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Office of the State Engineer
Interstate Stream Commission

New Mexico Unit of the Central Arizona Project
Draft Environmental Impact Statement
Volume 2

U.S. Department of the Interior
Bureau of Reclamation
Interior Region 8: Lower Colorado Basin

New Mexico Interstate Stream Commission

Estimated federal lead agency total costs associated with developing and producing this EIS: $3,738,600

April 2020

MISSION STATEMENTS

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The mission of the New Mexico Interstate Stream Commission is to investigate water supply, to develop, to conserve, to protect, and to do any and all other things necessary to protect, conserve, and develop the waters and stream systems of this state, interstate, or otherwise.

Front Cover: Gila River near Cliff, New Mexico

Contents

Tables

Acronyms and Abbreviations

°F	degrees Fahrenheit
ACEC	Area of Critical Environmental Concern
AF	acre-feet
AFY	acre-feet per year
APE	area of potential effect
ASR	Aquifer Storage and Recovery wells
aum	animal-unit-month
AWSA	Arizona Water Settlements Act of 2004
BIA	Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BMPs	best management practices
CAP	Central Arizona Project
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
COA	Conservation Opportunity Area
CRBPA	Colorado River Basin Project Act
CT	Census Tract
CUFA	New Mexico Consumptive Use and Forbearance Agreement
CWA	Clean Water Act
dB	decibel
DCH	designated critical habitat
DOI	Department of the Interior
EC	Electrical Conductivity
EIA	economic impact analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FMI	Freeport-McMoRan, Inc.
FY	fiscal year
GBIC	Gila Basin Irrigation Commission
GDP	Gross Domestic Product
GIS	geographic information system
GLO	Government Land Office
gpm	gallon per minute
GRIC	Gila River Indian Community
GVID	Gila Valley Irrigation District
IBA	Important Bird and Biodiversity Area
IDC	interest during construction
IMPLAN	input-output model
ISC	New Mexico Interstate Stream Commission
ITA	Indian Trust Asset
LF	linear feet

MBTA	Migratory Bird Treaty Act
mg/l	milligrams per liter
MIS	management indicator species
NAGPRA	Native American Graves Protection and Repatriation Act
NAMS	North American Monsoon
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NM Unit	New Mexico Unit
NMAC	New Mexico Annotated Code
NMDGF	New Mexico Department of Game and Fish
NMDOH	New Mexico Department of Health
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environment Department
NMHPD	New Mexico Historic Preservation Division
NMOSA	New Mexico Office of the State Auditor
NMOSE	New Mexico Office of the State Engineer
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
O&M	operation and maintenance
OM&R	operation, maintenance, and replacement
ORV	outstandingly remarkable value
SHA	Occupational Safety and Health Administration
PCH	proposed critical habitat
PR&Gs	Principles, Requirements, and Guidelines
RM	river mile
RNCA	Riparian National Conservation Area
ROD	Record of Decision
ROW	right-of-way
SCIDD	San Carlos Irrigation and Drainage District
SCIP	San Carlos Irrigation Project
SHPO	State Historic Preservation Officer
SSPA	S. S. Papadopulos & Associates, Inc.
SWPPP	stormwater pollution prevention plan
SWReGAP	Southwest Regional Gap Analysis Project
TCP	traditionally cultural property
THPO	Tribal Historic Preservation Officer
TMDL	total maximum daily load
TNC	The Nature Conservancy
U.S.	United States
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WSA	Wilderness Study Area

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Appendix A. Maps

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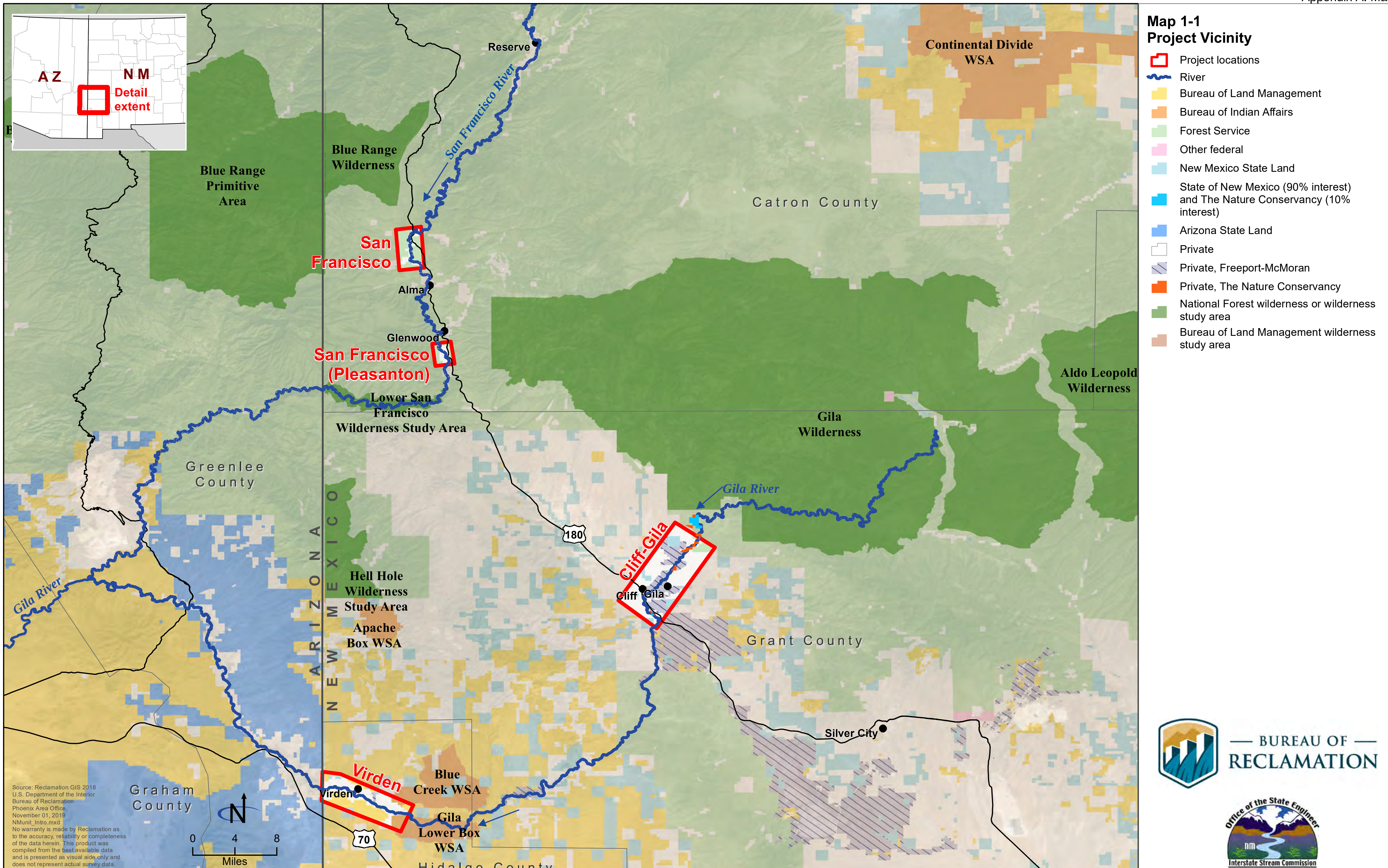
Map 1-1
Project Vicinity
Project locations
River
Bureau of Land Management
Bureau of Indian Affairs
Forest Service
Other federal
New Mexico State Land
State of New Mexico (90% interest) and The Nature Conservancy (10% interest)
Arizona State Land
Private
Private, Freeport-McMoran
Private, The Nature Conservancy
National Forest wilderness or wilderness study area
Bureau of Land Management wilderness study area
AZ
NM
Detail extent
Reserve
Continental Divide WSA
San Francisco River
Blue Range Wilderness
Blue Range Primitive Area
Catron County
San Francisco
Alma
Glenwood
San Francisco (Pleasanton)
Lower San Francisco Wilderness Study Area
Aldo Leopold Wilderness
Gila Wilderness
Greenlee County
Gila River
180
Cliff-Gila
Cliff
Gila
Hell Hole Wilderness Study Area
Apache Box WSA
ARIZONA
NEW MEXICO
Grant County
Silver City
Gila River
Virden
Virden
Blue Creek WSA
Gila Lower Box WSA
70
Graham County
Hidalgo County
N
0 4 8
Miles
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
NMunit_Intro.mxd
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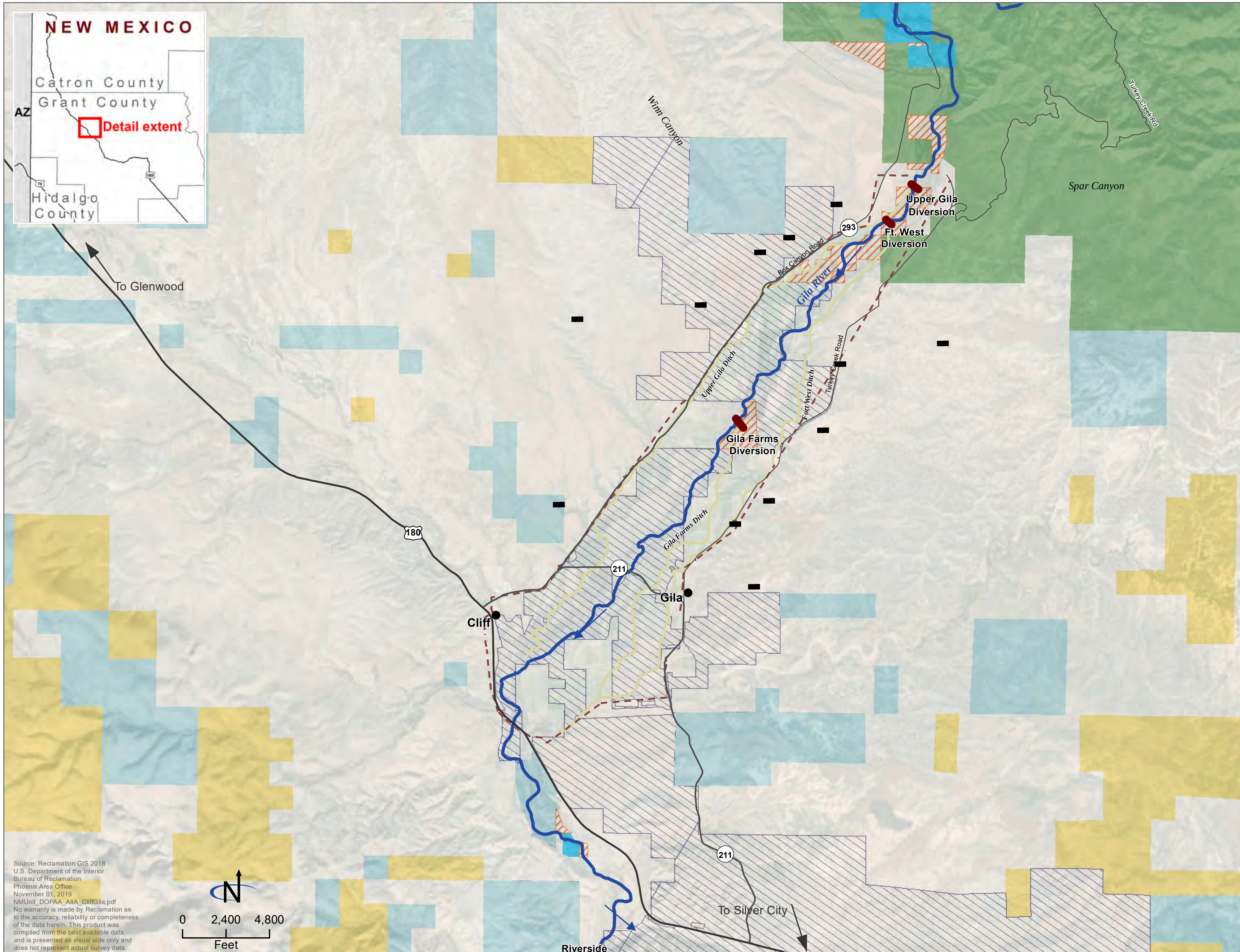

Map 2-1

Alternative A: Cliff-Gila

Existing Features

- Push-up diversion*
- River or creek
- Irrigation ditch
- Electrical power line
- Jurisdictional flood-sediment control dam

Surface Ownership

- Bureau of Land Management
- Forest Service
- State
- State of New Mexico (90% interest) and The Nature Conservancy (10% interest)
- Private
- Private, Freeport-McMoran
- Private,The Nature Conservancy

*Push-up diversion locations are approximate and vary from year-to-year depending on riverbed conditions. Only selected push-up diversions and ditches are shown.

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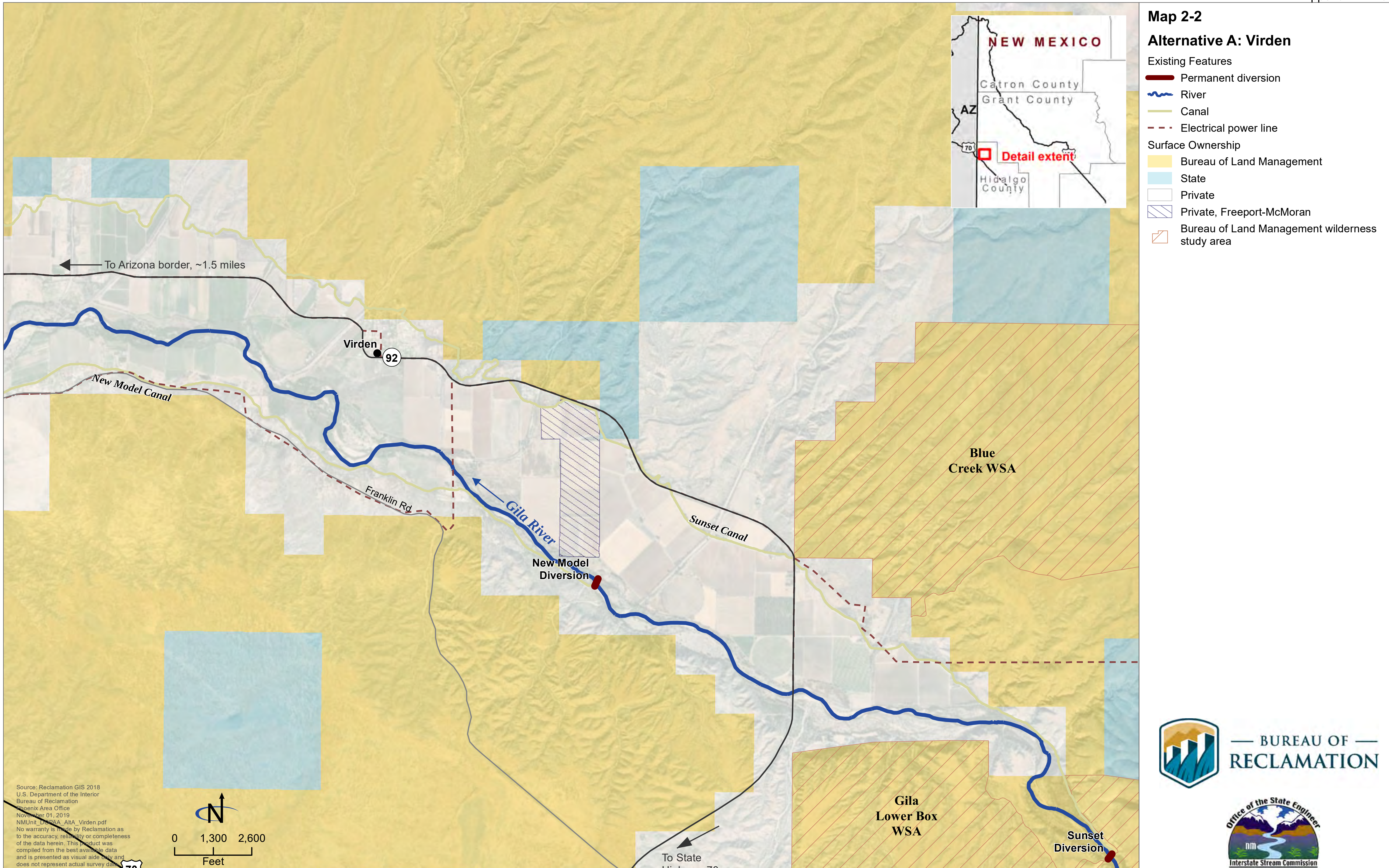
Map 2-2
Alternative A: Virden
Existing Features
Permanent diversion
River
Canal
Electrical power line
Surface Ownership
Bureau of Land Management
State
Private
Private, Freeport-McMoran
Bureau of Land Management wilderness study area
NEW MEXICO
Catron County
Grant County
AZ
70
Detail extent
Hidalgo County
To Arizona border, ~1.5 miles
Virden
92
New Model Canal
Franklin Rd
Gila River
New Model Diversion
Sunset Canal
Blue Creek WSA
Gila Lower Box WSA
Sunset Diversion
To State Highway 70
70
0 1,300 2,600
Feet
N
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
NMUnit_DOPAA_AltA_Virden.pdf
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Map 2-3
Alternative A: San Francisco

Existing Features

- Push-up diversion*
- River or creek
- Irrigation ditch
- Electrical power line

*Push-up diversion locations are approximate and vary from year-to-year depending on riverbed conditions. Only selected push-up diversions are shown.

Surface Ownership

- Forest Service
- Private

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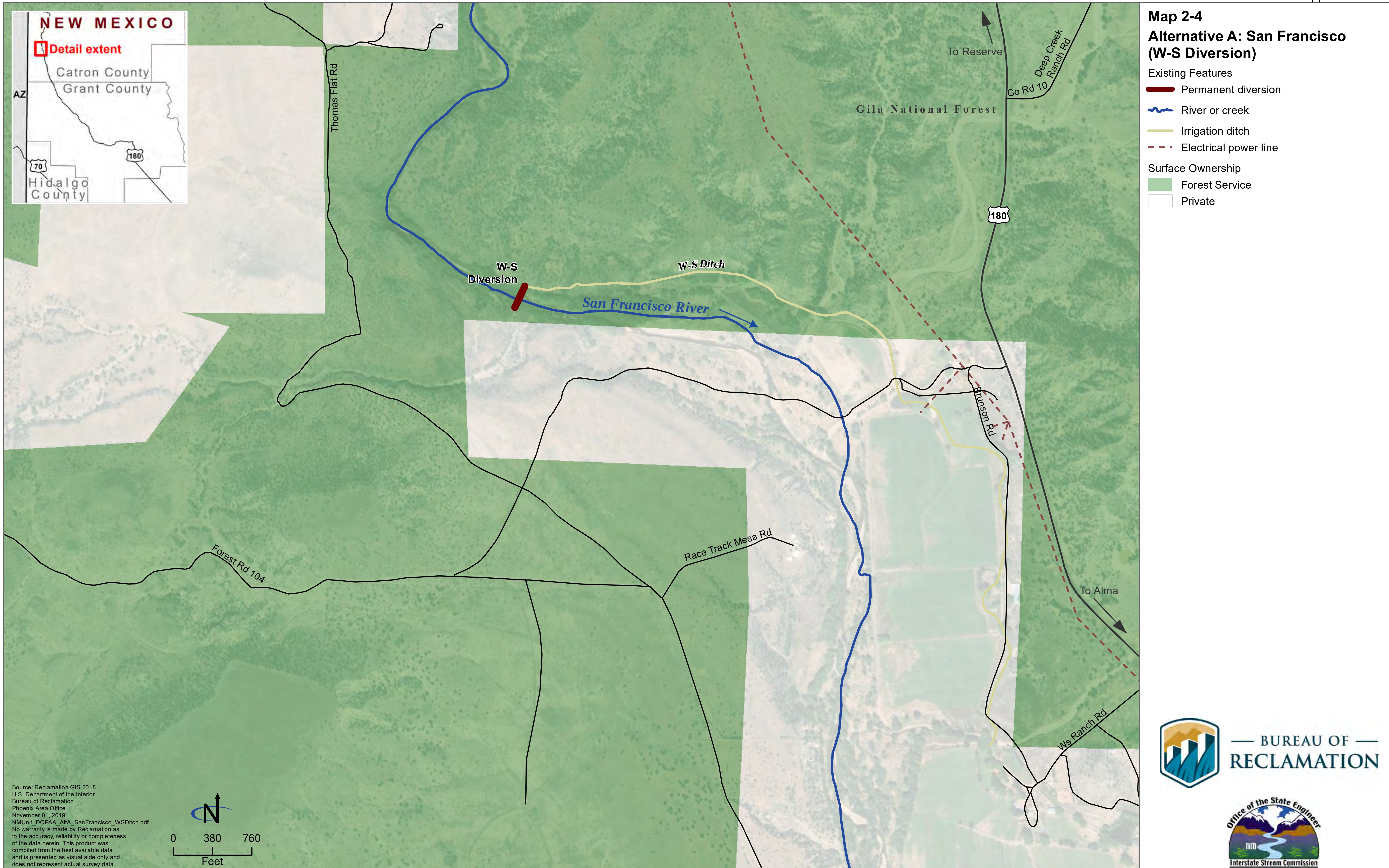
Map 2-4
Alternative A: San Francisco (W-S Diversion)
Existing Features
Permanent diversion
River or creek
Irrigation ditch
Electrical power line
Surface Ownership
Forest Service
Private
NEW MEXICO
Detail extent
Catron County
Grant County
AZ
70
180
Hidalgo County
W-S Diversion
W-S Ditch
San Francisco River
Gila National Forest
To Reserve
To Alma
Co Rd 10
Deep Creek Ranch Rd
180
Thomas Flat Rd
Brunson Rd
Race Track Mesa Rd
Forest Rd 104
Ws Ranch Rd
N
0 380 760
Feet
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
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NMUnit_DOPAA_AltA_SanFrancisco_WSDitch.pdf
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Map 2-5
Alternative A: San Francisco (Pleasanton)
Existing Features
River or creek
Irrigation ditch
Permanent diversion
Surface Ownership
Forest Service
Private
NEW MEXICO
Catron County
Detail extent
Grant County
AZ
70
180
Hidalgo County
San Francisco River
Pleasanton East-Side Diversion
East Pleasanton Lateral
To Alma
180
Pleasanton East-Side Ditch
Pleasanton West-Side Ditch
To Pleasanton
Pleasanton
N
0
550
1,100
Feet
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
NMUnit_DOPAA_AltA_SanFrancisco_Pleasanton.pdf
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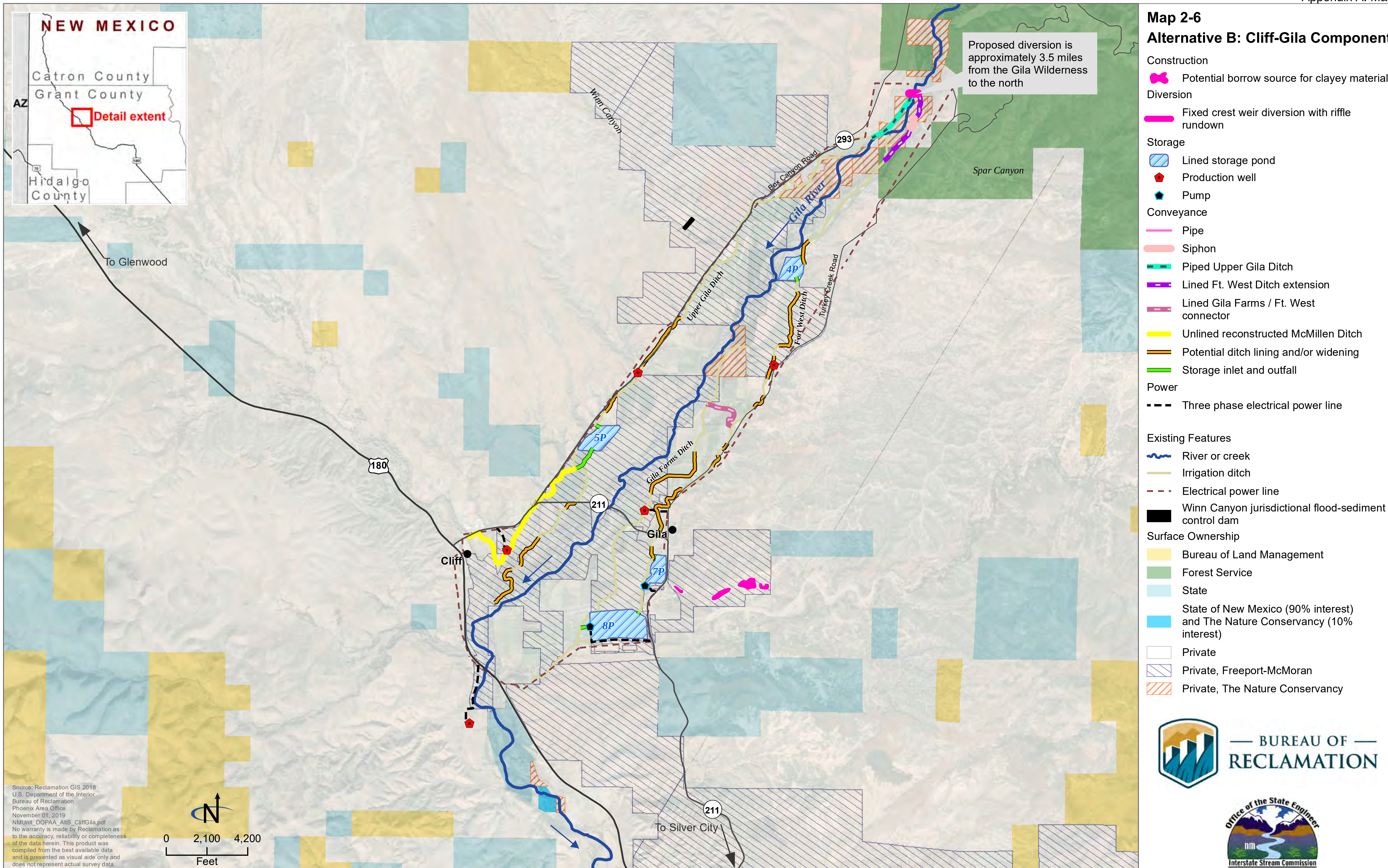

Map 2-6
Alternative B: Cliff-Gila Components
Construction
Potential borrow source for clayey material
Diversion
Fixed crest weir diversion with riffle rundown
Storage
Lined storage pond
Production well
Pump
Conveyance
Pipe
Siphon
Piped Upper Gila Ditch
Lined Ft. West Ditch extension
Lined Gila Farms / Ft. West connector
Unlined reconstructed McMillen Ditch
Potential ditch lining and/or widening
Storage inlet and outfall
Power
Three phase electrical power line
Existing Features
River or creek
Irrigation ditch
Electrical power line
Winn Canyon jurisdictional flood-sediment control dam
Surface Ownership
Bureau of Land Management
Forest Service
State
State of New Mexico (90% interest) and The Nature Conservancy (10% interest)
Private
Private, Freeport-McMoran
Private, The Nature Conservancy
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NEW MEXICO
Catron County
Grant County
Hidalgo County
AZ
Detail extent
Proposed diversion is approximately 3.5 miles from the Gila Wilderness to the north
Spar Canyon
Winn Canyon
Box Canyon Road
Gila River
Upper Gila Ditch
Fort West Ditch
Turkey Creek Road
Gila Farms Ditch
293
180
211
To Glenwood
Cliff
Gila
To Silver City
4P
5P
7P
8P
0
2,100
4,200
Feet
N
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
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NMUnit_DOPAA_AltB_CliffGila.pdf
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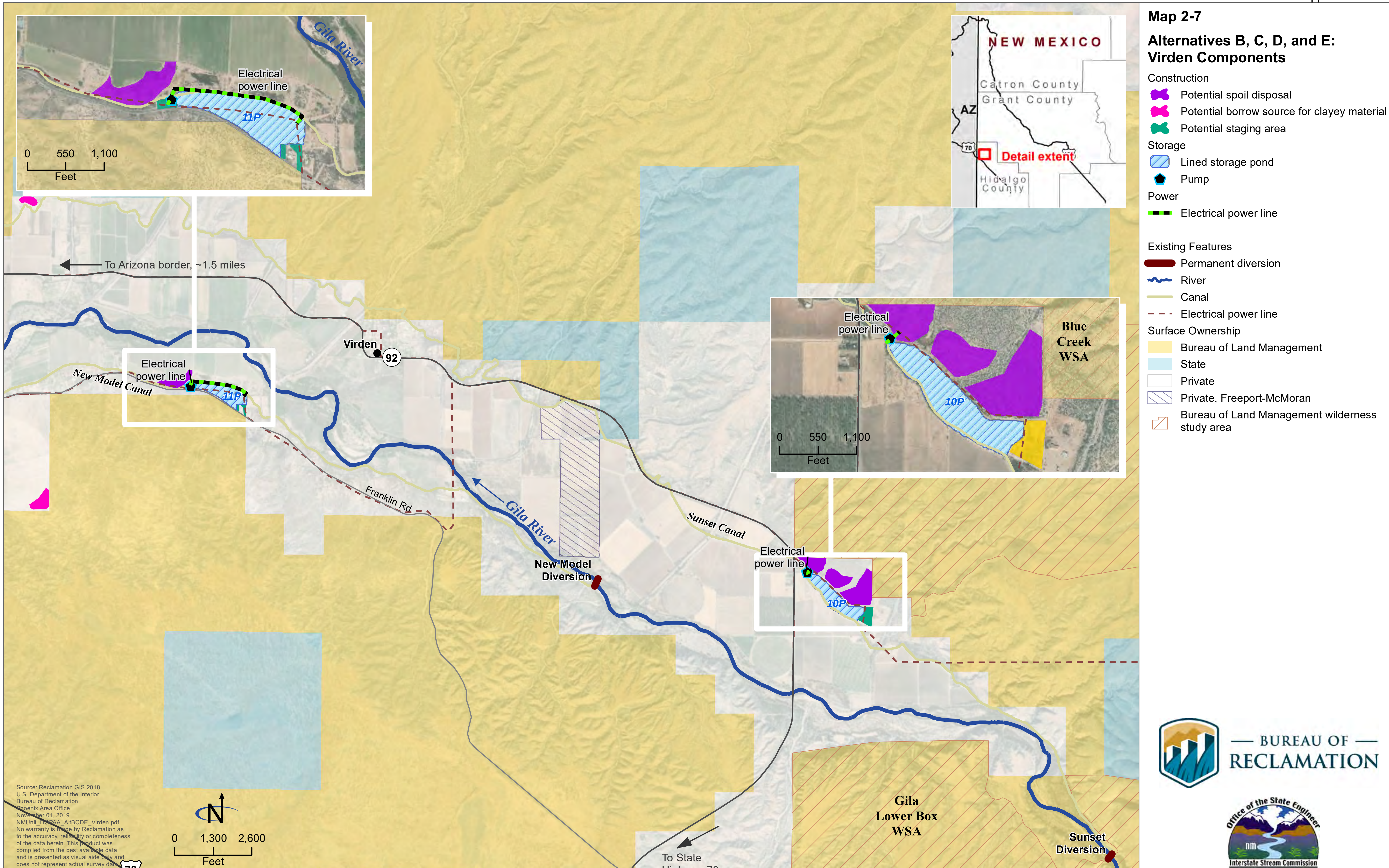
Map 2-7
Alternatives B, C, D, and E: Virden Components
Construction
Potential spoil disposal
Potential borrow source for clayey material
Potential staging area
Storage
Lined storage pond
Pump
Power
Electrical power line
Existing Features
Permanent diversion
River
Canal
Electrical power line
Surface Ownership
Bureau of Land Management
State
Private
Private, Freeport-McMoran
Bureau of Land Management wilderness study area
NEW MEXICO
Catron County
Grant County
AZ
70
Detail extent
Hidalgo County
Gila River
Electrical power line
11P
0 550 1,100
Feet
To Arizona border, ~1.5 miles
Virden
92
New Model Canal
Franklin Rd
Gila River
New Model Diversion
Sunset Canal
Electrical power line
10P
Blue Creek WSA
Gila Lower Box WSA
Sunset Diversion
To State Highway 70
N
0 1,300 2,600
Feet
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
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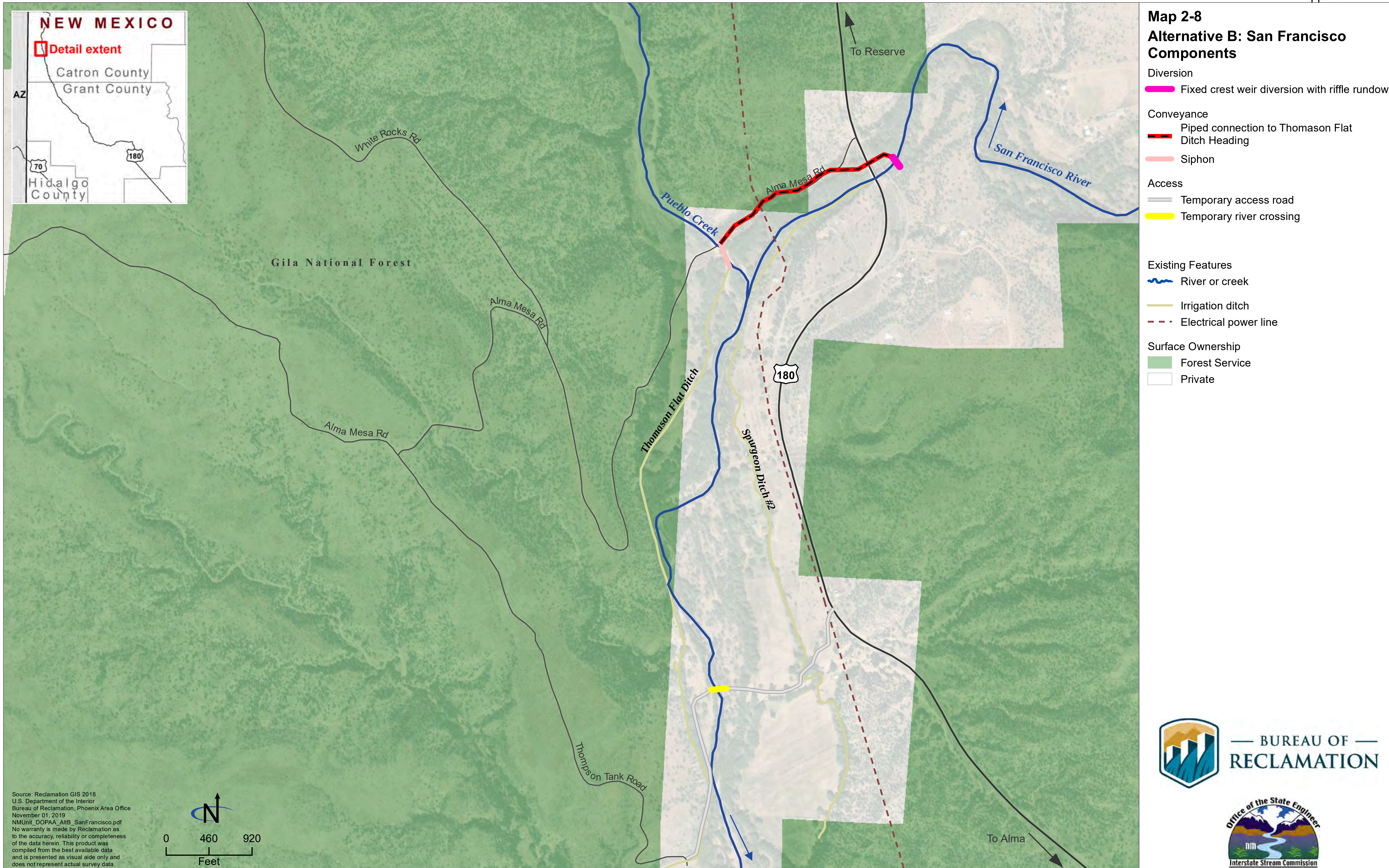
Map 2-8
Alternative B: San Francisco Components
Diversion
Fixed crest weir diversion with riffle rundown
Conveyance
Piped connection to Thomason Flat Ditch Heading
Siphon
Access
Temporary access road
Temporary river crossing
Existing Features
River or creek
Irrigation ditch
Electrical power line
Surface Ownership
Forest Service
Private
NEW MEXICO
Detail extent
Catron County
Grant County
AZ
Hidalgo County
70
180
Gila National Forest
White Rocks Rd
Alma Mesa Rd
Alma Mesa Rd
Alma Mesa Rd
Thompson Tank Road
Pueblo Creek
Thomason Flat Ditch
Spurgeon Ditch #2
San Francisco River
To Reserve
To Alma
180
N
0
460
920
Feet
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation, Phoenix Area Office
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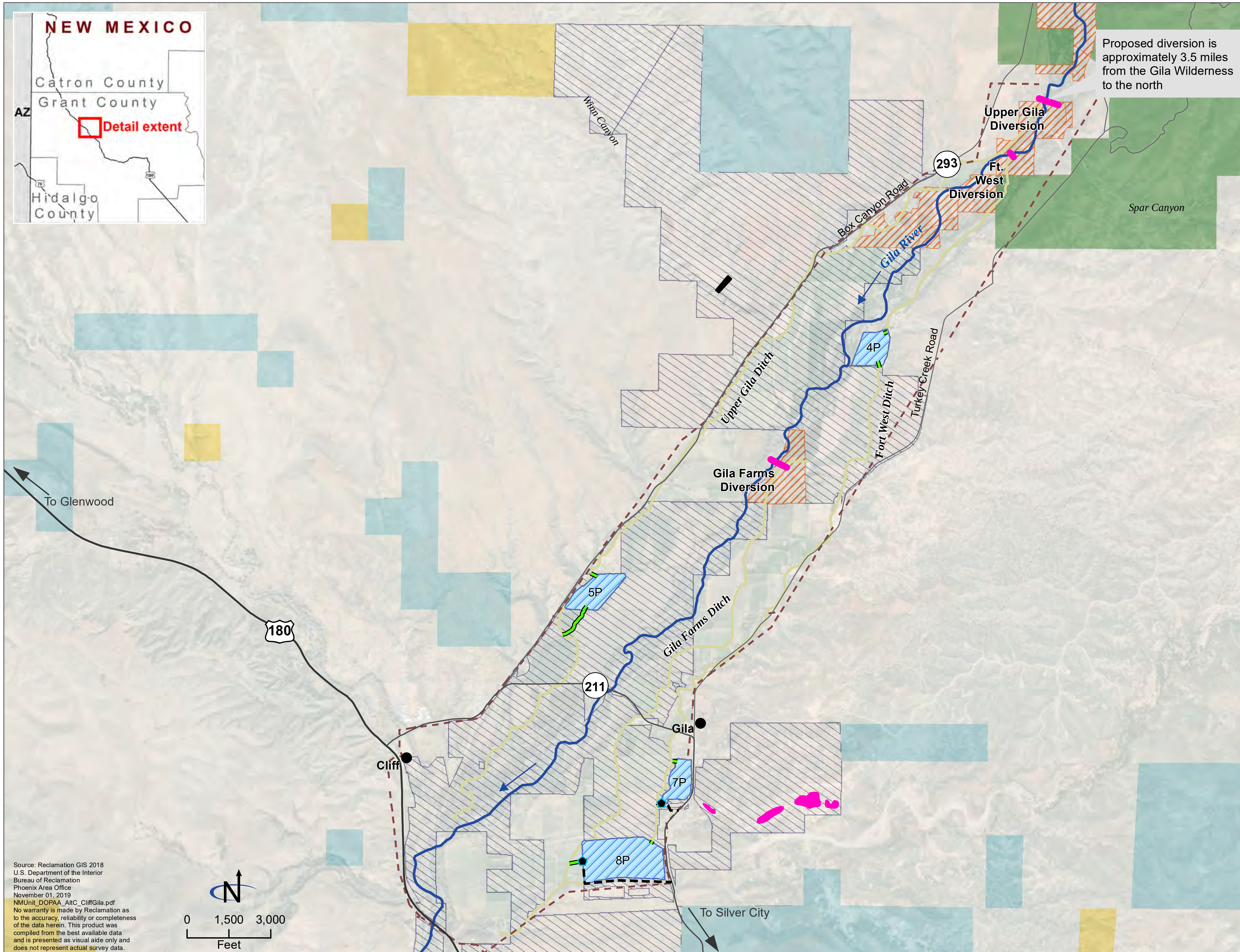
Map 2-9
Alternative C: Cliff-Gila Components



