LAKE POWELL PIPELINE PROJECT
VEGETATION RESOURCES STUDIES

DRAFT VEGETATION COMMUNITIES REPORT

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Vegetation Communities Study Report
Executive Summary

ES-1 Introduction

This study report describes the results and findings of an analysis to evaluate vegetation communities along the proposed alternative alignments of the Lake Powell Pipeline Project (LPP Project). The purpose of the analysis, as defined in the 2008 Vegetation Communities Study Plan prepared for the Federal Energy Regulatory Commission (Commission), was to describe the baseline vegetation characteristics present in the LPP Project corridor, to identify and locate the presence of unique vegetation communities or habitat types and other sensitive areas, to analyze project-related impacts to vegetation resources, and to provide measures to minimize adverse effects to native vegetation and to facilitate site restoration following disturbance for the benefit of special status plant species and to preclude the spread of invasive weeds.

ES-2 Methodology

The analysis of vegetation communities follows methodology identified and described in the Preliminary Application Document, Scoping Document No. 1 and the Vegetation Communities Study Plan filed with the Commission.

ES-3 Key Results of the Vegetation Communities Mapping

GIS based vegetation mapping resulted in a total of 4,726 classified polygons; 3,443 of these classified polygons represented natural communities and 1, 283 represented anthropogenic types. Table ES-1 details by Ecological Region the numbers of classified polygons, ecological systems, alliances, associations, and acreage. Over 340 plant species were identified during field surveys to the species level or finer.

Table ES-1
Vegetation Mapping Summary

	Colorado Plateau Region	Great Basin Region	Mohave Desert Region
GIS Classified Polygons	2,817	316	310
Corridor Acreages	18,045	1,072	1,904
Ecological Systems	15	11	12
Alliances	208	35	53
Associations	567	92	116

By mapping the vegetation communities at this scale, the ecological hierarchy is presented from Ecological Region to alliance, and association representing species presence, vegetation densities, and plant physiognomy. The understanding of the distribution and successional development of vegetation communities can contribute to an accurate assessment of the consequences of land disturbances, and development of on-site management actions and restoration practices.

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 Vegetation Communities 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 13,000 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 Indian Reservation. The South Alternative extends south around the Kaibab Indian Reservation. The Existing Highway Alternative follows an Arizona state highway through the Kaibab Indian Reservation. The Southeast Corner Alternative follows the Navajo-McCullough Transmission Line corridor through the southeast corner of the Kaibab Indian Reservation. The transmission line alignment alternatives are common to all the pipeline and penstock alignment alternatives. Map 1-1 shows the overall proposed project 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 (Map 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 (Map 1-2).

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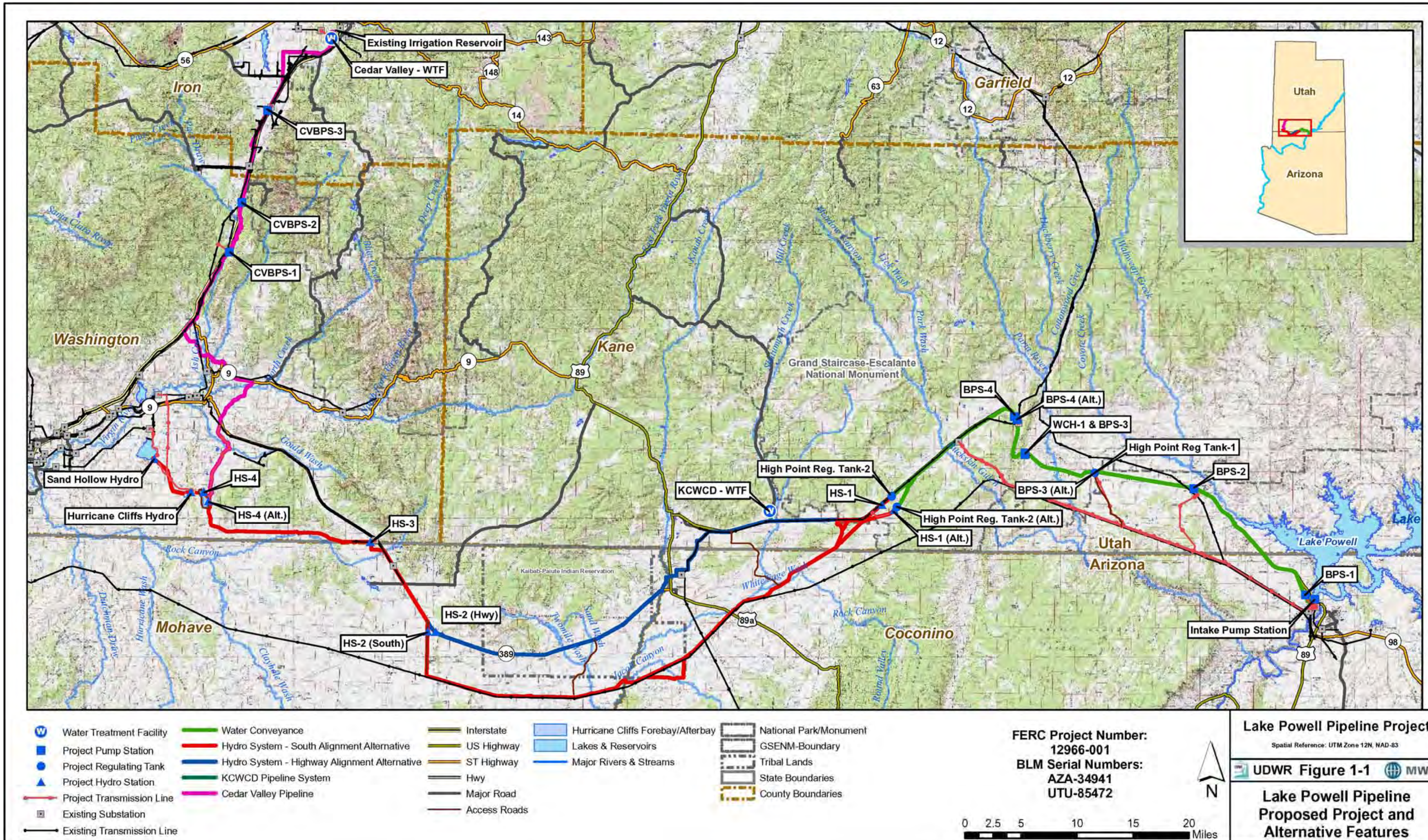

Map 1-1
Proposed Project and Alternative Features

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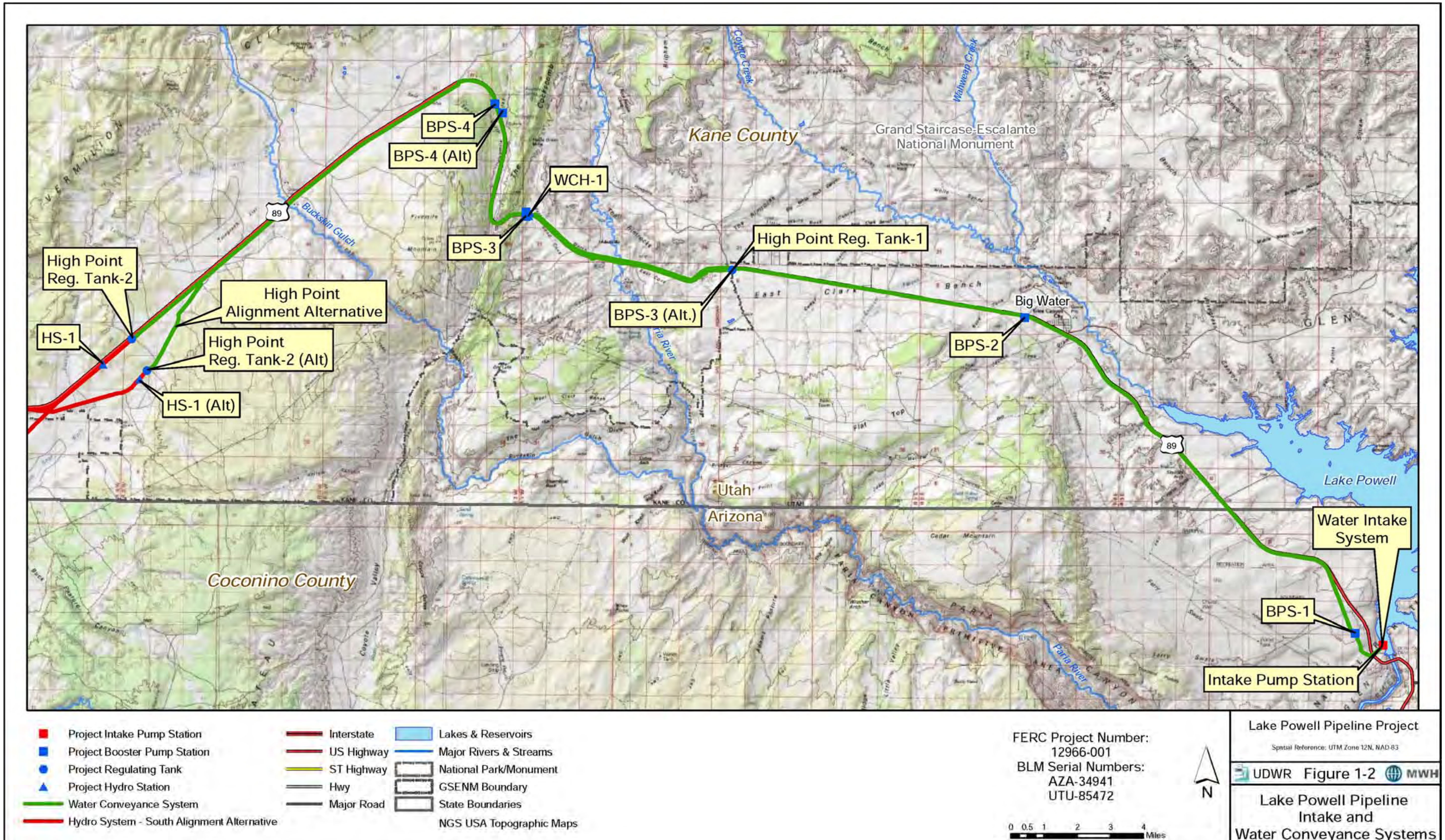

Map 1-2
Intake and Water Conveyance Systems

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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 (Map 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 (Map 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 (Map 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 (Map 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.

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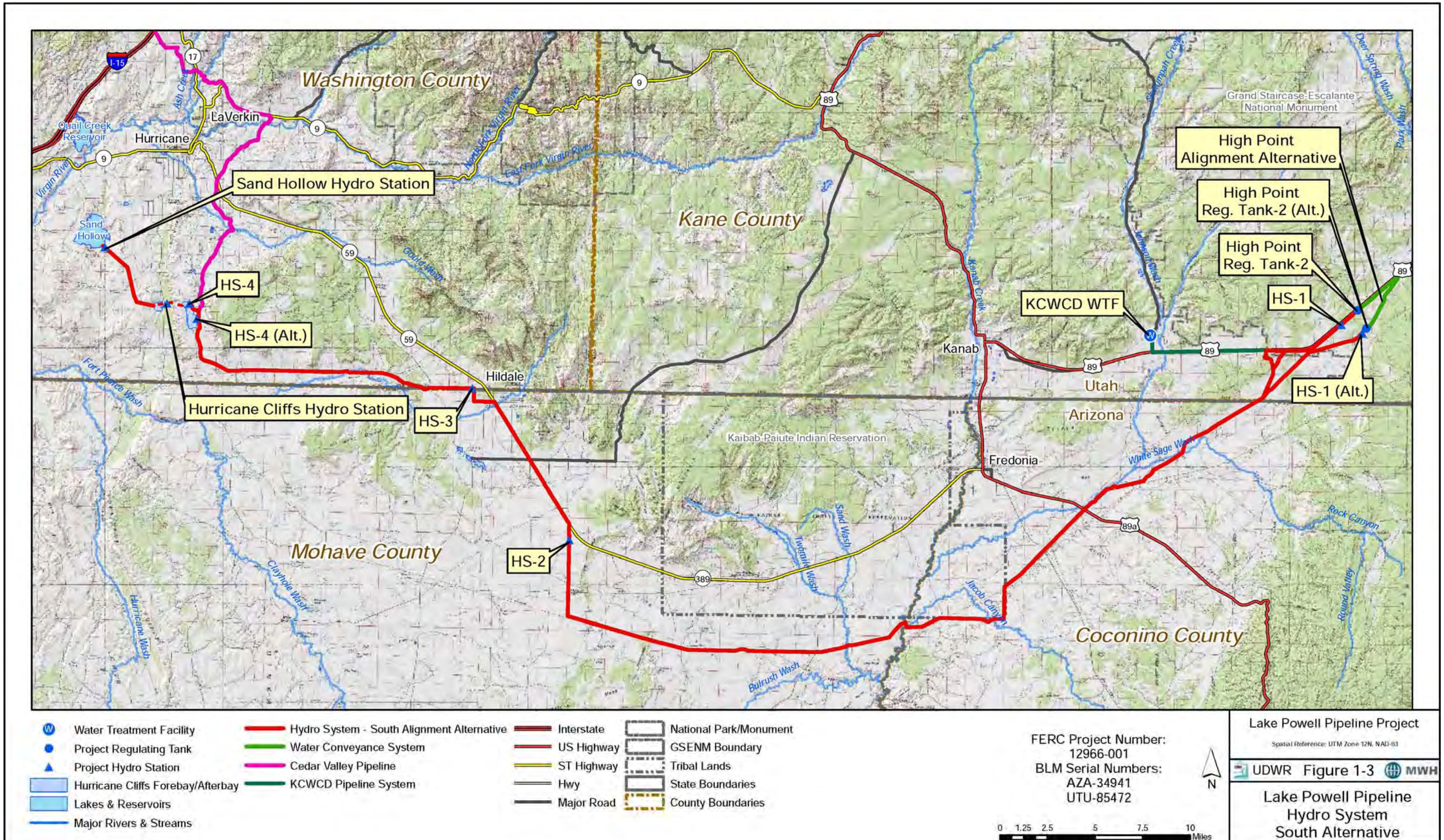

Map 1-3
Hydro System South Alternative

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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 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 (Map 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 (Map 1-4). Three booster pump stations (CBPS) 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.

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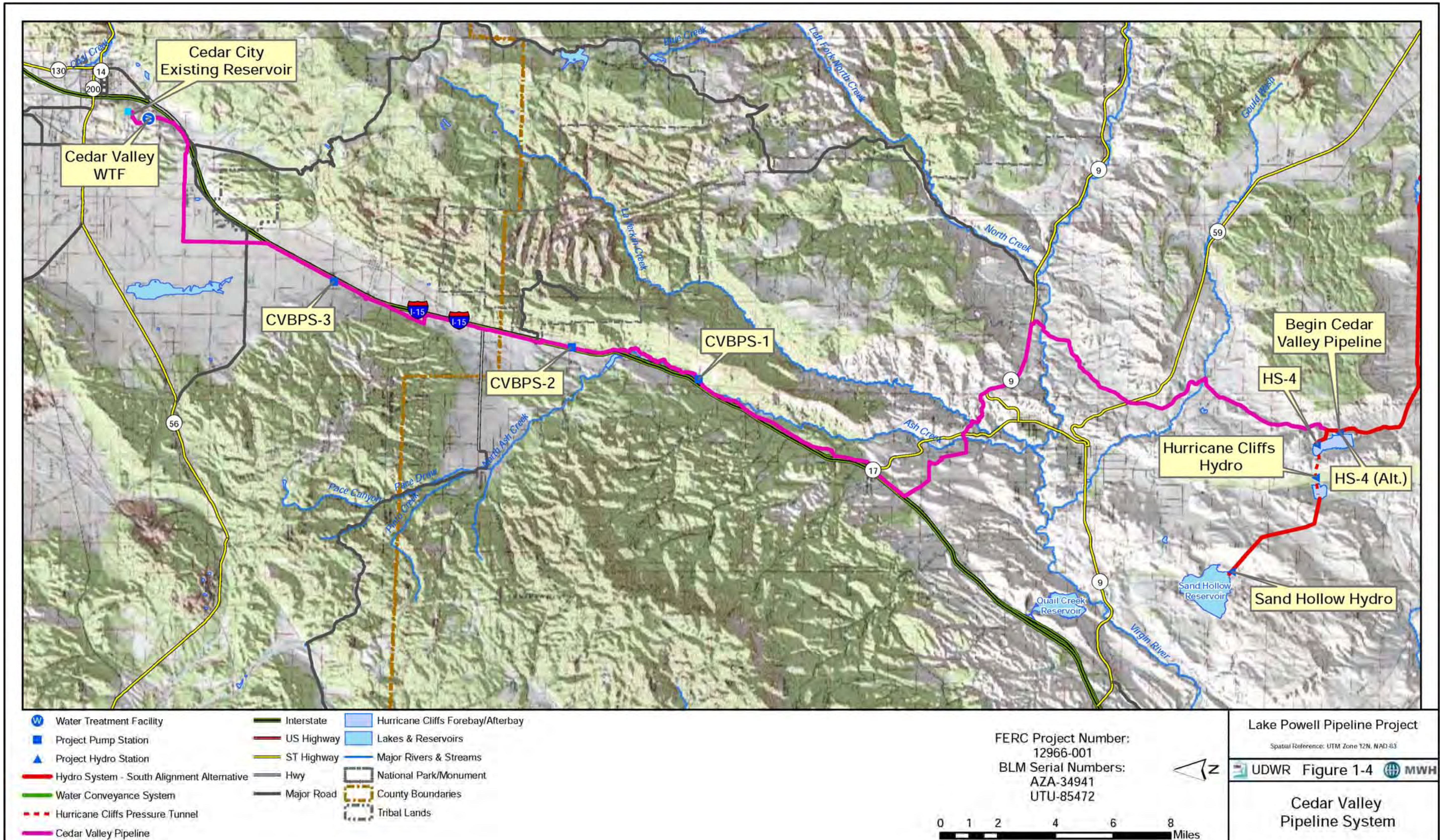

Map 1-4
Cedar Valley Pipeline System

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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 would continue across La Verkin 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. CBPS-1 would be sited adjacent to an existing gravel pit east of Interstate 15. CBPS-2 would be sited on private property on the east side of Interstate 15 and south of the Kolob entrance to Zion National Park. CBPS-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 (Map 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 (Map 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 (Map 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.

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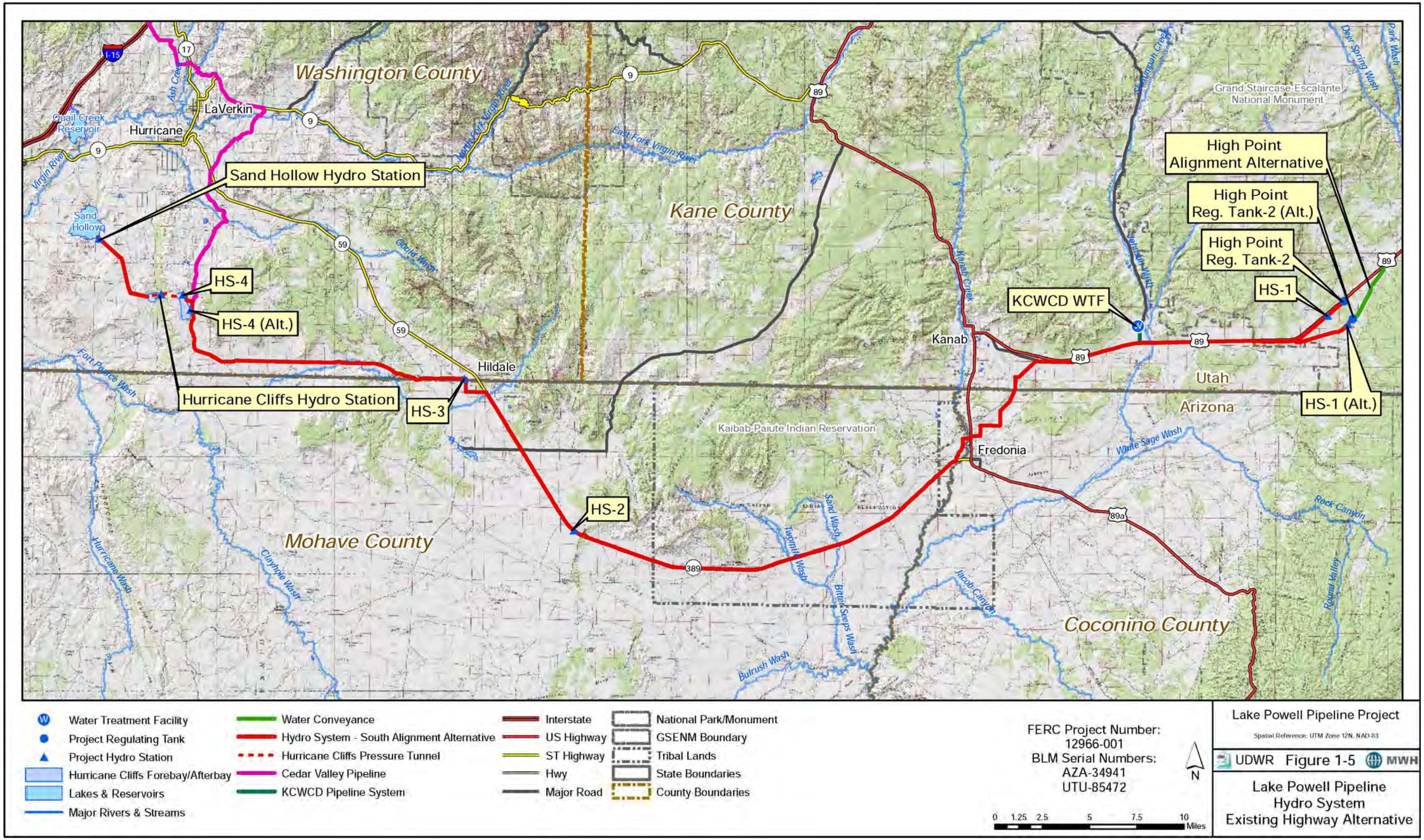

Map 1-5
Hydro System Existing Highway Alternative

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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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 County, Utah.

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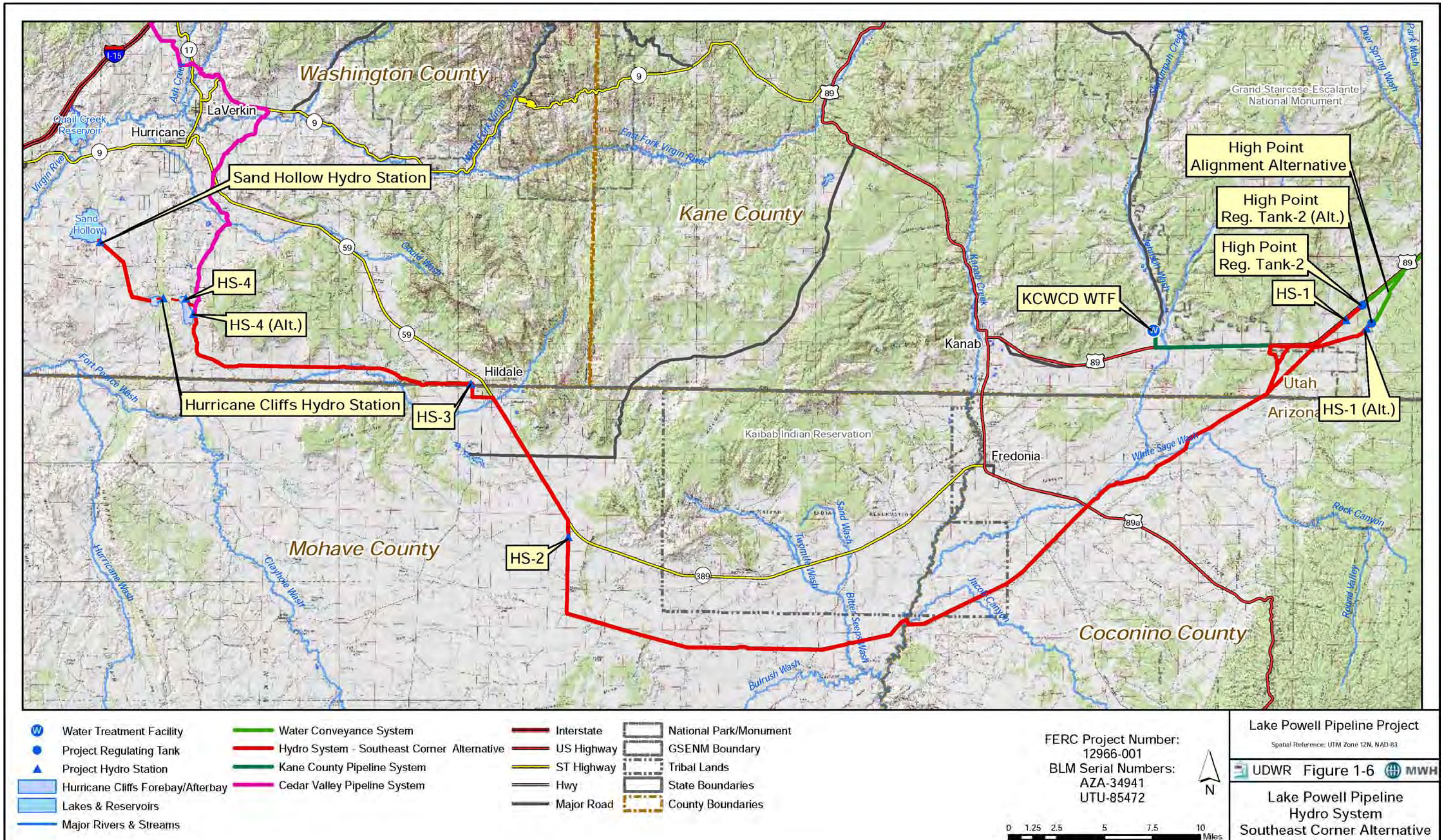

Map 1-6
Hydro System Southeast Corner Alternative

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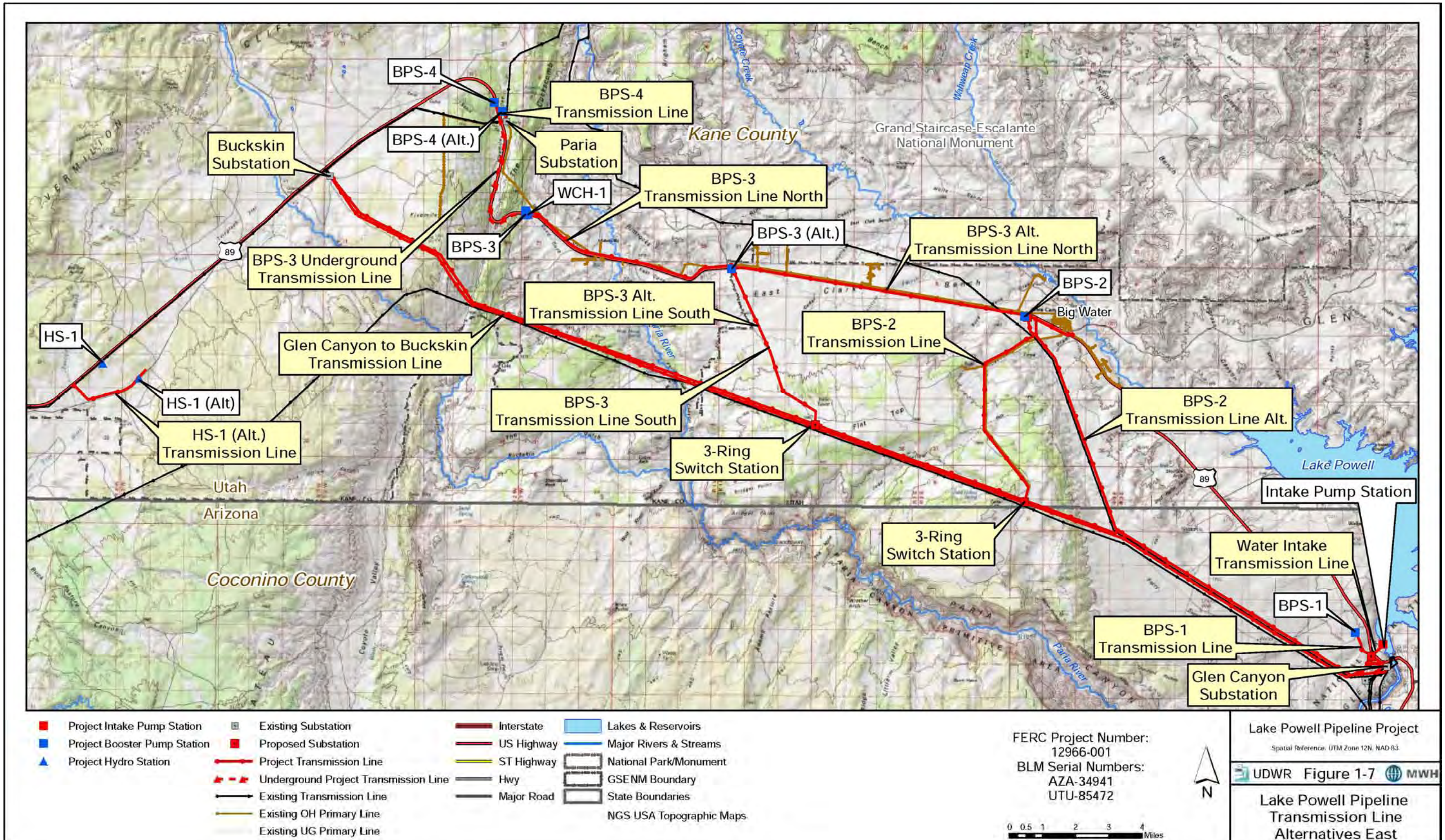

Map 1-7
Transmission Line Alternatives East

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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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 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 (Map 1-8).

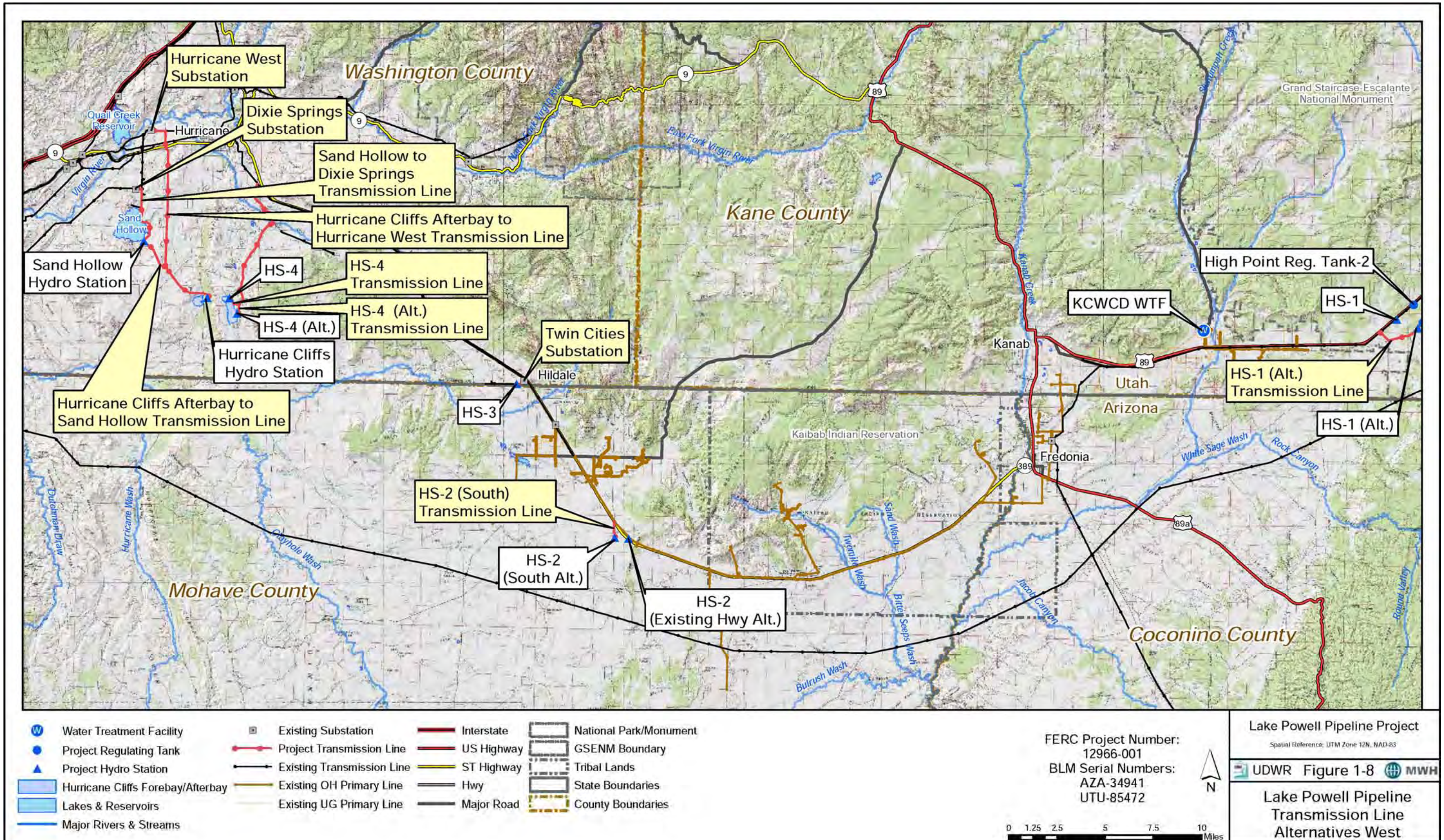
The proposed new **Hurricane Cliffs Afterbay to Sand Hollow Transmission Line** would consist of a new 69 kV transmission line from the Hurricane Cliffs peaking power plant and substation, and run northwest to the Sand Hollow Hydro Station substation. This new 69 kV transmission line would be about 4.9 miles long in Washington County, Utah (Map 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 (Map 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 (Map 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 CBPS-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 (Map 1-9). The new CBPS-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 (Map 1-9). The new CBPS-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 (Map 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 (Map 1-9).



Map 1-8
Transmission Line Alternatives West

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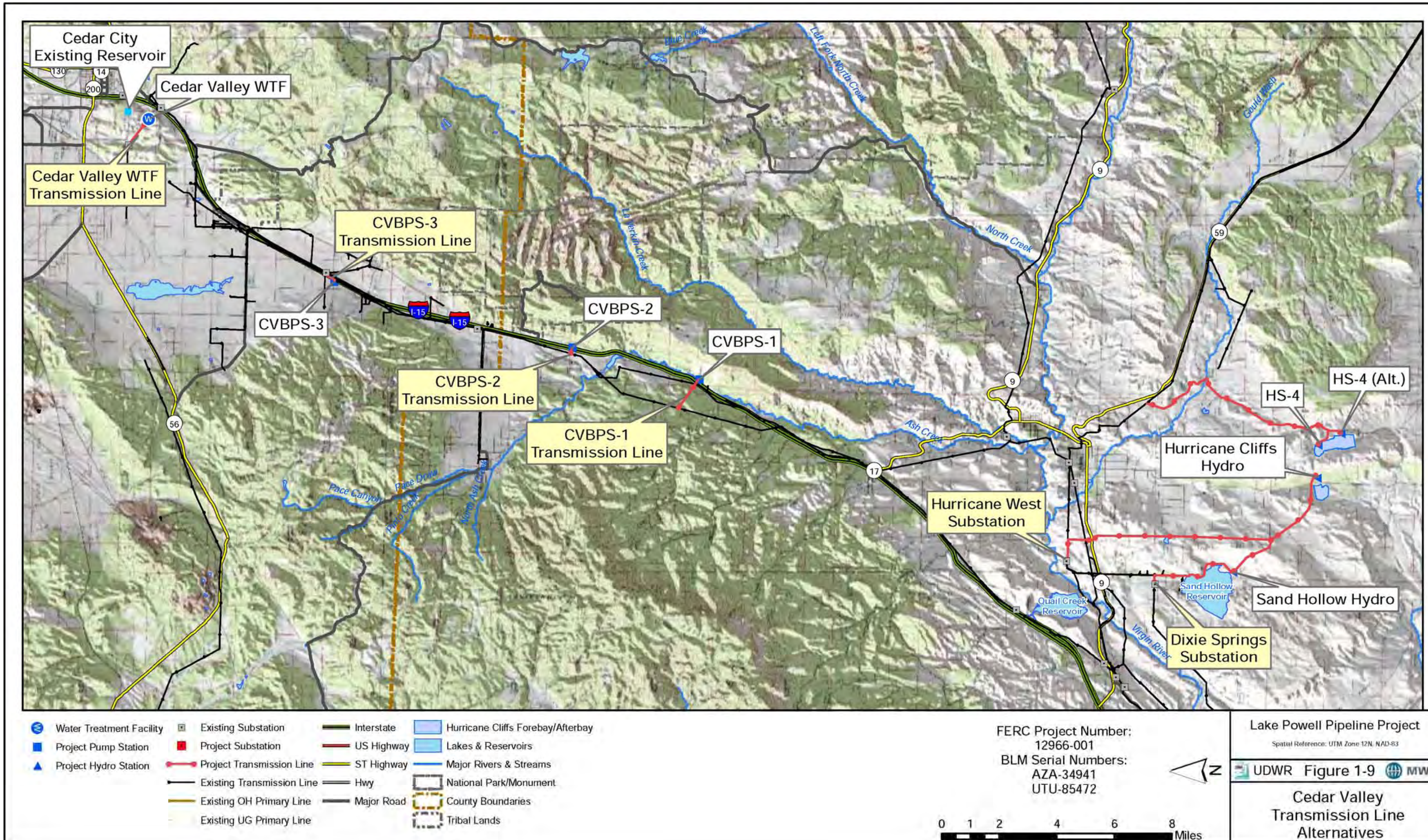

Map 1-9
Cedar Valley Transmission Line Alternatives

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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 102 gallons per capita per day (gpcd) (UDWR 2008a). This culinary water use rate is reduced by 30.5 gpcd to account for water conservation attained from 2005 through 2020, yielding 71.5 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 14.9 gpcd, or an 85.4 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.

Chapter 2
Study Area

2.1 Project Overview

This report characterizes the vegetation communities present in the Lake Powell Pipeline (LPP) survey area based on the results of field surveys conducted in 2009 and 2010 by Logan Simpson Design Inc. (LSD). The proposed LPP project is a water convaency system designed to deliever 86,249 acre-feet of water annually from Lake Powell in the vicinity of Glen Canyon Dam to portions of Washington, Iron, and Kane counties, Utah. The project includes water intake facilities at Lake Powell; approximately 270 miles of proposed and alterntive routes for buried pipeline; a combined conventional peaking and pumped storage hydro station; five conventional in-line hydro stations; hydro-electric generation facilities consisting of a forebay reservoir, tunnel/shaft facility, and afterbay reservoir at the Hurricane Cliffs; an infiltration reservoir west of Cedar City; and transmission lines and associated sub-stations to provide power to the pumping stations. The proposed and alternative corridor alignments analyzed is as configured in April 2009 and amended in 2010 (Appednix A; see also Chapter 1).

2.2 Project Alignment

The proposed pipeline alignment and analyzed alternatives traverses federal, state, county, tribal, municipal, and private lands in Coconino and Mohave counties in Arizona; and Kane, Washington, and Iron counties in Utah (Map 2-1). From the project's origin at Lake Powell immediately upstream from Glen Canyon Dam in Coconino County, Arizona, the pipeline alignment follows the U.S. Highway (US) 89 transportation corridor into Kane County, Utah, to an area east of Kanab, where several alternative alignments are being considered. The northern alignment runs north and west of Fredonia, then enters Mohave County, Arizona, and crosses the Kaibab Indian Reservation within the State Route (SR) 389 transportation corridor, also within Arizona. The southern alignment occurs south of the Kaibab Indian Reservation, within the Navajo-McCullough Transmission Line corridor. Approximately seven miles southeast of the communities of Colorado City and Hildale, which straddle the Arizona-Utah state line, the alternatives converge and extend westward to the forebay facility atop the Hurricane Cliffs, in Washington County, Utah. From the afterbay facility situated at the base of the Hurricane Cliffs, a portion of the alignment continues north to Quail Creek Reservoir. The pipeline alignment also continues northward from the forebay, crosses US 59 and the Virgin River, follows the SR 9 Highway transportation corridor through Toquerville, then turns northward, following the Interstate 15 (I-15) transportation corridor to just southwest of Cedar City, in Iron County. Additionally, a transmission line substation is analyzed for the expansion along Henrieville Creek, northeast of Henrieville in Garfield County, Utah (see Chapter 1 for a detailed description of the project segments).

