2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of San Juan County, New Mexico. The areas studied by detailed and approximate methods were selected with priority given to all known flood hazards and areas of projected development.

All or portions of the flooding sources listed in Table 2, "Scope of Study," were studied by 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.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through May 2007.

Table 2 – Scope of Study

Table 2a – New Flooding Sources Studied by Enhanced Approximate Methods

Stream Name	Downstream Limit	Upstream Limit
Bloomfield Canyon Creek	Confluence with San Juan River	Confluence with Bloomfield Canyon Creek Tributary
Bloomfield Canyon Creek Tributary	Confluence with Bloomfield Canyon Creek	800 ft downstream of Utah Road

Table 2b – Flooding Sources Restudied by Enhanced Approximate Methods

Stream Name	Downstream Limit	Upstream Limit
Animas River	Confluence with San Juan River	1200 ft downstream of Murray Dr / US-64
Animas River	Confluence with Porter Arroyo	Confluence with Carl Arroyo
San Juan River	11,300 ft downstream of La Plata River	2050 ft upstream of La Plata River
San Juan River	Confluence of Farmington Glade	10,100 ft upstream of Confluence with San Juan River

Table 2c - Redelinedated Flooding Sources

Stream Name	Downstream Limit	Upstream Limit
Animas River	1,200 ft downstream of Murray Dr / US-64	Confluence with Porter Arroyo
Animas River	Confluence with Carl Arroyo	200 ft upstream of W Aztec Blvd / SH-516
Bluff Split	Confluence with Animas River	Divergence from Animas River
Butler Arroyo	Confluence with Dustin Arroyo	1,500 ft upstream of Butler Ave
Carl Arroyo	1,300 ft upstream of confluence with San Juan River	Hawkeye St
Carl Arroyo (Left Bank)	Confluence with Carl Arroyo	Divergence from Carl Arroyo
Dustin Arroyo	Confluence with Butler Arroyo	200 ft upstream of Sunrise Pkwy
Farmers Mutual Ditch	600 ft downstream of Westland Park Dr	Divergence from San Juan River
Farmington Glade	Confluence with San Juan River	2,000 ft upstream of Pinon Hills Blvd
Hampton Arroyo	800 ft upstream of confluence with Animas River	1,300 ft upstream of NE Aztec Blvd / US-550
Hood Arroyo	Confluence with San Juan River	14,600 ft upstream of confluence with Hood Arroyo Tributary
Hood Arroyo Tributary	Confluence with Hood Arroyo	300 ft downstream of College Blvd
La Plata River	Confluence with San Juan River	3100 ft upstream of Coyote Dr
Murray Split	Confluence with Animas River	Divergence from Animas River
Porter Arroyo	Country Club Dr	10,850 ft upstream of confluence with Porter Arroyo Tributary A
Porter Arroyo Tributary A	Confluence with Porter Arroyo	2,200 ft upstream of confluence with Porter Arroyo
Porter Arroyo Tributary B	Confluence with Porter Arroyo	200 ft upstream of College Blvd
Porter Arroyo Tributary C	Confluence with Porter Arroyo	College Blvd
San Juan River	Hogback	11,300 ft downstream of La Plata River
San Juan River	2,050 ft upstream of La Plata River	Confluence with Farmington Glade
San Juan River	10,100 ft upstream of confluence with San Juan River	7,500 ft downstream of US-550
Westland Park Drive Runoff	1,000 ft downstream of divergence from Farmers Mutal Ditch	Divergence from Farmers Mutual Ditch
Wyper Arroyo	200 ft downstream of E. Main St / SH-516	4,500 ft upstream of confluence with Wyper Arroyo Tributary
Wyper Arroyo Tributary	Confleuence with Wyper Arroyo	4,200 ft upstream of confleunce with Wyper Arroyo

The Ute Mountain Indian Reservation was designated as "Area Not Included" on the previous San Juan County (Unincorporated Areas) FIRM before the countywide study was performed. There was no flood hazard data for these areas so they were converted to Zone D.

