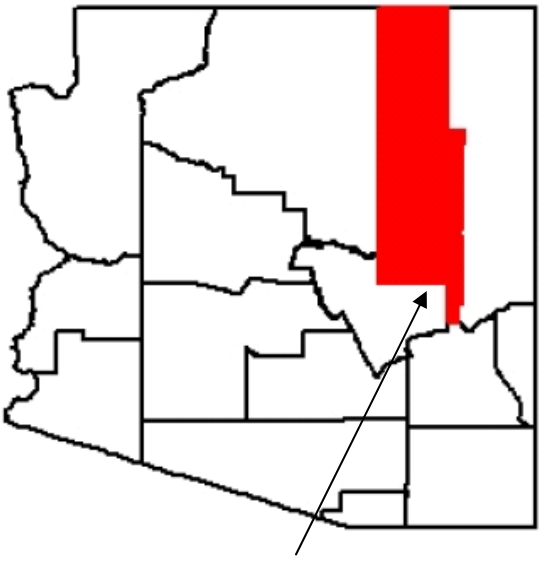
FLOOD INSURANCE STUDY

NAVAJO COUNTY, ARIZONA

AND INCORPORATED AREAS

VOLUME 1 OF 3

Community Name	Community Number
NAVAJO COUNTY,	
UNINCORPORATED AREAS	040066
HOLBROOK, CITY OF	040067
PINETOP-LAKESIDE, TOWN OF	040127
SHOW LOW, CITY OF	040069
SNOWFLAKE, TOWN OF	040070
TAYLOR, TOWN OF	040071
WINSLOW, CITY OF	040072



Navajo County

September 26, 2008

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
04017CV001A

NOTICE TO
FLOOD INSURANCE STUDY USERS

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

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

Old Zone	New Zone
A1 through A30	AE
B	X (Shaded)
C	X (Unshaded)

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

Initial Countywide FIS Effective Date: September 26, 2008

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FLOOD INSURANCE STUDY
NAVAJO COUNTY, ARIZONA AND INCORPORATED AREAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and supersedes the FIS reports and/or Flood Insurance Rate Maps (FIRMs), Flood Boundary and Floodway Maps (FBFMs) in the geographic area of Navajo County, Arizona, including the Cities of Holbrook, Show Low and Winslow, the Towns of Pinetop-Lakeside, Snowflake, and Taylor and the unincorporated areas of Navajo County (referred to collectively herein as Navajo County), and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This FIS study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Navajo County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than those on which this federally supported study is based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3(c). In such cases, however, it shall be understood that the State (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

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

The FIS was prepared to include the unincorporated areas of, and incorporated areas, within Navajo County in a countywide format. Information on the authority and acknowledgements for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown below.

Navajo County

The original hydrologic and hydraulic analyses for the Navajo County FIS were performed by Cella, Barr, Evans and Associates, for the Federal Emergency Management Agency (FEMA), under Contract No. H-4607. This work, which was completed in August 1980, covered all significant flooding sources affecting Navajo County. The Navajo County FIS was revised on August 16, 1988, to incorporate detailed flooding information for Rainbow Lake, which was previously studied by approximate methods.

The Navajo County FIS also was revised on September 30, 1992, to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw.

The Navajo County FIS was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek.

The Navajo County FIS was again revised on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from river mile (RM) 1.6 near the City of Heber to RM 3.4, was studied by detailed methods.

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary, Hog Wash, and Hog Wash Tributary. URS was contracted by FEMA to perform this floodplain delineation study under contract number EMW-2000-CO-0247 Task Order 198.

The Navajo County FIS was further revised on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek and Upper Silver Creek (formerly Silver Creek), Rocky Arroyo, White Mountain Lake, and Mexican Lake within Navajo County. The corporate limits were also updated for the county. The hydrologic analyses for all the revised reaches, with the exception of the Mexican/White Mountain Lake System, were adopted from the "Silver Creek Drainage Study" prepared for Navajo County by KHE (Kaminski-Hubbard Engineering, Inc., May 17, 1991). The hydrologic analysis for the Mexican/White Mountain Lake System incorporated a new rating curve and reservoir routing based on more accurate topographic data included in the HEC-l model prepared by KHE. The hydraulic analyses were performed by Tetra Tech, Inc. (formerly ASL Consulting Engineers), for Navajo County under Project Order No. 2343-0001 (ASL Consulting Engineers, August 2000). This study was completed in August 2000 and submitted to FEMA.

The hydrologic and hydraulic analysis restudy for Cottonwood Wash, from the confluence with Silver Creek to 10 miles upstream, was completed in August 2004 by HDR Engineering, Inc. under IDIQ contract number EMF-2003-CO-0045, Task Order 2.

City of Holbrook

The hydrologic and hydraulic analyses for the City of Holbrook study were performed by Cella, Barr, Evans and Associates, for the Federal Emergency Management Agency, under Contract No. H-4607. This work, which was completed in November 1980, covered all significant flooding sources.

Town of Pinetop-Lakeside

The hydrologic and hydraulic analyses for Town of Pinetop-Lakeside study were performed by Celia Barr and Associates in 1980.

The Town of Pinetop-Lakeside study was revised on August 16, 1988, to incorporate changes in corporate limits due to annexations of portions of Navajo County. The annexed areas included an additional reach of Billy Creek which was previously studied by detailed methods and shown on the FIRMs for Navajo County and Pinetop-Lakeside. Also, a portion of Rainbow Lake, which was studied by detailed methods, was included in the revision. Rainbow Lake was previously studied by approximate methods and shown on the Navajo County FIRM. The detailed flooding information for Rainbow Lake is based on data contained in a report entitled Final Drainage Report for the Shores at Rainbow Lake, Lakeside, Navajo County, Arizona prepared by Collar, Williams, and White Engineering, Inc., Phoenix, Arizona, in March 1986, and revised in April 1986. Based on this report, the 1- and 0.2-percent annual chance flood elevations on Rainbow Lake are 6,712.8 and 6,714.0 feet National Geodetic Vertical Datum, respectively. The changes resulted in revisions to the Vicinity Map, the Floodway Data table, and flood profiles.

The Town of Pinetop-Lakeside study was further revised on September 29, 1989, to incorporate detailed flooding information along Billy Creek from RM 1.62 to RM 3.40 above the confluence of Show Low Creek. The study was completed by the USACE, Los Angeles District, California, in February 1988, as a part of the Limited Map Maintenance Program.

City of Show Low

The original hydrologic and hydraulic analyses for the City of Show Low study were performed by Cella, Barr, Evans, and Associates for the FEMA, under Contract No. 11-4607. This study was completed in September 1980.

Town of Snowflake

The original hydrologic and hydraulic analyses for this study were performed by Cella, Barr, Evans and Associates, for the Federal Emergency Management Agency, under Contract No. H-4607. This work, which was completed in December 1980, covered all significant flooding sources affecting Snowflake.

The Town of Snowflake study was revised February 16, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek and Cottonwood Wash. The new hydrologic analysis was based on a study prepared by Kaminski-Hubbard Engineering, Inc. (KHE), which utilized the USACE HEC-1 computer model. The HEC-1 model included the effects of physical changes such as a dam, and reservoir and diversion structures that were constructed since the Flood Insurance Study was completed. These structures are known as the Schoens Dam, Millet Swale retention area, Ortega Lake diversion system, and Rocky Arroyo Wash diversion system into Long Lake.

Town of Taylor

The original hydrologic and hydraulic analyses for the Town of Taylor study were performed by Cella, Barr, Evans and Associates, for FEMA, under Contract No. 8-4607. This work, which was completed in February 1980, covered all significant flooding sources affecting Taylor.

The Town of Taylor study was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek. The new hydrologic analyses were based on a study prepared by Kaminski - Hubbard Engineering, Inc. (KHE), which utilized the USACE HEC-l computer model. The HEC-l model included the effects of physical changes such as a dam, reservoirs, and diversion, structures that were constructed since the FIS was completed. These structures are known as the Sohoens Dam, Millet Swale retention area, Ortega Lake diversion system, and Rooky Arroyo Wash diversion system into Long Lake.

The Town of Taylor study was again revised on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek (formerly Silver Creek) within the Town of Taylor. The corporate limits were also updated for the Town. The hydrologic analyses were adopted from the “Silver Creek Drainage Study” prepared for the areas of Navajo County, Arizona, by KHE (Kaminski-Hubbard Engineering, Inc., May 17, 1991) The hydraulic analyses were performed by Tetra Tech, Inc. (formerly ASL Consulting Engineers), for Navajo County under Project Order No, 2343-0001 (ASL Consulting Engineers, August 2000). This study was completed in August 2000 and submitted to FEMA.

City of Winslow

The original hydrologic and hydraulic analyses for the City of Winslow study were performed by Celia, Barr, Evans and Associates, for the FEMA, under Contract No. H-4607. This work, which was completed in December 1979, covered all significant flooding sources affecting Winslow.

Planimetric base map information was provided in digital format for FIRM panels. Public Land Survey System (PLSS) and land ownership data were provided by Arizona Land Resource Information System (ALRIS.). Information on roads was provided by Navajo County. Digital Orthophotographic Quarter Quadrangles (DOQQ) were provided from ARIA (Arizona Regional Imagery Archive) and by U.S Geological Survey (USGS). Users of this FIRM should be aware that minor adjustments may have been made to specific base map features.

The coordinate system used for the production of this FIRM is Universal Transverse Mercator (UTM) Zone 12, North American Datum of 1983 (NAD 83), and GRS 1980 spheroid. Corner coordinates shown on the FIRM are in latitude and longitude referenced to NAD 83. Differences in datum and spheroid used in the production of FIRMs for adjacent counties may result in slight positional differences in map features and at the county boundaries. These differences do not affect the accuracy of information shown on the FIRM.

In September 2008, HDR Engineering Inc. completed a countywide DFIRM and FIS for the County of Navajo. HDR Engineering Inc. was hired as an IDIQ study contractor for FEMA Region IX under contract number EMF-2003-CO-0045, Task Order 12. The DFIRM process included digitizing floodplain boundaries from the effective paper FIRMs and fitting them to a digital base map, thus converting the existing manually produced FIRMs to digitally produced FIRMs, referred to as DFIRMs. Individual community effective FIS reports were also combined into one report for the entire county.

1.3 Coordination

Consultation Coordination Officer's (CCO) meetings may be held for each jurisdiction in this countywide FIS. An initial CCO meeting is held typically with representatives of FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is typically held with the representatives of FEMA, the community, and the study contractor to review the results of the study.

Navajo County

The initial community meeting for the unincorporated areas of Navajo County, attended by representatives of Navajo County, FEMA, and the study contractor, was held on August 8, 1977. This meeting was organized by the Consultation Coordination Officer, appointed by FEMA, and was held to explain the nature and purpose of the FIS. The Arizona Water Commission served as the State coordinating agency for the study of Navajo County.

During the course of this study, contact was maintained with the USGS, the U.S. Army Corps of Engineering (USACE), the National Resources Conservation Services (NRCS), formerly known as the U.S. Soil Conservation Services (SCS), the Arizona Department of Transportation (ADOT), the Director of the Navajo County Engineering Department, and the Navajo County Planning and Zoning Administrator.

The results of this study were reviewed at an intermediate/final CCO meeting held on July 24, 1980. Representatives of Navajo County, FEMA, and the study contractor attended this meeting. No changes were made to the study as a result of this meeting.

No initial or final community coordination and consultation meeting was held for the August 16, 1987 revisions of the Navajo County FIS.

An initial CCO meeting was held on August 9, 1988, for a revision of study completed on September 30, 1992. Representatives of FEMA, Navajo County, the ADWR, the City of Show Low, and the study contractor attended this meeting.

A meeting was held with the staff of Navajo County, the Cities of Winslow and Show Low, and representatives of the study contractor on June 7, 1989, as part of a data-collection site visit.

The results of the September 30, 1992 study revisions for Navajo County were reviewed at the final CCC meeting held on March 10, 1992. Representatives of Navajo County, the Cities of Winslow and Show Low, the ADWR, FEMA, and the study contractor attended this meeting.

No initial or final community coordination and consultation meeting was held for the March 2, 1994 revisions, incorporating the effects of new hydrological and hydraulic analysis for Silver Creek.

On February 25, 1992, an initial CCO meeting was held with representatives of Navajo County, the ADWR, FEMA, and the study contractor. The stream to be studied and the limits of study were identified at the meeting. Available mapping, previous studies, and other data were also discussed.

During the preparation of the study, telephone discussions were held between the study contractor and representatives of Navajo County and the State of Arizona.

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary A, Hog Wash, and Hog Wash Tributary A. An initial CCO meeting was conducted on September 17, 2002 and was attended by representatives of FEMA IX, Navajo County and the study contractor.

City of Holbrook

For the City of Holbrook, an initial CCO meeting, attended by representatives of the City of Holbrook, FEMA, and the study contractor, was held on October 18, 1978. This meeting was held to explain the nature and purpose of the FIS and designated detailed methods for the study of Little Colorado River and Whiting Creek.

During the course of this study, contact was maintained with the U.S. Geological Survey (USGS), the USACE, NRCS, ADOT, and the Holbrook City Manager. The Arizona Water Commission served as the State coordinating agency.

The final CCO meeting for the City of Holbrook was held on July 24, 1980. Representatives of FEMA, the study contractor, and the City attended the meeting. No issues were raised at the meeting.

Town of Pinetop-Lakeside

For the Town of Pinetop-Lakeside, FEMA approved the preparation of a FIS using data from the Navajo County FIS (Federal Emergency Management Agency, 1981), on July 16, 1985.

No initial or final community coordination and consultation meeting was held for the August 16, 1988 revisions of the Town of Pinetop-Lakeside study.

No initial or final community coordination and consultation meeting was held for the September 29, 1989 revisions of the Town of Pinetop-Lakeside study

City of Show Low

For the City of Show Low, an initial coordination meeting, attended by representatives of the City of Show Low, FEMA, and the study contractor, was held on August 8, 1977. This meeting was held to explain the nature and purpose of the FIS. The Arizona Water Commission served as the State coordinating agency.

During the course of this study, contact was maintained with the USGS, the USACE, the NRCS, the ADOT, the White Mountain Independent News office, and the City of Show Low Planning and Zoning Director for general community information.

An initial CCO meeting for the restudy of the City of Show Low was held on August 9, 1988, with representatives of FEMA, Navajo County, the Arizona Department of Water Resources (ADWR), the City of Show Low, and the study contractor.

A meeting was held with the staff of Navajo County, the City of Show Low, and representatives of the study contractor, on June 8, 1989 as part of a data-collection site visit.

On June 19, 1990, the results of the study for the City of Show Low were reviewed at an intermediate meeting. Representatives of the City of Show Low, Navajo County, the ADWR, FEMA and the study contractor attended the meeting.

The final CCO meeting to review the results of the study for the City of Show Low was held on September 26, 1991. Representatives of the City of Show Low, Navajo County, the ADWR, FEMA and the study contractor attended the meeting. All issues raised at the meeting have been addressed in this study.

Town of Snowflake

For the Town of Snowflake an initial coordination meeting, attended by representatives of the Town of Snowflake, FEMA, and the study contractor was held on October 18, 1978. This meeting was held to explain the nature and purpose of the FIS. The Arizona Water Commission served as the State coordinating agency.

Contact was maintained during the course of this study with the U.S. Geological Survey, the U.S. Army Corps of Engineers, the U.S. Soil Conservation Service and the Arizona Department of Transportation.

An intermediate/final CCO meeting for the Town of Snowflake was held on July 24, 1980. Representatives of FEMA, the study contractor, and the Town of Snowflake attended the meeting. No issues were raised at the meeting.

No initial or final community coordination and consultation meeting was held for the February 16, 1994 revisions of the Town of Snowflake study.

Town of Taylor

For the Town of Taylor, an initial coordination meeting, attended by representatives of the Town of Taylor, FEMA, and the study contractor, was held on August 8, 1977. This meeting was held to explain the nature and purpose of the FIS and to identify the streams to be studied by detailed and approximate methods.

During the course of this study, contact was maintained with the USGS, the USACE, the NRCS, the ADOT, the White Mountain Independent News, and the Town of Taylor's Public Works Director for general community information.

A final CCO meeting to review the results of the study for the Town of Taylor was held on July 24, 1980. Representatives of the Town of Taylor, FEMA, and the study contractor attended the meeting. No significant changes to the study resulted from this meeting.

No initial or final community coordination and consultation meeting was held for the March 2, 1994 revisions of the Town of Taylor study.

No initial or final community coordination and consultation meeting was held for the November 19, 2003 revisions of the Town of Taylor study.

City of Winslow

For the City of Winslow, an initial CCO meeting, attended by representatives of the City of Winslow, FEMA, and the study contractor, was held on August 8, 1977. This meeting was held to identify the streams to be studied by detailed methods and the streams to be studied by approximate methods.

During the course of the original study, contact was maintained with the USGS, the USACE, the NRCS, the ADOT, the Arizona Water Commission, and the City of Winslow Administrator for general community information.

A combined intermediate and final CCO meeting to review the results of the original study for the City of Winslow was held on January 23, 1980. Representatives of the City of Winslow, FEMA, and the study contractor attended this meeting. No significant changes to the study resulted from this meeting.

For the updated study of the City of Winslow, an initial CCO meeting, attended by representatives of FEMA, Navajo County, ADWR, and the study contractor, was held on August 9, 1988.

As part of a data collection site visit, a meeting with the staff of Navajo County, the City of Winslow, as well as representatives of the study contractor was held on June 7, 1989.

The results of the restudy for the City of Winslow were reviewed at an intermediate CCO meeting held on June 19, 1990. Representatives of Navajo County, the City of Winslow, the ADWR, FEMA, and the study contractor attended this meeting.

A final CCO meeting to review the results of the study was held on March 9, 1992. Representatives of FEMA, the study contractor, the City of Winslow and the ADWR attended this meeting. All issues raised at that meeting have been addressed in this study.

