used to delineate the erosion hazard setbacks were provided by the District for watercourses in Area 3 from existing FIS floodplain delineations (detailed), and hydraulic and hydrologic studies prepared by PBS&J were used for the watercourses in Area 2. Once the Level 1 setbacks were delineated, a field reconnaissance was conducted to review the adequacy of the defined setback and identify those reaches where the Level 1 approach is inadequate or inappropriate. Where the Level 1 approach was not adequate or appropriate, erosion hazard setbacks were delineated using geomorphic methods.

*Geomorphic Characteristics and Stability of Natural Washes*

Geomorphic evaluations were undertaken in order to determine the overall stability of existing alluvial fans and natural washes within Areas 3 and 4. The overall stability of these geomorphic features was evaluated based on a review of available aerial photography, topographic mapping, and field reconnaissance. Portable GPS equipment was utilized to identify areas of instability, and these areas are summarized on several maps included in Volume VII.

## 9.3 Area 3

The hydrologic and hydraulic evaluations undertaken for Area 3 are summarized in Volume V of the ADMS. The erosion hazards and geomorphology studies undertaken are summarized in Volumes VI and VII of the ADMS.

The Buckeye Structures were originally designed to protect I-10, farmlands, and the Town of Buckeye from the 100-year flood; consequently, the storage pool was intended to contain the runoff volume from the 100-year storm event. The adequacy of the spillway is determined by evaluating the PMF.

### 9.3.1 Hydrology

The hydrology for Area 3 was developed utilizing HEC-WMS 7.0 (January 2003). The results were used to obtain frequency-stage relationships for the Buckeye Structures and as the basis for unsteady flow flood routing through the reservoirs. This study also provides updated hydrologic models for both the existing and future conditions; specifically this study updates the current hydrologic study for the area (Alpha Engineering, 1996). The updated hydrology can be used to determine existing and future drainage problems and as the basis for developing alternatives to mitigate those identified problems.

The peak discharge hydrographs from all the events were used as input for an unsteady hydraulic model of the Buckeye Structures to develop a frequency-stage relationship, facilitate FRS management, and prepare an update of the emergency action plan for the structures (see the PMF report to ADWR for further details).

For the future condition hydrologic analysis, the major changes to the model included revision of the land use classification, which affected the rainfall loss parameters and added 80% of the 100-year, 2-hour on-site retention requirement to the model. For storm events less than 100-year recurrence frequency, peak discharges and runoff volumes are effectively attenuated by the retention basins. For the 100-year or greater storm event, however, a 10~15% increase of peak discharge and runoff volume compared to pre-development conditions was observed. This increase raises the maximum water surface elevations in the Buckeye Structures approximately 0.2 foot for the storm events.

### 9.3.2 Hydraulics

The purpose of the hydraulic analysis is to quantify the extent of overtopping by various storm events up to the PMF and develop dynamic stage-frequency relationships for the Buckeye Structures to facilitate dam management and risk assessment. Because the Buckeye Structures are very long, the use of level pool routing methods to represent system response during major storms has been questioned. Dynamic routing methods are believed to provide a better assessment of flooding conditions for long dams; however, the modeling is more complex and labor-intensive. As a result, the District requested that PBS&J evaluate the operation of the Buckeye Structures using an alternative dynamic routing approach.

This was accomplished by conducting an unsteady flow analysis of FRS hydraulics using the U.S. Army Corps of Engineers HEC-RAS (Version 3.1.1) computer program. Associated with the FRS hydraulics analysis, downstream inundation mapping for emergency spillway discharges from FRS No. 2 and No. 3 to the RID Canal was developed. The emergency spillway inundation analyses were included in a separate report. Another objective is to determine whether the HEC-RAS model can provide a cost-effective alternative to two-dimensional modeling for this type of study.