The Navajo Indian Reservation was designated as "Panels not Printed" on the previous San Juan County (Unincorporated Areas) FIRM before the 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 San Juan County.

In addition to the detailed studies listed in Table 2; new automated approximate analyses were conducted for the Animas River between the City of Aztec and the New Mexico / Colorado boundary as well as for the San Juan River between the City of Bloomfield and Navajo Reservoir.

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

Table 3, "Letters of Map Change" indicates LOMCs that have been incorporated into this countywide revision.

Table 3 – Letters of Map Change

Case Number	Community	Old Panel	New Panel
96-06-155P	City of Aztec	3500650005B	35045C0730F
06-06-B008P	San Juan County (Unincorporated Areas)	3500640150B	35045C0385F, 35045C0425F
06-06-B009P	San Juan County (Unincorporated Areas)	3500640375B	35045C0800F
07-06-0188P	San Juan County (Unincorporated Areas)	3500640350B	35045C0395F
07-06-0730P	San Juan County (Unincorporated Areas)	3500640350B	35045C0395F

2.2 Community Description

San Juan County is located in the northwestern corner of New Mexico. It is bordered by the unincorporated areas of Montezuma, La Plata and Archuleta Counties, Colorado, to the north; the unincorporated areas of Rio Arriba and Sandoval Counties to the east; the unincorporated areas of McKinley County to the south; and the unincorporated areas of Apache County, Arizona, to the west. The estimated population in 2006 was 124,473 (Reference 2).

City of Aztec: The City of Aztec is located on the Animas River in the northeastern portion of San Juan County in northwestern New Mexico. Aztec is the county seat and is also the home of Aztec Ruins National Monument. The estimated population for Aztec in 2006 was 7,056 (Reference 3).

City of Bloomfield: The City of Bloomfield is located on the San Juan River in the northeastern portion of San Juan County in northwestern New Mexico. The city is located at the crossroads of the U.S. Highway (US) 64 and US-550, both major truck routes. The estimated 2006 population is 7,409 (Reference 3).

City of Farmington: Farmington lies in northwest New Mexico in north central San Juan County at an average elevation of 5,400 feet above sea level in a region that is characterized by mountain ranges and high plateaus. The city is approximately 150 miles northwest of Santa Fe, the state capital; 165 miles south of Grand Junction, Colorado; and 40 miles southwest of Durango, Colorado. The nearest communities are Aztec, 14 miles northwest; Bloomfield, 13 miles to the east; and Fruitland, 10 miles to the west. The city is located north of the confluence of the Animas and San Juan Rivers. The La Plata River joins the San Juan River near the southwest sector of Farmington.

Farmington had an estimated population of 43,573 in 2006 (Reference 4) and continued growth is anticipated.

From the time Farmington was founded in 1876 to the early 1950s, the community was a small, agriculturally oriented trade and service center. Then development of oil and gas resources reached boom proportions as thousands of wells were developed in the surrounding area. That development led to an unprecedented expansion of industrial and manufacturing activities and tremendously increased the economic importance of those activities on the local level. The boom period began to recede about 1958 and the city reverted to a rural trade and service center in which non-industry related activities gained in economic importance. The short period of recession that began in 1958 leveled off in the mid 1960s as the employment structure became more stabilized. In addition to employment associated with the oil and gas industry, job opportunities in the construction trades and various manufacturing plants became more plentiful. Also, increased demand for personal and public (governmental) services, public utility and transportation services, and meeting the needs of increasing numbers of vacationists and recreationists added to a more diversified

economic base for the community. Expansion of retail trade has made Farmington the dominant retail sales center of the Four Corners region.

Surface access in the Farmington area consists principally of US-64, a major truck highway, which leads to the east and west, and State Highway (SH) 516 leading to the northeast. SH-371, a minor route, provides access to the south. A network of city streets and county roads provides arterial routes for local traffic. Scheduled airline flights are maintained to the Four Corners Regional Airport.