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

Table 1 - INITIAL AND FINAL CCO MEETINGS

Community Name	Initial CCO Date	Final CCO Date
Navajo County, (unincorporated Areas)	August 8, 1977 August 9, 1988 February 25, 1992 September 17, 2002 March 16, 2005	July 24, 1980 March 10,1992
Holbrook, City of	October 18, 1978	July 24, 1980
Pinetop-Lakeside, Town of	July 16, 1985	N/A
Show Low, City of	August 8, 1977 August 9, 1988	September 26, 1991
Snowflake, Town of	October 18, 1978	July 24, 1980
Taylor, Town of	August 8, 1977	July 24, 1980
Winslow, City of	August 8, 1977 August 9, 1988	January 23, 1980 March 9, 1992

For this Countywide FIS, the initial CCO meeting was held on March 16, 2005 for Navajo County and Incorporated Areas. This meeting was attended by representatives of FEMA, HDR Engineering, the study contractor, Navajo County, the Towns of Pinetop-Lakeside, Snowflake, and Taylor, and the Cities of Holbrook, Show Low and Winslow.

The final CCO meeting for the Countywide FIS was held on October 24, 2007 for Navajo County and Incorporated Areas. This meeting was attended by representatives of FEMA, HDR Engineering, the study contractor, Navajo County, the Towns of Holbrook, Snowflake, and Taylor, and the City of Winslow.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the geographic area of Navajo County, Arizona, including the Cities of Holbrook, Show Low and Winslow, the Towns of Pinetop-Lakeside, Snowflake, and Taylor, and the unincorporated areas of Navajo County. The scope and methodologies used in preparation of this Countywide FIS were agreed upon in joint consultation between FEMA and Navajo County. The areas studied by detailed methods were selected with priority given to all known flood hazards and areas of projected development and proposed construction.

Navajo County

The following streams were studied by detailed methods: Billy Creek (near Lakeside); Black Canyon Wash (near Heber); Buckskin Wash (near Heber); Little Colorado River (near Holbrook, Winslow, and Woodruff); Pinedale Wash (near Pinedale); Porter Canyon Draw (near Holbrook); Show Low Creek (near Show Low); Silver Creek (near Show Low and Shumway); Town Wash (near Clay Springs); Walnut Gulch Creek (near

Pinetop); and Whiting Creek (near Holbrook). Various other streams throughout the county were studied by approximate methods. Areas not included are the Navajo, Hopi, and Port Apache Indian Reservations and the Navajo-Hopi Joint Use Area. Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development, at the time of initial study, or re-study.

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

In the August 16, 1988 revisions of Navajo County FIS, Rainbow Lake was studied in detail.

For the September 30, 1992 restudy, riverine flooding of the Little Colorado River from the Atchison, Topeka & Santa Fe Railroad (ATSFRR) bridge to the north section line of Sections 4 and 5, Township 19 North, Range 16 East; Ruby Wash line of Township 19was studied by detailed methods.

Show Low Creek was studied in detail from immediately upstream of Show Low Lake to the southern corporate limit of the City of Show Low. The Oklahoma Flat Draw was also studied in detail from State Highway 260 to the northern limits of the Pine Meadow Development.

The Navajo FIS was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek.

On June 5, 1997, revision of the Navajo FIS included certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from FM 1.6 near the City of Heber to FM 3.4, was studied by detailed methods.

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary, Hog Wash, Hog Wash Tributary. Study limits for Linden Draw extends from the upstream end located near the center of the SE quarter of Section 7, T10N, R21E to the downstream end located near Lone Pine Dam Road. Study limits for Linden Draw Tributary extend from the NE quarter of Section 6, T10N, R21E to the confluence with Linden Draw located approximately1,000 feet north of the northern section line of Section 5, T10N, R21E. Study limits for Hog Wash extend from the upstream end nearby the Deuces Wild Road cul-de-sac in Section 16, T10N, R21E to the downstream end 500 feet upstream of the confluence with Show Low Creek. Hog Wash Tributary extends from approximately 1,000 feet upstream of the North section line of Section 15, T10N, R21E to the confluence with Hog Wash located a few hundred feet upstream of State Route 260 (SR260).

The November 19, 2003 revision incorporated new flood hazard information for Lower Silver Creek and Upper Silver Creek (formerly Silver Creek), Rocky Arroyo, White Mountain Lake, and Mexican Lake within Navajo County.

A hydrologic and hydraulic restudy was completed in August 2004 to incorporate detailed flooding information for a ten mile section of Cottonwood Wash within the Town of Snowflake, the Town of Taylor and through portions of Navajo County. A floodway analysis of Cottonwood Wash was also completed.

City of Holbrook

For study of the City of Holbrook, the flooding caused by overflow from Little Colorado River and Whiting Creek was studied by detailed methods.

Town of Pinetop-Lakeside

For the Town of Pinetop-Lakeside, Billy Creek was studied by detailed methods between 0.6 and 1.62 miles upstream of its confluence with Show Low Creek. The upstream 0.82 mile of this reach of Billy Creek is within the Pinetop-Lakeside corporate limits.

For the Town of Pinetop-Lakeside, Walnut Gulch Creek also was studied by detailed methods between 2.25 and 3.45 miles upstream of its confluence with Rainbow Lake. This entire reach of Walnut Gulch Creek is within the Pinetop - Lakeside corporate limits.

Revisions on August 16, 1988, incorporated changes in corporate limits due to annexations of portions of Navajo County. The annexed areas include an additional reach of Billy Creek which was previously studied by detailed methods. Also, a portion of Rainbow Lake, which was studied by detailed methods, was included in the revision.

In the revisions of September 29, 1989, a portion of Billy Creek from RM 1.62 to RM 3.40 above the confluence of Show Low Creek was studied in detail.

City of Show Low

Within the limits of the City of Show Low, the streams limits designated for detailed and approximate study were determined by FEMA with community and the study contractor input, at the CCO meeting held on August 8, 1977. Patricks Wash, Whipple Wash, Fools Hollow Wash, Fools Hollow Wash East Branch, Navajo Pines Wash (between River Mile 1.3 and River Mile 1.72), and Show Low Creek were designated for study by detailed methods during this meeting. The stream channels designated for study by approximate methods at this meeting included Meadow View Wash, Rolling Acres Wash, Bordons Wash, and Navajo Pines Wash above River Mile 1.72.

An additional reach of Show Low Creek to be studied by detailed methods was identified at the initial CCO meeting held on August 9, 1988. Representatives of FEMA, Navajo County, the ADWR, the City of Show Low, and ACK Engineers, Inc., the study contractor, attended the meeting.

Town of Snowflake

For the Town of Snowflake, the limits of the detailed and approximate study were determined by FEMA during community and study contractor consultations held on October 18, 1978. Silver Creek and Cottonwood Wash from the confluence with Silver Creek to River Mile 2.22 were designated for study by detailed methods during the meeting. Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development available at the time of study. During the same meeting, Cottonwood Wash above River Mile 2.22 was designated for study by approximate methods.

In the revisions on February 16, 1994, a new hydrologic and hydraulic restudy was completed for Silver Creek and Cottonwood Wash.

In August 2004, a hydrologic and hydraulic restudy was completed to incorporate detailed flooding information for a ten mile section of Cottonwood Wash within the Town of Snowflake. A floodway analysis of Cottonwood Wash was also completed.

Town of Taylor

For the Town of Taylor, flooding from Airport Wash, Railroad Grade Wash, and Silver Creek was studied by detailed methods. Flooding on Pinedale Wash was studied by approximate methods. Pinedale Wash was initially designated to be studied by detailed methods during a meeting held on August 8, 1977, but it was later determined that the drainage basin area contributing to this stream channel was less than 1 square mile, and thus, not appropriate for detailed study.

This study was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek.

This study was revised again on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek (formerly Silver Creek) within the Town of Taylor.

City of Winslow

For the City of Winslow, flooding of the Little Colorado River, from the Atchison, Topeka and Santa Fe Railway Bridge to the north section line of Sections 4 and 5, Township 19 North, Range 16 East and Ruby Wash, from the Atchison, Topeka and Santa Fe Railway Bridge to the north line of Township 19 were studied by detailed methods. Flooding from Icehouse Wash and Mikes Wash was studied by approximate methods in the original study.

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

Table 2 - FLOODING SOURCES STUDIED BY DETAILED METHODS

Airport Wash	Billy Creek
Black Canyon Wash	Buckskin Wash
Cottonwood Wash	Fools Hollow Wash
Fools Hollow Wash East Branch	Hog Wash
Hog Wash Tributary	Joseph City Wash
Linden Draw	Linden Draw Tributary
Little Colorado River	Lower Silver Creek
Mesa Wash	Mexican Lake Outlet
Navajo Pines Wash	Oklahoma Flat Draw
Patricks Wash	Pinedale Wash
Porter Canyon Draw	Railroad Grade Wash
Rocky Arroyo Creek	Ruby Wash
Show Low Creek	Silver Creek
Town Wash	Upper Silver Creek
Walnut Gulch Creek	Whipple Wash
Whiting Creek	

All or portions of the flooding sources listed in Table 3, "Flooding Sources Studied by Approximate Methods," were studied by approximate methods. Approximate analyses were used to study only those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon, by FEMA and Navajo County.

Table 3 - FLOODING SOURCES STUDIED BY APPROXIMATE METHODS

Association Tank	Bagnal Draw	Bagnal Wash	Baldwin Draw
Bell Cow Canyon Creek	Belvins Lake	Big Tank	Blairs Spring Wash
Brookbank Canyon Creek	Brown Creek	Buckhorn Draw	Bushman Draw
The Canal	Canyon Creek	Carr Draw	Carrizo Wash
Cedar Lake	Chamise Tank	Charlie Ross Tank	Chevelon Creek
Chevelon Tank	Chimney Canyon Creek	Chuck Box Lake	Clear Creek
Colbath Wash	Concho Flat Wash	Corbet Tank	Cow Lake
Coyote Tank	Crescent Tank	Day Wash	Decker Wash
Digger Wash	Dodson Wash	Dry Creek	Dry Island
Dry Lake	Dry Lake Tank	Duck Lake Tank	ES Tank
East Fork Cottonwood Wash	East Snowflake Ditch	East Washboard Wash	Fern Feather Wash
Fern Tank	Fivemile Draw	Fivemile Wash	Flat Tank
Flat Wash	Fools Hollow Lake	Four Tank	Grover Springs Canyon Creek
Hatch Draw	Hay Hollow Draw	Hay Hollow Wash	Horse Tank
Hoyle Canyon Creek	Humpy Wash	Indian Rock Tank	Jacks Canyon Creek
Jim Camp Wash	Knoll Tank	Leroux Wash	Lithodendron Wash
Little Mormon Lake	Long Draw	Long Lake	Lost Tank Canyon Creek
Louis Hunt Tank	Louis Hunt Tank Draw	Love Lake	Mackelprang Spring
Manila Wash	Marty Tank	McDonald Canyon Creek	Mexican Hollow Wash
Milky Wash	Mikes Wash	Millet Swale	Morgan Wash
Mortensen Wash	Nicks Camp Canyon Creek	Pasture Tank	Phoenix Park Wash
Pierce Wash	Pierce Wash Tank	Porter Creek	Potato Wash
Pour Off Canyon Creek	Prince Tank	Puerco River	Purcell Draw
Rainbow Lake	Red Hill Tank	Red Knoll Tank	Riddle Tank

Table 3 - FLOODING SOURCES STUDIED BY APPROXIMATE METHODS

Right Hand Draw	Rocky Draw	Round Tank	Sacaton Tank
Saunders Tank	Scott Reservoir	Scott Wash	Section 18 Tank
Section Twentynine Tank	Seeps Salt Wash	Settling Tank	Sevenmile Draw
Sheepskin Tank	Sheepskin Wash	Shingle Canyon Creek	Sixmile Draw
Stinson Wash	Stock Tank	Tank	Tank in Flat
Tanner Wash	Tenmile Draw	Three Way Tank	Twin Lakes
Twin Wash	Walnut Draw	Ward Tank	Washboard Wash
West Adamana Tank	West Fork Cottonwood Wash	West Hay Hollow Draw	West Hay Hollow Wash
Wildhorse Wash	Wilford Canyon Creek	Willow Patch Creek	Wilson Draw
Woodruff Lake			

As part of this countywide FIS, updated analyses were included for the flooding sources shown in Table 4, "Scope of Revision."

Table 4 - SCOPE OF REVISION

Stream	Limits of Revised or New Detailed Study
Cottonwood Wash	51,969 ft upstream of confluence with Silver Creek
Cottonwood Wash Split Flow	3,465 ft upstream of confluence with Cottonwood Wash
Hog Wash	From 1,300 ft to 18,800 ft upstream of confluence with Show Low Creek
Hog Wash Tributary	From 200 ft to 5,700 ft upstream of confluence with Hog Wash
Linden Draw	From 13,000 ft to 35,700 ft upstream of confluence with Show Low Creek
Linden Draw Tributary	From 100 ft to 8,100 ft upstream of confluence Linden Draw

This FIS also incorporates the determinations of letters issued by FEMA resulting in map changes (Letter of Map Revisions [LOMR], Letter of Map Revision – based on Fill [LOMR-F], and Letter of Map Amendment [LOMA], as shown in Table 5, "Letter of Map Change."

Table 5 - LETTERS OF MAP CHANGE

Community	Flooding Source(s)/Project Identifier	Date Issued	Type	Case Number
Navajo County	Ruby Wash Levee Freeboard Improvement	04/28/1999	102	99-09-443P

Table 5 - LETTERS OF MAP CHANGE

Community	Flooding Source(s)/Project Identifier	Date Issued	Type	Case Number
Navajo County	Joseph City Floodplain Delineation Study	04/20/2000	102	99-09-1226
Navajo County	Holbrook Levee Project	03/20/1998	102	98-09-379P
Navajo County	Levee South Of City Of Winslow Airport	02/28/1994	102A	93-09-574P

2.2 Community Description

Navajo County

Navajo County is located in northeastern Arizona. Navajo County is bordered to the north by San Juan County, Utah; to the south by Gila and Graham Counties; to the east by Apache County; and to the west by Coconino County. The County is approximately 212 miles long and 47 miles wide and the total area of the County is approximately 6,343,400 acres, or 9,910 square miles. The City of Holbrook, the county seat, is approximately 150 miles northeast of the City of Phoenix. Other sizable towns within the County include the towns of Show Low and Snowflake and the City of Winslow. The population of the County was estimated to be 97,470 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000). Major growth areas include the area in and around the newly-incorporated town of Pinetop-Lakeside (July 24, 1984) and the towns of Show Low, Snowflake, and Taylor. Concentrated development within flood hazard areas has occurred only in the vicinity of the communities of the City of Holbrook and the City of Winslow along the Little Colorado River.

The highest elevations within the County range from approximately 7,000 to 8,300 feet on the Black Mesa in the northern part of the County, to 6,500 to 7,500 feet along the Mogollon Rim in the southern part of the County. The lowest point in the County, located north of the City of Winslow, is approximately 4,800 feet. The physiography of the County consists of high plateaus, ranging from slightly to strongly incised, composed primarily of sandstone and shale. One small area in the extreme southern tip of the County and another area north of Pinetop-Lakeside are dominated by basaltic rocks. A third area, lying approximately 50 miles north of the City of Holbrook, is dominated by volcanic materials consisting of basalt-capped mesas, cinder cones, and exposed volcanic necks. Approximately 18 percent of the County consists of deeply incised “badlands” and roughly-broken land composed of highly-erodible materials that contribute large amounts of sediment to the drainage system. The Little Colorado River watershed drains all but the extreme southern and northern parts of the County.

Annual precipitation ranges from approximately 8 inches near the City of Winslow to 30 inches or more along the Mogollon Rim. Vegetation types present in the County are strongly influenced by the amount of precipitation available during the year. Vegetation cover on the Black Mesa is generally pinyon pine and juniper, with an understory of brush and grasses. In the lower, drier areas of the County, the vegetation is generally comprised of sparse stands of brush and short grasses. Further south, approaching the Mogollon Rim, vegetation again becomes dominated by pinyon pine, juniper, and assorted brush and grasses. Ponderosa Pine forests are located in the zones of higher precipitation and elevation along the Mogollon Rim.

Heber Area

The unincorporated community of Heber-Overgaard is located approximately 45 miles west of the City of Show Low on State Highway 260. The population for this community was estimated to be 2,722 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

Heber-Overgaard is located within the high mountainous regions of the southwestern corner of the County and the surrounding vegetation is comprised primarily of Ponderosa Pine forest. Soils of the area are Type B with moderate infiltration rates (U.S. Department of Agriculture). The average annual precipitation is approximately 23 inches and the principal precipitation is in the form of snow during the winter months.

The community of Heber-Overgaard is located near the confluence of two major washes, Buckskin Wash and Black Canyon Wash. These stream channels are relatively well-incised and, as a result, few homes have been constructed within areas subject to extreme flood hazard.

Pinedale-Clay Springs Area

The unincorporated communities of Pinedale and Clay Springs are located approximately 15 miles west of the City of Show Low along State Highway 260. The population of the Pinedale-Clay Springs area has not been computed; however, it is estimated that their combined population is approximately 200 people.

Pinedale and Clay Springs are within the high mountainous regions of northern Arizona and the surrounding vegetation is mostly Ponderosa Pine, with some juniper. The climate of the area is cool, with daytime summer temperatures averaging 72°F and daytime winter temperatures averaging 40°F. Soils of the area are comprised of Type B with moderate infiltration rates (U.S. Department of Agriculture).

The principal stream system near the community of Pinedale is Pinedale Wash. At the time of this study, no homes or businesses had been constructed within the floodplain areas of this wash. The principal stream channel through the community of Clay Springs is Town Wash, a small mountain stream with a basin area of approximately 3.5 square miles. Some homes have been constructed within the floodplain areas of Town Wash; however, historically flooding has created very few problems.

Shumway Area

The small unincorporated community of Shumway is located approximately 5 miles south of the Town of Taylor along State Highway 77. No population information is available for the community of Shumway; however, it is estimated that fewer than 100 people reside in this community.

The community of Shumway is located within a transition zone between the high plateau deserts and the pine forests of the White Mountains. The surrounding vegetation is characteristically comprised of juniper and grasslands.

Climate of the area is basically warm and semi-arid to arid. However, the winter temperatures may be significantly lower than adjoining desert areas. Mean daytime temperatures during the winter months average 45°F and the mean annual precipitation is approximately 10 inches at Shumway. Soils of the area are Type C with a low infiltration capacity (U.S. Department of Agriculture).

