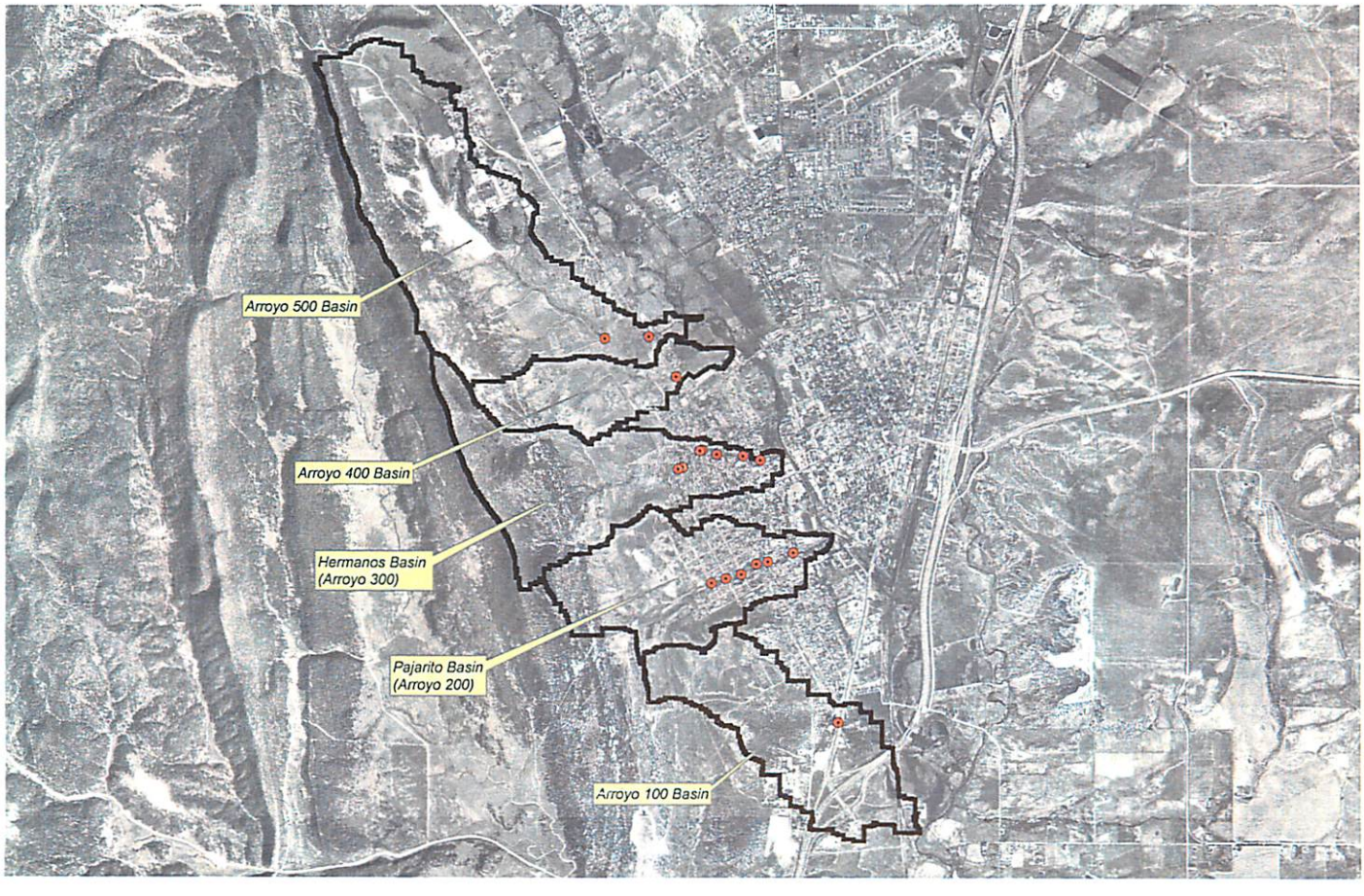
United States Department of Agriculture
Natural Resources Conservation Service
Albuquerque, New Mexico

Las Vegas Floodplain Management Study

San Miguel County, New Mexico



Las Vegas
Floodplain Management Study

San Miguel County, New Mexico

September, 2006

Prepared for and in cooperation with the City of Las Vegas

and the

Tierra y Montes Soil and Water Conservation District

Prepared by

USDA-Natural Resources Conservation Service

Albuquerque, New Mexico

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ABBREVIATIONS

Ac	Acres
Ac-Ft	Acre-feet
cfs	Cubic feet per second
CN	Runoff Curve Number
D.A.	Drainage Area
EPA	Environmental Protection Agency
A.S.	Auxiliary Spillway
FT	Feet
m.s.l.e.	mean sea level elevation
NFIP	National Flood Insurance Program
NM	New Mexico
NMCRIS	New Mexico Cultural Resources Information System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PCI	Per Capita Income
PSIAC	Pacific Southwest Interagency Committee
SC	Clayey Sand
SC-SM	Silty and Clayey Sand
SM	Silty Sand
SP	Poorly Graded Sand
Sq. Mi.	Square Mile
Tc	Time of Concentration
TR	Technical Release
US	United States
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service

Las Vegas
Floodplain Management Study

Introduction

Local Study Needs

The City of Las Vegas and the Tierra y Montes Soil and Water Conservation District requested the Natural Resources Conservation Service (NRCS) to conduct a study of the five arroyos on the west side of Las Vegas. Potential residential and commercial development in the area and constricted channels necessitate responsible management of land and water to reduce soil erosion and flood hazard. This report presents map data, the 100-year flood zone delineation, and recommendations for floodplain management. The City and District will use the information to promote the welfare of the community, ensure wise land use, and provide a consistent process for development. Implementation of a development process will benefit all residents.

The study completed a resource inventory of the immediate watershed and identified areas of environmental and cultural concern. This information provides the sponsors with more accurate information. Specific objectives for this study are:

1. Improve storm water management to:
   - reduce flood losses,
   - provide more accurate standards for underground storm systems, and
   - incorporate TR-55 or similar model for use by city management.
2. Improve bank stabilization and erosion control to:
   - reduce sedimentation,
   - improve water quality,
   - protect wetlands,
   - enhance wildlife habitat, and
   - protect fisheries.
3. Improve terrain management, zoning, and planning standards to guide and regulate development, in order to:
   - provide land for open space,
   - provide land for urban agricultural use,
   - educate all publics on proper land use,
   - provide historical flood and drainage data for management proposes, and
   - identify potential areas of future growth.
4. Implement study recommendations by:
   - training key city employees in areas of hydrology and storm water management,
   - identifying critical areas where bank stabilization, erosion control and other types of mitigation are needed, and
   - developing ordinances, policies, and procedural guides.

Study Authorities

This study was conducted by the USDA-Natural Resources Conservation Service in cooperation with the City of Las Vegas and the Tierra y Montes Soil and Water Conservation District under the authority of Public Law 83-566, Section 6. The NRCS Floodplain Management Program is designed to assist communities evaluate flood damage risks and alternatives that will reduce those risks. The objectives listed on page 1will result in better management of the stream channel and riparian area, improved recreational opportunities, and reduced cost for projects and developments in the planning area.

Description of Study Area

Las Vegas is located in San Miguel County where the Sangre de Cristo Mountains meet the Great Plains. The City is situated at an elevation of 6,470 feet and covers approximately ten square miles. The drainage area for this study makes up 4.2 square miles in and around Las Vegas. The study will evaluate five arroyos which originate in the Sangre de Cristo Mountains on the west side of the community and empty into the Gallinas River. These arroyos have 7.2 linear miles of channel and will be evaluated for present floodplain conditions.

The Gallinas River is an important tributary to the Pecos River. It is the source of domestic water supply for Las Vegas and is the third most important cold water fishery on the east side of the Sangre de Cristo Range. It provides about ninety percent of the water for Storrie Lake and this water is used to irrigate 6,450 acres of cropland. Over 3,000 of these acres are part of the Las Vegas National Wildlife Refuge.

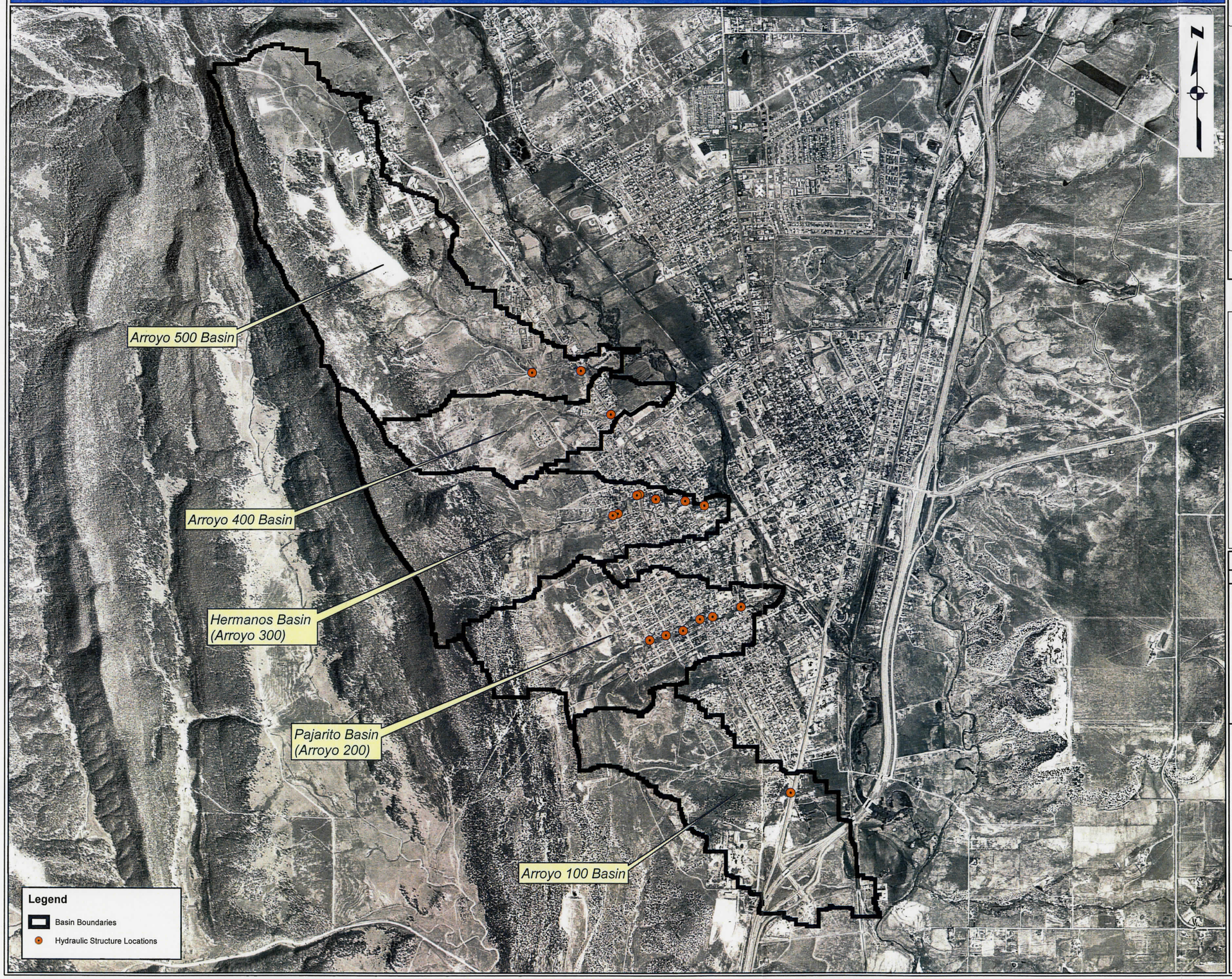
The sponsors of the study are the City of Las Vegas and the Tierra y Montes Soil and Water Conservation District. The study area is located in New Mexico Congressional District 3.

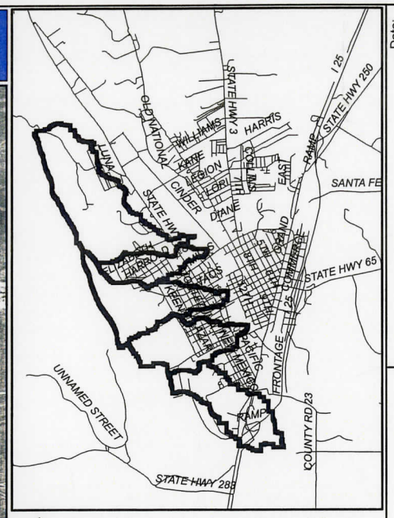
Location

The City of Las Vegas is 60 miles east of Santa Fe, New Mexico. The study area is located in western San Miguel County, New Mexico. Map 1 shows the location of the study area within Las Vegas and New Mexico. The study area extends west to the Creston and east to the Gallinas River including the portion of Las Vegas which is west of the Gallinas River.

The study evaluated five arroyos. For the study, these five arroyos were designated as arroyos 100, 200, 300, 400, and 500. Arroyo-200 is also designated as the Pajarito Arroyo and Arroyo-300 as the Hermanos Arroyo. All of the arroyos are western tributaries of the Gallinas River, which flows southeast into the Pecos River. The area is within Hydrologic Unit 1306000108.

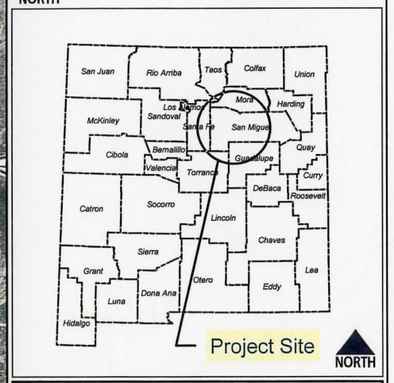
Las Vegas Floodplain Management Study Basins





Project Location Map

NORTH



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N

Site Plan

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Miles

		Date:
Designed:	Atiq Syed / Dan Murray	June, 2006
Drawn:	Eduardo Zuniga	June, 2006
Checked:	Roger Ford / Atiq Syed	June, 2006
Approved:	David Pacheco	September, 2006

Floodplain Boundary

Site Plan, Location Map, and Drawing Index

San Miguel County, New Mexico

NRCS

Natural Resources Conservation Service
United States Department of Agriculture

File Name:
FloodplainSitePlan.mxd

Drawing Name:

Sheet 1 of 11

Climate

The climate in the study area is semiarid, averaging seventeen inches of precipitation per year. Temperatures range between -26 and 99 degrees Fahrenheit for the period 1961 to 1990. Average daily temperatures are the lowest in January, 44.8 degrees, and highest in July, 82.7 degrees. The average annual temperature is about 64 degrees. Las Vegas has an average of 36 days per year with precipitation of 0.10 inch or more. Over 75 percent of the annual precipitation falls in the five month period from May to September. The average annual snowfall is 38 inches. Typically, severe thunderstorm activity occurs during the summer months as a result of warm moist air from the Gulf of Mexico.

Geology and Geomorphology

The West Las Vegas study area is located at the eastern boundary of the Sangre de Cristo Mountains. It rests on the northward-plunging Las Vegas syncline, a bedrock structural trough extending several thousand feet into the subsurface. The western edge of the study area is marked by a hogback ridge (called "The Creston") of sharply dipping Paleozoic and Mesozoic strata. This hogback is actually only part of the eastern limb of the Creston Anticline, a five-mile wide downfolded structure, cored by Precambrian metamorphic rocks, that trends north-south along the Sangre de Cristo mountain front. The Gallinas River forms the eastern edge of the study area.

The eastern side of the hogback is made up largely of Mesozoic sandstones, siltstones, and shales of the Chinle, Morrison, and Dakota formations. Runoff from precipitation that falls on the hogback surface is carried by the arroyos to the Gallinas River. The arroyos are incised into a surface underlain mainly by Cretaceous shales, and mantled in places by several feet of gravel. The northern quarter of the study area is on the Niobrara Formation, consisting of shale, siltstone, and a few thin beds of limestone. The eastern and western edges of the study area are on the Graneros Shale (shale with a few thin bentonite beds), while the central portion is on the Greenhorn Limestone (interbedded shale and limestone). The dissected area in and around the arroyos consists of low hills, terrace and pediment remnants, and narrow arroyo valleys, covered mostly by gravel or soil. A few prominent bedrock knolls remain as erosional remnants northwest of Las Vegas.

Ground Water Resources

Ground water conditions in the hogback area are extremely variable due to the steep dip of the beds. In the major part of the study area, water can be obtained from the Graneros Shale or the Greenhorn Limestone within a depth of a few hundred feet. Drawdown is fairly rapid, however, and water quality is variable. Water of better quality and greater quantity can be obtained by drilling to the underlying Dakota Sandstone. The Dakota is 300-400 feet below the surface in the north part of the study area and becomes shallower toward the south.

There have been very few publications dealing with groundwater quality around Las Vegas. The main sources of groundwater contamination are from leaking underground and above ground storage tanks, manufacturing facilities, private and public sewage treatment plants, as well as

septic tanks and cesspools. Point-source contamination sources include centralized sewage treatment works and landfills. Non-point sources are responsible for 64 percent of all supply well contamination and predominantly consist of household septic tanks and cesspools. Nitrate contamination is prevalent in areas where there are high densities of septic tanks and cesspools. High nitrate concentrations can also be seen around sewage treatment plants.

As of January 1, 1994, there have been 13 point source groundwater contamination sites and 14 contaminated public and private water supply wells reported in San Miguel county. Of the 13 point source contamination sites only two are currently being cleaned up while the other eleven are not, due to lack of resources.

Soils

The Soil Survey of San Miguel County Area was completed in 1977 and published in 1981. The intensity of the mapping was carried out at medium intensity (Order 3 level) for broad land use planning on the rangeland and forest land. High intensity mapping (Order 2 level) for intense land use planning was completed on the cropland and urban land areas. The Order 3 mapping is at a scale of 1:48,000 and the Order 2 mapping is at a scale of 1:24,000.

The western part of the study area is primarily mapped as Rock Outcrop-Haploborolls complex (RH). This complex is very steep. This part of the area is known as the Creston Ridge. Landforms that occur are mountain ridges and slopes. Slopes range from 35 to 70 percent. Rock outcrops of sandstone, shale, and limestone comprise approximately fifty percent of the western section. Haploboroll soils have highly variable properties ranging from shallow to very deep, with various textures. The rock outcrop is in hydrologic soil group D, which means that they have high runoff potential and very slow infiltration rates. The Haploborolls are in hydrologic soil group B which have moderately low runoff potential and moderately rapid infiltration rates. Water erosion hazard is high and soil blowing hazard is slight.

The middle portion of the study area has a moderate to high water erosion hazard and a moderate to high soil blowing hazard. The landforms in this part of the study area are a complex of uplands, terraces, and fans. Slopes range from 1 to 25 percent. This portion of the study area contains the map units listed in Table 1.

The Colmor, Swastika, Tinaja and Vermijo soils are very deep. Surface textures are loams, gravelly loams, and clay loams and silty clay loams. Subsoil textures are clay loams, silty clay loams, and gravelly loams and clay. The Colmor and Tinaja soils are in hydrologic soil group B. Swastika soils are in hydrologic soil group C, which are soils with a moderately high runoff potential and a slow infiltration rate. Limitations include high shrink-swell potential for Swastika and Vermijo soils, and a high content of rock fragments in the Tinaja soils.