The area around Farmington is predominantly desert-like and comprises extensive plateaus with low, protruding mesas. Terrain to the north and east rises abruptly to high mountain ranges; those to the east forming a portion of the Continental Divide. A high plateau cut by numerous arroyos lies to the south. Evolution of the present surface structures of northwestern New Mexico started near the close of the Mesozoic era (about 70 million years ago). At that time, a great physical change of the earth referred to as the Laramide Revolution, was begun. Tremendous forces in the crustal portion of the earth precipitated an extensive uplifting which resulted in the forming of the Rocky Mountains. There followed a period of glaciations and then erosion caused by weathering and streamflow.

Through many centuries, agents of weathering slowly eroded away the high ranges, and water removed millions of tons of rock materials from the mountains. Following the period of surface wasting and erosion, layers of sands, clays and gravels (referred to as the Eocene beds) were deposited over much of the region, which then had a general level appearance with occasional areas of relief. A renewal of volcanic action with consequential deposition of volcanic residue then occurred and was followed by a period of widespread erosion, alleviation and plateaus formation during which the present main drainage patterns were established. Subsequently, a general uplifting of the entire region took place and great faulting occurred. As valleys deepened, streamways were superimposed on the underlying rock and throughout the region an old-age erosion surface evolved. Later, glaciers became prevalent in the higher elevations and upon their melting many terminal moraines were deposited. The huge canyons of the region were eventually excavated due mainly to the efforts of flowing water. Continual erosion associated with streamflow and weathering and favored by aridity resurrected mountains, cut gorges or water gaps, and ultimately produced the present landscape.

The area consists chiefly of sandstone and some lesser amounts of shale. Cretaceous coal-bearing rock formations (Mesa Verde series) are widespread around the edges of the Upper San Juan Basin and constitute an important resource in the region. After many centuries of erosion in an arid climate, the landscape is distinguished by mesas, cuestas, rock terraces, retreating escarpments, canyons, and dry washes. In some parts, volcanic necks and buttes are prevalent. The physical features of the area are generally sharply separated. Some land areas rise table-like on all sides above the surrounding terrain; others abut against higher land in step-like fashion; and some have steep inclines while

others have gentle slopes. They also differ in the degree of dissection by streams, and, due to varying elevation and stages in the erosion cycle; the various features may have different temperatures, rainfall and vegetation.

Farmington has a semi-arid climate with topography significantly influencing precipitation and temperature. Within San Juan County the annual precipitation ranges from about 8 to 10 inches, while the headwaters of the Animas and San Juan Rivers in Colorado can experience more than 50 inches of precipitation. About half the annual precipitation occurs as rain during the months of July through October when cloud burst storms produce high intensity but short duration rainfall, and about half occurs almost uniformly during the remainder of the year. Most of the precipitation in the higher headwater regions occurs as snow. Winters are relatively cold with an average daily temperature of about 32 degrees Fahrenheit (°F) and summers are warm with average daily temperatures of about 73°F. Temperature extremes at Farmington have ranged from a winter low of -20°F to a summer high of 103°F. The average growing season between killing frosts is about 150 days.

Several critical factors such as elevation, exposure, temperature, and moisture availability determine the native vegetation found in the study area drainage basin from Farmington up to the headwaters. Vegetation around Farmington is sparse and consists of annual grasses, desert shrubs, cedar and cottonwood. In the foothills, pinon pine, juniper, oak, mountain mahogany, sagebrush, service-berry, and annual grasses predominate. Plateau areas are barren and nearly void of plant cover. In the higher elevations, vegetation consists of native grasses, brush, ponderosa pine, spruce, and stands of Douglas fir and aspen. The mountain areas above timberline have alpine vegetation.

Soils in the study area include a wide range of types that directly affect local runoff. With the alluvial soils which occupy the nearly level landscapes that lie adjacent to or are intermingled with the Animas, San Juan, and La Plata Rivers, runoff is slow and flood hazards are severe. The soil series used for irrigated cropland, pasture, residential and industrial areas consist of somewhat excessively drained soils and permeability ranging from moderately slow to rapid. The most abundant soil type found in the drainage basins of Farmington Glade, the arroyos and the washes has moderately rapid permeability and medium runoff, and the erosion hazard is severe.