Construction
- Potential borrow source for clayey material

Diversion
- Rock vane weir diversion

Storage
- Lined storage pond
- Pump

Conveyance
- Storage inlets and outfalls

Power
- Three phase electrical power line

Existing Features
- River
- Irrigation ditch
- Electrical power line
- Winn Canyon jurisdictional flood-sediment control dam

Surface Ownership
- Bureau of Land Management
- Forest Service
- State
- Private
- Private, Freeport-McMoran
- Private, The Nature Conservancy

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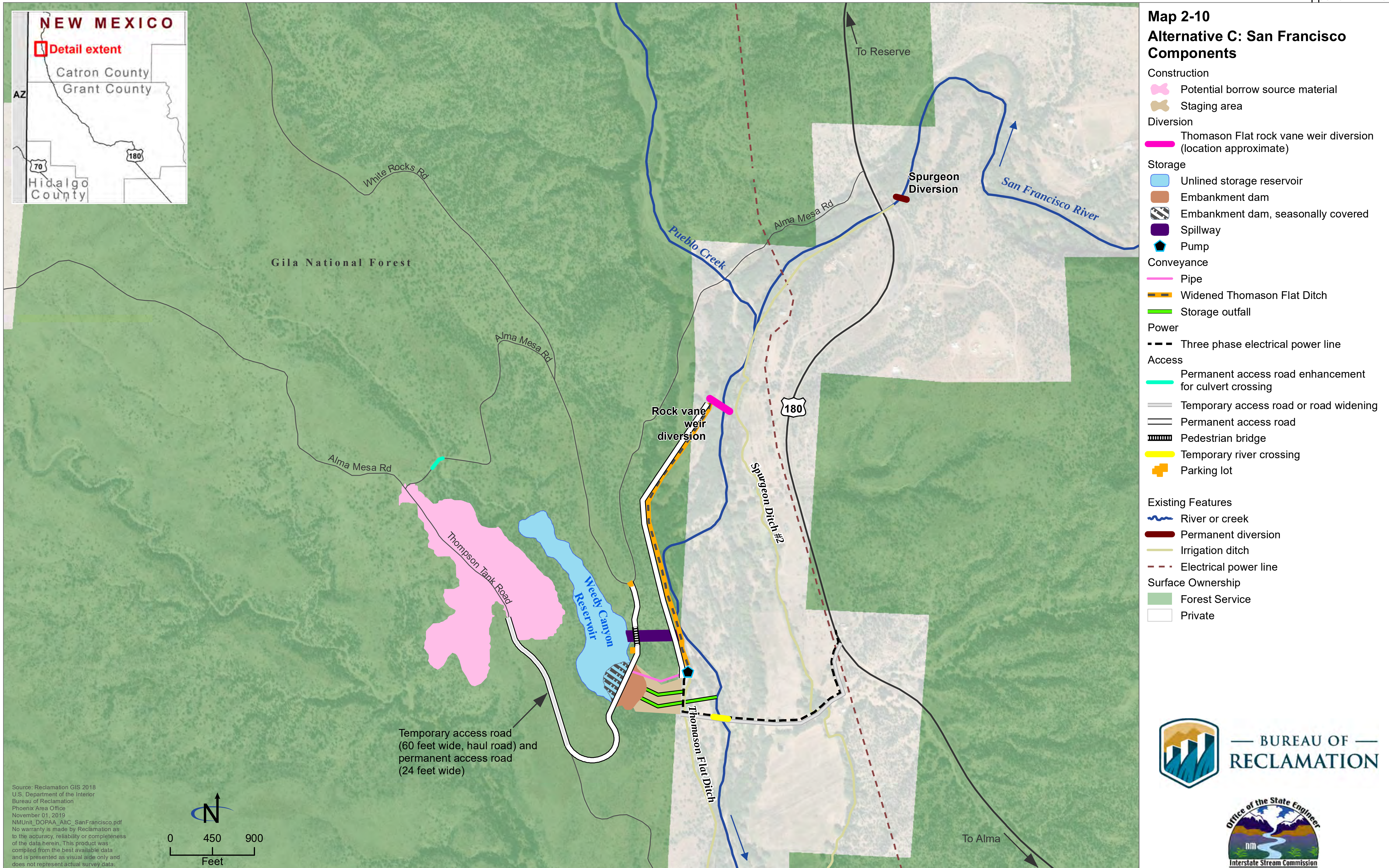
Map 2-10
Alternative C: San Francisco Components
Construction
Potential borrow source material
Staging area
Diversion
Thomason Flat rock vane weir diversion (location approximate)
Storage
Unlined storage reservoir
Embankment dam
Embankment dam, seasonally covered
Spillway
Pump
Conveyance
Pipe
Widened Thomason Flat Ditch
Storage outfall
Power
Three phase electrical power line
Access
Permanent access road enhancement for culvert crossing
Temporary access road or road widening
Permanent access road
Pedestrian bridge
Temporary river crossing
Parking lot
Existing Features
River or creek
Permanent diversion
Irrigation ditch
Electrical power line
Surface Ownership
Forest Service
Private
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Interstate Stream Commission
NEW MEXICO
Detail extent
Catron County
Grant County
AZ
70
180
Hidalgo County
Gila National Forest
White Rocks Rd
Alma Mesa Rd
Alma Mesa Rd
Alma Mesa Rd
Thompson Tank Road
Weedy Canyon Reservoir
Pueblo Creek
San Francisco River
To Reserve
Spurgeon Diversion
Rock vane weir diversion
Spurgeon Ditch #2
Thomason Flat Ditch
180
To Alma
Temporary access road (60 feet wide, haul road) and permanent access road (24 feet wide)
N
0
450
900
Feet
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
NMUnit_DOPAA_AltC_SanFrancisco.pdf
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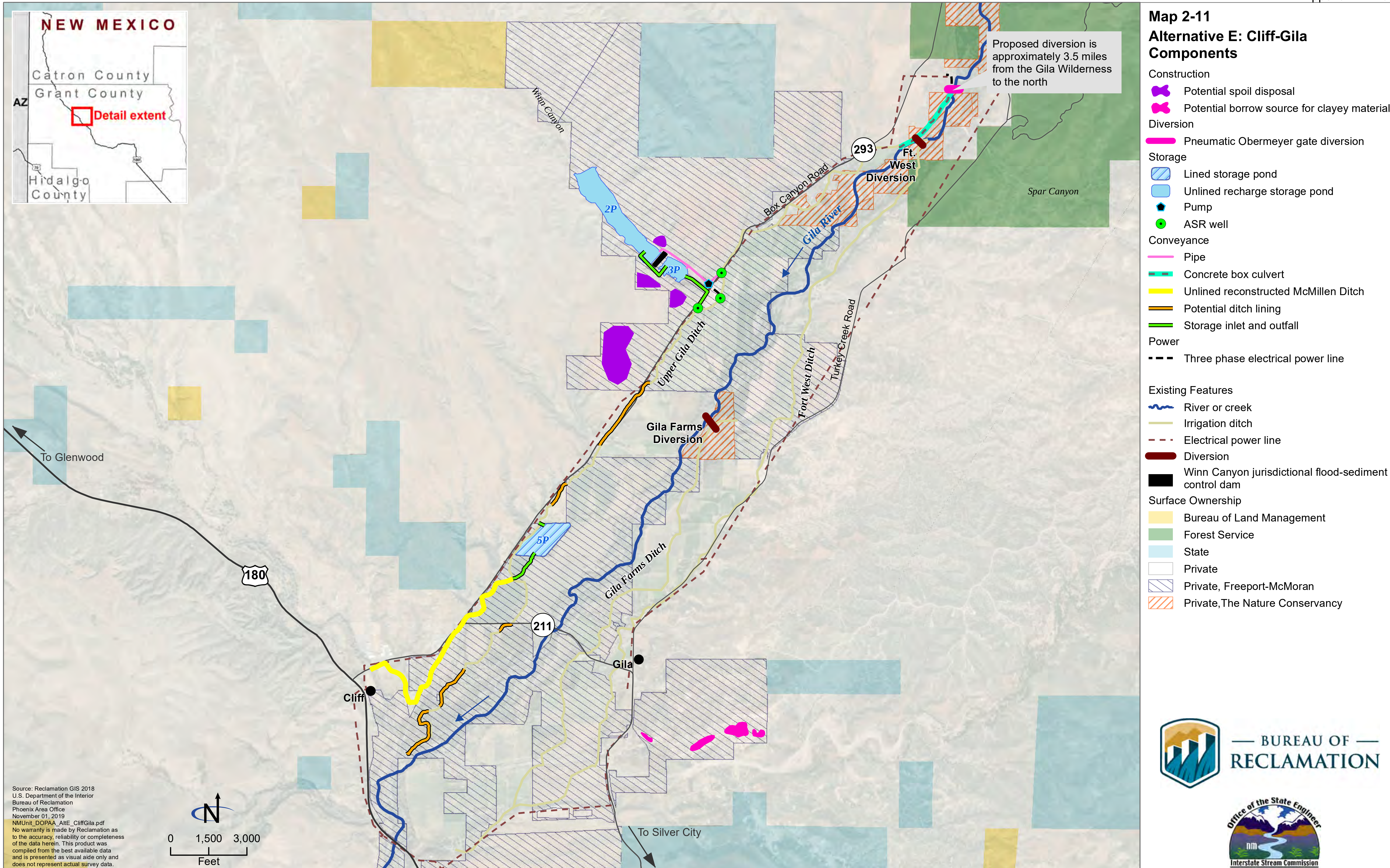
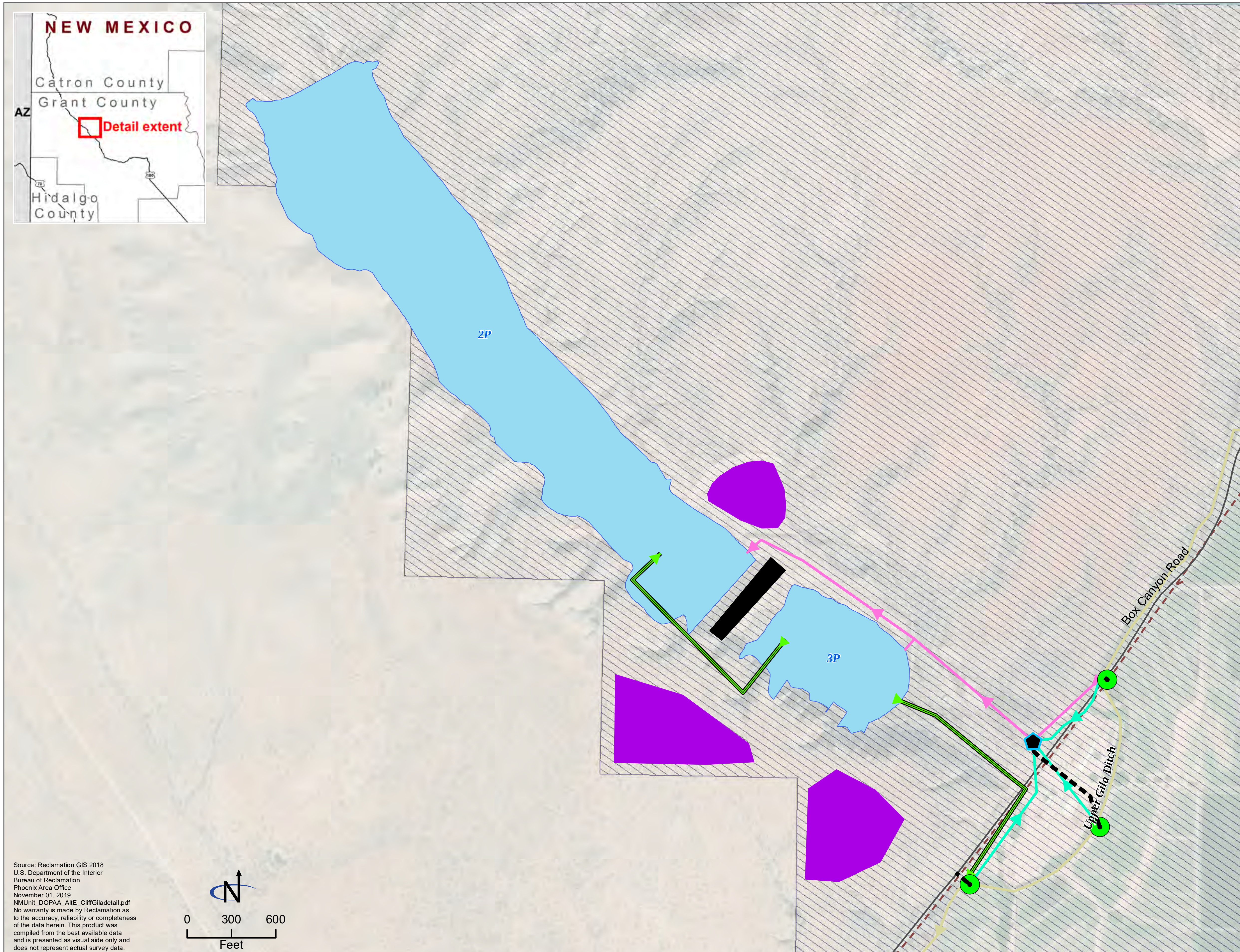


Map 2-11
Alternative E: Cliff-Gila Components



Map 2-12
Alternative E: Cliff-Gila Components (ASR Detail)

Construction
- Potential spoil disposal

Storage
- Unlined recharge storage pond
- Aquifer storage and recovery (ASR) well
- Pump

Conveyance
- Pipe
- Pipe for ASR well connection
- Storage outlet

Existing Features
- Irrigation ditch
- Electrical power line
- Winn Canyon jurisdictional flood-sediment control dam

Surface Ownership
- State
- Private
- Private, Freeport-McMoran

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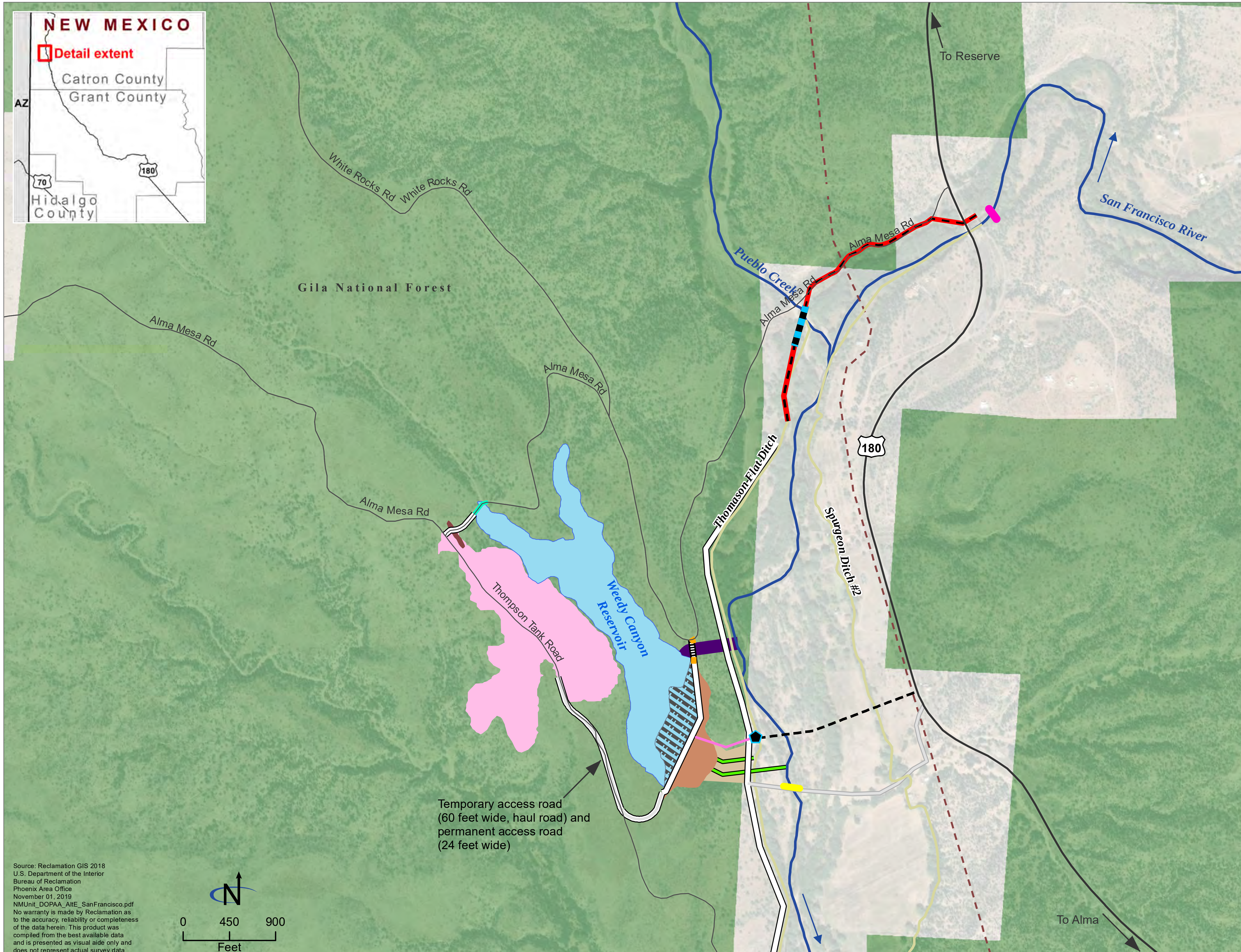

Map 2-13
Alternative E: San Francisco Components

Construction
- Potential borrow source material
- Staging area

Diversion
- Fixed crest weir diversion with riffle rundown

Storage
- Unlined storage reservoir
- Embankment dam
- Embankment dam, seasonally covered
- Spillway
- Saddle Dam
- Pump

Conveyance
- Pipe
- Elevated pipe
- Piped Thomason Flat Ditch extension
- Storage outfall

Power
- Three phase electrical power line

Access
- Permanent access road enhancement for culvert crossing
- Temporary access road or road widening
- Permanent access road
- Pedestrian bridge
- Temporary river crossing
- Parking lot

Existing Features
- River or creek
- Irrigation ditch
- Electrical power line

Surface Ownership
- Forest Service
- Private

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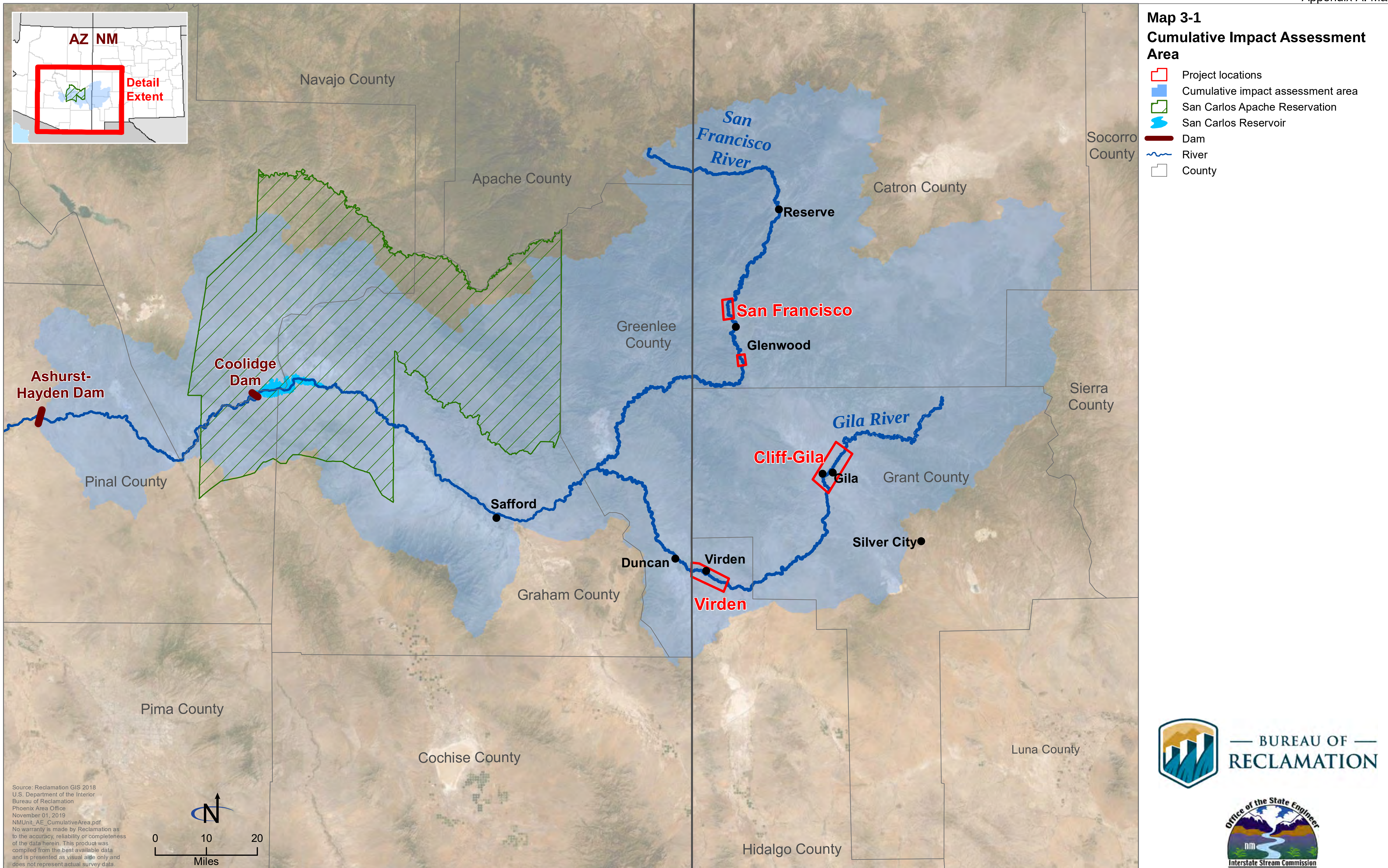
Map 2-14
Alternative E: San Francisco Components (Pleasanton)


Map 3-1
Cumulative Impact Assessment Area
Project locations
Cumulative impact assessment area
San Carlos Apache Reservation
San Carlos Reservoir
Dam
River
County
AZ
NM
Detail Extent
Navajo County
Apache County
Catron County
Socorro County
Greenlee County
Sierra County
Grant County
Pinal County
Graham County
Pima County
Cochise County
Hidalgo County
Luna County
San Francisco River
Gila River
Reserve
San Francisco
Glenwood
Coolidge Dam
Ashurst-Hayden Dam
Cliff-Gila
Gila
Safford
Silver City
Duncan
Virden
Virden
0
10
20
Miles
N
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
NMUnit_AE_CumulativeArea,pdf
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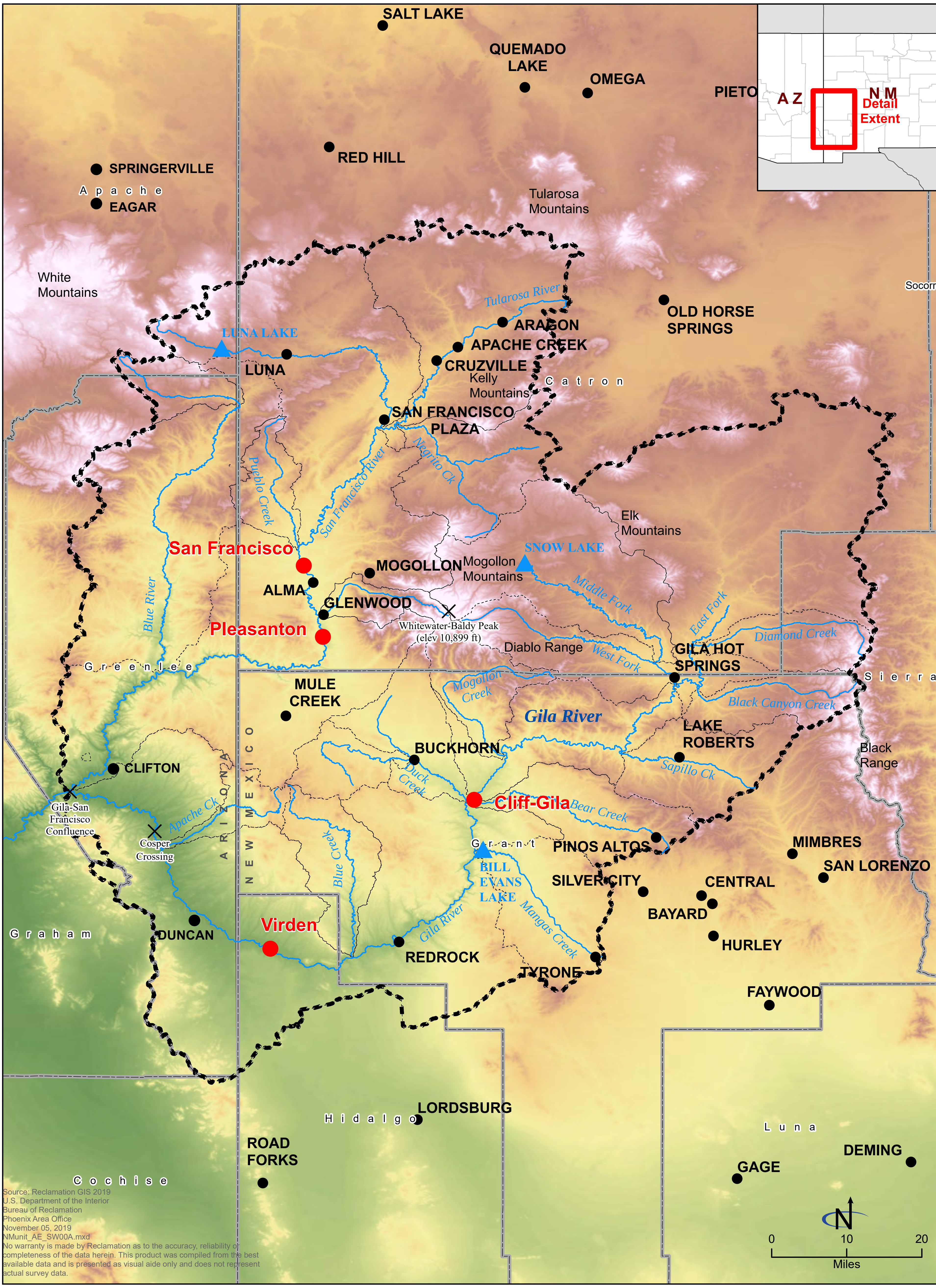


Map 3-2
Major Surface Water Features above the Gila-San Francisco River Confluence

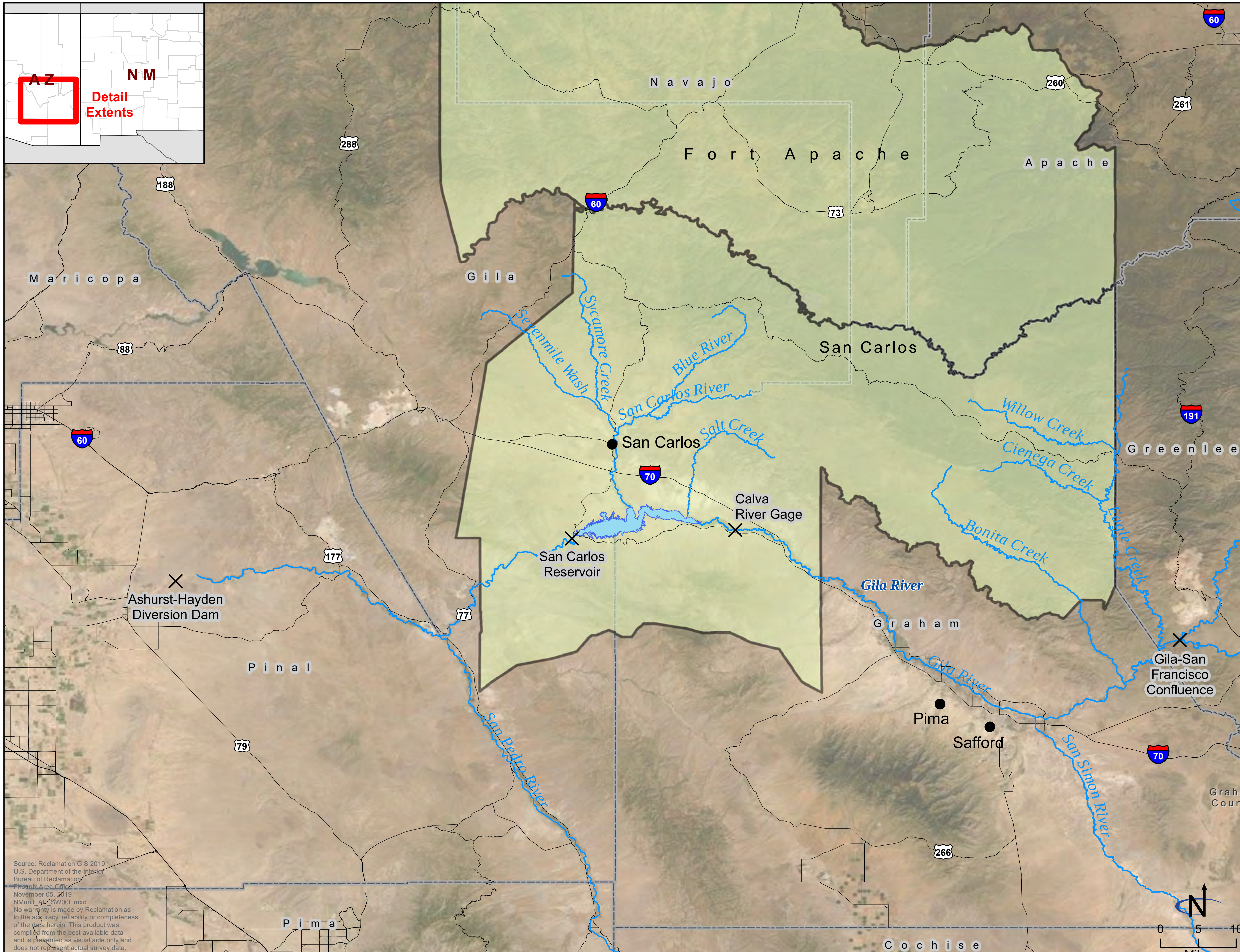
- Town/City
- Project Locations
- Point of Interest
- Reservoirs
- Counties
- Confluence Drainage Area
- Drainage Area
- Rivers/Streams

