City of Albuquerque

Planning Department

Development & Building Services Division

DRAINAGE AND TRANSPORTATION INFORMATION SHEET

(REV 02/2013)

Project Title: Calabacillas N. Branch Arroyo Building Permit #:________ City Drainage #: B10/D050

DRB#: ________ EPC#: ________ Work Order#: ________

Legal Description: ________

City Address: ________

Engineering Firm: Bohannan Huston Contact: ________

Address: 7500 Jefferson St NE Albuq NM 87109

Phone#: ________ Fax#: ________ E-mail: ________

Owner: ________ Contact: ________

Address: ________

Phone#: ________ Fax#: ________ E-mail: ________

Architect: ________ Contact: ________

Address: ________

Phone#: ________ Fax#: ________ E-mail: ________

Surveyor: ________ Contact: ________

Address: ________

Phone#: ________ Fax#: ________ E-mail: ________

Contractor: ________ Contact: ________

Address: ________

Phone#: ________ Fax#: ________ E-mail: ________

TYPE OF SUBMITTAL: DMP

- [x] DRAINAGE REPORT
- [ ] DRAINAGE PLAN 1st SUBMITTAL
- [ ] DRAINAGE PLAN RESUBMITTAL
- [ ] CONCEPTUAL G & D PLAN
- [ ] GRADING PLAN
- [ ] EROSION & SEDIMENT CONTROL PLAN (ESC)
- [ ] ENGINEER'S CERT (HYDROLOGY)
- [ ] CLOMR/LOMR
- [ ] TRAFFIC CIRCULATION LAYOUT (TCL)
- [ ] ENGINEER'S CERT (TCL)
- [ ] ENGINEER'S CERT (DRB SITE PLAN)
- [ ] ENGINEER'S CERT (ESC)
- [ ] SO-19
- [ ] OTHER (SPECIFY)

CHECK TYPE OF APPROVAL/ACCEPTANCE SOUGHT:

- [ ] SIA/FINANCIAL GUARANTEE RELEASE
- [ ] PRELIMINARY PLAT APPROVAL
- [ ] S. DEV. PLAN FOR SUB'D APPROVAL
- [ ] S. DEV. FOR BLDG. PERMIT APPROVAL
- [ ] SECTOR PLAN APPROVAL
- [ ] FINAL PLAT APPROVAL
- [ ] CERTIFICATE OF OCCUPANCY (PERM)
- [ ] CERTIFICATE OF OCCUPANCY (TCL TEMP)
- [ ] FOUNDATION PERMIT APPROVAL
- [ ] BUILDING PERMIT APPROVAL
- [ ] GRADING PERMIT APPROVAL
- [ ] PAVING PERMIT APPROVAL
- [ ] WORK ORDER APPROVAL
- [ ] GRADING CERTIFICATION
- [ ] SO-19 APPROVAL
- [ ] ESC PERMIT APPROVAL
- [ ] ESC CERT. ACCEPTANCE
- [x] OTHER (SPECIFY) INFO

WAS A PRE-DESIGN CONFERENCE ATTENDED: ____ Yes ____ No ____ Copy Provided

DATE SUBMITTED: ________ By: ________

Requests for approvals of Site Development Plans and/or Subdivision Plats shall be accompanied by a drainage submittal. The particular nature, location, anc scope to the proposed development defines the degree of drainage detail. One or more of the following levels of submittal may be required based on the followin

1. **Conceptual Grading and Drainage Plan**: Required for approval of Site Development Plans greater than five (5) acres and Sector Plans
2. **Drainage Plans**: Required for building permits, grading permits, paving permits and site plans less than five (5) acres
3. **Drainage Report**: Required for subdivision containing more than ten (10) lots or constituting five (5) acres or more
4. **Erosion and Sediment Control Plan:** Required for any new development and redevelopment site with 1-acre or more of land disturbing area, includinę project less than 1-acre than are part of a larger common plan of development

Cherne, Curtis

From: Cherne, Curtis
Sent: Thursday, October 31, 2013 2:37 PM
To: 'Bingham, Brad'
Subject: calabacillas west bracnh arroyo DSWQMP

Brad,
Thank you for submitting this existing conditions report for our files.

Hydrology provides the following general comment.
The report states "As HEC-HMS is now the regionally accepted hydrologic modeling method…". HEC-HMS has not been adopted by the City of Albuquerque.
Hydrology is looking forward to future discussions on the topic.

Curtis

Albuquerque
Metropolitan
Arroyo
Flood
Control
Authority

2600 Prospect N.E., Albuquerque, NM 87107
Phone: (505) 884-2215 Fax: (505) 884-0214
Website: www.amafca.org

Mr. Curtis Cherne, P.E. C.F.M
Floodplain Administrator
City of Albuquerque
600 2nd St. NW Suite 201
Albuquerque, NM 87102

September 18, 2013

RE: Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan

Dear Curtis,

AMAFCA is pleased to share the Existing Conditions Hydrology Report for the aforementioned project with you and your staff. Once your review is done, please contact me to discuss at 884-2215 or 238-1277.

As always, our coordinated effort to manage the watershed is greatly appreciated.

Sincerely,
AMAFCA

Bradley L. Bingham, P.E.
Drainage Engineer

Cc: Bryan Wolfe, City Engineer, CoA

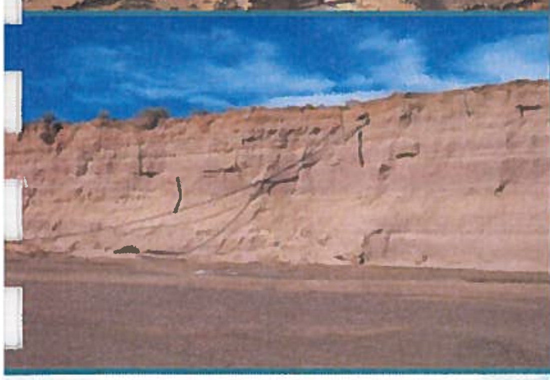
DMG – info.

September 5, 2013

CALABACILLAS WEST BRANCH ARROYO DRAINAGE & STORM WATER QUALITY MANAGEMENT PLAN

PHASE I, TASK C
EXISTING CONDITIONS HYDROLOGY REPORT

AMAFCA



Submitted by:

TETRA TECH

and

Bohannan Huston

6121 Indian School Road NE
Suite 205
Albuquerque, NM 87110
(505) 881-3188

EXECUTIVE SUMMARY

The Calabacillas West Branch Arroyo (CWB) watershed is located in the northwest area of Albuquerque, and straddles the city limits of Albuquerque and Rio Rancho. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) contracted Tetra Tech to provide engineering services to develop the Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan to identify arroyo and storm water quality improvements needed for the CWB as the watershed develops.

The CWB has one point of discharge to the AMAFCA Swinburne Dam. The CWB drainage basin includes diversions from the Piedras Marcadas Arroyo watershed via the Las Ventanas Detention Dam and Outfall Pipe.

Tetra Tech completed the Field Reconnaissance of the CWB on March 5, 2013. A longitudinal profile of the CWB was also created to facilitate assessment of the existing channel. These data were analyzed and compared to the data presented by Mussetter Engineering, Inc. (MEI) in the 1999 Calabacillas Arroyo Prudent Line Study and Related Work – Development of a Prudent Line for the West Branch ("1999 Prudent Line Study"). The Field Reconnaissance Report identifies locations where existing prudent lines are being encroached upon by lateral migration, and where vertical degradation is problematic. The 1999 Prudent Line Study is the basis for recommended sediment bulking factors for various reaches of the arroyo for the 2013 existing conditions hydrology modeling.

The hydrologic analysis was completed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), based on SSCAFCA's Development Process Manual (DPM), Chapter 22, Drainage, Flood Control and Erosion Control (Revised April 2010), to be compatible with separate analysis being completed for the Calabacillas Watershed by SSCAFCA. Fifty sub basins were modeled, with a total area of 11.09 sq. mi. This includes eight basins, totaling 1.92 sq. mi., that drain through the AMAFCA Las Ventanas or Little Window Detention Dams. 2-year (yr.), 10-yr, and 100-yr, 6-hour and 24-hour storm events (50%, 10% and 1% probability events, respectively) were modeled for this study. The precipitation depths, for the analyzed events, were extracted from the NOAA Atlas 14. For the 6 hour and 24 hour storms respectively, the rainfall depth for the 2-year event is 0.968 inches and 1.23, the 10-year event is 1.47 inches and 1.79 inches, and the 100-yr event is 2.27 inches and 2.66 inches. In this analysis, no depth-area reduction factor was used as the analysis results will ultimately be used for planning and development of recommended infrastructure.

The 2103 existing conditions HEC-HMS hydrology is compared to the 1999 existing conditions AYHMO hydrology. Flow rates and volumes in the lower reaches of the CWB are higher than the 1999 AHYMO due to the development within the watershed over the last 14 years.

At Swinburne Dam, the predicted 1999 100-yr flow rate was 1440 cfs (1603 cfs bulked) and the volume was 220 ac-ft. The 2013 HEC-HMS model predicts 2144 cfs (2390 cfs bulked) and a volume of 424 ac-ft. at the same location. Similar flow and volume increases are predicted in the lower reaches of the arroyo due to development with the watershed over the last ten years.

At the Old Black Ranch, an analysis point above any development, the predicted 1999 100-yr flow rate was 1190 cfs (1288 cfs bulked) and the volume was 170 ac-ft. The 2013 HEC-HMS model predicts 1506 cfs (1632 cfs bulked) and a volume of 185 ac-ft. at the same location. Increases predicted in the upper reaches of the watershed may be attributable to using 100% A treatment in upper basins in 1999, as compared to the 2013 modeling where these basins were modeled with a combination of A, B, C, and D treatments. For example, the basin QR23, the site of the borrow pit located at the future Quail Ranch Pond Site, used land treatments of 61% A, 2% B, 36% C, and 0% D.

As HEC-HMS is now the regionally accepted hydrologic modeling method, further analysis of the reasons for the 1999-2013 changes in flow rates and volumes within the CWB watershed is likely a moot exercise.

2013 Existing Conditions Analysis Points HEC-HMS						1999 Existing Conditions Analysis Points AHYMO				
Event	BULKING FACTOR	Peak Discharge (cfs)		Runoff Volume (ac-ft.)		Event	BULKING FACTOR	Peak Discharge (cfs)		Runoff Volume (ac-ft.)
		Unbulked	Bulked					Unbulked	Bulked	
AP1 (RT.QR4)						No equivalent analysis point				
2	1.40%	0	0	0						
10	2.80%	118	121	10.4						
100	5.50%	671	708	55.1						
AP2 (RT.QR20)						Concentration Point 4				
2	1.40%	0	0	0		2	0.00%	0	0	0
10	2.80%	125	128	11.5		10	2.80%	110	114	10
100	5.60%	712	752	60.6		100	5.60%	660	714	70
AP3 (RT.QR24)						From AHYMO R1				
2	1.10%	0	0	0		2	0.00%	0	0	not reported
10	4.20%	165	172	19.1		10	4.10%	111	115	
100	7.60%	954	1026	92.3		100	7.40%	713	771	
AP4 (RT.PW4)						Concentration Point 2				
2	1.60%	0	0	0		2	0.00%	0	0	0
10	5.30%	171	180	22.3		10	5.20%	120	125	20
100	9.70%	1019	1117	108.5		100	9.50%	780	844	90
AP5 (RT.PW10)						Concentration Point 1				
2	1.90%	5	5	0.9		2	0.00%	0	0	0
10	4.20%	280	292	38.7		10	4.00%	190	198	30
100	8.40%	1506	1632	184.7		100	8.20%	1190	1288	170
AP7 (RT.PW14)						No equivalent analysis point				
2	2.60%	38	38	5.6						
10	4.40%	326	341	51.1						
100	8.10%	1807	1954	222.4						
AP8 (RT.VR5)						From AHYMO R6				
2	4.40%	92	96	14.2		2	0.00%	0	0	not reported
10	6.10%	371	394	65.9		10	6.00%	210	223	
100	8.70%	1972	2144	249.5		100	8.50%	1440	1562	
AP9 (RT.SEV1)						Concentration Point L				
2	4.70%	125	131	19.2		2	0.00%	0	0	not reported
10	6.60%	388	413	74.2		10	6.20%	210	223	
100	11.10%	2038	2264	263.6		100	11.00%	1440	1598	
AP10 (SWINBURNE_INFLOW)						Concentration Point 0				
2	6.00%	191	202	76		2	0.00%	0	0	0
10	7.20%	477	511	167.3		10	6.70%	210	224	40
100	11.50%	2144	2390	424		100	11.30%	1440	1603	220

Abbreviations and Definitions

Abbreviations

Ac-ft.:	acre-feet; a volume of water one foot deep covering one acre or 43,560 cubic feet
AHYMO:	Albuquerque version of HYMO (hydrologic model program)
AMAFCA:	Albuquerque Metropolitan Arroyo Flood Control Authority
BHI:	Bohannan-Huston, Inc.
cfs:	cubic feet per second, used to quantify flow rate of water
CWB:	Calabacillas West Branch Arroyo
DMP:	Drainage management plan
HEC-HMS:	U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS:	U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System
PMP:	Probable maximum precipitation
Q:	variable used to represent flow rate of water, units are cfs
RCP:	reinforced concrete pipe
MEI:	Mussetter Engineering, Inc.
SSCAFCA	Southern Sandoval County Arroyo Flood Control Authority
Tetra Tech	Tetra Tech, Inc.

