JULY 2005

BUCKEYE/SUN VALLEY AREA DRAINAGE MASTER STUDY
TECHNICAL DATA NOTEBOOK

CONTRACT FCD 2002C027

VOLUME VI: SEDIMENT TRANSPORT STUDIES

FINAL

PREPARED FOR

Flood Control District of Maricopa County

2801 W. DURANGO STREET
PHOENIX, ARIZONA 85009-6399

PREPARED BY

PBSJ

7310 N. 16TH STREET, SUITE 310
PHOENIX, ARIZONA 85020-5250
PHONE: (602) 943-1003 FAX: (602) 943-1303

IN ASSOCIATION WITH

LTM Engineering, Inc
epg
AYRES ASSOCIATES
Entellus

JULY 2005
BUCKEYE/SUN VALLEY AREA DRAINAGE MASTER STUDY
TECHNICAL DATA NOTEBOOK CONTRACT FCD 2002C027
VOLUME VI: SEDIMENT TRANSPORT STUDIES

TECHNICAL MEMORANDUM T2.6.7

Sediment Yield Analysis (Subtask 2.6.7)
Buckeye/Sun Valley Area Drainage Master Study

Contract No. FCD 2002C027

Prepared for:

Flood Control District of Maricopa County

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Prepared by:

AYRES ASSOCIATES

Ayres Associates Inc
3665 JFK Parkway
Building 2, Suite 200
Fort Collins, Colorado 80525

REGISTERED GEOLOGIST
CERTIFICATE NO
39950
WILLIAM J.
SPITZ
Date Signed 05/29/05
ARIZONA, U.S.A.

May 2005

AYRES ASSOCIATES

TECHNICAL MEMORANDUM T2.6.7

To: Kathryn Gross, Valerie Swick – Flood Control District of Maricopa County, AZ

From: William J. Spitz, R.G., Anthony Alvarado, and Jim Schall, Ph.D.

Date: May 20, 2005

Re: **Technical Memorandum T2.6.7 (Contract No. FCD 2002C027)**
Buckeye/Sun Valley ADMS Sediment Yield Analysis (Subtask 2.6.7)

This Technical Memorandum (TM) is submitted by Ayres Associates in support of Subtask 2.6.7 of the Buckeye/Sun Valley Area Drainage Master Study (ADMS) Scope of Work (Contract FCD 2002C027).

The Buckeye/Sun Valley Area Drainage Master Study (ADMS) is being performed for the Flood Control District of Maricopa County (District) and the Town of Buckeye under Contract FCD. 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, and develop preliminary solutions to mitigate the identified concerns. Arizona Revised Statutes Title 48, Chapter 21, requires the Board of Directors to identify flood control problems and prepare plans that, when implemented, will eliminate or minimize flooding problems.

Task 2.6 represents the Geomorphic Evaluation and Landform Stability Assessment portion of the Scope of Work (SOW). The purpose of Task 2.6 is to provide a qualitative assessment of potential erosion and sedimentation hazards of primary washes, lateral and vertical stream instability, piedmont landform stability within the drainage networks of Area 3 (Buckeye Structures) and Area 4 (North Sun Valley) of the Buckeye/Sun Valley ADMS watershed, evaluate the 100-year storm event sediment yield for each of the three Buckeye Flood Retarding Structures (FRS), and delineate erosion hazard zones for watercourses within Areas 2 and 3 that have existing FEMA Flood Insurance Study (FIS) floodplain delineations.

1. OBJECTIVE

This TM documents the methodology and results of the sediment yield analysis performed under Subtask 2.6.7 by Ayres Associates. The objective of Subtask 2.6.7 was to evaluate the 100-year storm event sediment yield for each of the three Buckeye Flood Retarding Structures (FRS) and compare the results with the original sediment yield analysis performed for the design of the structures. Included in this TM is supporting documentation for the analysis with examples of the various calculations used.

2. METHODS

2.1 Field Data Collection

Field reconnaissance was performed to locate and measure areas of deposition along the FRSs. Sediment samples (**Figure 2.1**) 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 the 2003 MrSID aerial photography of the location.

Figure 2.1. Bulk sediment sample taken at the downstream end of White Tanks Wash.

All Terrain Vehicles (ATVs) with utility racks were the main mode of transportation used in the field reconnaissance (**Figure 2.2**). The Trimble GeoXT, which is shown mounted on the ATV in **Figure 2.3**, is part of the Trimble GeoExplorer CE Series, a handheld Windows CE device with an integrated Trimble GPS receiver. The GPS system uses the Wide Area Augmentation System (WAAS), which was created by the Federal Aviation Administration (FAA) as a free-to-air differential correction service. With Windows CE, the device is capable of incorporating mobile Geographic Information System (GIS) field software. The Trimble GeoXT provides sub-meter GPS accuracy with the portability of a fully editable mobile GIS database. For this project, the software used was ESRI's ArcPad 6.0, which is the mobile form of ArcGIS with GPSCorrect.

Figure 2.2. All Terrain Vehicle used for field data collection.

Figure 2.3. The Trimble GeoXT handheld GIS-based GPS unit (arrow) mounted on the ATV.

Using ArcPad with the georeferenced aerial orthophotography and the GPS Tracking Log, photos taken in the field were georeferenced and the sediment sample locations were accurately determined.

The portability of the Trimble GeoXT for use with the ATVs was accomplished using a GPS-mount placed on the front utility rack of the ATV. The mounted GPS was readily visible and allowed for easy tracking of the current location and navigation to a specific site.

2.2 Measurement of Sediment Deposition Volumes

The data collected in the field were used to estimate the volume of sediment deposition along each FRS. ArcGIS was the GIS software used for the sediment yield analysis. Ten-foot contour topography and 2003 MrSID orthophotography were obtained from the District and overlaid in ArcGIS. The topography and orthophotography were then utilized to guide the delineation and measurement of the actual deposition zones. The volume of sediment deposited along each FRS over the past 30 years was then calculated using the measured areas and field-estimated depths. **Table 2.1** presents the results as well as latitude and longitude locations of each major zone of deposition identified in the field or by using the orthophotography. If the average depth of deposition was unknown, a conservative estimated depth of 1 foot was used. **Figure 2.4** shows the FRS Area 3 drainage basins and sub-basins with the location of each deposition zone and the active alluvial fans in the area.

The largest volume of deposited sediment is found along FRS #1, which captures drainage from areas that include White Tank Wash and the major active alluvial fans at USGS Sites 36 through 39, as well as two lesser active fans identified in the field. The largest contribution of sediment (at Deposition Zone #1) is from the active fan area of USGS Site 36 (White Tank Fan).

Table 2.1. Major Depositional Zones along the Buckeye Flood Retarding Structures.

#	Latitude	Longitude	FRS	Area (ft^2)	Average Depth (ft)	Volume (ac-ft)	Total FRS Volume
1	33° 27' 24.07"	112° 44' 38.90"	1	462,168	1.8	19.1	44.6
2	33° 27' 09.13"	112° 43' 27.61"	1	67,577	2.8	4.3	
3	33° 26' 52.34"	112° 42' 13.36"	1	123,181	1.0	2.8	
4	33° 26' 19.52"	112° 39' 48.39"	1	11,688	2.0	0.5	
5	33° 26' 08.85"	112° 38' 52.28"	1	72,852	2.5	4.2	
6	33° 26' 02.85"	112° 38' 24.23"	1	11,456	1.0	0.3	
7	33° 26' 03.45"	112° 36' 27.09"	1	584,376	1.0	13.4	
8	33° 26' 25.95"	112° 35' 43.98"	2	24,080	1.0	0.6	2.7
9	33° 26' 24.04"	112° 34' 37.43"	2	11,358	1.5	0.4	
10	33° 26' 33.42"	112° 34' 18.61"	2	6,276	2.0	0.3	
11	33° 26' 34.75"	112° 34' 17.19"	2	21,032	2.8	1.4	
12	33° 26' 55.39"	112° 33' 17.48"	3	29,545	1.0	0.7	3.0
13	33° 27' 03.79"	112° 32' 48.39"	3	6,879	2.5	0.4	
14	33° 27' 02.17"	112° 32' 39.78"	3	10,773	2.0	0.5	
15	33° 27' 03.08"	112° 32' 37.44"	3	11,930	2.0	0.5	
16	33° 27' 36.36"	112° 31' 41.74"	3	9,265	3.0	0.6	
17	33° 28' 01.80"	112° 31' 31.98"	3	23,291	0.5	0.3	

2.3. Initial Comparison With Original FRS Study

The only previous sediment yield study completed on the Buckeye FRSs was conducted on the area at the east edge of FRS #1 on sub-basin Q1 (**Figure 2.5**). This calculation was performed in 1974 by the Soil Conservation Service (SCS) using the Universal Soil Loss Equation (USLE) method. The study provides an estimated sediment yield of 0.015 ac-ft per square-mile per year and a volume of deposition over 25 years equal to 6 ac-ft (**Table 2.2**). This equals an average annual sediment storage in sub-basin Q1 of 0.09 ac-ft/mi^2/yr for the 25-year period.

Table 2.2. Comparison of 1974 and 2004 Estimated Volume Calculations at Sub-basin Q1.

Study	Deposition Area (ft^2)	Volume (ac-ft)	Sediment Storage (ac-ft/mi^2/yr)
2004 Measured (Zone #7)	314,353*	7.2 (30 yrs)	0.09
1974 USLE Analysis	440,000	6.0 (25 yrs)	0.09

*The western part of Deposition Zone #7 falls outside of the sub-basin Q1 and therefore was not included in the comparison.

Deposition Zone #7, which was an area that was measured in the field in 2004, matches the outlet area for the SCS sub-basin Q1. Based on the field measurements of the area, the estimated deposition volume that occurred over the past 30 years is 7.2 ac-ft, which produces an average annual sediment storage of 0.09 ac-ft/mi^2/yr.

From the results of this comparison, it can be concluded that the 1974 analysis of this area was reasonable and that some of the same assumptions made in the SCS analysis can also be made in the current analysis.

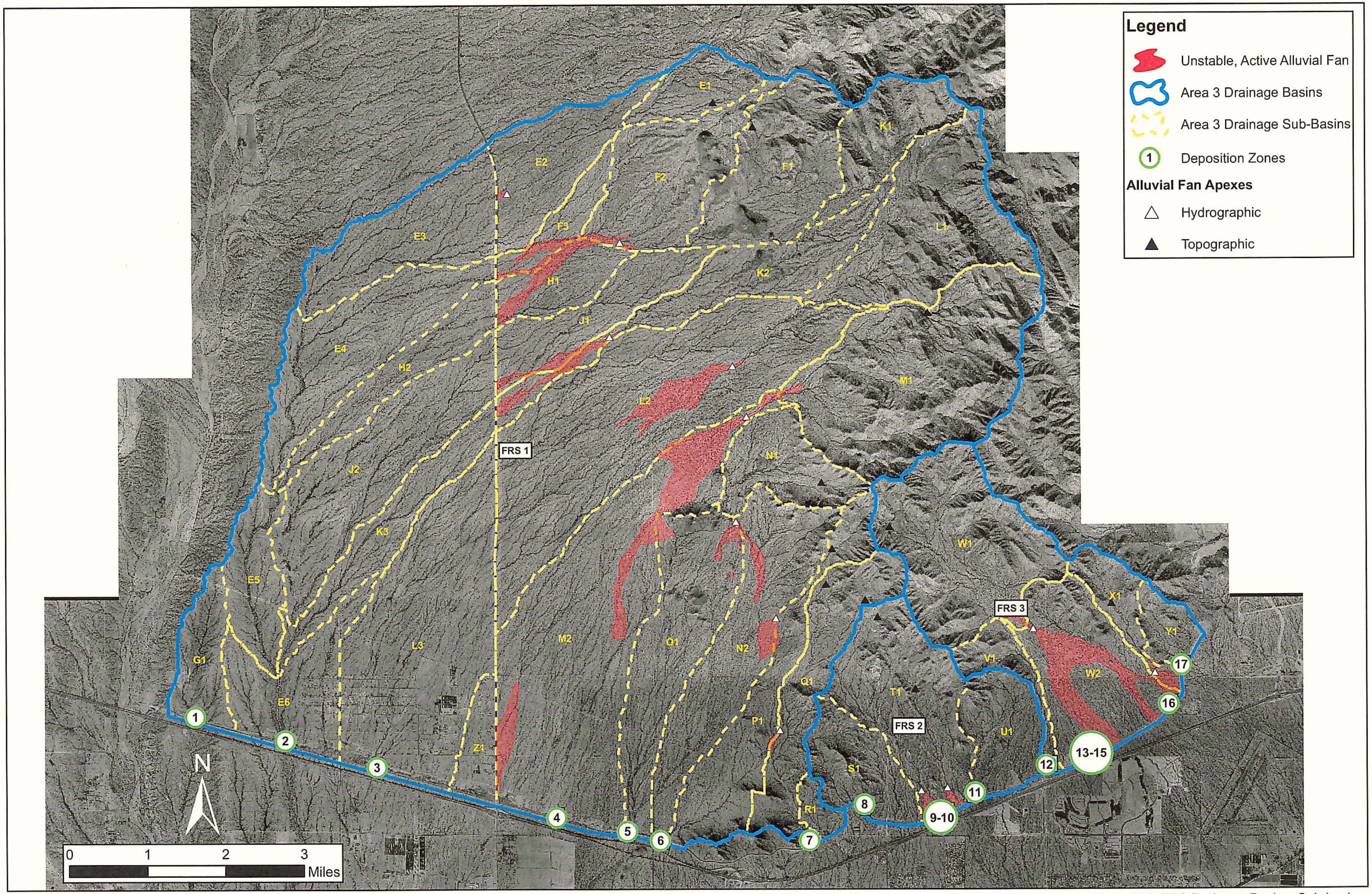

Figure 2.4. FRS Drainage Basins, Sub-basins, and Locations of Deposition Zones.

