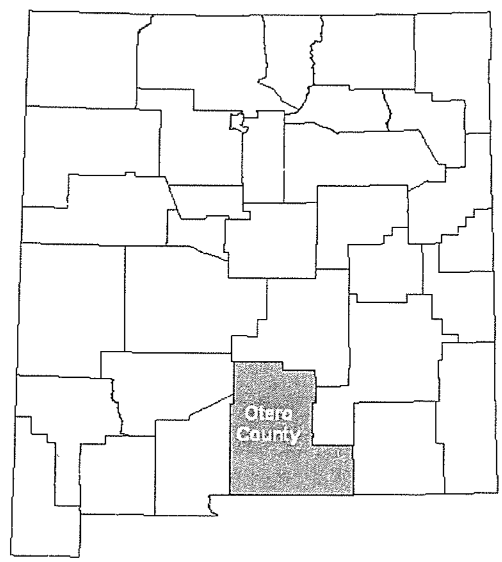
FLOOD INSURANCE STUDY

OTERO COUNTY, NEW MEXICO,

AND INCORPORATED AREAS



VOLUME 1 OF 2

Community Name	Community Number
ALAMOGORDO, CITY OF	350045
*CLOUDCROFT, VILLAGE OF	350111
MESCALERO APACHE INDIAN RESERVATION	350041
OTERO COUNTY (UNINCORPORATED AREAS)	350044
TULAROSA, VILLAGE OF	350046

*Non Flood-Prone Community

EFFECTIVE: December 17, 2010

Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER
35035CV001A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Selected Flood Insurance Rate Map panels for the community contain information that was previously shown separately on the corresponding Flood Boundary and Floodway Map panels (e.g., floodways, cross-sections). Former flood hazard zone designations have been changed as follows:

Old Zone	New Zone
A1 through A30	AE
B	X
C	X

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: December 17, 2010

TABLE OF CONTENTS

Volume 1

FIGURES

FLOOD INSURANCE STUDY
OTERO COUNTY, NEW MEXICO AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and supersedes the FIS reports and Flood Insurance Rate Maps (FIRMs) in the geographic area of Otero County, New Mexico, including the City of Alamogordo, the Villages of Cloudcroft and Tularosa, the Mescalero Apache Indian Reservation; and unincorporated areas of Otero County (hereinafter referred to collectively as Otero County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Otero County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

Otero County includes the Village of Cloudcroft, which does not contain any Special Flood Hazard Areas (SFHAs) and is non-flood prone.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This FIS was prepared to include all jurisdictions within Otero County in a countywide FIS. The authority and acknowledgments prior to this countywide FIS were compiled from the previously identified FIS reports for flood prone jurisdictions within Otero County and are shown below:

Alamogordo, City of: The hydrologic and hydraulic analyses for this study were prepared by the U. S. Army Corps of Engineers (USACE), Albuquerque District for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-E-0105, Project Order No. 1, and amendment thereto. This study was completed in September 1981.

Cloudcroft, Village of: A FIS has not previously been published for this community, though a Flood Hazard Boundary Map (FHBM, Reference 1) was prepared.

Mescalero Apache Reservation: A FIS has not previously been published for this community. A small section of stream located in Otero County, NM was studied and had a published profile included in the Village of Ruidoso in Lincoln County, NM. This portion of stream was removed from the Lincoln County DFIRM and included on the Otero County map. The hydrologic and hydraulic analyses for the original study were performed by Boyle Engineering Corporation for the FEMA, under Contract Number H-4602. This study was completed in September 1980.

Otero County (Unincorporated Areas): A FIS has not previously been published for this community, though a FIRM (Reference 2) was previously published.

Tularosa, Village of: A FIS has not previously been published for this community, though a FHBM (Reference 3) was prepared.

For this first time countywide study, MAPVI (the study contractor) compiled existing data to convert the previous Otero County FIS into digital format. MAPVI also conducted limited detailed studies on the Hay River and Beeman Canyon Creek. In addition, MAPVI redelineated all previous flooding sources studied by detailed methods and refined all previous approximate studies. This work was completed in August 2008 under Contract No. EMT-2002-CO-0052.

Base map information shown on the FIRMs was derived from multiple sources, including the United States Geographical Survey (USGS), 1989, Otero County Assessors Office, and U.S Census Bureau, 2000 and 2006. Additional information was photogrammetrically compiled at scales of 1:6,000 and 1:12,000 from aerial photography dated 1997 to 2006.

The projection used in the preparation of the FIRMs was New Mexico State Plane Central Zone (FIPS 3002). The horizontal datum was NAD83, GRS80 spheroid. Flood elevations on this FIRM are referenced to the North American Vertical Datum of 1988. Differences in datum, spheroid, projection, or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences across jurisdiction boundaries. These differences do not affect the accuracy of the FIRMs.

1.3 Coordination

An initial Preliminary DFIRM Community Coordination (PDCC) meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied by detailed methods. A final PDCC meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study. All problems raised in the meeting have been addressed in this study.

The dates of the initial and final PDCC meetings held for Otero County and the incorporated communities within its boundaries are shown in Table 1, "Initial and Final PDCC Meetings."

Table 1 – Initial and Final PDCC Meetings

Community	Initial PDCC Date	Final PDCC Date
City of Alamogordo	1	March 25, 1982
City of Cloudcroft	1	1
City of Tularosa	1	1
Mescalero Apache Indian Reservation	2	2
Unincorporated Areas (Otero County)	1	1

[1]Data not available
[2]Never Mapped

For this countywide revision, an initial PDCC meeting was held on May 22, 2007, and was attended by representatives of the community, the study contractor, and FEMA. A final PDCC meeting was held on February 3, 2009, and was attended by representatives of the community, the study contractor, and FEMA.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Otero County, New Mexico. Those areas studied by detailed and approximate methods were chosen with consideration given to all proposed construction and forecasted development through May 2007.

All or portions of the flooding sources listed in Table 2, "Flooding Sources Studied by Detailed and Limited Detailed Methods," were studied by detailed and limited detailed methods. Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Published Separately).

All flooding sources that had been previously studied by detailed methods and not subsequently restudied were redelineated. This process consisted of updating the floodplain boundaries based on the most current topographic data. New hydrologic and hydraulic analyses were not performed on the redelineated flooding sources.

The Mescalero Apache Indian Reservation was designated as "Area Not Included" on the previous Otero County (Unincorporated Areas) FIRMs before a countywide study was performed. There was no flood hazard data for these areas, so they were converted to Zone D.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by FEMA and Otero County.

Table 2 – Flooding Sources Studied by Detailed and Limited Detailed and Detailed Methods

Table 2a – Flooding Sources Studied by Limited Detailed Methods

Stream Name	Downstream Limit	Upstream Limit
Beeman Canyon Creek	1,700 ft upstream of N Scenic Drive	Alamogordo Water Supply Reservoir
Hay River	US-54	Riata Road
Hay River Tributary No 1	Confluence with Hay River	Riata Road

Table 2b – Redelineated Flooding Sources

Stream Name	Downstream Limit	Upstream Limit
Cherokee Bill Canyon	Otero County Boundary	860 ft upstream of County Boundary
Flow Path #1	Confluence with Flow Path #3	2,700 ft upstream of Fairgrounds Rd
Flow Path #2	Alamogordo Water Supply Reservoir	850 ft upstream of confluence with Flow Path #3
Flow Path #3	1,400 ft downstream of Eddy Dr	Confluence with Flow Path #2
Flow Path #4	Confluence with Flow Path #5	18th St
Flow Path #5	1,500 ft downstream of Lavelle Rd	1,600 ft upstream of Scenic Dr
Flow Path #6	Confluence with Flow Path #7	100 ft downstream of Marble Canyon Rd
Flow Path #7	Confluence with Flow Path #5	Mouth of Marble Canyon
Flow Path #8	Confluence with Flow Path #5	Scenic Drive
Flow Path #9	Confluence with Flow Path #10	Puerto Rico Ave
Flow Path #10	Divergence from Flow Path #5	Confluence with Flow Path #9
Flow Path #11	Confluence with Flow Path #9	Divergence from Flow Path #23
Flow Path #12	400 ft downstream of Union Pacific Railroad	Divergence from Flow Path #16
Flow Path #13	Confluence with Flow Path #3	Alamogordo Water Supply Reservoir
Flow Path #14	Confluence with Flow Path #3	1,800 ft upstream of Rainbow Ln
Flow Path #15	Confluence with Flow Path #8	1,300 ft upstream of Scenic Drive