Definitions

basin:	a region in which runoff flows to a common point
hydrology:	an earth science dealing with occurrence and distribution of the earth's water, including rainfall and the resulting runoff
hydraulics	operated by or employing water. Hydraulic structures in this report are those which convey runoff (pipes, channels, streets, and dams
model:	a set of numerical data that describes the watershed conditions. Input date for the model includes rainfall, area of basins, slopes, and land usage. Output includes volume and flow rate of runoff.
watershed:	region in which many basins drain to a common point

1.0 INTRODUCTION

1.1 Scope

The Calabacillas West Branch Arroyo (CWB) watershed is located on the northwest area of Albuquerque, and straddles the city limits of Albuquerque and Rio Rancho. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) contracted Tetra Tech to provide engineering services to develop the Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan to identify arroyo improvements needed for the CWB as the watershed develops.

The CWB is a major tributary to the Calabacillas Main Branch Arroyo. Its confluence with the main branch is within the reservoir area of the AMAFCA Swinburne Detention Dam. The CWB, while small in comparison to the Calabacillas Main Branch, is a substantial part of the west side drainage system. With an area of approximately 5,960 acres, 1999 AHYMO hydrology models predict the CWB watershed would generate a peak flow of about 1,300 cfs in a 100-yr. event under current conditions, and this would increase to about 5,000 cfs under 2036 development conditions. The current floodplain covers approximately 165 acres, and impacts 100 different parcels. The 1999 Prudent Line limits span roughly 270 acres, and impact 184 parcels. As such, compilation of a Drainage Management Plan (DMP) for this arroyo will impact many private owners, multiple jurisdictions, and gives AMAFCA a great opportunity to extend the open space character of the arroyo west to the Rio Puerco divide. This DMP is also a key part of the AMAFCA/SSCAFCA joint effort to evaluate the Calabacillas Main Branch and resulting inflows to Swinburne Dam.

The watershed area is relatively long and linear in layout. The general limits of the watershed are the Rio Puerco divide to the west, the Calabacillas Middle Branch divide to the north, Swinburne Dam (located on Unser Blvd.) to the east, and Irving Blvd to the south. The CWB has one point of discharge to the AMAFCA Swinburne Dam. The CWB drainage basin includes diversions from the Piedras Marcadas Arroyo watershed via the Las Ventanas Detention Dam and Outfall Pipe.

Tetra Tech completed the Field Reconnaissance of the CWB on March 5, 2013. Representatives from AMAFCA, Tetra Tech, BHI, and SSCAFCA performed a reconnaissance-level investigation of the CWB. The field reconnaissance trip included qualitative observations and sediment sampling. A longitudinal profile of the CWB was also created to facilitate assessment of the existing channel. These data were analyzed and compared to the data presented by Mussetter Engineering, Inc. (MEI) in the Calabacillas Arroyo Prudent Line Study and Related Work – Development of a Prudent Line for the West Branch, MEI, 1999 ("1999 Prudent Line Study"). The Field Reconnaissance Report identifies locations where existing prudent lines are being encroached upon by lateral migration, vertical degradation is problematic, and was able to extrapolate the 1999 sediment bulking factors for various reaches of the arroyo for the 2013 existing conditions hydrology modeling.

1.2 Authorization

This Existing Conditions Hydrology Report, intended to support the Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan was conducted by Tetra Tech with subconsultant assistance from BHI. Tetra Tech teamed with BHI on this project, with BHI subcontracted to perform HMS clear water modeling, prepare a PMP Hydrology Report to the NM Office of the Sate Engineer, and to assist in the development of storm drainage and storm water quality facility options. Tetra Tech will focus on the sediment transport through the arroyo, and will evaluate vertical stability, equilibrium slopes and complete all other tasks for the resulting Drainage and Storm Water Quality Management Plan.

Mr. Brad Bingham, PE, was the Project Manager for AMAFCA, and Mr. John Kelly, PE, was Tetra Tech's Project Manager. Tetra Tech staff who contributed significantly to the work included Dr. Robert Mussetter PE, Mr. Stuart Trabant, PE, and Mr. Kyle Shour, EI. BHI staff included Mr. Craig Hoover, PE, Ms. Alandren Etlantus, PE, and Mr. Jonathan Ellison, EI.

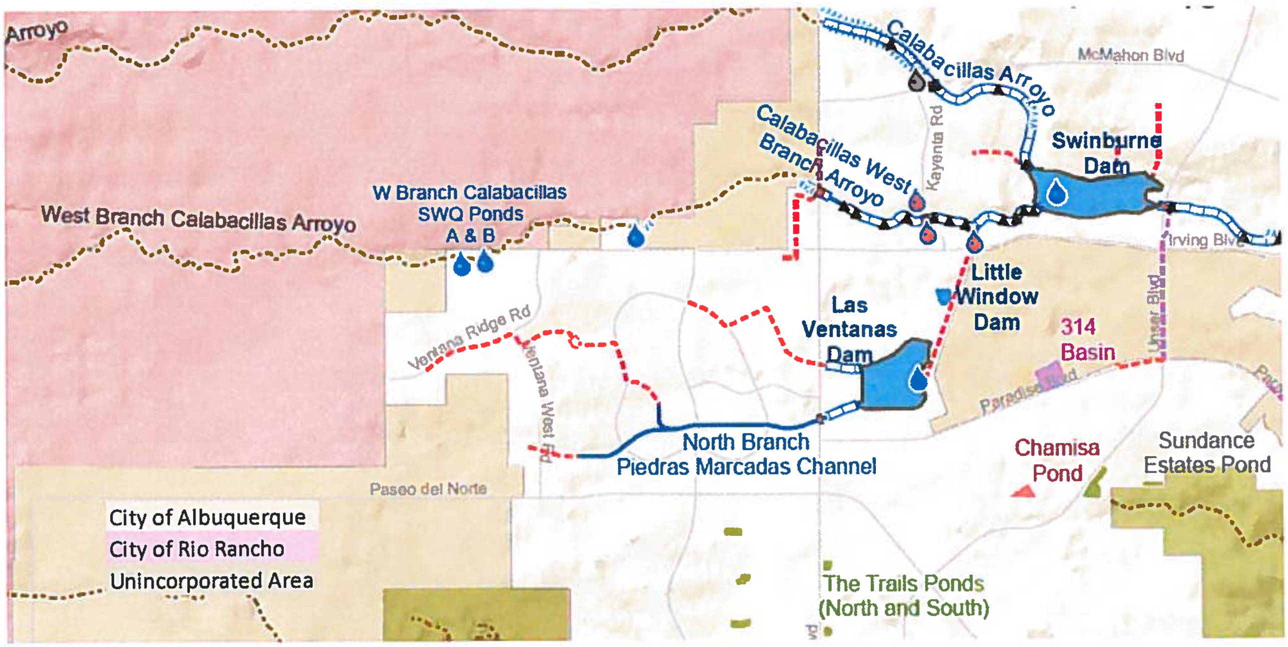


Figure 1 – Vicinity map of Calabacillas West Branch Arroyo

The vicinity map shows the overlapping jurisdictions of AMAFCA, Bernalillo County, the city of Albuquerque, and the city of Rio Rancho in the CWB watershed.

1.3 List of Tasks for Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan

The following is a list and brief description of tasks required for the Calabacillas West Branch Arroyo Drainage and Storm Water Quality Management Plan:

a. Coordination and Communication

The completion of the project includes coordinating this work with a coincident and complementary effort being conducted by the Southern Sandoval County Arroyo Flood Control Authority ("SSCAFCA"). SSCAFCA is performing similar analyses on the Calabacillas Middle Branch and Main Branch Arroyos, with the intent to combine the West Branch model into the SSCAFCA model to evaluate impacts to the AMAFCA Swinburne Dam. This will include evaluation of 100-year and PMP hydrology, and sediment transport to the dam on an annualized basis as well as for selected storm events. Coordination and communication among AMAFCA, Bernalillo County, and the city of Rio Rancho is also anticipated to resolve developed conditions land treatments that are different in various master planning documents.

b. Literature Review and As-Built Drawing Collection

A literature review document has been produced in order to better understand the history of drainage, development, open space and multiuse planning objectives for the CWB and its watershed. This review looked at eleven relevant planning documents and fourteen relevant technical documents addressing the CWB watershed. The review also identified 29 drainage structures or pipe discharges as existing features within the CWB. As-built drawings have also been obtained for all drainage structures within or discharging to the arroyo. This Literature Review Report was produced by Tetra Tech and BHI and submitted to AMAFCA on March 1, 2013.

c. Mapping

The BHI-produced 2012 Mid-Region Council of Governments (MRCOG) digital aerial photography and 2010 LiDAR topography was used as base mapping for this project. Since this is a master planning project, field surveys were not used to verify pipe inverts or slopes, as that level of detail is best suited for future design projects.

d. Field Reconnaissance

The field reconnaissance included qualitative observations and sediment sampling. A longitudinal profile of the CWB was also created to facilitate assessment of the existing channel. These data were analyzed and compared to the data presented by the 1999 Prudent Line Study. The intent was to make recommendations on the validity of the 1999 Prudent Line Study with regard to aggradation/degradational zones, prudent limits, and appropriate bulking factors for the DMP design storms. The *Calabacillas West Branch Arroyo Field Reconnaissance Report* was prepared by Tetra Tech and submitted to AMAFCA concurrently with this report.

e. Existing Conditions Hydrology and Hydraulics (this report)

This report evaluates existing conditions hydrology for the CWB, using land treatments and storm drainage facilities that exist today. Sediment bulking factors have been extrapolated from the 1999 Prudent Line Study. Flow rates and volumes have been determined at key analysis points for the 2-year, 10-year, and 100-year, 6-hr and 24-hr duration storm events.

f. PMP Hydrology Report to the NM Office of the State Engineer

This report will develop hydrologic input parameters for the PMP design storms. This will include delineation of drainage basins, land treatment, rainfall duration and intensity, reach lengths and sediment bulking. HEC-HMS modeling will be done for the PMP design storms, which are the 6-hr. Local HMR-5, 6 hr. Local EM-1110-2-1411, and the 72 hr. General distribution. PMP volumes and peak flow rates will be provided at the Swinburne Dam reservoir. A PMP Hydrologic Analysis Report will be prepared and submitted to the NMOSE.

g. Resolution of Developed Conditions Land Treatments

The CWB watershed has multiple overlapping jurisdictions. The watershed is wholly within AMAFCA and Bernalillo County jurisdiction. The upper reach of the watershed was annexed by the city of Rio Rancho in 2008. As such, the Rio Rancho Comprehensive Plan, and the Bernalillo County Comprehensive Plan, as well as privately produced Paradise West Master Plan and the Quail Ranch Master Plan were reviewed, and the conflicting land uses have been identified. AMAFCA will take the lead in resolving these conflicts prior to the developed conditions hydrology modeling.

This work is also being conducted simultaneously with a complementary SSCAFCA effort on the Calabacillas Main and Calabacillas Middle Branches, in order to have one unified hydrologic model for the Swinburne Dam watershed to support dam safety and emergency action plan efforts for the dam. Coordination of these land treatments and all other hydrologic inputs is ongoing with SSCAFCA.

h. Developed Conditions Hydrology and Hydraulics

This task will analyze developed-conditions peak flows and volumes, based on the land treatments agreed to among AMAFCA, SSCAFCA, the city of Rio Rancho, and Bernalillo County. Two developed conditions scenarios will be evaluated:

- DCM#1, a developed conditions hydrology model with existing flood control facilities and the proposed Paseo del Volcan Diversion to the Calabacillas Middle Branch ("PdV Diversion") assumed to be in place
- DCM#2, a developed conditions hydrology models with existing flood control facilities and the PdV Diversion and Quail Ranch Pond assumed to be in place.

i. Sediment and Erosion Analyses

This includes sediment continuity analysis for both developed conditions scenarios. Sediment transport relationships will be developed for appropriate subreaches of the arroyo. Sediment supply from upstream and local tributaries will be estimated. Equilibrium slope analysis will be performed for each subreach. For DCM#1, Engineer will compute prudent limits for the arroyo from Universe Blvd. (approx. Sta. 55+00) upstream to approximately Sta. 381+00, the alignment of future Paseo Del Volcan. For DCM #2, Engineer will compute prudent limits from Universe Blvd. (approx. Sta. 55+00) to outlet of the proposed Quail Ranch Pond, at approximately Sta. 284+00.

j. Development of Facility Options for Developed Conditions

This task will provide recommendations for options for proposed drainage facilities within the watershed and set policy for drainage management in the CWB. This will include consideration of planning documents, storm water quality considerations, watershed management, right of way needs and construction estimates.