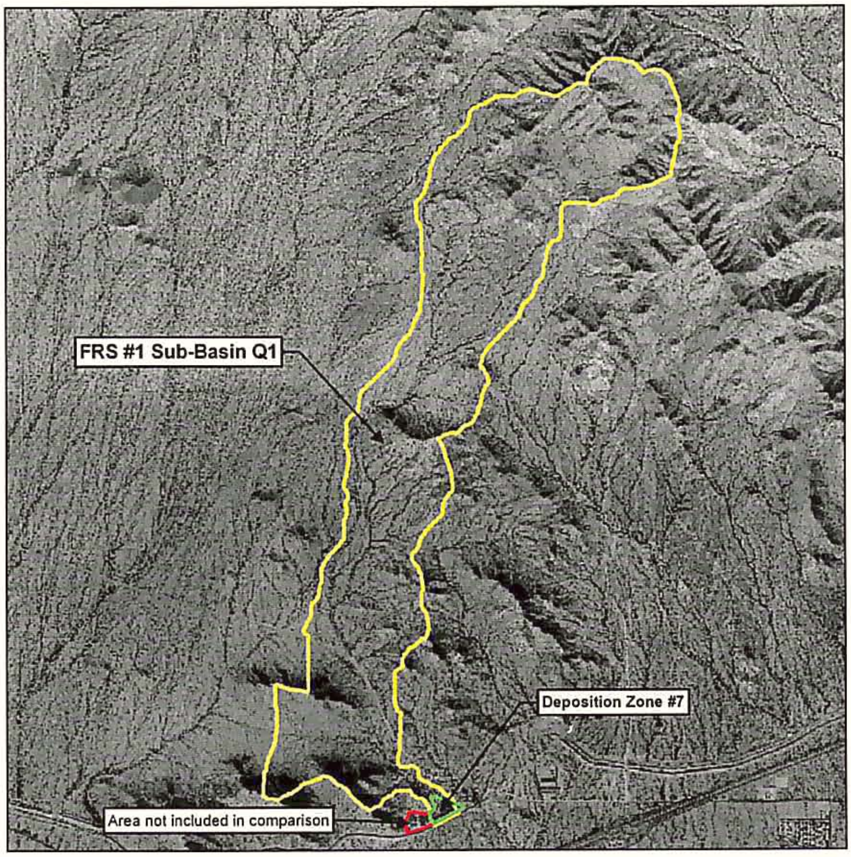

Figure 2.5. Deposition Zone #7 with sub-basin Q1 shown, as well as the portion of the area that was not included in the comparison.

2.4 Average Annual Sediment Yield Analysis Using RUSLE2

The current sediment yield calculations were conducted using the Revised Universal Soil Loss Equation (RUSLE). The computer program, RUSLE2, developed by the NRCS, was used to perform the analysis. RUSLE has the same form as the original USLE:

$$A = RKLSCP$$

where:

A = Average annual soil loss (not the sediment yield)
R = Rainfall erosivity
K = Soil erodibility
LS = Slope length and steepness
C = Cover management factor
P = Support conservation practices

Initially, RUSLE2 was used to calculate the average annual soil loss. However, RUSLE2 can be used to estimate storm event soil loss by adjusting the rainfall erosivity factor (Kelsey 2002). The rainfall erosivity value was adjusted to account for the 100-year, 24- and 6-hour events to provide an event-based soil loss (see Section 2.5).

2.4.1 Rainfall Erosivity

The R factor represents the rainfall erosivity of the climate at a particular location. The RUSLE2 climate database was utilized for the rainfall erosivity for the average annual analysis. In the USA climate database for Arizona, the erosivity for "Phoenix at point" was used. This rainfall erosivity value was 22.6.

2.4.2 Soil Erodibility

The K factor represents the base soil erodibility as determined using the soil erodibility nomograph. The K factor is an empirical measure of soil erodibility that is affected by intrinsic soil properties. Soils survey data of the area for RUSLE2 were acquired from the NRCS National RUSLE2 Database. The soil data for the drainage area of the three Buckeye FRSs is from two soil surveys: the southern part of the drainage area is from a soil survey of the central part of Maricopa County (Hartman 1977) and the northern part of the drainage area is from a soil survey of the Aguila-Carefree Area (Camp 1986). The soils mapping was also obtained in the form of a GIS shapefile, which provides the location and total area of each of the soil types. The GIS information was invaluable in determining the slope and the total area of each soil type.

The resulting soil types are shown in **Tables 2.3**, **2.4**, and **2.5**. For each soil description there were usually two or three soil types associated with it in the RUSLE2 database. For example, for the NRCS soil, Carrizo-Gunsight complex, 1 to 5 percent slopes, the user could select either "Carrizo gravelly sandy loam" or "Gunsight very gravelly sandy loam." For the purposes of this analysis, the soil type that gave the higher soil erodibility was used in the RUSLE2 calculation. In this example, "Gunsight very gravelly sandy loam" had a K value of 0.37 while "Carrizo gravelly sandy loam" has a K value of 0.32. Therefore, "Gunsight very gravelly sandy loam" was the soil type used to define K in calculating the soil loss for Carrizo-Gunsight complex.

2.4.3 Slope Length and Steepness

The LS factor jointly represents the effect of steepness, slope length, and shape (convex, concave, or uniform slopes) on sediment production. ArcGIS software was utilized to calculate the steepness or slope of each soil group using the NRCS soil survey GIS information. **Tables 2.6**, **2.7**, and **2.8** provide the calculated slopes. Slope length was estimated using the calculated slopes. If the slopes were 5 percent or less, the slope length input into RUSLE2 was 200 feet. If the slopes were between 5 and 15 percent, the slope length input into RUSLE2 was 100. If the slopes were greater than 15 percent, the slope length input into RUSLE2 was 30 feet (Tables 2.6, 2.7, and 2.8). These slope length estimates are based on the estimates made in the original 1974 sediment yield study. The shape was assumed to be a uniform up and down contouring over the course of the entire area. All three of these variables, the steepness or slope, the slope length, and the shape were input into RUSLE2 to calculate the LS factors shown in Tables 2.6, 2.7, and 2.8.

2.4.4. Cover Management Factor

The C factor, or cover management factor, is the ratio of soil loss from an area with specified vegetation and management to that from the fallow condition on which the factor K is evaluated. In the original 1974 study, a C factor of 0.3 for desert shrub was used. This was assumed to be reasonable and a C factor of 0.3 was used for the current analysis as well.

Table 2.3. Soil Groups and Erodibility Values for Buckeye FRS #1.

NRCS Soil Description	RUSLE2 Soil Type	Soil Erodibility K
Antho sandy loams	Antho sandy loam 25%	0.28
Carrizo very gravelly sand	Carrizo very gravelly sand 100%	0.06
Carrizo-Gunsight complex, 1 to 5 % slopes	Gunsight very gravelly sandy loam 30%	0.43
Cheriono-Rock outcrop complex	Cherioni extremely stony loam 60%	0.74
Chuckawalla-Gunsight complex, 1 to 8 % slopes	Gunsight very gravelly loam 35%	0.57
Cipriano very gravelly loam	Cipriano very gravelly loam 100%	0.74
Coolidge-Laveen association	Coolidge sandy loam 40%	0.28
Denure-Momoli-Carrizo complex	Momoli gravelly sandy loam 30%	0.43
Ebon-Gunsight-Cipriano association, 3 to 25 % slopes	Gunsight very gravelly sandy loam 20%	0.43
Ebon-Pinamt complex, 20 to 40 % slopes	Ebon very gravelly loam 45%	0.32
Gachado-Lomitas-Rock outcrop complex, 7 to 55 % slopes	Gachado very gravelly loam 45%	0.43
Gilman-Antho association	Gilman loam 50%	0.37
Gunsight-Cipriano complex, 1 to 7 % slopes	Gunsight very gravelly sandy loam 45%	0.43
Gunsight-Pinal complex, 1 to 10 % slopes	Pinal gravelly loam 30%	0.37
Gunsight-Rillito complex, 0 to 10 % slopes	Gunsight gravelly loam 40%	0.37
Gunsight-Rillito complex, 1 to 25 % slopes	Gunsight very gravelly loam 40%	0.57
Gunsight-Rillito complex, low precipitation, 1 to 40 % slopes	Gunsight very gravelly loam 40%	0.57
Harqua-Gunsight complex, 0 to 5 % slopes	Gunsight gravelly loam 35%	0.37
Perryville-Rillito complex, 0 to 3 % slopes	Perryville loam 35%	0.37
Pinal gravelly loam	Pinal gravelly loam 100%	0.37
Pinamt-Tremant complex, 1 to 10 % slopes	Tremant gravelly loam 35%	0.74
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	Quilotosa extremely gravelly sandy loam 50%	0.12
Rillito gravelly loam, 1 to 8 % slopes	Rillito gravelly loam 100%	0.37
Sal-Cipriano complex, 1 to 10 % slopes	Sal extremely gravelly loam 50%	0.37
Tremant gravelly loams, low precipitation	Tremant gravelly loam 35%	0.74

Table 2.4. Soil Groups and Erodibility Values for Buckeye FRS #2.

NRCS Soil Description	RUSLE2 Soil Type	Soil Erodibility K
Antho sandy loams	Antho gravelly sandy loam 30%	0.28
Cheriono-Rock outcrop complex	Cherioni extremely stony loam 60%	0.74
Gunsight-Pinal complex, 1 to 10 % slopes	Pinal gravelly loam 30%	0.37
Gunsight-Rillito complex, 0 to 10 % slopes	Gunsight gravelly loam 40%	0.37
Gunsight-Rillito complex, 1 to 25 % slopes	Gunsight very gravelly loam 40%	0.57
Pinamt-Tremant complex, 1 to 10 % slopes	Tremant gravelly loam 35%	0.74
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	Quilotosa extremely gravelly sandy loam 50%	0.12
Tremant-Rillito complex, 0 to 5 % slopes	Rillito gravelly loam 30%	0.37

Table 2.5. Soil Groups and Erodibility Values for Buckeye FRS #3.

NRCS Soil Description	RUSLE2 Soil Type	Soil Erodibility K
Antho-Carrizo-Maripo complex	Antho gravelly sandy loam 30%	0.28
Denure-Momoli-Carrizo complex	Momoli gravelly sandy loam 30%	0.43
Gunsight-Rillito complex, 0 to 10 % slopes	Gunsight gravelly loam 40%	0.37
Harqua-Gunsight complex, 0 to 5 % slopes	Gunsight gravelly loam 35%	0.37
Pinamt-Tremant complex, 1 to 10 % slopes	Tremant gravelly loam 35%	0.74
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	Quilotosa extremely gravelly sandy loam 50%	0.12
Rock outcrop-Cheriono complex	Cherioni extremely stony loam 60%	0.74

Table 2.6. Slope, Slope Length, and LS Factors for Buckeye FRS #1.

NRCS Soil Description	Slope	Slope Length (ft)	LS Factor
Antho sandy loams	1.7%	200	0.24
Carrizo very gravelly sand	1.9%	200	0.28
Carrizo-Gunsight complex, 1 to 5 % slopes	2.5%	200	0.36
Cheriono-Rock outcrop complex	21.6%	30	2.00
Chuckawalla-Gunsight complex, 1 to 8 % slopes	2.6%	200	0.37
Cipriano very gravelly loam	11.4%	100	1.60
Coolidge-Laveen association	1.4%	200	0.20
Denure-Momoli-Carrizo complex	2.2%	200	0.31
Ebon-Gunsight-Cipriano association, 3 to 25 % slopes	7.7%	100	0.96
Ebon-Pinamt complex, 20 to 40 % slopes	12.1%	100	1.70
Gachado-Lomitas-Rock outcrop complex, 7 to 55 % slopes	22.5%	30	2.10
Gilman-Antho association	1.2%	200	0.17
Gunsight-Cipriano complex, 1 to 7 % slopes	4.7%	200	0.70
Gunsight-Pinal complex, 1 to 10 % slopes	5.7%	100	0.70
Gunsight-Rillito complex, 0 to 10 % slopes	1.9%	200	0.27
Gunsight-Rillito complex, 1 to 25 % slopes	4.0%	200	0.57
Gunsight-Rillito complex, low precipitation, 1 to 40 % slopes	1.5%	200	0.21
Harqua-Gunsight complex, 0 to 5 % slopes	2.2%	200	0.31
Perryville-Rillito complex, 0 to 3 % slopes	1.5%	200	0.21
Pinal gravelly loam	6.3%	100	0.78
Pinamt-Tremant complex, 1 to 10 % slopes	5.8%	100	0.72
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	35.3%	30	3.20
Rillito gravelly loam, 1 to 8 % slopes	1.5%	200	0.22
Sal-Cipriano complex, 1 to 10 % slopes	3.4%	200	0.42
Tremant gravelly loams, low precipitation	1.4%	200	0.20

Table 2.7. Slope, Slope Length, and K Factors for Buckeye FRS #2.

NRCS Soil Description	Slope (%)	Slope Length (ft)	LS Factor
Antho sandy loams	2.3%	200	0.28
Cheriono-Rock outcrop complex	24.1%	30	0.74
Gunsight-Pinal complex, 1 to 10 % slopes	6.1%	100	0.37
Gunsight-Rillito complex, 0 to 10 % slopes	2.4%	200	0.37
Gunsight-Rillito complex, 1 to 25 % slopes	8.8%	100	0.57
Pinamt-Tremant complex, 1 to 10 % slopes	7.4%	100	0.74
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	36.2%	30	0.12
Tremant-Rillito complex, 0 to 5 % slopes	3.9%	200	0.37

Table 2.8. Slope, Slope Length, and K Factors for Buckeye FRS #3.