Eight storm events (both existing and future conditions) were simulated in the HEC-RAS unsteady models. The results were compared to level pool routing results. A summary of the hydraulic results is presented below:

1. The original FRS design can safely contain and convey runoff for storms up to the 500-year event without overtopping the emergency spillways.
2. Emergency spillways for all FRSs are overtopped during the PMF; however, the discharge capacity of the spillways is not fully utilized.
3. The unsteady model analyses can identify problems with existing associated structures (roadways and culverts, principal spillway, etc.) that are ignored in less sophisticated models.
4. Additional analyses with floodway overtopping were conducted. The results highlight the following considerations in future dam rehabilitation:
5. The original analyses provide the minimum depths to be leveled for the floodways to avoid overtopping during a PMF event.
6. The additional analyses provide the maximum overtopping discharges for the floodways, which could be a weak link in the Buckeye Structures system.
7. Transverse roadways affect the FRS hydraulic characteristics significantly. More discharge could be expected at the emergency spillways if the roadways did not exist.
8. The floodway discharge does not affect the emergency spillway hydraulic profile.

### 9.3.3 Sediment Transport Studies

Sediment transport studies within Area 3 included an analysis of the sediment yield to the FRS, an evaluation of the recommended erosion hazards setbacks for selected major drainageways, and an evaluation of the geomorphic characteristics and stability of existing natural washes and drainageways.

***Sediment Yield Evaluations***

The 100-year storm event sediment yield for each of the three Buckeye FRSs was estimated as part of the study. These results were compared to the results of the original sediment yield analysis performed for the design of the structures.

Field reconnaissance was performed to locate and measure areas of deposition along the FRSs. Sediment samples were taken at various locations and the depths of the deposition were estimated. In some places, the outline of the deposition zone was determined; otherwise, the deposition area was measured using 2003 aerial photography. The data collected in the field were used to estimate the volume of sediment deposition along each FRS. ArcGIS was the Geographic Information System (GIS) software used for the sediment yield analysis.

The analysis was accomplished using Universal Soil Loss Equation, RUSLE2, and a concentration by volume approach. The concentration by volume approach gave the most reasonable results and the deposition trends for this approach were analyzed.

Deposition trends were examined for each of the sub-basins of the FRS drainage areas. Deposition was determined using the sediment loading for both the 100-year, 24-hour storm and the 100-year, 6-hour storm for each of the sub-basins, given the calculated

sediment load for each concentration level. The deposition area was obtained using the 100-year, 24-hour and 100-year, 6-hour storm pool areas provided by PBS&J. It was assumed that the ponded area of the 100-year flows would be a reasonable estimate of where the sediment load from the sub-basins would be deposited. The pool area for each sub-basin was calculated using ArcGIS software.

These estimated depths should not be utilized to determine actual overtopping depths along each FRS, but instead only to reveal the depositional trends that might occur during the 100-year 6-hour storm and 100-year 24-hour storm events. As expected, the results show that the estimated depths for a 50 percent concentration are rather large, even given depths above 30 feet for sub-basins N, O, P, and Q. The results for a 50 percent concentration are extremely conservative given that even in a mudflow event, concentrations this high would not be expected throughout the entire storm event. At the other extreme, a 5 percent concentration might be on the low side for a storm as large as the 100-year occurring in an arid region with active alluvial fans. Therefore, it is reasonable to conclude something between the 5 percent concentration and the 20 percent concentration. There were four sub-basins that showed a higher depositional potential. This is consistent with the deposition depths seen in the field reconnaissance.

A qualitative assessment of the existing conditions for 46 primary washes within Areas 3 and 4 was undertaken as part of the ADMS. The primary washes assessed are defined as those intermittent streams and washes delineated by a combination dot and dash blue line on the USGS 7.5-minute topographic quadrangle maps for the study area. All primary washes including White Tank Wash and its primary tributaries are included in the assessment

The existing geomorphic characteristics and identified stream reaches that could be problematic with regard to lateral and vertical instability under existing and future developed conditions were determined through an extensive field investigation of the area.