Table 2b – Redelineated Flooding Sources

Stream Name	Downstream Limit	Upstream Limit
Flow Path #16	Union Pacific Railroad	Divergence from Alamo Canyon Creek
Flow Path #17	U.S. Highway 70	2,100 ft upstream of S Florida Ave
Flow Path #18	Confluence with Flow Path #30	Divergence from Flow Path #17
Flow Path #19	Union Pacific Railroad	Divergence from Flow Path #5
Flow Path #20	Union Pacific Railroad	Confluence with Flow Path #4
Flow Path #21	Union Pacific Railroad and Confluence with Flow Path #31	Divergence from Flow Paths #4 and #25
Flow Path #22	Union Pacific Railroad	Confluence with Flow Path #4
Flow Path #23	Confluence with Flow Path #9	Cuba Ave
Flow Path #24	Confluence with Flow Path #4	250 ft upstream of Granada
Flow Path #25	Confluence with Flow Paths #4 and #21	Divergence from Flow Path #5
Flow Path #26	Confluence with Flow Path #5	Divergence from Flow Path #6
Flow Path #27	280 ft downstream of Sunbeam Avenue	Mouth of Marble Canyon
Flow Path #28	Confluence with Flow Path #15	1,000 ft upstream of Scenic Drive
Flow Path #29	Union Pacific Railroad	Puerto Rico Ave
Flow Path #30	2,700 ft downstream of Flow Path #18	US-54
Flow Path #31	1,600 ft downstream of Lavelle Rd	Union Pacific Railroad and Divergence from Flow Path #21
Flow Path #32	Alamogordo Corporate Limits	600 ft northeast of intersection of Camino del Norte & Camino Valle Verde
Flow Path #33	1,500 ft downstream of Lavelle Rd	Union Pacific Railroad

All approximate analyses not subsequently studied by detailed methods were refined for this countywide update based on orthophotography and the best available topographic data.

2.2 Community Description

Otero County is located in south central New Mexico. It is bordered by Doña Ana and Sierra Counties on the west, Lincoln County to the north, Chaves and Eddy Counties to the east and El Paso and Hudspeth Counties, Texas to the south. The estimated population in 2006 was 62,744 (Reference 4).

The dominant landscape feature in Otero County is the Tularosa Basin, which is a graben basin and part of the Rio Grande Rift zone. The Tularosa Basin is a hydrologically closed basin that extends 150 miles north to south and up to 60 miles east to west. Surface water that doesn't evaporate or soak into the ground eventually accumulates at playas (intermittent lakes), the largest of which is Lake Lucero at the southwest end of the famous White Sands National Monument. To the north of Lake Lucero, there are extensive alkali flats, which today produce additional gypsum for White Sands.

The basin is surrounded by the Sacramento Mountains to the east and by the San Andres Mountains to the west. Both mountain ranges are almost entirely comprised of limestone. Gypsum deposits eroded from the mountains and transported to the basin are the primary source of the gypsum sand that makes up the dunes in White Sands National Monument. The Sacramento Mountains are home to the Lincoln National Forest and Mescalero Indian Reservation, while the San Andres Mountains are dry and barren, located almost entirely within White Sands Missile Range making them inaccessible to the general public.

The area's climate is more moderate than other desert areas because of its high elevation and proximity to the mountain range, which provides shelter from the wind's cold as well as cooling rain showers in summer's heat. With elevations ranging from 4,300 feet to 9,500 feet, the county has an ideal climate of warm days and cool nights. There are 350 days of sunshine each year. Winter days stay comfortable with temperatures in the 50s and 60s. The basin averages 15 inches of precipitation per year, and 315 days are precipitation free. The months of July-August get approximately 6 inches of moisture, while the mountain areas average 32 inches of precipitation and 92 inches of snow (Reference 5).

Historically, the area is the home of the Mescalero Apache Indians. The current reservation, established in 1873 by President Ulysses S. Grant, is covered in forest with timber operations, recreation, and tourism being the primary economic activities. Tribal population now exceeds 3,300 (Reference 6).

Village of Cloudcroft: Cloudcroft is located in the Sacramento Mountains, 16 miles east, and 5,000 feet above Alamogordo. US Highway 82 runs east to west through the village. The village was established in 1898 as both a logging operation and a tourist attraction. High mountain meadows and cool air are a welcome relief from the surrounding desert. Summer temperatures reach the upper 70's but the nighttime lows remain in the cool 40's and 50's (Reference 7).

Village of Tularosa: The Village of Tularosa was established in 1862 by Hispanic settlers from the Rio Grande Valley. The City of Roses was named for the rose colored reeds growing along the banks of the Rio Tularosa, which flows along the northern edge of the village. The original acequia (ditch irrigation system) is still functioning. Tularosa is nestled at the bottom of the Sacramento Mountains at the junction of US Highways 54 and 70. Its population in 2000 was 2,858 (Reference 8).

City of Alamogordo: Alamogordo (big cottonwood in Spanish) is the largest city and county seat. The city is located at the junction of US Highways 54 and 70 approximately 85 miles north-northeast of El Paso, Texas. Alamogordo was established in 1898 as a terminal for the El Paso and Northern Railroad. Ranching, mining, and logging were the principal economic activities at that time. Today, the local economy is dominated by the defense industry, with Holloman Air Force Base, White Sands Missile Range, and Fort Bliss located nearby. A recent national survey ranked Alamogordo as one of the 50 healthiest places to live in the U.S. (Reference 5). As of 2003, an estimated 35,551 people live in Alamogordo (Reference 9).

The city is situated at the foot of the Sacramento Mountains on an alluvial fan. There are four major and several smaller watersheds contributing to floodflow. The major watersheds from north to south are the Dry, Beeman, Marble, and Alamo Canyons. The Beeman and Marble Canyon alluvial fans flow into the central part of the city. The Dry Canyon fan borders the north edge of the city and the Alamo Canyon fan borders the southern part of the city. All of the arroyos are ephemeral and, except for Dry Canyon, flow westward of the Sacramento escarpment. Dry Canyon flows northwestwardly to its outwash fan where it bends to the southwest and continues across the fan toward Alamogordo. All of the fans have numerous channels across them and flows shift back and forth. The channels are shallow even though the slopes of the fans are steep. The flows passing through the fan, feather out to the point where there are no definite channels, allowing fans to spread over a wide area. The natural drainage pattern has been changed somewhat by the Southern Pacific Railroad and US Highway 54/70.

Below the fan the gradient becomes flatter and stream flow disperses to the floor of the Tularosa Basin, which contains numerous sinkholes. Stream slopes vary from 850 feet per mile in the area between Marble and Alamo Canyon to 269 feet per mile in Dry Canyon and 149 feet per mile in the area of the northern corporate limits.

For this countywide revision, detailed studies were conducted for Beeman Canyon Creek, which is located northeast of the City of Alamogordo, and the Hay River and its tributary, which are located midway between Alamogordo and Tularosa, along US Highway 54/70.

