Lake Powell Pipeline

Draft Study Report 8
Paleontological Resources

March 2011

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Draft Paleontological Resources Study Report

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Paleontological Resources Study Report
Executive Summary

ES-1 Introduction

This study report describes the results and findings of a paleontological resources study to evaluate conditions along the proposed alternative alignments of the Lake Powell Pipeline (LPP) Project, No Lake Powell Water Alternative, and No Action Alternative. The purpose of the analysis, as defined in the 2008 Paleontological Resources Study Plan prepared for the Federal Energy Regulatory Commission (Commission), was to identify paleontological localities within the LPP Project area, identify vertebrate and other fossils in the LPP Project area, identify paleontologically sensitive formations within the LPP Project area, determine potential impacts on paleontological resources during construction and operations of the alternatives, and analyze cumulative impacts on paleontological resources within the LPP Project area from construction and operation activities.

ES-2 Methodology

The analysis of impacts on paleontological resources follows methodology identified and described in the Preliminary Application Document, Scoping Document No. 1 and the Paleontological Resources Study Plan filed with the Commission.

ES-3 Key Results of the Paleontological Resources Impact Analyses

A literature search was performed on the Utah and Arizona paleontological databases to review previously recorded localities. A total of 69 previously recorded fossil localities were found in the literature within two miles of features of the LPP Project; 58 of these were in Utah and 11 were in Arizona. The 58 Utah localities included 8 plant impressions or petrified wood fossils, 33 invertebrate fossils, 3 invertebrate trace fossils, 12 vertebrates and 8 vertebrate tracks (the total is more than 58 as some localities have more than 1 fossil type). The 11 Arizona localities included 3 plant fossils, 1 invertebrate (insects) fossil site, 7 vertebrate fossils and 3 vertebrate tracks (the total is more than 11 as some localities have more than 1 fossil type).

The field surveys resulted in recording a total of 49 new fossil localities in boundaries or corridors of proposed or alternative features of the LPP Project; 24 in Arizona and 25 in Utah. These new fossils consisted of plant localities, invertebrate localities, and vertebrate and invertebrate track localities. No vertebrate bone fossils were found during the surveys. The Utah surveys resulted in recording 3 new plant localities (petrified wood and plant impressions), 20 new invertebrate localities and 2 new track localities (1 vertebrate and 1 invertebrate). The Arizona surveys resulted in recording 2 new plant localities (petrified wood and plant impressions), 20 new invertebrate localities, and 2 new vertebrate track localities.

Eleven geological units were identified as present on or along the various features of the LPP Project. These were rated using the Potential Fossil Yield Classification (PFYC) System, which is intended to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered an intermediate point in the analysis, and should be used to assist in determining the need for further mitigation assessment or actions. The classifications range from Class 1

– Very Low to Class 5 – Very High. Table ES-1 summarizes the PFYC classification of the geological units.

Table ES-1
PFYC Rating for Geological Formations Found along or at Features of the Proposed LPP Project

Geological Formations	Potential Fossil Yield Classification Rating
Pliocene and Pleistocene sediments	Class 3b - Unknown Potential
Entrada Sandstone - Jurassic	Class 3a - Moderate Potential
Carmel Formation – Jurassic Upper Member Judd Hollow Tongue	Class 3a - Moderate Potential
Page Sandstone - Jurassic	Class 2 - Low Potential
Navajo Sandstone - Jurassic	Class 3a - Moderate Potential
Kayenta Formation - Jurassic	Class 3a - Moderate Potential
Moenave Formation or Wingate Sandstone	Class 3a - Moderate Potential
Whitmore Point and Springdale Members	Class 4 - High Potential
Chinle Formation – Triassic Upper members including the Petrified Forest Member and the Lower or Shinarump Member	Class 4 - High Potential
Moenkopi Formation – Triassic Upper Red Member Shnabkaib Member Middle Red Member Lower Red member Timpoweap Member	Class 3a -Moderate Potential
Kaibab Limestone - Permian	Class 3a -Moderate Potential
Toroweap Formation - Permian	Class 3a -Moderate Potential

Chapter 1
Introduction

1.1 Introduction

This chapter presents a summary description of the alternatives studied for the Lake Powell Pipeline (LPP) project, located in north central Arizona and southwest Utah (Figure 1-1) and identifies the issues and impact topics for the Paleontological Resources Study Report. The alternatives studied and analyzed include different alignments for pipelines and penstocks and transmission lines, a no Lake Powell water alternative, and the No Action alternative. The pipelines would convey water under pressure and connect to the penstocks, which would convey the water to a series of hydroelectric power generating facilities. The action alternatives would each deliver 86,249 acre-feet of water annually for municipal and industrial (M&I) use in the three southwest Utah water conservancy district service areas. Washington County Water Conservancy District (WCWCD) would receive 69,000 acre-feet, Kane County Water Conservancy District (KCWCD) would receive 4,000 acre-feet and Central Iron County Water Conservancy District (CICWCD) could receive up to 13,249 acre-feet each year.

1.2 Summary Description of Alignment Alternatives

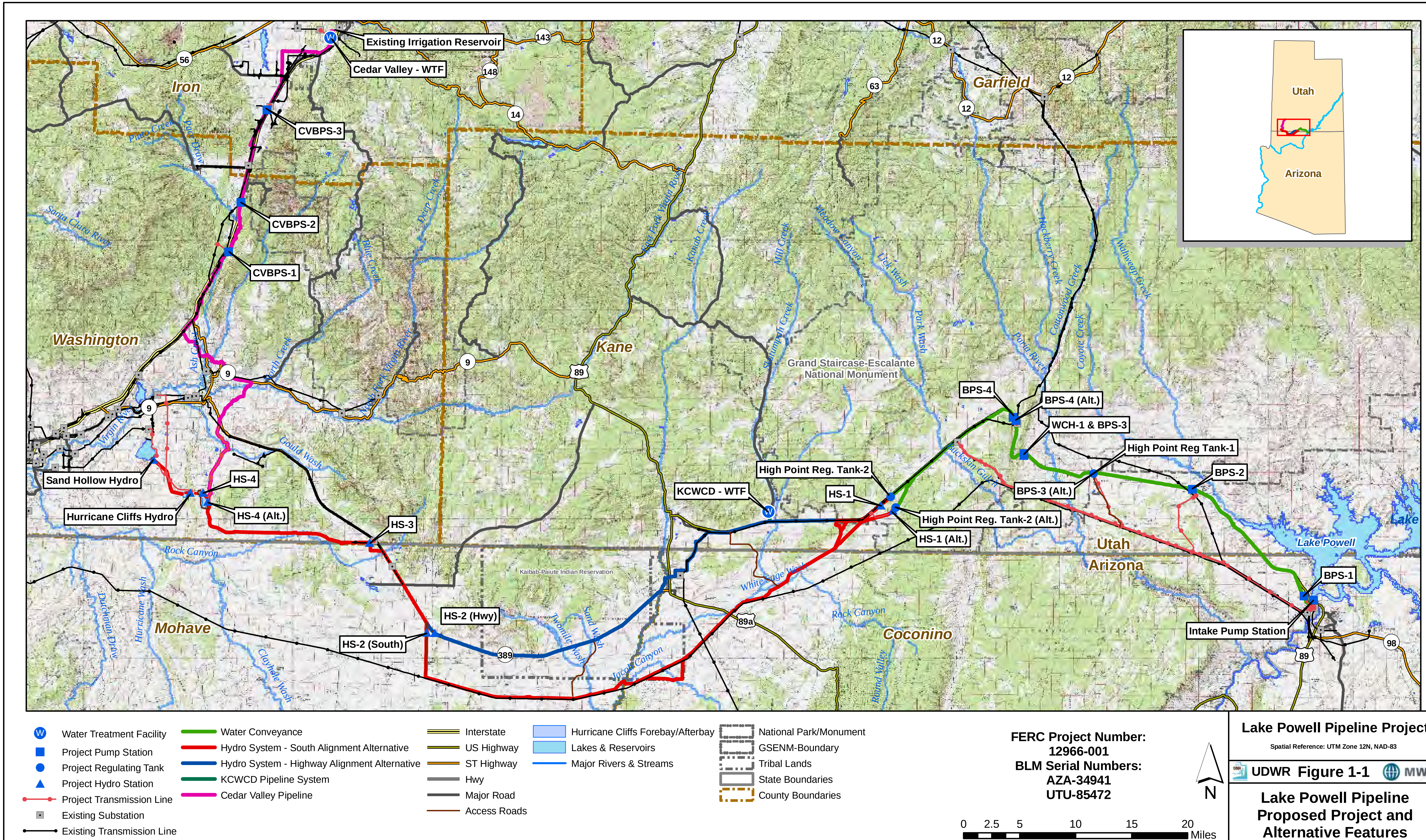
Three primary pipeline and penstock alignment alternatives are described in this section along with the electrical power transmission line alternatives. The pipeline and penstock alignment alternatives share common segments between the intake at Lake Powell and delivery at Sand Hollow Reservoir, and they are spatially different in the area through and around the Kaibab-Paiute Indian Reservation. The South Alternative extends south around the Kaibab-Paiute Indian Reservation. The Existing Highway Alternative follows an Arizona state highway through the Kaibab-Paiute Indian Reservation. The Southeast Corner Alternative follows the Navajo-McCullough Transmission Line corridor through the southeast corner of the Kaibab-Paiute Indian Reservation. The transmission line alignment alternatives are common to all the pipeline and penstock alignment alternatives. Figure 1-1 shows the overall proposed project and alternative features from Lake Powell near Page, Arizona to Sand Hollow and Cedar Valley, Utah.

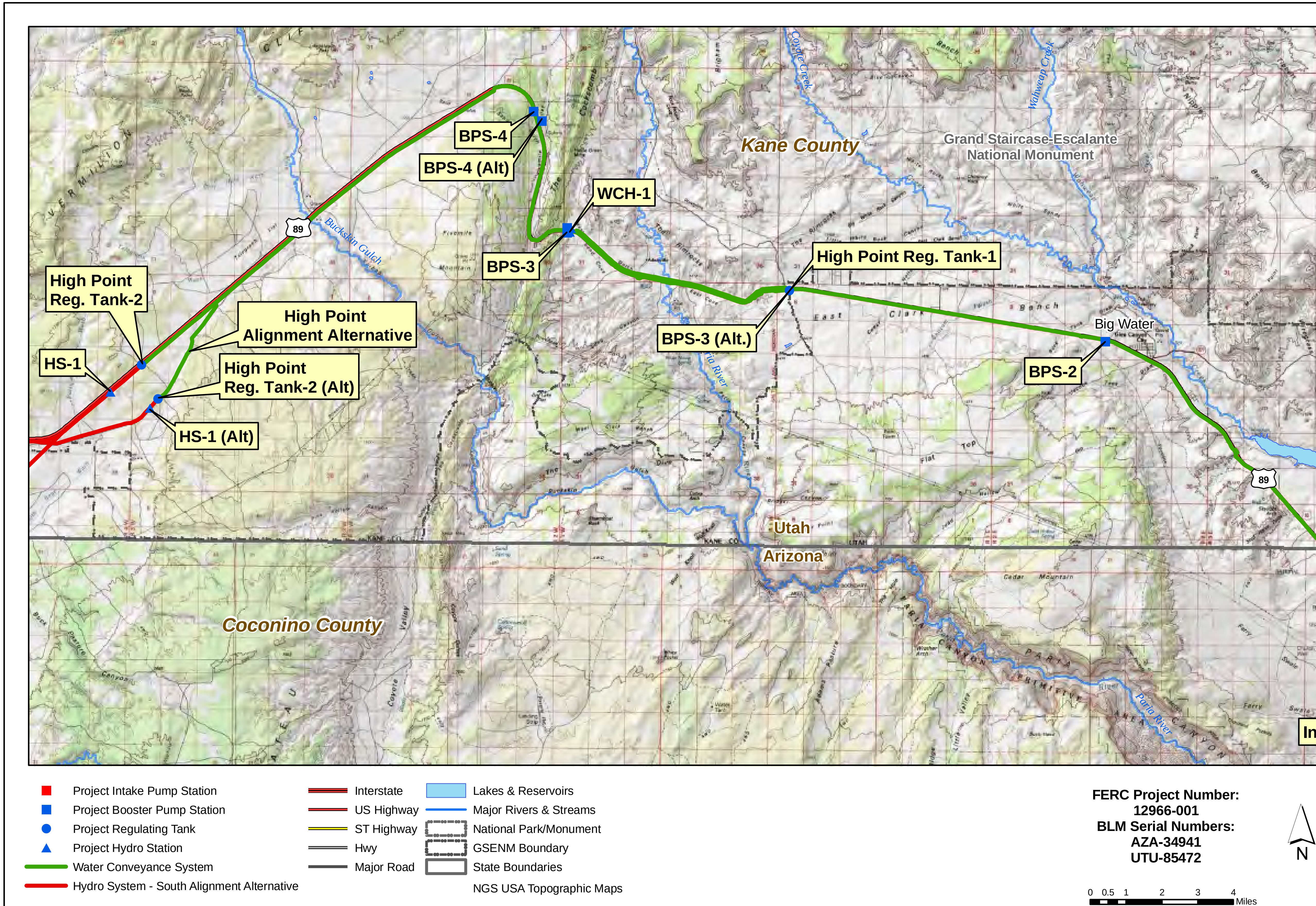
1.2.1 South Alternative

The South Alternative consists of five systems: Intake, Water Conveyance, Hydro, Kane County Pipeline, and Cedar Valley Pipeline.

The **Intake System** would pump Lake Powell water via submerged horizontal tunnels and vertical shafts into the LPP. The intake pump station would be constructed and operated adjacent to the west side of Lake Powell approximately 2,000 feet northwest of Glen Canyon Dam in Coconino County, Arizona (Figure 1-2). The pump station enclosure would house vertical turbine pumps with electric motors, electrical controls, and other equipment at a ground level elevation of 3,745 feet mean sea level (MSL).

The **Water Conveyance System** would convey the Lake Powell water from the Intake System for about 51 miles through a buried 69-inch diameter pipeline parallel with U.S. 89 in Coconino County, Arizona and Kane County, Utah to a buried regulating tank (High Point Regulating Tank-2) on the south side of U.S. 89 at ground level elevation 5,695 feet MSL, which is the LPP project topographic high point


Existing Irrigation Reservoir
Cedar Valley - WTF
CVBPS-3
CVBPS-2
CVBPS-1
Iron
Washington
Kane
Garfield
Mohave
Coconino
Utah
Arizona
Grand Staircase-Escalante
National Monument
Kaibab-Paiute Indian Reservation
Lake Powell
Lake
Sand Hollow Hydro
Hurricane Cliffs Hydro
HS-4
HS-4 (Alt.)
HS-3
HS-2 (Hwy)
HS-2 (South)
KCWCD - WTF
High Point Reg. Tank-2
HS-1
High Point Reg. Tank-2 (Alt.)
HS-1 (Alt.)
BPS-4
BPS-4 (Alt.)
WCH-1 & BPS-3
High Point Reg Tank-1
BPS-3 (Alt.)
BPS-2
BPS-1
Intake Pump Station
Santa Clara River
Pinto Creek
Ash Creek
North Creek
Gould Wash
Deep Creek
Blue Creek
North Fork Virgin River
East Fork Virgin River
Kanab Creek
Johnson Creek
Mill Creek
Meadow Canyon
Deer Wash
Park Wash
Paria River
Hackberry Creek
Cottonwood Creek
Coyote Creek
Wahweap Creek
Buckskin Gulch
Rock Canyon
Hurricane Wash
Dutchman Draw
Clayhole Wash
Twomile Wash
Sand Wash
Jacob Canyon
White Sage Wash
Round Valley
Virgin River
56
143
148
14
12
63
9
89
389
89a
98
Utah
Arizona
Water Treatment Facility
Project Pump Station
Project Regulating Tank
Project Hydro Station
Project Transmission Line
Existing Substation
Existing Transmission Line
Water Conveyance
Hydro System - South Alignment Alternative
Hydro System - Highway Alignment Alternative
KCWCD Pipeline System
Cedar Valley Pipeline
Interstate
US Highway
ST Highway
Hwy
Major Road
Access Roads
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams
National Park/Monument
GSENM-Boundary
Tribal Lands
State Boundaries
County Boundaries
FERC Project Number:
12966-001
BLM Serial Numbers:
AZA-34941
UTU-85472
0 2.5 5 10 15 20
Miles
N
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 1-1 MWH
Lake Powell Pipeline
Proposed Project and
Alternative Features



Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 1-2 MWH

Lake Powell Pipeline Intake and Water Conveyance Systems

(Figure 1-2). The pipeline would be sited within a utility corridor established by Congress in 1998 which extends 500 feet south and 240 feet north of the U.S. 89 centerline on public land administered by the Bureau of Land Management (BLM) (U.S. Congress 1998). Four booster pump stations (BPS) located along the pipeline would pump the water under pressure to the high point regulating tank. Each BPS would house vertical turbine pumps with electric motors, electrical controls, and other equipment. Additionally, each BPS site would have a substation, buried forebay tank and a surface emergency overflow detention basin. BPS-1 would be sited within the Glen Canyon National Recreation Area adjacent to an existing Arizona Department of Transportation maintenance facility located west of U.S. 89. BPS-2 would be sited on land administered by the Utah School and Institutional Trust Lands Administration (SITLA) near the town of Big Water, Utah on the south side of U.S. 89. BPS-3 and an in-line hydro station (WCH-1) would be sited at the east side of the Cockscomb geologic feature in the Grand Staircase-Escalante National Monument (GSENM) within the Congressionally-designated utility corridor. BPS-3 (Alt) is an alternative location for BPS-3 on land administered by the BLM Kanab Field Office near the east boundary of the GSENM on the south side of U.S. 89 within the Congressionally-designated utility corridor. Incorporation of BPS-3 (Alt.) into the LPP project would replace BPS-3 and WCH-1 at the east side of the Cockscomb geologic feature. BPS-4 would be sited on the west side of U.S. 89 and within the Congressionally-designated utility corridor in the GSENM on the west side of the Cockscomb geologic feature.

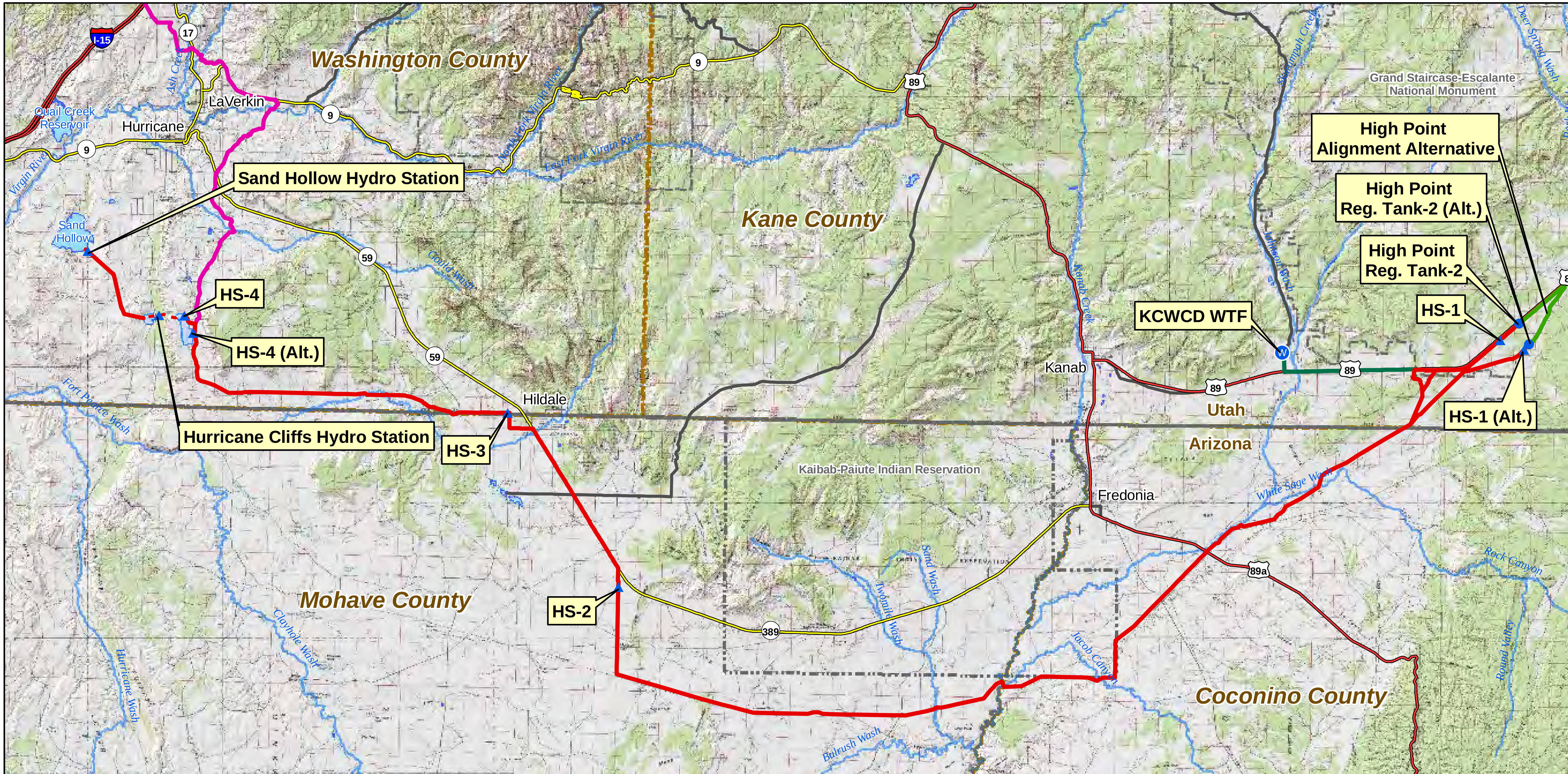
The High Point Alignment Alternative would diverge south from U.S. 89 parallel to the K4020 road and continue outside of the Congressionally-designated utility corridor to a buried regulating tank (High Point Regulating Tank-2 (Alt.) at ground level elevation 5,630 feet MSL, which would be the topographic high point of the LPP project along this alignment alternative (Figure 1-2). The High Point Alignment Alternative would include BPS-4 (Alt.) on private land east of U.S. 89 and west of the Cockscomb geologic feature (Figure 1-2). Incorporation of the High Point Alignment Alternative and BPS-4 (Alt.) into the LPP project would replace the High Point Regulation Tank-2 along U.S. 89, the associated buried pipeline and BPS-4 west of U.S. 89.

A rock formation avoidance alignment option would be included immediately north of Blue Pool Wash along U.S. 89 in Utah. Under this alignment option, the pipeline would cross to the north side of U.S. 89 for about 400 feet and then return to the south side of U.S. 89. This alignment option would avoid tunneling under the rock formation on the south side of U.S. 89 near Blue Pool Wash.

A North Pipeline Alignment option is located parallel to the north side of U.S. 89 for about 6 miles from the east boundary of the GSENM to the east side of the Cockscomb geological feature.

The **Hydro System** would convey the Lake Powell water from High Point Regulating Tank-2 at the high point at ground level elevation 5,695 feet MSL for about 87 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah and Coconino and Mohave counties, Arizona to Sand Hollow Reservoir near St. George, Utah (Figure 1-3). The High Point Alignment Alternative would convey the Lake Powell water from High Point Regulating Tank-2 (Alt.) at the high point at ground level elevation 5,630 feet MSL for about 87.5 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah and Coconino and Mohave counties, Arizona to Sand Hollow Reservoir near St. George, Utah (Figure 1-3). Four in-line hydro generating stations (HS-1, HS-2 HS-3 and HS-4) with substations located along the penstock would generate electricity and help control water pressure in the penstock. HS-1 would be sited on the south side of U.S. 89 within the Congressionally-designated utility corridor through the GSENM. The High Point Alignment Alternative would include HS-1 (Alt.) along the K4020 road within the GSENM and continue along a portion of the K3290 road.

The proposed penstock alignment and two penstock alignment options are being considered to convey the water from the west GSENM boundary south through White Sage Wash. The proposed penstock



- Water Treatment Facility
- Project Regulating Tank
- Project Hydro Station
- Hurricane Cliffs Forebay/Afterbay
- Lakes & Reservoirs
- Major Rivers & Streams
- Hydro System - South Alignment Alternative
- Water Conveyance System
- Cedar Valley Pipeline
- KCWCD Pipeline System
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- National Park/Monument
- GSENM Boundary
- Tribal Lands
- State Boundaries
- County Boundaries

FERC Project Number:
12966-001
BLM Serial Numbers:
AZA-34941
UTU-85472

N

0 1.25 2.5 5 7.5 10 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 1-3** MWH

Lake Powell Pipeline Hydro System South Alternative

alignment would parallel the K3250 road south from U.S. 89 and follow the Pioneer Gap Road alignment around the Shinarump Cliffs. One penstock alignment option would parallel the K3285 road southwest from U.S. 89 and continue to join the Pioneer Gap Road around the Shinarump Cliffs. The other penstock alignment option would extend southwest through currently undeveloped BLM land from the K3290 road into White Sage Wash.

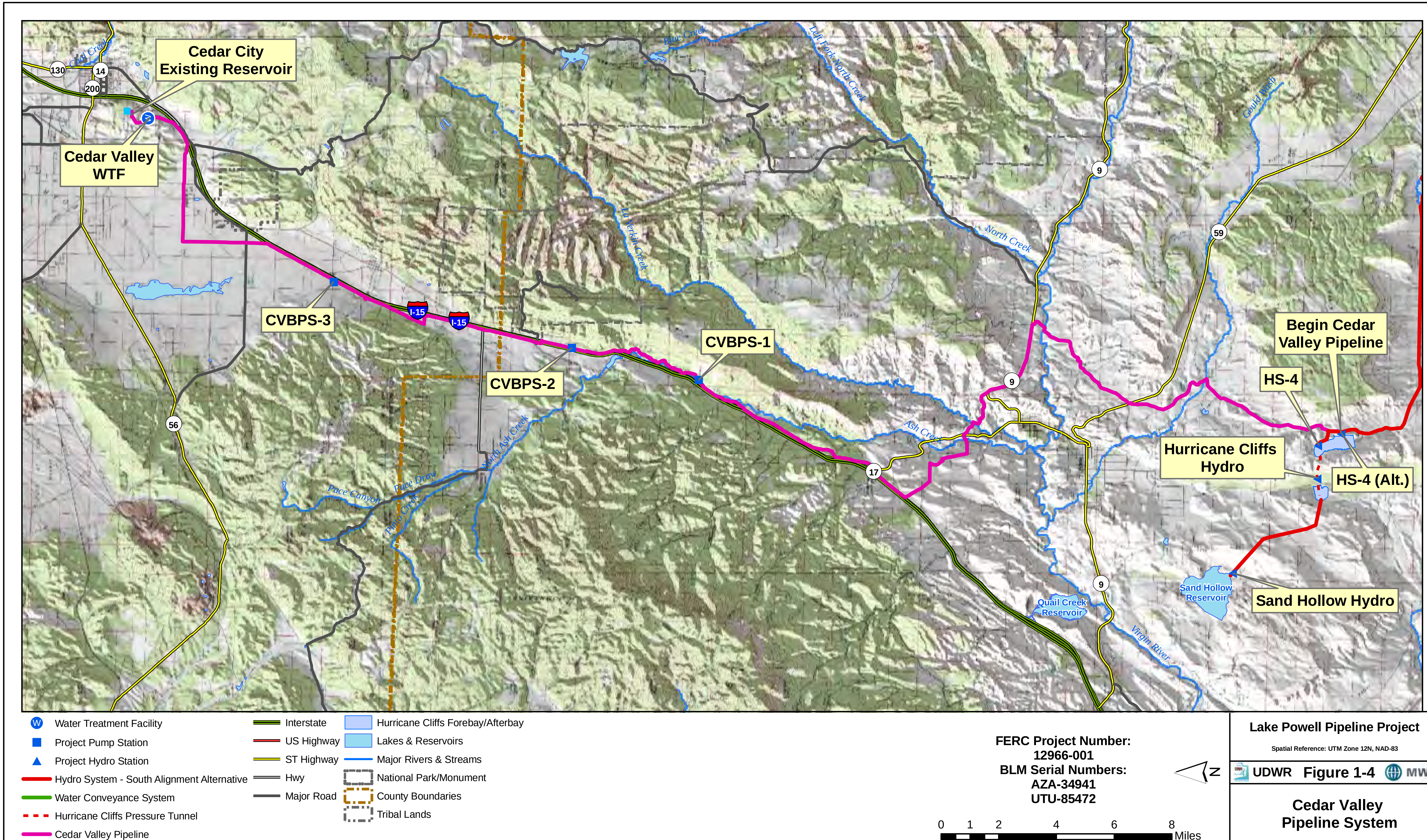
The penstock alignment would continue through White Sage Wash and then parallel to the Navajo-McCullough Transmission Line, crossing U.S. 89 Alt. and Forest Highway 22 toward the southeast corner of the Kaibab Indian Reservation. The penstock alignment would run parallel to and south of the south boundary of the Kaibab Indian Reservation, crossing Kanab Creek and Bitter Seeps Wash, across Moonshine Ridge and Cedar Ridge, and north along Yellowstone Road to Arizona State Route 389 west of the Kaibab Indian Reservation. HS-2 would be sited west of the Kaibab Indian Reservation. The penstock alignment would continue northwest along the south side of Arizona State Route 389 past Colorado City to Hildale City, Utah and HS-3.

The penstock alignment would follow Uzona Road west through Canaan Gap and south of Little Creek Mountain and turn north to HS-4 (Alt.) above the proposed Hurricane Cliffs forebay reservoir. The forebay reservoir would be contained in a valley between a south dam and a north dam and maintain active storage of 11,255 acre-feet of water. A low pressure tunnel would convey the water to a high pressure vertical shaft in the bedrock forming the Hurricane Cliffs, connected to a high pressure tunnel near the bottom of the Hurricane Cliffs. The high pressure tunnel would connect to a penstock conveying the water to a pumped storage hydro generating station. The pumped storage hydro generating station would connect to an afterbay reservoir contained by a single dam in the valley below the Hurricane Cliffs. A low pressure tunnel would convey the water northwest to a penstock continuing on to the Sand Hollow Hydro Station. The water would discharge into the existing Sand Hollow Reservoir.

The peaking hydro generating station option would involve a smaller, 200 acre-foot forebay reservoir with HS-4 discharging into the forebay reservoir, with the peaking hydro generating station discharging to a small afterbay connected to a penstock running north along the existing BLM road and west to the Sand Hollow Hydro Station. A low pressure tunnel would convey the water to a high pressure vertical shaft in the bedrock forming the Hurricane Cliffs, connected to a high pressure tunnel near the bottom of the Hurricane Cliffs. The high pressure tunnel would connect to a penstock conveying the water to a peaking hydro generating station, which would discharge into a 200 acre-foot afterbay reservoir. A penstock would extend north from the afterbay reservoir along the existing BLM road and then west to the Sand Hollow Hydro Station. The water would discharge into the existing Sand Hollow Reservoir.

The **Kane County Pipeline System** would convey the Lake Powell water from the Lake Powell Pipeline at the west GSENM boundary for about 8 miles through a buried 24-inch diameter pipe in Kane County, Utah to a conventional water treatment facility located near the mouth of Johnson Canyon. The pipeline would parallel the south side of U.S. 89 across Johnson Wash and then run north to the new water treatment facility site (Figure 1-3).

The **Cedar Valley Pipeline System** would convey the Lake Powell water from the Lake Powell Pipeline just upstream of HS-4 or HS-4 (Alt.) for about 58 miles through a buried 36-inch diameter pipeline in Washington and Iron counties, Utah to a conventional water treatment facility in Cedar City, Utah (Figure 1-4). Three booster pump stations (CVBPS) located along the pipeline would pump the water under pressure to the new water treatment facility. The pipeline would follow an existing BLM road north from HS-4, cross Utah State Route 59 and continue north to Utah State Route 9, with an aerial crossing of the Virgin River at the Sheep Bridge. The pipeline would run west along the north side of Utah State Route 9 and parallel an existing pipeline through the Hurricane Cliffs at Nephi’s Twist. The pipeline



Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 1-4** MWH

Cedar Valley Pipeline System

would continue across LaVerkin Creek, cross Utah State Route 17, and make an aerial crossing of Ash Creek. The pipeline would continue northwest to the Interstate 15 corridor and then northeast parallel to the east side of Interstate 15 highway right-of-way. CVBPS-1 would be sited adjacent to an existing gravel pit east of Interstate 15. CVBPS-2 would be sited on private property on the east side of Interstate 15 and south of the Kolob entrance to Zion National Park. CVBPS-3 would be sited on the west side of Interstate 15 in Iron County. The new water treatment facility would be sited near existing water reservoirs on a hill above Cedar City west of Interstate 15.