The principal riverine system in near the community of Shumway is Silver Creek, which is one of the major tributaries to the Little Colorado River. Historical flood flow records indicate the occurrence of several large-magnitude flows along Silver Creek during the

period of human occupancy. Several homes have been constructed near the floodplain fringes of Silver Creek; however, little damage has occurred during recent years.

Woodruff

The unincorporated community of Woodruff is located approximately 15 miles southeast of Holbrook off State Highway 77 (SH 77). No population statistics are available for the Woodruff area; however, it is estimated that fewer than 100 people comprise this community. The elevation at Woodruff is approximately 5,700 feet. Woodruff is located within the high desert areas of northern Arizona and the surrounding vegetation is comprised mostly of sparse grasses and small shrubs. The climate, topography, and soils are very similar to the City of Holbrook area. The Little Colorado River is the major river system passing through the community. At Woodruff, the Little Colorado River is characterized by a highly incised stream channel with relatively narrow floodplain widths. Historically, flooding along the river has presented very few problems.

City of Holbrook

The City of Holbrook is located near the eastern border of Navajo County in east-central Arizona, approximately 85 miles east of Flagstaff, along Interstate Highway 40. The total land area contained within the corporate limits is approximately 6 square miles. The population of the City of Holbrook was estimated to be 4,917 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000). Holbrook is an important trading center at the junction of several transportation lines in addition to being a service center for travelers and surrounding ranches and farms. The City of Holbrook is the Navajo County seat. The economy of the region is based on Federal, State, and local government agencies; wholesale and retail trade; light manufacturing; and retail services.

The Little Colorado River and its major tributary, the Puerco River, drain an area of approximately 11,300 square miles upstream of the City of Holbrook. Elevations within the drainage area range from 11,500 feet at Mt. Baldy, southwest of Springerville, to just under 5,100 feet at the City of Holbrook. Whiting Creek, which originates locally and is comprised of a small desert watershed, is the only other stream system that affects the City of Holbrook.

The City of Holbrook study area lies in a shallow desert valley. Soils of the region are classified as Type C, with a low infiltration rate (U.S. Department of Agriculture). There are two general Type C soil types. The first soil type is the Moenkopie Rock Outcrop Association, which have reddish-brown, sandy loam profiles and may be gravelly in some places. The depth to hard reddish sandstone or sandy shale is normally from 4 to 12 inches. The second soil type is the Palma-Clovis Association, which are deep soils on old upland alluvium. Palma have a reddish-brown loamy fine sand profile. Clovis is similar to Palma, but grades to calcareous, very fine sandy loam below a depth of approximately 30 inches. (U.S. Department of Agriculture, May 1969).

The climate for the City of Holbrook is similar to that for the City of Winslow; and consists of warm and arid conditions, with normal annual precipitation averaging 8 inches. The principal rainy season generally begins in June and continues through September. During the fall months, there are occasional rains and snows. Winter storms occurring between late October and April reflect strong orographic influences (William B. Sellers, Richard C. Hill, 1974). During the winter months, precipitation is principally in the form of snow.

Except for large trees and shrubs associated with the riparian community, the vegetation in the City of Holbrook is sparse, with grasses and small shrubs dominating the area. Vegetation cover of the Little Colorado River drainage basin ranges from mountain

forests to nearly barren desert. The vegetation found in the drainage basins contributing flow to Whiting Creek consists entirely of sparse desert brush.

Town of Pinetop-Lakeside

The Town of Pinetop-Lakeside was incorporated on July 24, 1984, and is located in southeastern Navajo County on the Mogollon Rim. The unincorporated communities of Lakeside and Pinetop are located approximately 15 miles south of the City of Show Low on State Highway 260 (SH 260). The population of the Town of Pinetop-Lakeside was estimated to be 3,582 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

Soils in the area are Type B with moderate infiltration rates when thoroughly wetted (U.S. Department of Agriculture). The climate in this area is similar to the cooler, more mountainous regions of northern Arizona. The principal precipitation is in the form of snow during the winter months and normal annual precipitation is approximately 21 inches. The surrounding vegetation is predominantly Ponderosa Pine forest.

The principal stream systems in Pinetop-Lakeside are Billy Creek and Walnut Gulch Creek. Population increases and the pressure for land development have resulted in some homes being constructed within the flood hazard areas of these creeks. The stream channels in this area are highly incised and contained within well defined limits and, as a result, the communities of Lakeside and Pinetop have relatively few significant flooding problems.

City of Show Low

The City of Show Low is located in southeastern Navajo County, approximately 200 miles northeast of Phoenix, on U.S. Highway 60. The total land area contained within the corporate limits is approximately 15.5 square miles. The population of the City of Show Low was estimated to be 7,695 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

The principal riverine system in the community is Show Low Creek, which originates south of Show Low in the White Mountains and flows northward through the City of Show Low. Show Low Creek and its tributaries have a drainage area of approximately 87 square miles at the City of Show Low. Elevations within the drainage area range from 10,000 feet within the White Mountains south of Show Low to just under 6,400 feet at the City of Show Low.

There are five reservoirs within the watershed and the largest is Show Low Lake. Show Low Lake, and its retention structure, Jacques Dam, are privately owned by the Phelps Dodge Corporation. Jacques Dam is an earthen embankment dam with a concrete spillway located at the north end of Show Low Lake.

Precipitation in the study area is generally characterized by two seasons. One season lasts from July to mid-September and primarily results from local convective storms. The other season extends from December through March and is mainly created by cyclonic (frontal) storms. Mean annual precipitation, including approximately 24 inches of snowfall, ranges from a low of 14 inches in the north part of the watershed and up to 25 inches in the south. The melting of accumulated snow may sometimes result in a greater volume of runoff, but often at a lesser rate than the runoff caused by summer convective storms. The frost-free season is normally 120 to 140 days long, with mean annual air temperature ranging from 45°F to 52°F (Sellers, W.D., R.H. Hill, and M. Sanderson - Rae, undated.).

Natural vegetation in the areas upstream of Jacques Dam consists primarily of ponderosa pine. The vegetation coverage of the area downstream of Jacques Dam consists primarily of pinyon pine and juniper, which is in sharp contrast to the upstream area. Ground cover in the form of brush and assorted grasses also is present. Grasses found include: blue and sideoates grama, spike and mountain muhly, Arizona fescue, junegrass, dropseed, and western wheatgrass.

Town of Snowflake

The Town of Snowflake is located in southeastern Navajo County and is immediately adjacent to the Town of Taylor. It is approximately 60 miles east of Flagstaff along Interstate Highway 40, and then 35 miles south along State Highway 77. The land area contained within the corporate limits is approximately 23 square miles. The Town of Snowflake was founded in the late l800s and after the initial settling of the town, livestock, forestry, and railroading contributed to the development of Snowflake. The population of the Town of Snowflake was estimated to be 4,460 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

The Town of Snowflake lies within a high desert region of Arizona named the Colorado Plateau. Topography of the region consists of valley floors contained by incised stream terraces formed during earlier fluvial events. Vegetation in the region is comprised mostly of desert brush with an average surface cover of 5 to 10 percent.

Silver Creek and its major tributary, Cottonwood Wash, drain an area of approximately 685 square miles upstream of the Town of Snowflake. Elevations within the drainage area range from 10,000 feet within the White Mountains south of Show Low to just under 5,600 feet at the Town of Snowflake.

The climate is warm and semiarid and normal annual precipitation for the basin ranges from approximately 10 inches near the Town of Snowflake to approximately 30 inches in the White Mountains south of Show Low. The annual average precipitation in the basin is approximately 14 inches. The principal rainy season is in midsummer, generally beginning in June and continuing through September. During the fall months, there are occasional rains and snows. Winter storms occurring between late October and April reflect strong orographic influences. During the winter months, precipitation is principally in the form of snow.

Flooding problems for the community are enhanced by the existence of a severe constriction in the flood plain topography immediately downstream of the confluence of Silver Creek and Cottonwood Wash. The constriction results in a noticeable backwater effect that occurs during even moderate flood events. Local residents have been quoted as saying “the river floods backwards.”

Town of Taylor

The Town of Taylor is located in south-eastern Navajo County and shares a common boundary with the City of Snowflake to the south. To the north, east, and west, the town is surrounded by unincorporated areas of Navajo County. It is approximately 60 miles east of Flagstaff along Interstate Highway 40, then 35 miles south along State Highway 77. The total land area contained within the corporate limits is approximately 12 square miles. The community was founded in the late 1800s and after the initial settling of the town, livestock, forestry, and railroad contributed to the development of Taylor. The population of the Town of Taylor was estimated to be 3,176 persons in 2000 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

The principal riverine system in the community is Silver Creek, which originates south of Show Low, Arizona in the White Mountains and flows northerly to the confluence with Show Low Creek just south of the Town of Taylor. Silver Creek and its tributaries have a drainage area of approximately 410 square miles at the Town of Taylor. Elevations within the drainage area range from 10,000 feet within the White Mountains south of Show Low to just under 5,600 feet at the Town of Taylor. Other stream systems affecting the Town of Taylor include: Airport Wash, Railroad Grade Wash, and Pinedale Wash. Their basins are small desert watersheds which originate locally.

The Town of Taylor is within a high desert region of Arizona called the Colorado Plateau. Topography of the region consists of valley floors contained by incised stream terraces formed during earlier fluvial events. Soils in the Town of Taylor area are comprised of the Moenkopie-Rook Dutorop Association, These soils consist of shallow and very shallow sandstone and shale rook outcroppings on upland areas. Moenkopie soils have reddish brown sandy loam profiles which may be gravelly in places. Depth to hard reddish sandstone or sandy shale is generally 4 to 12 inches. Soils in this association are used mainly to provide grazing for livestock and wildlife (U.S. Department of Agriculture, Soil Conservation Service, May 1969).

The climate in the area is basically warm and semiarid. Annual precipitation for the basin ranges from approximately 10 inches near the Town of Taylor to approximately 30 inches in the White Mountains south of Show Low. The basin average annual precipitation is approximately 14 inches.. The principal rainy season is in midsummer, generally beginning in June and continuing through September. During the fall months there are occasional rains and snows. The winter storms which generally affect the southwestern United States from late October through April, reflect strong orographic influences. During the winter months, precipitation is principally in the form of snow.

Most of the floodplain areas of Silver Creek within the corporate limits of the Town of Taylor are used for agricultural purposes; however, several homes and businesses have been constructed within the floodplain areas between Cattle Lane and Willow Lane. Development within the floodplain areas of Silver Creek has been minimal during the last decade. Recent flooding has resulted in an increased awareness of the problem and only rarely will a new structure be built in the floodplain of Silver Creek that is subject to significant flood hazards.

City of Winslow

The City of Winslow is located in west-central Navajo County, in east-central Arizona. To the west, Winslow is adjacent to the unincorporated areas of Coconino County, Arizona. Winslow is located approximately 35 miles east of the City of Flagstaff, Arizona, along Interstate Highway This community was founded in the late 1800's and after the initial settling of the city, raising stock became the prominent industry which, along with railroading, helped the development of Winslow. The population of the city began to flourish during the construction of the Atchison, Topeka & Santa Fe Railway. The increasing numbers of tourists passing through the city along Interstate Highway 40 brought a demand for services that added substantially to the growth potential. The establishments of the state prison complex and the Homolovi Ruins State Park also contribute to the growth of Winslow. The population of the city was estimated to be 9,520 in 2002 (U.S. Census Bureau, Census 2000 Summary File 1 county, 2000).

The Little Colorado River flows adjacent to the City of Winslow and originates in the White Mountains, then flows northerly to St. Johns, and then northwesterly to its confluence with Puerco River, which is upstream of the City of Holbrook. From the City of Holbrook, the river flows westerly to its confluence with Clear Creek and Cottonwood

Wash, which is upstream of the City of Winslow. From the City of Winslow, the river flows northwesterly to the Colorado River in the Grand Canyon. The Little Colorado River and its tributaries have a drainage area of approximately 16,000 square miles at the City of Winslow. Elevations within the drainage area range from 11,500 feet at Mt. Baldy southwest of Springerville to just under 4,900 feet at the City of Winslow. The average streambed slope is approximately 26 feet per mile and the streambed slope varies from a maximum of over 270 feet per mile near the headwaters, to a minimum of 3 feet per mile in the desert section near the City of Winslow. Most of the areas along the Little Colorado River adjacent to the City of Winslow are underdeveloped. However, several homes have been constructed within the floodplain areas of the Little Colorado River outside the corporate limits of the City of Winslow.

Ruby Wash originates in the hills south of the City of Winslow, flows northerly through the east part of the city, and then joins the Little Colorado River near the north line of Township 19. The original watershed of Ruby Wash consisted of 31.4 square miles. However, it has been reduced to approximately 22.8 square miles since the construction of the Ruby Wash Diversion Levee in 1972 (Department of the Army, Corps of Engineers, August 1972). Between State Route 87 and Interstate Highway 40, the wash has been channelized to a 70-foot wide trapezoidal section. One of its major tributaries is Icehouse Wash, which merges with Ruby Wash immediately downstream of the bridge on North Park Drive.

Soils in this area are composed of two major groups: the Tours Navajo Trail Association and the Moenkopie Association. These soils have been classified by the NRCS as Hydrologic Group B and D Soils, respectively (U.S. Department of Agriculture, 1975). Other soils of the region are classified as Type C indicating slow infiltration rates when thoroughly wetted (U.S. Department of Agriculture)

The climate in the study area is basically a warm semiarid type. Mean annual precipitation at the City of Winslow is approximately 8 inches and approximately 12 inches of snowfall are included within the annual precipitation. The principal rainy season is in midsummer, generally beginning in June and continuing through September. During the fall months, there are occasional rains and snows. The winter storms which generally affect the southwestern United States from late October through April reflect orographic influences. During the winter months, precipitation is principally in the form of snow. The frost free season is normally 130 to 175 days long, with a mean annual air temperature ranging from 50°F to 55°F.

Vegetation in the area is comprised mostly of desert brush with an average surface cover of 5 to 10 percent. Natural vegetation consists primarily of grasses that include Alkali sacaton, blue grama, three awn, sand dropseed, saltgrass, chamiza, shadscale, rabbitbrush, and sand sagebrush. Scattered juniper trees also exist. Vegetal cover of the Silver Creek drainage basin ranges from mountain forests to almost barren deserts. The vegetal cover of the drainage basins contributing flow to Airport Wash, Railroad Grade Wash, and Pinedale Wash consists entirely of sparse desert brush.

2.3 Principal Flood Problems

Navajo County

The USGS operates a recording stream gage (No. 3945) at RM 203.01 near Woodruff. Because of the incised stream channel, flooding along the Little Colorado River near Woodruff has presented very few problems to life and property. The record of historical floodflows at this location is as follows:

Date	Annual Peak Discharge (cfs)
December 5, 1919	25,000
July 21, 1929	10,700
February 10, 1932	10,200
July 26, 1940	13,000
January 19, 1952	10,200
December 19, 1978	9,320

City of Holbrook

Historical records of major flood flow events in the Holbrook area indicate that many of these flows have resulted in significant damage to property. Floods generally occur from long-duration, low-intensity regional storms, occasionally with snowmelt. Annual peak flows of 24,000 cubic feet per second (cfs) and 25,000 cfs were recorded in October 1969 and December 1978, respectively. Floods of this magnitude have a recurrence interval of 15 years to 20 years. Unprotected residential and commercial properties on the south side of Little Colorado River received heavy flood damage in 1970 and 1971. A rubble dike built by local interests prevented the 1972 flood (20,300 cfs) from causing additional damage to the south side properties.

Quantitative measurements of early floods on Little Colorado River (before 1950) are scanty. The greatest flood peak on Little Colorado River at Holbrook for which data are available occurred in December 1923 and was estimated to be 60,000 cfs. A summary of historical flood peaks is provided below (U.S. Department of the Army, Corps of Engineers, March 1976).

Date	Peak Discharge(cubic feet per second)
December 19, 1923	60,000
October 4, 1969	24,200
August 5, 1957	21,800
August 12, 1968	21,000
September 6, 1970	19,700
September 30, 1971	20,000
October 1, 1972	20,300
December 21, 1978	25,000

These discharge values have return periods of from less than 10 years to 80 years as determined from stream gage records (1906, 1923, and 1950 through 1979) compiled by the USACE (U.S. Department of the Army, Corps of Engineers, March 1976), and a subsequent flood flow-frequency analysis performed by the study contractor.

Town of Pinetop-Lakeside

There is no record of historical flooding available for the Town on Pinetop-Lakeside because the community has experienced few significant flood problems.

City of Show Low

The history of flooding on streams within the City of Show Low indicates that flooding may occur during any season of the year; however, the majority of floods occurred during December, January, and February. Historical floodflow events have been recorded at a USGS gaging station on Show Low Creek located upstream of the City of Show Low near Lakeside. The flood of December 1978 had a discharge of approximately 5,550 cfs. Discharges of major peak flows at the USGS gaging station are provided below.

Date	Approximate Peak Flows (cfs)
March 23, 1954	2,040
January 7, 1965	2,430
December 30, 1965	3 880
December 26, 1971	5,450
December 18, 1978	5,550
February 15, 1980	1,860
December 27, 1984	5,430

Most of the flooding sources within Show Low are characteristically small, local watersheds comprising less than 10 square miles in basin area. Since these basins are not capable of generating extremely large discharges, several homes and businesses have been constructed within the floodplain areas of these washes. No significant damage or loss of life would be expected to occur; however, it could be expected that several homes would experience flooding depths from 1.0 to 2.0 feet during a less frequent floodflow event.

Show Low Creek regularly generates high magnitude floodflows and represents more potential for damage and loss of life than the local watersheds. This potential has been recognized and, subsequently, few homes or businesses have been constructed within the flood hazard areas.

Town of Snowflake

Historical records of major floodflow events in the Snowflake area indicate that many of these floods have resulted in damage to property. Historical floodflow events have been recorded at a USGS gaging station on Silver Creek, located below the confluence with Cottonwood Wash. There are no gaging stations on Cottonwood Wash or Silver Creek above the confluence. The discharge values recorded at the gaging station have return periods of from less than 10 years to 25 years, as determined from stream - gage records and a subsequent floodflow frequency analysis performed by the study contractor. Historical floodflows for Silver Creek as recorded between 1919 and 1978 at the USGS gage at Snowflake are shown below.