NRCS Soil Description	Slope (%)	Slope Length (ft)	LS Factor
Antho-Carrizo-Maripo complex	2.8%	200	0.28
Denure-Momoli-Carrizo complex	4.1%	200	0.43
Gunsight-Rillito complex, 0 to 10 % slopes	2.3%	200	0.37
Harqua-Gunsight complex, 0 to 5 % slopes	1.9%	200	0.37
Pinamt-Tremant complex, 1 to 10 % slopes	7.4%	100	0.74
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 % slopes	37.3%	30	0.12
Rock outcrop-Cheriono complex	27.8%	30	0.74

2.4.5 Support Conservation Practices

Support conservation practices were not taken into account in this analysis; therefore, the P factor was assumed to be 1.0.

2.4.6 Average Annual Sediment Yield Results

The average annual sediment yield analysis was performed for each of the Buckeye FRSs (**Tables 2.9**, **2.10**, and **2.11**). An average annual soil loss was calculated in RUSLE2 for each soil group. Given these results and the GIS calculated total area of each soil group, an area weighted soil loss for each FRS drainage basin was computed. Channel erosion was taken into account as being 20 percent of the total soil loss as assumed in the original 1974 study. The sediment delivery, or how much of the sediment loss actually is transported to the FRS, was assumed to be 70 percent. The trap efficiency, or how much of the sediment is deposited in the FRS as opposed to flowing to the Hassayampa River, was assumed to be 65 percent. These same assumptions were made in the original 1974 sediment yield analysis. Accounting for these factors provided a final resultant sediment storage value or an estimate of how much sediment would be deposited at each FRS.

The results indicate that the calculated sediment storage is 0.20 ac-ft/mi^2/yr for FRS #1, 0.70 ac-ft/mi^2/yr for FRS #2, and 0.40 ac-ft/mi^2/yr for FRS #3. The calculated sediment storage of FRS #2 is higher than either of the calculated sediment storages for FRS #1 and #3 because of its high slope over a smaller area and also because it has a higher percentage of relict fan and mountain soil types. The calculated sediment storage of FRS #1 is lowest because of its lower average slope compared to the other two drainage areas.

These numbers appear reasonable when compared to other measured sediment yield data from the Southwest (**Table 2.12**). Table 2.12 presents actual data based on total sediment deposited over a certain period of time.

The numbers also appear reasonable when compared to computed average annual sediment yield estimates from previous Maricopa County studies as shown in **Table 2.13**. The previous studies conducted in the Maricopa County area have an arithmetic average of 0.65 ac-ft/mi^2/yr, which can be viewed as an upper limit of most of the estimates (JE Fuller 2003). The calculated sediment storage of FRS #2 is higher than the previous study average most likely because of higher average slope over a relatively small area.

3.5 Single Event Sediment Yield Analysis

A single event sediment yield analysis was performed on the 100-year, 6- and 24-hour events. Initially, the 100-year, 6- and 24-hour event-based sediment yield analyses were performed using the same parameter values as the average annual analysis in RUSLE2 with the exception of the R factor being adjusted to account for the events. However, this approach produced unreasonably low sediment loads so a different approach was taken. The second approach predicted a sediment load and deposition based on an assumption of the sediment concentration by volume given the flow characteristics that the flood would have. This approach led to a more reasonable prediction of the sediment deposition at the FRSs.

Table 2.9. FRS #1 Average Annual Sediment Yield RUSLE2 Results

					Annual R Factor	22.6				Sediment: tons/acre-ft	2156.22
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	LS Factor	C Factor	K Factor	RUSLE2 Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/yr)
Antho sandy loams	Arizona\Phoenix at point	1 ANTHO SANDY LOAMS\ANTHO sandy loam 25%	6965.35	14.36%	1.7%	200	0.24	0.30	0.28	0.4	0.059
Carrizo very gravelly sand	Arizona\Phoenix at point	14 CARRIZO VERY GRAVELLY SAND\CARRIZO very gravelly sand 100%	2473.06	5.10%	1.9%	200	0.28	0.30	0.06	0.1	0.005
Carrizo-Gunsight complex, 1 to 5 percent slopes	Arizona\Phoenix at point	15 CARRIZO-GUNSIGHT COMPLEX, 1 TO 5 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 30%	3454.05	7.12%	2.5%	200	0.36	0.30	0.43	0.9	0.067
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	482.21	0.99%	21.6%	30	2.00	0.30	0.74	9.9	0.098
Chuckawalla-Gunsight complex, 1 to 8 percent slopes	Arizona\Phoenix at point	19 CHUCKAWALLA-GUNSIGHT COMPLEX, 1 TO 8 PERCENT SLOPES\GUNSIGHT very gravelly loam 35%	1454.62	3.00%	2.6%	200	0.37	0.30	0.57	1.3	0.039
Cipriano very gravelly loam	Arizona\Phoenix at point	21 CIPRIANO VERY GRAVELLY LOAM\CIPRIANO very gravelly loam 100%	260.70	0.54%	11.4%	100	1.60	0.30	0.74	7.5	0.040
Coolidge-Laveen association	Arizona\Phoenix at point	CV COOLIDGE-LAVEEN ASSOCIATION\COOLIDGE sandy loam 40%	721.22	1.49%	1.4%	200	0.20	0.30	0.28	0.3	0.005
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	2306.75	4.76%	2.2%	200	0.31	0.30	0.43	0.8	0.039
Ebon-Gunsight-Cipriano association, 3 to 25 percent slopes	Arizona\Phoenix at point	47 EBON-GUNSIGHT-CIPRIANO ASSOCIATION, 3 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 20%	704.65	1.45%	7.7%	100	0.96	0.30	0.43	2.5	0.036
Ebon-Pinamt complex, 20 to 40 percent slopes	Arizona\Phoenix at point	49 EBON-PINAMT COMPLEX, 20 TO 40 PERCENT SLOPES\EBON very gravelly loam 45%	446.62	0.92%	12.1%	100	1.70	0.30	0.32	3.6	0.033
Gachado-Lomitas-Rock outcrop complex, 7 to 55 percent slopes	Arizona\Phoenix at point	52 GACHADO-LOMITAS-ROCK OUTCROP COMPLEX, 7 TO 55 PERCENT SLOPES\GACHADO very gravelly loam 45%	535.04	1.10%	22.5%	30	2.10	0.30	0.43	6.0	0.066
Gilman-Antho association	Arizona\Phoenix at point	GM GILMAN-ANTHO ASSOCIATION\GILMAN loam 50%	456.13	0.94%	1.2%	200	0.17	0.30	0.37	0.4	0.004
Gunsight-Cipriano complex, 1 to 7 percent slopes	Arizona\Phoenix at point	68 GUNSIGHT-CIPRIANO COMPLEX, 1 TO 7 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 45%	94.77	0.20%	4.7%	200	0.70	0.30	0.43	1.8	0.004
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	585.35	1.21%	5.7%	100	0.70	0.30	0.37	1.6	0.019
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	1332.15	2.75%	1.9%	200	0.27	0.30	0.37	0.6	0.016
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	4194.56	8.65%	4.0%	200	0.57	0.30	0.57	2.0	0.173
Gunsight-Rillito complex, low precipitation, 1 to 40 percent slopes	Arizona\Phoenix at point	71 GUNSIGHT-RILLITO COMPLEX, LOW PRECIPITATION, 1 TO 40 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	378.99	0.78%	1.5%	200	0.21	0.30	0.57	0.7	0.006
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	61.37	0.13%	2.2%	200	0.31	0.30	0.37	0.7	0.001
Perryville-Rillito complex, 0 to 3 percent slopes	Arizona\Phoenix at point	PRB PERRYVILLE-RILLITO COMPLEX, 0 TO 3 PERCENT SLOPES\PERRYVILLE loam 35%	1038.32	2.14%	1.5%	200	0.21	0.30	0.37	0.5	0.010
Pinal gravelly loam	Arizona\Phoenix at point	PT PINAL GRAVELLY LOAM\PINAL gravelly loam 100%	38.09	0.08%	6.3%	100	0.78	0.30	0.37	1.8	0.001
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1952.98	4.03%	5.8%	100	0.72	0.30	0.74	3.2	0.129
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam	8411.65	17.35%	35.3%	30	3.20	0.30	0.12	2.4	0.416
Rillito gravelly loam, 1 to 8 percent slopes	Arizona\Phoenix at point	102 RILLITO GRAVELLY LOAM, 1 TO 8 PERCENT SLOPES\RILLITO gravelly loam 100%	7261.00	14.97%	1.5%	200	0.22	0.30	0.37	0.5	0.073
Sal-Cipriano complex, 1 to 10 percent slopes	Arizona\Phoenix at point	106 SAL-CIPRIANO COMPLEX, 1 TO 10 PERCENT SLOPES\SAL extremely gravelly loam 50%	1988.08	4.10%	3.4%	200	0.42	0.30	0.37	1.0	0.039
Tremant gravelly loams, low precipitation	Arizona\Phoenix at point	114 TREMANT GRAVELLY LOAMS, LOW PRECIPITATION\TREMANT gravelly loam 35%	129.93	0.27%	1.4%	200	0.20	0.30	0.74	0.9	0.014
		Total	48490.90	100.00%						Total Soil Loss (tons/ac/yr)	1.39
										Total Soil Loss(ac-ft/sq-mi/yr)	0.41
										Channel Erosion (20% of Total)	0.08
										Total Erosion	0.50
										Estimated 70% Delivery	0.35
										Estimated 65% Trap Efficiency	0.23
										Sediment Storage (ac-ft/sq-mi/yr)	**0.20**

Table 2.10. FRS #2 Average Annual Sediment Yield RUSLE2 Results

					Annual R Factor	22.6				Sediment: tons/acre-ft	2156.22
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	LS Factor	C Factor	K Factor	RUSLE2 Soil Loss (Tons/Ac/Yr)	Weighted-Average Soil Loss (tons/ac/yr)
Antho association	Arizona\Phoenix at point	AL ANTHO ASSOCIATION\ANTHO gravelly sandy loam 30%	76.89	2.06%	2.3%	200	0.33	0.30	0.28	0.56	0.012
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	695.20	18.66%	24.1%	30	2.30	0.30	0.74	11	2.052
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	524.60	14.08%	6.1%	100	0.75	0.30	0.37	1.7	0.239
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	96.47	2.59%	2.4%	200	0.34	0.30	0.37	0.76	0.020
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	103.75	2.78%	8.8%	100	1.40	0.30	0.57	4.9	0.136
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1103.25	29.61%	7.4%	100	0.92	0.30	0.74	4.2	1.243
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam	494.30	13.26%	36.2%	30	3.30	0.30	0.12	2.5	0.332
Tremant-Rillito complex, 0 to 5 percent slopes	Arizona\Phoenix at point	TSC TREMANT-RILLITO COMPLEX, 0 TO 5 PERCENT SLOPES\RILLITO gravelly loam 30%	558.66	14.99%	3.9%	200	0.56	0.30	0.37	1.3	0.172
		Total	3726.48	100.00%						Total Soil Loss (tons/ac/yr)	4.21
										Total Soil Loss (ac-ft/sq-mi/yr)	1.25
										Channel Erosion (20% of Total)	0.25
										Total Erosion	1.50
										Estimated 70% Delivery	1.05
										Estimated 65% Trap Efficiency	0.68
										Sediment Storage (ac-ft/sq-mi/yr)	**0.70**

Table 2.11. FRS #3 Average Annual Sediment Yield RUSLE2 Results

					Annual R Factor	22.6				Sediment: tons/acre-ft	2156.22
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	LS Factor	C Factor	K Factor	RUSLE2 Soil Loss (Tons/Ac/Yr)	Weighted-Average Soil Loss (tons/ac/yr)
Antho-Carrizo-Maripo complex	Arizona\Phoenix at point	3 ANTHO-CARRIZO-MARIPO COMPLEX\ANTHO sandy loam 35%	806.13	14.36%	2.8%	200	0.40	0.30	0.28	0.68	0.098
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	9.60	0.17%	4.1%	200	0.60	0.30	0.43	1.6	0.003
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	143.20	2.55%	2.3%	200	0.32	0.30	0.37	0.72	0.018
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	86.88	1.55%	1.9%	200	0.27	0.30	0.37	0.6	0.009
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1508.85	26.87%	7.4%	100	0.92	0.30	0.74	4.2	1.129
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam	2992.43	53.29%	37.3%	30	3.30	0.30	0.12	2.6	1.386
Rock outcrop-Cherioni complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	13.54	0.24%	27.8%	30	2.60	0.30	0.74	13	0.031
		Total	5615.45	100.00%						Total Soil Loss (tons/ac/yr)	2.67
										Total Soil Loss (ac-ft/sq-mi/yr)	0.79
										Channel Erosion (20% of Total)	0.16
										Total Erosion	0.95
										Estimated 70% Delivery	0.67
										Estimated 65% Trap Efficiency	0.43
										Sediment Storage (ac-ft/sq-mi/Yr)	**0.40**

Table 2.12. Comparison of Sediment Yield Data from the Southwest.

Watershed	Area (mi^2)	Period (years)	Sediment Yield ($ac\text{-}ft/mi^2/yr$)
Buckeye Flood Retarding Structures			
FRS #1	75.8	-	0.20
FRS #2	5.8	-	0.70
FRS #3	8.8	-	0.40
New Mexico (Curtis 1976)			
Santa Cruz	93.1	27.4	0.27
Santa Cruz R #6	3.12	6.7	3.30
Santa Cruz R #3	1.16	7.0	9.10
Zia Pueblo	2.40	7.0	5.84
Tortugas Arroyo	20.54	9.7	0.69
Upper Rio Hondo	93.9	12.9	0.54
Oak Creek	9.41	6.0	3.32
Upper Gila Valley Region	0.33	8.7	1.54
Southeastern Arizona – Walnut Gulch Experimental Watershed (Renard 1972)			
Basin 201	0.17	-	0.33
Basin 214	0.58	-	0.31
Basin 223	0.17	-	0.38
Glendora, California (PSIAC 1974)			
Bell Canyon #4	0.06	39	0.88
Eagle, Colorado (PSIAC 1974)			
Boca Mountain	< 0.01	7	0.65

Table 2.13. Comparison of Sediment Yield Analysis Results in Maricopa County.