1.2.2 Existing Highway Alternative

The Existing Highway Alternative consists of five systems: Intake, Water Conveyance, Hydro, Kane County Pipeline, and Cedar Valley Pipeline. The Intake, Water Conveyance and Cedar Valley Pipeline systems would be the same as described for the South Alternative.

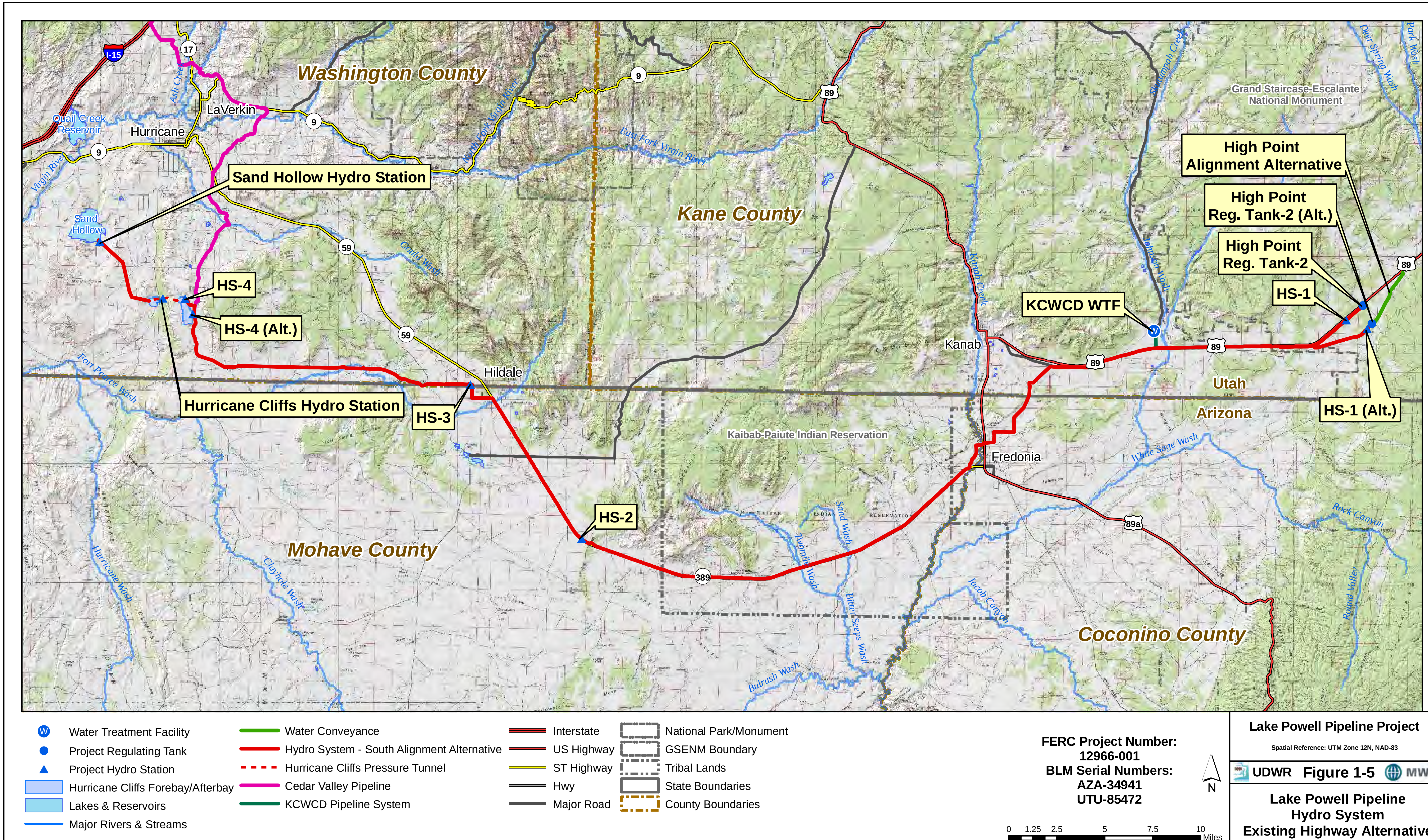
The **Hydro System** would convey the Lake Powell water from the regulating tank at the high point at ground elevation 5,695 feet MSL for about 80 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah and Coconino and Mohave counties, Arizona to Sand Hollow Reservoir near St. George, Utah (Figure 1-5). The High Point Alignment Alternative would convey the Lake Powell water from High Point Regulating Tank-2 (Alt.) at the high point at ground level elevation 5,630 feet MSL for about 80.5 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah and Coconino and Mohave counties, Arizona to Sand Hollow Reservoir near St. George, Utah (Figure 1-3). The High Point Alignment Alternative would rejoin U.S. 89 about 2.5 miles east of the west boundary of the GSENM. Four in-line hydro generating stations (HS-1, HS-2 HS-3 and HS-4) located along the penstock would generate electricity and help control water pressure in the penstock. HS-1 would be sited on the south side of U.S. 89 within the Congressionally-designated utility corridor through the GSENM. The High Point Alignment Alternative would include HS-1 (Alt.) along the K4020 road within the GSENM and continue along a portion of the K3290 road to its junction with the pipeline alignment along U.S. 89.

The penstock would parallel the south side of U.S. 89 west of the GSENM past Johnson Wash and follow Lost Spring Gap southwest, crossing U.S. 89 Alt. and Kanab Creek in the north end of Fredonia, Arizona. The penstock would run south paralleling Kanab Creek to Arizona State Route 389 and run west adjacent to the north side of this state highway through the Kaibab-Paiute Indian Reservation past Pipe Spring National Monument. The penstock would continue along the north side of Arizona State Route 389 through the west half of the Kaibab-Paiute Indian Reservation to 1.8 miles west of Cedar Ridge (intersection of Yellowstone Road with U.S. 89), from where it would follow the same alignment as the South Alternative to Sand Hollow Reservoir. HS-2 would be sited 0.5 mile west of Cedar Ridge along the north side of Arizona State Route 389.

The **Kane County Pipeline System** would convey the Lake Powell water from the Lake Powell Pipeline crossing Johnson Wash along U.S. 89 for about 1 mile north through a buried 24-inch diameter pipe in Kane County, Utah to a conventional water treatment facility located near the mouth of Johnson Canyon (Figure 1-5).

1.2.3 Southeast Corner Alternative

The Southeast Corner Alternative consists of five systems: Intake, Water Conveyance, Hydro, Kane County Pipeline, and Cedar Valley Pipeline. The Intake, Water Conveyance, Kane County Pipeline and Cedar Valley Pipeline systems would be the same as described for the South Alternative.



Washington County
Kane County
Mohave County
Coconino County
LaVerkin
Hurricane
Quail Creek Reservoir
Sand Hollow
Virgin River
Ash Creek
I-15
17
9
59
89
89a
389
Sand Hollow Hydro Station
HS-4
HS-4 (Alt.)
Hurricane Cliffs Hydro Station
HS-3
HS-2
Hildale
Kanab
Fredonia
Kanab Creek
East Fork Virgin River
North Fork Virgin River
Gould Wash
Fort Pearce Wash
Hurricane Wash
Clayhole Wash
Kaibab-Paiute Indian Reservation
Sand Wash
Twomile Wash
Bitter Seeps Wash
Bulrush Wash
Jacob Canyon
White Sage Wash
Rock Canyon
Johnson Wash
Deer Spring Wash
Park Wash
Grand Staircase-Escalante National Monument
High Point Alignment Alternative
High Point Reg. Tank-2 (Alt.)
High Point Reg. Tank-2
HS-1
HS-1 (Alt.)
KCWCD WTF
Utah
Arizona
Water Treatment Facility
Project Regulating Tank
Project Hydro Station
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams
Water Conveyance
Hydro System - South Alignment Alternative
Hurricane Cliffs Pressure Tunnel
Cedar Valley Pipeline
KCWCD Pipeline System
Interstate
US Highway
ST Highway
Hwy
Major Road
National Park/Monument
GSENM Boundary
Tribal Lands
State Boundaries
County Boundaries
FERC Project Number:
12966-001
BLM Serial Numbers:
AZA-34941
UTU-85472
N
0 1.25 2.5 5 7.5 10 Miles
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
UDWR
Figure 1-5
MWH
Lake Powell Pipeline
Hydro System
Existing Highway Alternative

The **Hydro System** would be the same as described for the South Alternative between High Point Regulating Tank-2 and the east boundary of the Kaibab-Paiute Indian Reservation. The penstock alignment would parallel the north side of the Navajo-McCullough Transmission Line corridor in Coconino County, Arizona through the southeast corner of the Kaibab Indian Reservation for about 3.8 miles and then follow the South Alternative alignment south of the south boundary of the Kaibab-Paiute Indian Reservation, continuing to Sand Hollow Reservoir (Figure 1-6).

1.2.4 Transmission Line Alternatives

Transmission line alternatives include the Intake (3 alignments), BPS-1, Glen Canyon to Buckskin, Buckskin Substation upgrade, Paria Substation upgrade, BPS-2, BPS-2 Alternative, BPS-3 North, BPS-3 South, BPS-3 Underground, BPS-3 Alternative North, BPS-3 Alternative South, BPS-4, BPS-4 Alternative, HS-1 Alternative, HS-2 South, HS-3 Underground, HS-4, HS-4 Alternative, Hurricane Cliffs Afterbay to Sand Hollow, Hurricane Cliffs Afterbay to Hurricane West, Sand Hollow to Dixie Springs, Cedar Valley Pipeline booster pump stations, and Cedar Valley Water Treatment Facility.

The proposed new **Intake Transmission Line** would begin at Glen Canyon Substation and run parallel to U.S. 89 for about 2,500 feet to a new switch station, cross U.S. 89 at the Intake access road intersection and continue northeast to the Intake substation. This 69 kV transmission line would be about 0.9 mile long in Coconino County, Arizona (Figure 1-7). One alternative alignment would run parallel to an existing 138 kV transmission line to the west, turn north to the new switch station, cross U.S. 89 at the Intake access road intersection and continue northeast to the Intake substation. This 69 kV transmission line alternative would be about 1.2 miles long in Coconino County, Arizona (Figure 1-7). Another alternative alignment would bifurcate from an existing transmission line and run west, then northeast to the new switch station, cross U.S. 89 at the Intake access road intersection and continue northeast to the Intake substation. This 69 kV transmission line alternative would be about 1.3 miles long in Coconino County, Arizona (Figure 1-7).

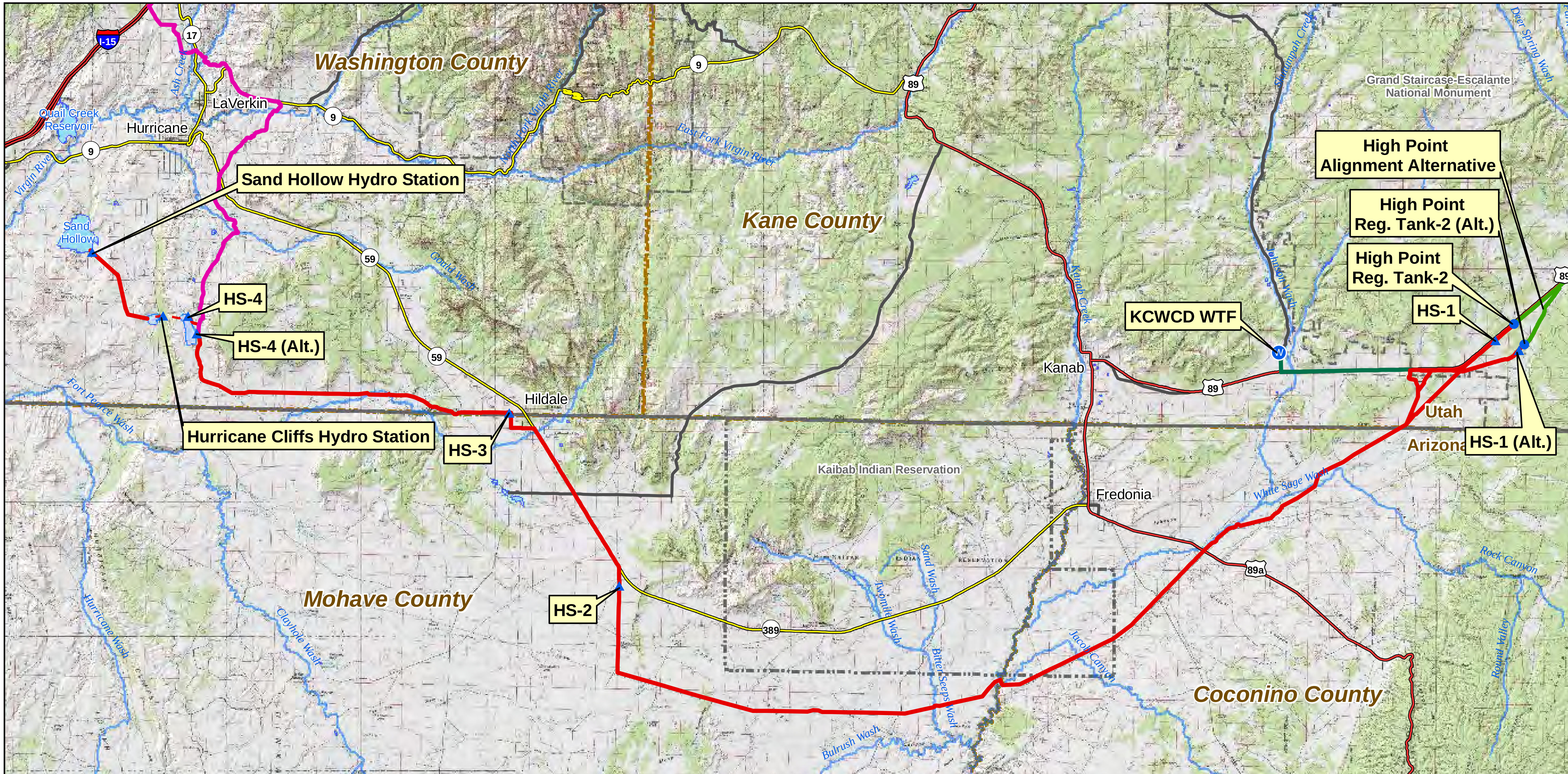
The proposed new **BPS-1 Transmission Line** would begin at the new switch station located on the south side of U.S. 89 and parallel the LPP Water Conveyance System alignment to the BPS-1 substation west of U.S. 89. This 69 kV transmission line would be about 1 mile long in Coconino County, Arizona (Figure 1-7).

The proposed new **Glen Canyon to Buckskin Transmission Line** would consist of a 230 kV transmission line from the Glen Canyon Substation to the Buckskin Substation, running parallel to the existing 138 kV transmission line. This transmission line upgrade would be about 36 miles long through Coconino County, Arizona and Kane County, Utah (Figure 1-7).

The existing **Buckskin Substation** would be upgraded as part of the proposed project to accommodate the additional power loads from the new 230 kV Glen Canyon to Buckskin transmission line. The substation upgrade would require an additional 5 acres of land within the GSENM adjacent to the existing substation in Kane County, Utah (Figure 1-7).

The existing **Paria Substation** would be upgraded as part of the proposed project to accommodate the additional power loads to BPS-4 Alternative. The substation upgrade would require an additional 2 acres of privately-owned land adjacent to the existing substation in Kane County, Utah (Figure 1-7).

The proposed new **BPS-2 Transmission Line** alternative would consist of a new 3-ring switch station along the existing 138 kV Glen Canyon to Buckskin Transmission Line and a new transmission line from the switch station to a new substation west of Big Water and a connection to BPS-2 substation in Kane



Water Treatment Facility
Project Regulating Tank
Project Hydro Station
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams

Water Conveyance System
Hydro System - Southeast Corner Alternative
Kane County Pipeline System
Cedar Valley Pipeline System

Interstate
US Highway
ST Highway
Hwy
Major Road

National Park/Monument
GSENM Boundary
Tribal Lands
State Boundaries
County Boundaries

FERC Project Number:
12966-001
BLM Serial Numbers:
AZA-34941
UTU-85472

N

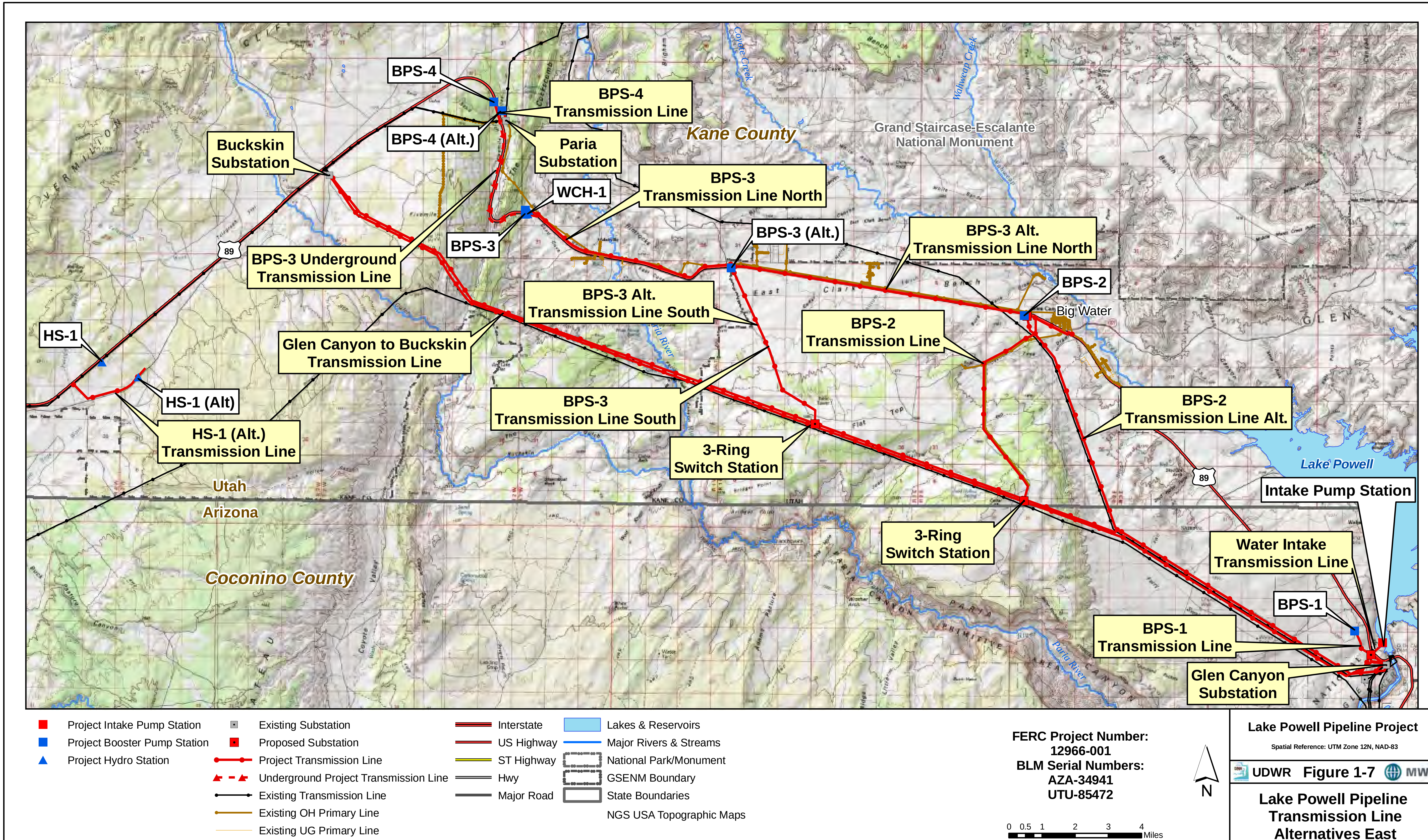
0 1.25 2.5 5 7.5 10 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 1-6** MWH

Lake Powell Pipeline
Hydro System
Southeast Corner Alternative


BPS-4
BPS-4 Transmission Line
BPS-4 (Alt.)
Paria Substation
Buckskin Substation
Kane County
Grand Staircase-Escalante National Monument
BPS-3 Transmission Line North
WCH-1
BPS-3
BPS-3 (Alt.)
BPS-3 Alt. Transmission Line North
BPS-3 Underground Transmission Line
BPS-2
Big Water
BPS-3 Alt. Transmission Line South
BPS-2 Transmission Line
Glen Canyon to Buckskin Transmission Line
HS-1
HS-1 (Alt)
HS-1 (Alt.) Transmission Line
BPS-3 Transmission Line South
BPS-2 Transmission Line Alt.
3-Ring Switch Station
Lake Powell
Intake Pump Station
Utah
Arizona
3-Ring Switch Station
Water Intake Transmission Line
Coconino County
BPS-1
BPS-1 Transmission Line
Glen Canyon Substation
89
Project Intake Pump Station
Project Booster Pump Station
Project Hydro Station
Existing Substation
Proposed Substation
Project Transmission Line
Underground Project Transmission Line
Existing Transmission Line
Existing OH Primary Line
Existing UG Primary Line
Interstate
US Highway
ST Highway
Hwy
Major Road
Lakes & Reservoirs
Major Rivers & Streams
National Park/Monument
GSENM Boundary
State Boundaries
NGS USA Topographic Maps
FERC Project Number: 12966-001
BLM Serial Numbers: AZA-34941 UTU-85472
0 0.5 1 2 3 4 Miles
N
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
UDWR
Figure 1-7
MWH
Lake Powell Pipeline Transmission Line Alternatives East

County, Utah. The new transmission line would parallel an existing distribution line that runs northwest, north and then northeast to Big Water. This new 138 kV transmission line alternative would be about 7 miles long across Utah SITLA-administered land, with a 138 kV connection to the BPS-2 substation (Figure 1-7).

The new **BPS-2 Alternative Transmission Line** would consist of a new 138 kV transmission line from Glen Canyon Substation parallel to the existing Rocky Mountain Power 230 kV transmission line, connecting to the BPS-2 substation west of Big Water. This new 138 kV transmission line alternative would be about 16.5 miles long in Coconino County, Arizona and Kane County, Utah crossing National Park Service-administered land, BLM-administered land and Utah SITLA-administered land (Figure 1-7).

The new **BPS-3 Transmission Line North** alternative would consist of a new 138 kV transmission line from BPS-2 paralleling the south side of U.S. 89 within the Congressionally designated utility corridor west to BPS-3 at the east side of the Cockscomb geological feature. This new 138 kV transmission line alternative would be about 15.7 miles long in Kane County, Utah (Figure 1-7).

The new **BPS-3 Transmission Line South** alternative would consist of a new 3-ring switch station along the existing 138 kV Glen Canyon to Buckskin Transmission Line and a new transmission line from the switch station north along an existing BLM road to U.S. 89 and then west along the south side of U.S. 89 within the Congressionally designated utility corridor to BPS-3 at the east side of the Cockscomb. This new 138 kV transmission line alternative would be about 12.3 miles long in Kane County, Utah (Figure 1-7).

The new **BPS-3 Underground Transmission Line** alternative would consist of a new buried 24.9 kV transmission line (2 circuits) from the upgraded Paria Substation to BPS-3 on the east side of the Cockscomb geological feature. This new underground transmission line would be parallel to the east and south side of U.S. 89 and would be about 4.1 miles long in Kane County, Utah (Figure 1-7).

The new **BPS-3 Alternative Transmission Line North** alternative would consist of a new 138 kV transmission line from BPS-2 paralleling the south side of U.S. 89 west to BPS-3 Alternative near the GSENM east boundary within the Congressionally-designated utility corridor. This new 138 kV transmission line alternative would be about 9.3 miles long in Kane County, Utah (Figure 1-7).

The proposed new **BPS-3 Alternative Transmission Line South** alternative would consist of a new 3-ring switch station along the existing 138 kV Glen Canyon to Buckskin Transmission Line and a new transmission line from the switch station north along an existing BLM road to BPS-3 Alternative near the GSENM east boundary and within the Congressionally-designated utility corridor. This new 138 kV transmission line alternative would be about 5.9 miles long in Kane County, Utah (Figure 1-7).

The new **BPS-4 Transmission Line** alternative would begin at the upgraded Paria Substation and run parallel to the west side of U.S. 89 north to BPS-4 within the Congressionally designated utility corridor. This new 138 kV transmission line would be about 0.8 mile long in Kane County, Utah (Figure 1-7).

The proposed new **BPS-4 Alternative Transmission Line** would begin at the upgraded Paria Substation and run north to the BPS-4 Alternative. This 69 kV transmission line would be about 0.4 mile long in Kane County, Utah (Figure 1-7).

The proposed new **HS-1 Alternative Transmission Line** would begin at the new HS-1 Alternative and run southwest parallel to the K4020 road and then northwest parallel to the K4000 road to the U.S. 89 corridor where it would tie into the existing 69 kV transmission line from the Buckskin Substation to the

Johnson Substation. This 69 kV transmission line would be about 3 miles long in Kane County, Utah (Figure 1-7).

The proposed new **HS-2 South Transmission Line** alternative would connect the HS-2 hydroelectric station and substation along the South Alternative to an existing 138 kV transmission line paralleling Arizona State Route 389. This new 34.5 kV transmission line would be about 0.9 mile long in Mohave County, Arizona (Figure 1-8).

The proposed new **HS-3 Underground Transmission Line** would connect the HS-3 hydroelectric station and substation to the existing Twin Cities Substation in Hildale City, Utah. The new 12.47 kV underground circuit would be about 0.6 mile long in Washington County, Utah (Figure 1-8).

The proposed new **HS-4 Transmission Line** would consist of a new transmission line from the HS-4 hydroelectric station and substation north along an existing BLM road to an existing transmission line parallel to Utah State Route 59. The new 69 kV transmission line would be about 8.2 miles long in Washington County, Utah (Figure 1-8).

The new **HS-4 Alternative Transmission Line** alternative would connect the HS-4 Alternative hydroelectric station and substation to an existing transmission line parallel to Utah State Route 59. The new 69 kV transmission line would be about 7.5 miles long in Washington County, Utah (Figure 1-8).

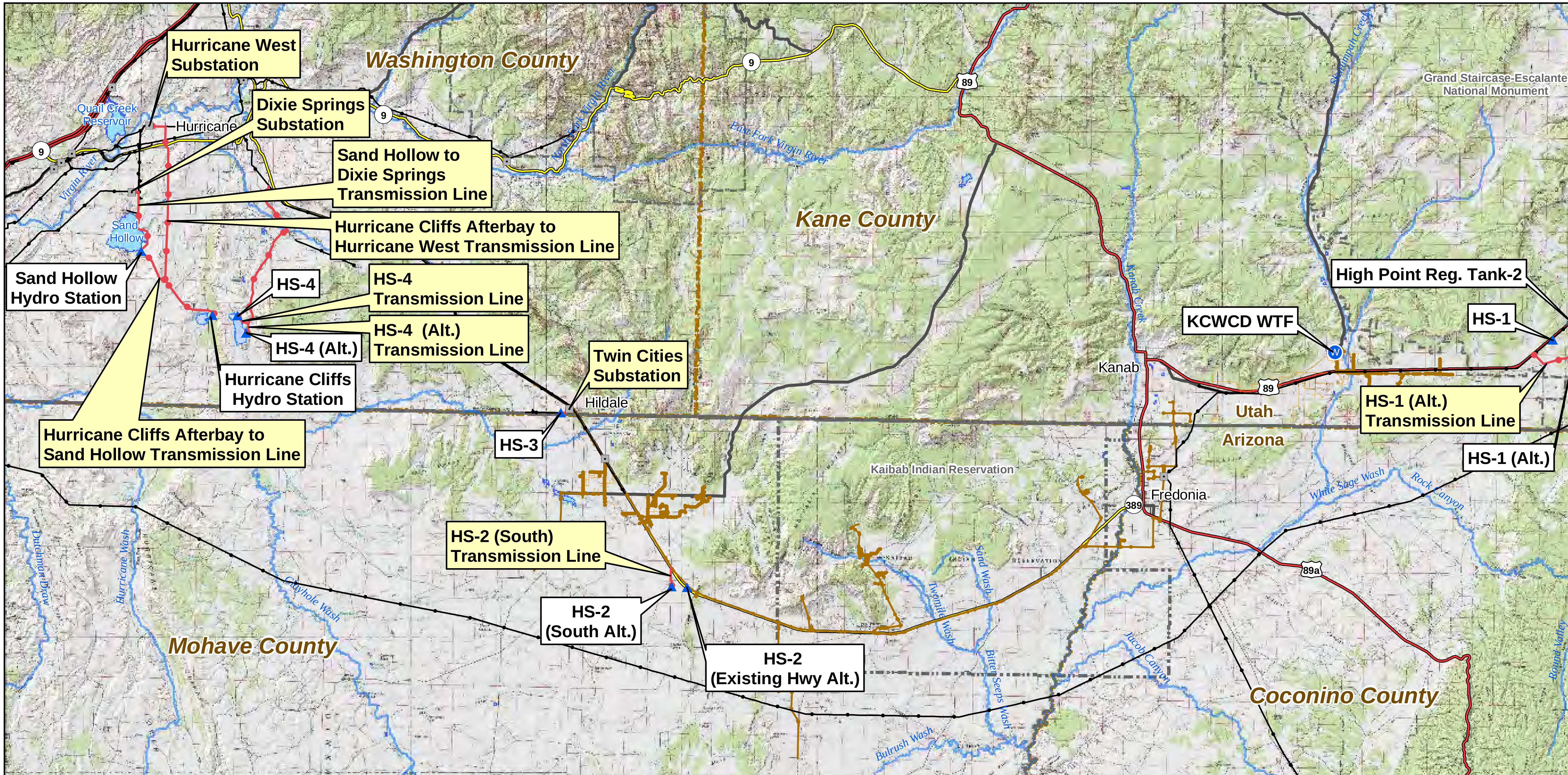
The proposed new **Hurricane Cliffs Afterbay to Sand Hollow Transmission Line** would consist of a new 69 kV transmission line from the Hurricane Cliffs peaking power plant and substation, and run northwest to the Sand Hollow Hydro Station substation. This new 69 kV transmission line would be about 4.9 miles long in Washington County, Utah (Figure 1-8).

The proposed new **Hurricane Cliffs Afterbay to Hurricane West Transmission Line** would consist of a new 345 kV transmission line from the Hurricane Cliffs pumped storage power plant and run northwest and then north to the planned Hurricane West 345 kV substation. This new 345 kV transmission line would be about 10.9 miles long in Washington County, Utah (Figure 1-8).

The proposed new **Sand Hollow to Dixie Springs Transmission Line** would consist of a new 69 kV transmission line from the Sand Hollow Hydro Station substation around the east side of Sand Hollow Reservoir and north to the existing Dixie Springs Substation. This new 69 kV transmission line would be about 3.4 miles long in Washington County, Utah (Figure 1-8).

The three **Cedar Valley Pipeline** booster pump stations would require new transmission lines from existing transmission lines paralleling the Interstate 15 corridor. The new CVBPS-1 transmission line would extend southeast over I-15 from the existing transmission line to the booster pump station substation for about 1.3 miles in Washington County, Utah (Figure 1-9). The new CVBPS-2 transmission line would extend east over I-15 from the existing transmission line to the booster pump station substation for about 0.2 mile in Washington County, Utah (Figure 1-9). The new CVBPS-3 transmission line would extend west over I-15 from the existing transmission line and southwest along the west side of Interstate 15 to the booster pump station substation for about 0.6 mile in Iron County, Utah (Figure 1-9).

The **Cedar Valley Water Treatment Facility Transmission Line** would begin at an existing substation in Cedar City and run about 1 mile to the water treatment facility site in Iron County, Utah (Figure 1-9).