The Litle, Mion, and Penrose soils are shallow or moderately deep (20 to 40 inches) to bedrock. Surface textures are silt loam, clay loam, and channery silt loam. Channery is a term used for thin, flat rock fragments of sandstone and hard shale. Subsoil textures are silty clay loam, clay loam, clay, and channery clay loam. These three soils are in hydrologic group D. Limitations also include high shrink-swell potential for Litle soils. In addition, Vermijo soils are rarely flooded.

The eastern part of the study area is comprised of Manzano clay loam (Md), 1 to 3 percent slopes and Ustifluvents (UF), frequently flooded. Ustifluvents is a higher category soil survey term. Higher category names are used for complex areas of highly variable soil properties. The landforms included are alluvial fans and the floodplain of the Gallinas river. Slopes range from 1 to 3 percent. Surface textures are clay loams for Manzano soils and variable for Ustifluvents. Subsoil textures are loam for Manzano and variable for Ustifluvents. Manzano soils are in hydrologic group B. Limitations include frequent flooding of Ustifluvents areas. The water erosion hazard is moderate and the soil blowing hazard is moderate.

Table 1. Soils of the Middle Portion of the Study Area.

Map Unit	Soil Name and Slope
Cf	Colmor Loam, 1 to 3 percent slopes,
Cg	Colmor silt loam, 3 to 5 percent slopes
Lo	Litle clay loam, 1 to 3 percent slopes,
ME	Mion-Penrose association, hilly,
PM	Penrose-Litle-Mion association, undulating,
Sy	Swastika clay loam, 3 to 5 percent slopes,
Va	Vermijo silty clay loam, 0 to 3 percent slopes, and
TG	Tinaja gravelly loam, hilly.

Vegetation and Wildlife

The study area consists of urban built up, rangeland, woodland, rock outcrop and some small riparian and wetland areas. Wildlife species present within the study area reflect existing habitat and the effects of urbanization. Species within the project area include pigeons, gold finch, house sparrows, mule deer, elk, black bear, wild turkey, prairie dog, scaled quail, meadowlark, nuthatch, jays, thrushes, woodpeckers, gray fox, morning dove, redwing black bird, cottontail rabbit, skunk pocket gopher, deer mouse and ravens.

Most of the project area falls within the Pecos-Canadian Plains and Valleys and Southern Rocky Mountain Major Land Resource Area. Loamy, Shallow, Gravelly, Swale and Woodland range sites make up the majority of the non-urban sites. A majority of the non-urban range and woodland sites within the project area are in good to excellent condition. The plant community reflects these good conditions with a good diversity of plants.

Loamy upland sites are dominated by Blue grama, Western wheatgrass, galleta, Buffalograss, Wolftail, Penstemen, Indian paintbrush, Fringed sage. The Shallow sites are dominated by Blue grama, Sideoats grama, Needlegrass, Oneseed juniper, Little bluestem, and Indiangrass. The gravelly sites are dominated by Sideoats grama, Blue grama, Little bluestem, New Mexico feathergrass, Big Bluestem, Needle and thread, Wolftail, and Red threeawn. Swale sites are

dominated by Western wheatgrass, Blue grama, Vine-mesquite, Galleta, Alkali sacaton, Buffalograss, and Fourwing saltbush. The Woodland sites are dominated by ponderosa pine, pinon pine, juniper, big bluestem, blue grama, sideoats grama, western wheatgrass, bottlebrush squirreltail, wolftail, sleepygrass, fringed sage, and primrose species.

Wetland and riparian sites along the five major drainages are dominated by sedges, rushes, vine-mesquite, wildrye, Redtop, Red clover, brome, with some scattered groves of cottonwood, willow, and Russian olive. The majority of the riparian and wetland sites that do exist within the project area are along the Gallinas River and within small pockets associated with springs, drains and small ponds.

Surface Water Quality

The quality of the water in the upper segment of the Gallinas River from Elk Mountain to Montezuma is described as cool, clear, highly oxygenated, slightly alkaline and contains low amounts of nutrients and dissolved chemical constituents. An intensive water quality study was conducted by the New Mexico Environment Department (NMED) over a period of 8 months during 1993. During that time, there were five exceedences of the numeric quality standards, two for turbidity, two for phosphorus and one for fecal coliform. With the exception of the two elevated turbidity measurements, the above exceedences were barely above stream standards and appeared to be both isolated and minor.

The two turbidity exceedences, however, demonstrated the contrast in the direct effects of various land management practices on stream sediment loading. Following heavy rains on August 2, 1993, turbidity rose from 4 to 11 NTU on U.S. Forest Service land (USFS). In comparison, downstream turbidity was 47 NTU on adjacent private lands. Reduced riparian vegetation, unstable stream banks, farming, and increased human activities have increased stream sediment loading in this section of the Gallinas River.

Downstream of Montezuma, nutrient levels were generally low to the Las Vegas Wastewater Facility where a significant increase occurred. Mean total phosphorus concentrations increased over 500 percent approximately one-quarter mile below the outfall and several miles downstream at San Augustin. Total nitrogen concentrations increased 600 percent and 300 percent at the same downstream sites. The high concentrations of nutrients resulted in ten stream standard exceedences for un-ionized ammonia at the sampling site just below the outfall and five stream standard violations for pH at San Augustin. Samples for determination of pesticide levels resulted in all less than the minimum quantification levels. Two exceedences of the fecal coliform bacteria standard were observed both above and below the wastewater treatment facility in July and can be directly attributed to the high turbidity levels in Pecos Arroyo.

In the same 1993 study, a biological assessment was performed on the upper Gallinas Watershed from the end of Forest Road 263 downstream to below Montezuma. The analysis of the macroinvertebrate community at the reference sites show it to be healthy, diverse and composed of numerous clean-water taxa. The stream bottom and riparian habitats show a gradual downstream pattern of decline in quality due to a loss of vegetation, changes in geology, channel alteration and reductions in stream-bank stability.

In a separate study conducted by Dr. Gerald Z. Jacobi of New Mexico Highlands University between 1987 through 1990; collected a diverse group of aquatic macroinvertebrates from five study locations in the watershed. The first three sampling sites were upstream of the confluence of the Gallinas and the El Porvenir while the fourth and fifth sites were downstream near Montezuma.

All five locations were rated high for habitat and water quality using the BCI methodology of Winget and Mangum during all sampling seasons for the three years. Occasionally, stations four and five contained more interstitial fines than did the upstream stations.

All three upstream locations were rated as "nonimpaired" with regard to biological condition. Conditions were indicative of excellent water and habitat quality which received minimal irritations. All sites had low concentrations of total dissolved solids and little suspended sediment.

The two downstream locations, site four at the mouth of El Porvenir Canyon and site five at Montezuma, always indicated lower biological conditions. They were rated slightly impaired or lower. Sediment loading, total alkalinity, sulfate, and hardness concentrations increased in downstream order. Site four, which was downstream of private homes and grazing land, was generally the lowest rated site during the survey, twice receiving moderately impaired ratings. Most of the slightly impaired ratings at site five were higher than at site four.

It appears the condition of the benthic macroinvertebrate communities are quite healthy along the part of the river flowing through USFS land. On private lands, however, the quality of the communities decreases somewhat and is probably related to both the amount of sediment entering the river and the overall condition of the riparian habitat. Although unpaved roads and recreational areas within the USFS boundary are a source of some sediment loading, the overall condition of the riparian strip appears to be more adequate in reducing sediment and providing suitable habit when compared to conditions on the private lands located immediately downstream.

Threatened and Endangered Species

No endangered or threatened plant and animal species were observed during the inventories conducted for this study. Prior to implementation of any alternatives, the U.S. Fish and Wildlife Service (USF&WS) must be consulted to assure that no listed species would be affected by the proposed alternatives. Those species that may occur in the study area and are listed in the Federal and state endangered and threatened list are shown in Table 2.

New Mexico Rare and Endangered List 1, plant species that may be found within the study area include Golden Lady's Slipper, Holy Ghost ipomopsis and Wooly lily. Taxa (or species) are included on List 1 for any one of the following criteria:

1. The taxon is listed as threatened or endangered under the provisions of the Federal Endangered Species Act;
2. The taxon is so rare across its entire range and of such limited distribution and population size that unregulated collection could jeopardize its survival in New Mexico; or

3. The taxon may be widespread in adjacent states or Mexico, but its numbers are being significantly reduced to such a degree that within the foreseeable future the survival of the taxon within New Mexico is jeopardized.

Pecos fleabane and Sandia alum root are listed as New Mexico List 2 plant species. New Mexico List 2 taxa are considered to be rare because of restricted distribution or low numerical density. They need not be endemic to New Mexico, but must be regionally endemic or rare throughout their range. Since they are rare, these species are sensitive to long-term or climatic events that Could eventually threaten them with extinction or extirpation. Therefore, List 2 species are monitored by the State of New Mexico to determine if they should ever be elevated to List 1 endangered species status. They are not protected by state statute or policy.

Table 2. Federal and State Threatened and Endangered Animal Species that May Occur in the Study Area.

Species	Federal Listing	State Listing
Plains Minnow	Candidate	
Bald Eagle	Endangered	Threatened
Northern Goshawk	Candidate	
Common Black-hawk		Threatened
Ferruginous Hawk	Candidate	
American Peregrin Falcon	Endangered	Endangered
Broad-billed Hummingbird		Threatened
Southwestern Willow Flycatcher	Endangered	Threatened
Long -eared Myotis Bat	Candidate	
Long-legged Myotis Bat	Candidate	
Townsend's Big-eared Bat	Candidate	
Meadow Jumping Mouse	Candidate	Threatened
Swift Fox	Candidate	
American Marten		Threatened

Any alternatives developed for the study area should include a detailed inventory of wildlife species and habitat. This inventory would detail the plant and wildlife species habitat occurring in the study area. As alternatives are developed and implemented, care must be taken to assure that no threatened and endangered species are adversely affected.

Social and Economic

Las Vegas once served as a vital commercial center for the region due to its position along the Santa Fe Trail and the railroad. Las Vegas' economic fortune declined in 1905 when railroad traffic was diverted south. Drought and the agricultural depression of the 1920's and 30's helped bring almost a century of boom town prosperity to a close. Since then, Las Vegas has survived by state government employment. It is the home to New Mexico Highlands University, Luna Vocational Technical Institute, Las Vegas Medical Center, Northeastern Regional Hospital, and is the seat for San Miguel County.

In the 2000 census, San Miguel County had a population 30,126 and more than two-thirds of that population is under 18 years of age. At the same time, Las Vegas had a population of 14,753 and is the largest municipality in the northeastern quadrant of New Mexico. The current growth rate of the community is three to four percent per year. Las Vegas and San Miguel County are culturally diverse; however, the area reflects the traditions and values of its Hispanic population which accounts for approximately seventy percent. Most of the land in San Miguel County is privately owned, and Table 6 shows the acreage of land held privately and by the state and Federal governments. A diverse economy exists within the county, and Table 3 lists the number of jobs in nine different employment sectors. This table also indicates that forty-seven percent of the jobs are with state and local governments, and another forty-one percent are in the retail and services sectors.

Table 3. Nonagricultural Employment in San Miguel County in 1994.

Industry	Employment Numbers
Manufacturing	355
Transportation and Utilities	152
Wholesale Trade	96
Retail Trade	1,565
Finance, Insurance, and Real Estate	244
Services	1,859
Federal Government	159
State Government	2,506
Local Government	1,352
Total	8,288

Table 4. Gross Receipts from Selected Agricultural Enterprises.

Cattle and calves	$23,530,000
Hay	$1,439,000
Vegetables and Fruit	$179,000
Chile	$88,000

Table 5. Population and Age Distribution for San Miguel County in 2000.

Age	Male	Female
Under 5 years	988	972
5 to 9 years	1,150	1,093
10 to 14 years	1,244	1,229
15 to 17 years	843	750
18 and 19 years	549	643
20 years	252	251
21 years	213	227
22 to 24 years	550	587
25 to 29 years	812	911
30 to 34 years	855	917
35 to 39 years	1,151	1,138
40 to 44 years	1,206	1,157
45 to 49 years	1,041	1,051
50 to 54 years	1,000	993
55 to 59 years	740	811
60 and 61 years	248	291
62 to 64 years	379	354
65 and 66 years	238	207
67 to 69 years	292	305
70 to 74 years	411	478
75 to 79 years	294	410
80 to 84 years	190	251
85 years and over	163	291
TOTAL	30,126	

Table 6. Land Ownership in San Miguel County.

	Acres	Percent
Private	2,466,357	81.3
Federal	394,099	13
State	173,808	5.7
Total Acres	3,034,264	

Agriculture, another sector of the local economy, was not listed in Table 5, but Table 6 lists the gross receipts for several selected agricultural commodities. Cattle and calf enterprises are located east of Las Vegas on the rangeland of central and eastern San Miguel County. Hay, vegetables and fruit are grown on the cropland irrigated from Storrie Lake.

The land uses within the study area are urban and rangeland. The eastern portion of the area is within the city limits of Las Vegas. The western portion of the study area is very steep and rocky. The middle portion of the study area is rangeland and will probably develop into residential areas.

Cultural Resources

A review of the New Mexico Cultural Resources Information System (NMCRIS) for the study area revealed the presence of 19 currently recorded sites. A check of the most recent listing of the National Register of Historic Places and the New Mexico State Register of Cultural Properties shows that some of these recorded sites are listed on the National and State Register. These National and State Register sites, located in Las Vegas, include the Old Town Residential District, the Plaza, the Acequia Madre, the Presbyterian Mission and Our Lady of Sorrows churches, the cemetary, and assorted residential houses. Located just outside of Las Vegas is Camp Luna, used during World War I and II by the U.S. Army. Historic buildings are still present at the camp although it is no longer a U.S. Army post. The other currently recorded sites range from prehistoric campsites with hearths and lithics and groundstone to a historic railroad bed and historic Hispanic and Anglo house foundations and trash dumps from the US Territorial to New Mexico Statehood period. The time period runs from early prehistoric (9500 BC) to modern day.

Given the above data, the probability of encountering other prehistoric and historic sites is very high. The study area has not been completely surveyed and there are undoubtedly prehistoric and historic sites in and around Las Vegas that have not yet been recorded or evaluated. If federal funding, permits, or assistance are used to implement ground disturbing projects within the study area, the National Historic Preservation Act (NHPA) will apply. A professional archeological inventory and assessment of the sites would be the initial step in complying with the stipulations of the NHPA.

Investigations and Analyses

Scoping

Major floods in Las Vegas have been recorded since 1857. Between 1857 and 1966 a total of $3.8 million in actual flood damage was recorded. These dollar damages have not been adjusted for inflation. In 1968, the Soil Conservation Service estimated average annual flood damages at $57,000. Many of these damages were from floods on the Gallinas River. However, intensive summer thunderstorms centered over the five arroyos studied can cause damage. Since these storms occur with very intense rainfall, they usually cause the greatest flood damage. For example, in June 1995 a large storm over the Arroyo Hermanos affected forty-eight residential and business buildings. A damage assessment completed by the American Red Cross listed

thirty-four buildings which sustained damage. On August 21, 1995, a public meeting was held to obtain input, information, and concerns from the public. The residents were able to discuss their concerns, issues and possible causes of flooding in the area.

Flood damages from the five arroyos are primarily to urban developments and irrigation canals and laterals. Floodwater in the City damages culverts and buildings because the arroyos have been constricted by sediment and trash and because upstream developments are increasing the volumes and peak rates of runoff. Flow in the arroyos have high velocities and are hazardous. The floodwaters also damage streets through erosion and sediment deposition. After a flood, there are expenses for removing sediment and repairing the streets. As the watershed west of existing improvements is developed, there is a potential for greater increases in flood damage.

The Acequia Madre crosses Arroyos 100, 200, 300, and 400 in the study area. It carries irrigation water to cropland in and south of the City. Floodwaters have damaged the acequia. This damage includes washing the ditch out and depositing sediment in it. During the summer growing season, thunderstorms can interrupt the flow of irrigation water and this can significantly reduce crop yield.

Table 7. Concerns, Possible Causes of Flooding Problems, and Opportunities

Damages which are occurring and other problems
Degradation of arroyo banks
Damage to houses and other public buildings
Can not cross Arroyo Monteca when water is flowing
Stagnant water and mosquitoes
Acequia Madre carrying debris during floods and depositing at building (Acequia Madre flows under these buildings)
Downstream flood damage
Possible causes of flood damage
Trees, tires, debris in channels
People dumping in channels
Sediment deposits in channels
Crossings on Perez, Romero and New Mexico Ave.
People changing water course without knowing effects
Alterations of existing arroyos tends to create problems
Limited City staff to follow-up on alterations occurring
Opportunities
Retention of water for downstream Irrigation use
Bank stabilization
Recreation
Diversions
Clean out channels (maintenance)
Beautification - wild flower plantings
Use steps to control grade (grade stabilization structures)
Additional outlets to river
Terraces in upstream areas
Acequias used to divert water off the arroyos

Erosion and Sediment Yield

For purposes of evaluating erosion and sediment yield, the study area was divided into two broad geomorphic units. Unit 1 consists of the dissected lower portion of the watershed, underlain by Cretaceous sediments. This unit has characteristic slopes of five to fifteen percent, silty clay loam soils, and vegetative cover consisting of grass and juniper. Unit 2 consists of the hogback ridge, with slopes ranging from twenty percent to nearly vertical, and has an average slope of thirty percent. For Unit 2, soils are mainly gravelly or sandy loams and vegetative cover is primarily pine and oak.

An evaluation of sediment yield was done for the two geomorphic units using the Pacific Southwest Inter-Agency Committee (PSIAC, 1968) method. Each unit was rated at several different locations and a composite rating was compiled for each unit. The weighted average annual sediment-yield for the Las Vegas study area was determined to be 0.19 acre-feet per square mile, which is considered to be in the low category for the Southwest. Ratings for the individual units are shown in Table 8.

Table 8. Average Annual Sediment Yield.

Geomorphic Unit	1	2
Geomorphic Position	Hill and Terraces	Hogsback
Area (Square miles)	3.6	1.1
PSIAC Rating (ac-ft/sq.mi/year)	0.16	0.26
Sediment Yield (ac-ft/yr)	0.6	0.3

Average sediment yield is low in Unit 1 and can be attributed about equally to sheet and rill, gully, and channel-bank erosion. Sediment yield in Unit 2 is low to moderate, and is primarily due to natural background rates of sheet and rill erosion on very steep slopes. With very few exceptions, the study area is in very good condition from an erosion and sedimentation standpoint. Total cover, including vegetation, rock, and litter, is on the order of 70 to 80 percent in most of the study area. Sediment-yield rates are only slightly higher than natural background rates, the difference being due mainly to the concentration of runoff by roads.

The total volume of sediment yield in the study area is approximately 0.9 acre-feet in an average year. Based on soil textural data (Soil Conservation Service, 1981), this sediment is made up of about 70 percent fines, 27 percent sands, and 3 percent gravel. Sediment delivery ratios were estimated for fine and coarse materials produced by sheet and rill, gully, and streambank erosion, respectively. The percentage of the total sediment that reaches the Gallinas River from the study area was estimated to be about 0.5 acre-feet per year, equivalent to about 900 tons. The remainder of the sediment is stored as floodplain and channel deposits in the arroyo system. The inventory team observed deposits of silt and sand on the arroyo bottoms at several locations in the study area. These deposits were typically upstream of culverts in the lower part of the watershed, where water may be temporarily backed up during very high discharge conditions. Such an event occurred in early 1995.