The San Juan, Animas and La Plata Rivers flow year-round, whereas Porter, Hood, Dustin, Butler, College and Wyper Arroyos, and Farmington Glade normally have running water only after rainstorms that occur most frequently during the summer months. The San Juan River is the principal waterway in northwestern New Mexico and all other streams under study are direct or indirect tributaries to it. The San Juan River is the second largest tributary of the Colorado River, originating on the western slope of the Continental Divide in the Rocky Mountains in southwestern Colorado. The river originates in Colorado then flows

through New Mexico, then back into Colorado before joining the Colorado River at Lake Powell in Utah.

The Animas River, the largest tributary of the San Juan River, originates in the San Juan Mountains in Colorado at elevations over 14,000 feet and combines with the San Juan River at the City of Farmington. Porter, Hood, and Wyper Arroyos and College Arroyo, tributaries to the Animas River, flow in a general southerly direction throughout their courses and drain the northeastern sector of the City of Farmington. Butler Arroyo flows southerly for about half its course then southwesterly for the other half to join Farmington Glade, which meanders from north to south through the county until joining the San Juan River in Farmington. In general, Butler Arroyo and Farmington Glade drain the north and northwestern sectors. The La Plata River follows a south-southwesterly course through the county, and joins the San Juan River west of the City of Farmington. The Animas River trends a southwesterly course along the eastern portion of the city and combines flows with the San Juan River south of the City of Farmington. The San Juan River winds along the southern edge of Farmington in a westerly direction.

For the first revision, six arroyos were studied by detailed methods. All of the arroyos are ephemeral in character, flowing only during periods of heavy rainfall. Wyper Arroyo discharges into the Animas River within the City of Farmington and is the northernmost arroyo analyzed. Carl Arroyo is west of Wyper Arroyo. Hood Arroyo is west of Carl Arroyo. The next Arroyo downstream is Porter Arroyo. Butler Arroyo, west of Porter Arroyo, flows into Farmington Glade and Dustin Arroyo discharges into Butler Arroyo.

There are no major bodies of water in or near the City of Farmington. The principal bodies of water in the tributary drainage area are manmade lakes developed for irrigation, flood control, power generation, recreation, and municipal and industrial water supply.

Approximate drainage areas of the streams and watercourses under study, together with pertinent stream gradients are shown in Table 4, "Drainage Areas and Stream Gradients around Farmington."

The floodplains of the streams under study are moderately to sparsely developed. Residential, commercial, agricultural and light industrial properties are in floodplain areas. Along the washes and arroyos, some residential development exists and there are some irrigation facilities and small commercial establishments. Lands along the San Juan and La Plata Rivers are mainly agricultural with scattered residences and some industrial development. Residential and commercial developments are prevalent along the lower reach of Farmington Glade. Development along the Animas River is quite extensive and includes residential, commercial and light industrial developments; agricultural land; and recreation facilities. Oil and gas wells are prominent throughout the area, some within the floodplains of several of the streams. Increased pressure for more use of floodplains will continue. Residential, commercial and industrial

Table 4 – Drainage Areas and Stream Gradients around Farmington, NM

Flooding Source	Location	Approximate Drainage Area (sq. mi.)	Average Gradient[1] (ft/mi.)
Animas River	At Mouth	1,360.00	21
Butler Arroyo	Just above confluence with Dustin Arroyo	0.32	252
Butler Arroyo (below confluence with Dustin Arroyo)	At Mouth	2.00	133
Carl Arroyo	At Mouth	1.62	[2]
College Arroyo	24th Street	1.00	101
Dustin Arroyo	Just above confluence with Butler Arroyo	0.60	260
Farmington Glade	At Mouth	40.00	61
Hood Arroyo	At Mouth	2.06	114
La Plata River	At Mouth	580.00	31
Porter Arroyo	At Mouth	2.24	120
San Juan River	Gaging Station at Farmington	7,240.00	11
Wyper Arroyo	At Highway 550	1.44	125

[1] Within Study Reach
[2] Data Not Available

growth will continue to impinge on open or agricultural lands, generally in the north-northeastern sector of Farmington.