Water Treatment Facility
Project Regulating Tank
Project Hydro Station
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams
Existing Substation
Project Transmission Line
Existing Transmission Line
Existing OH Primary Line
Existing UG Primary Line
Interstate
US Highway
ST Highway
Hwy
Major Road
National Park/Monument
GSENM Boundary
Tribal Lands
State Boundaries
County Boundaries

FERC Project Number:
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BLM Serial Numbers:
AZA-34941
UTU-85472

0 1.25 2.5 5 7.5 10 Miles

N

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 1-8** MWH

Lake Powell Pipeline Transmission Line Alternatives West

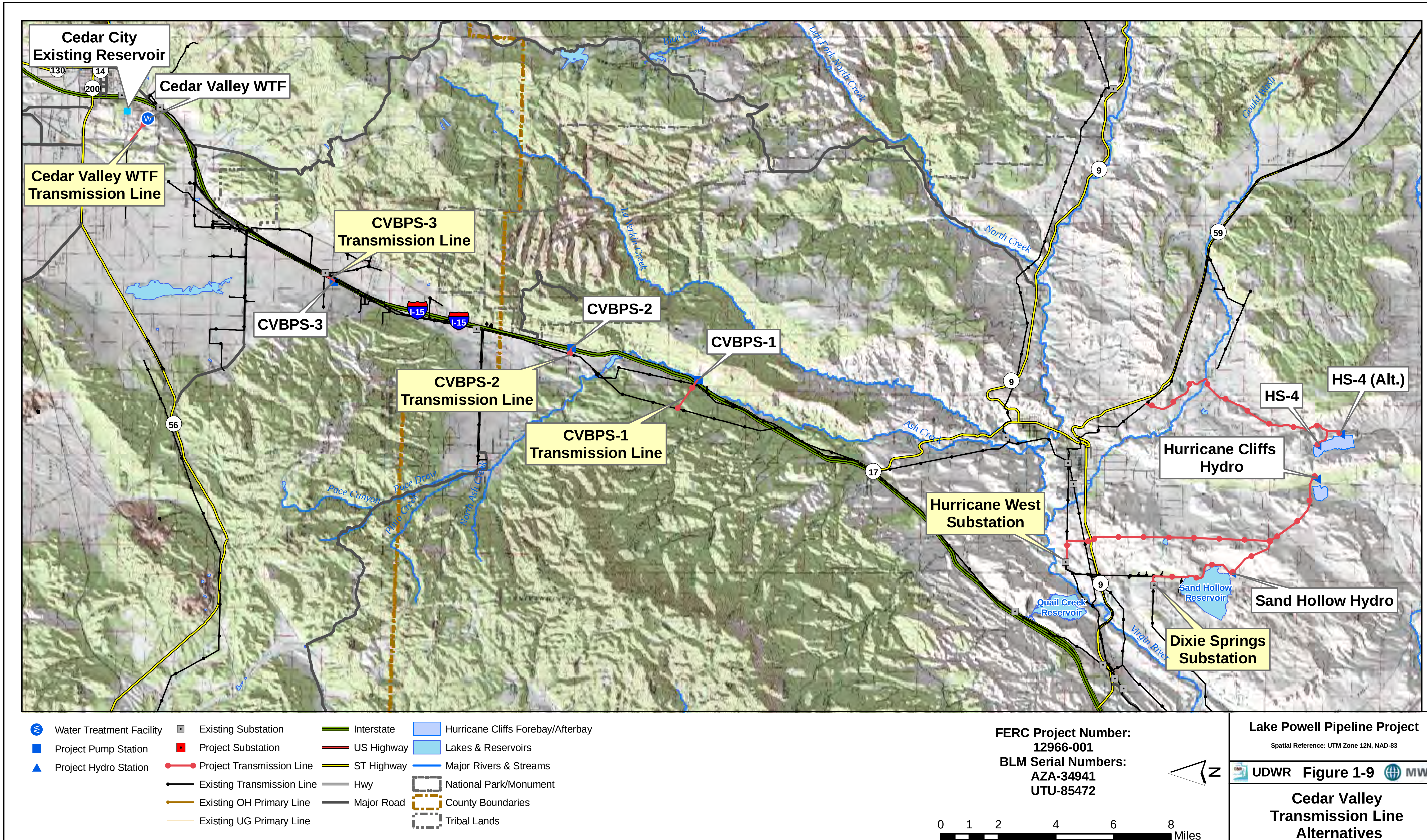

Figure 1-9
Cedar Valley Transmission Line Alternatives

1.3 Summary Description of No Lake Powell Water Alternative

The No Lake Powell Water Alternative would involve a combination of developing remaining available surface water and groundwater supplies, developing reverse osmosis treatment of existing low quality water supplies, and reducing residential outdoor water use in the WCWCD and CICWCD service areas. This alternative could provide a total of 86,249 acre-feet of water annually to WCWCD, CICWCD and KCWCD for M&I use without diverting Utah's water from Lake Powell.

1.3.1 WCWCD No Lake Powell Water Alternative

The WCWCD would implement other future water development projects currently planned by the District, develop additional water reuse/reclamation, and convert additional agricultural water use to M&I use as a result of urban development in agricultural areas through 2020. Remaining planned and future water supply projects through 2020 include the Ash Creek Pipeline (5,000 acre-feet per year), Crystal Creek Pipeline (2,000 acre-feet per year), and Quail Creek Reservoir Agricultural Transfer (4,000 acre-feet per year). Beginning in 2020, WCWCD would convert agricultural water to secondary use and work with St. George City to maximize existing wastewater reuse, bringing the total to 96,258 acre-feet of water supply per year versus demand of 98,427 acre-feet per year, incorporating currently mandated conservation goals. The WCWCD water supply shortage in 2037 would be 70,000 acre-feet per year, 1,000 acre-feet more than the WCWCD maximum share of the LPP water. Therefore, the WCWCD No Lake Powell Water Alternative needs to develop 69,000 acre-feet of water per year to meet comparable supply and demand requirements as the other action alternatives.

The WCWCD would develop a reverse osmosis (RO) advanced water treatment facility near the Washington Fields Diversion in Washington County, Utah to treat up to 40,000 acre-feet per year of Virgin River water with high total dissolved solids (TDS) concentration and other contaminants. The RO advanced water treatment facility would produce up to 36,279 acre-feet per year of water suitable for M&I use. The WCWCD would develop the planned Warner Valley Reservoir to store the diverted Virgin River water, which would be delivered to the RO advanced water treatment facility. The remaining 3,721 acre-feet per year of brine by-product from the RO treatment process would require evaporation and disposal meeting State of Utah water quality regulations.

The remaining needed water supply of 32,721 acre-feet per year to meet WCWCD 2037 demands would be obtained by reducing and restricting outdoor residential water use in the WCWCD service area. The Utah Division of Water Resources (UDWR) estimated 2005 culinary water use for residential outdoor watering in the communities served by WCWCD was 97.4 gallons per capita per day (gpcd) (UDWR 2009). This culinary water use rate is reduced by 30.5 gpcd to account for water conservation attained from 2005 through 2020, yielding 66.9 gpcd residential outdoor water use available for conversion to other M&I uses. The equivalent water use rate reduction to generate 32,721 acre-feet per year of conservation is 56.6 gpcd for the 2037 population within the WCWCD service area. Therefore, beginning in 2020, the existing rate of residential outdoor water use would be gradually reduced and restricted to 10.3 gpcd, or an 89.4 percent reduction in residential outdoor water use.

The combined 36,279 acre-feet per year of RO product water and 32,721 acre-feet per year of reduced residential outdoor water use would equal 69,000 acre-feet per year of M&I water to help meet WCWCD demands through 2037.

1.3.2 CICWCD No Lake Powell Water Alternative

The CICWCD would implement other future groundwater development projects currently planned by the District, purchase agricultural water from willing sellers for conversion to M&I uses, and convert additional agricultural water use to M&I use as a result of urban development in agricultural areas through 2020. Remaining planned and future water supply projects through 2020 include additional groundwater development projects (3,488 acre-feet per year), agricultural conversion resulting from M&I development (3,834 acre-feet per year), and purchase agricultural water from willing sellers (295 acre-feet per year). Beginning in 2020, CICWCD would have a total 19,772 acre-feet of water supply per year versus demand of 19,477 acre-feet per year, incorporating required progressive conservation goals. The CICWCD water supply shortage in 2060 would be 11,470 acre-feet per year. Therefore, the CICWCD No Lake Powell Water Alternative needs to develop 11,470 acre-feet of water per year to meet comparable supply and demand limits as the other action alternatives.

The remaining needed water supply of 11,470 acre-feet per year to meet CICWCD 2060 demands would be obtained by reducing and restricting outdoor residential water use in the CICWCD service area. The UDWR estimated 2005 culinary water use for residential outdoor watering in the communities served by CICWCD was 84.5 gpcd (UDWR 2007). A portion of this residential outdoor water would be converted to other M&I uses. The equivalent water use rate to obtain 11,470 acre-feet per year is 67.8 gpcd for the 2060 population within the CICWCD service area. Therefore, the existing rate of residential outdoor water use would be gradually reduced and restricted to 16.7 gpcd beginning in 2023, an 80 percent reduction in the residential outdoor water use rate between 2023 and 2060. The 11,470 acre-feet per year of reduced residential outdoor water use would be used to help meet the CICWCD demands through 2060.

1.3.3 KCWCD No Lake Powell Water Alternative

The KCWCD would use existing water supplies and implement future water development projects including new groundwater production, converting agricultural water rights to M&I water rights as a result of urban development in agricultural areas, and developing water reuse/reclamation. Existing water supplies (4,039 acre-feet per year) and 1,994 acre-feet per year of new ground water under the No Lake Powell Water Alternative would meet projected M&I water demand of 6,033 acre-feet per year within the KCWCD service area through 2060. The total potential water supply for KCWCD is about 12,140 acre-feet per year (4,039 acre-feet per year existing culinary plus secondary supply, and 8,101 acre-feet per year potential for additional ground water development up to the assumed sustainable ground water yield) without agricultural conversion to M&I supply. Short-term ground water overdrafts and new storage projects (e.g., Jackson Flat Reservoir) would provide reserve water supply to meet demands during drought periods and other water emergencies.

1.4 Summary Description of the No Action Alternative

No new intake, water conveyance or hydroelectric features would be constructed or operated under the No Action Alternative. The Utah Board of Water Resources' Colorado River water rights consisting of 86,249 acre-feet per year would not be diverted from Lake Powell and would continue to flow into the Lake until the water is used for another State of Utah purpose or released according to the operating guidelines. Future population growth as projected by the Utah Governor's Office of Planning and Budget (GOPB) would continue to occur in southwest Utah until water and other potential limiting resources such as developable land, electric power, and fuel begin to curtail economic activity and population in-migration.

1.4.1 WCWCD No Action Alternative

The WCWCD would implement other future water development projects currently planned by the District, develop additional water reuse/reclamation, convert additional agricultural water use to M&I use as a result of urban development in agricultural areas, and implement advanced treatment of Virgin River water. The WCWCD could also limit water demand by mandating water conservation measures such as outdoor watering restrictions. Existing and future water supplies under the No Action Alternative would meet projected M&I water demand within the WCWCD service area through approximately 2020. The 2020 total water supply of about 96,528 acre-feet per year would include existing supplies, planned WCWCD water supply projects, wastewater reuse, transfer of Quail Creek Reservoir supplies, and future agricultural water conversion resulting from urban development of currently irrigated lands. Each future supply source would be phased in as needed to meet the M&I demand associated with the forecasted population. The No Action Alternative would not provide WCWCD with any reserve water supply (e.g., water to meet annual shortages because of drought, emergencies, and other losses). Maximum reuse of treated wastewater effluent for secondary supplies would be required to meet the projected M&I water demand starting in 2020. The No Action Alternative would not provide adequate water supply to meet projected water demands from 2020 through 2060. There would be a potential water shortage of approximately 139,875 acre-feet per year in 2060 under the No Action Alternative (UDWR 2008b).

1.4.2 CICWCD No Action Alternative

The CICWCD would implement future water development projects including converting agricultural water rights to M&I water rights as a result of urban development in agricultural areas, purchasing "buy and dry" agricultural water rights to meet M&I demands, and developing water reuse/reclamation. The Utah State Engineer would act to limit existing and future ground water pumping from the Cedar Valley aquifer in an amount not exceeding the assumed sustainable yield of 37,600 ac-ft per year. Existing and future water supplies under the No Action Alternative meet projected M&I water demand within the CICWCD service area during the planning period through agricultural conversion of water rights to M&I use, wastewater reuse, and implementing "buy and dry" practices on irrigated agricultural land. Each future water supply source would be phased in as needed to meet the M&I demand associated with the forecasted population. The CICWCD No Action Alternative includes buying and drying of agricultural water rights covering approximately 8,000 acres between 2005 and 2060 and/or potential future development of West Desert water because no other potential water supplies have been identified to meet unmet demand. The No Action Alternative would not provide CICWCD with any reserve water supply (e.g., water to meet annual shortages because of drought, emergencies, and other losses) after 2010 (i.e., after existing supplies would be maximized).

1.4.3 KCWCD No Action Alternative

The KCWCD would use existing water supplies and implement future water development projects including new ground water production, converting agricultural water rights to M&I water rights as a result of urban development in agricultural areas, and developing water reuse/reclamation. Existing water supplies (4,039 acre-feet per year) and 1,994 acre-feet per year of new ground water under the No Action Alternative would meet projected M&I water demand of 6,033 acre-feet per year within the KCWCD service area through 2060. The total potential water supply for KCWCD is about 12,140 acre-feet per year (4,039 acre-feet per year existing culinary plus secondary supply, and 8,101 acre-feet per year potential for additional ground water development up to the assumed sustainable ground water yield) without agricultural conversion to M&I supply. Short-term ground water overdrafts and new storage projects (e.g., Jackson Flat Reservoir) would provide reserve water supply to meet demands during drought periods and other water emergencies.

1.5 Identified Issues

This Paleontological Resources Study Report for the Lake Powell Pipeline discusses the geological formations within the APE, their known fossil faunas and floras, and uses this information for rating the paleontological sensitivity of each formation based on the Potential Fossil Yield Classification (PFYC) System for Paleontological Resources on Public Lands (See Appendix A and Appendix B). Further, information concerning known fossil localities within 1 mile or 2 of either side of the pipeline corridor was studied to determine the potential for encountering fossils during pipeline construction (See Appendix C). On-ground surveys were performed during the summer of 2009 to identify actual on-ground occurrences of fossils at and along the various features of the Lake Powell Pipeline project (See Appendix D).

1.5.1 Previous Work and Methods

Most of the previous paleontology work in the project area is of a general or regional nature, covering broad areas, on the fauna and flora of the geologic formations of concern and not specific to any studies directly on or near the proposed project facilities. Sixty-nine previously recorded paleontology localities have been identified within approximately 1 or 2 miles of the various proposed features of the project (11 in Arizona and 58 in Utah). These known localities are listed by state in two tables, along with maps, in Appendix C; one table for Arizona localities and one table for Utah localities.

The Paleontology database maintained by the Utah Geological Survey (UGS) and several publications on paleontology in the Grand Staircase-Escalante National Monument have been reviewed as geologic formations occurring in the project Study Area also occur throughout the Monument (Doelling et al. 2000; Gillette and Hayden 1997; Foster et al. 2001; Hamblin 1998; Hamblin and Foster 2000; and Doelling and Davis 1989).

Arizona information was more general and regional in nature, but bits and pieces of information on some specific localities was obtained. General paleontological information, with articles covering Arizona paleontology, was found in several publications, including: Miller (1985); McCracken (2003); Heckert, Lucas, and Tanner, editors (2005),Vertebrate Paleontology in Arizona, NMMNH&S Bulletin No. 29; Nesbitt, Parker and Irmis, editors (2005), Guidebook to the Triassic Formations of the Colorado Plateau in northern Arizona: Geology, Paleontology, History, MSWM Bulletin No. 9; and White and Morgan (2005), Vertebrate Paleontology of Arizona, MSWM Bulletin No. 11.

The following individuals were contacted either by email, mail, phone or in person for information related to paleontology in the project study area: Martha Hayden, Utah Geological Survey; Patricia Hester, New Mexico Bureau of Land Management; Alan Titus, Grand Staircase–Escalante National Monument; David Gillette, Museum of Northern Arizona; Charles Bullettes, Kaibab Band of Paiute Indians; John Spence, Glen Canyon National Recreation Area; Andrea Bornemeier, Pipe Spring National Monument; John Herron, Arizona Strip Bureau of Land Management; Andrew Milner, St. George City Paleontologist; Spencer Lucas, New Mexico Museum of Natural History; Don Lofgren, Raymond Alf Paleontology Museum; and Nancy Pearson, Arizona State Museum.

A number of geological maps were consulted to compile the list of geologic formations to be impacted by project features. Judging from these maps, the Tropic Shale and Dakota Formation, though close to proposed features, will not be impacted.

Compilation of the faunal and floral lists (Appendix B) began with applicable lists prepared by Gillette and Hayden (1997) for the Grand Staircase-Escalante National Monument. These lists were expanded by additional information from the literature (see References Cited), with more recent publications that related to northern Arizona in particular.

Chapter 2
Geological Formations, Paleontology and Sensitivity

According to geological maps of the study area (Billingsley and Workman 2000; Billingsley, Priest, and Felger 2004; Billingsley, Priest, and Felger 2008; Wilson and Moore 1959; Moore, Wilson, and O'Haire 1960; Cook 1960; Wilson, Moore, and Cooper 1969; Hintze 1980; Doelling and Davis 1989; Hurlow 1998; Moore and Sable 2001; Hurlow and Biek 2003; Biek 2003 and 2007; Hayden 2004a & b; Doelling and Willis 2006; Rowley et al. 2006; Biek et al. 2007; Hayden and Sable 2008; and Doelling 2008) the following geological formations, listed youngest to oldest, are exposed at or near the proposed pipeline route and alternative routes:

Entrada Sandstone - Jurassic
Carmel Formation - Jurassic
Upper Member
Judd Hollow Tongue
Page Sandstone - Jurassic
Navajo Sandstone
Kayenta Formation
Moenave Formation or Wingate Sandstone
Whitmore Point Member
Springdale Sandstone
Chinle Formation - Triassic
Owl Rock Member
Petrified forest Member
Shinarump Member
Moenkopi Formation - Triassic
Upper Red Member
Shnabkaib Member
Middle Red Member
Lower Red member
Timpoweap Member
Kaibab Limestone - Permian
Toroweap Formation - Permian

These formations are described with their Potential Fossil Yield Classification (PFYC) Sensitivity Ratings (see Appendix A for definitions) in reverse order, oldest to youngest. General paleontology of each formation is also discussed with more complete faunal and floral lists in Appendix B.

2.1 Toroweap Formation and Kaibab Limestone - Permian

The Toroweap Formation and Kaibab Limestone are exposed along the proposed pipeline route in the northeast quarter of Section 10, Township 43 South, Range 13 West. This is the area where the pipeline drops west over the Hurricane Cliffs from the Hurricane Cliffs Forebay to the Hurricane Hydro Station and Hurricane Cliffs Afterbay. The Harrisburg Member of the Kaibab Limestone is exposed in the northwest corner of the proposed Hurricane Cliffs Forebay. Kaibab Limestone is also exposed along the Glen Canyon to Buckskin Transmission line on Five Mile Mountain, along the pipeline in the bottom of Kanab Creek and at the top of Nephi's Twists west of LaVerkin.

The Toroweap Formation is Early Permian. It consists of three members, the Segilman Member, Brady Canyon Member and Wood Ranch Member, that were deposited when a shallow sea moved out, then in, and then out again (regression, transgression and regression). Hayden (2004a) says there are 115 feet (36 meters) in the lower part of The Divide quadrangle of the Seligman Member and describes it as forming "a poorly exposed slope near the base of the Hurricane Cliffs. It consists of a lower pale-yellowish-brown, fine-grained sandstone; a middle interbedded yellowish-gray, calcareous, very fine-grained sandstone and grayish-yellow, gypsiferous, calcareous siltstone; and an upper medium-gray, thin-bedded, sandy limestone."

The Brady Canyon Member, according to Hayden (2004a), "consists of a medium-light-gray to dark-gray, medium- to coarse-grained, thick-bedded, fossiliferous limestone with reddish-brown, rounded chert nodules. The limestone contains abundant poorly preserved crinoid stems and disarticulated brachiopods, and also coral and sponge fragments; it is slightly dolomitic near its base and top. It forms the prominent, lower cliff along the Hurricane Cliffs and is 200 feet thick (60 meters) thick."

The Wood Ranch Member is a slope-forming unit commonly covered with talus (Hayden 2004a). Hayden further describes it as "grayish-pink to very-pale-orange, very thick-bedded gypsum with interbeds of light-brownish-gray siltstone, pale-red shale, and yellowish-gray to light-gray, laminated to thin-bedded dolomite and limestone. Bedding is distorted from dissolution of gypsum. This member is 320 feet (98 meters) thick."

The Kaibab Limestone was also deposited by the sea moving in and out of the area, and consists of two members, the Fossil Mountain Member and Harrisburg Member (Nielson 1986). Hayden (2004a) says "The Fossil Mountain Member forms the upper prominent limestone cliff of the Hurricane Cliffs. It consists of yellowish-gray, abundantly fossiliferous, cherty limestone that contains silicified fossils, including corals, brachiopods, crinoids, and bryozoans." The thickness of the Kaibab Limestone is 300 feet (91 meters) (Hayden 2004a).

The Harrisburg Member in The Divide quadrangle, according to Hayden (2004a), "is light-gray, fossiliferous, sandy, fine- to medium-grained limestone interbedded with red and gray gypsiferous siltstone and sandstone, and gray gypsum beds several feet thick." A period of erosion during Late Permian and Early Triassic time removed part of the Harrisburg Member. Hayden (2004a) gives the thickness of the Harrisburg Member in The Divide quadrangle as ranging from 30 to 175 feet (9 to 53 meters).

Billingsley and others (2008) say that the Harrisburg Member of the Kaibab Formation is hard to distinguish from the Timpoweap member of the Moenkopi Formation (see quote below).

PFYC Sensitivity Rating – **Class 3a - Moderate Potential**

2.2 Moenkopi Formation - Triassic

From the west side of the Cockscomb west to the Hurricane Cliffs, the formation encountered the most by the various project features is the Moenkopi Formation. The Moenkopi Formation in the study area has six members. They are, in ascending order, the Timpoweap Member, Lower Red Member, Virgin Limestone Member, Middle Red Member, Shnabkaib Member and Upper Red Member.

In speaking of the Timpoweap Member of the Moenkopi Formation, Billingsley and others (2008) say the Timpoweap Member "is difficult to distinguish from the Harrisburg Member of the Kaibab Formation at north edge and is mapped as Harrisburg Member of the Kaibab Formation in that area, whereas adjoining geologic map of the Kaibab Plateau in Utah is mapped, in part, and Timpoweap Member of the Moenkopi Formation" (Sable and Hereford 2004).

The map of The Divide quadrangle by Hayden (2004a) shows the Timpoweap Member of the Moenkopi Formation overlaying the Kaibab Limestone above the Hurricane Cliffs. Timpoweap also occurs as the pipeline crosses the Kaibab Anticline at the north end of Buckskin Mountain. According to Doelling et al. (2000) the

Timpoweap at Buckskin Mountain “consists of highly resistant carbonate rocks, sandstone, chert breccia, and siltstone.” Gastropods and bivalves are listed by Doelling and Davis (1989) in the Timpoweap Member. The thickness of the Timopoweap Member varies from 50 to 125 feet (15 to 38 meters) (Hayden 2004a).

The Lower Red Member represents deposits made on a tidal flat by meandering streams and is described by Doelling and Davis (1989) as “reddish- to chocolate-brown interbedded siltstone and fine-grained sandstone. The siltstone is earthy weathering and forms slopes. The sandstone is commonly silty, arkosic, and micaceous, platy to blocky weathering, calcareous, ripple-marked, and forms slight ledges.” The Lower Red Member is about 250 feet (76 meters) thick (Doelling and Davies 1989).

The Virgin Limestone Member forms a prominent ledge overlying the Lower Red Member. Doelling and Davis (1989) say it “consists of interbedded yellow-tan cliff-forming sandstone, siltstone, and limestone.” They further state that “in Washington County the Virgin Limestone is quite fossiliferous, containing fragments of mollusks, crinoid stems, and the guide fossil *Trirolites*. Ostracodes and oolites are also present. These megafossils were not found at the Buckskin Mountain exposures. The Virgin Limestone was deposited in shallow marine or brackish water environments.” The Virgin Limestone Member is usually about 75 feet (23 meters) thick (Hayden 2004b).

The Middle Red Member is the thickest member of the Moenkopi. It is exposed east of the Paunsaugunt fault, between the Shinarump Flats and the Cockscomb, and has much alluvial cover (Doelling and Davis 1989). Doelling and Davis (1989) describe it as being about 370 feet (113 meters) thick and as an “interbedded medium-brown mudstone or siltstone and light-brown, tan, or gray-green, fine-grained, silty sandstone. Many beds are criss-crossed with gypsum veinlets.”

The Shnabkaib Member was “probably deposited in restricted embayments of a sea surrounded by low tidal-flat and mud-flat areas. The open sea lay to the west and encroached eastward from time to time” (Doelling et al. 2000). They describe the member as a “ledge- and slope forming unit consisting of ledges of white to light green silty gypsum and light-brown very fine-grained sandstone and slopes of earthy weathering very fine-grained sandstone and red and green-gray siltstone.” The Shnabkaib Member is about 220 feet (67 meters) thick (Doelling and Davis 1989).

The Upper Red Member is at the top of the Moenkopi Formation in the study area. It is a tidal flat deposit of interbedded dark chocolate-brown to red-brown siltstone and light-brown to red-brown sandstone (Doelling et al. 2000). Doelling et al. (2000) state that “the lower half forms a steep slope and the upper half weathers into ledges.” The thickness of the Upper Red Member is about 125 feet (38 meters) (Doelling and Davis 1989). Generally speaking, body fossils in the Moenkopi Formation are rare and the largest concentration of fossils is along the Little Colorado River valley in northern Arizona from St. Johns to Cameron (Nesbitt 2005a and 2005b). Trace fossils in the form of invertebrate and vertebrate tracks and footprints, on the other hand, are quite wide spread in the Moenkopi (Hamblin 1998; Hamblin et al. 2000; Hamblin and Foster 2000; and Peabody 1956).

PFYC Sensitivity Rating – **Class 3a - Moderate Potential**

2.3 Chinle Formation - Triassic

The Chinle Formation has two mapped units exposed along the pipeline alternative routes in places from the Cockscomb west to Fredonia, and from the Sevier Fault at the west side of the Kaibab-Paiute Indian Reservation west and northwest to the Utah border. These two mapped units are grouped into the Lower or Shinarump Member (including part of the Monitor Butte Member) and the Upper Members, which includes the Church Rock, Owl Rock, Petrified Forest and Monitor Butte Members (Doelling 2008).

The Shinarump Member forms the Shinarump Cliffs, which cross this area in both Utah and Arizona. The Shinarump Member in the Shinarump Cliffs varies from 6 to 50 feet (2 to 15 meters). Doelling and Davis (1989) describe it as consisting “of lenticular and massive, cliff-forming beds of conglomerate, conglomeratic sandstone, and sandstone, with occasional thin partings of green or gray mudstone.” They mention that petrified logs are occasionally found in the conglomerates.

Within the “Upper Members” (Doelling 2008), the Petrified Forest Member is listed on the Kane County Geology map by Doelling and Davis (1989) as “varicolored, banded slope-forming mudstone, claystone, sandstone, siltstone, limestone, and conglomerate, locally contains abundant petrified wood; 155 feet (47 meters).”

According to Gillette and Hayden (1997), the Chinle “floral and faunal list spans a broad spectrum of fossils, including plants, petrified wood, snails, clams, fish, insects, horseshoe crabs, ostracodes, fish, reptiles and tracks. The formation has a diverse fauna of vertebrates from exposures in the southwestern United States” (Irmis 2005; Parker 2005).

PFYC Sensitivity Rating – **Cass 4 - High Potential**

2.4 Moenave and Wingate Formations - Jurassic

The Moenave Formation overlies Triassic rocks in the western half of Kane County and the Wingate overlies Triassic rocks in the eastern half of the county. At the Cockscomb, in the middle of the county, the Moenave overlies a thin tongue of Wingate, 42 to 60 feet (13 to 18 meters) thick (Doelling and Davis 1989). The only place the Lake Powell Pipeline will come in contact with the Moenave and Wingate formations will be at the Cockscomb. To the west, the Moenave forms the base of the Vermilion Cliffs and ranges up to 435 feet (133 meters) thick (Doelling and Davis 1998). Two members of the Moenave Formation are recognized through this area, the Whitmore Point Member and the Springdale Sandstone. The pipeline remains south of the Vermilion Cliffs.

Doelling and Davis (1989) describe the Wingate Formation on the Kane County geology map as “reddish-orange or brown cliff-forming massive sandstone.” They describe the Moenave as “reddish flat-bedded fine-grained sandstone and siltstone, thin to thick cliff- forming beds.”

Fossils from the Moenave Formation include stromatolites, petrified wood, pollen spores, fish, a crocodile and trace fossils (Gillette and Hayden 1997). Gillette and Hayden did not list any fossils from the Wingate within the Grand Staircase-Escalante National Monument, but the author discovered dinosaur tracks in the Wingate in Long Canyon, approximately 65 miles northeast of the pipeline project (Hamblin 1998; Hamblin and Foster 2000).
PFYC Sensitivity Rating – (In general) **Class 3a - Moderate Potential**

(However, the Whitmore Point Member and Springdale Sandstone, recently reassigned to the Kayenta Formation by Biek and Hylland [2007], would be rated – **Class 4 - High Potential**

2.5 Kayenta Formation - Jurassic

The Kayenta Formation may be encountered at the pipeline’s beginning at Lake Powell and at the Cockscomb. Doelling et al. (2000) tell us that Kayenta is “dominantly fluvial, but lacustrine and eolian beds are interbedded, notably in the upper part of the unit.” They describe the Kayenta Formation as a “succession of lenticular, mostly medium grained, fluvial crossbedded, thick-bedded sandstone with thinner red interbeds of siltstone and mudstone, subordinate thin to medium beds of gray or lavender-gray limestone, and thin to thick beds of intraformational pebble conglomerate." Doelling and Willis (2006) give the Kayenta thickness as 190 to 340 feet (58 to 104 meters).

Fossils mentioned by Doelling et al. (2000) include locally abundant dinosaur tracks, petrified wood and "undiagnostic vertebrate bone fragments" in the Grand Staircase-Escalante National Monument. Dinosaur skeletons and tracks have been reported from the Kayenta Formation in northern Arizona (Welles 1954 and 1971; and Morales 1986).

PFYC Sensitivity Rating – **Class 3a - Moderate Potential**

2.6 Navajo Sandstone - Jurassic

The Navajo Sandstone will be encountered as the pipeline climbs out of Glen Canyon north and northwest of the Glen Canyon dam, and at the Cockscomb. The Navajo Sandstone generally has a lot of bare-rock outcrops and high-angle cross-beds forming "cliffs, domes, monuments, and other bizarre forms. Locally, thin lenses of limestone, dolomite, or dark-red sandy mudstone are present" (Doelling et al. 2000). Doelling et al. (2000) further describe the Navajo Sandstone as "a light-colored, fine- to medium-grained, massive sandstone" and say that it "is dominantly an eolian deposit laid down in dunes above a shallow water table. The thin limestones, dolomites, and dark-red sandy mudstones were deposited in oases, playas, or ponds." The thickness of the Navajo Sandstone in Hackberry Canyon along the Cockscomb is 1362 feet (415 meters) (Doelling and Davis 1989).

Fossils are somewhat rare in the Navajo Sandstone and are mostly limited to animal tracks. These include tracks of dinosaurs, other reptiles and some invertebrates. Tracks, and occasional petrified wood, have been found associated with interdune "oasis" deposits (Gillette and Hayden 1997). Vertebrate tracks are occasionally found on dune faces in the Navajo Sandstone with several occurrences to the north in the Grand Staircase-Escalante National Monument (Hamblin and Foster 2000) and to the south near the Arizona boarder (Milan et al. 2008). Regionally, several dinosaurs have also been reported from the Navajo Sandstone (Weishample 1990).