Hydrology

Several hydrologic models are available to estimate existing and future runoff volumes (acre-feet) and peak flows (cubic feet per second). "Computer Program for Project Formulation Hydrology" Technical Release 20 (TR-20), February 1992, USDA-Natural Resources Conservation Service was selected because of proven reliability, familiarity with the program, multiple sub-watershed and routing capabilities, and ability to model reservoir routing and channel modifications.

The study area includes the five main arroyos that contribute to the Gallinas River from the west side including: Pajarito (Arroyo-200) and Hermanos or Monteca (Arroyo-300). The other three unnamed arroyos are located west of the intersection of Highway 85 and NM Avenue (Arroyo-100) and the two arroyos (400 & 500) that cross Highway 65 (Hot Springs Blvd.) between Porter Avenue and the Las Vegas Medical Center. The five drainage areas were further divided into 19 subareas for the hydrologic analysis.

There are three small drainage areas mixed in between Arroyos 100 through 400 that drain directly into the Gallinas River. These areas were not analyzed for flooding due to their small size and multiple drainage paths to the river. This is not to say that there is not a significant flood risk in these areas. The areas are generally fully developed with both residential and commercial structures, and have a high percentage of impervious area.

TR-20 input parameters include basin size, time of concentration, rainfall, and runoff curve number. Basin sizes ranged from 0.37 to 1.50 square miles. The total watershed area is 3.86 square miles.

Time of concentration (Tc) is the time in hours that it takes runoff to travel from the most distant point to the basin outlet. Time of concentration values were computed with the Modified Kirpich Equation. Due to the generally high length to width ratios of the drainage areas and steep channel slopes, decreasing the Tc values was not considered appropriate for future conditions. If extensive concrete channel improvements are installed in the middle and upper portions of the watershed, the future condition Tc values may need to be reconsidered. Decreasing Tc values would tend to increase the peak flows. However, runoff volumes would not be affected by a change in Tc. NRCS NM-II-75 rainfall distribution was used to represent the high intensity storms of the Las Vegas area. The type NM II-75 places 75 percent of the 24-hour precipitation in the most intense one-hour period. Rainfall values for the 2-, 5-, 10-, 25-, 50- and 100-year, 24-hour events were used to develop the existing runoff hydrology. Precipitation values were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 2, Frequency Atlas of the Western United States. The 24-hour rainfalls used are shown in Table 9.

Soils information was derived from the Soil Survey of San Miguel County Area. And USDA curve numbers were used in the computer model to define the infiltration/runoff phenomena for various soils, cover types, and conditions. Runoff curve numbers are based on field investigations, aerial photography, soil textures, land use, cover, and cover condition. These six factors were used with Table 2-2, in TR-55, to assign runoff curve numbers for existing conditions. Runoff volumes are determined from curve number and rainfall values. A curve number of 98 indicates very little infiltration, resulting in almost all precipitation becoming

runoff (road surfaces). A curve number of 65 indicates high infiltration (sandy soil) and low runoff. Curve numbers ranged from 69 to 87. The flood hazard zone maps and profiles are based on existing conditions. Basin hydrologic parameters and delineation were developed from the ortho-topographic maps with 4 feet contour intervals for import into HEC-RAS (Hydrologic Engineering Center-Hydrologic Modeling System). Basin delineations are shown on Map 2 through 6.

The five main arroyos studied were subdivided into three or more sub-areas each. The analysis points of interest or outlets are at the arroyo confluences with the Gallinas River except for Arroyo-100. The analysis point for Arroyo-100 is at the junction with Interstate 25.

Two-, five-, 10-, 25-, 50-, and 100-year basin peak discharges are provided in Appendix C of this report.

Table 9. Precipitation Values for 24-Hour Duration.

Return Period in Years	Percent Chance of an Equal or Larger Storm Event	24-Hour Precipitation in Inches
2	50	2.0
5	20	2.7
10	10	3.2
25	4	3.8
50	2	4.3
100	1	4.7

Hydraulics

The five arroyos in the study area were analyzed using HEC-RAS with HEC-GeoRAS. HEC-GeoRAS, a set of procedures, tools, and utilities for processing GIS data in ArcView GIS, was used to assist in hydraulic model development and analysis. Spatially referenced depiction and visualization of flood depths and velocities developed by GeoRAS provided valuable tools for evaluating impacts associated with flooding and flood damage reduction alternatives. The development of HEC-GeoRAS has linked ArcMap/ArcView GIS (ESRI, 1996) to the Army Corps of Engineers HEC-RAS model. HEC-GeoRAS provides specific access to GIS procedures that assists in the creation and evaluation of hydraulic models using digital terrain data.

The geometric import file was created in HEC-GeoRAS from the ortho-topographic maps with 4 feet contour intervals for import into HEC-RAS. The ortho-topographic map was developed by Thomas R. Mann and Associates, engineering consulting firm, during the mid 1990's. The import file is an ascii file format containing header, stream network, and cross-sectional information. Information contained in the import file includes river, reach and station identifiers; cross-sectional cut lines; cross-sectional surface lines; cross-sectional bank stations; downstream reach lengths for the left overbank, main channel, right overbank; and cross-sectional roughness coefficients. Friction losses due to floodwater flowing against the arroyo bottom and sides are modeled by channel roughness. For this study, Manning's "n" values were used for channel roughness. Field investigations and Supplement B (National Engineering Handbook, Section 4,

Hydraulics) were used to estimate "n" values. The "n" values used in the model ranged between 0.025 to 0.045 depending on the physical conditions in the arroyo and its banks. This increased value reflects vegetation and desert pavement.

The discharges used in the HEC-RAS model are the clean water discharges computed by TR-20. Water surface profile data and velocity data exported from HEC-RAS was processed in Arc Map for floodplain delineation and floodplain inundation depths.

Appendix B shows the 100-year floodplain and water surface profiles for the five arroyos, and Appendix C provides the HEC-RAS output tables. The 100-year flood is displayed as flood hazard zones with projected water surface profiles. In addition, the flow overtopping at the 17 hydraulic structures is also shown in flood hazard maps.

Existing Hydraulic Structures

There are a total of 17 hydraulic structures in the study area: 2 in Arroyo-500, 1 in Arroyo-400, 7 in Arroyo-300 (Hermanos Arroyo), 6 in Arroyo-200 (Pajarito Arroyo), and 1 in 100 Arroyo. Descriptions of each hydraulic structure along with pictures are provided in the sections below. Other "structures" of various shapes and sizes along the developed reaches include different types of flood proofing, constructed mostly by landowners for the purpose of confining storm runoff in the arroyos. The effectiveness of these structures is not easy to analyze without a much more detailed field survey.

Two general conditions exist with respect to the channel hydraulics and structures. The first condition consists of channel reaches where there is no development along the arroyos and there are no structures, i.e. culverts or bridges. The flood flow velocities are generally moderate to fast and the floodplain is fairly narrow. Most of the flood risk is confined to channel bank stability problems. This condition is typical of Arroyos 100, 400, 500 and the upper reaches of 200 and 300. The second condition is found in the highly developed channel reaches of Arroyos 200 and 300, where numerous undersized culverts and bridges are located that restrict the flood flows. These channel restrictions cause a backwater effect during flood flows, which causes the water surface to rise and overtop the road surface at the culvert crossings. This also results in a much wider floodplain immediately upstream of the culvert crossings and typically impacts commercial or residential structures along the arroyos. In addition, these reaches also tend to have sharp channel bends either natural or man-made. Downstream property damage and channel bank stability problems are typical in these areas.

Hydraulic structures in Arroyo-500

This basin is located at the most northern end of the study area with an approximate size of 1.4 square miles. There are a total of 2 hydraulic structures in this basin; a 2-barrel circular metal pipe culvert located at U.S. Highway 65 and a 2-barrel circular concrete pipe culvert at Mt. Calvary Cemetery Road (Figures 1 and 2). Based on hydrologic investigations, a 100-year flood flow event at the U.S. Highway-65 culvert would be about 2,010 ft^3/sec, while the design flow capacity of this culvert is 1860 ft^3/sec. Similarly, the culvert at Mt. Calvary Cemetery Road has a design flow capacity of 1800 ft^3/sec, while a 100-year flood flow would be about 1,930 ft^3/sec.

Both of the culverts in the Arroyo-500 basin are undersize and HEC-RAS model results show that they will overtop during a 100-year flood event (Appendix B).

Besides the culverts inadequate flow bypass capacities, lack of regular maintenance such as presence of trees, brush, and debris in the arroyo could further deteriorate existing flood conditions in the vicinity of these structures. For example, the 2-barrel culvert at Mt. Calvary Cemetery Road is 40% plugged with sediments, debris, and brush at its downstream ends (Figure 2).

Figure 1. Upstream (1) and downstream (2) sections of a 2-barrel circular culvert at U.S. Highway 65 in the Arroyo-500 basin.

(1) (2)

Figure 2. Upstream (1) and downstream (2) sections of a 2-barrel culvert at Mt. Calvary Cemetery Road in the Arroyo-500 basin.

(1) (2)

Hydraulic structures in Arroyo-400

This basin is next to and south of the Arroyo-500 basin in the study area (Map 1). It has an approximate area of 0.4 square miles. This basin has one hydraulic structure: a 2-box concrete culvert located at U.S. Highway 65 (Figure 3). At the downstream end of this culvert, there is a flood diversion channel known as the Encino Channel (Figure 4). This channel runs north of Mills Avenue and East of Hot Springs Boulevard (NM 65). Though the Encino channel is located downstream of the culvert at NM 65, it does not collect flow directly from the culvert outlet as it is not aligned with the arroyo. Ideally, it should have been built immediately downstream of the culvert to bypass flow directly into the Gallinas River, but due to property acquisition problems the channel was built at its current location.

HEC-RAS model results show that the Encino Channel will effectively intercept a 100-year flood event along the eastern part of the basin and will provide flood protection to properties located south-east of the channel, but properties located north-east of the channel and in the surrounding area of the culvert would be inundated. The computed 100-year flood flow event at this location is about 660 ft^3/sec and the design flow capacity of the culvert is 650 ft^3/sec. This culvert is slightly undersize and therefore could overtop during a 100-year flood event. Properties located in the vicinity of the culvert both upstream and downstream could potentially experience damage (Appendix B). Regular maintenance such as tree, debris and sediment removal will significantly improve flow bypass and could minimize flooding in the vicinity of this structure.

Figure 3. Upstream (1) and downstream (2) section of the 2-box culvert at U.S. Highway 65 in the Arroyo-400 basin.

(1) (2)

Figure 4. Upstream section (1) of the Encino Channel and mid section view (2) looking downstream.

(1) (2)

Hydraulic structures in Arroyo-300 (Hermanos Arroyo)

The Arroyo-300 is also known as the Hermanos arroyo with an approximate size of 0.9 square miles. This basin is highly urbanized compared to the rest of the study area. There are a total of 7 hydraulic structures in this basin which are surrounded by a mix of residential and commercial properties. A brief description of each hydraulic structure and its impact on the surrounding area during a flood event is given below.

Single box culvert at Gonzales Street:

This single box culvert is the first and the most downstream hydraulic structure in the Hermanos arroyo (Figure 5). During a site-investigation of the study area, three storm sewer pipes (12 to 24 inches) were observed just upstream of the culvert along the southern end of the arroyo (Figure 6). These pipes are approximately 60 feet apart from each other and discharge directly into the arroyo. This additional storm sewer flow could impede the flow capacity of the culvert at Gonzales Street.

The design capacity of the culvert at Gonzales Street is 1,350 ft^3/sec and the computed discharge at this location from a 100-year flood event is 1,560 ft^3/sec. This culvert is undersize and HEC-RAS model results shows that it is not capable of safely passing a 100-year flood event. There is a high probability of flood water overtopping at Gonzales Street during high flows.

Figure 5. Upstream (1) and downstream (2) sections of the single box culvert at Gonzales Street in the Hermanos Arroyo.

(1) (2)

Figure 6. Storm sewer flow contribution at the upstream section of the culvert on Gonzales street in the Hermanos Arroyo.

Single box arched culvert at Hot Springs Road:

This single box arched culvert is the second hydraulic structure in the Hermanos Arroyo (Figure 7). HEC-RAS model results show that that this culvert has adequate capacity to bypass a 100-year flood event without any concerns. The design capacity of this culvert is 1,725 ft^3/sec and computed flow from a 100-year flood event at this location is 1,560 ft^3/sec. There is sufficient flow storage area at the upstream end of this culvert, which helps in reducing flow stress on the structure (Figure 8).

Figure 7. Upstream (1) and downstream (2) section of the arch culvert at Hot Springs Road in the Hermanos Arroyo.

(1) (2)

Figure 8. Southern end (right bank) of the flow storage area immediately upstream of the culvert at Hot Springs road in the Hermanos Arroyo.

Two box culvert at Church Street:

This two box culvert is the 3rd hydraulic structure in the Hermanos Arroyo (Figure 9). The computed 100-year flood event at this location is approximately 1,520 ft^3/sec and the design flow capacity of the culvert is 1,500 ft^3/sec. This culvert is slightly undersize. HEC-RAS model results show that it will overtop during a 100-year flood event. There is heavy vegetation and debris both at the upstream and downstream ends of this culvert. Figure 9 shows the presence of shopping carts at the culvert inlet. Regular maintenance such as debris and brush removal will significantly improve flow bypass and minimize flooding in the vicinity of this structure.

Figure 9. Upstream section of a 2-box culvert at Church Street in the Hermanos Arroyo; the presence of heavy vegetation and debris can impede flow through the culvert.

Single box culvert at New Mexico Avenue-1:

This single box culvert is the 4th hydraulic structure in the Hermanos Arroyo (Figure 10). The design capacity of this culvert is 1,500 ft^3/sec and a 100-year flood event at this location is computed to be 1,520 ft^3/sec. HEC-RAS model results show that it will overtop during a 100-year flood event. The overtopping of New Mexico Avenue is due to its insufficient flow bypass capacity and the presence of a short confining reach created by the upstream culvert, which is about 15 feet upstream from it.

Figure 10. Upstream (1) and downstream (2) sections of a single box culvert at New Mexico Avenue-1 in the Hermanos Arroyo.

(1) (2)

Single box culvert at New Mexico Avenue-2:

This single box culvert is the 5th hydraulic structure in the Hermanos Arroyo (Figure 11). As mentioned above, this culvert is approximately 15 feet upstream from the culvert at New Mexico Avenue-1. During high flow conditions the two culverts clog flow in the arroyo between two culverts. This could cause severe flooding conditions in the area. The design capacity of this culvert is 1,500 ft^3/sec and a 100-year flood event at this location is computed to be 1,520 ft^3/sec. HEC-RAS model results show that this culvert is not capable of safely passing a 100-year flood event.

Figure 11. Upstream (1) and downstream (2) section of a single box culvert at New Mexico Avenue-2 in the Hermanos Arroyo.

(1) (2)

Single box culvert at un-named Street:

This single box culvert is the 6th hydraulic structure in the Hermanos Arroyo (Figure 12). This culvert is located on a private driveway between New Mexico Avenue-2 and Lopez Street. The design capacity of this culvert is 1,400 ft^3/sec and a 100-year flood event at this location is computed to be 1,440 ft^3/sec. This culvert is undersize and HEC-RAS model results shows that it is not capable of safely passing a 100-year flood flow. This culvert is very old and unsafe for regular traffic use. Figure 12 show the condition of the culvert and the presence of heavy vegetation in the arroyo.

Figure 12. Upstream (1) and downstream (2) section of a single box culvert at unnamed street between New Mexico Avenue-2 and Lopez Street in the Hermanos Arroyo.

(1) (2)

Two box culvert at Lopez Street:

This two box culvert is the 7th and last hydraulic structure in the Hermanos Arroyo (Figure 13). The design capacity of this culvert is 1,430 ft^3/sec and the 100-year flood flow at this location is computed to be 1,440 ft^3/sec. This culvert is slightly undersize and HEC-RAS model results show that it would overtop during a 100-year flood event. Regular maintenance such as debris and brush removal from the arroyo in the vicinity of this culvert will significantly improve its flow bypass capacity

Figure 13. Upstream (1) and downstream (2) section of a single box culvert at Lopez Street in the Hermanos Arroyo.

(1) (2)

Hydraulic structures in Arroyo-200 (Pajarito Arroyo)

The Arroyo-200 is also known as the Pajarito Arroyo and has an approximate area of 0.7 square miles. There are a total of 6 hydraulic structures in this arroyo. A brief description of each structure is given below.

Single box culvert at South Pacific Street:

This single box culvert is the first and most downstream hydraulic structure in the Pajarito Arroyo (Map 1, Figures 14 & 15). The design capacity of this culvert is 1,745 ft^3/sec and the flow from a 100-year flood event is computed to be 1,420 ft^3/sec. It has a rise of 10 feet and a span of 20 feet. Because of its appropriate size, it will pass a 100-year flood flow without any problems. HEC-RAS model results show no flooding problems in the vicinity of this structure.

Figure 14. Upstream (1) and downstream (2) sections of a single box culvert at South Pacific Street in the Pajarito Arroyo.

(1) (2)

Figure 15. Storm sewer flow contribution to the culvert at South pacific street (1), and an irrigation pipe located at the downstream end of the same culvert.

(1) (2)

Three box culvert at Perez Street:

This three box culvert is the second hydraulic structure in the Pajarito Arroyo and is upstream of the culvert at South Pacific Street (Figure 16). The design capacity of this culvert is 1,600 ft^3/sec and the computed 100-year flood event is 1,520 ft^3/sec. Theoretically, the culvert should not have any problems bypassing the 100-year flood flow as its design capacity is more than a 100-year flow. However, due to the arroyo's physical characteristics, flooding in this area occurs during high flows. These physical characteristics include: 1) the presence of a short steep confining reach between this culvert and the upstream culvert at New Mexico Avenue, and 2) a sharp 90 degrees bend in the arroyo as it enters the culvert at Perez Street. These conditions allow for flow accumulation and restricted flow movement through this section of the arroyo which results in flow overtopping both at Perez and New Mexico Avenue culverts.

Figure 16. Upstream (1) and downstream (2) sections of the 3-box culvert at Perez Street in the Pajarito Arroyo; the sharp bend in the arroyo can be seen in the first picture.

(1) (2)

Single box culvert at New Mexico Avenue:

This single box culvert is the 3rd hydraulic structure in the Pajarito Arroyo (Figure 17). The design flow capacity of this culvert is 1,500 ft^3/sec and the computed flow at this location from a 100-year flood event is 1400 ft^3/sec. This culvert overtops during a 100-year flood event due to backwater flow conditions created at the outlet section by the culvert downstream. Also, design deficiencies in hydraulic structure and the presence of heavy vegetation in the arroyo could lead to such conditions.

Figure 17. Upstream (1) and downstream (2) sections of a single box culvert at New Mexico Avenue-1 in the Pajarito Arroyo.

(1) (2)

Single box culvert at Montezuma Street:

This single box culvert is the 4th hydraulic structure in the Pajarito Arroyo (Figure 18). The design capacity of this culvert is 1,200 ft^3/sec and computed 100-year flood event at this location is 1,300 ft^3/sec. HEC-RAS model results show that this culvert is undersize and is not capable of safely passing a 100-year flood event. The overtopping of Montezuma Street is mainly due to its undersized culvert, restricted flow movement due to the presence of a 24-inch sanitary sewer pipeline underneath the deck, and lack of proper maintenance in the vicinity of the arroyo.