Peak Discharges Date (Cubic Fee per Second)	Annual Approximate	Return Period (Years)
December 5, 1919	25,000	23
July 21, 1929	10,500	8
July 26, 1940	11,000	9
January 19, 1952	10,100	8
December 21, 1978	7,400	5

Regular flood damage is anticipated due to periodic flooding along Silver Creek. There are no concentrated developments within the hazard areas; however, there are several small scattered farmhouses and associated structures on the flood plain. One of the major reasons that even small floods result in property damage is that Silver Creek has a minimal channel capacity. The channel would not likely contain a flow with a 2-year return period throughout most reaches within the community.

A significant amount of flood damage would be expected during less frequent flows on Cottonwood Wash. Several residential home sites are in the flood plain fringe of Cottonwood Wash along West Street and Minnerly Street. Flow depths of 2 to 3 feet can be expected during a 100 - year flood.

Town of Taylor

Historical records of major floodflow events in the Taylor area indicate that many of these flows have resulted in significant damage to property. Historical floodflow events have been recorded at a USGS gaging station on Silver Creek at Snowflake, which is boated downstream of Taylor below the confluence with Cottonwood Wash (drainage area 275 square miles). Major peak flows on Silver Creek near Taylor are listed as follows: (1) the maximum flood for Silver Creek occurred on December 5, 1919; and (2) the most recent flood occurred on December 21, 1978.

It cannot be ascertained what percentage of these gauged flows should be attributed to floods on Silver Creek above the confluence with Cottonwood Wash. Therefore, the flood record given is subject to uncertainty. The discharge values recorded at this gaging station have a recurrence interval of from less than 10 years to 90 years, as determined from stream - gage records and a subsequent floodflow frequency analysis performed by the study contractor.

A key problem within Taylor occurs in the floodplain of Silver Creek between Cattle Lane and Willow Lane. Periodic flooding of homes in this area occurs because of inadequate channel capacity. It is estimated that the channel cannot contain flood peaks with a return period in excess of 2 years. Sufficient data are not available to define the return period of the other flooding sources.

City of Winslow

Historic floodflow events for the City of Winslow have been recorded on the Little Colorado River, indicating flow magnitudes between 19,700 cfs and 57,500 cfs between 1923 and 1978., as recorded at the USGS gage (No. 3970) at River Mile (RM) 189.99. These discharge values have a return period of from less than 10 years to an 80 - year event, as determined from stream-gage records compiled by the USACE and their

subsequent floodflow frequency analysis (U.S. Department of the Army, Corps of Engineers, December 1975; Federal Emergency Management Agency, March 16, 1981). The December 1923 flood was the maximum flood of record. The USCS does not operate a stream gage at Winslow; however, because of the severity of the December 1978 flood, a discharge of 57,500 cfs was computed for the Little Colorado River from stream gages located on tributary channels (Clear Creek and Cleveland Creek) that generated most of that flow.

Prior to the completion of the Winslow Levee along the Colorado River, historical records of major floodflow events in the Winslow area indicate that many of these flows have resulted in significant damage to properties (Federal Emergency Management Agency, March 16, 1981). Near Winslow, several homes within the Bushman Acres and Ames Acres subdivisions were constructed within the flood hazard areas of the Little Colorado River. These subdivisions experience flooding quite frequently, as most of these homes are within the 10-percent annual chance floodplain of the Little Colorado River. There have been no reportings of any significant damage or loss of life caused by flooding in Ruby Wash.

Flooding in Winslow generally results from regional, orographic cloud storms originating in the Pacific Ocean and occurring during the winter months of December through February.

2.4 Flood Protection Measures

Navajo County

Several flood-control structures have been constructed in the Winslow area to eliminate or reduce the magnitude of existing flood hazards. Approximately 0.25 mile north of the City of Winslow, Navajo County has constructed a levee of varying cross-section dimensions along the Little Colorado River, The construction of this levee has been completed in various stages and is not on a set schedule. It does not meet FEMA levee standards. The upstream limit of the levee is approximately 1,000 feet north of the Interstate Highway 40 (I-40) alignment. Thus, floodwater conveyed beneath the I-40 bridge may immediately enter the overbank area west of the Little Colorado River channel alignment and inundate several residential, industrial, and agricultural properties. In its present state, the county levee appears to do very little, if anything, to protect residents of this area from their existing flood hazards of greater than 5-year frequency along the Little Colorado River. This is evident by the periodic flooding of lands west of the county levee during historical floodflow events. The main purpose of the levee appears to be the stabilization of the horizontal alignment of the Little Colorado River channel. The highly erosive fine-grained soils of the area have resulted in significant damage to property near the river during historic events. In order to prevent this bank erosion, used oars were tied together and placed on the east slope of the levee.

No flood-control structures have been constructed in the communities of Woodruff, Shumway, Lakeside, Pinetop, Pinedale, Clay Springs, or Heber for the purpose of eliminating or reducing the magnitude of existing flood hazards.

County officials intend to adopt an ordinance to delineate areas of flood hazard or to prohibit development in flood hazard areas based on the results of this FIS.

City of Holbrook

The USACE has constructed a flood-control levee along the Little Colorado River at Holbrook. This structure has been in place since 1948. At that time, the levee was

designed to protect Holbrook and county lands north of the river from floods of up to 60,000 cfs (approximately the 1-percent chance of annual exceedance). Because of sediment buildup on the channel bottom, it is estimated that a flow of approximately 28,000 cfs could overtop the levee and cause flooding in Holbrook. No flooding has occurred north of the levee since it was built; however, no floods in excess of 28,000 cfs have occurred since its construction.

City officials have adopted ordinances to regulate development in flood hazard areas based on this Flood Insurance Study.

Town on Pinetop-Lakeside

No flood - control structures have been constructed for the flooding sources affecting Pinetop - Lakeside.

City of Show Low

No major flood control structures have been constructed in the Show Low area for the purpose of eliminating or reducing the magnitude of existing flood hazards.
City officials have adopted ordinances to regulate development in flood hazard areas based on this Flood Insurance Study.

Town of Snowflake

There have been no major flood control structures constructed in the Snowflake area for the purpose of eliminating or reducing the magnitude of existing flood hazards. Locally, there have been some efforts to prevent flooding by constructing pushup earthen levees; however, these structures would undoubtedly fail during a major floodflow.

Town officials have adopted ordinances to regulate development in flood hazard areas based on this Flood Insurance Study.

Town of Taylor

Town officials intend to adopt an ordinance either to delineate areas of flood hazard or to prohibit development in flood hazard areas based on this FIS.

There have been no major flood control structures constructed in the Taylor area for the purpose of eliminating or reducing the magnitude of existing flood hazards.

City of Winslow

Several flood - control structures have been constructed in the Winslow area for the purpose of eliminating or reducing the magnitude of existing flood hazards. The USACE has designed and constructed the Ruby Wash Diversion Levee, which is a rock and earth levee extending 5.3 miles from the high ground near the southwest corner of the Winslow airport to the Little Colorado River south of the Atchison, Topeka and Santa Fe Railway Bridge east of Winslow. The construction of this levee was completed in 1970. Flows in Ruby Wash and in other streams crossing the alignment of the levee are diverted to the Little Colorado River, eliminating flood hazards along Ruby Wash. Ruby Wash channel and Icehouse Wash channel, which were previously construed to convey these flows, now serve only to capture and convey local urban runoff generated primarily from areas north of the Ruby Wash Diversion Levee (Federal Emergency Management Agency, March 16, 1981, City of Winslow, Arizona, December 1970 and Department of the Army, Corps of Engineers, Los Angeles District, August 1972).

Navajo County attempted to minimize the flooding problems along the Little Colorado River by constructing an earthen levee from the Atchison, Topeka and Santa Fe Railway to approximately one - quarter mile north of McHood Drive near Ames Acres. This levee was overtopped and breached at several locations during a major flood in December 1978 (Arizona Department of Water Resources, November 1980).

A new levee was constructed by Navajo County in 1989 with assistance from the ADWR. Rock riprap was placed at several short sections of the levee to protect the earthen embankment from erosion.

Based on improvements completed in 1991, this levee was recognized as providing 1-percent annual chance flood protection.

3.0 ENGINEERING METHODS

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

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

Each incorporated community within, and the unincorporated areas of Navajo County has a previously printed FIS report. The hydrologic analyses described in those reports have been compiled and are summarized below.

Navajo County

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

Peak discharges established by the USACE were used for the Little Colorado River near Winslow (U.S. Department of the Army, Corps of Engineers, March 1976) and Holbrook (U.S. Department of the Army, Corps of Engineers, December 1975). Peak discharges for the Little Colorado River near Woodruff were determined using Methods for Estimating the Magnitude and Frequency of Floods in Arizona (Arizona Department of Transportation, September 1978).

The determination of peak discharge values for Silver Creek utilized flood data from four gaging stations. These gaging stations are located on the Little Colorado River above Lyman Reservoir (USGS gage No. 3840, with 38 years of record); along Chevelon Creek below Wildcat Canyon (USGS gage No. 3975, with 23 years of record); along Silver Creek below the confluence with Cottonwood Wash (USGS gage No. 3935, with 36 years of record); and on the Little Colorado River at Woodruff (USGS gage No. 3945, with 53 years of record). Historical floodflow data compiled at these gaging station locations were used to compute a regional log-Pearson Type III (U.S. Water Resources Council, Hydrology Committee, March 1976) frequency distribution. This procedure was required because of the paucity of local data.

Peak discharges for the Little Colorado River near Woodruff were determined using Methods for Estimating the Magnitude and Frequency of Floods in Arizona (Arizona Department of Transportation, September 1978).

Historical floodflow data compiled at the USGS gage No. 09-390500 at Lakeside were used to compute a regional log-Pearson Type III frequency distribution for peak discharges for the lower reach of Show Low Creek below the approximate elevation of 6,340.

For the remaining detailed study streams, peak discharge values for the various return periods were based on a floodflow frequency analysis compiled by the study contractor. The hydrologic analysis utilized regional information, historical floodflow records from several gaging stations in the region, and techniques presented in an ADOT publication (Arizona Department of Transportation, September 1978) and the NRCS computer program TR-20 (U.S. Department of Agriculture, Soil Conservation Service, May 1965).

Peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas. Floodplain boundaries were developed from aerial photography (Cooper Aerial Surveys, April 25, 1979) and field surveys to define topographic boundaries with specific consideration of expected flows.

In the August 16, 1988 revisions, flooding information for Rainbow Lake is based on data contained in a report entitled Final Drainage Report for the Shores at Rainbow Lake, Lakeside, Navajo County, Arizona prepared by Collar, Williams, and White Engineering, Inc., Phoenix, Arizona, in March 1986 and revised in April 1986. Based on this report, the 1- and 0.2-percent annual chance flood elevations on Rainbow Lake are 6712.8 and 6714.0 feet NGVD, respectively.

Within the limits of the unincorporated areas of Navajo County, the study was revised on September 30, 1992, to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw.

The same discharges that were generated for the 1981 FIS (Federal Emergency Management Agency, March 16, 1981) for the Little Colorado River at Winslow were used in this study because little change has been reported in the upstream watershed.

Because of the absence of historical gaging data in the study area, the peak flows used for Ruby Wash in this study were obtained through hydrologic modeling. The hydrologic modeling was performed by using the HEC-l computer program (U.S. Department of the Army, Corps of Engineers, January 1985). The model utilizes a standard NRCS Type II rainfall distribution for a 24-hour duration storm, Total rainfall depths were taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas published for Arizona (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1973). Initial abstraction and losses were based upon the NRCS curve

number method. Curve numbers were estimated by weighted method on the basis of the soil information provided in the U.S. Department of Agriculture, Soil Conservation Service, General Soils Map.

The runoff hydrographs were computed using the NRCS unit hydrograph. The computed runoff hydrographs were then routed from various points in the watershed to the outlet by the kinematic wave method. Reservoir routing through fully characterized outflow structures such as culverts and weirs was performed by input of appropriate reservoir area-volume-elevation data into the model. Elevations and surface areas used in the model were based upon either the “as-built” documents obtained from the ADOT for the State Highway 87 and 1-40, or the 1:4,800, 4-foot contour interval mapping flown for this project in 1989 (Cooper Aerial of Phoenix, Inc., April 20, 1989)

A USGS gaging station (Gaging Station 09-390500) is located on Show Low Creek. However, the station could not provide adequate peak flow information for this study because it is located approximately 6 miles upstream of the northern study limits. Therefore, the peak flows used in this study were obtained through hydrologic modeling.

For Show Low Creek, the hydrologic modeling was performed by means of the HEC-1 computer program (U.S. Department of the Army, Corps of Engineers, January 1985). The hydrographs from various watersheds were first routed to the location of Gaging Station 09-390500. The ordinates of the resulting hydrograph were then adjusted proportionally according to the ratio of the peak flow obtained from gaging records, by means of the log-Pearson Type III method, to the peak flow derived from modeling. Finally, the adjusted resulting hydrograph was used as the inflow hydrograph and was routed through Show Low Lake to the City of Show Low's southern corporate limit.

The NRCS Type II rainfall distribution was used as the rainfall input of the model. Precipitation values for the 1-percent annual chance, 24-hour storm were obtained from the NOAA Atlas for Arizona (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1973). The stage-storage-discharge curves for each retention structure in the watershed were adopted from a dam safety study report prepared for Jaques Dam (Leedshill-Herkenhoff, Inc., June 1983)

Spillway crest elevation values were used to set the initial storage volume for each of these structures. The runoff curve numbers were derived from the soil and vegetation cover information provided by the U.S. Forest Service (USFS) (U.S. Department of Agriculture, Forest Service, Undated and Reprinted June 1989).

Gaging data were obtained from the USGS for Gaging Station 09-390500, which is located on Show Low Creek near Lakeside, This station has been in continuous service from May 1953 to the present. The annual peak flow for each of these years was recorded and tabulated. The log-Pearson Type III method was used to estimate the 1-percent chance of annual exceedance at the gaging station.

For Oklahoma Flat Draw, in the absence of historical gaging data in the study area, the peak flows used in this study were obtained through hydrologic modeling. The hydrologic modeling was performed using the HEC-l computer program (U.S. Department of the Army, Corps of Engineers, January 1985)

SCS Type II rainfall distribution was used as the rainfall input of the model. Precipitation values for the 1-percent annual chance, 24-hour storm were obtained from the NOAA Atlas for Arizona (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1973). The runoff curve numbers were derived from the soil and

vegetation cover information provided by the USFS (U.S. Department of Agriculture, Forest Service, Undated and Reprinted June 1989).

The runoff hydrographs were computed by use of the NRCS unit hydrograph. The computed runoff hydrographs were then routed from various points in the watershed to the outlet by the kinematic wave method. Reservoir routing through fully characterized outflow structures such as culverts and weirs was performed by input of appropriate reservoir area-volume-elevation data into the model.

Elevations and surface areas used in the model were based either upon the as-built documents obtained from the ADOT for the SR 260, or the 1:4,800, 4-foot contour interval mapping flown for this project in 1989 (Cooper Aerial of Phoenix, Inc., May 18, 1989).

The March 2, 1994, revisions incorporated the effects of new hydrologic and hydraulic analyses for Silver Creek.

The new hydrologic analyses were based on a study prepared by Kamineki-Hubbard Engineering, Inc. (KHE),that used the USACE HEC-l computer model. The HEC-l model included the effects of physical changes such as a dam, reservoir, and diversion structures that were constructed since the original FIS was completed. The structures included were Schoens Dam, the Millet Swale retention area, the Ortega Lake diversion system, and the Rocky Arroyo Wash diversion system into Long Lake.

An additional revision took affect on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from FM 1.6 near the City of Heber to FM 3.4, was studied by detailed methods.

The 1-percent chance of annual exceedance discharge was determined by the same method used for Buckskin Wash in the March 2, 1994, FIS (Federal Emergency Management Agency, Flood Insurance Study, March 2, 1994). This method consisted of the regional regression formula, as developed by the NRCS for the ADOT, which is presented below (Arizona Department of Transportation, September 1978).

$$Q_{100} = 553A^{0.61} \text{ X } E^{-1.13} \text{ X } P^{0.915}$$

Where A = Area in square miles
E = Elevation factor in thousands of feet
P = Mean annual precipitation in inches

The area and elevation factors were determined from the USGS 7.5-Minute Series Topographic Maps for the area (U.S. Department of the Interior, 1955 & 1990) The precipitation factor was estimated based on data used as input for the effective FIS dated March 2, 1994. The adopted study discharge is shown in Table 1, Summary of Discharges.

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary A, Hog Wash, Hog Wash Tributary A. The peak discharges for Linden Draw and Hog Wash and their tributaries were calculated using USGS regression equations included in the Water Resources Investigation Report 94-4002 for Arizona, Region 3 (USGS 1993). The USGS also includes regression equations for 16 regions in the southwestern U.S. These equations were investigated and were found to have an average standard error of prediction higher than those of the Arizona regression equations. In addition, the 0.2-percent annual chance peak discharges are estimated based on extrapolation in the southwest regression equations. Therefore, to determine the 10-percent annual chance, 2-

percent annual chance, 1-percent annual chance, and 0.2-percent annual chance peak discharges, URS recommends using USGS regression equations for Arizona instead of the USGS regression equations for the southwestern United States.

The boundaries for the drainage areas were determined based on the USGS topographic maps Show Low North, Arizona; Show Low South, Arizona; Red Top Mountain, Arizona; and Pinedale, Arizona (scale of 1:24,000). The estimated total drainage areas for Linden Draw and Hog Wash are 16.85 square miles and 4.91 square miles, respectively. These areas were divided into sub-areas used to determine peak discharge for Linden Draw and Hog Wash at different locations along the main stream.

The peak discharges for Linden Draw and Hog Wash were determined based on USGS Regression Equations for Region 3 in Arizona (USGS 1993). These resulting 1-percent annual chance peak discharges were then compared to three indirect methods listed in ADOT's Hydrology Manual (ADOT 1993). A comparison of results show that the computed discharges for both Linden Draw and Hog Wash are within the range of flows developed from the indirect methods and can be used for the hydraulic analysis of the project site.