2.0 PROJECT AREA DESCRIPTION

2.1 Calabacillas West Branch Watershed

For the purposes of discussion, the CWB can be divided in to two general subreaches based on geomorphic and anthropogenic characteristics:

1. From the mouth at Station 0+00 to Universe Blvd at Station 55+00, the lower reach
2. From Universe Blvd at Station 55+00 to Station 350+00, the upper reach

The lower reach of the CWB has been modified by the construction of Swinburne Dam, where excavation of the Main Branch within the reservoir lowered the base level of the CWB by approximately 6 feet. This was identified in the 1999 Prudent Line Study. This resulted in incision in the lower reach. The 1999 Prudent Line Study compared the bed profile from a 1996 survey performed by BHI with the profile developed from a 1986 topography (taken from the Leedshill-Herkenhoff, Inc. HEC-2 model used in the previous prudent line study. MEI noted that the lower 500 feet of the arroyo had degraded by approximately 5 feet, and that the degradation over the next 4,500 feet ranged from 1-3 feet, The lower reach of the CWB has since been stabilized by ten grade control structures ("GCS") and two road crossing structures (Kayenta Pl. and Universe Blvd.)

Tetra Tech has compared the bed profile for the lower reach from the 1996 survey to the bed profile developed from the 2010 MRGCOG LiDAR topography as shown in Figure 2.

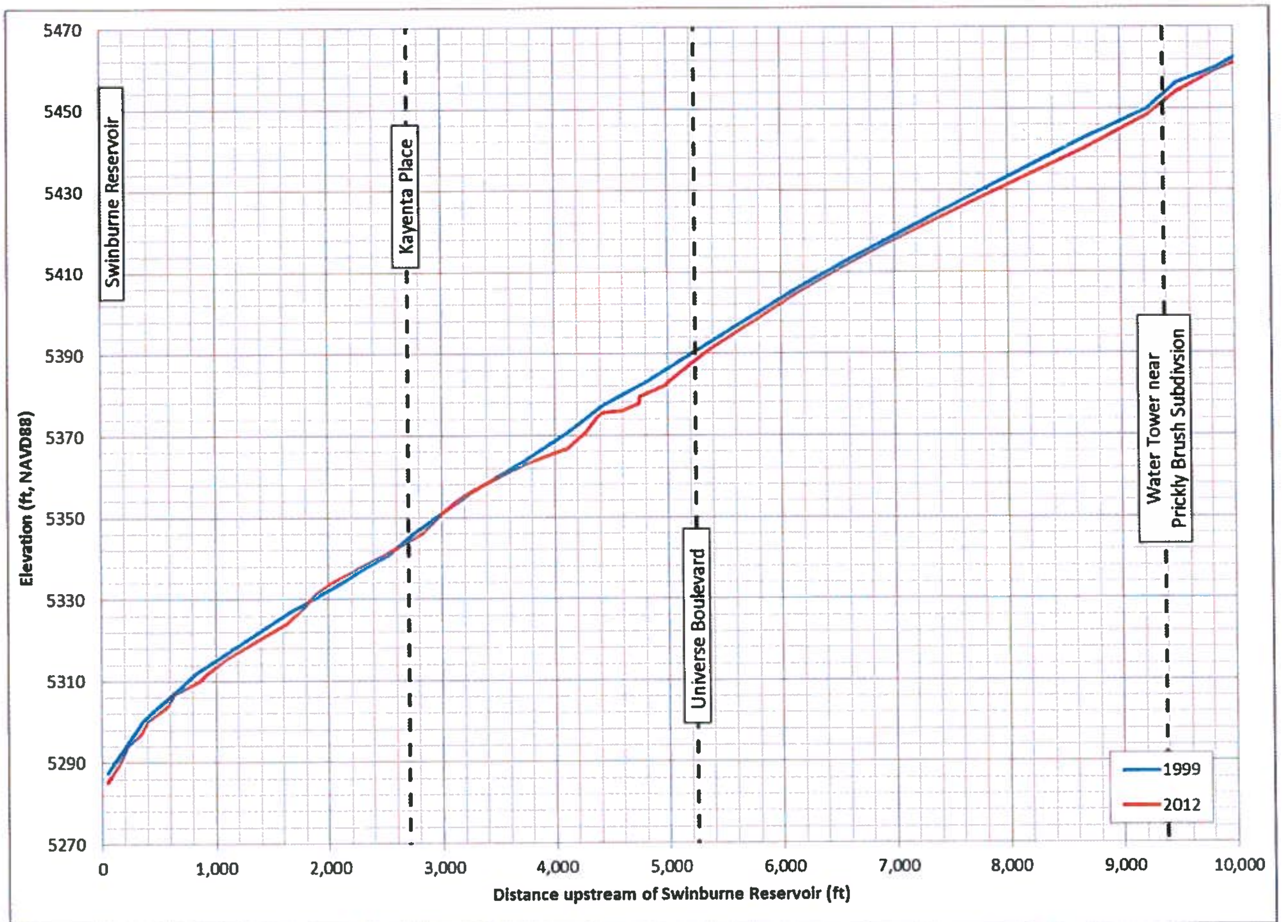


Figure 2 – CWB Profile Comparison, Sta 0+00 to 100+00

Review of the CWB profile comparison in the lower reach shows the arroyo adjusting to the upper and lower sill elevations of GCS-1 through GCS-4. The clear water inputs from the Las Ventanas Detention Dam have degraded the arroyo near Station 13+00 (1,300 feet upstream of Swinburne Dam Reservoir. The erosion below GCS-9 is apparent at Station 40+00. Just upstream of GCS-9, the arroyo has adjusted to the upper and lower sill elevations of GCS-10.

The upper reach of the CWB arroyo has not been stabilized, other than a short reach of rip rap bank protection located at the old New Mexico Utilities Well site at Station 93+80. Some bed degradation has occurred in this reach due to the clear water discharge from well wash water. The above profile comparison shows that degradation.

Tetra Tech has compared the bed profile for the entire CWB reach from the 1996 survey to the bed profile developed from the 2010 MRGCOG LiDAR topography as shown in Figure 3.

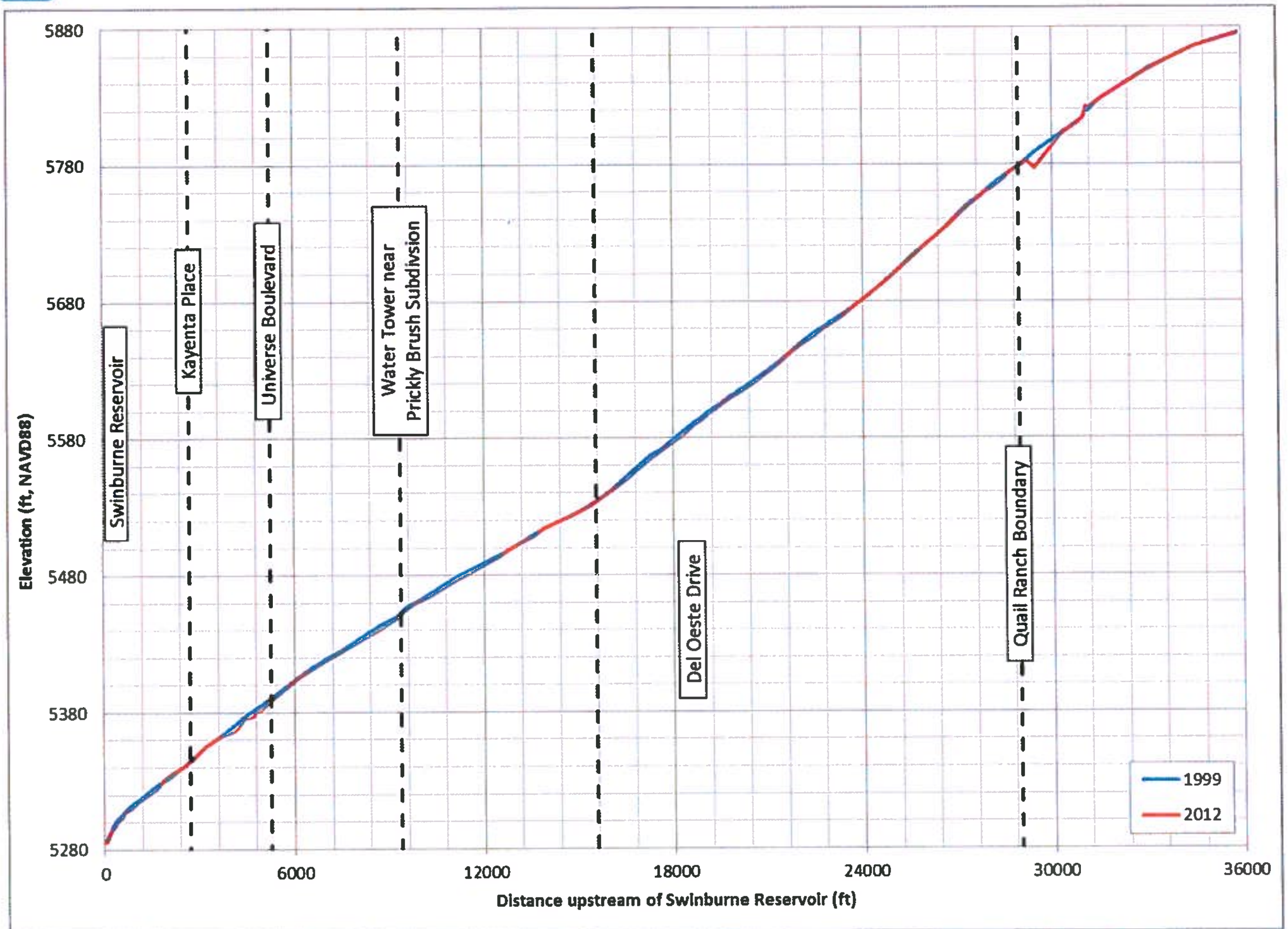


Figure 3 – CWB Profile Comparison, Sta 0+00 to 360+00

Review of the CWB profile in the upper reach shows very stable bed profiles with the exception of the borrow pit excavated at the location of the proposed Quail Ranch Pond at Station 290+00. The detention impact of this borrow pit was not included in the existing conditions routings. The blip in the profile above the Quail Ranch Pond site is a small stock tank. Both these features are identified in the *Calabacillas West Branch Arroyo Field Reconnaissance Report*.

2.2 Piedras Marcadas Watershed Diversions to Calabacillas West Branch

a. Las Ventanas Detention Dam Diversion

The Las Ventanas Detention Dam and Outfall Pipe captures flows from the North Branch of the Piedras Marcadas Arroyo and a small portion of the CWB watershed. Flows are routed through the 172 ac-ft. (storage at crest of spillway) detention dam reservoir which discharges to a 42" RCP through an inclined-port principle spillway inlet structure. Flows are diverted north in the outfall pipe. The outfall pipe intercepts flows from the Little Window Detention Dam and from the Seville Unit 9 subdivision. The outfall storm drain is a 66" RCP that conveys 149 cfs to the CWB in the 100-year event.

3.0 EXISITING CONDTIONS HYDROLOGIC ANALYSIS

3.1 Previous Drainage Studies

The primary drainage planning document used to date in this watershed is the *Calabacillas Arroyo Prudent Line Study and Related Work: Development of a Prudent Line for the West Branch*, MEI, 1999. The 1999

Prudent Line Study used the AHYMO program. MEI used an AHYMO previously developed by Avid Engineering (Avid, 1995) The Avid model, developed to support design of bank protection at the old New Mexico Utilities Well Site, covered the upper CWB watershed from the well site (9,500 feet upstream of Swinburne Dam) to the watershed limits. MEI revised the Avid model to include the arroyo downstream to Swinburne Dam and to account for the effects of the Las Ventanas subdivision.

The MEI existing conditions model predicts a 100 year–6 hour flow rate of 1440 cfs (1560 cfs bulked) at Swinburne Dam. The MEI developed conditions model used land treatment assumptions consistent with fully developed conditions, (impervious area = 42%) equivalent to single family residential use with an average of four DU/acre. The MEI developed conditions model predicts a 100 year–6 hour flow rate of 4950 cfs (5450 cfs bulked) at Swinburne Dam. The 1999 Prudent Line limits were based on the AHYMO modeling, and development to date has honored those prudent limits.

The MEI model predates the Quail Ranch DMP, which included the Paseo del Volcan diversion of the Boca Negra to the Calabacillas Middle Branch, and included the 75 acre-ft. Quail Ranch detention dam with an inflow of 1,320 cfs and outflow of 295 cfs, with the five-year event retained in the reservoir. Given this, and a region wide shift to the public domain HEC-HMS hydrology model, AMAFCA has directed the preparation of a new HEC-HMS model for the CWB watershed. The use of the HEC-HMS model is required by the New Mexico Office of the State Engineer Dam Safety Bureau and it use is encouraged by local regulatory agencies.

3.2 Hydrologic Model

The CWB watershed was analyzed to identify existing conditions flow rates to facilitate the development of a Drainage and Storm Water Quality Management Plan including the determination of drainage improvements needed in the area. The hydrologic analysis was completed using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS), based on SSCAFCA's Development Process Manual (DPM), Chapter 22, Drainage, Flood Control and Erosion Control (Revised April 2010), to be compatible with separate analysis being completed for the Calabacillas Watershed by SSCAFCA. Several elements need to be considered to build a complete hydrologic model. The elements developed for the CWB Model include basin delineation, land treatments, precipitation, time of concentration, and routing. The existing conditions watershed analyses and data inputs are discussed in the following sections

3.3 HEC-HMS Input Parameters

a. Basin Delineation

The topographic surface data used for determining the basin boundaries was taken from the 2010 LiDAR aerial mapping of Mid-Region Council of Governments (2010 MRCOG Mapping). The data was resampled using a 10 foot grid size within the project area digital elevation model (DEM). Resampling the data to a 10 foot grid size ensures the capture of the required detail needed for analysis without adversely affecting processing time in ArcGIS.