Elevation

Value

11,425 ft

1,730 ft



Map 3-3
Major Surface Water Features between the Gila-San Francisco Confluence and the Ashurst-Hayden Diversion Dam

Rivers/Streams
Point of Interest
Counties
Tribal Reservation
Town/City

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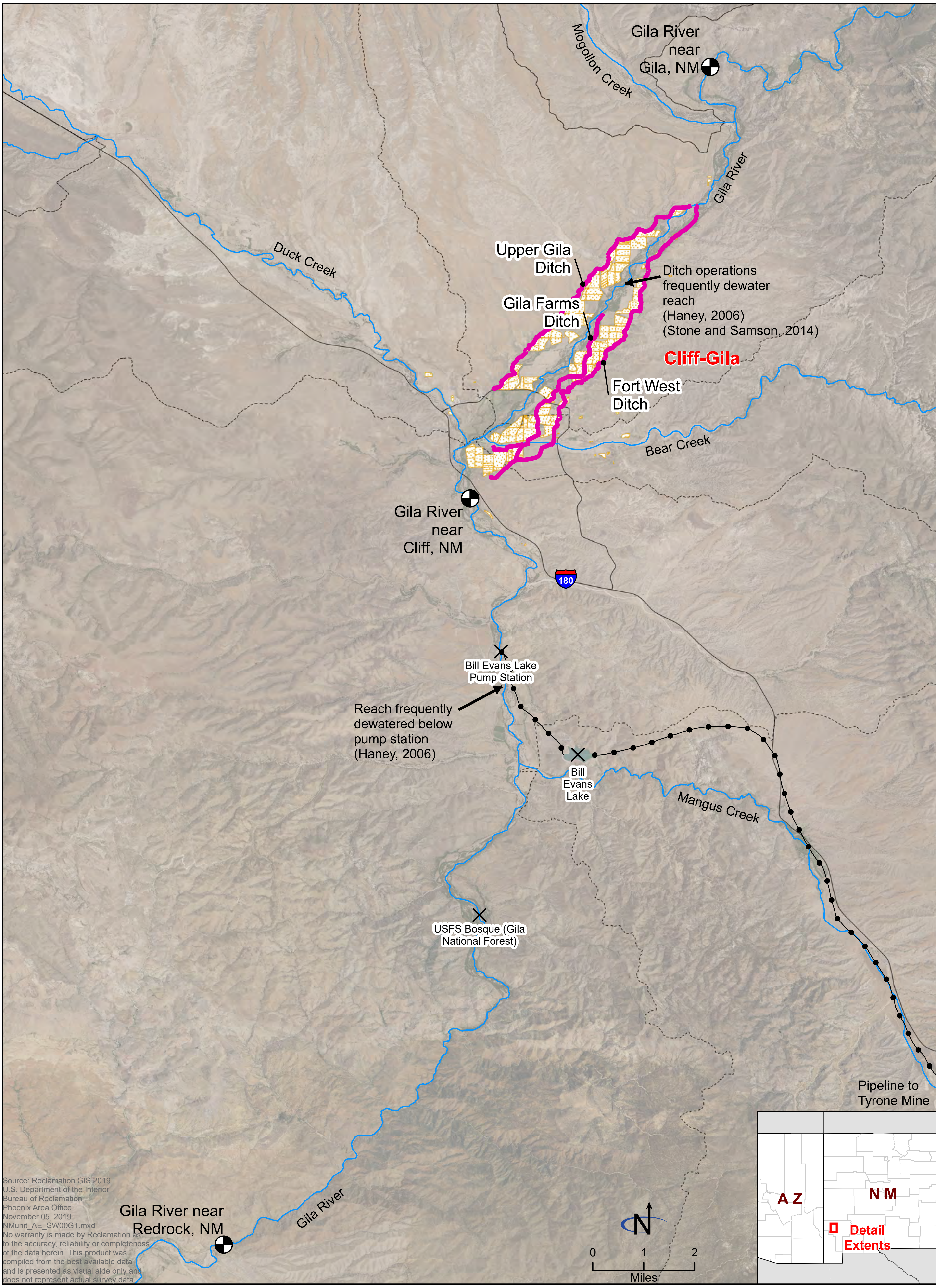

Map 3-4
Detail of Surface Water Features - Cliff-Gila Location

Symbol	Symbol	Symbol
Point of Interest	Rivers/Streams	Ditch
	Flow Gages	Irrigated Area
	Pipeline	Drainage Area

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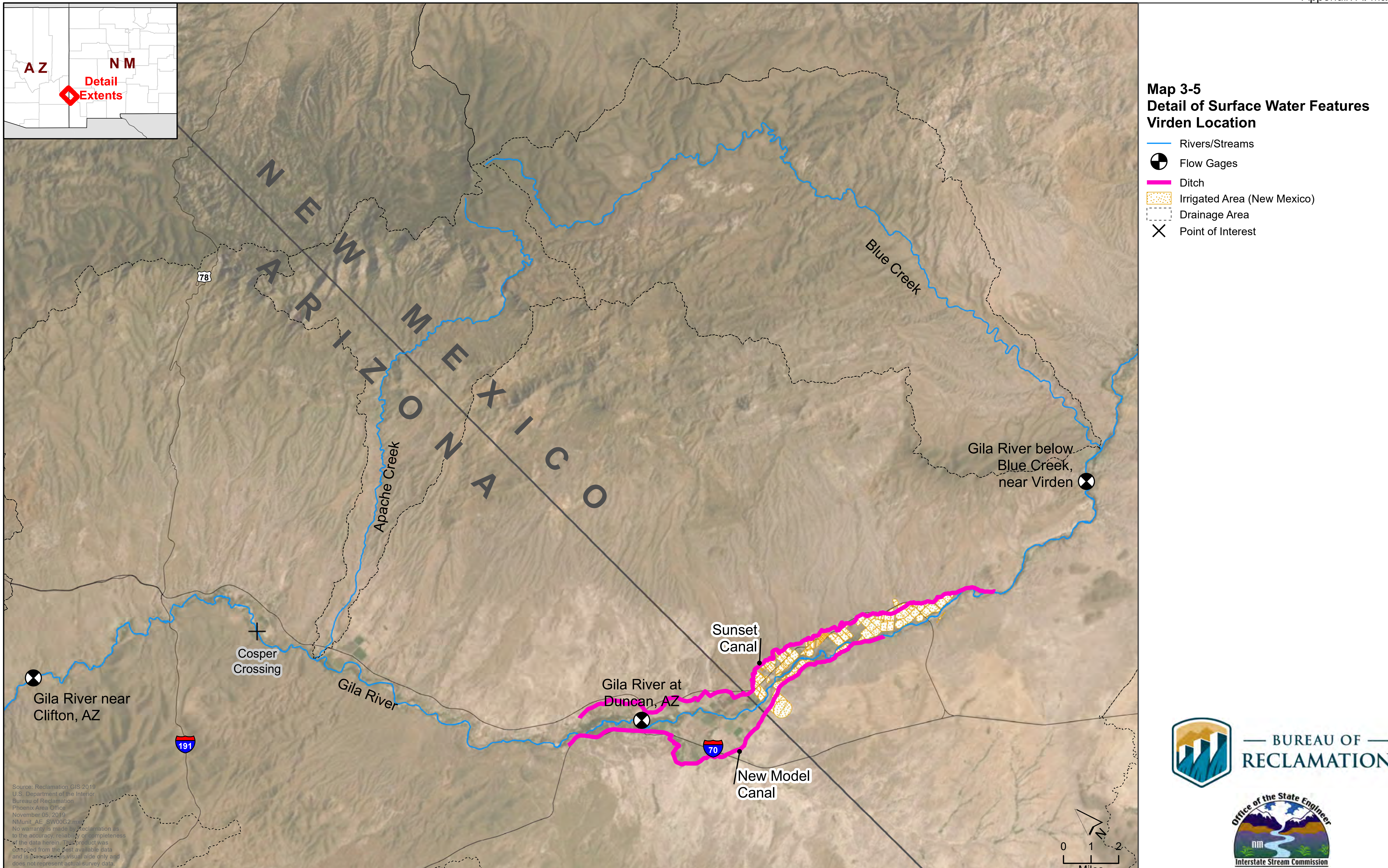
Map 3-5
Detail of Surface Water Features
Virden Location
Rivers/Streams
Flow Gages
Ditch
Irrigated Area (New Mexico)
Drainage Area
Point of Interest
A Z
N M
Detail Extents
NEW MEXICO
ARIZONA
Blue Creek
Apache Creek
Gila River
Gila River below Blue Creek, near Virden
Gila River near Clifton, AZ
Gila River at Duncan, AZ
Cosper Crossing
Sunset Canal
New Model Canal
78
191
70
0
1
2
Miles
N
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Interstate Stream Commission
Source: Reclamation GIS 2019
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 05, 2019
NMunit_AE_SW00G2.mxd
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Map 3-6
Detail of Surface Water Features - San Francisco Location

Rivers/Streams
Flow Gages
Ditch
Irrigated Area
Drainage Area

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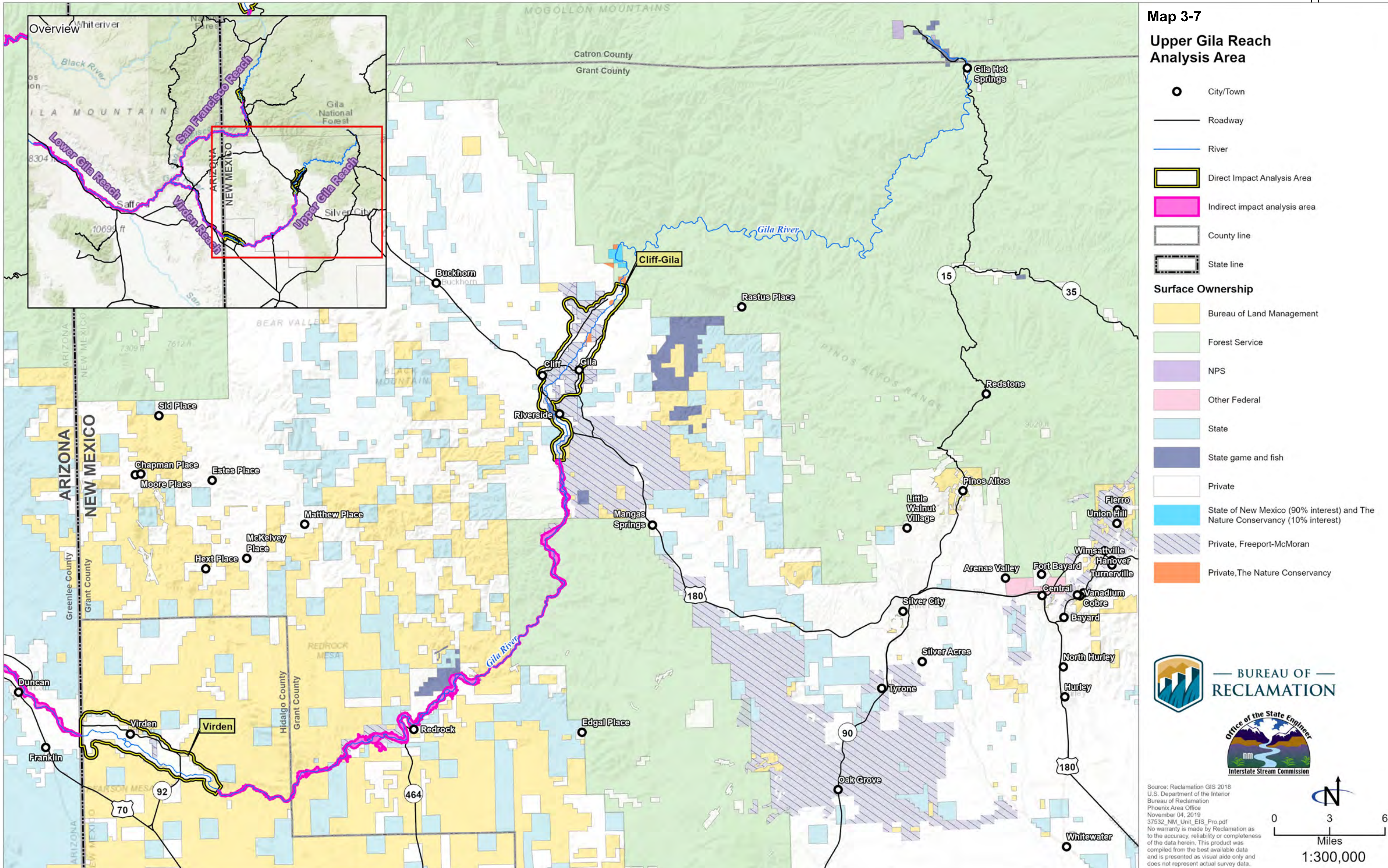
Map 3-7
Upper Gila Reach Analysis Area
City/Town
Roadway
River
Direct Impact Analysis Area
Indirect impact analysis area
County line
State line
Surface Ownership
Bureau of Land Management
Forest Service
NPS
Other Federal
State
State game and fish
Private
State of New Mexico (90% interest) and The Nature Conservancy (10% interest)
Private, Freeport-McMoran
Private,The Nature Conservancy
Overview
San Francisco Reach
Lower Gila Reach
Virden Reach
Upper Gila Reach
Gila National Forest
Silver City
ARIZONA
NEW MEXICO
MOGOLLON MOUNTAINS
Catron County
Grant County
Greenlee County
Hidalgo County
Gila Hot Springs
Gila River
Cliff-Gila
Buckhorn
Rastus Place
Cliff
Gila
Riverside
Redstone
Sid Place
Chapman Place
Moore Place
Estes Place
Matthew Place
McKelvey Place
Hext Place
Mangas Springs
Pinos Altos
Little Walnut Village
Fierro
Union Hill
Wimsattville
Hanover
Turnerville
Arenas Valley
Fort Bayard
Central
Vanadium
Cobre
Bayard
Silver City
Silver Acres
North Hurley
Hurley
Tyrone
Oak Grove
Whitewater
Edgal Place
Redrock
Duncan
Franklin
Virden
15
35
180
90
92
70
464
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 04, 2019
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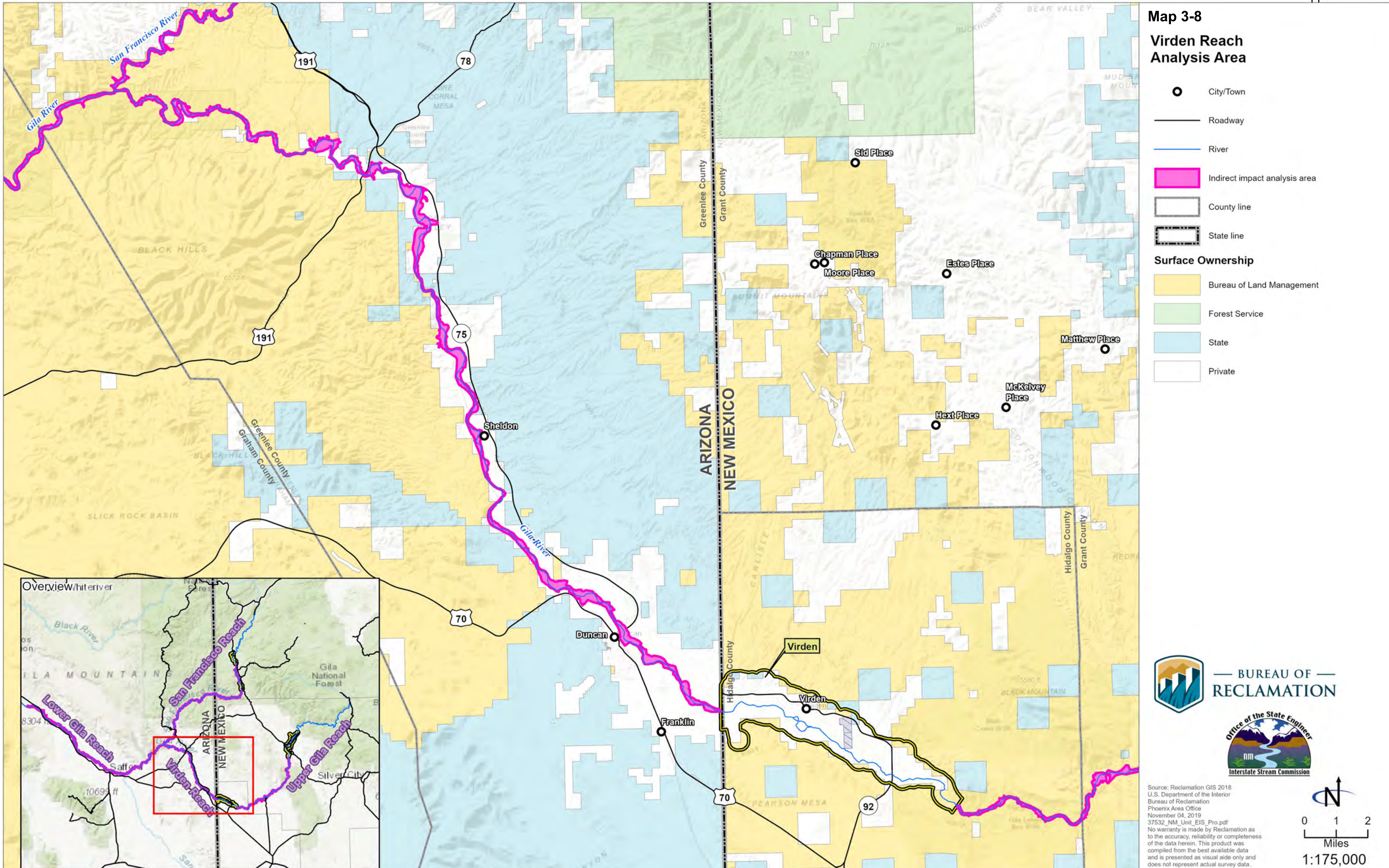
Map 3-8
Virden Reach Analysis Area
City/Town
Roadway
River
Indirect impact analysis area
County line
State line
Surface Ownership
Bureau of Land Management
Forest Service
State
Private
ARIZONA
NEW MEXICO
Greenlee County
Grant County
Graham County
Hidalgo County
Gila River
San Francisco River
Sid Place
Chapman Place
Moore Place
Estes Place
Matthew Place
McKelvey Place
Hext Place
Sheldon
Duncan
Franklin
Virden
191
78
75
70
92
BLACK HILLS
SLICK ROCK BASIN
PEARSON MESA
Overview
Black River
Gila National Forest
San Francisco Reach
Lower Gila Reach
Virden Reach
Upper Gila Reach
Silver City
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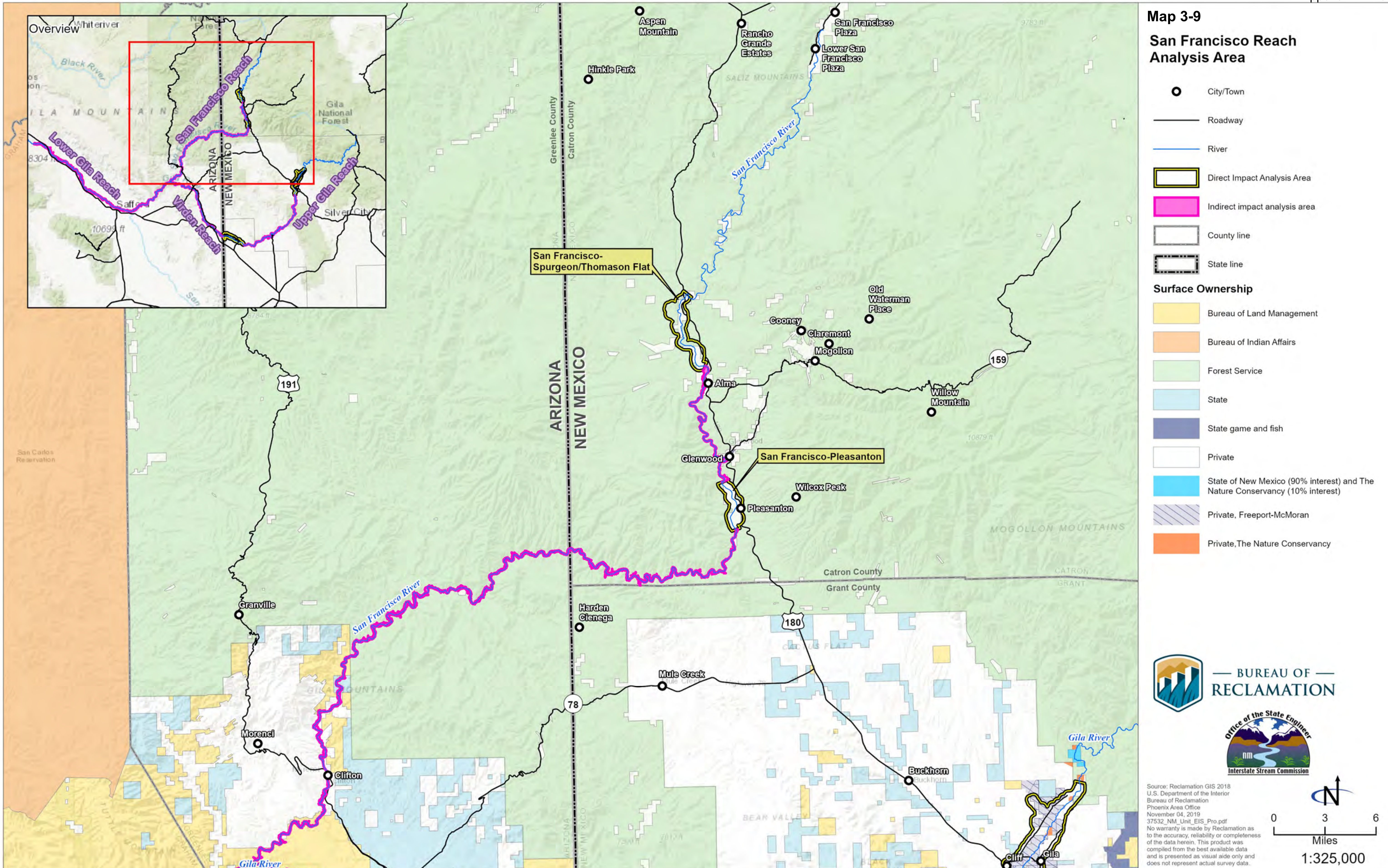
Map 3-9
San Francisco Reach Analysis Area
City/Town
Roadway
River
Direct Impact Analysis Area
Indirect impact analysis area
County line
State line
Surface Ownership
Bureau of Land Management
Bureau of Indian Affairs
Forest Service
State
State game and fish
Private
State of New Mexico (90% interest) and The Nature Conservancy (10% interest)
Private, Freeport-McMoran
Private,The Nature Conservancy
Overview
Lower Gila Reach
San Francisco Reach
Virden Reach
Upper Gila Reach
ARIZONA
NEW MEXICO
San Francisco-Spurgeon/Thomason Flat
San Francisco-Pleasanton
Aspen Mountain
Rancho Grande Estates
San Francisco Plaza
Lower San Francisco Plaza
Hinkle Park
San Francisco River
Old Waterman Place
Cooney
Claremont
Mogollon
Alma
Willow Mountain
Glenwood
Wilcox Peak
Pleasanton
MOGOLLON MOUNTAINS
Catron County
Grant County
Greenlee County
Catron County
Granville
Harden Cienega
Mule Creek
Morenci
Clifton
Buckhorn
Cliff
Gila
Gila River
San Carlos Reservation
191
159
180
78
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 04, 2019
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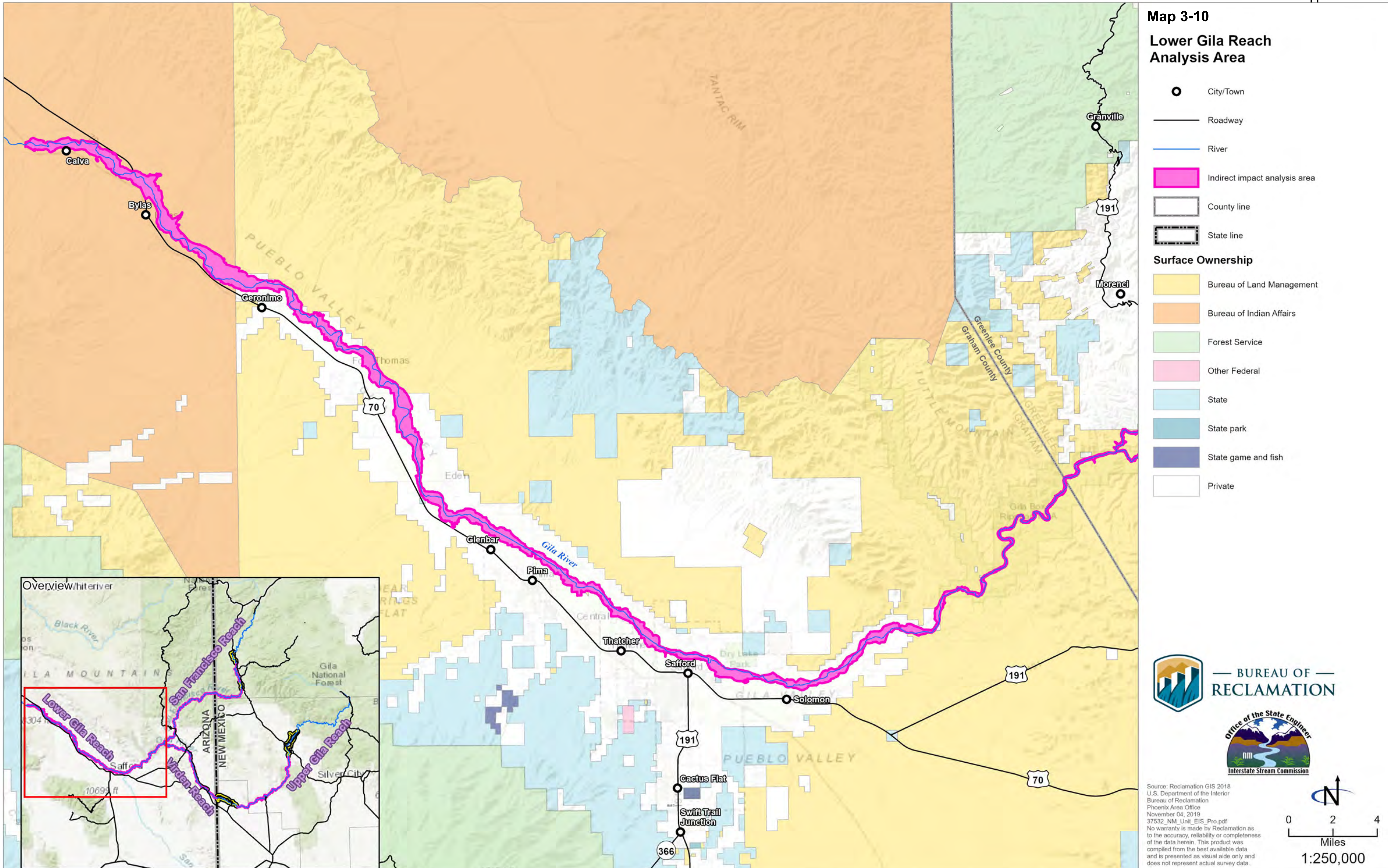
Map 3-10
Lower Gila Reach Analysis Area
City/Town
Roadway
River
Indirect impact analysis area
County line
State line
Surface Ownership
Bureau of Land Management
Bureau of Indian Affairs
Forest Service
Other Federal
State
State park
State game and fish
Private
Calva
Bylas
Geronimo
Fort Thomas
Eden
Glenbar
Pima
Central
Thatcher
Safford
Solomon
Cactus Flat
Swift Trail Junction
Granville
Morenci
Gila River
Pueblo Valley
Tantac Rim
Greenlee County
Graham County
70
191
366
Overview
Lower Gila Reach
San Francisco Reach
Virden Reach
Upper Gila Reach
ARIZONA
NEW MEXICO
Gila National Forest
BUREAU OF RECLAMATION
Interstate Stream Commission
Source: Reclamation GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 04, 2019
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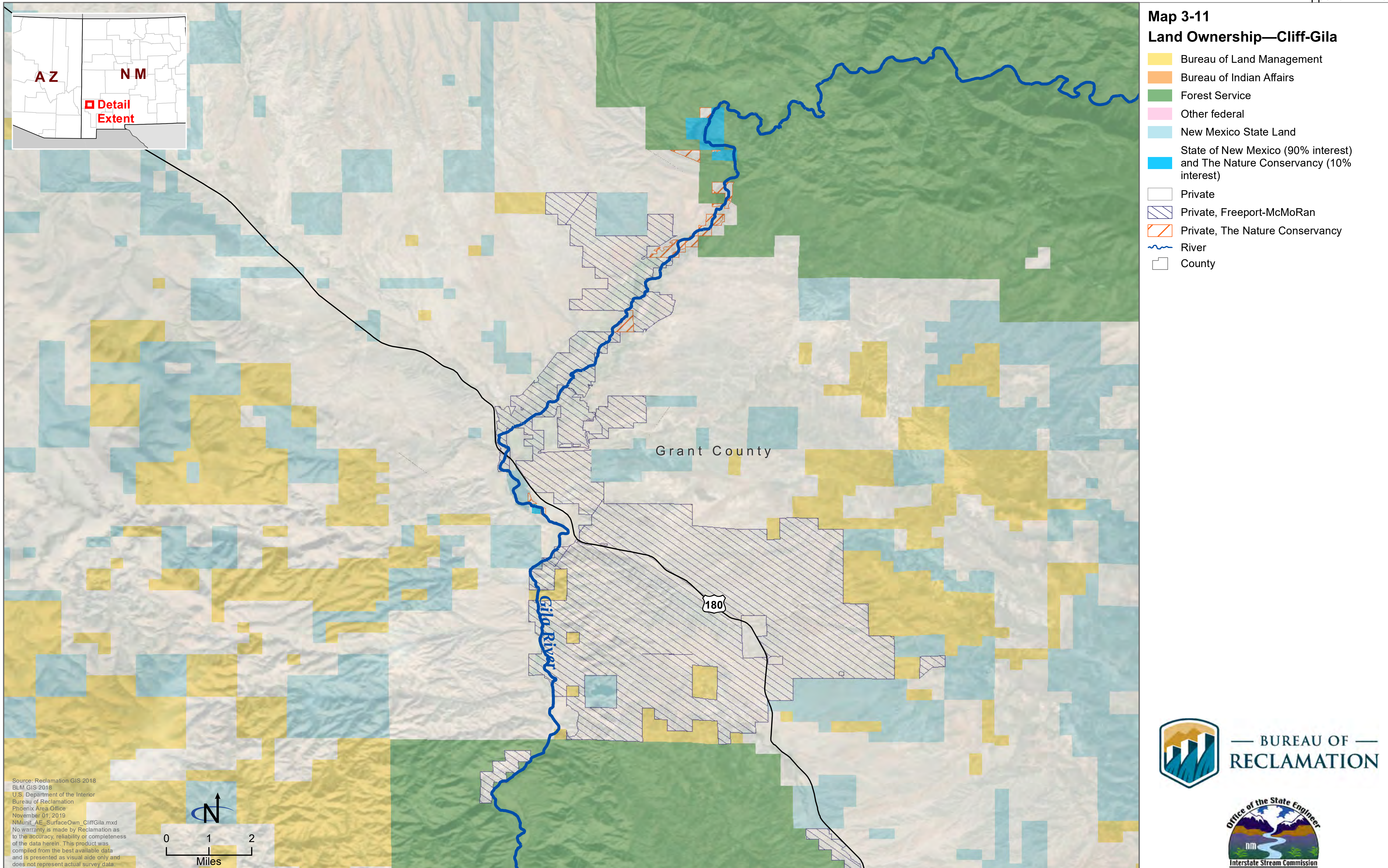
Map 3-11

Land Ownership—Cliff-Gila



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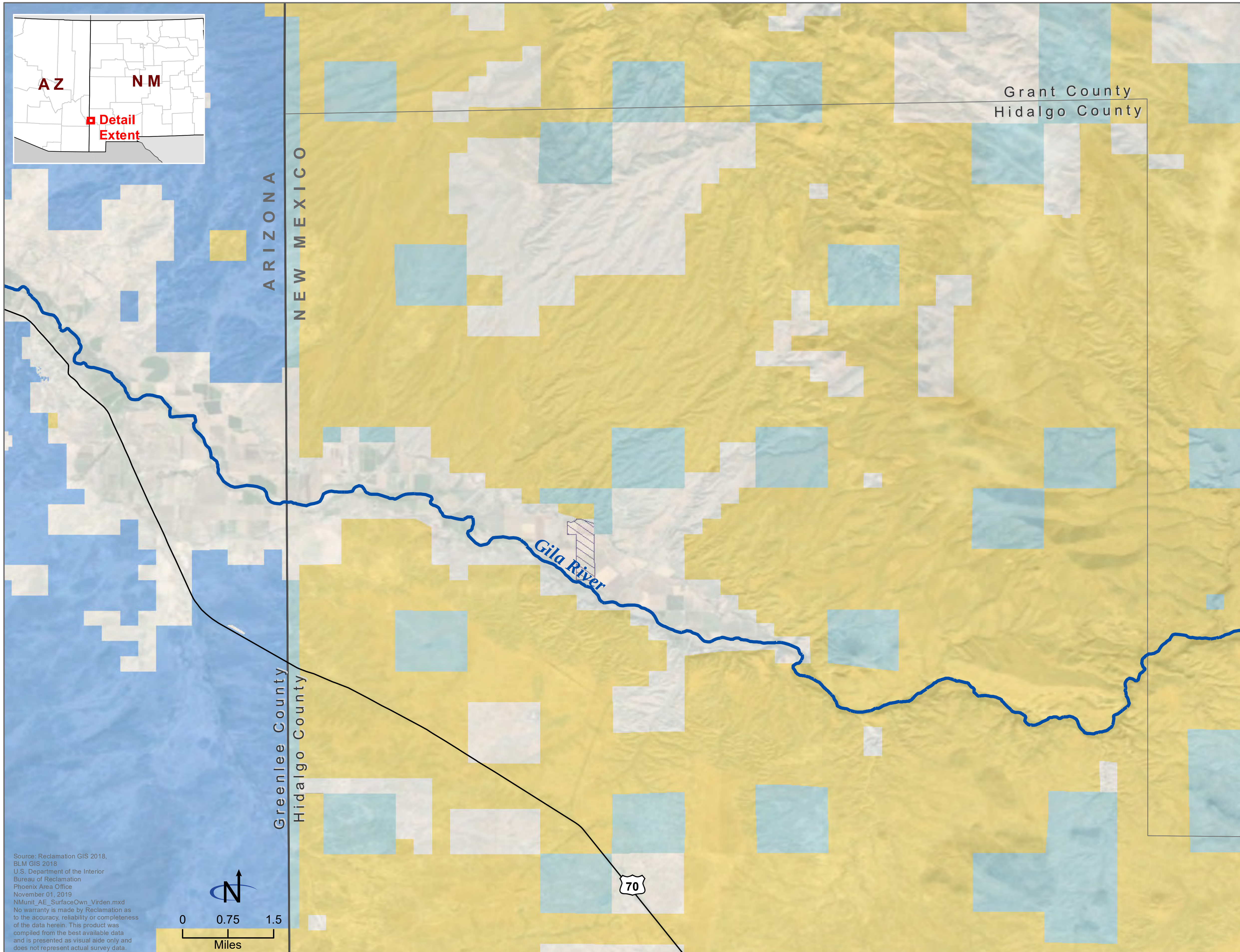
Map 3-12
Land Ownership—Virden