Another revision took affect on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek and Upper Silver Creek (formerly Silver Creek), Rocky Arroyo, White Mountain Lake, and Mexican Lake within Navajo County. The County's corporate limits also were updated. The hydrologic analyses for all the revised reaches, with the exception of the Mexican/White Mountain Lake System, were adopted from the "Silver Creek Drainage Study" prepared for Navajo County by KHE (Kaminski-Hubbard Engineering, Inc., May 17, 1991). The hydrologic analysis for the Mexican/White Mountain Lake System incorporated a new rating curve and reservoir routing based on more accurate topographic data included in the HEC-l model prepared by KHE.

The peak discharges were established using the HEC-l hydrologic computer model developed by the USACE (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, September 1990). Drainage-basin delineations for Lower Silver Creek, Upper Silver Creek, and Rocky Arroyo Creek were made using l"=200' scale topographic mapping with 2-foot contour intervals, provided by Navajo County, supplemented with USGS 7.5-minute quadrangle maps (Kenney Aerial Mapping, Inc., 1998 and U.S. Department of the Interior, Geological Survey, 1968). Drainage-basin delineations for the Mexican/White Mountain Lake area were made using l"=200' scale topographic mapping with 1-foot contour intervals (Kenney Aerial Mapping, Inc., 1998 and U.S. Department of the Interior, Geological Survey, 1982).

The Cottonwood Wash study was once again revised in August 2004 by HDR Engineering Inc. Three separate approaches were used and compared to determine the most reasonable estimate for the base flood (1-percent-annual-chance) discharge. These included analysis of existing gage data, regional regression analysis, and rainfall-runoff modeling (i.e. HEC-1 model). The results of the three analyses were evaluated and compared for reasonableness. The final recommended approach was to use the results of the revised HEC-1 model. The model was used to generate the 10-, 2-, 1- and 0.2-percent-annual-chance storm events for use in the revised FIS.

City of Holbrook

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

The gage at Holbrook was correlated with the three other gages and its period of record was extended using the HEC - l Regional Frequency Program (U.S. Department of the Army, Corps of Engineers, 1973). The magnitude of the peak discharges used in the hydrologic analysis of Little Colorado River was based on a flood flow-frequency analysis compiled by the USACE (U.S. Department of the Army, Corps of Engineers, December 1975). Flood data were compiled at four gaging stations located on Little Colorado River covering a 29-year period between 1950 and 1979 at Holbrook (U.S. Geological Survey Gage No. 3970), a 49-year period between 1917 and 1975 at Woodruff (U.S. Geological Survey Gage No. 3945), a 36-year period between 1929 and 1972 at Hunt (U.S. Geological Survey Gage No. 3880), and a 32-year period above Zuni (U.S. Geological Survey Gage No. 3865). Using the adopted frequency curve at Holbrook, the 1-percent annual chance regional flood for Little Colorado River at Holbrook is estimated to be 54,000 cfs.

Peak discharge values for Whiting Creek are based on a flood flow-frequency analysis compiled by the study contractor. The hydrologic analysis used techniques presented in the ADOT publication, Methods of Estimating the Magnitude and Frequency of Floods in Arizona (Arizona Department of Transportation, September 1978).

Town of Pinetop-Lakeside

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the Pinetop-Lakeside community.

For Billy and Walnut Gulch Creeks, peak discharge values for the selected recurrence intervals were based on a floodflow-frequency analysis compiled by the study contractor. The hydrologic analysis utilized regional information, historical floodflow records from several gaging stations in the region, and techniques presented in an ADOT publication (Arizona Department of Transportation, September 1978) and the NRCS computer program TR - 20 (U.S. Department of Agriculture, May 1965).

City of Show Low

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the Show Low community.

Peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas.

The magnitudes of the peak discharges used in the hydrologic analyses of Patricks Wash, Whipple Wash, Fools Hollow Wash, Fools Hollow Wash East Branch, Navajo Pines Wash, and the lower reach of Show Low Creek are based on floodflow-frequency analyses compiled by the study contractor. Peak discharge values for the small, local watersheds (Patricks Wash, Whipple Wash, Fools Hollow Wash, Fools Hollow Wash East Branch, and Navajo Pines Wash) were determined by a procedure for drainage channels in the State of Arizona with insufficient streamflow records available to allow for floodflow-frequency computations. This procedure used a method presented in an ADOT publication (Arizona Department of Transportation, December 1968.). This method consists of two different approaches that are functions of the drainage area size. Historical floodflow data compiled at USGS Gaging Station 09-390500 at Lakeside were used to compute a regional log-Pearson Type III frequency distribution for peak discharges on Show Low Creek. This USGS gaging station on Show Low Creek has been in continuous service since May 1953. The annual peak flow for each of these years was recorded and tabulated.

A USGS gaging station (Gaging Station 09-390500) at Lakeside is located on Show Low Creek. However, the station could not provide adequate peak flow information for this study because it is located approximately 6 miles upstream of the northern study limits. Therefore, the peak flows used in this study were obtained through hydrologic modeling.

For Show Low Creek, the hydrologic modeling was performed by means of the HEC - 1 computer program (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, September 1981, revised January 1985). The hydrographs from various watersheds were then routed to the location of the gaging station mentioned above. The ordinates of the resulting hydrograph were adjusted proportionally according to the ratio of the peak flow obtained from gaging records, by means of the log-Pearson Type III method, to the peak flow derived from modeling. Finally, the adjusted resulting hydrograph was used as the inflow hydrograph and was routed through Show Low Lake to the City of Show Low's southern corporate city limits.

The NRCS Type II rainfall distribution was used as the rainfall input of the model. Precipitation values for the 1-percent annual chance, 24-hour storm were obtained from the National Oceanographic and Atmospheric Administration Atlas for Arizona (U.S. Department of Commerce, 1973.). The stage-storage-discharge curves for each of the retention structures in the watershed were adopted from a dam safety study report prepared for Jaques Dam (Leedshill - Herkenhoff, Inc., June 1983.). Spillway crest elevation values were used to set the initial storage volume for each of these structures. The runoff curve numbers were derived from the soil and vegetation cover information provided by the U.S. Forest Service (USFS) (U.S. Department of Agriculture, Forest Service, Undated and Reprinted June 1989). The log-Pearson Type III method was used to estimate the 1-percent annual chance flood at the gaging station location. The estimated 1-percent annual chance peak flows at various locations in the study area are presented in Table 1. No other return interval floods were estimated in this study.

Town of Snowflake

The hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the Snowflake community.

The magnitude of the peak discharges used in this hydrologic analysis of Silver Creek and Cottonwood Wash is based on floodflow frequency analyses compiled by the SC. The determination of peak discharge values for Silver Creek and Cottonwood Wash used flood data at four gaging stations located within the physiographic region. These gaging stations are located on Little Colorado River above Lyman Reservoir, along Chevelon Creek below Wildcat Canyon, along Silver Creek below the confluence with Cottonwood Wash, and on Little Colorado River at Woodruff. Historical fboodflow data compiled at these gaging station locations were used to compute a regional log-Pearson Type III frequency distribution. This procedure was required because of the paucity of local data. Discharges for Silver Creek and Cottonwood Wash above their confluence are similar although the drainage area of Cottonwood Wash is approximately one-half that of Silver Creek, due to the shape of the watersheds and different slopes. Silver Creek has a long, oblong drainage area. Cottonwood Wash has a short, circular drainage area with a steeper slope.

A restudy for the Town of Snowflake was revised on February 16, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek and Cottonwood Wash. The new hydrologic analysis was based on a study prepared by KHE, which utilized the USACE HEC - 1 computer model.

The HEC - 1 model included the effects of physical changes such as a dam, and reservoir and diversion structures that were constructed since the FIS was completed. These structures are known as the Schoens Dam, Millet Swale retention area, Ortega Lake diversion system, and Rocky Arroyo Wash diversion system into Long Lake. Floodways and floodplain boundaries were delineated using topographic maps prepared by KHE at scales of 1:2,400 and 1:4,800, with a contour interval of 2 feet.

Town of Taylor

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

Peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas.

The magnitude of the peak discharges used in this hydrologic analysis of Silver Creek, Airport Wash, and Railroad Grade Wash are based on floodflow frequency analyses compiled by the SC. The determination of peak discharge values for Silver Creek utilized flood data at four gaging stations located within the same physiographic region. These gaging stations are located on Little Colorado River above Lyman Reservoir (USGS gage No. 3940 with 38 years of record), along Chevelon creek below Wildcat Canyon (USGS gage No. 3975 with 23 years of record), along Silver Creek below the confluence with Cottonwood Wash (USGS gage No. 3925 with 51 years of record), and on Little Colorado River at Woodruff (USGS gage No. 3945 with 53 years of record). Historical floodflow data compiled at these gaging station locations were used to compute a regional log-Pearson Type III (U.S. Water Resources Council, Hydrology Committee, March 1976) frequency distribution. This procedure was required because of the paucity of local data.

Peak discharge values for the small local watersheds (Airport Wash and Railroad Grade Wash) were determined by a procedure for drainage channels in the State of Arizona which have insufficient streamflow records available to allow for floodflow frequency computations. This procedure utilized a method presented in the ADOT publication entitled Hydrologic Design for Highway Drainage in Arizona (State of Arizona, Department of Transportation, December 1968). This method consists of two different approaches which are a function of the drainage-area size. The method pertains to areas where existing and projected urbanization has a negligible influence on expected basin discharges. The streams studied by detailed methods in Taylor to which this pertains are Airport Wash and Railroad Grade Wash.

The study within limits of the Town of Taylor was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek. The new hydrologic analyses were based on a study prepared by KHE, which utilized the USACE HEC - l computer model. The HEC - l model included the effects of physical changes such as a dam, reservoirs, and diversion, structures that were constructed since the original FIS was completed. The structures included were Schoens Dam, the Millet Swale retention area, the Ortega Lake diversion system, and the Rocky Arroyo Wash diversion system into Long Lake. The floodway and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, with a contour interval of 2 feet.

This study was revised again on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek (formerly Silver Creek) within the Town of Taylor. The Town of Taylor corporate limits also were updated .The hydrologic analyses were

adopted from the “Silver Creek Drainage Study” prepared for the unincorporated areas of Navajo County, Arizona, by KHE (Kaminski - Hubbard Engineering, Inc., May 17, 1991).

Peak discharges were established by using the HEC-1 hydrologic computer model developed by the USACE (U.S. Department of the Army, Corps of Engineers, September, 1990). Drainage-basin delineations were made using 1”=200’ scale topographic mapping with 2-foot contour intervals, provided by Navajo County, supplemented with USGS 7,5-minute quadrangle maps (U.S. Department of the Interior, Geological Survey, 1968).

City of Winslow

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the Winslow community.

The same discharges as generated in the original FIS (Federal Emergency Management Agency, March 16, 1981) for the Little Colorado River at Winslow were used in the restudy because little change has been reported in the upstream watershed.

Because of the absence of historical gaging data in the study area, the peak flows used for Ruby Wash in this study were obtained through hydrologic modeling. The hydrologic modeling was performed by means of the HEC-1 computer program (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, September 1981, Revised January 1985). The model utilizes a standard NRCS Type II rainfall distribution for a 24-hour duration storm. Total rainfall depths were taken from the National Oceanic and Atmospheric Atlas published for Arizona (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1973). Initial abstraction and losses were based upon the NRCS curve number method. Curve numbers were estimated by weighted method on the basis of the soil information provided in U.S. Department of Agriculture, NRCS, General Soils Map, 1975.

The runoff hydrographs were computed by use of the NRCS unit hydrograph. The computed runoff hydrographs were then routed from various points in the watershed to the outlet by the kinematic wave method. Reservoir routing through fully characterized outflow structures, such as culverts and weirs, was performed by the input of appropriate reservoir area-volume-elevation data into the model. Elevations and surface areas used in the model were based either upon the “as-built” documents obtained from the ADOT for the SR 87 and Interstate Highway 40, or upon the 1:4,800, 4-foot contour interval mapping flown for this project in 1989 (Cooper Aerial of Phoenix, Inc., April 20, 1989). The estimated 1-percent annual chance peak flows at various locations in this study area are presented in Table 1.

In the original study, peak discharge values for streams studied by approximate methods were developed on the basis of an average expected discharge per acre from the contributing basin areas.

A summary of the drainage area-peak discharge relationships for all the streams studied by detailed methods is shown in Table 6, “Summary of Discharges.”

Table 6 - SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Airport Wash					
At Confluence With Railroad Grade Wash	1.28	234	456	555	905
Billy Creek					
At Stream Mile 1.0	18.51	1,400	2,460	3,380	5,250
Black Canyon Wash					
Immediately Below Confluence With Buckskin	70.85	4,940	10,240	13,250	22,800
At State Highway 260	40.45	2,920	6,040	7,820	13,000
Buckskin Wash					
At State Highway 260	30.00	2,450	3,830	6,770	12,400
Approximately 1.45 miles upstream of Highway 260	28.60	--	--	6,530	--
Cottonwood Wash					
At Confluence with Silver Creek	272.45	2,770	10,200	13,920	25,680

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Upstream of Confluence with Dodson Wash	257.77	2,630	9,930	13,570	25,300
At Upstream limit	176.79	2,110	7,740	10,100	18,470
Fools Hollow Wash					
Above West Adams	5.98	770	1,910	2,570	5,000
At West Sylvester	9.37	1,020	2,520	3,390	6,100
Fools Hollow Wash East Branch	0.75	55	165	220	450
Hog Wash					
At Upstream Limit of Detailed Study	1.62	362	927	1,264	2,393
Upstream of the Confluence of Tributary A	2.76	514	1,306	1,774	3,339
Downstream of the Confluence of Tributary A	3.91	644	1,628	2,208	4,136
At Downstream Limit of Detailed Study	4.91	746	1,877	2,542	4,747

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Hog Wash Tributary					
At Upstream Limit of Detailed Study	0.63	201	528	725	1,396
At Confluence with Hog Wash	1.15	298	774	1,060	2,025
Joseph City Wash					
At Sante Fe Railroad	32.50	--	--	2,047[1]	--
Just Downstream of Highway 40	--	--	--	5,657	--
At Interstate Highway 40	30.64	--	--	6,200	--
Immediately Below Confluence	29.71	--	--	6,200	--
At Confluence with Mesa Wash	23.34	--	--	5,300	--
Linden Draw					
At Upstream of Limit of Detailed Study	6.84	886	2,192	2,952	5,452

[1] Due to breakout flow

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Upstream of the Confluence of Tributary	8.70	1,037	2,557	3,439	6,333
Downstream of the Confluence of Tributary	13.77	1,397	3,414	4,578	8,379
At Downstream Limit of Detailed Study	16.85	1,596	3,889	5,209	9,512
Linden Draw Tributary					
At Upstream Limit of Detailed Study	1.49	337	863	1,174	2,221
At Confluence with Linden Draw	5.07	742	1,853	2,504	4,655
Little Colorado River					
At Canary Avenue	8,100	8,400	19,500	26,000	45,600
At Holbrook	11,300	26,00	45,000	54,000	79,000
At Interstate Highway 40	16,000	36,400	55,900	65,000	109,000
At State Highway 77	11,300	26,00	45,000	54,000	79,000
At Winslow (Interstate Highway 40)	16,000	--	--	65,000	--

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
At Obed Road	--	--	--	60,000	--
Lower Silver Creek					
At Shumway Road	187.45	5,100	12,000	16,000	28,600
Immediately Below Confluence With Show Low	410	8,400	19,500	26,000	45,600
Upstream of Cross Section S (Approximately 4,000 feet upstream of Willow Lane)	410	8,400	19,500	26,000	45,600
Mesa Wash	6.37	--	--	2,500	--
Navajo Pines Wash	0.38	50	124	165	320
Oklahoma Flat Draw					
At Confluence of Main Channel and Oklahoma Flat	7.46	--	--	4,860	--
At North End of Study Limit	8.52	--	--	5,244	--

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Entering Pine Crest Lakes Development (South of State Highway 260 and Old Crook Road)	3.05	--	--	2,671	--
Upstream of Twin 4-foot by 8-foot Box Culvert Under State Highway 260	3.30	--	--	2,918	--
Patricks Wash	0.63	66	156	219	410
Pinedale Wash					
At Pinedale Road	5.25	680	1,690	2,270	4,500
Porter Canyon Draw					
At McLaws Road	93.63	5,660	9,570	11,640	17,000
Railroad Grade Wash					
At Confluence With Airport Wash	1.84	269	526	641	1,030
Below Confluence With Airport Wash	3.67	555	1,082	1,318	2,200

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Rocky Arroyo					
At the Confluence With White Mountain Lake	37.75	--	--	5,539	--
Ruby Wash					
At Confluence With Icehouse Wash	18.4	--	--	2,800	--
At North Park Drive	15.9	--	--	2,222	--
At outlet From Spreading Basin at North Park Drive South of McHood Road	27.8	--	--	4,219	--
At Santa Fe Railroad Crossing	12.5	--	--	1,293	--
Upstream of Interstate Highway 40	12.8	--	--	1,365	--
Show Low Creek					
At City of Show Low Southern Corporate Limits 1.56 Miles Upstream of U.S. Highway 60	81.4	--	--	14,426	--

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
At South Corporate Limits With City of Show Low	81.4	--	--	16,890	--
Below Jaques Dam	73.6	--	--	14,226	--
Inflow to Show Low Lake at USGS Gaging Station 09-	68.3	--	--	16,890	--
Silver Creek					
At Outlet With Mexican Lake	114.25	--	--	9,350	--
Downstream of Confluence With Cottonwood Wash	489	2,900	8,000	12,850	27,000
Upstream of Confluence With Cottonwood Wash	217	2,460	5,555	9,640	15,000
Town Wash					
At Old State Highway 260	2.90	480	1,215	1,645	3,080
Upper Silver Creek					
At Confluence With White Mountain Lake	55.83	--	--	12,200	--

-- Not available

Table 6 (cont'd)- SUMMARY OF PEAK DISCHARGES

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharges (cfs) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Walnut Gulch Creek					
At Stream Mile 2.21	3.23	480	1,190	1,600	2,960
Whipple Wash	1.95	236	531	708	1,010
Whiting Creek					
At Hill Road (Holbrook)	1.95	378	669	815	2,176
At Mouth	1.95	378	669	815	2,176

-- Not available

3.2 Hydraulic Analyses

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

Cross sections were determined from topographic maps and field surveys. All bridges, dam, and culverts were field surveyed to obtain elevation data and structural geometry. All topographic mapping used to determine cross sections are referenced in Section 4.1.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (see Section 4.2), selected cross-section locations are also shown on the FIRM.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All qualifying bench marks within a given jurisdiction that are cataloged by the National Geodectic Survey (NGS) and entered into the National Spatial Reference System (NSRS) as First of Second Order Vertical and have a vertical stability classification of A, B, or C are shown and labeled on the Firm with their 6-character NSRS Permanent Identifier.