Figure 18. Upstream (1) and downstream (2) sections of a single box culvert at Montezuma Street in the Pajarito Arroyo (note: a 24-inch pipe across the culvert opening).

(1) (2)

Two barrel arch culvert at Romero Street:

This single box culvert is the 5th hydraulic structure in the Pajarito Arroyo (Figure 19). This culvert has 2 barrel arch pipes with a rise of 6.5 feet. Because of its appropriate size it will safely pass a 100-year flood event without any problems. The design capacity of this culvert is approximately 1,650 ft^3/sec, while the flow from a 100-year flood event would be 1,300 ft^3/sec. HEC-RAS model results show that there are no concerns of flooding in the vicinity of this structure.

Figure 19. Upstream (1) and downstream (2) sections of a two barrel arch culvert at Romero Street in the Pajarito Arroyo.

(1) (2)

Two barrels concrete culvert at Salazar Street:

This two barrels culvert is the 6th and last hydraulic structure in the Pajarito Arroyo (Figure 20). The design capacity of this culvert is 1,150 ft^3/sec and the computed 100-year flood event at this location is about 1,000 ft^3/sec. Though the design flow capacity is more than the 100-year flood flow the culvert still overtops during a 100-year flood event. This is mainly due to the improper layout of the hydraulic structure (design deficiencies). The downstream section of the culvert is very unstable and could possibly wash away in a flood event (Figure 21).

Figure 20. Upstream (1) and downstream (2) sections of a two barrel culvert at Salazar Street in the Pajarito Arroyo.

(1) (2)

Figure 21. Unstable condition of Salazar road at the culvert location at Salazar Street.

Hydraulic structures in Arroyo-100

This basin is next to the Pajarito Arroyo and is the southern most basin in the study area with an approximate area of 0.7 square miles. There is one hydraulic structure in this basin located at U.S. Highway 85 (Figure 22 & 23). This two box culvert has a rise of 5 ft and a span of 6 feet. The design capacity of this culvert is 1,100 ft^3/sec and the computed 100-year flood event is

1,200 ft^3/sec. HEC-RAS model results show that this culvert does not have the capacity to safely pass a 100-year flood flow and will overtop U.S. Highway 85 during such an event (Appendix B). This is mainly due to the inadequate size of the structure. Also, there is brush and small trees at the upstream section of the arroyo and debris and heavy vegetation growing at the downstream end. Regular maintenance such as debris and brush removal from the arroyo in the vicinity of this culvert will significantly improve its flow bypass capacity as there is not much difference between the culvert design capacity and a 100-year flood event.

Figure 22. Upstream section of a single box culvert at U.S. Highway 85 in the 100 Arroyo Basin.

Figure 23. Downstream section of the culvert at U.S. Highway 85 in the 100 Arroyo Basin.

Recommendations for Floodplain Management

The primary objectives of floodplain management are the reduction of flood damage and the preservation (or restoration) of natural floodplain values. The sponsors are in a relatively good position to develop and adopt a comprehensive watershed management plan. Fortunately, very little development has taken place in the floodplain. Many communities are faced with costly remedies such as having to floodproof and/or remove existing structures in order to reduce repetitive flood damages. Preventing development in the floodplain and floodway is the preferred and least costly solution. It also promotes the maintenance of the natural resources of the floodplain.

The following information has been edited from the Floodplain Management Handbook, U.S. Water Resources Council, September 1981. In addition, the information in Appendix A will assist in the review and regulation of future development. The three general strategies for reducing flood losses are modifying the flood, reducing the danger and susceptibility to damage, and reducing the financial and social impacts of flooding. Table 10 displays these three strategies and measures for implementing each strategy.

Table 10. Strategies and Measures for Flood Loss Reduction.

Strategy	Measures
Modify Flooding	Dams and Reservoirs
	Levees and walls
	Channel alterations
	Diversions
	Land treatment
	Onsite detention
Modify Susceptibility to Flooding	Floodplain regulations
	Development and redevelopment
	Warning and preparedness
	Floodproofing
Modify Impact of Flooding	Flood insurance
	Relief and recovery

Modify Flooding

The first strategy involves keeping flood waters away from developments and populated areas by decreasing runoff, increasing channel capacity, or containing, diverting, or storing floodwater. These measures typically mean high capital costs in large public project activities.

Dams and reservoirs capture and temporarily hold floodwater upstream of flood-prone areas. Excess water is gradually released after the flood threat has passed. Use of dams requires sites capable of storing sufficient amounts of water which are upstream but fairly close to the area to be protected. Because of their cost, large dams and reservoirs are usually feasible only where they protect urban areas or high value agricultural lands. For some heavily developed urban areas, dams and reservoirs may provide the only practical means for significantly reducing flood damage.

The protection afforded by a dam is greatest in the area immediately downstream. Protection further downstream is reduced by flows from tributaries and by runoff from areas of land below the dam. Protection can also decrease over time as the reservoir gradually fills with sediment.

Levees and walls confine floodwater to the existing stream and a selected portion of the floodplain. Each of these measures protects only the area immediately behind it and only against the selected flood height for which it was designed.

Levees are normally constructed of earth. The width of a levee's base must be several times greater than the levee's height for stability. As a result, levees more than a few feet in height require significant land rights between the stream and the property to be protected. Significant space may also be required for setting levees back far enough from the channel to provide adequate flow capacity. Levees are best suited for use along large rivers where their construction is less likely to be a severe encroachment on the floodplain. Floodwalls are usually constructed of concrete or steel and take up far less room. They are more suitable for use in congested areas.

Channel alterations reduce flooding by increasing the capacity of the stream or arroyo. The various types of alterations include: deepening or widening the channel, removing debris, paving the channel, and raising or enlarging bridges and culverts that restrict flow. Underground conduits can also be installed to carry part or all of a small stream's flow.

Channel alterations reduce the height of a flood. It is sometimes possible, by extensively reconstructing an arroyo channel, to contain major floods within its banks. Unfortunately, such alterations sometime increase flooding downstream by accelerating the flow of floodwater.

Diversions intercept flood flows upstream of a damage-prone area and route them around the area through an artificial channel. Diversions may either completely re-route an arroyo or only collect and transport flows that exceed the normal capacity of the channel or that would cause damage.

Diversions are particularly well suited for protecting developed areas because they don't require land acquisition or construction within the protected area. However, opportunities for diversions are often limited by the nature of local land formations and soil conditions. There must also be a channel available into which the diversion can empty. The receiving channel must have enough capacity to carry the flow diverted through the diversion without causing further flooding.

Land treatment measures are used to reduce runoff of water to arroyos or other areas. Techniques of land treatment include maintenance of trees, shrubbery and vegetative cover, terracing, slope stabilization and waterways. These measures reduce water flow by improving infiltration of rainfall into the soil, slowing and reducing runoff, and reducing sedimentation that

can clog culverts or storage reservoirs. While the effect of any individual measure is small, extensive land treatment programs can effectively reduce flooding.

The main objective of onsite detention is to prevent excessive runoff from developed or developing areas. Flooding generally increases significantly from lands which have been stripped of vegetation or covered with buildings, pavements and other impervious materials. Also, onsite detention can trap pollutants which would improve water quality.

The principal onsite detention measures can be achieved by reducing land clearing and providing temporary storage for some or all runoff from a property. Use of these measures may be voluntary or required by regulatory or permit programs. Regulations requiring onsite detention are often part of zoning or other broad programs controlling land use and development in upland areas.

The cost of individual onsite detention measures is usually low. However, the cost often falls on the owner of the land where flood waters arise, while most other flood control measures are paid for by the people in the protected area or by the general public.

Onsite detention ponds or reservoirs can lose their effectiveness over time if they are not regularly cleaned and maintained. This can involve a significant cost. Another potential is the lack of unified control over patterns of flow drainage. However, this problem can be handled through broad scale planning of the overall system.

Modify Susceptibility to Flooding

A diverse range of measures is available to reduce the danger and susceptibility to damages from flooding. By and large, they involve little or no construction and have low capital cost.

Floodplain regulations designate flood-prone areas and limit their uses to those compatible with the degree of flood risk. They serve several purposes including:

1. Preventing new development that could result in loss of life and excessive damage to property or reduce the potential for such losses and damages.
2. Protecting unwary buyers from purchasing land or homes in flood-prone areas.
3. Preventing encroachments that decrease the flood carrying capacity of floodplains, increase flood heights, or otherwise aggravate flood problems.
4. Reducing public costs for emergency operations, relief, evacuations, and restoration.
5. Reducing the need for future expenditures for construction, operation and maintenance of reservoirs, levees and other flood control measures.
6. Preserving natural floodplain values.

Development and redevelopment are implemented through public policies which encourage development away from flood prone areas. Utilities, streets, schools and other community facilities attract developers and purchasers to an area. Public policies that limit the extension of services and construction of community facilities in floodplain areas discourage unwise private development. Actions to adopt this kind of public policy must usually be taken well before development pressures occur and should be supplemented with other regulatory measures to ensure success. Limiting extension of utilities and other public facilities into flood-prone areas also limits the need for their repair and replacement after floods.

Redevelopment programs can also be undertaken to correct existing problems. They can include relocating existing buildings to safe sites or demolishing undesirably located structures and providing replacements in a flood-free site. Areas vacated in either way are usually converted to a suitable open space use. Remaining structures may be modified to make them more resistant to flood damage.

Warning and preparedness assist residents and businesses located in flood-prone areas by allowing time for evacuation. The National Weather Service makes flood forecasts for about 2,500 locations, mostly along major streams. The availability of specific flood warnings for other locations depends on the development of flood warning systems by local authorities.

In local flood warning systems, measurements of precipitation, temperature or stream levels upstream of an area are used to predict whether flooding will occur, when it will arrive, and its severity. Local flood warning programs must provide for collecting data, making flood predictions, and disseminating warnings. Warning systems are normally established on a community, county or watershed basis.

The concept of floodproofing (or more accurately, flood resistant construction practices) is to modify buildings, their sites or their contents to keep water out or to reduce the damage caused by water entry. Floodproofing can also be used to reduce disruption of activities, to maintain vital services in operation during a flood, and to permit faster recovery from flooding.

Unlike measures that modify the flooding by protecting large areas or long sections of streams, floodproofing is used to protect individual buildings or small groups of buildings. The most frequently used method of floodproofing is the elevation of buildings above expected flood levels. Small flood walls or levees can be used to protect single buildings or small groups of properties. They have the advantage of protecting the whole enclosed area rather than just the building.

These measures are also useful for protecting buildings for which other floodproofing measures cannot be used because of the building's size or lack of structural strength.

Modify the Impact of Flooding

Some flood losses are likely to take place in developed areas despite measures to control flooding and reduce susceptibility to damages. The primary means for reducing the catastrophic financial impact of flooding on individuals and communities are flood insurance and provisions for relief and recovery.

Flood insurance is offered through private insurance companies and is underwritten or guaranteed by the Federal government. The National Flood Insurance Program (NFIP) provides an opportunity for owners and renters of flood-prone properties to insure against some flood losses. The insurance is available in areas where the local government is participating in the Federal program. The 100-year floodplain map provided by the Natural Resources Conservation Service in this study could be adopted by the city to regulate development and allow residents to obtain flood insurance.

Flood insurance is applicable to all areas subject to flooding. It can be used along with other floodplain management measures which act directly to reduce losses. Owners and renters of

existing structures have the option of purchasing flood insurance. However, financial institutions making loans for purchase of new or existing buildings in flood-prone areas often require the purchaser to buy the insurance.

The major costs to the local government for participation in the National Flood Insurance Program are those for developing and enforcing the required floodplain regulations. The cost to policyholders depends on the amount of coverage purchased and the degree of flood risk.

Relief and recovery occurs after flood damage occurs. The impact of floods on individuals and communities can be reduced by these relief and recovery measures. Losses caused by disruptions and interruptions to businesses, industry, utilities and transportation facilities can be reduced if these activities are quickly returned to normal operation after a flood. This can be accomplished through advance planning for debris removal, pumping of flood water, and restoration of utilities and other community services. This advance planning can be included in flood preparedness plans.

Simply returning a community to its pre-flood condition re-establishes the original risk of flooding. In many cases, opportunities arise after floods to eliminate unsuitable developments which have been damaged or to rebuild essential structures in a way that will minimize future flood losses.

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List of Preparers

George Chavez, State Resource Conservationist, Natural Resources Conservation Service

Roger Ford, Planning Engineer, Natural Resources Conservation Service

Herman Garcia, Area Range Conservationist, Natural Resources Conservation Service

Macario Herrera, District Coordinator, Tierra y Montes SWCD

Michael Johnson, Archaeologist, Natural Resources Conservation Service

Martina L. Padilla, Civil Engineer Aide, Natural Resources Conservation Service

Dan Murray, Agricultural Engineer, Natural Resources Conservation Service

Cyrus Sokoll, District Conservationist, Natural Resources Conservation Service

Atiq Syed, Hydraulic Engineer, Natural Resources Conservation Service

Kathleen Woida, Geologist, Natural Resources Conservation Service

Liz Beth Walker, District Conservationist, Natural Resources Conservation Service

Eduardo Zuniga, Civil Engineering Technician, Natural Resources Conservation Service

Appendix A: Elements of Terrain Management Plans.

Elements of Terrain Management Plans

This appendix provides details specific to floodplain management and regulation of development within the floodplain. Many of the problems associated with flood damages are a direct result of human caused changes beyond the floodplain but within the watershed. Sediment-producing activities within a watershed should be a major concern of any floodplain manager. One means of controlling sediment producing activities as well as flood damages is with terrain management plans.

The New Mexico Subdivision Act (Chapter 348 of the Laws of 1973, 31st Legislature, First Session), as amended, requires the counties of New Mexico to establish subdivision regulations. In making a determination as to whether or not a subdivider can fulfill the proposals contained in his/her disclosure statement and whether or not the subdivision plans conform to county regulations and the Act, the County Board of Commissioners must request opinions from the local Soil and Water Conservation District and others. The local Soil and Water Conservation District reviews the subdivision proposal in relation to terrain management. To assist districts with their reviews, the NRCS developed the New Mexico Subdivision Review Guide. This appendix has been edited from that guide.

Elements of a terrain management plan include: Soils, Grading, Floodplain Management, Storm Drainage, Roads, Erosion Control, and Revegetation and Landscaping. Listed under each element below are the essential features which should be included in the plan and a description of how these features should be planned.

It should be noted that if the terrain management plan does not contain sufficient information about particular features, the needed information should be obtained from the developer.

Soils

The San Miguel County Soil Survey will provide needed information to determine the principal detrimental or unfavorable features of the soils. Limiting features are described by one of three terms: Slight, Moderate and Severe. These terms are defined in the following paragraphs.

Slight means good suitability and is a rating given soils with properties favorable for the intended use. The degree of limitation is minor and can be overcome easily.

Moderate means fair suitability and is a rating given soils with properties moderately favorable for the intended use. This degree of limitation can be overcome or modified by special planning, design or maintenance. Some soils rated as moderate require treatment such as artificial drainage.

Severe means poor suitability and is a rating given soils that have one or more properties unfavorable for the rated use, such as steep slopes, bedrock near the surface, flooding hazard, high shrink-swell potential, a seasonal high water table or low bearing strength. This degree of limitation generally requires major soil reclamation, special designs or intensive maintenance.

Soils having several limitations or which are shown as unsuitable for the intended purpose should not be used for the purpose unless the developer has clearly shown in the plan how these limitations will be overcome.

The major categories shown in a soil survey and used in reviewing a terrain management plan are: Building Site Development, Construction Material, Local Roads and Streets, Underground Utilities, Water Control Structures, and Erosion Control Structures

Evaluation of suitability provided by an NRCS soil survey is limited to a five-foot depth. These are general suitability estimates and are not to be used for foundation design.

Grading

Land grading, filling and clearing operations can cause many problems when performed incorrectly, such as leaving large bare areas subject to wind or water erosion. Grading should not proceed beyond actual development needs. Topsoil should be replaced to aid in revegetation of construction sites. Operations should be planned and designed to enhance natural scenic beauty of the area. Special erosion control measures are usually necessary on sandy soils. The following text lists questions and requirements that should be addressed in the plan.

A. Preserve, match or blend with the natural contours of the land.
   1. Does the plan adequately describe how grading operations will be performed to blend slopes and fills into the natural contours of the land?
   2. Does the plan retain or replace trees and other native vegetation to stabilize hillsides, retain moisture, reduce erosion, reduce runoff and preserve the natural scenic beauty?
   3. Have cuts and fills been designed to minimize the area of exposure and reduce the sharp angles at the toe and sides?
   4. Does the plan prevent the deposit of sediment into floodplains, drainage channels, watercourses and water bodies?

B. Discharges attributable to grading should be prohibited whether the discharge is direct or indirect:
   1. Does the plan prevent sediment and other organic or earthen materials from being discharged into a watercourse, water body, drainage channel, or floodplain?
   2. Does the plan store, stockpile or waste materials where they are not susceptible to erosion and deposition into a watercourse, waterbody, drainage channel, or floodplain?
      a. Does the plan for grading, land forming, and protective cover provide for the prevention of erosion?
      b. Does the plan call for temporary or permanent structural measures to prevent damaging runoff originating on the slope itself?
      c. Do planned structural measures adequately provide for the limitations of the site?

C. When native ground cover is planned to be removed or disturbed or when fill material is planned to be placed on a site, does the plan call for the exposed surface to be treated to the extent necessary to prevent dust from blowing off the construction site?

D. Does the work schedule for grading and filling operations limit the bare soil exposure to the shortest possible time before cover is established?

E. What provisions are made for disposal of vegetation during clearing operations?

F. What is the disposition of earth removed during grading operations?

G. Are the maximum cut and fill slopes compatible with soil stability or erodibility as shown in the soil survey or in city regulations?

H. What provisions were made to prevent runoff from flowing over bare soil slopes?

I. Are mechanical stabilization measures planned for erodible bare soil slopes?

J. If a borrow area is shown, is revegetation planned for the disturbed area?

K. If arroyos or other flow areas are in the planning area, is runoff properly conveyed to a safe outlet?

L. Are provisions made for water and erosion control in borrow ditches along streets and roads?

Floodplain Management

Subdivisions and developments should be planned, constructed and maintained so that:

A. Dwellings are not located within the 100-year floodplain.

B. Structures, fill or excavations, alone or in combination with present or future works, do not adversely affect the capacity of the floodplain.

C. Roads are not located in the floodplain unless specifically approved by the State Highway Department and the road does not conflict with item B above.

D. Confined animal shelters and other structures with a potential for high flood damage are not located in the floodplain.

E. Existing and proposed utilities are free from the threat of flood damage.

Storm Drainage-Drainage Plan

Subdivisions and developments should be planned, constructed and maintained to:

A. Protect and preserve existing natural drainage channels, except where erosion and water control measures are approved.

B. Provide temporary measures to prevent damaging runoff waters from leaving the site until construction is completed and permanent control measures are installed.

C. Protect structures and other works from flood hazards, using the 100-year frequency storm for calculating flood levels.

D. Provide a system in which runoff water within the subdivision is removed without causing harm or damage to the environment, property or persons inside or outside the subdivision area.

E. Assure that waters drained from the subdivision do not contain pollutants or sedimentary materials of any greater quantity than would occur in the absence of the subdivision.

F. Assure that waters are drained from the subdivision in such a manner that they will not cause erosion outside of the subdivision to any greater extent than would occur in the absence of the subdivision.