The detailed study area along Beeman Canyon Creek is composed of alluvial fan deposits. These alluvial fan deposits tend to be thick, massive and highly lenticular gravel lenses, rather than well-stratified with slopes of 2 to 20 percent. On short steep fans, gravels show minimal weathering and are weakly cemented with caliche; probably Wisconsinan and Holocene age. On broad, more gently sloping fans, gravels are more weathered and commonly cemented by caliche. The deposits are probably pre-Wisconsinan age. In the southern half of the state, the gravel facies is characterized by creosote bush cover. (References 10 and 11). The drainage appears to be incised into these older alluvial fan deposits, but shows no alluvial fan morphology of its own. With the exception of the downstream end, the channel is "natural" and appears to have meandering/braided morphology. The channel is moderately vegetated, while the channel bottom is generally free of vegetation.

The Hay River and its tributary are composed of alluvial fan deposits. These alluvial fan deposits tend to be thick, massive and highly lenticular sand lenses, rather than well-stratified with slopes of 2 to 20 percent. The sand lenses are comprised of sandy alluvium with subordinate amounts of fine gravel, silt, and clay. Based on the field photos, geologic maps, and Fryberger (Reference 12), the source bedrock is the Permian (Yeso Formation and Abo Redbed facies) and Pennsylvanian age. According to Hunt (References 10 and 11), the Permian bedrock in this area is mostly gypsiferous. At the upstream limit of the study reach (just downstream of US Highways 54/70), the channel has been straightened. The channel had gone through several cycles of sedimentation and dredging. The excess sediment has been used to build spoil banks along the channel. Between US Highways 54/70 and the railroad, the channel is deeply entrenched with highly erodible vertical channels banks and the banks are undergoing active erosion and undercutting. Downstream of the railroad, the channel material contains significantly more clay. Instead of a deep, wide channel, there are several small channels that could be overtopped easily. These small channels were interconnected in several locations. The amount of vegetation in the channel significantly increases in this portion of the study reach.

2.3 Principal Flood Problems

Reliable and factual data concerning the details of flooding in Alamogordo are meager. Information furnished by the Southern Pacific Railroad indicates that from 1935 to 1959, eleven floods exceeded the capacity of the railroad's drainage structures and overtopped the tracks by as much as two feet. Three other floods during the same period where reported by individuals.

The flood problems in Alamogordo result from flash floods in Dry, Beeman, Marble, and Alamo Canyons as well as several intervening unnamed arroyos, all originating in the Sacramento Mountains east of the city. These floodflows, after entering the city, are retarded and diverted by various obstructions such as buildings, roads, streets, walls and the railroad. Most of the drainage structures are inadequate to pass large flows.

Discharges from Dry and Beeman Canyons and the unnamed arroyos diverted by the Tays-Holcomb ditch caused flooding in the northern section of the city. Floodflows enter this section of the city from the northeast and collect in a large flat area to the east of US Highway 54/70 and north of the principal business district. Outlets to the west under the highway and railroad can discharge these waters at the rate of about 1,500 cubic feet per second (cfs); but when the flow exceeds this amount, the water turns southward and passes through the business district.

Floods that originate in Marble Canyon and adjacent arroyos move westward through the south section of the city to drainage outlets under the highways and railroads; but these facilities are not adequate to pass flows in excess of 3,000 cfs. The channel capacity in the vicinity of Canyon Road is about 1,800 cfs. The topography of Alamogordo is such that surface waters have high velocities. Much of the flood damage is the result of scour and the deposition of rocks and sediment. In some places, the floodwater is temporarily obstructed, causing damage by ponding and inundation. Particularly heavy damages occur when the water accumulates and is held back by US Highway 54/70 and the railroad embankment.

A major flood occurred on August 17, 1959. This storm started at 12:30 pm and ended at 2:20 pm, during which 2.31 inches of rain fell at Alamogordo. A bucket survey conducted to determine the storm pattern indicated the maximum rainfall was 3.5 inches at a point southeast of the city near the base of the mountains. Runoff in south Alamogordo was severe and caused the McKinley Ditch to overflow its banks. The ditch contained the flow from the upper end to just above the Cuba Avenue crossing where the double 10- x 10-foot concrete box culvert could not pass the flow. The overflow entered the ditch in the vicinity of the Old New Mexico Army National Guard area. The ditch overflowed at the 1st Street crossing. This overflow, augmented by sheetflow, came across the cemetery and flow from a ditch that intercepts areas southwest of Canyon Road, caused extensive flooding in the Plainview Acres subdivision. The overflow then reentered McKinley Ditch in the vicinity of a wooden bridge on Florida Avenue extension.

The north-south feeder ditch on Washington Avenue did not overflow but Bellamah Ditch overflowed near its upstream end. This overflow channeled down Abbot Avenue and caused flood damage in that area. The overflow then entered McKinley Ditch near its junction with Bellamah Ditch. The flow from McKinley diverges into three channels which pass under the highway and railroad. The flow exceeded the capacity of the three highway culverts and overflowed the highway. The railroad trestles became plugged with debris and water overtopped the tracks for a distance of 3,000 feet. There is a low levee about 20 feet east of the railroad embankment, but water spread out of the channels and breached the levee. Flows dissipated in the area west of the railroad.

The USGS made four-slope area determinations to estimate peak flows. The estimated peak discharges in the Washington Avenue Ditch near the intersection of 7th Street and Washington Avenue was 245 cfs, and on the Bellamah Ditch at 10th Street was 1,130 cfs. Two determinations were made on McKinley Ditch. The estimated peak discharges at Canyon Road Bridge was 3,170 cfs, and near the Florida Avenue extension, 2,840 cfs. It is believed that the latter determination does not represent the total peak flow from the drainage area above that point, because of the considerable overflow and spreading water through the flooded area between Canyon Road Bridge and the bridge on the Florida Avenue extension.

On August 26, 1959, an intense, localized storm occurred over the city. Rainfall at radio station KALG measured 2.51 inches in about two hours. The existing ditch system carried most of the flow. The damages that occurred were due to runoff from rainfall over the developed urban area. A study of the rainfall patterns of the two 1959 storms indicate that the damages would have been much greater if the storms, which were confined to the southern section of the city, had been centered over the contributing drainages.

The storm of August 15, 1961 centered over Marble and Alamo Canyons and produced a reported 4 inches of rainfall in two hours in the foothills above Alamogordo. The majority of the flood flows came from Marble Canyon, and the city manager reported an estimated stage of 20 feet at the narrow canyon mouth. A diversion dike and several roads were washed out to bedrock. A significant thunderstorm occurred on the evening of August 23rd and the early morning of August 24th, 1984. The storm caused extensive damage to areas north of Alamogordo, including the collapse of a bridge in Las Luz, New Mexico. The storm produced minor flooding in the northern section of the city, primarily from flows originating from Dry Canyon.

The summer of 2006 was one of the wettest on record for Otero County. Flooding from various storm events throughout Otero County resulted in the county being declared a Federal Disaster Area. On June 22, 2006, the city of Alamogordo experienced intense thunderstorms. At approximately 4:20 pm, rain and hail began falling over the Marble Canyon drainage area just east of the city. The event lasted approximately 90 minutes with radar estimates of up to 2.9 inches of precipitation falling over the majority of the 3.48 square mile watershed. Engineers estimate that the event corresponded to a 0.2-percent chance annual storm with duration of 90 minutes. At approximately 4:40 pm, another cell moved over the southeastern edge of the city. This event lasted approximately 60 minutes and gage readings of up to 1.34 inches were reported. Engineers estimated that the second event corresponded to a 10-percent annual chance storm with duration of 60 minutes. Damage from these two storms was estimated at two million dollars.

Rains in early August 2006 caused the Sacramento River in Timberon to overflow, washing out bridges and culverts. Flooding also occurred in Boles Acres, Oro Vista, and Three Rivers. Additional heavy rainstorms during August 13th and 14th of 2006 brought flooding to Alamogordo and the northern portions of Otero County. Flooding closed US Highway 82 near Mayhill. Heavy rains occurred again on August 16, 2006 causing arroyos to overflow in portions of Alamogordo and Boles Acres. High waters on August 22, 2006 forced evacuations of James Canyon, near Mayhill, while mudslides occurred in Tularosa Canyon near Mescalero.