Bench marks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classifications. NSRS vary widely in vertical stability classifications. NSRS vertical stability classifications are as follows:

- Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)
- Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutment)
- Stability C: Monuments which may be affected by surface ground movements (e.g., concrete monument blow frost line)
- Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line, or steel witness post)

In addition to NSRS bench marks, the FIRM may also show vertical control monuments established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM in the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for bench marks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

Navajo County

Flood elevations for the streams studied by detailed methods for the areas of Navajo County were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (U.S. Department of the Army, Corps of Engineers, November 1976, with updates). For the stream channels studied by detailed methods, cross sections were compiled using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Cooper Aerial Surveys, 1980 and U.S. Department of the Army, Corps of Engineers, Floodplain Management, 1973), in order to simulate the character of stream channels and their adjacent overbanks. Stream channel geometry used in this floodplain analysis was developed specifically for this FIS. Aerial photogrammetric methods were used to compile the topographic maps of the stream channels and adjacent floodplain areas for developing the cross-sectional geometry (Cooper Aerial Surveys, 1980 and U.S. Department of the Army, Corps of Engineers, Floodplain Management, 1973).

Roughness factors (Manning's "n") used in hydraulic computations were chosen by engineering judgment and based on field observations of the streams and floodplain areas. A summary of the Manning's "n" values used for floodplain modeling of the streams studied in detail is shown in Table 2. The dimensions of structures that produce backwater were identified through field measurements.

Starting water-surface elevations (WSEL5) for the Little Colorado River at Holbrook, Whiting Creek, and Porter Canyon Draw were determined by normal-depth calculations. Starting WSELs for all other detailed study streams were determined by critical depth calculations. Flood profiles were drawn showing computed WSELs to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Because of the shallow nature of flooding along the downstream portion of Whiting Creek, no profile for it is shown in this study.

This study was revised on August 16, 1988, to incorporate detailed flooding information for Rainbow Lake, which was previously studied by approximate methods.

The flooding information for Rainbow Lake is based on data contained in a report entitled Final Drainage Report for the Shores at Rainbow Lake, Lakeside, Navajo County, Arizona prepared by Collar, Williams, and White Engineering, Inc., Phoenix, Arizona, in March 1986 and revised in April 1986. Based on this report, the 100- and 0.2-percent annual chance flood elevations on Rainbow Lake are 6712.8 and 6714.0 feet NGVD, respectively.

The changes resulted in revisions to the Summary of Discharges table, Manning's "n" Values table, Floodway Data table, and Flood Insurance Zone Data table.

On September 30, 1992, a study revision for the unincorporated areas Navajo County was completed to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. The revision was performed by AGK and includes a hydraulic analysis for the 1-percent annual chance flow along the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. The mapping generated by Cooper Aerial of Phoenix, Inc., for the Little Colorado River (Cooper Aerial of Phoenix, Inc., April 20, 1989), Ruby Wash (Cooper Aerial of Phoenix, Inc., April 20, 1989), Show Low Creek (Cooper Aerial of Phoenix, Inc., May 5, 1989), and Oklahoma Flat Draw (Cooper Aerial of Phoenix, Inc., May 18, 1989) and the HEC-2 computer data generated by AGK were utilized to determine flood limits. Cross-section data for the backwater analyses of the Little Colorado River, Ruby Wash, Show Low

Creek, and Oklahoma Flat Draw were determined by obtaining digitized cross sections from Cooper Aerial (Cooper Aerial of Phoenix, Inc., April 20, 1989, May 5, 1989 & May 18, 1989). WSELs for the 1-percent chance of annual exceedance were computed using the USACE HEC-2 Step Backwater Computer Program (U.S. Department of the Army, Corps of Engineers, February 1989). The relevant WSEL from the 1981 FIS for the City of Winslow (Federal Emergency Management Agency, March 16, 1981) was used as the starting WSEL for the Little Colorado River. Critical depth was used as the starting WSEL for Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. Channel and overbank roughness (Manning's "n") factors used in the hydraulic computations were chosen by engineering judgment and based on field observation of the streams and floodplain areas.

This study was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek.

The USACE HEC-2 computer model was utilized by KHE for the hydraulic analyses for Silver Creek. Although the revised hydraulic analyses included the 10-, 2-, 1-, and 0.2-percent annual chance recurrence interval floods, only a revised 1-percent chance of annual exceedance plain and floodway were mapped. The effective 0.2-percent annual chance floodplain boundaries were deleted in the revision area because revised boundaries based on the lower discharge were not developed. As a result of the hydrologic and hydraulic analyses, the peak discharges and BFEs decreased, and the 1-percent annual chance floodway and floodplain boundaries changed.

The floodway and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, with a contour interval of 2 feet.

The Summary of Discharges table, Floodway Data table, and Flood Profile panels for Silver Creek were revised as a result of these analyses. In addition, the Floodway Data Table and Flood Profile Panels were revised to show the correct stream distances along Silver Creek.

As a result of this revision, the flooding shown between Cross Sections A and N on the previous FIRM no longer affects Navajo County. Therefore, profiles and Floodway Data Tables for Navajo County were revised to reflect these changes.

An additional revision was completed on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from FM 1.6 near the City of Heber to FM 3.4, was studied by detailed methods.

Channel and overbank cross sections were digitized from the aerial photogrammetric survey conducted for this study (Cooper Aerial of Phoenix, Inc., January 15, 1993). WSELs were computed through the use of the USACE HEC-2 computer program (U.S. Department of the Army, Corps of Engineers, September 1990). The starting WSEL was set equal to the WSEL in the effective FIS at the upstream limit of study. Supercritical flow conditions can occur in some channel reaches. Whenever supercritical flow occurs, the profiles were computed based on critical depths.

Manning's "n" roughness values were estimated based on field observations and USACB and USGS criteria (Chow, yen T., 1959 and U.S. Department of the Interior, 1987).

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary A, Hog Wash, Hog Wash Tributary A.

The limits of study for Linden Draw were from 800 feet upstream of Lone Pine Dam Road to 3.8 miles upstream at the limit of detailed study. The water surface profiles for the 10-, 2-, 1-, and 0.2-percent annual chance floods were computed using the USACE Engineers HEC-RAS computer model (HEC 2001). The starting water surface elevations were based on the normal depth of the downstream limit of the hydraulic model.

The limits of study for Linden Draw Tributary A are from the confluence with Linden Draw to 1.3 miles upstream to the limit of detailed study at Burton Lane. The starting water surface elevation for Linden Draw Tributary was based on the water surface elevation of Linden Draw at the confluence of the two reaches. This assumption is based on the ratio of the two drainage areas being approximately 0.60. FEMA 37 (FEMA 1995) recommends a coincident peak assumption if the ratio of the drainage areas falls between 0.6 and 1.4.

The limits of study for Hog Wash are from 1300 feet upstream of Show Low to 2.7 miles upstream. The water surface profiles for the 10-, 2-, 1-, and 0.2-percent annual chance floods were computed using HECRAS. The starting water surface elevations were based on the normal depth of the downstream limit of the hydraulic model.

The limits of study for Hog Wash Tributary A are from the confluence with Hog Wash to 0.9 miles upstream at the limit of detailed study. The water surface profiles for the 10-, 2-, 1-, and 0.2-percent annual chance floods were computed using HEC-RAS. The starting water surface elevations were based on the normal depth of the downstream limit of the hydraulic model.

Another revision took affect on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek and Upper Silver Creek (formerly Silver Creek), Rocky Arroyo, White Mountain Lake, and Mexican Lake within Navajo County. The hydraulic analyses were performed by Tetra Tech, Inc. (formerly ASL Consulting Engineers), for Navajo County under Project Order No. 2343-0001 (ASL Consulting Engineers, August 2000). This study was completed in August 2000 and submitted to FEMA.

Lower Silver Creek was restudied from approximately 21,300 feet upstream to approximately 22,000 feet upstream of Willow Lane and from approximately 23,100 feet upstream of Willow Lane to approximately 100 feet downstream of the confluence with Show Low Creek. BFEs, floodplain boundary delineations, and regulatory floodway boundary delineations increased and decreased along the revised reach.

Upper Silver Creek was studied from the confluence with White Mountain Lake to approximately 16,000 feet upstream. Bourdon Ranch Road, BFEs, and a regulatory floodway from approximately 10,900 feet upstream to approximately 16,000 feet upstream of the confluence with White Mountain Lake were added along the revised reach. Mexican/White Mountain Lake Outlet was studied from the confluence of Mexican Lake Outlet and Silver Creek to approximately 8,000 feet upstream. Rocky Arroyo was studied from White Mountain Lake to approximately 5,200 feet upstream, where it meets State land. BFEs were added, and the floodplain boundary delineations increased and decreased along the revised reach.

The WSELs were computed using the USACE HEC-RAS computer program (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, September 1998). The Lower Silver Creek starting WSEL was established from the 1994 FIS for the unincorporated areas of Navajo County. The Upper Silver Creek and Rocky Arroyo Creek starting WSELs were established from the static WSEL of White Mountain Lake.

The starting WSEL for the Mexican/White Mountain Lake Outlet System was determined by using critical depth at the confluence of Lower Silver Creek and peak flow from the KHE report. Supercritical flow regimes were used in the HEC-PAS hydraulic models for Mexican/White Mountain Lake Outlet and Rocky Arroyo. However, critical depth was not mapped for these two revised reaches.

Channel and overbank cross sections were determined from Navajo County 200-foot, horizontal scale topographic mapping with 2-foot contour intervals (Cooper Aerial Surveys, 1980); field measurements; and as-built drawings of channels and structures. Bridges and culverts were modeled according to their configurations.

Manning's "n" values were determined from site visits to the study area. Contraction and expansion coefficients of 0.1 and 0.3 were used for open-channel sections. Contraction coefficients of 0.3 to 0.5 were used at culverts and bridges, depending on the configuration.

A restudy was completed in August 2004 to incorporate detailed flooding information for a ten mile section of Cottonwood Wash within the Town of Snowflake and the Town of Taylor and through portions of unincorporated Navajo County. HEC-GeoRAS was used to generate cross sections for the hydraulic analysis. The revised hydraulic analyses included the 10-, 50-, 100-, and 0.2-percent annual chance recurrence interval floods. The Cottonwood Wash starting elevation was established by using the normal depth. Estimates for roughness coefficients (Manning's "n" values) were determined from site visits to the study area.

The floodways for Cottonwood Wash were computed on the basis of equal-conveyance reduction from each side of the flood plain, except in those areas where topography, physiographic features, or manmade structures prevented this method from being used. Equal-conveyance reduction computations are done in two parts. First, the floodway boundaries are determined at each cross section by specifying a target increase in water-surface elevation. Then, a step-backwater computation is performed to determine the actual increase in elevation. The second part takes into consideration the effects of encroachment downstream of any particular cross section. Using a 1.0-foot target increase for the streams studied resulted in increases of more than 1.0 foot at several cross sections. Therefore, less than 1.0-foot targets were used in order that the 1.0-foot maximum criterion would not be exceeded. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed.

City of Holbrook

Flood elevations for Little Colorado River and Whiting Creek were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, November 1976 with updates). In order to simulate the character of stream channels and their adjacent overbanks, cross sections were compiled using topographic maps at a scale of 1:2400, with a contour interval of 4 feet (Cooper Aerial Surveys, 1973) for the stream channels specified for study by detailed methods. Field reconnaissance determined below-water cross sections to be insignificant because flow was shown as less than 6 inches deep in the aerial photographs used to provide the topographic maps.

The starting water-surface elevation on Little Colorado River was at normal depth. On Whiting Creek, the starting water-surface elevation was the backwater elevation from Little Colorado River. Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Due to the shallow nature of flooding found along Whiting Creek, no profile has been shown for it in this study.

Town of Pinetop-Lakeside

Flood elevations for Billy and Walnut Gulch Creeks were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (U.S Department of the Army, Corps of Engineers, November 1976, with updates). To simulate the character of stream channels and their adjacent overbanks, cross sections were compiled using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Cooper Aerial Surveys, 1980). Photogrammetric methods were used to compile the topographic maps of the stream channels and adjacent flood plain areas for developing the cross sectional geometry (Cooper Aerial Surveys, 1980).

Starting water-surface elevations for Billy and Walnut Gulch Creeks were determined by critical-depth calculations.

This study was revised on August 16, 1988, to incorporate changes in corporate limits due to annexations of portions of Navajo County. The detailed flooding information for Rainbow Lake is based on data contained in a report entitled Final Drainage Report for the Shores at Rainbow Lake, Lakeside, Navajo County, Arizona prepared by Collar, Williams, and White Engineering, Inc., Phoenix, Arizona, in March 1986, and revised in April 1986. Based on this report, the 100 - and 500 - year flood elevations on Rainbow Lake are 6,712.8 and 6,714.0 feet National Geodetic Vertical Datum, respectively. The changes resulted in revisions to the Vicinity Map, the Floodway Data table, and flood profiles.

The Town of Pinetop-Lakeside study was further revised on September 29, 1989, to incorporate detailed flooding information along Billy Creek from RM 1.62 to RM 3.40 above the confluence of Show Low Creek. The study was completed by the Core of Engineers (COE), Los Angeles District, California, in February 1988, as a part of the Limited Map Maintenance Program.

Water-surface profiles were determined using the USACE HEC-2 step-backwater computer program.

City of Show Low

For those stream courses studied by detailed methods, flood elevations were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (U.S. Department of the Army, Corps of Engineers, 1976.). Cross section data were obtained from topographic maps in the 1980 study by Cella, Barr, Evans, and Associates (U.S. Department of the Army, Corps of Engineers, 1976.) that were compiled photogrammetrically from aerial photos. The accuracy of cross sections is 1 foot. For the study completed in 1990, the accuracy of cross section is 2 feet. Depth of flow in the stream channel during photogrammetric plotting was less than 6 inches. Therefore, below water-surface elevations are insignificant. The dimensions of backwater-producing structures were identified through field measurement.

Starting water-surface elevations for the tributary streams were initiated at critical depth within the 1-percent annual chance plain limits of Show Low Creek. Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals.

Shallow flooding occurs along Patricks Wash between West McNeil and U.S. Highway 60; the 1-percent chance of annual exceedance cannot be contained by a 24-inch corrugated metal pipe, thereby causing ponding in a shopping center parking lot. Shallow flooding occurs on Whipple Wash downstream of cross section D and on Fools Hollow Wash East Branch due to sheet flow.

Little information exists on flood elevations and historical discharges; therefore, flow profiles were not compared with historical events. The hydraulic analysis of the 1-percent annual chance flow in Show Low Creek upstream of a point 1.56 miles upstream of U.S. Highway 60 was performed by AGK Engineers, Inc. Cross section data for the backwater analysis of Show Low Creek was determined by obtaining digitized cross sections from Cooper Aerial of Phoenix, Inc. (Cooper Aerial of Phoenix, Inc., May 5, 1989). Critical depth was used as the starting water-surface elevation for Show Low Creek.

Town of Snowflake

Flood elevations for the streams studied by detailed methods were determined using the U.S. Army Corps of Engineers HEC - 2 computer program for the computation of water - surface profiles (Arizona Department of Economic Security, July 1, 1978).

Cross section data were obtained from topographic maps (Cooper Aerial Surveys, Topographic Maps, April 1979), which were compiled photogrammetrically from aerial photographs. The accuracy of cross sections is 1 foot. Depth of flow in the stream channel during photogrammetric plotting was less than 6 inches. Therefore, below-water surface elevations are insignificant. The dimensions of backwater-producing structures were identified through field measurements.

The starting water-surface elevations for Silver Creek were determined by critical depth calculations at a point downstream of the corporate limits of the Town of Snowflake. One hydraulic model was used to compute the water-surface profile from River Mile 18.1 to the limit of the detailed study (River Mile 23.4). Flood elevations for the streams studied by detailed methods were determined using the USACE HEC-2 computer program for the computation of water-surface profiles (Arizona Department of Economic Security, July 1, 1978).

The main channel of Silver Creek has many stands of phreatophytic vegetation lining the channel banks. A Manning's "n" value of 0.13 was used for ineffective flow areas (ponding areas).

The starting water-surface elevations for Cottonwood Wash were determined at the confluence with Silver Creek (River Mile 0.00), with one hydraulic model used to compute the water-surface profile from River Mile 0.00 to the limit of detailed study (River Mile 2.22).

There is little information on flood elevations and historical discharges; therefore, flow profiles were not compared with historical events. Flow profiles were not compared with a study done by the NRCS because the hydrology does not concur (U.S. Department of Agriculture, Soil Conservation Service, May 1978).

The restudy for the Town of Snowflake was completed on February 16, 1994, to incorporate the effects of new hydraulic analyses for Silver Creek and Cottonwood Wash.

The USACE HEC-2 computer model was used by KHE to revise the hydraulic analyses for Cottonwood Wash from the confluence with Silver Creek to Apache Railroad and the entire reach of Silver Creek in the Town of Snowflake, Arizona. The revised hydraulic analyses, which utilized the new peak discharges, did not cover the entire existing detailed study reach for Cottonwood Wash. Because of the difference in peak discharges, the revised flood profiles and floodplain and floodway boundaries at the upstream limit did not tie into the existing flood boundaries and profiles. Therefore, a note explaining that the mismatch is due to the decrease in peak discharges was added on the FIRM and FIS report.

The revised hydraulic analyses included the 10-, 50- 100-, and 0.2-percent annual chance recurrence interval floods. However, only revised delineations were developed for the 1-percent annual chance floodplain and floodway. Because of this and that the discharges are significantly decreased, the effective 0.2-percent annual chance floodplain boundaries were deleted for this revised reach. As a result of these analyses, the peak discharges and base (1-percent annual chance) flood elevations (BFEs) decreased and the 1-percent annual chance floodway and floodplain boundaries changed.

The Summary of Discharges Table, Floodway Data Table, and Flood Profile Panels for Silver Creek and Cottonwood Wash, have been revised as a result of this analysis.