2.3 Land Ownership

The federal lands along the project alignment are managed and administered by agencies of the U.S. Department of the Interior, including the Bureau of Reclamation (Reclamation), the National Park Service (NPS), and the Bureau of Land Management (BLM). BLM administers the majority of the federal land, which consists primarily of open space used for livestock grazing leases, wildlife habitat, highway and road corridors, and utility corridors. The Grand Staircase-Escalante National Monument occurs within the BLM lands. The Reclamation land includes about 34 acres adjacent to Lake Powell and immediately north of Glen Canyon Dam; this land is used for construction material storage and controlled access open space. The NPS land is within the Glen Canyon National

Recreation Area (GCNRA). State lands include those managed by the Utah School and Institutional Trust Lands Administration (SITLA); Arizona State Land Department; and Utah State Park lands that includes both Quail Creek State Park and Sand Hollow State Park located near Hurricane, Utah. County lands occurring near the project alignment are primarily used for county roads and rights-of-way. The tribal lands belong to the Kaibab Paiute Tribe in Arizona, and the Paiute Indians in Cedar Valley, Utah. Municipal lands along the proposed project alignment include the communities of Big Water, Kanab, Hildale, Apple Valley, Hurricane, La Verkin, Toquerville, and Kanarraville in Utah, and Fredonia and Colorado City in Arizona. Private land within and near the project alignment is used for livestock grazing and agriculture, and residential, commercial, and industrial developments.

2.4 Ecological Setting

Three main ecological regions—the Colorado Plateau, Great Basin, and Mohave Desert—are represented within the project area (Map 2-2). The vast majority of the project area, from Lake Powell to Hurricane, occurs within the Colorado Plateau Ecological Region. The project area north of Toquerville (northeast of Hurricane) to Cedar City occurs within the Great Basin Ecological Region. The Mohave Desert Ecological Region is represented by the area southwest of Hurricane. Diverse landforms, geological exposures, and elevation gradients present across the project area contribute to the biodiversity and unique character of the vegetation of the ecological regions.

2.5 Climate

The LPP project area experiences hot, dry summers and moderate air temperatures during winter months at the lower elevations, with cooler temperatures and snowfall at the higher elevations. Primary urban centers in the project area are Page, Arizona (elevation 4,300 feet), Kanab, Utah (elevation 4,970 feet), the City of St. George, Utah (elevation 3,000 feet), and Cedar City, Utah (elevation 5,623 feet). Average monthly maximum temperatures throughout 2008 and 2009, and in 2010 (through the end of the field season), as compared to 30-year averages, are shown in Figure 2-1, Figure 2-2, and Figure 2-3 (USU 2010 and Weather Underground 2010).

Average total precipitation in the communities near the project area ranges from 6.46 inches in Page to 10.60 inches in Cedar City annually. The 2008, 2009 and 2010 average annual precipitation for urban centers across the LPP corridor, as compared to 30-year averages, are provided in Figure 2-4, Figure 2-5, and Figure 2-6, respectively (USU 2010 and Weather Underground 2010).

2.5.1 Climactic Effects on Vegetation Field Surveys

Climactic factors affecting the field survey are local temperatures and precipitation throughout 2008, 2009, and 2010. Temperatures and precipitation during, and immediately prior to the 2009 and 2010 field surveys, would be expected to affect the onset of germination and the phenology of plant species occurring within the project corridor, and therefore the availability of individuals to be observed in the field. Temperatures and precipitation during 2008 have also been included in this discussion, as climactic conditions during the 2008 growing season would have influenced the quantity of seeds available for germination, and winter rains in late 2008 (and early 2009) would have affected germination rates. While climactic factors would have affected all targeted species, their effects were likely most pronounced on annuals occurring within the corridor. For instance, many of the targeted annual species, such as *Camissonia exilis*, depend upon winter precipitation for germination; therefore, winter precipitation is an important factor affecting the field survey. It is also important to note that the properties of the seed bank are not just the result of short-term climactic conditions, but of conditions experienced within the project area over multiple years, and resulting in the accumulation of seed over time. In addition to these variables, the seed bank is affected by non-climactic factors such as seed viability, seed dispersal, and predation.

Temperatures during 2008, 2009, and 2010 were similar to 30-year averages, with some notable differences. In all four cities, during 2008, maximum temperatures in May were lower than the 30-year average, while high temperatures in November were warmer than average. During 2009, maximum temperatures in May were higher than the 30-year average, which was followed by a considerably cooler than average June, with temperatures varying from 30-year averages by more than six and a half degrees Fahrenheit in St. George and Page.

During 2010, May temperatures were lower than the 30-year average, particularly in the area of St. George, where this temperature difference approximated eight degrees Fahrenheit. Temperatures in Page and Kanab slightly exceeded 30-year averages in June, while St. George and Cedar City continued to see lower-than-average temperatures. By July and August, temperatures in all four cities exceeded 30-year averages.

Precipitation was more variable than temperatures from 30-year averages in 2008, 2009, and 2010. This variation is particularly notable during 2008 in the communities of Page, St. George, and Cedar City, where precipitation exceeded the average in both the early part of the year, as well as at the end. Throughout 2009, precipitation was lower than the 30-year average in all four communities, with the only exception of May, when precipitation in Page and Kanab exceeded the average considerably. Also of note is the concentration of precipitation from April through September in the Kanab area, with no precipitation recorded prior to April. This contrasts sharply with trends over the 30-year average, in which precipitation is distributed throughout the year, with the highest amounts occurring in winter. A similar trend occurred in the Page area, with the majority of precipitation concentrated from May through September, and extremely high precipitation in May. Early 2010 saw higher than average precipitation levels in all cities but Kanab, with much higher levels in January in the vicinity of St. George, and in March in the vicinity of Cedar City. At the end of the 2010 survey, lower than average precipitation was experienced in Kanab and Cedar City, while higher than average precipitation occurred in Page and St. George.

In 2008, lower than average high temperatures in May, and higher than average temperatures as late as November, would have created a long growing season, resulting in a high seed set. Additionally, high amounts of precipitation recorded in November and December of 2008, and in early 2009, particularly in Page, St. George, and Cedar City, likely resulted in a high rate of germination of the annuals within the project area, in turn increasing the overall quantity of seed available in the seed bank for the 2009 season. Higher than average temperatures in early 2009 likely induced early germination, while late rains, particularly in Kanab and Page, extended the blooming period outside of that historically observed, as evidenced by locating flowers of *Camissonia exilis* as late as August 5^{th}. The resulting effect was a wide field survey window in 2009, allowing surveys to begin early in the year and to extend late into the summer. The 2010 survey would have benefited from higher than average precipitation over the winter of 2009-2010. While lower than average temperatures in the early part of the 2010 field season, particularly around St. George, may have delayed the phenological period of spring flowering plants, the abundance of annuals, particularly *C. exilis*, and *Phacelia pulchella* var. *atwoodii*, observed during the survey suggests that this effect was minimal. In order to optimize the probability of encountering target annual species, field work was adjusted to accommodate for climactic conditions wherever possible.

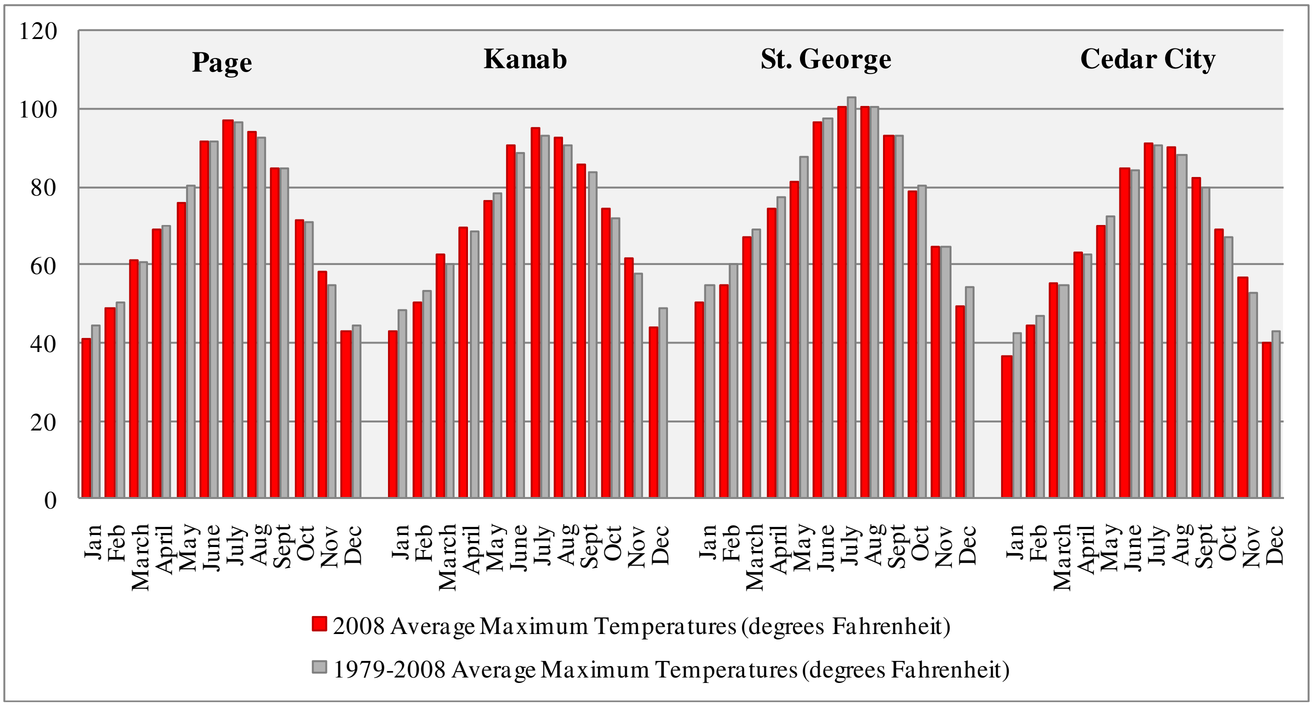


Figure 2-1
2008 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

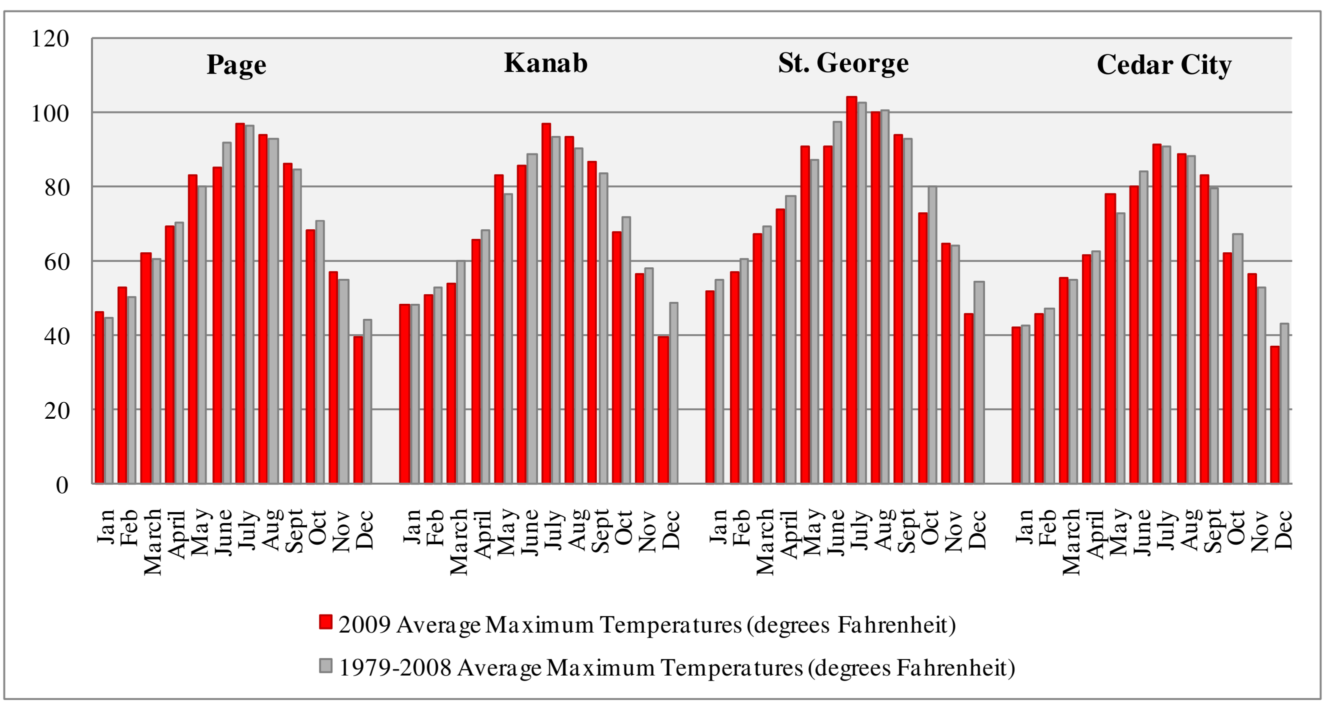


Figure 2-2
2009 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

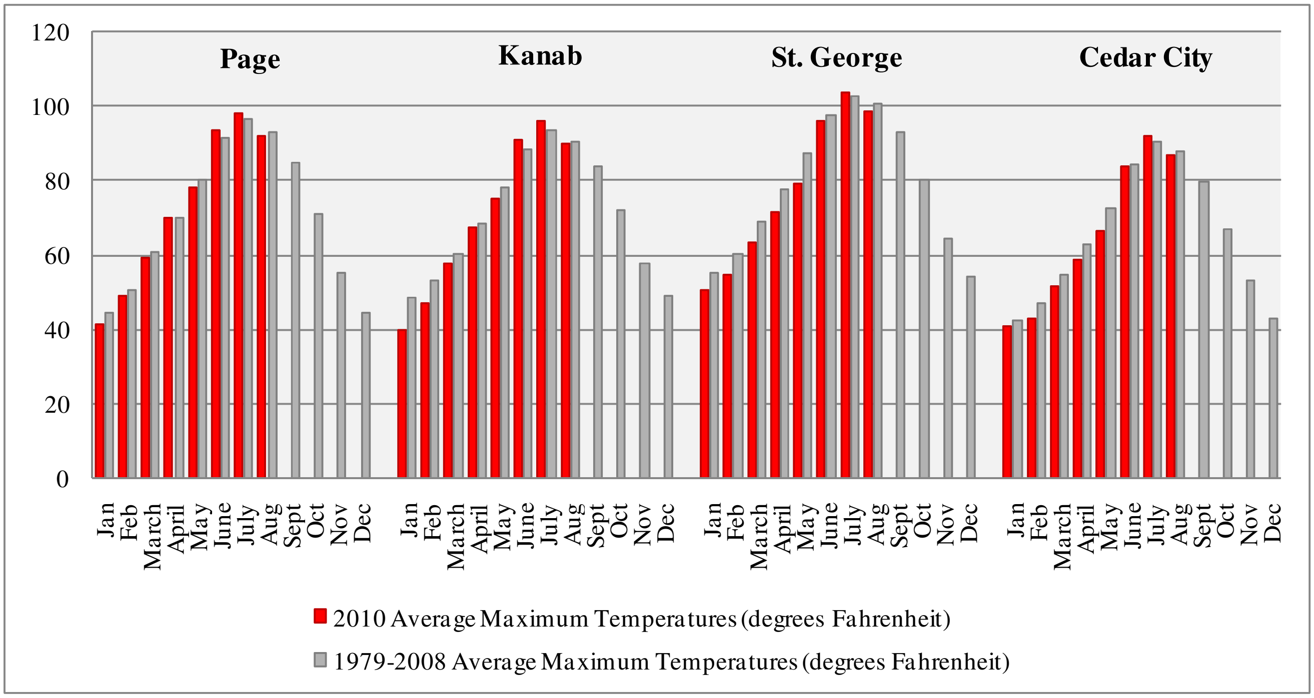


Figure 2-3
2010 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

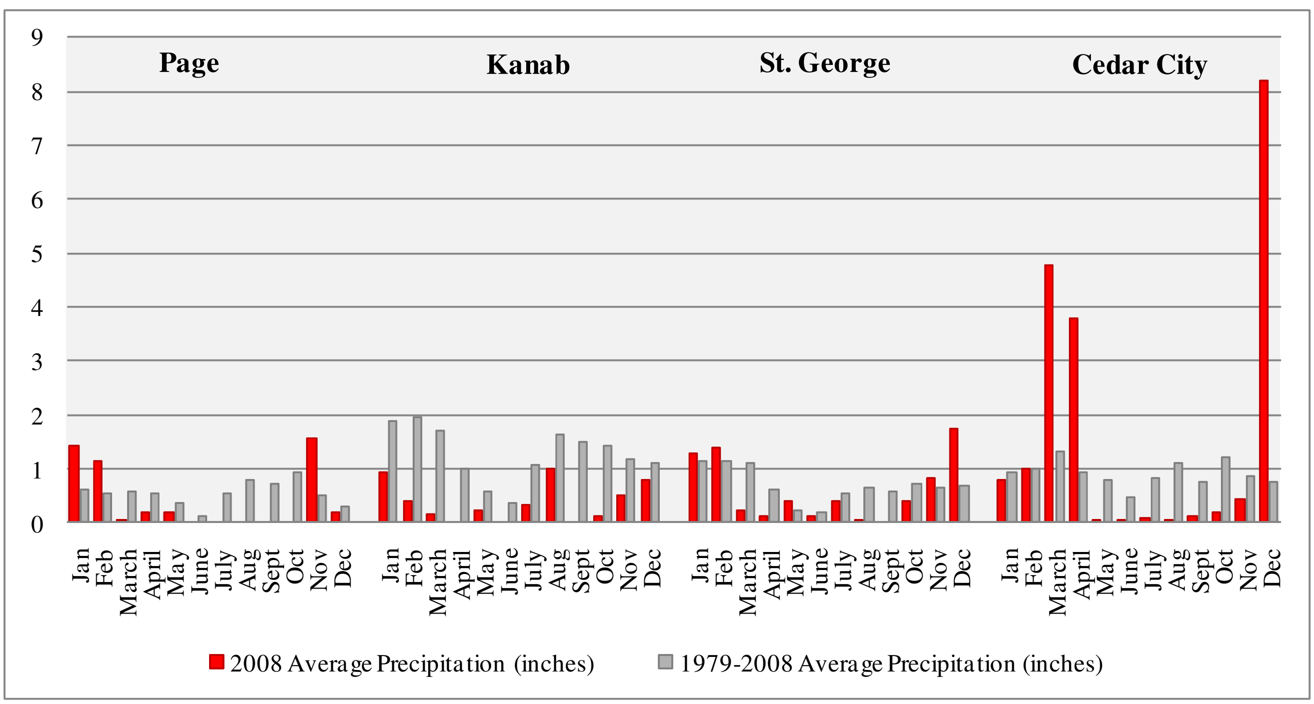


Figure 2-4
2008 Average Monthly Precipitation, as Compared to 30-year Averages

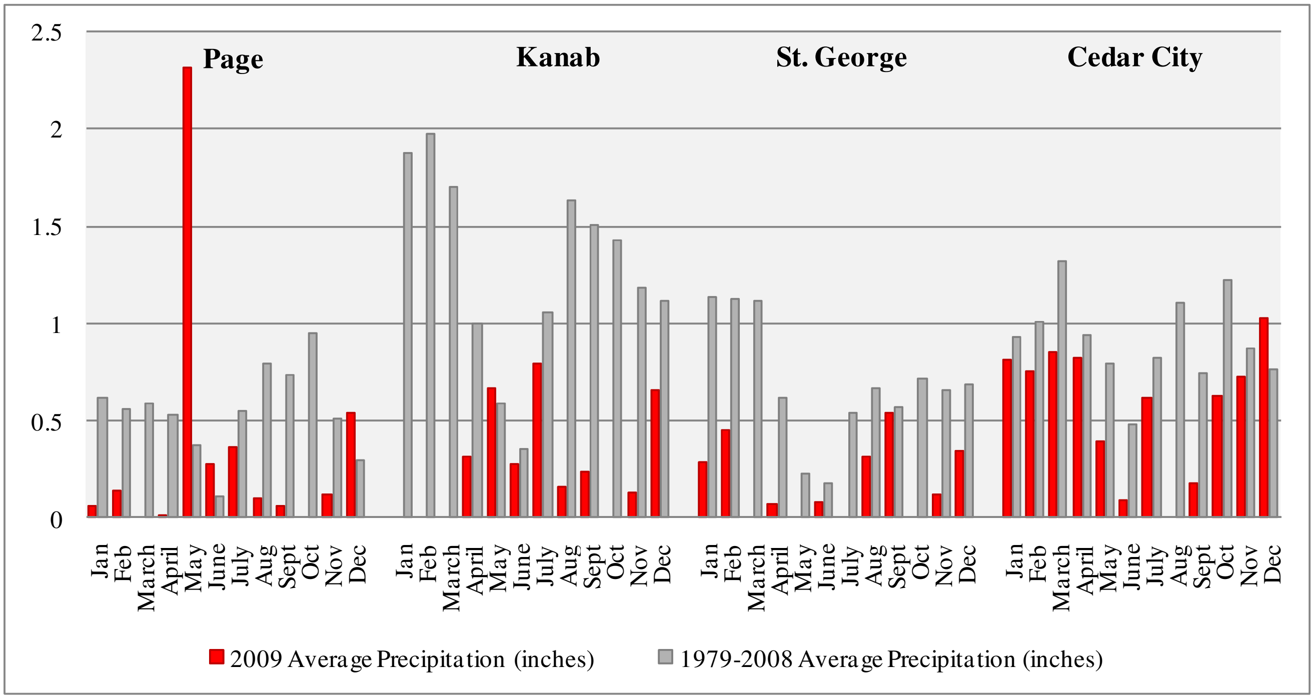


Figure 2-5
2009 Average Monthly Precipitation, as Compared to 30-year Averages

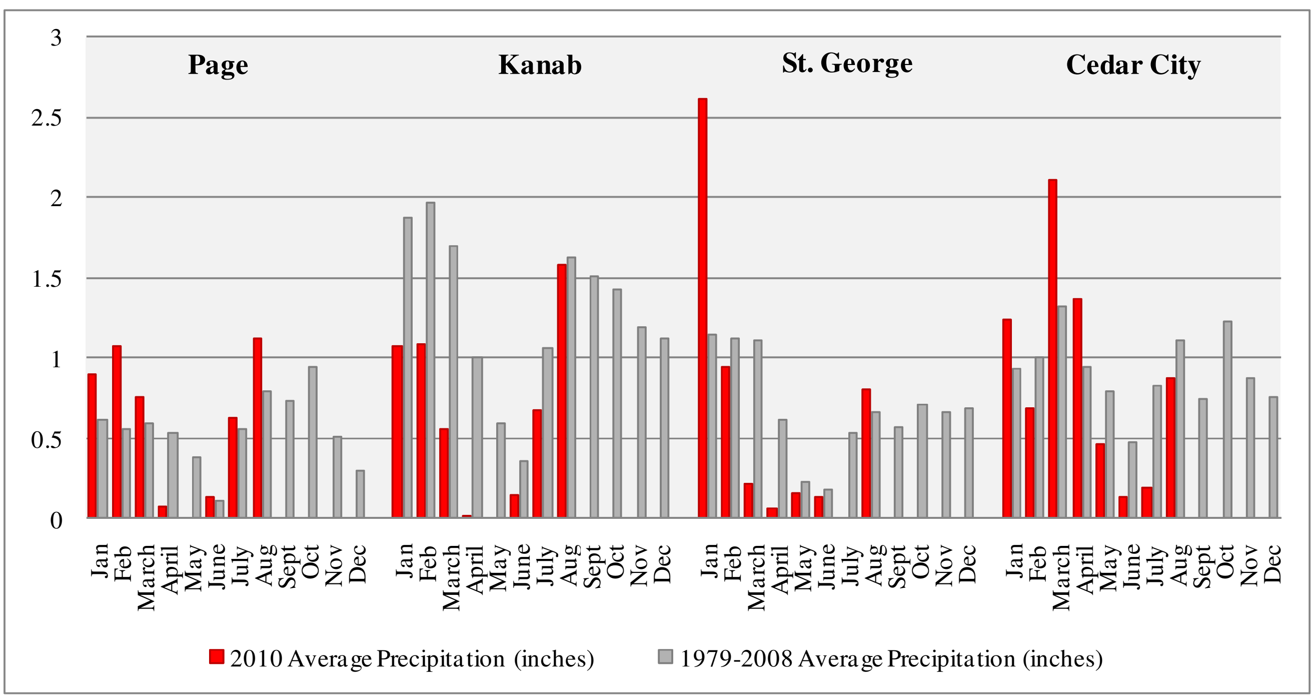
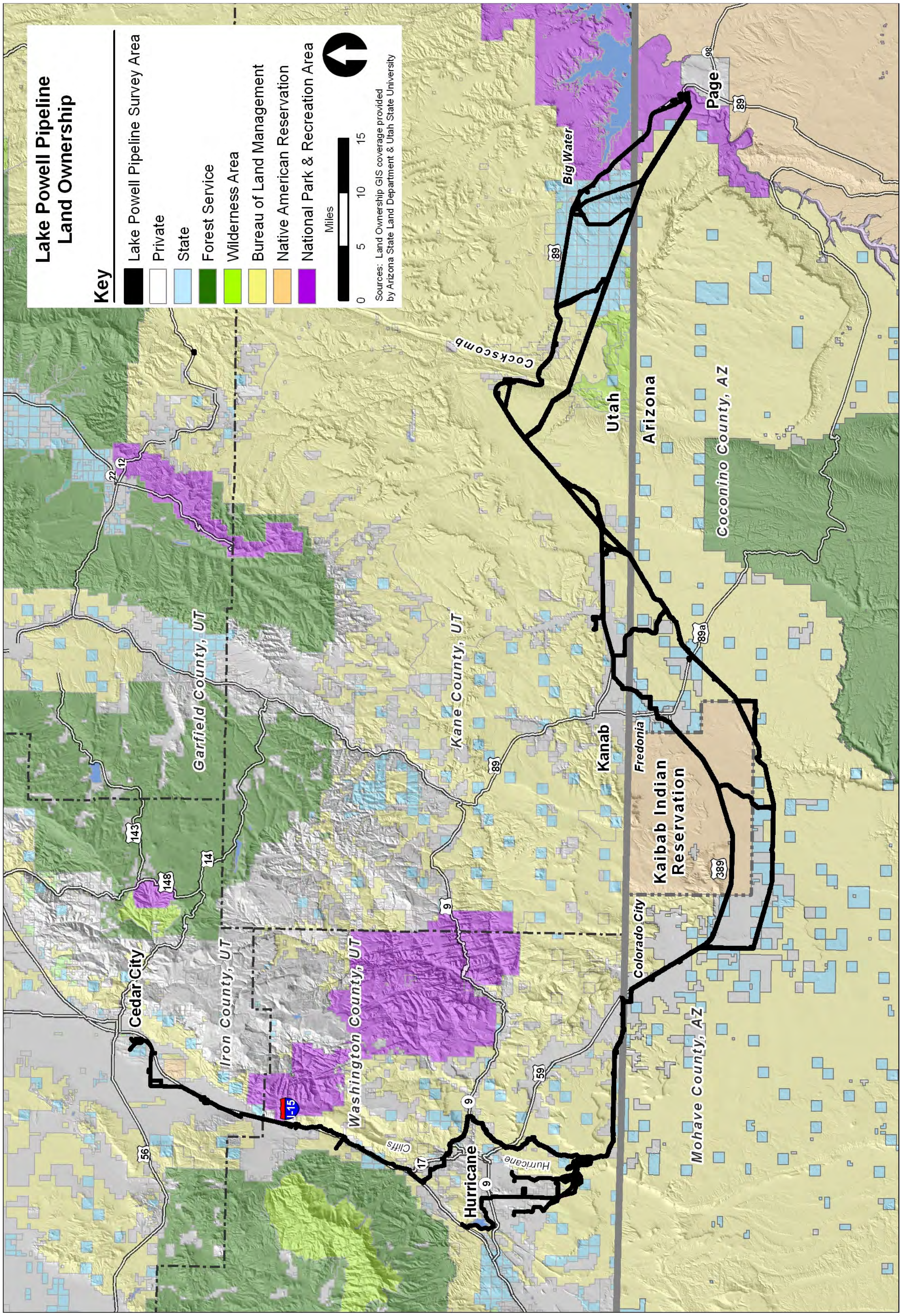


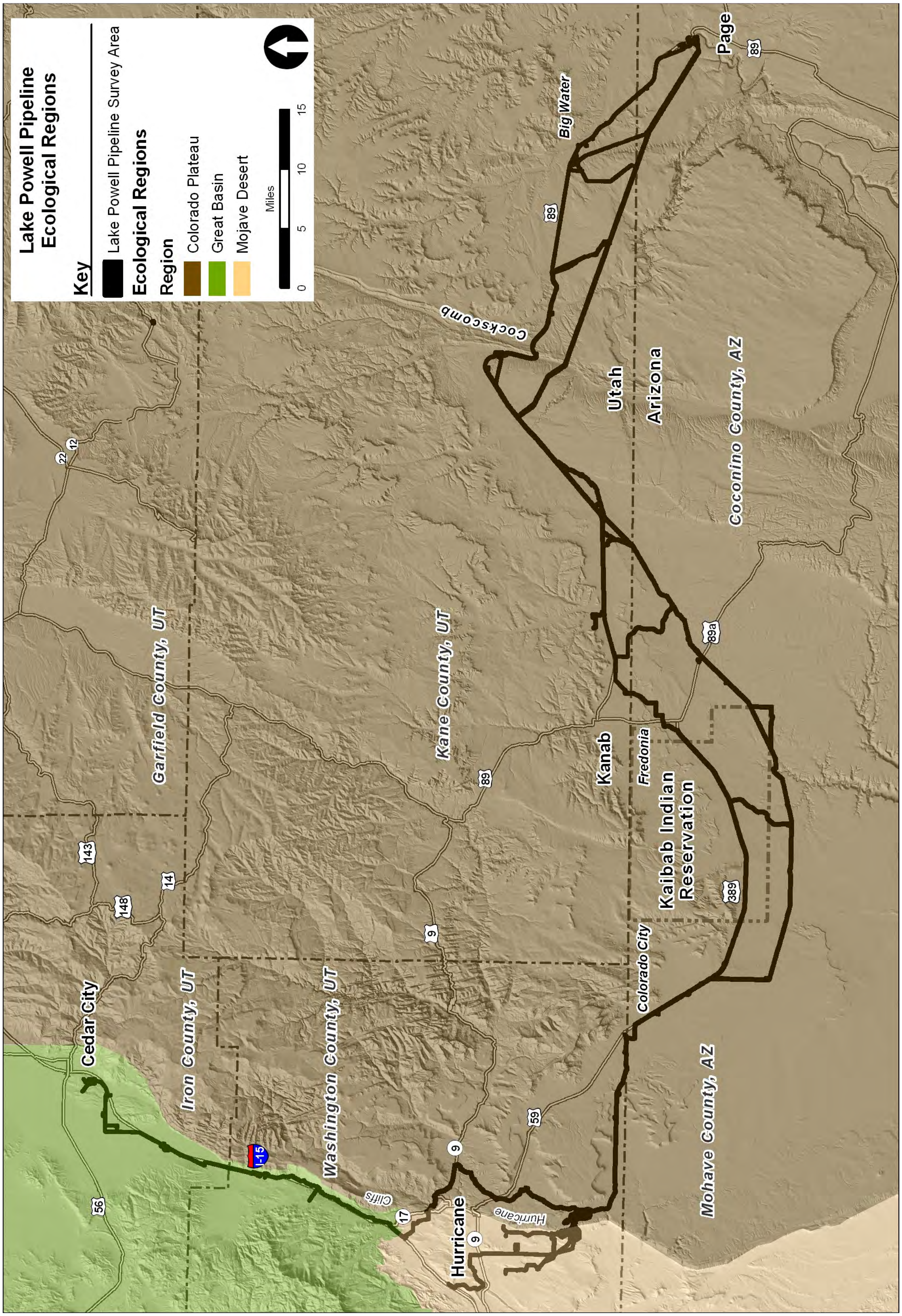
Figure 2-6
2010 Average Monthly Precipitation, as Compared to 30-year Averages

2.6 Study Corridor

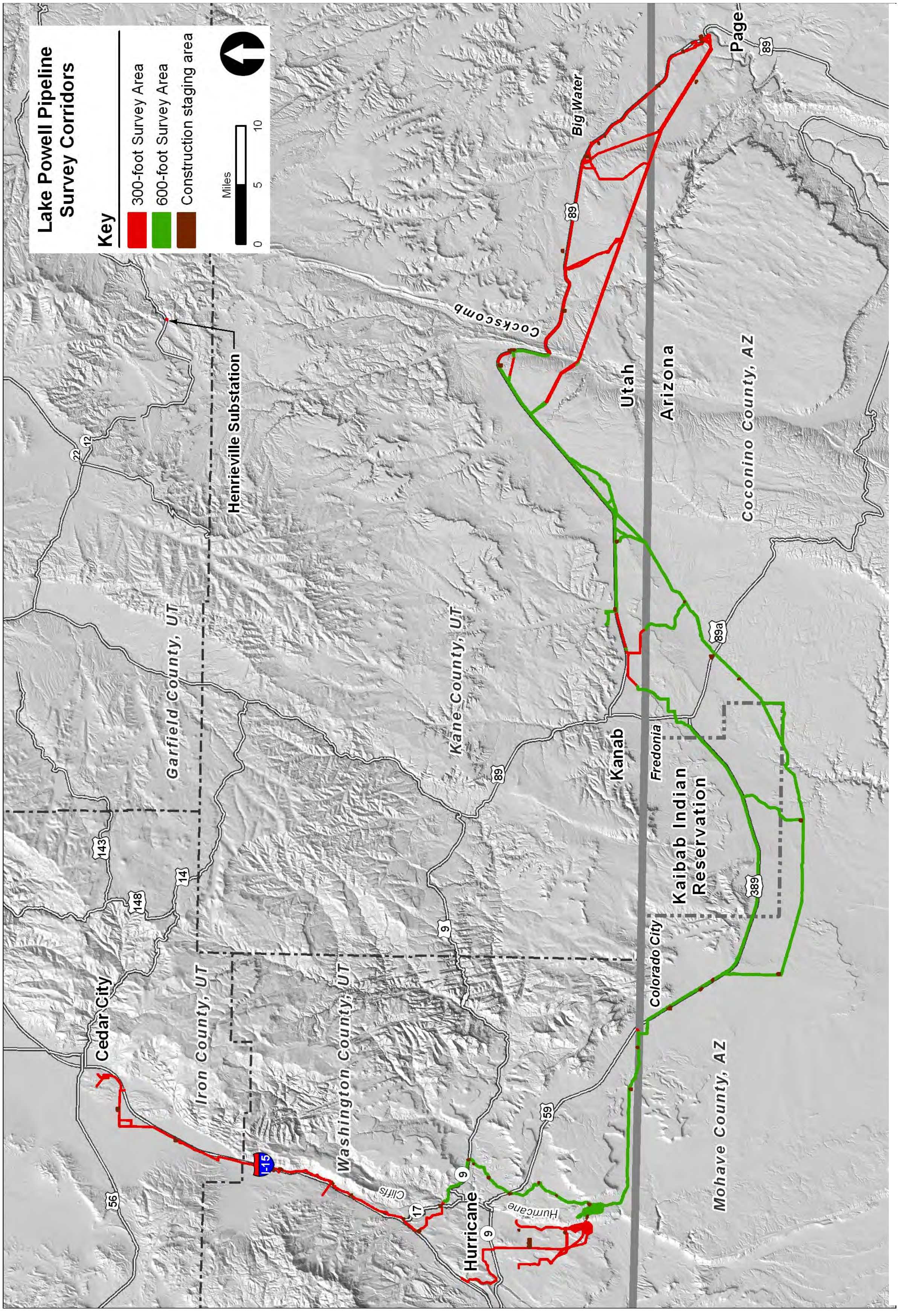
For purposes of the LPP project vegetation community mapping, the study area is defined as the alignment of the buried pipeline and alternatives; other facilities associated with the pipeline such as hydro stations and reservoirs; transmission lines; and construction staging areas. The width of the study area for the linear elements was determined by the U.S. Fish and Wildlife Service based on a general evaluation of the geologic origin of soils, with larger survey corridors in areas with greater potential for occurrence of sensitive plant species. The survey corridors were established based on the pipeline or transmission center line, extending 150 feet on either side for a 300-foot-wide total width, or for areas with greater potential for special plant resources, 300 feet on either side of the center line for a 600-foot-wide total width. Generally, the 300-foot-wide corridors occurred between Lake Powell and the Cockscomb, and west of the Hurricane Cliffs extending northward to Cedar City. All other linear elements had a 600-foot-wide survey corridor (Map 2-3). Vegetation community mapping was undertaken concurrently with surveys for noxious weeds and special status plant species.



Map 2-1
Land Ownership



Map 2-2
Ecological Regions



Map 2-3
Vegetation Resources Survey Area

Chapter 3
Methodology

3.1 Purpose and Approach to Vegetation Community Mapping

The purpose of this report is to describe the baseline vegetation characteristics present in the Lake Powell Pipeline (LPP) project corridor, to identify and locate the presence of unique vegetation communities or habitat types and other sensitive areas, to analyze project-related impacts to vegetation resources, and to provide measures (i.e., best management practices) to minimize adverse effects to native vegetation and to facilitate site restoration following disturbance for the benefit of special status plant species and to preclude the spread of invasive weeds. A review was conducted of existing vegetation land-cover maps developed by the multi-state, U.S. Geological Survey (USGS)-sponsored Southwest Regional Gap Analysis project (SWReGAP). These maps were created primarily from remote imaging, and the scale and resolution proved to be insufficient for the purposes of the LPP project to provide for consistent analysis of current vegetation conditions accros the project area.

Vegetation mapping of the LPP survey area was based on detailed field surveys that identified and mapped the distribution of plant species and vegetation communities within the survey area to at least a minimum resolution scale of 2 acres. Vegetation classification is based on a hierarchical nomenclature system, and vegetation communities are classified based on species composition and domanance, plant growth form and stature (height and canopy cover), and plant density. Highest resolution vegetation community mapping of the LPP survey area was that of plant association; associations are grouped into alliances based on similarities in speices composition; and alliances are grouped into ecological systems that reflect major geographic regions (e.g., Colorado Plateau, Great Basin, and Mohave Desert). The completed vegetation community mapping of the LPP survey area uses terminology and classification standards consistent with the US National Vegetation Classification System (NVCS) administered by NatureServe and adopted by many federal land management agencies.

Survey results for special status plant species and noxious and invasive weeds are addressed in a separate report that includes an integrated assessment of project-related impacts to all vegetation resources.

3.2 Pre-survey Preparations, Field Equipment, and Materials

Prior to conducting surveys for vegetation communities, the survey team performed a variety of activities to focus the field work, maximize efficiency and thoroughness, and to identify ways to facilitate post-survey data analysis and the interpretation of results. Preparation for conducting surveys of vegetation communities consisted of obtaining landcover maps developed by the SWReGAP. These maps were utilized to determine previously-documented ecological systems occurring throughout the LPP survey area. Subsequently, a review of vegetation communities identified and mapped during the 2009 survey season was conducted in preparation for 2010 surveys.

A set of project area maps was developed to serve as a reference tool for the vegetative community surveys. Project alternatives and alignments were overlaid on aerial and topographic maps using GIS software. Aerial maps with a 1:2,500 scale were produced for field use with sufficient scale and clarity to map landscape and vegetative features. In 2009, ecological systems predicted by the SWReGAP program were color coded as a dissolve onto the maps. Following the 2009 field season it was determined that this color coding did not aid in vegetation community mapping and was removed for the 2010 field season. Topographic maps from 1:24,000 scale digital raster graphics (DRG) were produced to show elevations, natural features, and cultural features. Reconnaissance grade geologic mapping was overlaid onto the DRGs from state digital geology maps.

Field surveys for vegetation communities were planned to occur simultaneously with surveys for noxious weeds and special status species. Fifty-meter belt transect surveys, aimed at enhancing vegetation community data, and collecting quantitative density data for both noxious weeds and special status species, were conducted separately. Lists of commonly encountered species within the Colorado Plateau, Great Basin, and Mojave Desert were prepared. These lists contained commonly encountered species arranged alphabetically by row, with up to 10 columns for separate vegetation communities, creating individual cells for recording relative abundance of each species within each vegetation community (Appendix A). Vegetation community data were recorded onto these data sheets, and the boundaries for each associated vegetation community were hand-drawn onto the prepared field maps.

GIS software was also used to load the survey area onto Trimble, Juno, and Garmin Global Positioning System (GPS) units to track surveyor locations while in the field. A data dictionary (electronic data collection template) was created to record pertinent information about noxious weeds and rare plants identified during the field survey. This data dictionary was loaded on the Trimble and Juno GPS units. Additional maps including gazetteers and atlases, BLM maps, State of Utah and Arizona maps, and real-time navigation mapping software were utilized to determine access points to the pipeline corridor.

Each surveyor was given copies of the prepared rare plant and noxious weed identification cards to carry in the field, in order to provide a search image of the species and its unique habitat characteristics and to aid in the identification of rare plants or noxious weeds when similar species were present. To further gain familiarity with target plant species, crew members had the opportunity to research and photograph herbarium samples at the BLM St. George interagency office at the beginning of the 2009 field season, and at the BLM Kanab field office during the 2010 field season. Crew members were also able to observe several rare plants in their natural settings at previously known locations, including *Echinocactus polycephalus* var. *xeranthemoides*, *Eriogonum mortonianum*, *Eriogonum thompsoniae* var. *atwoodii*, *Pediocactus sileri*, and *Pediomelum epipsilum*. Follow-up visits were made to the herbaria at University of Nevada – Las Vegas and Lake Mead National Recreation Area to verify voucher samples of some of the more difficult to identify species found. In addition to the identification cards, each morning prior to going out into the field potential species to be found that day were identified and reviewed with the aid of taxonomic reference guides.