2.4 Flood Protection Measures

The City of Alamogordo has constructed levees and channels to protect the developed areas against floodwaters. None of the channels are lined and their capacities are severely restricted by numerous bridge and culvert crossings. The protective work consists generally of two separate systems. One system comprises the Tays-Holcomb Ditch and Indian Wells Ditch, which intercept runoff from the northeast and convey it into a small reservoir (Alamogordo Water Supply Reservoir). This reservoir was originally built for irrigation purposes, but is now unused, and the dam is subject to failure from major floods. Field reconnaissance conducted for this countywide revision indicates the concrete on the upstream side of the spillway structure has been corroded and undercut, indicating that water has crested the spillway structure.

The Indian Wells Ditch intercepts runoff from Dry Canyon and the area below the Tays-Holcomb Ditch and conveys it westward under US Highways 54/70 and the Southern Pacific Railroad tracks. The Tays-Holcomb Ditch has a capacity approaching 1,100 cfs in the lower reaches. The capacity of the Indian Wells Ditch varies from about 400 cfs in the upper portion to about 2,200 cfs in the lower reaches.

The second system consists of the McKinley Ditch and four feeder ditches. It collects runoff from the south and southeast areas of the city. The channel capacity of the McKinley Ditch ranges from about 1,500 to 3,000 cfs. One feeder ditch located between Oregon and Washington Avenues runs south from Indian Wells Road to near 2nd Street where it intersects McKinley Ditch. The Bellamah feeder ditch runs east along Abbott Avenue and joins McKinley Ditch about 1,100 feet upstream from the Canyon Road crossing. The third feeder ditch intercepts flow from the area down slope of Canyon Road and enters McKinley Ditch at the 1st Street Crossing. The other feeder ditch begins at 5th Street and runs south along Alaska Avenue until it enters McKinley Ditch. About 1,500 feet downstream of Alaska Avenue, the McKinley Ditch splits into three channels which convey the flow under US Highways 54/70 and the Southern Pacific Railroad into the undeveloped area southwest of Alamogordo.

Non-structural measures of flood protection are also being used to aid in the prevention of future flood damage. These measures are in the form of land use regulations adopted from the Code of Federal Regulations, which control building within areas that have a high risk of flooding.

The Alamogordo Flood Control Project is a plan sponsored and shared by the USACE and the City of Alamogordo. The plan outlines systems of channels to collect, regulate, and discharge arroyo runoff through the city to reduce the flooding problems. The plan proposes two independent elements: the South Channel and McKinley Channel System and the Northern System. Phase I of the South Channel was completed in 2003, and the design and construction of the South Diversion Channel and McKinley Channel are underway. The project design capacity is the 1-percent annual chance storm. Flood control plans for the northern portion of the city have not been made final at this time.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this FIS. Flood events of a magnitude, which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood, which equals or exceeds the 1-percent annual chance flood in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this FIS. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the county.

Peak discharge-drainage area relationships for streams studied in detail for all communities within Otero County are shown in Table 3, "Summary of Discharges."

For each community within Otero County that had a previously printed FIS report, the hydrologic analyses described in those reports have been compiled and are summarized below.

City of Alamogordo: In the absence of stream gaging stations and associated data, regional frequency curves for peak discharges and flood volumes were constructed using Snyder's synthetic unit hydrograph procedures (Reference 13) and rainfall frequency duration data (Reference 14). These analyses followed recommended procedures outlined by the Water Resources Council (Reference 15). The USACE HEC-1 computer program (Reference 16) was used to develop discharge rates. Discharge rates computed by the HEC-1 program were plotted on log-probability paper to develop frequency curves. Rainfall data used for the HEC-1 program were developed from a report prepared by the National Weather Service (NWS, Reference 17).

Discharges for the 0.2-percent annual flood were determined by straight-line extrapolation of a single-log graph of flood discharges computed for frequencies up to the 1-percent annual flood.

Because of the alluvial fan flood flow, there are numerous shifts in flows among all the channels; therefore, the peak discharges are in many cases attenuated in the downstream direction.

Mescalero Apache Reservation: A discrete event model SCS-TR20 was used for Cherokee Bill Canyon.

Countywide Update: New hydrologic analyses were conducted for Beeman Canyon Creek and the Hay River and its tributary. Drainage basins were delineated for each flooding source based on USGS Topographic Maps (Reference 18) supplemented by a USGS 10-meter Digital Elevation Model (DEM, Reference 19). The Southwestern United States Region 16 Regression Equations are applicable for Otero County (References 20, 21 and 22). The Region 16 equations use drainage areas in square miles and mean annual evaporation in inches to develop a flow rate. Mean annual evaporation was obtained from the National Oceanic and Atmospheric Administration (NOAA) Technical Report NWS 33 (Reference 23).

The National Resources Conservation Service (NRCS formerly known as SCS) Unit Hydrograph Methodology was utilized within HEC-HMS Hydrologic Modeling System software version 3.1.0 (Reference 24), developed by the USACE, to develop the run-off volume that was necessary for modeling the hydrology of the Hay River and its tributary.

Soil types vegetative cover, and land use classifications were used to determine the average curve number for each watershed. Soil types were obtained from the NRCS in GIS format. Land use classifications were determined by inspecting the available orthophotography (Reference 19).

The traditional Type II rainfall distribution was revised to define four different distributions for the different physiographic regions in New Mexico by the NRCS. The Hay River watershed splits two rainfall distributions. A Type II-75 was selected as the appropriate distribution for this analysis to provide a conservative approximation of the peak runoff. This distribution has 75% of the rainfall in a 1-hour window within the total 24 hour event, which is more consistent with they type of rainfall events New Mexico experiences.

Table 3 -- Summary of Discharges

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
BEEMAN CANYON CREEK					
3350 ft downstream of Scenic Dr at the Sports Complex	2.62	*	*	2,380	*
CHEROKEE BILL CANYON					
At Confluence with Rio Ruidoso (downstream of county boundary)	47.00	300	1,400	1,900	2,800
FLOW PATH #1					
Cross Section I	13.30	1,950	4,425	5,730	10,000
Cross Section E[1]	20.00	1,950	2,900	2,900	2,900
Cross Section A[2]	*	170	170	170	170
FLOW PATH #2					
Cross Section U	*	150	290	380	610
Cross Section S	1.50	425	835	1,090	1,600
Cross Section Q	1.80	885	1,745	2,270	2,270
Cross Section O	2.30	450	450	450	450
Cross Section C	2.70	860	1,195	1,410	1,950
Cross Section B	3.00	1,140	1,730	2,105	3,050
Cross Section A	*	1,315	2,070	2,545	3,760
FLOW PATH #3					
Cross Section AC	*	525	1,510	2,115	2,200
At Station 8505[3]	0.60	1,070	1,760	2,410	3,600
Cross Section O	*	540	540	540	540
Cross Section M	1.10	910	910	910	910
Cross Section I	*	1,100	5,140	5,590	7,900
Cross Section H	*	1,100	4,300	4,390	4,500
Cross Section D	*	1,100	4,800	4,890	5,000

* Undetermined.
[1] Flows above 2,900 cfs for the 2-, 1- and 0.2% annual chance flood flow southwesterly toward Flow Path #14.
[2] Flows in excess of 170 cfs flow southwesterly toward Flow Path #14.
[3] Feet above downstream of Limit of Detailed Study