### *Erosion Hazards Setback*

Erosion hazard setbacks for watercourses within Areas 2 and 3 that have existing floodplain delineations were determined as part of the evaluations. Hydraulic and hydrologic data used to delineate the erosion hazard setbacks were provided by the District for watercourses in Area 3 from existing floodplain delineations (detailed), and hydraulic and hydrologic studies prepared by PBS&J were used for the watercourses in Area 2. Once the Level 1 setbacks were delineated, a field reconnaissance was conducted to review the adequacy of the defined setback and identify those reaches where the Level 1 approach is inadequate or inappropriate. Where the Level 1 approach was not adequate or appropriate, erosion hazard setbacks were delineated using geomorphic methods.

### *Geomorphic Characteristics and Stability of Natural Washes*

Geomorphic evaluations were undertaken in order to determine the overall stability of

existing alluvial fans and natural washes in within Areas 2, 3 and 4. The overall stability of these geomorphic features was evaluated based on a review of available aerial photography, topographic mapping, and a site field reconnaissance. Portable GPS equipment was utilized to identify areas of instability; these areas are summarized on several maps included in Volume VII.

### 9.3.4 FRS Analysis for Area 3

To analyze the Buckeye FRS structures, the District requested a comparison of extreme event peak flows, presented as a ratio of the 100-year event. The analysis indicates that the 10-year storm varies between 30 to 50%, while the 200-year and 500-year events average 120% and 145%, respectively. The 6-hour PMF, which in this study is greater than the 72-hour PMF, generates flows that are 500% of the 100-year storm.

Extreme event runoff volumes were also compared to the 100-year storm. The 10-year event averages 45% of the 100-year event, while the 200-year event produces 115% more than that of 100-year event. The 500-year event produces about 140% of the 100-year event; and the 6-hour PMP, which again was greater than the 72-hour PMP, is 600% of the 100-year event.

Overtopping of the FRS crest during the PMF occurs only on portions of FRS No. 1 and No. 2.

## 9.4 Area 4

Area 4 was not studied by detailed hydrologic/hydraulic methods; rather, a summary of existing evaluations and studies was undertaken.

There are several proposed developments within Area 4 north of Wagner Wash and the CAP Canal. Work in Area 4 included a review of available Master Drainage Plans for the proposed developments to identify any geomorphic problems or inconsistencies associated with development along primary watercourses area and identify those areas where additional studies may be required.

The following documents were reviewed as part of the work:

1. FIS for Wagner Wash (FEMA, 1991),
2. Festival Ranch Master Drainage Study (Kimley-Horn, 2000),
3. Festival Ranch Drainage Plan & Update to Master Drainage Plan (CVL, 2003),
4. Sun Valley Preliminary Master Drainage Study (Erie & Associates, 2001), and
5. Spurlock Ranch Drainage Master Plan (CMX, 2003).

The FIS for Wagner Wash was examined because Wagner Wash provides base level control for many of the washes in Area 4 that drain to it from the north. The primary area of concern is the reach located between the two crossings of the Sun Valley Parkway and the reach upstream of the parkway. The profile of Wagner Wash, which is based on 1990 topographic mapping, between the crossings shows a distinct knickzone that extends

from the upper crossing to about 3,500 feet downstream. There is a maximum grade change on the profile of about 4 feet over about 660 feet just downstream of the crossing.

A recent field examination revealed that the wash in this reach is indeed incised. Currently, there is a large, 4-5 foot high boulder drop structure in place across the channel immediately downstream of the upstream parkway crossing, which verifies that the wash has undergone at least 4 feet of incision recently. This incision on Wagner Wash poses a potential problem to tributary washes downstream of the drop structure in that the incision on Wagner Wash can and will induce incision and headcutting in the tributary washes. Tributary washes on the south side of Wagner Wash are already exhibiting evidence of incision and headcutting. If the grade on the northern tributary streams is not controlled, incision and channel widening may progress upstream and create severe erosion problems and threaten development along unprotected areas.

A similar situation with the potential for future problems exists upstream of the parkway near the aqueduct where Wagner Wash was previously captured by a stock tank. The tank dam has since been breached and the wash passes through the dam along a steep knickzone with a 4–foot drop over a distance of about 170 feet. The tributary channels in this area also exhibit evidence of active incision and widening.