- Bureau of Land Management
- New Mexico State Land
- Arizona State Land
- Private
- Private, Freeport-McMoRan
- River
- County

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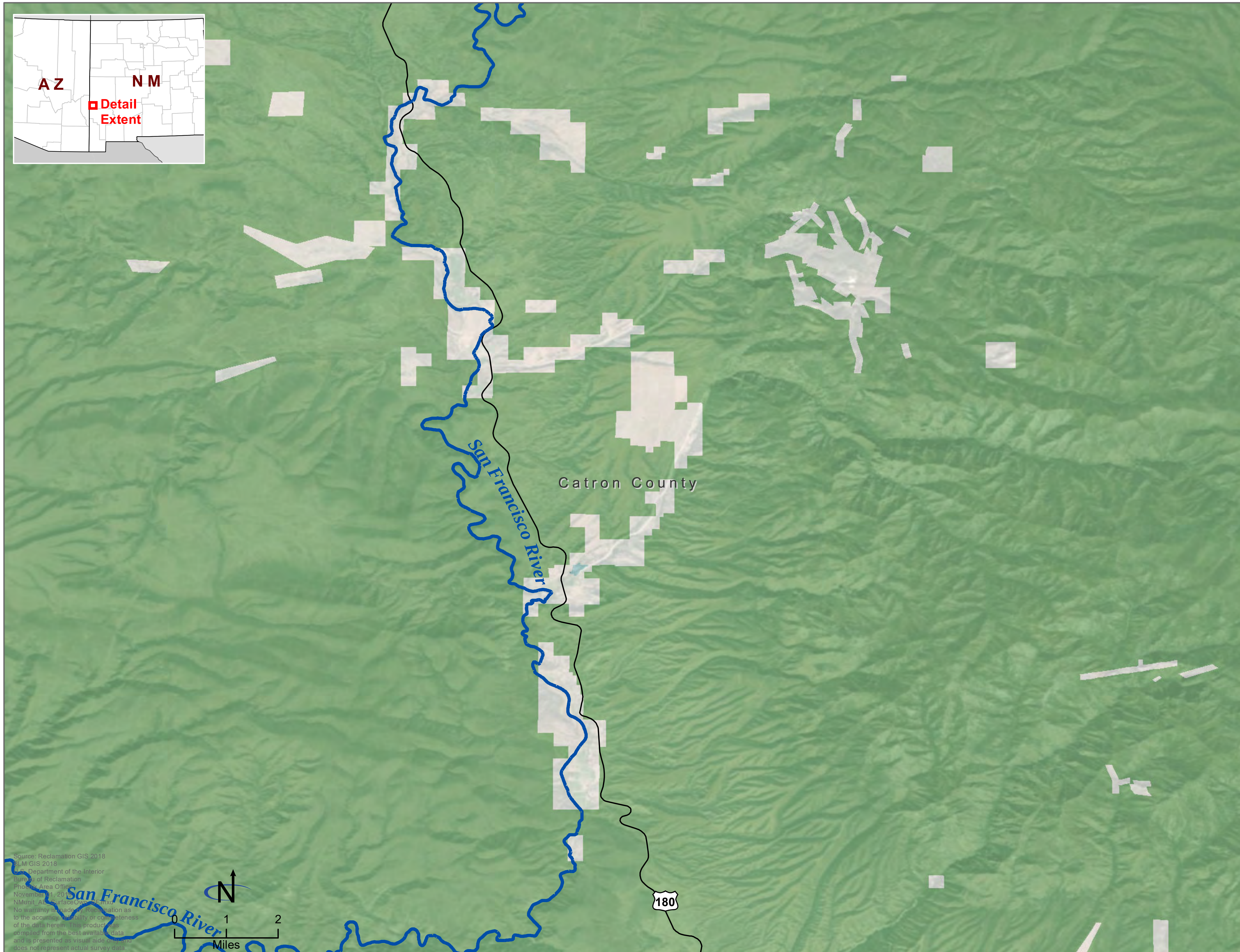


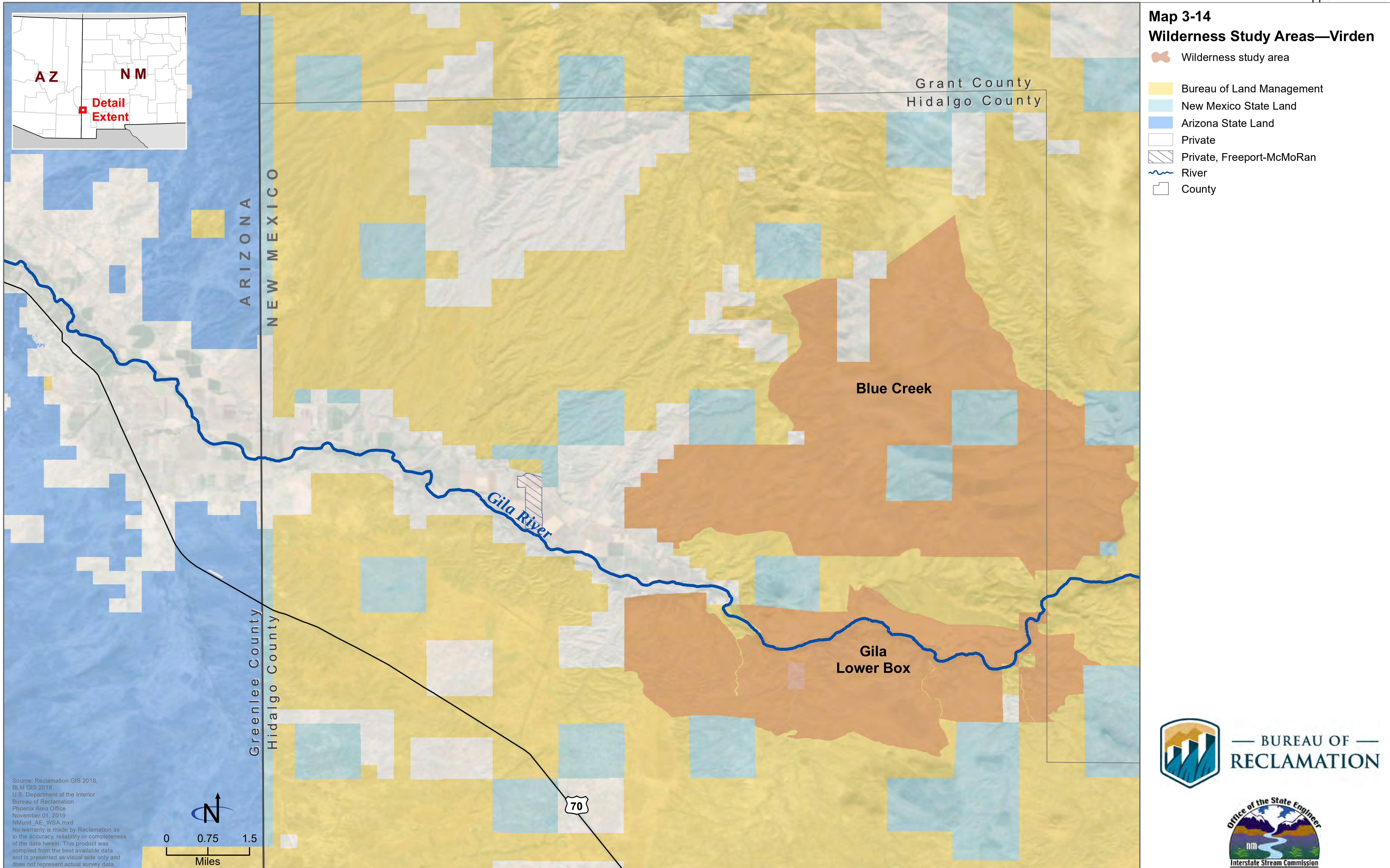
Map 3-13

Land Ownership—San Francisco

Forest Service

Private

River


Map 3-14
Wilderness Study Areas—Virden
Wilderness study area
Bureau of Land Management
New Mexico State Land
Arizona State Land
Private
Private, Freeport-McMoRan
River
County
AZ
NM
Detail Extent
Grant County
Hidalgo County
ARIZONA
NEW MEXICO
Greenlee County
Hidalgo County
Blue Creek
Gila Lower Box
Gila River
70
N
0
0.75
1.5
Miles
Source: Reclamation GIS 2018,
BLM GIS 2018
U.S. Department of the Interior
Bureau of Reclamation
Phoenix Area Office
November 01, 2019
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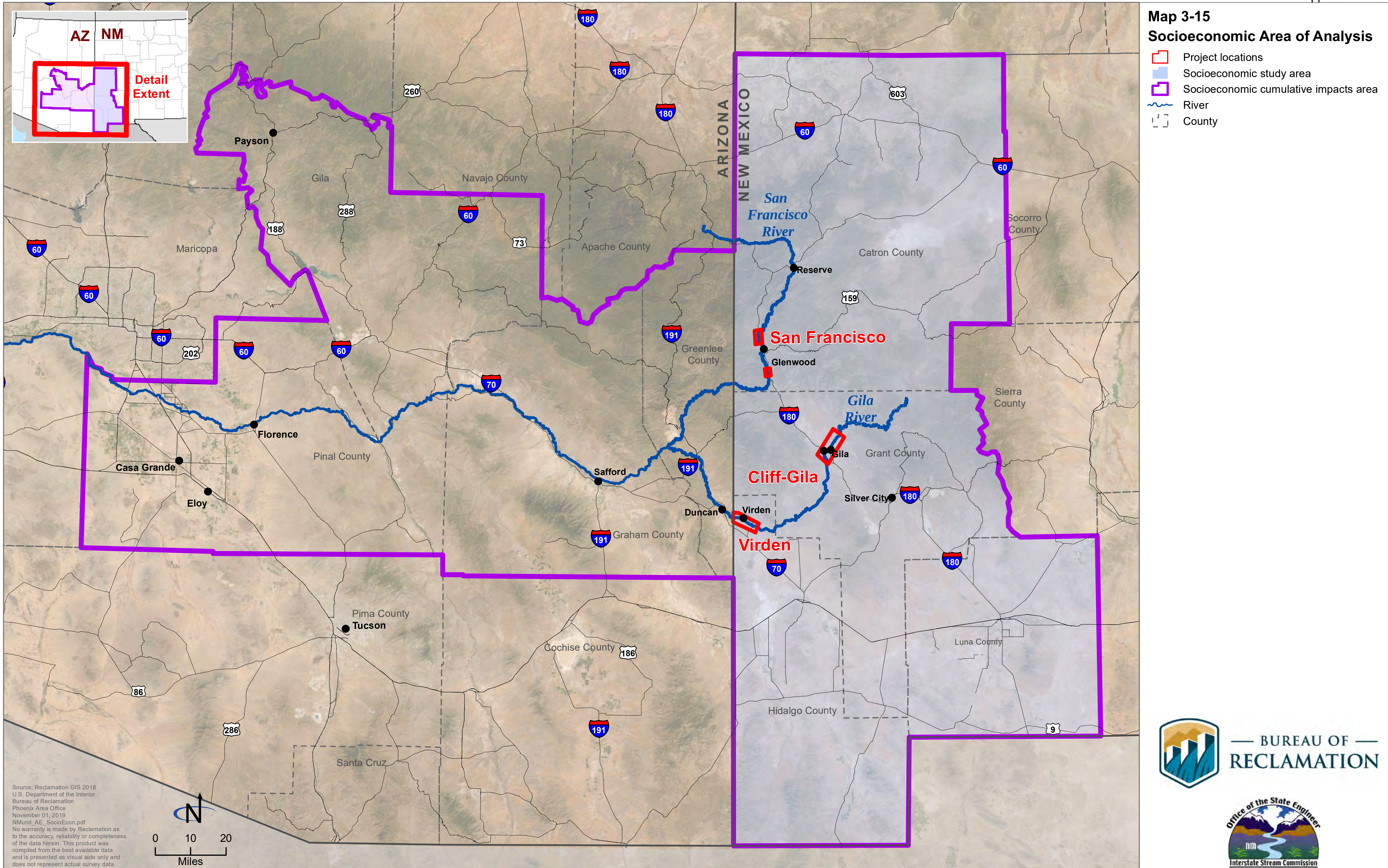
Map 3-15
Socioeconomic Area of Analysis



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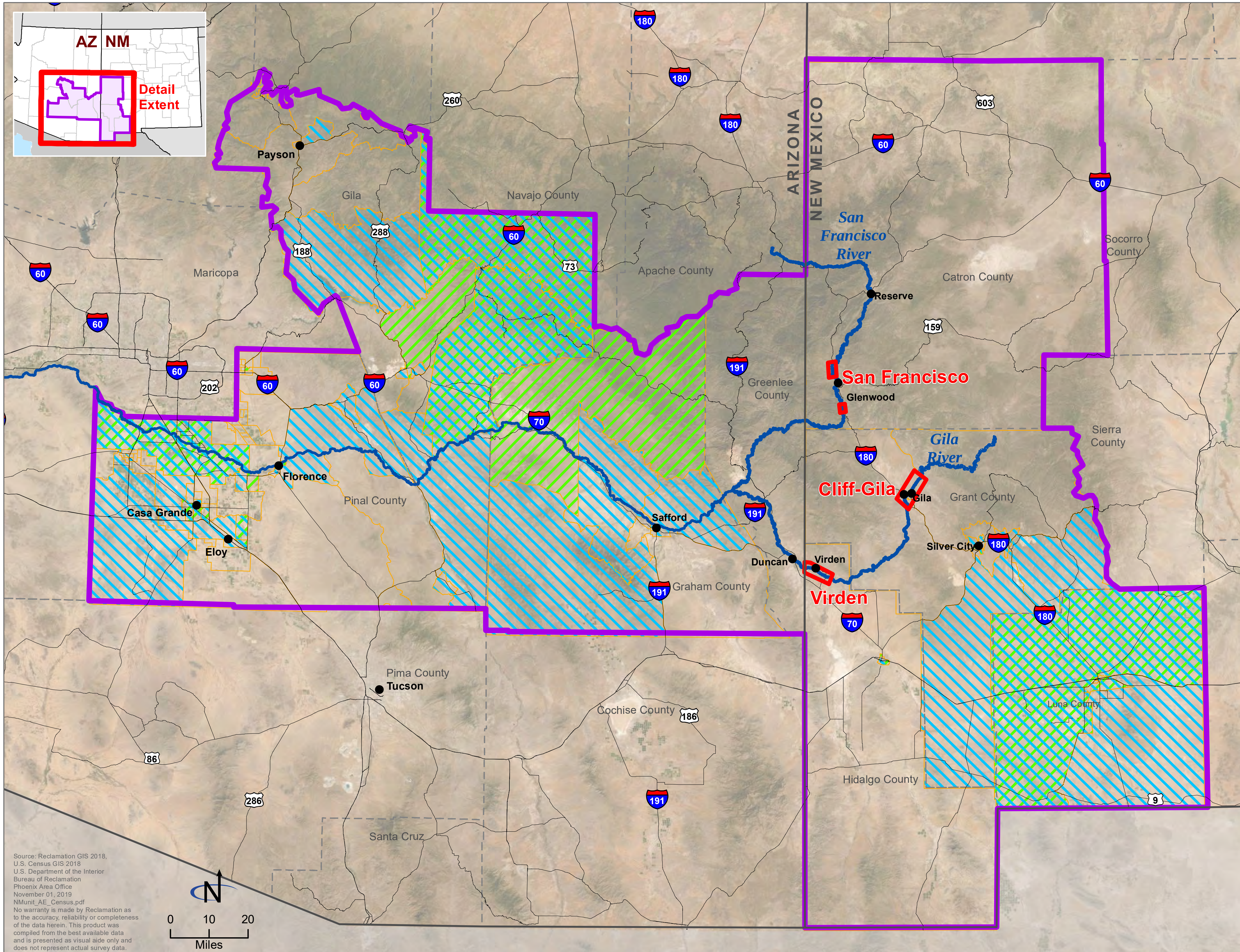
Map 3-16

Populations Identified for Further Analysis based on Poverty and Minority Data



- Project locations
- Socioeconomic cumulative impacts area
- Minority populations based on CEQ guidelines*
- Low-income populations based on CEQ guidelines*
- Census tract
- River
- County

*Populations identified for further environmental justice analysis are identified at the Census Tract level based on US Census Bureau 2012-2016 American Community Survey (ACS) data

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Appendix B. Preliminary List of Actions for the NM Unit

Table B-1. Preliminary List of Actions for the NM Unit

Agency/Issue	Approval Action

Reclamation
 	
Role: Lead Federal agency for all environmental compliance activities under NEPA, Section 7 of the ESA, and NHPA Section 106
• Prepare all NEPA documents (e.g., biological assessment, Draft EIS, Final EIS, and ROD) jointly with ISC
  o Ensure the EIS complies with CEQ, DOI, and Reclamation NEPA requirements
  o Review and approve project mitigation
  o Ensure all information is adequate to issue a ROD based on the Final EIS analysis
• Fulfill the PR&G requirements
• Fulfill obligations under Section 7 of the ESA
• Fulfill obligations under Section 106 of NHPA
	Approve all contracts stated in the NM Unit Agreement, Sections 9.1 through 9.5
	
	Authorize all diversions of AWSA water, in compliance with the CUFA and the AWSA
	
	Approve and provide additional funding to construct a NM Unit, in accordance with the AWSA
	
	Serve as signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance; serve as consultation lead for NHPA Section 106 and New Mexico Cultural Properties Act consultation

Agency/Issue	Approval Action
ISC **Role:** Joint Lead agency with Reclamation for all environmental activities under NEPA • Prepare all NEPA documents (e.g., biological assessment, Draft EIS, Final EIS, and ROD) jointly with Reclamation • Work with Reclamation to fulfill the PR&G requirements • Work with Reclamation to fulfill obligations under Section 7 of the ESA • Work with Reclamation to fulfill obligations under Section 106 of NHPA Administer the NM Unit Fund, in accordance with the AWSA and the NM Unit Fund statute, New Mexico Statutes Annotated 1978, Section 72-14-45.	Approve all contracts stated in the NM Unit Agreement, Sections 9.1 through 9.5 Approve any uses of funds in the NM Unit Fund, including the environmental compliance process and potential construction, operation, and maintenance of a NM Unit Serve as a signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance
Advisory Council on Historic Preservation **Role:** Review the programmatic agreement and provide guidance or mediation on request	Serve as a signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance
USFS **Role:** Review the EIS and other resultant studies for compliance with applicable Federal environmental regulations	As applicable, issue FLPMA ROW grants; evaluate consistency of the Proposed Action with existing forest management plans; serve as a signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance; issue Archaeological Resources Protection Act of 1979 permits for archaeological investigations; as applicable, provide comments and concur with determinations of eligibility, effect, and sufficiency
U.S. Army Corps of Engineers **Role**: Cooperating agency; review the EIS for compliance with CWA regulations	As applicable, approve CWA Section 404 dredge and fill permits, once NMED has approved the Section 401 Water Quality certification
USFWS **Role:** Cooperating agency; review the EIS for compliance with applicable Federal environmental regulations	As applicable, prepare and issue a biological opinion, in accordance with Section 7 of the ESA; evaluate project for consistency with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act; evaluate impacts and recommend mitigation measures for fish and wildlife habitat as part of the EIS process under the Fish and Wildlife Coordination Act

Agency/Issue	Approval Action
U.S. EPA **Role:** Review the EIS for compliance with applicable Federal environmental regulations	As applicable, approve the National Pollutant Discharge Elimination System (NPDES) permit, in accordance with CWA Section 402
Affected Indian Tribes **Role:** Review the EIS and other resultant studies and provide technical information; participate in government-to-government consultation	Consult on identification of, effects on, and mitigation for cultural resources and Indian trust assets in the project area; Reclamation invited tribes to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance
NMDOT **Role:** Review the EIS and other resultant studies; provide technical information on potential road crossings	As applicable, issue permits for road crossings and any infrastructure within NMDOT highway ROWs; serve as a signatory or concurring party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance; as applicable, provide comments and concur with determinations of eligibility, effect, and sufficiency NMDOT ROW permit requirements: • NMDOT must approve any proposed work within NMDOT ROWs. • NMDOT design standards and policies must be considered for proposed work within NMDOT ROWs. • Any structures installed within NMDOT ROWs would require a maintenance agreement. • Any road closures would require a traffic control plan that is approved and stamped by a New Mexico Registered Engineer.
NMED **Role:** Review the EIS for compliance with applicable state requirements and provide technical information	As applicable, issue Clean Air Act, air quality permits, and CWA, Section 401 Water Quality certification
New Mexico Historic Preservation Department **Role:** Review the EIS and resultant cultural resource investigations and provide technical information	Serve as a signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance; provide comments and concur with determinations of eligibility, effect, and sufficiency; issue permits for archaeological investigations on state, county, municipal, or private land; lead consultation for disposition of human remains inadvertently discovered on state, county, municipal, or private lands
New Mexico State Land Office **Role:** Review the EIS and other resultant studies and provide technical information	As applicable, issue right-of-entry and ROW permits for preconstruction, construction, operation, and maintenance; serve as a signatory party to the programmatic agreement for NHPA Section 106 and New Mexico Cultural Properties Act compliance; as applicable, provide comments and concur with determinations of eligibility, effect, and sufficiency

Agency/Issue	Approval Action
NMOSE **Role**: Provide technical information	Issue all applicable permits to divert, store, and beneficially use water, including permits for well drilling, aquifer storage and recovery, and dam safety
NMOSE, Dam Safety Bureau **Role:** Permit new or modified dams; inspect dams during construction and operation	Dams that equal or exceed 25 feet in height and exceed 15 AF of storage or dams that equal or exceed 50 AF of storage and equal or exceed 6 feet in height are under the jurisdiction of the NMOSE, Dam Safety Bureau. Constructing a new dam or modifying an existing dam requires approval from the Dam Safety Bureau.
County Road or Utility Department **Role:** Issue permits or authorizations for county road closures or realignments	Issue permits or authorizations for any county road closures or realignments; the Entity may be required to prepare supporting studies and an engineering analysis.

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Appendix C. Best Management Practices and Standard Operating Procedures

This appendix lists BMPs and standard operating procedures that would be applied during construction of the NM Unit.

C.1 Water

- The contractor would not stockpile construction materials in areas where high water or stormwater flows could wash them away. At the completion of construction, any and all excess construction materials and debris would be removed to an appropriate off-site location.
- The construction contractor would store petroleum products at least 30 feet from stormwater channels, washes, and rivers and outside the 100-year floodplain. The contractor would line and install dikes in petroleum storage areas to safely contain leaks and spills.
- Hay bales, silt fences, or other appropriate erosion controls would be placed immediately downslope of exposed soils or fill to prevent sediment transport. The contractor would use siltation and turbidity control measures, such as silt fences and hay bales, in all areas where stormwater runoff could wash disturbed soils into the stream. Such measures would remain in place until project surface disturbance is complete and exposed soils are stabilized.
- The contractor would need to obtain all applicable permits—Section 401, 402, and 404—under the CWA before construction begins. The terms and conditions of the permits and certification would be incorporated into the project.
- The contractor would file a NPDES permit notice of intent with the EPA before construction begins. In accordance with the NPDES permit requirements, the contractor would prepare an approved stormwater pollution prevention plan, which would be available for inspection before construction begins.
- Dewatering operations would require, and must comply with, applicable permits and regulations.
- The contractor would minimize the use of heavy equipment, such as a backhoe or excavator, in flowing water, to the extent practicable, and the equipment would be subject to applicable permit conditions.
- The contractor would schedule construction during periods when the probability of rain, runoff, and streamflow is expected to be low and when soil above the floodplain is dry; this is to minimize unacceptable soil compaction and displacement and sediment delivery.
- The contractor would pipe streamflow around the work area to reduce the potential for sediment to be released into the stream.

C.2 Wildlife

- The contractor would train all on-site project personnel in environmental awareness of sensitive biological resources, restrictions and measures to protect biological resources, and worker responsibilities during construction.
- To protect migratory birds, a qualified biologist would survey all vegetation that could contain active bird nests that is scheduled to be disturbed during the breeding bird season (February 15 to August 31, or as determined by best available science for the area). The biologist's survey would take place within 48 hours before vegetation disturbance. If an active nest is discovered, the contractor would establish an avoidance buffer appropriate for the species, as determined by a qualified biologist. There would be no activities within the buffer until young birds have fledged, or as otherwise determined by the biologist. If a nest becomes active during construction, Reclamation would determine the appropriate buffered distance.
- A qualified biologist would be on-site during dewatering operations to salvage native fish and aquatic and semiaquatic wildlife that may become stranded. Block netting would be installed upstream and downstream of the project locations, and depletion sampling would be conducted prior to initiating any dewatering activities. All work in the immediate area would cease if any Federally listed species are observed in the construction area, in which case the contractor would immediately notify Reclamation and the USFWS. Project activities would be halted until the USFWS has been consulted.
- The contractor's personnel would properly dispose of all human garbage, including food scraps, in closed containers, which would be removed from the project site daily to prevent attracting natural and nonnative predators.
- The contractor would restrict construction personnel and vehicles to the project footprint.
- The contractor would restrict workers from bringing domestic animals to the project site.
- Since most of the proposed construction would take place adjacent to agricultural fields, burrowing owl surveys would need to be conducted at least 120 days before ground disturbing activities. If surveys are conducted in the fall or winter and occupied burrows or owls are found, Reclamation would implement the conservation measures identified in the burrowing owl clearance protocol (AZGFD 2009) and would then survey the area 30 days prior to the ground disturbing activities. The same protocol would need to be followed if surveys are conducted in spring or summer and occupied burrows or owls are found. A 35-meter (100-ft) radius buffer that excludes all heavy machinery and foot traffic would be set up around the active burrow entrances until the appropriate conservation action can be determined.
- As transmission lines and lower voltage powerlines are replaced and maintained, installed equipment would meet the most current Avian Powerline interaction Committee design standards to prevent bird electrocutions.

Species specific BMPs

Gartersnakes

- In an attempt to avoid, minimize, or mitigate potential negative effects on the northern Mexican and narrow-headed gartersnakes, a permitted biologist would survey the project area for the presence of gartersnakes immediately prior to initiation of construction, and move any gartersnakes encountered away from the project area. Construction access roads would be

surveyed two times per day, and any gartersnakes encountered would be moved away from the roads. All holes or other types of cover within the erosion control area that could function as a snake shelter would be marked with a construction flag prior to the application of a geomat or other erosion control material. These erosion control materials would be modified as necessary or placed a reasonable distance from the flagged locations in order to not bury any potential dormant snakes.
- Any northern Mexican or narrow-headed gartersnake fatalities would be thoroughly documented and reported to the USFWS.

Southwestern willow flycatchers and Yellow-billed cuckoos

- To avoid impacts to flycatchers and cuckoos, construction activities, as well as operation and maintenance work, would be scheduled outside of the breeding season for these species, which generally occurs from April through August. If work must be scheduled, the area would be surveyed by a trained biologist immediately prior (within 48 hours) to being disturbed. If an active nest is discovered, vegetation clearing activities would not be allowed to proceed in the vicinity of the nest(s). No activities would occur within an appropriate buffered distance from active nests until after the young birds have fledged from the nest. If an active nest is discovered, Reclamation would determine the appropriate buffered distance.

All Threatened and Endangered Species

- If any Federally listed species are observed in a construction area, all work in the immediate area would cease. Reclamation and USFWS personnel would be notified immediately to determine next steps.

C.3 Vegetation

- Vegetation disturbances would be limited to the project area, and the contractor would use site-specific measures on disturbed areas to promote revegetation. All revegetation would allow for natural regeneration of native trees and herbaceous revegetation; where native species are scarce, the contractor would revegetate the areas with native, certified weed-free seed. Revegetation would occur in areas where there is an immediate threat of invasive and noxious weeds encroaching before native species can naturally regenerate.
- The contractor would close any user-created tracks and restore them to natural conditions to the extent possible (conditions that existed prior to construction of project components).
- Personnel would power wash equipment before and after it is allowed on the construction site to prevent introduction or incidental spread of invasive plant species.
- The contractor would identify and treat areas of noxious weeds at the construction site before and after construction, using integrated pest management practices that Reclamation approves.

C.4 Cultural

- Imported earthen material, approved by a Reclamation archaeologist, must come from an approved borrow source.

C.5 Air

- The contractor would stabilize all construction areas, including haul roads, contractor use areas, and open stockpiles, against dust emissions by applying water or chemical suppressants or implementing other reasonable measures.
- Contractor personnel would maintain speeds of less than 25 miles per hour within the construction footprint.
- Operators would cover truck beds when hauling soil or sediment.
- The contractor would not be permitted to dispose of construction materials by burning.
- The contractor would not operate equipment and vehicles that show excessive exhaust emissions until corrective repairs or adjustments are made to reduce such emissions to acceptable levels. Personnel would minimize unnecessary idling of diesel-powered construction equipment.

C.6 Noise

- Construction would be restricted to daylight hours.
- The contractor would restrict project-induced daytime noise to less than 65 dBA (A-weighted dB);[1] the contractor would restrict nighttime construction noise to less than 60 dBA.
- The contractor would maintain exhaust mufflers on construction equipment in good working condition.
- Workers would be required to use appropriate engineering controls or personal protective equipment to protect them from excessive noise.
- Mitigation measures would be implemented for noise levels above 48.6 dB within wildlife habitat.

C.7 Hazardous Materials

- Workers would be required to use personal protective equipment during handling and any cleanup of hazardous materials.
- If hazardous fluids are stored on-site, the contractor would place fuels and lubricants in clearly marked aboveground containers, with approved secondary containment.
- The contractor would properly containerize, label, and transport any hazardous wastes to a permitted disposal facility, in accordance with Federal and state regulations.

[1] A-weighted decibels, abbreviated dBA, are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted system, the decibel values of sounds at low frequencies are reduced compared with unweighted decibels, in which no correction is made for audio frequency.

Appendix D. Summary of Scoping Issues and Related EIS Resource Topics

Below is a table containing a detailed summary of issues identified through scoping and the corresponding resource topics for analysis in **Chapter 3** of the EIS.

Table D-1. Scoping Issues and Related EIS Resource Topics

Scoping Issues	Resource Topics for Analysis in the EIS
Water Resources and Water Quality • How would the Proposed Action affect surface water and groundwater? • What is the potential for the Proposed Action to lower groundwater tables and affect riparian and wetland vegetation? • Will the Joint Leads verify the water quality of wells? • How would the Proposed Action affect natural hydrology, riverine structure, and water quality?	Water resources, vegetation, aquatic and terrestrial wildlife, geology and soils
Vegetation • How would instream structures and canal lining affect wildlife (including special status species), riparian vegetation, and riparian habitat and wetlands? • How would altering groundwater levels and river flow regimes affect native riparian vegetation and wetlands?	Water resources, vegetation, aquatic and terrestrial wildlife, special status species
Aquatic and Terrestrial Wildlife • How would the Proposed Action affect wildlife and wildlife habitat, particularly special status species, native fish, and aquatic species? • How would the Proposed Action's impacts, when considered with cumulative impacts, affect the recovery of special status species? • Would the Proposed Action increase the potential for the introduction of nonnative species? • Will the EIS evaluate the Proposed Action's impact on downstream flows and the wildlife and riparian vegetation that depend on these flows? • How would the project affect mitigation areas and their values?	Water resources, vegetation, aquatic and terrestrial wildlife, special status species, land use
Cultural and Historic Resources • What measures will be taken to protect known and unknown archaeological sites and areas of cultural significance from damage? • Will the Proposed Action include archaeological surveys throughout the project area? • Will the New Mexico Historic Preservation Division and the State Historic Preservation Officer enforce mitigation measures?	Cultural and historic resources

Scoping Issues	Resource Topics for Analysis in the EIS
Geology and Soils • What is the potential for surface irrigation, and what is the cost-benefit analysis of implementing surface irrigation? • Will the EIS evaluate the geology of storage ponds, wells, reservoirs, and ditches? • Will the EIS evaluate soils and topography as barriers?	Water resources, geology and soils
Land Use • What are the potential impacts of the Proposed Action on recreation? • Will the EIS evaluate recreation as a beneficial use? • What is the potential for the Proposed Action to decrease the tourism value for recreationists?	Water resources, land use, socioeconomic resources
Socioeconomic Resources • What is the cost-benefit analysis of the Proposed Action? • How would the Proposed Action affect local, regional, and national populations, and what are the associated costs of these impacts? • Who would benefit from the project? Would the project benefit local users and associations or divert funds from community water projects? • Will the EIS evaluate the number of people served by the Proposed Action, compared with community water projects? • Who would pay for the Proposed Action? What are the potential costs to taxpayers? • What is the total cost of the Proposed Action, including mitigation costs and costs for metering, water accounting, and enforcing AWSA water use stipulations? What is the impact of international trade policies on the cost of materials? • Will the EIS evaluate unforeseen costs for maintenance and reconstruction? • Will the EIS evaluate whether the cost of water per acre-foot would increase dramatically for water users? • What are the potential benefits of continuing water dedication to instream flow or for storing water for downstream users? • What are the effects of water metering?	Water resources, land use, socioeconomic resources
Indian Trust Assets • How would the Proposed Action affect ITAs, including tribal water rights? How would these rights be accommodated? • What are the potential effects of the Proposed Action on the water quality, quantity, and timing of water for tribal water users and the subsequent effects on tribal agricultural activities? • What is the potential for the Proposed Action to reduce water in the San Carlos Reservoir and the subsequent impact on tribes? • How will the impacts on tribal religion and culture be considered during the planning process?	Indian Trust Assets
Environmental Justice • How would the Proposed Action evaluate and analyze environmental justice issues, including how water rights may be conserved for all communities?	Environmental justice

Scoping Issues	Resource Topics for Analysis in the EIS
Public Health and Safety • Would the Proposed Action manage mosquito populations? • Would the Proposed Action increase runoff of agricultural products due to increased agricultural activity? • Would the Proposed Action's infrastructure present a hazard for human safety, particularly for river recreationists?	Water resources, public health and safety

Source: EMPSi 2018

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Appendix E. Glossary

Acre-foot (AF). The amount of water that would cover 1 acre with 1 foot of water. One AF is equal to 0.326 million gallons.

