FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 1 OF 4

COCONINO COUNTY, ARIZONA

AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
COCONINO COUNTY, UNINCORPORATED AREAS	040019
FLAGSTAFF, CITY OF	040020
FREDONIA, TOWN OF	040021
HAVASUPAI INDIAN RESERVATION	040023
PAGE, CITY OF	040113
SEDONA, CITY OF	040130
TUSAYAN, TOWN OF	040139
WILLIAMS, CITY OF	040027

FEMA

REVISED:

March 21, 2023

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FLOOD INSURANCE STUDY REPORT
COCONINO COUNTY, ARIZONA

SECTION 1.0 – INTRODUCTION

1.1 The National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a voluntary Federal program that enables property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

For decades, the national response to flood disasters was generally limited to constructing flood-control works such as dams, levees, sea-walls, and the like, and providing disaster relief to flood victims. This approach did not reduce losses nor did it discourage unwise development. In some instances, it may have actually encouraged additional development. To compound the problem, the public generally could not buy flood coverage from insurance companies, and building techniques to reduce flood damage were often overlooked.

In the face of mounting flood losses and escalating costs of disaster relief to the general taxpayers, the U.S. Congress created the NFIP. The intent was to reduce future flood damage through community floodplain management ordinances, and provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection.

The U.S. Congress established the NFIP on August 1, 1968, with the passage of the National Flood Insurance Act of 1968. The NFIP was broadened and modified with the passage of the Flood Disaster Protection Act of 1973 and other legislative measures. It was further modified by the National Flood Insurance Reform Act of 1994 and the Flood Insurance Reform Act of 2004. The NFIP is administered by the Federal Emergency Management Agency (FEMA), which is a component of the Department of Homeland Security (DHS).

Participation in the NFIP is based on an agreement between local communities and the Federal Government. If a community adopts and enforces floodplain management regulations to reduce future flood risks to new construction and substantially improved structures in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community as a financial protection against flood losses. The community's floodplain management regulations must meet or exceed criteria established in accordance with Title 44 Code of Federal Regulations (CFR) Part 60, *Criteria for Land Management and Use*.

SFHAs are delineated on the community's Flood Insurance Rate Maps (FIRMs). Under the NFIP, buildings that were built before the flood hazard was identified on the community's FIRMs are generally referred to as "Pre-FIRM" buildings. When the NFIP

was created, the U.S. Congress recognized that insurance for Pre-FIRM buildings would be prohibitively expensive if the premiums were not subsidized by the Federal Government. Congress also recognized that most of these floodprone buildings were built by individuals who did not have sufficient knowledge of the flood hazard to make informed decisions. The NFIP requires that full actuarial rates reflecting the complete flood risk be charged on all buildings constructed or substantially improved on or after the effective date of the initial FIRM for the community or after December 31, 1974, whichever is later. These buildings are generally referred to as "Post-FIRM" buildings.

1.2 Purpose of this Flood Insurance Study Report

This Flood Insurance Study (FIS) Report revises and updates information on the existence and severity of flood hazards for the study area. The studies described in this report developed flood hazard data that will be used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive than the minimum Federal requirements. Contact your State NFIP Coordinator to ensure that any higher State standards are included in the community's regulations.

1.3 Jurisdictions Included in the Flood Insurance Study Project

This FIS Report covers the entire geographic area of Coconino County, Arizona.

The jurisdictions that are included in this project area, along with the Community Identification Number (CID) for each community and the United States Geological Survey (USGS) 8-digit Hydrologic Unit Code (HUC-8) sub-basins affecting each, are shown in Table 1. The FIRM panel numbers that affect each community are listed. If the flood hazard data for the community is not included in this FIS Report, the location of that data is identified.

The location of flood hazard data for participating communities in multiple jurisdictions is also indicated in the table.

Jurisdictions that have no identified SFHAs as of the effective date of this study are indicated in the table. Changed conditions in these communities (such as urbanization or annexation) or the availability of new scientific or technical data about flood hazards could make it necessary to determine SFHAs in these jurisdictions in the future.

Table1: Listing of NFIP Jurisdictions

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C0025G[1], 04005C0050G[1], 04005C0075G[1], 04005C0100G[1], 04005C0125G[1], 04005C0150G[1], 04005C0156G, 04005C0157G, 04005C0158G, 04005C0159G, 04005C0165G[1], 04005C0166G[1], 04005C0167G, 04005C0168G[1], 04005C0169G[1], 04005C0176G, 04005C0177G[1], 04005C0178G[1], 04005C0179G[1], 04005C0185G, 04005C0190G, 04005C0195G, 04005C0225G, 04005C0250G[1], 04005C0275G[1], 04005C0300G[1], 04005C0325G[1], 04005C0350G, 04005C0375G, 04005C0400G, 04005C0425G[1], 04005C0450G[1], 04005C0475G[1], 04005C0500G[1], 04005C0525G[1], 04005C0550G[1], 04005C0575G[1], 04005C0600G[1], 04005C0625G[1], 04005C0650G, 04005C0675G[1], 04005C0700G[1], 04005C0725G, 04005C0750G,	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 17080205, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C0775G[1], 04005C0800G[1], 04005C0825G[1], 04005C0850G[1], 04005C0875G[1], 04005C0900G[1], 04005C0925G[1], 04005C0950G[1], 04005C0975G[1], 04005C1000G[1], 04005C1025G[1], 04005C1050G, 04005C1075G, 04005C1100G, 04005C1125G[1], 04005C1150G[1], 04005C1175G[1], 04005C1200G[1], 04005C1225G[1] 04005C1250G[1], 04005C1275G[1], 04005C1300G[1], 04005C1325G[1], 04005C1350G[1], 04005C1375G[1], 04005C1400G[1], 04005C1425G[1], 04005C1450G[1], 04005C1475G[1], 04005C1500G[1], 04005C1525G[1], 04005C1550G[1], 04005C1575G[1], 04005C1600G[1], 04005C1625G[1], 04005C1650G[1], 04005C1675G[1], 04005C1700G[1], 04005C1725G[1], 04005C1750G[1], 04005C1775G[1], 04005C1800G[1], 04005C1825G[1], 04005C1850G[1],	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C1875G[1], 04005C1900G[1], 04005C1925G[1], 04005C1950G[1], 04005C1975G[1], 04005C2000G[1], 04005C2025G[1], 04005C2050G[1], 04005C2075G[1], 04005C2100G[1], 04005C2125G[1], 04005C2150G[1], 04005C2175G[1], 04005C2200G[1], 04005C2225G[1], 04005C2250G[1], 04005C2275G[1], 04005C2300G[1], 04005C2325G[1], 04005C2350G[1], 04005C2375G[1], 04005C2400G[1], 04005C2425G[1], 04005C2450G[1], 04005C2475G[1], 04005C2500G[1], 04005C2525G[1], 04005C2550G[1], 04005C2575G[1], 04005C2600G[1], 04005C2625G[1], 04005C2650G[1], 04005C2700G[1], 04005C2725G[1], 04005C2750G[1], 04005C2775G[1], 04005C2800G[1], 04005C2825G[1], 04005C2850G[1], 04005C2875G[1], 04005C2900G[1], 04005C2925G[1], 04005C2950G[1],	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C2975G[1], 04005C3000G[1], 04005C3025G[1], 04005C3050G[1], 04005C3075G[1], 04005C3100G[1], 04005C3125G[1] 04005C3150G[1], 04005C3175G[1], 04005C3200G, 04005C3225G, 04005C3250G, 04005C3275G[1], 04005C3300G, 04005C3325G[1], 04005C3350G[1], 04005C3375G[1], 04005C3400G[1], 04005C3425G[1], 04005C3450G[1], 04005C3475G[1], 04005C3500G[1], 04005C3525G[1], 04005C3550G[1], 04005C3575G[1], 04005C3600G[1], 04005C3625G[1], 04005C3650G[1], 04005C3675G[1], 04005C3700G[1], 04005C3725G[1], 04005C3750G[1], 04005C3775G, 04005C3800G, 04005C3825G, 04005C3850G, 04005C3875G[1], 04005C3900G, 04005C3925G[1], 04005C3950G[1], 04005C3975G[1], 04005C4000G[1], 04005C4025G[1], 04005C4050G[1],	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C4075G[1], 04005C4100G[1], 04005C4125G[1], 04005C4150G[1], 04005C4175G[1], 04005C4200G[1], 04005C4225G[1], 04005C4250G[1], 04005C4275G[1], 04005C4300G, 04005C4325G, 04005C4350G, 04005C4375G, 04005C4400G, 04005C4425G, 04005C4450G[1], 04005C4475G[1], 04005C4500G[1], 04005C4525G, 04005C4550G[1], 04005C4575G[1], 04005C4600G[1], 04005C4625G[1], 04005C4650G[1], 04005C4675G[1], 04005C4700G[1], 04005C4725G[1], 04005C4750G[1], 04005C4775G[1], 04005C4800G[1], 04005C4825G[1], 04005C4850G, 04005C4875G, 04005C4900G, 04005C4925G, 04005C4950G[1], 04005C4975G[1], 04005C5000G[1], 04005C5025G, 04005C5050G, 04005C5075G[1], 04005C5100G[1], 04005C5125G[1], 04005C5150G[1],	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C5175G[1], 04005C5200G[1], 04005C5225G[1], 04005C5250G[1], 04005C5275G[1], 04005C5300G[1], 04005C5325G[1], 04005C5350G[1], 04005C5375G[1], 04005C5400G[1], 04005C5425G[1], 04005C5450G[1], 04005C5475G[1], 04005C5500G[1], 04005C5525G[1], 04005C5550G[1], 04005C5575G, 04005C5600G[1], 04005C5625G[1], 04005C5650G[1], 04005C5675G[1] 04005C5700G[1] 04005C5725G[1], 04005C5750G[1], 04005C5775G[1], 04005C5800G, 04005C5825G, 04005C5850G[1], 04005C5875G[1], 04005C5900G[1], 04005C5925G[1], 04005C5950G[1], 04005C5975G[1], 04005C6000G[1], 04005C6025G[1], 04005C6050G[1], 04005C6075G[1], 04005C6100G[1], 04005C6125G[1], 04005C6150G[1], 04005C6175G[1], 04005C6200G[1], 04005C6225G[1], 04005C6250G[1],	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C6275G, 04005C6300G, 04005C6325G[1], 04005C6330G[1], 04005C6335G[1], 04005C6336G[1], 04005C6337G[1], 04005C6338G[1], 04005C6339G, 04005C6341G[1], 04005C6342G[1], 04005C6344G[1], 04005C6375G[1], 04005C6400G[1], 04005C6425G, 04005C6430G[1], 04005C6435G[1], 04005C6440G, 04005C6445G[1], 04005C6455G[1], 04005C6460G[1], 04005C6465G[1], 04005C6470G, 04005C6500G[1], 04005C6525G[1], 04005C6550G[1], 04005C6575G[1], 04005C6600G[1], 04005C6625G[1], 04005C6650G, 04005C6675G, 04005C6700G, 04005C6701G[1], 04005C6703G[1], 04005C6704G[1], 04005C6710G, 04005C6715G[1], 04005C6720G[1], 04005C6750G, 04005C6775G, 04005C6800G, 04005C6801G, 04005C6802G,	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C6803G[1], 04005C6804G, 04005C6806G, 04005C6807G, 04005C6808G, 04005C6809G, 04005C6811G, 04005C6812G, 04005C6813G[1], 04005C6814G[1], 04005C6816G, 04005C6818G, 04005C6819G, 04005C6826G, 04005C6827G, 04005C6831G, 04005C6832G, 04005C6833G, 04005C6834G, 04005C6836G, 04005C6838G, 04005C6839G, 04005C6845G, 04005C6875G, 04005C6900G[1], 04005C6925G[1], 04005C6950G[1], 04005C6975G, 04005C7000G, 04005C7025G[1], 04005C7050G[1], 04005C7075G[1], 04005C7100G[1], 04005C7125G, 04005C7136G[1], 04005C7137G[1], 04005C7139G[1], 04005C7127H, 04005C7129H, 04005C7130H[1], 04005C7131H, 04005C7132H, 04005C7133H, 04005C7134H, 04005C7138H, 04005C7145H,	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C7155G, 04005C7175G, 04005C7200G, 04005C7225G[1], 04005C7250G[1], 04005C7275G[1], 04005C7300G, 04005C7325G, 04005C7350G[1], 04005C7375G[1], 04005C7400G[1], 04005C7425G[1], 04005C7430G[1], 04005C7431G[1], 04005C7432H, 04005C7434H, 04005C7442G[1], 04005C7444H, 04005C7451H, 04005C7452G[1], 04005C7453H, 04005C7454G[1], 04005C7457G, 04005C7459G, 04005C7460G, 04005C7461H, 04005C7462H, 04005C7463H, 04005C7464G[1], 04005C7466G[1], 04005C7467G, 04005C7468G[1], 04005C7469G[1], 04005C7500G, 04005C7505G, 04005C7510G, 04005C7511G, 04005C7512G, 04005C7513G[1], 04005C7514G, 04005C7520G,	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Coconino County, Unincorporated Areas *(continued)*	040019	14070006, 14070007, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	04005C7550G[1] 04005C7575G[1] 04005C7600G[1], 04005C7625G, 04005C7650G, 04005C7657H, 04005C7659H, 04005C7670G[1], 04005C7700G, 04005C7716G[1], 04005C7717G, 04005C7718G[1], 04005C7719G, 04005C7725G, 04005C7750G, 04005C7775G[1], 04005C7800G[1], 04005C7825G[1], 04005C7850G, 04005C7875G, 04005C7900G, 04005C7925G[1], 04005C7950G[1], 04005C7975G[1], 04005C8000G[1], 04005C8025G[1], 04005C8050G[1], 04005C8075G[1], 04005C8100G[1], 04005C8125G[1], 04005C8150G[1], 04005C8175G[1], 04005C8200G[1], 04005C8225G[1], 04005C8250G[1], 04005C8275G[1], 04005C8300G[1], 04005C8325G[1], 04005C8350G[1], 04005C8375G[1], 04005C8400G[1], 04005C8425G[1], 04005C8450G[1], 04005C8475G[1]	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Flagstaff, City of	040020	15020015, 15060202	04005C6802G, 04005C6804G, 04005C6806G, 04005C6807G, 04005C6808G, 04005C6809G, 04005C6812G, 04005C6814G[1], 04005C6816G, 04005C6817G, 04005C6818G, 04005C6819G, 04005C6826G, 04005C6827G, 04005C6828G, 04005C6829G, 04005C6831G, 04005C6832G, 04005C6833G, 04005C6834G, 04005C6836G, 04005C6837G, 04005C6838G, 04005C6839G, 04005C6845G, 04005C7131H, 04005C7132H, 04005C7155G	
Fredonia, Town of	040021	15010003	04005C0156G, 04005C0157G, 04005C0158G, 04005C0159G	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Havasupai Indian Reservation	040023	15010002, 15010004	04005C2150G[1], 04005C2175G[1], 04005C2200G[1], 04005C2225G[1], 04005C2625G[1], 04005C2650G[1], 04005C2675G[1], 04005C2700G[1], 04005C2725G[1], 04005C3175G[1], 04005C3200G, 04005C3225G, 04005C3250G, 04005C3750G[1]	
Page, City of	040113	14070006	04005C0375G, 04005C0400G	
Sedona, City of	040130	15060202	04005C7444H, 04005C7463H, 04005C7657H, 04005C7659H, 04005C7700G	
Tusayan, Town of	040139	15010004	04005C3825G, 04005C3850G	

Table1: Listing of NFIP Jurisdictions (Continued)

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
Williams, City of	040027	15010004, 15060201, 15060202	04005C6330G[1], 04005C6335G[1], 04005C6337G[1], 04005C6338G[1], 04005C6339G, 04005C6341G[1], 04005C6342G[1], 04005C6343G, 04005C6344G[1], 04005C6375G[1], 04005C6701G[1], 04005C6702G, 04005C6703G[1], 04005C6704G[1], 04005C6706G, 04005C6710G, 04005C6750G	

[1] Panel Not Printed

1.4 Considerations for using this Flood Insurance Study Report

The NFIP encourages State and local governments to implement sound floodplain management programs. To assist in this endeavor, each FIS Report provides floodplain data, which may include a combination of the following: 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance flood elevations (the 1-percent-annual-chance flood elevation is also referred to as the Base Flood Elevation (BFE)); 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/or in many components of the FIS Report, including Flood Profiles, Floodway Data tables, Summary of Non-Coastal Stillwater Elevations tables, and Coastal Transect Parameters tables (not all components may be provided for a specific FIS).