Preliminary basin boundaries were determined using ArcGIS loaded with HEC-GeoHMS and Arc Hydro software. Developing basin boundaries using the HEC-GeoHMS program consists of two main processing routines, DEM preprocessing steps, followed by the sub basin processing steps. In the preprocessing steps, a HydroDEM is created to correct for isolated low points in the Raw DEM. The resampled 10 foot grid size MRCOG surface was used to create the HydroDEM and determine grids for flow direction, flow accumulation, streams, stream links and catchments (basins). This raster data was used to create polyline and polygon shapefiles for streamlines, and basin boundaries respectively.

The basins were further refined and boundaries were modified to account for analysis points, such as culverts, roadways, ponds, and storm sewers. The basin boundaries determined using the HEC-GeoHMS tools were compared with field observations, previous drainage analysis reports and aerial imagery to verify that the boundaries were in good agreement with watershed conditions and other data sources. For the developed areas in the watershed, basins were modified based on the drainage analysis reports for the subdivisions. Basins in the undeveloped areas were modified to allow for analysis points to be located at future road crossings proposed in the Master Plans for Quail Ranch and Paradise West. A total of 50 basins were delineated with sizes ranging from 0.01 sq. mi. to 0.48 sq. mi. with an average basin size of approximately 0.22 sq. mi. Figure 4 shows the drainage basins developed in this study. Table A below summarizes the HEC-HMS input parameters for these basins.

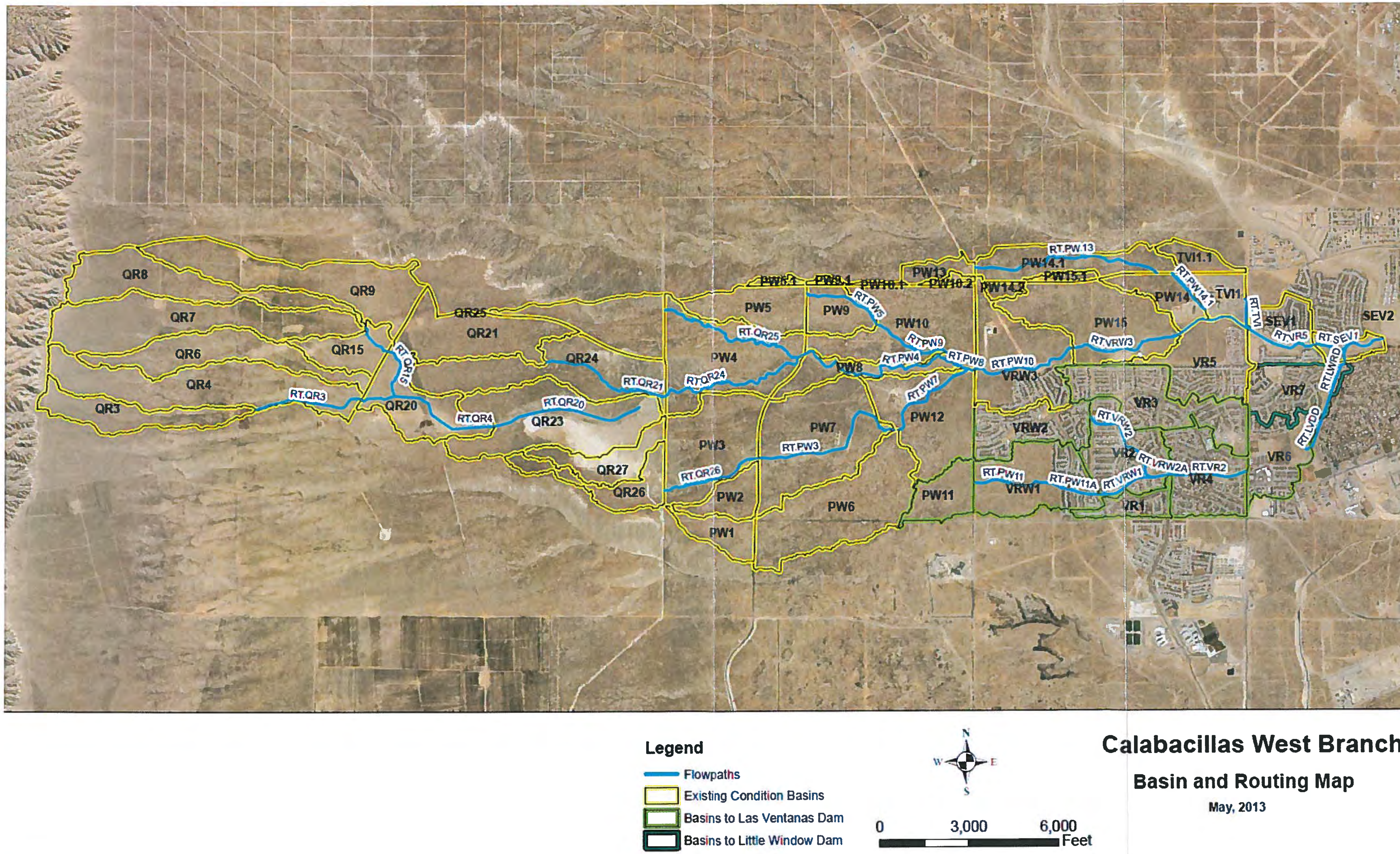


Figure 4 – Calabacillas West Branch Drainage Basin Map

Table A – HEC-HMS Input parameters

West Calabacillas Existing Conditions Model										
	Area	Land Treatments %					Initial	Constant	Storage	Time of
Basin	(Sq. Mi.)	A	B	C	D	Impervious (%)	Loss (in)	Rate (in/hr.)	Coefficient (HR)	Concentration (hr.)
QR7	0.470	97%	1%	2%	0%	0%	0.643	1.651	0.707	0.484
QR9	0.429	99%	0%	1%	0%	0%	0.646	1.658	0.596	0.407
QR8	0.319	95%	2%	2%	0%	0%	0.639	1.641	0.744	0.511
QR3	0.196	97%	2%	1%	0%	0%	0.645	1.656	0.507	0.347
QR4	0.473	97%	2%	1%	0%	0%	0.645	1.655	0.704	0.482
QR6	0.281	99%	0%	1%	0%	0%	0.648	1.663	0.669	0.457
QR15	0.129	100%	0%	0%	0%	0%	0.650	1.670	0.478	0.326
QR20	0.232	95%	0%	4%	0%	0%	0.637	1.632	0.729	0.502
QR21	0.292	100%	0%	0%	0%	0%	0.650	1.670	0.802	0.547
QR23	0.464	61%	2%	36%	0%	0%	0.538	1.356	0.653	0.489
QR24	0.406	91%	6%	3%	0%	0%	0.633	1.622	0.668	0.461
QR25	0.234	91%	9%	0%	0%	0%	0.636	1.630	0.327	0.225
PW4	0.422	88%	12%	1%	0%	0%	0.631	1.616	0.432	0.299
PW3	0.345	95%	5%	0%	0%	0%	0.642	1.649	0.296	0.203
QR26	0.148	70%	0%	30%	0%	0%	0.559	1.415	0.548	0.402
QR27	0.140	39%	0%	61%	0%	0%	0.468	1.159	0.505	0.405
PW2	0.100	98%	2%	0%	0%	0%	0.646	1.660	0.274	0.187
PW7	0.475	99%	1%	0%	0%	0%	0.648	1.664	0.448	0.306
PW6	0.455	97%	1%	0%	2%	2%	0.648	1.664	0.592	0.442
PW1	0.100	94%	1%	3%	2%	2%	0.638	1.637	0.286	0.216
PW5	0.181	99%	1%	0%	0%	0%	0.649	1.667	0.331	0.226
PW5.1	0.016	98%	2%	0%	0%	0%	0.647	1.663	0.197	0.134
PW9	0.120	100%	0%	0%	0%	0%	0.649	1.669	0.332	0.226
PW9.1	0.010	100%	0%	0%	0%	0%	0.650	1.669	0.196	0.133
PW10	0.408	98%	1%	1%	0%	0%	0.645	1.657	0.405	0.277
PW12	0.346	96%	2%	3%	0%	0%	0.640	1.641	0.452	0.311
PW8	0.133	88%	8%	3%	0%	0%	0.628	1.607	0.496	0.344
PW10.2	0.014	93%	6%	2%	0%	0%	0.636	1.631	0.317	0.218
PW10.1	0.006	100%	0%	0%	0%	0%	0.650	1.670	0.196	0.133
VRW3	0.350	64%	10%	10%	16%	16%	0.596	1.519	0.348	0.306
PW13	0.055	95%	0%	4%	0%	0%	0.636	1.632	0.421	0.290
PW14.2	0.024	99%	0%	1%	0%	0%	0.648	1.665	0.322	0.220
PW14.1	0.212	99%	1%	0%	0%	0%	0.649	1.667	0.506	0.345
PW15	0.401	95%	3%	1%	1%	1%	0.641	1.646	0.466	0.345

West Calabacillas Existing Conditions Model										
Basin	Area (Sq. MI)	Land Treatments %				Impervious (%)	Initial Loss (in)	Constant Rate (in/hr.)	Storage Coefficient (HR)	Time of Concentration (hr.)
		A	B	C	D					
PW14	0.119	82%	5%	4%	9%	9%	0.628	1.610	0.347	0.288
PW15.1	0.023	98%	2%	0%	0%	0%	0.647	1.660	0.195	0.133
TVI1	0.096	19%	18%	17%	45%	45%	0.506	1.267	0.269	0.278
TVI1.1	0.064	99%	0%	0%	1%	1%	0.650	1.669	0.298	0.215
VR5	0.258	38%	14%	14%	34%	34%	0.552	1.397	0.369	0.360
SEV1	0.170	7%	23%	27%	42%	42%	0.450	1.110	0.266	0.280
PW11	0.121	98%	0%	0%	1%	1%	0.648	1.665	0.332	0.242
VRW1	0.302	65%	8%	8%	18%	18%	0.605	1.543	0.321	0.285
VRW2	0.200	0%	21%	23%	56%	56%	0.424	1.038	0.273	0.301
VR2	0.250	0%	22%	23%	55%	55%	0.423	1.033	0.269	0.297
VR4	0.250	0%	23%	24%	54%	54%	0.425	1.040	0.376	0.412
VR1	0.080	0%	20%	22%	59%	59%	0.421	1.030	0.204	0.227
VR3	0.328	0%	24%	22%	53%	53%	0.429	1.051	0.344	0.376
VR6	0.193	0%	18%	50%	33%	33%	0.390	0.941	0.358	0.383
VR7	0.194	2%	16%	33%	49%	49%	0.411	1.001	0.335	0.367
SEV2	0.055	25%	27%	35%	14%	14%	0.482	1.199	0.197	0.184

b. Loss Methods (Land Treatment)

The loss method in HEC-HMS provides an estimate of the precipitation that is intercepted, or infiltrates into the soil, and therefore is not part of the total storm runoff. The rainfall loss for this study was calculated using the Initial and Constant Loss Method outlined in SSCAFCA's DPM. This rainfall loss is associated with the land treatment classifications A, B, C, and D. Table F-4 in Section 22.2 of the DPM defines the recommended values for the Initial Abstraction and Infiltration rate for each land treatment type. These treatment types were used to classify the area's hydrologic properties. Table F-2 in Section 22.2 of the DPM defines the land conditions associated with the four treatment types: A, B, C and D. Type A, which is most pervious, is associated with undisturbed land. Type D, which is most impervious, is used for paved areas and roofs.

The existing CWB watershed consists of largely undeveloped areas with the developed areas located in the eastern parts of the watershed area. The land treatments for the developed areas in the watershed were classified from available subdivision drainage reports. For developed areas in which reports were not accessible, aerial imagery was used to determine the dwelling units per acre (du/ac). Based on this du/ac the percentage of Land treatment D could be calculated based on equations from Table F-3 of the DPM. Then the remaining percentage was spilt equally between Land Treatments B and C with Treatment Type A set equal to 0. For undeveloped areas the land treatments were determined based on the level of compaction by human activity and the slope according to the descriptions in Table F-2 of the DPM, with areas undisturbed by human activity but with greater slopes being characterized as either Treatment Type B or C depending upon the magnitude of the basin slope. Using the MRCOG 2010 surface, a slope grid was created and classified into the following 3 categories: Slopes from 0-10 percent (Treatment Type A), Slopes from 10-20 percent (Treatment Type B), and Slopes greater than 20 percent (treatment Type C). The aerial imagery was also used to determine areas that are Treatment Type C based on soil compaction by human activity. This information was compiled in an existing Land Treatment shapefile. This shapefile was used to determine the area of each land treatment for each sub basin. Using this information the initial loss (initial abstraction), constant rate (infiltration), and percent impervious were calculated for each sub basin using the procedures outlined in the SSCAFCA DPM. The land treatment percentages and calculated losses are summarized in Table A.

c. Precipitation

2-year (yr), 10-yr, and 100-yr, 6-hour and 24-hour storm events (50%, 10% and 1% probability events, respectively) were modeled for this study. The precipitation depths, for the analyzed events, were extracted from the NOAA Atlas 14. For the 6 hour and 24 hour storms respectively, the rainfall depth for the 2-year event is 0.968 inches and 1.23 inches, the 10-year event is 1.47 inches and 1.79 inches, and the 100-yr event is 2.27 inches and 2.66 inches. In this analysis, no depth-area reduction factor was used as the analysis results will ultimately be used for planning and development of recommended infrastructure.