3.3 Survey

In 2009, surveys commenced in the vicinity of Hurricane, Utah and generally moved east (increasing in elevation) toward Page, Arizona. The 300-foot-wide and 600-foot-wide alignments, plus associated facilities, construction staging areas, and transmission line corridors comprised the survey area. Surveys began in mid-April 2009 and were mostly complete by early August 2009. Areas along the pipeline were revisited as late as mid-September 2009 if private land access was granted or to verify and collect target plant species during the blooming period. Surveys in 2010 were conducted in areas were the project footprint had been modified since the previous summer, these primarily included areas adjacent to the forebay and afterbay, as well as the Hydro System High Point Alignment Alternative. Surveys during the 2010 field season began in mid April and were completed by the end of July.

Total coverage of the 600-foot-wide corridor (177.2 miles) was achieved during the 2009 field season, using a combination of pedestrian surveys (81 percent) and windshield/binocular surveys (19 percent) (Map 3-1 and Map 3-2). Approximately 91 percent of the 300-foot-wide corridor (168.3 miles) was surveyed either on foot (52 percent) or by windshield/binocular surveys (39 percent), with nine percent of the area interpreted via aerial images. With the realignment of portions of the pipeline in 2010, 14.4 miles of 600-foot-wide corridor and

48.5 miles of 300-foot-wide corridor were added to the survey area. The entire 600-foot survey area (100 percent) and 86 percent of the 300-foot survey area were completed by pedestrian survey, with the remaining 14 percent of the 300-foot survey area interpreted via aerial images. Lands that were not surveyed on foot included private property, areas with impassible terrain, or areas where rare plants would not expected to be encountered based on soils and habitat requirements, or along roadsides where ruderal vegetation was dominant. Where surveys were not conducted on foot, these areas were assessed to rule out the potential presence of special species' habitat (using aerial maps, soil maps, and general visual assessments to make a determination). Windshield surveys were conducted with a driver plus one to three observers. The surveys were generally conducted at low speeds, with frequent stops to examine vegetation on foot. Binocular surveys were conducted from vantage points, such as the summit of Cedar Mountain and the western edge of Judd Hollow, as well as other high points within the survey area that were accessible by a four-wheel-drive vehicle. In some areas where windshield surveys were conducted, the strategic placement of 50-meter transects (along right-of-ways where private property was the limiting factor) served to increase survey coverage in those areas.

Each survey day began with a pre-survey crew meeting. In these brief meetings, crew members were assigned to teams and individuals were given job assignments by the field manager. Survey site locations were disclosed and sensitive landscape features, private property, and site access were discussed. A list of special status plants with a potential to occur within the survey site area was created by researching the survey site's elevation ranges and soil types. The targeted rare plant species were presented to the crew by the lead field botanist, with focus on identifying characteristics and unique habitat requirements. Each crew member was given plant identification cards for all target special status species, as well as noxious weed species.

Surveys began by using the Trimble or Juno GPS unit to log the start positions of the survey. Crew members lined up to walk parallel transects along the length of the 300-foot or 600-foot-wide corridor (Map 3-1). On a 300-foot-wide corridor, seven to twelve crew members were spaced 25 to 40 feet apart. On a 600-foot-wide corridor, 10 to 24 crew members were spaced 15 to 30 feet apart. In some segments, the 600-foot-wide corridor was treated as two 300-foot-wide corridors and covered by a crew suitable for a 300-foot-wide corridor by walking down one half of the corridor and returning on the other half. When this approach was used, the Garmin tracking feature was used to mark the inside edge of the first band surveyed (the centerline of the 600-foot-wide corridor) so that the second band did not overlap the first. The spacing of crew members was based on the complexity of the terrain and presence of sensitive landscape features. When sensitive landscape characteristics were present (presence of rock outcrops, gypsum outcrops or soils, unique vegetation communities, and known occurrences of rare plants), crew members were spaced closer together (15 feet or less) and moved at a slower pace. Often, the crew manager roamed throughout the transect, mapping and typing plant communities and compiling a list of plants and their relative abundances. A typical transect length was two to four miles, covering six to twelve miles per day.

The roving crew manager regularly roamed throughout the survey corridor targeting any changes in vegetation or soil conditions to determine and map boundaries of plant communities. He or she was also the botanical lead compiling a list of plants and their relative abundances, as well as collecting vouchers of unknown specimens for later transfer to plant presses. Abundance codes represent a rank order of the species density within a mapped unit of a plant community. The code 'rare' was used when 1-5 plants were present, with 'occasional', 'common', 'abundant', and 'dominant' representing increasing rank order. No absolute numbers can be given for any abundance other than rare. When plants varied greatly in biomass (e.g., trees versus grasses), abundances were weighted for biomass. Thus, nine trees would represent a much higher abundance rank than nine clumps of a grass species. For species in less than 5 percent of the available habitat, a 'localized' modifier was added to the abundance rank. While this approach is qualitative, it is widely applied by botanists in reconnaissance surveys of plant communities. It offers a useful, low cost comparison metric of the variation in species abundances across a range of plant communities.

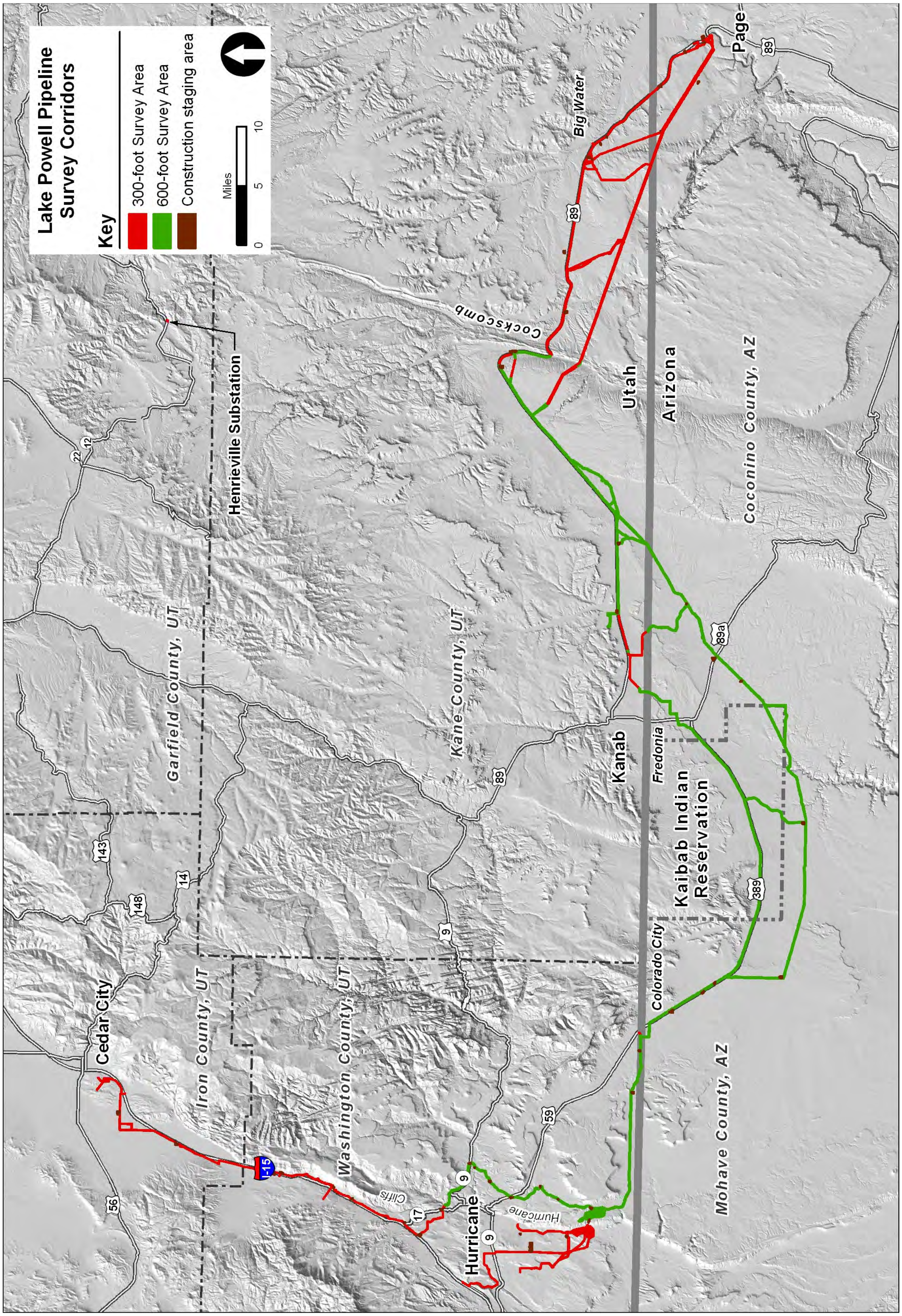
Field workers utilized aerial photographs of the areas they were surveying which allowed for field mapping of distinct boundaries between plant communities, as well as approximate transition points between different plant communities. While a vegetation classification wasn't completed until after the completion of field work, knowledge of the alliances and associations previously typed for the region in the US National Vegetation Classification (NVC) provided a starting point for mapping. By delineating communities using changes in cover type, a bottom-up approach could be taken (i.e., combining field delineated cover types into associations, which were grouped into alliances, and finally assigned to appropriate ecological systems using geographic regions and geomorphologic landscape features).

To help in correctly identifying plants, one field vehicle transported a set of floras, including a Utah Flora, a pre-print of the Flora of Mohave County, Arizona and all the published volumes of Intermountain Flora. Upon the return to the vehicles, field crews would share their collected unknown plant specimens with the botanical lead. The most important of these specimens could then be keyed out. Additionally, a collection of digital images was carried by one of the botanical leads on a Pocket PC. The set consisted of photographs and drawings for over 1000 potentially occurring plants in the counties being studied.

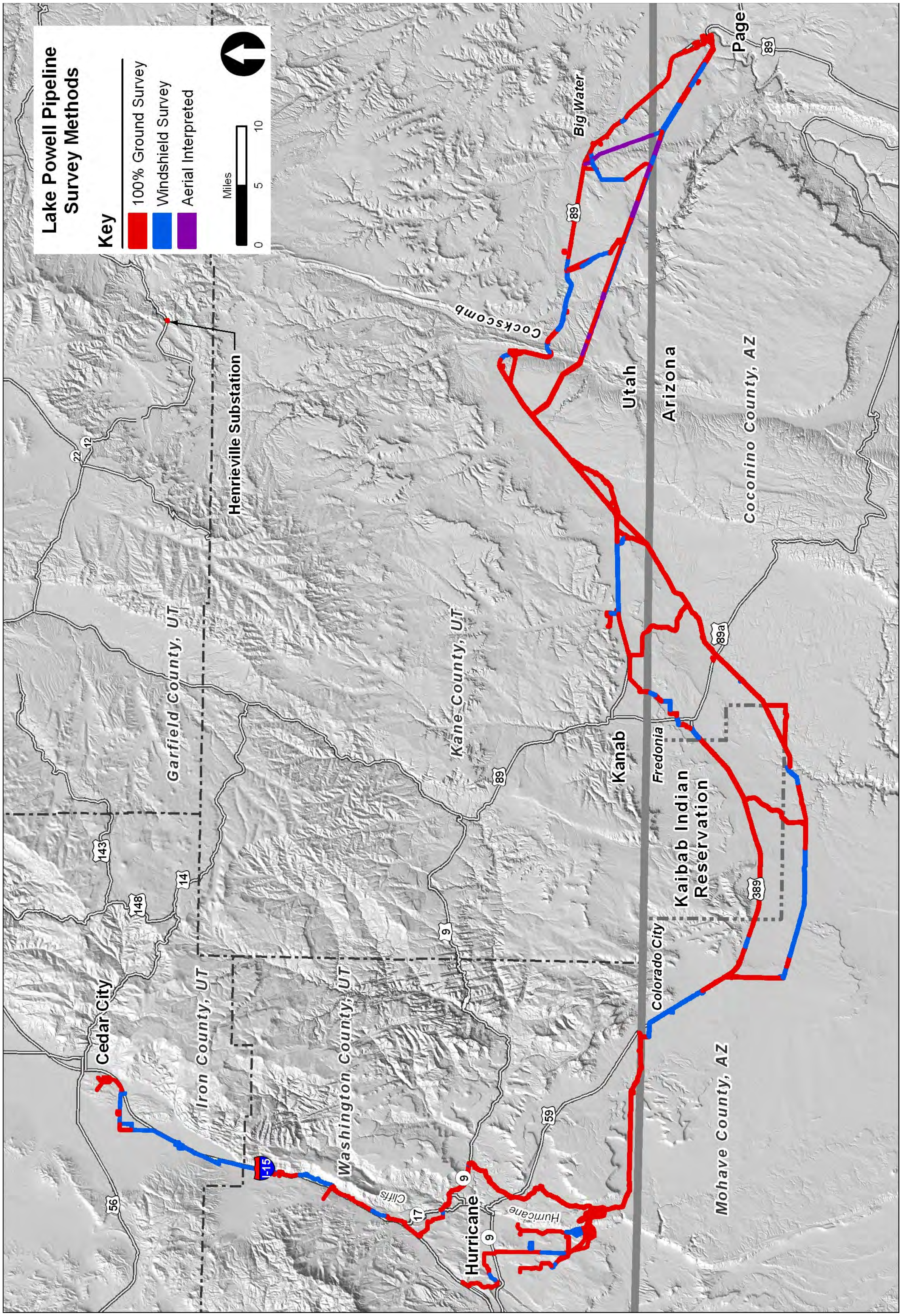
Field surveys for special status species and noxious weeds, as well as for vegetation communities, were planned to occur simultaneously. Fifty-meter belt transect surveys, aimed at collecting quantitative density data for both special status species and noxious weeds, were conducted separately. Field data sheets were created for recording the results of these surveys, and included the following information: date; beginning and ending time of the survey; the names of all crew members; location of the survey segment; topographic and aerial maps used; Global Positioning System (GPS) file name; Universal Transverse Mercator (UTM) coordinates and elevation at the four corners of the survey segment; photo log ; soils information; vertebrate species observed; special status species potentially occurring within the area and species observed; noxious weed species observed; land use, and vegetation community information (Appendix B). A separate data sheet was created for the 50-meter belt transects, and included many of the same data fields used for the larger survey segments, with the addition of a list of the plants most likely to be encountered.

3.4 50-meter Transects

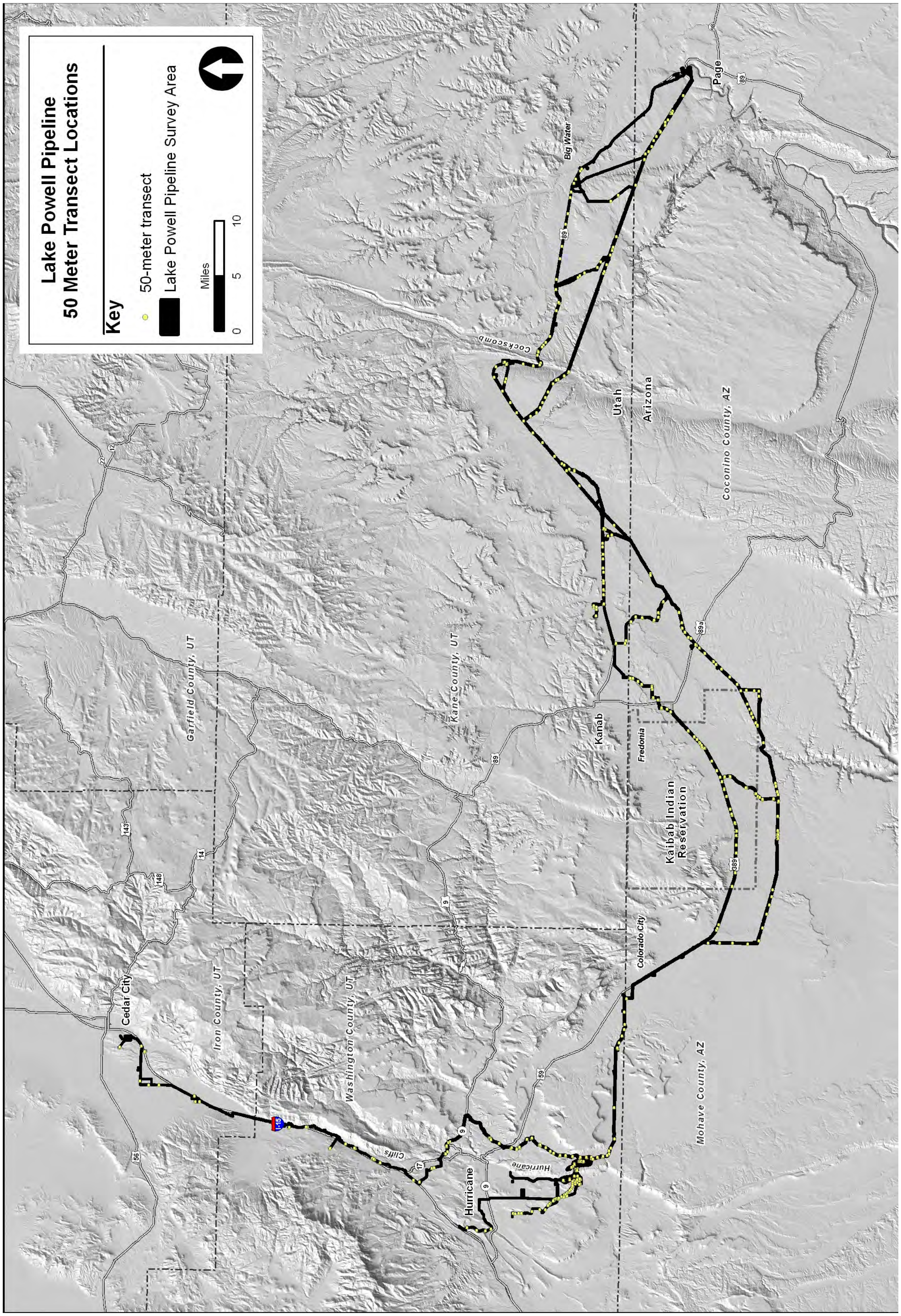
Quantitative plant density data was obtained by placing 50-meter transects systematically throughout the pipeline and transmission line corridor areas (Map 3-3). Transect locations were stratified to cover a wide variety of vegetation communities and geographical locations. Data collected from these transects provided a way to check the vegetation association, alliance and ecological system classification; quantify noxious and invasive plant densities; and complement rare plant density data collected during previous field surveys. The 50-meter transects also provided plant density data used to quantify reconnaissance vegetation classification along the 300-foot-wide corridor, for areas where field surveys were not conducted. During 2009, transect surveys were conducted from late August to mid-September, and during 2010, from mid April to mid June.



Map 3-1
Survey Corridors



Map 3-2
Survey Methods



Map 3-3
50-meter Transect Locations

The 50-meter transects were placed by visually assessing changes in the vegetative community along the corridor, or by identifying apparent landform changes on aerial maps. When this occurred, teams would stop and randomly orient the 50-meter transect. Teams measured out 50 meters with a 100 meter tape and took GPS coordinates and photographs at the start and end of each transect. Individual plants within a 1 meter distance (measured with a meter stick) along the 50-meter transect line were identified and tallied on a data sheet (Appendix C).

Occasionally plant density was too high to efficiently or accurately count (e.g., some grass and herbaceous species) and a relative abundance was recorded instead. To calculate total vegetation cover along the 50-meter transect, living plants were tallied when intersected at the end of the 1 meter point, then the total was multiplied by two to obtain percent plant cover. Additional data collected along each transect included: slope and aspect, community type, hydrology, land use, distance from the nearest road, and the amount and type of disturbance present.

3.5 Analysis

Based upon vegetation community field mapping, vegetation communities were mapped to ecological system, alliance and association levels using ArcGIS 9.3 software. Where field mapping was not possible, digital image interpretation was combined with field reconnaissance to determine appropriate ecological systems. The reconnaissance techniques included binocular surveys and mapping from high points and windshield surveys of private land.

For 2009, the 50-m transect data sheets were individually reviewed and a US NVC compliant vegetation association assigned. For 2010 data, only transects taken in areas without field mapping where analyzed. These data were considered as a secondary source for classification purposes, since the 1 meter transect width was insufficient to accurately determine tree cover. Transects were often displayed in ArcMap against recent aerial imagery and the vegetation classification was modified, if necessary, to reflect the surrounding cover classes for trees, shrubs and understory species. The cover cut points needed to determine physiognomic class for the US NVC were: 0-10 percent, 10-25 percent, 25-60 percent and over 60 percent.

3.6 Classification of the Vegetation of the Lake Powell Pipeline Project

3.6.1 Plant Communities

Plant communities, ecological communities, and natural communities are interchangeable terms for ensembles of primarily native species of plants. These communities have plant species which independently respond to environmental gradients such as elevation, aspect, slope, and various soil properties. Species can also respond dependently to each other, with some better adapted to competition from neighboring species, or better at resisting natural and artificial disturbances to the ensemble. While the number of potential permutations of species and their individual abundances is large, vegetation is often observed as a comparatively small number of reoccurring patterns on the landscape. When an ensemble is repetitive, it may be classified using a variety of standardized naming protocols.

One such system is referred to as the US National Vegetation Classification System (US NVCS). Its protocols were revised by the Federal Geographic Data Committee (FGDC) in 2008 and it is named “The National Vegetation Classification Standard (Version 2.0), FGDC-STD-005-2008.” The system includes standards for data collection, data analysis, data presentation, and quality control/quality assurance through peer review. Ideally, the

US NVCS will foster the development and use of a consistent NVC, to produce uniform statistics about vegetation resources across the nation based on data gathered at local, regional, or national levels.

US NVCS states that it shall be followed by all Federal agencies for vegetation classification data collected directly or indirectly (through grants, partnerships, or contracts) using Federal funds. The FGDC hopes that non-Federal organizations will find the NVCS useful for making their efforts compatible with those of nearby Federal land managers and/or any activities that involve Federal agencies. Because of the preponderance of federally owned land within the LPP project area, plant communities were named, when practical, to NVC compliant alliances and associations, organized by ecological systems.

The NVCS (Version 2.0) does not preclude alternative classification approaches and systems that address particular needs of Federal agencies. However, it does require that vegetation mapping and inventory units crosswalk (correlation) to the NVC. To that end, Ecological Systems were adopted as the broadest category of classification. It is a crosswalked hierarchal system developed by NatureServe.

Where vegetative is dominated in part or whole by non-native species, terms such as semi-natural or ruderal maybe used. The difference between semi-natural and ruderal is a continuum in how exotic the vegetative composition of the ensemble is. Semi-natural communities are typically invaded by one or a few regionally common exotic or invasive species, sometimes to the exclusion of natives. The soils may have suffered severe erosion or silt deposition, but a seed bank of native species is present and native vegetation can be expected to recover over time. Ruderal Vegetation is typically a larger suite of non-native species which colonize ground laid bare from human activities. Road building, land grading, agriculture, and quarry operations may have contributed an opportunistic ensemble of plant species which can persist without human intervention. As opportunists, these species are found over a broader range of habitats than most native plants.

3.6.2 Ecological Systems

Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by resource managers in the field.

The Ecological Systems classification recognizes groupings of plant communities at a coarser hierarchical level than alliance. Alliances within an ecological system share the same ecological processes and landscape positions. The Ecological Systems classification of NatureServe is the framework for regionally arranging known and expected alliances and associations. It provided a hierarchy level which correlated better than alliances with the vegetation signatures obtained by legacy 30 meter resolution LandSat TM imagery. It was also developed to narrow a wide classification hierarchy gap between the formation and alliance levels of vegetation classification.

LSD has refined classification for the LPP project area for geographic simplification and more clarity. Since NatureServe ecological systems often overlap to geographic regions beyond their naming convention, LSD chose to constrain each ecological system to a single, widely recognized region. These include the Great Basin Ecological Region, the Mohave Desert Ecological Region and the Colorado Plateau Ecological Region. For example, active and stabilized dunelands are herein recognized as three regionalized ecological systems: Great Basin Active and Stabilized Dunes, Mohave Desert Active and Stabilized Dunes, and Colorado Plateau Active and Stabilized Dunes. Never-the-less, the NatureServe and LSD ecological systems retain correspondences which can be crosswalked. In this case, all three regionalized ecological systems crosswalk to NatureServe's "Inter-Mountain Basins Active and Stabilized Dune Ecological System."

3.6.3 Alliances

The alliance is a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species which, as a rule, are found in the uppermost strata of the vegetation. Plant species that are dominant (cover the greatest area) and diagnostic (found consistently in some vegetation types but not others) are the foundation of both alliance and association names. At least one species from the dominant and/or uppermost stratum is included in each name. Alliance names include the physiognomic class (e.g., "Forest", "Woodland", "Herbaceous") in which they are classified, followed by the word "alliance" to distinguish them from associations. The lowest possible number of species is used for an alliance name, up to a maximum of four.

The FGDC's original 1997 Vegetation Classification Standard required that Alliance names were tied to the physiognomic class representing their vegetation, which has greatly complicated naming and made remote sensing identification of alliances (and associations) more difficult. NVCS relaxes this requirement, as long as names can be crosswalked. LSD applied these new protocols to simplify naming or geographically restrain to individual regions some of the previously named alliances and associations listed online at NatureServe Explorer (www.natureserve.org). LSD also created many new alliances and associations when warranted by field data, and maintained the correspondences needed to crosswalk them.

3.6.4 Associations

The association is the finest level of the hierarchy, and the basic unit for vegetation classification in North America. It is a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy. Associations may occur at variable spatial scales. The variation is driven by the steepness of the environmental gradients and patterning of disturbance processes across the landscape.

The same association can occur at different scales under different environmental and disturbance conditions. Uniformity of physiognomy and habitat conditions may include patterned fine-scale heterogeneity. An example on the LPP Project would be the *Atriplex canescens* / *Pleuraphis jamesii* Shrub Herbaceous Association, where the shrub, *Atriplex canescens*, is scattered at less than 10 percent cover, but the dominant species is a grass, *Pleuraphis jamesii,* at over 10 percent cover. Associations use the same naming conventions as alliances. Typically the word “association” is left off the type name.

3.6.5 Physiognomic Classes

Along with proper taxonomic identification of the dominant and diagnostic plants necessary to name an alliance or association, determination of its physiognomic class is essential to proper classification. Physiognomy refers to the growth form of a plant. Woodlands and forests must be dominated by trees over 5 meters tall. Shrublands must be dominated by shrubs (or medium trees) between 0.5 to 5 meters tall or tall shrubs 1.8 to 5 meters tall. Dwarf-shrublands are dominated by dwarf-shrubs (and low or ground shrubs and low or ground trees) under 0.5 meter tall. Canopy cover of trees must be determined to identify forests (60-100 percent cover) versus woodlands (25-60 percent cover) versus sparse woodlands (10-25 percent cover). Canopy cover of shrubs determines shrublands or dwarf-shrublands (25-100 percent cover) versus sparse shrublands and sparse dwarf-shrublands (10-25 percent cover). Herbaceous vegetation is between 10 and 100 percent cover. Sparsely Vegetated is defined as greater than 1 percent, and up to 10 percent cover. For associations only, a sparse understory modifier signifies less than 20 percent cover to the understory strata in forests, woodlands and shrublands.

LSD used the following key to determine physiognomic classes in the field:

1 Trees >5m tall 60-100% cover 2

2 Understory <20% cover .... **Sparse Understory Forest** (association level mapping only)

2' Understory =>20% cover .... **Forest**

1' Trees >5m tall less than 60% cover 3

3 25-60% cover of trees >5m tall 4

4 Understory <20% cover .... **Sparse Understory Woodland** (associations level mapping only)

4' Understory =>20% cover .... **Woodland**

3' Trees >5m 0-25% cover 5

5 0-25% cover of any size trees 6

6 25% or more cover of 0.5-5m shrubs AND 10-25% cover of any size trees 7

7 Shrubs average =>0.5m tall .... **Wooded Shrubland**

7' Shrubs average <0.5m tall .... **Wooded Dwarf Shrubland**

6' Less than 25% cover of 0.5-5m tall shrubs AND 0-25% of any size trees 8

8 10-25% cover of trees >5m tall .... **Sparse Woodland**

8' <10% cover of trees >5m tall 9

5' Greater than 25% cover of trees <5m tall 9

9 25-100% cover of 0.5-5m tall woody vegetation 10

10 Understory <20% cover ....
Sparse Understory Shrubland (association level mapping only)

10' Understory =>20% cover .... **Shrubland**

9' less than 25% cover of 0.5-5m tall woody vegetation 11

11 >25% cover of <5m tall woody vegetation .... **Shrubland**

11' 10-25% cover of <5m tall woody vegetation 12

12 10 to 25% cover of 0.5-5m tall woody vegetation
.... **Sparse Shrubland**

12' less than 10% cover of 0.5-5m tall woody vegetation 13

13 25-100% cover of <0.5m tall woody vegetation **Dwarf Shrubland**

13' less than 25% cover of <0.5m tall woody vegetation 14

14 >25% cover of <5m tall woody vegetation .... **Dwarf Shrubland**

14' 10-25% cover of <5m tall woody vegetation 15

15 10-25% cover of <0.5m tall woody vegetation .... **Sparse Dwarf Shrubland**

15' less than 10% cover of <0.5 tall woody vegetation 16

16 >10% cover of herbaceous, perennial vegetation 17

17 1 to 10% cover of any sized trees .... **Wooded Herbaceous Vegetation**

17' 1 to 10% cover of any sized shrub..................................... **Shrub Herbaceous Vegetation**

17'' 0 to 1% cover of any sized trees .... **Herbaceous Vegetation**

16' 0-10% cover of perennial vegetation at peak growing season of a typical year 20

20 >1 to 10% cover of vegetation.. **Sparse Vegetation**

20' 1% cover, or less, of any vegetation at peak growing season in a typical year ....
.... **Non-Vegetated**

3.6.6 Understanding Plant Community Names

At least one species from the dominant and/or uppermost stratum is included in an alliance or association name. In rare cases where the combination of species in the upper and lower strata is strongly diagnostic, species from other strata are included in the name. Species occurring in the same stratum are separated by a hyphen (-), and those occurring in a different strata are separated by a slash (/). Species occurring in the uppermost stratum are listed first, followed successively by those in lower strata. In physiognomic types where there is a dominant herbaceous layer with a scattered woody layer, alliance names can be based on species found in the herbaceous layer and/or the woody layer, whichever is more diagnostic of the type.

Species inconsistently found in occurrences of alliances or associations may be placed in parentheses. These parenthetical names are generally listed alphabetically. In cases where a particular genus is dominant or diagnostic, but the presence of individual species of the genus may vary among occurrences, only the specific epithets are placed in parentheses. An example is *Pinus monophylla* - (*Juniperus osteosperma*) Woodland, where higher elevation ensembles lack *Juniperus osteosperma*.

In cases where diagnostic species are unknown or in question, a more general term (e.g., "Mixed Desert Scrub") is currently allowed as a "placeholder". A substrate term (e.g., "Gypsum Badlands"), or one that is descriptive of the height of the vegetation (e.g., "Dwarf"), can also be used as a modifier when such a term is necessary to adequately characterize the alliance or association. NVCS permits the use of geographic region modifiers, like *Artemisia filifolia* Colorado Plateau Shrubland. Rather than implement a wholesale change and regionally modify associations, this report simply classifies them under the Great Basin, Mohave Desert, or Colorado Plateau region. Thus, some alliances and association may appear under more than one region, even if there isn't a significant difference in the species composition between regions.

With few exceptions, the authority for vascular plant species nomenclature in alliance and association names follows the nationally standardized Kartesz list. It is maintained by the US Department of Agriculture in their online Plants Database (http://plants.usda.gov/). In the LPP Project, the Kartesz list was followed for all other applications of botanical nomenclature, with the exceptions of recognizing *Pediocactus sileri* as distinct from *Sclerocactus sileri* and *Pediomelum epipsilum* rather than *Pediomelum megalanthum* var. *epipsilum*.

In many cases previously described alliances or associations may have been too narrowly defined to account for the physiognomy in early or later seral stages. Upon review of the 4,750 typed polygons within the survey area, the gaps in the NVS classification were apparent. Also, the endemic flora of the study area produced some unique alliances and associations, especially on gypsum badlands. Thus, to meet project needs and based on field data, new plant community types were named.

Chapter 4
Vegetation Communities

4.1 Ecological Systems

The following section details all of the ecological systems identified during the 2009 and 2010 field seasons. These ecological systems are first organized by ecological region – Colorado Plateau, Great Basin, and Mohave Desert; then within each of these ecological regions the representative ecological systems are listed alphabetically. Each ecological system description includes geographic distribution, alliances and associations (with acreage), physiognomy and composition, disturbance regimes, relationship to the US National Vegetation Classification (NVC) System, and a map depicting the location of the ecological system in relation to the entire LPP survey area. For reference, a map of the three ecological regions is included above in Chapter 2 (Map 2-2). A map that includes all place names and MWH reaches referenced in the descriptions below is provided in Appendix D. Appendix E contains a series of maps that include the ecological systems found throughout the LPP survey area.

4.2 Colorado Plateau Region

The vast majority of the LPP survey area is classified as Colorado Plateau (18,045 acres of the 21,021 total acres surveyed). The Colorado Plateau extends from Lake Powell west to the Hurricane Cliffs east of Hurricane, Utah (Map 2-2). Here, in the Hurricane area, the Colorado Plateau Region meets up with the Great Basin Region to the north and the Mohave Desert Region to the south.

Within the Colorado Plateau Region of the LPP survey area there are 15 ecological systems, 209 alliances, and 568 associations. Table 4-1 lists the Colorado Plateau Ecological Systems and notes the number of alliances, associations, and acreages for each.

Table 4-1
Colorado Plateau Region

Page 1 of 2

Ecological System	Number of Alliances	Number of Associations	Acreage
Colorado Plateau Active and Stabilized Dune	12	38	839.4
Colorado Plateau Big Sagebrush Shrubland	7	51	3758.5
Colorado Plateau Blackbrush-Mormon-tea Shrubland	10	37	1827.5
Colorado Plateau Grassland	5	6	540.2
Colorado Plateau Greasewood Flat	1	10	185.4
Colorado Plateau Gypsum Badland	24	44	907.2
Colorado Plateau Juniper Savanna	3	3	30.5

Table 4-1
Colorado Plateau Region
Page 2 of 2

Ecological System	Number of Alliances	Number of Associations	Acreage
Colorado Plateau Lower Montane Riparian Woodland and Shrubland	8	13	113.9
Colorado Plateau Mixed Bedrock Canyon and Tableland	27	67	840.8
Colorado Plateau Mixed Desert Scrub	32	104	4328.4
Colorado Plateau Mixed Low Sagebrush Shrubland	2	6	63.6
Colorado Plateau Pinyon-Juniper Woodland	18	70	2415.2
Colorado Plateau Shrub-Steppe	24	61	1919.6
Colorado Plateau Volcanic Rock and Cinder Land	4	5	84.2
Colorado Plateau Wash	32	53	191.0

4.2.1 Colorado Plateau Active and Stabilized Dune Ecological System

4.2.1.1 Geographic distribution

The Colorado Plateau Active and Stabilized Dune Ecological System is predominantly found within the eastern portion of the LPP survey area. The exceptions to this are along Highway 389 both east and west of Cottonwood Wash (west of Fredonia), along Mount Trumbull Road, along Highway 389 west of Mount Trumbull Road, along Highway 389 west of Yellowstone Road, and just south of the Virgin River (near Sheep Bridge Road, east of Hurricane). Within the pipeline corridor this system was found scattered along Highway 89 from the Glen Canyon Dam area to just west of Big Water, as well as near the Paria Canyon area, the Cockscomb area, and Five mile Valley. Within the transmission line corridor this system was found scattered from the Glen Canyon Dam area to the Cockscomb and along both north/ south transmission line corridors near Cedar Mountain (Map 4-1).

4.2.1.2 Alliances and associations

Within the survey area, the Colorado Plateau Active and Stabilized Dune Ecological System is comprised of 12 alliances. The *Artemisia filifolia* Shrubland Alliance is the most common alliance. It consists of 15 associations; the most abundant are the *Artemisia filifolia* Shrubland and the *Artemisia filifolia - Ephedra* (*nevadensis, torreyana, viridis*) Sparse Shrubland. The second most common alliance is the *Ephedra nevadensis* Shrubland Alliance. Woodlands are rather rare on dunes, and primarily dominated by *Juniperus osteosperma Coleogyne ramosissima,* with or without *Ephedra nevadensis* as a co-dominant*,* is infrequent on duneland and restricted to the eastern end of the pipeline and transmission line reaches. This ecological system totals 839.4 acres within the survey area. Acreage by alliance and association is as follows:

Artemisia filifolia **Shrubland Alliance**		**585.4 acres**
Artemisia (filifolia, tridentata) Shrubland	5.8 acres	
Artemisia filifolia - Atriplex canescens - Vanclevea stylosa Shrubland	9.3 acres	
Artemisia filifolia - Atriplex canescens Shrubland	3.2 acres	
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Shrubland	94.3 acres	
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Sparse Shrubland	121.5 acres	
Artemisia filifolia - Ephedra nevadensis - Vanclevea stylosa Shrubland	61.2 acres	
Artemisia filifolia - Gutierrezia sarothrae Shrubland	2.9 acres	
Artemisia filifolia - Tamarix chinensis Semi-natural Shrubland	3.5 acres	
Artemisia filifolia - Vanclevea stylosa Shrubland	50.2 acres	
Artemisia filifolia / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	2.6 acres	
Artemisia filifolia Shrubland	160.1 acres	
Artemisia filifolia Sparse Shrubland	9.4 acres	
Juniperus osteosperma / Artemisia filifolia / (Bromus tectorum, Salsola tragus, Erodium cicutarium) Semi-natural Wooded Shrubland	3.9 acres	
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	1.3 acres	
Juniperus osteosperma / Artemisia filifolia Wooded Shrubland	56.3 acres	
Artemisia filifolia **Sparsely Vegetated Alliance**		**8.1 acres**
Artemisia filifolia Sparse Vegetation	8.1 acres	
Artemisia tridentata **Shrubland Alliance**		**0.4 acres**
Juniperus osteosperma / Artemisia filifolia Wooded Shrubland	0.4 acres	
Coleogyne ramosissima - Ephedra nevadensis **Shrubland Alliance**		**19.3 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	19.3 acres	
Coleogyne ramosissima **Shrubland Alliance**		**2.5 acres**
Coleogyne ramosissima Dwarf-shrubland	2.5 acres	
Ephedra nevadensis **Shrubland Alliance**		**157.5 acres**
Ephedra nevadensis - Gutierrezia sarothrae Sparse Shrubland	7.1 acres	
Ephedra nevadensis - Vanclevea stylosa / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	26.8 acres	
Ephedra nevadensis - Vanclevea stylosa Shrubland	81.8 acres	
Ephedra nevadensis Shrubland	6.7 acres	
Ephedra nevadensis Sparse Shrubland	1.7 acres	
Juniperus osteosperma / Ephedra (torreyana, nevadensis) - Gutierrezia sarothrae Wooded Shrubland	13.2 acres	
Juniperus osteosperma / Ephedra (torreyana, nevadensis) Wooded Shrubland	20.1 acres	
Ephedra nevadensis **Sparsely Vegetated Alliance**		**7.9 acres**
Ephedra nevadensis Sparse Vegetation	7.9 acres	

***Gutierrezia sarothrae* Shrubland Alliance**		**2.1 acres**
Gutierrezia sarothrae Dwarf-shrubland	2.1 acres	
***Juniperus osteosperma* Woodland Alliance**		**33.2 acres**
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	5.1 acres	
Juniperus osteosperma / Artemisia filifolia Woodland	9.7 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Woodland	1.4 acres	
Juniperus osteosperma / Chrysothamnus greenei Woodland	7.5 acres	
Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	1.4 acres	
Juniperus osteosperma Woodland	4.6 acres	
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	3.5 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**1.8 acres**
Pinus edulis - Juniperus osteosperma Woodland	1.8 acres	
Sparse Vegetation		**2.4 acres**
Unclassified		**18.8 acres**

Figure 4-1
Colorado Plateau Active and Stabilized Dune Ecological System

4.2.1.3 Physiognomy and composition

The Colorado Plateau Active and Stabilized Dune Ecological System is most frequently a shrubland, sparse shrubland, or dwarf shrubland (Figure 4-1). Occasionally it is a wooded shrubland, sparse woodland, or woodland.