This section presents important considerations for using the information contained in this FIS Report and the FIRM, including changes in format and content. Figures 1, 2, and 3 present information that applies to using the FIRM with the FIS Report.

- Part or all of this FIS Report may be revised and republished at any time. In addition, part of this FIS Report may be revised by a Letter of Map Revision (LOMR), which does not involve republication or redistribution of the FIS Report. Refer to Section 6.5 of this FIS Report for information about the process to revise the FIS Report and/or FIRM.

It is, therefore, the responsibility of the user to consult with community officials by contacting the community repository to obtain the most current FIS Report components. Communities participating in the NFIP have established repositories of flood hazard data

or floodplain management and flood insurance purposes. Community map repository addresses are provided in Table 30, "Map Repositories," within this FIS Report.

- New FIS Reports are frequently developed for multiple communities, such as entire counties. A countywide FIS Report incorporates previous FIS Reports for individual communities and the unincorporated area of the county (if not jurisdictional) into a single document and supersedes those documents for the purposes of the NFIP.

  The initial Countywide FIS Report for Coconino County became effective on September 3, 2010 (FEMA 2010). Refer to Table 27 for information about subsequent revisions to the FIRMs.

- FEMA does not impose floodplain management requirements or special insurance ratings based on Limit of Moderate Wave Action (LiMWA) delineations at this time. The LiMWA represents the approximate landward limit of the 1.5-foot breaking wave. If the LiMWA is shown on the FIRM, it is being provided by FEMA as information only. For communities that do adopt Zone VE building standards in the area defined by the LiMWA, additional Community Rating System (CRS) credits are available. Refer to Section 2.5.4 for additional information about the LiMWA.

  The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Visit the FEMA Web site at https://www.fema.gov or contact your appropriate FEMA Regional Office for more information about this program.

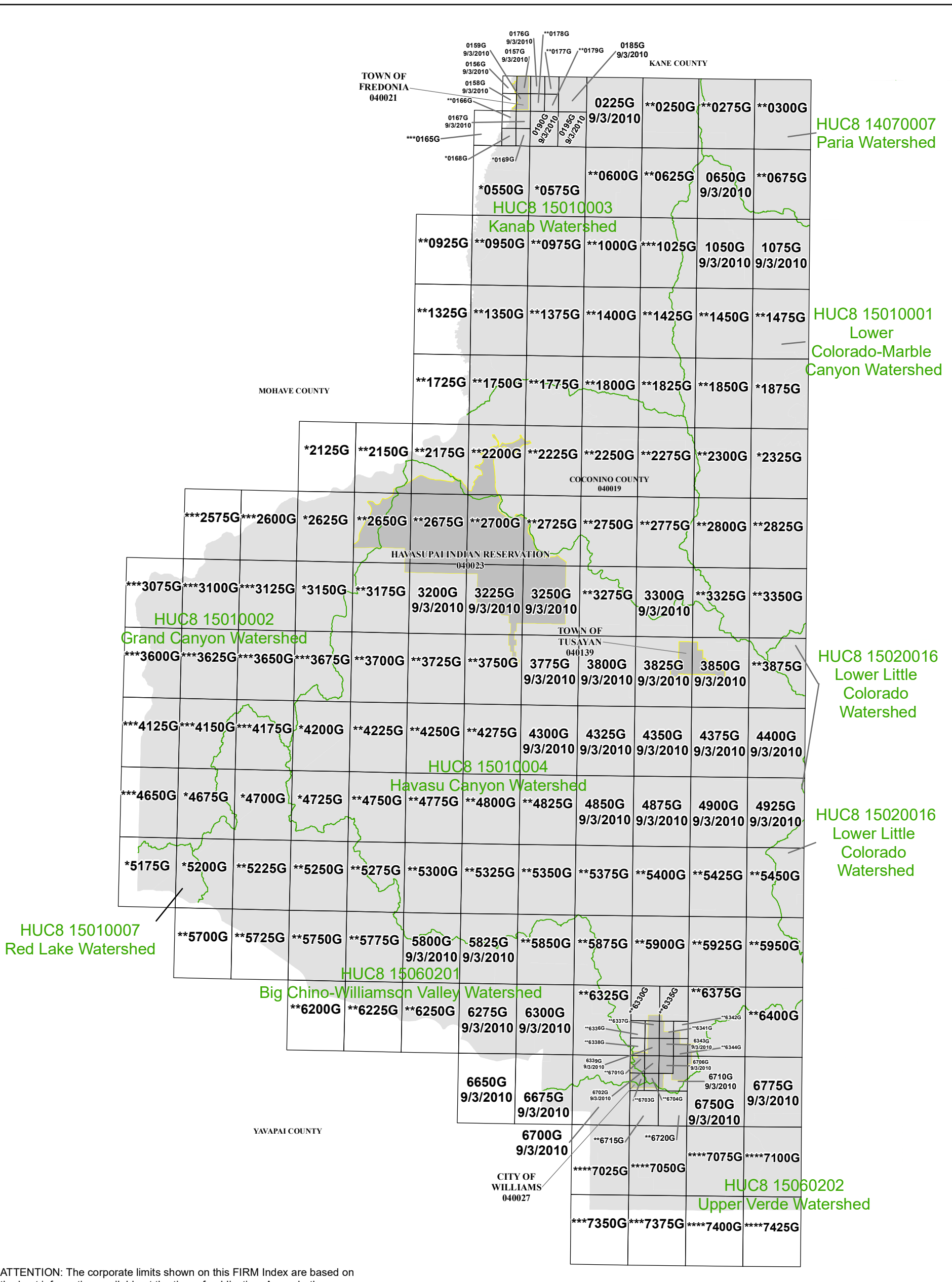
- Previous FIS Reports and FIRMs may have included levees that were accredited as reducing the risk associated with the 1-percent-annual-chance flood based on the information available and the mapping standards of the NFIP at that time. For FEMA to continue to accredit the identified levees, the levees 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."

  Since the status of levees is subject to change at any time, the user should contact the appropriate agency for the latest information regarding levees presented in Table 8 of this FIS Report. For levees owned or operated by the U.S. Army Corps of Engineers (USACE), information may be obtained from the USACE National Levee Database (nld.usace.army.mil). For all other levees, the user is encouraged to contact the appropriate local community.

- FEMA has developed a *Guide to Flood Maps* (FEMA 258) and online tutorials to assist users in accessing the information contained on the FIRM. These include how to read panels and step-by-step instructions to obtain specific information. To obtain this guide and other assistance in using the FIRM, visit the FEMA Web site at https://www.fema.gov/online-tutorials.

The FIRM Index in Figure 1 shows the overall FIRM panel layout within Coconino County, and also displays the panel number and effective date for each FIRM panel in the county.

Figure 1: FIRM Index



ATTENTION: The corporate limits shown on this FIRM Index are based on the best information available at the time of publication. As such, they may be more current than those shown on FIRM panels issued before March 21, 2023.

N

1 in = 63,333 feet 1:760,000

Feet 0 16,00032,000 64,000 96,000 128,000

Map Projection:
Universal Transverse Mercator Zone 12 North;
North American Datum 1983

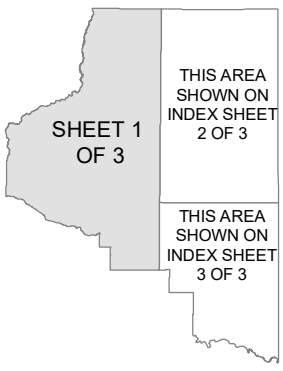
THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

HTTPS://MSC.FEMA.GOV

SEE FLOOD INSURANCE STUDY FOR ADDITIONAL INFORMATION

*PANEL NOT PRINTED - RESERVATION IN ZONE D, REST OF PANEL IN ZONE X
**PANEL NOT PRINTED - NO SPECIAL FLOOD HAZARD AREAS
***PANEL NOT PRINTED - AREA IN ZONE D
****PANEL NOT PRINTED - PRESCOTT NATIONAL FOREST IN ZONE D, REST OF PANEL IN ZONE X
*****PANEL NOT PRINTED - APACHE-SITGREAVES NATIONAL FOREST IN ZONE D, REST OF PANEL IN ZONE X

COCONINO COUNTY, AZ
INDEX LOCATOR DIAGRAM



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP INDEX (Sheet 1 of 3)

COCONINO COUNTY, ARIZONA And Incorporated Areas

PANELS PRINTED:

0156, 0157, 0158, 0159, 0167, 0176, 0185, 0190, 0195, 0225, 0650, 1050, 1075, 3200, 3225, 3250, 3300, 3775, 3800, 3825, 3850, 4300, 4325, 4350, 4375, 4400, 4850, 4875, 4900, 4925, 5800, 5825, 6275, 6300, 6339, 6343, 6650, 6675, 6700, 6702, 6706, 6710, 6750, 6775

FEMA

MAP NUMBER
04005CIND1C

MAP REVISED
March 21, 2023

Figure 1: FIRM Index

ATTENTION: The corporate limits shown on this FIRM Index are based on the best information available at the time of publication. As such, they may be more current than those shown on FIRM panels issued before March 21, 2023.

1 in = 45,917 feet 1:551,000

N

Feet

0 17,000 34,000 68,000 102,000

Map Projection:
Universal Transverse Mercator Zone 12 North;
North American Datum 1983

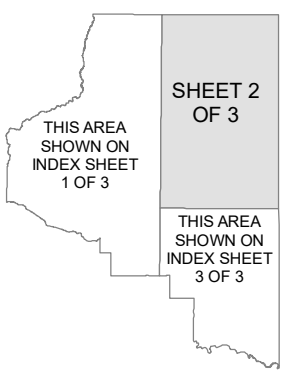
THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

HTTPS://MSC.FEMA.GOV

SEE FLOOD INSURANCE STUDY FOR ADDITIONAL INFORMATION

*PANEL NOT PRINTED - RESERVATION IN ZONE D, REST OF PANEL IN ZONE X
**PANEL NOT PRINTED - NO SPECIAL FLOOD HAZARD AREAS
***PANEL NOT PRINTED - AREA IN ZONE D

COCONINO COUNTY, AZ
INDEX LOCATOR DIAGRAM



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP INDEX (Sheet 2 of 3)

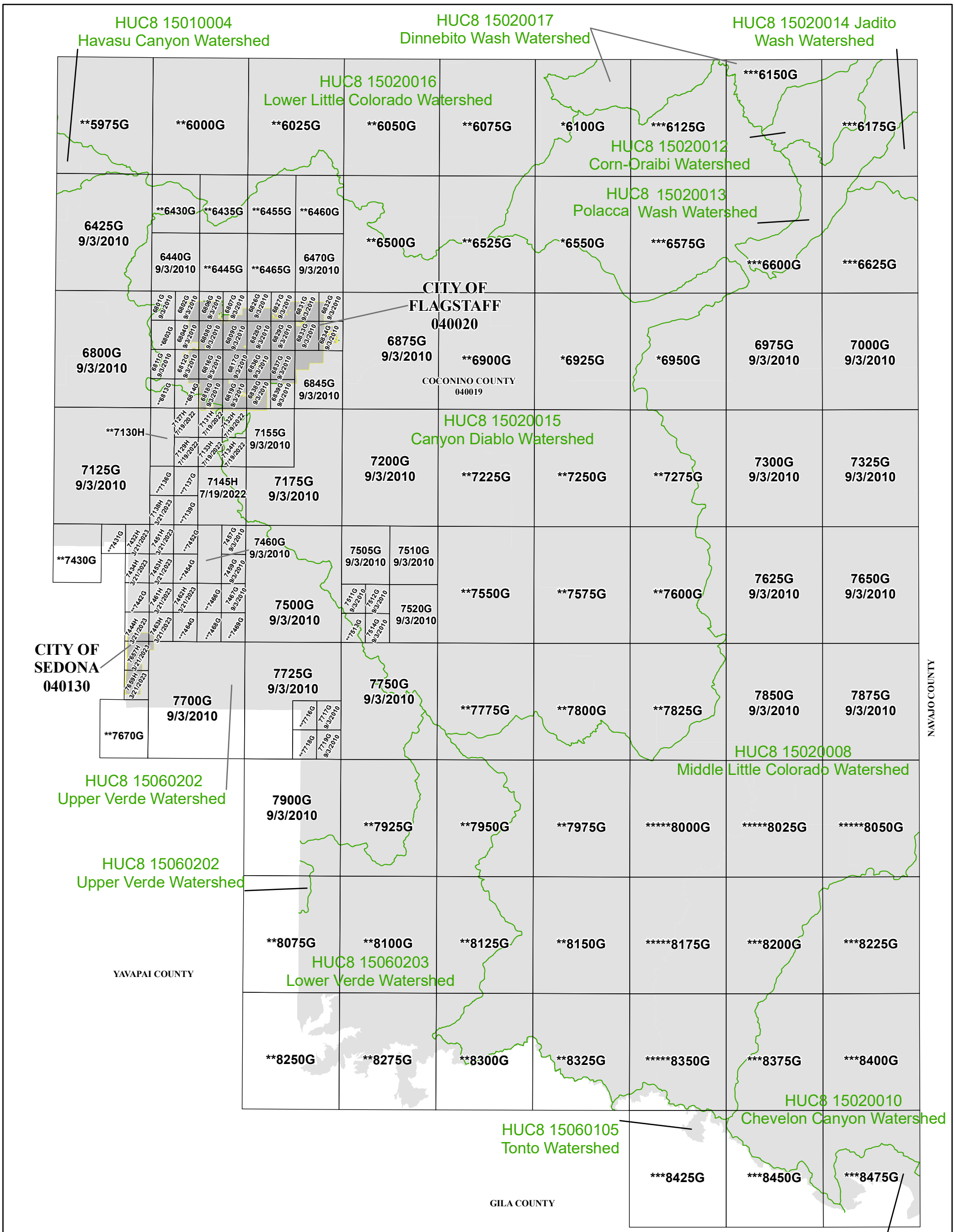
COCONINO COUNTY, ARIZONA And Incorporated Areas
PANELS PRINTED:
0350, 0375, 0400, 0725, 0750, 1100, 3900, 4425, 4525, 5025, 5050, 5575

FEMA

MAP NUMBER
04005CIND2C

MAP REVISED
March 21, 2023

Figure 1: FIRM Index



ATTENTION: The corporate limits shown on this FIRM Index are based on the best information available at the time of publication. As such, they may be more current than those shown on FIRM panels issued before March 21, 2023.

N

1 in = 36,960 feet 1:443,520

Feet
0 9,000 18,000 36,000 54,000 72,000

Map Projection:
Universal Transverse Mercator Zone 12 North;
North American Datum 1983

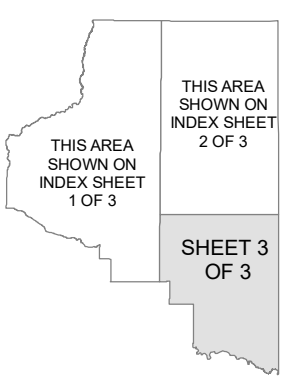
THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

HTTPS://MSC.FEMA.GOV

SEE FLOOD INSURANCE STUDY FOR ADDITIONAL INFORMATION

*PANEL NOT PRINTED - RESERVATION IN ZONE D, REST OF PANEL IN ZONE X
**PANEL NOT PRINTED - NO SPECIAL FLOOD HAZARD AREAS
***PANEL NOT PRINTED - AREA IN ZONE D
****PANEL NOT PRINTED - PRESCOTT NATIONAL FOREST IN ZONE D, REST OF PANEL IN ZONE X
*****PANEL NOT PRINTED - APACHE-SITGREAVES NATIONAL FOREST IN ZONE D, REST OF PANEL IN ZONE X

COCONINO COUNTY, AZ
INDEX LOCATOR DIAGRAM



NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP INDEX (Sheet 3 of 3)

COCONINO COUNTY, ARIZONA And Incorporated Areas

PANELS PRINTED:

6425, 6440, 6470, 6800, 6801, 6802, 6804, 6806, 6807, 6808, 6809, 6811, 6812, 6816, 6817, 6818, 6819, 6826, 6827, 6828, 6829, 6831, 6832, 6833, 6834, 6836, 6837, 6838, 6839, 6845, 6875, 6975, 7000, 7125, 7127, 7129, 7131, 7132, 7133, 7134, 7138, 7145, 7155, 7175, 7200, 7300, 7325, 7432, 7434, 7444, 7451, 7453, 7457, 7459, 7460, 7461, 7462, 7463, 7467, 7500, 7505, 7510, 7511, 7512, 7514, 7520, 7625, 7650, 7657, 7659, 7700, 7717, 7719, 7725, 7750, 7850, 7875, 7900

FEMA

MAP NUMBER
04005CIND3C

MAP REVISED
March 21, 2023

Each FIRM panel may contain specific notes to the user that provide additional information regarding the flood hazard data shown on that map. However, the FIRM panel does not contain enough space to show all the notes that may be relevant in helping to better understand the information on the panel. Figure 2 contains the full list of these notes.