The storm hyetograph used for this analysis is a temporal distribution that was created using the procedure outlined in the SSCAFCA DPM for the 6-hour and 24-hour durations. This distribution places the storm peak at 1.42 hours, and approximately 80% of the precipitation falls within the one hour period around the storm peak. The 100-yr 24-hour event hyetograph is shown in Figure 5. The tabulated distributions for all storm events included in this study, the 2-year (yr), 10-yr, and 100-yr, 6-hour and 24-hour storms, are included in Appendix A.

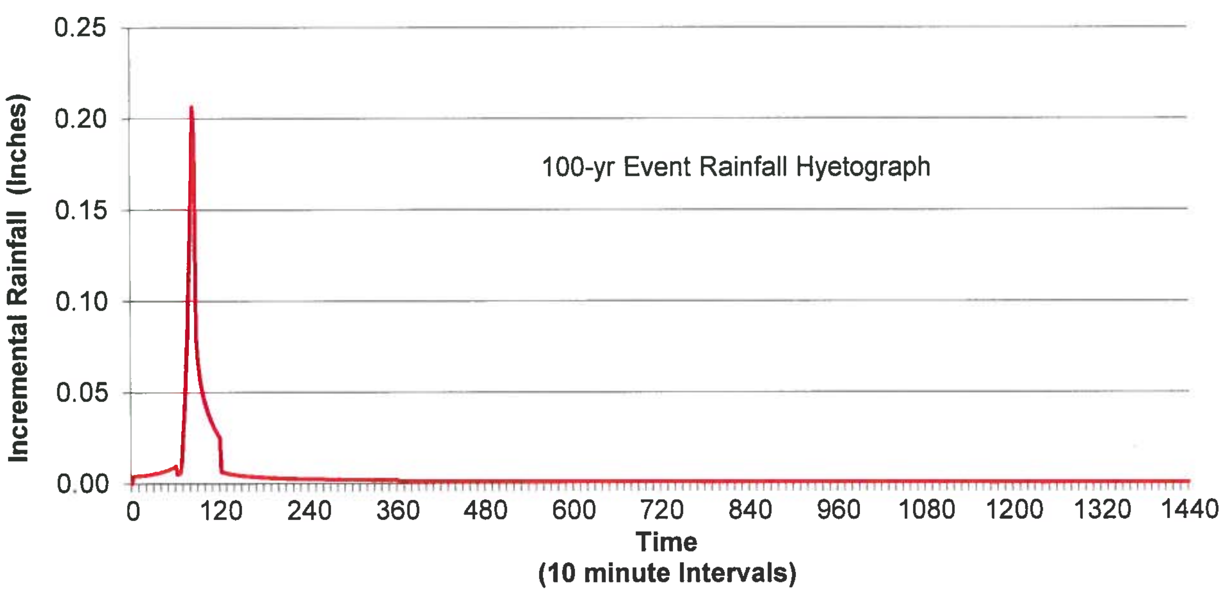


Figure 5 – 100 year – 6 hours Rainfall Hyetograph

d. Time of Concentration

Time of concentration estimates the time needed for water to flow from the most remote point in the basin to the basin outlet. The SSCAFCA DPM specifies three different equations to determine time of concentration (T_c) for flow lengths up to 4,000 ft, 4,000 ft to 12,000 ft, and in excess of 12,000 ft. Using the HydroDEM and HEC-GeoHMS sub basin processing tools the input parameters for these calculations such as: sub basin area, longest flow path, flow path slope and basin centroid were determined. T_c calculations are provided in Appendix B and summarized in Table A – HEC-HMS Input parameters.

e. Storage Coefficient

The storage coefficient relates the effects of direct runoff storage in the watershed to the unit hydrograph shape and is dependent on the time of concentration, initial loss, constant loss, and land treatments for each subbasin. Storage coefficients were calculated for each sub basin using the procedure outlined in the DPM. Calculations are provided in Appendix C and are summarized in Table A.

f. Routing

The Muskingum-Cunge Routing method was used for this study; this method is appropriate for this study and is consistent with the SSCAFCA DMP. The required input for this method includes the cross-section geometry, channel length and slope, and Manning's n-values for routes. These routes were drawn in a GIS shapefile, shown on Figure 4, and are based on the current drainage patterns evident from aerial imagery at the time of this study. For all routes, the shape, length, average slope and average Manning's n were determined from the aerial imagery, the DEM for the area, and pertinent drainage reports. For natural channels the cross-section was approximated as a rectangular channel with each arroyo bottom width determined from the 2012 MRCOG aerial imagery. For circular routes (such as storm drains), the diameter was taken from the applicable drainage reports or from the City of Albuquerque GIS Storm Drain shapefile. For trapezoidal routes (such as improved channels), the side slopes and bottom width were determined from applicable drainage reports. The appropriate Manning's n was selected from Table F-7 in the DPM. Table B below outlines the routing parameters used in the hydrologic analysis.

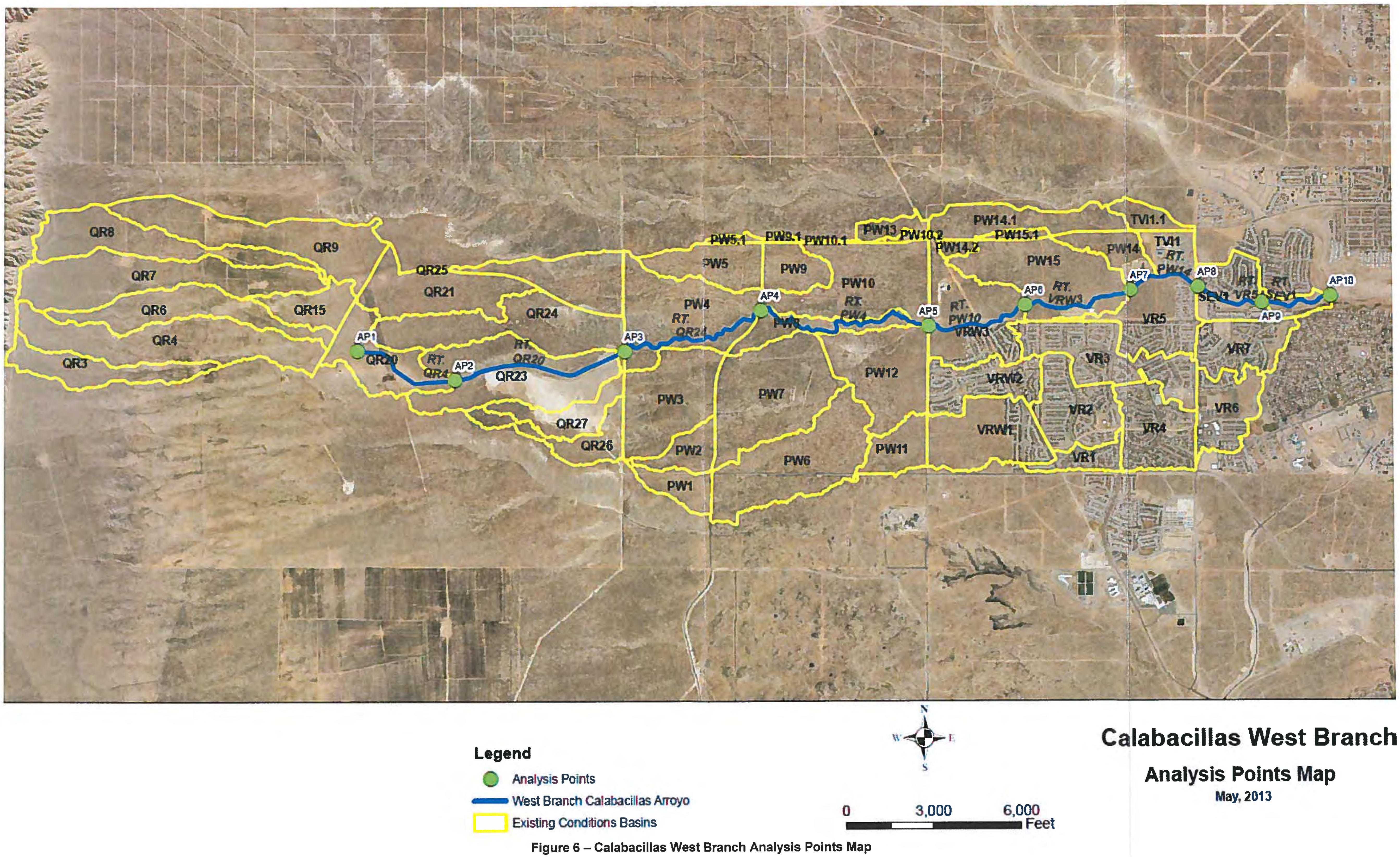


Figure 6 – Calabacillas West Branch Analysis Points Map

Table B – Routing Parameters

Muskingum-Cunge Routing Parameters							
Reach	Length (FT)	Slope (FT/FT)	Manning's n	Shape	Diameter (FT)	Width (FT)	Side Slope (xH:1V)
RT.QR8	1276	0.007	0.055	Rectangular	-	30	-
RT.QR3	3809	0.014	0.013	Rectangular	-	30	-
RT.QR4	5044	0.005	0.055	Rectangular	-	30	-
RT.QR20	5198	0.014	0.055	Rectangular	-	13	-
RT.QR21	4586	0.020	0.055	Rectangular	-	10	-
RT.QR24	5769	0.020	0.013	Rectangular	-	10	-
RT.QR25	5811	0.022	0.055	Rectangular	-	10	-
RT.PW4	6709	0.018	0.055	Rectangular	-	12	-
RT.PW3	5852	0.019	0.055	Rectangular	-	5	-
RT.PW7	3599	0.018	0.055	Rectangular	-	12	-
RT.PW5	2871	0.021	0.055	Rectangular	-	30	-
RT.PW9	3417	0.019	0.055	Rectangular	-	12	-
RT.PW10	3783	0.013	0.055	Rectangular	-	15	-
RT.VRW3	3970	0.015	0.055	Rectangular	-	15	-
RT.PW13	6662	0.018	0.055	Rectangular	-	10	-
RT.PW14.1	1701	0.017	0.055	Rectangular	-	6	-
RT.PW14	1569	0.013	0.055	Rectangular	-	15	-
RT.TVI	1108	0.010	0.055	Circular	5.0	0	-
RT.VR5	2440	0.012	0.055	Rectangular	-	40	-
RT.SEV1	2506	0.023	0.055	Rectangular	-	45	-
RT.PW11	3184	0.023	0.055	Rectangular	-	15	-
RT.PW11A	1234	0.012	0.013	Circular	7.0	-	-
RT.VRW1	2094	0.029	0.013	Trapezoidal	-	10	3
RT.VRW2	2862	0.019	0.055	Circular	7.0	-	-
RT.VRW2A	1246	0.015	0.013	Trapezoidal	-	10	3
RT.VR2	2606	0.006	0.013	Trapezoidal	-	10	3
RT.LVDD	2257	0.010	0.013	Circular	3.5	-	-
RT.LWD	1549	0.010	0.055	Circular	5.0	-	-

3.4 Sediment Continuity and Vertical Stability

For the existing conditions hydrology the results of the 1999 Prudent Line Study were evaluated during the field reconnaissance. Tetra Tech was to assess and make recommendations on the validity of the 1999 Prudent Line Study with regard to aggradation/degradational zones, prudent limits, and appropriate bulking factors for design storms

a. Bed Material Sediment Transport Relationships

The results of the 1999 Prudent Line Study were evaluated during the field reconnaissance. Two additional sediment samples were obtained from the arroyo and compared to those used in the 1999 Prudent Line Study. The gradations closely matched, as shown in Figure 7.