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #4					
Cross Section S	*	100	100	100	100
Cross Section O	0.30	450	615	675	2,590
Cross Section N	*	815	1,115	1,220	1,500
Cross Section L	0.80	1,135	1,350	1,350	1,350
At Station 2890[1]	1.10	1,650	1,650	1,650	1,650
Cross Section AC	*	700	700	700	700
FLOW PATH #5					
Cross Section AW	3.40	1,515	3,130	4,060	6,900
Cross Section AT	*	1,515	2,450	2,450	2,450
Cross Section AQ	*	1,515	3,130	3,800	3,800
Cross Section AP	*	3,200	3,200	3,200	3,200
Cross Section AN	*	2,400	2,400	2,400	2,400
At Station 15980[2]	*	1,500	1,500	1,500	150
Cross Section AG	*	1,400	1,400	1,400	1,400
At Station 14000[2]	*	1,900	2,500	3,050	4,800
Cross Section AD	*	500	500	500	500
Cross Section Y	3.70	2,600	3,200	3,750	4,950
Cross Section X	*	3,690	4,900	4,900	4,900
Cross Section U	*	3,100	3,100	3,100	3,100
At Station 11540[2]	*	2,250	2,250	2,250	2,250
At Station 9270[2]	4.40	1,440	1,640	1,765	2,025
At Station 7630[2]	*	400	510	550	630
Cross Section B	4.90	4,400	6,550	7,950	11,000
Cross Section A	*	6,700	12,210	15,680	25,000

* Undetermined.
[1] Feet above confluence with Flow Path #5
[2] Feet above downstream of Limit of Detailed Study

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #6					
At upstream of Shawnee Trail	0.54	218	397	492	774
At confluence with Flow Path # 7	0.85	299	331	358	413
FLOW PATH #7					
Downstream of Bellamah Avenue	4.51	482	630	948	1325
SOUTH DIVERSION CHANNEL Downstream of Scenic Drive	4.75	1379	2719	3501	5258
At confluence of Flow Path #28	4.87	1635	3158	4052	6091
At confluence of Flow Path #8	*	1992	3785	4829	7228
FLOW PATH #8					
At confluence of Flow Path #28	0.68	145	254	310	484
FLOW PATH #9					
Cross Section K	*	1,450	1,670	1,780	2,040
Cross Section F	*	1,450	1,640	1,765	2,025
FLOW PATH #10					
Cross Section J	*	1,130	1,250	1,320	1,460
Cross Section H	*	1,130	1,250	1,320	1,400
Cross Section D	*	1,010	1,130	1,215	1,395

REVISED DATA

REVISED DATA

* Undetermined.
~~[1] Feet above confluence with Flow Path #7~~
~~[2] Feet above confluence with Flow Path #5~~

REVISED TO REFLECT LOMR EFFECTIVE: September 23, 2013

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #6					
Cross Section P	*	250	500	645	1,100
Cross Section N	*	250	360	360	360
Cross Section K	*	250	300	300	300
Cross Section G	*	1,910	3,230	3,815	6,160
Cross Section F	*	200	200	200	200
Cross Section E	*	100	100	100	100
At Station 1660 [1]	0.50	200	200	200	200
Cross Section A	0.90	500	1,100	1,650	3,400
FLOW PATH #7					
Cross Section R	3.60	1,800	3,670	4,750	8,000
Cross Section Q	*	300	1,550	1,750	3,500
Cross Section P	*	300	1,550	1,300	1,300
Cross Section O	*	300	1,550	1,200	1,200
Cross Section N	*	300	900	900	900
Cross Section M	3.70	500	1,100	1,650	3,400
At Station 470 [2]	*	500	500	500	500
Cross Section O	*	2,500	2,500	2,500	2,500
FLOW PATH #8					
Cross Section I	*	625	1,280	1,660	2,760
Cross Section D	2.30	1,090	2,225	2,885	4,800
FLOW PATH #9					
Cross Section K	*	1,450	1,670	1,780	2,040
Cross Section F	*	1,450	1,640	1,765	2,025
FLOW PATH #10					
Cross Section J	*	1,130	1,250	1,320	1,460
Cross Section H	*	1,130	1,250	1,320	1,400
Cross Section D	*	1,010	1,130	1,215	1,395

* Undetermined.
[1] Feet above confluence with Flow Path #7
[2] Feet above confluence with Flow Path #5

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #11					
Cross Section H	*	980	980	980	980
At Station 3435[1]	*	535	535	535	535
Cross Section D	*	1,500	1,500	1,500	1,500
Cross Section C	*	800	800	800	800
Cross Section A	*	2,150	2,440	2,565	2,825
FLOW PATH #12[2]					
Cross Section V	12.40	0	185	315	830
Cross Section U	*	0	185	310	825
At Station 12130 [3]	*	0	180	310	815
At Station 11570 [3]	*	0	180	305	800
Cross Section O	*	0	1,230	1,350	8,000
Cross Section M	*	0	1,215	1,335	7,655
Cross Section L	*	0	2,745	4,870	11,995
Cross Section K	*	0	2,665	4,720	11,480
Cross Section I	*	0	2,530	4,480	10,910
Cross Section G	*	0	2,350	4,175	10,285
At Station 20[3]	13.00	0	2,350	2,350	2,350
FLOW PATH #13					
Cross Section E	3.40	0	4,200	4,600	6,800
Cross Section C	*	170	4,390	4,790	6,990
Cross Section A	*	1,100	5,140	5,590	7,900
FLOW PATH #14					
Cross Section E	*	815	1,170	1,200	1,200
Cross Section D	1.60	950	1,365	1,410	1,470
Cross Section C	*	950	1,895	3,660	9,300
Cross Section B	*	0	500	500	500
At Confluence with Flow Path #3	*	1,100	4,800	4,890	5,000

* Undetermined.
[1] Feet above confluence with Flow Path #9
[2] Alamo Canyon drainage area divided equally between Flow Paths #12 & #16
[3] Feet above Union Pacific Railroad

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #15[1]					
Cross Section C	*	580	1,180	1,540	2,540
At Station 1520[2]	*	795	1,620	2,105	3,500
Cross Section A	*	1,090	2,225	2,885	4,800
FLOW PATH #16[3]					
Cross Section Y	12.40	495	6,200	8,650	17,000
Cross Section X	*	495	6,195	8,640	16,990
Cross Section W	*	490	6,185	8,635	16,965
Cross Section V	*	490	6,000	8,320	16,135
Cross Section P	*	480	5,895	8,200	15,945
Cross Section O	*	475	5,795	8,080	15,745
Cross Section M	*	465	5,690	7,950	15,505
Cross Section I	*	460	4,555	6,770	8,000
Cross Section H	*	445	4,285	6,355	7,410
Cross Section G	*	440	2,650	2,650	2,650
At Station 4530[4]	*	430	2,515	2,515	2,515
Cross Section F	*	425	2,420	2,420	2,420
Cross Section E	0.60	420	1,000	1,500	2,500
Cross Section C	1.20	420	1,570	1,570	1,570
FLOW PATH #17					
Cross Section Y	1.30	555	1,140	1,490	2,500
Cross Section Q	*	555	700	700	700
Cross Section M	*	340	340	340	340
FLOW PATH #18					
At Station 14750[5]	*	340	540	700	1,190
At Station 10550[5]	*	495	1,050	1,350	2,300
At Station 25410[5]	2.00	1,005	5,550	5,850	6,800
FLOW PATH #19					
Cross Section G	*	590	**	**	**
At Station 4600[4]	*	1,440	**	**	**

REVISED DATA

* Undetermined.
** See Flow Path #23
[1] Drainage Area included in that shown for Flow Path #8
[2] Feet above confluence with Flow Path #8
[3] Alamo Canyon drainage area divided equally between Flow Paths #12 & #16
[4] Feet above Union Pacific Railroad
[5] Feet above confluence with Flow Path #30