4.2.1.4 Disturbance regimes

The *Artemisia filifolia* Shrubland Alliance is the typical plant community on both stable and active dunes. *Artemisia filifolia* is an increaser species under artificial disturbances such as grazing, trampling, and OHV trails. It also increases under natural disturbances such as sand deposition from wind erosion. *Artemisia filifolia* Shrubland is a monotypic association, without significant cover by any other shrub. This is due to a long history of disturbances which have led to a reduction in competing species. Severe disturbance can reduce cover to where the *Artemisia filifolia* Shrubland Alliance is a sparse shrubland. Recovery is evident when the canopy cover of *Artemisia filifolia* is less than 25 percent, but various *Ephedra* species gain in cover, eventually bringing the association back over 25 percent total shrub cover.

In eastern Kane County, *Vanclevea stylosa* often co-dominates with *Artemisia filifolia*, *Ephedra nevadensis*, or both on windswept dunes. Under grazing disturbance these shrublands can become semi-natural associations with dominance in the understory by the invasive species *Bromus rubens*, *Erodium cicutarium* or *Salsola tragus*. *Vanclevea stylosa* is absent on dunes with trees.

The *Artemisia filifolia - Ephedra* (*nevadensis*, *torreyana*, *viridis*) Shrubland association is typically a higher diversity plant community which appears to be the most persistent seral stage, given 100-150 years of grazing pressure. Many associations of *Artemisia filifolia - Ephedra* (*nevadensis*, *torreyana*, *viridis*) are sparse shrublands and those with *Ephedra nevadensis* more dominant than *Artemisia filifolia* have *Psoralidium junceum* as common or abundant. *Psoralidium junceum* is likely a decreaser species under grazing disturbance. Thus, *Artemisia filifolia - Ephedra* (*nevadensis*, *torreyana*, *viridis*) Sparse Shrubland associations with common or abundant *Psoralidium junceum*, are probably the least disturbed examples of the Colorado Plateau Active and Stabilized Dune Ecological System. As the shrub canopy for any association in this ecological system increases beyond 25 percent total cover, plant species richness appears to decrease. Thus, maximum plant biodiversity is attained under moderate levels of natural disturbance, such as sand movement from prevailing wind. If the wind is blocked by man-made structures, bodies of water, or drift fencing, decreased species richness and increased shrub cover can be expected.

At higher elevations, *Ephedra viridis* replaces *Ephedra nevadensis* in the *Artemisia filifolia - Ephedra* (*nevadensis*, *torreyana*, *viridis)* Shrubland Alliance. Areas classified as *Ephedra nevadensis* Shrubland Alliance are occasionally transitional to the Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System. The difference is that the sandy soils are dune forming in the Colorado Plateau Active and Stabilized Dune Ecological System and sandsheets in the Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System. That difference is relative and was especially difficult to determine for private lands where the land had to be classified from afar. For most of the surveyed land in the survey area, the presence of *Vanclevea stylosa* is considered diagnostic of sand dunes. Thus, most of the *Ephedra nevadensis* Shrubland Alliance in the Colorado Plateau Active and Stabilized Dune Ecological System has *Vanclevea stylosa* as a co-dominant. A fifth of that acreage is semi-natural land, with *Erodium cicutarium*, *Bromus rubens*, or *Salsola tragus* as the invasive dominant in the understory. Possible reasons for *Vanclevea stylosa* dominance include recolonization after wildfire, and natural revegetation in sand dune blowouts and crests where shrubs have been buried. *Vanclevea stylosa* is likely an increaser under grazing. When disturbed along roadsides, the weedy *Grindelia squarrosa* will increase in dominance and can become abundant.

When under protection from wildfire, higher elevation plant communities in this ecological system may have *Juniperus osteosperma* invade. Plant diversity decreases minimally from the allelopathic influences of junipers when the tree cover is less than 25 percent and shrub cover is over 25 percent. Such areas are classified as wooded shrublands. These shrublands can occur with a variety of understory dominants, including *Artemisia filifolia* or *Ephedra nevadensis* and disturbance indicators *Gutierrezia sarothrae* or (rarely) *Artemisia tridentata*. Under grazing pressure, semi-natural woodlands can occur with invasive understory herbs and grasses like *Erodium cicutarium*, *Bromus rubens*, or *Salsola tragus.*

Juniperus osteosperma is an uncommon tree canopy dominant in this ecological system. As *Juniperus osteosperma* invades a duneland at the higher elevations of the survey area, plant communities pass through the various wooded shrubland seral stages to a *Juniperus osteosperma* Woodland Alliance. The canopy cover of trees (including *Pinus edulis*) can be either 10-25 percent in sparse woodlands or over 25 percent in woodlands. It always exceeds the shrub cover which is occasionally absent, but more typically dominated by either *Artemisia filifolia* or *Chrysothamnus greenei*. Understory dominance by grasses represents a seral stage in good or excellent range condition and is discussed under the Colorado Plateau Juniper Savanna Ecological System.

Replacing *Artemisia filifolia* in some lower altitude areas of the Colorado Plateau is *Coleogyne ramosissima*. The *Coleogyne ramosissima - Ephedra nevadensis* Dwarf-shrubland Alliance solely consists of the *Coleogyne ramosissima - Ephedra nevadensis* Dwarf-shrubland association. This alliance is best suited to more stable dunes.

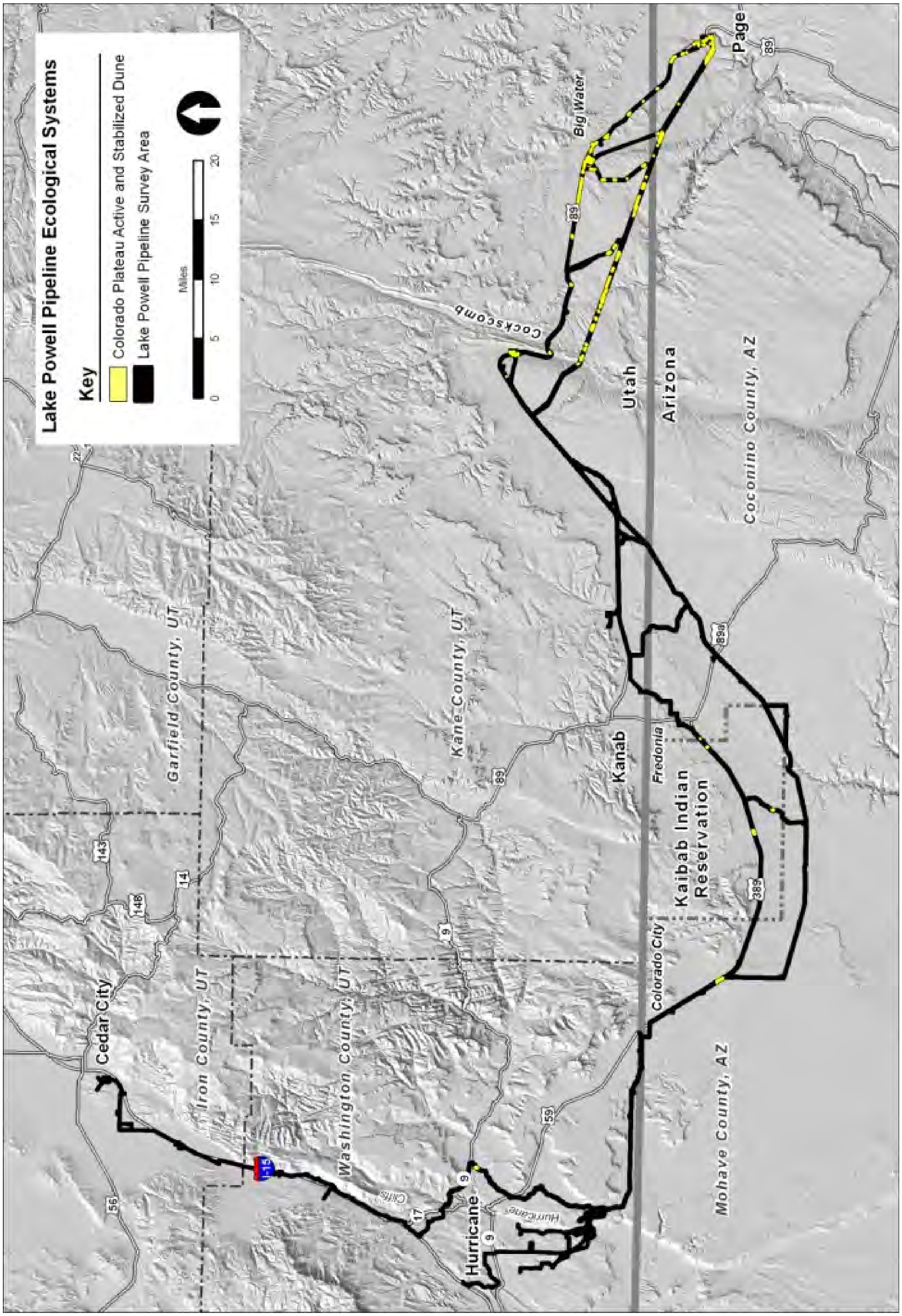
Where the dunes are active, *Ephedra nevadensis* can outcompete *Coleogyne ramosissima* in growth rate, thus staying above building dune crests.

The *Gutierrezia sarothrae* Shrubland Alliance is represented by a rarely occurring dwarf-shrubland association on dunes. There are insufficient occurrences to determine its disturbance regime although *Gutierrezia sarothrae* is an increaser under grazing. Sparsely vegetated alliances with *Artemisia filifolia* or *Ephedra nevadensis* dominance are also rare, with insufficient occurrences to determine disturbance regimes.

4.2.1.5 Relationship to the US National Vegetation Classification System

NatureServe's Inter-Mountain Basins Active and Stabilized Dune Ecological System crosswalks to three regionalized ecological systems for the LPP survey area: Great Basin Active and Stabilized Dunes, Mohave Desert Active and Stabilized Dunes, and Colorado Plateau Active and Stabilized Dunes. None of these regionalized systems include the concept behind NatureServe's Southern Colorado Plateau Sand Shrubland, which is a sandsheet landform difficult to differentiate from either dunelands or the mixed-textured soils of bajadas. Plant communities in which *Artemisia filifolia* dominates or co-dominates, but which do not occur on dunes, were typically placed into the Colorado Plateau Mixed Desert Scrub or Colorado Plateau Wash Ecological Systems.

Three of the alliances and eight of the associations in The Colorado Plateau Active and Stabilized Dune Ecological System required minor name changes from types previously described in the US NVC. Two alliances and 25 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-1
Colorado Plateau Active and Stabilized Dune Ecological System

4.2.2 Colorado Plateau Big Sagebrush Shrubland Ecological System

4.2.2.1 Geographic distribution

The Colorado Plateau Big Sagebrush Shrubland Ecological System is found predominantly within the central portion of the LPP survey area. Occurrences were documented from the Cockscomb in the east to the Hurricane Cliffs in the west. The areas of greatest concentration for Big Sagebrush Shrubland are along Highway 89 from just west of the Cockscomb to Fredonia and the southest corner of the Kaibab Indidan Reservation.There are other more minor occurrences near Colorado City and just east of the Hurricane Cliffs (Map 4-2).

4.2.2.2 Alliances and associations

Within the survey area, the Colorado Plateau Big Sagebrush Shrubland Ecological System is comprised of seven alliances. Three of those are Big Sagebrush alliances, with naming variations dependent on the subspecies. When the subspecies was not determined, the alliance is simply named *Artemisia tridentata* Shrubland Alliance. Where the *Artemisia tridentata* subspecies was determined, the alliance was either the *Artemisia tridentata* ssp. *tridentata* Shrubland Alliance or the *Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance.

There are several alliances with minor acreages which best fit into Colorado Plateau Big Sagebrush Shrubland Ecological System. These include the *Amelanchier utahensis* Shrubland Alliance on talus slopes; the *Ericameria nauseosa* Shrubland Alliance of disturbed areas, and the *Salsola tragus* Semi-natural Herbaceous Alliance along roadsides and disturbed areas.

This ecological system totals 3,758.5 acres within the survey area. Acreage by alliance and association is as follows:

Amelanchier utahensis **Shrubland Alliance**		**1.1 acres**
Amelanchier utahensis Shrubland	1.1 acres	
Artemisia filifolia **Shrubland Alliance**		**49.3 acres**
Artemisia filifolia - Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae / (Salsola tragus, Erodium cicutarium) Semi-natural Shrubland	26.6 acres	
Artemisia filifolia - Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Shrubland	22.7 acres	
Artemisia tridentata **Shrubland Alliance**		**763.5 acres**
Artemisia (filifolia, tridentata) / Pleuraphis jamesii Shrubland	112.5 acres	
Artemisia tridentata - Atriplex confertifolia Shrubland	1.5 acres	
Artemisia tridentata - Ephedra viridis Shrubland	6.7 acres	
Artemisia tridentata - Ericameria nauseosa Shrubland	31.7 acres	
Artemisia tridentata - Gutierrezia sarothrae / Sparse Understory Shrubland	3.4 acres	
Artemisia tridentata - Gutierrezia sarothrae Shrubland	25.4 acres	
Artemisia tridentata - Gutierrezia sarothrae Sparse Shrubland	16.7 acres	
Artemisia tridentata / (Erodium cicutarium, Salsola tragus, Ceratocephala testiculata, Bromus (rubens, tectorum)) Semi-natural Shrubland	42.5 acres	

Artemisia tridentata / (Erodium cicutarium, Salsola tragus, Ceratocephala testiculata, Bromus (rubens, tectorum)) Semi-natural Sparse Shrubland	63.8 acres	
Artemisia tridentata / Pleuraphis jamesii / Sandstone Outcrop Sparse Shrubland	6.2 acres	
Artemisia tridentata / Pleuraphis jamesii Shrubland	45.9 acres	
Artemisia tridentata / Sparse Understory Shrubland	301.9 acres	
Artemisia tridentata Shrubland	97.6 acres	
Artemisia tridentata ssp. vaseyana / (Erodium cicutarium, Salsola tragus, Lolium perenne) Semi-natural Sparse Shrubland	7.7 acres	
***Artemisia tridentata ssp. tridentata* Shrubland Alliance**		**542.0 acres**
Artemisia tridentata ssp. tridentata - Ericameria nauseosa Shrubland	14.6 acres	
Artemisia tridentata ssp. tridentata - Tamarix chinensis Semi-natural Shrubland	16.2 acres	
Artemisia tridentata ssp. tridentata / (Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	1.4 acres	
Artemisia tridentata ssp. tridentata / (Erodium cicutarium, Salsola tragus) Semi-natural Sparse Shrubland	5.5 acres	
Artemisia tridentata ssp. tridentata / Sparse Understory Shrubland	368.8 acres	
Artemisia tridentata ssp. tridentata Shrubland	105.8 acres	
Artemisia tridentata ssp. tridentata Sparse Shrubland	11.4 acres	
Juniperus osteosperma / Artemisia tridentata ssp. tridentata Wooded Shrubland	18.2 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**2306.4 acres**
Artemisia (tridentata ssp. vaseyana, nova) Shrubland	11.7 acres	
Artemisia (tridentata ssp. vaseyana, nova) Sparse Shrubland	11.6 acres	
Artemisia tridentata ssp. tridentata Shrubland	1.9 acres	
Artemisia tridentata ssp. vaseyana - Chrysothamnus greenei Shrubland	24.1 acres	
Artemisia tridentata ssp. vaseyana - Coleogyne ramossissima Shrubland	19.3 acres	
Artemisia tridentata ssp. vaseyana - Ephedra nevadensis Shrubland	11.3 acres	
Artemisia tridentata ssp. vaseyana - Ericameria nauseosa Shrubland	9.1 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae / (Pleuraphis jamesii, Sporobolus cryptanthus) Shrubland	40.0 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae / (Pleuraphis rigida, Bouteloua gracilis) Sparse Shrubland	8.0 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae / Sparse Understory Shrubland	91.0 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Shrubland	118.9 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Sparse Shrubland	9.2 acres	
Artemisia tridentata ssp. vaseyana / (Erodium cicutarium, Salsola tragus, Lolium perenne) Semi-natural Shrubland	108.6 acres	
Artemisia tridentata ssp. vaseyana / (Erodium cicutarium, Salsola tragus, Lolium perenne) Semi-natural Sparse Shrubland	79.0 acres	

Artemisia tridentata ssp. vaseyana / (Pleuraphis jamesii, Hesperostipa comata ssp. comata) Shrubland	75.9 acres	
Artemisia tridentata ssp. vaseyana / Agropyron desertorum Semi-natural Shrubland	14.2 acres	
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Shrubland	39.4 acres	
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Sparse Shrubland	1.8 acres	
Artemisia tridentata ssp. vaseyana / Pleuraphis rigida - (Erodium cicutarium, Salsola tragus, Lolium perenne) Semi-natural Shrubland	6.8 acres	
Artemisia tridentata ssp. vaseyana / Sparse Understory Shrubland	802.7 acres	
Artemisia tridentata ssp. vaseyana Shrubland	784.8 acres	
Artemisia tridentata ssp. vaseyana Sparse Shrubland	37.3 acres	
***Ericameria nauseosa* Shrubland Alliance**		**1.4 acres**
Ericameria nauseosa Shrubland	1.4 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**94.9 acres**
Artemisia tridentata / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	27.8 acres	
Artemisia tridentata ssp. tridentata / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	26.3 acres	
Artemisia tridentata ssp. vaseyana / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	40.8 acres	

Figure 4-2
Colorado Plateau Big Sagebrush Shrubland Ecological System

4.2.2.3 Physiognomy and composition

The Colorado Plateau Big Sagebrush Shrubland Ecological System is primarily shrubland or sparse shrubland (Figure 4-2). Occasionally it is a sparse understory shrubland or shrub herbaceous vegetation. Wooded shrubland is rare. Sparse woodland communities only occur in a mosaic with sparse shrublands.

4.2.2.4 Disturbance regimes

Artemisia tridentata increases under grazing disturbance and fire suppression. It dominates in a long-lived seral stage where shrub cover progressively increases over 75-100 years and shades out the understory. However, it is subject to invasion by *Juniperus osteosperma* and ultimately *Pinus edulis*. *Artemisia tridentata* dominated communities represent an intermediate seral stage in disturbed areas of both *Pinus monophylla – Juniperus osteosperma* and *Pinus edulis – Juniperus osteosperma* woodland. These disturbances include logging, wildfire, and chaining.

Artemisia tridentata ssp. *vaseyana* is a preferred browse subspecies among various *Artemisia tridentata* subspecies, although there was no evidence of it decreasing in the survey area from native ungulate browsing. When burned in the survey area, *Artemisia tridentata* is replaced by *Ericameria nauseosa*, *Gutierrezia sarothrae,* and *Chrysothamnus greenei*.

Pleuraphis jamesii is a decreaser under grazing. It more often dominates the understory in *Artemisia tridentata* ssp. *vaseyana* communities versus *Artemisia tridentata* ssp. *tridentata,* where it is classified as the *Artemisia tridentata* ssp. *tridentata* / *Pleuraphis jamesii* Shrubland association. Additional decreaser grasses can dominate the understory individually or in combination, such as *Sporobolus cryptandrus*, *Hesperostipa comata*, *Bouteloua gracilis*, and *Achnatherum parishii*.

Gutierrezia sarothrae, *Ericameria nauseosa,* and rarely *Atriplex canescens* are increasers in this ecological system. *Gutierrezia sarothrae* and *Ericameria nauseosa* dominate in abandoned agricultural fields, cleared woodlands, depleted pastures, and burned rangeland. *Ericameria nauseosa* is adapted to disturbance and sandy soils. Over time and in the absence of disturbance, *Gutierrezia sarothrae and Ericameria nauseosa* would be replaced by *Artemisia tridentata* or *Artemisia filifolia*, depending on depth of the sand. *Gutierrezia sarothrae* and *Chrysothamnus greenei* are typical of overgrazed rangelands which may have been burned or chained to increase forage production. Severe disturbance results in a number of invasive species which can co-dominate. These are classified as semi-natural associations. Foremost among them would be *Tamarix chinensis* which can co-dominate with *Artemisia tridentata* ssp. *tridentata* near dry washes. Herbaceous invasives include *Salsola tragus*, *Erodium cicutarium*, *Bromus tectorum*, and *Ceratocephala testiculata*. The disturbances leading to their dominance include siltation from flash flooding, soil erosion, trampling, over grazing, and wildfire. These invasives can dominate monotypic *Artemisia tridentata* shrublands and sparse shrublands, or may co-dominate with increaser shrubs such as *Gutierrezia sarothrae, Chrysothamnus greenei,* and *Ericameria nauseosa*. *Juniperus osteosperma* is an increaser under fire suppression. Drought limits its invasion of low elevation communities of *Artemisia tridentata*. Once communities attain more tree cover than shrub cover, they are classified as a Colorado Plateau Pinyon-Juniper Woodland Ecological System. Chaining and chopping are used in and adjacent to the LPP survey area to control juniper invasion. By maintaining this ecological system (and the Colorado Plateau Low Sagebrush Ecological System), these management practices (chaining and chopping) increase deer winter range browse (AGFD 2009) and prevent tree encroachment on transmission lines, respectively.

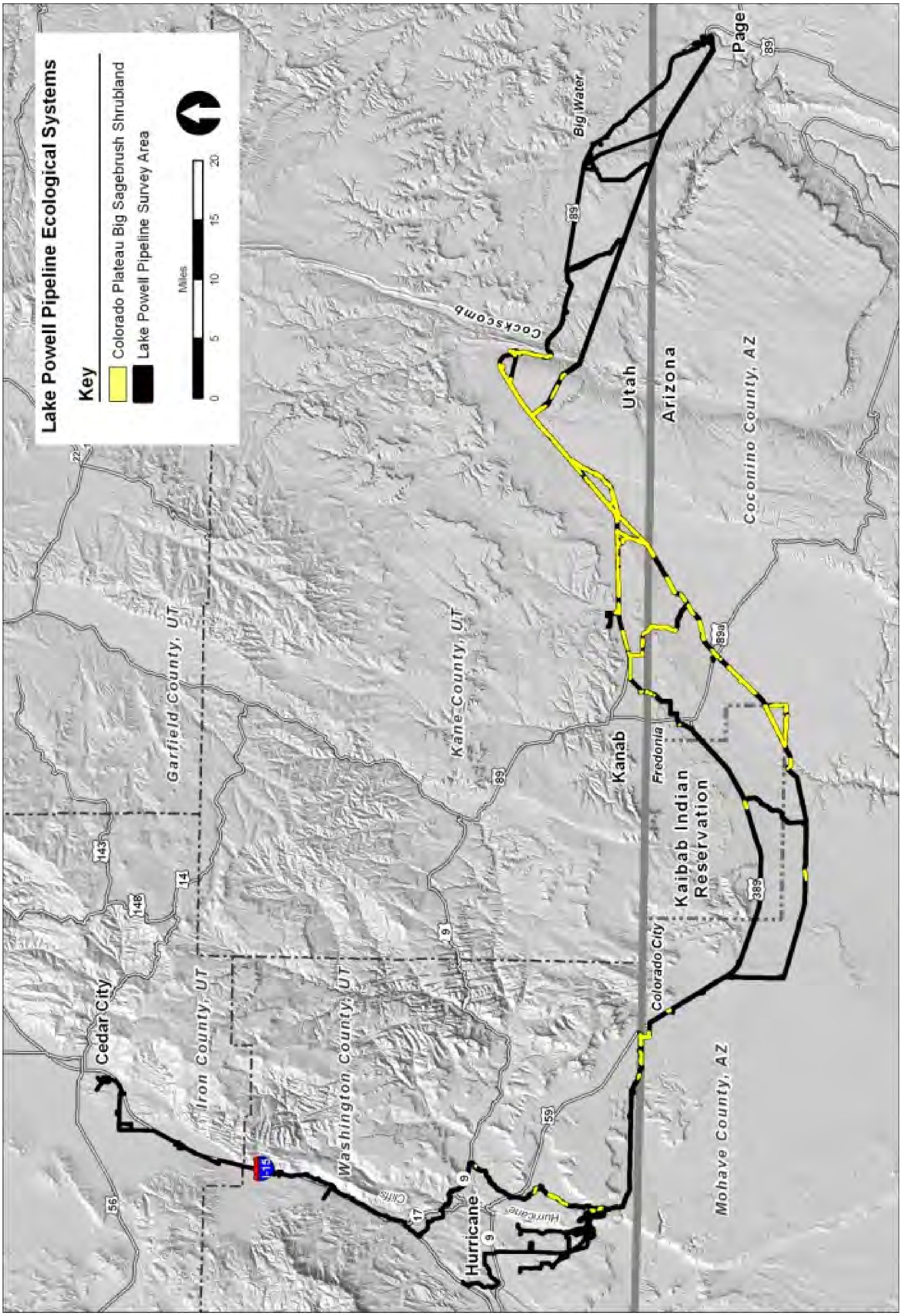
4.2.2.5 Relationship to the US National Vegetation Classification System

The various *Artemisia tridentata* dominated alliances readily crosswalk to NatureServe's Inter-Mountain Basins Big Sagebrush Shrubland Ecological System.

The Colorado Plateau Big Sagebrush Shrubland Ecological System includes a number of alliances and associations dominated by species other than *Artemisia tridentata.* The *Ericameria nauseosa* Shrubland Alliance and its three associations crosswalk to NatureServe's Inter-Mountain Basins Big Sagebrush Shrubland Ecological System. So do the three associations with various subspecies of *Artemisia tridentata* in the *Salsola tragus* Semi-natural Shrub Herbaceous Alliance.

The *Amelanchier utahensis* Shrubland Alliance, with its *Amelanchier utahensis* Shrubland association, crosswalks to NatureServe's Rocky Mountain Lower Montane-Foothill Shrubland Ecological System. Within the Colorado Plateau Region of the LPP survey area, *Amelanchier utahensis* occurs with *Artemisia tridentata* on talus slopes.

One alliance and eight associations in this ecological system required minor name changes from types previously described in the US NVC. One alliance and 18 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-2
Colorado Plateau Big Sagebrush Shrubland Ecological System

4.2.3 Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System

4.2.3.1 Geographic distribution

The Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System is found in three distinct areas within the LPP survey area. Within the eastern portion of the survey area, Blackbrush-Mormon-tea Shrubland occurs along both the pipeline corridor and the transmission line corridor from the Glen Canyon Dam area west to the Cockscomb area. In the central protion of the survey area it was documented along Highway 389 near Yellowstone Road, along Yellowstone Road, and along the southern transmission line corridor. In the western portion of the survey area, Blackbrush-Mormon-tea Shrubland occurs along the Honeymoon Trail, and Forebay and north to LaVerkin Creek (Map 4-3).

4.2.3.2 Alliances and associations

Within the survey area, the Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System is comprised of 10 alliances. The most common is the *Coleogyne ramosissima* Shrubland Alliance.

Various *Ephedra* dominated alliances are nearly as common as the *Coleogyne ramosissima* Shrubland Alliance; the *Ephedra nevadensis* Shrubland Alliance is most abundant, including eight associations. The mixed *Ephedra nevadensis - Ephedra torreyana* communities include two physiognomy types: the *Ephedra nevadensis - Ephedra torreyana* Shrubland Alliance and the *Ephedra nevadensis - Ephedra torreyana* Sparse Shrubland Alliance. Two of the three *Ephedra* species in the LPP survey area are individually recognized as alliances: the *Ephedra nevadensis* Shrubland Alliance and the *Ephedra torreyana* Shrubland Alliance. *Ephedra viridis* is co-dominant in the *Ephedra nevadensis - Ephedra viridis* Shrubland Alliance.

The *Artemisia filifolia* Shrubland Alliance is found on disturbed sandsheet habitat. The other alliance that is associated with disturbance is the *Chrysothamnus viscidiflorus* Shrubland Alliance.

This ecological system totals 1,827.5 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**123.9 acres**
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Shrubland	102.2 acres	
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Sparse Shrubland	21.7 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**16.6 acres**
Chrysothamnus viscidiflorus - Ephedra (torreyana, nevadensis) Shrubland	16.6 acres	
***Coleogyne ramosissima* - Ephedra nevadensis Shrubland Alliance**		**4.1 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	4.1 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**807.4 acres**
Coleogyne ramosissima - Artemisia filifolia Shrubland	15.0 acres	
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	7.3 acres	
Coleogyne ramosissima - Ephedra nevadensis Shrubland	90.8 acres	
Coleogyne ramosissima - Ephedra viridus Shrubland	17.5 acres	

Coleogyne ramosissima - Ephedra viridus Sparse Shrubland	19.5 acres	
Coleogyne ramosissima - Eriogonum corymbosum Shrubland	8.6 acres	
Coleogyne ramosissima - Fallugia paradoxa / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	1.8 acres	
Coleogyne ramosissima - Gutierrezia sarothrae Dwarf-shrubland	12.4 acres	
Coleogyne ramosissima - Gutierrezia sarothrae Shrubland	114.8 acres	
Coleogyne ramosissima - Gutierrezia sarothrae Sparse Shrubland	15.3 acres	
Coleogyne ramosissima - Hymenoclea salsola Shrubland	6.5 acres	
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Dwarf-shrubland	5.6 acres	
Coleogyne ramosissima / (Sporobolus cryptandrus, Pleuraphis rigida) Sparse Shrubland	18.0 acres	
Coleogyne ramosissima Dwarf-shrubland	55.5 acres	
Coleogyne ramosissima Shrubland	410.6 acres	
Coleogyne ramosissima Sparse Dwarf-shrubland	5.7 acres	
Juniperus osteosperma / Coleogyne ramosissima Wooded Shrubland	2.6 acres	
***Ephedra (nevadensis, torreyana)* Shrubland Alliance**		**173.7 acres**
Ephedra nevadensis - Ephedra torreyana Shrubland	106.1 acres	
Ephedra nevadensis - Ephedra torreyana Sparse Shrubland	67.7 acres	
***Ephedra nevadensis - Ephedra viridis* Shrubland Alliance**		**42.3 acres**
Ephedra nevadensis - Ephedra viridis Shrubland	42.3 acres	
***Ephedra nevadensis* Shrubland Alliance**		**424.8 acres**
Ephedra nevadensis - Gutierrezia sarothrae Dwarf-shrubland	26.5 acres	
Ephedra nevadensis - Gutierrezia sarothrae Shrubland	67.1 acres	
Ephedra nevadensis - Gutierrezia sarothrae Sparse Shrubland	30.9 acres	
Ephedra nevadensis - Vanclevea stylosa Shrubland	8.8 acres	
Ephedra nevadensis / (Erodium cicutarium, Bromus rubens) Semi-natural Sparse Shrubland	107.2 acres	
Ephedra nevadensis / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	43.1 acres	
Ephedra nevadensis Shrubland	89.0 acres	
Ephedra nevadensis Sparse Shrubland	52.2 acres	
***Ephedra torreyana* Shrubland Alliance**		**118.3 acres**
Ephedra torreyana - Psorothamnus fremontii Shrubland	100.7 acres	
Ephedra torreyana Shrubland	8.8 acres	
Ephedra torreyana Sparse Shrubland	8.8 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**8.2 acres**
Coleogyne ramosissima / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	8.2 acres	
Unclassified		**108.2 acres**

Figure 4-3
Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System

4.2.3.3 Physiognomy and composition

The Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System is commonly shrubland, sparse shrubland, or dwarf-shrubland; occasionally sparse dwarf shrubland (Figure 4-3). It is rarely wooded shrubland, shrub herbaceous vegetation, or a mosaic of shrubland/dwarf-shrubland.

4.2.3.4 Disturbance regimes

Within the LPP survey area, *Artemisia filifolia* and *Hymenoclea salsola* are increaser species under prolonged grazing disturbance in the Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System. *Hymenoclea salsola* infrequently dominates on grazed land with *Coleogyne ramosissima* as co-dominant. *Artemisia filifolia* is especially adapted to sandsheet habitat and would tend to increase in dominance over *Ephedra* sp. where there is soil erosion, blowouts, or heavy grazing. However, *Ephedra nevadensis* is co-dominant in all Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System occurrences of the *Artemisia filifolia* Shrubland Alliance within the LPP survey area. This suggests that the *Artemisia filifolia* Shrubland Alliance within this ecological system may represent a more disturbed seral stage of the *Ephedra nevadensis* Shrubland Alliance. Grasses which decrease under grazing pressure include *Hesperostipa comata*, *Bouteloua gracilis*, and *Sporobolus cryptandrus*. *Bouteloua eriopoda* is only common in the *Artemisia filifolia* Shrubland Alliance, and *Pleuraphis jamesii* is locally dominant in the *Coleogyne ramosissima* / (*Sporobolus cryptandrus*, *Pleuraphis jamesii*) Sparse Shrubland association.

Another alliance of disturbed land in this ecological system is the *Chrysothamnus viscidiflorus* Shrubland Alliance. Only included in this ecological system are those occurrences where *Chrysothamnus viscidiflorus* co-dominates with an *Ephedra* species. Especially degraded occurrences of this alliance will also have *Ericameria nauseosa* or *Gutierrezia sarothrae* as a dominant and reduced coverage of *Pleuraphis jamesii* and *Hesperostipa comata*.

The *Coleogyne ramosissima* Shrubland Alliance is very common within this ecological system. Younger communities will typically be dwarf shrublands (less than 1.6 feet [0.5 meters] tall) and older communities will be shrublands (greater than or equal to 1.6 feet [0.5 meters] tall). Shallow or rocky soils may only support dwarfed, but otherwise mature *Coleogyne ramosissima* under 1.6 feet (0.5 meters) tall. This association typically has *Coleogyne ramosissima* as the sole dominant. *Gutierrezia sarothrae* and *Ephedra nevadensis* are occasionally co-dominant, with the former as an increaser under fire or grazing. Other infrequent co-dominants include *Artemisia filifolia* (on sandy soils), *Eriogonum corymbosum*, and *Ephedra viridus*. The *Coleogyne ramosissima* Sparse Shrubland can represent a disturbed seral stage when co-dominated by *Gutierrezia sarothrae*. Associations in good or excellent range condition will have *Sporobolus cryptandrus* co-dominant. Co-dominance by *Coleogyne ramosissima* and *Ephedra nevadensis* represents better range quality than communities dominated solely by *Coleogyne ramosissima*, an intermediate type to an *Ephedra nevadensis* Shrubland. The dynamics of *Coleogyne ramosissima* and *Ephedra nevadensis* in relation to each other requires further study. In *Ephedra nevadensis* Shrublands, major decreaser species include *Pleuraphis jamesii*, *Sporobolus cryptandrus*, *Hesperostipa comata*, and *Bouteloua gracilis*. Increaser species include *Gutierrezia sarothrae* and *Vanclevea stylosa.* Invasive herbaceous species include *Erodium cicutarium*, *Bromus tectorum, Bromus rubens*, and *Salsola tragus*. Young communities will be dwarf shrublands, maturing to shrublands where site conditions are favorable. Canopy cover increases as communities recover from disturbance. Early seral sites are typically shrub herbaceous vegetation, sparse shrublands, or dwarf shrublands.

Coleogyne ramosissima co-dominates with *Ephedra nevadensis* in shrubland/dwarf shrubland mosaics. Both species have far more cover than any other plant in these communities. These may be earlier seral stages than *Coleogyne ramosissima* Shrublands. Another mixed community is the *Ephedra nevadensis - Ephedra torreyana* Shrubland Alliance. It is a more advanced seral stage than the *Ephedra nevadensis - Ephedra torreyana* Sparse Shrubland Alliance, except where the latter is on poor soils. Rarely will *Pleuraphis jamesii* co-dominate as a decreaser grass under grazing.

Another *Ephedra* type is the *Ephedra torreyana* Shrubland Alliance. The highest quality range condition association is the *Ephedra torreyana / Pleuraphis jamesii* Shrubland, which is classified in the Colorado Plateau Shrub-Steppe Ecological System. Rarely does *Psorothamnus fremontii* co-dominate with *Ephedra torreyana* in shrublands.

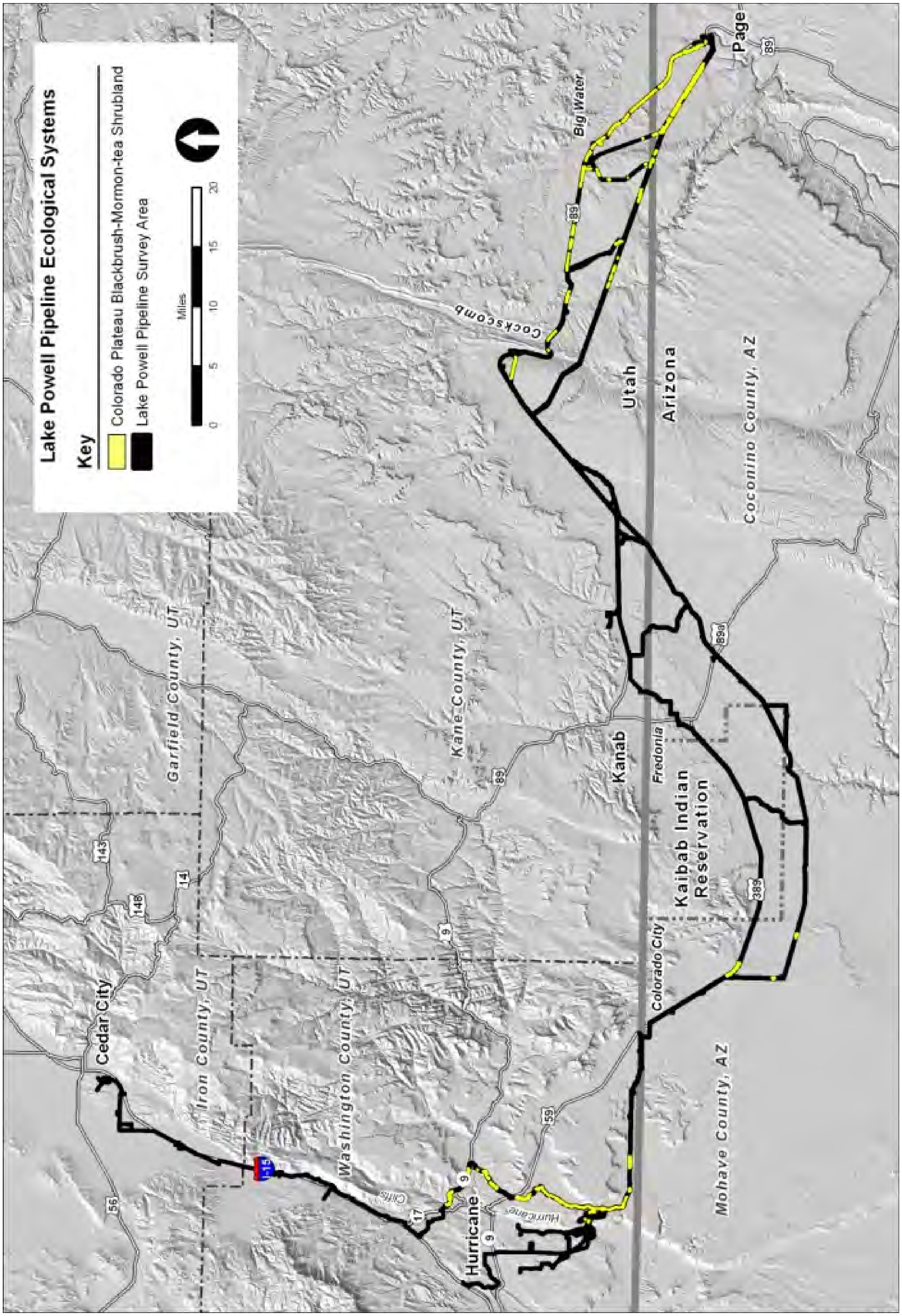
The *Ephedra viridis* Shrubland Alliance is rather rare in the LPP survey area and contains the highest elevational range *Ephedra* among the three *Ephedra* species. Where *Ephedra viridis* is the dominant shrub in a shrub herbaceous vegetation association, it is classified as either in the Colorado Plateau Mixed Bedrock Canyon and Tableland or Colorado Plateau Shrub-Steppe Ecological System.

The *Chrysothamnus viscidiflorus* Shrubland Alliance may be a historically burned remnant of a *Coleogyne ramosissima* Shrubland Alliance. Rangelands dominated by *Coleogyne ramosissima* underwent widespread burning in the late 1940s in an effort to change their dominance to something more palatable and productive for cattle (see also Colorado Plateau Mixed Desert Scrub). The most degraded communities are classified as the *Coleogyne ramosissima* / (*Erodium cicutarium*, *Bromus rubens*, *Bromus tectorum*, *Salsola tragus*) Semi-natural Sparse Dwarf-shrubland. Conversely, the highest range quality is represented by the *Coleogyne ramosissima / Pleuraphis jamesii* Shrubland and the *Ephedra torreyana / Pleuraphis jamesii* Shrubland, which are classified within the Colorado Plateau Shrub-Steppe Ecological System. *Pleuraphis jamesii* more commonly dominants the understory of *Coleogyne ramosissima* communities in sparse shrublands on basalt soils in the Colorado Plateau Volcanic Rock and Cinder Land Ecological System. However, it can also occur in on sandsheets in shrublands west of Page, Arizona.

4.2.3.5 Relationship to the US National Vegetation Classification System

The Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System crosswalks directly to NatureServe's Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System. It expands on NatureServe's system by including the early seral *Hymenoclea salsola* Shrubland Alliance and late seral *Juniperus osteosperma* Wooded Shrubland Alliance. It also includes mixed *Artemisia filifolia* and *Ephedra* sp. dominated communities not on sand dunes.