If the drainage basin in which the subdivision is located is only partially developed, it should be required that the design and construction of the drainage system have sufficient inlet flow capacities and inlet flowline elevations to adequately serve the entire drainage basin. This suggested requirement is based on the assumption that the entire basin will eventually be developed.

Roads

Roads shall be located and designed to:

A. Preserve natural features, vegetation and topography and to protect the natural environment.

B. Ensure proper drainage.

Erosion Control

The plan should clearly indicate that installed measures will prevent or control erosion. At a minimum the following items should be considered:

A. Based on the soils involved, are designed road grades flat enough to prevent erosion?

B. Are borrow areas or drainage features designed to prevent erosion or sediment deposition?

C. Are culvert inlets and outlets properly protected from erosion and sedimentation?

D. Will critical area treatment or special plantings be needed? If so, are the plans adequate?

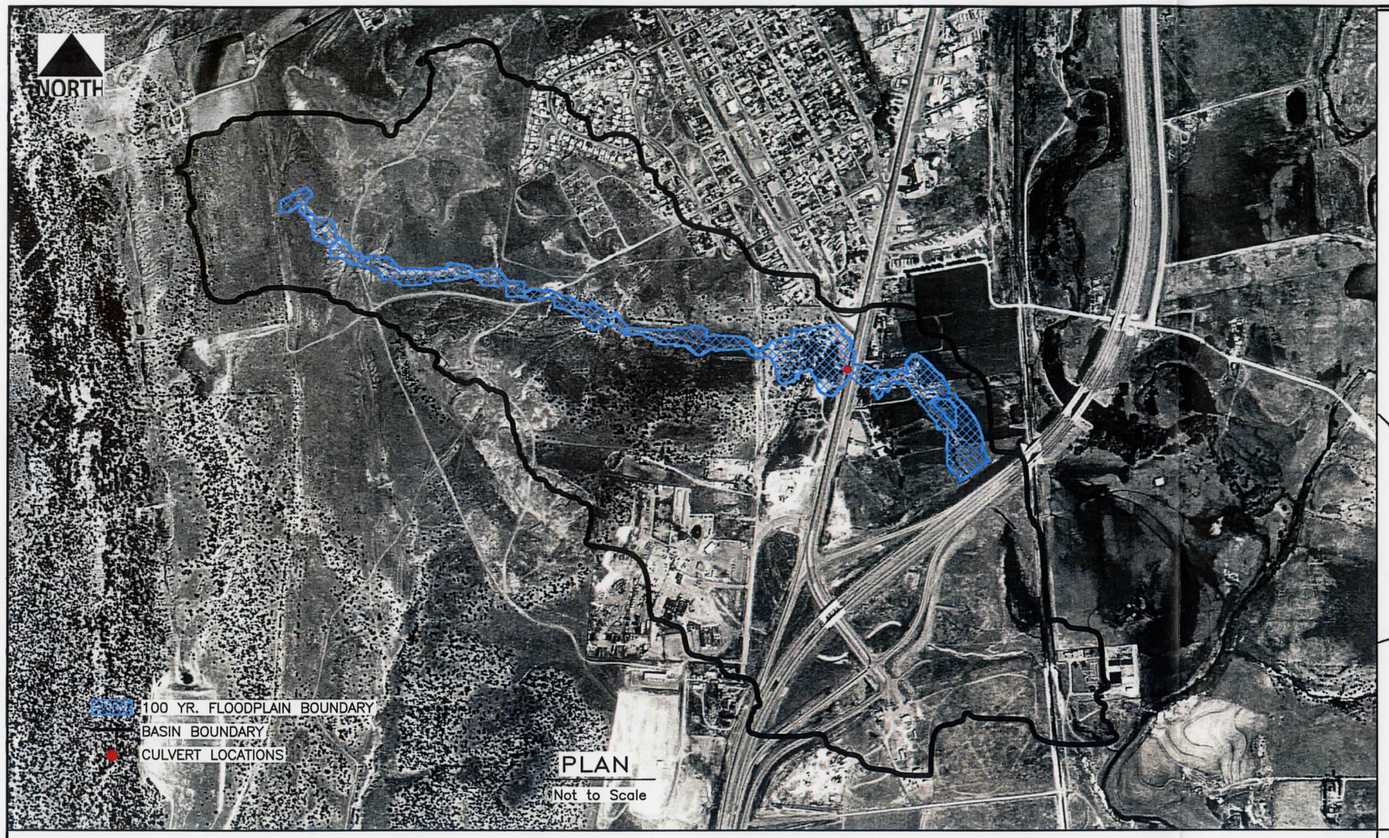
E. Will temporary soil stabilization be needed? If so, is it adequately planned?

F. Is adequate soil stabilization planned on permanent slopes?

Landscaping and Vegetation

Revegetation should be an important part of any subdivision plan. A definite time schedule for installing plant cover would be necessary to prevent erosion, particularly in areas with sandy soils.

Appendix B: Floodplain Maps and Water Surface Profiles.



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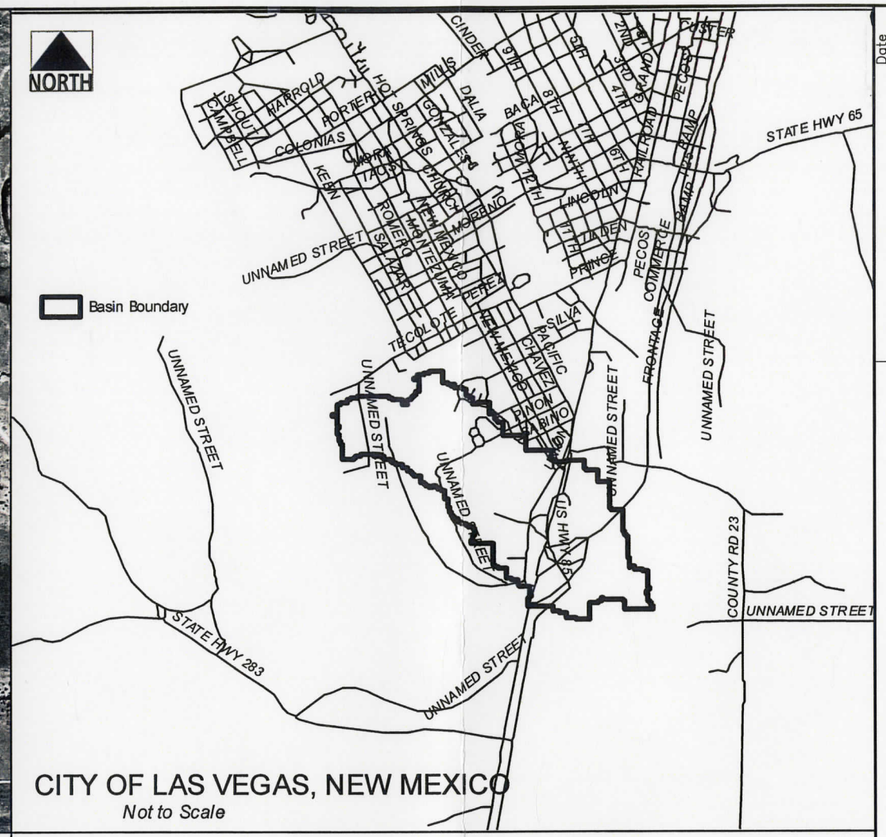

CITY OF LAS VEGAS, NEW MEXICO
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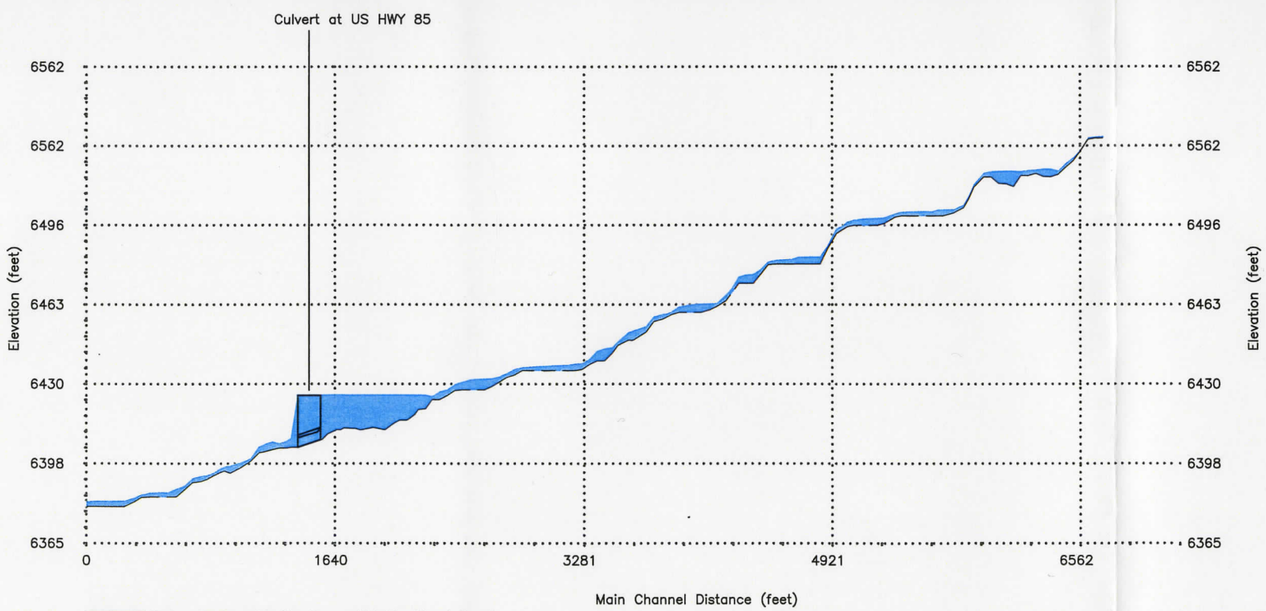

PROFILE

Culvert at US–85 looking dowstream.

Culvert at US–85 looking from above standing on the west side embankment of US–85.

Culvert at US–85 looking upstream.

Looking dowstream from culvert on east side of US–85.

		Date
Designed	Atiq Syed/Dan Murray	June–2006
Drawn	Eduardo M. Zuniga	June–2006
Checked	Roger Ford	June–2006
Approved	David Pacheco	September–2006

New Mexico

ARROYO 100

100 YR. FLOODPLAIN BOUNDARY

Plan, Profile, Vicinity Map and Photos

San Miguel County

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

File Name
Arroyo100.dwg

Drawing Name

Sheet 2 of 11

ARROYO 100

100 YR. FLOODPLAIN BOUNDARY

San Miguel County, New Mexico

NRCS

Natural Resources Conservation Service
United States Department of Agriculture

		Date:
Designed:	Atiq Syed / Dan Murray	June, 2006
Drawn:	Eduardo Zuniga	June, 2006
Checked:	Roger Ford / Atiq Syed	June, 2006
Approved:	David Pacheco	September, 2006

File Name: Arroyo100.mxd

Drawing Name:

Sheet 3 of 11

PLAN

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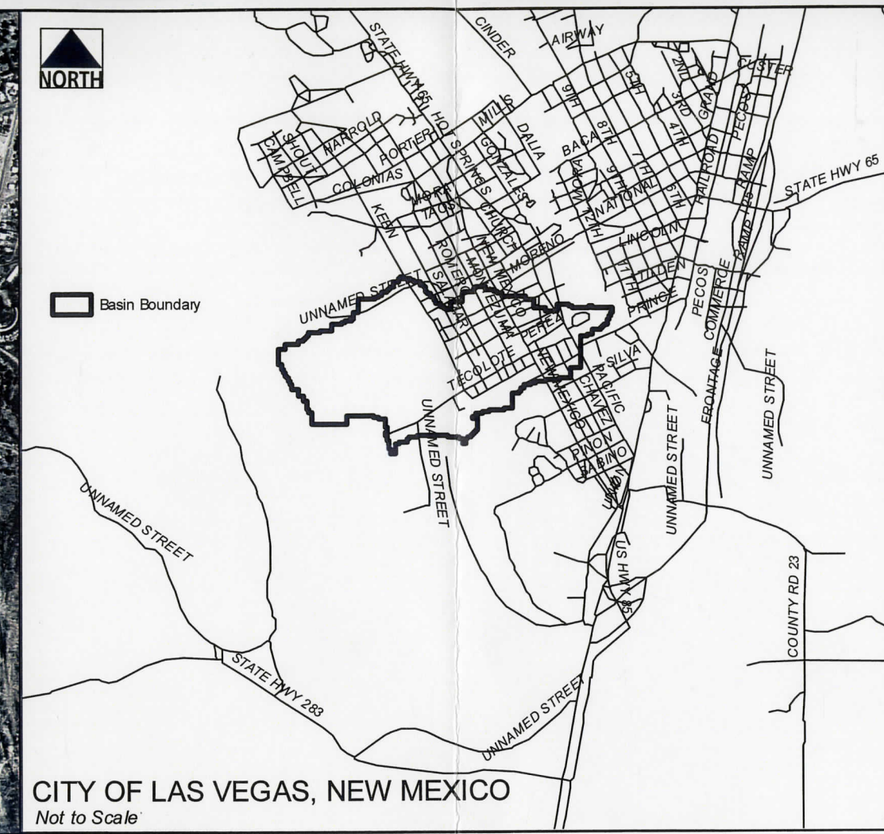

CITY OF LAS VEGAS, NEW MEXICO

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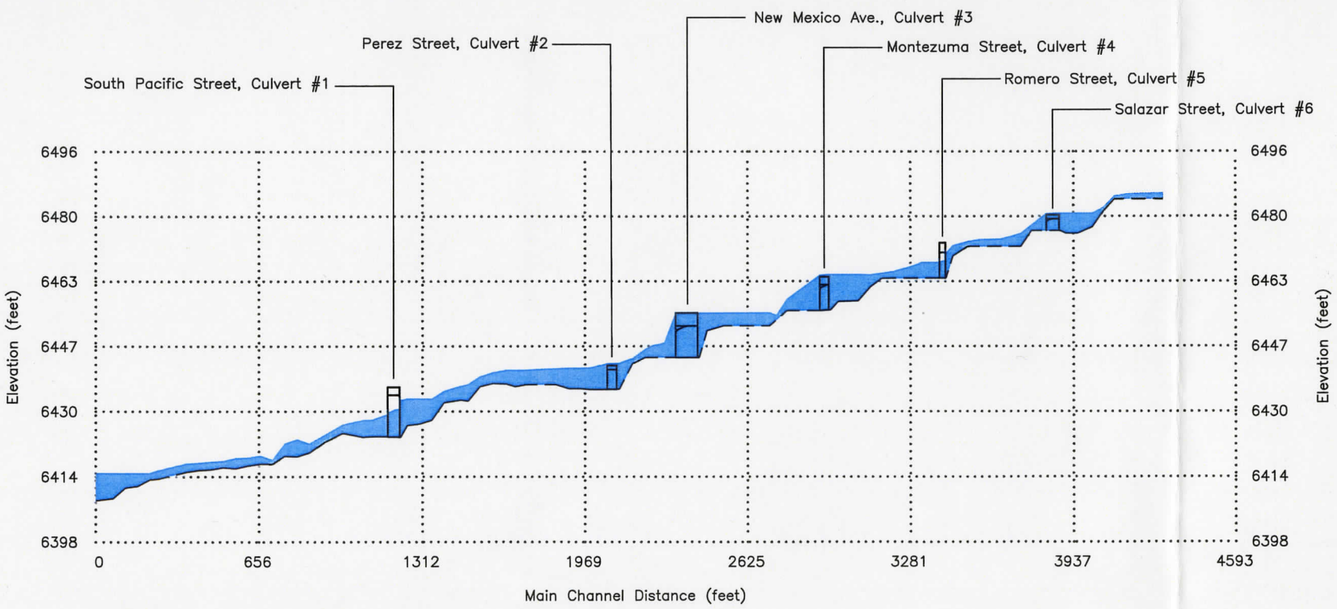

PROFILE

Not to Scale

Culvert at Salazar Street looking dowstream.

Culvert at Romero Street looking dowstream.

Culvert at Montezuma Street looking dowstream.

Culvert at New Mexico Avenue looking dowstream.

Culvert at Perez Street looking dowstream.

Culvert at South Pacific Street looking dowstream.

Culvert at Salazar Street looking upstream.

Culvert at Romero Street looking upstream.

Culvert at Montezuma Street looking upstream.

Culvert at New Mexico Avenue looking upstream.

Culvert at Perez Street looking upstream.

Culvert at South Pacific Street looking upstream.

		Date
Designed	Atiq Syed/Dan Murray	June-2006
Drawn	Eduardo M. Zuniga	June-2006
Checked	Roger Ford	June-2006
Approved	David Pacheco	September-2006

PAJARITO ARROYO 200

100 YR. FLOODPLAIN BOUNDARY

Plan, Vicinity Map and Photos

San Miguel County

New Mexico

NRCS

Natural Resources Conservation Service
United States Department of Agriculture

File Name
PajaritoArroyo.dwg

Drawing Name

Sheet 4 of 11

PAJARITO ARROYO 200

100 YR. FLOODPLAIN BOUNDARY

San Miguel County, New Mexico

Designed: Atiq Syed / Dan Murray — Date: June 2006

Drawn: Eduardo Zuniga — June 2006

Checked: Roger Ford / Atiq Syed — June 2006

Approved: David Pacheco — September 2006

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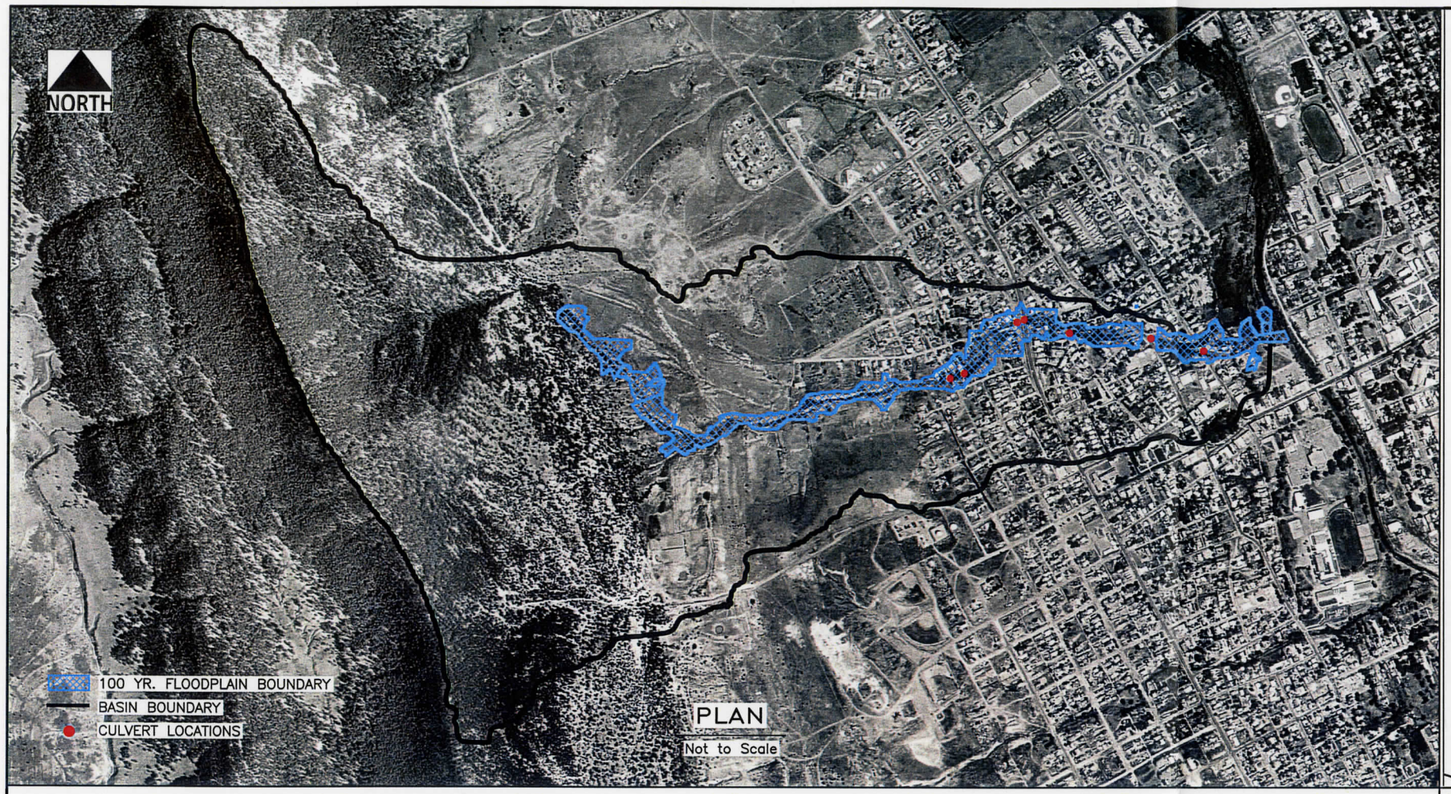
File Name: PajaritoArroyo200.mxd