REVISED TO REFLECT LOMR EFFECTIVE: September 23, 2013

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #15[1]					
Cross Section C	*	580	1,180	1,540	2,540
At Station 1520[2]	*	795	1,620	2,105	3,500
Cross Section A	*	1,090	2,225	2,885	4,800
FLOW PATH #16[3]					
Cross Section Y	12.40	495	6,200	8,650	17,000
Cross Section X	*	495	6,195	8,640	16,990
Cross Section W	*	490	6,185	8,635	16,965
Cross Section V	*	490	6,000	8,320	16,135
Cross Section P	*	480	5,895	8,200	15,945
Cross Section O	*	475	5,795	8,080	15,745
Cross Section M	*	465	5,690	7,950	15,505
Cross Section I	*	460	4,555	6,770	8,000
Cross Section H	*	445	4,285	6,355	7,410
Cross Section G	*	440	2,650	2,650	2,650
At Station 4530[4]	*	430	2,515	2,515	2,515
Cross Section F	*	425	2,420	2,420	2,420
Cross Section E	0.60	420	1,000	1,500	2,500
Cross Section C	1.20	420	1,570	1,570	1,570
FLOW PATH #17					
Cross Section Y	1.30	555	1,140	1,490	2,500
Cross Section Q	*	555	700	700	700
Cross Section M	*	340	340	340	340
FLOW PATH #18					
At Station 14750[5]	*	340	540	700	1,190
At Station 10550[5]	*	495	1,050	1,350	2,300
At Station 25410[5]	2.00	1,005	5,550	5,850	6,800
FLOW PATH #19					
Cross Section G	*	590	**	**	**
At Station 4600 [4]	*	1,440	**	**	**

* Undetermined.
** See Flow Path #23
[1] Drainage Area included in that shown for Flow Path #8
[2] Feet above confluence with Flow Path #8
[3] Alamo Canyon drainage area divided equally between Flow Paths #12 & #16
[4] Feet above Union Pacific Railroad
[5] Feet above confluence with Flow Path #30

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #20					
Cross Section D	0.30	1,650	**	**	**
FLOW PATH #21					
Cross Section E	0.30	1,985	**	**	**
FLOW PATH #22					
Cross Section E	0.30	200	1,835	2,005	4,330
FLOW PATH #23					
Cross Section F	*	***	5,550	7,250	12,850
Cross Section E	*	***	6,075	8,985	18,250
Cross Section D	0.30	***	8,725	11,635	20,900
FLOW PATH #24					
Cross Section G	*	0	0	0	1,750
FLOW PATH #25					
Cross Section E	*	50	3,100	4,800	10,400
Cross Section D	*	850	3,940	5,600	11,200
Cross Section C	*	1,750	4,800	6,500	12,100
Cross Section A	*	1,850	4,900	6,600	12,200
FLOW PATH #26					
Dowstream of 10th Street	0.77	135	446	623	1,330
FLOW PATH #27					
Cross Section F	*	1,500	2,520	3,000	4,500
FLOW PATH #28					
Dowstream of South Scenic Drive	0.47	326	552	696	1,045

REVISED DATA

REVISED DATA

[*] Undetermined.
[**] See Flow Path #23
[***] See Flow Paths #19, #20 & #21
[1] Drainage Area Included in that shown for Flow Path #8

REVISED TO REFLECT LOMR EFFECTIVE: September 23, 2013

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #20					
Cross Section D	0.30	1,650	**	**	**
FLOW PATH #21					
Cross Section E	0.30	1,985	**	**	**
FLOW PATH #22					
Cross Section E	0.30	200	1,835	2,005	4,330
FLOW PATH #23					
Cross Section F	*	***	5,550	7,250	12,850
Cross Section E	*	***	6,075	8,985	18,250
Cross Section D	0.30	***	8,725	11,635	20,900
FLOW PATH #24					
Cross Section G	*	0	0	0	1,750
FLOW PATH #25					
Cross Section E	*	50	3,100	4,800	10,400
Cross Section D	*	850	3,940	5,600	11,200
Cross Section C	*	1,750	4,800	6,500	12,100
Cross Section A	*	1,850	4,900	6,600	12,200
FLOW PATH #26					
Cross Section C	*	1,710	3,170	3,900	6,700
FLOW PATH #27					
Cross Section F	*	1,500	2,520	3,000	4,500
FLOW PATH #28[1]					
Cross Section D	*	545	1,115	1,440	2,400
Cross Section A	*	795	1,620	2,105	3,500

*Undetermined.
**See Flow Path #23
***See Flow Paths #19, #20 & #21
[1] Drainage Area included in that shown for Flow Path #8

Table 3 -- Summary of Discharges (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
FLOW PATH #29					
Cross Section D	*	540	1,220	1,880	3,060
At Station 4140[1]	*	1,000	1,970	2,740	4,240
Cross Section C	0.50	1,810	3,545	3,990	8,780
FLOW PATH #30					
Cross Section Q	*	510	6,130	8,470	15,715
At Station 4770[2]	*	510	4,500	4,500	6,100
Cross Section A	1.60	850	4,840	4,840	6,440
FLOW PATH #31					
Cross Section F	*	2,635	4,505	6,340	10,975
At Station 8430[2]	*	3,100	4,970	6,805	11,440
Cross Section E	*	615	5,595	7,070	9,460
At Station 5810[2]	*	1,315	6,295	7,770	10,160
Cross Section D	*	1,315	4,500	4,500	4,500
Cross Section A	0.40	3,555	4,500	4,500	4,500
FLOW PATH #32					
Cross Section H	1.50	400	1,630	3,970	9,615
FLOW PATH #33					
Cross Section F	0.30	195	770	1,195	2,490
At Station 4200[2]	0.70	197	10,375	12,100	15,010
HAY RIVER					
Upstream of Riata Rd	25.78	*	*	7,046	*
HAY RIVER TRIBUTARY NO. 1					
Upstream of Riata Rd	0.99	*	*	404	*

* Undetermined

[1] Feet above Union Pacific Railroad ditch and extension of 16th Street

[2] Feet above downstream of Limit of Detailed Study

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1). Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed, selected cross sections locations are also shown on the Flood Insurance Rate Maps (Published Separately).

For each community within Otero County that had a previously printed FIS report, the hydraulic analyses described in those reports have been compiled and are summarized below.

City of Alamogordo: Cross sections for the backwater analyses of the flooding sources were obtained from aerial photographs flown in May and June 1980, at negative scales of 1:15,300, 1:22,800, and 1:31,200 (Reference 25). All bridges, levees, and culverts were field checked to obtain elevation data and structural geometry.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the streams and floodplain areas. Roughness values used for the Flow Paths within the City of Alamogordo are presented in Table 4.

Water surface elevations of floods of the selected recurrence intervals were computed though use of the USACE HEC-2 step-backwater computer program (Reference 26) and the FEMA Alluvial Fan Methodology (Reference 27). Flood Profiles were drawn showing computer water surface elevations for floods of the selected recurrence intervals. Starting water surface elevations for the flow paths were calculated by a rating curve using the highway embankment as a control section. Water surface elevations in the individual arroyos were started using elevations established by routing procedures or critical depth – whichever controlled.

Initial computations indicated that none of the channels would carry flows of the magnitude considered in this study. Cultural development and street alignment often dictated the direction and severity of flooding.

The interchange of significant quantities of flow between the flow paths alters the hydrologic characteristics of the total drainage system. Backwater computations based on HEC-2 were made for each independent flow path using a random range of enveloping discharges. At the point of flow separation, rating curves were constructed and added to obtain a composite rating. This procedure provided a method to proportion flows in each flow path. HEC-1 computer runs used to formulate the hydrology were examined and revised to account for the adjusted contributing subareas and relocation of concentration points. Primarily, the revised methodology consists of adjusting the peak flows by adding or deducting flow gains or losses between flow paths.

The Alamogordo Water Supply Reservoir was judged to be unsafe and was reported to the New Mexico State Engineers Office for analysis under the Dam Safety Program. It was determined that the dam could contain the 10-percent chance annual flood and that larger floods would cause dam failure. Therefore, a constant breach section was assumed in the middle of the structure and the normal backwater analysis was done for all floods larger than the 10-percent chance annual flood. The following information was considered during the development of the preceding procedure:

a. The State Engineer was expected to order the dam breached or repaired. On September 29, 1981, the State Engineer directed the city to breach or repair the dam before the next rainy season. The dam has since been partially removed to make way for a park.

b. The severity of the floodplains developed from a dynamic dam break analysis as used in the Dam Safety Program is considered inappropriate for a FIS.

c. Previous FIS have not analyzed sudden dam failure.