The drainage basins north of the CAP Canal flow southerly and pond along its upstream dikes. There are two existing concrete overflow structures designed for the 100-year frequency, 6-hour duration flow to cross the aqueduct and drain into Wagner Wash. The ongoing incision of Wagner Wash between the parkway and the canal could be exacerbated by clear water releases from the upstream ponded area.

For the most part, the drainage plans for the proposed developments in Area 4 call for some form of retention and/or detention and maintaining existing drainage patterns in their natural conditions and locations wherever possible. The use of retention and detention basins is primarily based on the large, infrequent flow events like the 100-year 2-hour storm (retention) or the 100-year 6-hour storm (detention). The downstream channels may require grade control to counter the potential erosion associated with clear water releases from these basins.

However, the review of the drainage plans reveals that there does not appear to be any concern with smaller, more frequent flow events, which could be problematic. The increase of impervious area associated with development means that there will likely be more frequent, flashy runoff from small precipitation events because of the decrease in infiltration of precipitation. This can lead to an increase in erosion potential along unprotected washes. In addition, an increase in the frequency of flow events and even the potential development of intermittent base flows can induce the colonization and growth of riparian vegetation along a channel. In turn, an increase in the amount and density of riparian vegetation can potentially induce narrowing and degradation of the channel over time.

## 10.0 IDENTIFICATION OF PROBLEM AREAS

Existing and future flooding and drainage related problems that were identified during the course of this study are provided below:

**Area 1**

1. The Buckeye Structures in Area 3 protect the majority of Area 1 from flooding due to extreme rainfall-runoff events occurring in the upper portions of Area 2. However, both the RID and the BID can overtop during extreme rainfall-runoff events that occur within Area 1. Flow paths are generally not well defined. As development occurs within Area 1, the peak runoff volumes and flow rates are expected to increase significantly. As shown in Figure 4, Existing Flood Sources, one can see that a majority of the drainage complaints occur in Buckeye.

**Area 2**

1. Several flood-prone tributaries to the Hassayampa River in Area 2 have been delineated for the 100-year frequency event.
2. There are several active alluvial fans and unstable washes within Area 2 that will require consideration and potential mitigation as development occurs within and adjacent to these areas.

**Area 3**

1. There are concerns with the sedimentation within the Buckeye Structures and the overall dam safety of the earthen embankments that is currently being investigated by others.
2. There are several active alluvial fans and unstable washes within Area 3 that will require consideration and potential mitigation as development occurs within and adjacent to these areas.

**Area 4**

1. There are several active alluvial fans and unstable washes within Area 4 that will require consideration and potential mitigation as development occurs within and adjacent to these areas.

## 11.0 ACRONYM LIST

| | |
|---|---|
| ADMP | Area Drainage Master Plan |
| ADMS | Area Drainage Master Study |
| ADOT | Arizona Department of Transportation |
| ADWR | Arizona Department of Water Resources |
| APS | Arizona Public Service |
| BID | Buckeye Irrigation District |
| BLM | Bureau of Land Management |

| | |
|---|---|
| CAP | Central Arizona Canal |
| cfs | cubic feet per second |
| FEMA | Federal Emergency Management Agency |
| FIS | Flood Insurance Study |
| FRS | Flood Retarding Structures |
| GIS | Geographic Information Systems |
| MAG | Maricopa Association of Governments' |
| MCDOT | Maricopa County Department of Transportation |
| MCP&D | Maricopa County Department of Planning and Development |
| NFIP | National Flood Insurance Program |
| NTP | Notice to Proceed |
| PIP | Public Involvement Plan |
| PMF | Probable Maximum Flood |
| PMP | Probably Maximum Precipitation |
| RID | Roosevelt Irrigation District |
| SCS | Soil Conservation Service |
| SPRR | Southern Pacific Railroad |
| TDN | Technical Data Notebooks |
| UPRR | Union Pacific Railroad |
| USACE | United State Army Corps of Engineers |
| WTMRP | White Tank Mountains Regional Park |

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