Figure 2: FIRM Notes to Users

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products, or the National Flood Insurance Program in general, please call the FEMA Mapping and Insurance eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Flood Map Service Center website or by calling the FEMA Mapping and Insurance eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to Table 27 in this FIS Report.

To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

The map is for use in administering the NFIP. It may not identify all areas subject to flooding, particularly from local drainage sources of small size. Consult the community map repository to find updated or additional flood hazard information.

BASE FLOOD ELEVATIONS: For more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, consult the Flood Profiles and Floodway Data and/or Summary of Non-Coastal Stillwater Elevations tables within this FIS Report. Use the flood elevation data within the FIS Report in conjunction with the FIRM for construction and/or floodplain management.

FLOODWAY INFORMATION: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the FIS Report for this jurisdiction.

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 4.3 "Non-Levee Flood Protection Measures" of this FIS Report for information on flood control structures for this jurisdiction.

Figure 2. FIRM Notes to Users

PROJECTION INFORMATION: The projection used in the preparation of the map was Universal Transverse Mercator (UTM) Zone 12. The horizontal datum was the North American Datum of 1983 NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov.

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed in Table 30 of this FIS Report.

BASE MAP INFORMATION: Base map information shown on the FIRM was provided by derived from USDA Farm Service Agency NAIP orthophotography dated 2017.

The map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables may reflect stream channel distances that differ from what is shown on the map.

Corporate limits shown on the map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate limit locations.

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within Coconino County, Arizona, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to Table 27 of this FIS Report to determine the most recent FIRM revision date for each community. The most recent FIRM panel effective date will correspond to the most recent index date.

ATTENTION: The corporate limits shown are based on the best information available at the time of publication of this FIRM Index. As such, they may be more current than those shown on FIRM panels issued before March 21, 2023.

SPECIAL NOTES FOR SPECIFIC FIRM PANELS

This Notes to Users section was created specifically for Coconino County, Arizona, effective March 21, 2023.

Figure 2. FIRM Notes to Users

FLOOD RISK REPORT: A Flood Risk Report (FRR) may be available for many of the flooding sources and communities referenced in this FIS Report. The FRR is provided to increase public awareness of flood risk by helping communities identify the areas within their jurisdictions that have the greatest risks. Although non-regulatory, the information provided within the FRR can assist communities in assessing and evaluating mitigation opportunities to reduce these risks. It can also be used by communities developing or updating flood risk mitigation plans. These plans allow communities to identify and evaluate opportunities to reduce potential loss of life and property. However, the FRR is not intended to be the final authoritative source of all flood risk data for a project area; rather, it should be used with other data sources to paint a comprehensive picture of flood risk.

Each FIRM panel contains an abbreviated legend for the features shown on the maps. However, the FIRM panel does not contain enough space to show the legend for all map features. Figure 3 shows the full legend of all map features. Note that not all of these features may appear on the FIRM panels in Coconino County.

Figure 3: Map Legend for FIRM

SPECIAL FLOOD HAZARD AREAS: The 1-percent-annual-chance flood, also known as the base flood or 100-year flood, has a 1-percent chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1-percent-annual-chance flood. The Base Flood Elevation is the water surface elevation of the 1-percent-annual-chance flood. 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. See note for specific types. If the floodway is too narrow to be shown, a note is shown.

	Special Flood Hazard Areas subject to inundation by the 1-percent-annual-chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains. No base (1-percent-annual-chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.
Zone AO	The flood insurance rate 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 depths derived from the hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1-percent-annual-chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1-percent-annual-chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.
Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.
	Regulatory Floodway determined in Zone AE.

Figure 3: Map Legend for FIRM

OTHER AREAS OF FLOOD HAZARD

Shaded Zone X: Areas of 0.2-percent-annual-chance flood hazards and areas of 1-percent-annual-chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.

Future Conditions 1-Percent-Annual-Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.

Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1-percent-annual-chance flood. See Notes to Users for important information.

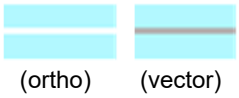
Area with Flood Risk due to Levee: Areas where a non-accredited levee, dike, or other flood control structure is shown as providing protection to less than the 1-percent-annual-chance flood.

OTHER AREAS

Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

Unshaded Zone X: Areas of minimal flood hazard.

FLOOD HAZARD AND OTHER BOUNDARY LINES



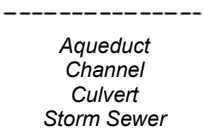
Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)

Limit of Study

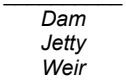
Jurisdiction Boundary

Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet

GENERAL STRUCTURES



Channel, Culvert, Aqueduct, or Storm Sewer



Dam, Jetty, Weir

Levee, Dike, or Floodwall

Figure 3: Map Legend for FIRM

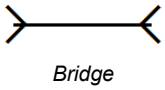
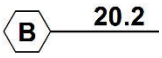
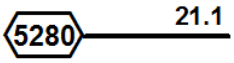
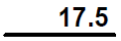
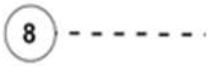
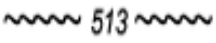
	Bridge
REFERENCE MARKERS	
	River mile Markers
CROSS SECTION & TRANSECT INFORMATION	
	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
	Coastal Transect
	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
	Base Flood Elevation Line
ZONE AE (EL 16)	Static Base Flood Elevation value (shown under zone label)
ZONE AO (DEPTH 2)	Zone designation with Depth
ZONE AO (DEPTH 2) (VEL 15 FPS)	Zone designation with Depth and Velocity
BASE MAP FEATURES	
	River, Stream or Other Hydrographic Feature
	Interstate Highway
	U.S. Highway
	State Highway
	County Highway

Figure 3: Map Legend for FIRM

MAPLE LANE	Street, Road, Avenue Name, or Private Drive if shown on Flood Profile
RAILROAD	Railroad
	Horizontal Reference Grid Line
	Horizontal Reference Grid Ticks
+	Secondary Grid Crosshairs
Land Grant	Name of Land Grant
7	Section Number
R. 43 W. T. 22 N.	Range, Township Number
$^{42}76^{000m}E$	Horizontal Reference Grid Coordinates (UTM)
365000 FT	Horizontal Reference Grid Coordinates (State Plane)
80° 16' 52.5"	Corner Coordinates (Latitude, Longitude)

SECTION 2.0 – FLOODPLAIN MANAGEMENT APPLICATIONS

2.1 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 hazard in the community.

Each flooding source included in the project scope has been studied and mapped using professional engineering and mapping methodologies that were agreed upon by FEMA and Coconino County as appropriate to the risk level. Flood risk is evaluated based on factors such as known flood hazards and projected impact on the built environment. Engineering analyses were performed for each studied flooding source to calculate its 1-percent-annual-chance flood elevations; elevations corresponding to other floods (e.g. 10-, 4-, 2-, 0.2-percent-annual-chance, etc.) may have also been computed for certain flooding sources. Engineering models and methods are described in detail in Section 5.0 of this FIS Report. The modeled elevations at cross sections were used to delineate the floodplain boundaries on the FIRM; between cross sections, the boundaries were interpolated using elevation data from various sources. More information on specific mapping methods is provided in Section 6.0 of this FIS Report.

Depending on the accuracy of available topographic data (Table 22), study methodologies employed (Section 5.0), and flood risk, certain flooding sources may be mapped to show both the 1-percent and 0.2-percent-annual-chance floodplain boundaries, regulatory water surface elevations (BFEs), and/or a regulatory floodway. Similarly, other flooding sources may be mapped to show only the 1-percent-annual-chance floodplain boundary on the FIRM, without published water surface elevations. In cases where the 1-percent and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM. Figure 3, “Map Legend for FIRM”, describes the flood zones that are used on the FIRMs to account for the varying levels of flood risk that exist along flooding sources within the project area. Table 2 and Table 3 indicate the flood zone designations for each flooding source and each community within Coconino County, respectively.

Table 2, “Flooding Sources Included in this FIS Report,” lists each flooding source, including its study limits, affected communities, mapped zone on the FIRM, and the completion date of its engineering analysis from which the flood elevations on the FIRM and in the FIS Report were derived. Descriptions and dates for the latest hydrologic and hydraulic analyses of the flooding sources are shown in Table 12. Floodplain boundaries for these flooding sources are shown on the FIRM (published separately) using the symbology described in Figure 3. On the map, the 1-percent-annual-chance floodplain corresponds to the SFHAs. The 0.2-percent-annual-chance floodplain shows areas that, although out of the regulatory floodplain, are still subject to flood hazards.

Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data. The procedures to remove these areas from the SFHA are described in Section 6.5 of this FIS Report.

Table 2: Flooding Sources Included in this FIS Report

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Baderville Tributary to Rio de Flag	Coconino County, Unincorporated Areas	At confluence with Rio de Flag	Approximately 0.2 mile south of Hashknife Trail Road	15020015	1.7		Y	AE	1981
Bow and Arrow Wash	Flagstaff, City of	Approximately 1,800 feet upstream of Lake Mary Road	At South Lone Tree Road crossing	15020015	3.5		Y	AE	2004
Cataract Creek	Williams, City of	Approximately 0.36 mile north of U.S. Interstate 40	Approximately 0.5 mile upstream Santa Fe Reservoir dam	15010004	3		Y	AE	1981
Cataract Creek (Embankment ID #20)	Williams, City of	Downstream of U.S. Interstate 40	Upstream of U.S. Interstate 40	15010004	0.1		N	A	2008
Cataract Creek Tributary	Williams, City of	At confluence with Cataract Creek	At City Reservoir	15010004	0.9		Y	AE	1981
Cemetary Wash	Williams, City of	At U.S. Interstate 40	Approximately 0.12 mile west of Williams, City of	15010004	0.8		Y	AE	1981
Clay Avenue Wash (Rio de Flag confluence)	Flagstaff, City of	Approximately 0.3 mile upstream from confluence with Rio de Flag	Approximately 0.9 mile upstream from confluence with Rio de Flag	15020015	0.625		Y	AE	2004
Clay Avenue Wash	Flagstaff, City of	At intersection of West Clay Avenue and U.S. Interstate 40 Business	At Forest Service Road 506	15020015	2		Y	AE	1995

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Clay Avenue Wash Split Flow	Flagstaff, City of	At confluence with Clay Avenue Wash, approximately 125 feet downstream of West Shellie Drive	At confluence with Clay Avenue Wash, approximately 750 feet upstream of West Shellie Drive	15020015	0.2		N	AE	1981
Country Club Wash	Flagstaff, City of	At confluence with Rio de Flag	At golf course pond north side of East Mt. Pleasant Drive	15020015	1.1		Y	AE	1981
Detention Basin	Flagstaff, City of	At South Wild West Trail	Approximately 0.2 miles upstream from South Wild West Trail	15020015		0.009	N	AE	1981
Dewey Grade Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Downstream of Old Munds Highway	15060202	0.2		Y	AE	2016
Fanning Drive Wash	Flagstaff, City of	At confluence with Rio de Flag	Approximately 140 feet north east of Skyline Drive and Forest Brook Street	15020015	2.1		Y	AE	1995
Golf Course Creek	Sedona, City of	Confluence with Memorial Park Wash	Approximately 500 feet US from Hwy 179	15060202	0.2		N	AE	2018
Gravesite Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Approximately 800 ft upstream of I-17	15060202	0.5		Y	AE	2016
Harrenburg Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Approximately 1300 feet upstream of the confluence with Pumphouse Wash	15060202	0.5		Y	AE	2016
Holy Cross Wash	Sedona, City of	Confluence with Oak Creek	Easement at W Mallard Dr	15060202	0.2		Y	AE	2018
Howard Draw Wash	Coconino County, Unincorporated Areas	Lower Lake Mary	At intersection of Forest Service Road 235 and Crimson Road	15020015	2		Y	AE	1981
Kanab Creek	Fredonia, Town of	Approximately 0.2 miles north east of Rt. 89A and Cowboy Drive	Approximately 0.3 miles north east of Rt. 89A and Cowboy Drive	15010003	0.2		Y	AE	1981

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Margs Draw Wash	Coconino County, Unincorporated Areas; Sedona, City of	Confluence with Morgan Wash	Approximately 580 feet US from Canyon Dr	15060202	0.2		Y	AE	2018
Memorial Knolls Wash	Sedona, City of	Confluence with Memorial Park Wash	Approximately 990 feet US from Hwy 179	15060202	0.2		Y	AE	2018
Memorial Park Wash	Sedona, City of	Confluence with Oak Creek	Approximately 840 feet US from Doodlebug Rd	15060202	0.8		Y	AE	2018
Morgan Wash	Coconino County, Unincorporated Areas; Sedona, City of	Confluence with Oak Creek	Approximately 1,050 feet US from Cypress Ct	15060202	0.9		Y	AE	2018
Mormon Lake	Coconino County, Unincorporated Areas	At northern intersection of Mormon Lake Road and County Road 3	At southern intersection of Mormon Lake Road and County Road 3	15020015		4.8	N	A	1981
Mountainaire Wash	Coconino County, Unincorporated Areas	Confluence with Schoolhouse Draw Wash	Downstream of NF-700L Forest Rd	15060202	1.1		Y	AE	2016
Munds Canyon Creek	Coconino County, Unincorporated Areas	Confluence with Oak Creek	Approximately 13,900 feet US from confluence	15060202	2.6		Y	AE	2018
Oak Creek	Coconino County, Unincorporated Areas; Sedona, City of	Confluence with Verde River	Intersection with N State Route 89A	15060202	17.2		Y	AE	2018
O'Neil Springs Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Approximately 2,900 feet upstream of the confluence with Pumphouse Wash	15060202	0.5		Y	AE	2016
O'Neil Tank Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Approximately 1,200 feet above the confluence with Pumphouse Wash	15060202	0.2		Y	AE	2016
Painted Memorial Wash	Sedona, City of	Confluence with Memorial Park Wash	Approximately 1,165 feet US from confluence	15060202	0.2		Y	AE	2018

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Peaceful Valley Wash	Flagstaff, City of	At confluence with Rio de Flag	Approximately 1.5 miles east of the south end of Lake Elaine	15020015	2.2		Y	AE	1981
Peak View Wash	Flagstaff, City of	Approximately 130 feet downstream of Cooper Drive	Approximately 120 feet upstream of Lois Lane	15020015	0.2		Y	AE	2004
Penstock Avenue Wash	Flagstaff, City of	At Railhead Avenue	At Smokerise Drive	15020015	0.5		Y	AE	1995
Pumphouse Wash	Coconino County, Unincorporated Areas	At the downstream limit of effective flooding	Approximately 8,400 feet upstream of I-17	15060202	4.5		Y	AE	2016
Rio de Flag (upstream study)	Coconino County, Unincorporated Areas; Flagstaff, City of	At Narrows Dam	Approximately 500 feet downstream of the Hidden Hollow Road crossing	15020015	1.2		Y	AE	2008
Rio de Flag (downstream study)	Coconino County, Unincorporated Areas; Flagstaff, City of	At Rio Ranch Road crossing	At U.S. Route 66	15020015	15.1		Y	AE	2008
Rio de Flag Split Flow	Flagstaff, City of	At confluence with Rio de Flag at North Bonito Street	At confluence with Rio de Flag near North Thorpe Road	15020015	0.2		Y	AE	1981
San Miguel Wash	Sedona, City of	Confluence with Golf Course Creek	Approximately 470 feet US from confluence	15060202	0.1		Y	AE	2018
Santa Fe Wash East	Williams, City of	Approximately 0.4 mile north of US Interstate 40	At U.S. Route 66	15010004	1.9		Y	AE	1981