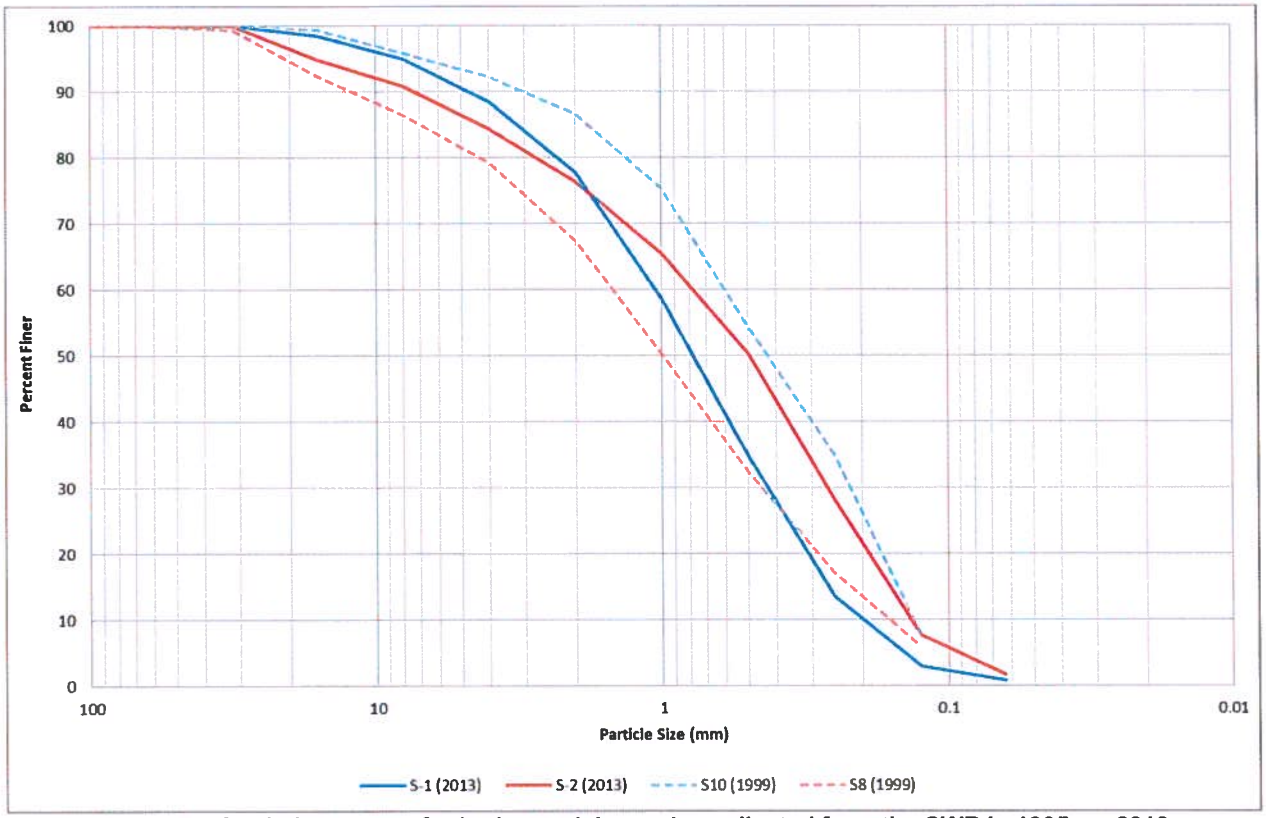


Figure 7 – Gradation curves for bed material samples collected from the CWB in 1995 vs. 2013

b. Sub Reach Bulking Factors

Bulking factors under existing conditions were estimated using information from the 1999 Prudent Line Study. For the 1999 Prudent Line Study, hydrologic (AHYMO) and hydraulic (HEC-RAS) modeling was performed to estimate sediment-transport conditions using bed material information collected for that study. The bulking factors were determined by comparing the estimated total volume of sediment (bed material load plus washload) to discharge over a range of discharges up to the 100-year peak flow event under existing and 2036 development conditions on a subreach basis (Tables 1 and 2).

The bulking factors under existing conditions were updated for this study by incorporating information from the HEC-HMS model. The HEC-HMS model results indicate higher peak discharges than the AHYMO model results over the range of modeled hydrographs over the model domain. While this is to be expected in the lower portions of the reach that have been affected by development (primarily Subreaches 6 through 8, and to a much lesser degree Subreaches 4 and 5), there does not appear to be any reason for increased flows in the upper portion of the study reach. To resolve this discrepancy, it was assumed that the previously estimated bulking factors under existing conditions are representative for the range of discharges that are less than the 10-year (AHYMO) peak discharge. This is a conservative estimate because the 1999 Prudent Line Study indicated that for any flow rate in this range of discharges, the bulking factors would decrease from existing to 2036 development conditions. For discharges in excess of the 10-year (AHYMO) peak discharge, it was assumed that the bulking factor would increase relative to the increased discharge predicted by the HEC-HMS model as compared to the change in discharge from existing to 2036 development conditions as predicted by the AHYMO model (Table 3).

For example, in Subreach 8, the HEC-HMS model indicates that the existing 100-year peak discharge is about 2,150 cfs, compared to peak discharges from the AHYMO model of 1,440 cfs and 4,950 cfs under existing (1999) and 2036 development conditions, respectively. As such, the HEC-HMS-based discharge represents 20 percent of the expected increase from existing (1999) to 2036 development conditions.

The 1999 Prudent Line Study indicated the 100-year bulking factor for Subreach 8 would increase from 11.3 percent to 12.3 percent from existing (1999) to 2036 development conditions, so the existing conditions bulking factor associated with the HEC-HMS peak discharge (2150 cfs) was increased by 20 percent to 11.5 percent. The subreach-based bulking factors were then distributed appropriately along the HEC-HMS model reaches (Table 4).

Table C – Summary of bulking factors for 1999 conditions (hydrology based on AHYMO model)

	Supply		R1		R2		R3		R4		R5		R6		R7		R8	
	RT QR20		RT QR 24		RT PW 4				RT PW10		RT PW 14		RT VR5		RT SEV1		AP-10	
Event	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF
2-yr	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
-	10	1.6%	10	1.8%	10	1.8%	10	2.1%	14	2.0%	14	2.1%	11	2.4%	11	2.2%	11	2.9%
5-yr	20	1.8%	20	2.4%	21	2.3%	21	2.7%	28	2.3%	28	2.5%	30	2.9%	30	3.1%	30	4.4%
-	26	2.0%	27	2.6%	27	2.5%	27	2.9%	37	2.5%	37	2.6%	30	2.9%	30	3.1%	30	4.4%
-	50	2.2%	51	3.0%	53	3.1%	53	3.7%	75	2.9%	75	3.1%	67	4.1%	67	3.9%	67	4.6%
-	70	2.4%	72	3.5%	75	3.4%	75	4.3%	120	3.4%	120	3.6%	140	5.3%	140	5.2%	140	5.9%
10-yr	110	2.8%	111	4.1%	120	3.9%	120	5.2%	190	4.0%	190	4.1%	210	6.0%	210	6.2%	210	6.7%
25-yr	300	4.1%	310	5.7%	330	5.5%	330	7.3%	510	6.0%	510	5.8%	570	6.9%	570	8.9%	570	9.4%
50-yr	462	4.9%	481	6.6%	510	6.2%	510	8.4%	828	7.3%	828	6.8%	994	7.9%	994	10.3%	994	10.6%
100-yr	656	5.5%	713	7.4%	777	7.1%	777	9.5%	1190	8.2%	1190	7.7%	1440	8.5%	1440	11.0%	1440	11.3%

Table D – Summary of bulking factors for 2036 development conditions (hydrology based on AHYMO model)

	Supply		R1		R2		R3		R4		R5		R6		R7		R8	
	RT QR20		RT QR 24		RT PW 4				RT PW10		RT PW 14		RT VR5		RT SEV1		AP-10	
Event	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF
-	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
-	25	1.0%	27	1.7%	29	1.5%	29	2.0%	41	1.2%	41	1.4%	43	2.5%	43	2.2%	45	2.9%
-	50	1.2%	54	2.2%	58	2.0%	58	2.7%	82	1.7%	82	1.9%	86	3.2%	86	3.1%	91	3.8%
-	100	1.7%	108	3.0%	116	2.8%	116	3.9%	164	2.5%	164	2.5%	172	4.4%	172	4.3%	182	5.1%
-	200	2.5%	215	4.0%	231	3.7%	231	5.3%	327	3.6%	327	3.5%	344	5.2%	344	6.1%	364	6.8%
2-yr	530	4.1%	571	5.8%	613	5.3%	613	7.5%	867	5.9%	867	5.4%	911	6.5%	911	8.7%	964	9.1%
5-yr	909	5.1%	988	7.1%	1067	6.3%	1067	8.8%	1530	7.4%	1530	6.9%	1609	7.3%	1609	9.7%	1684	10.2%
10-yr	1253	5.7%	1363	7.5%	1475	7.0%	1475	9.6%	2125	8.2%	2125	7.8%	2222	7.9%	2222	10.4%	2313	10.8%
25-yr	1751	6.5%	1929	8.0%	2109	7.7%	2109	10.4%	3126	9.2%	3126	8.7%	3350	8.7%	3350	11.2%	3466	11.8%
50-yr	2123	7.0%	2338	8.3%	2549	8.1%	2549	11.0%	3768	9.6%	3768	9.3%	4070	9.2%	4070	11.3%	4200	12.1%
100-yr	2510	7.4%	2742	8.6%	2987	8.5%	2987	11.3%	4458	9.7%	4458	9.7%	4814	9.6%	4814	11.3%	4954	12.3%

Table E – Summary of bulking factors for existing (2013) conditions (hydrology based on HEC-HMS model)

	Supply		R1		R2		R3		R4		R5		R6		R7		R8	
	RT QR20		RT QR 24		RT PW 4				RT PW10		RT PW 14		RT VR5		RT SEV1		AP-10	
Event	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF
-	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
-	10	1.6%	10	1.8%	10	1.8%	10	2.1%	14	2.0%	14	2.1%	11	2.4%	11	2.2%	11	2.9%
-	20	1.8%	20	2.4%	21	2.3%	21	2.7%	28	2.3%	28	2.5%	30	2.9%	30	3.1%	30	4.4%
-	26	2.0%	27	2.6%	27	2.5%	27	2.9%	37	2.5%	37	2.6%	45	3.4%	45	3.4%	45	4.5%
-	50	2.2%	51	3.0%	53	3.1%	53	3.7%	75	2.9%	75	3.1%	67	4.1%	67	3.9%	67	4.6%
-	70	2.4%	72	3.5%	75	3.4%	75	4.3%	120	3.4%	120	3.6%	140	5.3%	140	5.2%	140	5.9%
10-yr (99)	110	2.7%	111	3.8%	120	3.7%	120	4.8%	190	3.7%	190	3.8%	210	5.5%	210	5.6%	210	6.2%
10-yr	125	2.8%	165	4.2%	171	4.0%	171	5.3%	280	4.2%	330	4.4%	380	6.1%	401	6.6%	488	7.2%
25-yr	323	4.1%	430	5.9%	455	5.6%	455	7.6%	677	6.2%	820	6.1%	920	7.1%	958	9.2%	1054	9.8%
50-yr	502	5.0%	671	6.8%	715	6.4%	715	8.7%	1049	7.5%	1271	7.2%	1407	8.1%	1463	10.5%	1563	10.8%
100-yr	712	5.6%	954	7.6%	1019	7.2%	1019	9.7%	1498	8.4%	1802	8.1%	1975	8.7%	2047	11.1%	2153	11.5%

Table F – Summary of bulking factors by HMS model reach for existing (2013) conditions (hydrology based on HEC-HMS model)

	RT.QR4		RT.QR20		RT.QR24		RT.PW4		RT.PW10		RT.VRW3		RT.PW14		RT.VR5		RT.SEV1		SWINBURNE_ INFLOW		
Event	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF	Q (cfs)	BF			Q (cfs)	BF	EVENT
2-yr	0	1.4%	0	1.4%	0	1.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	
-	5	1.5%	5	1.5%	5	1.4%	5	1.6%	5	1.9%	14	2.1%	11	2.0%	11	2.4%	11	2.2%	11	2.9%	
-	10	1.6%	10	1.6%	11	1.8%	11	2.2%	12	2.0%	31	2.5%	38	2.6%	30	2.9%	30	3.1%	30	4.4%	
5-yr	20	1.8%	20	1.8%	27	2.6%	27	2.9%	37	2.5%	37	2.6%	45	2.7%	45	3.4%	45	3.4%	45	4.5%	
-	26	2.0%	27	2.0%	33	2.1%	40	2.1%	74	2.4%	82	2.5%	85	2.5%	67	4.1%	67	3.9%	67	4.6%	
-	70	2.4%	72	2.4%	75	3.5%	75	4.3%	120	3.4%	120	3.6%	140	3.6%	92	4.4%	125	4.7%	191	6.0%	2-yr
-	110	2.7%	111	2.7%	120	3.9%	120	4.8%	190	3.7%	190	3.8%	210	3.9%	154	5.3%	195	5.5%	272	6.4%	5-yr
10-yr	118	2.8%	125	2.8%	165	4.2%	171	5.3%	280	4.2%	302	4.3%	326	4.4%	388	6.1%	401	6.6%	477	7.2%	10-yr
25-yr	305	4.0%	323	4.1%	430	5.9%	455	7.6%	677	6.2%	738	5.8%	820	6.1%	920	7.1%	958	9.2%	1054	9.8%	25-yr
50-yr	474	4.8%	502	5.0%	671	6.8%	715	8.7%	1049	7.5%	1139	6.9%	1271	7.2%	1407	8.1%	1463	10.5%	1563	10.8%	50-yr
100-yr	671	5.5%	712	5.6%	954	7.6%	1019	9.7%	1506	8.4%	1618	7.8%	1807	8.1%	2038	8.7%	2038	11.1%	2144	11.5%	100-yr

a. HEC-RAS Model Comparison

Tetra Tech developed a new HEC-RAS model incorporating the 2010 LiDAR mapping and new structures and bank protection that have been constructed since the 1999 model was developed. The new model was set up to overlap cross sections from the 1999 model as often as was reasonable. Some cross sections did not overlap between the two models because of arroyo realignment or the construction of grade control structures and road crossings. The two models were compared by reach, with two equivalent event discharges modeled. The discharges were selected from Table 3.1, *Summary of reach-averaged conditions for the West Branch of Calabacillas* Arroyo, from the 1999 Prudent Line Study. The HEC-RAS Models are in digital form in Appendix D.