PFYC Sensitivity Rating – **Class 3a - Moderate Potential**

2.7 Carmel Formation and Page Sandstone - Middle Jurassic

The Page Sandstone sits unconformably above the Navajo Sandstone and intertongues with the Carmel Formation. This intertonguing represents movements of the Carmel Sea, which came in from Canada to northern Arizona during Middle Jurassic time (Doelling et al. 2000). The geologic map of Coconino County, Arizona (Moore, Wilson, and O'Haire 1960) is of small scale and lacking in detail for mapped units in Arizona. However, Doelling and Willis (2006), on the geology map of the Smoky Mountain 30'x 60' Quadrangle, show the Judd Hollow Tongue of the Carmel, the Thousand Pockets Tongue of the Page Sandstone and the Carmel upper unit (which is the combined Paria and Winsor Members of the Carmel Formation) in the area between Lake Powell and the Cockscomb.

The Judd Hollow Tongue of the Carmel is described by Doelling and Willis (2006) as "interbedded red-brown sandstone, siltstone and red and lavender limestone." They describe the Thousand Pockets Member of the Page Sandstone as "Yellow, white, or brown, massive, cross-bedded sandstone, with common thin, red siltstone partings."

The upper unit of the Carmel Formation, as mapped by Doelling and Willis (2006), is composed of an upper part (Winsor Member) that is a "mostly medium- to dark-red-brown to brown, slope-forming and earthy-weathering, silty sandstone or siltstone intercalated with sporadic irregular beds of very pale gray, calcarious, fine-grained sandstone that is locally gypsiferous" and lower part (Paria Member) that is "mostly dark-red-brown siltstone or silty sandstone with a few tan or brown fine-grained sandstone beds capped by silty or sandy, white to very pale red-gray, chippy-weathering limestone." The combined thickness of the Carmel Formation in Kane County, Utah ranges from 100 to 700 feet (30 to 213 meters) (Doelling and Davis 1989).

Other than one possible vertebrate track, fossils are not known from the Page Sandstone (Foster et al. 2001). Foster, et al. (2001) say the Carmel Formation in the Grand Staircase-Escalante National Monument was not particularly fossiliferous. The Carmel Formation is fairly fossiliferous in other areas, particularly to the west, and includes numerous kinds of invertebrates, invertebrate trace fossils and dinosaur tracks (Lockley el al. 1998; Hamblin 2002; Nelson 1990; Tang and Bottjer 1997; Wilson 1997).

PFYC Sensitivity Rating – Carmel Formation **Class 3a - Moderate Potential**

–Page Sandstone **Class 2 - Low Potential**

2.8 Entrada Sandstone - Jurassic

The Entrada Sandstone is exposed in places between Lake Powell and the Cockscomb is and mapped as an undivided unit, though three members are recognized north and east of this area (Doelling and Willis 2006). Foster et al. (2001) say the "Entrada Sandstone consists largely of reddish cross-bedded sandstone, tan and reddish-brown siltstone, and white to gray, large-scale cross-bedded sandstone." Few fossils are known from the Entrada Sandstone. One large tracksite and several smaller sites have been found to the north along the Straight Cliffs in the Grand Staircase-Escalante National Monument (Foster et al. 2000).
PFYC Sensitivity Rating – **Class 3a - Moderate Potential**

2.9 Pliocene and Pleistocene Sediments

Much of the surface at or along features of the Lake Powell Pipeline Project is covered with alluvium. This is particularly the case from Lake Powell to the Cockscomb, which is covered with what was mapped as mixed eolian and alluvial deposits with some alluvial gravels (Doelling and Willis 2006). There is a potential for encountering Pleistocene, even Pliocene age sediments, during trenching operations for a pipeline. With this age of sediments comes the potential for encountering "ice age" mammals. There are a number of mammals known from the Colorado Plateau (Nelson 1990).

PFYC Sensitivity Rating – **Class 3b - Unknown Potential** (in the LPP Project area)

Chapter 3
Paleontology of Lake Powell Pipeline Project Areas

3.1 Fossils Identified During the Literature Search

A total of 69 previously recorded fossil localities were found in the literature within two miles of features of the Lake Powell Pipeline Project; 58 of these were in Utah and 11 were in Arizona.

UTAH: of the 58 Utah localities, 8 had plant impressions or petrified wood fossils, 33 had invertebrate fossils, 3 had invertebrate trace fossils, 12 had vertebrates and 8 had vertebrate tracks (Total is more the 58 as some localities have more than 1 fossil type). (Appendix C)

ARIZONA: of the 11 Arizona localities, 3 had plant fossils, 1 had invertebrates (insects) fossils, 7 had vertebrate fossils and 3 had vertebrate tracks (Total is more than 11 as some localities have more than 1 fossil type. (Appendix C)

3.2 Fossils Identified During the Ground Surveys

A total of 49 new fossil localities were recorded in boundaries or corridors of proposed features of the Lake Powell Pipeline Project; 24 in Arizona and 25 in Utah. These consisted of plant localities, invertebrate localities, and vertebrate and invertebrate track localities. No vertebrate bone fossils were found during the surveys.

UTAH: there were 3 plant localities (petrified wood and plant impressions), 20 invertebrate localities and 2 track localities (1 vertebrate and 1 invertebrate).

ARIZONA: there were 2 plant localities (petrified wood and plant impressions), 20 invertebrate localities and 2 vertebrate track localities.

The following shows the formation and formation members in which fossils were found during surveys:

Toroweap Formation – Not surveyed because of steep train on the Hurricane Cliffs, but has common invertebrate fossils.

Kaibab Limestone – Permian – Crinoid, Brachiopods, Bryozoans, Horn Coral, Sponges

Moenkopi Formation – Triassic

Upper Red Member – nothing

Shnabkaib Member – nothing

Middle Red Member – nothing

Virgin Limestone – Crinoids, Brachiopods

Lower Red Member – nothing

Timpoweap Member – Gastropods, Bivalves, Scaphopods, small animal tracks

Chinle Formation – Triassic

Upper Members – Petrified wood

Shinarump Member – Petrified wood and plant impressions

Glen Canyon Group – Jurassic

Navajo Sandstone – Dinosaur Tracks

Kayenta Formation – nothing

Wingate/Moenave Formations – nothing

Carmel Formation – Jurassic – nothing

Entrada Formation – Jurassic – nothing

Pleistocene Sediments – Mammal tracks

3.3 Discussion of Fossils/Formations Discovered During the Surveys

3.3.1 Kaibab Formation - Permian

Wherever the Kaibab Formation is encountered in the proposed project, invertebrate fossils are present. These fossils include crinoids, brachiopods, bryozoans, horn corals and sponges (Figures 3-1 and 3-2). These are all common Permian Age fossils.

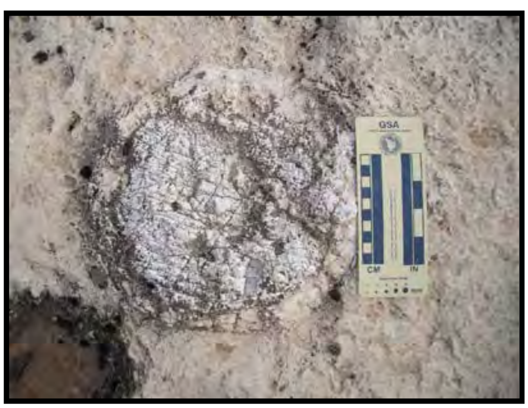

Figure 3-1
Fossil Sponge

Figure 3-2
Horn Coral and Bryozoan

The Kaibab Formation is exposed along the Glen Canyon to Buckskin Transmission Line on the east flank of Five Mile Mountain. Kaibab Formation exposures occur along the southern pipeline alternative in the bottom of Kanab Creek. The Forebay area has exposures of the Kaibab Formation at the northwest corner. The Kaibab Formation is also exposed at the head of Nephi’s Twist along the Cedar Valley Pipeline.

3.3.1.1 Utah Locality 42Ka2166i

New survey areas were surveyed for paleontological resources during July and August of 2010. Three new fossil localities were recorded, including two invertebrate fossil localities in Utah. This invertebrate fossil locality is on the east side of Five Mile Mountain on the new transmission line corridor in the Kaibab Formation. Fossils found include brachiopods, horn corals, bryozoans and scaphopods (Figures 3-3 and 3-4). The locality was recorded as Utah locality 42Ka2166i. It occurs within the Grand Staircase-Escalante National Monument.

Figure 3-3
Crinoids, Bryozoans and Brachiopods

Figure 3-4
Horn Coral and Brachiopods

3.3.2 Moenkopi Formation - Triassic

Invertebrate fossils were found in two members of the Moenkopi Formation, the Timpoweap and the Virgin Limestone. In addition, invertebrate tracks were found in the Timpoweap's upper part.

The west flank of Five Mile Mountain has exposures of the Moenkopi Formation's Timpoweap Member. Gastropods and bivalves were found along the Glen Canyon to Buckskin Transmission Line, particularly in rocks excavated from existing power pole holes (Figure 3-5).

Figure 3-5
Gastropods and Bivalves

There are numerous outcrops of the Timpoweap Formation in the southeast corner of the Kaibab-Paiute Indian Reservation and south of the reservation boundary to the west side of Kanab Creek. Gastropods, bivalves and scaphopods are fairly common in these outcrops, many having an orange color against a tan limestone matrix (Figure 3-6).

Figure 3-6
Gastropods, Bivalves and Scaphopods

Several gastropods were found in the Timpoweap in the Forebay area, but otherwise fossils were scanty in rock outcrops in that area. More fossiliferous layers may be covered by alluvium in the Forebay area.

A small, thin slab of sandstone with small animal tracks was found from the upper part of the Timpoweap Member several miles southwest of the town of Virgin along the Cedar Valley Pipeline. These may be limulid (horseshoe crab) tracks (Figure 3-7).

Figure 3-7
Tracks of Small Animal

Virgin Limestone outcrops are seen along the pipeline southeast and north of the Forebay, and also the bench east of the Forebay. Star-shaped crinoids and brachiopods occur in the Virgin Limestone in many of these outcrops (Figures 3-8, 3-9, and 3-10).

Figure 3-8
Small Brachiopods

Figure 3-9
Large Brachiopods

Figure 3-10
Star-Shaped Crinoids

3.3.2.1 Utah locality 42Ka2165i

This invertebrate fossil locality was found during the survey of an alternate pipeline route paralleling Highway 89 between Kanab and the Cockscomb. The rock exposure here is the Timopweap Member of the Moenkopi Formation, and the fossils occur along a small drainage south of the dirt road. Brachiopods, gastropods and one ammonite were found in several spots along this drainage (Figures 3-11 and 3-12). The locality was recorded as Utah locality 42Ka2165i. It occurs within the Grand Staircase-Escalante National Monument.

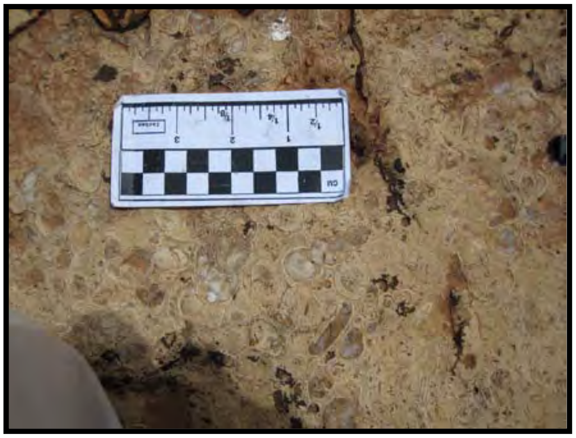

Figure 3-11
Gastropods

Figure 3-12
Ammonite

3.3.3 Chinle Formation - Triassic

The Shinarump, or Lower Member of the Chinle Formation, has petrified wood and plant impressions. It is exposed along the Shinarump Cliffs where the two pipeline alternatives cross it. It is also exposed at Moonshine Ridge and Canaan Gap where petrified wood and plant impressions have been found (Figures 3-13 and 3-14).

Figure 3-13
Petrified Log

Figure 3-3
Plant Impressions on Bottom of Sandstone

Petrified wood is also known to occur in the upper members of the Chinle Formation. The only locality recorded is a minor petrified wood occurrence long the northern pipeline alternative east of Kanab, Utah.

3.3.4 Glen Canyon Group (Wingate/Moenave, Kayenta, and Navajo) - Jurassic

The only formation of the Glen Canyon Group where fossils were discovered during the survey was the Navajo Sandstone at a locality near Glen Canyon Dam (Figures 3-15, 3-16, 3-17 and 3-18). This locality has 60 to 70 small tridactyl tracks of *Grallator*-type.

Figure 3-4
Lake Powell Track Site

Figure 3-5
Track – *Grallator*

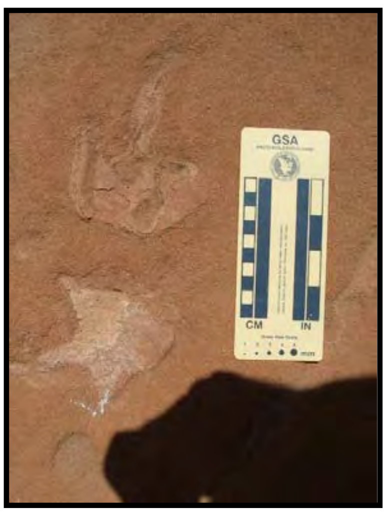

Figure 3-6
Two *Grallator* Tracks

Figure 3-7
Map of Track Site

3.3.4.1 Arizona Fossil Locality LPPAzCo19t

The third locality surveyed for the additional survey area was another dinosaur track locality in Arizona near Glen Canyon Dam. It was found in the Glen Canyon Dam area during survey of transmission line corridors. This fossil locality is located up on the Navajo Sandstone cliffs west of Highway 89. The tracks are *Grallator*-type tracks similar to those found at the first dinosaur track site found during the original surveys (Figures 3-19 and 3-20). However, this locality is very small, consisting of only four or five very faint impressions on a small sandstone shelf. This locality was recorded as Arizona fossil locality LPPAzCo19t. It occurs within the Glen Canyon National Recreation Area.

Figure 3-8
Dinosaur Track

Figure 3-20
Looking North from Track Site

3.3.5 Pleistocene Sediments

One track locality was identified in what is assumed to be Pleistocene sediments on the west side of east Clark Bench. At this site, about a 12.5 track molds have eroded out of a hilltop of unconsolidated sediments in an unusual occurrence (Figures 3-21 and 3-22).

Figure 3-21
Mammal Track Mold – Rightside-up

Figure 3-22
Mammal Track Mold – Upside-down

Chapter 4
Summary

4.1 General

Eleven geological units were identified as present on or along the various features of the Lake Powell Pipeline Project. These were rated using the Potential Fossil Yield Classification (PFYC) System (Appendix A). One formation (Chinle) and the two members of the Moenave Formation (Whitmore Point and Springdale) were rated as having a High Potential for discovery of significant fossils. Eight units were identified as having a Class 3a - Moderate rating (Entrada, Carmel, Navajo Sandstone, Kayenta Formation Moenave/Wingate, Moenkopi, Kaibab and Toroweap). One unit (Pleistocene sediments) was rated as Class 3b - Unknown potential. One unit was rated as having a Low Potential (Page Sandstone, sometimes listed as a member of the Carmel) (Table 4-1).

Table 4-1
PFYC Rating for Geological Formations Found along or at Features of the Proposed LPP

Geological Formations	Potential Fossil Yield Classification Rating
Pliocene and Pleistocene sediments	Class 3b - Unknown Potential
Entrada Sandstone - Jurassic	Class 3a - Moderate Potential
Carmel Formation – Jurassic Upper Member Judd Hollow Tongue	Class 3a - Moderate Potential
Page Sandstone - Jurassic	Class 2 - Low Potential
Navajo Sandstone - Jurassic	Class 3a - Moderate Potential
Kayenta Formation - Jurassic	Class 3a - Moderate Potential
Moenave Formation or Wingate Sandstone	Class 3a - Moderate Potential
Whitmore Point and Springdale Members	Class 4 - High Potential
Chinle Formation – Triassic Upper members including the Petrified Forest Member and the Lower or Shinarump Member	Class 4 - High Potential
Moenkopi Formation – Triassic Upper Red Member Shnabkaib Member Middle Red Member Lower Red member Timpoweap Member	Class 3a -Moderate Potential
Kaibab Limestone - Permian	Class 3a -Moderate Potential
Toroweap Formation - Permian	Class 3a -Moderate Potential

Much of the area crossed by various features of the LPP project has a cover of alluvium. Other areas have a covering of basalt. Some alluvial covering is thin, and pipeline construction could encounter formations below the alluvial cover.

The results of ground surveys show that the two units with a High Potential (Chinle Formation and the Whitmore Point and Springdale Members of the Moenave Formation) have limited surface exposure. However, there are areas where the Chinle is covered by alluvium, and pipeline construction could reach this formation.

Common invertebrate fossils were recorded in the Kaibab Formation, Timpoweap and Virgin Limestone members of the Moenkopi Formation.

Petrified wood and plant impressions were recorded in both the lower member (Shinarump) and upper members of the Chinle Formation. This is a fairly common occurrence for the Chinle. The Chinle's High Potential is based on known vertebrate fossils from the Chinle in other areas surrounding the project area. However, no vertebrate fossils were found during the surveys.

Three units were identified with trace fossils in the form of tracks. A small sandstone slab with a small invertebrate trackway was found in the Timpoweap Member of the Moenkopi. A small dinosaur track site was discovered in the Navajo Sandstone near Glen Canyon Dam. Also, a site with what appears to be mammal tracks was discovered in sediments thought to be Pleistocene in age.

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Abbreviations and Acronyms

Abbreviation/Acronym	Meaning/Description
Alt	Alternative
BLM	U.S. Bureau of Land Management
BPS	Booster Pump Station
CBPS	Cedar Booster Pump Station
CICWCD	Central Iron County Water Conservancy District
GOBP	Governor's Office of Planning and Budget
gpcd	gallons per capita per day
GSENM	Grand Staircase-Escalante National Monument
HS	Hydro System
KCWCD	Kane County Water Conservancy District
LPP	Lake Powell Pipeline
M&I	Municipal and Industrial
MSL	mean sea level
NAD	North American Datum
NPS	National Park Service
PFYC	Potential Fossil Yield Classification
RO	Reverse Osmosis
SITLA	School and Institutional Trust Lands Administration
TDS	Total Dissolved Solids
UDWR	Utah Division of Water Resources
UGS	Utah Geological Survey
UTM	Universal Transverse Mercator
WCH	Water Conveyance Hydro
WCWCD	Washington County Water Conservancy District

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Appendix A
Potential Fossil Yield Classification System

Occurrences of paleontological resources are closely tied to the geologic units (i.e., formations, members or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources.

Using the Potential Fossil Yield Classification (PFYC) system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils, and their sensitivity to adverse impacts, with a higher class number indicating a higher potential. This classification is applied to the geologic formation, member or other distinguishable unit, preferably at the most detailed mappable level. It is not intended to be applied to specific paleontological localities or small areas within units. Although significant localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment.

The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered at an intermediate point in the analysis, and should be used to assist in determining the need for further mitigation assessment or actions.

The descriptions for the classes below are written to serve as guidelines rather than as strict definitions. Knowledge of the geology and the paleontological potential for individual units or preservational conditions should be considered when determining the appropriate class assignment. Assignments are best made by collaboration between land managers and knowledgeable researchers.

Class I **- Very Low.** Geologic units that are not likely to contain recognizable fossil remains.

- Units that are igneous or metamorphic, excluding reworked volcanic ash units.
- Units that are Precambrian in age or older.

(1) Management concern for paleontological resources in Class 1 units is usually negligible or not applicable.

(2) Assessment or mitigation is usually unnecessary except in very rare or isolated circumstances.

The probability for impacting any fossils is negligible. Assessment or mitigation of paleontological resources is usually unnecessary. The occurrence of significant fossils is non-existent or extremely rare.

Class 2 **- Low.** Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

- Vertebrate or significant invertebrate or plant fossils not present or very rare.
- Units that are generally younger than 10,000 years before present.
- Recent aeolian deposits.
- Sediments that exhibit significant physical and chemical changes (i.e., diagenetic alteration).

(1) Management concern for paleontological resources is generally low.

(2) Assessment or mitigation is usually unnecessary except in rare or isolated circumstances.

The probability for impacting vertebrate fossils or scientifically significant invertebrate or plant fossils is low. Assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist, but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

***Class 3* - Moderate** or **Unknown.** Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance and predictable occurrence; or sedimentary units of unknown fossil potential.

- Often marine in origin with sporadic known occurrences of vertebrate fossils.
- Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low.
  (or)
- Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Class 3a **- Moderate Potential.** Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for hobby collecting. The potential for a project to be sited on or impact a significant fossil locality is low, but is somewhat higher for common fossils.

Class 3b **- Unknown Potential.** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this Class may eventually be placed in another Class when sufficient survey and research is performed. The unknown potential of the units in this Class should be carefully considered when developing any mitigation or management actions.

(1) Management concern for paleontological resources is moderate; or cannot be determined from existing data.

(2) Surface-disturbing activities may require field assessment to determine appropriate course of action.

This classification includes a broad range of paleontological potential. It includes geologic units of unknown potential, and also units of moderate or infrequent occurrence of significant fossils. Management considerations cover a broad range of options as well, and could include pre-disturbance surveys, monitoring or avoidance. Surface-disturbing activities will require sufficient assessment to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources. These units may contain areas that would be appropriate to designate as hobby collection areas due to the higher occurrence of common fossils and a lower concern about affecting significant paleontological resources.

***Class 4* - High.** Geologic units containing a high occurrence of significant fossils. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface disturbing activities may adversely affect paleontological resources in many cases.

Class 4a **-** Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres. Paleontological resources may be susceptible to adverse impacts from surface disturbing actions. Illegal collecting activities may impact some areas.

Class 4b - These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a protective layer of soil, thin alluvial material or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

- Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.
- Areas of exposed outcrop are smaller than two contiguous acres.
- Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.
- Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action.

(2) A field survey by a qualified paleontologist is often needed to assess local conditions.

(3) Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered.

(4) Class 4 and Class 5 units may be combined as Class 5 for broad applications, such as planning efforts or preliminary assessments, when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation and other management considerations are similar at this level of analysis, and impacts and alternatives can be addressed at a level appropriate to the application.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation considerations must include assessment of the disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access resulting in greater looting potential. If impacts to significant fossils can be anticipated, on-the-ground surveys before authorizing the surface disturbing action will usually be necessary. On-site monitoring or spot-checking may be necessary during construction activities.

Class 5 - **Very High.** Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a - Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface disturbing actions. Unit is frequently the focus of illegal collecting activities.

Class 5b - These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.

- Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted.
- Areas of exposed outcrop are smaller than two contiguous acres.
- Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions.
- Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

(1) Management concern for paleontological resources in Class 5 areas is high to very high.

(2) A field survey by a qualified paleontologist is usually necessary before surface disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions.

(3) Official designation of areas of avoidance, special interest and concern may be appropriate.

The probability for impacting significant fossils is high. Vertebrate fossils or scientifically significant invertebrate fossils are known or can reasonably be expected to occur in the impacted area. On-the-ground surveys before authorizing any surface disturbing activities will usually be necessary. On-site monitoring may be necessary during construction activities.

Appendix B
Faunal and Floral Lists by Geological Formation

(The faunal and floral lists from Gillette and Hayden (1997) were used as a beginning point and then expanded with new and additional information from a number other sources listed in the bibliography.)

Toroweap Formation

Braciopods
Bivalves
Small crinoid stems

Kaibab Formation

Algae
Stromatolites
Sponges
Actinoceolia
Corals
Campophylluml
Chonetes sp.
Favosites sp.
Lithostrotionl
Lophophyllum sp.
Crinoids
Echinoids
Echinocrinus sp.
Bryozoans
Batostomella sp.
Fenestella sp.
Hemitrypa sp.
Lioclema sp.
gastropods
Phyllopora sp.
Polypora sp.
Rhombopora sp.
Septopora sp.
Tabulipora sp.
Brachiopods
inarticulates
Lingula sp.
Terabratula sp.
Peniculauris bassi
Productus (Dictyoclostus) occidentalis
ammonoids and nautiloids
Echinauris subhorrida
Koslowskia meridionalis
Cliothyridina?
Composita sp.
Derbya sp.
Dielasma sp.
scaphopods
Marginifera sp.
Orthotetes sp.
Productus sp.

Pugnax sp.
Pustula sp.
conodonts
Schizophoria sp.
Spiriferina sp.
Spirorbis sp.

Nǔcula sp.
Parallelodonl
Pernipecten sp.
Pleurophorus sp.
Pleurophorellal
Pseudomonotis sp.
Pferifl sp.
Schizodus sp.
Solenomya?
Squamularial
Squamularia sp.

Adisina sp.
Bellerophon sp.
Girtyellal
Goniospira sp.
Bucanopsis sp.
Euomphalus sp.
Euphemus sp.
Naticopsisl
Platyceras sp.
Pleurotomaria sp.

Metacoceras sp.
Nautilus sp.
Orthocerasl
Meekoceras sp.
nautiloids

Plagioglypta sp.

Delaria sp.

Bivalves

Acanthopecten sp.
Astartella sp.
Aviculopecten sp.
Deltopecten sp.
Edmondia sp.
Leda sp.
Lima sp.
Myalina sp.
Myoconchal
Nucula sp.
Parallelodonl
Pernipecten sp.
Pleurophus sp.
Pleurphorus sp.
Pleurophorellal
Pseudomonotis sp.
Pferifl sp.
Schizodus sp.
Solenomya?
Squamularial
Squamularia sp.

Gastropods

Adisina sp.
Bellerophon sp.
Girtyellal
Goniospirs sp.
Bucanopsis sp.
Euomphalus sp.
Euphemus sp.
Naticopsist
Platyceras sp.
Pleurotomaria sp.

Ammonoids and Nautiloids

Metacoceras sp.
Nautilus sp.
Orthocerasl
Meekoceras sp.
Nautiloids

Scaphopods

Plagioglypta sp.

Trilobites

Delaria sp.
Griffithides sp.

Conodonts

Anchignathodus
Ellisonia
Neogondolella
Neostreptognathodus
Xariogathu

Moenkopi Formation

Algal debris
Plants
Crinoids
- *Isocrinus sp.*
- *Pentacrinus sp.*

Echinoids
Brachiopods
- *Discina sp.*
- *Hemiprionites sp.*
- *Pugnax sp.*
- *Pugnoides sp.*
- *Spirorbis sp.*

Gastropods
- naticoid gastropod
- *Aviculopecten sp.*
- *Eucyclus?*
- *Macrochilinal*
- *Natica sp.*
- *Naticopsis sp.*
- *Neritinal*
- *Pleurotomaria sp.*
- *Pseudomelania sp.*
- *Solariellal*
- *Turritella sp.*

Bivalves
- coquina beds
- dysodont bivalve
- *pectens*
- *Bulimorpha sp.*
- *Entolium sp.*
- *Myalina sp.*
- *Monotis sp.*
- *Myophoria sp.*
- *Pseudomonotis sp.*

Ammonoids and Nautiloids
- *Anasibirites sp.*
- *Cordillerites sp.*
- *Hungarites sp.*
- *Meekoceras sp.*
- *Paranannites sp*
- *Pleurophorus sp.*
- *Pseudosageoceras sp.*
- *Submeekoceras sp.*
- *Tirolites sp.*
- *Wasatchites sp.*
- *Xenoceltites sp.*

Nautiloids
- Genus indeterminate

Scaphopods
- *Laevidentalium?*
- *arthropods*
- *ostracodes*
- *Limulus tracks*
- *Halicyne sp.*

Worm tubes and trails
Vertebrates
Ostichthyes
Moenkopia
Taphrognathus
- fish scales and vertebrae

Amphibians
Hadrokkosaurus
Virgilius
Eocyclotosaurus
Quasicylotosaurus
Wellesaurus
Cosgriffius
Reptiles
Anisodontosaurus
Ammorhynchus
Arizonasaurus
Rhadalognathus
- reptile footprints
- *Parotosaurus sp.*
- *Rotodactylus tracks*
- *Chirotherium tracks*
- *Trigonodus sp.*
- *Akropus?*
- *Scoyenia*

Chinle Formation

Plants
- *Ephedra chinlena* (pollen)
- Ferns
- Charcoal fragments
- Petrified wood and logs
- *Neocalamites sp.*
- *Araucarioxylon sp.*
- *Sphenozamites leaf*
- *Woodworthia sp.*

Gastropods
- *Lioplacodes sp.*
- *Lymnaea sp.*
- *Triasammicola sp.*
- *Valvata sp.*

Bivalves
- *Diplodon sp.*
- *Unio sp.*

Insect burrows
- *Paleobyprestis sp.*
- *Paleeoscolytus sp.*
- *Paleopidus sp.*
- insect wing

Limuloid trails
- *Kouphichiniwn sp.*

Ostracodes
- *Cyzicus sp.*

Worm trails

Fish
Chondrichthyes
Reticulodus
Lungfish burrows
- *Lepidotes sp.*
- *Lepidotus sp.*
- *Pholidophorus sp.*
- *Semionotus kanabensis, n. sp.*
- Amphibians
- *Kalamoikelor*
- *Metoposaurus*
- Reptiles
- Synapida
- *Placerias*
- Reptilia incertae sedis
- *Vancleavea*
- *Acallosuchus*
- *Uatchitodon*
- Phytosaurs
- *Machaeoprosopus*
- *Pseudopalatus*
- *Sphenosuchians*
- *Hesperosuchus*
- *Parrishia*
- Aetosaurs
- *Acaenasuchus*
- Dinosaurs
- *Chindesaurus*
- *Camposaurus*
- dinosaur bones and teeth reptile Tracks
- *Eubrontes sp.*
- *Grallator sp.*
- *Anchisauripes sp.*

Moenave Formation – Wingate Sandstone

Stromatolites palynomorphs
- *Callialasporites sp.*
- *Chasmatosporites sp.*
- *Cordlina sp.*
- *Corollina sp.*
- *Cycadopites sp.*
- *Granulatisporites sp.*
- *Podocarpiditesl*
- *Todisporites sp.*
- *Triassic bisaccates*

Plants
- petrified wood fragments
- Ferns
- Cycads
- Horsetrail
- Conifers

Invertebrates
Ostracods
Conchostracian arthopods
Invertebrate traces
Insects- beetles, dragonflies?
Worms
Clams
Snails
Horseshoe crabs
bioturbation
Vertebrates

Fish
- fish swim tracks and coprolites
- fish scales
- Coelocanths
- *Lepidotes sp.*
- *Lepidotus sp.*
- *Lepidotus walcotti*
- *Lissodus*
- *Pholodophorus sp.*
- *Seminotus kanabensis*
- *Semionotus sp.*

Reptiles
- *Protosuchus sp.*
- *Megapnosaurus*
- *Syntarsaurus*
- *Unassigned reptiles*

Reptile tracks
- *Grallator*
- *Eubrontes*
- *Anomoepus*
- *Batrachopus*
- *Tetrasauropus*
- *Brasilichnium*
- *Anchisauripus*
- *Dilophosauripus*
- Theropod dinosaur trackway

Kayenta Formation

Petrified wood fragments
Bivalves
  unio sp.
Traces
  worm holes or roots casts
Vertebrates
Fish
Amphibians
Prosalirus
  Eocaecilia
Reptiles
  Synapsids
  Oligokyphus
  Dinnebitodon
  Kayentatherium
  Dinnetherium
  turtles
  Kayentachelys
  Crocodiles
  Kayentasauchus
  Eopneumatosuchus
  Protosuchus?
  Calsoyasuchus
  Pterosaurs
  Rhamphinion
  Dinosaurs
  Scutellosaurus
  Scelidosaurus?
  Massospondylus
Dilophosaurus
Syntarus

Reptile tracks
  Grallator
  Eubrontes
  Kayentapus
  Anomoepus
  Brasilichnium
  Dilophosauripus
  Anchisauripus
  Hopiichnus
  Ornithischian
  Bird-like tracks