2.3 Principal Flood Problems

Floods in San Juan County result from general rainstorms, snowmelt sometimes augmented by rain and from cloudburst storms. General rain floods have caused the most severe damage along the Animas and La Plata Rivers and have usually occurred during the months of September and October. This type of flood results from prolonged heavy rainfall over tributary areas and is characterized by high peak flows of moderate duration. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions, or when the ground is frozen and infiltration is minimal. The more frequent floods on the San Juan River would result from general rain on the tributary drainage area downstream from the Navajo Dam (a multiple-purpose reservoir about 40 miles upstream from Farmington). Major floods (1-percent annual chance flood discharge or greater) would result from excessive snowmelt runoff generated in the watershed upstream from Navajo Reservoir. As previously mentioned, general rainstorms normally occur during September and October.

volume and long duration, and marked diurnal fluctuation in flow. Rainfall on melting snow may hasten the melting process and increase flooding.

As noted earlier, cloudburst storms of small areal extent, which account for about half of the normal annual precipitation in the Farmington area, can be expected during the summer and fall months.

City of Aztec: Aztec flooding problems are limited to occasional overflow of the Animas River. Hampton Arroyo is contained within the main channel. The magnitude of the estimated 1-percent annual chance discharge for tributary inflows was considered negligible to the main stream magnitudes.

Local residents were asked to provide any information pertaining to historical flood elevations to the local newspaper. Information of any extreme high-water elevations was not recovered from any local residents.

City of Farmington: The Farmington area has a long history of flooding with the earliest flood of record occurring in 1859, but little definitive data are available on 19th century floods or cloudburst floods that have occurred. Since 1904 until 1976, a total of 23 flood events (on individual streams --not concurrent flooding on all streams) were recorded. A flood that occurred as a result of a severe rainstorm in October 1911 over the southwestern corner of Colorado and the northwest corner of New Mexico is generally considered the largest and most damaging ever known in the Farmington area. A peak flow of 30,000 cfs was estimated to have occurred on the Animas River at Farmington during that flood. Although the USGS stream gage on the Animas River at Farmington had not yet been installed, a stream gage existed on the river at Aztec with a drainage area of approximately 1,265 square miles. A peak of 23,800 cfs at the Aztec gage was recorded by the State Engineers Office. Peak flows of the La Plata and San Juan Rivers are not available, but were undoubtedly of great magnitude. Three lives were lost during the flood and 150 miles of river bottoms were devastated. Houses, personal property, farm buildings, crops and bridges were swept away by floodwaters, and erosion was widespread. Only two bridges in the entire county were undamaged. Miles of the Denver and Rio Grande Western Railroad were destroyed. Railroad losses were estimated to be in the millions and other flood damages were estimated to total about one-half million dollars.

Major rain floods occurred on the La Plata River in 1904 and 1909. On the Animas and San Juan Rivers, snowmelt flooding occurred in 1884, rain flooding in 1909. During the latter part of June 1927, melting snow augmented by general rain over the San Juan River basin created the highest flows and most widespread flood on the La Plata, Animas and San Juan Rivers since the flood of October 1911. The rainstorm lasted from June 26 to 28 and produced a peak flow of 25,000 cfs on the Animas River at Farmington. During the 1927 flood, damage to railroad bridges and inundation of roads and bridge approaches caused railroad and highway traffic to be temporarily discontinued between Farmington and

neighboring communities. Some erosion and crop damage occurred in bottom land areas.