The events reflect the 5-yr and 10-yr events, chosen as they have significant impact on sediment transport. Resulting changes in velocity, hydraulic depth, top width and energy slope were evaluated as shown in Table G, below.

Table G – HEC RAS Model Comparison 1999 – 2013

HEC-RAS Results		*1999*				*2012*				*Comparison*			
Subreach	Flow (cfs)	Velocity (fps)	Hydraulic Depth (ft)	Top Width (ft)	Energy Slope (ft/ft)	Velocity (fps)	Hydraulic Depth (ft)	Top Width (ft)	Energy Slope (ft/ft)	Velocity	Hydraulic Depth	Top Width	Energy Slope
0	25	2.00	0.43	56	0.0290	2.17	0.49	51	0.0267	9%	13%	-9%	-8%
	100	2.89	0.77	69	0.0190	3.14	0.75	74	0.0234	9%	-2%	8%	23%
1	27	2.45	0.28	45	0.0309	2.43	0.63	56	0.0223	-1%	130%	27%	-28%
	108	3.53	0.56	61	0.0232	3.35	0.89	81	0.0207	-5%	58%	33%	-11%
2	29	2.36	0.33	44	0.0253	2.62	0.40	35	0.0204	11%	19%	-20%	-19%
	116	3.55	0.65	56	0.0195	3.61	0.70	62	0.0186	2%	7%	10%	-5%
3	29	2.58	0.36	35	0.0220	3.16	0.50	19	0.0218	23%	41%	-45%	-1%
	116	4.13	0.75	41	0.0207	4.42	0.90	31	0.0195	7%	20%	-24%	-6%
4	41	2.44	0.44	41	0.0154	2.63	0.48	36	0.0176	8%	9%	-11%	14%
	164	3.74	0.89	51	0.0133	3.98	0.89	50	0.0175	6%	0%	-1%	31%
5	41	2.48	0.44	41	0.0178	2.66	0.49	35	0.0162	7%	10%	-14%	-9%
	164	3.79	0.85	54	0.0163	3.83	0.83	54	0.0160	1%	-3%	-1%	-2%
6	43	2.84	0.43	37	0.0209	3.20	0.47	33	0.0173	13%	8%	-11%	-17%
	172	4.19	0.86	50	0.0181	4.65	0.94	44	0.0139	11%	9%	-12%	-23%
7	43	3.07	0.51	29	0.0215	2.84	0.43	38	0.0192	-7%	-15%	34%	-10%
	172	4.69	1.03	36	0.0176	4.39	0.88	48	0.0179	-6%	-15%	34%	2%
8	45	2.68	0.37	55	0.0273	3.01	0.44	37	0.0242	13%	19%	-33%	-11%
	182	4.00	0.78	64	0.0205	4.52	0.87	49	0.0211	13%	11%	-24%	3%

The comparisons show both upward and downward changes in all hydraulic parameters and confirm the need for updated hydraulic modeling for the developed conditions hydrologic modeling and the subsequent equilibrium slope analyses, prudent line computations, and reach-specific sediment bulking factors. This analysis is included in the upcoming developed conditions hydrologic and hydraulic modeling as part of Phase II, Task A.4 in the scope of work.

b. Equilibrium Slope Analyses

Equilibrium slope analysis was not needed for the existing conditions hydrology. For the developed conditions modeling, Tetra Tech will determine equilibrium slopes for each arroyo sub reach to allow for layout of grade control structures and other storm drainage facilities during the development of options phase.

3.5 Existing Conditions Model

HEC-HMS existing conditions hydrologic models were developed for this study as discussed in the preceding sections. 2-yr, 10-yr and 100-yr 6-hr and 24-hr storm events were modeled. The existing conditions model, which models the current existing drainage conditions at the time of this study, is based on the 2010 MRCOG surface data, 2012 MRCOG aerial imagery along with drainage reports for Albuquerque Technical Vocational Institute's West Side Campus, Ventana Ranch and Ventana Ranch West.

The basins developed for this model have been named to correspond with the master plans or subdivision that they fall within. "QR" corresponds to basins within the Quail Ranch; "PW" for Paradise West; "VRW" for Ventana Ranch West; "VR" for Ventana Ranch; "TVI" for Albuquerque Technical Vocational Institute's West Side Campus; and "SEV" for the Seville Subdivision.

The CWB has a drainage area of approximately 11.1 square miles. In general, runoff flows from the west to the east and will discharge from the study area at CWB inlet to the Swinburne Dam. Currently flow from the watershed reaches the CWB either through natural drainage ways or drainage facilities that have been constructed to divert flow from the Las Ventanas Detention Dam and Little Window Dam that ultimately are conveyed to the CWB through a single outfall located downstream of Kayenta Road. This diverted flow accounts for a drainage area of approximately 1.92 square miles and includes Basins: PW11, VRW1, VRW2, VR1, VR2, VR3, VR4, VR6 and VR7. Runoff from all other basins in the study area is directly conveyed to the CWB.

A summary of the clear water existing hydrology for the CWB watershed in this report is presented in Table G. For each hydrologic element, the table provides the contributing area in square miles (sq. mi.), peak discharge in cubic feet per second (cfs) and runoff volume in acre-feet (ac-ft.) for the 2-yr, 10-yr and 100-yr 6-hr and 24-hr storm events. The 100-yr 24-hr storm event produces 424 ac-ft. of runoff with a peak flow of 2,153 cfs in existing clear water conditions. HEC-HMS model outputs for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr and 100-yr events are included in Appendix E. Digital HEC-HMS models are included on CD in Appendix E. The 5-yr, 25-yr and 50-yr models were developed for sediment bulking calculations and are not summarized in the body of this report.

Table H – HEC-HMS Model Results

Existing Conditions HEC-HMS Model Subbasins Results							
Basin ID	Drainage Area (mi^2)	Peak Discharge (Q_2) (cfs)	Volume (V_2) (ac-ft.)	Peak Discharge (Q_{10}) (cfs)	Volume (V_{10}) (ac-ft.)	Peak Discharge (Q_{100}) (cfs)	Volume (V_{100}) (ac-ft.)
QR7	0.4703	0	0	26.9	2.2	139.6	11.4
QR9	0.4292	0	0	28.4	1.9	149.3	10.3
QR8	0.3193	0	0	17.9	1.5	91.1	7.8
QR7_9	1.2188	0	0	71.6	5.6	372	29.5
RT.QR8	1.2188	0	0	71	5.6	369.4	29.5
QR3	0.1955	0	0	15.3	0.9	79	4.7
RT.QR3	0.1955	0	0	15	0.9	78.2	4.7

Existing Conditions HEC-HMS Model Subbasins Results							
Basin ID	Drainage Area (mi^2)	Peak Discharge (Q_2) (cfs)	Volume (V_2) (ac-ft.)	Peak Discharge (Q_{10}) (cfs)	Volume (V_{10}) (ac-ft.)	Peak Discharge (Q_{100}) (cfs)	Volume (V_{100}) (ac-ft.)
QR4	0.4732	0	0	26.8	2.1	140.5	11.4
QR6	0.2806	0	0	16.6	1.3	87.9	6.8
QR3_6	0.9493	0	0	49.2	4.3	301.1	22.9
QR15	0.1295	0	0	10.2	0.6	54.9	3.1
QR3_15	2.2976	0	0	120.8	10.5	712.1	55.5
RT.QR4	2.2976	0	0	117.5	10.4	671	55.1
QR20	0.2319	0	0	13.5	1.1	67.8	5.7
QR3_20	2.5295	0	0	125.1	11.5	722.7	60.8
RT.QR20	2.5295	0	0	124.5	11.5	712	60.6
QR21	0.2924	0	0	14	1.3	75.7	7
RT.QR21	0.2924	0	0	13.9	1.3	75.2	7
QR23	0.4645	0.2	0	55.4	4.2	187.8	14.8
QR24	0.4061	0	0	26.5	2	130.1	10.1
QR3_24	3.6925	0.2	0	165.8	19.1	967.1	92.4
RT.QR24	3.6925	0.2	0	164.6	19.1	953.6	92.3
QR25	0.2336	0	0	29.6	1.1	143.9	5.8
RT.QR25	0.2336	0	0	29.1	1.1	140.4	5.8
PW4	0.4222	0	0	42.7	2.1	204.8	10.5
QR3_25_PW4	4.3483	0.2	0	173.1	22.3	1035.1	108.6
RT.PW4	4.3483	0.1	0	170.7	22.3	1018.5	108.5
PW3	0.3455	0	0	46.5	1.6	228.4	8.4
QR26	0.1482	0	0	18.9	1.2	67.4	4.5
QR27	0.1403	4	0.2	29.4	1.8	82.4	5.3
PW2	0.1005	0	0	13.9	0.5	70.6	2.4
QR26_PW3	0.7345	4	0.2	93	5.1	396.9	20.6
RT.PW3	0.7345	3.7	0.2	92	5.1	390.1	20.6
PW7	0.4753	0	0	41	2.1	214.5	11.4
PW6	0.4550	3.4	0.5	33.9	2.8	160.7	11.8
PW1	0.0999	1.3	0.1	15.8	0.7	69.7	2.7
PW3_PW7	1.7647	5.5	0.9	161	10.6	783.4	46.5
RT.PW7	1.7647	6	0.9	158.5	10.6	768.9	46.4
PW5	0.1806	0	0	20.5	0.8	107	4.3
PW5.1	0.0165	0	0	3.1	0.1	15.2	0.4
PW5_5.1	0.1971	0	0	22.7	0.9	119.3	4.7
RT.PW5	0.1971	0	0	22.5	0.9	117.9	4.7

Existing Conditions HEC-HMS Model Subbasins Results							
Basin ID	Drainage Area (mi^2)	Peak Discharge (Q_2) (cfs)	Volume (V_2) (ac-ft.)	Peak Discharge (Q_{10}) (cfs)	Volume (V_{10}) (ac-ft.)	Peak Discharge (Q_{100}) (cfs)	Volume (V_{100}) (ac-ft.)
PW9	0.1203	0	0	13.6	0.5	71.1	2.9
PW9.1	0.0095	0	0	1.8	0	8.8	0.2
PW9_9.1	0.1298	0	0	14.8	0.6	78.1	3.1
PW5_9	0.3269	0	0	30	1.4	177.7	7.8
RT.PW9	0.3269	0	0	29.1	1.4	175.2	7.8
PW10	0.4080	0	0	39.7	1.8	203	9.8
PW12	0.3457	0	0	31.4	1.6	157	8.4
PW8	0.1331	0	0	12.1	0.7	57	3.3
PW10.2	0.0233	0	0	3.1	0.1	14.8	0.6
PW10.1	0.0058	0	0	1.1	0	5.4	0.1
PW1_12	7.3558	6	0.9	285.1	38.7	1523.1	185
RT.PW10	7.3558	5.1	0.9	280.2	38.7	1505.5	184.7
VRW3	0.3503	30.5	3.6	92.5	7.1	255.8	15.8
PW_VRW3	7.7061	30.8	4.5	305	45.8	1631.6	200.5
RT.VRW3	7.7061	30.6	4.5	302.2	45.8	1617.9	200.3
PW13	0.0551	0	0	5.5	0.3	27.1	1.4
PW14.2	0.0244	0	0	2.9	0.1	14.9	0.6
PW13_14.2	0.0795	0	0	8.1	0.4	40.8	1.9
RT.PW13	0.0795	0	0	7.8	0.4	40.1	1.9
PW14.1	0.2124	0	0	16.1	0.9	85.3	5.1
PW13_14.1	0.2919	0	0	16.1	1.3	95.2	7
RT.PW14.1	0.2919	0	0	15.9	1.3	91.6	7
PW15	0.4011	2.4	0.3	37.7	2.3	177.9	10.3
PW14	0.1191	6.2	0.7	23.2	1.6	77.4	4.3
PW15.1	0.0233	0	0	4.5	0.1	21.7	0.6
PW14_VRW3	8.5415	37.6	5.6	327.3	51.2	1821.2	222.5
RT.PW14	8.5415	37.5	5.6	326.3	51.1	1807.4	222.4
TVI1	0.0959	28.6	2.9	59.9	4.7	116.6	8
TVI1.1	0.0636	0.2	0	8.1	0.3	41.2	1.6
TVI_TOTAL	0.1595	28.8	2.9	67.9	5	156.1	9.5
RT.TVI	0.1595	28.8	2.9	67.4	5	155.1	9.5
VR5	0.2576	46.6	5.7	105	9.8	222.4	17.6
VR_TVI_PW	8.9586	92.9	14.2	372.5	65.9	1980.7	249.5
RT.VR5	8.9586	92.3	14.2	370.9	65.9	1972.4	249.5
SEV1	0.1696	52.2	4.9	111.3	8.2	212.8	14.1