One alliance and eight of the associations in this ecological system required minor name changes from types previously described in the US NVC. Two alliances and 25 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-3
Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System

4.2.4 Colorado Plateau Grassland Ecological System

4.2.4.1 Geographic distribution

The Colorado Plateau Grassland Ecological System has a limited distribution within the LPP survey area. The Grassland Ecological System is found predominatly along Cottonwood Canyon Road, just south of Highway 89 and both east and west of Mount Trumbull Road along the transmission line corridor south of the Kaibab Indian Reservation (Map 4-4).

4.2.4.2 Alliances and associations

Within the survey area, the Colorado Plateau Grassland Ecological System is comprised of five alliances. The ecological system totals 540.2 acres within the survey area. Acreage by alliance and association is as follows:

***Achnatherum hymenoides* Herbaceous Alliance**		**289.3 acres**
Achnatherum hymenoides Herbaceous Vegetation	289.3 acres	
***Bouteloua gracilis* Herbaceous Alliance**		**5.5 acres**
Bouteloua gracilis Herbaceous Vegetation	5.5 acres	
Herbaceous Vegetation		**13.2 acres**
***Hesperostipa comata* Herbaceous Alliance**		**1.3 acres**
Hesperostipa comata Herbaceous Vegetation	1.3 acres	
***Pleuraphis jamesii* Herbaceous Alliance**		**231.0 acres**
Pleuraphis jamesii - (Erodium cicutarium, Bromus tectorum, Salsola tragus) Semi-natural Herbaceous Vegetation	46.8 acres	
Pleuraphis jamesii Herbaceous Vegetation	184.1 acres	

4.2.4.3 Physiognomy and composition

The Colorado Plateau Grassland Ecological System is comprised exclusively of alliances and associations where the herbaceous vegetation is dominated by grasses (Figure 4-4).

Figure 4-4
Colorado Plateau Grassland Ecological System

4.2.4.4 Disturbance regimes

The Colorado Plateau Grassland Ecological System has had a long history of management for livestock forage. Mormon ranchers had taken control of most water sources within the survey area by the 1870s and this vegetation type has been grazed by livestock since that time. Fire has long been a management tool to increase forage production and tends to minimize shrub invasion into what was anecdotally noted as being rich in bunchgrasses (Anderson 1998). However, determining successional states and transitions in this system would require an analysis of historic data.

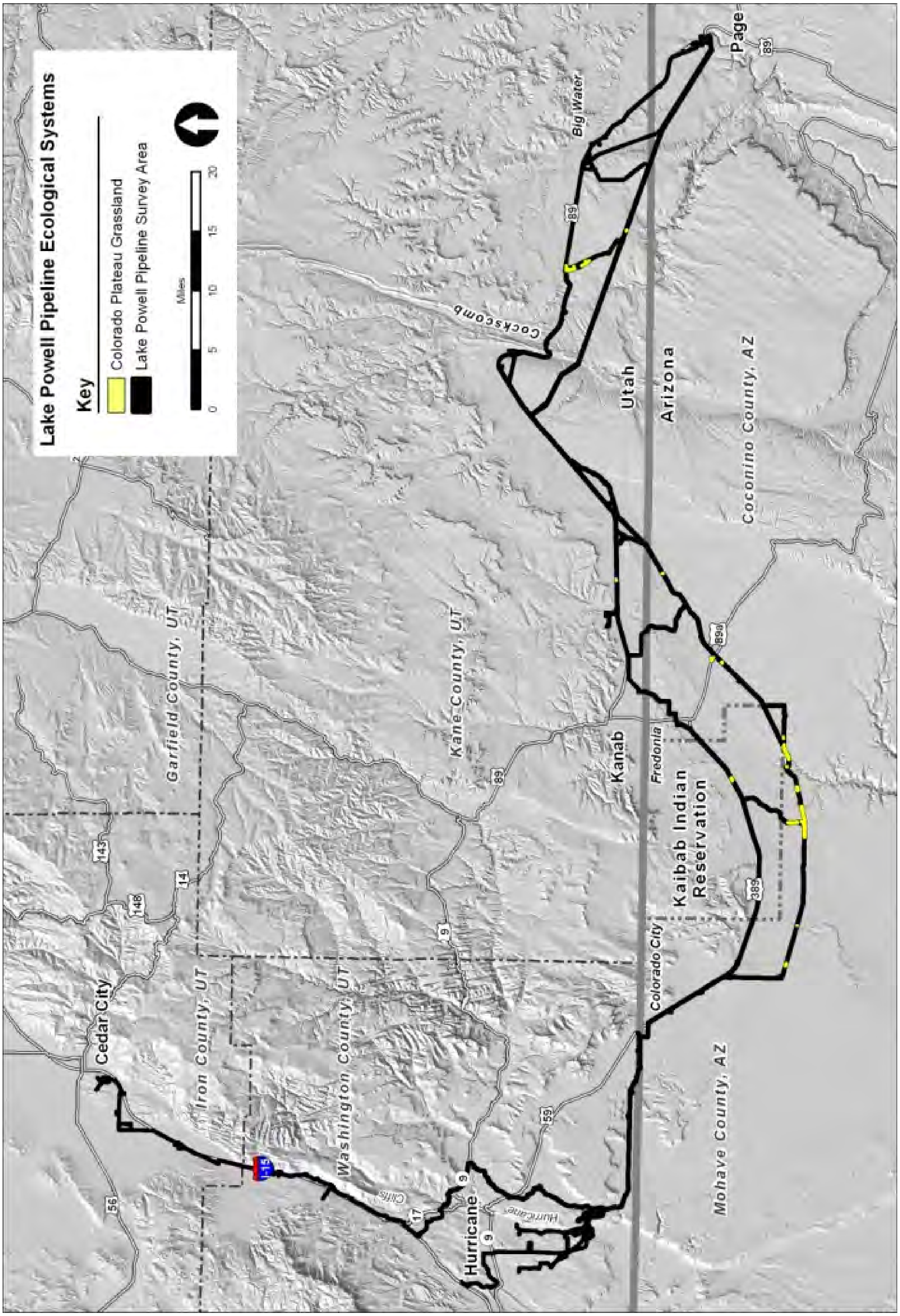
In general, this ecological system has been subjected to overgrazing. Overgrazing decreases palatable grasses such as *Achnatherum hymenoides*, *Bouteloua gracilis*, *Hesperostipa comata*, and *Pleuraphis jamesii*. These four grasses, alone or in combination, are primary components of the Colorado Plateau grasslands in the LPP survey area. Upon overgrazing or excessive burning, less palatable shrubs and invasive herbs will eventually co-dominate. The invasive species include *Salsola tragus* and *Erodium cicutarium*, with *Bromus tectorum* sometimes co-occurring. *Aristida purpurea* is an increaser grass and *Sphaeralcea ambigua* an early seral colonizer of burned range. When the range is reduced to dominance by invasives, the vegetation is then classified as a semi-natural Invasive Upland Vegetation type.

When invasive shrub species *(Lycium pallidum*, *Chrysothamnus viscidiflorus*, or *Chrysothamnus greenei*) represent up to 10 percent cover and herbaceous cover exceeds 10 percent, the community is classified as a shrub herbaceous in the Colorado Plateau Mixed Scrub Ecological System. Once shrubs exceed 10 percent, the community is classified under either the Colorado Plateau Shrub-Steppe or Colorado Plateau Mixed Desert Scrub Ecological System. Shrub-Steppe will typically have greater than 10 percent and up to 25 percent cover of shrubs, with the cover of herbaceous vegetation greater than that of shrubs. Thus, in the absence of fire to control shrub growth in grazed herbaceous vegetation, the successional pathway would be from Colorado Plateau Grassland to Colorado Plateau Shrub-Steppe to Colorado Plateau Mixed Desert Scrub or Big Sagebrush Shrubland.

4.2.4.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Grassland Ecological System is closely allied with the Colorado Plateau Shrub-Steppe Ecological System and, to a lesser extent, sparse shrublands and sparse dwarf shrublands of the Colorado Plateau Mixed Desert Scrub Ecological System. It also is similar to grassy, early seral communities in the Colorado Plateau Big Sagebrush Ecological System. Obtaining data on percent cover of grasses is a very time consuming procedure. Differentiating between 10 and 11 percent cover of grasses versus 10 or 11 percent cover of woody vegetation is arbitrary. Borderline communities can classify either way, depending on the observer and number of points in a sample. The occurrences assigned to this ecological system were done conservatively, with the intention that they have a clear dominance by grasses. That dominance would be obvious on the ground as well as in aerial imagery, where the even, smooth texture of the vegetation is diagnostic.

The Colorado Plateau Grassland Ecological System crosswalks to NatureServe's Intermountain Basins Semi-Desert Grassland, apart from the geographic difference. One alliance and one association in this ecological system required minor name changes from types previously described in the US NVC. One association is a new type for the Colorado Plateau Region, not previously described in the national classification.



Map 4-4
Colorado Plateau Grassland Ecological System

4.2.5 Colorado Plateau Greasewood Flat Ecological System

4.2.5.1 Geographic distribution

The Colorado Plateau Greasewood Flat Ecological System is found sporadically throughout the LPP survey area. It had been documented from as far east as East Cove (east of the Cockscomb) to as far west as Short Creek near Canaan Gap (west of Colorado City). The greatest concentration of greasewood flats occurred near Fredonia; here it was documented on both the east and west sides of Highway 89, where the proposed pipeline crosses the highway (Map 4-5).

4.2.5.2 Alliances and associations

Within the survey area, The Colorado Plateau Greasewood Flat Ecological System is comprised of one alliance, with 10 associations. This ecological system totals 185.4 acres within the survey area. Acreage by alliance and association is as follows:

***Sarcobatus vermiculatus* Shrubland Alliance**		**185.4 acres**
Sarcobatus vermiculatus - Artemisia tridentata / (× Triticosecale rimpuai, Agropyron cristatum) Semi-natural Shrubland	17.4 acres	
Sarcobatus vermiculatus - Artemisia tridentata Shrubland	18.8 acres	
Sarcobatus vermiculatus - Artemisia tridentata Sparse Shrubland	0.9 acres	
Sarcobatus vermiculatus - Atriplex confertifolia / (Salsola tragus, Ceratophylla testulata) Semi-natural Shrubland	13.3 acres	
Sarcobatus vermiculatus - Gutierrezia sarothrae / Salsola tragus Semi-natural Shrubland	43.6 acres	
Sarcobatus vermiculatus - Gutierrezia sarothrae / Salsola tragus Semi-natural Sparse Shrubland	2.6 acres	
Sarcobatus vermiculatus - Gutierrezia sarothrae Shrubland	3.5 acres	
Sarcobatus vermiculatus - Gutierrezia sarothrae Sparse Shrubland	2.2 acres	
Sarcobatus vermiculatus / Salsola tragus Semi-natural Shrubland	12.7 acres	
Sarcobatus vermiculatus Shrubland	70.5 acres	

4.2.5.3 Physiognomy and composition

The Colorado Plateau Greasewood Flat Ecological System is frequently a shrubland, and occasionally a sparse shrubland (Figure 4-5).

4.2.5.4 Disturbance regimes

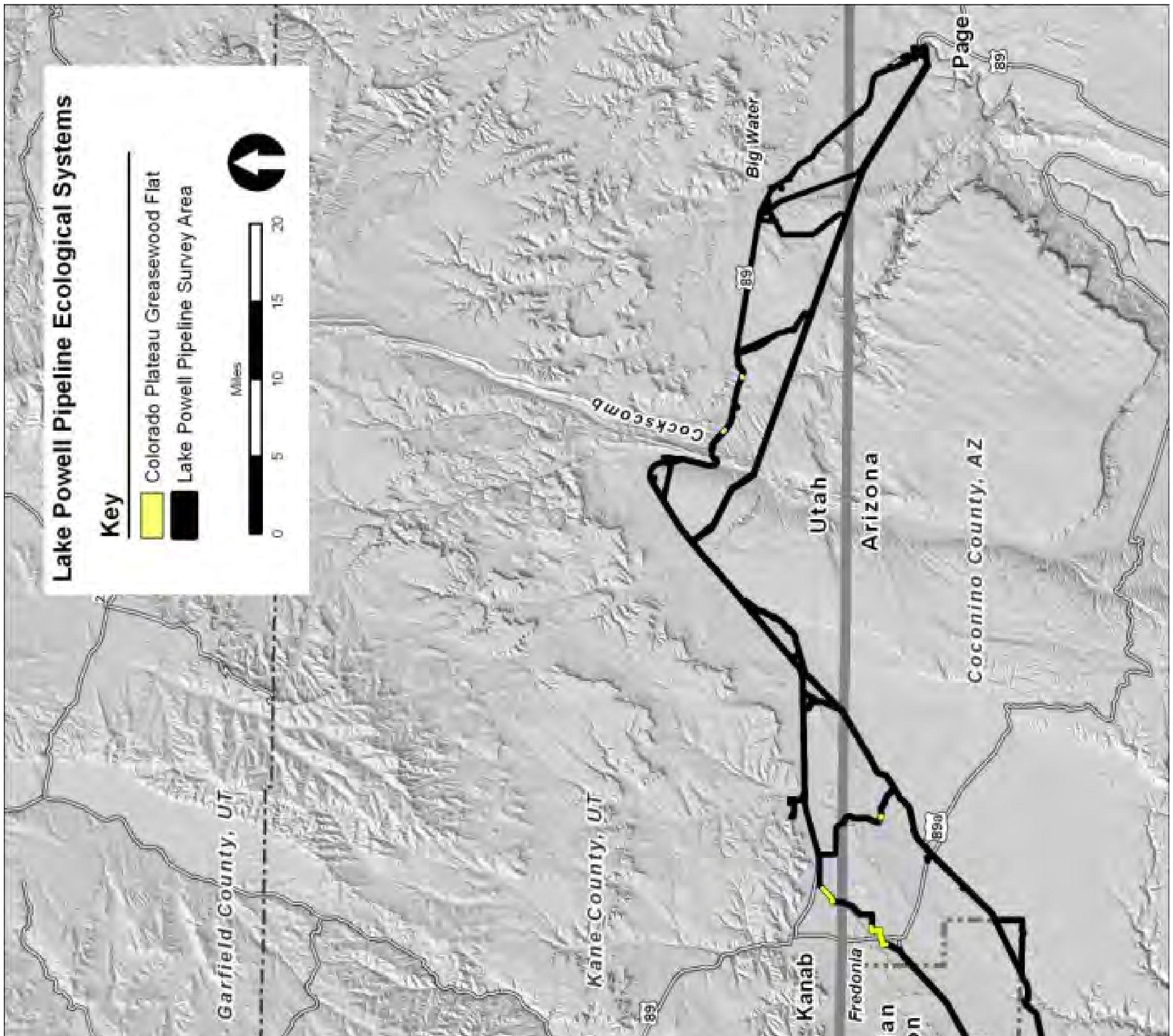
Sarcobatus vermiculatus is an increaser under grazing. Co-dominating shrubs which increase under grazing include *Gutierrezia sarothrae*, *Artemisia tridentata* (probably var. *tridentata*), and *Atriplex confertifolia*. Where palatable shrubs, forbs and grasses such as *Pleuraphis jamesii* have been grazed out, a monocultural *Sarcobatus vermiculatus* Shrubland association will remain. Invasive species can become dominant with heavy disturbance, including siltation, soil erosion, fire, and brush clearing. These species include *Salsola tragus* and *Ceratocephala testiculata.* Seeded grasses, such as × *Triticosecale rimpuai* and *Agropyron cristatum*, may also dominate the understory, although they are more likely to be stray plants from nearby agricultural lands.

Figure 4-5
Colorado Plateau Greasewood Flat Ecological System

4.2.5.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Greasewood Flat Ecological System crosswalks to NatureServe's Inter-Mountain Basins Greasewood Flat Ecological System. However, the Inter-Mountain Basins Greasewood Flat Ecological System is a broader concept which includes non-salic soil alliances of species other than *Sarcobatus vermiculatus*. Those alliances are classified in the Colorado Plateau Mixed Desert Shrub Ecological System.

Three of the associations in the Colorado Plateau Greasewood Flat Ecological System required minor name changes from types previously described in the US NVC. Seven associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-5
Colorado Plateau Greasewood Flat Ecological System

4.2.6 Colorado Plateau Gypsum Badland Ecological System

4.2.6.1 Geographic distribution

The Colorado Plateau Gypsum Badland Ecological System is found scattered throughout the LPP survey area. Gypsum Badlands occur from just west of Telegraph Wash along Highway 89 to the Shinarump Cliffs area and sporadically to the Johnson Wash area. It dominates the landscape from east of Fredonia across the Kaibab Indian Reservation to the Pipe Springs National Monument turnoff along Highway 389. Another large area dominated by this System is located along the Honeymoon Trail north past The Divide to Highway 59 and onto Highway 9 (east of La Verkin) (Map 4-6).

4.2.6.2 Alliances and Associations

Within the survey area, The Colorado Plateau Gypsum Badland Ecological is comprised of 24 alliances, including 44 associations. Ecological systems like this one, which provide habitat for special status plants, are typically split in the US NVC into more narrowly defined alliances and associations than ecological systems which do not provide habitat for special status plants. This ecological system totals 907.2 acres. Acreage by alliance and association is as follows:

***Artemisia biglovii* Shrubland Alliance**		**46.3 acres**
Artemisia bigelovii - Chrysothamnus greenei Gypsum Badlands Sparse Dwarf-shrubland	15.0 acres	
Artemisia bigelovii - Ephedra torreyana / Cryptobiotic Gypsum Badlands Sparse Shrubland	31.3 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**126.7 acres**
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Gypsum Badlands Shrubland	61.9 acres	
Artemisia tridentata ssp. vaseyana Gypsum Badlands Shrubland	2.4 acres	
Artemisia tridentata ssp. vaseyana Gypsum Badlands Sparse Shrubland	8.6 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Gypsum Badlands Wooded Shrubland	51.5 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Gypsum Badlands Wooded Shrubland	2.3 acres	
***Atriplex confertifolia* Shrubland Alliance**		**84.3 acres**
Atriplex confertifolia / Salsola tragus Semi-natural Gypsum Badlands Dwarf-shrubland	3.1 acres	
Atriplex confertifolia Gypsum Badlands Dwarf-shrubland	60.9 acres	
Atriplex confertifolia Gypsum Badlands Sparse Dwarf-shrubland	1.6 acres	
Atriplex confertifolia Gypsum Badlands Sparse Dwarf-shrubland	18.7 acres	
***Atriplex confertifolia* Sparsely Vegetated Alliance**		**7.4 acres**
Atriplex confertifolia Gypsum Badlands Sparse Vegetation	7.4 acres	

***Chrysothamnus viscidiflorus* Shrubland Alliance**		**16.4 acres**
Chrysothamnus viscidiflorus Gypsum Badlands Sparse Dwarf-shrubland	16.4 acres	
***Ephedra (nevadensis, torreyana)* Shrubland Alliance**		**31.2 acres**
Ephedra (nevadensis, torreyana) Gypsum Badlands Sparse Shrubland	28.1 acres	
Ephedra torreyana - (Atriplex spp.) / Cryptobiotic Gypsum Badlands Sparse Shrubland	3.1 acres	
***Ephedra torreyana* Shrubland Alliance**		**78.2 acres**
Ephedra (nevadensis, torreyana) Gypsum Badlands Sparse Shrubland	78.2 acres	
***Ericameria nauseosa* Shrubland Alliance**		**3.3 acres**
Ericameria nauseosa Shrubland	3.3 acres	
***Eriogonum (corymbosum, mortonianum, thompsoniae)* Shrubland Alliance**		**109.5 acres**
Eriogonum (corymbosum, mortonianum, thompsoniae) / Cryptobiotic / Sparse Understory Gypsum Badlands Shrubland	15.7 acres	
Eriogonum (corymbosum, mortonianum, thompsoniae) Gypsum Badlands Shrubland	24.3 acres	
Eriogonum (corymbosum, mortonianum, thompsoniae) Gypsum Badlands Sparse Dwarf-shrubland	3.5 acres	
Eriogonum (corymbosum, mortonianum, thompsoniae) Gypsum Badlands Sparse Shrubland	66.0 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**87.6 acres**
Eriogonum corymbosum - Artemisia tridentata ssp. vaseyana Gypsum Badlands Sparse Shrubland	82.7 acres	
Eriogonum corymbosum Gypsum Badlands Shrubland	2.9 acres	
Eriogonum corymbosum Gypsum Badlands Sparse Vegetation	2.0 acres	
***Eriogonum corymbosum* Sparsely Vegetated Alliance**		**4.0 acres**
Eriogonum corymbosum Gypsum Badlands Sparse Vegetation	4.0 acres	
***Eriogonum thompsoniae var. atwoodii* Sparsely Vegetated Alliance**		**1.1 acres**
Eriogonum thompsoniae var. atwoodii Gypsum Badlands Sparse Vegetation	1.1 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**10.7 acres**
Gutierrezia sarothrae Gypsum Badlands Dwarf-shrubland	10.7 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**2.0 acres**
Gutierrezia sarothrae Gypsum Badlands Sparse Vegetation	2.0 acres	
***Juniperus osteosperma* Sparsely Vegetated Alliance**		**20.7 acres**
Juniperus osteosperma / Eriogonum corymbosum / Pediomelum epipsilum Gypsum Badlands Wooded Sparse Vegetation	10.3 acres	
Juniperus osteosperma / Mahonia fremontii Gypsum Badlands Sparse Vegetation	0.3 acres	
Juniperus osteosperma Gypsum Badlands Sparse Vegetation	10.1 acres	

***Juniperus osteosperma* Woodland Alliance**		**24.6 acres**
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Gypsum Badlands Woodland	15.8 acres	
Juniperus osteosperma Gypsum Badlands Sparse Woodland	8.9 acres	
***Mahonia fremontii* Shrubland Alliance**		**10.1 acres**
Mahonia fremontii Gypsum Badlands Shrubland	5.8 acres	
Mahonia fremontii Gypsum Badlands Sparse Shrubland	4.2 acres	
***Mahonia fremontii* Sparsely Vegetated Alliance**		**6.2 acres**
Mahonia fremontii Gypsum Badlands Sparse Vegetation	6.2 acres	
Mixed Desert Shrub Shrubland Alliance		**126.6 acres**
Ephedra torreyana - (Atriplex spp.) / Cryptobiotic Gypsum Badlands Sparse Shrubland	119.5 acres	
Mixed Desert Shrub Gypsum Badlands Shrubland	7.1 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**16.0 acres**
Pinus edulis - Juniperus osteosperma / Chrysothamnus greenei / (Pediomelum epipsilum) Gypsum Badland Woodland	16.0 acres	
***Pinus monophylla - (Juniperus osteosperma)* Woodland Alliance**		**45.0 acres**
Pinus monophylla - Juniperus osteosperma / Mahonia fremontii Gypsum Badlands Sparse Woodland	45.0 acres	
***Pleuraphis jamesii* Herbaceous Alliance**		**18.9 acres**
Pleuraphis jamesii Gypsum Badlands Herbaceous Vegetation	12.2 acres	
Pleuraphis jamesii Gypsum Badlands Sparse Vegetation	6.7 acres	
***Psorothamnus fremontii* Sparsely Vegetated Alliance**		**10.7 acres**
Psorothamnus fremontii Gypsum Badlands Sparse Vegetation	10.7 acres	
***Purshia (stansburiana, glandulosa, mexicana)* Sparsely Vegetated Alliance**		**4.7 acres**
Purshia glandulosa Gypsum Badlands Sparse Vegetation	4.7 acres	

4.2.6.3 Physiognomy and composition

The Colorado Plateau Gypsum Badland Ecological System is most commonly comprised of sparse vegetation, sparse shrublands, and shrublands; occasionally sparse dwarf-shrublands and dwarf-shrublands (Figure 4-6, Figure 4-7); infrequently woodland and wooded shrubland; and rarely sparse understory shrubland and herbaceous vegetation. This ecological system is a complex of landforms, vegetation, and soils. Within any mapped area, inclusions of other physiognomic types may be present.

4.2.6.4 Disturbance regimes

The Colorado Plateau Gypsum Badland Ecological System is comprised of alliances and association with vegetation that has adapted to gypsum-rich substrate. Plant species with a preference to such soils are called

Figure 4-6
Colorado Plateau Gypsum Badland Ecological System, mud wash

gypsophiles (Meyer 1986). The vegetal strata from ground level to 6.5 feet (2 meters) tall is the strata where gypsophile plants dominate. As trees invade landforms underlain by the Moenkopi Formation, their shading and allelopathic influence reduces the density and diversity of shrub and herbaceous strata plant species. If the tree strata is impacted by mechanisms such as fire, chopping, logging, disease, or drought kill, gypsophiles are the first species to recolonize the land. Notable in this ecological system is lack of invasive species, even on disturbed land. Apparently the suite of invasive species found in the LPP survey area on the Colorado Plateau is not adapted to gypsum soils.

Gypsum badlands shrublands are a robust and long persistent successional state. Lower elevations in the survey area are below the climatically controlled limit for *Juniperus osteosperma*. At higher elevations, tree invasion is slowed by drought stress. These tree species include *Pinus monophylla*, *P. edulis* and *Juniperus osteosperma*. On highly eroded soils they often represent less than 10 percent cover in sparsely vegetated associations, or 10 to 25 percent cover in sparse woodlands.

Long term grazing will favor increaser shrubs such as *Artemisia bigelovii*, *A. tridentata* ssp. *vaseyana*, *Atriplex confertifolia*, *Chrysothamnus viscidiflorus*, *Ericameria nauseosa*, *Eriogonum corymbosum*, *Gutierrezia sarothrae*, and *Psorothamnus fremontii*. Dominance by one or more of these non-gypsophile shrubs on a Colorado Plateau Gypsum Badland will make the vegetation appear less like a gypsum badland. It is even more difficult to classify a gypsum soil-based plant community as gypsum badland if the understory is heavily grazed and trampled. Gypsophiles which decrease under grazing and land disturbance associated with grazing may include *Cryptantha semiglabra*, *Pediocactus sileri*, *Phacelia palmeri*, *P. constancei*, *Eriogonum insigne*, *Astragalus episcopus*, *Pediomelum epipsilum*, and *Polygala subspinosa*.

Once a gypsum-bearing soil looses a vegetal composition of gypsophiles, the vegetation is primarily classified into the Colorado Plateau Mixed Desert Scrub or Colorado Plateau Big Sagebrush Shrubland Ecological Systems. If protected from grazing, the gypsophiles can recolonize and the plant community succession will often classify into the Mixed Desert Scrub Shrubland Alliance of the Colorado Plateau Gypsum Badland Ecological System.

Ephedra nevadensis and E. torreyana can dominate gypsum badlands alone or in combination and are most common on ridges. *Ephedra torreyana* often dominates gypsum badlands without co-dominance by *E. nevadensis* where there is intact cryptobiotic crust on the surface. *Mahonia fremontii* dominates gypsum badlands with little ground cover and poor understory species diversity.

4.2.6.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Gypsum Badland Ecological System crosswalks only in concept to NatureServe's Intermountain Basins Shale Badlands Ecological System. Because the badlands in the survey area are widely recognized for the influence of gypsum on plants, a "gypsum badlands" modifier was considered more diagnostic than a "shale" modifier. NatureServe's data on this Intermountain region system was obtained primarily in

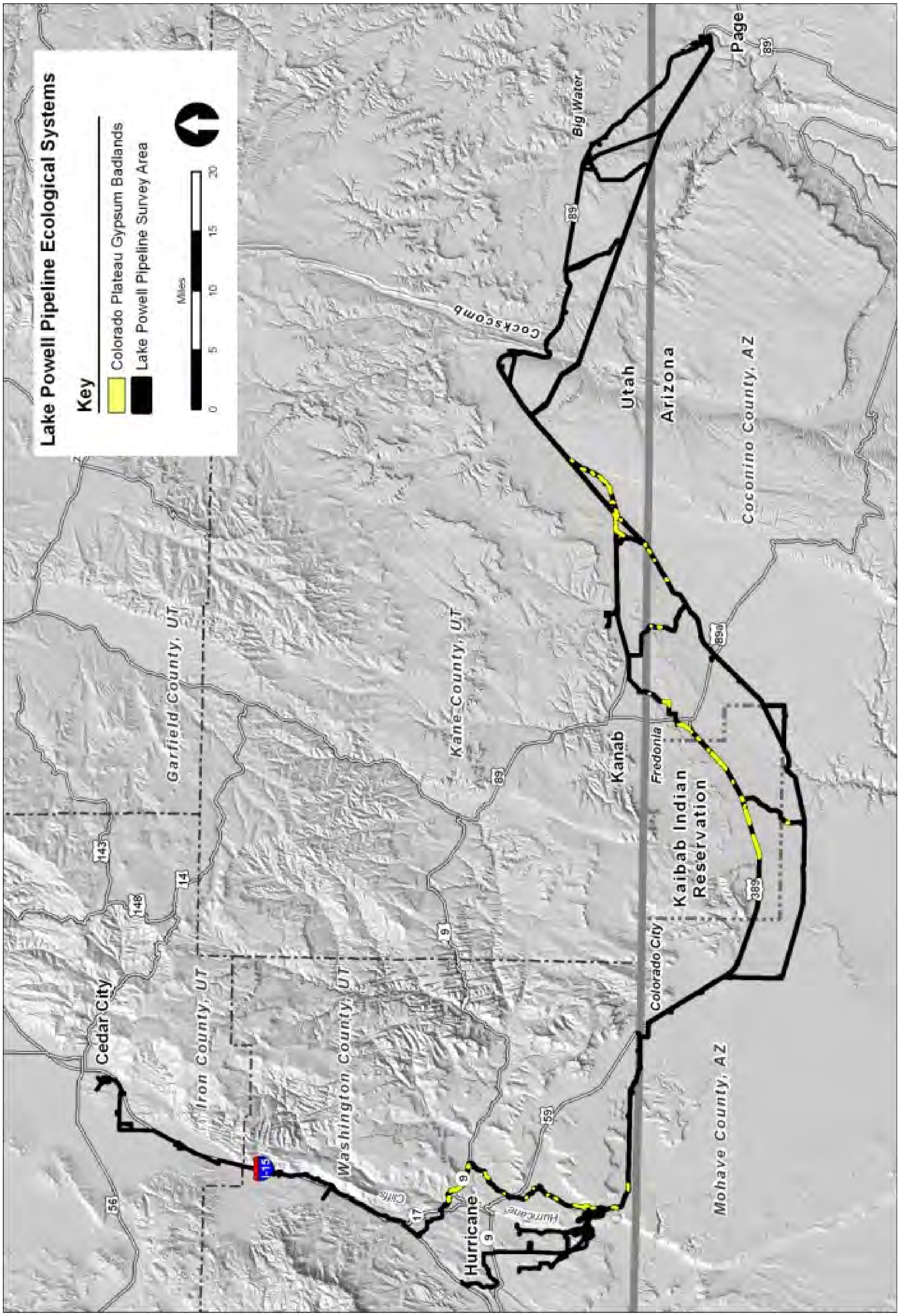
Petrified Forest National Park, Arizona. The distances between that park and the LPP survey area is too great and the floristic differences too profound, to consider the two as biogeographically similar.

A number of alliances on gypsum bearing soils do not differ significantly in species composition from those occurring on non-gypsum soils. Thus, while their alliance name is modified with “gypsum badlands”, they could alternately be classified in other ecological systems. These include *Pleuraphis jamesii* Gypsum Badlands Herbaceous Vegetation Alliance, *Psorothamnus fremontii* Gypsum Badlands Sparsely Vegetated Alliance, *Atriplex confertifolia* Gypsum Badlands Shrubland Alliance, and *Ephedra* (*nevadensis, torreyana*) Gypsum Badlands Sparsely Vegetated Alliance.

Figure 4-7
Colorado Plateau Gypsum Badland Ecological System, Cryptobiotic Ridge

NatureServe’s Intermountain Basins Shale Badlands Ecological System is exclusively a shrubland system. An innovation in the Colorado Plateau Gypsum Badland Ecological System is that the presence of gypsum badlands topography was considered diagnostic even if the vegetation was wooded or herbaceous. This facilitates discussion of disturbance regimes, even if gypsum may not strongly influence the vegetal composition in early or late seral stages.

Five of the alliances and seven of the associations in this ecological system required minor name changes from types previously described in the US NVC. Ten alliances and 33 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-6
Colorado Plateau Gypsum Badland Ecological System

4.2.7 Colorado Plateau Juniper Savanna Ecological System

4.2.7.1 Geographic distribution

The Colorado Plateau Juniper Savanna Ecological System is found in three distinct areas within the LPP survey area. From east to west, the first occurrence is located north of Flat Top along the north/ south transmission line, the second occurrence is just west of the Cockscomb, and the last occurrence is more centrally located, approximately three miles west of the Pipe Springs National Monument turnoff along Highway 389 (Map 4-7).

4.2.7.2 Alliances and associations

Within the survey area, the Colorado Plateau Juniper Savanna Ecological System is comprised of three alliances and their three associations. This ecological system totals 30.5 acres within the survey area. Acreage by alliance and association is as follows:

***Hesperostipa comata* Herbaceous Alliance**		**16.9 acres**
Juniperus osteosperma / (Bouteloua gracilis, Pleuraphis jamesii, Hesperostipa comata) Wooded Herbaceous Vegetation	16.9 acres	
***Pleuraphis rigida* Herbaceous Alliance**		**9.3 acres**
Juniperus osteosperma / (Bouteloua gracilis, Pleuraphis jamesii, Hesperostipa comata) Wooded Herbaceous Vegetation	9.3 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**4.4 acres**
Juniperus osteosperma / Salsola tragus Semi-natural Wooded Herbaceous Vegetation	4.4 acres	

4.2.7.3 Physiognomy and composition

Within the survey area, The Colorado Plateau Juniper Savanna Ecological System is comprised exclusively of wooded herbaceous vegetation (Figure 4-8).

Figure 4-8
Colorado Plateau Juniper Savanna Ecological System

4.2.7.4 Disturbance regimes

The Colorado Plateau Juniper Savanna Ecological System represents high range quality by virtue of having a grass dominated understory with a tree canopy of less than 25 percent cover. By definition, *Juniperus osteosperma* is the dominant tree.

The land use history of these communities has not been researched, so only assumptions can be made.

The first is that grazing has not eliminated the grasses over time. High range quality is indicated when one or more grasses, such as *Sporobolus cryptandrus*,
co-dominant in the herbaceous strata. *Achnatherum hymenoides* is the common co-dominating grass in the *Juniperus osteosperma* Woodland Alliance, when that alliance occurs on dunes. But as tree canopy increases, the allelopathic character of *Juniperus osteosperma* progressively reduces the density of other species that may co-dominate under a sparser canopy cover, such as *Psoralidium junceum* and *Achnatherum hymenoides*. *Juniperus osteosperma* Woodland Alliance communities with *Bromus tectorum* as co-dominate are disturbed and considered semi-natural; although they were too rare in the LPP survey area to recognize as an association. *Pleuraphis jamesii*, *Hesperostipa comata*, and *Bouteloua gracilis* are also decreaser grasses under grazing.

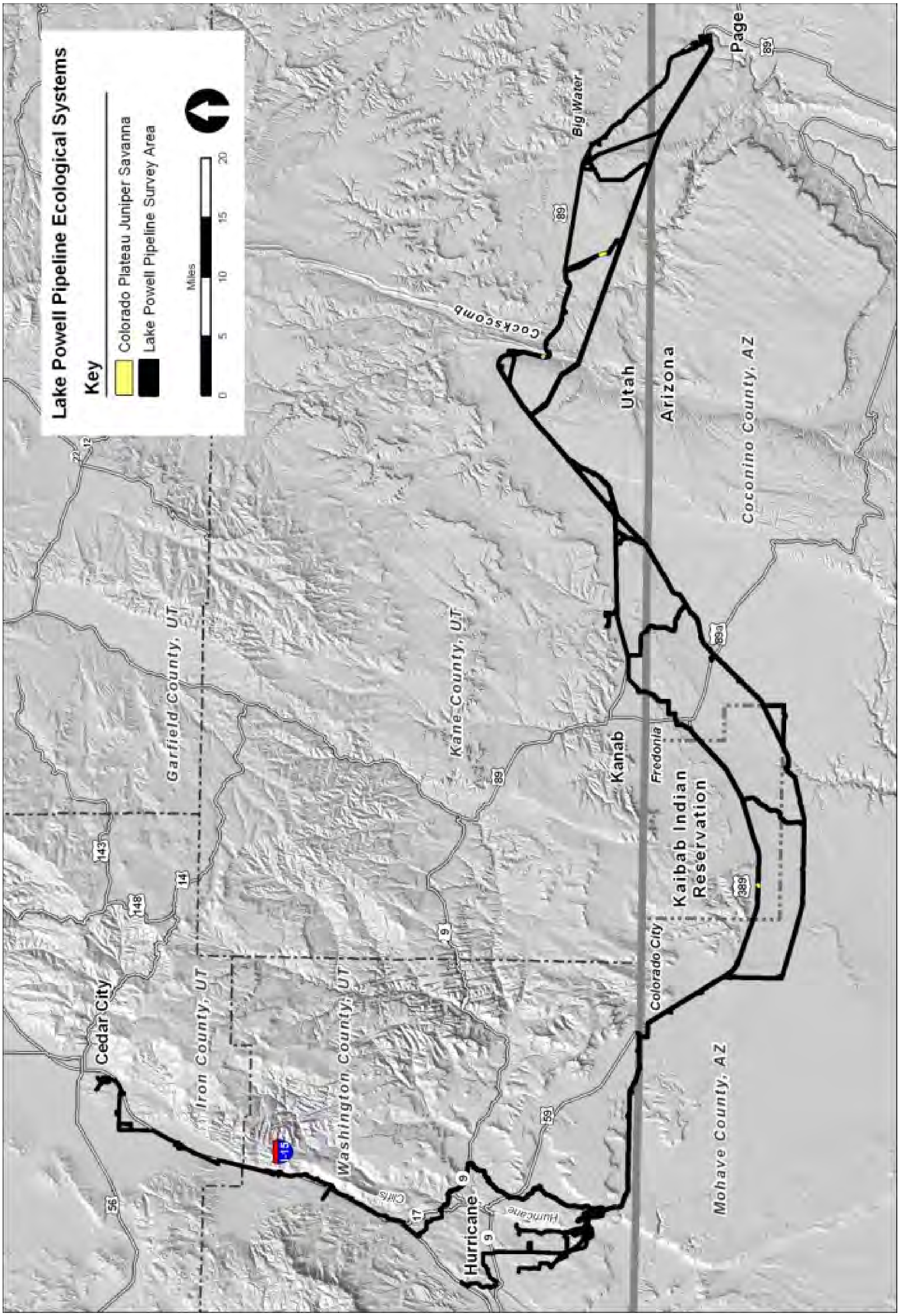
The second assumption is that periodic fire has played a role in reducing shrub competition and keeping the tree canopy open. The shrubs which locally attain dominance include *Ephedra nevadensis*, *Atriplex canescens*, *Yucca angustissima,* and *Gutierrezia sarothrae*. The latter three are increasers under grazing and the latter two are early seral species following fire.

The *Salsola tragus* Semi-natural Herbaceous Alliance represents the most disturbed of the three alliances in this ecological system. *Juniperus osteosperma* co-dominates with the invasive herb *Salsola tragus*, indicating heavy grazing pressure. *Gutierrezia sarothrae* is always common, also indicating grazing pressure. In the *Juniperus osteosperma* / (*Bouteloua gracilis*, *Pleuraphis jamesii*, *Hesperostipa comata*) Wooded Herbaceous Vegetation, shrubs are typically a minor component. The persistence of the association depends on favorable climatic conditions and periodic fire. Under climatic warming or a crown fire, these may transition to the Colorado Plateau Grassland Ecological System. Conversely a ground fire would help maintain the savanna-like character of the association.

4.2.7.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Juniper Savanna Ecological System crosswalks in concept to NatureServe's Inter-Mountain Basins Juniper Savanna Ecological System. However, only the Juniperus osteosperma / Hesperostipa comata Wooded Herbaceous Vegetation association has a one to one correspondance. Fourteen of the 16 associations included in the NatureServe system are woodlands. This study takes a more conservative approach and limits savannas to systems in which both tree and shrub cover are less than 10 percent and grasses dominate the understory. Furthermore, the Colorado Plateau Juniper Savanna Ecological System is confined in this study to just the Colorado Plateau Region, rather than NatureServe's Inter-Mountain Basins Juniper Savanna Ecological System ranging from western Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho.

One alliance in this ecological system required a minor name change from a type previously described in the US NVC. One alliance and both associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-7
Colorado Plateau Juniper Savanna Ecological System

4.2.8 Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System

4.2.8.1 Geographic distribution

The Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System is found intermittently throughout the LPP survey area. It is most often found adjacent to rivers, creeks, washes, and vegetated stock ponds. Some examples include: Lower Blue Pool Wash, Upper Paria River, Seaman Wash, Whitesage Wash, Johnson Wash, Kanab Creek, Cottonwood Wash, Bitter Seep Wash, Twomile Wash, Short Creek, Gould Wash, and the Virgin River and its tributaries (Map 4-8).