Navajo Sandstone

Plants
Petrified wood
Algal mounds
Land shells
Crustaceans
Invertebrate tracks
Octopoichnus (spider)
Paleohelcura (scorpion)
Vertebrates
  Crocodiles
Protosauchus
Segisauris

Dinosaurs
Ammosaurus
Reptile tracks
  Brazilichnium
  Eubrontes
  Grallator
  Otozoum
  Brachycheirotherium
  Anchisaurpus
  Anomoepus

Carmel Formation

Plants
- algal stromatolites

Corals
- *Astrocoenia ?*

Crinoids
- *Pentacrinus sp.*

Echinoids

Brachiopods
- *Rhynochonella sp. bivalves*
- *Astarte*

Bivalves
- *micrite*
- *Camptonectes sp.*
- *Cardinia sp.*
- *Dosinia sp.*
- *Eumicrotis sp.*
- *Gervillia sp.*
- *Gresslya ?*
- *Inoceramus sp.*
- *Isocyprina ?*
- *Lima sp.*
- *Modiola sp.*
- *Myalina sp.*
- *Myophoria sp.*
- *Nerinea*
- *Ostrea sp.*
- *Pecten sp.*
- *Pholadomya sp.*
- *Pinna sp.*
- *Pleuromya sp.*
- *Pronoella*
- *Quenstedtia sp.*
- *Tancredia sp.*
- *Trigonia sp.*

Gastropods
- *Cossmannea*
- *Natica sp.*
- *Neritina sp.*
- *Solarium*[1]*?*
- *Volsella sp.*

Ammonoids

Arthropods
- ostracodes

Worm tubes, trails, and borings

Vertebrates

Reptile tracks

Carmelopodus untermannorum

Swim tracks

Entrada Formation

Reptiles
- Tracks Theropoda
- *?Megalosauripus*
- *?Therangospodus*
- *cf. Brontopodus*

silicified logs

coalified logs

insect burrow and nests

Brackish-water invertebrates

Vertebrates
- sharks
- rays
- fish
- turtles
- crocodiles
- orhithischian dinosaurs
- saurischian dinosaurs
- marsupial mammals
- multituberculate mammals

Dinosaur tracks

Pleistocene sediments (fossils known from the Colorado Plateau)

Tortoise
Lizards
Snakes
Birds
Mammals
- mammoths
- mastodons
- mountain goats
- bighorn sheep
- pronghorn antelope
- ground sloth
- Shrub ox
- musk ox
- camels
- horses
- tapirs
- bison
- bears
- wolves, dogs, foxes
- cats

Appendix C
Paleontological Localities Previously Recorded in Utah and Arizona

Table C-1
Lake Powell Pipeline Paleontological Localities Previously Recorded in Utah
Page 1 of 4

Utah Number	Reference	Land Manager	Location	Geologic Formation	Description
42Ka0003	Peabody, 1956	BLM	SW, NE,24,43S,5W 378550e/4102200n	Moenkopi	Chirotherium trackway.
42Ka0004	Peabody, 1956; Foster et al, 2001	BLM GS-E	C, SW, SW,25,41S,2W 413394e/4118713n	Moenkopi Lower Red	Camp's 1951 Lacertoid tracksite.
42Ka0009	Auld, 1976	BLM GS-E	SE, SW, SE,27,42S,3W 401252e/4108871n	Moenkopi Virgin Limestone	Molluscs.
42Ka0011	Gregory & Moore, 1931; Baird, 1975; Foster et al, 2001	BLM GS-E	NW,9,43S,2W 408672e/4105083n	Kaibab	Crinoids, gastropods.
42Ka0016	Gregory, 1948	BLM GS-E	SW,25,42S,3W 404099e/4109567n	Moenkopi, Timpoweap	Gastropods, ammonites, bivalves.
42Ka0017	Gregory, 1948	BLM GS-E	SE, SW, NE,15,44S,2W 410816E/4103465n	Moenkopi Timpoweap	Bivalves, gastropods.
42Ka0194	Wilson, 1959	BLM	30,43S,5W	Moenave	Vertebrate.
42Ka0218	Jeff Eaton	BLM GS-E	C, NE,36,42S,1W 423979e/4108122n	Dakota	Crocodile, turtle, fish, mammal tooth.
42Ka0219	Jeff Eaton	BLM GS-E	SW, SW, NE,36,42S,1W 423635e/4107878n	Dakota	Crocodile, turtle, fish.
42Ka0220	Jeff Eaton	BLM GS-E	SW, SW, NE,36,42S,1W 423774e/4107835n	Dakota	Turtle, fish (Lepidotes, lungfish).
42Ka0223	Bramble, 1979	BLM	NE, SE,15,43S,2E 440042e/4102462n	Loess deposits	Rat midden- plant & animal debris.
42Ka 224	Bramble, 1979	BLM GS-E	SW, SE, SW,30,42S,1E 424916e/4108939n	Dakota	Plant debris and impressions; turtle bone.
42Ka289	Alden Hamblin (2-26-98)	BLM GS-E	NW, SE, SE,30,42S,1E 425753e/4108915n	Dakota	Turtle shell.
42Ka0290	Alden Hamblin, (2-26-98)	Glen Canyon NRA	SW,12,43S,2E A- 442595e/4104170n B- 443511e/4104010n C- 441832e/4103964n	Tropic Shale	Gryphea shells, fossiliferous concretions.
42Ka0344	Hutchinson, 1997	BLM GS-E	SE, NW, SE,30,42S,1E 424480e/4108971	Dakota	Turtle, fish, crocodile and dinosaur fragments.
42Ka0382	Alan Titus	BLM GS-E	NE, SE, NE,36,42S,1W 424204e/4108221	Dakota	Plant stems and leaf impressions, rare bone.

Table C-1
Lake Powell Pipeline Paleontological Localities Previously Recorded in Utah

Utah Number	Reference	Land Manager	Location	Geologic Formation	Description
42Ka0383	Alan Titus	BLM GS-E	NE, SE, NE,36,42S,1W 424331e/4108189n	Dakota	Crocodile, turtles, fish, plants (wood).
42Ka0503	Gregory, 1946	BLM GS-E	NW, SW,25,42S,3W 403769e/4109482n	Kiabab	Productid, Martinoid brachiopods
42Ka0504	Noble, 1928	BLM GS-E	SE, NW, NE,9,43S,2W 408672e/4105083n	Kaibab	Rugose coral, bryozoa, crinozoans, brachiopods.
42Ka0505	Gregory, 1948; Foster, et al,2001	Private	NE, NW, NE,3,44S,4W 391414e/4097851n	Moenkopi Virgin Limestone	Bivalves, gastropods.
42Ka0535	G. Winterfeld	BLM GS-E	11,43S,2W 412180e/4104755n	Kayenta	Wood.
42Ka0553	Foster, et al, 2001	BLM GS-E	NE,34,42S,2W 411362e/4108039n	Kaibab	Gastropods – turitellids; brachiopods.
42Ka0554	Foster, et al, 2001	BLM GS-E	SE,34,42S,2W 410988e/4107950	Kaibab	Crinoids; brachiopods, including spiriferids; rugose corals; bryozoans.
42Ka0555	Foster, et al, 2001	BLM GS-E	SE,34,42S,2W 410947e/4107982n	Kaibab	Bivalves.
42Ka0579	Hamblin and Foster, 2000	BLM GS-E	18,43S,1W 415816e/4103564n	Page Sandstone	Possible small theropod tracks.
42Ka0582	Foster et al, 2001	BLM GS-E	SE,25,42S,1W 424123e/4108903n	Dakota	Fish vertebrae, bivalves, invertebrate traces.
42Ka0615	Peabody, 1956	BLM GS-E	SE, SW, SE,27,41S,2W 411278e/4118454n	Moenkopi	Tracks - three sets of three-toe marks .
42Ka0676	A.H.Hamblin	BLM GS-E	SW, SE, SW,23,41S,2W 412150e/4120020n	Moenkopi	Lizard track float.
42Ka1663	Titus, 2005 (6-28-05)	BLM GS-E	NE,24,43S,5W 379000e/4102250n	Chinle, Black Forest	Metoposaur & phytosaur bones, scutes, & teeth.
Ka -MNA 1536	David Gillette	BLM GS-E	NE, SE, SE,25,42S,1W 424293e/4108375n	Dakota	Mollusca – bivalves – Pterioida – Inoceramidae – *Inoceramus* – shell.
Ka – NMA 821-1	David Gillette	BLM GS-E	SW, SW, NE,36,42S,1W 423780e/4107780n	Dakota	Minor invertebrates.
Ka – NMA 821 - 2	David Gillette	BLM GS-E	NE, SW, NE,36,42S,1W 423980e/4108120n	Dakota	Minor invertebrates.
42Ws0010	Auld, 1976	Zion NP	28,43S,12W 303550e/4098950n	Moenkopi, Virgin Limestone	Invertebrates.
42Ws0011	Auld, 1976	BLM/State	SE, SW,17,41S,12W 302215e/4121220n	Moekopi Virgine Limestone	Invertebrates.
42Ws0012	Auld, 1976	BLM	NE, SW,15,41S,12W 305620e/4121210	Moenkopi Virgin Limestone	Invertebrates.

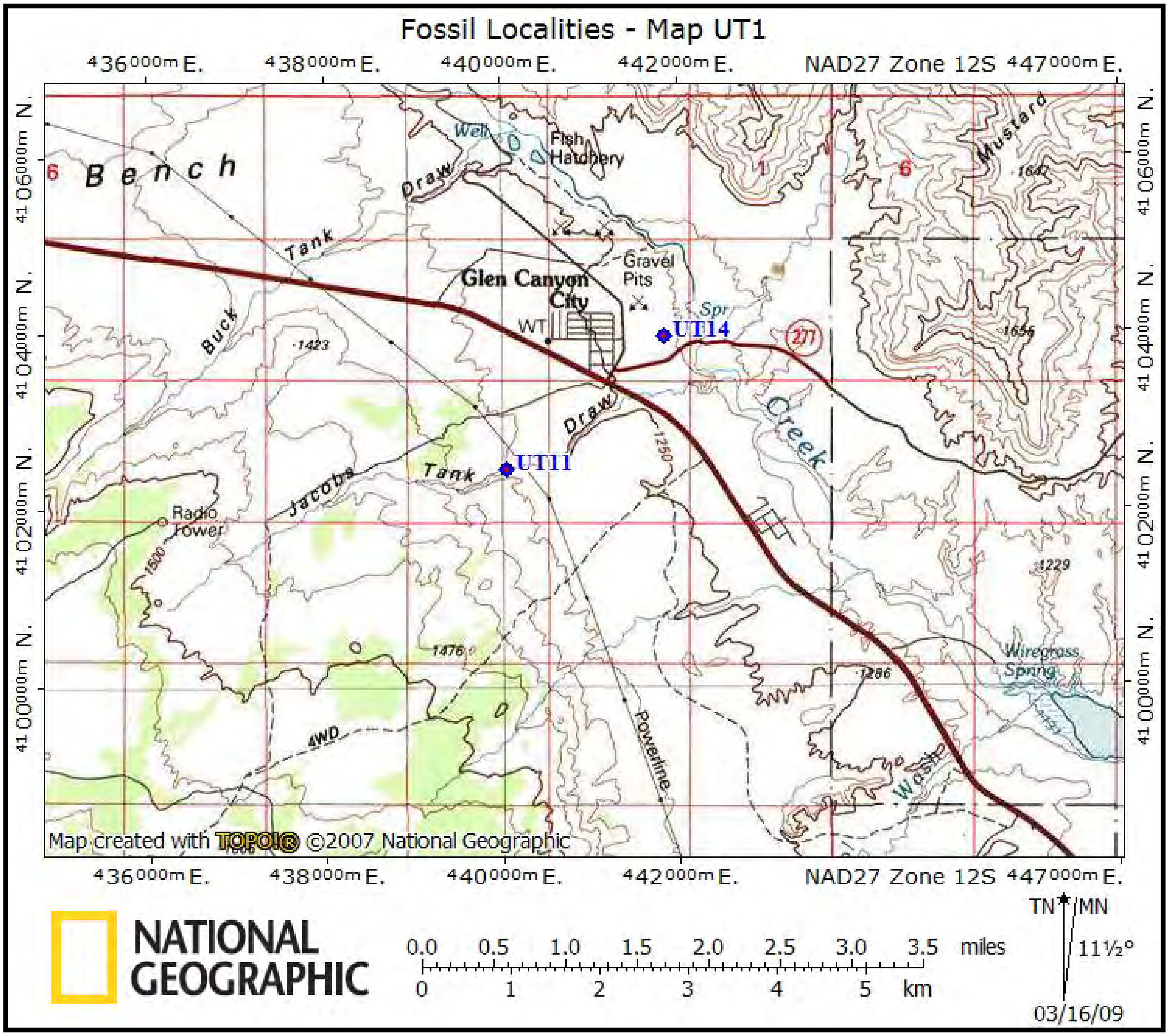
Table C-1
Lake Powell Pipeline Paleontological Localities Previously Recorded in Utah

Utah Number	Reference	Land Manager	Location	Geologic Formation	Description
42Ws0013	Auld, 1976	BLM	NE, SE,27,41S,12W 305975e/4117980n	Moenkopi Virgin Limestone	Invertebrates.
42Ws0014	Auld, 1976	BLM	24,43S,13W 298605e/4100700n	Moenkopi Virgin Limestone	Invertebrates.
42Ws0017	Day, 1967	BLM	SE,18,43S,10W 320325e/4101395n	Moenave Dinosaur Canyon	Vertebrate.
42Ws0026	Williams, 1947	Zion NP	E,21,38S,12W 305700e/4149490n	Moenkopi Timpoweap	Invertebrates.
42Ws0068	Dobbin, 1934	Private?	22,41S,13W 296000e/4120150n	Carmel	Invertebrates.
42Ws0088	Bassler, 1922	BLM	23,43S,13W 297840e/4100600n	Kaibab	Invertebrates.
42Ws0089	Bassler, 1922	Private?	25,41S,13W 298250e/4118200n	Kaibab	Invertebrates.
42Ws0112	Sohl, 1965	Private?	22,41S,13W 296050e/4120200n	Carmel	Invertebrates.
42Ws0122	Stewart et al., 1972	Zion NP	E,C,21,38S,12W 305275e/4149500n	Chinle Petrified Forest	Plants.
42Ws0154	Wade Miller	BLM	E/W,18/17,42S,12W 301450e/4111790n	Moenkopi Shnabkaib	Pelecypods (as molds) & burrows of unknown invertebrates.
42Ws0155	Wade Miller	Private	NE, NW35/36,41S,13W 298240e/4117275n	Kaibab Harrisburg ?	Abundant crinoids, brachiopods, bryozoans, corals gastropods & burrows.
42Ws0204	Hamblin, 2002(So.Cor) (9-8-2001)	BLM	SW, NE,19,42S,13W 291138e/4110565n	Navajo Sandstone	Brazilichnium tracks.
42Ws0228	Don DeBlieux, A. Milner	Zion NP	NE, NE,28,38S,12W 305483e/4148589n	Chinle Petrified Forest	Petrified wood.
42Ws0229	Andrew Milner, D. DeBlieux	Zion NP	SE, SE, SE,21,38S,12W 305618e/4148865n	Moenave?	Dinosaur tracks – *Grallator*?
42Ws0275	Jenny McGuire	Zion NP	NE, SW,28,38S,12W 305333e/4147573	Chinle Petrifies Forest	Petrified wood.
42Ws0298	F.by Jenny McGuire (4-26-03)	Zion NP	NW, NW,28,38S,12W 304290e/4148587n	Moenkopi, Virgin Limestone	Vertebrate tract site, swim tracks, lizard-like tracks.
42Ws0299	F.by Jenny McGuire (4-26-03)	Zion NP	SW, NW,28,38S,12W 304321e/4148324n	Moenkopi, Virgin Limestone	Scallop shells.

Table C-1
Lake Powell Pipeline Paleontological Localities Previously Recorded in Utah

Utah Number	Reference	Land Manager	Location	Geologic Formation	Description
42Ws0308	F.by Ron Long/Jenney McGuire (3-13-03)	Zion NP	SW, NW,28,38S,12W 304431e/4148148n	Moenkopi, Virgin Limestone	Burrows?
42Ws0310	J.Kirkland (3-13-03)	Zion NP	NW, SE,29,38S,12W 303494e/4147758n	Kaibab	Brachiopods and bivalves.
42Ws0340	DeBlieux/ Mickelson (3/17/05	Zion NP	SE, NW,28,38S,12W 304602e/4148250n	Moenkopi, Virgin Limestone	Swim tracks, invertebrate traces, burrows.
Ws Hurricane cliffs	Blakey, 1979	BLM	SE, 26, 42S,13W (Blakey shows sec.27, but is probably sec. 26)	Moenkopi Timpoweap	Ammonites.
Ws NMMNHS 5323	Spencer Lucas	BLM	T42S, R13W	Moenkopi	Meekoceratidae – *Meekoceras.*
42In0001	Stewart, et al., 1972	Zion NP	10,38S,12W 306540e/4152295n	Moenkopi Timpoweap	Mollusks – *Aviculopecten*?

Notes: Ka: Kane County; Ws: Washington County; In: Iron County.


Fossil Localities - Map UT1
436000m E.
438000m E.
440000m E.
442000m E.
NAD27 Zone 12S
447000m E.
4106000m N.
4104000m N.
4102000m N.
4100000m N.
Bench
Tank
Buck
Draw
Well
Fish Hatchery
Mustard
Gravel Pits
Glen Canyon City
WT
Spr
UT14
277
1423
1656
1647
Draw
Creek
Tank
UT11
Jacobs
Radio Tower
1500
1250
1229
1476
1286
Wiregrass Spring
4WD
Powerline
Wash
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
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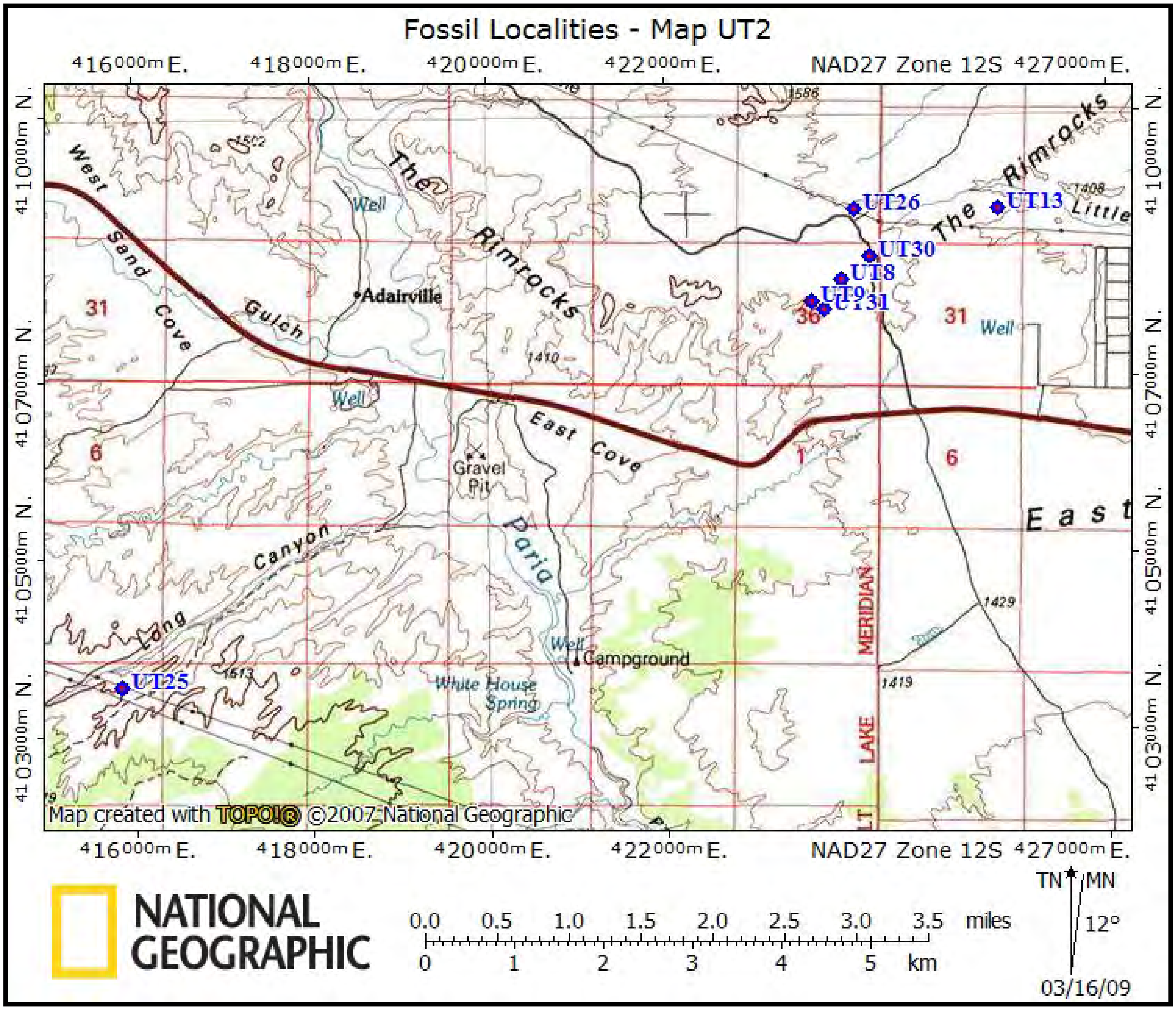
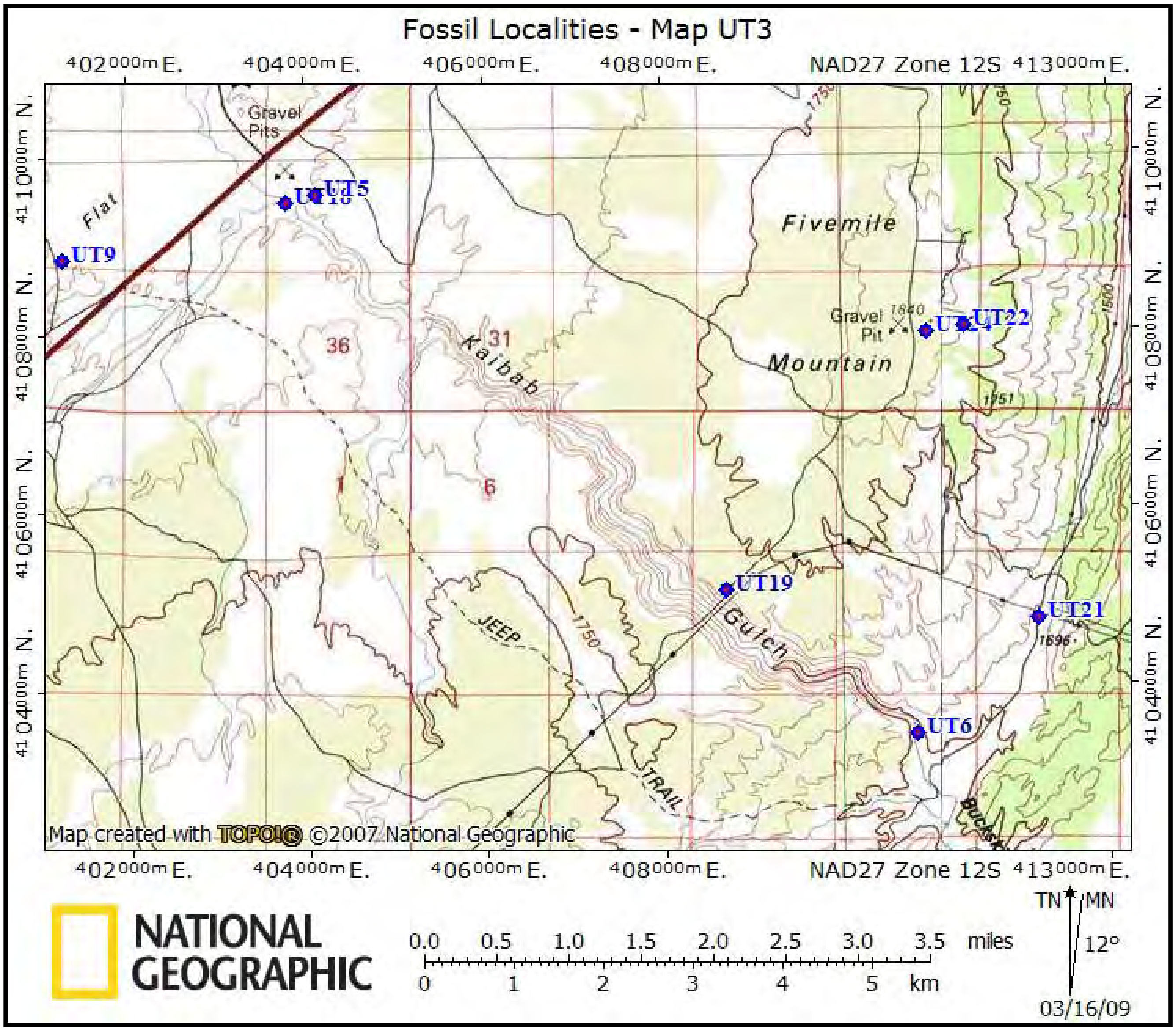
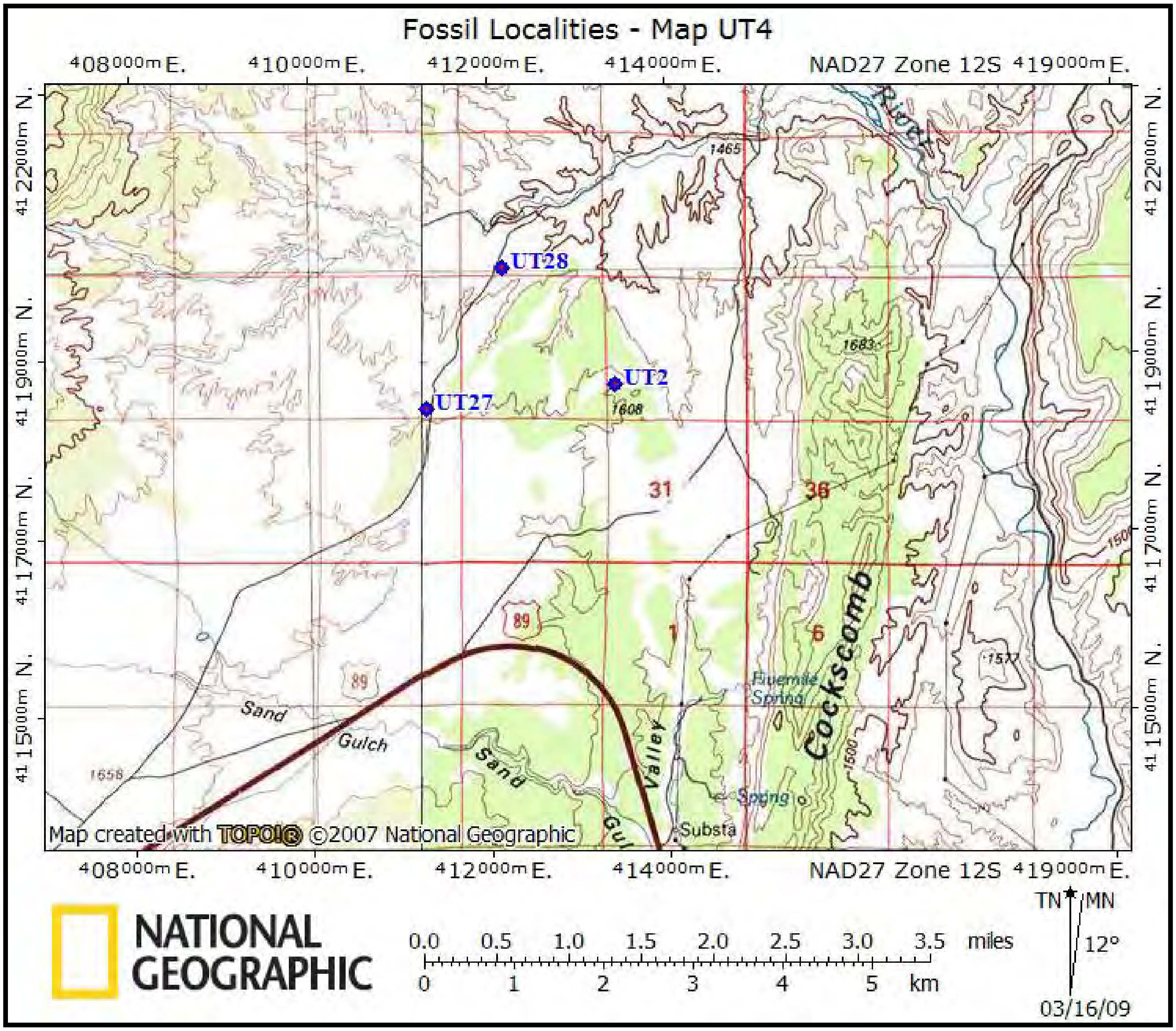
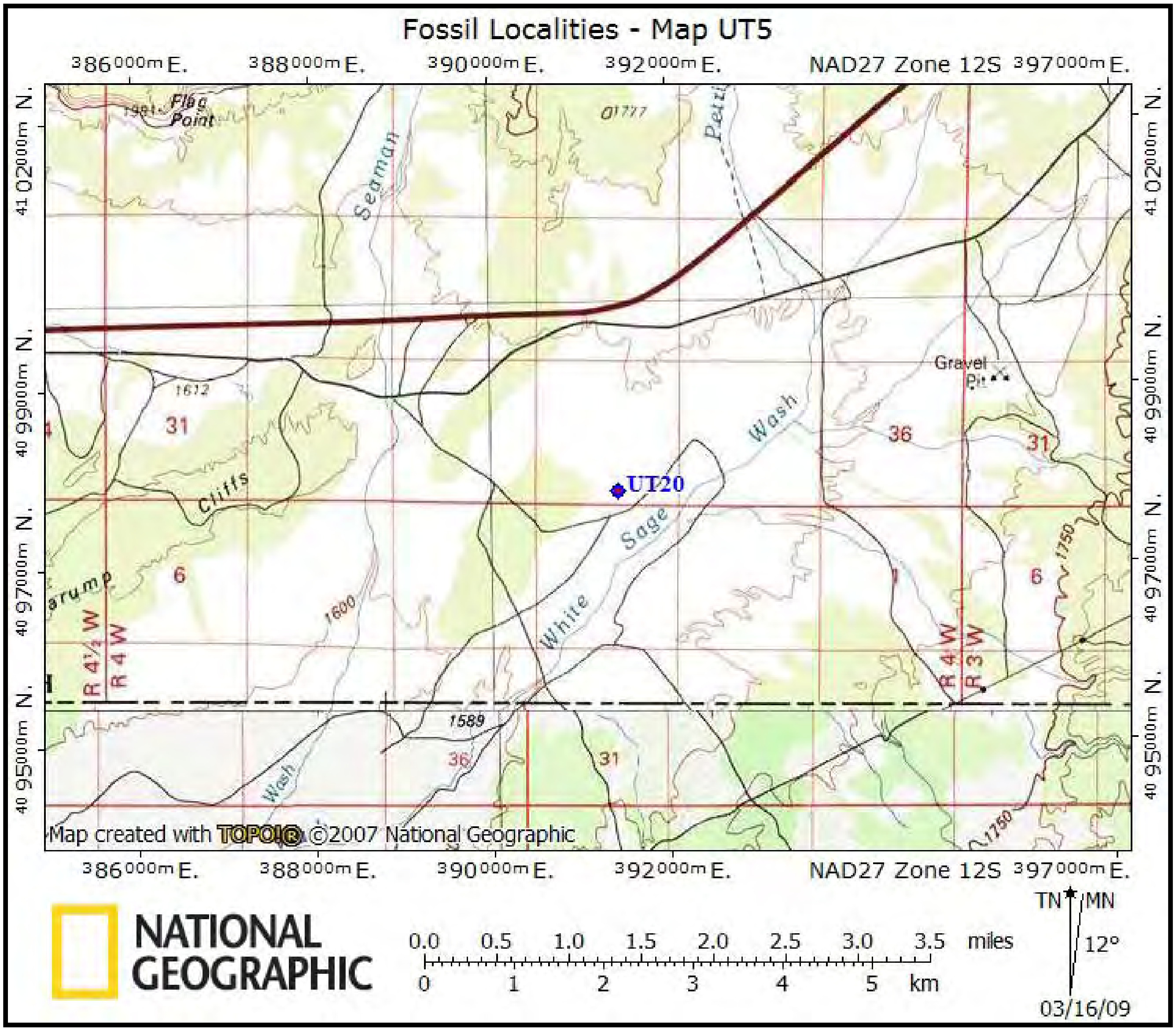
0 1 2 3 4 5 km
TN MN
11½°
03/16/09