Existing Conditions HEC-HMS Model Subbasins Results							
Basin ID	Drainage Area (mi²)	Peak Discharge (Q_2) (cfs)	Volume (V_2) (ac-ft.)	Peak Discharge (Q_{10}) (cfs)	Volume (V_{10}) (ac-ft.)	Peak Discharge (Q_{100}) (cfs)	Volume (V_{100}) (ac-ft.)
VR_TVI_PW_SEV	9.1282	125.6	19.2	388.7	74.2	2040.9	263.6
RT.SEV1	9.1282	125.3	19.2	387.8	74.2	2037.5	263.6
PW11	0.1214	0.6	0.1	14.5	0.6	71.6	3
RT.PW11	0.1214	0.5	0.1	14.2	0.6	71.1	3
RT.PW11A	0.1214	0.5	0.1	14.2	0.6	70.2	3
VRW1	0.3016	31.7	3.6	88.3	6.7	236.7	14.3
PW11_VRW1	0.4230	31.7	3.6	88.5	7.3	278.1	17.3
RT.VRW1	0.4230	31.7	3.6	88.2	7.3	275.4	17.3
VRW2	0.2003	78.1	7.7	148.8	12.1	267	19.7
RT.VRW2	0.2003	77.9	7.7	148.3	12.1	265.8	19.7
RT.VRW2A	0.6233	109.1	11.3	235.5	19.4	531.1	37
VR2	0.2503	97.1	9.4	186.1	14.9	335.2	24.4
VRW1_2_VR2	0.8736	203.7	20.7	416.5	34.3	846.9	61.4
RT.VR2	0.8736	203.3	20.7	415.5	34.3	845.7	61.4
VR4	0.2497	77.2	9.1	146.5	14.6	265.6	23.9
VR1	0.0797	38.1	3.2	72.7	5	128.9	8.1
VRW_VR1_4	1.2030	309.8	33	616	53.8	1208.6	93.4
VR3	0.3276	106.3	11.9	203.3	19	369.1	31.3
VR6	0.1927	46.5	4.7	101	8.3	196.9	15
Las Ventanas Dam	1.7233	51.8	49.7	62.9	81.1	72.1	139.7
RT.LVDD	1.7233	51.8	49.7	62.9	81.1	72.1	139.7
VR7	0.1938	61.2	6.6	119.6	10.7	219.9	17.9
Little Window Dam	0.1938	18.1	6.6	26.3	10.7	32.9	17.9
LVDD_LWD	1.9171	69.4	56.3	88.8	91.8	104.6	157.5
RT.LWD	1.9171	69.4	56.3	88.8	91.8	104.6	157.5
SEV2	0.0552	8.2	0.6	30.7	1.3	71.4	2.8
SWINBURNE_INFLOW	11.1005	190.6	76	476.6	167.3	2143.8	424

c. Peak Flow Rates and Volumes at Key Analyses Points

Analysis points, as shown in Figure 6, are located at key reaches along the CWB and correspond to reaches that were analyzed in the 1999 AHYMO model used in the analysis for the 1999 Prudent Line Study. A summary of the analysis points is presented in Table I. For each analysis point, the table provides the bulking factor in percent, unbulked and bulked peak discharge in cubic feet per second, and runoff volume in acre-feet for the 2-yr, 10-yr and 100-yr events. Digital HEC-RAS models are included in Appendix E.

Table I – 2013 Existing Conditions Analysis Points

2013 Existing Conditions Analysis Points									
Event	BULKING FACTOR	Peak Discharge (cfs)		Runoff Volume (ac-ft.)	Event	BULKING FACTOR	Peak Discharge (cfs)		Runoff Volume (ac-ft.)
		Unbulked	Bulked				Unbulked	Bulked	
AP1 (RT.QR4)					AP6 (RT.VRW3)				
2	1.40%	0	0	0	2	2.50%	31	31	4.5
10	2.80%	118	121	10.4	10	4.30%	302	315	45.8
100	5.50%	671	708	55.1	100	7.80%	1618	1744	200.3
AP2 (RT.QR20)					AP7 (RT.PW14)				
2	1.40%	0	0	0	2	2.60%	38	38	5.6
10	2.80%	125	128	11.5	10	4.40%	326	341	51.1
100	5.60%	712	752	60.6	100	8.10%	1807	1954	222.4
AP3 (RT.QR24)					AP8 (RT.VR5)				
2	1.10%	0	0	0	2	4.40%	92	96	14.2
10	4.20%	165	172	19.1	10	6.10%	371	394	65.9
100	7.60%	954	1026	92.3	100	8.70%	1972	2144	249.5
AP4 (RT.PW4)					AP9 (RT.SEV1)				
2	1.60%	0	0	0	2	4.70%	125	131	19.2
10	5.30%	171	180	22.3	10	6.60%	388	413	74.2
100	9.70%	1019	1117	108.5	100	11.10%	2038	2264	263.6
AP5 (RT.PW10)					AP10 (SWINBURNE_INFLOW)				
2	1.90%	5	5	0.9	2	6.00%	191	202	76
10	4.20%	280	292	38.7	10	7.20%	477	511	167.3
100	8.40%	1506	1632	184.7	100	11.50%	2144	2390	424

d. Flow Rate and Volume Comparisons to 1999 AHYMO Model

The 2103 existing conditions HEC-HMS hydrology is compared to the 1999 existing conditions AYHMO hydrology in Table J. Flow rates and volumes in the lower reaches of the CWB are higher than the 1999 AHYMO due to the development within the watershed over the last 14 years.

At Swinburne Dam, the 1999 100-yr flow rate was 1440 cfs (1603 cfs bulked) and the volume was 220 ac-ft. The 2013 HEC-HMS model predicts 2144 cfs (2390 cfs bulked) and a volume of 424 ac-ft.

Increases predicted in the upper reaches of the watershed may be attributable to using 100% A treatment in upper basins in 1999, as compared to the 2013 modeling where these basins were modeled with a combination of A, B, C, and D treatments. For example, the basin QR23, the site of the borrow pit located at the future Quail Ranch Pond Site, used land treatments of 61% A, 2% B, 36% C, and 0% D.

As HEC-HMS is now the regionally accepted hydrologic modeling method, further analysis of the reasons for the 1999-2013 changes in flow rates and volumes within the CWB watershed is likely a moot exercise.

Table J – Flow Rate and Volume Comparisons 2013 HEC-HMS to 1999 AHYMO

2013 Existing Conditions Analysis Points HEC-HMS						1999 Existing Conditions Analysis Points AHYMO				
Event	BULKING FACTOR	Peak Discharge (cfs) Unbulked	Peak Discharge (cfs) Bulked	Runoff Volume (ac-ft.)		Event	BULKING FACTOR	Peak Discharge (cfs) Unbulked	Peak Discharge (cfs) Bulked	Runoff Volume (ac-ft.)
AP1 (RT.QR4)						No equivalent analysis point				
2	1.40%	0	0	0						
10	2.80%	118	121	10.4						
100	5.50%	671	708	55.1						
AP2 (RT.QR20)						Concentration Point 4				
2	1.40%	0	0	0		2	0.00%	0	0	0
10	2.80%	125	128	11.5		10	2.80%	110	114	10
100	5.60%	712	752	60.6		100	5.60%	660	714	70
AP3 (RT.QR24)						From AHYMO R1				
2	1.10%	0	0	0		2	0.00%	0	0	not reported
10	4.20%	165	172	19.1		10	4.10%	111	115	
100	7.60%	954	1026	92.3		100	7.40%	713	771	
AP4 (RT.PW4)						Concentration Point 2				
2	1.60%	0	0	0		2	0.00%	0	0	0
10	5.30%	171	180	22.3		10	5.20%	120	125	20
100	9.70%	1019	1117	108.5		100	9.50%	780	844	90
AP5 (RT.PW10)						Concentration Point 1				
2	1.90%	5	5	0.9		2	0.00%	0	0	0
10	4.20%	280	292	38.7		10	4.00%	190	198	30
100	8.40%	1506	1632	184.7		100	8.20%	1190	1288	170
AP6 (RT.VRW3)						No equivalent analysis point				
2	2.50%	31	31	4.5						
10	4.30%	302	315	45.8						
100	7.80%	1618	1744	200.3						
AP7 (RT.PW14)						No equivalent analysis point				
2	2.60%	38	38	5.6						
10	4.40%	326	341	51.1						
100	8.10%	1807	1954	222.4						
AP8 (RT.VR5)						From AHYMO R6				
2	4.40%	92	96	14.2		2	0.00%	0	0	not reported
10	6.10%	371	394	65.9		10	6.00%	210	223	
100	8.70%	1972	2144	249.5		100	8.50%	1440	1562	

2013 Existing Conditions Analysis Points HEC-HMS						1999 Existing Conditions Analysis Points AHYMO				
Event	BULKING FACTOR	Peak Discharge (cfs) Unbulked	Peak Discharge (cfs) Bulked	Runoff Volume (ac-ft.)		Event	BULKING FACTOR	Peak Discharge (cfs) Unbulked	Peak Discharge (cfs) Bulked	Runoff Volume (ac-ft.)
AP9 (RT.SEV1)						Concentration Point L				
2	4.70%	125	131	19.2		2	0.00%	0	0	not reported
10	6.60%	388	413	74.2		10	6.20%	210	223	
100	11.10%	2038	2264	263.6		100	11.00%	1440	1598	
AP10 (SWINBURNE_INFLOW)						Concentration Point 0				
2	6.00%	191	202	76		2	0.00%	0	0	0
10	7.20%	477	511	167.3		10	6.70%	210	224	40
100	11.50%	2144	2390	424		100	11.30%	1440	1603	220

e. Structure Capacity vs. Flow Rate

As would be expected, none of the existing structure design capacities in the arroyo are exceeded by the 100-year 6 hour existing conditions flow rates.

Table K – Structure Capacity vs. Flow Rate

	Facility Type	Sta Location	Design Q per Design Documents	Q100 Existing Conditions
	Swinburne Dam	0+00		
GCS -1	Soil cement drop structure	2+25	5450	2401
GCS-2	Soil cement drop structure	4+15	5450	2401
GCS -3	Soil cement drop structure	6+40	5450	2401
GCS -4	Soil cement drop structure	9+40	5450	2401
	Las Ventanas Dam Outfall 60" pipe	15+40	149	140
GCS - 5	Riprap drop structure	17+90	3000	2274
GCS - 6	Riprap drop structure	21+40	3000	2274
GCS - 7	Riprap drop structure	24+90	3000	2274
Kayenta	Kayenta Crossing, Pipe Arch	26+10	4800	2147
GCS - 8	Riprap Drop Structure	30+10	5300	2147
GCS - 9	Riprap Drop Structure	36+30	5300	2147
GCS - 10	Riprap Drop Structure	42+80	5300	2147
GCS -11	Univ. Plaza, Riprap/conc. drop structure	46+10	5300	2147
	Univ. Plaza, 40' bot. conc. channel	46+20	5300	2147
	Univ. Xing, Concrete Drop Structure	49+10	4700	1948
Universe	Universe Crossing, Pipe Arch	50+80	4700	1948
	Riprap bank protection, Left	53+60	4700	1948
	NMUI, Riprap Bank Protection, Left	84+60	4652	1739

The only location where existing flow rate nears structure design capacity is the Las Ventanas Detention Dam Outfall Pipe. Note that flows into the outfall pipe are controlled by the two dams, and that the basins draining to the dams are essentially built out. The dam was designed for fully developed conditions.

It is noted that GCS-5, GCS-6, and GCS-7 were designed for less than the 1999 Prudent Line Study developed conditions flow rate of 4900 cfs. Per negotiations with the developer, each was sized for 3,000 cfs, which was more than two times the existing 100-yr event of 1440 cfs, and well over the ten year developed conditions event of 2310 cfs. This approach was justified by the regulatory agencies, considering the risk and consequence of failure, as well as the dedication of right of way to AMAFCA and the City of Albuquerque in excess of the 1999 prudent limits.

It is also noted that the Field Reconnaissance Report identifies GCS-9 as the failed structure. Failure of the structure was not due to exceedence of the design inflow, but rather the location of a subsequently constructed storm drain outfall that undermined the downstream sill of the structure.

4.0 REFERENCES

Mussetter Engineering, Inc. 1999. Calabacillas Arroyo Prudent Line Study and Related Work: Development of a Prudent Line for the West Branch, Albuquerque, New Mexico. Report prepared for the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA).

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5.0 APPENDICES

(All Appendices are on attached CD)

5.1 Appendix A Tabulated Storm Distributions

5.2 Appendix B, Time of Concentration Calculations

5.3 Appendix C, Storage Coefficient Calculations

5.4 Appendix D, HEC-RAS Digital Models

5.5 Appendix E, HEC-HMS Digital Models

5.6 Appendix F, Calabacillas West Branch Arroyo Drainage & Storm Water Quality Management Plan: Field Reconnaissance Report