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Santa Fe Wash West	Williams, City of	Approximately 0.4 mile north of US Interstate 40	At North Grand Canyon Boulevard	15010004	1.6		Y	AE	1981
School Soldier Wash	Sedona, City of	Confluence with Oak Creek	Approximately 1,300 feet US from Camielle Ct	15060202	0.5		N	AE	2018
Schoolhouse Draw Wash	Coconino County, Unincorporated Areas	At confluence with Pumphouse Wash	Approximately 2,500 feet upstream of NF-707 Forest Road	15060202	2.2		Y	AE	2016
Schultz Creek	Coconino County, Unincorporated Areas; Flagstaff, City of	Approximately 2,000 feet downstream of the Fort Valley Road crossing	At Shultz Pass Road	15020015	1.4		Y	AE, AO	2004
Sinclair Wash	Coconino County, Unincorporated Areas; Flagstaff, City of	At confluence with Rio de Flag	Approximately 0.1 mile west of Constitution Boulevard	15020015	3.5		Y	AE	1981
Soldier Wash	Sedona, City of	Confluence with Oak Creek	Approximately 0.9 miles US from AZ-89-Alt	15060202	1.5		Y	AE	2018
Spruce Avenue Wash	Flagstaff, City of	North of Walmart on Huntington Drive	Approximately 0.1 mile north of crossing the Arizona National Scenic Trail	15020015	2		Y	AE	1981
Stoneman Lake	Coconino County, Unincorporated Areas	At Stoneman Lake Road	At Lake View Court	15060202		0.2	N	AE	1981
Substation Soldier Wash	Sedona, City of	Confluence with Soldier Wash	Approximately 2,140 feet US from confluence	15060202	0.4		N	A	2018
Switzer Canyon Wash	Coconino County, Unincorporated Areas; Flagstaff, City of	At eastern U.S. Route 66 crossing	Approximately 2,800 feet upstream of San Francisco Street crossing	15020015	4.9		Y	AE, AH	2004

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Table Top Airport Wash	Sedona, City of	Confluence with Oak Creek	Approximately 2,100 feet US from Creek View Circle Spur	15060202	0.5		Y	AE	2018
Tributary 1 To Baderville Tributary	Coconino County, Unincorporated Areas	At confluence with Baderville Tributary	Approximately 275 feet west of North Hadrians Walk	15020015	0.5		Y	AE	1981
Tributary 2 To Baderville Tributary	Coconino County, Unincorporated Areas	At confluence with Baderville Tributary	Approximately 75 feet north of North Galloway Trail	15020015	0.3		Y	AE	1981
Unnamed Wash	Flagstaff, City of	At West High Country Trail	At Detention Basin	15020015	0.4		Y	AE	1981
West Fork Oak Creek	Coconino County, Unincorporated Areas	Confluence with Oak Creek	Approximately 1,810 feet US from confluence	15060202	0.3		N	A	2018
West Street Wash	Flagstaff, City of	At 6th Avenue	Approximately 0.1 mile east of Cedar Avenue	15020015	0.4		N	AE	1981
Unnamed Streams, Tucker Flat Wash, Schoolhouse Draw, Pumphouse Wash, Wildcat Canyon Creek, Rio de Flag, Cataract Creek	Coconino County, Unincorporated Areas; Flagstaff, City of; Williams, City of	Various	Various	15010004, 15020015, 15060202	*		N	A	2008

Table 2: Flooding Sources Included in this FIS Report (Continued)

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Various Zone A Streams within Coconino County	Coconino County, Unincorporated Areas; Havasupai Indian Reservation; Sedona, City of; Tusayan, Town of	Various	Various	14070006, 14070007, 17080205, 15010001, 15010002, 15010003, 15010004, 15010007, 15020008, 15020010, 15020012, 15020013, 15020014, 15020015, 15020016, 15020017, 15020018, 15060103, 15060105, 15060201, 15060202, 15060203	*		N	A	1981
Various Zone A Streams within the Flagstaff, City of	Flagstaff, City of	Various	Various	15020015, 15060202	*		N	A	1981
Various Zone A Streams within the Fredonia, Town of	Fredonia, Town of	Various	Various	15010003	*		N	A	1981
Various Zone A Streams within the Williams, City of	Williams, City of	Various	Various	15010004, 15060201, 15060202	*		N	A	1981

*Data not available

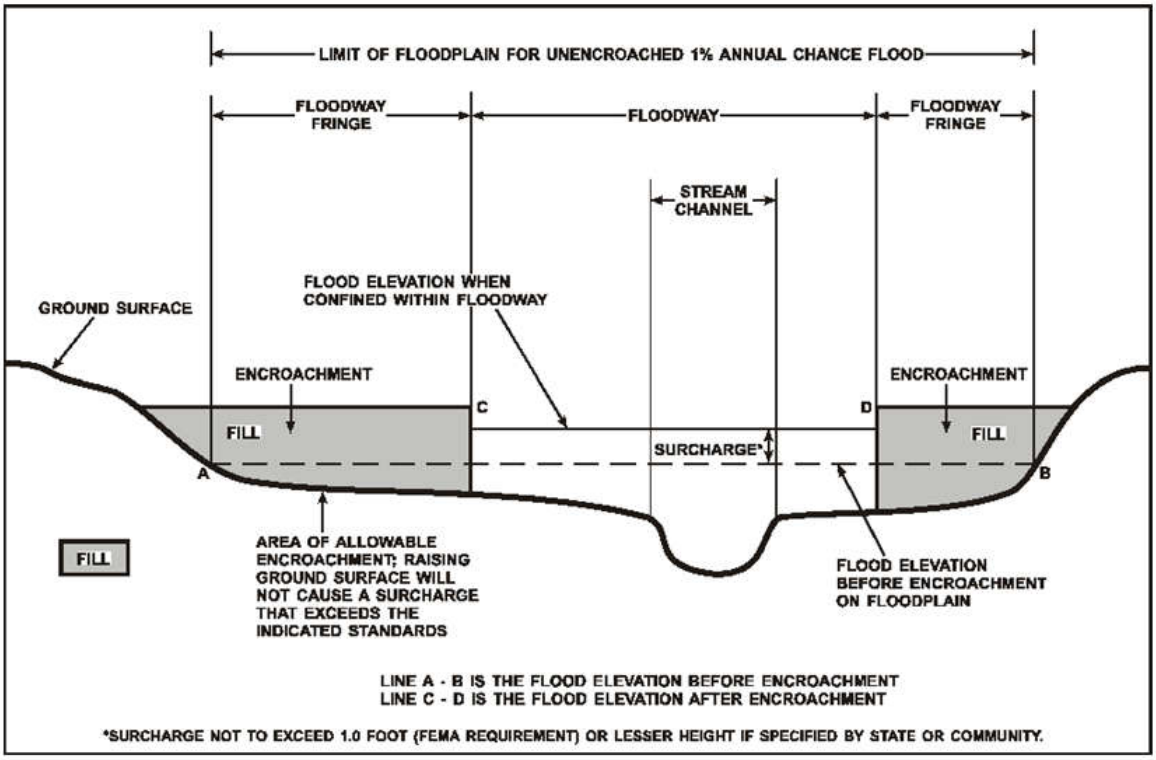
2.2 Floodways

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 balancing floodplain development against increasing flood hazard. With this approach, the area of the 1-percent-annual-chance floodplain on a river is divided into a floodway and a floodway fringe based on hydraulic modeling. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment in order to carry the 1-percent-annual-chance flood. The floodway fringe is the area between the floodway and the 1-percent-annual-chance floodplain boundaries where encroachment is permitted. The floodway must be wide enough so that the floodway fringe could be completely obstructed without increasing the water surface elevation of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 4.

To participate in the NFIP, Federal regulations require communities to limit increases caused by encroachment to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this project are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway projects.

Figure 4: Floodway Schematic



Floodway widths presented in this FIS Report and on the FIRM were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. For certain stream segments, floodways were adjusted so that the amount of floodwaters conveyed on each side of the floodplain would be reduced equally. The results of the floodway computations have been tabulated for selected cross sections and are shown in Table 23, “Floodway Data.”

All floodways that were developed for this Flood Risk Project are shown on the FIRM using the symbology described in Figure 3. In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown on the FIRM. For information about the delineation of floodways on the FIRM, refer to Section 6.3.

2.3 Base Flood Elevations

The hydraulic characteristics of flooding sources were analyzed to provide estimates of the elevations of floods of the selected recurrence intervals. The BFE is the elevation of the 1-percent-annual-chance flood. These BFEs are most commonly rounded to the whole foot, as shown on the FIRM, but in certain circumstances or locations they may be rounded to 0.1 foot. Cross section lines shown on the FIRM may also be labeled with the BFE rounded to 0.1 foot. Whole-foot BFEs derived from engineering analyses that apply to coastal areas, areas of ponding, or other static areas with little elevation change may also be shown at selected intervals on the FIRM.

BFEs are primarily intended for flood insurance rating purposes. Cross sections with BFEs shown on the FIRM correspond to the cross sections shown in the Floodway Data table and Flood Profiles in this FIS Report. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS Report in conjunction with the data shown on the FIRM. For example, the user may use the FIRM to determine the stream station of a location of interest and then use the profile to determine the 1-percent-annual-chance elevation at that location. Because only selected cross sections may be shown on the FIRM for riverine areas, the profile should be used to obtain the flood elevation between mapped cross sections. Additionally, for riverine areas, whole-foot elevations shown on the FIRM may not exactly reflect the elevations derived from the hydraulic analyses; therefore, elevations obtained from the profile may more accurately reflect the results of the hydraulic analysis.

2.4 Non-Encroachment Zones

Some States and communities use non-encroachment zones to manage floodplain development. For flooding sources with medium flood risk, field surveys are often not collected and surveyed bridge and culvert geometry is not developed. Standard hydrologic and hydraulic analyses are still performed to determine BFEs in these areas. However, floodways are not typically determined, since specific channel profiles are not developed. To assist communities with managing floodplain development in these areas, a “non-encroachment zone” may be provided. While not a FEMA designated floodway, the non-encroachment zone represents that area around the stream that should be reserved to convey the 1-percent-annual-chance flood event. As with a floodway, all surcharges must fall within the acceptable range in the non-encroachment zone.

General setbacks can be used in areas of lower risk (e.g. unnumbered Zone A), but these are not considered sufficient where unnumbered Zone A is replaced by Zone AE. The NFIP requires communities to ensure that any development in a non-encroachment area causes no increase in BFEs. Communities must generally prohibit development within the area defined by the non-encroachment width to meet the NFIP requirement.

Non-encroachment determinations may be delineated where it is not possible to delineate floodways because specific channel profiles with bridge and culvert geometry were not developed. Any non-encroachment determinations for this Flood Risk Project have been tabulated for selected cross sections and are shown in Table 24, “Flood Hazard and Non-Encroachment Data for Selected Streams.” Areas for which non-encroachment zones are provided show BFEs and the 1-percent-annual-chance floodplain boundaries mapped as zone AE on the FIRM but no floodways.

2.5 Coastal Flood Hazard Areas

This section is not applicable to this Flood Risk Project.

2.5.1 Water Elevations and the Effects of Waves

This section is not applicable to this Flood Risk Project.

Figure 5: Wave Runup Transect Schematic

[Not Applicable to this Flood Risk Project]

2.5.2 Floodplain Boundaries and BFEs for Coastal Areas

This section is not applicable to this Flood Risk Project.

2.5.3 Coastal High Hazard Areas

This section is not applicable to this Flood Risk Project.

Figure 6: Coastal Transect Schematic

[Not Applicable to this Flood Risk Project]

2.5.4 Limit of Moderate Wave Action

This section is not applicable to this Flood Risk Project.

SECTION 3.0 – INSURANCE APPLICATIONS

3.1 National Flood Insurance Program Insurance Zones

For flood insurance applications, the FIRM designates flood insurance rate zones as described in Figure 3, "Map Legend for FIRM." Flood insurance zone designations are assigned to flooding sources based on the results of the hydraulic or coastal analyses. Insurance agents use the zones shown on the FIRM and depths and base flood elevations

in this FIS Report in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

The 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (e.g. Zones A, AE, V, VE, etc.), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of additional flood hazards.

Table 3 lists the flood insurance zones in Coconino County.

Table 3: Flood Zone Designations by Community

Community	Flood Zone(s)
Coconino County, Unincorporated Areas	A, AE, AO, X, D
Flagstaff, City of	A, AE, AH, AO, X
Fredonia, Town of	A, AE, X
Havasupai Indian Reservation	A, X, D
Page, City of	AE, X, D
Sedona, City of	A, AE, X
Tusayan, Town of	A, X
Williams, City of	A, AE, AH, AO, X

SECTION 4.0 – AREA STUDIED

4.1 Basin Description

Table 4 contains a description of the characteristics of the HUC-8 sub-basins within which each community falls. The table includes the main flooding sources within each basin, a brief description of the basin, and its drainage area.

Table 4: Basin Characteristics

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
Big Chino-Williamson Valley	15060201	Big Chino Wash	Contains ~4.9% of the county area along the western edge of the county. Contains mostly unincorporated areas but also includes a small portion of the City of Williams.	2,153
Canyon Diablo	15020015	San Francisco Wash	Contains ~6.4% of the county area in the southern third of the county. This HUC8 is entirely contained within the county and includes almost all of the City of Flagstaff as well as unincorporated areas.	1,198
Chevelon Canyon	15020010	Pierce Wash	Contains ~1.3% of the county area along the southern tip of the county. Encompasses only unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	819
Corn-Oraibi	15020012	Oraibi Wash	Contains ~0.6% % of the county area along the eastern edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	731
Dinnebito Wash	15020017	Dinnebito Wash	Contains ~2.5% of the county area along the eastern edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	818

Table 4: Basin Characteristics (Continued)

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
Grand Canyon	15010002	Colorado River	Contains ~7.3% of the county area along the western edge. The HUC8 encompasses unincorporated areas and a small portion of the Havasupai Indian Reservation. Flood hazards have not been studied in this HUC8 within Coconino County.	2,551
Havasu Canyon	15010004	Havasu Creek	Contains ~15.7% of the county area within the middle of the county. This HUC8 is the largest watershed within the county and is contained entirely within the county. This HUC8 encompasses mostly unincorporated areas as well as most of the Havasupai Indian Reservation and most of the City of Williams.	2,932
Jadito Wash	15020014	Jadito Wash	Contains ~0.1% % of the county area along the eastern edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	938
Kanab	15010003	Kanab Creek	Contains ~5.3% of the county area along the northwestern corner, encompassing mostly unincorporated areas as well as the entire Town of Fredonia.	2,362
Lower Colorado-Marble Canyon	15010001	Colorado River	Contains ~7.9% of the county area in the northern third of the county. The HUC8 is entirely contained within the county and encompasses only unincorporated areas.	1,467
Lower Lake Powell	14070006	Colorado River	Contains ~7.5% of the county area along the northeastern corner of the county. The HUC8 encompasses mostly unincorporated areas as well as the entire City of Page.	2,934

Table 4: Basin Characteristics (Continued)

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
Lower Little Colorado	15020016	Little Colorado River	Contains ~12.8% of the county area in the center of the county. This HUC8 is second largest watershed in the county and is entirely contained within the county. This HUC8 only encompasses unincorporated areas.	2,392
Lower San Juan	14080205	San Juan River	Contains ~0.2% % of the county area along the northeastern corner, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	2,437
Lower Verde	15060203	Verde River	Contains ~1.4% of the county area along the southern edge, encompassing only unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	1,965
Middle Little Colorado	15020008	Little Colorado River	Contains ~8.0% of the county area in the southern third of the county. Encompasses only unincorporated areas.	2,522
Moenkopi Wash	15020018	Moenkopi Wash	Contains ~9.5% of the county area in the northeastern portion of the county. It is the third largest HUC8 within the county and encompasses only unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	2,649
Paria	14070007	Paria River	Contains ~2.0% of the county area along the northern edge, encompassing only unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	1,418
Polacca Wash	15020013	Polacca Wash	Contains ~0.3% % of the county area along the eastern edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	1,155

Table 4: Basin Characteristics (Continued)

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
Red Lake	15010007	Truxton Wash	Contains ~0.3% of the county area along the western edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	1,415
Tonto	15060105	Tonto Creek	Contains ~0.1% % of the county area along the southern edge, encompassing unincorporated areas. Flood hazards have not been studied in this HUC8 within Coconino County.	1,047
Upper Salt	15060103	Salt River	Contains ~0.1% % of the county area along the southern edge, encompassing areas county. Flood hazards have not been studied in this HUC8 within Coconino County.	2,152
Upper Verde	15060202	Verde River	Southwest of Coconino County basin	2,508

4.2 Principal Flood Problems

Table 5 contains a description of the principal flood problems that have been noted for Coconino County by flooding source.