Fossil Localities - Map UT2
416000m E.
418000m E.
420000m E.
422000m E.
NAD27 Zone 12S
427000m E.
4110000m N.
4107000m N.
4105000m N.
4103000m N.
UT26
UT13
UT30
UT8
UT9
UT31
UT25
The Rimrocks
West Sand Cove
Gulch
Adairville
Well
East Cove
Gravel Pit
Paria
Long Canyon
Campground
White House Spring
MERIDIAN
LAKE
Little
East
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 miles
0 1 2 3 4 5 km
TN MN
12°
03/16/09


Fossil Localities - Map UT3
402000m E.
404000m E.
406000m E.
408000m E.
NAD27 Zone 12S
413000m E.
4110000m N.
4108000m N.
4106000m N.
4104000m N.
Gravel Pits
Flat
UT9
UT5
Fivemile
Mountain
Gravel Pit
UT22
36
31
Kaibab
1
6
UT19
UT21
Gulch
JEEP
TRAIL
UT6
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 miles
0 1 2 3 4 5 km
TN MN
12°
03/16/09



Fossil Localities - Map UT4
408000m E.
410000m E.
412000m E.
414000m E.
NAD27 Zone 12S
419000m E.
4122000m N.
4119000m N.
4117000m N.
4115000m N.
UT28
UT2
UT27
1465
1683
1608
1577
1658
31
36
1
6
89
Sand
Gulch
Sand
Valley
Cockscomb
Fivemile Spring
Spring
Substa
River
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 miles
0 1 2 3 4 5 km
TN
MN
12°
03/16/09



Fossil Localities - Map UT5
386000m E.
388000m E.
390000m E.
392000m E.
NAD27 Zone 12S
397000m E.
41 02000m N.
40 99000m N.
40 97000m N.
40 95000m N.
Flag Point
Seaman
Petti
Wash
Sage
White
Cliffs
Gravel Pit
UT20
31
36
6
R 4½ W
R 4 W
R 3 W
1612
1600
1589
1750
Map created with TOPO! ©2007 National Geographic
NATIONAL GEOGRAPHIC
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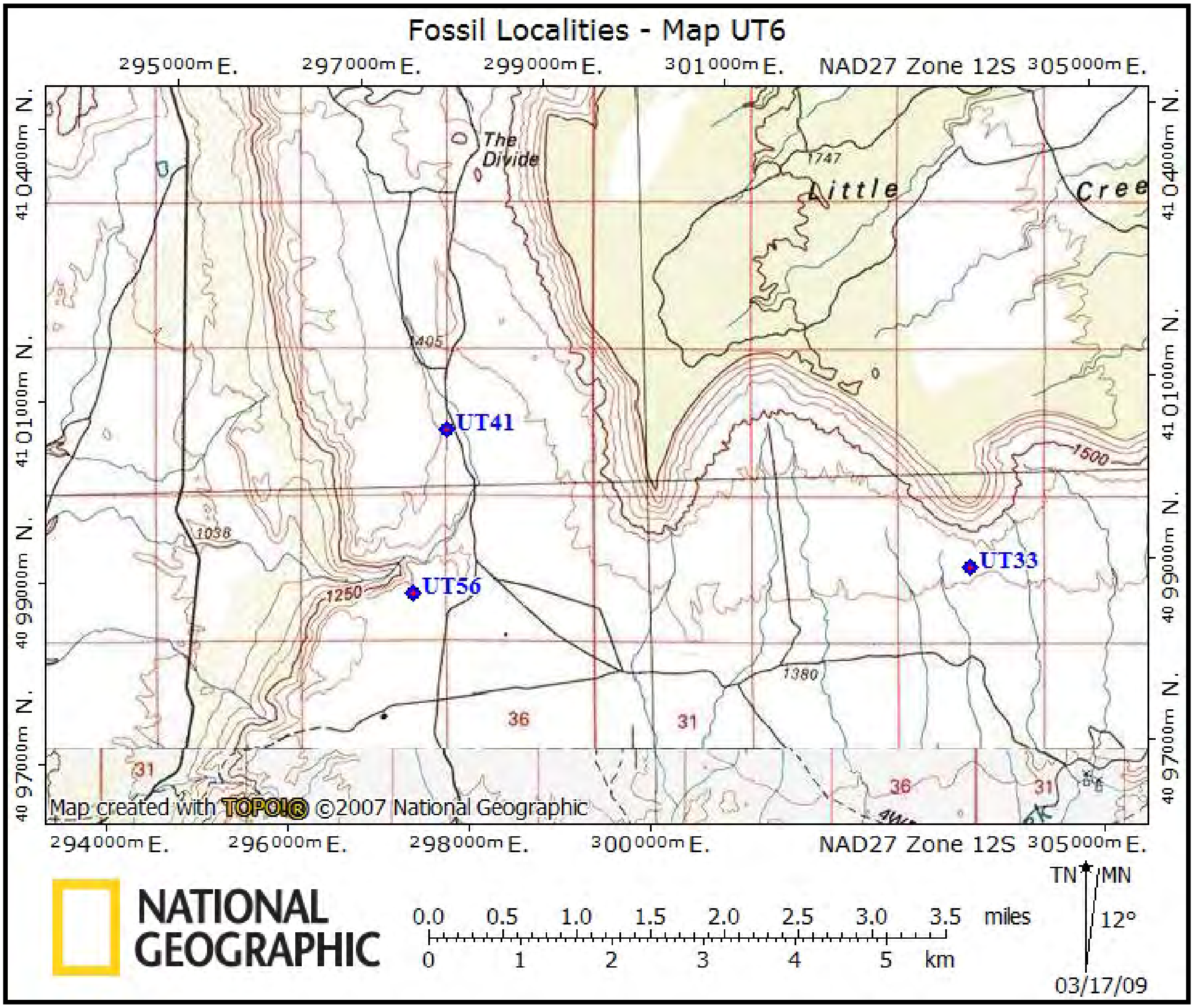
0 1 2 3 4 5 km
TN MN
12°
03/16/09


Fossil Localities - Map UT6
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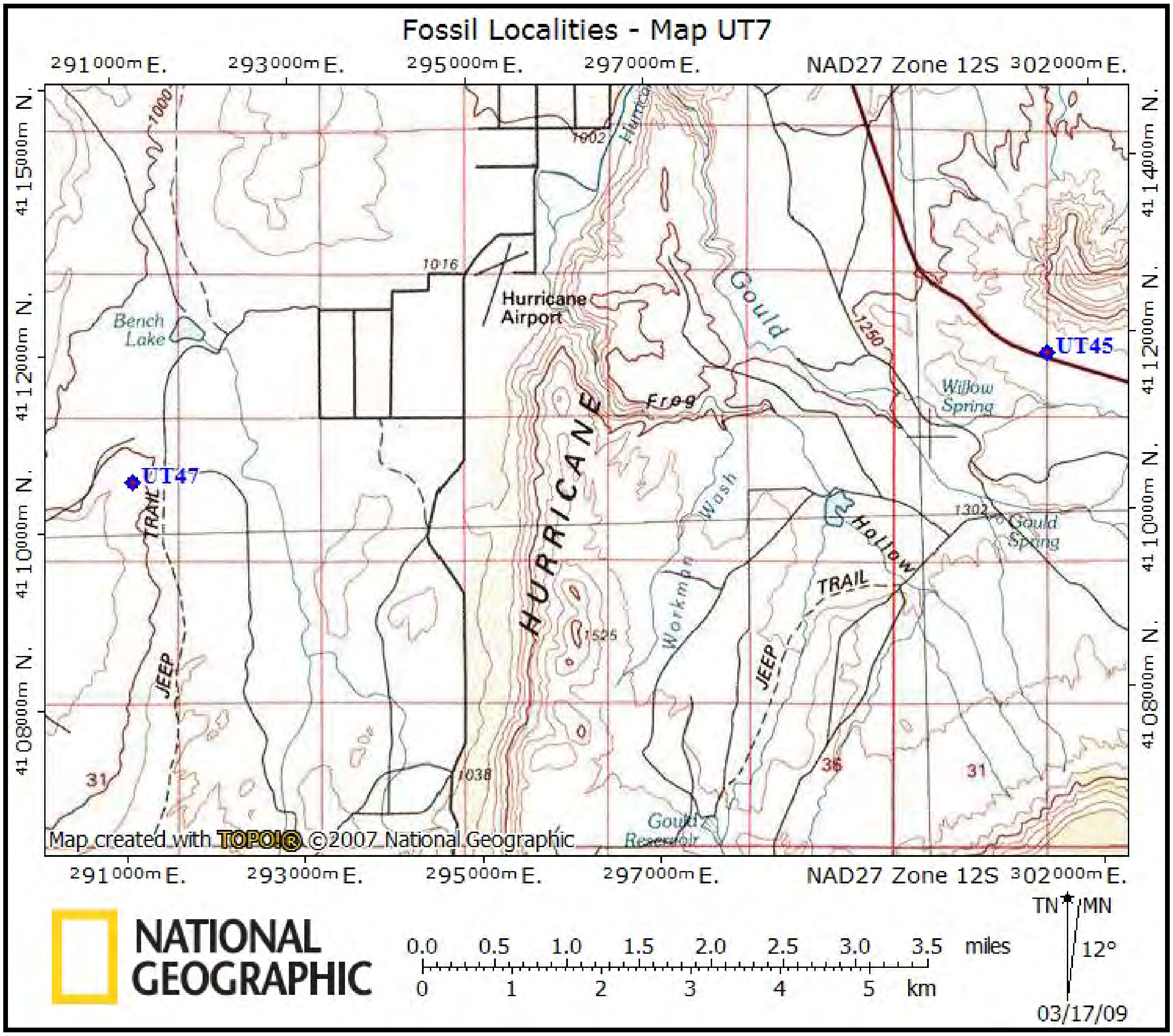
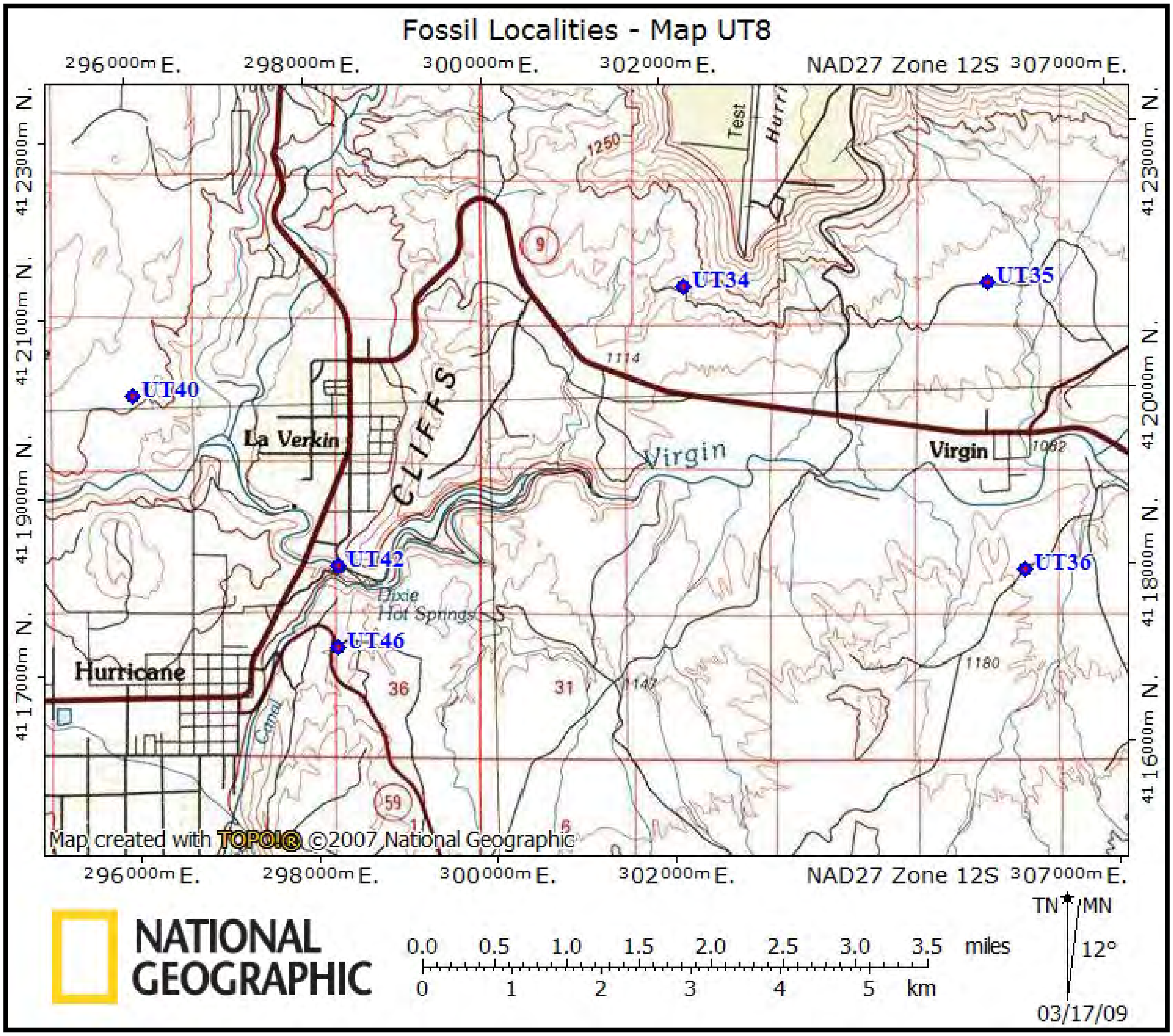
297000m E.
299000m E.
301000m E.
NAD27 Zone 12S
305000m E.
The Divide
1747
Little
Cree
1405
UT41
1500
1038
UT56
UT33
1250
1380
36
31
31
36
31
Map created with TOPO!® ©2007 National Geographic
294000m E.
296000m E.
298000m E.
300000m E.
NAD27 Zone 12S
305000m E.
4104000m N.
4101000m N.
4099000m N.
4097000m N.
NATIONAL GEOGRAPHIC
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 miles
0 1 2 3 4 5 km
TN
MN
12°
03/17/09


Fossil Localities - Map UT7
291000m E.
293000m E.
295000m E.
297000m E.
NAD27 Zone 12S
302000m E.
4115000m N.
4112000m N.
4110000m N.
4108000m N.
4114000m N.
4112000m N.
4110000m N.
4108000m N.
UT45
UT47
Bench Lake
Hurricane Airport
Gould
Frog
HURRICANE
Wash
Workman
Hollow
TRAIL
JEEP
Willow Spring
Gould Spring
Gould Reservoir
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 miles
0 1 2 3 4 5 km
TN MN
12°
03/17/09



Fossil Localities - Map UT8
NAD27 Zone 12S
UT34
UT35
UT40
UT42
UT46
UT36
La Verkin
Virgin
Hurricane
CLIFFS
Dixie
Hot Springs
Canal
Map created with TOPO!® ©2007 National Geographic
NATIONAL
GEOGRAPHIC
miles
km
TN
MN
12°
03/17/09

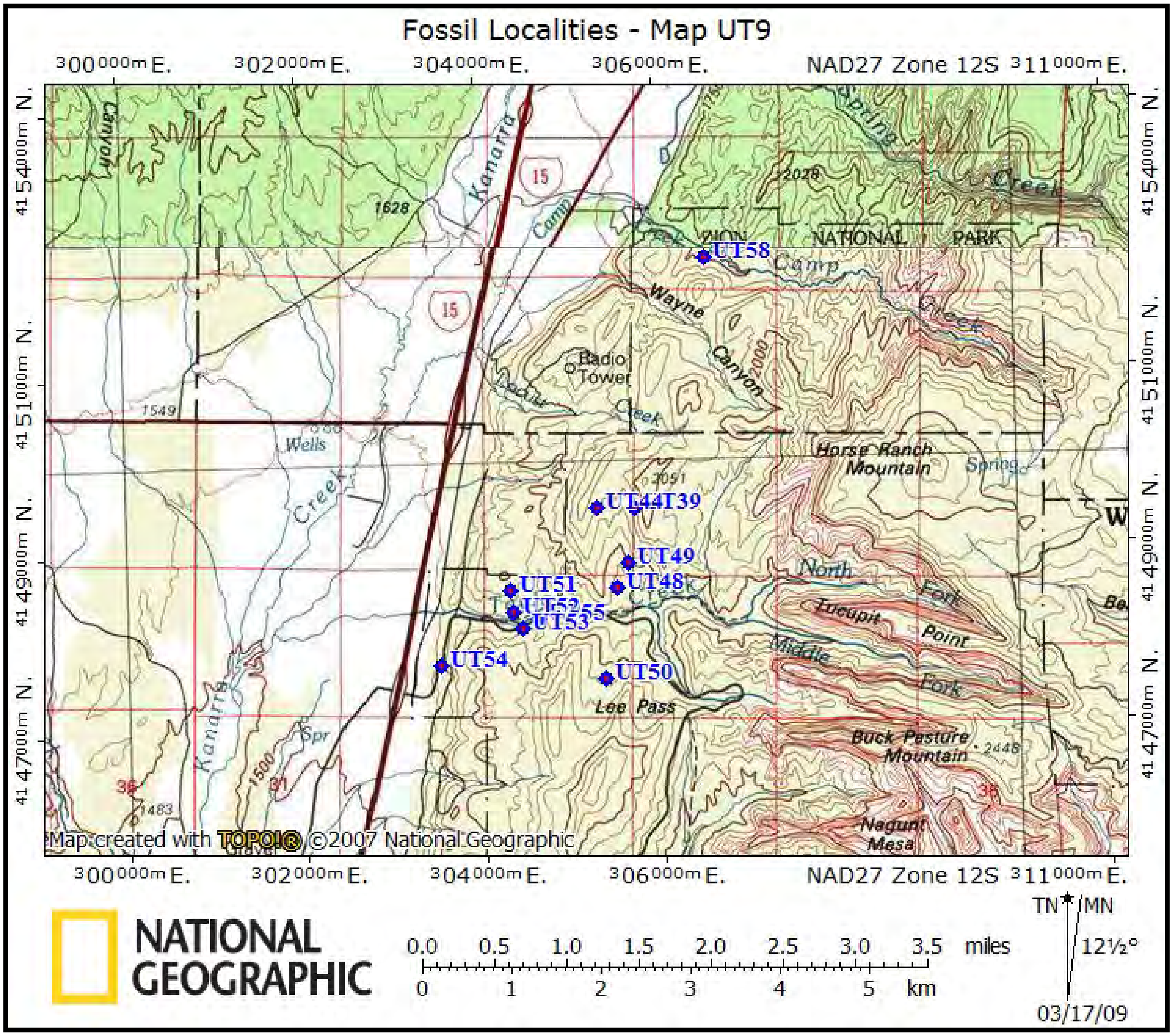

Fossil Localities - Map UT9
NAD27 Zone 12S
UT58
UT44
UT39
UT49
UT48
UT51
UT52
UT53
UT54
UT50
ZION NATIONAL PARK
Wayne Canyon
Radio Tower
Horse Ranch Mountain
North Fork
Taucupit Point
Middle Fork
Lee Pass
Buck Pasture Mountain
Nagunt Mesa
Kanarra
Camp Creek
Wells
Map created with TOPO!® ©2007 National Geographic
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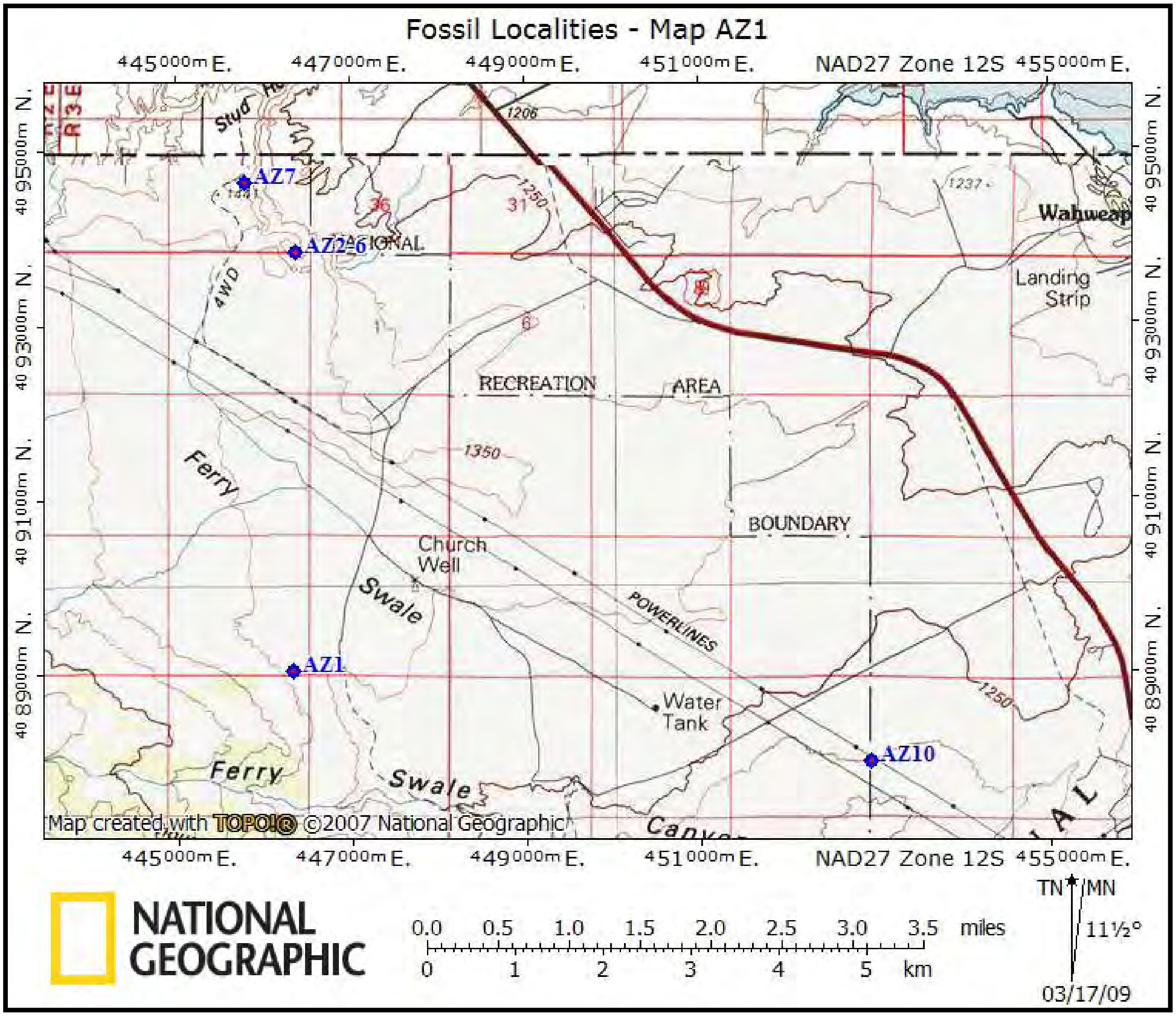
Table C-2
Paleontological Localities Previously Recorded in Arizona

Arizona Number	Reference	Land Manager	Location	Geologic Formation	Description
03AZCO-1	Alan Titus	BLM	SE, SE, SE,14,41N,7E 446301e/4089053n	Navajo Upper	Eubrontes and *Grallator*-type tracks.
05AZCO-1-a	Alan Titus	BLM	SE, SE, SE,35,41N,7E 446348e/4093855n	Dakota Lower	Turtle – Baenid.
05AZCO-1-b	Alan Titus	BLM	SE, SE, SE,35,41N,7E 446357e/4093862n	Dakota Lower	Possible small theropod.
05AZCO-1-c	Alan Titus	BLM	SE, SE, SE,35,41N,7E 446355e/4093849n	Dakota Lower	Baenid turtle plastron and carapace.
05AZCO-1-d	Alan Titus	BLM	SE, SE, SE,35,41N,7E 446342e/4093830n	Dakota Lower	Turtle.
05AZCO-1-e	Alan Titus	BLM	SE, SE, SE,35,41N,7E 446313e/4093806n	Dakota Lower	Turtle in a concretion.
LBA2005-2	B. Albright	BLM	SW, SW, NE,35,42N,7E 445778e/4094663n	Dakota Middle	Plant location- beautiful leaf impressions in claystone, insects.
AZ Kaibab-Piaute Indian Reservation, MH	Charley Bulletts	Kaibab-Piaute Indian Reservation	East side of Reservation	Moenkopi	Tracks.
Pipe Spring Tracks- AZ, MH	Cuffey, 1998	NPS	NW, SE, SE,17,40N,4W 344849e/4080998n	Navajo	Eubrontes-type dinosaur tracks.
DMB-UPL-1 CO, AZ	Simms, 1979	BLM	NE, SE,21,41N,8E 452927e/4087990n	Loess, cemented sand	Plant and animal bones, mammal bones. *Neotoma, Sylvilagus, Peromyscus, Taxidea,* and Ovis (?).
CL 37.38 AZ, MH	Kate Zeigler, Linda Hurley	Private	SE, NW, SW,9,40N,5W 335804e/4082986n	Moenave, below Springdale sandstone	Fish.

Notes: CO: Coconino County, AZ; MH: Mohave County, AZ.


Fossil Localities - Map AZ1
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447000m E.
449000m E.
451000m E.
NAD27 Zone 12S
455000m E.
4095000m N.
4093000m N.
4091000m N.
4089000m N.
AZ7
AZ2-6
AZ1
AZ10
Wahweap
Landing Strip
RECREATION
AREA
BOUNDARY
Ferry
Swale
Church Well
POWERLINES
Water Tank
Canyon
Map created with TOPO!® ©2007 National Geographic
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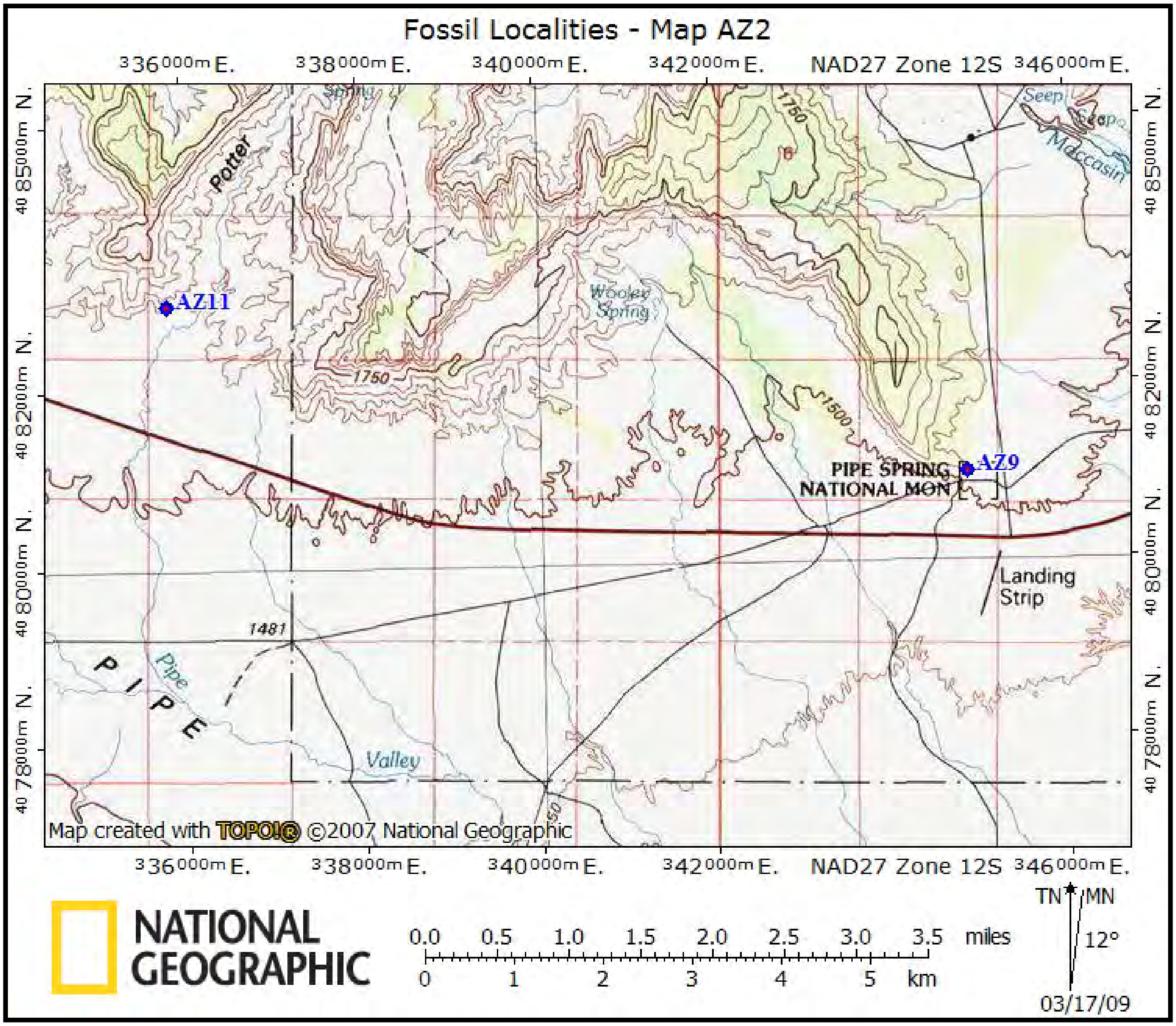
Fossil Localities - Map AZ2
336000m E.
338000m E.
340000m E.
342000m E.
NAD27 Zone 12S
346000m E.
4085000m N.
4082000m N.
4080000m N.
4078000m N.
AZ11
AZ9
PIPE SPRING
NATIONAL MON
Potter
Wooley Spring
Moccasin
Seep
Landing Strip
Pipe
PIPE
Valley
1750
1500
1481
Map created with TOPO!® ©2007 National Geographic
NATIONAL GEOGRAPHIC
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Appendix D
Paleontological Localities Recorded in Utah and Arizona

Table D-1
Paleontological Localities Recorded in Utah: Lake Powell Pipeline Features

Page 1 of 3

Utah Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
42Ka1977p	Private/UDOT	5/4/09	373287mE/4098593mN NW, NW, SE, SW, sec. 33, 42S, 5W Thompson Point Quadrangle UT-AZ 1987	Chinle	Several minor pieces of petrified wood.
42Ka1978t	BLM	5/27/09	NE-423598mE/4106571mN, SE-423620mE/4106556mN, NW-422587mE/4106568mN, SW-423601mE/4106548mN NW, SW, SW, NE, sec. 1, 42S, 1W Bridger Point Quadrangle UT-AZ 1981	Pleistocene deposit?	Possible mammal track molds.
42Ka1979i	State of Utah	6/9/09	N-411453mE/4106087mN, S-411487mE/4105987mN, W-411609mE/4106015mN, E-411552mE/4105971mN NW, SE, SW, sec. 2, 43S, 2W West Clark Bench Quadrangle UT-AZ 1981	Kaibab	Brachiopods, crinoids, corals, bryozoans, sponges.
42Ka1980i	BLM	6/9/09	N-411028mE/4106274mN, E-411576mE/4106186mN, S-411475mE/4106141mN, W- 411416mE/4106197mN SE, SE, NE, SE, sec. 3, 43S, 2W NE, NE, SE, SE, sec. 3, 43S, 2W West Clark Bench Quadrangle UT-AZ 1981	Kaibab	Brachiopods, crinoids, corals, bryozoans, sponges.
42Ka1981i	BLM	6/9/09	N-411028mE/4106850mN, E-411050mE/4106186mN, S-411041mE/4106660mN, W-411014mE/4106742mN SE, SE, NW, SE, sec. 3, 43S, 2W NE, SE, NW, SE, sec. 3, 43S, 2W Pine Hollow Canyon Quadrangle UT-AZ 1987	Kaibab	Brachiopods, bryozoans, corals, sponges, crinoids.
42Ka1982i	BLM	6/9/09	409592mE/4107931mN NW, SW, NE, SE, sec. 33, 42S, 2W Pine Hollow Canyon Quadrangle UT-AZ 1987	Moenkopi/ Timpoweap	Brachiopod mold, gastropods.
42Ka1983i	State of Utah	6/9/09	408302mE/4108582mN SE, SE, NE, NE, sec. 32, 42S, 2W Pine Hollow Canyon Quadrangle UT-AZ 1987	Moenkopi/ Timpoweap	Tiny gastropods, oolites.
42Ka1984i	State of Utah	6/9/09	407764mE/4108852mN SW, NE, NW, NE, sec. 32, 42S, 2W Pine Hollow Canyon Quadrangle UT-AZ 1987	Moenkopi/ Timpoweap	Gastropods and brachiopods.
42Ka2165i	BLM	7/13/10	398229mE/4104764mN SW, SW, NE, SW, sec. 8, 43S, 3W Petrified Hollow Quadrangle UT-AZ 1987	Moenkopi/ Timpoweap	One ammonite; numerous, large 2- to 3-inch gastropods.
42Ka2166i	BLM	7/15/10	411695mE/4106047mN NE, SW, SW, sec. 2, 43S, 2W West Clark Bench Quadrangle UT-AZ 1981	Kaibab	Brachiopods, horn corals, bryozoans, etc. Also scaphopods above.
42Ws552p	Private	6/24/09	316070mE/4097143mN SW, NE, NW, SW sec. 35,43S, 11W Smithsonian Butte Quadrangle UT-AZ 1980	Chinle/ Shinarump	Plant impressions.