4.2.8.2 Alliances and associations

Within the survey area, The Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System is comprised of eight alliances and 13 associations. This ecological system totals 113.9 acres within the survey area. Acreage by alliance and association is as follows:

***Baccharis sp.* Shrubland Alliance**		**10.3 acres**
Baccharis sp. Shrubland	10.3 acres	
***Elaeagnus angustifolia* Semi-natural Woodland Alliance**		**4.9 acres**
Elaeagnus angustifolia Semi-natural Woodland	4.9 acres	
***Juniperus osteosperma* Woodland Alliance**		**1.8 acres**
Juniperus osteosperma / Tamarix chinensis Semi-natural Woodland	1.8 acres	
***Populus fremontii* Woodland Alliance**		**33.1 acres**
Populus fremontii / Elaeagnus angustifolia Semi-natural Sparse Woodland	6.6 acres	
Populus fremontii / Tamarix chinensis Semi-natural Woodland	18.4 acres	
Populus fremontii Sparse Woodland	4.7 acres	
Populus fremontii Woodland	3.3 acres	
***Salix exigua* Shrubland Alliance**		**2.0 acres**
Salix exigua / Tamarix chinensis Semi-natural Shrubland	2.0 acres	
***Salix sp.* Shrubland Alliance**		**1.4 acres**
Salix sp. Shrubland	1.4 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**0.8 acres**
Tamarix chinensis / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	0.8 acres	

***Tamarix chinensis* Semi-natural Shrubland Alliance**	**59.6 acres**
Tamarix chinensis Semi-natural Shrubland	48.5 acres
Tamarix chinensis Semi-natural Sparse Shrubland	9.7 acres
Tamarix chinensis Semi-natural Sparse Vegetation	1.3 acres

4.2.8.3 Physiognomy and composition

The Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System is commonly shrubland (Figure 4-9), occasionally sparse shrubland, and rarely woodland, shrub herbaceous vegetation, or sparse vegetation. A mosaic of shrubland and sparse vegetation is also rare.

Figure 4-9
Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System

4.2.8.4 Disturbance regimes

Native trees and tall shrubs provide shade for livestock, which are often pastured in riparian areas. These species include *Populus fremontii*, *Fraxinus velutina*, *Baccharis* sp. and *Salix* sp. Early seral stages of *Populus* and *Fraxinus* are shrublands (i.e., less than 16.4 feet [5 meters] tall, on average), maturing to woodlands and eventually forests after long periods without major flooding or artificial disturbance. These wooded communities have been subject to logging since settlement of the region around 1870. Both *Populus fremontii* and *Fraxinus velutina* can be uprooted by violent flooding – an occasional natural disturbance to streams and rivers in this region. Silt deposition from upstream erosion, as well as frequent bank cutting, can result in replacement by invasive shrubs and trees, particularly *Elaeagnus angustifolia* and *Tamarix chinensis.* These species, individually or in combination, out-compete the native flora, resulting in a semi-natural community which is extremely difficult to eradicate. *Salsola tragus*, an invasive herb, is often dominant or common in the understory. Occasionally *Bromus rubens* or *Erodium cicutarium* will also dominate the understory as invasive species.

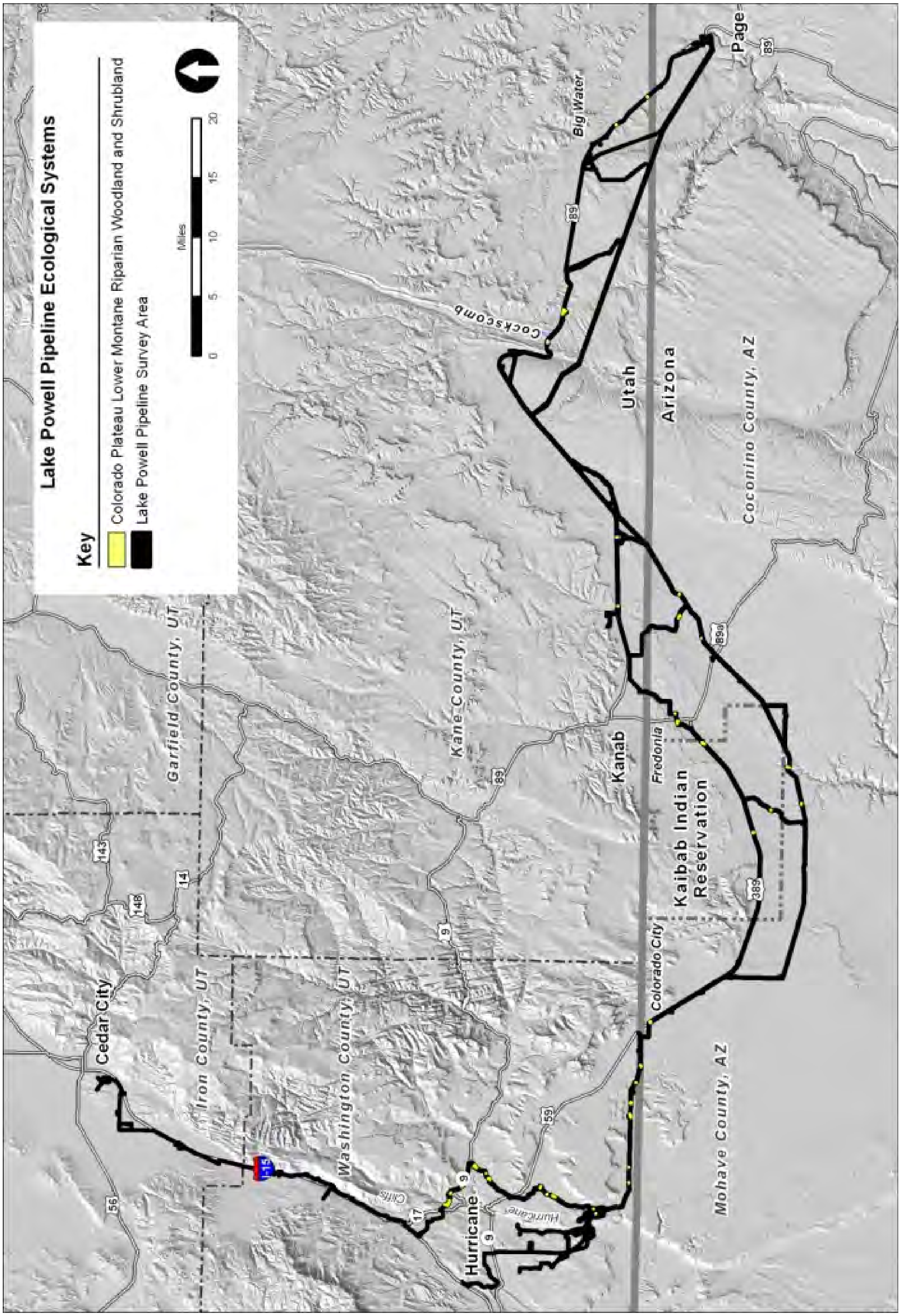
Other shrubs may dominate in areas with specialized edaphic factors.

4.2.8.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System crosswalks primarily to NatureServe's North American Warm Desert Lower Montane Riparian Woodland and Shrubland. There is a duplication of some higher elevation alliances under NatureServe's Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland. The approach for the LPP survey area has been to regionalize the concept of a riparian shrubland and woodland. Within the three survey area regions, riparian communities typically have a channel in which water flows at some time during the year. In contrast, the Colorado Plateau

Wash ecological system is restricted to communities where water is typically only present during and after a flash flood.

Three of the alliances and five of the associations in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and five associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-8
Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System

4.2.9 Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System

4.2.9.1 Geographic distribution

The Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System is found scattered throughout the LPP survey area. Greater numbers of occurrences occur within the eastern portion of the survey area along the southern transmission line corridor. Through this stretch Mixed Bedrock Canyon and Tableland was documented on the west side of the Glen Canyon Dam area, through the south end of the Cedar Mountains, east and west of the Paria Canyon, to the Cockscomb. It was documented sporadically along the proposed pipeline corridor from Glen Canyon Dam to Kimball Valley along Highway 89. From the Kimball Valley to nearly Kanab Creek there was only one occurrence documented. Occurrences of this ecological system are also concentrated briefly along the southern proposed pipeline corridor from approximately five miles east of Kanab Creek to Kanab Creek adjacent to the southern boundary of the Kaibab Indian Reservation. Four significantly smaller occurrences were documented on the far west side of the survey area, one near Short Creek at Canaan Gap, one in the Forebay, one north of The Divide, and the other adjacent to the Virgin River just south of Highway 9 (Map 4-9).

4.2.9.2 Alliances and associations

Within the survey area, the Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System is comprised of 27 alliances, including 67 associations. Below is a listing of the alliances and their associations. This ecological system totals 840.8 acres within the survey area. Acreage by alliance and association is as follows:

***Amelanchier utahensis* Shrubland Alliance**		**1.7 acres**
Pinus edulis - Juniperus osteosperma / Shepherdia routundifolia - Amelanchier utahensis Sandstone Bedrock Wooded Shrubland	1.7 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**1.7 acres**
Artemisia tridentata ssp. vaseyana Shrubland	1.7 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**1.1 acres**
Coleogyne ramosissima - Gutierrezia sarothrae Shrubland	1.1 acres	
***Coleogyne ramosissima* Sparsely Vegetated Alliance**		**22.3 acres**
Coleogyne ramosissima - Ephedra nevadensis Sparse Vegetation	3.0 acres	
Coleogyne ramosissima Sandstone Slickrock Sparse Vegetation	4.5 acres	
Coleogyne ramosissima Sparse Vegetation	14.8 acres	
***Ephedra nevadensis* Shrubland Alliance**		**10.8 acres**
Juniperus osteosperma / Ephedra (torreyana, nevadensis) / Sandstone Outcrop Wooded Shrubland	10.8 acres	
***Ephedra nevadensis* Sparsely Vegetated Alliance**		**31.5 acres**
Ephedra nevadensis Sandstone Slickrock Sparse Vegetation	7.1 acres	
Ephedra nevadensis Sparse Vegetation	16.2 acres	

Eriogonum corymbosum - Ephedra nevadensis - Coleogyne ramosissima Sandstone Slickrock Sparse Vegetation	8.2 acres	
***Ericameria nauseosa* Shrubland Alliance**		**2.6 acres**
Ericameria nauseosa / (Cryptobiotic) Shrubland	1.3 acres	
Pinus edulis - Juniperus osteosperma / Ericameria nauseosa Wooded Shrubland	1.3 acres	
***Ericameria nauseosa* Sparsely Vegetated Alliance**		**3.9 acres**
Ericameria nauseosa - Artemisia biglovii Sandstone Bedrock Sparse Vegetation	1.4 acres	
Ericameria nauseosa Sandstone Bedrock Sparse Vegetation	2.4 acres	
***Ericameria teretifolia* Shrubland Alliance**		**17.6 acres**
Ericameria teretifolia Dwarf-shrubland	17.6 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**83.9 acres**
Eriogonum corymbosum - Ephedra nevadensis - Coleogyne ramosissima Sandstone Slickrock Sparse Vegetation	9.0 acres	
Eriogonum corymbosum - Ephedra nevadensis Sandstone Slickrock Sparse Shrubland	2.0 acres	
Eriogonum corymbosum - Ericameria nauseosa Sandstone Bedrock Sparse Shrubland	12.5 acres	
Eriogonum corymbosum - Ericameria teretifolia Shrubland	24.3 acres	
Eriogonum corymbosum Shrubland	34.8 acres	
Eriogonum corymbosum Sparse Shrubland	1.2 acres	
***Eriogonum corymbosum* Sparsely Vegetated Alliance**		**152.5 acres**
Eriogonum corymbosum - Ephedra nevadensis - Coleogyne ramosissima Sandstone Slickrock Sparse Vegetation	146.6 acres	
Eriogonum corymbosum - Ericameria nauseosa Sandstone Bedrock Sparse Shrubland	4.5 acres	
Eriogonum corymbosum Sparse Vegetation	1.4 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**15.7 acres**
Gutierrezia sarothrae Dwarf-shrubland	4.3 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	2.3 acres	
Juniperus osteosperma / Gutierrezia sarothrae Wooded Dwarf-shrubland	9.1 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**20.1 acres**
Gutierrezia sarothrae Sandstone Slickrock Sparse Vegetation	12.2 acres	
Gutierrezia sarothrae Sparse Vegetation	7.9 acres	
***Juniperus osteosperma* Sparsely Vegetated Alliance**		**79.1 acres**
Juniperus osteosperma / Artemisia biglovii / Sandstone Outcrop Sparse Vegetation	1.6 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Sparse Vegetation	1.2 acres	

Juniperus osteosperma / Chrysothamnus greenei Sandstone Bedrock Sparse Vegetation	19.2 acres	
Juniperus osteosperma / Gutierrizia sarothrae Sandstone Bedrock Sparse Vegetation	13.9 acres	
Juniperus osteosperma / Sandstone Outcrop Sparse Vegetation	21.5 acres	
Juniperus osteosperma / Shepherdia rotundifolia / Sandstone Outcrop Sparse Vegetation	7.8 acres	
Juniperus osteosperma Sandstone Slickrock Sparse Vegetation	13.9 acres	
***Juniperus osteosperma* Woodland Alliance**		**155.8 acres**
Juniperus osteosperma / Artemisia biglovii Sparse Woodland	5.9 acres	
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	13.3 acres	
Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	17.1 acres	
Juniperus osteosperma / Purshia glandulosa Sandstone Bedrock Sparse Woodland	16.4 acres	
Juniperus osteosperma / Sandstone Outcrop Sparse Vegetation	8.0 acres	
Juniperus osteosperma / Shepherdia rotundifolia / Sandstone Outcrop Sparse Vegetation	2.1 acres	
Juniperus osteosperma / Shepherdia rotundifolia Sparse Woodland	84.6 acres	
Juniperus osteosperma Sparse Woodland	3.7 acres	
Juniperus osteosperma Woodland	4.7 acres	
Non-vegetated		**45.9 acres**
Non-vegetated Sandstone Outcrop	44.8 acres	
Sandstone Bedrock Non-vegetated	1.1 acres	
***Pinus edulis - Juniperus osteosperma* Sparsely Vegetated Alliance**		**24.4 acres**
Pinus edulis - Juniperus osteosperma Sandstone Slickrock Sparse Vegetation	7.0 acres	
Pinus edulis - Juniperus osteosperma Sparse Vegetation	17.4 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**32.0 acres**
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Sandstone Bedrock Sparse Woodland	6.2 acres	
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Sandstone Slickrock Sparse Woodland	1.8 acres	
Pinus edulis - Juniperus osteosperma / Artemisia bigelovii Sparse Woodland	3.7 acres	
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Sparse Woodland	5.3 acres	
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland	1.5 acres	
Pinus edulis - Juniperus osteosperma / Shepherdia rotundifolia Sparse Woodland	11.7 acres	
Pinus edulis - Juniperus osteosperma Woodland	1.8 acres	

***Pinus edulis* Woodland Alliance**		**22.2 acres**
Pinus edulis / Coleogyne ramosissima Sparse Woodland	22.2 acres	
***Purshia glandulosa* Mixed Shrubland Alliance**		**33.9 acres**
Purshia glandulosa Mixed Shrubland	33.9 acres	
***Quercus x pauciloba* Shrubland Alliance**		**21 acres**
Quercus x pauciloba Shrubland	21 acres	
***Rhus trilobata* Shrubland Alliance**		**0.5 acres**
Rhus trilobata Shrubland	0.5 acres	
Sandstone Bedrock Sparse Vegetation		**1.0 acres**
***Shepherdia rotundifolia* Shrubland Alliance**		**35.2 acres**
Pinus edulis - Juniperus osteosperma / Shepherdia routundifolia - Amelanchier utahensis Sandstone Bedrock Wooded Shrubland	6.2 acres	
Shepherdia rotundifolia / Sandstone Outcrop Sparse Shrubland	10.1 acres	
Shepherdia rotundifolia Shrubland	18.9 acres	
Sparse Vegetation		**12.5 acres**
***Sphaeralcea (ambigua, coccinea, parviflora)* Herbaceous Alliance**		**11.4 acres**
Ephedra viridis / Sphaeralcea parviflora Shrub Herbaceous Vegetation	11.4 acres	
Unclassified		**19.7 acres**

4.2.9.3 Physiognomy and composition

The Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System is commonly sparse vegetation and shrublands (Figure 4-10); infrequently sparse woodland and sparse shrubland; and rarely woodland or wooded shrubland. Slickrock sandstone typically has sparser vegetal cover and fewer plant species than does sandstone bedrock outcrop.

4.2.9.4 Disturbance regimes

Coleogyne ramosissima, *Ephedra nevadensis,* and *Eriogonum corymbosum* are localized dominants on sparsely vegetated slickrock. Edaphic factors rather than succession probably control the presence or absence of *Juniperus osteosperma* and *Eriogonum corymbosum* as co-dominants.

Ephedra nevadensis is commonly dominant in sparsely vegetated communities. The substrate is almost always sandstone bedrock outcrop. It is often co-dominated by *Eriogonum corymbosum*, which probably increases under disturbance but may also indicate deeper soils. Where *Eriogonum corymbosum* is the sole dominant, it is in shrublands on deeper soils. Occasionally the co-dominants are *Coleogyne ramosissima*, *Pleuraphis jamesii*, *Artemisia tridentata*, *Gutierrezia sarothrae*, *Atriplex canescens*, *Vanclevea stylosa*, or *Datura wrightii*. Increasers under grazing would include *Artemisia tridentata*, *Gutierrezia sarothrae*, *Atriplex canescens*, *Vanclevea stylosa*, and *Datura wrightii. Pleuraphis jamesii* would be the sole decreaser. *Vanclevea stylosa* is an indicator of the sandy soils of small wind-filled pockets in slickrock and bedrock topography. *Quercus* x *pauciflora* also dominates localized areas, especially near Calf Spring, where sand overlays sandstone with fissures. The *Quercus* forms dense stands which root into the bedrock and trap windblown sand. Like *Ephedra nevadensis*, this *Quercus* has the ability to grow and keep above the sand.

Figure 4-10
Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System

Gutierrezia sarothrae is occasionally the sole dominant and rarely co-dominant with *Juniperus osteosperma* in either sparsely vegetated communities, sparse shrublands, or sparse woodlands. Their distribution is perhaps more correlated to the ability of these species to colonize rocky slopes than to a natural or artificial disturbance regime. *Juniperus osteosperma*, *Pinus edulis*, *Artemisia bigelovii* and *A. nova* are species that are rocky land colonizers. Climatic warming would tend to increase mortality in these colonizers. Fire is unlikely to be a major factor in succession of treed communities, since only one percent of the ecological system has tree canopies over 25 percent. However, shrub canopies are occasionally more than 25 percent, so wildfires would be more likely in those shrubland communities. Fires are unlikely to travel far, since the landscape occurs as a mosaic in which sparse vegetation is common. Sparsely vegetated areas would likely act as natural fire breaks.

Pinus edulis-Juniperus osteosperma wooded shrublands, sparse woodlands, and woodlands follow a classic succession of shrub, then tree cover and height increasing with time since fire. Large shrubs that commonly dominate include: *Amelanchier utahensis*, *Fraxinus anomola*, *Purshia* glandulosa, and *Shepherdia rotundifolia*. In the absence of fire, logging, or chopping, density and cover would increase, although this would be held more in check by droughty soils, rockslides or flash floods than in the Colorado Plateau Pinyon-Juniper Woodland or Juniper Savanna Ecological Systems.

Ericameria teretifolia dominates alone in dwarf-shrublands, or with *Eriogonum corymbosum* in shrublands. *Ericameria teretifolia* is probably an increaser under grazing.

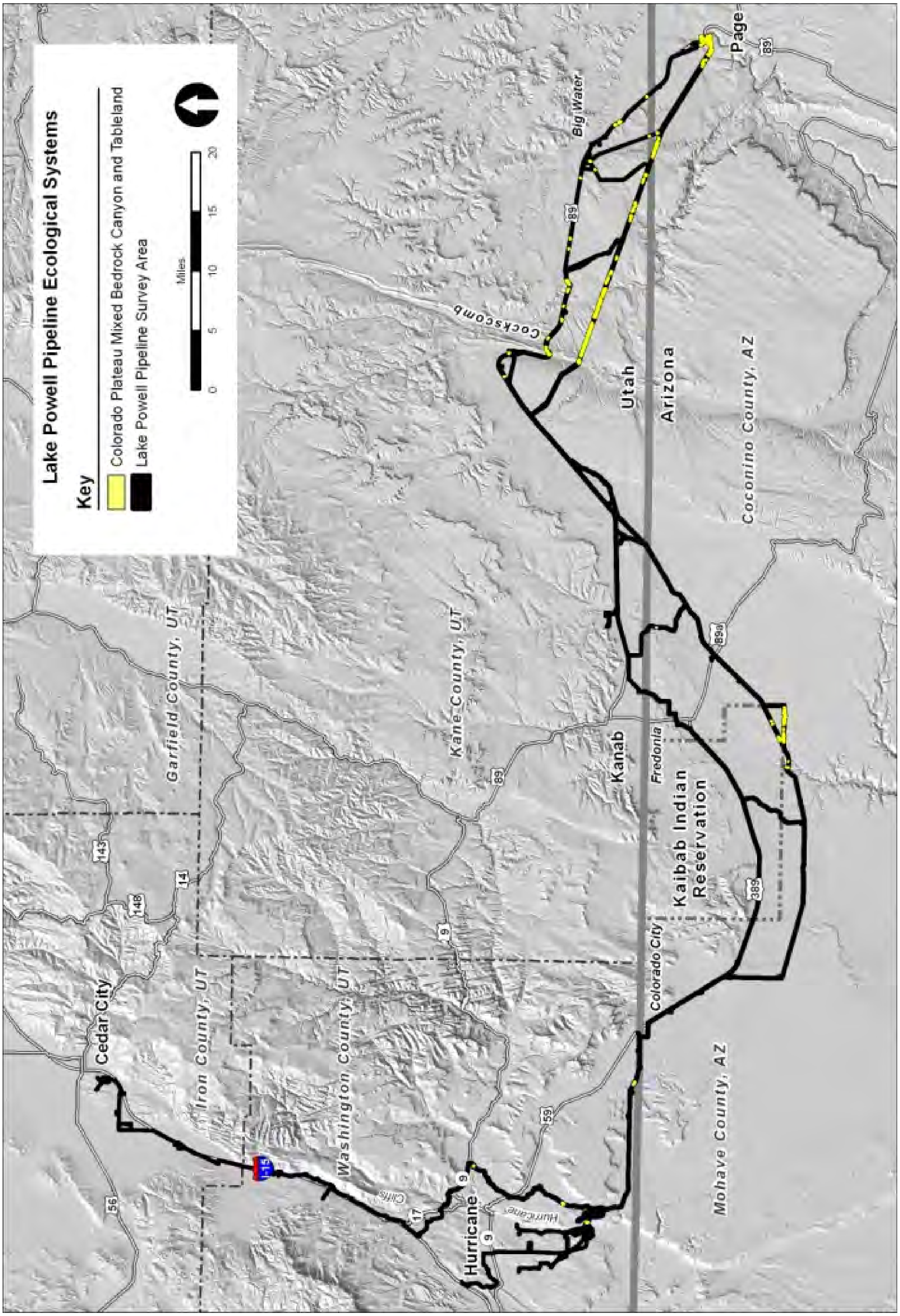
Ericameria nauseosa dominates sandstone cliffs along the Paria River. While it is often an indicator of grazing, in this setting it is ungrazed and associated with a continuous cryptobiotic cover holding steeply sloped soils in place.

4.2.9.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System crosswalks in concept to NatureServe's Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System. However, correspondence is weak with only the *Coleogyne ramosissima* Shrubland Alliance and *Juniperus osteosperma* Woodland Alliance cross-listed between the two systems. Many variations in physiognomic groups occur in the LPP survey area, supporting expansion of this system into additional alliances. While alliances may also classify to other ecological systems, presence of a bedrock canyon or tableland landform is the dominating factor in classifying occurrences here.

The *Purshia glandulosa* Mixed Shrubland Alliance has no relationship to any US NVC unit. It is found in the LPP survey area as isolated tall shrublands on rocky knolls. *Quercus* x *pauciflora* Shrubland could alternately be classified under the Colorado Plateau Active and Stabilized Dune Ecological System, but is placed here because topographically it occurs in sandstone canyon and tableland.

Eight of the alliances and 15 of the associations in this ecological system required minor name changes from types previously described in the US NVC. Two alliances and 36 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-9
Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System

4.2.10 Colorado Plateau Mixed Desert Scrub Ecological System

4.2.10.1 Geographic distribution

The Colorado Plateau Mixed Desert Scrub Ecological System is found throughout the LPP survey area. Occurrences were documented from as far east as the Glen Canyon Dam area, to as far west as the Forebay in the south and LaVerkin and the Nephi Twist area in the north (Map 4-10).

4.2.10.2 Alliances and associations

Within the survey area, the Colorado Plateau Mixed Desert Scrub Ecological System ecological system is comprised of 32 alliances, including 104 associations. It includes the greatest number of both alliances and associations in the Colorado Plateau Ecological Region of the LPP survey area. This ecological system totals 4,328.4 acres. Acreage by alliance and association is as follows:

***Aristida purpurea* Herbaceous Alliance**		**11.8 acres**
Lycium pallidum / Aristida purpurea Shrub Herbaceous Vegetation	11.8 acres	
***Artemisia filifolia* Shrubland Alliance**		**558.3 acres**
Artemisia filifolia - Atriplex canescens - Ephedra (nevadensis, torreyana, viridis) Shrubland	16.9 acres	
Artemisia filifolia - Atriplex canescens / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	5.6 acres	
Artemisia filifolia - Atriplex canescens / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Sparse Shrubland	10.9 acres	
Artemisia filifolia - Atriplex canescens Shrubland	3.2 acres	
Artemisia filifolia - Ericameria nauseosa Shrubland	16.3 acres	
Artemisia filifolia - Eriogonum corymbosum Shrubland	37.0 acres	
Artemisia filifolia - Gutierrezia sarothrae Shrubland	34.2 acres	
Artemisia filifolia - Psorothamnus fremontii Sparse Shrubland	2.5 acres	
Artemisia filifolia / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	38.8 acres	
Artemisia filifolia / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Sparse Shrubland	12.0 acres	
Artemisia filifolia Shrubland	354.5 acres	
Artemisia filifolia Sparse Shrubland	24.7 acres	
Juniperus osteosperma / Artemisia filifolia Wooded Shrubland	1.7 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**40.2 acres**
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Shrubland	40.2 acres	
***Atriplex canescens* Shrubland Alliance**		**814.8 acres**
Artemisia filifolia - Atriplex canescens / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	112.7 acres	

Atriplex canescens - Artemisia filifolia Shrubland	30.0 acres	
Atriplex canescens - Artemisia tridentata / Pleuraphis jamesii Sparse Shrubland	2.7 acres	
Atriplex canescens - Artemisia tridentata / Salsola tragus Semi-natural Shrubland	16.6 acres	
Atriplex canescens - Artemisia tridentata / Tamarix chinensis Semi-natural Shrubland	13.3 acres	
Atriplex canescens - Artemisia tridentata Shrubland	17.3 acres	
Atriplex canescens - Artemisia tridentata Sparse Shrubland	2.4 acres	
Atriplex canescens - Gutierrezia sarothrae / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	6.6 acres	
Atriplex canescens - Gutierrezia sarothrae / (Erodium cicutarium, Salsola tragus, Bromus (rubens, tectorum), Halogeton glomeratus) Semi-natural Shrubland	24.7 acres	
Atriplex canescens - Gutierrezia sarothrae / Pleuraphis jamesii - Salsola tragus Semi-natural Sparse Shrubland	36.5 acres	
Atriplex canescens - Gutierrezia sarothrae / Pleuraphis jamesii Shrubland	28.2 acres	
Atriplex canescens - Gutierrezia sarothrae Shrubland	3.5 acres	
Atriplex canescens - Krascheninnikovia lanata Shrubland	10.7 acres	
Atriplex canescens / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	175.8 acres	
Atriplex canescens / (Erodium cicutarium, Salsola tragus, Bromus (rubens, tectorum), Halogeton glomeratus) Semi-natural Shrubland	30.1 acres	
Atriplex canescens / (Erodium cicutarium, Salsola tragus, Bromus (rubens, tectorum), Halogeton glomeratus) Semi-natural Shrubland	81.6 acres	
Atriplex canescens / (Erodium cicutarium, Salsola tragus, Bromus (rubens, tectorum), Halogeton glomeratus) Semi-natural Sparse Shrubland	11.4 acres	
Atriplex canescens / Pleuraphis jamesii - (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	8.2 acres	
Atriplex canescens / Pleuraphis jamesii Shrubland	70.7 acres	
Atriplex canescens / Pleuraphis jamesii Sparse Shrubland	8.9 acres	
Atriplex canescens / Sporobolus cryptandrus Sparse Shrubland	10.5 acres	
Atriplex canescens Shrubland	62.1 acres	
Atriplex canescens Sparse Shrubland	50.2 acres	
***Atriplex confertifolia* Shrubland Alliance**		**49.7**
Atriplex confertifolia - Krascheninnikovia lanata / (Salsola tragus, Bromus (rubens, tectorum)) Semi-natural Sparse Shrubland	10.9 acres	
Atriplex confertifolia - Krascheninnikovia lanata / Sparse Understory Dwarf-shrubland	8.7 acres	
Atriplex confertifolia / Salsola tragus / Cryptobiotic Semi-natural Dwarf-shrubland	2.2 acres	

Atriplex confertifolia Dwarf-shrubland	21.3 acres	
Atriplex confertifolia Sparse Dwarf-shrubland	6.7 acres	
***Chrysothamnus greenei* Shrubland Alliance**		**105.7 acres**
Chrysothamnus greenei - Gutierrezia sarothrae Dwarf-shrubland	22.8 acres	
Chrysothamnus greenei Dwarf-shrubland	75.4 acres	
Chrysothamnus greenei Sparse Dwarf-shrubland	7.5 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**42.3 acres**
Chrysothamnus viscidiflorus / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Dwarf-shrubland	13.7 acres	
Chrysothamnus viscidiflorus Shrubland	27.0 acres	
Chrysothamnus viscidiflorus Sparse Shrubland	1.6 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**0.4 acres**
Coleogyne ramosissima Shrubland	0.4 acres	
***Cylindropuntia echinocarpa* Shrubland Alliance**		**46.1 acres**
Cylindropuntia echinocarpa Sparse Shrubland	46.1 acres	
***Cylindropuntia echinocarpa* Sparsely Vegetated Alliance**		**10.4 acres**
Cylindropuntia echinocarpa - Gutierrezia sarothrae Sparse Vegetation	10.4 acres	
***Ericameria linearifolia* Shrubland Alliance**		**169.5 acres**
Ericameria linearifolia Dwarf-shrubland	29.1 acres	
Ericameria nauseosa - Gutierrezia sarothrae Shrubland	67.0 acres	
Ericameria nauseosa / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	25.8 acres	
Ericameria nauseosa / (Salsola tragus, Erodium cicutarium, Brassica nigra, Agropyron cristatum) Semi-natural Shrubland	14.5 acres	
Ericameria nauseosa Shrubland	26.1 acres	
Ericameria nauseosa Sparse Shrubland	6.9 acres	
***Ericameria nauseosa* Sparsely Vegetated Alliance**		**45.5 acres**
Ericameria nauseosa Sparse Vegetation	45.5 acres	
***Ericameria teretifolia* Shrubland Alliance**		**71.0 acres**
Ericameria teretifolia Dwarf-shrubland	70.6 acres	
Juniperus osteosperma / Ericameria teretifolia Wooded Dwarf-shrubland	0.4 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**55.7 acres**
Eriogonum corymbosum - Artemisia nova Sparse Shrubland	16.9 acres	
Eriogonum corymbosum - Ericameria nauseosa Shrubland	33.5 acres	
Eriogonum corymbosum - Gutierrezia sarothrae Shrubland	2.4 acres	
Eriogonum corymbosum Shrubland	2.9 acres	

Erodium cicutarium **Semi-natural Herbaceous Alliance**		**6.6 acres**
Lycium pallidum / Erodium cicutarium Semi-natural Shrub Herbaceous Vegetation	6.6 acres	
Fallugia paradoxa **Shrubland Alliance**		**4.6 acres**
Fallugia paradoxa - Coleogyne ramosissima Sparse Shrubland	1.2 acres	
Fallugia paradoxa Shrubland	3.4 acres	
Gutierrezia sarothrae **Shrubland Alliance**		**543.9 acres**
Gutierrezia sarothrae / (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Dwarf-shrubland	116.6 acres	
Gutierrezia sarothrae / (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Sparse Dwarf-shrubland	38.4 acres	
Gutierrezia sarothrae - Grindelia squarrosa Sparse Dwarf-shrubland	8.8 acres	
Gutierrezia sarothrae Dwarf-shrubland	335.1 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	45.0 acres	
Gutierrezia sarothrae **Sparsely Vegetated Alliance**		**5.8 acres**
Gutierrezia sarothrae Sparse Vegetation	5.8 acres	
Halogeton glomeratus **Semi-natural Herbaceous Alliance**		**1.5 acres**
Gutierrezia sarothrae / Halogeton glomeratus Semi-natural Shrub Herbaceous Vegetation	1.5 acres	
Juniperus osteosperma **Woodland Alliance**		**9.0 acres**
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	9.0 acres	
Krascheninnikovia lanata **Shrubland Alliance**		**188.1 acres**
Krascheninnikovia lanata / (Erodium cicutarium, Salsola tragus, Ceratocephala testiculata) Semi-natural Dwarf-shrubland	117.4 acres	
Krascheninnikovia lanata Dwarf-shrubland	67.2 acres	
Krascheninnikovia lanata Sparse Dwarf-shrubland	3.5 acres	
Larrea tridentata **Shrubland Alliance**		**0.4 acres**
Larrea tridentata Sparse Shrubland	0.4 acres	
Lycium pallidum **Shrubland Alliance**		**83.3 acres**
Lycium pallidum Shrubland	15.5 acres	
Lycium pallidum Sparse Shrubland	67.8 acres	
Mixed Desert Shrub Shrubland Alliance		**476.8 acres**
Mixed Desert Scrub / *(Bromus rubens, Salsola tragus, Erodium cicutarium)* Semi-natural Shrubland	6.7 acres	
Mixed Desert Scrub Shrubland	460.4 acres	
Mixed Desert Scrub Sparse Shrubland	9.6 acres	

***Pleuraphis jamesii* Herbaceous Alliance**		**222.3 acres**
Atriplex canescens - Gutierrezia sarothrae / Pleuraphis jamesii Shrub Herbaceous Vegetation	52.8 acres	
Atriplex canescens / Pleuraphis jamesii Shrub Herbaceous Vegetation	169.5 acres	
***Psorothamnus fremontii* Shrubland Alliance**		**72.1 acres**
Psorothamnus fremontii - Gutierrezia sarothrae Shrubland	20.9 acres	
Psorothamnus fremontii / (Salsola tragus, Bromus rubens) Semi-natural Shrubland	11.8 acres	
Psorothamnus fremontii Shrubland	39.5 acres	
***Purshia glandulosa* Mixed Shrubland Alliance**		**1.3 acres**
Purshia glandulosa Mixed Shrubland	1.3 acres	
Ruderal Vegetation		**1.8 acres**
***Salsola tragus* Semi-natural Herbaceous Alliance**		**406.0 acres**
Atriplex canescens / Salsola tragus - (Pleuraphis jamesii, Achnatherum hymenoides) Semi-natural Shrub Herbaceous Vegetation	171.5 acres	
***Atriplex canescens / Salsola tragus* Semi-natural Shrub Herbaceous Vegetation**		**95.4 acres**
Chrysothamnus greenei / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	25.4 acres	
Gutierrezia sarothrae / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	80.6 acres	
Krascheninnikovia lanata / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	1.3 acres	
Lycium andersonii / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	4.6 acres	
Lycium pallidum / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	2.1 acres	
Yucca baccata / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	25.1 acres	
Sparse Vegetation		**0.7 acres**
***Sphaeralcea (ambigua, coccinea, parviflora)* Herbaceous Alliance**		**16.7 acres**
Atriplex canescens / Sphaeralcea parviflora Shrub Herbaceous Vegetation	3.2 acres	
Gutierrezia sarothrae / Sphaeralcea parviflora Shrub Herbaceous Vegetation	13.5 acres	
Unclassified		**266.4 acres**

4.2.10.3 Physiognomy and composition

The Colorado Plateau Mixed Desert Scrub Ecological System is most commonly a shrubland or dwarf shrubland (Figure 4-11); and less commonly a sparse shrubland. Occasionally it is sparse vegetation or shrub herbaceous vegetation. Rarely is it wooded shrubland, sparse woodland, sparse dwarf shrubland, or sparse understory dwarf shrubland. Rarely are there mosaics of physiognomic types which include: wooded dwarf shrubland/dwarf shrubland, sparse woodland/dwarf shrubland, or sparse shrubland/herbaceous vegetation. These areas have indistinct boundaries between types.

Figure 4-11
Colorado Plateau Mixed Desert Scrub Ecological System

4.2.10.4 Disturbance regimes

Mixed Desert Shrub Shrubland is one of the largest alliances in the Colorado Plateau Mixed Desert Scrub Ecological System; it has a mix of shrub species which seemingly change with each step across the landscape. *Salsola tragus* is the only major invasive in what are rare occurrences of semi-natural communities. *Pleuraphis jamesii* co-dominates occasionally, but those associations are classified under the Colorado Plateau Shrub-Steppe Ecological System.

Other alliances with large acreage totals in this ecological system are *Artemisia filifolia* Shrubland Alliance, *Atriplex canescens* Shrubland Alliance, and *Gutierrezia sarothrae* Dwarf-shrubland Alliance. *Artemisia filifolia* and *Gutierrezia sarothrae* are increasers under grazing and resprout or colonize after fire. *Atriplex canescens* is a decreaser under grazing and can resprout after fire. This region was subjected to both prescribed and indiscriminate burning with the goal of increasing livestock forage production. *Coleogyne ramosissima* communities were the prime target of these burns. This opened up the range to colonization by invasive species such as *Bromus tectorum*, *Salsola tragus*, and *Erodium cicutarium*. When one or more invasive species dominate the shrub understory, the association is classified as a semi-natural type. Thus, semi-natural associations represent poorer range condition than natural associations. Where decreaser grasses are dominant in the understory of these shrubs, the plant community is classified under the Colorado Plateau Shrub-Steppe Ecological System.

Atriplex canescens is a major component of this ecological system, although most communities are semi-natural. *Atriplex canescens* dominated communities are frequently co-dominated by the increaser shrub *Gutierrezia sarothrae*. Good to excellent range condition is represented by the *Atriplex canescens / Pleuraphis jamesii* Shrub Herbaceous Alliance. Where large areas are burned or over-grazed, these may degrade to *Atriplex canescens* / (*Salsola tragus*, *Erodium cicutarium*) Semi-natural Shrub Herbaceous Vegetation, with intermediate stages difficult to classify. There can be significant year to year variability in the relative abundance of the decreaser grass *Pleuraphis jamesii* versus the main invasive, *Salsola tragus*. Timing of rainfall plays a role, with cool season rains favoring *Pleuraphis* and warm season rains favoring both. *Erodium cicutarium, Halogeton glomeratus, Bromus rubens,* and *Tamarix chinensis* are additional invasives which can increase in dominance under grazing or fire disturbance.

Another successional transition in *Atriplex canescens* communities is to co-dominance with the increaser shrubs *Artemisia tridentata* or *Eriogonum corymbosum* in the *Atriplex canescens - Artemisia tridentata* Shrubland and *Eriogonum corymbosum* Shrubland Alliances. Again, *Pleuraphis jamesii* is the only decreaser species.

Widespread alliances of lesser acreage include *Krascheninnikovia lanata* Dwarf-shrubland, *Ericameria liniarifolia* Shrubland, *E. teretifolia* Shrubland, *Chrysothamnus greenei* Shrubland, and *Chrysothamnus viscidiflorus* Shrubland. *Krascheninnikovia lanata* provides winter livestock forage and wildlife browse and is a decreaser under grazing in the survey area. *Chrysothamnus viscidiflorus* is an increaser under grazing. *Salsola tragus* is the only major invasive plant in the *Krascheninnikovia lanata* Dwarf-shrubland, invading under grazing pressure or after wildfire. *Erodium cicutarium* and *Bromus rubens* are the major invasive species in the *Chrysothamnus viscidiflorus* Shrubland. Some of these shrubs are difficult to distinguish from each other in vegetative condition. *Ericameria linearifolia*, *Chrysothamnus greenei*, and *Ericameria teretifolia* can be especially hard to identify on heavily grazed rangeland, where only a central stem and a few denuded branches remain following grazing. There are no decreasers which dominate the understory for any occurrence of these alliances, indicating that fair to poor range condition defines the alliances and association of Colorado Plateau Mixed Desert Scrub Ecological System.