Active channel. The portion of the channel that is frequently flooded by the low-flow channel.

Adjudicated water. Gila and San Francisco River water in New Mexico adjudicated pursuant to the 1964 U.S. Supreme Court Decree in *Arizona v. California* and state adjudications.

Air pollution. Degradation of air quality resulting from unwanted chemicals or other materials occurring in the air.

Alluvial aquifer. A permeable formation that forms naturally underground by deposition of weathered material, such as sand and silt particles, and stores or conducts groundwater to wells and springs. Water flow in these types of aquifers is very slow.

Ambient air quality. The state of the atmosphere at ground level as defined by the range of measured or predicted ambient concentrations of all significant pollutants for all averaging periods of interest.

Annual average daily traffic (AADT). The total volume of vehicle traffic on a highway or road for a year divided by 365 days.

Annual AWSA diversion. The actual annual amount of water projected to be diverted under operational restrictions and infrastructure capabilities. Diversions can be incremental; therefore, diversions can exceed the total storage capacity.

Aquifer storage and recovery (ASR). A process that conveys water underground to replenish groundwater stored in aquifers, which is later recovered for reuse.

Archaeological site. A location that contains material remains of past human activities, generally defined as over 50 years old.

Artifact. A human-modified object, often appearing on an archaeological site, that typically dates to over 45 years in age.

Attainment area. A geographic area in which levels of a criterion air pollutant meet the health-based National Ambient Air Quality Standard for that specific pollutant.

AWSA water. Water from the Gila River; its tributaries, including the San Francisco River; and underground water sources in New Mexico, made available for consumptive use in New Mexico as described in the CRBPA and as amended by the AWSA.

Bankfull. The water level, or stage, at which a stream, river, or lake is at the top of its banks and any further rise would result in water moving into the floodplain.

Bankfull width. The horizontal distance from bank to bank at an elevation equal to the bankfull elevation at any cross section.

Base flow. Sustained low flows in a stream, often composed largely of groundwater effluent.

Borrow pit. In construction and civil engineering, a borrow pit, also known as a sand box, is an area where material (usually soil, gravel, or sand) has been dug for use at another location. Borrow pits can be found close to many major construction projects.

Buildout. The area of land projected to be developed as part of a municipality or district in the future. Generally, the prediction is for maximum capacity for the residential, commercial, industrial, and municipal development of that community.

Cienega. Small marsh.

Climate. Climate is the generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years.

Climate change. Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from:

- natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun
- natural processes within the climate system (e.g., changes in ocean circulation)
- human activities that change the atmosphere's composition (e.g., driving automobiles) and the land surface (e.g., deforestation, reforestation, urbanization, and desertification)

Coanda screen: A tilted profile wire bar screen. Only the bottom layer of water falls through the screen while fish and debris pass over.

Component. Project components are the proposed NM Unit infrastructure, modifications to existing facilities or construction activities related to diversion, delivery or storage of water, and electrical power service.

Consumptive use. Consumptive use is the amount of water used up by applying that water to crops or other beneficial use. Under the Consumptive Use and Forbearance Agreement (CUFA), consumptive use also includes reservoir/pond evaporation losses. The total consumptive use is the sum of the AWSA consumptive use and reservoir/pond evaporation, pursuant to Paragraph 2.15 of the CUFA as required by Section 304(f) of the CRBPA.

Cooperating agency. A Federal, state, tribal, or local agency having special expertise with respect to an environmental issue or jurisdiction by law. During the NEPA process, a cooperating agency assists the lead agency by participating at the earliest possible time; participating in the scoping process; participating in developing information and preparing environmental analyses, including portions of the EIS where it has special expertise; and participating in making available staff support at the lead agency's request to enhance the agency's interdisciplinary capabilities.

Corrosive soil. A sensitive soil type with the potential to corrode concrete or steel. The common indicators of a soil's tendency to corrode materials are its porosity, electrical conductivity or resistivity, dissolved salt content, moisture content, and pH.

Criteria pollutant. The EPA uses six "criteria pollutants" as indicators of air quality and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called National Ambient Air Quality Standards. The criteria pollutants are ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead.

Critical habitat. Specific geographic areas, whether occupied by listed species or not, that are determined to be essential for the conservation and management of listed species and that have been formally described in the *Federal Register*.

Cultural resource. The present expressions of human culture and the physical remains of past activities, such as historic buildings, structures, objects, districts, landscapes, and archaeological sites. These resources can be significant in the context of national, regional, or local history, architecture, archaeology, engineering, or culture. They also may include sacred sites and natural features of landscapes that are significant to living communities.

Cut slope. The excavated portion of a roadway upslope of the road surface.

Decree water. Gila River water adjudicated pursuant to Globe Equity Decree No. 59, dated June 29, 1935.

Dewater. To remove or redirect water from a portion of the river in order to construct instream facilities.

Emergent wetland. Wetland type that contains emergent plants (erect, rooted, herbaceous, and water loving) as the tallest life form with at least 30 percent coverage.

Environmental Protection Agency (EPA)/New Mexico Water Quality Control Commission Standards. Drinking water quality standards of New Mexico.

Ephemeral. A drainage basin or stream that flows during storms or other wet times. It typically is not supplied by groundwater.

Erosive soil. A soil that meets National Soil Survey Handbook definitions for susceptibility to erosion by wind or water. The U.S. Department of Agriculture defines soils susceptible to erosion by water using a K factor, which ranges from 0.02 to 0.69. Soils with K values less than 0.15 are considered resistant to water erosion; those with K values greater than or equal to 0.40 are assumed to have a high potential for water erodibility.

In order to estimate susceptibility to wind erosion, the USDA uses a wind erodibility index, which assigns soils to eight groups. Those in Group 1 are the most susceptible to wind erosion, and those in Group 8 are the least susceptible. Group classification is based on the composition of the surface, including texture, size, and durability of surface clods; rock fragments; organic matter; and carbonate presence. For this EIS, Groups 1 through 4 were considered to have a high potential of wind erosion, averaging a minimum of 85 tons of soil per acre per year lost to wind.

Excavation. The exposure, processing, and recording of archaeological remains.

Exchange. A process by which water, under certain conditions, may be diverted out of priority at one point by replacing a like amount of water at a downstream location.

Expansive clay. A type of sensitive soil that has a high shrink-swell potential. This is the relative change in volume to be expected with changes in moisture content (that is, the extent to which the soil shrinks as it dries out or swells when it gets wet). Soils with a high shrink-swell potential have a 6 percent or greater linear extensibility, a liquid limit greater than 40 percent, and a plasticity index greater than 25 percent.

Federal action. An action by a Federal agency. This may include supplying funding for a project, authorizing or permitting a project, or undertaking or sponsoring a project.

Flood Insurance Rate Map. An official map FEMA publishes that shows locations of flood risks in a community.

Floodplain. Flat areas next to rivers and streams that are subject to inundation from precipitation. Any area that can be inundated with water. In this EIS, a floodplain can refer to either an area having unique vegetation or channel characteristics caused by flooding or a regulatory area, generally the 1 percent annual change (100-year) flood.

Fluvial. Related to rivers or streams.

Fugitive dust. Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction operations.

General circulation model. A type of computer model used to predict or forecast global climate. These models are coupled with projections of future greenhouse gas emissions and other assumptions to predict future climate scenarios.

Greenhouse gas. Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

Groundwater. Water found under ground in porous rock strata and soils.

Hazardous waste. The EPA defines hazardous waste as waste that is dangerous or potentially harmful to health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.

Historic built environment. Buildings, structures, objects, districts, and linear features such as roads, trails, and acequias (irrigation ditches) that are at least 50 years old.

Historic property. Cultural resources—such as historic buildings, structures, objects, districts, or archaeological sites—that are listed on, or eligible for inclusion on, the NRHP.

Hydric soil. Soils in which anaerobic conditions have developed.

Hydrograph. A graph of flow past a point in a river over time.

Impaired water. A water body that repeatedly exceeds regulatory water quality limits in one or more types of contamination or conditions.

Indian Trust Assets (ITAs). Legal interests in property held in trust by the U.S. for the beneficial interest of Federally recognized Indian tribes or individual Indians**.**

Indirect economic impact. The change in sales, income, or employment in the local region in industries that supply goods and services directly to affected businesses.

Induced impact. The change in sales in the local impact region that results from changes in local household spending of income, for example, on housing, utilities, and groceries. Induced impact is from income earned in the tourism, construction, and other supporting industries.

Intake. A location or structure through which water is taken into a channel or pipe from a river.

Intermittent. A stream or drainage that flows periodically during the year. It may flow during certain seasons or storm, but it does not flow year-round. Intermittent streams may or may not be supplied by groundwater.

Isolated occurrence. Cultural manifestations that are at least 50 years old that do not meet the definition of an archaeological site; it is typically a location with fewer than 10 artifacts or with an isolated feature that lacks integrity.

Kiva. A Native American ceremonial structure common in the Southwest.

Laydown area. A space of ground or pavement (usually covered with rock and/or gravel) located near or at the construction site that is for the temporary receipt, storage, and partial assembly of the project equipment and materials to be installed or constructed.

Long-term impacts. Long-term impacts are permanent, generally occurring during operations. Long-term impacts typically last beyond the construction period, and the resources affected may not regain their preconstruction conditions for a longer period of time.

Loss. Loss of water that results from such factors as system loss and evaporation.

Macroalgae. Large aquatic plants.

Maximum contaminant level. The legal threshold limit on the level of a hazardous substance that is allowed in drinking water under the Safe Drinking Water Act. The limit is usually expressed as a concentration in milligrams or micrograms per liter of water.

Mesic. Of, characterized by, or adapted to a moderately moist habitat.

Midden. An area of accumulated domestic refuse.

Mitigation measure. A measure taken to offset the adverse impacts of an action or activity.

National Ambient Air Quality Standard. The specified average concentration of an air pollutant in ambient air during a specified time period, at or above which level the public health may be at risk. National ambient air quality standards have been set for the following criteria pollutants: carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, lead, and two categories of particulate matter (particulate matter with an aerodynamic diameter of 10 microns or less [PM_{10}] and particulate matter with an aerodynamic diameter of 2.5 microns or less [$PM_{2.5}$]).

National Flood Insurance Program. A Federal program enacted by Congress in 1968 intended to promote beneficial floodplain management and reduce national costs of floods.

National Pollution Discharge Elimination System (NPDES). A program created by the CWA of 1972 that regulates discharge of pollutants into public waters.

National Register of Historic Places (NRHP). A listing of resources that are considered significant at the national, state, or local level and that have been found to meet specific criteria of historic significance, integrity, and age.

Near bank stress and bank erosion hazard indices (NBS/BEHI). The NBS/BEHI, defined by Rosgen, illustrate the potential resiliency of a particular bank to channel forming flows. They consider bank angles, grain size composition, vegetation cover, root density, and armoring, as well as the relationship between the deepest near-shore depths to bank heights.

NM CAP water. Water from the CAP available to users in Arizona, by the CRBPA, as amended by the AWSA, in exchange for consumptive use of AWSA water in New Mexico.

Paleontological resource. Any fossilized remains or traces of organisms that are preserved in, or on, the earth's crust, that are of scientific interest, and that provide information about the history of life.

Particulate matter. One of the six "criteria" pollutants for which the EPA established National Ambient Air Quality Standards. Particulate matter is defined as two categories: fine particulates with an aerodynamic diameter of 10 micrometers (PM_{10}) or less, and fine particulates with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$).

Parts per billion (ppb). A measure of the amount of one substance found in a second, which is the carrier; one part in one billion.

Parts per million (ppm). A measure of the amount of one substance found in a second, which is the carrier; one part in one million.

Perennial stream. A stream that flows continuously throughout the year.

Phreatophyte. Any plant species that obtains a significant portion of the water that it needs to survive from the zone of saturation or the capillary fringe above the zone of saturation. These species are found in riparian ecosystems and other areas characterized by shallow groundwater, such as bottomlands.

Pipe bursting. A trenchless method of replacing buried pipelines by breaking existing pipelines and pushing them from their original location. The replacement pipe, attached behind the bursting head, is then fed into place, filling the cavity left behind by the bursting head.

Pool. Aquatic habitat in a stream with a low gradient that is normally deeper and wider than aquatic habitats immediately above and below it.

Protocol survey. A wildlife survey of threatened and endangered species that is designed to provide clear guidelines to surveyors in order to standardize methods and produce uniform reporting of results.

Qualitative. A form of assessment that analyzes the impacts in a descriptive manner (e.g., low, moderate, or high).

Quantitative. A form of impact assessment that analyzes the impacts using numerical metrics (e.g., acres or cubic feet per second).

Return flow. Water that returns to streams and rivers after it has been applied to beneficial use. Return flows may return as surface flow or as an inflow of tributary groundwater.

Riffle. A rocky or shallow part of a stream or river with rough water.

Riffle rundown. A constructed rocky or shallow part of a stream or river to dissipate flow energy and/or provide erosion control.

Riparian. Areas along creeks or streams and between the aquatic and terrestrial environment; river-influenced.

Riverine. Wetland contained within a channel.

Scour. Removal of granular bed material or sediment, such as sand or silt, by hydrodynamic forces from around an object, such as a river or coastal structure.

Section 404 permit. An authorization the U.S. Army Corps of Engineers grants under Section 404 of the Clean Water Act to place dredge or fill material in a Water of the U.S.

Sedimentation. The transport of sediment into a waterbody.

Sensitive soils. A collection of soil types whose properties give them special cause of consideration and analysis. These soil types are erosive soil, corrosive soil, or expansive clay.

Short-term impacts. Short-term impacts are temporary, generally occurring during construction.

Sinuosity. Sinuosity provides an index of the degree of channel meander, or the number of bends in a river over a given distance. A ratio of 1.0, where the channel length is the same as the down valley distance, indicates a perfectly straight channel. The degree of sinuosity is generally characterized as low for ratios less than 1.2, moderate for ratios of 1.2 to 1.5, and high for ratios greater than 1.5.

Special status species. Species that are identified by federal or state agencies for special management consideration.

Spoil pile. A pile built of the waste material (spoil) removed during construction. Spoil is earth and rock excavated or dredged during construction activities.

Stationary source. Refers to a stationary source of emissions. Prevention of Significant Deterioration permits are required for major new stationary sources of emissions that emit 100 tons or more per year of carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, or particulate matter.

Storage right. A water right that is measured in terms of volume. Storage rights allow a water user to store water for later beneficial use.

Stormwater best management practice. A set of treatment or prevention activities or constructed facilities intended to reduce pollutants entering public waters.

Stormwater pollution prevention plan. A requirement of the NPDES intended to limit erosion and sediment transport during construction projects using BMPs.

Surface water. Water that flows on the surface, either in streams or as surface runoff across the ground.

Target irrigation demand. The amount of water required to fulfill irrigation demands for users who benefit by diverted water.

Total dissolved solids (TDS). Combined content of all inorganic and organic substances contained in a liquid, which are present in a molecular, ionized, or micro-granular form. Primary sources of TDS are agricultural runoff, leaching of soil contamination, and point-source water pollution discharge from industrial or sewage treatment plants.

Transfer. The sale or purchase of a water right.

Trust land. Land held in trust by the U.S. for Federally recognized Indian tribes or individual Indians.

Turbidity. The cloudiness of water due to the presence of suspended particles.

Upland. Hills, plains, mesas, or other areas not in riparian areas or wetlands, where the vegetation is not supplied by hydrology from a stream or drainage.

Water delivery. The amount of water delivered to a water user.

Water demand. The amount of water that municipalities or regions require for everyday functioning.

Water right. In the Western United States, a usufructuary right to use a portion of the waters of a given state by reason of appropriation in accordance with its priority date and other factors.

Waters of the United States. As defined in the CWA, all waters that are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide. All interstate waters, including interstate wetlands. All other waters, such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, whose use, degradation, or destruction could affect interstate or foreign commerce.

Weir: A low dam built across a river to raise the level of water upstream or regulate flow.

Wetland. Area that is wet enough to support plant growth typically found in saturated soil conditions.

Zone A floodplains. Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Neither base flood elevations nor flood depths have been established for these floodplains.

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Appendix F. References

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An interdisciplinary team of staff from Reclamation and the ISC prepared this EIS, in collaboration with Environmental Management and Planning Solutions, Inc. (EMPSi) and its subcontractors.

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Appendix H. Index

Appendix I. DRAFT Principles, Requirements and Guidelines (PR&G) based analysis of the New Mexico Unit of the Central Arizona Project

Executive Summary

This analysis is based on an application of the Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies (PR&G) to the proposed New Mexico Unit of the Central Arizona Project (New Mexico Unit). The PR&G describe how Federal agencies should evaluate proposed infrastructure projects, grants and programs that may affect water resources. The New Mexico Unit Agreement specifically states that environmental compliance would include an analysis of alternatives consistent with the PR&G. This PR&Gs analysis supports the New Mexico Unit Draft Environmental Impact Statement.

This PR&G evaluation includes three types of analyses:

1. An economic analysis, which addresses whether the nation is better off with an action or without an action, and focuses on economic benefits and cost to the public as a whole (all of the United States).
2. A financial analysis, which is an evaluation of cash flows and affordability of a project or action from the perspective of groups that are paying all or a portion of project costs.
3. A regional impacts analysis, which determines the effects on the local population of an action relative to baseline conditions.

1) Economic Analysis

This study uses a combination of scaled and standard methods of analysis to evaluate economic benefits and costs. A standard analysis is a comprehensive analysis that seeks to evaluate all of the relevant benefits and costs using original or secondary data. A scaled analysis is an analysis that is more limited in scope and would typically rely on benefits transfer methods.

Benefits: Two categories of economic benefits are considered in this economic analysis:

- Irrigation water supply benefits, which are estimated using four different approaches:
  - An evaluation of water lease and purchases using water transaction data for agricultural water supplies,
  - An analysis of irrigated and non-irrigated agricultural land values,
  - An analysis of cash rent data for irrigated and non-irrigated land, and
  - Farm budget analysis of representative irrigated and non-irrigated farm operations.

The estimated annual irrigation water supply benefits using the methods mentioned above range from $33.48 to $310 per acre-foot of irrigation water. This is a fairly wide range of estimated benefits. However, assuming the AWSA water will primarily be used to supplement production of higher valued crops that are marginal under current conditions, the benefits for higher valued crops would range from $153.25 to about $310 per acre-foot.

- Ecosystem benefits: Potential erosion reduction/prevention and soil fertility/productivity benefits associated with cultivated irrigated crop production. The assumed ecosystem benefits are $68.88 per acre.

Costs: Economic costs represent the full resource costs of a project to the nation. Economic costs categories include:

- construction;
- operation, maintenance, and replacement (OM&R) including CAP exchange costs;
- interest during construction (IDC), and
- potential ecosystem costs: The average ecosystem benefit associated with short and long-term disturbed acres that would be lost (i.e. costs) can be represented by$149.53 annually per disturbed acre.

The estimated economic benefits and costs of each alternative are summarized in Table ES-1. It should be noted that Alternative A (No Action alternative) has ongoing annual OM&R costs and as a result the economic costs for Alternative A would not be zero. Therefore, the estimated economic cost of each alternative does not reflect an incremental increased cost compared to No Action. The exact economic costs under Alternative A are unknown at this time.

Table ES-1 – Estimated annual benefits and costs by alternative

Alternative	Total Annual Economic Benefits	Total Annual Economic Costs	Acre foot of water applied
Alternative B	$560,745	$2,276,858	2,220
Alternative C	$581,694	$4,614,108	2,303
Alternative D	$110,338	$357,715	439
Alternative E	$478,556	$6,764,485	1,895

These results are based on the assumption that the only benefits generated by the projects are related to the irrigated agricultural production and some ecosystem service benefits. There are additional effects associated with each of the alternatives that cannot be quantified but should be noted. Under the PR&G, these unquantifiable values must be given due consideration.

- The project alternatives may provide additional flows during periods when no flows would exist under existing conditions.
- Potential benefits could include improvements to surface water and riparian habitats during critical times of the year. This could also translate into potential improvement in recreational opportunities.
- Potential benefits from increased agricultural production and employment that could help sustain the local economy and maintain the population base and lifestyle of the region.

The results of the economic analysis show that none of the alternatives would generate positive net benefits. The results also show that Alternative D is the most cost-effective alternative, based on the economic cost per acre foot of water applied.

2) Financial and Cost-Effectiveness Analysis

This financial analysis of costs reflects the project costs potentially passed on to the water users. Two scenarios are used to analyze financial costs for each action alternative: (1) no public funding for the project; and (2) up to $60 million[1] in public funding available for construction-related costs from the New Mexico Unit Fund[2] (State funds). Financial costs are **not** equivalent to economic costs. Financial costs can be used to assess the ability of project beneficiaries to cover their share of costs (costs remaining after outside funding is provided for the project). The financial costs of each alternative are shown in Table ES-2.

Table ES-2 – Financial costs paid by water users after accounting for State construction funding for each alternative

Alternative	**Acre foot of water applied**	**Total Annual Financial Costs to be paid by water Users**		**Total Financial Costs per Acre-Foot Applied**	
		No State Funding	**With State funding**	**No State Funding**	**With State Funding**
Alternative B	2,220	$3,449,935	$550,749	$1,554	$248
Alternative C	2,303	$4,379,556	$2,504,598	$1,880	$1,088
Alternative D	439	$320,461	$118,454	$730	$270
Alternative E	1,895	$6,302,426	$4,535,175	$3,326	$2,395

Based on the financial analysis, the lowest financial cost per acre foot to be paid by water users with state funding is for Alternative B ($248 per acre-foot) followed by Alternative D ($270 per acre-foot). The lowest cost without state funding is Alternative D ($730 per acre-foot).

3) Regional Impacts Analysis

A regional impact analysis is an evaluation of the effect of an alternative on income, employment, and the value of output produced on the immediate region in which the proposed project is located. The analysis area is Catron County, Grant County, Hidalgo County, and Luna County in New Mexico. An IMPLAN model was used to estimate the regional impacts. Regional impacts could be from the following:

- Agricultural production, which occurs as a result of increased irrigation acreage, increased yields, a change in cropping patterns, or a combination of all three factors. This assumes that one-half of expenditures are spent within the region. The results are summarized in Table ES-3.
- Construction activities, which would generate short term regional impacts assuming the source of funding originates from outside of the region. The results are summarized in Table ES-4.

[1] Based on the balance shown in the 2019 New Mexico Unit Fund Report to the New Mexico Legislature, prepared by the New Mexico Interstate Stream Commission. Available at: https://www.ose.state.nm.us/Basins/Colorado/AWSA/Reports_to_Legislature/2019_NM_UnitFundRept.pdf

[2] Distribution of funds from the New Mexico Unit Fund is under the discretion of the New Mexico Interstate Stream Commission in consultation with the NM CAP Entity. At this time, no decision has been made by the ISC on future use of the Unit Fund for construction of the NM Unit or for any additional non-NM Unit projects. Use of this funding scenario in the EIS in no way obligates the Commission to allocate any funding from the New Mexico Unit Fund to the NM Unit Project.

- OM&R activities: Assuming that the majority of OM&R activities would be provided by personnel within the study area and that all of the expenditures are paid by entities within the study area, the OM&R impacts would be negligible.

Table ES-3 – Regional impacts from agricultural production

Alternative	Employment	Value Added	Value of Output
Alternative B	19	$679,605	$1,222,996
Alternative C	19	$687,551	$1,245,059
Alternative D	3	$152,733	$283,440
Alternative E	16	$565,298	$1,027,519

Table ES-4 – Regional impacts from construction activities

Alternative	Employment	Value Added	Value of Output
Alternative B	302	13,505,691	33,166,638
Alternative C	522	19,566,377	54,740,473
Alternative D	40	1,418,000	4,039,056
Alternative E	963	38,357,997	102,987,432

The results show that Alternative C would generate the highest positive regional impacts.

4) Conclusion

This PR&Gs analysis concluded that none of the alternatives would generate positive net economic benefits. Alternative D is the most cost-effective alternative, and Alternative B has the lowest financial cost per acre-foot to be paid by water users. Finally, Alternative C would generate the highest positive regional impacts.

The conclusions of the three analyses in terms of the desirability of an action may be different, but this difference is due to the affected population considered rather than inconsistency of the analysis. The PR&Gs perspective considers all benefits and costs to whomever they accrue while the regional/local perspective would not include costs paid by those located outside the local region. Another reason why different perspectives could arrive at different conclusions is the inability to monetize or accurately define and measure some of the benefits and costs of an action. Unquantifiable benefits, such as those related to maintenance of the rural population base and lifestyle of the region, are nevertheless to be given due consideration under the PR&Gs analysis.

DRAFT Principles, Requirements and Guidelines (PR&G) based analysis of the New Mexico Unit of the Central Arizona Project

Introduction

This introduction includes a background description of the Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies (PR&G) and a discussion of the different analytical perspectives included in this analysis.

The Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies

This analysis of the benefits and costs associated with potential projects that would form the New Mexico Unit of the Central Arizona Project (New Mexico Unit) is based on an application of the PR&G. The New Mexico Unit Agreement dated November 23, 2015 between the United States through the Secretary of the Interior and the New Mexico CAP Entity specifically stated that environmental compliance would include an analysis of alternatives consistent with the PR&G. The PR&G describe how Federal agencies should evaluate proposed water resource developments. The PR&G include three components.

1. The Principles and Requirements for Federal Investments in Water Resources (P&R, 2013) which provide general inputs required to analyze Federal investment alternatives
2. Interagency Guidelines (IG, 2014) which provide more detailed guidance for affected Federal agencies for determining the applicability of the P&R; and
3. Agency Specific Procedures (ASP) which provide agency specific guidance on identifying which programs and activities are subject to the PR&G and the framework for analyzing water resource projects, programs, and activities.

The goal of Department of the Interior's (DOI) Agency Specific Procedures is to ensure that DOI bureaus and offices consistently apply a common framework for analysis of water resources projects, programs, activities, and related actions involving Federal investments in accordance with the Water Resources Development Act (WRDA) of 2007. The WRDA specifies that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by

1. Seeking to maximize sustainable economic development;
2. Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used;
3. Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

Within DOI there are two main categories of activities that require a PR&G analysis: infrastructure projects that may affect water resources and grants and programs that may affect water resources.

The P&R, IG, and ASP are statements of policy, not regulations, intended to describe expectations for implementing consistent methods of evaluation and management of the government. The PR&G provide a framework for evaluating water resource investments from a broad public benefit perspective. Public benefits include environmental, economic, and social effects. These benefits can include monetary and non-monetary effects and can also allow for consideration of quantified and unquantified effects. As a result, the benefits and costs included as part of a PR&G analysis may not be entirely quantified in monetary terms. In addition, to the extent possible, a PR&G analysis should identify areas of risk and uncertainty and address ecosystem impacts and sustainable economic development.

The intent of a PR&G analysis is to provide an evaluation from a perspective that is broader than a traditional economic analysis, which typically considers only quantifiable and monetized benefits. A traditional analysis of benefits and costs is an integral part of a PR&G analysis, but other non-traditional categories of benefits and costs are also important to social well-being. All project costs and benefits should be based on the real resource values as measured through market exchange values or other methods that estimate resource value and that agencies "should strive to maximize public benefits, with appropriate consideration of costs." In addition, a PR&G analysis must reflect the tradeoffs that exist between competing goals. For example, the provision of water supplies for irrigation may reflect a tradeoff with providing water for environmental purposes.

A PR&G analysis includes components that are useful for preparing other documents such as Environmental Impact Statements and other planning documents. However, a PR&G analysis focuses on benefits and cost to the public as a whole (all of the United States) rather than impacts to the local region that is directly impacted. This analysis of the New Mexico Unit includes an evaluation of regional impacts and financial impacts to local project beneficiaries, which is not typically addressed in a PR&G analysis, to support the New Mexico Unit Environmental Impact Statement.

The Department of the Interior has issued Agency Specific Procedures for implementing the PR&G (Department of the Interior, 2015). The Agency Specific Procedures indicate that a PR&G analysis can vary in scope and magnitude depending on the extent and effects of the action under consideration. Two levels of analysis are identified: "standard" and "scaled". In general, the level of analysis should be commensurate with the significance of project investment and the potential environmental impacts. While there is not a clear distinction between the different levels of analysis, the two types of analysis can generally be distinguished in several ways.

A standard analysis is described as a comprehensive analysis that seeks to evaluate all of the relevant benefits and costs associated with the project or activity using original or secondary data. The types of economic analysis techniques used for a standard analysis would be those that are used to estimate willingness to pay in a benefit-cost analysis of programs and activities that have some effect on the environment.

A scaled analysis is an analysis that is more limited in scope and would typically rely on benefits transfer methods (the use of results of previously completed studies to estimate benefits) and secondary data sources. A scaled analysis may be more appropriate for projects or activities with relatively low costs/low risks or with effects that are relatively easy to quantify. Similarly, if it appears that the magnitude of benefits and/or costs are such that refining benefit and cost estimates will not affect the outcome of the analysis, then a scaled analysis may be appropriate.

This analysis includes components that would be considered a scaled type of analysis, such as the estimation of ecosystem related benefits, and some that are more of a standard type of analysis, such as the methods used to estimate irrigation benefits. The primary category of project benefits associated with the New Mexico Unit of the Central Arizona Project (New Mexico Unit) is irrigated agriculture from increased and more reliable irrigation water supplies. Therefore, irrigation benefits generated by the project should be estimated as rigorously as possible and a standard type of analysis is appropriate. Environmental benefits are smaller than irrigation benefits, not unimportant but just smaller in magnitude, so a scaled analysis of a smaller benefit is less likely to create bias and is appropriate for use in estimating benefits.

A variety of methods are used to evaluate the potential irrigation benefits from the project alternatives, resulting in a range of benefits. All of the methods used to estimate benefits are based on market-based values or net farm income associated with an increased water supply. Some potential benefits associated with cultivated irrigated land were also included as part of the analysis.

The economic costs of a project include construction costs; operation, maintenance, and replacement (OM&R) costs; the Central Arizona Project (CAP) water exchange cost; and interest during construction (IDC). Construction and OM&R expenditures are clearly economic costs because they represent resources used to provide a good or service. Construction and OM&R costs are considered opportunity costs associated with these activities. An opportunity cost is the lost benefit an individual or business sustains when one alternative is chosen over another. The exchange cost for CAP water is also an economic cost because the price of CAP water is determined by real resources costs; specifically energy, operation, maintenance, and replacement costs associated with CAP water as determined by the Central Arizona Water Conservation District (CAWCD) Board of Directors. Therefore, the CAP exchange costs represent an economic cost associated with supplies provided by the New Mexico Unit of the CAP. Interest during construction (IDC) represents the difference between funds used for construction and the economic cost of capital invested in the project when the project is brought into service at the end of construction. Essentially it is the opportunity cost of funds that are not yet generating benefits.

All benefits and costs are analyzed in this analysis using a 100 year period of analysis. The Department of the Interior Agency Specific Procedures for applying the PR&G specifically state that the period of analysis should be the shorter of 1) the period of time over which the project being analyzed can reasonably be expected to have beneficial or adverse effects or 2) a period not to exceed 100 years. The engineering estimates indicate the proposed project would have a useful life of at least 100 years; therefore a 100 year period of analysis is used.

The Department of the Interior Agency Specific Procedures for applying the PR&G also discuss the rate at which future costs and benefits should be discounted. The discount rate is used to convert costs and benefits that occur at different points in time to a present value. For analysis of Federal water resource investments, the prescribed discount rate in OMB circular A-94 is the rate prescribed in the Federal requirements. The project plan formation and evaluation rate calculated by the Federal Treasury Department for the Bureau of Reclamation for fiscal year 2020 is 2.75%.

Analysis Perspectives

There are several different perspectives that can be taken when evaluating a project, policy or regulation (action). The PR&G represent a national level perspective related to the public at large and addresses whether society is better off with an action or without an action. An economic analysis is typically from the perspective of society as a whole. Another perspective is more regional, determining whether the local population is better off with an action or without an action. The conclusions of these perspectives in terms of the desirability of an action may be different, but this difference is due to the affected population considered rather than inconsistency of the analysis. The PR&G perspective considers all benefits and costs to whomever they accrue while the regional/local perspective would not include costs paid by those located outside the local region. Another reason why different perspectives could arrive at different conclusions is the inability to monetize or accurately define and measure some of the benefits and costs of an action. These different types of analyses and perspectives are described in more detail below.

Economic Analysis

An action is considered economically feasible when the benefits generated by the action, direct and indirect, are greater than the resource costs of the action. Economic feasibility implies that society is better off when an action is taken than without. An example of a direct benefit from increased water supplies is an increase in net farm revenues resulting from the application of irrigation water and increased crop production. An example of an indirect benefit is the value of reduced erosion on land where irrigation water is applied which helps maintain long-term soil productivity and reduced offsite sediment damages.

Economic analyses have traditionally focused on quantifiable, monetized benefits and costs. These traditional analyses typically present benefits and costs in terms of net benefits (total benefits minus total costs) or as a benefit-cost ratio (total benefits divided by total costs). Positive net benefits and/or a benefit-cost ratio greater than 1.0 indicates a project is economically justified. Potential benefit categories include agricultural water supplies, water quality, environmental quality, and others.

An economic analysis is from a broad national perspective, where benefits and costs could be monetized or non-monetized and could accrue to those inside or outside the project area. Interest during construction (IDC) is added to construction costs to represent the full economic cost of a project. In private project financing, IDC represents the interest that would accumulate on funds borrowed to finance construction of a facility. IDC accrues until a project generates benefits and can support project payments. In public financing, IDC represents the difference between funds appropriated for construction and the economic cost of capital invested in the project when the project is brought into service at the end of construction. This difference represents an economic cost that must be included in economic justification and can be thought of as an opportunity cost for funds that could be invested elsewhere if they were not tied up in project construction. This calculation is complicated somewhat if different construction periods are assumed for various components. For the purposes of calculating IDC in this analysis, it is assumed that the construction period for all diversion, storage structures, and other components is 5 years and the project planning rate of 2.75% is applied to calculate interest costs. IDC is calculated separately for each component and summed. Due to the relatively short period of construction, IDC is a relatively small portion of total economic costs.

Cost Effectiveness Analysis

A cost effectiveness analysis is similar to an economic analysis, but it answers a slightly different question. A cost effectiveness analysis identifies the alternative among a group of alternatives that can achieve a particular objective at the lowest cost or it can be used to identify the alternative that has the lowest cost per unit of change. For example, if two alternatives would each provide 100 acre-feet of increased irrigation water supplies of the same reliability and quality, cost effectiveness analysis is simple forward and the lowest cost alternative would be the most cost effective. If there are two alternatives under consideration and the first would provide 100 acre-feet of irrigation water and the second would provide 50 acre-feet of water, cost effectiveness can be evaluated by dividing the cost of each alternative by the acre-feet of water supplied. In this case, the costs of each alternative are converted into comparable costs per acre-foot of water and the lowest cost per acre-foot would be considered most cost effective. Costs must be monetized but monetization of benefits is not necessary in cost effectiveness analysis.