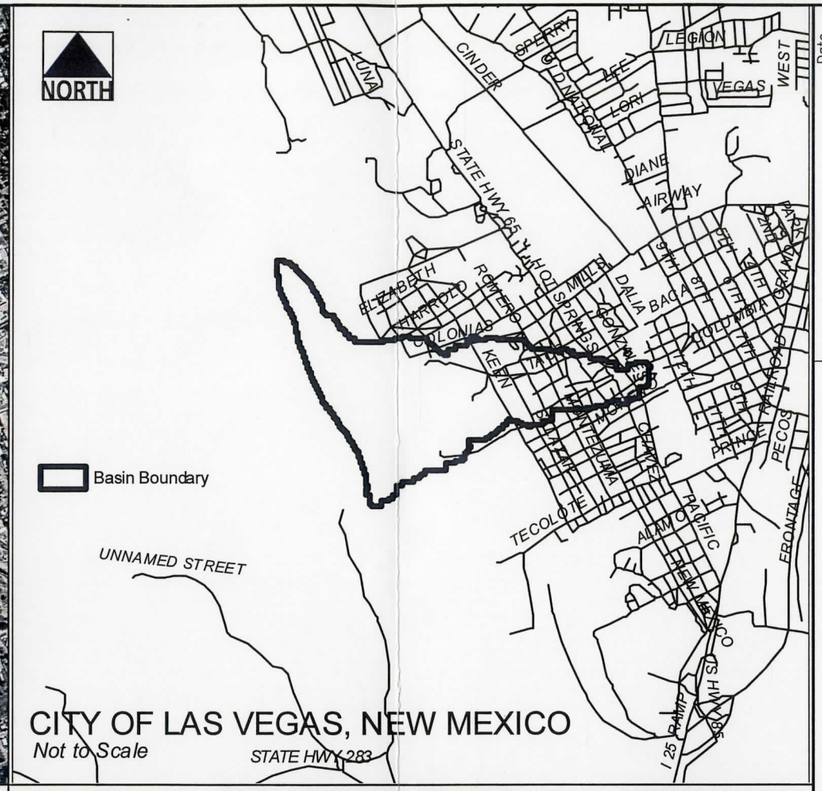
Drawing Name:

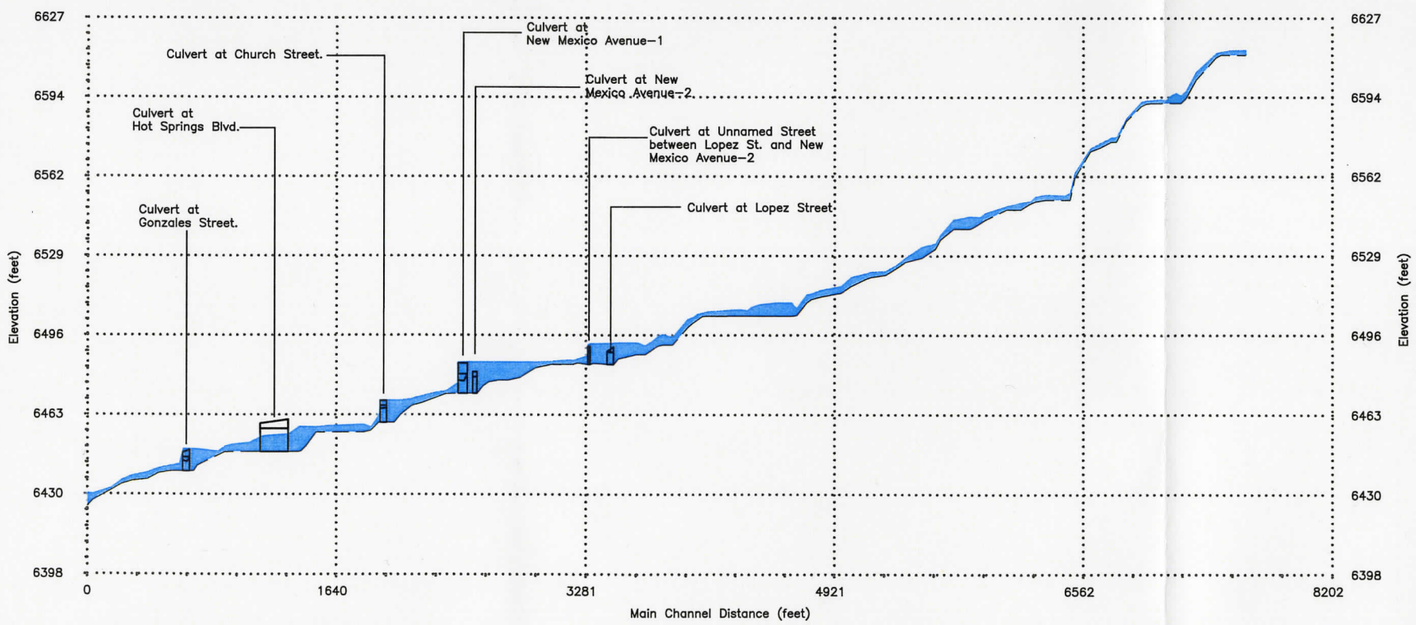
Sheet 5 of 11



PLAN

Not to Scale





PROFILE

Culvert at Lopez St. looking downstream.

Culvert at Lopez St. looking upstream.

Culvert at Unnamed St. looking downstream.

Culvert at Unnamed St. looking upstream.

Culvert at New Mexico Avenue–2 looking downstream.

Culvert at New Mexico Avenue–2 looking upstream.

Culvert at New Mexico Avenue–1 looking downstream.

Culvert at New Mexico Avenue–1 looking upstream.

Culvert at Church St. looking dowstream.

Culvert at Hot Springs Blvd. looking dowstream.

Culvert at Hot Springs Blvd. looking upstream.

Culvert at Gonzales St. looking dowstream.

Culvert at Gonzales St. looking upstream.

		Date
Designed	Atiq Syed/Dan Murray	June–2006
Drawn	Eduardo M. Zuniga	June–2006
Checked	Roger Ford	June–2006
Approved	David Pacheco	September–2006

New Mexico

HERMANOS ARROYO 300

100 YR. FLOODPLAIN BOUNDARY

Plan, Profile, Vicinity Map and Photos

San Miguel County

NRCS

Natural Resources Conservation Service
United States Department of Agriculture

File Name
HermanosArroyo.dwg

Drawing Name

Sheet 6 of 11

HERMANOS ARROYO 300

100 YR. FLOODPLAIN BOUNDARY

San Miguel County, New Mexico

NRCS

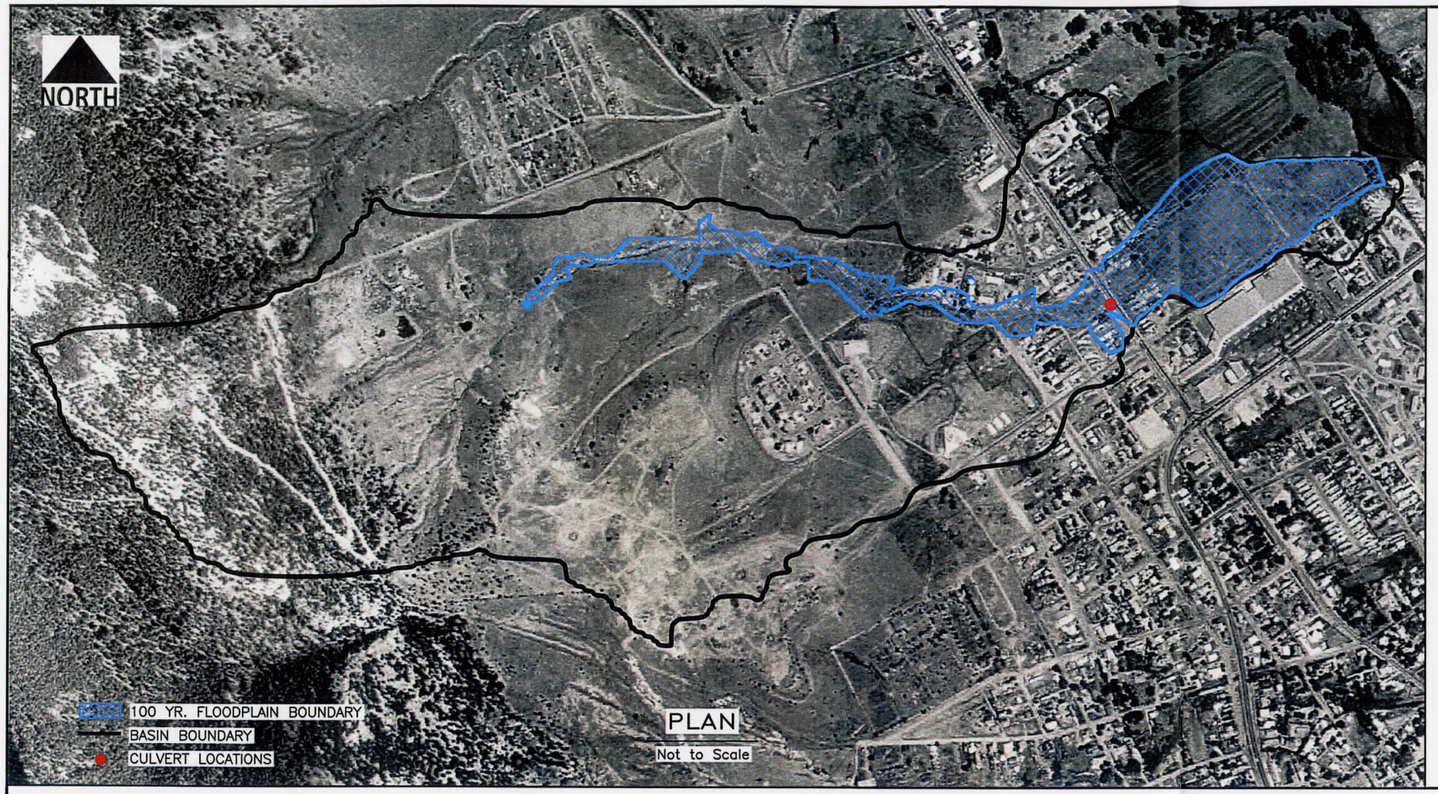
Natural Resources Conservation Service
United States Department of Agriculture

		Date:
Designed:	Atiq Syed / Dan Murray	June 2006
Drawn:	Eduardo Zuniga	June 2006
Checked:	Roger Ford / Atiq Syed	June 2006
Approved:	David Pacheco	September 2006

File Name: HermanosArroyo300.mxd

Drawing Name:

Sheet 7 of 11



PLAN

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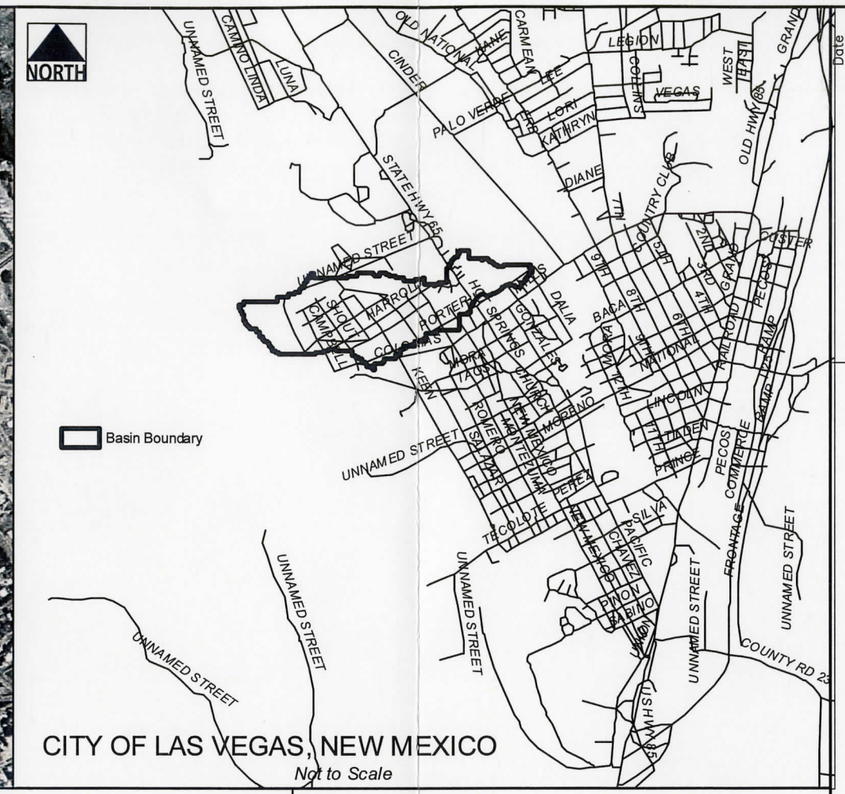
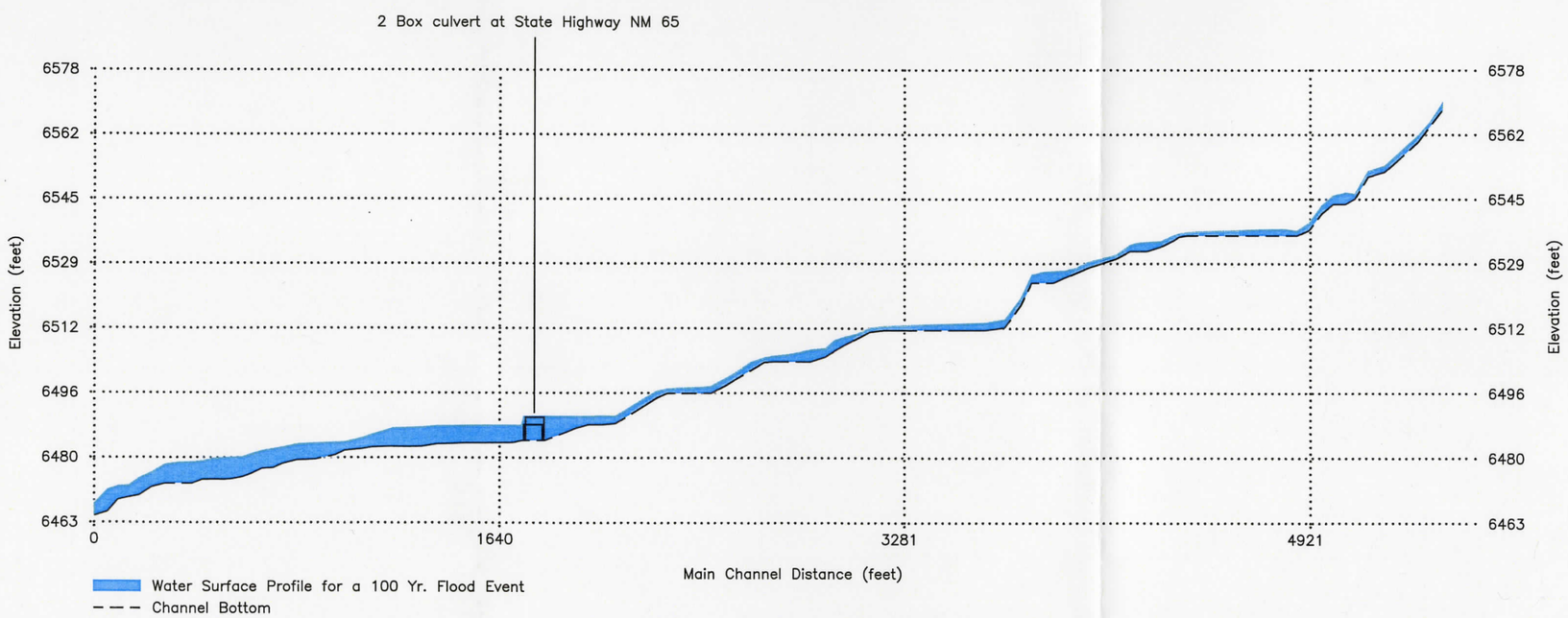




PROFILE

Culvert at US-NM State Highway 65 looking downstream.