Table 5: Principal Flood Problems

Flooding Source	Description of Flood Problems
Cataract Creek	The history of flooding in the City of Williams area indicates that constrictive hydraulic structures are a major contributing factor to flooding. Floodflows, backed up by constrictive hydraulic structures at road crossings, spread into the floodplain areas and in some instances flow overland into other washes. The overland floodflows are generally shallow, causing low-lying structures to be inundated by flows less than one foot deep. The flood of December 1978 was caused by rainfall on the snow-covered mountains above the City of Williams. Floodflows on Cataract Creek backed up at 5th Street, causing weir flow over 5th Street. This flow went overland, crossing at 2nd Street and the Burlington Northern & Santa Fe Railway. Flow also broke out on Cataract Creek at Edison Avenue, causing shallow flooding east to 2nd Street. This flood was estimated to have been approximately a 75-year flood.
Howard Draw Wash	Flooding has occurred on Howard Draw Wash in 1993, 1995, and 2004 affecting the subdivisions of Lake Mary Park and Lake Mary Meadows. High-water elevations on Lower Lake Mary in May 1980 ponded into the lower areas of Howard Draw Wash, inundating some roads and driveways, and making access difficult to some homes.
Kanab Creek	In the Town of Fredonia, floods on Kanab Creek are caused by snowmelt and rain on snow during the spring, and heavy rains in July and August. The first great flood on Kanab Creek to do appreciable damage occurred on July 29, 1883. It flooded all the farmlands and meadowlands in the canyon near Kanab, along with all the field crops south of the village, and scoured out a broad channel below the former valley floodplain. In 1884 and 1885, the flooding occurred daily for 3 or 4 weeks, continuing the erosion of the channel. As a result of these 3 years of floods, the streambed was cut down approximately 70 feet for a distance of 15 miles downstream of Kanab. Since 1886, the trenching action has continued, extending upward to the extreme headwaters of Kanab Creek and throughout its tributaries (USBR 1974). In 1890, an irrigation dam was built at the site of the present irrigation dam in the Town of Fredonia. That dam was washed away before it was completed. Another dam was completed in about 1892 and served until 1909. In that year, it was also washed away by a tremendous flood. The existing irrigation dam was completed a couple of years later (USBR 1974). There is no documented history of flooding since 1909. No recurrence interval of stage-discharge information for the Town of Fredonia has been established for the past floods. Recurrence intervals on past floods have not been estimated because of the large amount of erosion and deposition associated with the flooding of this stream.

Table 5: Principal Flood Problems

Flooding Source	Description of Flood Problems
Mormon Lake	History of water-surface elevations and flooding from Mormon Lake indicates a wide range of water levels. Mormon Lake has been dry on numerous occasions through the years. In 1927, a peninsula on the southwest comer of Mormon Lake became an island due to high water. The saddle of this peninsula has been checked to be an approximate elevation of 7,118 feet NAVD. This was the highest water level ever reached according to long-time residents of the area. The water level has fluctuated between these extremes through the years, with USGS topographic maps (USGS 1965) giving an elevation of 7,110 feet NAVD for the lake. Flood damages due to high water levels appear to have been slight in the past on Mormon Lake.
Munds Park Wash	History of flooding in the Munds Park Wash area is limited. However, as recently as December 2004, the golf course at Pinewood Country Club and adjacent residences were inundated by significant flooding. Flooding in 1979 at the Mormon Lake Road crossing spread to the west and caused shallow flooding in a small development before returning to Odell Lake. The Mormon Lake Road crossing has been changed from a dip section to a bridge, thus changing the potential for flooding at this site. Also, during flooding in 1979, the spillway on Odell Lake was washed out, causing flooding of the sparsely populated golf course area downstream. This spillway was rebuilt after the flooding in 1979.
Oak Creek	In Coconino County, in the City of Sedona, Oak Creek has flooded many times in past years. Significant flood flows occurred in the following years as recorded at the USGS gage station at Cornville: 1885, 1938, 1952, 1956, 1964, 1967, 1969, 1970, 1976, 1978, 1979, 1980, 1993, 1995, and 2004. In the flooding of 1980, the discharge measured at the Cornville gage station was 18,000 cubic feet per second (cfs) on February 15 and 25,000 cfs on February 19. These floods were estimated by the study contractor to have had approximately a 2-percent-annual-chance (50-year) recurrence interval in the vicinity of the City of Sedona. Damage due to flooding has been mostly in the form of erosion and, therefore, loss of land.
Rio de Flag	Significant flooding occurred in the upper reaches of the Rio de Flag in December 2004 affecting the unincorporated community of Fort Valley. Additionally, significant floodflows occurred on Rio de Flag in the following years: 1888, 1896, 1903, 1905, 1916, 1920, 1923, 1937, 1938, 1950, 1963, 1966, and 1973. Although some documentation exists for these floods, the descriptions are limited to flooding within the City of Flagstaff Due to light development in these areas at that time, damages were probably limited to erosion and loss of land.

Table 5: Principal Flood Problems

Flooding Source	Description of Flood Problems
Rio de Flag and associated streams within the City of Flagstaff	The past history of flooding within the City of Flagstaff indicates that flooding may occur during any season of the year. Three types of storms produce precipitation in the area: general winter storms, general summer storms, and local storms. Summer storms normally are high-intensity, short-duration local storms, but severe, general summer storms, usually associated with tropical cyclones, also occur. General winter storms cover large areas and are usually of long duration. Their intensities are normally light to moderate. Because climatic and drainage area characteristics are not conducive to continuous runoff, streamflow only occurs during and after rainfall and during periods of snowmelt. In areas of high permeability, as in the northern part of the drainage basin, little runoff occurs even from heavy rains. The following is a list of descriptions of known floods. The sources of these descriptions are newspaper accounts, railroad records, museum publications, U.S. Soil Conservation Service reports, and Flagstaff city officials (USACE - Los Angeles 1975). November 1888 – Flood was caused by intense rainfall of less than 1-day duration. It was during this flood that the “Bottomless Pits” opened up on the surface. A newspaper article in 1903 calls 1888 the largest flood to have occurred. Water extended from old Hotel Weatherford to the school and was said to be “deep enough for a horse to swim.” There may have been another flood, equally serious, in August 1888. July 1896 – Following heavy rain of short duration, the river overflowed its banks in many places within the City of Flagstaff, finding its old channel where the stream enters the city. South of the city, flat areas were covered with water. April 1903 – Melting snow and falling rain caused the river to overflow its banks and take its former course through the City of Flagstaff When the river reached its highest stage, that portion of the city lying between Leroux and Sitgreaves Streets, in the flat part of the city just north of the railroad tracks, was under 1 to 15 inches of water. The area of Coconino County south of the tracks and west of the stream was flooded. Since 1896, the river has had little water flowing in it. November 1905 – There was no mention of flooding in November or any other time of the year. The month of November, however, was the wettest month on record, to 1905. It rained 7.10 inches, which is 4.88 inches above average for the month of November. U.S. Weather Bureau records indicate 3.91 inches of rain fell between November 11 and November 27. January 1916 – Several days of snow and rain caused the river to run full, threatening to overflow in places. However, a freezing period retarded runoff from snowmelt enough to prevent damage. There had never been such a snowfall followed by steady rains, according to the oldest resident. The U.S. Weather Bureau measured 54 inches of snow in January, with an estimated 12 inches total water equivalent of snow and rainfall. February 1920 – A 3-day rain, falling on already saturated soil, resulted in flooding not equaled in the previous 25 years. The river overflowed its banks and converted the area south of the city into a sizable lake. In the Bottomless Pits area, water was said to be 30 feet deep, but this was probably an exaggeration. Railroad records give a high-water elevation of 6,765.3 feet NAVD, indicating a depth of approximately 19 feet. Flow in the Bottomless Pits area was augmented by runoff from Slaughter House, Switzer, and several other smaller canyons. Runoff could have been greater had it not

Table 5: Principal Flood Problems

Flooding Source	Description of Flood Problems
	snowed in Fort Valley. Precipitation in the City of Flagstaff was reported to be 1.85 inches. September 1923 – Nearly 3 days of hard rain caused the river to overflow its banks and flood more than one-third of the city, forming a lake that covered almost all the south side and extended to the east for several miles. Railroad records give a higher water elevation in the Bottomless Pits area of 6,762 feet NAVD. Precipitation in the City of Flagstaff was reported to be 2.12 inches. April 1937 – The river, through the city, was near or at channel capacity for several days because of melting snow. This was the first time since 1923 that floodwaters flowed into the Bottomless Pits. The water-surface elevation in the Bottomless Pits area is not known. March 1938 - Continuous rain falling on melting snow forced the river far over its banks at some points, and floodwaters lapped the floodbeams of several bridges. Much of the south side was under water. March 1950 – Rain and snowmelt caused the river to flow bankfull from Pa Lake to O'Leary Street. There was little, if any, overflow. March 1966 – Snowmelt flood. Elevation of high-water mark in Bottomless Pits area was 6,756 feet NAVD. April 1973 – Snowmelt flood. The river flowed bank-full for several days. No overflow. High-water elevation of 6,754.8 feet NAVD was estimated by a consultant to the city. The USGS measured a peak of 23 5 cfs at their staff gage north of the city. Flooding problems are aggravated by natural obstructions to floodflows including brush, trees, and other vegetation growing along the streambanks in the floodplain. These obstructions impede the flow of floodwaters, causing backwater and increased floodwater depths. Also, debris, such as brush, trees, and manmade objects, can be carried along by the floodwaters and possibly block bridge or culvert crossings. This debris is capable of causing a reduction in flow through the structure resulting in a higher backwater condition and increased floodwater depths. Many of the study areas in the City of Flagstaff consist of a small-capacity channel with many crossings and heavily developed floodplains. In such places, floodwater easily exceeds the capacity of the main flow channel and overflows into the floodplains where it is further impeded by the heavy development.
Stoneman Lake	History of water-surface elevations and flooding from Stoneman Lake indicates a wide range of water levels. Stoneman Lake has also been dry or near dry on numerous occasions through its history. According to long-time residents of the area, the lake was at a record high elevation in the spring of 1980. The level was recorded at 6,733.4 feet NAVD on May 2, 1980. The lake level rose slightly after that. The USGS topographic maps (USGS 1965) report a water- surface elevation of 6, 720 feet NAVD for the lake. Flood damages on Stoneman Lake have been in the form of inundation of land.
Various flooding sources	Significant flood events have affected several unincorporated communities in Coconino County in recent years, most notably 1993, 1995, and 2004. Affected communities include Fort Valley, Kachina Village, Mountain Dell, Pine Del, Munds Park, and Oak Creek Canyon.

Table 6 contains information about historic flood elevations in the communities within Coconino County.

Table 6: Historic Flooding Elevations

Flooding Source	Location	Historic Peak (Feet NAVD88)	Event Date	Approximate Recurrence Interval (years)	Source of Data
Rio de Flag	Bottomless Pits area	6,765.3	1920	N/A	Railroad records
Rio de Flag	Bottomless Pits area	6,762	1923	N/A	Railroad records
Rio de Flag	Bottomless Pits area	6,756	1966	N/A	High-water mark
Rio de Flag	N/A	6,754.8	1973	N/A	Flagstaff consultant

4.3 Non-Levee Flood Protection Measures

Table 7 contains information about non-levee flood protection measures within Coconino County such as dams, jetties, and or dikes. Levees are addressed in Section 4.4 of this FIS Report.

Table 7: Non-Levee Flood Protection Measures

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Cataract Creek	N/A	Breaching street crossings	Along the upper Cataract Creek	Floodplain management measures used in the past to reduce potential flood damages consisted of breaching street crossings on upper Cataract Creek to increase the capacity of the wash
Cataract Creek	Embankment ID #20	Levee like embankment	Within the City of Williams	A shallow levee like embankment structure was constructed along Cataract Creek
City Park Reservoir	City Park Reservoir	Reservoir	South of the City of Williams	City Park Reservoir was considered in the Coconino County FIS; however, due to the small size and storage capabilities of the dam, the flood protection provided by the dam is limited

Table 7: Non-Levee Flood Protection Measures

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Kanab Creek	N/A	Berm	Town of Fredonia, east side of Kanab Creek from the irrigation dam upstream to around the area east of McKinney Street	This berm provides flood protection by containing the 1-percent-annual-chance flood to Kanab Creek, thereby minimizing flooding between U.S. Alternate Highway 89 and Kanab Creek below McKinney Street
Kanab Creek	Flood Retarding Structure and Diversion Channel	Retarding structure and diversion channel	Northeast of the Town of Fredonia	Constructed by the U.S. Soil Conservation Service in the early 1970s northeast of town. The Flood Retarding Structure will retain the 1-percent-annual-chance flood originating from alluvial flooding from northeast of town. The Diversion Channel has a 100 cfs release rate.
Munds Park Wash	Odell Dam	Small, earth filled dam	Immediately upstream of Pinewood Country Club	A small, earthen dam with a concrete spillway creating Odell Lake, but its effect in reducing potential flood damage is minimal.
Munds Park Wash	N/A	Bridge	Intersection of Mormon Lake Road and Munds Park Wash	A bridge has been built at to replace a dip-section. This bridge will reduce flooding potential in a development southwest of the intersection
Oak Creek	N/A	Small dikes and riprapped embankments	Along Oak Creek in Coconino County	Several small dikes and riprapped embankments have been constructed by private landowners along Oak Creek in Coconino County to protect their property from inundation and erosion during floods
Rio de Flag	Embankment ID #14	Levee like embankment	Intersection of Rio de Flag and Interstate 40.	A shallow levee like embankment structure was constructed along Rio de Flag
Santa Fe Reservoir	Santa Fe Reservoir	Reservoir	Within the City of Williams	This dam was considered in the original study of the City of Williams. Due to the small size and storage capability of the dam, the flood protection provided is limited.

Table 7: Non-Levee Flood Protection Measures

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Soldier Wash	Driveway Culvert, Underpass, Brewer Road Culvert	Other / Misc Structure	Driveway Culvert, Underpass, Brewer Road Culvert	2 Culvert, 1 Underpass
Stoneman Lake	N/A	Small dike	Along Stoneman Lake	A small dike was built along Stoneman Lake in 1956 by the SCS and a private landowner to protect a portion of the surrounding area from flooding. Although the dike was built to have 2-foot freeboard above the highest-known water level at that time, the dike is presently under water. No significant building damage occurred due to the overtopping of the dike.
Tucker Flat Wash	Embankment ID #7	Levee like embankment	Tucker Flat Wash, eastern Coconino County	A shallow levee like embankment structure was constructed along Tucker Flat Wash
Unnamed Stream	Embankment ID #3	Levee like embankment	City of Flagstaff	A shallow levee like embankment structure was constructed along an unnamed stream
Unnamed Stream	Embankment ID #11	Levee like embankment	Along U.S. Route 66	A shallow levee like embankment structure was constructed along an unnamed stream
Upper Saginaw Reservoir	Upper Saginaw Reservoir	Reservoir	Within the City of Williams	This reservoir may or may not remain due to questions pertaining to the safety of the reservoir dam. This dam was considered in the original study of the City of Williams. Due to the small size and storage capability of the dam, the flood protection provided is limited.
Wildcat Canyon Creek	Embankment ID #12	Levee like embankment	East of the City of Flagstaff	A shallow levee like embankment structure was constructed along Wildcat Canyon Creek

4.4 Levees

This section is not applicable to this Flood Risk Project.

Table 8: Levees

[Not Applicable to this Flood Risk Project.]

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources 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 at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2-percent-annual-chance, respectively, of being equaled or exceeded during any year.

Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedance) during the term of a 30-year mortgage is approximately 26 percent (about 3 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.

The engineering analyses described here incorporate the results of previously issued Letters of Map Change (LOMCs) listed in Table 26, “Incorporated Letters of Map Change”, which include Letters of Map Revision (LOMRs). For more information about LOMRs, refer to Section 6.5, “FIRM Revisions.”

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied. A summary of the hydrologic methods applied to develop the discharges used in the hydraulic analyses for each stream is provided in Table 12. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

A summary of the discharges is provided in Table 9. Frequency Discharge-Drainage Area Curves used to develop the hydrologic models may also be shown in Figure 7 for selected flooding sources. A summary of stillwater elevations developed for non-coastal flooding sources is provided in Table 10. Stream gage information is provided in Table 11.