The *Atriplex confertifolia* Shrubland Alliance has only minor acreage in this ecological system. It has both natural and semi-natural associations, in combination with *Krascheninnikovia lanata*, or *Salsola tragus* as co-dominates.

Other increaser shrubs which form alliances in this ecological system include: *Cylindropuntia echinocarpa*, *Eriogonum corymbosum*, *Ericameria nauseosa*, *Lycium andersonii*, *L. pallidum,* and *Yucca baccata*. Major invasive species in these alliances include *Salsola tragus*, *Bromus rubens*, and *Erodium cicutarium*. Decreaser species include *Sporobolus cryptandrus* and *Hesperostipa comata.*

Psorothamnus fremontii is a long-lived shrub indicative of later seral stages. It is adapted to natural disturbance from debris deposition on steep slopes. Stable seral stages may have large individuals with a mixed age structure to the population.

Eriogonum corymbosum is an increaser shrub which always co-dominates with another shrub in this ecological system. The *Eriogonum corymbosum* Shrubland Alliance also has *Ericameria nauseosa* as an increaser species, along with *Gutierrezia sarothrae* and *Lycium pallidum*. When dominant with *Coleogyne ramosissima,* it classifies to a *Coleogyne ramosissima* Shrubland association. That association is less degraded than the one in which it co-dominates with *Ericameria nauseosa* as the *Eriogonum corymbosum* Shrubland association.

The *Ericameria nauseosa* Shrubland Alliance is a degraded type comprised of various associations lacking *Coleogyne ramosissima* and *Eriogonum corymbosum*. It is occasionally prone to invasive dominance by *Salsola tragus* and *Erodium cicutarium*. Other decreaser shrubs which can attain dominance under grazing disturbance include *Lycium pallidum* and *Gutierrezia sarothrae*. No increasers ever attain dominance, illustrating the poor range condition of this type.

Fallugia paradoxa can dominate alone or with *Coleogyne ramosissima* in this ecological system. There are too few occurrences to determine disturbance regimes.

Lycium pallidum, an increaser under grazing, typically dominates communities that also have invasives as the major understory species. *Lycium pallidum* alliances are indicators of long duration overgrazing. Where decreaser grasses are co-dominant, the alliances are classified in the Colorado Plateau Shrub-Steppe Ecological System. Invasives dominating semi-natural associations include *Erodium cicutarium* and *Salsola tragus*. A decreaser grass, *Hesperostipa comata*, can be locally dominate, but only in mosaics with semi-natural areas dominated by *Salsola tragus*.

4.2.10.5 Relationship to the US National Vegetation Classification Systems

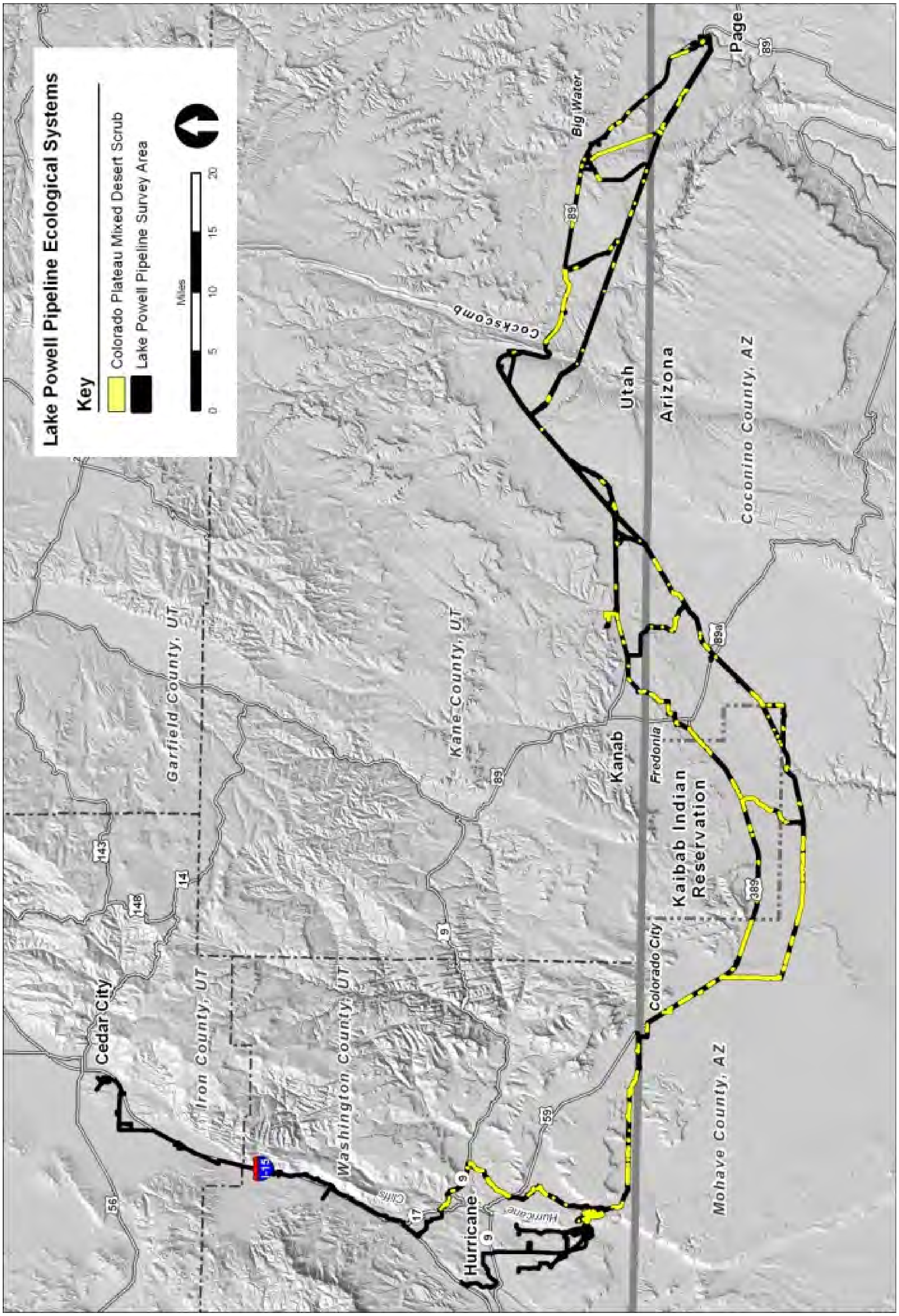
Despite the large total acreage for alliances within the Colorado Plateau Mixed Desert Scrub Ecological System, it does not directly crosswalk to any NatureServe ecological system. In part, it corresponds to NatureServe's Intermountain Basins Mixed Salt Desert Scrub Ecological System, which includes a number of alliances not defined by the presence of halophytes. The only halophyte with dominance on salic soils in the survey area is *Sarcobatus vermiculatus*. Associations where that shrub is dominant on the Colorado Plateau are strictly classified in this study as Colorado Plateau Greasewood Flat Ecological System. Thus, classification into a Mixed Desert Scrub ecological system is intuitive for alliances without *Sarcobatus vermiculatus*, such as those dominated by *Krascheninnikovia lanata*, *Atriplex confertifolia*, and *A. canescens*. *Atriplex confertifolia* communities alternately classify under the Colorado Plateau Gypsum Badlands Ecological System when gypsum is present at or near the surface of the soil.

Many of the shrub alliances can successionally advance to a wooded shrubland or sparse woodland physiognomic stage. These are included in this ecological system. Once the cover of trees increases to a woodland (25 percent or greater) they are classified under the Colorado Plateau Pinyon-Juniper Woodland Ecological System. *Juniperus osteosperma* / *Artemisia filifolia* Sparse Woodland is a single occurrence from an area that needs additional field work.

Larrea tridentata was documented as an unusual occurrence within the Colorado Plateau Region. Near the town of Virgin (outside the survey area), there are a few disjunct *Larrea tridentata* dominated communities atop the Hurricane Cliffs and on slopes above the Virgin River where it cuts through the Hurricane Cliffs.Whereas the Mohave Desert typically occurs no higher in elevation than the base of the cliffs, this disjunct community elevationally lies near the crest of the cliff formation.

Six of the alliances and 13 of the associations in this ecological system required minor name changes from types previously described in the US NVC. Eleven alliances and 73 associations are new types for the Colorado Plateau Region, not previously described in the national classification. Some of the new alliances and associations are due in part to a bottom-up sampling in which associations are primarily defined in this study by differences observed in the field. Existing types in the US NVC are classified by a top-down approach, where they are defined statistically by similarities and included into existing types whenever possible, even if the plants defining a given type are rare or occasional in the community.

Other new associations are the result of determining a physiognomic class which hadn't been previously described within an alliance. Sometimes the US NVC physiognomic class is incorrect. *Atriplex confertifolia* dominates associations which should consistently be classified as dwarf-shrublands. Associations classified as Shrub Herbaceous Vegetation are rare in the US NVC. The *Atriplex canescens* - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Sparse Shrubland and *Atriplex canescens* / *Pleuraphis jamesii* Shrubland associations could alternately be classified as Colorado Plateau Shrub-Steppe Ecological System. However, the NatureServe classification does not include any grass understory dominated *Atriplex canescens* or *Artemisia tridentata* communities within a shrub-steppe ecological system.



Map 4-10
Colorado Plateau Mixed Desert Scrub Ecological System

4.2.11 Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System

4.2.11.1 Geographic distribution

The Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System is found within the central portion of the LPP survey area. Scattered occurrences were documented along the southern transmission line corridor east of the Lower Paria River, on both the east and west side of Buckskin Gulch along Highway 89, across the southwest corner of the Kaibab Indian Reservation, and along Mount Trumbull Road (Map 4-11).

4.2.11.2 Alliances and associations

Within the survey area, the Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System is comprised of two alliances and six associations. This ecological system totals 63.6 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia bigelovii* Shrubland Alliance**		**8.7 acres**
Artemisia bigelovii Dwarf-shrubland	4.2 acres	
Artemisia bigelovii Sparse Dwarf-shrubland	4.5 acres	
***Artemisia nova* Shrubland Alliance**		**54.9 acres**
Artemisia (nova, bigelovii) Dwarf-shrubland	19.8 acres	
Artemisia (nova, bigelovii) Sparse Dwarf-shrubland	5.8 acres	
Artemisia nova Dwarf-shrubland	12.5 acres	
Artemisia nova Sparse Dwarf-shrubland	16.9 acres	

4.2.11.3 Physiognomy and composition

The Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System is comprised of associations which are either dwarf shrublands or sparse dwarf shrublands (Figure 4-12).

Figure 4-12
Colorado Plateau Mixed Low Sagebrush Ecological System

4.2.11.4 Disturbance regimes

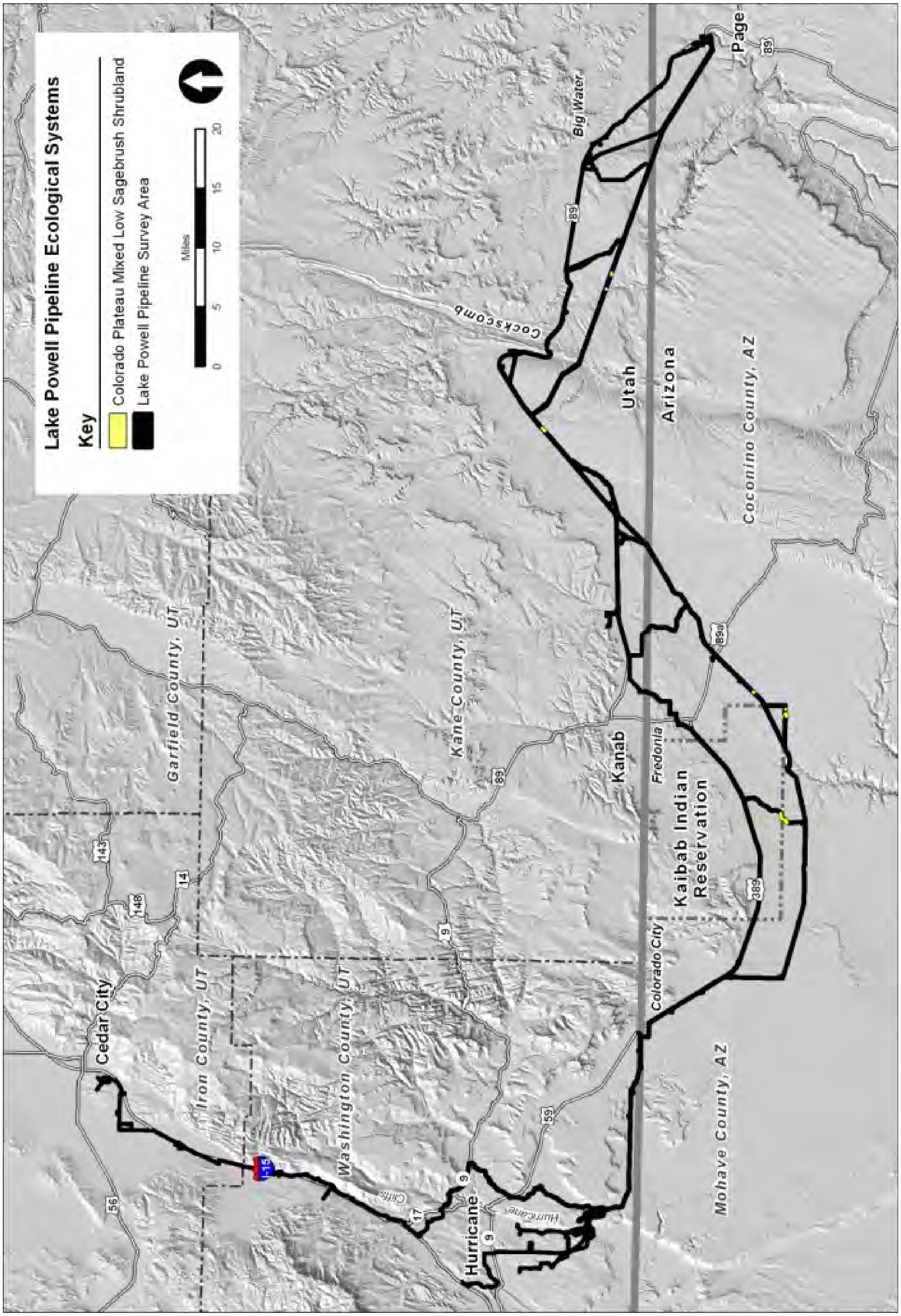
Plant communities within the Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System are controlled primarily by edaphic factors, versus disturbance regimes. These are long-lived, steady-state alliances which are resistant to drought and low nutrient levels associated with skeletal soils on bedrock substrates.

The *Artemisia nova / Pleuraphis jamesii* Dwarf-shrubland association, with co-dominating

Bouteloua gracilis in the *Artemisia bigelovii* Dwarf-shrubland association, represents good to excellent range condition in this ecological system. These are also the most prone to overgrazing. They are classified in the Colorado Plateau Shrub-Steppe Ecological System. Reduction in *Pleuraphis jamesii* leads to an *Artemisia nova* - *Ericameria nana* Shrubland association, or *Artemisia nova* Dwarf-shrubland association, classified under the Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System.

4.2.11.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System crosswalks to NatureServe's Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System. All six associations are name variations on existing associations in the US NVC for the Colorado Plateau Region.



Map 4-11
Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System

4.2.12 Colorado Plateau Pinyon-Juniper Woodland Ecological System

4.2.12.1 Geographic distribution

The Colorado Plateau Pinyon-Juniper Woodland Ecological System is found intermittantly throughout the LPP survey area. From east to west, occurrences are concentrated along the southern transmission line corridor from Cedar Mountain west to Highway 89 and along the northern pipeline corridor along Highway 89 from the Cockscomb west to nearly Fredonia, as well as along the north/ south transmission line corridor just west of Cedar Mountain, and along the transmission line north to Flat Top. West of Fredonia, occurrences are scattered along the southern proposed pipeline corridor west of Mount Trumbull Road and along the northern proposed pipeline corridor along Highway 389 west of the Pipe Springs National Monument turnoff to Colorado City. Two other groupings were documented, one near Short Creek west of Canaan Gap and one south of Highway 59 along the Honeymoon Trail to The Divide, adjacent to the Forebay area (Map 4-12).

4.2.12.2 Alliances and associations

Within the survey area, the Colorado Plateau Pinyon-Juniper Woodland Ecological System is comprised of 18 alliances with 70 associations. This ecological system totals 2415.2 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**16.9 acres**
Artemisia nova Sparse Dwarf-shrubland	16.9 acres	
***Artemisia filifolia* Shrubland Alliance**		**93.2 acres**
Juniperus osteosperma / Artemisia filifolia / (Bromus tectorum, Salsola tragus, Erodium cicutarium) Semi-natural Wooded Shrubland	3.8 acres	
Juniperus osteosperma / Artemisia filifolia Wooded Shrubland	89.4 acres	
***Artemisia nova* Shrubland Alliance**		**113.2 acres**
Juniperus osteosperma / Artemisia nova Wooded Dwarf-shrubland	23.3 acres	
Juniperus osteosperma / Artemisia nova Wooded Dwarf-shrubland	89.9 acres	
***Artemisia tridentata* Shrubland Alliance**		**94.3 acres**
Juniperus osteosperma / Artemisia tridentata / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Wooded Shrubland	19.1 acres	
Juniperus osteosperma / Artemisia tridentata Wooded Shrubland	69.9 acres	
Pinus monophylla - Juniperus osteosperma / Ephedra viridus Wooded Shrubland	5.3 acres	
***Artemisia tridentata ssp. tridentata* Shrubland Alliance**		**19.3 acres**
Juniperus osteosperma / Artemisia tridentata ssp. tridentata Wooded Shrubland	19.3 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**159.0 acres**
Artemisia tridentata ssp. vaseyana Shrubland	1.6 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Wooded Shrubland	1.0 acres	

Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Wooded Shrubland	134.8 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Wooded Shrubland	21.6 acres	
***Chrysothamnus greenei* Shrubland Alliance**		**118.6 acres**
Juniperus osteosperma / Chrysothamnus greenei Wooded Shrubland	118.6 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**236.2 acres**
Juniperus osteosperma / Coleogyne ramosissima Wooded Dwarf-shrubland	25.3 acres	
Juniperus osteosperma / Coleogyne ramosissima Wooded Shrubland	151.8 acres	
Pinus monophylla - Juniperus osteosperma / Coleogyne ramosissima Wooded Shrubland	59.1 acres	
***Ephedra nevadensis* Shrubland Alliance**		**170.8 acres**
Juniperus osteosperma / Ephedra (torreyana, nevadensis) - Gutierrezia sarothrae Wooded Shrubland	13.0 acres	
Juniperus osteosperma / Ephedra (torreyana, nevadensis) / Cryptobiotic Wooded Shrubland	0.5 acres	
Juniperus osteosperma / Ephedra (torreyana, nevadensis) / Pleuraphis jamesii Wooded Shrubland	1.7 acres	
Juniperus osteosperma / Ephedra (torreyana, nevadensis) Wooded Shrubland	134.7 acres	
Juniperus osteosperma / Ephedra nevadensis / (Bouteloua gracilis, Pleuraphis jamesii, Hesperostipa comata) Wooded Herbaceous Vegetation	8.2 acres	
Juniperus osteosperma / Ephedra nevadensis Wooded Shrubland	0.3 acres	
Pinus edulis - Juniperus osteosperma / Ephedra nevadensis Wooded Shrubland	12.4 acres	
***Ephedra torreyana* Shrubland Alliance**		**66.6 acres**
Juniperus osteosperma / Ephedra (torreyana, nevadensis) / Pleuraphis jamesii Wooded Shrubland	66.6 acres	
***Ericameria nauseosa* Shrubland Alliance**		**3.4 acres**
Juniperus osteosperma / Ericameria nauseosa Wooded Shrubland	2.0 acres	
Pinus edulis - Juniperus osteosperma / Ericameria nauseosa Wooded Shrubland	1.4 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**3.0 acres**
Pinus edulis - Juniperus osteosperma / Eriogonum corymbosum Wooded Shrubland	3.0 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**84.8 acres**
Juniperus osteosperma / Gutierrezia sarothrae Wooded Dwarf-shrubland	84.8 acres	
***Juniperus osteosperma* Sparsely Vegetated Alliance**		**7.7 acres**
Juniperus osteosperma / Artemisia nova Sparse Vegetation	2.1 acres	

Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Sparse Vegetation	5.6 acres	
***Juniperus osteosperma* Woodland Alliance**		**1001.2 acres**
(Pinus monophylla) - Juniperus osteosperma / Quercus x pauciloba Woodland	4.5 acres	
Juniperus osteosperma / (Bromus tectorum, Salsola tragus, Erodium cicutarium) Semi-natural Sparse Woodland	2.2 acres	
Juniperus osteosperma / (Bromus tectorum, Salsola tragus, Erodium cicutarium) Semi-natural Woodland	1.2 acres	
Juniperus osteosperma / Amelanchier utahensis Sparse Woodland	11.3 acres	
Juniperus osteosperma / Artemisia (tridentata ssp. vaseyana, nova) Sparse Woodland	8.7 acres	
Juniperus osteosperma / Artemisia biglovii Sparse Woodland	4.0 acres	
Juniperus osteosperma / Artemisia filifolia Sparse Woodland	23.9 acres	
Juniperus osteosperma / Artemisia nova Woodland	8.1 acres	
Juniperus osteosperma / Artemisia tridentata / Sparse Understory Woodland	16.7 acres	
Juniperus osteosperma / Artemisia tridentata Sparse Woodland	48.6 acres	
Juniperus osteosperma / Artemisia tridentata ssp. tridentata Sparse Woodland	23.9 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Sparse Woodland	63.3 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Woodland	248.8 acres	
Juniperus osteosperma / Artemisia tridentata Woodland	66.7 acres	
Juniperus osteosperma / Coleogyne ramosissima Sparse Woodland	64.2 acres	
Juniperus osteosperma / Coleogyne ramosissima Woodland	3.3 acres	
Juniperus osteosperma / Ephedra (nevadensis, viridis) Woodland	21.4 acres	
Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	74.6 acres	
Juniperus osteosperma / Fallugia paradoxa Sparse Woodland	1.1 acres	
Juniperus osteosperma / Gutierrezia sarothrae Sparse Woodland	10.6 acres	
Juniperus osteosperma / Gutierrezia sarothrae Woodland	50.7 acres	
Juniperus osteosperma / Salsola tragus Semi-natural Sparse Woodland	24.6 acres	
Juniperus osteosperma / Shepherdia rotundifolia Sparse Woodland	51.5 acres	
Juniperus osteosperma / Sparse Understory Woodland	32.8 acres	
Juniperus osteosperma Sparse Woodland	29.6 acres	
Juniperus osteosperma Woodland	104.8 acres	
Mixed Desert Shrub Shrubland Alliance		**24.9 acres**
Juniperus osteosperma / Mixed Desert Scrub Wooded Shrubland	24.9 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**203.3 acres**
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Woodland	36.3 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Sparse Woodland	40.2 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Woodland	9.7 acres	

Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Sparse Woodland	30.7 acres	
Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima Woodland	2.0 acres	
Pinus edulis - Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	16.8 acres	
Pinus edulis - Juniperus osteosperma / Ephedra nevadensis Woodland	0.02 acres	
Pinus edulis - Juniperus osteosperma / Gutierrezia sarothrae Sparse Woodland	10.3 acres	
Pinus edulis - Juniperus osteosperma / Pleuraphis jamesii Sparse Woodland	27.4 acres	
Pinus edulis - Juniperus osteosperma Woodland	29.9 acres	
***Pinus monophylla - (Juniperus osteosperma)* Woodland Alliance**		**10.2 acres**
Pinus monophylla - Juniperus osteosperma / Chrysothamnus greenei Woodland	10.2 acres	
***Purshia glandulosa* Mixed Shrubland Alliance**		**5.5 acres**
Juniperus osteosperma / Purshia glandulosa Wooded Shrubland	5.5 acres	

4.2.12.3 Physiognomy and composition

The Colorado Plateau Pinyon-Juniper Woodland Ecological System is most commonly a woodland (Figure 4-13); less commonly a sparse woodland or wooded Shrubland; occasionally a sparse understory woodland; and rarely a wooded dwarf shrubland, sparse or dwarf shrubland. Mosaics of sparse woodland/wooded sparse vegetation or wooded shrubland/sparse woodland are also rare.

Figure 4-13
Colorado Plateau Pinyon-Juniper Woodland Ecological System

4.2.12.4 Disturbance regimes

Seral development in the Colorado Plateau Pinyon-Juniper Woodland Ecological System is a predictable progression towards woodland following disturbances such as wildfire or logging. *Juniperus osteosperma*, *Pinus monophylla,* and *P. edulis* increase under fire suppression in this system. *Juniperus osteosperma* initially invades shrublands, but is kept in check by drought intolerance or fire. Global warming would be expected to force upwards the lower elevation limit of *Juniperus osteosperma*, resulting in increased mortality to trees that have already invaded this system. This would be most apparent in wooded shrubland associations which have *Coleogyne ramosissima* or *Ephedra nevadensis* as the dominant understory shrub.

Juniperus osteosperma can rapidly shift canopy dominance away from shrubs such as *Artemisia tridentata*, *A. filifolia*, *A. nova*, *A. bigelovii*, *Coleogyne ramosissima*, *Eriogonum corymbosum*, *Mahonia fremontii,* and *Rhus trilobata*. *Pinus monophylla* establishment may follow *Juniperus* invasion, although not at lower elevations where it cannot tolerate higher drought stresses. As tree cover increases, physiognomy shifts from wooded shrubland to sparse woodland, sparse understory woodland (especially when grazed), and eventually woodland. In rare cases the cover will develop into a forest. In the absence of fire or logging, *Juniperus osteosperma / Artemisia tridentata* Woodland will persist in lower elevations and *Pinus monophylla - Juniperus osteosperma / Artemisia tridentata* Woodland in higher elevations.

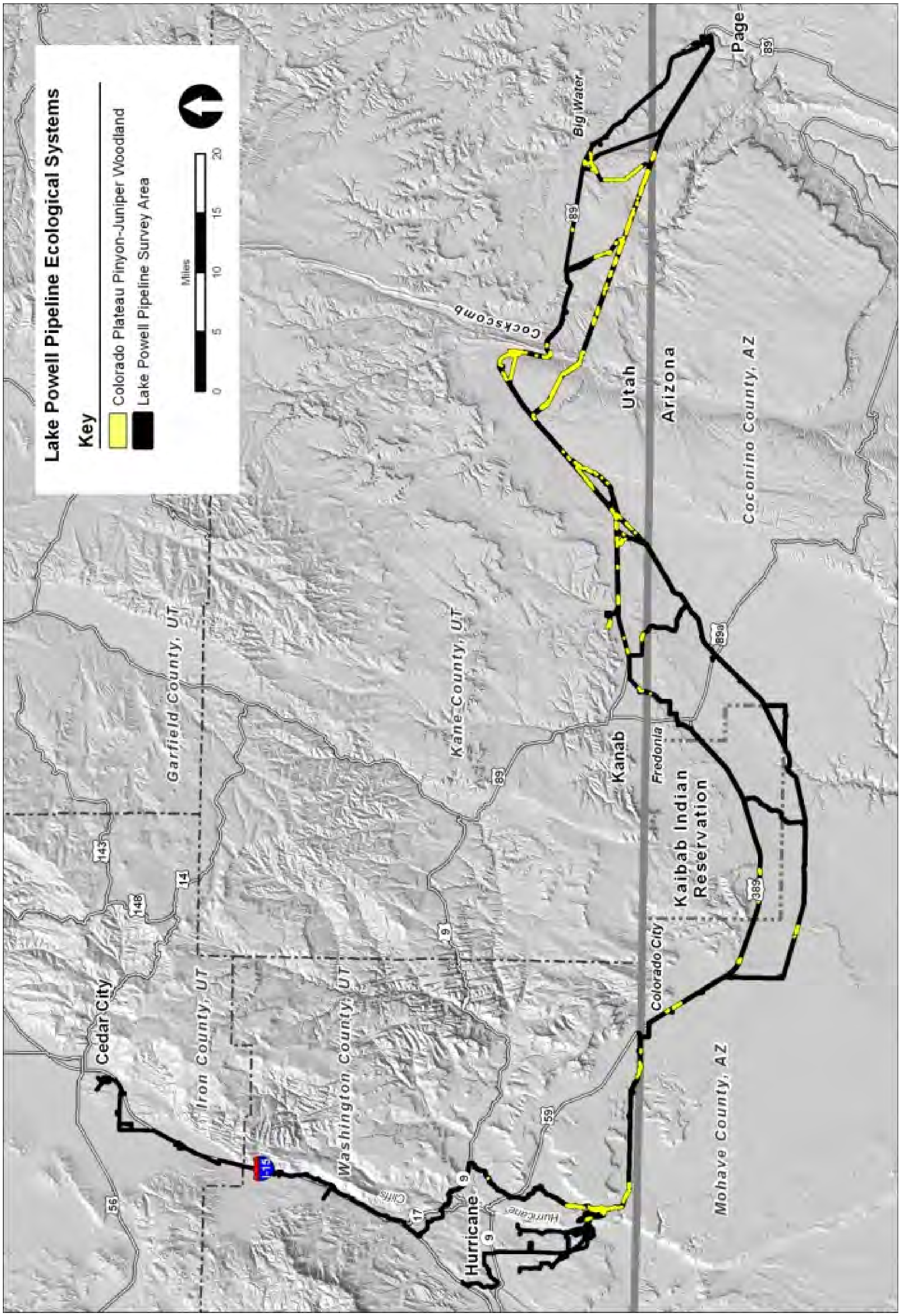
These woodlands become increasingly fire prone as their canopies close. Understory diversity and density decreases under the allelopathic effect of chemicals in the *Juniperus osteosperma* leaf litter. Younger stands rarely have an understory dominance of *Salsola tragus* or *Bromus tectorum.* These semi-natural communities have been impacted by nearby disturbance, edge effect from habitat fragmentation, or are of previous fire origin. Grazed occurrences often have *Gutierrezia sarothrae* as a shrub dominant. Older stands will often have an understory dominated by *Artemisia tridentata*, with occasional *Cordylanthus parviflorus* as a scattered native herb. Both species can withstand allelopathic chemicals.

When invading trees have their canopies raised by deer browsing, ground fires can kill shrubs but leave the junipers. These fires may lead to a Colorado Plateau Juniper Savanna Ecological System, as long as the grasses recover and co-dominate with 10 percent cover or more.

4.2.12.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Pinyon-Juniper Woodland Ecological System crosswalks in part to NatureServe's Colorado Plateau Pinyon-Juniper Woodland Ecological System. The most conspicuous difference is in how wooded shrubland associations are classified within both alliances and ecological systems in this report. Classification into an ecological system is based on the dominant species in the tallest strata (canopy), versus classification to alliance which is based on species in the strata (sub-canopy) with the greatest vegetal cover.

Three of the alliances and 19 of the associations in this ecological system required minor name changes from types previously described in the US NVC. Ten alliances and 43 associations are new types for the Colorado Plateau Region, not previously described in the national classification. Many of the new types are wooded shrublands.



Map 4-12
Colorado Plateau Pinyon-Juniper Woodland Ecological System

4.2.13 Colorado Plateau Shrub-Steppe Ecological System

4.2.13.1 Geographic distribution

The Colorado Plateau Shrub-Steppe Ecological System occurs intermittently throughout the LPP survey area. Occurrences were documented along the proposed pipeline corridor from the Glen Canyon Dam area along Highway 89 to the Cockscomb, along the transmission line corridor from the Glen Canyon Dam area to the Cockscomb, from the Petrified Hollow Wash area (Highway 89) to Cedar Ridge (Highway 389), and from Short Creek at Canaan Gap to Sheep Bridge Road at Highway 9 (Map 4-13).

4.2.13.2 Alliances and associations

Within the survey area, the Colorado Plateau Shrub-Steppe Ecological System is comprised of 24 alliances, that include 61 associations. This ecological system totals 1,919.6 acres within the survey area. Acreage by alliance and association is as follows:

***Achnatherum hymenoides* Herbaceous Alliance**		**82.7 acres**
Ephedra nevadensis / Achnatherum hymenoides Shrub Herbaceous Vegetation	34.8 acres	
Gutierrezia sarothrae / (Pleuraphis jamesii, Achnatherum hymenoides) Shrub Herbaceous Vegetation	47.8 acres	
***Artemisia filifolia* Shrubland Alliance**		**21.9 acres**
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) / (Heterostopa comata ssp. comata, Bouteloua gracilis) Shrubland	12.8 acres	
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) / Sporobolus cryptanthus Sparse Shrubland	6.0 acres	
Artemisia filifolia / Hesperostipa comata ssp. comata Shrubland	1.4 acres	
Artemisia filifolia / Pleuraphis jamesii Shrubland	1.7 acres	
***Artemisia nova* Shrubland Alliance**		**54.9 acres**
Artemisia nova / Pleuraphis jamesii Dwarf-shrubland	54.9 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**5.6 acres**
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Shrubland	5.6 acres	
***Atriplex confertifolia* Shrubland Alliance**		**81.9 acres**
Atriplex confertifolia - Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland	1.6 acres	
Atriplex confertifolia / Pleuraphis jamesii - Salsola tragus Semi-natural Dwarf-shrubland	0.4 acres	
Atriplex confertifolia / Pleuraphis jamesii Dwarf-shrubland	79.9 acres	
***Chrysothamnus greenei* Shrubland Alliance**		**175.3 acres**
Chrysothamnus greenei - Gutierrezia sarothrae / Pleuraphis jamesii Sparse Dwarf-shrubland	11.2 acres	
Chrysothamnus greenei / Pleuraphis jamesii - (Erodium cicutarium, Salsola tragus) Semi-natural Dwarf-shrubland	66.7 acres	

Chrysothamnus greenei / Pleuraphis jamesii Dwarf-shrubland	77.8 acres	
Chrysothamnus greenei / Pleuraphis jamesii Sparse Dwarf-shrubland	19.6 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**1.3 acres**
Chrysothamnus viscidiflorus / (Pleuraphis jamesii, Hesperostipa comata ssp. comata) Shrubland	1.3 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**47.0 acres**
Coleogyne ramosissima - Ephedra viridus / Sporobolus cryptandrus Shrubland	22.4 acres	
Coleogyne ramosissima / (Sporobolus cryptandrus, Pleuraphis rigida) Sparse Shrubland	15.3 acres	
Coleogyne ramosissima / Pleuraphis jamesii Shrubland	9.3 acres	
***Ephedra (nevadensis, torreyana)* Shrubland Alliance**		**3.5 acres**
Ephedra nevadensis - Ephedra torreyana / Pleuraphis rigida Shrubland	3.5 acres	
***Ephedra nevadensis* Shrubland Alliance**		**313.5 acres**
Ephedra nevadensis - Gutierrezia sarothrae / (Pleuraphis jamesii, Bouteloua gracilis) Shrubland	87.0 acres	
Ephedra nevadensis - Gutierrezia sarothrae / (Pleuraphis jamesii, Bouteloua gracilis, Hesperostipa comata ssp. comata) Shrubland	21.0 acres	
Ephedra nevadensis - Gutierrezia sarothrae / (Pleuraphis jamesii, Sporobolus cryptandrus, Bouteloua gracilis) Dwarf-shrubland	46.3 acres	
Ephedra nevadensis - Gutierrezia sarothrae / Pleuraphis jamesii Sparse Dwarf-shrubland	8.9 acres	
Ephedra nevadensis / (Bouteloua gracilis, Sporobolus cryptandrus, Achnatherum hymenoides) Shrubland	50.7 acres	
Ephedra nevadensis / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	11.5 acres	
Ephedra nevadensis / Achnatherum hymenoides Dwarf-shrubland	60.4 acres	
Ephedra nevadensis / Achnatherum hymenoides Shrubland	11.1 acres	
Ephedra nevadensis / Pleuraphis jamesii Shrubland	16.6 acres	
***Ephedra nevadensis* Sparsely Vegetated Alliance**		**2.0 acres**
Ephedra nevadensis / Pleuraphis jamesii Sparse Vegetation	2.0 acres	
***Ephedra torreyana* Shrubland Alliance**		**60.7 acres**
Ephedra torreyana / Pleuraphis jamesii Sparse Shrubland	60.7 acres	
***Ericameria nauseosa* Shrubland Alliance**		**16.6 acres**
Ericameria nauseosa - Gutierrezia sarothrae Shrubland / Pleuraphisjamesii Shrubland	1.4 acres	
Ericameria nauseosa / Achnatherum hymenoides Shrubland	9.6 acres	
Ericameria nauseosa Shrubland	5.6 acres	
***Ericameria teretifolia* Shrubland Alliance**		**7.9 acres**
Ericameria teretifolia / Achnatherum parishii Dwarf-shrubland	7.9 acres	

***Eriogonum corymbosum* Shrubland Alliance**		**133.2 acres**
Eriogonum corymbosum - Gutierrezia sarothrae / (Pleuraphis jamesii, Achnatherum hymenoides) Shrubland	126.6 acres	
Eriogonum corymbosum - Gutierrezia sarothrae / Pleuraphis jamesii Sparse Shrubland	6.5 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**297.1 acres**
Gutierrezia sarothrae - (Opuntia spp.) / Pleuraphis jamesii - Salsola tragus Semi-natural Sparse Dwarf-shrubland	38.5 acres	
Gutierrezia sarothrae - (Opuntia spp.) / Pleuraphis jamesii Dwarf-shrubland	30.7 acres	
Gutierrezia sarothrae - (Opuntia spp.) / Pleuraphis jamesii Sparse Dwarf-shrubland	115.5 acres	
Gutierrezia sarothrae / (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Sparse Dwarf-shrubland	48.6 acres	
Gutierrezia sarothrae / (Pleuraphis jamesii, Achnatherum hymenoides) Dwarf-shrubland	9.3 acres	
Gutierrezia sarothrae / Achnatherum hymenoides Sparse Dwarf-shrubland	3.3 acres	
Gutierrezia sarothrae / Pleuraphis jamesii - (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Dwarf-shrubland	49.8 acres	
Gutierrezia sarothrae / Pleuraphis rigida - Salsola tragus Semi-natural Dwarf-shrubland	1.5 acres	
***Hesperostipa comata* Herbaceous Alliance**		**12.5 acres**
Ephedra nevadensis / Hesperostipa comata ssp. comata Shrub Herbaceous Vegetation	12.5 acres	
***Krascheninnikovia lanata* Shrubland Alliance**		**157.4 acres**
Krascheninnikovia lanata / (Pleuraphis jamesii, Achnatherum hymenoides) - (Erodium cicutarium, Salsola tragus) Semi-natural Dwarf-shrubland	117.6 acres	
Krascheninnikovia lanata / Pleuraphis jamesii Dwarf-shrubland	39.8 acres	
Mixed Desert Shrub Shrubland Alliance		**230.8 acres**
Mixed Desert Scrub / Pleuraphis jamesii Shrubland	222.8 acres	
Mixed Desert Scrub / Pleuraphis jamesii Sparse Shrubland	7.9 acres	
***Pleuraphis jamesii* Herbaceous Alliance**		**117.9 acres**
Atriplex confertifolia / Pleuraphis jamesii Shrub Herbaceous Vegetation	4.1 acres	
Chrysothamnus greenei / Pleuraphis jamesii Shrub Herbaceous Vegetation	47.8 acres	
Ephedra nevadensis / Pleuraphis jamesii Shrub Herbaceous Vegetation	61.0 acres	
Ephedra viridus / Pleuraphis jamesii Shrub Herbaceous Vegetation	1.3 acres	
Gutierrezia sarothrae / Pleuraphis jamesii Shrub Herbaceous Vegetation	3.8 acres	
***Psorothamnus fremontii* Shrubland Alliance**		**2.8 acres**
Psorothamnus fremontii / Pleuraphis rigida - Salsola tragus Semi-natural Shrubland	2.8 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**8.3 acres**
Chrysothamnus greenei / Salsola tragus - Pleuraphis jamesii - Achnatherum hymenoides Semi-natural Shrub Herbaceous Vegetation	5.7 acres	

Chrysothamnus viscidiflorus / Pleuraphis jamesii - Salsola tragus Semi-natural Shrub Herbaceous Vegetation	2.7 acres	
***Sarcobatus vermiculatus* Shrubland Alliance**		**59.1 acres**
Atriplex confertifolia - Sarcobatus vermiculatus / Pleuraphis jamesii Shrubland	59.1 acres	
***Sporobolus cryptandrus* Herbaceous Alliance**		**3.3 acres**
Ericameria nauseosa / Sporobolus cryptandrus Shrub Herbaceous Vegetation	3.3 acres	
Unclassified		**22.3 acres**

4.2.13.3 Physiognomy and composition

The Colorado Plateau Shrub-Steppe Ecological System is most frequently a shrubland, dwarf shrubland, sparse dwarf shrubland, or shrub herbaceous vegetation (**Error! Reference source not found.**). It is infrequently a sparse dwarf shrubland and rarely a sparse shrubland, or mosaic of shrubland and herbaceous vegetation.