Watershed	Area (mi^2)	Average Annual Sediment Yield ($ac\text{-}ft/mi^2/yr$)
Buckeye Flood Retarding Structures		
FRS #1	75.8	0.20
FRS #2	5.8	0.70
FRS #3	8.8	0.40
Maricopa County Previous Studies		
Casandro Wash[1]	1.2	0.31
Rawhide Wash[1]	13.6	0.39
Phoenix Mountain Preserve (Tatum Wash)[2]	1.9	1.9
Shea Boulevard (Tatum Wash)[2]	2.2	2.1
Western Tributary (Cherokee Wash)[3]	0.1	2.16
Desert Park Tributary (Cherokee Wash)[3]	0.3	1.98
Desert Greenbelt Project, AZ[4]	8.6	0.10
Cave Creek, AZ[4]	121.0	0.31
Spookhill Dam, AZ[4]	16.4	0.15
Saddleback Dam, AZ[4]	30.0	0.08
Davis Tank, AZ[5]	0.2	0.96
Kennedy Tank, AZ[5]	1.0	0.27
Juniper Wash, AZ[5]	2.0	0.29
Alhambra Tank, AZ[5]	6.6	0.03
Black Hills Tank, AZ[5]	1.1	0.68
Black Hills Tank, AZ[6]	1.6	0.58
Mesquite Tank, AZ[5]	9.0	0.03
Tank 76, AZ[5]	1.2	0.21
Spook Hill ADMP[7]	3.0 - 14.0	0.13
North Peoria ADMP[8]	0.1 - 32.9	0.31
	Average	**0.65**

1. CH2M-Hill 1994
2. JE Fuller 1997
3. WEST Consulting 1997
4. Hjalmarson 1996
5. Peterson 1962
6. Langbien, Hains and Culler 1951
7. JE Fuller 2000
8. JE Fuller 2002

2.5.1 Approach Using RUSLE2 and Erosion Works

For the 100-year event analysis, the software program Erosion Works (American Excelsior 2004) was chosen to calculate the rainfall erosivity. Erosion Works is a program that takes a given rainfall intensity hyetograph and provides the corresponding R value for an event-based soil loss analysis.

To determine the 100-year, 24- and 6-hour hyetographs for each of the structures, the procedures in Volume I of the Draft Drainage Design Manual for Maricopa County (Sabol et al. 2003) were followed. The 100-year, 24- and 6-hour area averaged point rainfall depths for each structure were obtained from the Buckeye/Sun Valley Area Drainage Master Study Hydrology Report (PBS&J 2004). **Table 2.14** shows the values that were used. The depth-area reduction factor (Table 3.13) was determined next using Figures 2.1 and 2.2 in Volume I of the Draft Drainage Design Manual (Sabol et al. 2003). The depth-area reduction factor was applied to the area-averaged point rainfall depths, which was then applied to the dimensionless distributions in Table 2.4 and 2.5 (after determining the appropriate pattern number for the 6-hour storm) of the Draft Drainage Design Manual. **Figures 2.6** and **2.7** show the final rainfall intensity hyetographs used in determining the rainfall erosivity for each FRS for the 100-year, 24- and 6-hour storms, respectively. With these hyetographs, the 100-year, 24- and 6-hour event rainfall erosivity values were calculated (**Table 2.15**).

Table 2.14. Basin 100-Year Rainfall Depths and Area Reduction Factors.

Drainage Basin	Rainfall Depth (ft) (6-hr)	Depth-Area Reduction Factor (6-hr)	Rainfall Depth (ft) (24-hr)	Depth-Area Reduction Factor (24-hr)
FRS #1	3.23	0.82	4.16	0.86
FRS #2	3.28	0.96	4.13	0.91
FRS #3	3.26	0.94	4.14	0.88

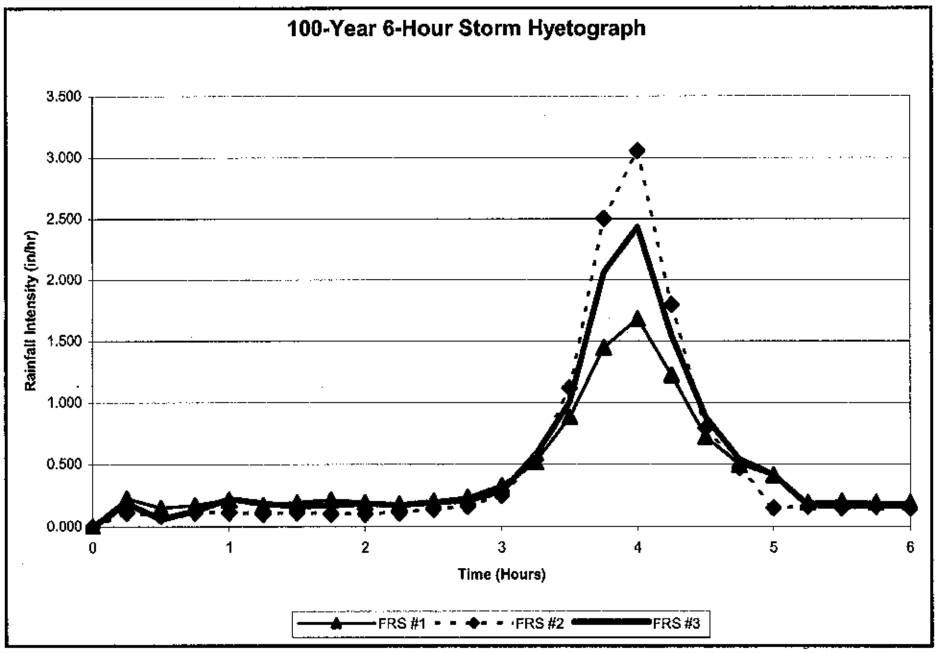

Figure 2.6. 100-Year 6-Hour Storm Hyetograph.

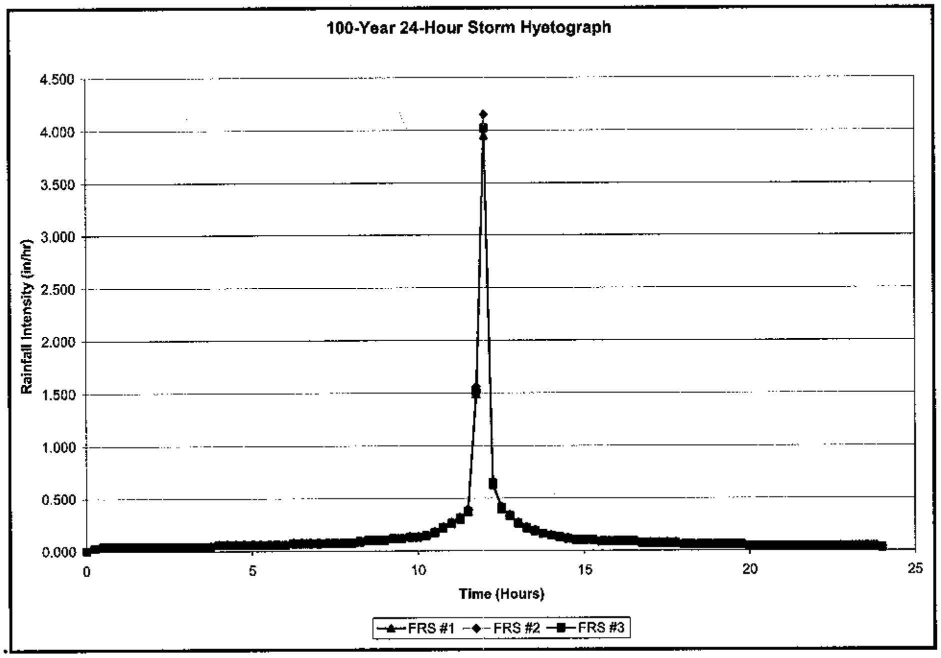

Figure 2.7. 100-Year 24-Hour Storm Hyetograph.

Table 2.15. Basin 100-Year Rainfall Erosivity Values.

Drainage Basin	Rainfall Erosivity R (6-hour)	Rainfall Erosivity R (24-hour)
FRS #1	31.72	66.96
FRS #2	77.47	74.38
FRS #3	57.77	69.62

2.5.2 Results of RUSLE2 and Erosion Works Approach

The results for the 100-year, 6-hour storm analysis are shown in **Tables 2.16**, **2.17**, and **2.18** with all RUSLE variables and values that were used. The calculated sediment storage for FRS #1 is 0.30 ac-ft/mi^2 per event, for FRS #2 was 2.30 ac-ft/mi^2 per event, for FRS #3 was 1.10 ac-ft/mi^2 per event. The final results for the 100-year, 24-hour storm analysis are shown in **Tables 2.19**, **2.20**, and **2.21**. The resulting sediment storage for FRS #1 was 0.70 ac-ft/mi^2 per event, for FRS #2 was 2.30 ac-ft/mi^2 per event, for FRS #3 was 1.30 ac-ft/mi^2 per event.

Compared to the average annual results, the results for the 100-yr event were not significantly greater. To better evaluate these results the sediment concentration by volume was computed (**Tables 2.22** and **2.23**). In an arid region the average sediment concentration throughout a large event, such as the 100-year flood, would be expected to be quite high. Concentrations of 5 percent (50,000 parts per million) or greater would not be unrealistic. However, many of the values in Tables 2.22 and 2.23 are considerably lower, suggesting that the single event application of the RUSLE may not be appropriate in an arid region. Therefore, an alternate approach to quantifying the single event sediment yield was adopted, as described in the following section.

Table 2.16. FRS #1 100-Year 6-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor 22.6		R (100yr 6hr) 31.72			RUSLE2	100-Year 6-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho sandy loams	Arizona\Phoenix at point	1 ANTHO SANDY LOAMS\ANTHO sandy loam 25%	6965.35	14.36%	1.7%	200	0.24	0.30	0.28	0.4	0.083
Carrizo very gravelly sand	Arizona\Phoenix at point	14 CARRIZO VERY GRAVELLY SAND\CARRIZO very gravelly sand 100%	2473.06	5.10%	1.9%	200	0.28	0.30	0.06	0.1	0.007
Carrizo-Gunsight complex, 1 to 5 percent slopes	Arizona\Phoenix at point	15 CARRIZO-GUNSIGHT COMPLEX, 1 TO 5 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 30%	3454.05	7.12%	2.5%	200	0.36	0.30	0.43	0.9	0.094
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	482.21	0.99%	21.6%	30	2.00	0.30	0.74	9.9	0.138
Chuckawalla-Gunsight complex, 1 to 8 percent slopes	Arizona\Phoenix at point	19 CHUCKAWALLA-GUNSIGHT COMPLEX, 1 TO 8 PERCENT SLOPES\GUNSIGHT very gravelly loam 35%	1454.62	3.00%	2.6%	200	0.37	0.30	0.57	1.3	0.055
Cipriano very gravelly loam	Arizona\Phoenix at point	21 CIPRIANO VERY GRAVELLY LOAM\CIPRIANO very gravelly loam 100%	260.70	0.54%	11.4%	100	1.60	0.30	0.74	7.5	0.057
Coolidge-Laveen association	Arizona\Phoenix at point	CV COOLIDGE-LAVEEN ASSOCIATION\COOLIDGE sandy loam 40%	721.22	1.49%	1.4%	200	0.20	0.30	0.28	0.3	0.007
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	2306.75	4.76%	2.2%	200	0.31	0.30	0.43	0.8	0.055
Ebon-Gunsight-Cipriano association, 3 to 25 percent slopes	Arizona\Phoenix at point	47 EBON-GUNSIGHT-CIPRIANO ASSOCIATION, 3 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 20%	704.65	1.45%	7.7%	100	0.96	0.30	0.43	2.5	0.051
Ebon-Pinamt complex, 20 to 40 percent slopes	Arizona\Phoenix at point	49 EBON-PINAMT COMPLEX, 20 TO 40 PERCENT SLOPES\EBON very gravelly loam 45%	446.62	0.92%	12.1%	100	1.70	0.30	0.32	3.6	0.047
Gachado-Lomitas-Rock outcrop complex, 7 to 55 percent slopes	Arizona\Phoenix at point	52 GACHADO-LOMITAS-ROCK OUTCROP COMPLEX, 7 TO 55 PERCENT SLOPES\GACHADO very gravelly loam 45%	535.04	1.10%	22.5%	30	2.10	0.30	0.43	6.0	0.093
Gilman-Antho association	Arizona\Phoenix at point	GM GILMAN-ANTHO ASSOCIATION\GILMAN loam 50%	456.13	0.94%	1.2%	200	0.17	0.30	0.37	0.4	0.005
Gunsight-Cipriano complex, 1 to 7 percent slopes	Arizona\Phoenix at point	68 GUNSIGHT-CIPRIANO COMPLEX, 1 TO 7 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 45%	94.77	0.20%	4.7%	200	0.70	0.30	0.43	1.8	0.005
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	585.35	1.21%	5.7%	100	0.70	0.30	0.37	1.6	0.027
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	1332.15	2.75%	1.9%	200	0.27	0.30	0.37	0.6	0.023
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	4194.56	8.65%	4.0%	200	0.57	0.30	0.57	2.0	0.243
Gunsight-Rillito complex, low precipitation, 1 to 40 percent slopes	Arizona\Phoenix at point	71 GUNSIGHT-RILLITO COMPLEX, LOW PRECIPITATION, 1 TO 40 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	378.99	0.78%	1.5%	200	0.21	0.30	0.57	0.7	0.008
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	61.37	0.13%	2.2%	200	0.31	0.30	0.37	0.7	0.001
Perryville-Rillito complex, 0 to 3 percent slopes	Arizona\Phoenix at point	PRB PERRYVILLE-RILLITO COMPLEX, 0 TO 3 PERCENT SLOPES\PERRYVILLE loam 35%	1036.32	2.14%	1.5%	200	0.21	0.30	0.37	0.5	0.014
Pinal gravelly loam	Arizona\Phoenix at point	PT PINAL GRAVELLY LOAM\PINAL gravelly loam 100%	38.09	0.08%	6.3%	100	0.78	0.30	0.37	1.8	0.002
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1952.98	4.03%	5.8%	100	0.72	0.30	0.74	3.2	0.181
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	8411.65	17.35%	35.3%	30	3.20	0.30	0.12	2.4	0.584
Rillito gravelly loam, 1 to 8 percent slopes	Arizona\Phoenix at point	102 RILLITO GRAVELLY LOAM, 1 TO 8 PERCENT SLOPES\RILLITO gravelly loam 100%	7261.00	14.97%	1.5%	200	0.22	0.30	0.37	0.5	0.103
Sal-Cipriano complex, 1 to 10 percent slopes	Arizona\Phoenix at point	106 SAL-CIPRIANO COMPLEX, 1 TO 10 PERCENT SLOPES\SAL extremely gravelly loam 50%	1988.08	4.10%	3.4%	200	0.42	0.30	0.37	1.0	0.055
Tremant gravelly loams, low precipitation	Arizona\Phoenix at point	114 TREMANT GRAVELLY LOAMS, LOW PRECIPITATION\TREMANT gravelly loam 35%	129.93	0.27%	1.4%	200	0.20	0.30	0.74	0.9	0.003
		Total	48490.90	100.00%						Total Soil Loss (tons/acre)	1.94
										Total Soil Loss (ac-ft/sq-mi)	0.58
										Channel Erosion (20% of Total)	0.12
										Total Erosion (ac-ft/sq-mi)	0.69
										Estimated 70% Delivery	0.48
										Estimated 65% Trap Efficiency	0.31
										Sediment Storage (ac-ft/sq-mi)	**0.30**