Table 9: Summary of Discharges

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Baderville Tributary to Rio de Flag	At confluence with Rio de Flag	8.1	*	*	*	385	*
Bow and Arrow Wash	Near Bennett Drive	*	*	*	*	146	*
	At Yaqui Drive	*	*	*	*	155	*
	At Intersection of Zumi Drive and Walapai Drive	*	*	*	*	194	*
	Approximately 1,320 feet upstream of Lone Tree Road	*	*	*	*	243	*
	Approximately 3,960 feet downstream of Lone Tree Road	*	*	*	*	320	*
	At confluence with Rio de Flag	2.9	160	*	320	420	700
Cataract Creek	At U.S. Highways 66 & 89	7.2	153	*	524	1,107	2,400
	At confluence with West Cataract Creek	7.2	153	*	519[2]	1,080[2]	2,400
	Downstream of confluence at Cataract Creek Tributary	6.6	136	*	486	1,064	2,400
	Upstream of Santa Fe Reservoir Dam	5.0	173	*	601	1,099	2,500
	Downstream of Santa Fe Reservoir Dam	5.0	110[1]	*	411[1]	938[1]	2,200[1]

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Cataract Creek Tributary	Downstream of City Park Dam	1.4	28[1]	*	91[1]	186[1]	360[1]
	Upstream of City Park Dam	1.4	64	*	257	481	1,100
Cemetary Wash	At confluence with West Cataract Creek	1.06	47[1]	*	185[1]	259[1]	*
	At U.S. Highways 66 & 89	1.06	50	*	209	385	1,050
Clay Avenue Wash	At confluence with Rio de Flag	12.7	80	*	290	450	1,020
	Approximately one mile above confluence with Rio de Flag	12.6	70	*	280	440	1,000
	Near upstream limit of detailed study	9.7	45	*	210	340	795
Clay Avenue Wash Split Flow	At confluence with Clay Avenue Wash	[3]	1	*	36	77	257
Country Club Wash	At confluence with Rio de Flag	1.6	60	*	130	170	300
	At upstream limit of detailed study, downstream of two reservoirs	1.0	20	*	40	50	90
Dewey Grade Wash	At confluence with Pumphouse Wash	0.2	65	87	105	124	169
Fanning Drive Wash	At confluence with Rio de Flag	2.6	290	*	570	730	1,200
	At Linda Vista Drive	1.0	118	*	238	307	506
	At upstream limit of detailed study	0.9	100	*	210	270	450

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Golf Course Creek	At confluence with San Miguel Wash	0.1	75	132	189	258	474
	Approximately 450 feet upstream of confluence with San Miguel Wash	0.07	48	85	123	169	312
Gravesite Wash	At confluence with Pumphouse Wash	0.7	230	307	365	428	575
	East of I-17, approximately 0.3 mi upstream of confluence with Pumphouse Wash	0.3	101	135	162	191	260
Harrenburg Wash	At confluence with Pumphouse Wash	6.5	1,408	1,896	2,285	2,715	3,781
Holy Cross Wash	Approximately 1225 feet upstream of confluence with Oak Creek	0.4	137	239	339	460	585
Howard Draw Wash	At confluence with Lower Lake Mary	9.5	2,370	*	3,920	4,510	6,400
Kanab Creek	At downstream limit of detailed study	287.0	2,830	*	7,560	10,500	21,500
Margs Draw Wash	Approximately 1300 feet upstream of confluence with Morgan Wash	1.4	298	514	727	986	1,786
Memorial Knolls Wash	Approximately 1075 feet upstream of confluence with Memorial Park Wash	0.02	24	44	63	88	165

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Memorial Park Wash	At confluence with Golf Course Creek	0.6	182	314	441	596	1,072
	**	0.4	133	230	326	441	798
	At confluence with Painted Memorial Wash	0.3	111	192	272	369	671
	At confluence with Memorial Knolls Wash	0.04	62	90	114	138	196
Morgan Wash	Approximately 160 feet upstream of confluence with Margs Draw Wash	7.5	896	1,539	2,177	2,942	5,304
	Approximately 3450 feet upstream of confluence with Margs Draw Wash	6.0	778	1,351	1,924	2,614	4,750
Mountainaire Wash	At confluence with Schoolhouse Draw Wash	1.5	434	577	691	817	1,109
	Approximately 500 feet upstream of Tonowanda Road	0.7	230	306	367	433	590
Munds Canyon Creek	At confluence with Oak Creek	64.4	7,108	9,877	12,024	14,685	21,417
Munds Park Wash	At Interstate Highway 17	44.3	5,780	*	10,140	13,040	20,000
	Approximately 600 feet upstream of Interstate Highway 17	21.7	2,870	*	4,970	6,360	9,300
Oak Creek	At Coconino-Yavapai County boundary	246.9	10,983	16,640	22,829	30,256	54,827

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Oak Creek *(continued)*	At confluence with Morgan Wash	245.04	10,890	16,498	22,648	30,031	54,470
	At confluence with Soldier Wash	236.37	10,465	15,851	21,821	29,001	52,837
	Approximately 2600 feet upstream of confluence with Soldier Wash	232.60	10,300	15,600	21,500	28,600	52,200
	Approximately 1.28 miles upstream of confluence with Soldier Wash	228.07	10,140	15,425	21,291	28,349	51,748
	Approximately 1.35 miles downstream of confluence with Munds Canyon Creek	224.23	10,008	15,276	21,112	28,132	51,361
	At confluence with Munds Canyon Creek	215.53	9,688	14,905	20,656	27,575	50,369
	Approximately 1500 feet upstream of confluence with Munds Canyon Creek	149.50	6,534	10,776	15,296	20,735	38,064
	Approximately 2.18 miles upstream of confluence with Munds Canyon Creek	147.76	6,421	10,613	15,075	20,446	37,541
	Approximately 1850 feet downstream of confluence with West Fork Oak Creek	143.67	6,145	10,210	14,528	19,728	36,242
	At confluence with West Fork Oak Creek	133.22	5,405	9,108	13,022	17,736	32,614

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Oak Creek *(continued)*	Approximately 1.60 miles upstream of confluence with West Fork Oak Creek	87.45	3,428	5,964	8,615	11,816	21,794
	Approximately 2.12 miles upstream of confluence with West Fork Oak Creek	83.41	3,271	5681	8,201	11,244	20,731
	Approximately 3.62 miles upstream of confluence with West Fork Oak Creek	81.78	3,210	5,572	8,042	11,026	20,328
O'Neil Springs Wash	At confluence with Pumphouse Wash	0.2	82	105	122	141	185
O'Neil Tank Wash	At confluence with Pumphouse Wash	1.0	278	354	413	477	625
Painted Memorial Wash	Approximately 1200 feet upstream of confluence with Memorial Park Wash	0.1	53	94	134	184	341
Peaceful Valley Wash	At confluence with Rio de Flag	4.3	110	*	260	360	670
	At upstream limit of study	1.7	40	*	100	140	260
Peak View Wash	At confluence with Rio de Flag (after diversion at Cooper Drive)	0.9	*	*	*	20	*
	Just upstream of the intersection of Cooper Drive and Peak View Tributary Wash	0.9	*	*	*	105	*

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Penstock Avenue Wash	At confluence with Rio de Flag	2.3	30	*	90	140	310
Pumphouse Wash	End of watershed, approximately 1.1 mi downstream (west) of Ancient Trail	20.3	3,745	5,141	6,282	7,617	10,507
	Confluence of Pumphouse Wash and Harrenburg Wash, approximately 0.1 mi west of Ancient Trail	18.7	3,575	4,958	6,026	7,183	9,867
	Approximately 0.1 mi west of Ancient Trail	12.2	2,423	3,343	4,043	4,799	6,570
	Upstream of Kachina Trail	11.6	2,423	3,273	3,939	4,669	6,400
	East of I-17, at confluence of Pumphouse Wash and Schoolhouse Draw Wash	9.4	2,078	2,801	3,387	4,022	5,520
	Upstream of confluence with Schoolhouse Draw Wash	4.3	1,158	1,540	1,858	2,198	3,026
	Upstream of confluence with Dewey Grade Wash	3.9	1,111	1,476	1,761	2,060	2,801

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Rio de Flag	Approximately 3.0 miles upstream of confluence with San Francisco Wash (at downstream limit of study)	198.4	1,401	*	3,239	4,484	8,300
	Flow upstream of final Tributary	129.6	1,123	*	2,573	3,502	6,500
	Flow upstream of Townsend Bridge	121.6	1,086	*	2,487	3,376	6,100
	Upstream of U.S. Highway 66	110.6	1,050	*	2,400	3,250	5,800
	At confluence of Switzer Canyon Wash	98.9	1,050	*	2,400	3,250	5,800
	Above confluence of Bow and Arrow Wash	80.3	900	*	2,000	2,700	4,750
	At confluence of Sinclair Wash	67.3	600	*	1,350	1,850	3,300
	Upstream of confluence of Clay Avenue Wash	53.7	510	*	1,100	1,450	3,000
	Above Crescent Drive	50.5	290	*	840	1,300	2,900
	At Narrows Dam	43.3	260	*	760	1,200	2,600
	At confluence of Hidden Hollow Wash	30.6	70	*	410	680	1,650
	Approximately 0.5 mile downstream of road proceeding south from Arizona Snow Bowl Access Road	29.0	70	*	400	660	1,600

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Rio de Flag *(continued)*	Approximately 0.5 mile upstream of road proceeding south from Arizona Snow Bowl Access Road	23.5	50	*	320	530	1,300
	Approximately 1.33 miles upstream of U.S. Highway 180	12.2	17	*	142	246	642
Rio de Flag Split Flow	At confluence with Rio de Flag	[4]	5.0	*	278	456	1,260
San Miguel Wash	Approximately 475 feet upstream of confluence with Golf Course Creek	0.1	38	68	98	136	253
Santa Fe Wash East	At confluence with Cataract Creek	5.8	304	*	792	1,305	2,500
	Upstream of confluence of Santa Fe Wash West	4.9	156	*	481	836	1,750
	At U.S. Highways 66 and 89	0.9	81	*	250	421	900
Santa Fe Wash West	At confluence with Santa Fe Wash East	0.9	184	*	419	708	1,340
	At U.S. Highways 66 & 89	0.6	182	*	393	633	1,340
School Soldier Wash	At State Route 89A	0.2	146	169	246	294	415
Schoolhouse Draw Wash	At confluence with Pumphouse Wash	5.2	1,015	1,377	1,661	1,974	2,712
	At confluence of Mountainaire Wash	4.6	927	1,251	1,511	1,798	2,471

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Schoolhouse Draw Wash *(continued)*	At NF-762 Forest Road	3.1	575	780	944	1,125	1,553
	Approximately 400 ft upstream of NF-707 Forest Road	1.7	328	445	539	642	885
Schultz Creek	At confluence with Rio de Flag	6.0	*	*	*	440	*
Sinclair Wash	At confluence with Rio de Flag	11.6	350	*	670	890	1,600
	At Palmer Avenue	8.0	100	*	320	470	990
	At upstream limit of detailed study	5.4	50	*	180	270	600
Soldier Wash	At SR-89A	3.3	1,110	1,359	2,237	2,796	4,317
	Downstream of confluence with Substation Soldier Wash	3.1	1,043	1,278	2,120	2,656	4,112
	Upstream of confluence with Substation Soldier Wash	2.3	813	998	1,630	2,057	3,195
Spruce Avenue Wash	At Santa Fe Avenue	7.3	240	*	460	580	930
	Above East Linda Vista Drive	5.7	60	*	180	260	520
	Near upstream limit of detailed study	5.3	50	*	160	230	480

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Switzer Canyon Wash	At confluence with Rio de Flag	11.0	280	*	600	800	1,400
	At downstream Turquoise Drive crossing	2.1	80	*	190	250	450
	At upstream corporate limits	*	*	*	*	150	*
	Approximately 528 feet upstream of intersection of Juniper Avenue and Turquoise Drive	*	*	*	*	150	*
	At upstream of Route 66	2.1	*	*	*	250	*
	At Atchison, Topeka, Santa Fe Railway	*	79	*	108	252	454
	At Enterprise Road	*	101	*	250	346	642
Table Top Airport Wash	Approximately 2700 feet upstream of confluence with Oak Creek	0.2	74	129	184	251	459
Tributary 1 to Baderville Tributary	At stream mile 0.76	3.4	*	*	*	162	*
Tributary 2 to Baderville Tributary	At stream mile 1.28	1.5	*	*	*	73	*

Table 9: Summary of Discharges (Continued)

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
West Street Wash	Below south driveway of High School	0.3	22	*	45	58	97

* Not calculated for this Flood Risk Project
** Not Provided (Atkins, 2012, 2018)
[1] Decrease due to storage upstream
[2] Decrease due to overbank losses upstream
[3] Floods caused by overflow from Clay Avenue Wash; hence, no applicable drainage area other than the drainage area of Clay Avenue Wash at this location
[4] Floods caused by overflow from Rio de Flag; hence, no applicable drainage area other than the drainage area of Rio de Flag at this location

Figure 7: Frequency Discharge-Drainage Area Curves

[Not Applicable to this Flood Risk Project.]

Table 10: Summary of Non-Coastal Stillwater Elevations

Flooding Source	Location	Elevations (feet NAVD88)				
		10-Percent-Annual-Chance	4-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Mormon Lake	22 miles south-southeast of the City of Flagstaff	7,115.9	*	*	7,120.4	7,123.4
Detention Basin	South of Sinclair Wash within the City of Flagstaff	*	*	*	6,925.4	*
Stoneman Lake (with diversion ditch closed)	30 miles south-southeast of the City of Flagstaff	6,728.6	*	*	6,732.8	6,735.2

*Not calculated for this Flood Risk Project

Table 11: Stream Gage Information used to Determine Discharges

Flooding Source	Gage Identifier	Agency that Maintains Gage	Site Name	Drainage Area (Square Miles)	Period of Record	
					From	To
Cataract Creek Tributary	*	USGS	*	*	*	*
Kanab Creek	*	USGS	*	*	01/01/1959	01/01/1968
Munds Park Wash	143	Yavapai County	Munds Park	*	12/07/1989	11/01/1994
Oak Creek	09504420	USGS	Oak Creek near Sedona	355	4/14/1985	*

* No data available

5.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Base flood elevations on the FIRM represent the elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations. These whole-foot elevations may not exactly reflect the elevations derived from the hydraulic analyses. 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 Report in conjunction with the data shown on the FIRM. The hydraulic analyses for this FIS 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.

For streams for which hydraulic analyses were based on cross sections, locations of selected cross sections are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 6.3), selected cross sections are also listed in Table 23, “Floodway Data.”

A summary of the methods used in hydraulic analyses performed for this project is provided in Table 12. Roughness coefficients are provided in Table 13. Roughness coefficients are values representing the frictional resistance water experiences when passing overland or through a channel. They are used in the calculations to determine water surface elevations. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