Cost effectiveness helps in choosing between two or more alternatives without estimating benefits and explicitly comparing benefits to costs. Cost effectiveness aids in choosing a lower cost option, but does not answer the question of whether or not any of the options are economically justified. This approach can be used when it is not possible to monetize important benefits associated with an alternative or if the estimation of monetary benefits is considered unreliable. The cost effectiveness approach is valid if all levels of service provided by each of the alternatives would be acceptable to water users.

Financial Analysis

A financial analysis is basically an evaluation of cash flows and affordability of a project or action from the perspective of individual businesses, households, and agencies. A financial analysis generally includes information on project costs, revenues and/or services generated by the project, and the financial resources available to pay for the project compared to project costs. A project is considered financially feasible if the financial resources of the project beneficiaries are sufficient to pay the capital and annual operation and maintenance costs associated with the project. A financial analysis would be an appropriate analysis to use for making a business case for a project.

Regional Impact Analysis

The primary purpose of a regional impact analysis is to evaluate the effect of an alternative on income, employment, and the value of output produced in the region where the proposed action is located. Regional impacts can include the following types of impacts:

- Short-term impacts from construction expenditures,
- Long-term impacts from operation, maintenance, and replacement expenditures,

- Long-term impacts from changes in production and income/revenue associated with an alternative,
- Long-term impacts from changes in expenditures associated with any changes in other activities associated with an alternative.

The total regional impacts associated with the location of an industry in a region are the sum of direct, indirect, and induced effects. Direct effects represent impacts on the industry that is immediately affected. Indirect effects account for inter-industry transactions. Induced effects measure the effects of the changes in household income on demand for goods and services such as housing, restaurants, and retail sales. Regional impacts are generally measured in terms of employment, income, and the value of output produced.

Regional economic impacts are generally not equivalent to economic benefits. Economic benefit is a measure of well-being from the perspective of all of society while regional economic impacts are a measure of changes in income and other factors from the perspective of a local community or region. Any project or program that results in increased spending in a region will increase economic activity and generate some level of positive regional impacts, but will not necessarily generate economic benefits. Therefore, in most cases regional impacts cannot be added to economic benefits as a measure of total benefit.

Increased employment can be considered an economic benefit if a region has “substantial and persistent unemployment” and its labor resources will be “employed or more effectively employed” with a project in place, then the net additional income to the unemployed and underemployed can be defined as a benefit. Substantial and persistent unemployment is defined in terms of a rate 50% to 100% above the national average over a 2 to 4 year period.

Economic Analysis of the New Mexico Unit of the CAP

Two categories of benefits are considered in this economic analysis of the New Mexico Unit, irrigation benefits and potential erosion reduction and soil fertility benefits associated with irrigated crop production. Cost categories include construction, OM&R, IDC, and potential ecosystem costs resulting from short-term and long-term disturbance of existing lands under each alternative. Project benefits associated with increased irrigation water supplies, benefits from reduced soil erosion and increased soil fertility, and environmental costs from land disturbance are more difficult to estimate than project costs related to construction and OM&R. Construction and OM&R related costs are based on engineering estimates of quantities and market prices of inputs required to build and operate alternative projects whereas increased irrigation water supply benefits, soil fertility benefits are not generally directly available in terms of market prices. Therefore, alternative methods for estimating irrigation water supply values, based on willingness to pay (WTP), are needed. WTP is defined as the maximum amount an individual is willing to pay for a product or service and is a measure of the value of a good or service to an individual. The various methods used to estimate irrigation water supply benefits are discussed below.

Irrigation Water Supply Benefits

Regardless of the technique used to estimate irrigation benefits, the components that need to be considered in the analysis include cropping patterns, crop yields, crop prices, and production costs. These components all contribute to the net return from agricultural production and the value of water as an input to production. Four measures are used in this analysis to estimate WTP or benefit of irrigation water: the amount paid for water in a sales or lease transactions for water for agricultural purposes, the capitalized value of water as it contributes to land values, the lease value of irrigated land versus the value for non-irrigated land, and the net revenues from crop production with irrigation water supplies compared to net revenues without irrigation water.

Water Transaction Data as a Measure of Value

Water lease and purchase transaction data for New Mexico and Arizona were obtained from the Water Strategist. The Water Strategist was published from 1987 to 2010 by Stratecon, Inc. and provided a summary of water lease and purchase transactions in the 17 western states. Publication of the Water Strategist ceased in 2010, therefore, the water transaction data used in this analysis generally does not go beyond 2010. Arizona data were included because end water uses for the two states are similar. Arizona agricultural production, in terms of irrigated crop types and yields, are similar to southwestern New Mexico and urban uses in the two states are also similar.

Water transaction data represent market-based values, where the price paid by the purchaser is an indicator of willingness to pay. If the water is purchased for irrigation, then the price paid by the purchaser is a measure of the benefit of irrigation water supplies. If the water is purchased for urban purposes, then the value is a measure of municipal and industrial water supply benefits. Transaction data were collected for both agricultural and urban water supply transactions.

Agricultural transactions are the basis for estimating irrigation benefits in this analysis. However, urban transaction data were obtained to better understand changes in water markets since 2010. The latest Water Strategist data were published in 2010. However, Stratecon, Inc. currently publishes the on-line Journal of Water, which provides some more recent New Mexico water transaction data from 2014 to 2016 for the Albuquerque Bernalillo County Water Utility Authority (ABCWUA). ABCWUA represents urban water use, so the average value of urban water transactions using the 1987 to 2010 Water Strategist data is compared to the average value from the 2014 to 2016 Journal of Water data to understand changes in New Mexico water markets over the last 10 years. Data pertaining to the ABCWUA was not used in this analysis to estimate irrigation benefits, but only for the evaluation of changes in water markets over time. Data were also obtained for urban water purchases to demonstrate for informational purposes the variation in water transaction values depending on type of use.

Water Transaction Data

There were 12 lease water transactions and 8 permanent water sales transactions to agricultural buyers reported in the Water Strategist for Arizona and New Mexico from 1987 to 2010 from which usable values per acre-foot could be derived. Most of the lease transactions were for a single year. There were 14 lease water transactions to urban buyers and 131 permanent water sales transactions to urban buyers over the same period. A little over 79% of all water transactions were permanent transfers for urban water use and nearly 88% of all transactions were for urban water use. The high percentage of water transactions going to urban water purposes reflects the concept that goods and services within a market move towards the "highest and best use." In other words, the high percentage of transactions representing transfers to urban uses reflects a relatively high value of water for urban use. Permanent water right and leased water transaction values for agricultural use are summarized in Table 1. All values are converted to 2019 dollars using the Consumer Price Index.

Table 1 – New Mexico and Arizona permanent water right and lease values for transactions to agricultural use indexed to 2019 dollars

	Type of Transfer	
Measure	**Sale for agricultural use**	**Lease for agricultural Use**
Annualized value per acre-foot		
Average	$86.07	$96.70
Maximum	$167.62	$246.72
Minimum	$60.53	$23.22
Median	$69.21	$80.33
Present value of a "permanent" right per acre-foot		
Average	$3,130	$3,516
Maximum	$6,095	$8,972
Minimum	$2,201	$844
Median	$2,517	$2,921

Source: Stratecon Inc. Water Strategist transaction data.

The water transaction values for agricultural use are fairly consistent whether looking at water right sales or leasing values. As expected, the lease values presented in Table 1 are slightly higher than the sales values. This was expected because a water right does not guarantee a specific quantity of water will be delivered while a lease value is for a specified quantity. Therefore, the annual equivalent value of a water right may understate the value of water and the lease values are likely to be the most accurate estimate of value. The annual equivalent permanent water right values are presented for completeness in using all available water transaction data and for comparison and support for using lease-based values.

The most representative measure of value (average, maximum, minimum, or median) is subject to interpretation. The high value may represent a willingness to pay for irrigation water for higher valued crops or for short term water supplies needed at a critical time. The average or median values could represent the value of water for an average cropping pattern or during normal weather and growing conditions. The low values could be representative of wet periods or demand for irrigating lower valued crops.

There are advantages and disadvantages in using the average and the median value as a representative value for a set of data. One advantage of using the average is that the calculation of the average includes every observation in the data set. However, a disadvantage of the average is that extreme values (outliers) can have a large and disproportional influence on the average value. If a data set includes a large number of observations and does not include outliers, the average value provides a good measure of central tendency and will be near the median value. An important advantage of using the median as a measure of central tendency is that extreme values (outliers) do not affect the median as strongly as they affect the average. Therefore, the median is appropriate when data outliers exist and the data set is not very large. Another advantage of the median is that the median is likely to be different for two data sets that have different distributions while the average may be the same or very similar for the same two data sets. It is important to capture differences implied by the distribution of values.

Considering that the New Mexico Unit of the CAP would provide a more secure water supply which could be used to support development of higher valued crops, such as pecans, the maximum value may be a reasonable estimate of irrigation water supply benefits. However, not all of the AWSA water would necessarily be used for high valued crop production. Some water would potentially be used for more traditional crops.

Assuming pecans producers would be willing to pay a higher price for water as a result of higher potential returns from pecan production and the cropping patterns presented in Table 14 in the cropping rotations, irrigation requirements, prices, and yield section, 25% of water supplied by the project could reflect the highest lease value of $246.72 per acre-foot. The remaining 75% could be valued at the lease average value of $96.70 per acre-foot. Based on these assumptions, the weighted value of agricultural water would be $134.21 per acre-foot of water per year in 2019 dollars.

Water transaction data were also obtained for urban water use and water transaction values for urban water use in 2019 dollars are presented in Table 2. Urban water values were obtained to provide a comparison of values for agricultural and urban use and also to provide a basis to update water values to more recent water supply conditions. This information can more readily help calculate the general fluctuation in the price of water. The only data available for New Mexico water transactions over the 2014 to 2016 period are transfers for water obtained by the ABCWUA for urban water uses. The urban transfer value data shown in Table 2 are compared to 2014 to 2016 ABCWUA data presented in Table 3 to estimate a water market price index that can be applied to agricultural water supply values to reflect more recent water market conditions.

Table 2 – New Mexico and Arizona permanent water right and lease values for transactions to urban use from 1987-2010 indexed to 2019 dollars

	Type of Transfer	
Measure	**Sale for Urban Use**	**Lease for Urban Use**
Annualized value per acre-foot (2019 dollars)		
Average	$89.32	$269.50
Maximum	$716.45	$1,404.20
Minimum	$10.12	$52.95
Median	$62.27	$119.91
Present value per acre-foot of a "permanent" right (2019 dollars)		
Average	$3,248	$9,800
Maximum	$26,053	$51,062
Minimum	$368	$1,926
Median	$2,264	$4,360

The change in average urban water values from the older transactions in the Water Strategist to average values from the newer transactions Journal of Water are used to represent the general change in New Mexico water markets that may apply to all types of use. Average weighted water prices over the years 2014 to 2016, where the weight is determined by the quantity of water associated with the transaction, for water obtained by the ABCWUA are shown in Table 3.

Table 3 – ABCWUA average water right values from 2014 to 2016 indexed to 2019 dollars

Weighted average price	**Water right value per acre-foot**	**Annualized water right value per acre-foot**	
		Over 100 years	**In perpetuity**
2014	$12,167	$358	$335
2015	$11,931	$351	$328
2016	$12,818	$378	$352

Source: Stratecon, Inc., Journal of Water, January 31, 2017.

The water right values from Table 3 in 2019 dollars range from $11,931to $12,818 per acre-foot and the annualized values range from $358 to $378 per acre-foot in 2019 dollars based on a 100-year period of analysis and $328 to $352 per acre-foot in perpetuity. The average water right value over the 2014 to 2016 period was about $12,305 per acre-foot in 2019 dollars and the average over the 1987 to 2010 period in 2019 dollars was $9,800, which represents a 25.6% increase. Applying the 25.6% increase to the weighted average agricultural water value of $134.21 per acre-foot results in a value of water of $168.57 per acre-foot per year in 2019 dollars. Applying the 25.6% increase to the high water lease value results in a value of $309.88per acre-foot per year in 2019 dollars.

An analysis presented by F. Lee Brown (2007) at the New Mexico Water Resources Research Institute's (WRRI) 52th Annual Water Conference evaluated water right transaction data throughout New Mexico. The transactions included water for a variety of purposes, including agriculture, and distinguished between values for water rights and bulk water. A water right transaction does not guarantee water delivery, but represents a maximum amount that can be taken if available. In New Mexico, water rights are generally measured in terms of the number of acre-feet of consumptive use per year. In some New Mexico basins, water rights are measured in terms of water right acres, which are the number of irrigated acres for which a property owner holds water rights. The term "bulk water" means the raw water commodity itself and is represented by leased or rented water. Bulk water is a quantity of water that is actually delivered over or at a specified time. Water rights transaction values presented by Brown (indexed to 2017 dollars for purposes of this analysis) are shown in Table 4. Bulk water prices based on short term lease rates are presented in Table 5.

Table 4 – Water rights prices per acre-foot indexed to 2019 dollars

Basin/District	Low price	Annual equivalent low price	High price	Annual equivalent high price
Santa Fe tributaries (urban influence)	$42,607	$1,172	$54,781	$1,506
Middle Rio Grande (upper basin)[1]	$24,347	$670	$42,607	$1,172
Middle Rio Grande(lower basin)[1]	$10,957	$301	$24,347	$670
Rio Hondo (upper tributaries)	$12,782	$351	$17,042	$469
Taos tributaries	$12,174	$335	$14,608	$402
Rio Hondo	$8,521	$234	-	-
Lower Rio Grande (agricultural)	$3,653	$100	$6,087	$167
Roswell Artesian Basin	$2,800	$77	$2,921	$80

[1]The terms upper basin and lower basin are used in the paper "Market Prices as Measures of Water Scarcity in New Mexico and the West." Presented at NM WRRI's 52th Annual Water Conference by F. Lee Brown. These designations are specific to his paper and do not represent official designations of the Middle Rio Grande.

Source: F. Lee Brown (2007)

Table 5 – Bulk lease water prices per acre-foot indexed to 2019 dollars

Basin/District	Price
Jicarilla/Santa Fe Contract	$609
Carlsbad Irrigation District	$122
San Juan Chama Project	$21 to $122

Source: F. Lee Brown (2007)

The greatest urban influences on water prices occur on the Santa Fe tributaries and the Rio Grande upper basin as described in Brown (2007). Urban influences also exist to a lesser extent for the Middle Rio Grande lower basin, the Rio Hondo upper tributaries, and the Taos tributaries as described in Brown (2007). The Lower Rio Grande and Roswell Artesian Basin values described in Brown (2007) are most likely to be representative of agricultural water values, with annualized values ranging from $80 to $167 per acre-foot using 2019 dollars. It should be noted that the annualized value of a permanent water right is not necessarily the same as the value of the actual amount of water delivered for every year. As described above in the introduction to the water transaction data, the annual equivalent value of a water right may understate the value of water because a water right does not necessarily represent a quantity of water that would actually be delivered. The data presented by Brown are well within the range of values described above using the Stratecon, Inc. data except for the Jicarilla/Santa Contract value.

A study by De Mouche, Landfair, and Ward (2011) projected water rights prices for the Rio Grande project into the future. A range of water right values for various scenarios was presented in the paper based on a range of assumptions regarding growth of food prices and levels of urban water conservation. The projected water rights values for 2020 were estimated to range from $2,964 to $3,759 per acre-foot. The equivalent annual value for these permanent water rights applying a discount rate of 2.75% ranges from $81.51 to $103.37 per acre-foot.

Four different scenarios are included in the forecast Rio Grande project water prices.

- Without increasing food prices and without an urban water conservation program
- With increasing food prices and without an urban water conservation program

- Without increasing food prices and with urban water conservation
- With increasing food prices and with urban water conservation

The projected values per acre-foot for each scenario are shown below in Table 6. The permanent water values are also converted into annual equivalent values.

Table 6 – Range of forecast 2020 water rights prices per acre-foot for the Rio Grande Project indexed to 2019 dollars

	Forecast Water Rights Price per acre-foot (2019 dollars)			
Measure	Without food price growth and with urban water conservation	With food price growth and with urban water conservation	Without food price growth and without urban water conservation	With food price growth and without urban water conservation
Present value of a permanent right	$3,609	$3,901	$4,284	$4,576
Annualized value per acre-foot (@ 2.75% rate)	$99	$107	$118	$126

Source: De Mouche, Landfair, and Ward, 2011.

Analysis of Differences in Land Values

Land value analysis is also considered an acceptable method for estimating irrigation benefits. Theoretically, the value of a parcel of land reflects the capitalized value of the expected net income or revenue that can be derived from the land. A land value analysis assumes that the net revenue associated with irrigation water supplies is capitalized into the land value and a comparison of irrigated land values and non-irrigated land values will reflect the present value of the net revenue stream difference over time. Therefore, the difference in land value for irrigated land and non-irrigated cropland is the benefit of irrigation water improvements because it represents the difference in net income generation.

Irrigated and non-irrigated cropland values for the southwest New Mexico region were obtained from the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). Land value data from 2008 to 2018 are shown in Table 7.

Table 7 – Irrigated and pastureland non-irrigated land values

Year	Irrigated value in $/acre	Non-irrigated value in $/acre	Nominal difference in value	Difference in value converted to 2019 $'s
2018	$3,930	$440	$3,490	$3,553
2017	$3,930	$440	$3,490	$3,640
2016	$3,930	$390	$3,540	$3,759
2015	$3,920	$390	$3,530	$3,795
2014	$3,930	$390	$3,540	$3,848
2013	$3,910	$400	$3,510	$3,883
2012	$4,450	$430	$4,020	$4,519
2011	$5,190	$410	$4,780	$5,473
2010	$5,290	$390	$4,900	$5,726
2009	$5,390	$390	$5,000	$5,914
2008	$5,360	$410	$4,950	$5,899

Source: USDA NASS, Quick Stats website https://quickstats.nass.usda.gov

The differences in values shown in Table 7 represent the present value of capitalized irrigation water supply benefits. The differences can be annualized over the 100 year period of analysis or in perpetuity to represent an annual equivalent value of irrigation water supplies per acre. The annual value of irrigation water per acre-foot are calculated assuming a range of irrigation applications of 2.5, 3.0, and 4.0 acre-feet per acre. The 2.5 acre-foot per acre use value coincides with lowest water use crops of pasture and corn, 3.0 acre-feet per acre was assumed by HDR Engineering for their hydrology study, and 4.0 acre-feet value coincides with pecan water irrigation requirements. Pecans are the representative high valued irrigated crop. The average annual irrigation water supply benefit based on the 2008 to 2018 data and a 100 year period of analysis is $133.91 per acre in 2019 dollars. The irrigation water benefit is $53.56 per acre-foot assuming an irrigation application rate of 2.5 acre-feet per acre, $44.64 per acre-foot assuming an application rate of 3.0 acre-feet per acre, and $33.48 per acre-foot assuming an application rate of 4.0 acre-feet per acre.

Cash Rent Data

Similar to the land value analysis discussed above, cash rent data can be used to evaluate the contribution of irrigation to the value of crop output as an input to production. USDA NASS cash rent data were obtained at the county level for southwestern New Mexico for irrigated cropland and non-irrigated pastureland. The difference in cash rent value between irrigated and non-irrigated land, assuming other land characteristics are similar, are attributable to the irrigation input. There were 12 observations for irrigated cropland cash rents and 22 pastureland observations over the last seven years of available data. The cash rent data are summarized in Table 8.

Table 8 - Cash rent based irrigation benefits

Measure	Cash rent per acre (2019 $'s)			Estimated value per acre-foot (2019 $'s)		
	Irrigated Cropland per acre	Non-irrigated pasture per acre	Difference in value per acre between irrigated and pastureland cash rents	Assuming average application of 2.5 acre-feet/acre	Assuming average application of 3.0 acre-feet/acre	Assuming average application of 4.0 acre-feet/acre
Average	$183.78	$2.03	$181.75	$72.70	$60.58	$45.44
Median	$195.52	$1.86	$193.66	$77.46	$64.55	$48.42
Maximum	$233.70	$4.35	$229.35	$91.74	$76.45	$57.34
Minimum	$82.28	$1.17	$81.11	$32.44	$27.04	$20.28

The cash rents presented in Table 8 are expressed as annual values. Therefore, dividing the difference in cash rents between irrigated and non-irrigated land by the assumed irrigation water application will result in an estimated irrigation benefit per acre-foot or water. Given the limited number of data observations, the median values are used as representative values. The median difference in cash rent is $193.66 per acre. The estimated irrigation water benefit is $77.46 per acre-foot assuming an irrigation application rate of 2.5 acre-feet per acre, $64.55 per acre-foot assuming an application rate of 3.0 acre-feet per acre, and $48.42 per acre-foot assuming an application rate of 4.0 acre-feet per acre.

Farm Budget Analysis

Irrigation water supply benefits can also be estimated using a farm budget approach. Farm budgeting is a process of estimating costs, returns and net farm income for a farm operation. Irrigation benefits are estimated by comparing net farm income for an operation that does not include irrigated acreage with an operation that does include irrigated production that could be supported by project water. The difference in net farm income is attributed to the irrigation water input. The dryland and irrigated farm budgets must be representative of the types of operations that exist in the four-county study area (Luna, Hidalgo, Grant, and Catron Counties) without project water and conditions that would exist with project water. Representativeness is considered in terms of cropping patterns, crop yields, output prices received, variable and fixed input requirements, and input prices. Irrigation water supply benefits estimated using the farm budget approach represent an annual value of benefit per unit of water.

Agriculture in the New Mexico Unit of the Central Arizona Project Study Area

Pastureland is the predominate agricultural land use in the study area. Other crops produced in the region include alfalfa, corn for grain and silage, cotton in Luna and Hidalgo County, some small grains in Luna County, and pecans in Grant, Hidalgo and Luna County. Irrigated crop acreages for the study area counties, based on the 2017 Census of Agriculture, are shown in Table 10. The Census of Agriculture data in Table 9 does not include pastureland. Pastureland data from the 2017 Census of Agriculture are presented in Table 10. The data in tables 9 and 10 indicate pastureland currently represents a major portion of productive agricultural land in the region and this pattern is likely to continue into the future with or without a project.

Table 9 – Irrigated crop acreage in the four-county study area region

Crop	Acreage by County			
	Catron	Grant	Hidalgo	Luna
Alfalfa	(D)	401	6,303	(D)
All Hay	155	1,127	7,091	6,770
Corn	-	(D)	2,539	1,565
Cotton	-	-	(D)	2,923
Pecans	-	14	(D)	1,658
Sorghum	-	-	-	463
Wheat	-	-	-	228

D – The Census of Agriculture does not provide data to avoid disclosure of individual producers

Table 10 – Pastureland acreage in the four-county study area region

Crop	Acreage by County			
	Catron	Grant	Hidalgo	Luna
Pasture	1,253,037	880,321	821,817	541,981
Pastured cropland	3,286	4,378	(D)	1,320

D – The Census of Agriculture does not provide data to avoid disclosure of individual producers

Cost and Return Estimates for Farms and Ranches are generated by the New Mexico State University College of Agricultural, Consumer and Environmental Sciences. The cost and return budgets are generated for several areas throughout New Mexico. A whole farm budget including alfalfa and alfalfa establishment, permanent pasture and pasture establishment, and livestock was available for Grant and Catron counties combined. The most recent information available for these counties was 2012. The total farm size budgeted was 60 acres and the amount of irrigation water used was 5 acre-feet per acre for alfalfa and 2.67 acre-feet per acre for pasture. Cost and return budgets are also available for Hidalgo County for 2018 which include alfalfa, cotton, corn, and sorghum. Specific detailed New Mexico pecan budgets are not available: however, pecan budgets are available from Oklahoma State University Department of Agricultural Economics Extension, the University of Georgia Pecan Extension, and Texas A&M AgriLife Extension. The Texas A&M pecan budget does not include first year planting or following year development costs. Therefore, for development costs, the Georgia and Oklahoma budgets were used for reference.

Cropping rotations, irrigation requirements, prices, and yields

The irrigated crops and cropping patterns used for estimating net revenues in the farm budget and regional impact analysis which represent the value of production associated with a project are based primarily on information provided in a New Mexico State University study of agricultural production in Southwest New Mexico from the 2004 Arizona Water Settlement Act (Ward, Crawford, and Schurr, 2014) and a study of the best agricultural uses of Arizona Water Settlement Act Water and Funds (Competitive Advantage Consulting Ltd., 2012). The above studies and information indicate alfalfa and pasture will remain the predominant crops in the Cliff-Gila and San Francisco Valley areas, with greater acreages of high valued crops such as pecans, grapes, and chilies possible if a supplemental source of water was available.

It is clear that with-project cropping patterns will not simply be a continuation of historical conditions because the supplemental water supply will provide increased reliability and potentially support higher valued crops that require higher levels of up-front investment relative to existing crops. The 2014 study by Ward, Crawford, and Schurr evaluated the potential impacts of AWSA water and storage on cropping patterns in the study area and provided specific crop acreages with AWSA water. This represents conditions similar to the with-project conditions. Table 11 shows a summary of cropping patterns presented in the Ward, Crawford, and Schurr study.

Table 11 – Cropping patterns with AWSA water and storage (Ward, Crawford, and Schurr; 2014)

Crop	**Hidalgo County (Virden Area) cropping percentages**	**Grant County (Cliff-Gila Area) cropping percentages**
Pasture	14.03%	81.75%
Alfalfa	15.89%	12.89%
Corn	22.70%	-
Cotton	31.77%	-
Pecans	5.14%	3.41%
Chilies	6.81%	-
Grapes	3.66%	1.95%

Pecans, chilies, and grapes were included as possible high valued crops with AWSA water and storage in the 2014 Ward, Crawford, and Schurr study. Pecans and grapes were included in both the Virden area and the Cliff-Gila area. Generally, crops included in an analysis of potential irrigation project benefits, as is required under the PR&G, must be considered commercially viable. Commercial viability implies that a representative operation can produce and market a crop that generates sufficient revenue to cover operating expenses, provides a return to labor and management, and provides income to support the farm operator. One piece of information that provides evidence of viability is the existence of crop production under current conditions, such as current pecan production.

Pecans and grapes are included in both the Ward, Crawford, and Schurr study and the Competitive Advantage Consulting Ltd. study as potential high valued crops that could be grown in the region. In addition, Appendix 2 of Ward, Crawford, and Schurr (2014) provides the results of Producer Panel interviews. The list of important crops provided by the Producer Panels includes wheat, sorghum, alfalfa, green chile, cotton, onions, and pecans. An important crop could be interpreted as the crop with the largest acreage, the crop that produces the greatest revenues, the crop best suited to local conditions, or the crop which the producer is most familiar with and is most likely to produce. As a further check on potential future crops that could be grown in the project area, USDA Agricultural Census pecan and grape acreage data were checked as an indicator of potential viability. USDA state level acreage data are shown in the Table 12 below.

Table 12 – New Mexico grape and pecan acreage

Year	New Mexico State Acreage	
	Grapes (acres)	Pecans (acres)
2017	1,280	50,722
2012	1,153	41,331
2007	1,103	39,245
2002	1,030	37,763
1997	1,249	31,815
Average	1,163	40,175

The state level data indicate grapes are a relatively minor crop in New Mexico compared to pecans. Grape producers would likely need to develop a marketing and distribution network to potentially become competitive in grape production, while a marketing structure currently exists for pecans. New Mexico ranks second in the United States in state level pecan production behind Georgia and a market structure currently exists in New Mexico for the production and distribution of pecans. Given the existing marketing potential for pecans and the potential for success of pecan production in the area, pecans are included in the with-project cropping rotation to represent a high valued crop. Projected grape acreage, along with chilies and other specialty crops, were accounted for as a part of pecan acreage.

Cotton is the predominant crop grown in the Virden Valley area, with approximately equal acreages of corn and alfalfa. Again, pecans are included to represent a potential high valued crop that could be grown in the area. The cropping patterns used to evaluate irrigated crop production with a project in place are shown in Table 13 below. As discussed above, the crop percentages closely follow those presented in Ward, Crawford, and Schurr (2014).

Table 13 – Assumed cropping patterns for irrigated acreage with AWSA water

Crop	Cropping Pattern by Project Location		
	Virden Valley	San Francisco River Valley	Cliff – Gila Valley
Pasture	10%	70%	70%
Alfalfa – Established	12%	12%	12%
Alfalfa – Establishing	3%	3%	3%
Corn	20%	-	-
Cotton	30%	-	-
Pecans	25%	15%	15%

Irrigation requirements are based on information from the 2012 study by Competitive Advantage Consulting Ltd., the 2018 New Mexico State University College of Agricultural, Consumer and Environmental Sciences projected crop cost and return estimates (New Mexico State University, 2018) obtained from website https://aces.nmsu.edu/cropcosts/, and a July 22, 2019 Growing the Valley podcast of Pecan Basics with Richard Heerema by Phoebe Gordon with the University of California Cooperative Extension. The irrigation requirement data for pecan production presented in the 2012 study by Competitive Advantage Consulting Ltd. Study and the New Mexico State University projected crop cost and return estimates indicate approximately 5 acre-feet of irrigation water needs to be applied to pecans for full production. However, in the July

22nd podcast Richard Heerema indicates that, with new irrigation application methods, 48 inches of irrigation water is sufficient for pecans; this is equivalent to 4 acre-feet of irrigation water per acre of land. Therefore, the 4 acre-feet irrigation application rate is used in this analysis for pecans.

For the agricultural farm budget analysis, the current condition is defined as the most recent 5-year average prices and yields. It is recognized that prices and yields can fluctuate considerably from year to year. To account for this fluctuation, the 5 -year average is used. New Mexico state level prices for each crop over the most recent 5 years were obtained from the New Mexico Annual Bulletin, New Mexico Agricultural Statistics compiled by the United States Department of Agriculture, National Agricultural Statistics Service, New Mexico Field Office. County level yields for the most recent five years were obtained from the United States Department of Agriculture, National Agricultural Statistics Service, data and statistics web page https://www.nass.usda.gov/Statistics_by_State/New_Mexico/index.php. Irrigation requirements, yields, and prices used in the farm budget analysis are shown in Table 14.

Table 14 – Irrigation requirements, yields, and prices used in the farm budget analysis

Crop	Irrigation requirement in acre-feet per acre	Yield	Yield units	5 year average Price per unit
Pasture	2.5	6 AUM/AC[1]	AUM	$72.00[1]
Alfalfa (Cliff – Gila)	4.4	6.72	Tons	$213.80
Pecans	4.0	1,420	Pounds	$2.37
Cotton (lint)	2.75	1,326	Pounds	$0.62
Cotton (seed)	-	0.62	Tons	$235.20
Corn	2.5	183.7	Bushel	$4.35
Alfalfa (Virden)	4.4	6.93	Tons	$213.80

[1]Pasture revenues are based on a value of $6.00 per animal-unit-month (AUM) and 6 months of grazing for an annual value of $72. Yield represents an average of 6 AUM per acre for the six-month period used to estimate the annual value. The value per AUM is based on information from the New Mexico State Land Office for grazing fees for ranches on State Trust land.

The farm budget model used for estimating irrigation benefits does not include livestock. The rationale for estimating benefits using the value of forage and feed rather than the value of livestock is that the value of irrigation for these crops is as an input to cattle production. Therefore, the irrigation water benefit is associated with feed crop production.

Land Investment Costs

Land value data for irrigated and non-irrigated land is available at the state level from the USDA National Agricultural Statistics Service (USDA NASS, 2018). The average value of irrigated land from 2008 to 2018 was $4,475 per acre and the average value of non-irrigated land over the same period was $407 per acre. Using average land values for all of New Mexico as a representative value for agricultural land in the southwestern New Mexico study area could overstate land values since this area generally produces lower irrigated and non-irrigated yields than other areas of the state. However, projected changes with a project in place could lessen potential differences in land values for all of New Mexico and land values in southwestern New Mexico.

Input Costs

Cost and return budgets from New Mexico State University Cooperative Extension, the University of Georgia Pecan Extension, and the Texas A&M AgriLife Extension were used as a source of input costs. These costs are summarized in Table 15.

Table 15 – Estimated input costs per acre used in farm budgets

Cost Category	Alfalfa establishment	Alfalfa	Corn	Cotton	Pecans 1st year	Pecans Full production
Seed/trees	$76.25	-	$91.88	137.70	513.00	-
Fertilizer	$32.90	-	$33.04	63.00	39.96	85.54
Chemicals	-	-	-	14.08	132.15	38.21
Other input costs	-	$67.87	-	-	30.00	24.23
Fuel, oil, lubricants	$39.14	$30.89	$32.90	-	29.98	89.97
Repairs	$12.65	$4.76	$8.79	-	37.00	49.84
Land taxes	$2.57	$2.57	$2.57	2.57	2.57	2.57
Other misc. expenses, Including custom work	$0.64	$140.68	$140.66	141.56	100.00	85.54

Farm Size

According to the 2017 USDA Census of Agriculture, the average sized farm operation in southwestern New Mexico ranges from 2,213 acres in Grant County to 5,622 acres in Hidalgo County and averages 3,640 acres in Catron County. An irrigated farm size of 300 acres was used to budget an irrigated operation, with 15 acres (5% of total cultivated acreage) for farmstead and waste. This size of an irrigated operation is large enough to fully employ a farm operator. As described in the Farm Budget Analysis section on page 19, irrigation water supply benefits based on farm budgeting requires estimation of net farm revenues for comparison with an irrigated operation. A larger dryland acreage operation is required to fully employ a farm operator. A 1,200 acre farm plus 30 acres for farmstead and waste was used for a dryland farm. The 300 acre size farm was most commonly used in the New Mexico State University Cooperative Extension budgets and the 1,200 acre dryland farm was the size necessary to fully employ a farm operator.

Taxes and Social Security

Property taxes were computed on the full assessed value of land and on the inventory value of all equipment and improvements included for the farm. New Mexico Cost and Return Estimates for the Hidalgo County – Virden area used a property tax rate of 0.739% of value. The property tax valuation for Hidalgo County estimated by the New Mexico Department of Finance and Administration for 2017 was 0.718%, which was used for the Virden Valley budgets.

There were no Cost and Return Estimates for Grant County, but the New Mexico Department of Finance and Administration estimates a non-residential property tax rate of 0.748% for the 2017 tax year. The 2017 property tax rate for Catron County was estimated to be 0.820% of property value. An average rate of 0.785% was used for the Cliff – Gila budgets and the San Francisco Valley budgets to simplify the farm budget analysis since the same cropping patterns and yields were used for both areas.

Social Security expenses are not included in a benefit analysis, as these expenses represent a benefit transfer, and thus, do not impact benefits to the Nation.