Culvert at US-NM State Highway 65 looking upstream.

		date
Designed	Atiq Syed/Dan Murray	June-2006
Drawn	Eduardo M. Zuniga	June-2006
Checked	Roger Ford	June-2006
Approved	David Pacheco	September-2006

New Mexico

ARROYO 400

100 YR. FLOODPLAIN BOUNDARY

Plan, Profile, Vicinity Map and Photos

San Miguel County

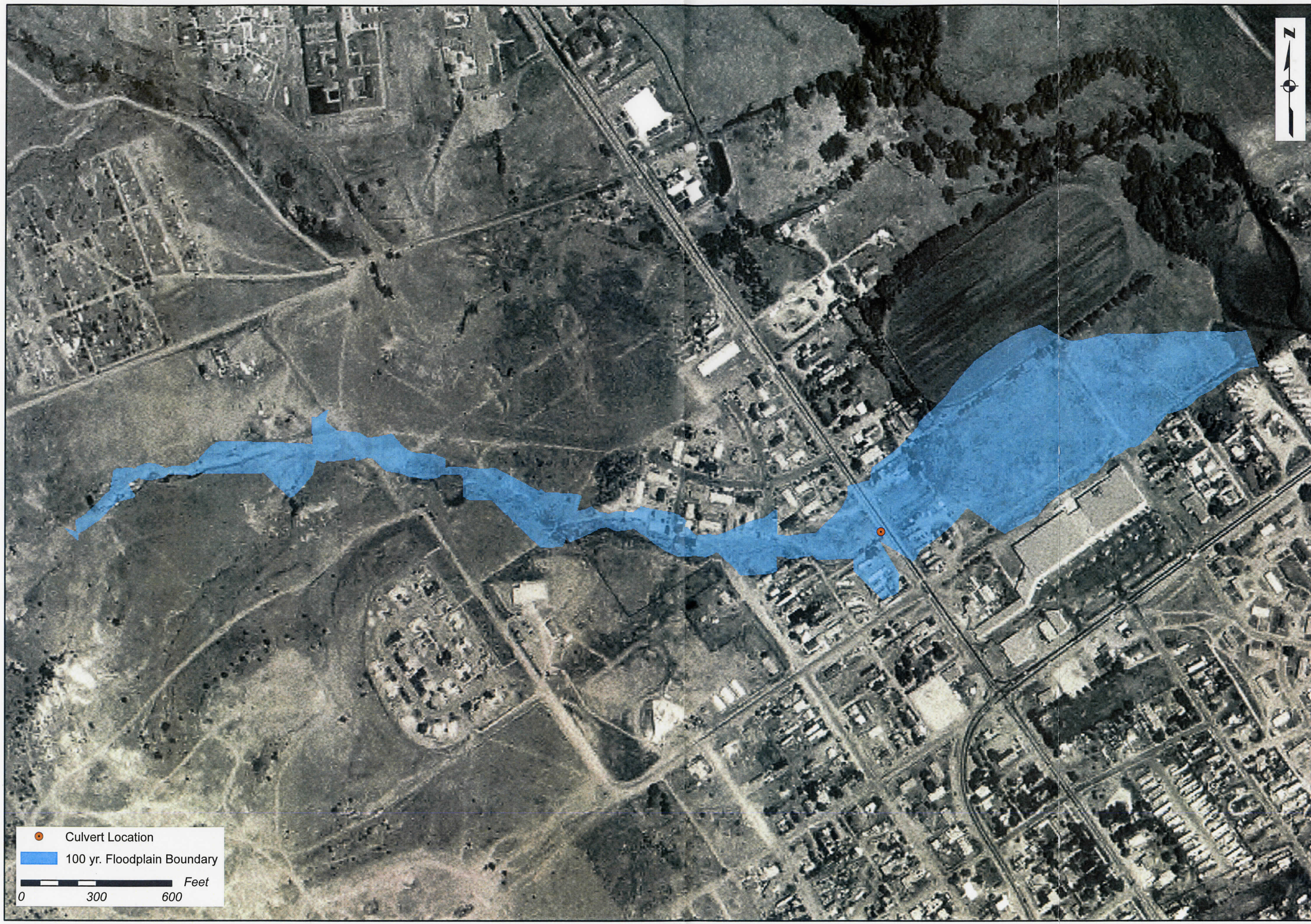
NRCS

Natural Resources Conservation Service
United States Department of Agriculture

File Name
Arroyo400.dwg

Drawing Name

Sheet 8 of 11



ARROYO 400

100 YR. FLOODPLAIN BOUNDARY

San Miguel County, New Mexico

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

		Date:
Designed:	Atiq Syed / Dan Murray	June, 2006
Drawn:	Eduardo Zuniga	June, 2006
Checked:	Roger Ford / Atiq Syed	June, 2006
Approved:	David Pacheco	September, 2006

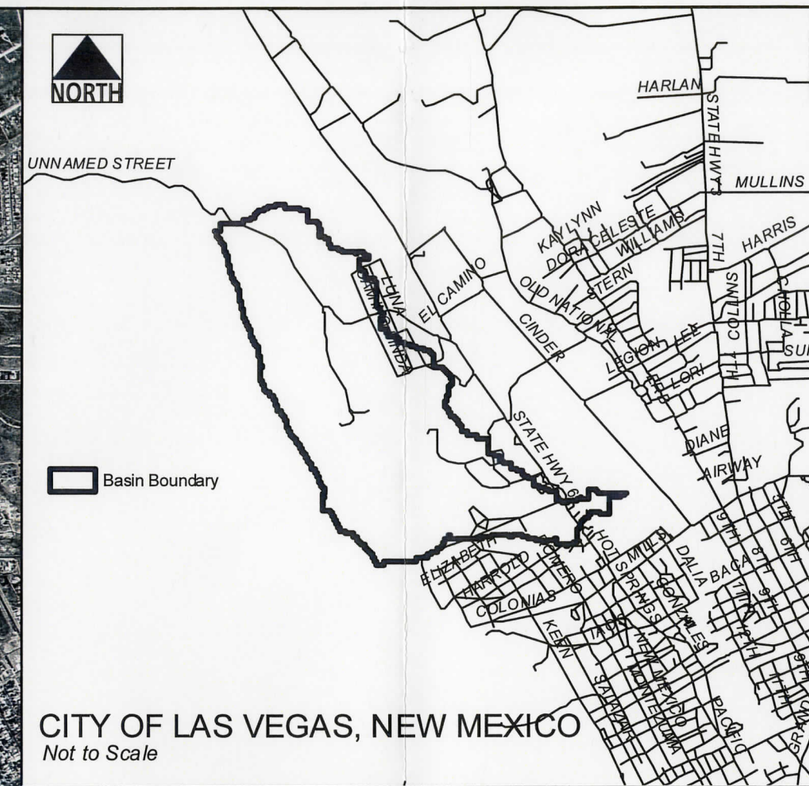
File Name: Arroyo400.mxd

Drawing Name:

Sheet 9 of 11

PLAN

Not to Scale



CITY OF LAS VEGAS, NEW MEXICO

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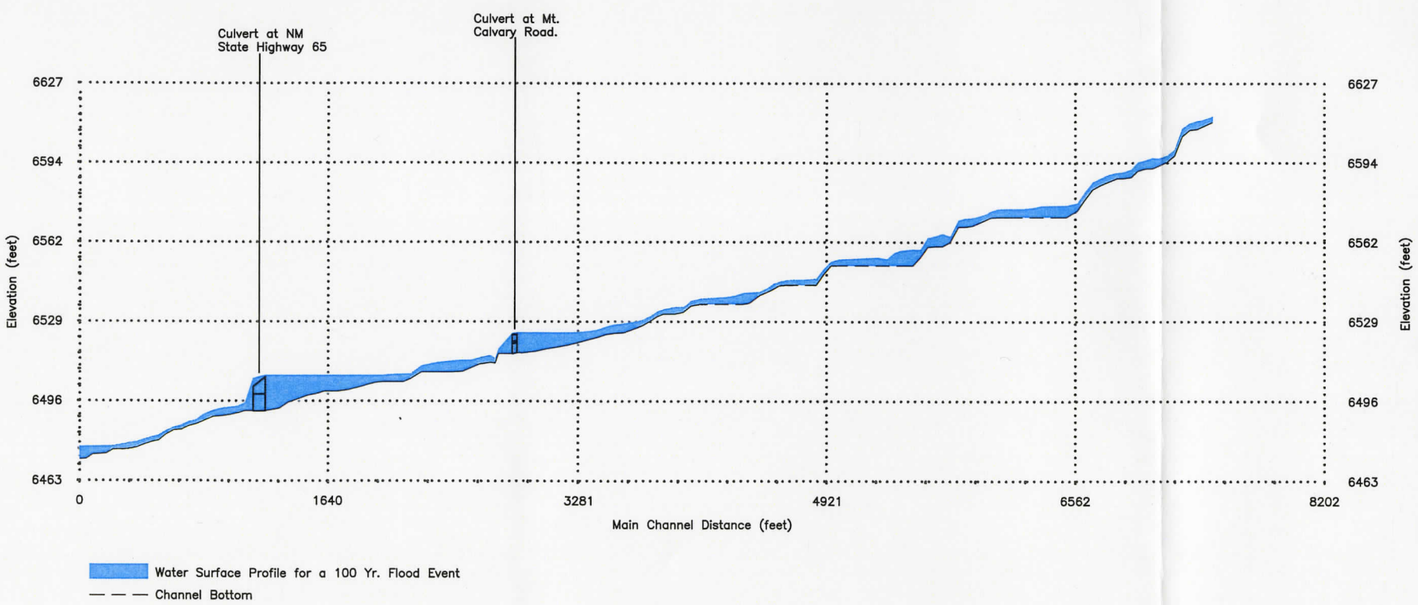


PROFILE

Culvert Mt. Calvary Road looking downstream.

Culvert Mt. Calvary Road looking upstream.

Culvert NM State Highway 65 looking downstream.

Culvert NM State Highway 65 looking upstream.

		Date
Designed	Atiq Syed/Dan Murray	June-2006
Drawn	Eduardo M. Zuniga	June-2006
Checked	Roger Ford	June-2006
Approved	David Pacheco	September-2006

New Mexico

ARROYO 500

100 YR. FLOODPLAIN BOUNDARY AND PROFILE

San Miguel County

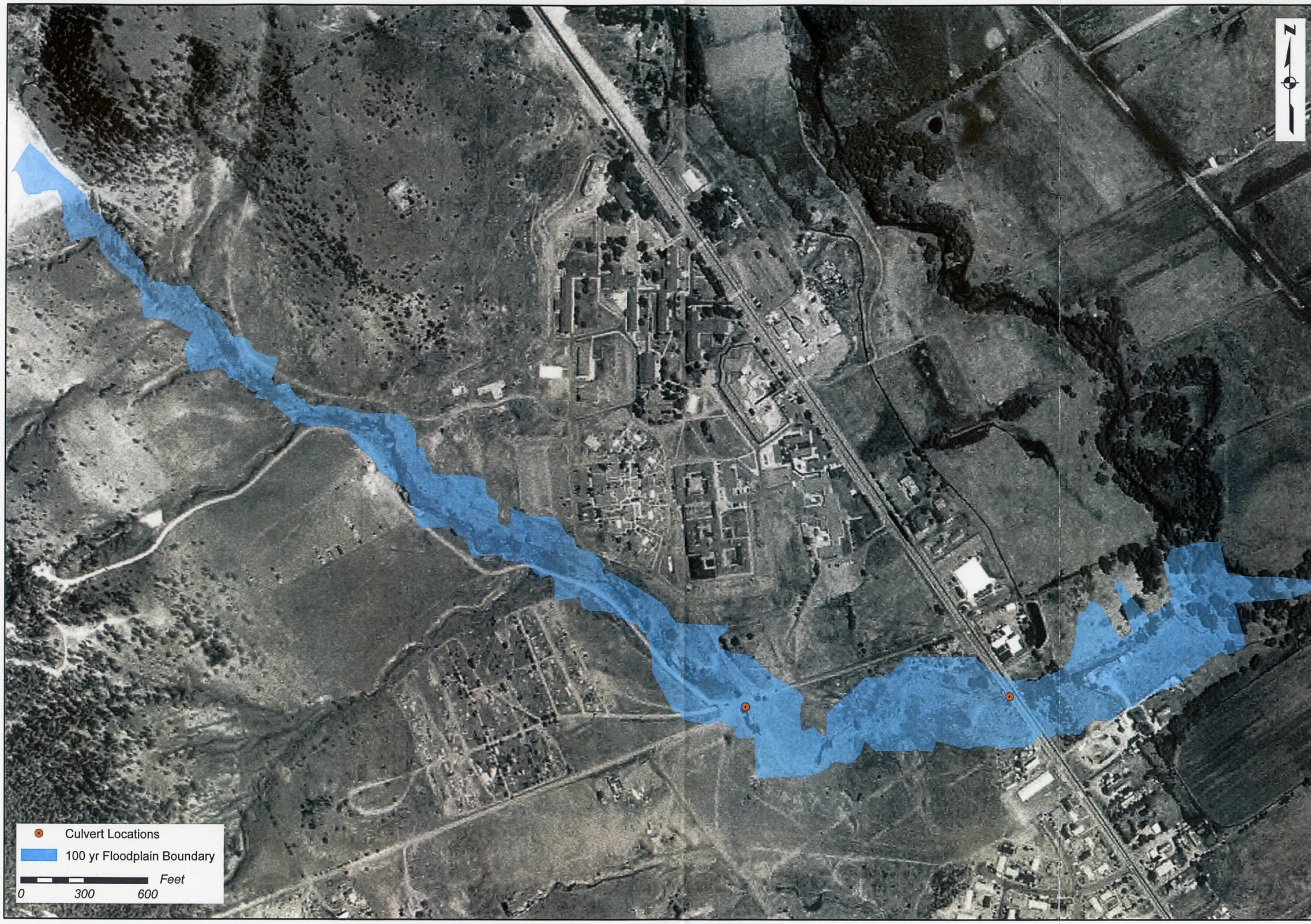
NRCS

Natural Resources Conservation Service
United States Department of Agriculture

File Name
Arroyo500.dwg

Drawing Name

Sheet 10 of 11



ARROYO 500

100 YR. FLOODPLAIN BOUNDARY

San Miguel County, New Mexico

NRCS

Natural Resources Conservation Service
United States Department of Agriculture

		Date:
Designed:	Atiq Syed / Dan Murray	June 2006
Drawn:	Eduardo Zuniga	June 2006
Checked:	Roger Ford / Atiq Syed	June 2006
Approved:	David Pacheco	September 2006

File Name:
Arroyo500.mxd

Drawing Name:

Sheet 11 of 11

Appendix C: Hydrology and Hydraulics.

Table 11. HEC-RAS hydraulics output for Arroyo-500.

River Station	Q Total (cfs)	Min Ch Elevation (ft)	W.S. Elevevation (ft)	Channel velocity (ft/sec)	Flow Area (sq-ft)	Top Width (ft)	Channel Froude Number
2280	1580	6611.22	6613.6	6.78	232.99	187.11	1.01
2265	1580	6609.78	6612.37	7.84	201.5	155.31	1.21
2250	1580	6608.37	6611.68	4.86	325.29	195.74	0.66
2235	1580	6608.01	6610.81	6.76	233.62	166.79	1.01
2220	1580	6605.38	6608.64	10.28	153.68	108.7	1.51
2205	1580	6597.44	6599.94	20.71	76.28	52.84	3.04
2190	1695	6594.85	6597.47	15.04	112.72	70.67	2.1
2171.737	1695	6593.21	6596.3	9.97	170.08	105.86	1.39
2159.999	1695	6592.13	6596.42	5.11	331.44	150.06	0.61
2145	1695	6592.03	6595.5	7.51	225.83	130.23	1
2130.394	1695	6591.08	6594.66	7.71	219.98	142.35	1.09
2117.431	1695	6588.52	6591.71	12.75	132.95	80.63	1.75
2100.655	1695	6588.03	6590.53	9.9	171.28	98.88	1.33
2088.742	1695	6588.03	6590.35	7.8	217.34	116.89	1.01
2070	1695	6586.42	6589.36	7.91	214.29	122.6	1.05
2054.414	1695	6585.04	6587.72	9.68	175.09	112.9	1.37
2039.999	1695	6583.4	6586.39	9.55	177.42	114.68	1.35
2024.999	1695	6579.33	6582.51	14.25	118.97	74.95	1.99
2009.602	1695	6574.71	6577.81	16.35	103.64	67.06	2.32
1988.059	1695	6572.02	6576.77	2.76	614.57	166.85	0.25
1961.508	1695	6572.02	6576.74	2.42	700.66	181.75	0.22
1950.389	1695	6572.02	6576.73	2.25	754.12	194.14	0.2
1937.859	1695	6572.02	6576.6	3.25	521.11	157.71	0.32
1923.315	1695	6572.02	6576.01	6.23	272.24	120.84	0.73
1901.816	1695	6572.02	6575.48	5.77	293.78	179.19	0.79
1887.587	1695	6572.02	6575.5	3.48	486.72	229.81	0.42
1868.315	1695	6572.02	6575.47	2.56	661.2	233.2	0.27
1850.43	1695	6572.02	6575.32	3.24	523.59	293.01	0.43
1836.767	1695	6571.82	6574.5	6.66	254.62	190.29	1.01
1826.036	1695	6570.83	6573.19	8.59	197.25	167.22	1.39
1815	1770	6569.82	6572.46	7.58	233.37	166.27	1.13
1800.288	1770	6568.47	6571.76	5.84	302.98	178.21	0.79
1784.538	1770	6568.01	6571.5	4.82	367.39	199.55	0.63
1771.869	1770	6568.01	6570.8	6.52	271.56	207.23	1
1754.999	1770	6561.75	6563.97	18.03	98.18	78.83	2.85
1739.999	1770	6560.01	6565.17	5.25	336.92	130.75	0.58
1725	1770	6560.01	6564.13	8.21	215.6	104.47	1.01
1709.999	1770	6559.71	6563.49	7.67	230.71	128.49	1.01
1694.999	1770	6555.45	6558.61	16.15	109.57	69.28	2.26
1679.999	1770	6552	6558.71	5.01	353.32	105.18	0.48
1664.999	1770	6552	6558.45	5.59	316.41	98.18	0.55
1653.715	1770	6552	6558.18	6.17	288.67	92.37	0.62
1642.126	1770	6552	6557.13	9.1	194.51	75.87	1
1627.584	1770	6552	6554.69	12.35	143.28	128.61	2.06
1609.457	1770	6552	6555.32	3.57	495.67	176.81	0.38
1540.597	1770	6552	6554.67	4.18	423.59	210.52	0.52
1528.404	1770	6552	6554.46	4.41	401.58	238.07	0.6
1515	1850	6552	6553.64	6.7	275.97	201.02	1.01
1499.999	1850	6548.46	6550.49	11.96	154.73	142.56	2.02
1484.999	1850	6544.03	6546.61	13.27	139.4	101.09	1.99
1470	1850	6544.03	6546.3	5.4	342.72	192.95	0.71
1454.71	1850	6544.03	6546.24	3.61	512.92	270.71	0.46
1439.999	1850	6544.03	6546.17	2.95	627.81	325.7	0.37
1424.999	1850	6544.03	6545.96	3.7	499.61	286.68	0.49
1409.999	1850	6543.7	6545.22	6.1	303.15	267.89	1.01
1398.269	1850	6542.28	6544.41	6.18	299.12	333.92	1.15
1385.282	1850	6541.01	6542.53	8.7	212.73	182.31	1.42
1370.763	1850	6539.71	6541.13	7.85	235.81	220.35	1.34
1349.787	1850	6536.52	6540.84	3.65	506.5	280.84	0.48
1335.937	1850	6536.02	6540.59	4.13	447.41	271.97	0.57
1320.384	1850	6536.02	6539.56	7.33	252.5	152.37	1
1301.341	1850	6536.02	6538.88	5.05	366.06	247.23	0.73

Table 12. HEC-RAS hydraulics output for Arroyo-400.