Town of Taylor

The starting water-surface elevations (WSELs) for Airport Wash and Railroad Grade Wash were calculated at critical depth. The starting WSELs for the upstream reaches of Silver Creek were calculated at critical depth, and the downstream reaches were calculated by normal depth. For those stream courses studied by detailed methods, flood elevations were determined utilizing the USACE computer program HEC-2 (U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, November 1976, with updates) for the computation of flood profiles. In order to simulate the character of stream channels and their adjacent overbanks, cross sections were drawn utilizing topographic maps (Cooper Aerial Surveys, July 1980) of the stream channels specified for study by detailed methods. Depth of flow in stream channels during photogrammetric plotting was less than 6 inches, and, therefore, below-water elevations are insignificant. The profile base line used for horizontal control was also obtained by field survey.

The roughness coefficients for bridges and culverts were assumed to be equivalent to the channel Manning's "n" value. There is little information on flood elevations and historical discharges; therefore, flow profiles were not compared with historical events. Flood profiles were drawn showing computed WSELs to an accuracy of 0.5 foot for floods of the selected recurrence intervals.

For Pinedale Wash, the approximate 1-percent annual chance elevation was determined using the developed discharges in conjunction with the Flood Hazard Boundary Map (FHBM) (U.S. Department of Housing and Urban Development, Federal Insurance Administration, April 30, 1976), aerial photography (Cooper Aerial Surveys, Aerial Photographs), and field surveys.

A revision of this study took affect on March 2, 1994, to incorporate the effects of new hydraulic analyses for Silver Creek. The USACE HEC-2 computer model was utilized by KHE for the hydraulic analyses for Silver Creek from the northern corporate limits of the Town of Taylor to approximately 3,600 feet upstream of Willow Lane. Although the revised hydraulic analyses included the 10-, 50-, 100-, and 0.2-percent annual chance recurrence interval floods, only a revised 1-percent annual chance floodplain and floodway were mapped. The effective 0.2-percent annual chance floodplain boundaries were deleted in the revision area because revised boundaries based on the lower discharge were not developed. As a result of the hydrologic and hydraulic analyses, the peak discharges and BFEs decreased, and the 1-percent annual chance floodway and floodplain boundaries changed.

The Summary of Discharges table, Floodway Data table, and Flood Profile Panels for Silver Creek were revised as a result of these analyses. In addition, the Floodway Data Table and Flood Profile Panels were revised to show the correct stream distances along

Silver Creek. The flooding shown between Cross Sections A and N on the previous FIRM no longer affects Navajo County and floodways and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, and a contour interval of 2 feet.

Another revision of the Town of Taylor study took affect on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek (formerly Silver Creek) within the Town of Taylor. The Town of Taylor corporate limits also were updated. The hydraulic analyses were performed by Tetra Tech, Inc. (formerly ASL Consulting Engineers), for Navajo County under Project Order No, 2343 - 0001 (ASL Consulting Engineers, August 2000). This study was completed in August 2000 and submitted to FEMA.

The USACE HEC-RAS hydraulic computer model (U.S. Department of the Army, Corps of Engineers, September 1998) was used by Tetra Tech, Inc., to revise the hydraulic analysis of Lower Silver Creek from approximately 11,850 feet upstream to approximately 21,300 feet upstream of Willow Lane and from approximately 22,000 feet upstream to approximately 23,100 feet upstream of Willow Lane.

The revised hydraulic analysis included only the 1-percent annual chance recurrence interval flood. Therefore, only revised delineations for the 1-percent annual chance floodplain and floodway were developed. As a result of this analysis, the peak discharge and BFEs increased and decreased, and the 1-percent annual chance floodway and floodplain boundaries changed

The WSELs were computed using the USACE HEC-RAS computer program (U.S. Department of the Army, Corps of Engineers, September 1998). The Lower Silver Creek starting WSEL was established by the Normal Depth (slope - area) method (S=.00214).

Channel and overbank cross sections were determined from Navajo County 200-foot, horizontal scale topographic mapping with 2-foot contour intervals (Cooper Aerial Surveys, July 1980), and field measurements. No bridges and culverts were modeled. Manning's "n" values were determined from site visits to the study area. Contraction and expansion coefficients of 0.1 and 0.3 were used for open-channel sections.

City of Winslow

A hydraulic analysis for the 1-percent annual chance flow in the Little Colorado River and Ruby Wash was performed by ACK Engineers, Inc. for the restudy of the City of Winslow. The mapping was generated by Cooper Aerial of Phoenix, Inc. (Cooper Aerial of Phoenix, Inc., April 20, 1989) and the HEC-2 computer data generated by AGK Engineers, Inc. were utilized in the determination of flood limits.

Engineers, Inc. were utilized in the determination of flood limits. Cross section data for the backwater analysis of the Little Colorado River and Ruby Wash were determined by obtaining digitized cross sections from Cooper Aerial of Phoenix, Inc. (Cooper Aerial of Phoenix, Inc., April 20, 1989).

Water-surface elevations for the 1-percent annual chance flood were computed using the USACE HEC-2 Step Backwater Computer Program (U.S. Department of the Army, Corps of Engineers, February 1989). The relevant water-surface elevation from the original FIS (Federal Emergency Management Agency, March 16, 1981) was used as the starting water-surface elevation for the Little Colorado River. The starting water-surface elevation for Ruby Wash was determined by normal depth calculations.

Table 7 contains a summary of Manning's "n" Values used in this countywide FIS study.

Table 7 - MANNINGS "n" VALUES

Stream	Stationing	Left Overbank "n"	Channel "n"	Right Overbank "n"
Airport Wash	N/A	0.040	0.030	0.040
Billy Creek	N/A	0.044 – 0.040	0.032 – 0.035	0.044 – 0.040
Black Canyon Wash[2]				
Near Heber	15.80 - 18.31	0.045	0.030	0.045
Buckskin Wash	0.00 – 1.54	0.045	0.030	0.045
Near Heber	1.54 – 3.43	0.045 – 0.060	0.030 – 0.050	0.045 – 0.060
Cottonwood Wash[3]				
	0-989	0.045	0.040	0.045
	1,389-4,439	0.060	0.035	0.045
	4,747-5,995	0.045	0.043	0.060
	6,080-7,232	0.059	0.052	0.065
	7,596-11,092	0.049	0.058	0.065
	11,525-21,872	0.055	0.040	0.055
	22,179-28,195	0.063	0.058	0.063
	28,596-32,830	0.061	0.045	0.061
	33,322-34,843	0.072	0.081	0.072
	34,956-51,969	0.049	0.048	0.049

[2] Stationing in miles.
[3] Stationing in feet.

Table 7 - MANNINGS "n" VALUES

Stream	Stationing	Left Overbank "n"	Channel "n"	Right Overbank "n"
Cottonwood Wash Split Flow[1]				
	296-548	0.063	0.058	0.063
	981-3,465	0.061	0.045	0.061
Fools Hollow Wash	N/A	0.044 - 0.064	0.027 – 0.035	0.044 - 0.064
Fools Hollow Wash East Branch	N/A	0.062	0.035	0.062
Hog Wash	N/A	0.05 – 0.10	0.04 – 0.06	0.045 – 0.10
Hog Wash Tributary	N/A	0.04 – 0.10	0.03 – 0.04	0.04 – 0.10
Joseph City Wash	0 – 2.80	0.030	0.040	0.030
Linden Draw	N/A	0.029 – 0.044	0.029 – 0.049	0.029 – 0.092
Linden Draw Tributary	N/A	0.029 – 0.044	0.034 – 0.035	0.029 – 0.034
Little Colorado River[2]	N/A	0.035 – 0.125	0.023 – 0.077	0.035 – 0.125
Near Holbrook	183.70 – 186.21	0.045	0.035	0.045
	186.21 – 187.37	0.055	0.035	0.060
	187.37 – 189.87	0.100	0.035	0.100
	189.87 – 191.45	0.045	0.035	0.045
	191.45 – 192.70	0.100	0.035	0.100
Near Joseph City	175.91 – 177.47	0.025 – 0.035	0.035 – 1.00	0.025 – 0.035
	177.47 – 177.68	0.025 – 0.035	0.035 – 0.100	0.025 – 0.035
	177.68 – 177.18	0.025 – 0.035	0.035 – 1.00	0.025 – 0.035
	177.18 – 178.76	0.025 – 0.035	0.035 – 0.100	0.025 – 0.035

1. Stationing in miles.
2. Stationing in feet.

Table 7 - MANNINGS "n" VALUES

Stream	Stationing	Left Overbank "n"	Channel "n"	Right Overbank "n"
	178.76 – 180.38	0.025 – 0.035	0.035 – 1.00	0.025 – 0.035
	180.38 – 181.78	0.025 – 0.035	0.035 – 0.100	0.025 – 0.035
Near Winslow	152.60 – 159.66	0.050	0.030	0.050
	159.66 – 159.69	1.50	0.030	1.50
	159.69 – 160.00	0.050	0.030	0.050
	160.00 – 160.10	0.050	0.030	0.040
Near Woodruff	201.50 – 202.08	0.050	0.030	0.050
	202.08 – 202.18	0.058	0.040	0.058
	22.18 – 202.41	0.060	0.040	0.055
	202.41 – 202.71	0.050	0.030	0.050
	202.71 – 202.81	0.060	0.055	0.060
	202.81 – 202.99	0.055	0.030	0.055
	202.99 – 203.22	0.050	0.030	0.050
Lower Silver Creek	N/A	0.040 – 0.050	0.015 – 0.045	0.040 – 0.050
Mesa Wash	0 - 1.06	0.030	0.045	0.030
Mexican / White Mountain Lake Outlet	N/A	0.065 – 0.072	0.018 – 0.065	0.065 – 0.072
Navajo Pines Wash	N/A	0.055 – 0.073	0.040 – 0.045	0.055 – 0.073
Oklahoma Draw	N/A	0.050 – 0.080	0.025 – 0.050	0.050 – 0.080
Patricks Wash	N/A	0.028 – 0.055	0.030 – 0.038	0.028 – 0.055
Pinedale Wash (Near Pinedale) [1]	1.10 – 2.14	0.045	0.040	0.045
Porter Canyon Draw (Near Holbrook) [1]	0.10 – 1.22	0.055	0.030	0.055

Table 7 - MANNINGS "n" VALUES

Stream	Stationing	Left Overbank "n"	Channel "n"	Right Overbank "n"
Railroad Grade Wash	N/A	0.040	0.030	0.040
Rocky Arroyo	N/A	0.055 – 0.080	0.055 – 0.080	0.055 – 0.080
Ruby Wash	N/A	0.030 – 0.080	0.025 – 0.035	0.030 – 0.080
Show Low (Near Show Low) [1]	20.04 – 20.39	0.062	0.040 – 0.045	0.062
Downstream of River Mile	20.06	0.055 – 0.062	0.040 – 0.045	0.055 – 0.062
Spillway of Jaques Dam	N/A	0.015	0.015	0.015
Upstream of River Mile	20.06	0.040 – 0.080	0.015 – 0.045	0.040 – 0.080
Silver Creek[1]	N/A	0.040 – 0.130	0.027 – 0.05	0.040 – 0.130
Near Shumway	27.37 – 32.63	0.040	0.027	0.040
Near Snowflake	18.14 – 22.80	0.130	0.041 – 0.045	0.050
Town Wash				
Near Clay Springs	7.6 – 8.61	0.040	0.030	0.040
Upper Silver Creek	N/A	0.060 – 0.125	0.025 – 0.110	0.060 – 0.125
Walnut Gulch Creek	2.21 – 3.45	0.040 – 0.044	0.032 - 0.035	0.040 – 0.044
Whipple Wash	N/A	0.078 – 0.091	0.035 – 0.055	0.078 – 0.091
Whiting Creek	0.10 – 1.43	0.055	0.030	0.055

1. Stationing in miles.

The conversion factor for each stream studied by detailed methods is shown below in Table 8, “Stream Conversion Factors.”

Table 8 - STREAM CONVERSION FACTORS

Stream Name	Elevation (feet NAVD above NGVD)
Airport Wash	2.7
Billy Creek	3.0
Black Canyon Wash	3.1
Buckskin Wash	3.2
Cottonwood Wash	2.7
Cottonwood Wash Split Flow	2.7
Fools Hollow Wash	3.0
Fools Hollow Wash East Branch	3.0
Hog Wash	2.9
Hog Wash Tributary	2.9
Joseph City Wash	2.5
Linden Draw	2.9
Linden Draw Tributary	2.9
Little Colorado River at City of Holbrook	2.4
Little Colorado River at Joseph City	2.7
Little Colorado River at City of Winslow	2.7
Little Colorado River at River Road	2.7
Lower Silver Creek	2.7
Mesa Wash	2.5
Mexican Lake Outlet	2.8
Navajo Pines Wash	3.0
Oklahoma Flat Draw	3.1
Patricks Wash	3.0
Pinedale Wash	3.0
Porter Canyon Draw	2.7
Railroad Grade Wash	2.7

Table 8 - STREAM CONVERSION FACTORS

Stream Name	Elevation (feet NAVD above NGVD)
Rocky Arroyo	2.8
Ruby Wash	2.4
Show Low Creek	2.9
Silver Creek	2.7
Town Wash	3.0
Upper Silver Creek	2.8
Walnut Gulch Creek	3.0
Whipple Wash	3.0
Whiting Creek	2.7

Levee Hazard Analysis

Some flood hazard information presented in prior FIRMs and in prior FIS reports for Navajo County and its incorporated communities was based on flood protection provided by levees. Based on the information available and the mapping standards of the National Flood Insurance Program at the time that the prior FISs and FIRMs were prepared, FEMA accredited the levees as providing protection from the flood that has a 1-percent-chance of being equaled or exceeded in any given year. For FEMA to continue to accredit the identified levees with providing protection from the base flood, the levees must meet the criteria of the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10), titled "Mapping of Areas Protected by Levee Systems."

On August 22, 2005, FEMA issued *Procedure Memorandum No. 34 - Interim Guidance for Studies Including Levees*. The purpose of the memorandum was to help clarify the responsibility of community officials or other parties seeking recognition of a levee by providing information identified during a study/mapping project. Often, documentation regarding levee design, accreditation, and the impacts on flood hazard mapping is outdated or missing altogether. To remedy this, *Procedure Memorandum No. 34* provides interim guidance on procedures to minimize delays in near-term studies/mapping projects, to help our mapping partners properly assess how to handle levee mapping issues.

While 44 CFR Section 65.10 documentation is being compiled, the release of more up-to-date FIRM panels for other parts of a community or county may be delayed. To minimize the impact of the levee recognition and certification process, FEMA issued *Procedure Memorandum No. 43 - Guidelines for Identifying Provisionally Accredited Levees* on March 16, 2007. These guidelines will allow issuance of preliminary and effective versions of FIRMs while the levee owners or communities are compiling the full documentation required to show compliance with 44 CFR Section 65.10. The guidelines also explain that preliminary FIRMs can be issued while providing the communities and levee owners with a specified timeframe to correct any maintenance deficiencies associated with a levee and to show compliance with 44 CFR Section 65.10.

FEMA contacted the communities within Navajo County to obtain data required under 44 CFR 65.10 to continue to show the levees as providing protection from the flood that has a 1-percent-chance of being equaled or exceeded in any given year.

FEMA understood that it may take time to acquire and/or assemble the documentation necessary to fully comply with 44 CFR 65.10. Therefore, FEMA put forth a process to provide the communities with additional time to submit all the necessary documentation. For a community to avail itself of the additional time, it had to sign an agreement with FEMA. Levees for which such agreements were signed are shown on the final effective FIRM as providing protection from the flood that has a 1-percent-chance of being equaled or exceeded in any given year and labeled as a Provisionally Accredited Levee (PAL). Communities have two years from the date of FEMA's initial coordination to submit to FEMA final accreditation data for all PALs. Following receipt of final accreditation data, FEMA will revise the FIS and FIRM as warranted.

FEMA coordinated with the U.S. Army Corps of Engineers, the local communities, and other organizations to compile a list of levees that exist within Navajo County. Table 9, "List of Levees Requiring Flood Hazard Revisions" lists all levees shown on the FIRM, to include PALs, for which corresponding flood hazard revisions were made.

Approximate analyses of "behind levee" flooding were conducted for all the levees in Table 9 to indicate the extent of the "behind levee" floodplains. The methodology used in these analyses is discussed below.

The approximate levee analysis was conducted using information from existing hydraulic models (where applicable) and USGS topographic maps.

The extent of the 1-percent-annual-chance flood in the event of levee failure was determined. Base flood elevations and topographic information (where available) were used to estimate an approximate 1-percent-annual-chance floodplain and traced along the contour line representing the base flood elevation. If base flood elevations were not available they were estimated from effective FIRM maps and available information. Topographic features such as highways, railroads, and high ground were used to refine approximate floodplain boundary limits.

Table 9 - LIST OF LEVEES REQUIRING FLOOD HAZARD REVISIONS

Community	Flood Source	Levee Inventory ID	Coordinates Latitude/Longitude	FIRM Panel	USACE Levee
Navajo County[1]	Ruby Wash	1	(-110.698, 35.068) (-110.698, 35.056)	04017C3004E 04017C3012E	No
Navajo County	Little Colorado River	2	(-110.680, 35.073) (-110.666, 35.016)	04017C3008E 04017C3016E 04017C3018E	No
Navajo County[1]	Little Colorado River	3	(-110.675, 35.031) (-110.675, 35.024)	04017C6016E 04017C3018E	No
City of Winslow[1]	Little Colorado River	4	(-110.697, 35.039) (-110.685, 35.030)	04017C3012E 04017C3016E 04017C3018E	No
City of Winslow[1]	Little Colorado River	5	(-110.681, 35.023) (-110.654, 35.012)	04017C3018E 04017C3019E	No
Navajo County City of Winslow	Little Colorado River	6	(-110.654, 35.012) (-110.653, 35.005)	04017C3019E	No
Navajo County City of Winslow	Ruby Wash and Ice House Wash	7	(-110.732, 35.007) (-110.703, 35.007)	04017C3015E	Yes
Navajo County City of Holbrook	Little Colorado River	9	(-110.200, 34.903) (-110.140, 34.897)	04017C3339E 04017C3343E 04017C3344E	Yes

Table 9 - LIST OF LEVEES REQUIRING FLOOD HAZARD REVISIONS

Community	Flood Source	Levee Inventory ID	Coordinates Latitude/Longitude	FIRM Panel	USACE Levee
Navajo County City of Holbrook	Little Colorado River	10	(-110.149, 34.899) (-110.140, 34.898)	04017C3344E	Yes
Navajo County[2]	Confluence of Puerco River and Dry Creek	11	(-109.918, 34.969) (-109.843, 34.971)	04017C3400E 04017C3425E	No
Navajo County City Winslow	Ruby Wash	12	(-110.703, 35.008) (-110.654, 35.005)	04017C3015E 04017C3018E 04017C3019E	Yes
City Winslow	Ruby Wash	13	(-110.685, 35.030) (-110.690, 35.021)	04017C3018E 04017C3015E	No
City Winslow	Mikes Wash	14	(-110.729, 35.040) (-110.724, 35.043)	04017C3015E	No

3.3 Vertical Datum

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

All flood elevations shown in this FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD88. It is important to note that adjacent communities may be referenced to NGVD29. This may result in differences in Base (1-percent-annual-chance) Flood Elevations (BFEs) across the corporate limits between the communities.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the NGVD and NAVD, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282
(301) 713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook (TSDN) associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

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

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section.