Labor Costs

Farm labor includes farm operator, family, and hired labor. Labor hours for management are allocated at 2,080 hours and quantities of hired labor depends on need. The average and median labor rates were obtained from the Bureau of Labor Statistics, Occupational Employment Statistics data. These rates are shown in Table 16. The average and the median rate will differ if there is a substantial number of laborers earning rates that are at the high or low end of the labor rate scale. This appears to have occurred in New Mexico, where the median wage is generally lower than the average wage. A 5-year average wage rate (2013–2017) was used in the farm budgets. Using the average wage reduces the chance of understating the costs of production and includes the full range of observed labor rates. The farm operator labor rate used in the budgets is $19.10 per hour and the family and hired labor rate used is $13.42 per hour.

Table 16 – Labor rates used for the New Mexico Unit farm budgets

Occupation title and year	**Nominal hourly average wage**	**Nominal hourly median wage**	**Hourly average wage (2017 $)**	**Hourly median wage (2017 $)**
First-Line Supervisors of Farming, Fishing, and Forestry Workers				
2017	$20.71	$20.54	$20.71	$20.54
2016	$17.69	$16.39	$18.07	$16.74
2015	$19.54	$17.87	$20.21	$18.48
2014	$17.89	$16.89	$18.52	$17.49
2013	$17.09	$15.92	$17.98	$16.75
5 year average	**$18.58**	**$17.52**	**$19.10**	**$18.00**
Farmworkers, Farm, Ranch, and Aquacultural Animals				
2017	$12.03	$10.87	$12.03	$10.87
2016	$12.95	$11.74	$13.23	$11.99
2015	$13.87	$13.40	$14.34	$13.86
2014	$12.38	$11.16	$12.82	$11.56
2013	$13.94	$14.46	$14.66	$15.21
5 year average	**$13.03**	**$12.33**	**$13.42**	**$12.70**

Source: Bureau of Labor Statistics, Occupational Employment Statistics. Website: https://www.bls.gov/oes/tables.htm.

Return to Equity, Labor, and Management

Return to equity can be thought of as a return on capital which is owned. There is no return to equity in a benefits budget since all assets are treated as debt and interest is charged on 100 percent of assets. The farm operator's labor is valued at the current wage for supervisory farm labor. Labor performed by the farm operator's family should be valued at the same wage as hired farm labor because they represent a substitute for hired labor. The return to labor is the sum of the estimated farm operator's wages and the farm family wages. The return to labor is subtracted from the net farm income estimated by the farm budgets.

Six percent of the farm budget variable costs is used to represent the farm operator's return to management, or the operator's management ability over and above the supervisory labor rate. Return to management is an opportunity cost to the farm operator because it represents the farm operator's ability to earn income by applying his or her management skills elsewhere. Six percent of variable costs is the rate provided in U.S. Bureau of Reclamation farm budget guidance.

Farm Budget Results

The results of the farm budgets are summarized in Table 17. The negative net farm income results should not be interpreted as a financial loss from the farm operation. An economic analysis of benefit, or value, requires assumptions about the opportunity costs associated with farm investment, which is not the case for the purposes of estimating financial or accounting net income or profit. Therefore, the net farm benefit per acre is not equal to net farm income estimates produced on cost and return budget estimates. The negative net dryland farm income values in Table 18 are based on the assumptions of a farm budget based benefit analysis, such as the assumption of 100% debt for farm investment, as noted above.

Table 17 – Irrigated and dryland farm budget results

Representative Farm	Farm Size	Gross Income	Variable Expenses	Fixed Expenses	Returns to Farm Family	Net farm income	Net farm benefit per acre
Virden Valley							
Irrigated	300	$456,432	$218,610	$109,876	$37,930	$90,016	$300.05
Dryland	1,200	$43,200	$44,400	$20,700	$31,500	-$53,400	-$44.50
Irrigation benefit							**$344.55**
San Francisco River Valley and Cliff – Gila Valley							
Irrigated	300	$296,473	$153,027	$76,913	$26,550	$39,983	$133.27
Dryland	1,200	$43,200	$44,400	$20,700	$31,500	-$53,400	-$44.50
Irrigation benefit							**$177.77**

The estimated irrigation benefit is the difference in net farm income with irrigated production and under non-irrigated dryland conditions. The irrigation benefit for the Virden Valley area is $344.55 per acre and the average acre-feet of water applied for the representative cropping pattern is 4.06 acre-feet per acre. The average benefit for the Virden Valley is estimated to be $84.86 per acre-foot. The irrigation benefit for the Cliff – Gila Valley and the San Francisco Valley areas is $177.77 per acre and the average acre-feet of water applied for the representative cropping pattern is 3.01 acre-feet per acre. The average benefit for the Cliff – Gila Valley and the San Francisco Valley areas is estimated to be $59.06 per acre-foot.

Irrigation Benefits if Project Provides a Supplemental Water Supply for Pecan Production

University of Georgia horticulture specialist Lenny Wells and New Mexico pecan specialist Richard Heerema (2014) indicated increasing irrigation water application from 1,200 gallons per day per acre (equivalent to approximately 1.34 acre-feet per acre annually) to 3,600 gallons per day per acre (4.03 acre-feet per acre annually) would increase pecan yield by about 28.2%. Assuming that increased irrigation water supplies and efficiency in irrigation application with the New Mexico Unit in place would result in a similar percentage increase in pecan yield, additional pecan revenues with the New Mexico Unit can be estimated.

As discussed in the farm budget analysis section, pecan yields with the project in place are estimated to be 1,420 pounds per acre with 4.0 acre-feet of water applied. The base level yield without supplemental water provided by the project would be 1,108 pounds per acre (a 28.2% yield increase from 1,108 pounds equals 1,420 pounds). The increase in gross revenues associated with the project would be the increased yield with the project (312 pounds per acre) multiplied by the price of pecans ($2.37 per pound), or $739 per acre.

A detailed pecan budget produced by the University of Georgia, College of Agricultural and Environmental Sciences indicates approximately 17% of the cost of pecan production is directly related to yields (for example, harvest, cleaning and transportation costs). Assuming that the project water is applied to existing acreage and non-yield related costs are covered by existing production, the net pecan revenues generated by New Mexico Unit water supplies could be $613 per acre. At 4.0 acre-feet of water per acre, the net benefit of irrigation water for pecans would be approximately $153.25 per acre-foot. Assuming all project-related water is used for increased pecan production, irrigation benefits would be $153.25 per acre-foot. This value is very close to the maximum agricultural water right value for the transactions-based benefit estimate presented in Table 1 ($167.62) and about two-thirds of the maximum lease-based agricultural value shown in Table 1 ($246.72).

Summary of Irrigation Water Supply Benefit Values

The estimated water supply benefits associated with the New Mexico Unit using the methods discussed above are summarized below.

- Water transaction based values – Benefits range from $96.70 per acre-foot for average revenue crops to $246.72 per acre-foot for high valued crops such as pecans. A weighted average based on 25% of the AWSA water being the highest lease value and 75% being an average value would result in a value of $134.21 per acre-foot.
- Applying the 25.6% increase in water values observed for the Middle Rio Grande from 2013 to 2017, the maximum water lease value would be about $310 per acre-foot per year.
- Land value based irrigation water supply values – Benefits range from $33.48 to $53.56 per acre-foot.
- Cash Rent based values – Irrigation benefits range from $48.42 to $77.46 per acre-foot.
- Farm budget based values – Irrigation water supply benefits are estimated to be $84.86 for the Virden Valley area and $59.06 per acre-foot for the Cliff-Gila Valley and San Francisco Valley areas.
- Supplemental Water Supply based values – Supplement water supply benefits for pecan were estimated to be $153.25 per acre-foot.

The estimated annual irrigation water supply benefits using the five methods discussed above range from $33.48 to $310 per acre-foot of irrigation water. This is a fairly wide range of estimated benefits. However, assuming the project water will primarily be used to supplement production of higher valued crops that are marginal under current conditions, the range of benefits for higher valued crops would range from $153.25 to about $310 per acre-foot. The mid-point of the range is about $230 per acre-foot.

Potential Ecosystem Benefits from the New Mexico Unit

Ecosystem services can be broadly defined as the benefits obtained as a result of ecosystem functions. The Millennium Ecosystem Assessment (2019) describes four categories of ecosystem services and provides specific examples within these categories.

- Provisioning: Food, Raw Materials, Fresh Water, and Medicinal Resources.
- Regulating: Local Climate, Carbon Sequestration, Moderation of Extreme Events, Wastewater Treatment, Soil Erosion and Fertility, Pollination, and Biological Control.
- Habitat or Supporting Services: Habitats for Species and Maintenance of Genetic Diversity.
- Cultural: Aesthetic Appreciation and Inspiration for Culture, Tourism, Spiritual Experience and Identity, and Recreation.

Functioning ecosystems provide a range of services that are essential to support economic activity and improve environmental conditions. Ecosystems directly and indirectly support services that contribute towards social welfare. Some are essential for human survival (such as food), while others support services that contribute toward human enjoyment (such as recreation).

The USDA Forest Service recognizes the public benefits generated by the above categories of ecosystem services and the need to increase public awareness of ecosystem services and support opportunities for market-based conservation on private and community lands (USDA Forest Service, 2019). Market-based conservation refers to transactions such as auctions and trading of credits as payment for ecosystem services. Forest Service efforts such as the Forests to Faucets project recognize some of these public benefits using GIS to model and map the continental United States land areas most important to surface drinking water, the role forests play in protecting these areas, and the extent to which these forests are threatened by development, insects and disease, and wildland fire.

The categories of ecosystem benefits listed above represent valuable services that, if not provided by an ecosystem, would require public or private expenditures in order to provide the service. As a result, these ecosystem services provide an actual benefit (avoided expenditure) to society. However, many of these ecosystem benefits are difficult to measure in terms of the quantity of service provided. The primary reason for the difficulty in estimating ecosystem benefit quantities is the uncertain linkage between the effect of a project or policy on ecosystem services. If the linkage can be reliably measured/evaluated, then the next step necessary to completely measure economic benefits is to monetize the service provided.

Technical Issues Associated With Evaluating Ecosystem Services Provided

Important technical issues associated with evaluating ecosystem benefits have been identified by Fischenich, et al. (2013). The identified issues include understanding the ecosystem, metric selection and combination, modeling and forecasting, addressing uncertainty, adaptive management, and documentation. Five of these technical issues are addressed in some detail below. The issue of documentation simply means that data sources, assumptions, modeling approaches, and the methods of evaluating environmentally related benefits need to be made clear and should be transparent.

Understanding the ecosystem and the services provided by the ecosystem
An evaluation of ecosystem service benefits cannot be completed without a clear understanding of the problems leading to ecological degradation, the relationship between remediation measures and ecological response, and the relationships among ecological conditions and those factors that are valued by society.

Metric selection and combinations of metrics used to evaluate ecosystem services
A metric refers to a quantifiable property that represents a measure of success towards achieving a goal or objective and is used as a measure of ecosystem service outcomes associated with a change. Technically sound metrics should consider the following:

- Measurable physical, chemical, and biological properties of the system that serve as targets for the restoration action. Examples include peak summer temperature, mean substrate size, frequency of floodplain inundation, species population, and wetland acreage.
- Output metrics that can be used to assess benefits and represent resources available for supporting a beneficial activity.
- Decision factors that reflects thresholds in output value, acceptable uncertainty or risk, stakeholder preferences, and any other relevant criteria.
- Performance measures that directly or indirectly reflect the selected metrics and are used to assess project success or the need for adaptive management actions.

Without these types of metrics, the quantity that should be multiplied by the resource value per unit is not known and benefits cannot be quantified.

Modeling and forecasting
Modeling is necessary in order to analyze environmental systems because it provides a basis for forecasting ecosystem responses to a project, program, or other change. These forecasted changes can then be converted into quantified benefit estimates. The modeling helps in understanding of the process of generating ecosystem benefits. However, it needs to be stressed that models represent a simplification of complex systems based on assumptions and limited data and limited understanding of the processes.

Addressing uncertainty
Methods for assessing uncertainty in the provision of ecosystem services may include sensitivity analyses, creation of scenarios, and analysis of uncertainty associated with individual model parameters. It is important to identify sources of uncertainty and quantify this uncertainty as much as possible, such as through the use of confidence intervals and other statistical analysis. These and other means of identifying, quantifying, evaluating, and otherwise considering uncertainties as part of the planning process provide important information that assists decision-making. Adaptive management can also be used to manage risks and maximize realized benefits.

Valuation of Ecosystem Service Benefits
Assuming the linkage between ecosystem and the quantity of ecosystem services can be quantified and the technical issues associated with assumed linkage are identified, the next challenge is to value the per unit value of those ecosystem service benefits. Some categories of

ecosystem services, such as recreation and water supply, can be valued using traditional types of economic analyses based on market data and/or cost of service information. For example, recreation benefit values provided by specific ecosystems/habitats can be estimated using travel cost modeling where the cost of traveling to a site (including the value of time) is used as a proxy for the price of recreation from which a demand curve can be derived and benefits estimated. The value of time is included as a part of travel cost because it represents an opportunity cost of travel, where you are giving up time spent doing some other activity. Water quality benefits associated with a wetland habitat can be used as a cost-based example for estimating benefits. Water quality benefits can be estimated as the avoided cost of building a water treatment facility that would provide the same level of water quality as provided by the wetland. The assumption is that, in the absence of the wetland habitat, the next best alternative to achieve the level of water quality experienced with the wetland would be to treat the water and the cost saved by not having to build the treatment facility as the benefit of the wetland habitat. Other types of services, such as species preservation, require the use of sophisticated survey and modeling techniques, such as contingent valuation, to estimate value.

Ecosystem valuation research results are available which provide a range of values for different types of ecosystem services in different geographical and biological areas and can be used as an application of benefits transfer. A summary of ecosystem services values is presented in the report "Sustaining Environmental Capital: Protecting Society and the Economy" (Executive Office of the President, 2011) and in "The Economics of Ecosystems and Biodiversity for Water and Wetlands" (Russi, et al., 2013). The ecosystem service values presented in the Executive Office of the President report (2011) are divided into the four categories of ecosystem service benefits and represent benefits in 2007 dollars. These values are converted into values per acre and indexed into 2019 dollars using the Bureau of Economic Analysis Consumer Price Index (CPI) for all urban consumers. The CPI is used because it is based on household/individual consumers and is a commonly used index for updating values related to changes affecting individuals. Potential ecosystem benefits are presented in Table 18. The habitat types that are most relevant to the habitat types in the study are inland wetlands, woodlands and grasslands.

Table 18 – Potential annual ecosystem benefits by type of habitat and benefit category in 2017 dollars

	Minimum per acre per year				**Maximum per acre per year**			
Habitat Type	Provisioning	Cultural	Regulating	Habitat	Provisioning	Cultural	Regulating	Habitat
Coastal systems	$0.50	$0	$81	$37	$3,612	$19,814	$14,568	$78
Coastal wetlands	$21	$5	$916	$13	$3,966	$1,389	$64,759	$32,913
Inland wetlands	$1	$310	$154	$5	$4,645	$4,018	$11,012	$1,661
Rivers and lakes	$559	$146	$146	$0	$2,763	$1,308	$2,382	$0
Temperate forests	$12	$0.50	$1.50	$0	$831	$46	$218	$1,232
Woodlands	$3	$0	$4	$0	$412	$0	$521	$0
Grasslands	$113	$0	$29	$0	$342	$5	$989	$143

The study by Russi, et al. (2013) does not divide ecosystem service values into the four categories of ecosystem service benefits, but does indicate where the average ecosystem service value for all benefit categories combined by habitat type fits within the range of estimated benefits. The estimated average ecosystem service benefit value as a percentage of the estimated maximum value from Russi, et al. (2013) is used to calculate average ecosystem service values, which are presented in Table 19.

Table 19 – Estimated average ecosystem benefit value by type of habitat and benefit category

Habitat Type	Average as a percentage of maximum value[1]	Average benefit per acre per year			
		Provisioning	Cultural	Regulating	Habitat
Coastal systems	5%	$181	$991	$728	$4
Coastal wetlands	15%	$595	$208	$9,714	$4,937
Inland wetlands	33%	$1,533	$1,326	$3,634	$548
Rivers and lakes	33%	$912	$431	$786	$0
Temperate forests	33%	$274	$15	$72	$407
Woodlands	5%	$21	$0	$26	$0
Grasslands	67%	$229	$4	$663	$96

[1]Source: Russi, et al. "The Economics of Ecosystems and Biodiversity (TEEB) for Water and Wetlands." Institute for European Environmental Policy & Ramsar Secretariat. February 2013.

The habitat types presented in Table 19 and Table 20 do not necessarily correspond with the types of ecosystem resources in southwestern New Mexico. Additional ecosystem service values were found which can help evaluate ecosystem service values that may be applicable to the study area.

A report by Patton, et al. (2012) provided approaches and estimates for ecosystem service benefits for four wildlife refuges, including Sevilleta and Bosque del Apache National Wildlife Refuge (NWR), both located in New Mexico. Although the conditions in Sevilleta and Bosque del Apache NWRs are not the same as in the study area, the results can provide an understanding of the likely magnitude of potential benefits associated with ecosystem services.

The Patton, et al. analysis provided estimates of gross economic values for four different types of services: storm protection, water quality, commercial fishing habitat, and carbon storage. The estimated values for Sevilleta and Bosque del Apache NWRs are shown below in Table 20.

Table 20 – NWR ecosystem service values

Type of service	Value per acre
Storm protection	$47
Water quality	$80
Commercial fishing habitat	$0
Carbon storage	$14
Total all services	**$141**

The overall goal of the research was to develop an ecologic-economic simulation model that can be used to evaluate economic value of ecosystem services supported by National Wildlife Refuges. The model would provide a way to evaluate ecosystem services when primary data studies are not possible due to funding and/or time constraints. The estimated values are directed towards wetland acreages.

A study by Izon, et al. (2010) estimated the value of protecting inventoried roadless areas (IRAs) in New Mexico. This is a hedonic study that uses differences in observed housing values combined with differences in housing characteristics to determine how much a specific characteristic influences price (one of which is roadless areas). Although this study is aimed at the value of IRA's, the study indicates that the policy debate involves questions about the relative values of protection versus development. New Mexico IRA's provide nonmarket environmental benefits, which are related to natural landscapes and amenities, including protected forests and grasslands. A large portion of IRAs in southwest New Mexico are part of the Gila National Forest, so this information is applicable to the study area.

Table 21 summarizes the values presented in the Izon, et al. study. Use of the terms direct effect and indirect effect should not be confused with similar terms used in the context of regional impact analysis. The direct effect, in the context of valuation of ecosystems benefits, shows the impact of a marginal change in IRAs density within an area, while the indirect effect is the impact of changes in IRAs density on neighboring areas. The aggregate effect is a measure of total benefits. Benefit estimates are not available for Luna County in the Izon study.

Table 21 – IRA benefit estimates from Izon et al. (2010)

County/State	IRA Acreage	Aggregate benefits	Aggregate benefit per acre	Direct benefits	Direct benefit per acre
Catron	422,957	$17,714,000	$41.88	$15,785,000	$37.32
Grant	218,545	$111,650,000	$510.88	$50,990,000	$233.32
Hidalgo	43,456	$2,575,000	$59.26	$2,152,000	$49.52
Rio Arriba	136,241	$138,551,000	$1,016.96	$79,903,000	$586.48
Sierra	129,108	$39,260,000	$304.09	$16,590,000	$128.50
Socorro	170,326	$12,699,000	$74.56	$6,202,000	$36.41
New Mexico	1,549,573	$1,889,425,000	$1,219.32	$1,241,063,000	$800.91

The Economics of Ecosystems and Biodiversity (TEEB) Database

Finally, ecosystem service value data were obtained from the ecosystem service valuation database created by The Economics of Ecosystems and Biodiversity (TEEB). TEEB is a global initiative with a stated objective of “making nature’s values visible” by including biodiversity and ecosystem services value as part of mainstream decision-making. One of the activities of this group to support recognition of the wide range of benefits provided by ecosystems was to create the TEEB Valuation Database from which values could be evaluated. The Database is in an Excel file format and available at https://www.es-partnership.org/services/data-knowledge-sharing/ecosystem-service-valuation-database/.

The TEEB Valuation Database includes 1,310 listed ecosystem service valuations, of which 102 observations are for studies based in the United States. There are 48 United States observations after removing studies valuing coastal wetlands, coral reefs, coastal habitats, coral reefs, and tropical forest areas not applicable to a temperate climate. Finally, observations based on studies valuing ecosystem services in the northeast, southeast, and northern Midwest United States were removed. The remaining 28 values represent studies in the southwest, rocky mountain, and southcentral regions of the United States that are most representative of the southwestern New Mexico region. Ecosystems represented by these remaining 28 ecosystem service values include cultivated land, desert, forests, fresh water, grasslands, and inland wetlands. Ecosystem services represented by these remaining 28 values are shown in Table 22. Total economic value is included as an ecosystem service and benefit category for cultivated land, desert, and grasslands. Total economic value is a concept that reflects human based values from a natural resource such as cultural values, rural lifestyle, use and non-use values, and others. Any of the ecosystems listed in Table 22 could include total economic value as an ecosystem benefit, but the TEEB Valuation database specifically identified total economic value for these three ecosystems.

Table 22 – Ecosystem service and benefit categories from the TEEB database applicable to southwest New Mexico

Ecosystems	**Ecosystem service categories**	**Ecosystem service benefit categories**
Cultivated Land	Erosion Soil fertility Total Economic Value	Erosion prevention Maintenance of soil structure Total Economic Value
Desert	Total Economic Value	Total Economic Value
Forest	Genepool Total Economic Value	Biodiversity protection Total Economic Value
Fresh Water	Energy Water Waste Recreation	Hydro-electricity Irrigation water Industrial water Waste treatment Recreation
Grasslands	Aesthetic Climate Erosion Total Economic Value Food	Attractive landscapes Carbon sequestration Gas regulation Erosion prevention Total economic value Food
Inland Wetlands	Waste treatment Recreation in Floodplains Extreme events (marshes)	Waste treatment Recreation Flood prevention

Total Economic Value referenced in Table 23 represents the sum of all benefits obtained from a resource. Typically these benefits include use value, option value, bequest value, and existence value. Use value is obtained by removing a product in nature (direct use value) such as timber or water, or through the benefit of a non-removable product in nature (indirect use value) such as a sunset or waterfall. Non-use values are derived from the existence of the natural resource, such as knowing a desirable species exists even though we may never see them. Option value represents the potential future ability to use a resource, even though it is not currently used. This reflects the willingness to preserve an option for potential future use. Bequest value is derived from the satisfaction of preserving a natural environment for future generations.

The TEEB valuation database values for the 28 observations are shown in Table 24. The range of median to average values for each of the ecosystems included in the TEEB valuation database shown in Table 21 represent a range of potential measures of central tendency for ecosystem values. The standard deviation shown in Table 23 is a measure of the amount of variation or dispersion of the data. Smaller standard deviations indicate reduced variation of the data. The ecosystem service values presented in Table 23 are within the range of values presented in the other studies discussed above, which provides supporting evidence for the magnitude of values presented in Table 23 and used in this analysis.

Table 23 – Ecosystem service values per acre (2019 $)

Ecosystem	Observations	Average	High	Low	Standard Deviation	Median	Median to Average range
Cultivated land	4	$72.96	$124.53	$29.52	$39.84	$68.88	$68.88 - $72.96
Desert	1	$184.87	NA	NA	NA	NA	NA - $184.87
Forests	3	$962.68	$2,645.65	$47.55	$1,459.36	$194.83	$194.83 - $962.68
Fresh water	9	$363.93	$1,521.47	$1.16	$485.78	$160.69	$160.69 -$363.93
Grasslands	8	$37.69	$149.67	$0.03	$51.76	$18.49	$18.49 – $37.69
Inland Wetlands	3	$929.10	$2,334.43	$226.43	$1,217.06	$226.43	$226.43 - $929.10

The TEEB database includes ecosystem service valuation benefits for cultivated land, which represent ecosystem benefits related to erosion prevention, maintenance of soil structure, and total economic value. To the extent that additional available irrigation supplies can contribute to resource improvements related to erosion prevention, soil fertility, and potentially other services, project benefits in addition to crop production benefits could accrue to cultivated land. Land values as determined by the market are a function of the direct benefits associated with productivity of the land to increase social welfare. So, the primary benefit of cultivated land is the value of crops produced. Suppose the value of cultivated land (or net revenue from crop production) is $500 per acre. Cultivated/irrigated land may have less wind erosion than non-cultivated land, which produces an off-site ecosystem benefit of $72.96 per acre. The market value of cultivated land (the private value the land holder gets) would be $500 per acre but the national benefit (public value) of cultivated land is $572.96 per acre. Desert land may produce $0 in net revenue (could be positive if a tourist site for example) so the private benefit is $0 but the public benefit would be $184.87 per acre.

Estimated Ecosystem Benefits from Implementation of the New Mexico Unit

Assuming the median ecosystem benefit value is the appropriate representative measure for the proposed project, the estimated ecosystem related benefits (such as erosion prevention and soil productivity) associated with cultivated irrigated crop production are $68.88 per acre, as shown in Table 23. Median values are appropriate for data that displays a wide range of values. The estimated ecosystem benefits for all alternatives are shown in Table 24.

Table 24 – Estimated annual ecosystem benefits by alternative

Project region	Annual acre-feet of AWSA water applied[1]	Acres supported by AWSA water applied	Ecosystem benefit for cultivated land at $68.88/acre
Alternative B			
Cliff-Gila Valley	1,770	588	$40,501
San Francisco Valley	11	4	$276
Virden Valley	439	136	$9,368
Total	2,220	728	**$50,145**
Alternative C			
Cliff-Gila	1,623	539	$37,126
San Francisco	241	80	$5,510
Virden	439	136	$9,368
Total	2,303	755	**$52,004**
Alternative D			
Cliff-Gila	0	0	$0
San Francisco	0	0	$0
Virden	439	136	$9,368
Total	439	136	**$9,368**
Alternative E			
Cliff-Gila	1,202	400	$27,552
San Francisco	254	84	$5,786
Virden	439	136	$9,268
Total	1,895	620	**$42,706**

1 Annual acre-feet of the AWSA water applied is the sum of total consumptive use and farm return flow, as calculated by HDR (2019). Applied acre-feet represent the amount of irrigation water delivered and applied to irrigated acreage for crop production.

Summary of Economic Benefits for the New Mexico Unit

The benefits from the New Mexico Unit are estimated using the median value obtained through the variety of methods described above. Ecosystem service benefits are included in the estimation of benefits. The benefit estimates in 2019 dollars are presented in Table 25.

Table 25 – Estimated New Mexico Unit annual benefits by alternative.

Alternative and project area	Acre-feet of AWSA water applied	Annual irrigation water supply benefits at $230/ acre-foot	Potential annual ecosystem service benefits at $68.88 per acre	Estimated annual benefits
Alternative B				
Cliff-Gila	1,770	$407,100	$40,501	$447,601
San Francisco	11	$2,530	$276	$2,806
Virden	439	$100,970	$9,368	$110,338
Total	**2,220**	**$510,600**	**$50,145**	**$560,745**
Alternative C				
Cliff-Gila	1,623	$373,290	$37,126	$410,416
San Francisco	241	$55,430	$5,510	$60,940
Virden	439	$100,970	$9,368	$110,338
Total	**2,303**	**$529,690**	**$52,004**	**$581,694**
Alternative D				
Cliff-Gila	0	$0	$0	$0
San Francisco	0	$0	$0	$0
Virden	439	$100,970	$9,368	$110,338
Total	**439**	**$100,970**	**$9,368**	**$110,338**
Alternative E				
Cliff-Gila	1,202	$276,460	$27,552	$304,012
San Francisco	254	$58,420	$5,786	$64,206
Virden	439	$100,970	$9,368	$110,338
Total	**1,895**	**$435,850**	**$42,706**	**$478,556**

Project Costs

The economic costs of Alternatives B, C, D, and E are presented in Tables 26 through 31. Construction, operation and maintenance (O&M), replacement, CAP exchange, and interest during construction (IDC) costs are presented for each alternative in Tables 27 through 30. Construction costs are presented as total costs and annual equivalent costs. All costs are discounted using the Federal water resources planning rate for fiscal year 2020 of 2.75% and include IDC assuming a 5 year construction period. It should be noted that the annual O&M and replacement costs for the No Action alternative (Alternative A) would not be zero, therefore, the O&M and replacement costs shown in Tables 27 through 30 should not be interpreted as an incremental increased cost associated with each alternative compared to No Action. The exact OM&R costs under Alternative A are unknown at this time.

Tables 30 and 31 compare alternative costs on a per acre-foot and per acre basis, using a range of water use estimates per acre. The 2.5 acre-foot per acre use value coincides with lowest water use crops of pasture and corn, 3.0 acre-feet per acre was assumed by HDR Engineering for their hydrology study, and 4.0 acre-feet value coincides with pecan irrigation requirements. Tables 30 and 31 are essentially an evaluation of cost effectiveness, where the costs of all alternatives can be compared using a common unit of cost (cost/acre-foot or per acre).

Table 26 – Economic Costs of Alternative B including construction, operation and maintenance (O&M), replacement, CAP exchange, and interest during construction (IDC) costs

Cost category	Cost Estimates			Annualized Cost at 2.75% discount rate for a 100 year period of analysis		
	Cliff-Gila Valley	**San Francisco River Valley**	**Virden Valley**	**Cliff-Gila Valley**	**San Francisco River Valley**	**Virden Valley**
Construction (5 year construction period assumed)						
Design	$3,703,649	$502,398	$724,797	$109,088	$14,798	$21,348
Construction Management	$1,463,400	$342,400	$385,400	$43,103	$10,085	$11,352
Diversion	$10,914,679	$2,368,550	-	$321,483	$69,764	-
Production Wells	$2,654,700	-	-	$78,192	-	-
Storage	$13,624,408	-	$4,398,654	$401,296	-	$129,559
Pump Facilities	$1,823,107	-	$1,349,500	$53,698	-	$39,748
Conveyance	$6,152,403	$1,401,909	-	$181,214	$41,292	-
Total Construction Cost	$40,336,358	$4,615,257	$6,858,351	$1,188,074	$135,939	$202,007
OM&R						
Diversion	$29,568	$30,088	-	$29,568	$30,088	-
Production Wells	$23,131	-	-	$23,131	-	-
Storage	$89,914	-	$42,455	$89,914	-	$42,455
Pump Facilities	$16,438	-	$21,904	$16,438	-	$21,904
Conveyance	$26,041	-	-	$26,041	-	-
Annual OM&R Cost	$185,092	$30,088	$64,359	$185,092	$30,088	$64,359
CAP Exchange						
Quantity of water (AF/year)	1,425	8	349	1,425	8	349
Exchange cost/acre-foot	$155	$155	$155	$155	$155	$155
Annual CAP Exchange Cost	$220,875	$1,240	$54,095	$220,875	$1,.240	$54,095
Interest During Construction (IDC)						
IDC cost	$2,866,334	$327,963	$487,360	$87,551	$10,018	$14,886

Table 27 – Economic Costs of Alternative C including construction, operation and maintenance (O&M), replacement, CAP exchange, and interest during construction (IDC)

Cost category	Cost Estimates			Annualized Cost at 2.75% discount rate for a 100 year period of analysis		
	Cliff-Gila Valley	San Francisco River Valley	Virden Valley	Cliff-Gila Valley	San Francisco River Valley	Virden Valley
Construction (5 year construction period assumed)						
Design	$2,079,626	$5,719,199	$724,797	$61,254	$168,454	$21,348
Construction Management	$821,710	$2,259,792	$385,400	$24,203	$66,560	$11,352
Diversion	$3,608,064	$1,018,656	-	$106,273	$30,004	-
Production Wells	-	-	-	-	-	-
Storage	$14,754,552	$42,510,200	$4,398,654	$434,583	$1,252,103	$129,559
Pump Facilities	$1,032,000	$10,525,000	$1,349,500	$30,397	$310,005	$39,748
Conveyance	$342,000	$224,000	-	$10,073	$6,598	-
Total Construction Cost	$19,736,616	$62,256,847	$6,858,351	$666,782	$1,833,724	$202,007
OM&R						
Diversion	$659,340	$219,780	-	$659,340	$219,780	-
Production Wells	-	-	-	-	-	-
Storage	$100,549	$234,000	$42,455	$100,549	$234,000	$42,455
Pump Facilities	$12,500	$43,400	$21,904	$12,500	$43,400	$21,904
Conveyance	$4,200	$2,940	-	$4,200	$2,940	-
Annual OM&R Cost	$776,589	$500,120	$64,359	$776,589	$500,120	$64,359
CAP Exchange						
Quantity of water	1,321	175	349	1,321	175	349
Exchange cost/acre-foot	$155	$155	$155	$155	$155	$155
Annual CAP Exchange Cost	$204,755	$27,125	$54,095	$204,755	$27,125	$54,095
Interest During Construction (IDC)						
IDC cost	$1,608,670	$4,424,020	$487,360	$49,136	$135,130	$14,886

Table 28 – Economic Costs of Alternative D including construction, operation and maintenance (O&M), replacement, CAP exchange, and interest during construction (IDC)

Cost category	Cost Estimates			Annualized Cost at 2.75% discount rate for a 100 year period of analysis		
	Cliff-Gila Valley	San Francisco River Valley	Virden Valley	Cliff-Gila Valley	San Francisco River Valley	Virden Valley
Construction (5 year construction period assumed)						
Design	-	-	$724,797	-	-	$21,348
Construction Management	-	-	$385,400	-	-	$11,352
Diversion	-	-	-	-	-	-
Production Wells	-	-	-	-	-	-
Storage	-	-	$4,398,654	-	-	$129,559
Pump Facilities	-	-	$1,349,500	-	-	$39,748
Conveyance	-	-	-	-	-	-
Total Construction Cost	-	-	$6,858,351	-	-	$202,007
OM&R						
Diversion	-	-	-	-	-	-
Production Wells	-	-	-	-	-	-
Storage	-	-	$42,455	-	-	$42,455
Pump Facilities	-	-	$21,904	-	-	$21,904
Conveyance	-	-	-	-	-	-
Annual OM&R Cost	-	-	$64,359	-	-	$64,359
CAP Exchange						
Quantity of water	-	-	349	-	-	349
Exchange cost/acre-foot	-	-	$155	-	-	$155
Annual CAP Exchange Cost	-	-	$54,095	-	-	$54,095
Interest During Construction (IDC)						
IDC cost	-	-	$487,360	-	-	$14,886

Table 29 – Economic Costs of Alternative E including construction, operation and maintenance (O&M), replacement, CAP exchange, and interest during construction (IDC)

Cost category	**Cost Estimates**			**Annualized Cost at 2.75% discount rate for a 100 year period of analysis**		
	Cliff-Gila Valley	**San Francisco River Valley**	**Virden Valley**	**Cliff-Gila Valley**	**San Francisco River Valley**	**Virden Valley**
Construction (5 year construction period assumed)						
Design	$5,978,200	$8,437,205	$724,797	$176,083	$248,511	$21,348
Construction Management	$2,362,129	$3,333,741	$385,400	$69,575	$98,193	$11,352
Diversion	$7,180,200	$2,368,550	-	$211,487	$69,764	-
ASR Wells	$828,700	-	-	$24,409	-	-
Storage	$30,840,000	$73,400,000	$4,398,654	$908,367	$2,161,937	$129,559
Pump Facilities	$9,930,000	$3,200,000	$1,349,500	$292,480	$94,253	$39,748
Conveyance	$7,957,000	$2,230,000	-	$234,367	$65,683	-
Construction Total	$65,076,229	$92,969,496	$6,858,351	$1,916,767	$2,738,341	$202,007
OM&R						
Diversion	$114,710	$30,088	-	$114,710	$30,088	-
Production Wells	-	-	-	-	-	-
ASR Wells	$4,109	-	-	$4,109	-	-
Storage	$308,400	$404,000	$42,455	$308,400	$404,000	$42,455
Pump Facilities	$99,300	$29,400	$21,904	$99,300	$29,400	$21,904
Conveyance	$114,600	$50,200	-	$114,600	$50,200	-
Annual OM&R Cost	$641,119	$513,688	$64,359	$641,119	$513,688	$64,359
CAP Exchange						
Quantity of water	927	183	349	927	183	349
Exchange cost/acre-foot	$155	$155	$155	$155	$155	$155
Annual CAP Exchange Cost	$143,685	$28,365	$54,095	$143,685	$28,365	$54,095
Interest During Construction (IDC)						
IDC cost	$4,624,365	$6,606,482	$487,360	$141,249	$201,792	$14,886

Table 30 – Summarized annual economic costs by alternative based on a 100 year period of analysis and a 2.75% discount rate

Costs by alternative	100 year period of analysis Cliff-Gila	San Francisco	Virden	Total combined
Alternative B				
Annualized economic cost (includes IDC)	$1,681,592	$177,285	$335,347	$2,194,224
Total annual acre-feet of water applied[1]	1,770	11	439	2,220
Total annual acre-feet of consumptive use	1,425	8	349	1,782
Cost of water applied[1] per acre-foot	$950	$16,117	$764	$988
Cost of consumptive use per acre-foot	$1,180	$22,161	$961	$1,231
Alternative C				
Annualized economic cost (includes IDC)	$1,697,262	$2,496,099	$335,347	$4,528,709
Total annual acre-feet of water applied[1]	1,623	241	439	2,303
Total annual acre-feet of consumptive use	1,321	175	349	1,845
Cost of water applied[1] per acre-foot	$1,046	$10,357	$764	$1,966
Cost of consumptive use per acre-foot	$1,285	$14,263	$961	$2,455
Alternative D				
Annualized economic cost (includes IDC)	-	-	$335,347	$335,347
Total annual acre-feet of water applied[1]	-	-	439	439
Total annual acre-feet of consumptive use	-	-	349	349
Cost of water applied[1] per acre-foot	-	-	$764	$764
Cost of consumptive use per acre-foot	-	-	$961	$961
Alternative E				
Annualized economic cost (includes IDC)	$2,842,820	$3,482,186	$335,347	$6,660,353
Total annual acre-feet of water applied[1]	1,202	254	439	1,895
Total annual acre-feet of consumptive use	927	183	349	1,459
Cost of water applied[1] per acre-foot	$2,365	$13,709	$764	$3,515
Cost of consumptive use per acre-foot	$3,067	$19,028	$961	$4,565

Table 31 – Summary of annualized New Mexico Unit of the CAP alternative economic costs based on a 100 year period of analysis and using a 2.75% discount rate

Annualized Alternative Costs	100 year time frame
Alternative B	
Applied cost per AF	$988
Applied Cost/acre @ 2.5 AF/acre	$2,470
Applied Cost/acre @ 3.0 AF/acre	$2,964
Applied Cost/acre @ 4.0 AF/acre	$3,952
Alternative C	
Applied cost per AF	$1,966
Applied Cost/acre @ 2.5 AF/acre	$4,915
Applied Cost/acre @ 3.0 AF/acre	$5,898
Applied Cost/acre @ 4.0 AF/acre	$7,864
Alternative D	
Applied cost per AF	$764
Applied Cost/acre @ 2.5 AF/acre	$1,910
Applied Cost/acre @ 3.0 AF/acre	$2,292
Applied Cost/acre @ 4.0 AF/acre	$3,056
Alternative E	
Applied cost per AF	$3,515
Applied Cost/acre @ 2.5 AF/acre	$8,788
Applied Cost/acre @ 3.0 AF/acre	$10,545
Applied Cost/acre @ 4.0 AF/acre	$14,060

Estimated Ecosystem Service Costs of the New Mexico Unit

Short-term and long-term disturbed acreage has been identified for each of the Action Alternatives. Disturbance of these acres can lead to lost ecosystem service benefits, especially considering that some acreages within these areas have been identified as affecting Threatened and Endangered Species habitat. The estimated disturbed acreages are shown in Table 32.