Table 2.17. FRS #2 100-Year 6-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor 22.6		R (100yr 6hr) 77.47			RUSLE2	100-Year 6-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho association	Arizona\Phoenix at point	AL ANTHO ASSOCIATION\ANTHO gravelly sandy loam 30%	76.89	2.06%	2.3%	200	0.33	0.30	0.28	0.56	0.040
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	695.20	18.66%	24.1%	30	2.30	0.30	0.74	11	7.034
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	524.60	14.08%	6.1%	100	0.75	0.30	0.37	1.7	0.820
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	96.47	2.59%	2.4%	200	0.34	0.30	0.37	0.76	0.067
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	103.75	2.78%	8.8%	100	1.40	0.30	0.57	4.9	0.468
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1103.25	29.61%	7.4%	100	0.92	0.30	0.74	4.2	4.262
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	494.30	13.26%	36.2%	30	3.30	0.30	0.12	2.5	1.137
Tremant-Rillito complex, 0 to 5 percent slopes	Arizona\Phoenix at point	TSC TREMANT-RILLITO COMPLEX, 0 TO 5 PERCENT SLOPES\RILLITO gravelly loam 30%	558.66	14.99%	3.9%	200	0.56	0.30	0.37	1.3	0.668
		Total	3726.48	100.00%						Total Soil Loss (tons/acre)	14.50
										Total Soil Loss (ac-ft/sq-mi)	4.30
										Channel Erosion (20% of Total)	0.86
										Total Erosion (ac-ft/sq-mi)	5.16
										Estimated 70% Delivery	3.61
										Estimated 65% Trap Efficiency	2.35
										Sediment Storage (ac-ft/sq-mi)	**2.30**

Table 2.18. FRS #3 100-Year 6-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor 22.6		R (100yr 6hr) 57.77			RUSLE2	100-Year 6-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho-Carrizo-Maripo complex	Arizona\Phoenix at point	3 ANTHO-CARRIZO-MARIPO COMPLEX\ANTHO sandy loam 35%	806.13	14.36%	2.8%	200	0.40	0.30	0.28	0.68	0.250
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	9.60	0.17%	4.1%	200	0.60	0.30	0.43	1.6	0.007
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	143.20	2.55%	2.3%	200	0.32	0.30	0.37	0.72	0.047
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	86.88	1.55%	1.9%	200	0.27	0.30	0.37	0.6	0.024
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1508.85	26.87%	7.4%	100	0.92	0.30	0.74	4.2	2.885
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	2992.43	53.29%	37.3%	30	3.30	0.30	0.12	2.6	3.542
Rock outcrop-Cherioni complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	13.54	0.24%	27.8%	30	2.60	0.30	0.74	13	0.080
		Total	5615.45	100.00%						Total Soil Loss (tons/acre)	6.83
										Total Soil Loss (ac-ft/sq-mi)	2.03
										Channel Erosion (20% of Total)	0.41
										Total Erosion (ac-ft/sq-mi)	2.43
										Estimated 70% Delivery	1.70
										Estimated 65% Trap Efficiency	1.11
										Sediment Storage (ac-ft/sq-mi)	**1.10**

Table 2.19. FRS #1 100-Year 24-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor	22.6	R (100yr 24hr)	66.96		RUSLE2	100-Year 24-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho sandy loams	Arizona\Phoenix at point	1 ANTHO SANDY LOAMS\ANTHO sandy loam 25%	6965.35	14.36%	1.7%	200	0.24	0.30	0.28	0.4	0.174
Carrizo very gravelly sand	Arizona\Phoenix at point	14 CARRIZO VERY GRAVELLY SAND\CARRIZO very gravelly sand 100%	2473.06	5.10%	1.9%	200	0.28	0.30	0.06	0.1	0.015
Carrizo-Gunsight complex, 1 to 5 percent slopes	Arizona\Phoenix at point	15 CARRIZO-GUNSIGHT COMPLEX, 1 TO 5 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 30%	3454.05	7.12%	2.5%	200	0.36	0.30	0.43	0.9	0.198
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	482.21	0.99%	21.6%	30	2.00	0.30	0.74	9.9	0.292
Chuckawalla-Gunsight complex, 1 to 8 percent slopes	Arizona\Phoenix at point	19 CHUCKAWALLA-GUNSIGHT COMPLEX, 1 TO 8 PERCENT SLOPES\GUNSIGHT very gravelly loam 35%	1454.62	3.00%	2.6%	200	0.37	0.30	0.57	1.3	0.116
Cipriano very gravelly loam	Arizona\Phoenix at point	21 CIPRIANO VERY GRAVELLY LOAM\CIPRIANO very gravelly loam 100%	260.70	0.54%	11.4%	100	1.60	0.30	0.74	7.5	0.119
Coolidge-Laveen association	Arizona\Phoenix at point	CV COOLIDGE-LAVEEN ASSOCIATION\COOLIDGE sandy loam 40%	721.22	1.49%	1.4%	200	0.20	0.30	0.28	0.3	0.015
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	2306.75	4.76%	2.2%	200	0.31	0.30	0.43	0.8	0.116
Ebon-Gunsight-Cipriano association, 3 to 25 percent slopes	Arizona\Phoenix at point	47 EBON-GUNSIGHT-CIPRIANO ASSOCIATION, 3 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 20%	704.65	1.45%	7.7%	100	0.96	0.30	0.43	2.5	0.108
Ebon-Pinamt complex, 20 to 40 percent slopes	Arizona\Phoenix at point	49 EBON-PINAMT COMPLEX, 20 TO 40 PERCENT SLOPES\EBON very gravelly loam 45%	446.62	0.92%	12.1%	100	1.70	0.30	0.32	3.6	0.098
Gachado-Lomitas-Rock outcrop complex, 7 to 55 percent slopes	Arizona\Phoenix at point	52 GACHADO-LOMITAS-ROCK OUTCROP COMPLEX, 7 TO 55 PERCENT SLOPES\GACHADO very gravelly loam 45%	535.04	1.10%	22.5%	30	2.10	0.30	0.43	6.0	0.196
Gilman-Antho association	Arizona\Phoenix at point	GM GILMAN-ANTHO ASSOCIATION\GILMAN loam 50%	456.13	0.94%	1.2%	200	0.17	0.30	0.37	0.4	0.011
Gunsight-Cipriano complex, 1 to 7 percent slopes	Arizona\Phoenix at point	68 GUNSIGHT-CIPRIANO COMPLEX, 1 TO 7 PERCENT SLOPES\GUNSIGHT very gravelly sandy loam 45%	94.77	0.20%	4.7%	200	0.70	0.30	0.43	1.8	0.010
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	585.35	1.21%	5.7%	100	0.70	0.30	0.37	1.6	0.057
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	1332.15	2.75%	1.9%	200	0.27	0.30	0.37	0.6	0.049
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	4194.56	8.65%	4.0%	200	0.57	0.30	0.57	2.0	0.513
Gunsight-Rillito complex, low precipitation, 1 to 40 percent slopes	Arizona\Phoenix at point	71 GUNSIGHT-RILLITO COMPLEX, LOW PRECIPITATION, 1 TO 40 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	378.99	0.78%	1.5%	200	0.21	0.30	0.57	0.7	0.017
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	61.37	0.13%	2.2%	200	0.31	0.30	0.37	0.7	0.003
Perryville-Rillito complex, 0 to 3 percent slopes	Arizona\Phoenix at point	PRB PERRYVILLE-RILLITO COMPLEX, 0 TO 3 PERCENT SLOPES\PERRYVILLE loam 35%	1038.32	2.14%	1.5%	200	0.21	0.30	0.37	0.5	0.030
Pinal gravelly loam	Arizona\Phoenix at point	PT PINAL GRAVELLY LOAM\PINAL gravelly loam 100%	38.09	0.08%	6.3%	100	0.78	0.30	0.37	1.8	0.004
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1952.98	4.03%	5.8%	100	0.72	0.30	0.74	3.2	0.382
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	8411.65	17.35%	35.3%	30	3.20	0.30	0.12	2.4	1.234
Rillito gravelly loam, 1 to 8 percent slopes	Arizona\Phoenix at point	102 RILLITO GRAVELLY LOAM, 1 TO 8 PERCENT SLOPES\RILLITO gravelly loam 100%	7261.00	14.97%	1.5%	200	0.22	0.30	0.37	0.5	0.217
Sal-Cipriano complex, 1 to 10 percent slopes	Arizona\Phoenix at point	106 SAL-CIPRIANO COMPLEX, 1 TO 10 PERCENT SLOPES\SAL extremely gravelly loam 50%	1988.08	4.10%	3.4%	200	0.42	0.30	0.37	1.0	0.115
Tremant gravelly loams, low precipitation	Arizona\Phoenix at point	114 TREMANT GRAVELLY LOAMS, LOW PRECIPITATION\TREMANT gravelly loam 35%	129.93	0.27%	1.4%	200	0.20	0.30	0.74	0.9	0.007
		Total	48490.90	100.00%						Total Soil Loss (tons/acre)	4.10
										Total Soil Loss (ac-ft/sq-mi)	1.22
										Channel Erosion (20% of Total)	0.24
										Total Erosion (ac-ft/sq-mi)	1.46
										Estimated 70% Delivery	1.02
										Estimated 65% Trap Efficiency	0.66
										Sediment Storage (ac-ft/sq-mi)	**0.70**

Table 2.20. FRS #2 100-Year 24-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor	22.6	R (100yr 24hr)	74.38		RUSLE2	100-Year 24-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho association	Arizona\Phoenix at point	AL ANTHO ASSOCIATION\ANTHO gravelly sandy loam 30%	76.89	2.06%	2.3%	200	0.33	0.30	0.28	0.56	0.038
Cheriono-Rock outcrop complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	695.20	18.66%	24.1%	30	2.30	0.30	0.74	11	6.754
Gunsight-Pinal complex, 1 to 10 percent slopes	Arizona\Phoenix at point	GWD GUNSIGHT-PINAL COMPLEX, 1 TO 10 PERCENT SLOPES\PINAL gravelly loam 30%	524.60	14.08%	6.1%	100	0.75	0.30	0.37	1.7	0.788
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	96.47	2.59%	2.4%	200	0.34	0.30	0.37	0.76	0.065
Gunsight-Rillito complex, 1 to 25 percent slopes	Arizona\Phoenix at point	70 GUNSIGHT-RILLITO COMPLEX, 1 TO 25 PERCENT SLOPES\GUNSIGHT very gravelly loam 40%	103.75	2.78%	8.8%	100	1.40	0.30	0.57	4.9	0.449
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1103.25	29.61%	7.4%	100	0.92	0.30	0.74	4.2	4.092
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	494.30	13.26%	36.2%	30	3.30	0.30	0.12	2.5	1.091
Tremant-Rillito complex, 0 to 5 percent slopes	Arizona\Phoenix at point	TSC TREMANT-RILLITO COMPLEX, 0 TO 5 PERCENT SLOPES\RILLITO gravelly loam 30%	558.66	14.99%	3.9%	200	0.56	0.30	0.37	1.3	0.641
		Total	3726.48	100.00%						Total Soil Loss (tons/acre)	13.92
										Total Soil Loss (ac-ft/sq-mi)	4.13
										Channel Erosion (20% of Total)	0.83
										Total Erosion (ac-ft/sq-mi)	4.96
										Estimated 70% Delivery	3.47
										Estimated 65% Trap Efficiency	2.26
										Sediment Storage (ac-ft/sq-mi)	**2.30**