Table 12: Summary of Hydrologic and Hydraulic Analyses

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Baderville Tributary to Rio de Flag	At confluence with Rio de Flag	Approximately 0.2 miles south of Hashknife Trail Road	Normal-depth calculations	HEC-2 step-backwater, WSPRO, J635	01/01/1981	AE w/ Floodway	Normal-depth calculations were used to determine the starting water-depth elevation for Baderville Tributary. Hydraulic calculations were performed using two USGS models. WSPRO was used for the culvert, road overflow, and floodway computations at Bader and Suzette Roads and the floodway analyses at cross sections D, E, G, and H. The backwater analyses and remaining floodway elevation computations were carried out by the J635 computer model (USGSa). Cross sections used for the study were surveyed by USGS personnel in October 1989. Normal-depth calculations were used to determine the starting water-depth elevation for Baderville Tributary. The revised hydraulic analysis was performed using the USACE HEC-2 step-backwater computer program. Because of the new topography, the BFEs were increased, the 1- and 0.2-percent-annual-chance floodplain boundaries were modified, and the 1-percent-annual-chance floodway was realigned. The HEC-2 hydraulic computer model was used to determine the base flood elevations. The starting water-surface elevation was taken from the previous study. The cross-section data for the channelized portions of the wash was obtained from the USGS and the City of Flagstaff Engineering Division. Overbank information was obtained from aerial topographic maps. Roughness coefficients were chosen by engineering judgment and based on field observations.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Bow and Arrow Wash	Approximately 1,800 feet upstream of Lake Mary Road	At South Lone Tree Road crossing	Discharges used were obtained from the City of Flagstaff FIS	HEC-RAS Version 3.1.3	04/01/2004	AE w/ Floodway	The expansion and contraction coefficients used in the HEC-RAS model were determined from the HEC-RAS User's Manual. For gradual transitions, which include more reaches in this study, the contraction and expansion coefficients were set as 0.1 and 0.3, respectively. At locations where the cross-sectional area and flow direction change abruptly, values of 0.2 to 0.4 and 0.4 to 0.6 were used for these coefficients. At structure location values of 0.3 and 0.5 were used. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. In this model, there appears to be two locations that produce hydraulic jumps due to a culvert and a change in slope. The first location is 1/2 mile downstream of Lake Mary Road along the wash. The channel in this location changes from a steep to a gradual slope, thus creating a hydraulic jump. The second location is just downstream of Lake Mary Road at the culvert outlet. There are several locations showing divided flows. These divided flows appear to be isolated islands and appear to be hydraulically connected both upstream and downstream. There are several locations showing divided flows. These divided flows appear to be isolated islands and appear to be hydraulically connected both upstream and downstream.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Bow and Arrow Wash *(continued)*	Approximately 1,800 feet upstream of Lake Mary Road	At South Lone Tree Road crossing	Discharges used were obtained from the City of Flagstaff FIS	HEC-RAS Version 3.1.3	04/01/2004	AE w/ Floodway	Along the wash between Leupp Drive to Yaqui Drive, there are several locations of supercritical flow conditions. These are mainly due to the wash crossings at developed areas. This development constricts flow between properties, thus creating either an expansion or contraction between cross sections.
Cataract Creek	Approximately 0.36 miles north of U.S. Interstate 40	Approximately 0.5 miles upstream Santa Fe Reservoir dam	SCS TR-20	HEC-2 step-backwater	03/01/1981	A, AE w/ Floodway, AO	Results were compared with data taken from a USGS gage station with 14 years of record on a tributary to Cataract Creek. Discharges on portions of Cataract Creek decrease due to overbank losses upstream. Discharges on portions of Cataract Creek decrease due to overbank losses upstream. Starting water-surface elevations for Cataract Creek were derived from normal-depth calculations.
Cataract Creek Tributary	At confluence with Cataract Creek	At City Reservoir	SCS TR-20	HEC-2 step-backwater	03/01/1981	AE w/ Floodway	Results were compared with data taken from a USGS gage station with 14 years of record on a tributary to Cataract Creek. Discharges decrease with increasing drainage area on Cataract Creek Tributary due to storage upstream. No profile is shown for Cataract Creek Tributary for approximately 370 feet downstream of City Port Dam due to the extreme steepness of the spillway (an approximate 18-foot vertical drop per 100 feet). Starting water-surface elevations for Cataract Creek Tributary were derived from normal-depth calculations.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Cemetery Wash	At U.S. Interstate 40	Approximately 0.12 miles west of Williams, City of	SCS TR-20	HEC-2 step-backwater	03/01/1981	AE w/ Floodway	Results were compared with data taken from a USGS gage station with 14 years of record on a tributary to Cataract Creek. Discharges on Cemetary Wash are due to overbank losses upstream. Starting water-surface elevations for Cemetary Wash were derived from a rating curve for the culverts at Interstate Highway 40.
Clay Avenue Wash (Rio de Flag confluence)	Approximately 0.3 mile upstream from confluence with Rio de Flag	Approximately 0.9 miles upstream from confluence with Rio de Flag	Not Provided	HEC-RAS Version 3.1.3, BOSS RMS Version 2000	04/01/2004	AE w/ Floodway	The revised hydraulic analyses resulted in changes to the BFEs, modifications to the floodplain boundaries, and the addition of a floodway along Clay Avenue Wash from approximately 0.300 mile to 0.925 mile upstream of the confluence with Rio de Flag. In support of this revision, the following technical data were submitted: A topographic map of Clay Avenue Wash from 0.3 mile upstream to 0.925 mile upstream of the confluence with Rio de Flag, prepared by the City of Flagstaff, dated May 1988; and as-built drawings of Westglen Mobile Home Park, Public and Private Improvements, prepared by P & D Technologies, dated January 25, 1989. The work study maps consisted of the 2-foot contour interval topographic mapping. Also, USGS 7.5-minute quadrangle topographic mapping with a 1:24,000 scale, with 20-foot contour intervals. However, due to the lack of accuracy or inconsistencies between mapping sources, these maps were used as reference purposes only and topographic information was obtained by field survey.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Clay Avenue Wash	At intersection of West Clay Avenue and U.S. Interstate 40 Business	At Forest Service Road 506	HEC-1	HEC-2 step-backwater	03/01/1995	AE w/ Floodway	The USACE had previously studied Rio de Flag and Sinclair Wash in a 1975 report (USACE-Los Angeles 1975). A study addressing floodflow peaks on Rio de Flag and other tributaries within the City of Flagstaff, including Clay Avenue Wash, Fanning Drive Wash, Sinclair Wash, and Switzer Canyon Wash, was published for the City of Flagstaff in 1979 (Arizona Engineering Company 1979). A complete review of the hydrology of both reports was conducted. The hydrology model from the City of Flagstaff report (Arizona Engineering Company 1979) was adopted with minor modifications for use in this FIS. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. Clay Avenue Wash has divided flow between cross sections P and T.
Clay Avenue Wash Split Flow	At confluence with Clay Avenue Wash, approximately 125 feet downstream of West Shellie Drive	At confluence with Clay Avenue Wash, approximately 750 feet upstream of West Shellie Drive	Not Provided	Not Provided	01/01/1981	AE	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. At the Rio de Flag and Clay Avenue Wash areas of split flow, the 10-percent-annual-chance flood is contained in the main channel.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Country Club Wash	At confluence with Rio de Flag	At golf course pond on north side of East Mt. Pleasant Drive	HEC-1	HEC-2 step-backwater	01/01/1981	AE w/ Floodway	Starting water-surface elevations for Rio de Flag, Peaceful Valley Wash, and Country Club Wash were based on storage-routing using the USACE HEC-1 computer program (USACE-HEC 1973). The storage-routing condition occurring at U.S. Highway 66 causes ponding upstream of U.S. Highway 66 past the confluences of Peaceful Valley Wash and Country Club Wash with Rio de Flag for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation.
Detention Basin	At South Wild West Trail	Approximately 0.2 miles upstream from South Wild West Trail	Not Provided	Not Provided	Not Provided	AE	
Dewey Grade Wash	Confluence with Pumphouse Wash	Downstream of Old Munds Highway	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Fanning Drive Wash	At confluence with Rio de Flag	Approximately 140 feet north east of Skyline Drive and Forest Brook Street	HEC-1	HEC-2 step-backwater	09/30/1995	AE w/ Floodway	The USACE had previously studied Rio de Flag and Sinclair Wash in a 1975 report (USACE - Los Angeles 1975). A study addressing floodflow peaks on Rio de Flag and other tributaries within the City of Flagstaff, including Clay Avenue Wash, Fanning Drive Wash, Sinclair Wash, and Switzer Canyon Wash, was published for the City of Flagstaff in 1979 (Arizona Engineering Company 1979). A complete review of the hydrology of both reports was conducted. The hydrology model from the City of Flagstaff report (Arizona Engineering Company 1979) was adopted with minor modifications for use in this FIS. No 0.2-percent-annual-chance flood elevations were modeled or plotted on the profiles for Fanning Drive Wash. The capacity of the wash would not convey the 0.2-percent-annual-chance flood. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. One area of shallow flooding along Fanning Drive Wash breaks out along Linda Vista Drive and flows south to U.S. Highway 66. Another area of shallow flooding occurs between Fanning Drive Wash, Linda Vista Drive, and Fanning Drive.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Fanning Drive Wash *(continued)*	At confluence with Rio de Flag	Approximately 140 feet north east of Skyline Drive and Forest Brook Street	HEC-1	HEC-2 step-backwater	09/30/1995	AE w/ Floodway	No 0.2-percent-annual-chance flood elevations were modeled or plotted on the profiles for Fanning Drive Wash. It is estimated that the 0.2-percent-annual-chance flood event for Fanning Drive Wash will break out between stations 1.88 and 1.50 along Linda Vista Drive. Most of this flooding will not return to the channel. The culvert on Fanning Drive Wash at the railroad has a small capacity compared to the entire flow; therefore, a weir equation was used to determine the backwater elevation behind the railroad embankment. No floodway is shown for this area.
Golf Course Creek	Confluence with Memorial Park Wash	Approximately 500 feet US from Hwy 179	Regression Equations - USGS	HEC-RAS version 5.0.3	05/30/2018	AE	
Gravesite Wash	Confluence with Pumphouse Wash	Approximately 800 ft upstream of I-17	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	
Harrenburg Wash	Confluence with Pumphouse Wash	Approximately 800 ft upstream of I-17	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	
Holy Cross Wash	Confluence with Oak Creek	Easement at W Mallard Dr	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Howard Draw Wash	Lower Lake Mary	At Intersection of Forest Service Road 235 and Crimson Road	SCS TR-20	HEC-2 step-backwater	01/01/1981	AE w/ Floodway	Because of the similar hydrologic characteristics of the Howard Draw Wash drainage area with that of the Oak Creek area, the TR-20 computer program (USDA, 1965) was also used to perform the hydrologic analysis for Howard Draw Wash, using similar input data. Because starting water-surface elevations for Howard Draw Wash were dependent on lake elevations of Lower Lake Mary, it was necessary to establish the lake elevations for selected recurrence intervals. This was done using a previous hydrology report for the City of Flagstaff (Hydrology Consultants, Inc. 1975).

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Kanab Creek	Approximately 0.2 miles north east of Route 89A and Cowboy Drive	Approximately 0.3 miles north east of Route 89A and Cowboy Drive	SCS TR-20 with Type 1 Storm Distribution; USGS Regression Equation, and USGS Index Method	HEC-2 step-backwater	03/01/1981	AE w/ Floodway	Several hydrologic methods were used to establish discharge-frequency relationships for Kanab Creek through the Town of Fredonia. The SCS TR-20 computer program (USDA 1965) was used, with a Type 1 storm distribution applied with precipitation data obtained from National Oceanic and Atmospheric Atlas Volumes VI and VIII (NOAA 1973B). The USGS Regression Equation (ADOT 1978) and the USGS Index Method (USGS 1962) were also used. These results were compared with the results obtained from a USGS gaging station with 9 years of record (1959 to 1968) on Kanab Creek above the Town of Fredonia as a further check of the results. Approximate flooding for Lost Spring Wash was determined from a Flood Hazard Boundary Map (FIA 1978), and tied into detailed flooding from Kanab Creek. Floodway widths extend beyond the Coconino County boundary for Kanab Creek.
Margs Draw Wash	Confluence with Morgan Wash	Approximately 580 feet US from Canyon Dr	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
Memorial Knolls Wash	Confluence with Memorial Park Wash	Approximately 990 feet US from Hwy 179	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
Memorial Park Wash	Confluence with Oak Creek	Approximately 840 feet US from Doodlebug Rd	HEC-HMS Version 4.2	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
Morgan Wash	Confluence with Oak Creek	Approximately 1,050 feet US from Cypress Ct	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Mormon Lake	At northern intersection of Mormon Lake Road and County Road 3	At southern intersection of Mormon Lake Road and County Road 3	SCS methods described in Technical Service Center Technical Note- P0-6	HEC-2 step-backwater	01/01/1981	A	Analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for Mormon Lake. No lake gage records exist for Mormon Lake. Approximate historic lake elevations were determined from recollections of long-time local residents and observations of high water marks from U.S. Forest Service aerial photographs (USDA 1978). Water-surface elevations were established in June 1980 when they were above normal water elevations. The 1-percent-annual-chance frequency lake elevation for Mormon Lake was established by adding the volume from a 10-day duration, 1-percent-annual-chance frequency storm to the mean maximum lake elevation as determined from historic information. The 10-day duration rainfall for a 1-percent-annual-chance storm was computed using SCS methods described in Technical Service Center Technical Note- P0-6 (USDA 1975). Precipitation values for the analysis were derived from the National Oceanic and Atmospheric Administration Atlas, Volume III (NOAA 1973a). Using the rainfall computed for the 10-day duration, 1-percent-annual-chance storms along with runoff curve numbers, the net volume of runoff was calculated using SCS procedures.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Mormon Lake *(continued)*	At northern intersection of Mormon Lake Road and County Road 3	At southern intersection of Mormon Lake Road and County Road 3	SCS methods described in Technical Service Center Technical Note-P0-6	HEC-2 step-backwater	01/01/1981	A	An elevation versus storage rating curve was prepared for Mormon Lake. Storage volume was computed by the use of USGS topographic maps (USGS, 1965). Using the mean maximum water-surface elevations determined from historic information with the net volumes of runoff for the 10-day duration storms and the elevation versus storage rating curves, the lake water- surface elevation for the selected recurrence interval was determined. No 2-percent-annual-chance flood elevation was determined for Mormon Lake.
Mountainaire Wash	Confluence with Schoolhouse Draw Wash	Downstream of NF-700L Forest Road	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	
Munds Canyon Creek	Confluence with Oak Creek	Approximately 13,900 feet US from confluence	HEC-HMS, Version 4.2	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Munds Park Wash	At U.S. Interstate 17	Approximately 1.0 miles upstream from East Pinewood Boulevard	SCS TR-20	HEC-2 step-backwater	01/01/1981	AE w/ Floodway	Input data for the TR-20 computer program was prepared for the Yavapai County FIS as part of the hydrology report on Oak Creek in Yavapai County (FEMA, 1991). To obtain peak floodflows at the required concentration points of Oak Creek and tributaries, Soldier Wash, and Munds Canyon, it was necessary to modify the TR-20 model by adding additional concentration points. Further modification, in the form of higher areal reduction factors applied to the precipitation data, was necessary to model the relatively higher peak floodflows occurring from the smaller drainage areas. Therefore, peak discharges for Munds Canyon, Soldier Wash, Munds Park, and upper reaches of Oak Creek are higher than peak discharges obtained at the same location when the lower Oak Creek peak discharges were being investigated.
Oak Creek	Confluence with Verde River	Intersection with N State Route 89A	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
O'Neil Springs Wash	Confluence with Pumphouse Wash	Approximately 2,900 feet above the confluence with Pumphouse Wash	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	
O'Neil Tank Wash	Confluence with Pumphouse Wash	Approximately 1,200 feet above the confluence with Pumphouse Wash	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Painted Memorial Wash	Confluence with Memorial Park Wash	Approximately 1,165 feet US from confluence	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
Peaceful Valley Wash	At confluence with Rio de Flag	Approximately 1.5 miles east of the south end of Lake Elaine	HEC-1	HEC-2 step-backwater	01/01/1981	AE w/ Floodway	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. Starting water-surface elevations for Peaceful Valley Wash were based on storage-routing using the USACE HEC-1 computer program (USACE-HEC 1973). The storage-routing condition occurring at U.S. Highway 66 causes ponding upstream of U.S. Highway 66 past the confluences of Peaceful Valley Wash.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Peak View Wash	Approximately 130 feet downstream of Cooper Drive	Approximately 120 feet upstream of Lois Lane	HEC-1	HEC-2 step-backwater	04/01/2004	AE w/ Floodway	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. In this model, there appears to be two locations where hydraulic jumps occur. The two locations, south of Mountain Drive and the other south of Lois Lane, both hydraulic jumps are due to the culverts at the crossing locations and the slope transition between steep to gradual at the structure, thus creating high velocities and hydraulic jumps downstream of the structure location. There is no divided flow in this model. However, there is a flow split at Cooper Drive near the confluence with the Rio de Flag Wash. There are two locations where supercritical flow conditions occur.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Penstock Avenue Wash	At Railhead Avenue	At Smokerise Drive	HEC-1	HEC-2 step-backwater	09/30/1995	AE w/ Floodway	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. Shallow flooding occurs east of Penstock Avenue Wash from between Empire and Commerce Avenues to between Railhead Avenue and U.S. Highway 66. No 0.2-percent-annual-chance flood elevations were modeled or plotted on the profiles for Penstock Avenue. It is estimated that the 0.2-percent-annual-chance flood event for Penstock Avenue Wash will break out below station 0.894 and return at station 0.11 resulting in shallow flooding of not more than 1.0 foot on the average. Most of this flooding will not return to the channel.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Pumphouse Wash	At the downstream limit of effective flooding	Approximately 8,400 ft upstream of I-17	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	Along Pumphouse Wash there are several homes/ buildings, close in proximity, which significantly impact the active flow in the floodplain; therefore, ineffective area was placed along the buildings to constrict the active flow area. This occurs mainly between cross sections 6514 through 8848. The floodway analysis for Pumphouse Wash was discontinued upstream of Interstate 17, due to backwater from the interstate embankment and culvert capacity. This area is ponding, so evaluating a floodway limit in this section was not deemed necessary. The floodway was discontinued between Pumphouse Wash cross sections 15194 through 16391. Structure 8515 along Pumphouse Wash was skewed manually in HEC-RAS to account for the smaller bridge opening due to its alignment along Pinon Trail. The bounding cross sections are perpendicular to the floodplain, so the geometry for the bridge was input into HEC-RAS with the smaller opening, rather than applying a skew angle in HECRAS. Structure 7693 along Pumphouse Wash was skewed using the HEC-RAS option in the modeling program, resulting in applying the skew angle automatically to the structure and bounding cross sections. The thalweg for Pumphouse Wash is forced to turn 90 degrees, just east of the Interstate 17, to flow through the Interstate 17 culvert (Structure 15073) and continue west. Before the construction of Interstate 17, the Pumphouse Wash had a more natural geometry and flowed north-east to south-west without the 90 degree turn at the interstate crossing. Since the construction of the interstate, Structure 15073 (Interstate 17