Recent floods in Farmington occurred in 1941, 1947, 1970, 1972, 1978, 1986, 1987, and 1988. The May 1941 flooding on the Animas, San Juan and La Plata Rivers resulted from general rains over large areas of the three drainage basins and unseasonable hot weather that precipitated excessive snowmelt runoff. A peak flow of 12,800 cfs on the Animas River was recorded at Farmington as a result of the combined rain and snowmelt flood. Stream channels and irrigation ditches were severely eroded, ditch headings were damaged, and agricultural lands and crops were damaged or destroyed. In August 1947, a cloudburst storm caused extensive damage and destruction along the arroyos; culverts, irrigation facilities, and agricultural lands and crops were damaged or destroyed. A portion of US-550 was washed out and traffic was disrupted for several days. Stream channels were eroded, and many acres of farmland were eroded or covered with debris.

In October 1972, severe flooding in Farmington Glade closed sections of Navajo Street, Municipal Drive and West Apache Street. During this event, the Federal Aviation Administration (FAA) in Farmington recorded 0.60 inches of rainfall on October 16 and an additional 0.63 inches on October 17. In Aztec, a reported 1.50 inches of rain fell during a one-hour period on October 17. In May 1978, rain mixed with melting snow contributed to minor flooding in Farmington. In July 1986, 2.21 inches of rain fell in five days in the Farmington area, and a summer rainstorm in August 1987 produced nearly an inch of rain in three quarters of an hour and flooded several homes and businesses in Farmington. The City of Aztec experienced damage to the streets and bridges during the flood of June 1988 when observers reported 1.10 inches of rain during the 45-minute storm; rainstorms in August 1988 again closed Navajo and Apache Streets in Farmington.

Floods that occurred on the Animas River in October 1911, June 1927, September 1909, and May 1941 have estimated recurrence frequencies of 100 years, 60 years, 30 years, and 10 years, respectively. Due to the lack of reliable streamflow records on the La Plata River and the limited period of streamflow records on the San Juan River since completion of Navajo Dam in 1962, data necessary to estimate the frequency of all floods except those of September 1970 and October 1972 (recurrence intervals of about once every 5 years) are not available for those streams.

Cloudburst storms lasting from several minutes to a few hours create the most severe flooding along Farmington Glade; Butler, Carl, College, Dustin, Hood, Porter and Wyper Arroyos. Cloudburst floods characteristically have high peak flows and high velocities, short duration and small volume of runoff. Data necessary to estimate the frequency of past floods on Farmington Glade; Butler, Carl, College, Dustin, Hood, Porter and Wyper Arroyos are not available.

San Juan County (Unincorporated Areas): Flood problems in San Juan County are limited to occasional overflow of the San Juan and Animas Rivers. The magnitude of the estimated 1-percent annual chance flood discharges for tributary inflows was considered negligible to the main stream magnitudes.

Local residents were asked to provide any information pertaining to historical flood elevations to the local newspaper. Information of any extreme high-water elevations was not recovered from any local residents.

2.4 Flood Protection Measures

City of Aztec: The Animas River and Hampton Arroyo have no flood protection measures.

City of Farmington: As noted, Navajo Reservoir is a multiple purpose project on the San Juan River about 40 miles upstream from the City of Farmington. This project was built by the Bureau of Reclamation and has been operational since 1963. Although constructed primarily for water conservation, it is operated for flood control in accordance with rules and regulations prescribed by the Secretary of the Army and provides a high degree of flood protection to areas downstream. There are no other flood control projects that afford protection to Farmington. A reservoir site on the Animas River at Howardsville, Colorado, has been investigated by the Bureau of Reclamation as a feature of the Animas-La Plata Project. The USACE investigated a retention dam project on Farmington Glade and channel improvement work on the lower reaches of several Farmington area arroyos; however, studies showed that these projects were not economically feasible at the time. Various Federal agencies studied the water resources development aspects of the upper Colorado River Basin for many years. A report published in 1971 (Reference 5) contains a reconnaissance type plan that identifies three areas in the Farmington region where future channel improvement and levee construction would be beneficial.

San Juan County (Unincorporated Areas): The San Juan River is regulated by Navajo Reservoir, approximately 35 miles upstream from the City of Bloomfield's western corporate limits, and approximately 49 miles upstream from the City of Farmington's western corporate limits, which provides some flood protection. The Animas River has no flood protection measures.

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