Table D-1
Paleontological Localities Recorded in Utah: Lake Powell Pipeline Features

Utah Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
42Ws553p	Private	6/24/09	314786mE/4097611mN NW, NE, SE, NW, sec.34, 43S, 11W Smithsonian Butte Quadrangle UT-AZ 1980	Chinle/ Shinarump	Plant impressions.
42Ws555i	State of Utah	6/25/09	N-301170mE/4098337mN, E-301190mE/4098298mN, S-301180mE/4098253mN, W-301170mE/4098304mN N½, NW, NW, NW, NW, sec. 32, 43S, 12W Little Creek Mountain Quadrangle UT-AZ 1980	Moenkopi/ Virgin	Brachiopods, star-shaped crinoids.
42Ws556i	BLM	7/7/09	298119mE/4106099mN NW, NE, SW, NW, sec. 1, 43S, 13W The Divide Quadrangle UT1986	Moenkopi/ Virgin	Star-shaped crinoids.
42Ws557i	BLM	7/709	298149mE/4106518mN NW, NE, NW, NW, sec. 1, 43S, 13W The Divide Quadrangle UT 1986	Moekopi/ Virgin	Star-shaped crinoids.
42Ws558i	State of Utah	7/7/09	298263mE/4106695mN NE, SE, SW, SW, sec. 36, 42S, 13W The Divide Quadrangle UT 1986	Moenkopi/ Virgin	Small brachiopods, star-shaped crinoids.
42Ws560i	BLM	7/8/09	N-299332mE/4113550mN, E-299337mE/4113524mN, S-299344mE/4113497mN, W-299329mE/4113525mN W½ , SW, NE, SE, sec. 12, 42S, 12W NW, SW, NE, SE, sec. 12, 42S, 12W Hurricane Quadrangle UT 1986	Moenkopi/ top of Timpoweap or bottom of Lower Red	Gastropods and bivalves.
42Ws561t	BLM	7/8/09	NE-302576mE/4117824mN, SE-302573mE/4117816mN, NW-302543mE/4117821mN, SW-302539mE/4117815mN Cntr, SE, SW, SE, sec. 29, 41S,12W Virgin Quadrangle UT 1980	Moenkopi/ Timpoweap	Small vertebrate tracks. With tail drag? Specimen not in situ, but in wash bottom. Location is approximate.
42Ws562i	BLM	7/9/09	299972mE/4122514mN SW, NW, NW, NW, sec.18,41S, 12W Hurricane Quadrangle UT 1986	Kaibab/ Harrisburg	Bivalves or brachiopods, gastropods.
42Ws559i	BLM	7-31-09 10-01-09	299421mE/4122698mN, NE, NE, NW, NE, sec. 13, 41S, 13W Hurricane Quadrangle UT 1986	Moenkopi/ Timpoweep	Bivalves.
42Ws563i	BLM	7/9/09	299318mE/4122652mN NW, NE, NW, NE, sec. 13, 41S, 13W Hurricane Quadrangle UT 1986	Moenkopi/ Timpoweap	Bivalves or brachiopods.
42Ws566i	BLM	7/22/09	297683mE/4102702mN SW, NE, SE, NE, sec. 14, 43S, 13W The Divide Quadrangle UT 1986	Moenkopi/ Virgin	Star-shaped crinoids.
42Ws567i	BLM	7/22/09	N-297685mE/4102267mN, E-297710mE/4102191mN, S-297679mE,4102143mN, W-297676mE/4102199mN NW, SE, NE, SE, sec. 14, 43S, 13W SW, SE, NE, SE, sec. 14, 43S, 13W The Divide Quadrangle UT 1986	Moenkopi/ Virgin	Brachiopods (2 inches).

Table D-1
Paleontological Localities Recorded in Utah: Lake Powell Pipeline Features

Utah Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
42Ws568i A, B, & C	BLM	7/23/09	(A) 296131mE/4104117mN, (B) 296348mE/4104165mN, (C) 296349mE/4104118mN S½, SW, SW, NW, sec. 11, 43S, 13W NW, NW, NW, SW, sec. 11, 43S, 13W The Divide Quadrangle UT 1986	Kaibab/ Harrisburg	Crinoids, bryozoans, sponges.
42Ws569i	BLM	7/23/09	296726mE/4102858mN NE, NW, SE, NW, sec. 14, 43S, 13W The Divide Quadrangle UT 1986	Moenkopi/ Timpoweap	Two small brown gastropods.

Table D-2
Paleontological Localities Recorded in Arizona: Lake Powell Pipeline Features

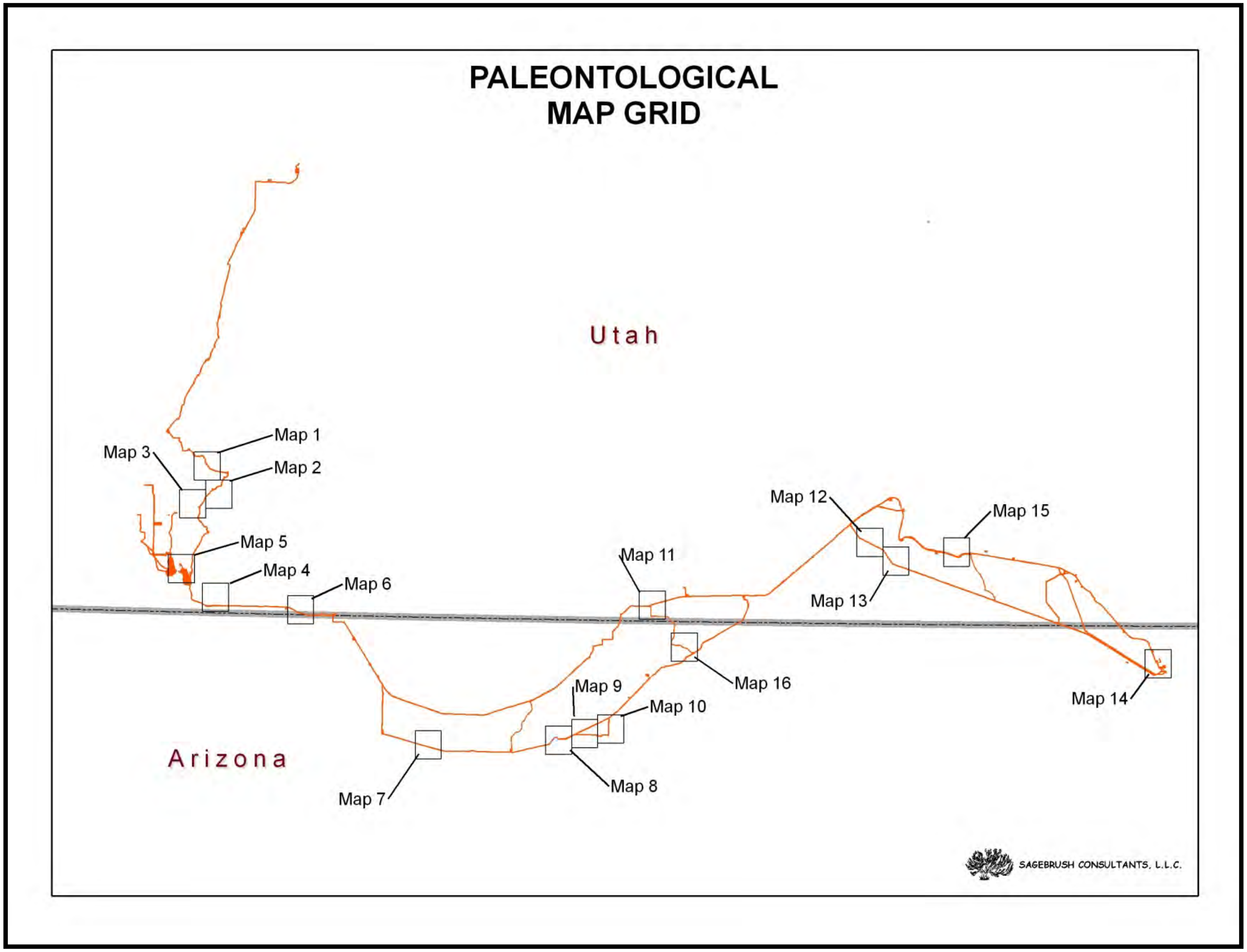
Arizona Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
LPPAzCo1i	Private	6/10/09	NE-378139mE/4091523mN, SW-378109mE/4091502mN- SW, NW, SW, SE,sec. 11, 41N, 1W Muggins Flat Quadrangle AZ 1992	Moenkopi/ Virgin	Gastropods, bivalves-sparse.
LPPAzCo2i	BLM	6/16/09	365916mE/4079214mN SW, SW, NW, SW,sec. 22, 40N,2W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap	Gastropods, bivalves, scaphopods.
LPPAzCo3i	BLM	7/29/09	NW-365932mE/4078388mN, NE-365959mE/4078392mN- NW, NW, SW, NW,sec.27,40N,2W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap	Gastropods, bivalves, scaphopods.
LPPAzCo4i	BLM	6/17/09	NE-365176mE/4077285mN, SE-365189mE/4077221mE, NW-365151mE/4077285mN, SW-365176mE/4077213mN, SW, SW, SE, SW, sec. 28, 40N, 2W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Gastropods.
LPPAzCo5i	BLM	8/4/09	364972mE/4077277mN W½, SE, SE, SW, sec. 28, 40N,2W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Gastropods.
LPPAzCo6i	BLM	6/17/09 8/4/09	N-363875mE/4077267mN, E-363902mE/4077212mN, S-363902mE/4077190mN, W-363877mE/4077230mN SW, SW, SE, SW, sec. 29, 40N, 2W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap	Gastropods.
LPPAzCo7i	BLM	6/17/09	N-363512mE/4077314mN, E-363549mE/4077266mN, S-363551mE/4077225mN, W-363485mE/4077230mN SW, SW, SW, SE, sec. 29, 40S, 2W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Gastropods, bivalves, scaphopods.
LPPAzCo8i	BLM	8/4/09	NE-363339mE/4077273mN, SE-363335mE/4077241mN, NW-363284mE/4077285mN, SW-363281mE/4077238mN SE, SW, SE, SW, sec. 29, 40S, 2W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange gastropods, scaphopods and bivalves.
LPPAzCo9i	BLM	6/17/09	NE-362662mE/4077330mN, S-362612mE/4077259mN, NW-362551mE/4077332mN E½, SE, SE, SE, sec. 30, 40S, 2W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange bivalves, gastropods, scaphopods.
LPPAzCo10i	BLM	6/17/09	NE-361010mE/4077362mN, SE-360989mE/4077283mN, NW-360907mE/4077361mN, SW-360920mE/4077283mN NW, NE, NE, NE, sec. 36, 40S, 3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange gastropods.
LPPAzCo11i	BLM	6/17/09 8/5/09	NE-358412mE/4076642mN, SE-358413mE/4076596mN, NW-358365mE/4076637mN, SW-358383mE/4076590mN Top, NW, NE, SW, sec. 35,40S,3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange gastropods, bivalves, scaphopods.
LPPAzCo12i	BLM	6/17/09 8/5/09	N-358196mE/4076623mN, E-358225mE/4076566mN S-358211mE/4076546mN, W-357707mE/4076551mN Top, NE, NW, SW, sec. 35,40S,3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange gastropods, bivalves, scaphopods.

Table D-2
Paleontological Localities Recorded in Arizona: Lake Powell Pipeline Features

Arizona Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
LPPAzCo13i	BLM	6/17/09 8/5/09	N-357818mE/4076608mN, E-357849mE/4076606mN, S-357745mE/4076532mN, W-357707mE/4076551mN NW, NE, NE, SE, sec. 34, 40S, 3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Harrisburg	Orange gastropods, bivalves, scaphopods.
LPPAzCo14i (A) & (B)	BLM	6/17/09 8/5/09	(A) N-357709mE/4076618mN, E-357738mE/4076616mN, S-357675mE/4076577mN, W-357665mE/4076584mN (B) N-357661mE/4076698mN, E-357686mE/4076665mN, S-357635mE/4076532mN, W- 357632mE/4076655mN SE, SW, SE, NE, sec. 34, 40S, 3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Fossil Mt.	Crinoids, brachiopods, sponges, coral, bryozoans.
LPPAzCo19t	NPS - GCNRA	8/04/10	456326mE/4087721mN SW, SW, NE, SW, sec.24, 41N, 8E Page Quadrangle AZ 1985	Navajo	Four or five very faint *Grallator*-type dinosaur tracks, approximately five by six inches, three-toed.
LPPAzMo1i	BLM	6/17/09 8/5/09	N-357557mE/4076954mN, E-357577mE/4076834mN, S-357570mE/4076711mN, W-357540mE/4076843mN NW, SW, SE, NE, sec. 34, 40S, 3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Fossil Mt.	Crinoids, brachiopods, sponges, coral, bryozoans.
LPPAzMo2i	BLM	6/17/09 8/5/09	N-357349mE/4076918mN, E-357387mE/4076902mN, S-357269mE/4076894mN, W-357360mE/4076905mN Cntr, NE, SW, NE, sec. 34, 40S,3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Fossil Mt.	Gastropods, bivalves, scaphopods, crinoids, brachiopods and bryozoans.
LPPAzMo3i	BLM	8/5/09	N-357295mE/4076872mN, E-357276mE/4076835mN, S-357269mE/4076799mN, W-357270mE/4076838mN SW, NE, SW, NE, sec. 34, 40S,3W Clear Water Spring Quadrangle AZ 1988	Kaibab/ Fossil Mt.	Occasional bivalves, gastropods and scaphopods- equivalent to orange fossil bed, but rock is weathered away.
LPPAzMo4p	Private	6/19/09	336059mE/4075534mN Cntr, SE, SE, NW, sec. 4, 39N, 5W Pipe Valley Quadrangle AZ 1988	Chinle/ Shinarump	Petrified wood- log.
LPPAzMo5p	BLM	6/24/09	317213mE/4096841mN Bot, NW, SW, NE, sec. 33, 42N,7W Smithsonian Butte Quadrangle UT-AZ 1980	Chinle/ Shinarump	Rusty colored plant impressions.
LPPAzCo15t	USBOR	7/1/09	N-456518mE/4088482mN, E-456518mE/4088474mN, S-456514mE/4088464mN, W-456518mE/4088476mN SW, NW, SE, NW, sec. 24, 41N,8E Page Quadrangle AZ 1985	Navajo	Dinosaur track site.
LPPAzCo16i	Kaibab-Paiute	7/14/09	365026mE/4079538mN N½, NE, NE, SW, sec. 21. 40N,2W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap or Kaibab/ Harrisburg	Bivalves, gastropods, scaphopods.
LPPAzCo17i	Kaibab-Paiute	7/14/09	361280mE/4077713mN SE, SW, NW, SW, sec. 30, 40N,2W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap or Kaibab/ Harrisburg	Bivalves, gastropods, scaphopods.

Table D-2
Paleontological Localities Recorded in Arizona: Lake Powell Pipeline Features

Arizona Number	Land Manager	Date	Location (UTMs in NAD 83)	Geologic Formation	Description
LPPAzCo18i	Kaibab-Paiute	7/14/09	NE-361112mE/4077665mN, SE-361123mE/4077627mN, NW-361012mE/4077600mN, SW-361037mE/4077569mN NE, NE, SE, SE, sec. 25, 40N, 3W Clear Water Spring Quadrangle AZ 1988	Moenkopi/ Timpoweap or Kaibab/ Harrisburg	Orange gastropods, scaphopods, bivalves.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Map 12
Map 13
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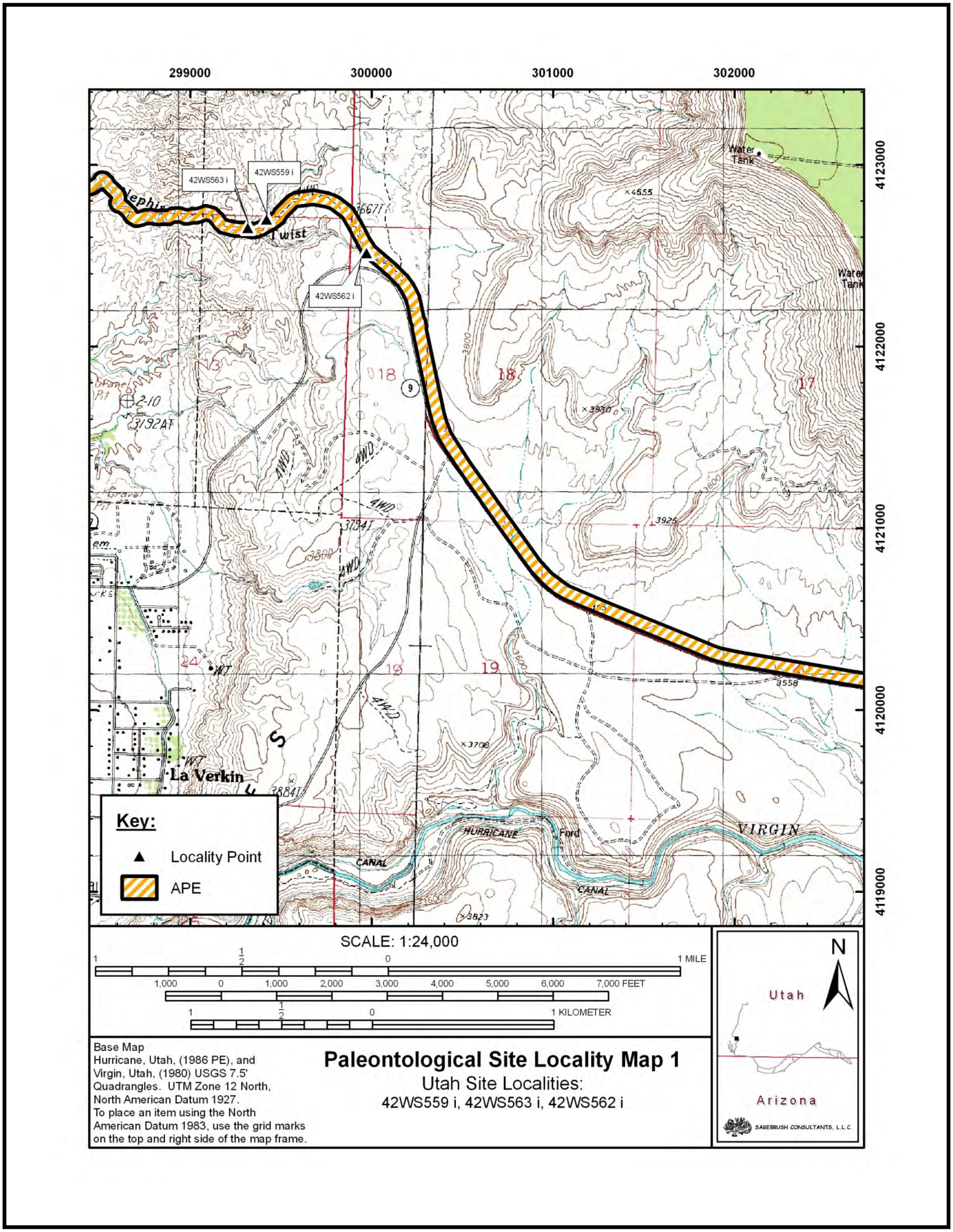
Map 15
Map 16
SAGEBRUSH CONSULTANTS, L.L.C.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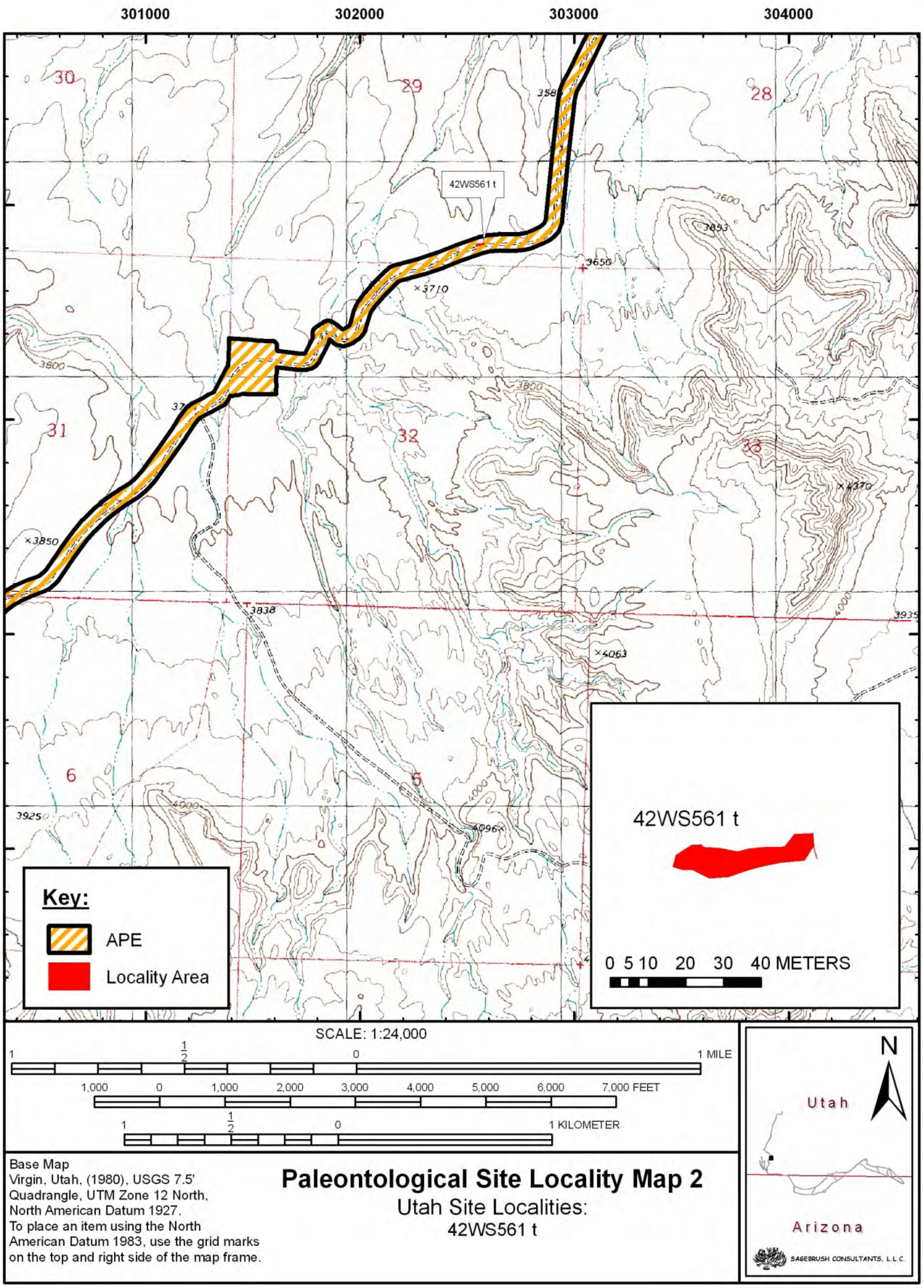
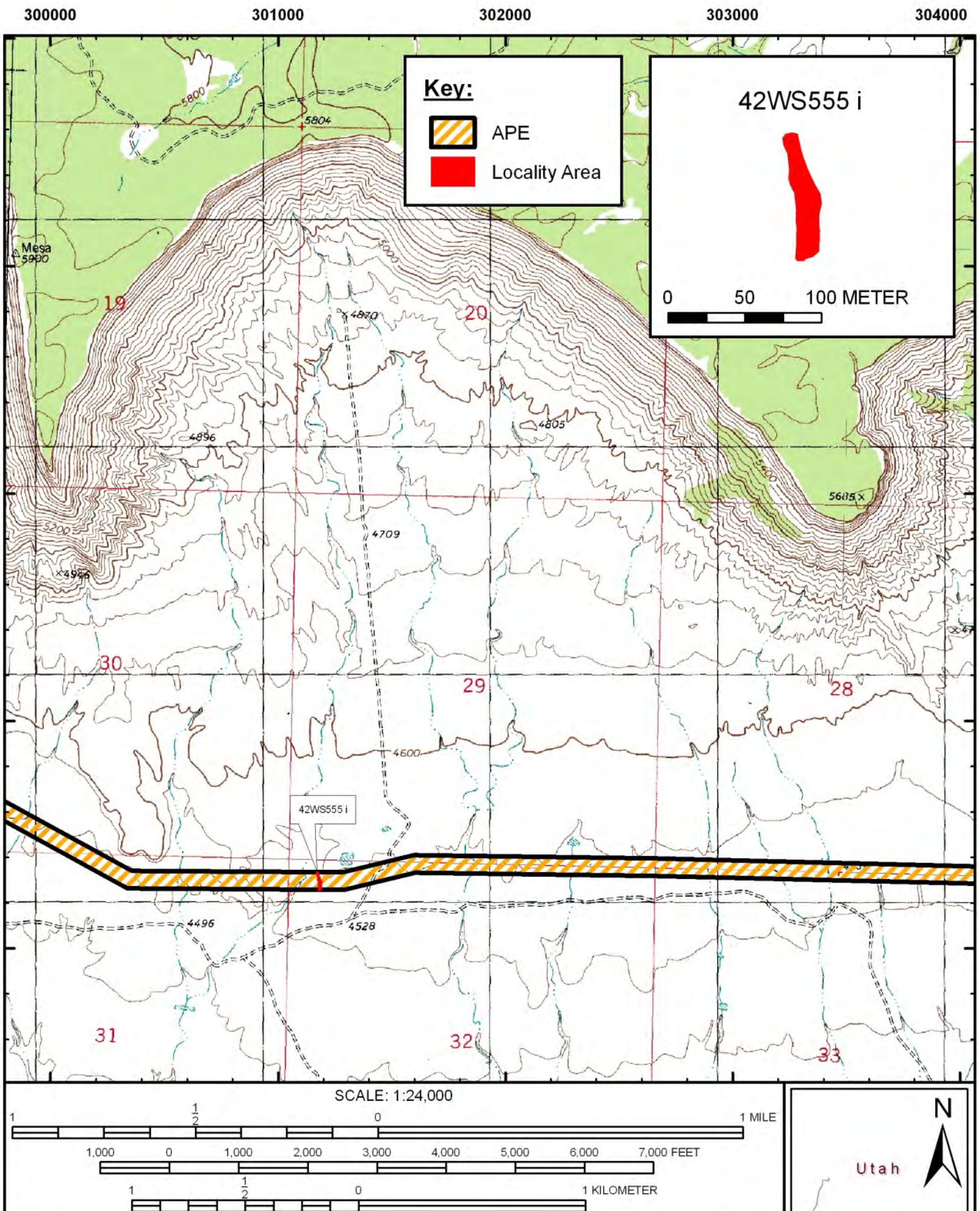
Water Tank
La Verkin
VIRGIN
HURRICANE
CANAL
Ford
Key:
Locality Point
APE
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Utah
Arizona
Base Map
Hurricane, Utah, (1986 PE), and Virgin, Utah, (1980) USGS 7.5' Quadrangles. UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 1
Utah Site Localities:
42WS559 i, 42WS563 i, 42WS562 i
SAGEBRUSH CONSULTANTS, L.L.C.



Base Map
Virgin, Utah, (1980), USGS 7.5' Quadrangle, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.

Paleontological Site Locality Map 2
Utah Site Localities:
42WS561 t



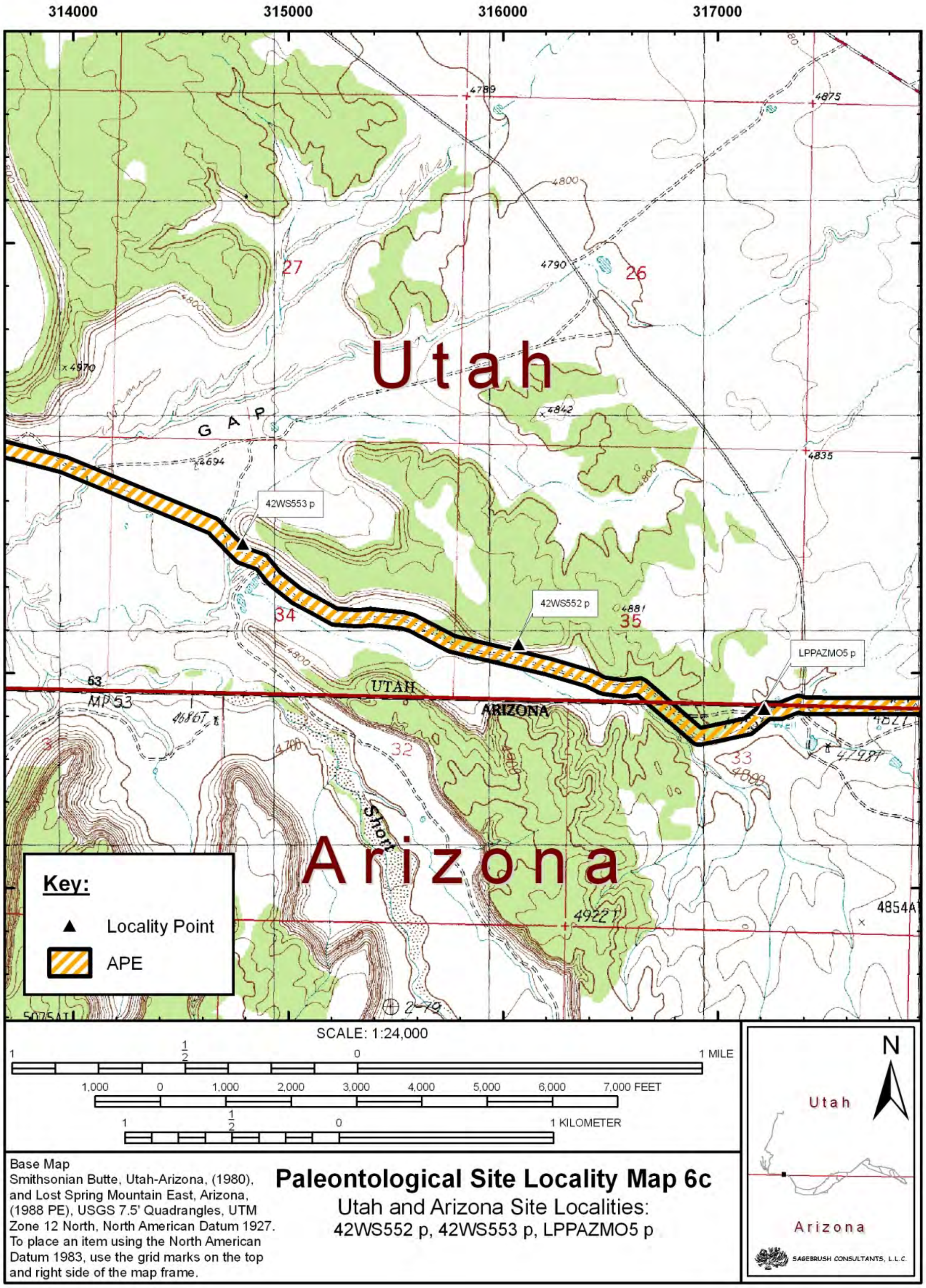
Base Map
Little Creek Mountain, Utah-Arizona, (1980), USGS 7.5' Quadrangle, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.