Table 2.21. FRS #3 100-Year 24-Hour Storm Sediment Yield RUSLE2 Results

					Annual R Factor	22.6	R (100yr 24hr)	69.62		RUSLE2	100-Year 24-hr
Soil Description	Climate	Soil Classification used in RUSLE2	Area (acre)	% of Total	Slope (%)	Slope Length (ft)	Net LS Factor	Net C Factor	Net K Factor	Avg Annual Soil Loss (tons/ac/yr)	Weighted-Average Soil Loss (tons/ac/event)
Antho-Carrizo-Maripo complex	Arizona\Phoenix at point	3 ANTHO-CARRIZO-MARIPO COMPLEX\ANTHO sandy loam 35%	806.13	14.36%	2.8%	200	0.40	0.30	0.28	0.68	0.301
Denure-Momoli-Carrizo complex	Arizona\Phoenix at point	29 DENURE-MOMOLI-CARRIZO COMPLEX\MOMOLI gravelly sandy loam 30%	9.60	0.17%	4.1%	200	0.60	0.30	0.43	1.6	0.008
Gunsight-Rillito complex, 0 to 10 percent slopes	Arizona\Phoenix at point	GYD GUNSIGHT-RILLITO COMPLEX, 0 TO 10 PERCENT SLOPES\GUNSIGHT gravelly loam 40%	143.20	2.55%	2.3%	200	0.32	0.30	0.37	0.72	0.057
Harqua-Gunsight complex, 0 to 5 percent slopes	Arizona\Phoenix at point	HLC HARQUA-GUNSIGHT COMPLEX, 0 TO 5 PERCENT SLOPES\GUNSIGHT gravelly loam 35%	86.88	1.55%	1.9%	200	0.27	0.30	0.37	0.6	0.029
Pinamt-Tremant complex, 1 to 10 percent slopes	Arizona\Phoenix at point	98 PINAMT-TREMANT COMPLEX, 1 TO 10 PERCENT SLOPES\TREMANT gravelly loam 35%	1508.85	26.87%	7.4%	100	0.92	0.30	0.74	4.2	3.476
Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes	Arizona\Phoenix at point	100 QUILOTOSA-VAIVA-ROCK OUTCROP COMPLEX, 20 TO 65 PERCENT SLOPES\QUILOTOSA extremely gravelly sandy loam 5	2992.43	53.29%	37.3%	30	3.30	0.30	0.12	2.6	4.268
Rock outcrop-Cherioni complex	Arizona\Phoenix at point	18 CHERIONI-ROCK OUTCROP COMPLEX, 5 TO 60 PERCENT SLOPES\CHERIONI extremely stony loam 60%	13.54	0.24%	27.8%	30	2.60	0.30	0.74	13	0.097
		Total	5615.45	100.00%						Total Soil Loss (tons/acre)	8.24
										Total Soil Loss (ac-ft/sq-mi)	2.44
										Channel Erosion (20% of Total)	0.49
										Total Erosion (ac-ft/sq-mi)	2.93
										Estimated 70% Delivery	2.05
										Estimated 65% Trap Efficiency	1.33
										Sediment Storage (ac-ft/sq-mi)	**1.30**

Table 2.22. Percentage by Volume of Sediment Loads for 100-year 6-hour Storm.

Area 3 Sub-Basin	RUSLE2 and Erosion Works Sediment Storage (ac-ft)	Runoff Volume (ac-ft)	Sediment by Volume (% Concentration)
G	0.33	79	0.42
E	3.54	1040	0.34
L	5.01	729	0.68
Z	0.21	50	0.42
M	3.93	632	0.62
N & O*	2.37	435	0.54
P	0.72	155	0.46
Q	0.66	159	0.41
R	0.09	23	0.39
S	3.22	104	3.00
T	6.90	231	2.90
U	3.22	111	2.82
V	0.77	56	1.36
W	4.29	400	1.06
X	3.08	64	4.59
Y	0.66	48	1.36
*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.			

Table 2.23. Percentage by Volume of Sediment Loads for 100-year 24-hour Storm.

Area 3 Sub-Basin	RUSLE2 and Erosion Works Sediment Storage (ac-ft)	Runoff Volume (ac-ft)	Sediment by Volume (% Concentration)
G	0.77	68	1.12
E	8.26	1637	0.50
L	11.69	976	1.18
Z	0.49	41	1.18
M	9.17	841	1.08
N & O*	5.53	477	1.15
P	1.68	160	1.04
Q	1.54	167	0.91
R	0.21	20	1.04
S	3.22	95	3.28
T	6.90	233	2.88
U	3.22	99	3.15
V	0.91	52	1.72
W	5.07	471	1.06
X	3.64	59	5.81
Y	0.78	42	1.82
*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.			

2.5.3 Approach Using Concentration By Volume

The sediment load was also estimated using a concentration by volume approach. Sediment concentrations by volume in arid regions can be very large, particularly during 100-year events. The Sediment and Erosion Design Guide (RCE 1994) recommends a range of 20 – 30 percent solids concentration by volume for a mud flood and up to a 50 percent solids concentration by volume for a mudflow. In a mudflood, the hydraulics of the flow are still basically governed by conventional hydraulics, whereas in a mudflow the flows behave more as a slurry. In areas with active alluvial fans, mudfloods, basically water driven floods with high sediment loads, could easily occur. Mudflow events might also occur, but would be more limited in areal coverage.

The concentration by volume approach has been used in previous master drainage plans in the Maricopa County area. For the Adobe Dam/Desert Hills Area Drainage Master Plan, a concentration by volume of 5 percent was used (JE Fuller 2003). This value is considerably lower than that recommended in the Sediment and Erosion Design Guide; therefore sediment loads were calculated for concentrations of 5, 20, and 50 percent solids by volume. The results are presented in **Tables 2.24** and **2.25**.

3. CONCLUSIONS AND RECOMMENDATIONS

The objective of Subtask 2.6.7 was to evaluate sediment yield for each of the three Buckeye FRSs during a 100-year storm event. The analysis was accomplished using 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 floodplain 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 floodplain area for each sub-basin was calculated using ArcGIS software.

The results of this analysis are shown in **Table 3.1** and **Table 3.2**. 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 thirty feet for sub-basins N and 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 flood 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: N, O, P, and Q. This is consistent with the deposition depths seen in the field reconnaissance. Sub-basins N and O were grouped *in the analysis because the main flow path for sub-basin* N *is redirected into sub-*basin O. There will be some deposition still in sub-basin N, but some of that deposition from the flow will occur in sub-basin O. Therefore, the two sub-basins were grouped together for the purpose of this analysis. Deposition Zone 5 is within this area where an average of 2.5 feet of deposition was seen in the field. A view of Deposition Zone 5 is shown in **Figure 3.1**. In the photo it can be seen that this zone has been mechanically excavated. However, the area around the trees in the center of the picture gives an accurate depiction of the deposition in this zone.

Table 2.24. 100-Year 6-hour Sediment Load using Concentration by Volume.

Sub-Basin	Drainage Area (sq/mi)	Runoff Volume (ac-ft)	Sediment Load @ 5% Concentration (ac-ft)	Sediment Load @ 20% Concentration (ac-ft)	Sediment Load @ 50% Concentration (ac-ft)
G	1.1	79	4.16	19.75	79.00
E	11.8	1040	54.74	260.00	1040.00
L	16.7	729	38.37	182.25	729.00
Z	0.7	50	2.63	12.50	50.00
M	13.1	632	33.26	158.00	632.00
N & O*	7.9	435	22.89	108.75	435.00
P	2.4	155	8.16	38.75	155.00
Q	2.2	159	8.37	39.75	159.00
R	0.3	23	1.21	5.75	23.00
S	1.4	104	5.47	26.00	104.00
T	3	231	12.16	57.75	231.00
U	1.4	111	5.84	27.75	111.00
V	0.7	56	2.95	14.00	56.00
W	3.9	400	21.05	100.00	400.00
X	2.8	64	3.37	16.00	64.00
Y	0.6	48	2.53	12.00	48.00

*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.

Table 2.25. 100-Year 24-hour Sediment Load using Concentration by Volume.

Sub-Basin	Drainage Area (sq/mi)	Runoff Volume (ac-ft)	Sediment Load @ 5% Concentration (ac-ft)	Sediment Load @ 20% Concentration (ac-ft)	Sediment Load @ 50% Concentration (ac-ft)
G	1.1	68	3.58	17.00	68.00
E	11.8	1637	86.16	409.25	1637.00
L	16.7	976	51.37	244.00	976.00
Z	0.7	41	2.16	10.25	41.00
M	13.1	841	44.26	210.25	841.00
N & O*	7.9	477	25.10	119.25	477.00
P	2.4	160	8.42	40.00	160.00
Q	2.2	167	8.79	41.75	167.00
R	0.3	20	1.05	5.00	20.00
S	1.4	95	5.00	23.75	95.00
T	3	233	12.26	58.25	233.00
U	1.4	99	5.21	24.75	99.00
V	0.7	52	2.74	13.00	52.00
W	3.9	471	24.79	117.75	471.00
X	2.8	59	3.11	14.75	59.00
Y	0.6	42	2.21	10.50	42.00

*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.

Table 3.1. 100-year 6-hour Depths of Deposition by Sub-Basin.

Sub-Basin	Deposition Area (ac)	5% Concentration Deposition Depth (ft)	20% Concentration Deposition Depth (ft)	50% Concentration Deposition Depth (ft)
G	81.35	0.09	0.40	1.62
E	199.36	0.46	2.17	8.69
L	222.71	0.29	1.36	5.46
Z	70.89	0.06	0.29	1.18
M	134.34	0.41	1.96	7.84
N & O	15.93	2.40	11.38	45.52
P	6.86	1.98	9.41	37.63
Q	7.21	1.93	9.19	36.75
R	12.45	0.16	0.77	3.08
S	35.37	0.26	1.23	4.90
T	42.32	0.48	2.27	9.10
U	12.03	0.81	3.85	15.38
V	13.79	0.36	1.69	6.77
W	95.76	0.37	1.74	6.96
X	10.15	0.55	2.63	10.50
Y	15.21	0.28	1.32	5.26
*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.				

Table 3.2. 100-year 24-hour Depths of Deposition by Sub-Basin.

Sub-Basin	Deposition Area (ac)	5% Concentration Deposition Depth (ft)	20% Concentration Deposition Depth (ft)	50% Concentration Deposition Depth (ft)
G	81.35	0.09	0.40	1.62
E	199.36	0.46	2.17	8.69
L	222.71	0.29	1.36	5.46
Z	70.89	0.06	0.29	1.18
M	134.34	0.41	1.96	7.84
N & O	15.93	2.40	11.38	45.52
P	6.86	1.98	9.41	37.63
Q	7.21	1.93	9.19	36.75
R	12.45	0.16	0.77	3.08
S	35.37	0.26	1.23	4.90
T	42.32	0.48	2.27	9.10
U	12.03	0.81	3.85	15.38
V	13.79	0.36	1.69	6.77
W	95.76	0.37	1.74	6.96
X	10.15	0.55	2.63	10.50
Y	15.21	0.28	1.32	5.26
*Sub-Basins N & O were grouped because the main flow from Sub-Basin N is redirected into the same opening onto FRS #1.				

Deposition Zone 6, as shown in **Figure 3.2** is located in sub-basin Q. Though the estimated deposition in this zone was only an average of 1 foot, there is the potential for significant sediment transport in the washes that are flowing into this zone as well as the potential from BSV Sites 7 and 8, which are not far upstream.

Figure 3.1. View looking downstream at Deposition Zone #5.

Figure 3.2. View looking across and downstream at Deposition Zone #6.

Within sub-basin Q is Deposition Zone 7 as shown in **Figure 3.3**. This zone is actually the BSV Site 9 active alluvial fan. While an average deposition of only 1 foot was measured here, it is an active alluvial fan located directly at FRS #1, with the potential for significant sediment deposition in a 100-year flood.

Figure 3.3. View southeast from a hill overlooking the fan at BSV Site 9 (Deposition Zone 7).

The USGS Site 36 active alluvial fan (White Tank Fan) is upstream of Zone 4 and within sub-basin M and would be a large source of sediment for this area. However, the area of deposition is large and, therefore, the potential deposition would be spread out. White Tanks Wash is within sub-basin E and is Deposition Zone 2. This area would also potentially have a large sediment load, but the deposition would be spread out as well.

In conclusion, it should be emphasized that the depths of deposition presented are estimated trends given the assumed floodplain deposition area and are not actual depths at the FRS.

4. REFERENCES

American Excelsior, 2004. Erosion Works. (http://www.erosionworks.com/index.php).

Camp, P.D., 1986. Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona, USDA Soil Conservation Service, 306 pp.

Curtis, Jr., N.M., 1976. Erosion and Sediment Yield in New Mexico, In: Proceedings of the Third Federal Inter-Agency Sedimentation Conference, Denver, CO.

CH2M Hill, 1994. Casandro Wash Dam, Report Prepared for Flood Control District of Maricopa County, AZ.

CH2M Hill, 1994. Rawhide Wash Detention Basin, Report Prepared for Flood Control District of Maricopa County, AZ.

Hartman, G.W., 1977. Soil Survey of Maricopa County, Arizona, Central Part, USDA Soil Conservation Service, 117 pp.

Hjalmarson, H.W., 1996. City of Scottsdale Desert Greenbelt Project, Review of Sediment Yield. Report prepared for George V. Sabol Consulting Engineers, Inc.