Table 32 - Short-term and long-term disturbed acreage by alternative

Location	Alternative B (acres)	Alternative C (acres)	Alternative D (acres)	Alternative E (acres)
Short-Term Disturbance Acreage Estimates				
Cliff-Gila	382	262	0	346
San Francisco	15	111	0	168
Virden	132	132	132	132
Total Short-term	**529**	**505**	**132**	**646**
Long-Term Disturbance Acreage Estimates				
Cliff-Gila	294	235	0	284
San Francisco	8	91	0	132
Virden	116	116	116	116
Total Long-term	**418**	**442**	**116**	**532**

This analysis assumes ecosystem benefits associated with short and long-term disturbed acres can be represented as the average of median values for cultivated land ($68.88) and forests ($194.83) and the average desert value ($184.87) or $149.53 annually per disturbed acre. For desert land the median is equal to the average value. The short-term and long-term disturbed acreage costs are shown in table 33. The annual short-term costs are assumed to occur over a 10-year period, which includes a 5 year construction period plus 5 years to recover and provide full ecosystem benefits. Short-term ecosystem impacts are converted into annual equivalent costs over a 100-year period by calculating the present value of short-term costs over ten years and applying the project planning rate of 2.75% to the present value. Using this approach all ecosystem costs represent an annual cost over 100 years and are comparable.

Table 33 – Annual ecosystem costs based on short-term and long-term disturbed acreage

Location	Alternative B	Alternative C	Alternative D	Alternative E
Short-Term Disturbance Acreage Estimates				
Cliff-Gila	$14,536	$9,970	0	$13,166
San Francisco	$571	$4,224	0	$6,393
Virden	$5,023	$5,023	$5,023	$5,023
Total Short-term	**$20,130**	**$19,217**	**$5,023**	**$24,582**
Long-Term Disturbance Acreage Estimates				
Cliff-Gila	$43,962	$35,140	$0	$42,467
San Francisco	$1,196	$13,607	$0	$19,738
Virden	$17,345	$17,345	$17,345	$17,345
Total Long-Term	**$62,504**	**$66,092**	**$17,345**	**$79,550**
Total long-term & short-term ecosystem costs	**$82,634**	**$85,309**	**$22,368**	**$104,132**

The total annual cost of Alternative B is $2,194,224, the total annual cost of Alternative C is $4,528,709, the total annual cost of Alternative D is $335,347, and the total cost of Alternative E is $6,660,353. Adding the short-term and long-term ecosystem disturbance related costs to the estimated construction and OM&R costs increases the economic costs of Alternative B by $82,634 annually (3.77%), Alternative C by $85,309 annually (1.88%), Alternative D by $22,368 annually (6.67%), and Alternative E by $104,132 annually (1.56%).

Other Potential Economic and Social Effects

There are additional effects associated with each of the alternatives that cannot be quantified but should be noted. First, the project alternatives will provide additional flows during periods when no flows would exist under existing conditions. These changes in flows are described in the Affected Environment and Environmental Consequences Chapter of the EIS. Potential benefits to surface water and riparian habitats are possible during critical times of the year. This could also translate into potential improvement in recreational opportunities. Finally, additional crop production revenues and jobs supported by the action alternatives would likely help sustain the local economy and maintain the population base and lifestyle of the region. Under the PR&G, these unquantifiable values must nevertheless be given due consideration.

Economic Analysis Summary

This PR&G analysis of the New Mexico Unit of the Central Arizona Project indicates that the estimated economic benefits generated by each alternative are less than the estimated economic costs. The benefits and costs are summarized in Table 34.

Table 34 – Estimated annual benefits and costs by alternative

Alternative and project area	Economic benefits	Economic Costs
Alternative B	$560,745	$2,276,858
Alternative C	$581,694	$4,614,108
Alternative D	$110,338	$357,715
Alternative E	$478,556	$6,764,485

Financial and Cost Effectiveness Analysis

This financial cost and cost effectiveness analysis reflects the full cost of each alternative on a per acre-foot basis as well as project costs potentially passed on to the water users. Two scenarios are used to analyze financial costs for each action alternative: (1) no public funding for the project; and (2) up to $60 million in public funding available for construction-related costs from the New Mexico Unit Fund[3] (State funds). It is also assumed that the lowest cost-per-acre project location for each Alternative would have the highest priority for construction. The financial costs can be used to assess the actual expenditures that water users would have to pay for water after accounting for New Mexico Unit funding. Financial costs are **not** equivalent to economic costs or cost effectiveness. Financial costs can be used to assess the viability of project beneficiaries to cover their share of costs while economic costs represent the full resource costs of a project to the nation which are used to evaluate economic feasibility and cost effectiveness represents the full cost of water on a per acre-foot basis. The financial costs and costs per acre-foot of each alternative are shown below in Tables 35 through 42. It is important to understand that Tables 35 through 42 focus on costs and do not consider benefits. Therefore, a relatively low cost per acre-foot does not necessarily translate into a high level of net economic benefit or profit. In addition, cost-effectiveness is represented by the full cost estimates, without state funding, per acre-foot presented in Tables 36, 38, 40 and 42.

[3] Distribution of funds from the New Mexico Unit Fund is under the discretion of the New Mexico Interstate Stream Commission in consultation with the NM CAP Entity. At this time, no decision has been made by the ISC on future use of the Unit Fund for construction of the NM Unit or for any additional non-NM Unit projects. Use of this funding scenario in the EIS in no way obligates the Commission to allocate any funding from the New Mexico Unit Fund to the NM Unit Project.

Table 35 – Financial costs paid by water users after accounting for State funding for Alternative B

Project Location	Annual Cost of Construction paid by water users		Cost of OM&R paid by water users		Exchange costs paid by water users		Total Annual Financial Costs paid by water Users	
	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding
Virden Valley	$202,007	$0	$64,359	$64,359	$54,095	$54,095	$320,461	$118,454
Cliff-Gila Valley	$1,188,074	$0	$185,092	$185,092	$220,875	$220,875	$2,962,207	$400,967
San Francisco River Valley	$135,939	$0	$30,088	$30,088	$1,240	$1,240	$167,267	$31,328
Total Alternative B	$1,526,020	$0	$279,539	$279,539	$276,210	$276,210	$3,449,935	$550,749

Table 36 – Financial costs and cost effectiveness per acre-foot for Alternative B

Project Location	Total Annual Financial Costs paid by water Users		Acre-feet of Water applied	Total Financial Costs per Acre-Foot Applied	
	No State funding	With State funding		No State funding	With State funding
Virden Valley	$320,461	$118,454	439	$730	$270
Cliff-Gila Valley	$2,962,207	$400,967	1,770	$1,674	$227
San Francisco River Valley	$167,267	$31,328	11	$15,206	$2,848
Total Alternative B	$3,449,935	$550,749	2,220	$1,554	$248

Table 37 – Financial costs paid by water users after accounting for State funding for Alternative C

Project Location	Annual Cost of Construction Paid by water users		Cost of OM&R Paid by water users		Exchange costs paid by water users		Total Annual Financial Costs paid by water Users	
	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding
Virden Valley	$202,007	$0	$64,359	$64,359	$54,095	$54,095	$320,461	$118,454
Cliff-Gila Valley	$666,782	$0	$776,589	$776,589	$204,755	$204,755	$1,648,126	$981,344
San Francisco River Valley	$1,833,724	$877,555	$500,120	$500,120	$27,125	$27,125	$2,360,969	$1,404,800
Total Alternative C	$2,702,513	$877,555	$1,341,068	$1,341,068	$285,975	$285,975	$4,329,556	$2,504,598

Table 38 – Financial costs and cost effectiveness per acre-foot for Alternative C

Project Location	Total Annual Financial Costs paid by water Users		Acre-feet of Water applied	Total Financial Costs per Acre-Foot Applied	
	No State funding	**With State funding**		**No State funding**	**With State funding**
Virden Valley	$320,461	$118,454	439	$730	$270
Cliff-Gila Valley	$1,648,126	$981,344	1,623	$1,015	$605
San Francisco River Valley	$2,360,969	$1,404,800	241	$9,797	$5,829
Total Alternative C	$4,329,556	$2,504,598	2,303	$1,880	$1,088

Table 39 – Financial costs paid by water users after accounting for State funding for Alternative D

Project Location	Annual Cost of Construction Paid by water users		Cost of OM&R Paid by water users		Exchange costs paid by water users		Total Annual Financial Costs paid by water Users	
	No State funding	**With State funding**	**No State funding**	**With State funding**	**No State funding**	**With State funding**	**No State funding**	**With State funding**
Virden Valley	$202,007	$0	$64,359	$64,359	$54,095	$54,095	$320,461	$118,454
Total Alternative D	$202,007	$0	$64,359	$64,359	$54,095	$54,095	$320,461	$118,454

Table 40 – Financial costs and cost effectiveness per acre-foot for Alternative D

Project Location	Total Annual Financial Costs paid by water Users		Acre-feet of Water applied	Total Financial Costs per Acre-Foot Applied	
	No State funding	With State funding		No State funding	With State funding
Virden Valley	$320,461	$118,454	439	$730	$270
Total Alternative D	$320,461	$118,454	439	$730	$270

Table 41 – Financial costs paid by water users after accounting for State funding for Alternative E

Project Location	Cost of Construction Paid by water users		Cost of OM&R Paid by water Users		Exchange costs paid by water users		Total Annual Financial Costs paid by water Users	
	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding	No State funding	With State funding
Virden Valley	$202,007	$0	$64,359	$64,359	$54,095	$54,095	$320,461	$118,454
Cliff-Gila Valley	$1,916,767	$351,523	$641,119	$641,119	$143,865	$143,685	$2,701,751	$1,136,327
San Francisco River Valley	$2,738,341	$2,738,341	$513,688	$513,688	$28,365	$28,365	$3,280,394	$3,280,394
Total Alternative E	$4,857,115	$3,089,864	$1,219,166	$1,219,166	$226,145	$226,145	$6,302,426	$4,535,175

Table 42 – Financial costs and cost effectiveness per acre-foot for Alternative E

Project Location	Total Annual Financial Costs paid by water Users		Acre-feet of Water applied	Total Financial Costs per Acre-Foot Applied	
	No State funding	With State funding		No State funding	With State funding
Virden Valley	$320,461	$118,454	439	$730	$270
Cliff-Gila Valley	$2,701,751	$1,136,327	1,202	$2,248	$945
San Francisco River Valley	$3,280,394	$3,280,394	254	$12,915	$12,915
Total Alternative E	$6,302,606	$4,535,175	1,895	$3,326	$2,393

Regional Economic Impacts

As discussed in the analysis perspectives in the introductory sections, a regional economic impact analysis is distinct from an analysis of economic benefits. Expenditures associated with a project may generate regional positive impacts but produce no economic benefit and may even result in negative benefits. Any project or program that results in increased spending in a region will increase economic activity and generate some level of positive regional impacts, but will not necessarily generate economic benefits. Therefore, regional impacts cannot be added to economic benefits as a measure of total benefit. While regional impacts are not technically a part of a PR&G analysis, a regional impact analysis does provide information useful for evaluating project alternatives.

The primary purpose of a regional impact analysis is to evaluate the effect of an alternative on income, employment, and the value of output produced on the immediate region in which the proposed project is located. For this analysis the impact region includes Catron County, Grant County, Hidalgo County, and Luna County. For the purposes of this analysis it is assumed that the effects associated with each proposal represent incremental impacts, or impacts that would occur in addition to what would exist without a project. The regional impacts that are evaluated in this analysis include:

- Short-term impacts from construction expenditures,
- Long-term impacts from OM&R expenditures,
- Long-term impacts from changes in the value of crop production resulting from increased irrigation water supplies.

Sources of data used to estimate regional impacts

The data used to estimate the regional impacts from construction and OM&R expenditures included cost sheets and summaries provided by the Bureau of Reclamation Phoenix Area Office for alternatives B, C, D, and E. The assessment of regional impacts from increased crop production associated with each of the project alternatives was based on cropping pattern, crop yield, crop price, and crop acreage information used in the farm budget analysis from which gross farm revenues were estimated

Gross Crop Revenues from Irrigation Deliveries with a Project

The irrigated crops and cropping patterns used to estimate the value of irrigation related production are based on the same sources of information used in the farm budget analysis. Using the same cropping patterns, yields, prices, and water use estimates as used in the farm budget analysis, the gross value of agricultural production can be estimated. The gross value of production is the basis for estimating the regional impacts of each alternative. The estimated additional gross crop revenues for each alternative are shown in Table 43.

Table 43 – Gross crop revenues used to estimate agricultural regional impacts

Region	**Pasture**	**Alfalfa**	**Corn**	**Cotton**	**Pecans**	**Total gross revenues**
Alternative B						
Cliff-Gila Valley	$192,024	$136,849	$0	$0	$320,554	$649,427
San Francisco Valley	$1,210	$862	$0	$0	$2,019	$4,091
Virden Valley	$6,610	$34,004	$24,452	$44,428	$128,727	$238,221
Total Gross Revenues	**$199,843**	**$171,715**	**$24,452**	**$44,428**	**$451,300**	***$891,739***
Alternative C						
Cliff-Gila Valley	$176,299	$125,643	$0	$0	$294,304	$596,246
San Francisco Valley	$26,309	$18,749	$0	$0	$43,918	$88,976
Virden Valley	$6,610	$34,004	$24,452	$44,428	$128,727	$238,221
Total Gross Revenues	***$209,218***	**$178,395**	**$24,452**	**$44,428**	**$466,949**	***$923,443***
Alternative D						
Cliff-Gila Valley	$0	$0	$0	$0	$0	$0
San Francisco Valley	$0	$0	$0	$0	$0	$0
Virden Valley	$6,610	$34,004	$24,452	$44,428	$128,727	$238,221
Total Gross Revenues	**$6,610**	**$34,004**	**$24,452**	**$44,428**	**$128,727**	***$238,221***
Alternative E						
Cliff-Gila Valley	$130,637	$93,100	$0	$0	$218,078	$441,815
San Francisco Valley	$27,518	$19,611	$0	$0	$45,938	$93,067
Virden Valley	$6,610	$34,004	$24,452	$44,428	$128,727	$238,221
Total Gross Revenues	***$164,765***	***$146,715***	$24,452	$44,428	$392,742	***$773,103***

Construction and O&M expenditures

Construction and OM&R estimates were obtained from cost sheets and summaries provided by the Bureau of Reclamation Phoenix Area Office for alternatives B, C, D, and E. These expenditures represent the value of final goods and services needed to build and maintain the evaluated alternatives. It should be noted that the regional impacts are generated only by those expenditures that are actually spent in the region. This is discussed more in the regional impact section below. The construction costs represent short term impacts and are presented in Table 44. Unlike construction related regional impacts, annual OM&R impacts would occur over the long term. The estimated annual OM&R costs for each alternative are shown in Table 45.

Table 44– Total estimated construction cost by alternative

Alternative	Area			Total Cost
	Cliff-Gila	San Francisco Valley	Virden Valley	
Alternative B	$40,336,358	$4,615,257	$6,858,351	$51,809,966
Alternative C	$19,736,616	$62,256,847	$6,858,351	$88,851,814
Alternative D	$0	$0	$6,858,351	$6,858,351
Alternative E	$65,076,229	$92,969,496	$6,858,351	$164,904,076

Table 45 – Estimated additional OM&R costs above current OM&R expenditure by alternative

Type of Cost	Area			Total Cost
	Cliff-Gila	San Francisco	Virden	
Annual OM&R				
Alternative B	$185,092	$30,088	$64,359	$279,539
Alternative C	$776,589	$500,120	$64,359	$1,341,068
Alternative D	$0	$0	$64,359	$64,359
Alternative E	$641,119	$513,688	$64,359	$1,219,166

Estimating regional impacts

The regional economic impacts from each project proposal are analyzed using the IMPLAN (IMpact analysis for PLANing) model. The model uses 2017 data. The IMPLAN model is based on national estimates of flows of commodities used by industries and commodities produced by industries. The flow of commodities to industry from producers and consumers, as well as consumption of the factors of production from outside the region, is represented within IMPLAN. These also account for the percentage of expenditures in each category within the region and expenditures that would flow outside the region.

In order to estimate the regional economic impacts associated with each proposal, estimates of changes in expenditures for final goods and services were input into the IMPLAN model. These final expenditures represent construction expenditures within the study region that originate from outside the region, OM&R expenditures that originate from outside the region and are spent in the region, and the gross value of crop production in the study area. IMPLAN sectors were matched up as closely as possible with each expenditure category. The expenditure categories, IMPLAN sector, and sector description used to estimate impacts are shown in Table 46.

Table 46 – IMPLAN sectors used to estimate regional impacts

IMPLAN Sector	IMPLAN sector Description	Final demand item used to estimate impacts
2	Grain farming	Corn
5	Tree nut farming	Pecans
8	Cotton farming	Cotton
10	All other crop farming	Alfalfa and Pasture
58	Construction of other new nonresidential structures	Construction Activities
62	Maintenance and repair construction of nonresidential structures	OM&R Activities

The final estimates of regional impacts were estimated used feed and pasture rather than cattle production supported by feed and pasture because it better represents all of the induced and indirect impacts associated with irrigation from a project. Simply including the value of cattle production as an impact misses the intermediate steps of providing feed to cattle production and results in a much lower and downward biased estimate of regional impacts. The IMPLAN model estimates impacts as the sector uses of final demand for each commodity. Since the primary use of alfalfa and pasture is for cattle production, the value of feed and pasture production does implicitly include cattle production as well as some direct sales. Inputting the value of cattle production directly into IMPLAN misses intermediate steps between feed/pasture production and use for cattle production.

The regional impacts associated with construction related expenditures for a New Mexico Unit project that is funded with State funds is complicated by the fact that some level of state funding associated with CAP Entity activities would continue without a project. Therefore, the regional impacts associated with the project is the difference between project funding and expected NMISC expenditures on non-NM Unit projects without a NM Unit project. This is discussed in more detail below.

The regional impacts associated with each of the alternatives are measured in terms of changes in employment, labor income, value added, and value of output. Employment is measured in terms of total jobs, which includes full-time and part-time employment. Part-time employment could be temporary or longer-term jobs working fewer than 40 hours per week. Labor income is measured in terms of employee compensation. Value added includes employee compensation (including benefits) and proprietor income (i.e., payments received by self-employed individuals), other property related income (payments for rents, royalties and dividends), and business taxes on production and imports less subsidies. Industry output is a measure of the value of industry's total production and is comparable to Gross Regional Product.

Regional Impacts from Agricultural Production

Regional impacts from agricultural production occur as a result of input requirements and income/revenues generated by agricultural activities. The basis for estimating agricultural related regional impacts associated with increased irrigation water supplies is the increased gross value of crop production. Increased value can be the result of increased irrigation acreage, increased yields, a change in cropping patterns, or a combination of all three factors. The IMPLAN model discussed in the Regional Impact Analysis section of Analysis Perspectives above uses gross revenues as an input representing final demand for agricultural commodities produced in the region. It is assumed that all production is sold and that the sales represent an inflow of expenditures to the region. The value of gross agricultural output produced as a result of project related irrigation water supplies in the study area is based on the same five-year average state prices, five year average county yields, water use requirements, and available irrigation water supplies used in the irrigation water supply economic benefit analysis presented above.

Regional impacts from agricultural production were also estimated using the value of cattle supported by feed and pasture. The estimated regional impacts based on cattle production alone were much less than impacts based on feed and pasture as the sector of final demand. This is because the IMPLAN model estimates the sector uses of final demand for each commodity.

Since the primary use of feed and forage is for cattle production, the value of feed and pasture production implicitly includes cattle production as well as some direct sales. Inputting the value of cattle production directly into IMPLAN misses intermediate steps between feed/pasture production and use for cattle production

The gross values of crop production associated with each crop are input into the IMPLAN model to estimate long term agricultural production impacts to the regional economy. The IMPLAN model accounts for the inputs needed to produce the final demand for agricultural products. The estimated regional economic impacts from agricultural output are presented in Table 47.

Table 47 – Estimated regional economic impacts from increased agricultural production resulting from increased irrigation supplies for each alternative

Type of Impact	Employment	Labor Income	Value Added	Value of output
Alternative B				
Direct	16	$363,116	$487,985	$872,310
Indirect	2	$71,223	$104,849	$184,661
Induced	1	$38,892	$86,771	$166,025
Total Impact	***19***	***$473,231***	***$679,605***	***$1,222,996***
Alternative C				
Direct	16	$381,446	$500,813	$896,594
Indirect	2	$68,632	$101,577	$183,634
Induced	1	$37,522	$85,161	$164,831
Total Impact	***19***	***$487,600***	***$687,551***	***$1,245,059***
Alternative D				
Direct	3	$70,379	$124,852	$229,068
Indirect	0	$12,984	$16,935	$32,522
Induced	0	$5,135	$10,946	$21,850
Total Impact	***3***	***$88,498***	***$152,733***	***$283,440***
Alternative E				
Direct	14	$314,348	$416,990	$748,206
Indirect	1	$54,913	$80,905	$148,136
Induced	1	$29,577	$67,403	$131,177
Total Impact	***16***	***$398,838***	***$565,298***	***$1,027,519***

Changes in the value of regional output associated with construction spending will also have impacts on State and Federal taxes paid, including income taxes. In addition to the regional impacts presented in Table 47, the fiscal impacts of Federal and State taxes were estimated by the IMPLAN model and are presented in Table 48. Although the impacts appear to be fairly small, it is important to account for these fiscal impacts.

Table 48 – Tax impacts from increased agricultural production

Type of Impact	Federal	State
Alternative B		
Tax Impact	$102,555	$42,892
Alternative C		
Tax Impact	$105,610	$44,687
Alternative D		
Tax Impact	$19,005	$10,014
Alternative E		
Tax Impact	$86,331	$37,135

To better understand the relative impacts of the various alternatives on the regional economy, total employment, value added, and value of output produced in the four-county region was obtained from the 2017 IMPLAN data. The regional impacts from increased agricultural production for each alternative are summarized in Table 49 and the regional economic data by county for the four-county region are presented in Table 50. Finally, Table 51 shows the percentage change in regional employment, value added, and output represented by changes in agricultural production for each alternative. The percentage change for each alternative is fairly small.

Table 49 - Employment, value added, and total value of output from agricultural production by alternative for the four-county study region

Alternative	Employment	Value Added	Value of Output
Alternative B	19	$679,605	$1,222,996
Alternative C	19	$687,551	$1,245,059
Alternative D	3	$152,733	$283,440
Alternative E	16	$565,298	$1,027,519

Table 50 – Employment, value added, and total value of output for the four county study area

County	Employment	Value Added	Value of Output
Catron	1,668	$84,884,259	$186,440,258
Grant	12,545	$1,110,660,860	$1,894,275,990
Hidalgo	2,107	$181,330,510	$291,114,248
Luna	10,266	$683,625,379	$1,511,807,670
Total	**26,586**	**$2,060,501,008**	**$3,883,638,166**

Table 51 – Long term percentage changes in annual employment, value added, and total value of output from changes in agricultural production relative to regional totals by alternative

Alternative	Employment	Value Added	Value of Output
Alternative B	0.0715%	0.0330%	0.0315%
Alternative C	0.0715%	0.0334%	0.0321%
Alternative D	0.0113%	0.0074%	0.0073%
Alternative E	0.0602%	0.0274%	0.0265%

Regional Impacts Associated with Construction Expenditures

Construction expenditures associated with the New Mexico Unit of the CAP would generate short term regional impacts assuming the source of funding originates from outside of the region. Construction related activities represent an increase in final demand for goods and services required to build the features associated with the various New Mexico Unit alternatives. However, only those expenditures originating from outside the region would generate positive regional impacts. For example, State funds used for construction represent an injection of expenditures into the region. Theoretically, any federal tax payments made by businesses and individuals within the region would not be included in those impacts but those payments would be a negligible percentage of total construction payments.

More importantly, not all construction activities and materials will be provided by companies located in the region. Employees and materials brought in from outside the region represent economic leakages outside the region. Specific information is not available from the engineering cost estimates from which the proportion of expenditures that occur within and outside of region can be assessed. Therefore, it was assumed that one-half of these expenditures would be allocated within the region. Tables 52 and 53 present regional impacts attributable to construction, based on the estimated construction expenditures assuming one-half of expenditures are within region spending. Changes in the value of regional output associated with construction spending will also have impacts on state and federal taxes paid, including income taxes. Federal and State tax impacts are presented in Table 55.

The AWSA directs the Secretary, acting through Reclamation, to disburse $66 million (adjusted for inflation in 2012 to $90.4 million) from the Lower Colorado River Basin Development Fund to the ISC in ten annual payments. Each payment is $9.04 million, and the first payment began in calendar year 2012. These disbursements are deposited into the New Mexico Unit Fund (Unit Fund), established in the New Mexico State Treasury and administered by the ISC. Currently, there are approximately $60 million in the Unit Fund. Pursuant to the AWSA, the ISC, in consultation with the Southwest New Mexico Water Study Group, which was succeeded by the Gila-San Francisco Water Commission and the New Mexico CAP Entity, may use the Unit Fund to pay costs of the New Mexico Unit or for any other water utilization alternatives to meet water supply demands in the Southwest Water Planning Region of New Mexico (AWSA 212(i)).

Since November 2014, the ISC has allocated $9.1 million out of the Unit Fund to 16 non-NM Unit projects in southwest New Mexico, as previously vetted by the ISC. In the past five years, only about 52 percent of the $9.1 million has been spent on those non-NM Unit projects by the grantees. Seven of the 16 projects are currently operational, while others are in various stages of design and construction. Progress has been slow due to technical, legal and financial issues and these issues have delayed construction or implementation of the remainder of the projects.

The ISC, in consultation with the New Mexico CAP Entity, has the discretion to allocate funds from the Unit Fund. However, there is uncertainty about how many, if any, new non-New Mexico Unit projects would be funded. It is also uncertain what the total funding allocation might be and where these new non-New Mexico Unit projects might be located within southwest New Mexico. As a result, future use of the Fund for non-New Mexico Unit projects cannot be estimated. However, what can be said is that the existing non-NM Unit project expenditures have occurred in the past and any future expenditures would partially offset the loss of regional economic effects if a New Mexico Unit project was not built. For example, an increase in expenditures of $1.0 million in one year compared to current conditions would translate into about 6 jobs, $150,000 in income, $590,000 in the value of output, and $49,000 in Federal and state tax revenue. The regional impacts presented below will overstate the regional impacts associated with each alternative because the other potential non-NM Unit projects are not taken into consideration.

Table 52 - Regional economic impacts from construction

Type of Impact	Employment	Labor Income	Value Added	Value of output
Alternative B				
Direct	238	$7,852,215	$10,035,915	$25,904,983
Indirect	36	$856,116	$1,730,078	$3,915,723
Induced	28	$765,832	$1,739,699	$3,345,933
Total Impact	***302***	***9,474,162***	***13,505,691***	***33,166,638***
Alternative C				
Direct	435	$12,843,960	$15,361,456	$44,425,907
Indirect	54	$1,129,014	$2,265,767	$6,218,627
Induced	33	$707,222	$1,939,154	$4,095,939
Total Impact	***522***	***14,680,195***	***19,566,377***	***54,740,473***
Alternative D				
Direct	34	$858,630	$1,129,158	$3,429,176
Indirect	3	$100,382	$163,959	$360,595
Induced	2	$58,580	$124,883	$249,286
Total Impact	***40***	***1,017,591***	***1,418,000***	***4,039,056***
Alternative E				
Direct	792	$24,348,089	$29,573,732	$82,452,038
Indirect	105	$2,258,780	$4,594,302	$11,966,843
Induced	67	$1,630,926	$4,189,964	$8,568,551
Total Impact	***963***	***28,237,794***	***38,357,997***	***102,987,432***

Table 53 – One-time percentage change in employment, value added, and total value of output from construction related expenditures relative to regional totals by alternative

Alternative	Employment	Value Added	Value of Output
Alternative B	1.1359%	0.6555%	0.8540%
Alternative C	1.9634%	0.9496%	1.4095%
Alternative D	0.1505%	0.0688%	0.1040%
Alternative E	3.6222%	1.8616%	2.6518%

Table 54 – Tax impacts from construction

Type of Impact	Federal	State
Alternative B		
Tax Impact	$1,982,777	$1,135,026
Alternative C		
Tax Impact	$2,791,395	$2,127,591
Alternative D		
Tax Impact	$200,276	$137,252
Alternative E		
Tax Impact	$5,526,274	$3,888,171

Regional Impacts Associated with Annual Operation, Maintenance, and Replacement Expenditures

OM&R costs can also lead to regional economic impacts if the expenditures represent additional spending within the region that otherwise would not have occurred. There are two basic questions that must be addressed in order to determine the extent to which OM&R expenditures result in regional impacts.

The first question is: will the OM&R related activities be completed by personnel located within the study region and will parts and other necessary equipment originate from within the region? For example, if mechanics must be brought in from outside the study region to complete a maintenance activity, then the majority of the pay earned by those mechanics would be spent outside of the region (except for lodging and meals expenditures while completing the activity). In such case, using those maintenance expenditures to estimate the regional impact associated with maintenance will overstate those impacts.

The second question is: who is paying for the OM&R activity? If the OM&R expenditures are paid by the beneficiaries of the water supplies who are located within the study region, then the OM&R payments must come from current expenditures on other goods and services (including savings). To the extent OM&R expenditures are a transfer from other categories of spending, assuming all OM&R expenditures generate regional impacts will overstate impacts. Therefore, the regional impacts from OM&R spending are represented by the difference in regional impact from spending on OM&R activities and the regional impact from current categories of spending.

For this analysis of the regional impacts from OM&R expenditures associated with the New Mexico Unit of the CAP, it can be assumed that the majority of OM&R activities would be provided by personnel within the study area but that all of the expenditures are paid by entities within the study area. Therefore, the regional impacts associated with OM&R activities result only from differences in the effects of different categories of spending on regional activity. Assuming the combination of current expenditures are typical for medium income households, transferring expenditures from the current categories of spending to OM&R expenditures would actually result in a slight negative regional impact. For the purposes of this analysis it is assumed that the OM&R impacts are negligible.

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