For the flooding sources studied by approximate methods, the boundaries of the 1-percent annual chance floodplains were delineated using topographic maps taken from the previously printed FIS reports, FHBMs, and/or FIRMS for all of the incorporated and unincorporated jurisdictions within Navajo County.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, and AH), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown because of limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM.

Navajo County

Between cross sections, the boundaries for the areas of Navajo County were interpolated using topographic maps at a scale of 1:2,400, with contour intervals of 2 and 4 feet (Cooper Aerial Surveys, 1980 and U.S. Department of the Army, Corps of Engineers, Floodplain Management, 1973, respectively).

The floodplain boundaries for approximate-study streams within the areas of Navajo County were delineated using aerial photographs at a scale of 1:8,400 (Cooper Aerial Surveys, April 25, 1979); topographic maps at a scale of 1:24,000, with contour intervals of 10 feet (U.S. Department of the Interior, 1970 & 1971) and 20 feet (U.S. Department of the Interior, 1971 & 1977), and at a scale of 1:62,500, with a contour interval of 40 feet (U.S. Department of the Interior, 1955 & 1990); visual approximations based on estimated runoff per acre; topography; and field surveys.

In accordance with FEMA guidelines, approximate floodplains less than 200 feet wide were determined to be areas of minimal flood hazard and were not delineated.

A revision was made within the areas of Navajo County on September 30, 1992, to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. The floodplain boundaries were delineated in the detailed study reach of the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet (Cooper Aerial of Phoenix, Inc., April 20, 1989, May 5, 1989 & May 18, 1989).

The March 2, 1994 revisions included the effects of new hydrologic and hydraulic analyses for Silver Creek. The floodway and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, with a contour interval of 2 feet.

This study was revised again on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from FM 1.6 near the City of Heber to FM 3.4, was studied by detailed methods. Floodplain and floodway boundaries were delineated using topographic maps at a scale of 1:2,400, with 2-foot contour intervals (Cooper Aerial of Phoenix, Inc., October 2, 1997).

The Navajo County FIS was revised on February 28, 2003, to incorporate hydrologic and hydraulic analyses for streams Linden Draw, Linden Draw Tributary A, Hog Wash, Hog Wash Tributary A. The flood boundaries of the 1 percent and 0.2 percent chance annual exceedance floods along each stream were delineated using the water surface elevations determined at each cross section. Between cross sections, the floodplain was delineated based on surveyed topographic mapping.

City of Holbrook

Between cross sections, the boundaries for the City of Holbrook were interpolated using topographic maps at a scale of 1:2,400, with a contour interval of 4 feet (Cooper Aerial Surveys, 1973).

Town of Pinetop-Lakeside

Between cross sections the boundaries for the Town of Pinetop-Lakeside were interpolated using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Cooper Aerial Surveys, 1980).

A revision was made within the Town of Pinetop-Lakeside on September 29, 1989 to incorporate detailed flooding information along Billy Creek from RM 1.62 to RM 3.40above the confluence of Show Low Creek. Flood boundaries were delineated using an aerial map prepared by Cooper Aerial Company, date December 19, 1986, at a scale of 1:40 and a contour interval of 1 foot.

City of Show Low

For the City of Show Low, the boundaries were interpolated using topographic maps at a scale of 1:2,400 and 1:4,800, with a contour interval of 2 and 4 feet, respectively (Cooper Aerial of Phoenix, Inc., May 5, 1989. and Cooper Aerial of Phoenix, Inc., May 5 1989).

Approximate flood boundaries for Patricks Wash, Whipple Wash, Meadow View Wash, Rolling Acres Wash, Bordons Wash, and Navajo Pines Wash were delineated using aerial photographs at a scale of 1:8,400 (Cooper Aerial Surveys, Aerial Photographs, October 1979). The study contractor determined that some areas previously shown on the Flood Hazard Boundary Maps (U.S. Department of Housing and Urban Development, 1976 and U.S. Department of Housing and Urban Development, 1979) are areas of minimal flooding; therefore, they were not delineated on the maps.

Town of Snowflake

Between cross sections, the boundaries for the Town of Snowflake were interpolated using topographic maps at a scale of 1:2400, with a contour interval of 2 feet (Cooper Aerial Surveys, Topographic Maps, April 1979).

The reach of Cottonwood Wash above River Mile 2.22 was studied by approximate methods. Flood boundaries were developed photogram metrically from aerial photographs at a scale of 1:8400 (U.S. Department of Agriculture, Soil Conservation Service, May 1978). These maps were field checked to ensure their validity.

The study contractor determined that some areas shown on the Flood Hazard Boundary Map (Department of Housing and Urban Development, Federal Insurance Administration, 1979) are areas of minimal flooding; therefore, they were not delineated on the maps.

This study was revised on February 16, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek and Cottonwood Wash. Floodways and floodplain boundaries were delineated using topographic maps prepared by KHE at scales of 1:2,400 and 1:4,800, with a contour interval of 2 feet.

Town of Taylor

Between cross sections the boundaries for the Town of Taylor were interpolated using topographic maps at a scale of 1:2,400, with a contour interval of 2 feet (Cooper Aerial Surveys, July 1980), and at a scale of 1:24,000 with a contour interval of 10 feet (U.S. Department of the Interior, Geological Survey, 1970).

In accordance with FEMA guidelines, approximate floodplains less than 200 feet wide were determined to be areas of minimal flood hazard and have not been delineated.

The approximate 1-percent annual chance boundary for Pinedale Wash was delineated using the determined elevation and the previously cited mapping (References 6 and 9). Approximate flood boundaries in some portions of the Town of Taylor were taken from the FHBM (U.S. Department of Housing and Urban Development, Federal Insurance Administration, April 30, 1976).

This study was revised on March 2, 1994, to incorporate the effects of new hydrologic and hydraulic analyses for Silver Creek. Floodways and floodplain boundaries were delineated using topographic maps prepared by KHE at a scale of 1:4,800, and a contour interval of 2 feet.

The Town of Taylor study was revised again on November 19, 2003, to incorporate new flood hazard information for Lower Silver Creek (formerly Silver Creek) within the Town of Taylor. The corporate limits were also updated for the Town. Channel and overbank cross sections were determined from Navajo County 200 - foot, horizontal scale topographic mapping with 2 - foot contour intervals (Cooper Aerial Surveys, July 1980), and field measurements. No bridges and culverts were modeled.

City of Winslow

Between cross sections, the boundaries for the City of Winslow were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet (Cooper Aerial of Phoenix, Inc., April 20, 1989).

4.2 Floodways

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

The floodways presented in this study were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain.

Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections. In cases where the floodway and 1-percent annual chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

Navajo County

For the Little Colorado River at Holbrook, where the USACE levee was used as the encroachment line on the north side of the Little Colorado River, equal-conveyance reduction from each side of the floodplain was not used. This was compatible with the developmental interests of Navajo County and the City of Holbrook. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed.

For the areas of Navajo County, an initial attempt to establish a floodway on the basis of a 1.0-foot increase in 1-percent annual chance WSEL criteria resulted in extreme backwater problems with the excessive encroachments. It was, therefore, necessary to limit the specified WSEL increases to less than 1.0 foot.

This FIS was revised on September 30, 1992, to incorporate detailed flooding information for the Little Colorado River, Ruby Wash, Show Low Creek, and Oklahoma Flat Draw. Floodways in areas of critical flow were determined so that a maximum rise of 1 foot occurred in the energy grade line.

This study was revised on June 5, 1997, to incorporate certain flooding information for Buckskin Wash. A reach of approximately 1.8 miles of Buckskin Wash, from FM 1.6 near the City of Heber to FM 3.4, was studied by detailed methods.

Where possible, the floodways presented in this revision were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. However, this could not be achieved at all times because of channel section configuration and high velocities and supercritical flows. As a result, floodway boundaries were based on encroachment analyses that limited both the maximum use in

WSELs and energy grade line to 1 foot. Channel velocities exceeded potential erosive magnitudes of 7 to 11 feet per second along approximately half the length of stream studied, at several locations, the natural channel banks govern the floodway encroachment.

City of Holbrook

The floodway boundary, on the north side of Little Colorado River was set at the levee, as approved by the community, the Federal Emergency Management Agency, and the study contractor. On the south side of the river, the boundary was computed to allow an increase in elevation of no more than 1.0 foot above the 100 - year flood.

Due to the shallow nature of the flooding, no floodway was determined for Whiting Creek.

City of Show Low

For Show Low Creek upstream of a point 1.56 miles upstream of U.S. Highway 60 to the Show Low Lake spillway, in areas of critical flow the 1.0 foot maximum increase criteria was applied to the computed energy grade line to determine the floodway encroachment. No floodways were determined for Whipple Wash below cross section D or for Fools Hollow Wash East Branch because the concept is not applicable to areas of shallow flooding.

Town of Taylor

An initial attempt to establish a floodway for Silver Creek, Airport Wash, and Railroad Grade Wash on the basis of a 1.0 - foot increase in 100 - year WSEL criteria resulted in extreme backwater problems with the excessive encroachments. It was, therefore, necessary to limit the specified WSEL increases to less than 1.0 foot.

Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 10, Floodway Data). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

Encroachment into areas subject to inundation by floodwater having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 10, “Floodway Data.” In order to reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside floodway.

The area between the 1-percent annual chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent annual chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

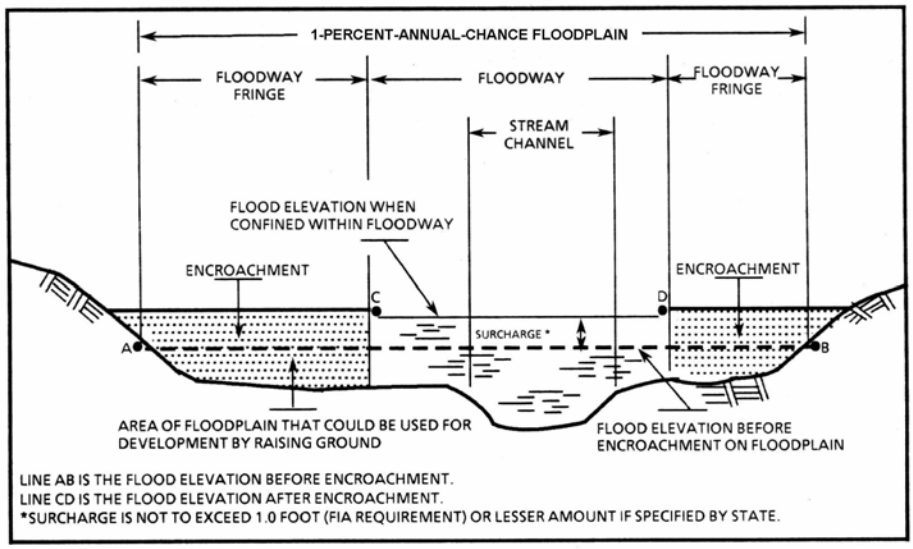

Figure 1 - FLOODWAY SCHEMATIC

In Navajo County, no floodway determinations were made for detailed study areas where flooding sources produced sheetflow over broad, unconfined, gently sloping terrain of relatively low relief. Floodway data are reported for all detailed study areas where the flooding sources produced riverine flooding. River flooding was determined on the basis of field investigation where watercourses were marked by well defined channels and identified by topographic and hydraulic analysis.

5.0 INSURANCE APPLICATION

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

Zone A

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

Zone AO

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

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplain that is determined in the FIS report by detailed methods. Whole-foot Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

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

Zone X

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

Zone D

Zone D is the flood insurance risk zone that corresponds to unstudied area where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

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

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

For floodplain management applications, the map shows by tints, screens, and symbols the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The current FIRM presents flooding information for the entire geographic area of Navajo County. Previously, FIRMs were prepared for each incorporated community and the unincorporated areas of the county identified as flood-prone. The countywide FIRM also includes flood hazard information that was presented separately on Flood Boundary and Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community are presented in Table 11, “Community Map History.”

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISION DATE(S)	FLOOD INSURANCE RATE MAP EFFECTIVE DATE	FLOOD INSURANCE RATE MAP REVISION DATE(S)
Navajo County, (Unincorporated Areas)	August 23, 1974	January 30, 1979	June 1, 1982	August 16, 1988 September 30, 1992 March 2, 1994 June 5, 1997 November 19, 2003
Holbrook, City of	October 29, 1976	None	September 30, 1983	None
Pinetop – Lakeside, Town of	February 19, 1987	None	February 19, 1987	August 19, 1988 September, 29 1989
Show Low, City of	June 7, 1974	February 20, 1976	February 3, 1982	August 3, 1992
Snowflake, Town of	April 5, 1974	March 19, 1976 August 7, 1979	March 1, 1982	February 16, 1994
Taylor, Town of	May 17, 1974	April 30, 1976	February 3, 1982	March 2, 1994 November 19, 2003
Winslow, City of	July 19, 1974	December 19, 1975	September 16, 1981	September 30, 1992

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

NAVAJO COUNTY, AZ
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

7.0 OTHER STUDIES

Navajo County

Other studies found for Navajo County include the USACE Floodplain Information report entitled Little Colorado River, Vicinity of Winslow, Navajo County, Arizona (U.S. Department of the Army, Corps of Engineers, Floodplain Information, March 1976), and the USACE Information Brochure entitled Alternative Proposals for Flood Control and Allied Purposes, Little Colorado River, Holbrook, Arizona (U.S. Department of the Army, Corps of Engineers, January 1978).

FISs were also prepared for the incorporated areas of the Cities of Winslow, Holbrook, Show Low, and the Towns of Taylor and Snowflake (FEMA, FIS, March 16, 1981, September 30, 1983, February 3, 1982, February 3, 1982, and March 1, 1982, respectively) and the adjacent unincorporated areas of Graham County, Apache County, and Coconino County (FEMA, FIS, April 5, 1988, and September 28, 1990, respectively). The results of those studies will be in general agreement with this analysis. Flood boundary delineations for this study supersede the FHBM (U.S. Department of Housing and Urban Development, Federal Insurance Administration, January 30, 1979).

City of Holbrook

The USACE also completed a preliminary hydrologic study of the Little Colorado River at Holbrook (U.S. Department of the Army, Corps of Engineers, December 1975). Flood elevation information from that report was compared to the results of this FIS. The profiles agreed to within 0.5 foot. The USACE report was prepared primarily to evaluate economic losses resulting from high-magnitude flood events and was not fully compatible with the requirements of the NFIP. Therefore, that information was not used in constructing profiles for this study. Discharge data from the USACE hydrologic study (U.S. Department of the Army, Corps of Engineers, December 1975) for Little Colorado River were used in this study. Elevation profiles were recomputed in this study using the most up-to-date topographic information.

A Flood Hazard Boundary Map for Holbrook has been previously published (U.S. Department of Housing and Urban Development, Federal Insurance Administration, January 30, 1979). This FIS is more detailed and, thus, supersedes that map.

City of Show Low

A FIS for the City of Show Low was published August 3, 1981 (Federal Emergency Management Agency, August 3, 1981.). The hydrologic analysis for the reach of Show Low Creek in that study was based on a 25-year gaging record at USGS gaging station 09-390500, located on Show Low Creek at Lakeside. In addition, the USGS has performed an unpublished preliminary log-Pearson Type III analysis at this gaging station. However, the analysis excluded 11 years of record of which the annual maximum flow was less than 150 cfs. Therefore, the 1-percent annual chance discharge derived from that analysis and the August 3, 1981, FIS is not in agreement with the discharge determined for this current study for Show Low Creek.

A report was prepared by Leedshill-Herkenhoff, Inc., in 1983 (Leedshill - Herkenhoff, Inc., June 1983.) concerning the adequacy of Jaques Dam, which is the retention structure of Show Low Lake. The peak flows at various locations in Show Low Lake watershed were estimated by use of the HEC-1 computer program (U.S. Department of the Army,

Corps of Engineers, Hydrologic Engineering Center, September 1981, revised January 1985.) with the Probable Maximum Peak as the model input.

Town of Snowflake

A Flood Hazard Boundary Map for the Town of Snowflake was published in 1979 (Department of Housing and Urban Development, Federal Insurance Administration, 1979). A Watershed Work Plan for Silver Creek was prepared by the NRCS in May 1978 (U.S. Department of Agriculture, Soil Conservation Service, May 1978). Due to the more detailed nature of this FIS, it supersedes the Flood Hazard Boundary Map and Watershed Work Plan FISs being prepared for the Town of Taylor and the areas of Navajo County (Federal Emergency Management Agency, unpublished and 8). These studies are in agreement with this FIS. This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

Town of Taylor

The RCS completed a preliminary study to compute discharges for Silver Creek (U.S. Department of Agriculture, Soil Conservation Service, unpublished); however, floodplain areas were not mapped.

The FISs for the unincorporated areas of Navajo County and the Town of Snowflake are being prepared and will agree with this study (Federal Emergency Management Agency, Flood Insurance Study, March 2, 1994.).

City of Winslow

The study reach of the Little Colorado River supersedes the data presented in the previous FIS for the City of Winslow (Federal Emergency Management Agency, March 16, 1981).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting FEMA, Region IX, Federal Insurance and Mitigation Administration, 1111 Broadway, Suite 1200, Oakland, California 94607-4052.

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