The elevation within the reservoir area was set at the top of dam since this is the maximum potential flood elevation that could occur. The hydraulic analyses for this study were based on some obstructed flow. The flood elevations shown on the profiles are thus considered valid only if the hydraulic structures remain relatively unobstructed, and do not fail.

<u>Mescalero Apache Reservation:</u> Aerial Photo Service of Tulsa, Oklahoma performed the aerial reconnaissance of Cherokee Bill Canyon, upstream of Pinecrest Drive, on November 21, 1975. Photos were taken from a flight height of 5,000 feet with a negative scale of 1":3,000. Photogrammetric models were controlled (horizontally and vertically) by Boyle, in accordance with the FEMA *Guidelines and Specifications for Study Contractors* (Reference 32). Digitized cross sections, accurate to within one foot, were provided by Aerial Photo Service. Mapping was compiled at a scale of 1" = 200'. No contours were plotted.

Water surface elevations were computed through use of the USACE's HEC-2 step-backwater computer program (Reference 26). Flood profiles were drawn showing computed water-surface elevations. Starting water-surface elevations for the flows were based on the slope-area method.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment based on field observations of the channel and floodplain areas. Roughness factors for Cherokee Bill Canyon are presented in Table 4.

Countywide Update: Detailed hydraulic analyses were conducted for Beeman Canyon Creek, Hay River, and Hay River Tributary No. 1. A terrain model was constructed for the study reaches from 10-meter DEMs (Reference 19) supplemented by 2-foot contours in the City of Alamogordo, and bare earth LiDAR (Reference 28). This model, along with field survey data for more detailed hydraulic cross-sections and all structure information, was used within the WISE software platform (Reference 29) to obtain all cross-section information.

Cross-sections were typically placed with the goal of approximate 500-foot spacing and in accordance with the FEMA *Guidelines and Specifications* (Reference 32). Cross-sections were also placed at all crossing structures, including bridges and culverts. All bridges and culverts were field checked to obtain elevation data and structural geometry.

Detailed hydraulic methodology for the flooding sources affected by new detailed studies is presented below:

Beeman Canyon Creek: The Beeman Canyon Creek study reach is a mountainous stream composed of alluvial fan deposits that flows toward the southwest into a pond on the northern edge of the City of Alamogordo. The overbank area consists of mesquite, creosote, and various cacti. A steep concrete rundown into a flat ponding area/channel is located at the downstream end of the study reach. The area is topographically steep with a total elevation change of approximately 50 feet over the 1.0 mile length of the reach. The starting water surface elevation was computed using the normal depth method at the downstream limit.

The USACE HEC-RAS River Analysis software 3.1.3 (Reference 30) was used for the one-dimensional hydraulic analysis. Manning's "n" values were established using engineering judgment based on field observations or were taken from previous FIS (Reference 31). These values are shown in Table 4.

Table 4 – Manning's Roughness Coefficients

Flooding Source	Study Date	Roughness Coefficients	
		Channel	Overbank
Beeman Canyon Creek	2008	0.045	0.05
Cherokee Bill Canyon	1980	0.035 – 0.065	0.035 – 0.065
Flow Paths within the City of Alamogordo	1981	0.022 - 0.060	0.025 - 0.070
Hay River	2008	[1]	0.046 - 0.135
Hay River Tributary No. 1	2008	[1]	0.046 - 0.135

[1] FLO-2D does not differentiate between channel and overbank "n" values, therefore range of values used in modeling is provided in "Overbank "

There is one culvert within the study reach, located at North Scenic Drive. The structure was modeled in accordance with the FEMA *Guidelines and Specifications* (Reference 32). In order to more accurately model water surface elevations, ineffective flow areas were used upstream and downstream of the structure to represent flow that is not actively conveyed. In order to more accurately estimate the contraction and expansion that occurs as water converges and expands to pass through a limited opening, ineffective flow was established at the culvert structure in accordance with the HEC-RAS manual.

Base Flood Elevations for Beeman Canyon Creek were developed using the WISE software (Reference 29).

Hay River and Hay River Tributary No. 1: These study reaches are located on an active alluvial fan approximately three miles south of the Village of Tularosa. Analysis of these stream reaches was therefore conducted in accordance with FEMA Guidelines and Specifications Appendix G "*Guidance for Alluvial Fan Flooding Analyses and Mapping* (Reference 21)." The FLO-2D software version 2006.10 (Reference 33), was used for all two-dimensional hydraulic analyses. FLO-2D uses the DEM to model the flow routing, depth, and velocity computations.

Because FLO-2D is a simple volume conservation model, a hydrograph is needed to represent the runoff volume for use in computation. The NRCS Unit Hydrograph Methodology was utilized within HEC-HMS software (Reference 24) to develop the run-off volume, as discussed previously.

According to the FLO-2D Users Manual, a limiting Froude Number of 0.90 to 0.98 is recommended. To maintain a Froude Number within this range, FLO-2D adjusts the Manning's "n" value for each grid cell. These values are shown in Table 4.

The FLO-2D User's Manual recommends bulking alluvial fan flooding for sediment loading. Because of the active alluvial determination and the sediment deposition problems documented during the field reconnaissance, a sediment bulking factor was applied to the Hay River and Hay River Tributary No. 1 FLO-2D model. The sediment bulking methodologies outlined in the "*Sediment and Erosion Design Guide*" (Reference 34) were used to calculate the Hay River and Hay River Tributary No. 1 bulking factors. This design manual provides guidance for the analysis of sediment areas and arroyos in the Albuquerque metropolitan area; however, the definition of arroyo processes described is applicable to Otero County streams. The sediment bulking calculation accounts for velocities, soil gradation, and other characteristics of the channelized sections. A bulking factor of 19%, which was the average of the bulking factors calculated individually for Hay River and Hay River Tributary No.1, was applied to the overall FLO-2D model.

There are 11 crossing structures that were identified during the field reconnaissance. Of these, 10 consist of relatively small culvert crossings and one is a bridge over Hay River at the railroad. During model computation, FLO-2D experienced depth convergence errors at all of the structures; therefore they were all removed from this analysis. The errors were caused by the relatively small conveyance capacity of the structures in relation to the peak discharge for the 1-percent annual chance flooding event.

Existing housing structures visually identifiable within the available orthophotography were accounted for as flow impediments by completely blocking out the overlapping grid cell. This allowed the model to see these housing structures as obstructions within the flow path and ultimately, provided a more accurate floodplain determination.

The inflow node for Hay River was set at a point immediately downstream of the US Highway 54/70 crossing. Due to the proximity of the upstream end of Hay River Tributary No.1 to the Hay River streamline, the inflow node for Hay River Tributary No. 1 was set at a location approximately 1,000 feet downstream of this flow divergence point. Moving the Hay River Tributary No. 1 inflow node ensured that a majority of the flow would follow the general tributary flow path and would not split and merge with the flow in Hay River.

The outflow was set to all nodes along the western boundary of the computational domain. Because the downstream flow exit location was unknown and limited development existed west of the study reach, the limiting area was created to prevent the model from unnecessarily calculating detention along the downstream limit.

Base Flood Elevations for the Hay River and Tributary were developed from the Maximum Water Surface Elevation contour generated by FLO-2D (Reference 33).

3.3 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the county must, therefore, be referenced to NAVD88. It is important to note that adjacent counties may be referenced to NGVD29. This may result in differences in BFEs across the county boundaries between the counties.

For this countywide revision the flood profiles and BFEs were revised to reflect the new datum values. Due to the statistically significant range in conversion factors, an average conversion factor could not be established for the entire county. With the approval of FEMA, and in accordance with Appendix B of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (Reference 32), an average conversion factor for the City of Alamogordo was established which is shown in Table 5 "Vertical Datum Conversions." Due to its location in the County, a single conversion factor for Cherokee Bill Canyon was established, which is also shown in Table 5.