River Station	Q Total (cfs)	Min Ch Elevation (ft)	W.S. Elevevation (ft)	Channel velocity (ft/sec)	Flow Area (sq-ft)	Top Width (ft)	Channel Froude Number
1665	355	6567.82	6569.55	5.35	66.37	76.57	1.01
1650	355	6563.91	6564.83	13.06	27.19	54.47	3.26
1635	355	6559.81	6561.44	8.24	43.09	51.54	1.59
1619.125	355	6556.92	6558.39	8.8	40.36	55.11	1.81
1607.125	355	6554.63	6556.13	8.24	43.08	57.16	1.67
1593.858	355	6552.23	6553.77	8.24	43.09	56.1	1.66
1573.084	355	6550.98	6552.43	4.34	81.75	137.4	0.99
1556.88	355	6545.41	6546.61	14.36	24.72	41.28	3.27
1545	355	6544.03	6546.9	3.37	105.49	69.81	0.48
1530	355	6544.03	6546.15	5.9	60.15	56.65	1.01
1515.976	355	6541.7	6543.7	9.99	35.55	35.49	1.76
1500	355	6537.4	6539.22	12.06	29.44	32.38	2.23
1485	355	6536.02	6537.19	8.12	43.71	47.24	1.49
1470	355	6536.02	6537.65	2.62	135.46	96.82	0.39
1455	355	6536.02	6537.61	1.87	189.37	130.78	0.27
1440	355	6536.02	6537.53	2	177.12	131.96	0.3
1425	355	6536.02	6537.44	2.17	163.34	129.06	0.34
1410	355	6536.02	6537.31	2.42	146.73	126.59	0.4
1395	355	6536.02	6537.2	2.17	163.57	155.02	0.37
1380	355	6536.02	6537.1	1.86	191.2	190.65	0.33
1361.796	355	6536.02	6536.99	1.8	196.76	214.77	0.33
1349.761	355	6536.02	6536.8	2.61	136.26	185.96	0.54
1340.001	355	6535.73	6536.51	2.87	123.67	276.14	0.76
1333.755	355	6534.88	6536.07	3.5	101.55	270.89	1.01
1316.924	355	6533.1	6534.48	3.73	95.1	130.37	0.77
1300.206	355	6532.02	6534.3	2.39	148.52	129.96	0.39
1290.738	355	6532.02	6534.16	2.85	124.62	116.49	0.49
1279.933	355	6532.02	6533.63	4.78	74.23	107.04	1.01
1262.179	355	6530.09	6531.03	7.22	49.19	104.01	1.85
1228.532	455	6527.89	6529.31	4.82	94.32	133.93	1.01
1213.213	455	6526.51	6527.78	6.12	74.35	104.21	1.28
1198.132	455	6525.23	6527.01	4.48	101.57	94.26	0.76
1185	455	6524.02	6526.87	3.2	142.21	99.17	0.47
1172.67	455	6524.02	6526.74	3.1	146.69	107.89	0.47
1158.176	455	6524.02	6526.01	5.74	79.31	79.72	1.01
1144.625	455	6518.31	6520.05	16.48	27.61	31.71	3.11
1125	455	6512.66	6514.68	10.64	42.78	48.06	1.99
1101.011	455	6512.01	6513.83	2.2	207.2	124.7	0.3
1091.925	455	6512.01	6513.79	2.24	202.88	127.19	0.31
1080.947	455	6512.01	6513.72	2.36	193.05	125.34	0.33
1063.794	455	6512.01	6513.61	2.37	191.74	134.78	0.35
1050.13	455	6512.01	6513.53	2.28	199.37	144.9	0.34
1038.734	455	6512.01	6513.46	2.29	198.48	149.75	0.35
1019.355	455	6512.01	6513.33	2.28	199.39	162.93	0.36
1004.092	455	6512.01	6513.2	2.3	197.58	179.98	0.39
987.264	455	6512.01	6513.08	2.07	219.87	215.69	0.36
976.1978	455	6512.01	6513	2	227.35	239.88	0.36
958.742	455	6511.58	6512.47	4.06	112	224.14	1.01
942.3314	455	6509.78	6511	5.23	87.01	125.78	1.11
927.1577	560	6508.24	6510.21	4.72	118.75	111.92	0.81
914.8341	560	6506.73	6509.34	6.39	87.65	69.84	1.01
903.9068	560	6505.25	6507.35	9.99	56.05	53.47	1.72
885	560	6504	6507.01	4.78	117.24	78.1	0.69
870.0001	560	6504	6506.28	5.79	96.67	95.23	1.01
854.9999	560	6504	6505.72	4.17	134.2	117.88	0.69
840	560	6504	6505.42	3.56	157.14	143.77	0.6
827.4351	560	6503.84	6504.93	4.26	131.33	192.33	0.91
812.0756	560	6501.81	6503.9	4.89	114.51	155.38	1
790.0157	560	6499.25	6500.87	8.46	66.22	81.6	1.65
780.0001	560	6497.97	6499.73	7.14	78.48	88.89	1.34
761.6379	560	6496	6497.71	7.42	75.48	76.82	1.32
750	560	6496	6497.48	3.56	157.14	135.03	0.58

Table 13. HEC-RAS hydraulics output for Arroyo-300 (Hermanos Arroyo).

River Station	Q Total (cfs)	Min Ch Elevation (ft)	W.S. Elevevation (ft)	Channel velocity (ft/sec)	Flow Area (sq-ft)	Top Width (ft)	Channel Froude Number
2400	1175	6612.01	6614.07	5.67	207.13	112.7	0.74
2390	1175	6612.01	6614	4.32	271.74	165.51	0.59
2380	1175	6612.01	6614.02	2.76	438.7	263.74	0.37
2370	1175	6612.01	6613.98	2.49	486.57	282.2	0.32
2350	1270	6612.01	6613.29	5.68	223.42	198.68	0.94
2340	1270	6610.89	6612.72	5.81	218.53	215.99	1.01
2300	1270	6601.54	6604.89	15.69	80.94	48.3	2.14
2280	1270	6594.03	6597.08	19.16	66.3	42.34	2.7
2270	1270	6592.03	6595.19	16.07	79.03	49.98	2.25
2260	1270	6592.03	6596.33	8.66	146.63	68.11	1.04
2250	1270	6592.03	6595.25	10.04	126.49	71.5	1.33
2240	1270	6592.03	6593.24	11.79	107.76	104.58	2.05
2230	1270	6592.03	6593.57	5.14	247.17	180.43	0.77
2220	1270	6592.03	6593.42	4.03	315.36	243.99	0.62
2210	1270	6592.03	6593.27	3.53	360.22	304.68	0.57
2200	1270	6591.77	6593.1	3.31	384.17	367.69	0.57
2190	1270	6590.81	6592.59	4.69	271.01	393.61	1
2160	1270	6584.68	6585.8	13.47	94.3	114.35	2.61
2140	1270	6576.02	6578	14.98	84.77	66.54	2.34
2130	1270	6576.02	6577.82	9.45	134.41	98.1	1.41
2070	1270	6573.56	6575.45	7.83	162.26	182	1.46
2050.95	1270	6572.02	6573.33	7.49	169.59	168.91	1.32
2019.999	1270	6561.16	6563.45	17.17	73.96	64.99	2.84
2010	1270	6552	6554.94	22.38	56.74	38.38	3.24
2000	1270	6552	6553.83	16.02	79.26	52.73	2.3
1970	1270	6552	6554.25	4.31	294.66	143.43	0.53
1960	1270	6552	6554.15	4.03	314.92	168.21	0.52
1940	1270	6551.28	6553.26	6.36	199.66	164.25	1.02
1930	1270	6550.43	6551.41	9.23	137.6	211.24	2.02
1911.208	1270	6548	6550.84	5.69	223.07	146.78	0.81
1882.8	1270	6548	6549.48	6.39	198.69	158.87	1.01
1840	1270	6543.77	6546.63	7.61	166.82	116.76	1.12
1829.999	1270	6542.42	6544.94	10.26	123.77	88.83	1.53
1820	1270	6541.11	6545.1	5.57	227.94	107.87	0.68
1810	1270	6540.03	6545.23	3.25	390.73	141.91	0.35
1776.458	1360	6540.03	6543.85	8.26	164.65	78.85	1.01
1750	1360	6535.56	6537.57	16.49	82.5	74.34	2.76
1740	1360	6531.76	6534.02	15.44	88.11	75.8	2.52
1712.753	1360	6528.02	6532.65	9.35	145.42	62.87	1.08
1679.999	1360	6526.31	6528.12	13.21	102.91	73.7	1.97
1660.665	1360	6523.62	6524.93	10.73	126.75	118.58	1.83
1639.288	1360	6520.9	6522.58	8.61	157.94	120.62	1.33
1609.999	1360	6520.01	6522.26	4.27	318.84	161.09	0.53
1600	1360	6519.26	6521.56	6.72	202.5	145.16	1
1579.999	1360	6517.26	6520.61	6.86	198.37	100.7	0.86
1569.999	1360	6516.31	6519.94	7.9	172.15	91.15	1.01
1550	1360	6513.48	6516.36	13.1	103.81	72.19	1.93
1509.999	1360	6512.01	6514.75	6.44	211.11	168.19	1.01
1490	1360	6510.88	6513.29	2.66	510.89	251.04	0.33
1480	1360	6509.38	6512.73	5.72	237.61	240.45	1.01
1470	1360	6508.73	6509.97	11.93	114.02	70.24	1.65
1460	1360	6504.23	6507.29	14.25	95.45	60.55	2
1450	1360	6504	6509.57	2.69	505.82	213.03	0.31
1440	1360	6504	6509.58	1.95	701.06	208.54	0.18
1430	1360	6504	6509.58	1.76	788.87	194	0.14
1420	1360	6504	6509.53	2.31	611.99	168.81	0.19
1410	1360	6504	6509.44	3.04	446.94	135.27	0.3
1400	1360	6504	6509.12	4.97	273.48	106.69	0.55
1390	1360	6504	6508.91	5.36	253.73	103.86	0.6
1379.999	1360	6504	6508.48	6.48	209.99	93.75	0.76
1369.999	1360	6504	6507.78	7.92	171.76	90.41	1.01
1359.999	1360	6504	6506.3	10.42	130.58	84.18	1.47

Table 14. HEC-RAS hydraulics output for Arroyo-200 (Pajarito Arroyo).

River Station	Q Total (cfs)	Min Ch Elevation (ft)	W.S. Elevevation (ft)	Channel velocity (ft/sec)	Flow Area (sq-ft)	Top Width (ft)	Channel Froude Number
1320	300	6484.02	6485.5	2.05	146.45	131.09	0.34
1305	300	6484.02	6485.45	1.58	190.22	155.85	0.25
1290	300	6484.02	6485.39	1.63	183.74	163.53	0.27
1277.197	300	6484.02	6485.32	1.8	166.74	153.3	0.3
1260	465	6484.02	6484.79	4.25	109.7	200.76	1
1246.21	465	6480.93	6481.86	9.14	50.88	86.84	2.1
1232.874	465	6476.94	6480.46	2.03	228.81	115.46	0.25
1215	465	6475.33	6480.49	0.64	731.99	248.46	0.07
1200.568	465	6475.33	6480.49	0.47	984.97	313.01	0.05
1193.255	465	6476.03	6480.46	0.88	826.87	322.18	0.07
1177.028	Culvert						
1158.462	630	6476.01	6477.64	7.3	128.25	136.53	1.01
1145.388	630	6472.02	6475.32	2.2	286.46	132.83	0.26
1132.135	965	6472.02	6474.58	6.29	153.41	128.49	1.01
1121.271	965	6472.02	6473.93	3.85	252.15	176.43	0.55
1108.747	965	6472.02	6473.89	2.73	354.85	216.28	0.37
1095	965	6472.02	6473.8	2.64	365.34	244.59	0.38
1080	965	6472.02	6473.32	4.78	201.91	185.08	0.8
1061.889	965	6469.55	6472.23	6.31	152.82	123.16	1
1053.642	965	6463.98	6470.36	3.04	492.21	165.06	0.21
1036.876	Culvert						
1023.876	1110	6464.03	6468.07	5.2	302.06	124.05	0.46
1014.92	1110	6464.01	6467.3	7.36	150.79	91.68	1.01
989.8613	1110	6464.01	6465.8	4.3	258.35	165.01	0.6
975.0001	1250	6464.01	6465.37	4.81	260.13	207.44	0.76
960.5175	1250	6461.78	6464.92	4.66	268.03	233.21	0.77
945.8317	1250	6458.3	6465.06	1.75	713.08	267.71	0.19
921.3112	1250	6458.15	6465.07	1.08	1159.94	320.99	0.1
911.8127	1250	6456	6465.06	1.54	1325.42	277.07	0.09
890.5083	Culvert						
856.7832	1250	6455.84	6458.77	9.58	186.86	106.48	0.99
844.497	1250	6453.54	6454.69	14.97	83.5	98.77	2.87
836.2135	1250	6452	6455.39	3.44	363.59	168.38	0.41
825	1250	6452	6455.38	2.61	479.17	204.51	0.3
813.8054	1250	6452	6455.36	2.19	571.08	232.38	0.25
793.8759	1250	6452	6455.31	2.25	555.5	229.1	0.25
780.2868	1250	6452	6455.27	2.22	564.12	233.97	0.25
759.4678	1250	6450.79	6455.26	1.55	807.26	285.46	0.16
749.7331	1250	6444	6455.19	2.82	652.82	137.86	0.15
727.7135	Culvert						
706.7623	1400	6444	6447.71	6.03	301.96	122.87	0.55
690.9485	1400	6444.03	6446.98	7.09	197.45	128.12	1.01
683.6241	1400	6444.03	6446.16	8.4	166.76	118.7	1.25
668.0001	1400	6442.45	6443.82	10.18	137.51	122.25	1.69
649.9576	1400	6436.06	6442.64	2.92	617.36	147.22	0.2
630.3557	Culvert						
614.7966	1400	6435.97	6441.42	4.19	450.11	130.76	0.32
605.7268	1400	6436.16	6441.41	3.31	422.98	133.85	0.33
589.8957	1400	6436.16	6441.41	2.5	559.27	155.79	0.23
573.1568	1400	6437.19	6441.2	3.85	363.21	137.12	0.42
550.5582	1400	6437.19	6441.05	3.74	374.69	143.47	0.41
537.3273	1400	6437.19	6440.85	4.34	322.67	143.81	0.51
523.5632	1400	6436.67	6440.91	2.55	548.86	196.09	0.27
511.8823	1400	6437.36	6440.85	2.76	507.51	198.47	0.3
495.7646	1400	6437.46	6440.22	6.01	232.86	132.64	0.8
480	1400	6436.68	6439.22	7.69	182.05	100.48	1.01
465	1400	6433	6437.19	4.2	333.64	120.64	0.44
456.4132	1400	6433.29	6436.82	5.77	242.48	101.76	0.66
435	1490	6432.62	6435.58	8.39	177.64	82.41	1.01
420	1490	6428.22	6433.57	4.08	364.9	95.59	0.37
405	1490	6427.25	6433.62	2.89	516.27	111.65	0.24
390	1490	6426.9	6433.64	2.14	697.86	160.65	0.18

Table 15. HEC-RAS hydraulics output for Arroyo-100.

River Station	Q Total (cfs)	Min Ch Elevation (ft)	W.S. Elevevation (ft)	Channel velocity (ft/sec)	Flow Area (sq-ft)	Top Width (ft)	Channel Froude Number
2055	210	6532.02	6532.69	1.3	161.34	253.1	0.29
2039.999	210	6532.02	6532.61	1.21	174.13	306.95	0.28
2024.999	210	6531.5	6532.27	3.05	68.81	242.45	1.01
2010	210	6526.74	6527.26	10.68	19.66	63.69	3.39
1995	210	6522.61	6523.96	6.39	32.84	48.35	1.37
1979.999	420	6519.95	6521.68	7.76	54.12	62.37	1.47
1964.999	420	6517.06	6518.64	9.46	44.38	56.03	1.87
1949.999	420	6516.01	6519.45	1.09	386.46	176.1	0.13
1934.999	420	6516.14	6519.44	1.05	399.14	198.04	0.13
1920	420	6517.45	6519.02	4.84	86.84	124.36	1.02
1904.999	420	6516.57	6518.81	2.09	201.43	136.41	0.3
1889.999	420	6516.57	6518.4	4.43	94.85	103.79	0.82
1874.999	420	6512.01	6518.6	0.53	786.72	182.76	0.05
1859.999	420	6513.19	6518.59	0.9	464.26	135.33	0.09
1844.999	420	6513.35	6518.55	1.67	264.05	129.13	0.17
1830	420	6516.01	6518.4	3	140.14	112.66	0.47
1814.999	420	6516.01	6517.71	5.32	78.96	93.14	1.02
1795.376	420	6511.75	6513.03	12.03	34.92	54.14	2.64
1784.999	420	6506.96	6508.25	11.87	35.38	54.47	2.6
1774.335	420	6503.28	6504.5	10.56	39.78	56.55	2.22
1755	420	6501.21	6502.66	5.3	79.24	109.96	1.1
1733.419	420	6500	6502.66	1.48	284.25	128.84	0.18
1724.999	420	6500	6502.62	1.93	217.63	102.63	0.23
1709.999	420	6500	6501.86	6.49	64.76	49.96	1
1703.619	420	6500	6501.94	3.52	119.48	123.33	0.63
1688.541	420	6500	6501.94	1.78	235.55	141.49	0.24
1674.977	420	6500	6501.89	1.88	223.72	137.16	0.26
1662.426	420	6500	6501.85	1.9	220.77	139.35	0.27
1649.943	635	6500	6501.62	3.44	184.71	127.97	0.5
1636.7	635	6499.44	6500.97	5.56	114.17	120.6	1.01
1613.748	635	6498.72	6499.34	5.26	120.67	92.18	0.81
1598.356	635	6496	6499.15	3.84	165.35	106.23	0.54
1572.125	635	6496	6498.88	3.05	208.44	144.93	0.45
1553.259	635	6496	6498.34	4.68	135.61	115.8	0.76
1540.384	635	6495.51	6497.59	5.83	108.96	104.03	1
1530	635	6494.19	6495.88	8.81	72.09	85.37	1.69
1517.773	635	6492.62	6494.6	7.41	85.64	80.62	1.27
1499.999	635	6486.35	6487.44	16.13	39.37	57.88	3.45
1484.999	635	6480.05	6483.13	2.82	225.4	122.23	0.37
1469.999	635	6480.02	6483.15	1.62	391.17	145.87	0.17
1453.774	635	6480.02	6483.12	1.83	349.71	132.7	0.19
1440	635	6480.02	6483.01	2.75	230.58	99.37	0.32
1429.072	635	6480.02	6482.16	7.11	89.36	58.27	1.01
1410	635	6480.02	6481.87	2.99	212.43	128.37	0.41
1395	635	6480.02	6481.68	3.32	191.37	128.29	0.48
1379.999	635	6479.73	6481.02	5.47	116.01	125.68	1
1364.999	635	6475.76	6477.82	11.19	56.74	54.81	1.94
1350	635	6472.02	6475.86	3.42	185.43	96.58	0.44
1335	635	6472.02	6475.66	3.76	168.67	92.4	0.49
1320.995	820	6472.02	6474.8	6.74	121.7	87.81	1.01
1305.618	820	6467.78	6469.63	15.49	52.94	55.39	2.79
1294.723	820	6464.76	6467.27	12.38	66.23	53.7	1.96
1276.85	820	6462.47	6463.81	9.91	82.76	104.19	1.96
1263.839	820	6461.16	6463.7	4.78	171.4	111.86	0.68
1245	820	6460.01	6463.6	3.42	240.05	105.1	0.4
1231.279	820	6460.01	6463.47	3.64	231.65	106.39	0.41
1214.999	820	6460.01	6462.96	5.51	148.81	101.11	0.8
1199.999	820	6460.01	6462.38	5.57	158.43	181.51	0.91
1185	820	6459.06	6460.32	8.56	95.79	144.48	1.85
1177.725	820	6458.27	6459.6	6.17	132.94	182.98	1.28
1169.642	820	6457.42	6459.35	3.93	208.85	170.58	0.63
1149.32	820	6456.2	6458.31	6.1	134.44	118.56	1.01

Table 16. Study area peak flows.

	Peak Flows (CFS)					
BASIN NAME	100-Year Flow	50-Year Flow	25-Year Flow	10-Year Flow	5-Year Flow	2-Year Flow
Arroyo 500 Basin	2025	1670	1260	820	515	190
Arroyo 400 Basin	830	690	525	325	210	85
Arroyo 300 Basin	1550	1275	955	615	380	140
Arroyo 200 Basin	1670	1420	1115	785	540	255
Arroyo 100 Basin	1190	1015	805	565	390	170