Hjalmarson, H.W., 1998. Upper Cave Creek/Apache Wash Watercourse Master Plan, Report Prepared for Flood Control District of Maricopa County, AZ.

JE Fuller Hydrology & Geomorphology, Inc. (JE Fuller), 1997. Tatum Wash Sedimentation Study, Report Prepared for Flood Control District of Maricopa County, AZ.

JE Fuller Hydrology & Geomorphology, Inc. (JE Fuller), 2000. Spook Hill Area Drainage Master Plan: Update Sedimentation Analysis, Report Prepared for Wood/Patel Associates and the Flood Control District of Maricopa County, AZ.

JE Fuller Hydrology & Geomorphology, Inc. (JE Fuller), 2002. North Peoria Area Drainage Master Plan: Sedimentation Engineering and Geomorphic Evaluation, Report Prepared for Stantec Consulting and the Flood Control District of Maricopa County, AZ.

JE Fuller Hydrology & Geomorphology, Inc. (JE Fuller), 2003. Adobe Dam/Desert Hills Area Drainage Master Plan: Sedimentation Engineering and Geomorphic Evaluation, Draft Report Prepared for Flood Control District of Maricopa County, AZ.

Kelsey, K. L., 2002. Use of the Revised Universal Soil Loss Equation (RUSLE) to Predict Event Soil Loss, Thesis - College of Natural Resources, University of Wisconsin, Stevens Point, WI.

Resource Consultants & Engineers, Inc., (RCE), 1994. Sediment and Erosion Design Guide Prepared for Albuquerque Metropolitan Arroyo Flood Control Authority, NM.

Pacific Southwest Inter-Agency Committee, 1974. Erosion and Sediment Yield Methods, Report of the Water Management Subcommittee, USDA Soil Conservation Service, 47 pp.

PBS&J, 2004. Area 3 Technical Data Notebook, Volume I: Hydrology Report, Buckeye/Sun Valley Area Drainage Master Study, Draft Report Prepared for Flood Control District of Maricopa County, AZ, Contract FCD 2002C027.

Renard, K.G., 1972. Sediment Problems in the Arid and Semiarid Southwest, Soil Conservation Society of America, Proceedings 27th Annual Meeting, Portland, OR, pp. 225-232.

Sabol, G.V., Rumann, J.M., Khalili, D., Waters, S.D., Lehman, T., Gerlach, R.M., Motamedi, A.M., and Loomis, T.R., Revised 2003. Draft Drainage Design Manual for Maricopa County, Volume I - Hydrology, Flood Control District of Maricopa County, AZ.

United States Department of Agriculture – Agriculture Research Service National Sedimentation Laboratory, 2004. Revised Universal Soil Los Equation Project.
(http://www.sedlab.olemiss.edu/rusle/overview.html)

United States Department of Agriculture – Agriculture Research Service National Soil Erosion Research Laboratory, 2004. Official NRCS RUSLE2 Database, Purdue University, West Lafayette, IN.
(http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm)

WEST Consulting (WEST), June 1997. Cherokee Wash Hydrologic, Hydraulic, and Sedimentation Study, Report Prepared for Flood Control District of Maricopa County, AZ.

TECHNICAL MEMORANDUM T2.6.5

Delineation of Erosion Hazard Setbacks (Subtask 2.6.5)
Buckeye/Sun Valley Area Drainage Master Study

Contract No. FCD 2002C027

Prepared for:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Prepared by:

AYRES ASSOCIATES

Ayres Associates Inc
3665 JFK Parkway
Building 2, Suite 200
Fort Collins, Colorado 80525

May 2005

AYRES ASSOCIATES

TECHNICAL MEMORANDUM T2.6.5

To: Kathryn Gross, Valerie Swick – Flood Control District of Maricopa County, AZ

From: Anthony Alvarado, William J. Spitz, R.G.

Date: May 20, 2005

Re: **Technical Memorandum T2.6.5 (Contract No. FCD 2002C027)**
Buckeye/Sun Valley ADMS Delineation of Erosion Hazard Zone (Subtask 2.6.5)

This Technical Memorandum (TM) is submitted by Ayres Associates in support of Subtask 2.6.5 of the Buckeye/Sun Valley Area Drainage Master Study (ADMS) Scope of Work (Contract FCD 2002C027).

The Buckeye/Sun Valley ADMS is being performed for the Flood Control District of Maricopa County (District) and the Town of Buckeye. 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, and develop preliminary solutions to mitigate the identified concerns. Arizona Revised Statutes Title 48, Chapter 21, requires the Board of Directors to identify flood control problems and prepare plans that, when implemented, will eliminate or minimize flooding problems.

Task 2.6 represents the Geomorphic Evaluation and Landform Stability Assessment portion of the Scope of Work (SOW). The purpose of Task 2.6 is to provide a qualitative assessment of potential erosion and sedimentation hazards of primary washes, lateral and vertical stream instability, piedmont landform stability within the drainage networks of Area 3 (Buckeye Structures) and Area 4 (North Sun Valley) of the Buckeye/Sun Valley ADMS watershed, evaluate the 100-year storm event sediment yield for each of the three Buckeye Flood Retarding Structures (FRS), and delineate erosion hazard zones for watercourses within Areas 2 and 3 that have existing FEMA Flood Insurance Study (FIS) floodplain delineations.

1. OBJECTIVE

This TM documents the methodology and results of the delineation of erosion hazard zones performed under Subtask 2.6.5 by Ayres Associates. The objective of Subtask 2.6.5 was to delineate erosion hazard zones for watercourses within Areas 2 and 3 that have existing FEMA Flood Insurance Study (FIS) floodplain delineations.

2. METHODS

Hydraulic and hydrologic data used to delineate the erosion hazard zones were provided by the District for watercourses in Area 3 from existing Flood Insurance Study (FIS) floodplain delineations (detailed), and hydraulic and hydrologic studies prepared by PBS&J as part of this SOW were used for the watercourses in Area 2. Once the Level 1 setbacks were determined, 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 is not adequate or appropriate, setbacks were determined using geomorphic methods.

2.1. Erosion Hazard Zone Delineation

The erosion hazard zones were delineated using the Level 1 approach as specified by the Draft Erosion Hazard Zone Delineation and Development Guidelines (EHZDDG) (JE Fuller 2003). The Level 1 approach is for channels with a drainage area that is less than fifty square miles, with any type of development, and with no unusual existing conditions. The setbacks for the Level 1 erosion hazard zone are estimated using the equations shown in **Table 2.1**.

Table 2.1. Level 1 Erosion Hazard Zone Setback Requirements (JE Fuller 2003).

Drainage Area	Setback Equations	
	Straight Channel	Outside of Bend
< 50 sq miles	$2 * Q_{100}^{0.5}$	$4*Q_{100}^{0.5}$
> 50 sq miles	Use Level 2 or Level 3 Methodology	
Minimum setback	Edge of Floodplain + 50 ft.	

The Q_{100} is the 100-year flood flow at the location of the setback. The setback equation for the outside of a channel bend is used where there is a 20° change in direction of the low flow channel. The transition from the straight reach of the upstream limb into a bend and back to a straight reach in the downstream limb requires a 1:1 upstream transition and a 4:1 downstream transition between setback boundaries. The minimum Level 1 setback is 50 feet landward from the edge of the 100-year floodplain. The setback distance is the distance from the nearest bank of the main channel or the edge of the floodplain. **Figure 2.1** provides an illustration of the typical Level 1 setback criteria.

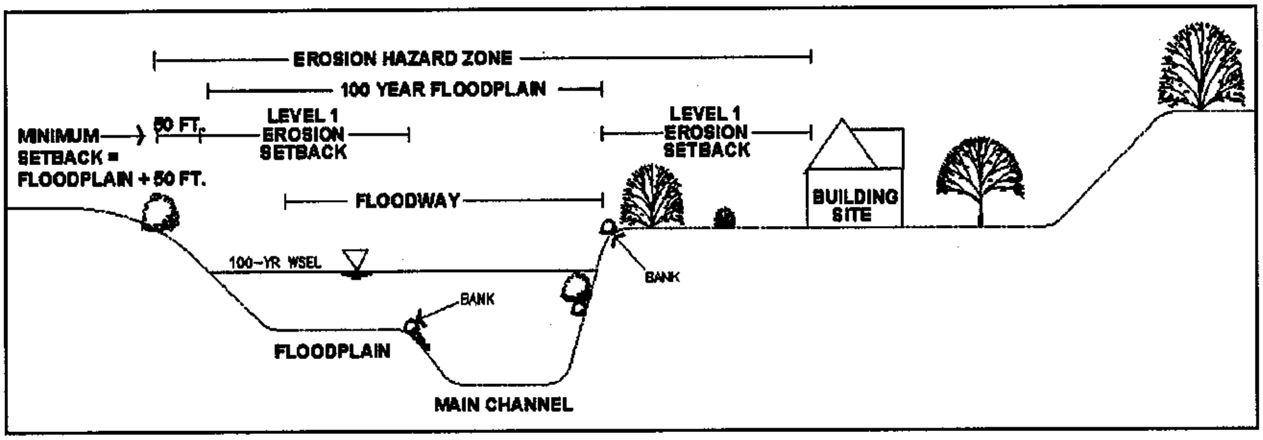

Figure 2.1. Illustration of the Level 1 erosion hazard zone and setbacks (JE Fuller 2003).

The low flow channel banklines were delineated using Geographic Information Systems (GIS) software package, ArcGIS for both Area 2 and 3. Ten-foot contour topography and 2003 MrSID orthophotography were obtained from the District and overlayed in ArcGIS. The topography and orthophotography were then utilized to determine the low flow banklines.

Once the low flow banklines were delineated, Bentley MicroStation, a CAD software package, was used to establish which reaches have bends that have greater than a 20° change in direction and which reaches are straight. With these low flow banklines and depending on whether the reach was a bendway or straight, the setback was calculated using the given discharge for that reach and then applied to the bankline.

The 100-year floodplain for Area 3 (including White Tank Wash and its tributaries) was obtained from the FIS Floodplain maps for the area. The 100-year floodplain mapping for Area 2 was provided by PBS&J. MicroStation was used to delineate the 100-year floodplain plus fifty feet setback boundary.

The 100-year floodplain plus fifty feet setback boundary was then overlain and compared to the calculated erosion hazard zone boundaries. The more conservative or furthest of the two boundaries from the channel was then used to define the final erosion hazard zone.

2.2. Field Verification

All Terrain Vehicles (ATVs) with utility racks (**Figure 2.2**) were the main mode of transportation used in the field reconnaissance of the channels in Area 3. The ATVs were used because of the large extent and relative inaccessibility of the study area, and allowed for quick and efficient movement across the landscape to verify the boundaries and check for problem areas in a short amount of time. Having less travel time allowed for more time to accurately verify the setback boundaries. The channels in Area 2 were examined by car at road crossings where private property restrictions were an issue, and on foot or by ATV where there were no private property restrictions.

Figure 2.1. The Trimble GeoXT handheld GIS-based GPS unit (arrow) mounted on the ATV.

The Trimble GeoXT, which is shown mounted on the ATV in Figure 2.2, is part of the Trimble GeoExplorer CE Series, a handheld Windows CE device with an integrated Trimble GPS receiver. With Windows CE, the device is capable of incorporating mobile GIS field software. For this project, ESRI's ArcPad 6.0, which is the mobile form of ArcGIS with GPSCorrect, was used. Using ArcPad with the georeferenced aerial orthophotography and the pre-defined setback boundary GIS files, the Trimble GeoXT enabled quick navigation and tracking along the erosion setback boundaries. Mobility was accomplished by mounting the Trimble GeoXT on the front utility rack of the ATV and allowed for easy tracking of the current location and navigation along the delineated setbacks. The Trimble GeoXT provides sub-meter GPS accuracy with the portability of a fully editable mobile GIS database.

2.3. Erosion Hazard Zone Mapping

The erosion hazard zone boundaries for Area 2 and Area 3 are delineated on the attached map sheets. The boundaries are based on either the erosion setbacks calculated using equations provided in the Level 1 approach, the 100-year floodplain plus 50 feet approach, or on field evidence of potential hazards that are not encompassed by the boundaries defined by the previous two approaches. Typical setbacks as delineated for White Tank Wash in Area 3 are shown in **Figure 2.2**. The erosion hazard zone boundaries would be the boundary farthest from the channel as defined either by the 100-year floodplain plus 50 feet, the calculated setback, or geomorphic information. The cross sections with the 100-year floodplain and the final erosion hazard zone for 3 reaches of White Tank Wash are shown in **Figure 2.3**.