Paleontological Site Locality Map 4
Utah Site Localities:
42WS555 i

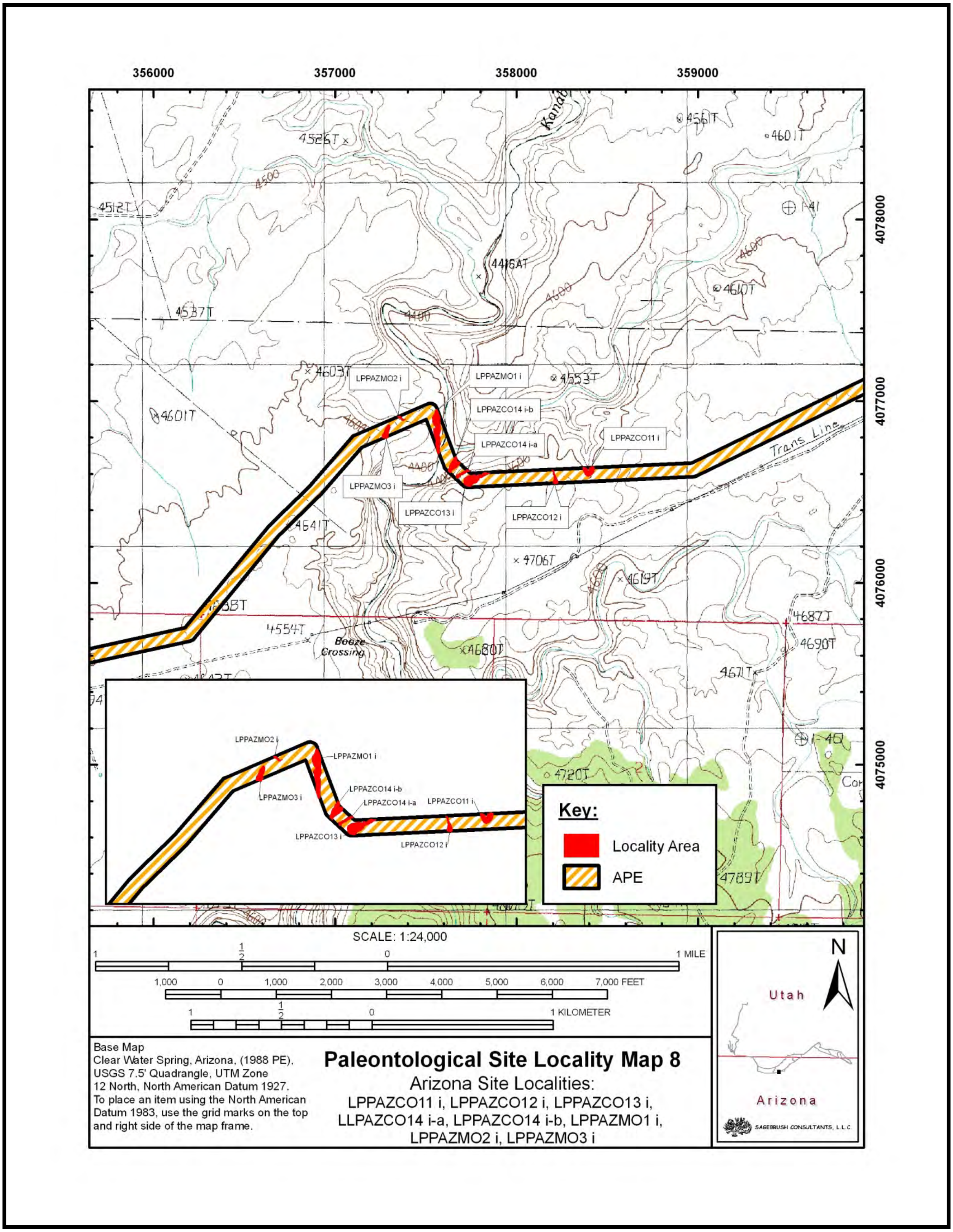
Base Map
Smithsonian Butte, Utah-Arizona, (1980), and Lost Spring Mountain East, Arizona, (1888 PE), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927. To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.

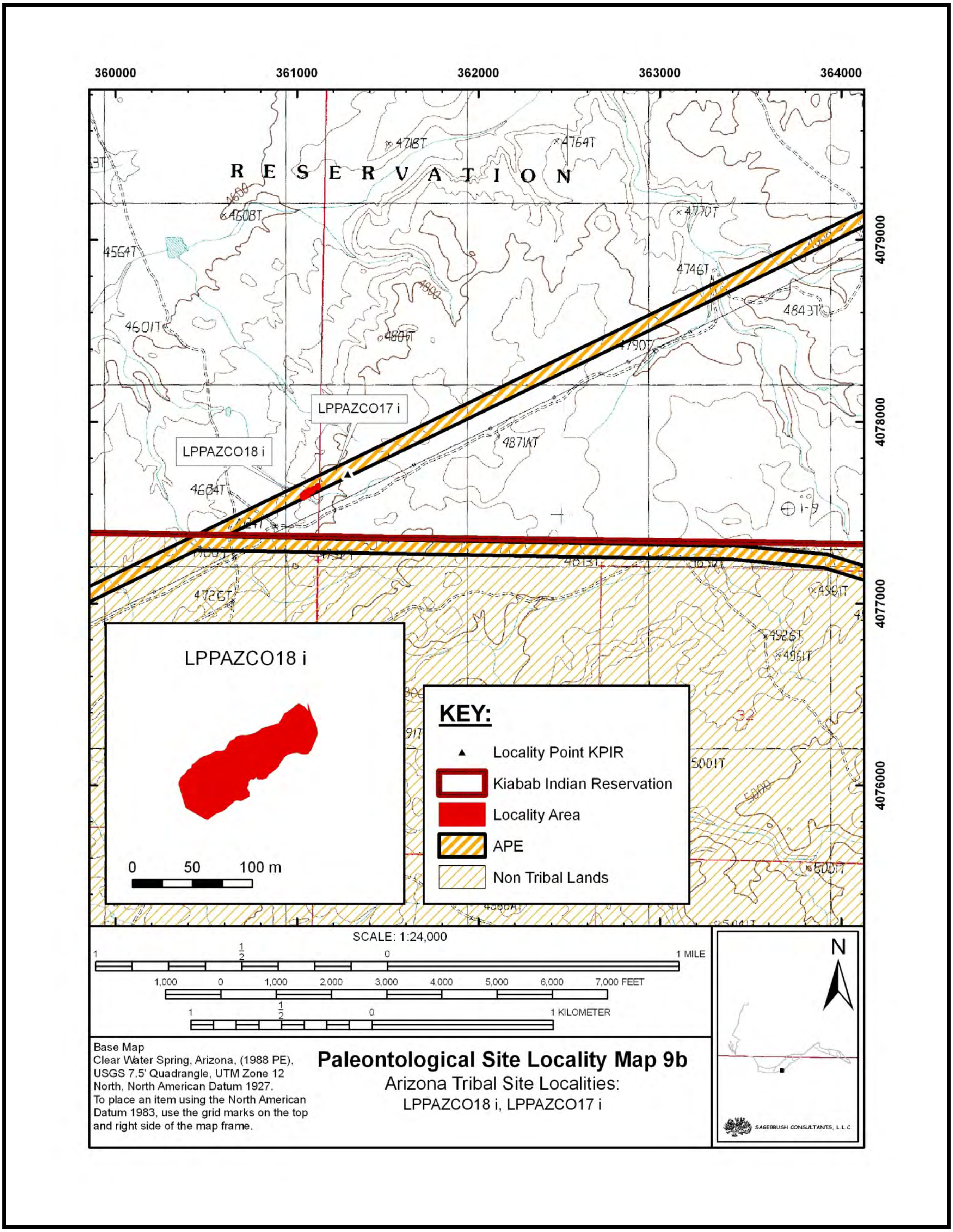
Paleontological Site Locality Map 6a

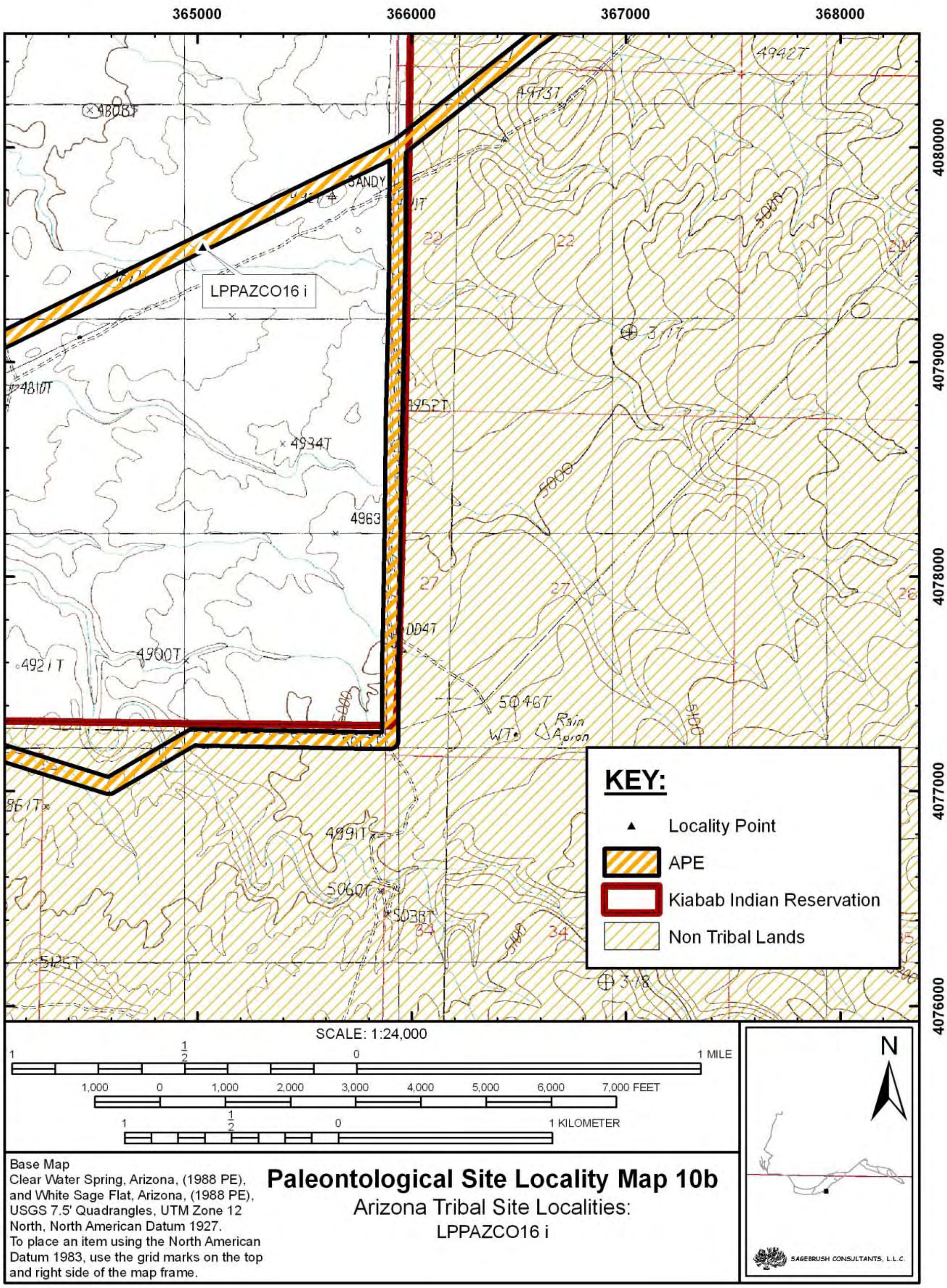
Utah Site Localities:
42WS552 p, 42WS553 p

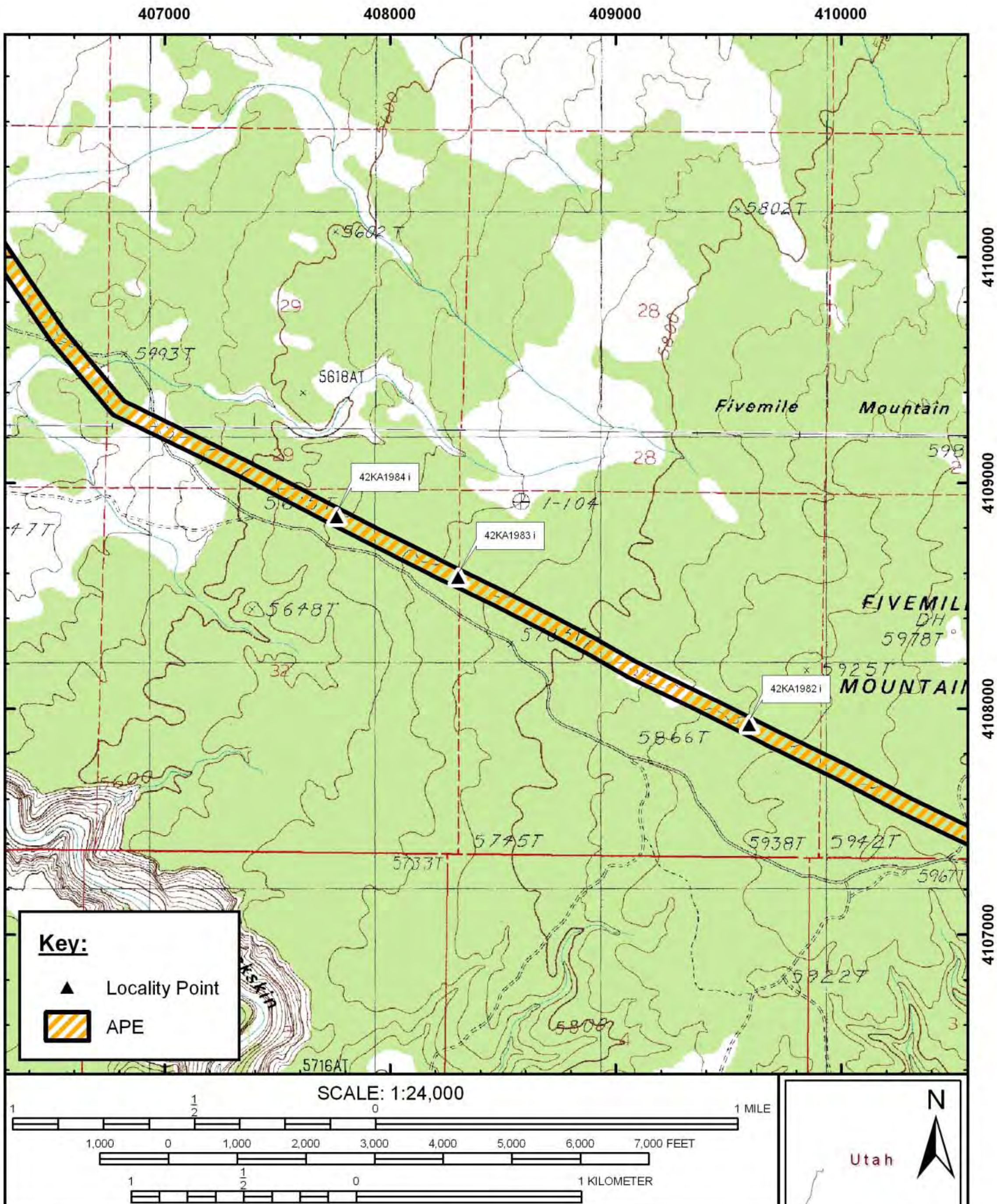


314000
315000
316000
317000
4099000
4098000
4097000
4096000
Utah
Arizona
42WS553 p
42WS552 p
LPPAZMO5 p
Key:
Locality Point
APE
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
Base Map
Smithsonian Butte, Utah-Arizona, (1980), and Lost Spring Mountain East, Arizona, (1988 PE), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927. To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 6c
Utah and Arizona Site Localities:
42WS552 p, 42WS553 p, LPPAZMO5 p
SAGEBRUSH CONSULTANTS, L.L.C.


356000
357000
358000
359000
4078000
4077000
4076000
4075000
LPPAZMO2 i
LPPAZMO1 i
LPPAZCO14 i-b
LPPAZCO14 i-a
LPPAZCO11 i
LPPAZMO3 i
LPPAZCO13 i
LPPAZCO12 i
Trans. Line
Booze Crossing
Key:
Locality Area
APE
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Utah
Arizona
SAGEBRUSH CONSULTANTS, L.L.C.
Base Map
Clear Water Spring, Arizona, (1988 PE),
USGS 7.5' Quadrangle, UTM Zone
12 North, North American Datum 1927.
To place an item using the North American
Datum 1983, use the grid marks on the top
and right side of the map frame.
Paleontological Site Locality Map 8
Arizona Site Localities:
LPPAZCO11 i, LPPAZCO12 i, LPPAZCO13 i,
LLPAZCO14 i-a, LPPAZCO14 i-b, LPPAZMO1 i,
LPPAZMO2 i, LPPAZMO3 i


360000
361000
362000
363000
364000
4079000
4078000
4077000
4076000
R E S E R V A T I O N
LPPAZCO17 i
LPPAZCO18 i
LPPAZCO18 i
0
50
100 m
KEY:
Locality Point KPIR
Kiabab Indian Reservation
Locality Area
APE
Non Tribal Lands
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Base Map
Clear Water Spring, Arizona, (1988 PE), USGS 7.5' Quadrangle, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 9b
Arizona Tribal Site Localities:
LPPAZCO18 i, LPPAZCO17 i
SAGEBRUSH CONSULTANTS, L.L.C.

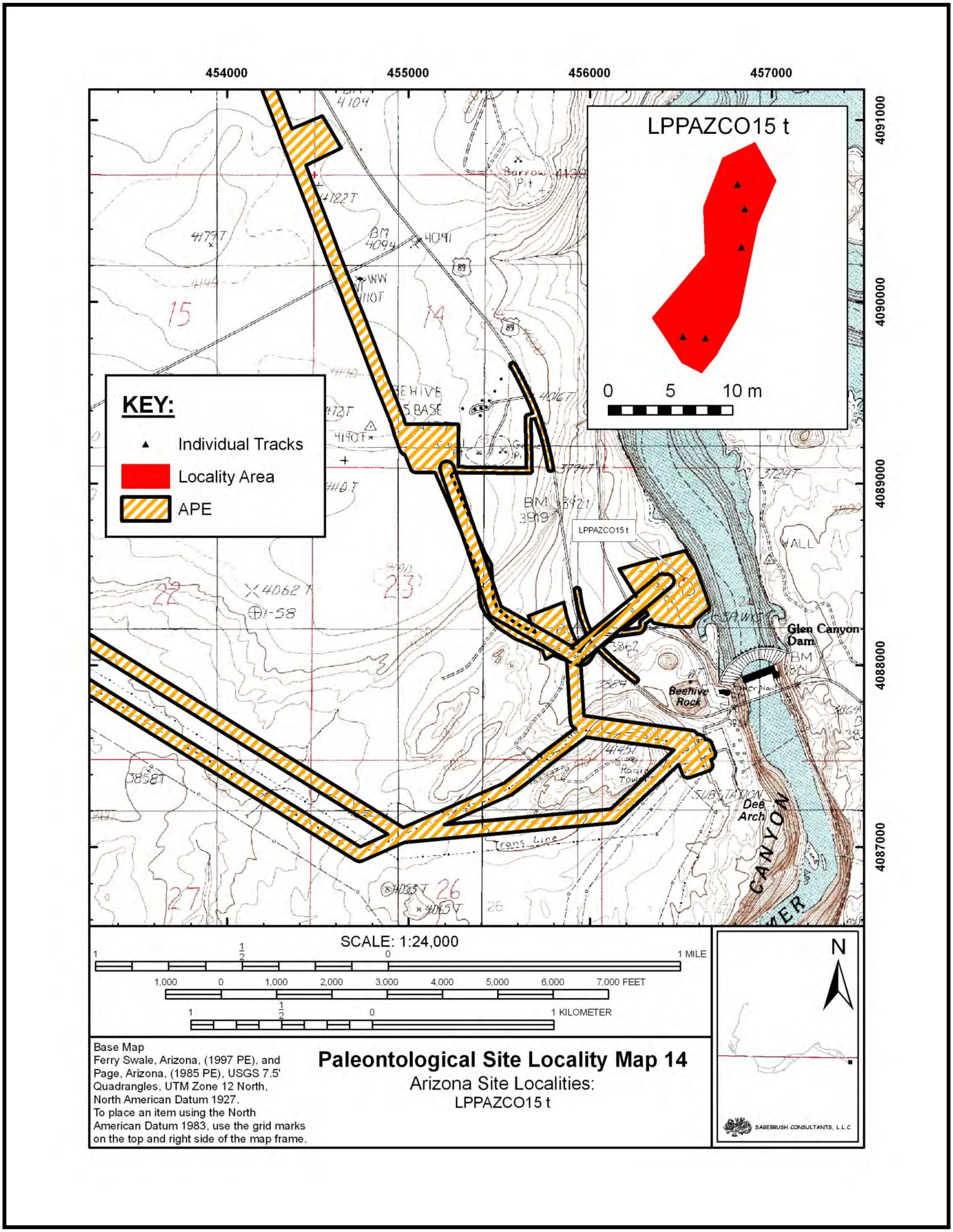

365000
366000
367000
368000
4080000
4079000
4078000
4077000
4076000
LPPAZCO16 i
KEY:
Locality Point
APE
Kiabab Indian Reservation
Non Tribal Lands
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Base Map
Clear Water Spring, Arizona, (1988 PE), and White Sage Flat, Arizona, (1988 PE), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 10b
Arizona Tribal Site Localities:
LPPAZCO16 i
SAGEBRUSH CONSULTANTS, L.L.C.

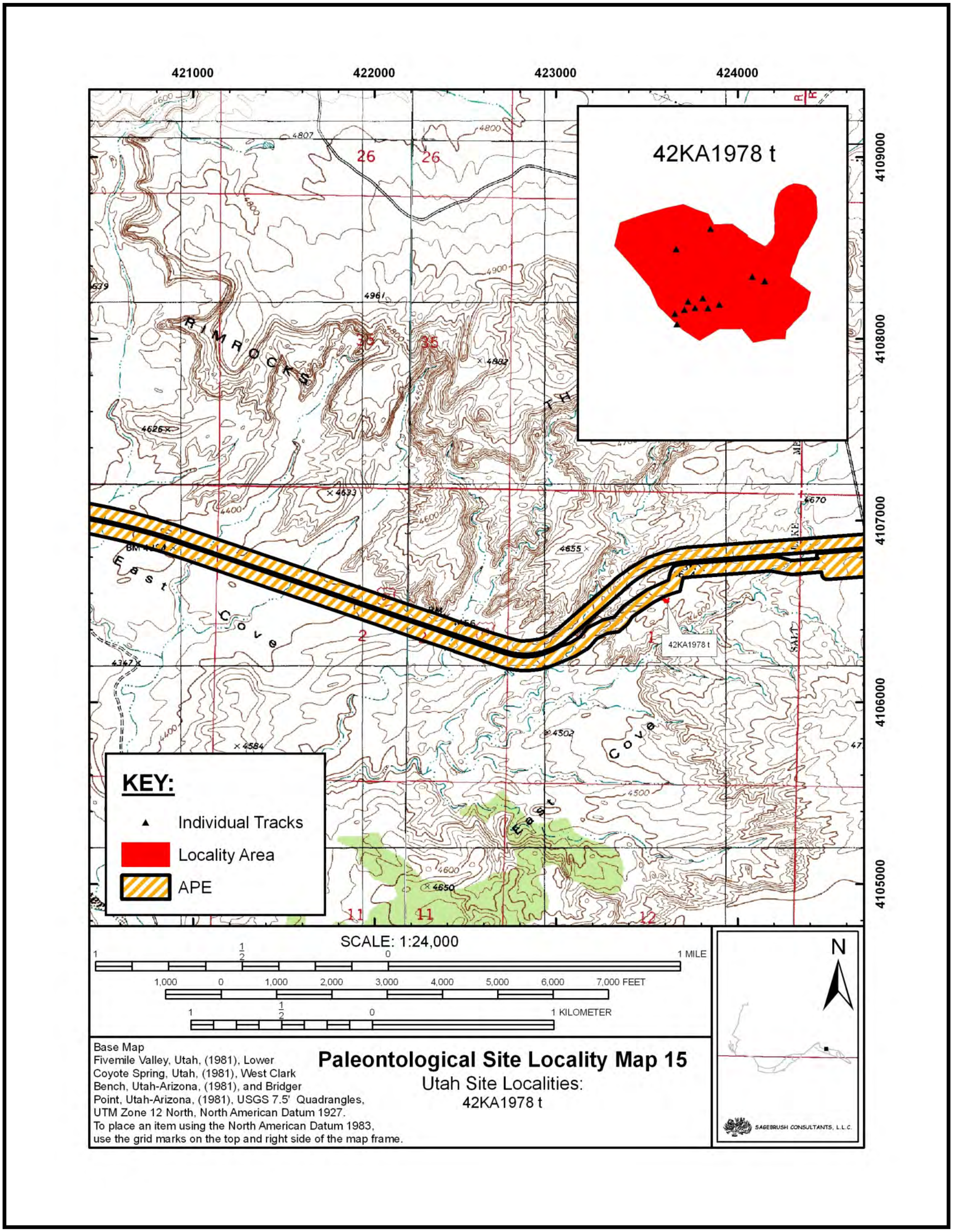


Base Map
Eightmile Pass, Utah, (1987 PE), and Pine Hollow Canyon, Utah-Arizona, (1987 PE), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927. To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.

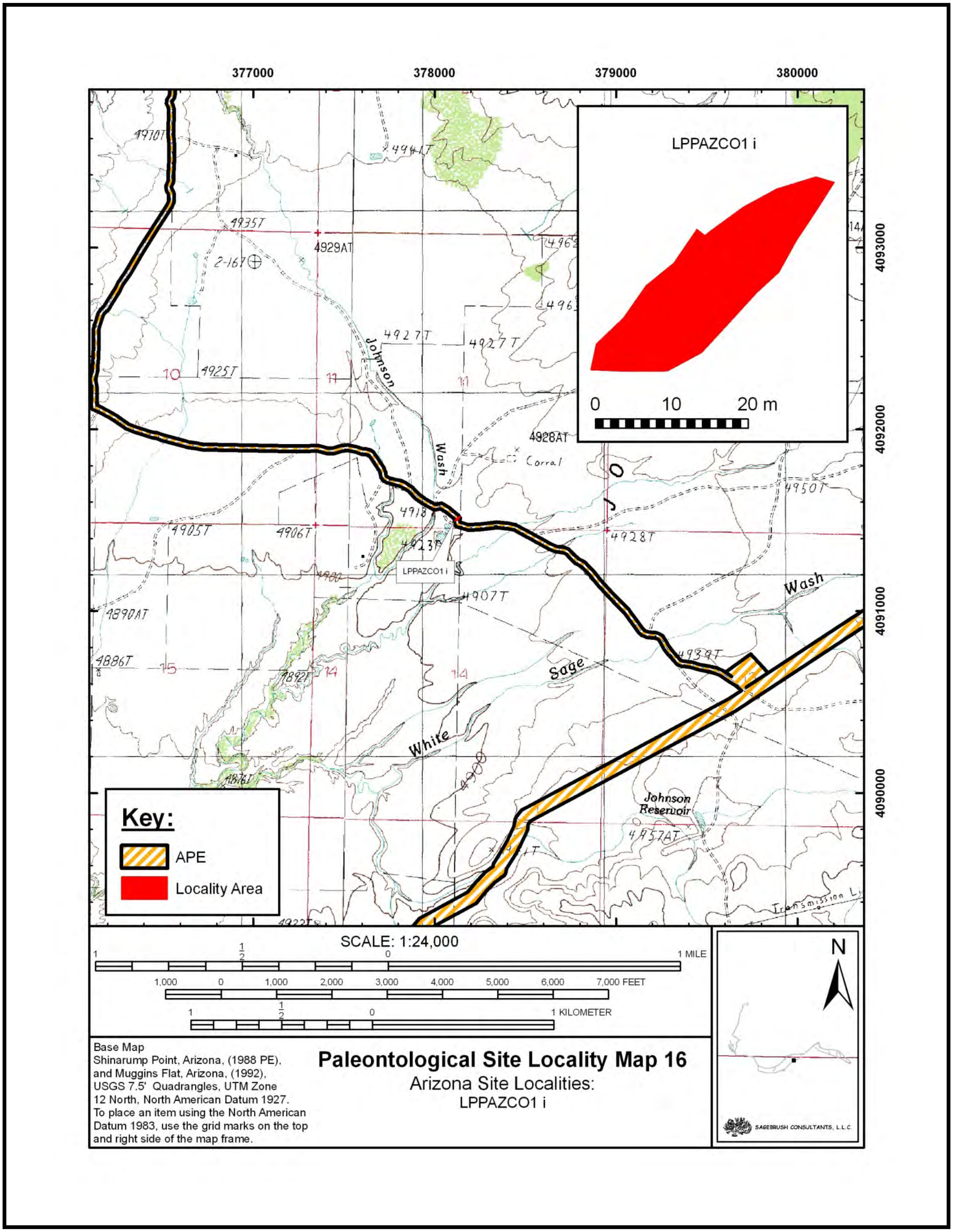
Paleontological Site Locality Map 12

Utah Site Localities:
42KA1982 i, 42KA1983 i, 42KA1984 i


454000
455000
456000
457000
4091000
4090000
4089000
4088000
4087000
LPPAZCO15 t
0 5 10 m
KEY:
Individual Tracks
Locality Area
APE
LPPAZCO15 t
Glen Canyon Dam
Beehive Rock
SUBSTATION
Dee Arch
CANYON
SCALE: 1:24,000
1 1/2 0 1 MILE
1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 FEET
1 1/2 0 1 KILOMETER
N
Base Map
Ferry Swale, Arizona, (1997 PE), and Page, Arizona, (1985 PE), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 14
Arizona Site Localities:
LPPAZCO15 t
SAGEBRUSH CONSULTANTS, L.L.C.



421000
422000
423000
424000
4109000
4108000
4107000
4106000
4105000
42KA1978 t
RIMROCKS
East
Cove
KEY:
Individual Tracks
Locality Area
APE
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Base Map
Fivemile Valley, Utah, (1981), Lower Coyote Spring, Utah, (1981), West Clark Bench, Utah-Arizona, (1981), and Bridger Point, Utah-Arizona, (1981), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927.
To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 15
Utah Site Localities:
42KA1978 t
SAGEBRUSH CONSULTANTS, L.L.C.


377000
378000
379000
380000
4093000
4092000
4091000
4090000
LPPAZCO1 i
0
10
20 m
Johnson
Wash
Corral
Sage
White
Johnson Reservoir
Transmission Li
Key:
APE
Locality Area
SCALE: 1:24,000
1 MILE
7,000 FEET
1 KILOMETER
N
Base Map
Shinarump Point, Arizona, (1988 PE), and Muggins Flat, Arizona, (1992), USGS 7.5' Quadrangles, UTM Zone 12 North, North American Datum 1927. To place an item using the North American Datum 1983, use the grid marks on the top and right side of the map frame.
Paleontological Site Locality Map 16
Arizona Site Localities:
LPPAZCO1 i
SAGEBRUSH CONSULTANTS, L.L.C.