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Pumphouse Wash *(continued)*	At the downstream limit of effective flooding	Approximately 8,400 ft upstream of I-17	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	culvert) along Pumphouse Wash forces the upstream flow to backwater on the east side of the interstate due to the highway embankment and culvert constriction. Because the interstate causes a backwater effect and the velocity head is negligible compared to the depth of flow, a junction at the intersection of Pumphouse Wash and Schoolhouse Draw Wash was deemed not necessary. Pumphouse Wash Structure 6970 is a triple barrel 12'x10' RCB culvert (modeled as bridge) with an interior angle under Pinon Trial, with two boxes (right side) having a shorter length than the third box (left side). This structure was modeled as a straight culvert on a skew in HEC-RAS assuming all three box culverts had a uniform length matching the longer culvert. This approximation was deemed appropriate for the purpose of floodplain mapping with the longer box length approximating the hydraulic losses occurring from the nonstandard geometry. Modeling, in the area of Pinon Trail on Pumphouse Wash, contained numerous closely spaced, low-flow driveway access structures, with non-standard geometries, and large skew angles. Adequate distance between structures did not exist to apply the standard cross section spacing at each structure. Therefore, minor adverse water surface slopes exist in the model in this area, limited to 0.3 feet or less. An attempt was made to stabilize the model, which included the deletion of extraneous cross sections where possible, and ignoring small wooden walkway bridges.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (upstream study)	At Narrows Dam	Approximately 500 feet downstream of the Hidden Hollow Road crossing	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	The USACE had previously studied Rio de Flag and Sinclair Wash in a 1975 report (USACE - Los Angeles 1975). A study addressing floodflow peaks on Rio de Flag and other tributaries within the City of Flagstaff, including Clay Avenue Wash, Fanning Drive Wash, Sinclair Wash, and Switzer Canyon Wash, was published for the City of Flagstaff in 1979 (Arizona Engineering Company 1979). A complete review of the hydrology of both reports was conducted. The hydrology model from the City of Flagstaff report (Arizona Engineering Company 1979) was adopted with minor modifications for use in this FIS.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (upstream study) *(continued)*	At Narrows Dam	Approximately 500 feet downstream of the Hidden Hollow Road crossing	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	An area of shallow flooding of less than 1. 0 foot occurs along Fremont Boulevard near its intersection with Rio de Flag. For the Rio de Flag restudy, the 10-, 2-, and 1-percent-annual-chance discharges were obtained using a transfer equation derived from USGS, 1999. The 0.2-percent-annual-chance discharge was obtained using graphical interpolation from log-probabilities plots. Hydrology flow values for the Rio de Flag were generated using the integration of FIS flow values and the USGS regression equations for various points along the stream path, and were extrapolated from existing FIS data for the 0.2-percent-annual-chance flood event where USGS equations were not available. A combined terrain was compiled using a combination of available 3’ DEM data, digitized contour data associated with the effective study and 30’ USGS DEMs for the Rio de Flag. Hydraulics were then calculated in HEC-RAS Version 3 .1.3 and used as the basis for determining floodplain and floodway extents.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (upstream study) *(continued)*	At Narrows Dam	Approximately 500 feet downstream of the Hidden Hollow Road crossing	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	The fourth apparent hydraulic jump is approximately 300 feet downstream of the culvert at Fremont Boulevard due to steep slopes and the impoundment created by Narrows Dam downstream. There are several locations that appear to produce supercritical flow conditions. Most of these locations are associated with roadway crossings and include the following: • Downstream from the culvert outlet at Fremont Boulevard, it appears that the flow is confined to the roadway culvert. This and the steep grades upstream from the culvert result in an acceleration of the flow and supercritical flow conditions. • Upstream from the culvert inlet at Fremont Boulevard, it appears that the flow is confined to the roadway culvert. This and the steep grades upstream result in an acceleration of the flow and supercritical flow conditions. Approximately 430 feet northwest of the roadway intersection of Fremont Boulevard and Boldt Drive, it appears that the flow is confined to the roadway culvert, thus creating supercritical flow conditions.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (downstream study)	At Rio Ranch Road crossing	At U.S. Route 66	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	The USACE had previously studied Rio de Flag and Sinclair Wash in a 1975 report (USACE - Los Angeles 1975). A study addressing floodflow peaks on Rio de Flag and other tributaries within the City of Flagstaff, including Clay Avenue Wash, Fanning Drive Wash, Sinclair Wash, and Switzer Canyon Wash, was published for the City of Flagstaff in 1979 (Arizona Engineering Company 1979). A complete review of the hydrology of both reports was conducted. The hydrology model from the City of Flagstaff report (Arizona Engineering Company 1979) was adopted with minor modifications for use in this FIS. Starting water-surface elevations for Rio de Flag were based on storage-routing using the USACE HEC-1 computer program (USACE - HEC 1973). The storage-routing condition occurring at U.S. Highway 66 causes ponding upstream of U.S. Highway 66 past the confluences of Peaceful Valley Wash and Country Club Wash with Rio de Flag for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (downstream study) *(continued)*	At Rio Ranch Road crossing	At U.S. Route 66	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	The best available mapping was used for approximate study analysis. Approximate study areas, described as lower Rio de Flag (approximately 1.7 miles), were studied to determine delineations for the 1-percent-annual-chance flood by use of normal depth calculations using Manning's equation. The remaining approximate study areas, described as Rio de Flag (approximately 0.7 mile below U.S. Highway 66), were delineated for the 1-percent-annual-chance flood based on the City of Flagstaff drainage report (Arizona Engineering Company 1979). An area of divided flow occurs on Rio de Flag along Bonito Street from Thorpe Road to Elm Avenue. For the Rio de Flag restudy, the 10-, 2-, and 1-percent-annual-chance discharges were obtained using a transfer equation derived from USGS 1999. The 0.2-percent-annual-chance discharge was obtained using graphical interpolation from log-probabilities plots. Hydrology flow values for the Rio de Flag were generated using the integration of FIS flow values and the USGS regression equations for various points along the stream path, and were extrapolated from existing FIS data for the 0.2-percent-annual-chance flood event where USGS equations were not available.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (downstream study) *(continued)*	At Rio Ranch Road crossing	At U.S. Route 66	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	A combined terrain was compiled using a combination of available 3' DEM data, digitized contour data associated with the effective study and 30' USGS DEMs for the Rio de Flag. Hydraulics were then calculated in HEC-RAS Version 3 .1.3 and used as the basis for determining floodplain and floodway extents. In this model, there are four apparent locations that produce hydraulic jumps due to culverts and a steep slope, approximately 1/2 mile downstream of the culvert located at El Paso Road, due to a steep slope in the wash. This slope creates high velocities and supercritical flow conditions. The second location is just downstream of the culvert at El Paso Road and the third location is just downstream of the culvert at El Compressor Road, both due to the obstruction of flow from the culvert. Just south of the county boundary continuing about ½ mile downstream along the wash, the flow is not contained in the channel and spreads over a large area. The cross sections show several small islands, but they are just local high points and the flow appears to be hydraulically connected. Hydrology flow values for the Rio de Flag were generated using the integration of FIS flow values and the USGS regression equations for various points along the stream path, and were extrapolated from existing FIS data for the 0.2-percent-annual-chance flood event where USGS equations were not available.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (downstream study) *(continued)*	At Rio Ranch Road crossing	At U.S. Route 66	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	There are several locations that appear to produce supercritical flow conditions. Most of these locations are associated with roadway crossings and include the following: • Approximately 330 feet southeast of the county boundary, it appears that the inundation limits are contracting between cross sections, thus creating a supercritical flow conditions. • Approximately 300 feet north of the county boundary, the slope gradually increases. This slope creates high velocities and supercritical flow conditions that continue in several different areas to approximately 1,850 feet south of the county boundary. Hydraulic model variables were obtained primarily from two sources: the existing FIS for the eastern portion of the study reach, and the Entellas restudy conducted in 2004 for the western portion of the study reach. This current study combined both model sections into one continuous model and incorporated the revised flow values. The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the floodplain. There are two exceptions to this statement. The first occurs from cross sections CJ to DE on Rio de Flag, through a heavily urbanized area of the City of Flagstaff, where the equal conveyance reduction method failed to produce an appropriate floodway. With the approval of the City of Flagstaff and FEMA, a floodway was established through this area of Rio de Flag using fixed encroachments.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag (downstream study) *(continued)*	At Rio Ranch Road crossing	At U.S. Route 66	HEC-1	HEC-2 step-backwater, HEC-RAS step-backwater Version 3.1.3	12/01/2008	AE w/ Floodway	The second exception occurs from U.S. Highway 66 to approximately cross section AN on the lower reach of detailed study of Rio de Flag. This reach of Rio de Flag is subjected to ponding of floodwaters behindU.S. Highway 66 due to a relatively small- capacity culvert under the high U.S. Highway 66 road embankment. The floodplain elevations and delineations on this reach of Rio de Flag were determined using the storage-routing option of the HEC-1 hydrology computer program. This storage-routing analysis involved determining the peak flood elevation occurring for the volume of floodwater entering the area behind U.S. Highway 66, the volume of floodwater exiting at the highway, and the storage capacity behind the highway. It, therefore, was also necessary to determine the floodway for this ponded area of Rio de Flag by volume analysis. The established floodway limits could not allow the base flood water-surface elevation to rise by more than 1.0 foot if the floodway fringe were to be completely filled in. It was found that an acceptable floodway could not be established in the ponded area of Rio de Flag, so the floodplain delineation was also established as the floodway limit.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Rio de Flag Split Flow	At confluence with Rio de Flag at North Bonito Street	At confluence with Rio de Flag near North Thorpe Road	Not Provided	Not Provided	01/01/1981	AE w/ Floodway	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. Rio de Flag Split Flow is separated from the main channel by an area of shallow flooding between Navajo Drive and Thorpe Road. The water-surface elevations are slightly higher in the main channel than in the adjacent area of ponding due to the slight amount of head needed to initiate weir flow. At the Rio de Flag and Clay Avenue Wash areas of split flow, the 10-percent-annual-chance flood is contained in the main channel.
San Miguel Wash	Confluence with Golf Course Creek	Approximately 470 feet US from confluence	Regression Equations - USGS	HEC-RAS, Version 4.1.0	05/30/2018	AE w/ Floodway	
Santa Fe Wash East	Approximately 0.4 mile north of US Interstate 40	At U.S. Route 66	SCS TR-20	HEC-2 step-backwater	03/01/1981	AE w/ Floodway, AH	Results were compared with data taken from a USGS gage station with 14 years of record on a tributary to Cataract Creek. Starting water-surface elevations for Santa Fe Wash East were determined using critical depth.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Santa Fe Wash West	Approximately 0.36 mile north of U.S. Interstate 40	At North Grand Canyon Boulevard	SCS TR-20	HEC-2 step-backwater	03/01/1981	AE w/ Floodway, AH, AO	Results were compared with data taken from a USGS gage station with 14 years of record on a tributary to Cataract Creek. A shallow flooding area east of the City of Williams for Santa Fe Wash West was determined using HEC-2 computations (USACE-HEC 1976) and engineering judgment. For the areas studied by approximate methods, 1-percent-annual-chance elevations were determined from normal depth calculations using Manning's equation. Starting water-surface elevations for Santa Fe Wash West were taken from Santa Fe Wash East.
School Soldier Wash	Confluence with Oak Creek	Approximately 1,300 feet US from Camielle Ct	HEC-HMS, Version 4.2	HEC-RAS Version 5.0.3	05/30/2018	AE	

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Schoolhouse Draw Wash	Confluence with Pumphouse Wash	Approximately 2,500 ft upstream of NF-707 Forest Road	HEC-1, Version 4.1	HEC-RAS, Version 4.1.0	09/01/2016	AE w/ Floodway	There is a large building located along the Schoolhouse Draw Wash low-flow channel, resulting in this building being located in the middle of the floodplain. This structure, located between cross sections 5983 and 6076, was modeled in HEC-RAS by applying a blocked obstruction area. The floodway analysis for Schoolhouse Draw Wash was discontinued upstream of Interstate 17, due to backwater from the interstate embankment and culvert capacity. This area is ponding, so evaluating a floodway limit in this section was not deemed necessary. The floodway was discontinued between Schoolhouse Draw Wash cross sections 5 through 2126. Structure 9327 along Schoolhouse Draw Wash was skewed using the HEC-RAS option in the modeling program, resulting in applying the skew angle automatically to the structure and bounding cross sections. The Schoolhouse Draw Wash merges into the Pumphouse Wash just upstream of Interstate 17 culvert (Structure 15073), on the east side of the interstate. The Schoolhouse Draw Wash used the water surface elevation at Pumphouse Wash cross section 15194 as the downstream boundary condition. The backwater limits correlate with the scarring of the natural ground per aerial imagery. The upstream limits of the study at Schoolhouse Draw Wash tie into an existing Zone A floodplain. In order to provide a transition to the wider Zone A limits, an area of Zone A floodplain was added.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Schultz Creek	Approximately 2,000 feet downstream of the Fort Valley Road crossing	At Shultz Pass Road	Discharges used were obtained from the City of Flagstaff FIS	HEC-RAS Version 3.1.3	04/01/2004	AE w/ Floodway, AO	Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation. The expansion and contraction coefficients used in the HEC-RAS model were determined from the HEC-RAS User's Manual. For gradual transitions, which include more reaches in this study, the contraction and expansion coefficients were set as 0.1 and 0.3, respectively. At locations where the cross-sectional area and flow direction change abruptly, values of 0.2 to 0.4 and 0.4 to 0.6 were used for these coefficients. At structure location values of 0.3 and 0.5 were used. In this model, there are several apparent locations that produce hydraulic jumps due to culverts and a confluence with Rio de Flag. At approximately 120 feet north of the confluence with Rio de Flag, there appears to be a hydraulic jump. This is due to the drop into the Rio de Flag at the confluence. Between Mary Russell Way and just downstream of Colter House Road, there are several locations in between these two roadways that have apparent hydraulic jumps, due to the obstructions of the culverts at the roadway crossings. Approximately 400 feet north of the confluence with Rio de Flag Wash, there is some flow that may leave the main wash.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Schultz Creek *(continued)*	Approximately 2,000 feet downstream of the Fort Valley Road crossing	At Shultz Pass Road	Discharges used were obtained from the City of Flagstaff FIS	HEC-RAS Version 3.1.3	04/01/2004	AE w/ Floodway	This flow is assumed to be small and the split was ignored in the model. Schultz Creek has a well-defined channel upstream of Highway 180. Downstream from the highway, the flow spreads through a wide area of shallowflow. There are several locations that appear to produce supercritical flow conditions. • Approximately 2,000 feet above the confluence with Rio de Flag, the wash flows through a developed area, where the flow is forced through streets and alleys resulting in supercritical flows. • Upstream from Highway 180, approximately 1/3 of a mile the slope gradually increases. This slope creates high velocities and supercritical flow conditions that continue to Highway 180. • Upstream from Mary Russell Way, it appears that the flow is confined to the roadway culvert. This and the steep grades upstream result in an acceleration of the flow and supercritical flow conditions that continues to approximately 1,300 feet north of the roadway crossing. Approximately 340 feet south of the city boundary, it appears that the inundation limits are contracting between cross sections, thus creating a supercritical flow conditions that continue to the corporate boundary limits.

Table 12: Summary of Hydrologic and Hydraulic Analyses (Continued)

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Sinclair Wash	At confluence with Rio de Flag	Approximately 0.1 mile west of Constitution Boulevard	HEC-1	HEC-2 step-backwater	01/01/1981	AE w/ Floodway	The USACE had previously studied Rio de Flag and Sinclair Wash in a 1975 report (USACE - Los Angeles 1975). A study addressing floodflow peaks on Rio de Flag and other tributaries within the City of Flagstaff, including Clay Avenue Wash, Fanning Drive Wash, Sinclair Wash, and Switzer Canyon Wash, was published for the City of Flagstaff in 1979 (Arizona Engineering Company 1979). A complete review of the hydrology of both reports was conducted. The hydrology model from the City of Flagstaff report (Arizona Engineering Company 1979) was adopted with minor modifications for use in this FIS. Water-surface elevations in the City of Flagstaff were computed with obstruction of modeled hydraulic structures considered. This approach was considered necessary because of the high debris potential due to urbanization and natural vegetation.
Soldier Wash	Confluence with Oak Creek	Approximately 0.9 miles US from AZ-89-Alt	HEC-HMS, Version 4.2	HEC-RAS Version 5.0.3	05/30/2018	AE w/ Floodway	