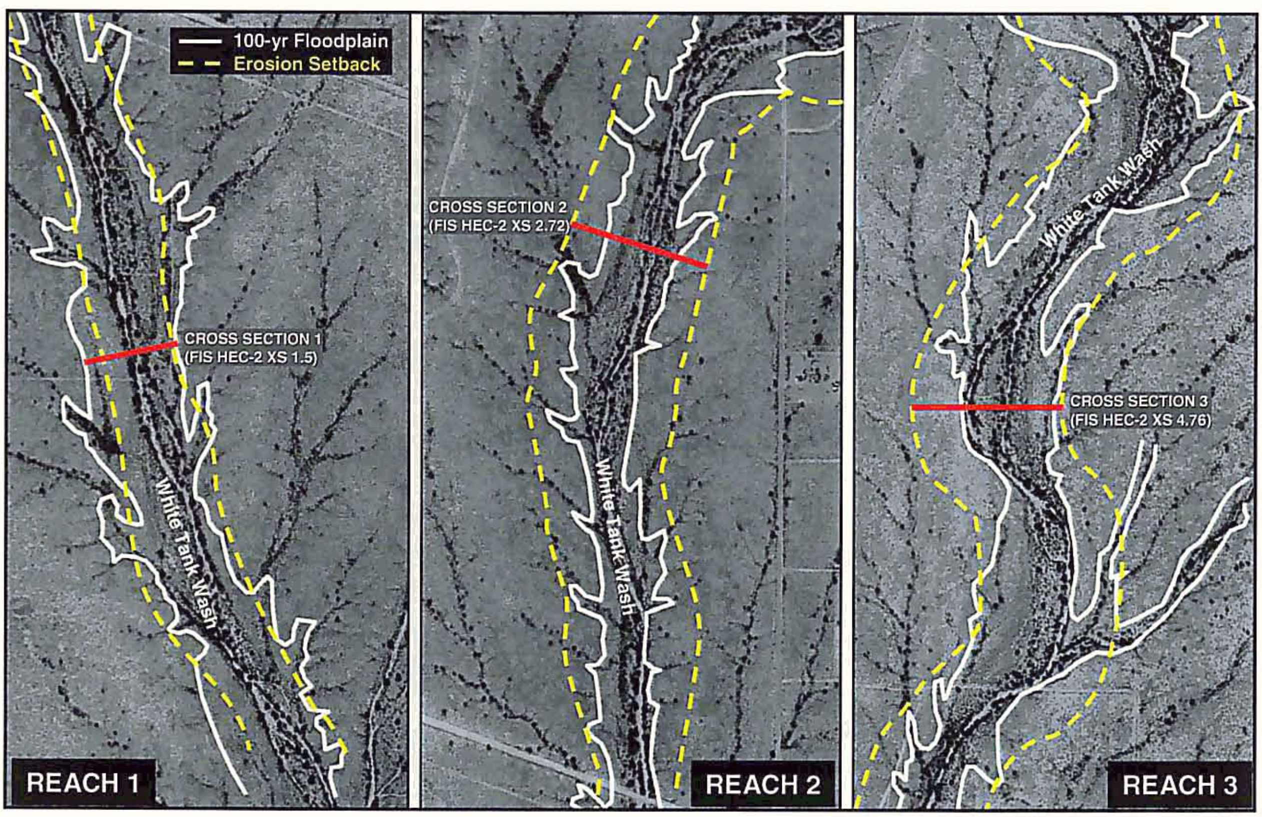

Figure 2.2. Reaches of White Tank Wash in Area 3 showing the 100-year floodplain, erosion hazard zone (EHZ) boundaries, and specific cross section locations.

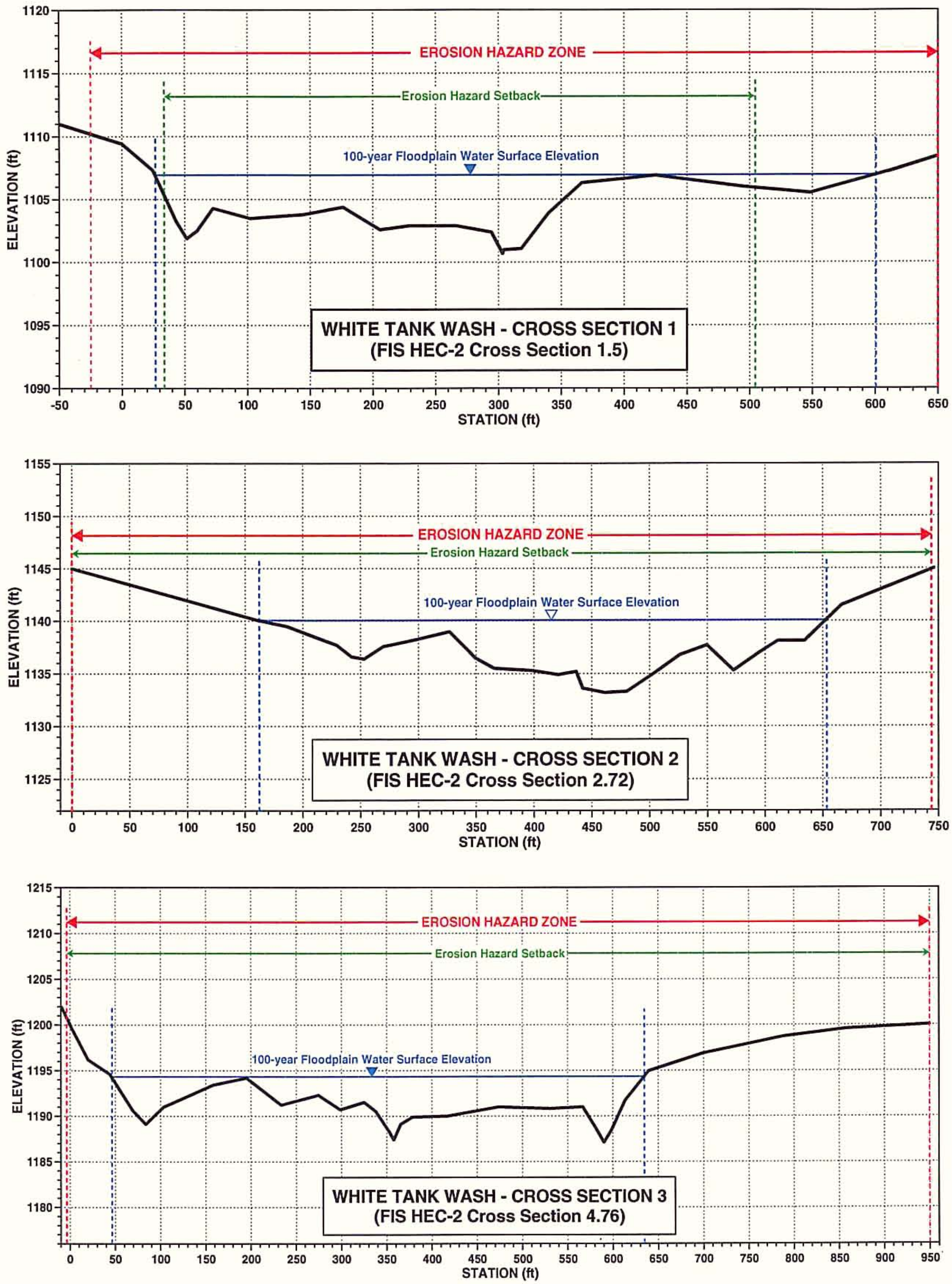

Figure 2.3. Cross sections and boundaries as shown in Figure 2.2.

The EHZ boundaries were modified at four major locations where the setback was inappropriate or inadequate. No reaches were modified in Area 2 and four reaches were modified in Area 3 as follows:

Area 3, Sheet 1, Map 02 – The modified EHZ boundary is located between approximately 600 and 1,000 feet upstream of match line B-B on the right bank side of the valley. The calculated setback in this area was shifted to the east because the area shows evidence of an old or inactive split flow channel north of the existing main channel. Although the downstream end of the split flow channel is within the 100-year floodplain, it does not appear that the 100-year floodplain is mapped far enough north to account for the middle and upper end of the split flow channel. This may be a function of the cross-section spacing and the model constraints, which may not have identified the upper end of the flow split. It appears that a portion of high flows may split well upstream and supply flow to this channel. If this were to occur, the split flow channel or the area along it may be susceptible to associated flood and erosion hazards further north than the boundaries defined by the current 100-year floodplain and the calculated erosion hazard setback. Therefore, the modified setback reflects these potential hazards and the EHZ boundary is defined as the right bank of the split flow channel plus 50 feet as a minimum.

Area 3, Sheet 5, Map 09 – The modified EHZ boundary is located from about 200 feet upstream of match line B-B to approximately 3,000 upstream of the match line on the right bank side of the valley. The area has been identified as an active alluvial fan (BSV Site #14). Therefore, the setback along the right bank of the channel in this reach is inappropriate. The exact location of the setback along this reach will be dependent upon further study of the active alluvial fan to determine the exact fan boundaries. However, for the purposes of mapping the EHZ, the EHZ boundary has been set at the northern fan boundary. It is recommended that District redefine the northern boundary as the north fan boundary plus 50 feet as a minimum to account for potential lateral erosion associated with the fan and to accommodate any future countermeasures.

Area 3, Sheet 5, Map 10 – The modified EHZ boundary is located between approximately 400 and 700 feet downstream of match line H-H along the right bank area. The calculated setback in this area was shifted to the north because the area contains what appears to be an active split flow channel along the right side of the floodplain. It does not appear that the 100-year floodplain is mapped far enough north. This may be a function of the cross-section spacing and the model constraints, which may not have identified the flow split. It appears that overbank flow occurs at the upstream end and frequently supplies flow to this split flow channel. It is likely that the split flow channel or the area along it is susceptible to associated flood and erosion hazards further north than the boundaries defined by the current 100-year floodplain and the calculated erosion hazard setback. Therefore, the modified setback reflects these potential hazards and the EHZ boundary is defined as the right bank of the split flow channel plus 50 feet as a minimum.

Area 3, Sheet 5, Map 10 – The modified EHZ boundary is located between approximately 400 and 1,400 feet upstream of match line I-I on the right bank area. The calculated setback in this area was shifted to the south because the area shows what appears to be an active split flow channel along the left side of the floodplain. It does not appear that the 100-year floodplain is mapped far enough south. This may be a function of the cross-section spacing and the model constraints, which may not have identified the flow split. It appears that overbank flow occurs at the upstream end and frequently supplies flow to this split flow channel. It is likely that the split flow channel or the area along it is susceptible to associated flood and erosion hazards further south than the boundaries defined by the current 100-year floodplain and the calculated setback. Therefore, the modified setback reflects these potential hazards and the EHZ boundary is defined as the left bank of the split flow channel plus 50 feet as a minimum.

3. CONCLUSIONS AND RECOMMENDATIONS

For the most part, the Level 1 EHZ boundaries appear reasonable. However, as described above, there are locations where the EHZ boundary has been shifted to account for flow splits that do not appear to have been identified and accounted for in the floodplain mapping. In these locations, the EHZ boundary has been shifted away from the associated bank of the split flow channel by a minimum of 50 feet. In one area, the recent identification of an active alluvial fan (BSV Site 14) along the right bank of the channel requires the delineation of an erosion setback along the northern margin of the fan to account for potential alluvial fan flooding. However, it is recommended that a 50-foot buffer be established between the northern fan margin and the EHZ boundary to account for potential erosion as well as the potential need for countermeasures along the fan margin.

In several locations, it appears that the EHZ boundary may be excessive. This often occurs where there is a meander bend in the main channel, but the main channel and floodway are deeply entrenched and bound by relict fan surfaces (see Cross Section 3 in Figures 2.2 and 2.3). It is evident that the channel has not encroached into these areas in tens of thousands of years and will likely not do so in the near future. Thus, there will likely be some resistance from developers where the boundary is several hundred feet away from the main channel and encompasses several hundred feet of higher relict fan surface between the channel and the setback. However, it is also noted that there are provisions for conducting a Level 2 erosion hazard zone setback analysis if the developer feels that the Level 1 boundary is excessive or too conservative.

The electronic files for this technical memo include GIS files for both Area 2 and Area 3. For each area, the 100-year floodplain, the 100-year floodplain plus 50 feet, the delineated low flow banklines, the calculated erosion hazard zone setbacks (based on the low flow banklines and the 100-year flood streamflow rates), and the final combined erosion hazard zones are all included in ESRI shapefile format. These files are also provided in an ArcGIS 9.03 geodatabase file for each area as well. The files are compiled on the attached CD being submitted with this technical memo.

4. REFERENCES

JE Fuller/Hydrology & Geomorphology, Inc. (JE Fuller), 2003. Draft Erosion Hazard Delineation and Development Guidelines, Prepared for Flood Control District of Maricopa County, Phoenix, AZ.

5. ATTACHMENTS

Erosion Hazard Setback Delineation Maps: Index Sheet, Area 2 Sheets 1-6, and Area 3 Sheets 1-6.

DELINEATION OF EROSION HAZARD ZONE
AREA 2 AND AREA 3
INDEX SHEET

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 2,000 4,000 6,000 Feet

SCALE: 1" = 2000 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AYRES ASSOCIATES

Area 2 Map 01

Area 2 Map 02

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN A
SHEET 1 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AYRES ASSOCIATES

Area 2 Map 03

Area 2 Map 04

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN C
SHEET 2 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Flood Control District of Maricopa County

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ Date Signed 5/20/05 ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN E
SHEET 3 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN E
SHEET 4 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Flood Control District of Maricopa County

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ Date Signed 5/2/05 ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN E
SHEET 5 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ Date Signed ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 2 - BASIN E
SHEET 6 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ Date Signed 5/20/05 ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH
SHEET 1 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH
SHEET 2 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

Erosion Hazard Zone
100 year Floodplain

0 200 400 600 Feet
SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH
SHEET 3 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ Date Signed 5/20/05 ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH
SHEET 4 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO 39950 WILLIAM J. SPITZ Date Signed ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH TRIBUTARY
SHEET 5 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

- Erosion Hazard Zone
- 100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REGISTERED GEOLOGIST CERTIFICATE NO. 39950 WILLIAM J. SPITZ, Date Signed, ARIZONA, U.S.A.

AYRES ASSOCIATES

DELINEATION OF EROSION HAZARD ZONE
AREA 3 - WHITE TANKS WASH TRIBUTARY
SHEET 6 OF 6

BUCKEYE/SUN VALLEY
AREA DRAINAGE MASTER STUDY
CONTRACT NO. FCD2002C027
TASK 2.6.5

Legend

Erosion Hazard Zone
100 year Floodplain

0 200 400 600 Feet

SCALE: 1" = 200 ft

FLOOD CONTROL
DISTRICT OF
MARICOPA COUNTY

REGISTERED GEOLOGIST
CERTIFICATE NO.
39950
WILLIAM J.
SPITZ
Date Signed 5/20/05
ARIZONA, U.S.A.

AYRES ASSOCIATES