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD29 should apply the stated conversion factor to elevations shown on the Flood Profiles and supporting data tables in the FIS report, which are shown at a minimum to the nearest 0.1 foot.

For more information regarding conversion between the NGVD and NAVD, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(310) 713-3242

Table 5 – Vertical Datum Conversions

Community	Conv. Factor
City of Alamogordo	+2.16 feet
Cherokee Bill Canyon	+2.49 feet

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages state and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1-percent annual chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent annual chance flood elevations; delineations of the 1-percent and 0.2-percent annual chance floodplains; and 1-percent annual chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, and Floodway Data tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance flood is employed to indicate additional areas of flood risk in the county. For the streams studied in detail, the 1-percent and 0.2-percent annual chance floodplains have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were originally interpolated using topographic maps at a scale of 1:4,800 with a contour interval of 5 feet (Reference 35).

In this countywide update, floodplains within the City of Alamogordo were redelineated using detailed topographic data supplied by the City of Alamogordo at 2-foot contour intervals (Reference 28), supplemented by USGS 10-meter DEMs (Reference 19). Floodplains were delineated using WISE (Reference 29). The same process was used to delineate the new floodplains for Beeman Canyon Creek.

Although cross sections were plotted on the profiles from the previous study, they were not plotted on the FIRMs from the previous study. Because the exact placement and orientation of the original cross sections could not be determined, cross sections from the previous study were not included on the DFIRMs. Cross-sections from new studies were placed on the DFIRMs.

The MAPPER tool, part of the FLO-2D software (Reference 33) was used to delineate the alluvial fan flooding for the Hay River and its tributary.

The boundaries of the 1-percent and 0.2-percent annual chance floods are shown on the FIRMs (Exhibit 2). On these maps, the 1-percent annual chance floodplain boundary corresponds to the boundary of areas of special flood hazards (Zone A, AE, AH and AO); and the 0.2-percent annual chance floodplain boundary corresponds to the boundaries of moderate flood hazards. In cases where the 1-percent and 0.2-percent annual chance floodplains are close together, only the 1-percent annual chance floodplain boundary has been shown. Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to limitations of the map scale, such areas are not shown.

For the streams studied by approximate methods, only the 1-percent annual chance floodplain boundary is shown on the FIRMs. Existing approximate analysis was refined using the DEMs discussed previously.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces the flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent annual chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent annual chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this FIS are presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

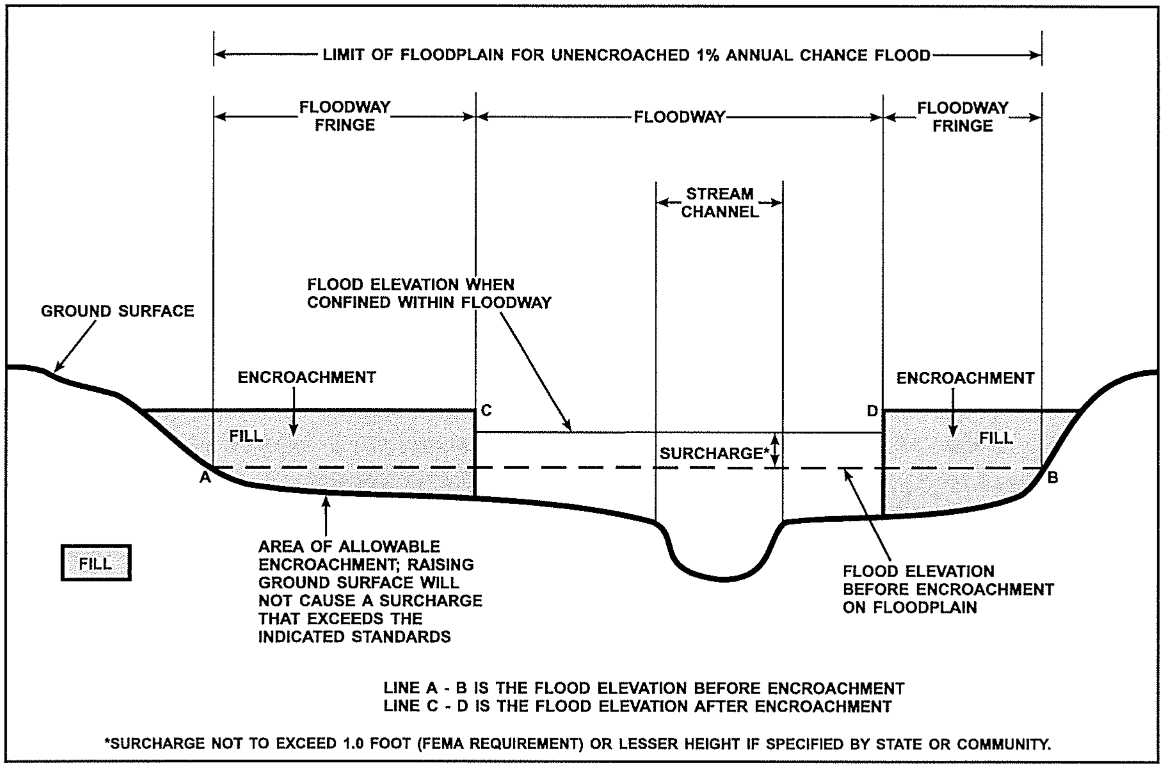
Floodways were not computed for this report because of non uniform channels, steep slopes resulting in high velocities, numerous split and divided flow patterns, loss of identifiable channel areas, channels of low capacity, and the high density of development. *Therefore the 1-percent annual chance floodplain is considered to be the floodway for this report.* There are no Floodway Data Tables contained in this FIS.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage and heightens potential flood hazards by further increasing velocities. To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The area between the floodway and 1-percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent annual chance flood by more than 1.0

foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1, "Floodway Schematic.

<u>Figure 1 – Floodway Schematic</u>



5.0 <u>INSURANCE APPLICATIONS</u>

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

<u>Zone A</u>

Zone A is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

<u>Zone AE</u>

Zone AE is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance risk zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance risk zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole foot base flood depths derived from the detailed hydraulic analyses are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent annual chance floodplain, areas within the 0.2-percent annual chance floodplain, and areas of 1-percent annual chance flooding where average depths are less than 1 foot, areas of 1-percent annual chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent annual chance flood by levees. No base flood elevations or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and shows selected whole-foot BFEs or average depths in the 1-percent annual chance floodplains that were studied by detailed methods. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map uses tints, screens, and symbols to show the 1-percent and 0.2-percent annual chance floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

The current FIRMs present flooding information for the entire geographic area of Otero County. Previously, separate FIRMs were prepared for each identified flood-prone incorporated community and the unincorporated areas of the county. Historical data relating to the maps prepared for each community, up to and including this countywide FIS are presented in Table 6, "Community Map History."

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE (S)	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISION DATE (S)
Alamagordo, City of	July 19, 1974	April 15, 1977	March 2, 1983	August 2, 1990
Cloudcroft, Village of	None	None	None	None
Mescalero Apache Indian Reservation	December 17, 2010	None	December 17, 2010	None
Otero County (Unincorporated Areas)	August 9, 1974	August 22, 1978	August 1, 1987	None
Tularosa, Village of	December 17, 2010	None	December 17, 2010	None

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

OTERO COUNTY, NM AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

This FIS report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP (References 1, 2, 3, and 31).

There are ongoing Flood Insurance Studies in Dona Ana, Lincoln, Chaves, and Eddy Counties, NM and El Paso County, TX. This study is in agreement with these studies.

A report on Survey for Flood Control for Alamogordo was prepared by the USACE (Reference 36). The data appearing in this report is considered invalid because of improved hydrology and hydraulic methods and changed watershed conditions.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this FIS can be obtained by contacting:

FEMA Region VI
Federal Insurance and Mitigation Division
800 North Loop 288
Denton, Texas, 76209