Figure 4-14
Colorado Plateau Shrub-Steppe Ecological System

4.2.13.4 Disturbance regimes

The Colorado Plateau Shrub-Steppe Ecological System represents a successional stage favored in managing rangelands for forage production. For over 150 years, this landscape has been important to ranchers as grazing land for livestock production. Since plant productivity in the desert system is low, the cost of management strategies must not exceed profit from sale of livestock. Thus, the low cost of using fire played an early role as a low cost management technique for reducing shrub competition and favoring grasses. When rangelands lacked a perennial grass component, fire converted the landscape to a mixed desert scrub system. When perennial grass was present and responded favorably after burning, fire converted the landscape to this shrub-steppe system. Of the two, shrub steppe is considered better range condition and the target state for continued rangeland management. Decreaser grasses in Shrub-Steppe are *Pleuraphis jamesii* and *Achnantherum hymenoides*.

The Mixed Desert Shrub Shrubland Alliance within the Colorado Plateau Shrub Steppe Ecological System has a mix of species which seemingly changes with each step across the land. What every alliance and association in this system has in common is dominance by a native grass in the shrub understory. If the understory loses grass dominance due to long periods of over grazing, siltation from flooding, catastrophic wildfire, or competition from invasive species, the alliances and associations are then re-classified into the Colorado Plateau Mixed Desert Scrub Ecological System. Invasives aren't generally dominant, unless a native grass is co-dominant in the community.

The *Atriplex confertifolia* Shrubland Alliance has shrub-steppe associations in the *Atriplex confertifolia / Pleuraphis jamesii* Shrubland association. The environmental factors controlling the comparative densities of *Atriplex confertifolia* versus the decreaser grass *Pleuraphis jamesii* stage are unknown. *Salsola tragus* is rarely dominant and the only invasive of note. The *Atriplex confertifolia* Shrubland Alliance is transitional to *Atriplex confertifolia - Sarcobatus vermiculatus / Pleuraphis jamesii* Shrubland.

There are many alliances dominated by increaser shrubs. These include the, *Artemisia filifolia* Shrubland, *Artemisia nova* Shrubland, *Chrysothamnus greenei* Shrubland, *Coleogyne ramosissima* Shrubland, and *Ericameria nauseosa* Shrubland. *Bouteloua gracilis*, *Hesperostipa comata*, *Pleuraphis jamesii, P. rigida* and *Sporobolus cryptanthus* are the decreaser grass species. *Erodium cicutarium* and *Salsola tragus* are rarely dominant and the only noteworthy invasives.

Gutierrezia sarothrae Shrubland is a major alliance dominated by an increaser shrub. Good to excellent range condition is indicated by decreaser grass dominance in the understory. These species include *Acnatherum hymenoides* and *Pleuraphis jamesii*. Degraded communities have *Erodium cicutarium*, *Bromus rubens*, or *Salsola tragus* dominating as invasive species. Once a native grass is no longer dominant, the community is classified in the Colorado Plateau Mixed Desert Scrub Ecological System.

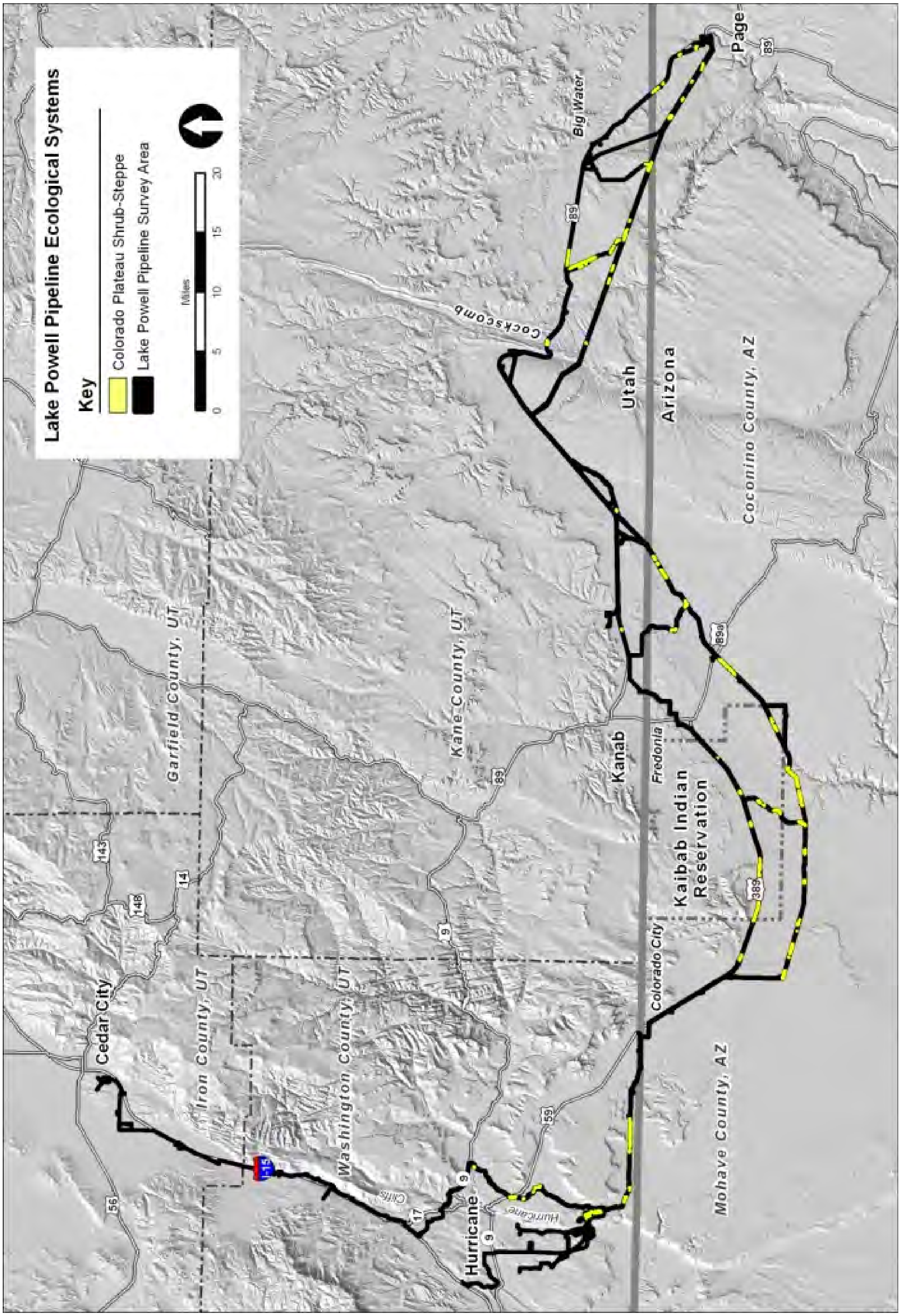
Alliances dominated by grasses and shrubs which decrease in abundance with grazing include *Krascheninnikovia lanata* Shrubland Alliance, *Achnatherum hymenoides* Herbaceous Alliance, *Pleuraphis jamesii* Herbaceous Alliance, and *Sporobolus cryptandrus* Herbaceous Alliance. Good to excellent range condition is indicated by decreaser grass dominance, such as *Acnatherum hymenoides* and *Pleuraphis jamesii*. Degraded communities have *Erodium cicutarium*, *Bromus rubens*, or *Salsola tragus* dominating as invasive species.

Ephedra nevadensis Shrubland is a major alliance in this ecological system. *E. nevadensis* provides valuable winter forage for livestock and wildlife. It is not reported to be either a decreaser or increaser under grazing. Communities must have *Achnatherum hymenoides*, *Pleuraphis jamesii*, *Bouteloua gracilis*, *Hesperostipa comata*, or *Sporobolus cryptandrus* dominant in the understory to be classified as Shrub-Steppe. Semi-natural types in this ecological system have one of the above grasses, plus co-dominance by one of the following invasive species: *Salsola tragus*, *Erodium cicutarium,* or *Bromus rubens*. Those communities without dominant native grasses are classified as Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System.

4.2.13.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Shrub-Steppe Ecological System crosswalks in concept to NatureServe's Inter-Mountain Basins Semi-Desert Shrub-Steppe Ecological System. It greatly expands upon the number of alliances and associations NatureServe includes in the system. As a rule, a community had to have a grass listed as dominant to be included in this type. Excluded were treed communities which are classified under Colorado Plateau Pinyon-Juniper Woodland Ecological System, *Artemisia tridentata* dominated communities which are classified under Colorado Plateau Big Sagebrush Ecological System, and other systems in which a landform was the major diagnostic characteristic.

Four of the alliances and nine of the associations in this ecological system required minor name changes from types previously described in the US NVC. Six alliances and 44 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-13
Colorado Plateau Shrub-Steppe Ecological System

4.2.14 Colorado Plateau Volcanic Rock and Cinder Land Ecological System

4.2.14.1 Geographic distribution

The Colorado Plateau Volcanic Rock and Cinder Land Ecological System is found within the far western portion of the LPP survey area. All occurrences were documented south of Highway 59 near The Divide and within the northern area of the Forebay, just west of the Honeymoon Trail (Map 4-14).

4.2.14.2 Alliances and associations

Within the survey area, the Colorado Plateau Volcanic Rock and Cinder Land Ecological System is comprised of four alliances and five associations. This ecological system totals 84.2 acres within the survey area. Acreage by alliance and association is as follows:

***Coleogyne ramosissima* Shrubland Alliance**		**16.8 acres**
Coleogyne ramosissima Shrubland	8.0 acres	
Pinus monophylla - Juniperus osteosperma / Coleogyne ramosissima Wooded Shrubland	8.7 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**23.5 acres**
Eriogonum fasciculatum / Erodium cicutarium Semi-natural Shrub Herbaceous Vegetation	23.5 acres	
Herbaceous Vegetation		**12.9 acres**
***Salsola tragus* Semi-natural Herbaceous Alliance**		**31.0 acres**
Yucca baccata / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	31.0 acres	

Figure 4-15
Colorado Plateau Volcanic Rock and Cinder Land Ecological System

4.2.14.3 Physiognomy and composition

Within the survey area, the Colorado Plateau Volcanic Rock and Cinder Land Ecological System is variously shrub herbaceous vegetation, herbaceous vegetation, wooded shrubland, and shrubland (Figure 4-15).

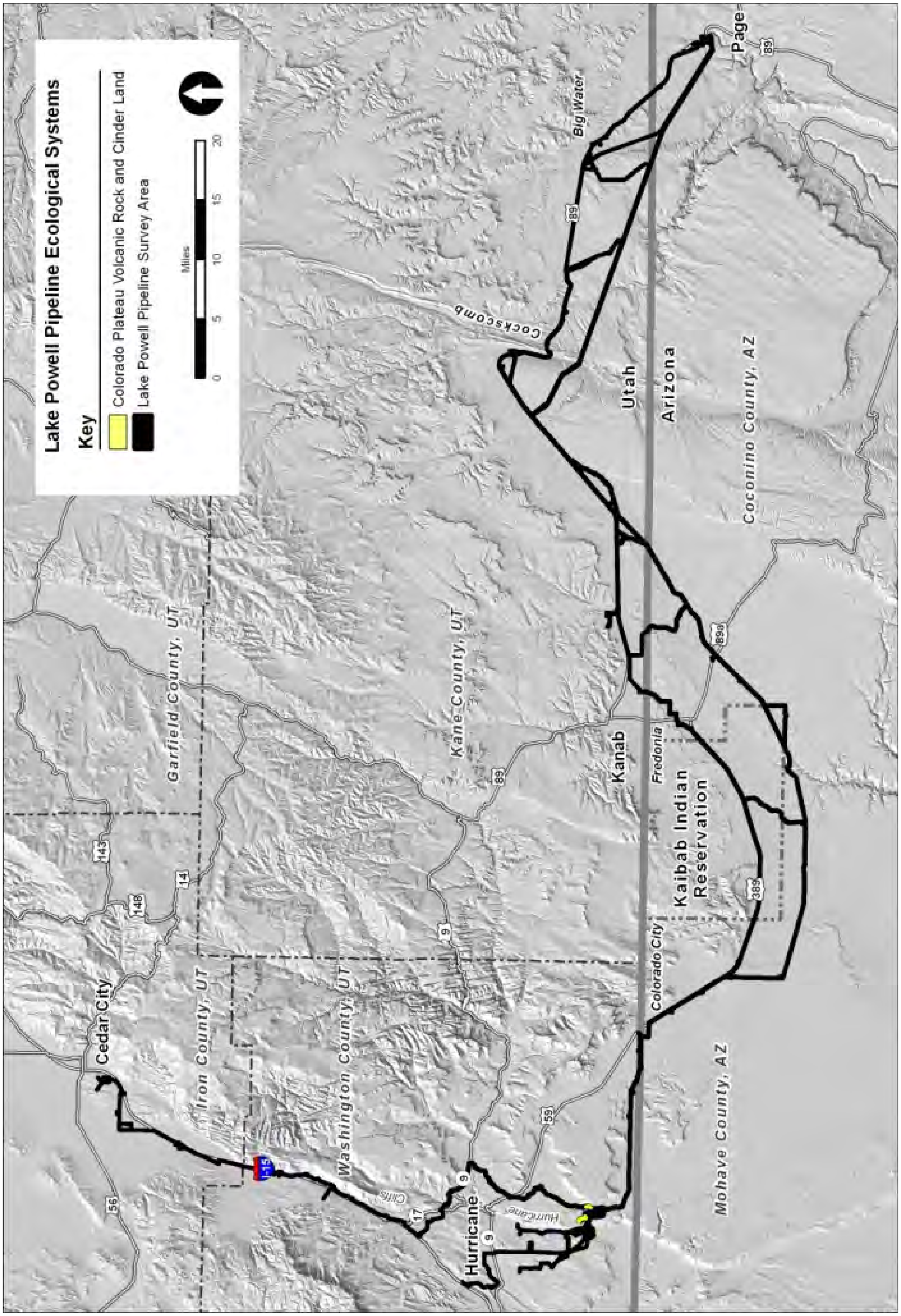
4.2.14.4 Disturbance regimes

Within the LPP project area, the Colorado Plateau Volcanic Rock and Cider Land Ecological System has been heavily burned since 2006. *Coleogyne ramosissima* Shrubland Alliance is the only natural vegetation alliance within this ecological system not impacted by recent wildfire. In the absence of fire and timber cutting, both *Pinus edulis* and *Juniperus* *osteosperma* invade shrublands leading to a *Pinus edulis - Juniperus osteosperma* Wooded Shrubland. These stands can be co-dominated by *Pleuraphis jamesii* when not grazed out, but are then classified as Shrub-Steppe. *Salsola tragus* and *Erodium cicutarium* are invasive species which have colonized the severly burned areas in this ecological system.

4.2.14.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Volcanic Rock and Cinder Land Ecological System crosswalks in concept only to NatureServe's Inter-Mountain Basins Volcanic Rock and Cinder Land Ecological System. None of the alliances in the survey area are included in the NatureServe ecological system. That system is ambiguously defined as having less than 10 percent vegetal cover, yet 13 of the 15 associations listed for the system have cover over 10 percent.

One alliance and one association in this ecological system required minor name changes from types previously described in the US NVC. Three associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-14
Colorado Plateau Volcanic Rock and Cinder Land Ecological System

4.2.15 Colorado Plateau Wash Ecological System

4.2.15.1 Geographic distribution

The Colorado Plateau Wash Ecological System is found scattered throughout the LPP survey area. While washes are characteristic of the Colorado Plateau topography, many are too small to be mapped on the 1:3,780 scale aerial imagery most commonly used in the survey area. Thus, the occurrences of this ecological system represent washes wide enough to be accurately delineated, across a 300 foot or 600 foot survey area, this is equal to an average minimum mapping area of 0.3 acre.

Wash locations are found scattered throughout the Region, occurring from just west of the Glen Canyon Dam on the east side of the survey area, to the Nephi Twist near La Verkin on the west side of the survey area. One hundred thirty-seven individual washes were documented across the proposed pipeline and transmission line corridors with the Colorado Plateau Region (Map 4-15).

4.2.15.2 Alliances and associations

A wide variety of species can dominate washes. Within the survey area, the Colorado Plateau Wash Ecological System has an exceptionally large number of alliances (32) and associations (53).This ecological system totals 191.0 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**15.5 acres**
Artemisia filifolia - Atriplex canescens Sparse Shrubland	1.8 acres	
Artemisia filifolia Shrubland	8.3 acres	
Artemisia filifolia Sparse Shrubland	5.4 acres	
***Artemisia filifolia* Sparsely Vegetated Alliance**		**1.0 acres**
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Sparse Vegetation	1.0 acres	
***Artemisia tridentata* Shrubland Alliance**		**9.4 acres**
Artemisia tridentata - Ericameria nauseosa Shrubland	5.8 acres	
Artemisia tridentata Shrubland	3.6 acres	
***Artemisia tridentata* ssp. *tridentata* Shrubland Alliance**		**17.5 acres**
Artemisia tridentata ssp. tridentata - Ericameria nauseosa Shrubland	4.4 acres	
Artemisia tridentata ssp. tridentata - Tamarix chinensis Semi-natural Shrubland	3.6 acres	
Artemisia tridentata ssp. tridentata Shrubland	8.3 acres	
Artemisia tridentata ssp. tridentata Sparse Shrubland	1.2 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**28.9 acres**
Artemisia tridentata ssp. vaseyana - Ericameria nauseosa Shrubland	0.7 acres	
Artemisia tridentata ssp. vaseyana Shrubland	23.3 acres	
Artemisia tridentata ssp. vaseyana Sparse Shrubland	4.9 acres	

Atriplex canescens **Shrubland Alliance**		**20.1 acres**
Atriplex canescens - Tamarix chinensis Semi-natural Shrubland	0.6 acres	
Atriplex canescens / (Erodium cicutarium, Salsola tragus, Bromus (rubens, tectorum), Halogeton glomeratus) Semi-natural Shrubland	1.5 acres	
Atriplex canescens / Salsola tragus Semi-natural Shrubland	5.5 acres	
Atriplex canescens Desert Wash Shrubland	6.2 acres	
Atriplex confertifolia **Shrubland Alliance**		**1.6 acres**
Atriplex confertifolia - Krascheninnikovia lanata Dwarf-shrubland	1.6 acres	
Ericameria nauseosa **Shrubland Alliance**		**14.3 acres**
Ericameria nauseosa - Gutierrezia sarothrae Shrubland	3.0 acres	
Ericameria nauseosa - Tamarix chinensis Semi-natural Desert Wash Shrubland	3.3 acres	
Ericameria nauseosa / (Bromus tectorum, Salsola tragus) Semi-natural Desert Wash Shrubland	2.2 acres	
Ericameria nauseosa Shrubland	5.9 acres	
Ericameria nauseosa **Sparsely Vegetated Alliance**		**1.9 acres**
Ericameria nauseosa Sparse Vegetation	1.9 acres	
Eriogonum fasciculatum **Shrubland Alliance**		**0.3 acres**
Eriogonum fasciculatum - Purshia glandulosa Shrubland	0.3 acres	
Fallugia paradoxa **Shrubland Alliance**		**3.0 acres**
Fallugia paradoxa Desert Wash Shrubland	3.0 acres	
Fraxinus anomala **Sparsely Vegetated Alliance**		**2.8 acres**
Amelanchier utahensis - Fraxinus anomala Sparse Vegetation	1.0 acres	
Fraxinus anomala - Tamarix chinensis Semi-natural Sparse Vegetation	0.7 acres	
Unclassified	1.1 acres	
Gutierrezia sarothrae **Shrubland Alliance**		**5.2 acres**
Gutierrezia sarothrae Dwarf-shrubland	5.2 acres	
Gutierrezia sarothrae **Sparsely Vegetated Alliance**		**0.9 acres**
Gutierrezia sarothrae / Salsola tragus Semi-natural Sparse Vegetation	0.9 acres	
Juniperus osteosperma **Sparsely Vegetated Alliance**		**3.5 acres**
Juniperus osteosperma / Purshia glandulosa Sparse Vegetation	2.9 acres	
Juniperus osteosperma Sandstone Slickrock Sparse Vegetation	0.6 acres	
Juniperus osteosperma **Woodland Alliance**		**16.9 acres**
Juniperus osteosperma / Fallugia paradoxa Sparse Woodland	2.7 acres	
Juniperus osteosperma Sparse Woodland	12.0 acres	
Juniperus osteosperma Woodland	2.1 acres	
Mixed Desert Shrub Shrubland Alliance		**0.7 acres**
Mixed Desert Scrub / Pleuraphis jamesii Shrubland	0.7 acres	

Mixed Desert Shrub Sparsely Vegetated Alliance		**1.6 acres**
Mixed Desert Shrub Sparse Vegetation	1.6 acres	
Non-vegetated		**2.7 acres**
***Populus fremontii* Sparsely Vegetated Alliance**		**4.0 acres**
Populus fremontii / Tamarix chinensis Semi-natural Wooded Sparse Vegetation	4.0 acres	
***Purshia (stansburiana, glandulosa, mexicana)* Shrubland Alliance**		**1.0 acres**
Juniperus osteosperma / Purshia glandulosa Wooded Shrubland	1.0 acres	
***Purshia glandulosa* Mixed Shrubland Alliance**		**2.9 acres**
Purshia glandulosa Mixed Shrubland	2.9 acres	
***Rhus trilobata* Shrubland Alliance**		**0.5 acres**
Rhus trilobata Sparse Shrubland	0.5 acres	
***Rhus trilobata* Sparsely Vegetated Alliance**		**2.1 acres**
Rhus trilobata Sparse Vegetation	2.1 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**0.2 acres**
Atriplex canescens / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	0.2 acres	
Sandstone Bedrock Sparse Vegetation		**0.4 acres**
***Sarcobatus vermiculatus* Shrubland Alliance**		**0.3 acres**
Sarcobatus vermiculatus - Gutierrezia sarothrae Sparse Shrubland	0.3 acres	
Shrubland		**2.0 acres**
Sparse Vegetation		**10.8 acres**
***Sphaeralcea (ambigua, coccinea, parviflora)* Herbaceous Alliance**	10.8 acres	**1.5 acres**
Sphaeralcea (ambigua, coccinea, parviflora) - (Salsola tragus, Erodium cicutarium) Semi-natural Herbaceous Vegetation	1.5 acres	
***Tamarix chinensis* Semi-natural Shrubland Alliance**		**2.0 acres**
Tamarix chinensis Semi-natural Shrubland	0.1 acres	
Tamarix chinensis Semi-natural Sparse Shrubland	1.9 acres	
Unclassified		**15.6 acres**

4.2.15.3 Physiognomy and composition

The Colorado Plateau Wash Ecological System is commonly shrubland (Figure 4-16); occasionally sparse shrubland or sparse vegetation; and rarely desert wash shrubland, dwarf shrubland, woodland, sparse woodland, wooded sparse vegetation, wooded shrubland, mixed shrubland, shrub herbaceaous vegetation or herbaceous vegetation.

Figure 4-16
Colorado Plateau Wash Ecological System

4.2.15.4 Disturbance regimes

Colorado Plateau Washes are a diverse ecological system with over 18 shrubs and trees as dominant species. *Artemisia filifolia* dominated communities occur in washes as mostly monocultures. The *Ephedra nevadensis* Sparsely Vegetated Alliance rarely occurs in washes as a sparsely vegetated community. *Ephedra* co-dominates with *Artemisia filifolia*, making this a community that could alternately be classified in the *Artemisia filifolia* Shrubland Alliance. *Datura wrightii* is an increaser forb in this type.

Artemisia tridentata ssp. *tridentata* and ssp. *vaseyana* dominate washes as shrublands and rarely sparse shrublands. Occasionally, they co-dominate in degraded seral stages with one or more of the following increaser shrubs: *Ericameria nauseosa, Lycium pallidum, Atriplex canescens, Gutierrezia sarothrae*, or *Tamarix chinensis*. All the co-dominants are increasers under grazing.

Tamarix chinensis co-dominates with *Fraxinus anomala* or *Populus fremontii* in degraded wooded dry washes. In degraded shrubby washes, *Tamarix chinensis* co-dominates with *Ericameria nauseosa, Lycium pallidum, Atriplex canescens,* or *Gutierrezia sarothrae*.

Atriplex canescens dominates washes as shrublands, with and without co-dominating shrubs. The co-dominants include *Gutierrezia sarothrae* and *Artemisia tridentata*. Degraded communities under grazing disturbance have *Salsola tragus* and *Erodium cicutarium* as invasive co-dominants. *Pleuraphis jamesii* is a rarely occurring increaser in the *Atriplex canescens* Desert Wash Shrubland association. *Atriplex confertifolia* rarely dominates in washes as dwarf-shrublands with *Krascheninnikovia lanata* and *Ericameria linearifolia*. *Pleuraphis jamesii* is a decreaser species in this alliance.

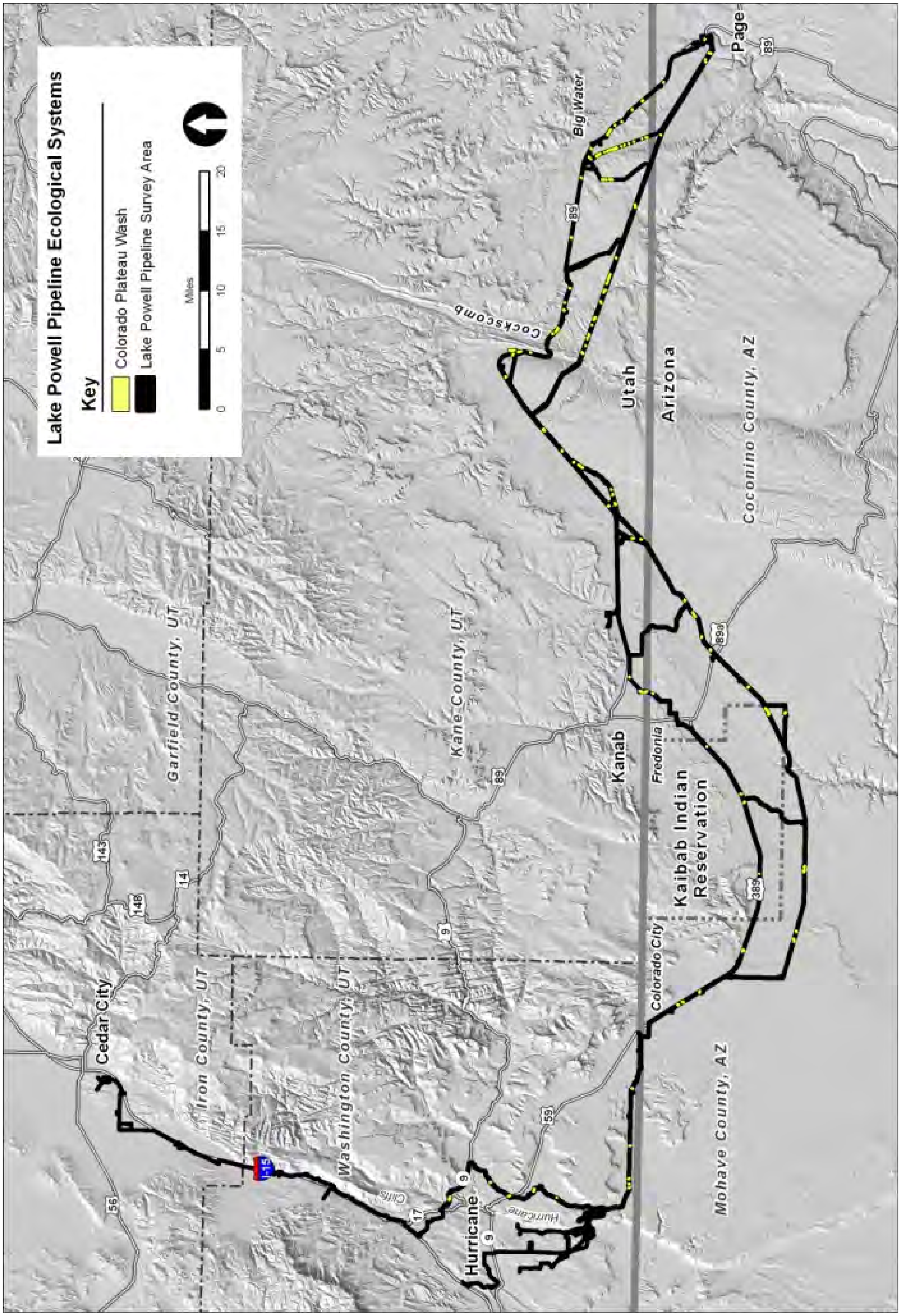
Within the Colorado Plateau Wash Ecological System, *Gutierrezia sarothrae* classifies into a *Gutierrezia sarothrae* Dwarf-shrubland, *Sarcobatus vermiculatus - Gutierrezia sarothrae* Sparse Shrubland, or *Gutierrezia sarothrae / Salsola tragus* Semi-natural Sparse Vegetation association. Another increaser shrub, *Ericameria nauseosa*, can co-dominate with *G. sarothrae*, or with *Artemisia tridentata. Ericameria. nauseosa* is typically found in semi-natural communities, co-dominated in the understory by the invasives *Bromus tectorum* or *Salsola tragus*. *Fallugia paradoxa* dominated washes routinely have localized co-dominance by *Artemisia tridentata* ssp. *vaseyana*. These shrublands have high shrub cover and a paucity of understory species, making inferences on disturbance regimes impossible. Another wash alliance often in proximity to *Artemisia tridentata* ssp. *vaseyana* is *Purshia glandulosa*. These sparse shrublands and shrubland communities are too few in number to make inferences on disturbance regimes.

Juniperus osteosperma co-dominates in a variety of wooded types, classified as *Juniperus osteosperma* Woodland, Sparse Woodland, and Sparse Vegetation associations. *Fallugia paradoxa* can co-dominate on the edges of channels in woodland washes, *Purshia glandulosa* on rocky washes, and *Ephedra nevadensis* in sandy washes.

4.2.15.5 Relationship to the US National Vegetation Classification Systems

The Colorado Plateau Wash Ecological System greatly expands on NatureServe's Inter-Mountain Basins Wash Ecological System. Only the *Artemisia tridentata* ssp. *tridentata* Shrubland Alliance, *Atriplex canescens* Shrubland Alliance, and *Ericameria nauseosa* Shrubland Alliance are presently classified in the US NVC system. The many additional alliances reflect the lack of sampling coverage for dry washes in the US NVC for the southern Colorado Plateau.

Nine of the alliances and 19 of the associations in this ecological system required minor name changes from types previously described in the US NVC. Five alliances and 19 associations are new types for the Colorado Plateau Region, not previously described in the national classification.



Map 4-15
Colorado Plateau Wash Ecological System

4.3 Great Basin Region

The Great Basin Region comprises 1,072 acres of natural and semi-natural lands within the identified LPP survey area. It lies north of the Mohave Desert Region's sand-derived soils, which have their northern extent just south of Anderson Junction on I-15. Lava flow topography represents much of the project immediately north of Anderson Junction, abruptly changing to valleys north of Ash Creek Reservoir, continuing to the northern terminus of the project, near historic Hamilton's Fort (Map 2-2).

Within the Great Basin Region of the study area there are 11 ecological systems, 35 alliances, and 92 associations. Table 4-2 lists the Great Basin Ecological Systems and notes the number of alliances, associations, and acreages for each.

Table 4-2
Great Basin Region

Ecological System	Number of Alliances	Number of Associations	Acreage
Great Basin Active and Stabilized Dune	1	1	2.2
Great Basin Big Sagebrush Shrubland	6	22	359.8
Great Basin Chaparral	5	9	38.8
Great Basin Gambel Oak-Mixed Montane Shrubland	2	3	5.1
Great Basin Greasewood Flat	1	4	64.5
Great Basin Lower Montane Riparian Woodland and Shrubland	4	8	17.8
Great Basin Mixed Desert Scrub	5	8	91.5
Great Basin Pinyon Juniper Woodland	8	33	475.0
Great Basin Semi-Desert Grassland	1	1	2.8
Great Basin Shrub-Steppe	1	2	12.3
Great Basin Volcanic Rock and Cinder Land	1	1	1.8

4.3.1 Great Basin Active and Stabilized Dune Ecological System

4.3.1.1 Geographic distribution

The Great Basin Active and Stabilized Dune Ecological System is found within the LPP survey area along the I-15 corridor, north of the I-15 Toquerville Exit. It is actively mined and only remnants are left of the natural vegetation (Map 4-16).

4.3.1.2 Alliances and associations

Within the study area, the Great Basin Active and Stabilized Dune Ecological System is comprised of one alliance, *Artemisia filifolia* Shrubland Alliance and one association, the *Artemisia filifolia* Shrubland This ecological system totals 2.2 acres within the study area.

4.3.1.3 Physiognomy and composition

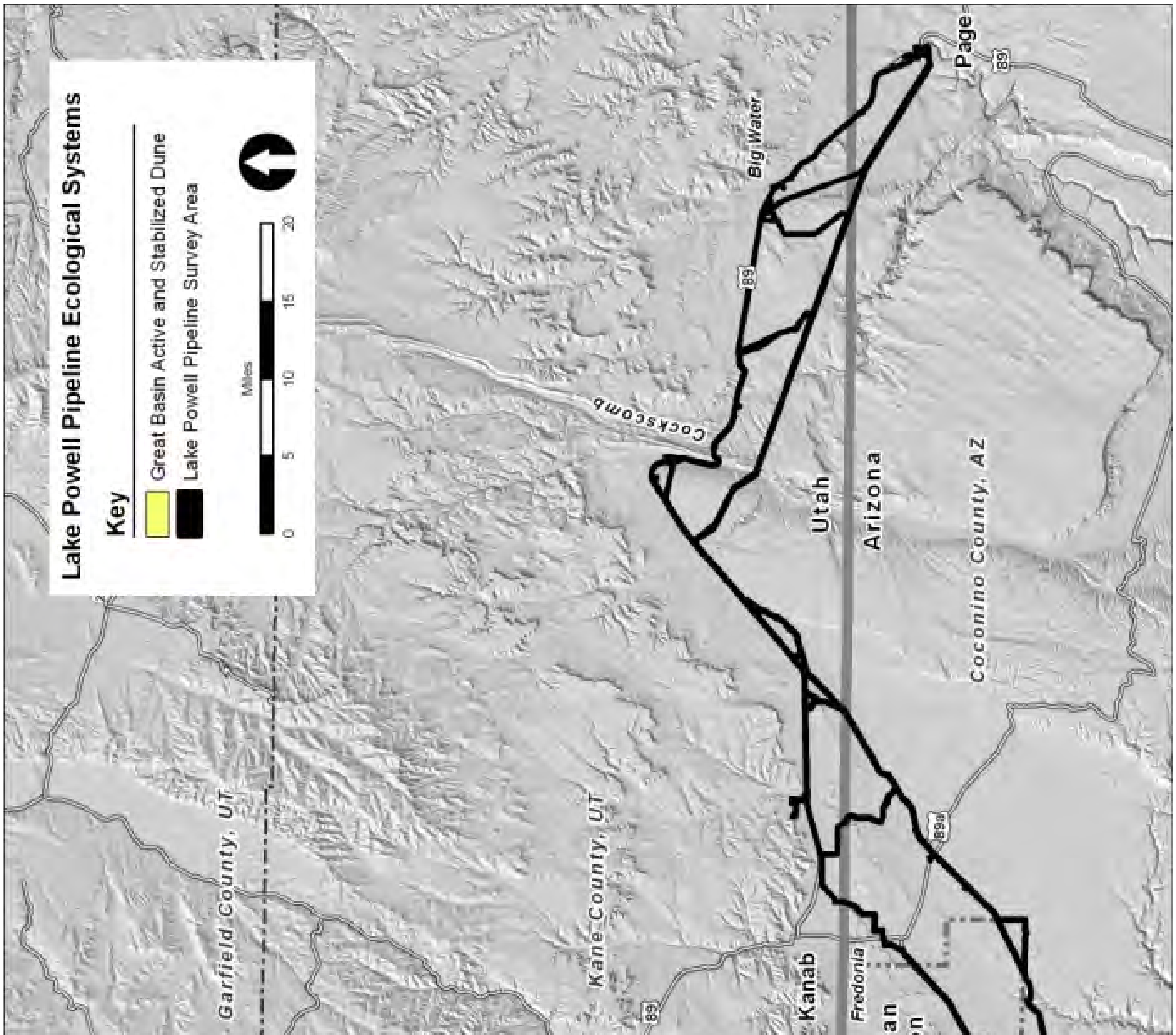
The Great Basin Active and Stabilized Dune Ecological System is dominated by shrublands.

4.3.1.4 Disturbance regimes

The only examples are small remnants left after sand quarrying of a dune. These are heavily affected by fragmentation and the edge effect with adjacent quarried or cleared lands makes it difficult to infer anything about their disturbance regime prior to quarrying.

4.3.1.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Active and Stabilized Dune Ecological System directly corresponds to NatureServe's Inter-Mountain Basins Active and Stabilized Dune Ecological System. There were no additions or modifications to alliances or associations in the Great Basin Active and Stabilized Dune Ecological System.



Map 4-16
Great Basin Active and Stabilized Dune Ecological System

4.3.2 Great Basin Big Sagebrush Shrubland Ecological System

4.3.2.1 Geographic distribution

The Great Basin Big Sagebrush Shrubland Ecological System is found throughout the northern portion of the LPP survey area. Big Sagebrush Shrubland was documented from just north of the I-15 at Toquerville Exit north along I-15 to Cedar City, with greater concentrations occurring in the north part of the survey area (Map 4-17).

4.3.2.2 Alliances and associations

Within the survey area, the Great Basin Big Sagebrush Shrubland Ecological System is comprised of six alliances and 22 associations. This ecological system totals 359.8 acres within the survey area. Acreage by alliance and association is as follows:

***Agropyron cristatum* Semi-natural Herbaceous Alliance**		**15.0 acres**
Artemisia tridentata ssp. vaseyana / Agropyron cristatum Semi-natural Shrub Herbaceous Vegetation	15.0 acres	
***Artemisia tridentata* Shrubland Alliance**		**24.7 acres**
Artemisia tridentata - Gutierrezia sarothrae / Sparse Understory Shrubland	2.3 acres	
Artemisia tridentata Shrubland	7.5 acres	
***Artemisia tridentata ssp. vaseyana* Shrubland Alliance**		**328.7 acres**
Artemisia tridentata / (Cardaria draba, Ceratocephala testiculata, Eriodium cicutarium) Semi-natural Shrubland	0.7 acres	
Artemisia tridentata ssp. vaseyana - Ericameria nauseosa Shrubland	15.8 acres	
Artemisia tridentata ssp. vaseyana - Gutierrezia sarothrae Shrubland	0.5 acres	
Artemisia tridentata ssp. vaseyana - Sarcobatus vermiculatus - (Ericameria teritifolia) / Chorospora tenella Semi-natural Sparse Shrubland	3.2 acres	
Artemisia tridentata ssp. vaseyana - Sarcobatus vermiculatus Shrubland	23.2 acres	
Artemisia tridentata ssp. vaseyana - Sarcobatus vermiculatus Sparse Shrubland	14.1 acres	
Artemisia tridentata ssp. vaseyana / (Erodium cicutarium, Salsola tragus, Lolium perenne) Semi-natural Sparse Shrubland	12.5 acres	
Artemisia tridentata ssp. vaseyana / Achnatherum hymenoides Shrubland	89.5 acres	
Artemisia tridentata ssp. vaseyana / Agropyron cristatum Semi-natural Shrubland	4.4 acres	
Artemisia tridentata ssp. vaseyana / Agropyron cristatum Semi-natural Sparse Shrubland	7.8 acres	
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii - Bromus (tectorum, rubens) Semi-natural Shrubland	1.7 acres	
Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Shrubland	8.2 acres	
Artemisia tridentata ssp. vaseyana / × Triticosecale rimpaui Semi-natural Sparse Shrubland	14.1 acres	

Artemisia tridentata ssp. vaseyana Shrubland	130.6 acres	
Artemisia tridentata ssp. vaseyana Sparse Shrubland	2.5 acres	
***Cardaria draba* Semi-natural Herbaceous Alliance**		**0.8 acres**
Artemisia tridentata / (Cardaria draba, Ceratocephala testiculata, Eriodium cicutarium) Semi-natural Shrub Herbaceous Vegetation	0.8 acres	
***Chorispora tenella* Semi-natural Herbaceous Alliance**		**2.8 acres**
Artemisia tridentata ssp. vaseyana / Chorispora tenella Semi-natural Shrub Herbaceous Vegetation	2.8 acres	
× *Triticosecale rimpaui* Semi-natural Herbaceous Alliance		**2.8 acres**
Artemisia tridentata ssp. vaseyana / × *Triticosecale rimpaui* Semi-natural Shrub Herbaceous Vegetation	2.4 acres	
Artemisia tridentata ssp. vaseyana / × *Triticosecale rimpaui* Semi-natural Shrub Herbaceous Vegetation	0.4 acres	

4.3.2.3 Physiognomy and composition

The Great Basin Big Sagebrush Shrubland Ecological System is comprised of both shrublands and sparse shrublands (Figure 4-17). The seral *Ericameria nauseosa* Shrubland Alliance is more commonly a sparse shrubland, whereas the other alliances are more commonly shrublands.

Figure 4-17
Great Basin Big Sagebrush Shrubland Ecological System

4.3.2.4 Disturbance regimes

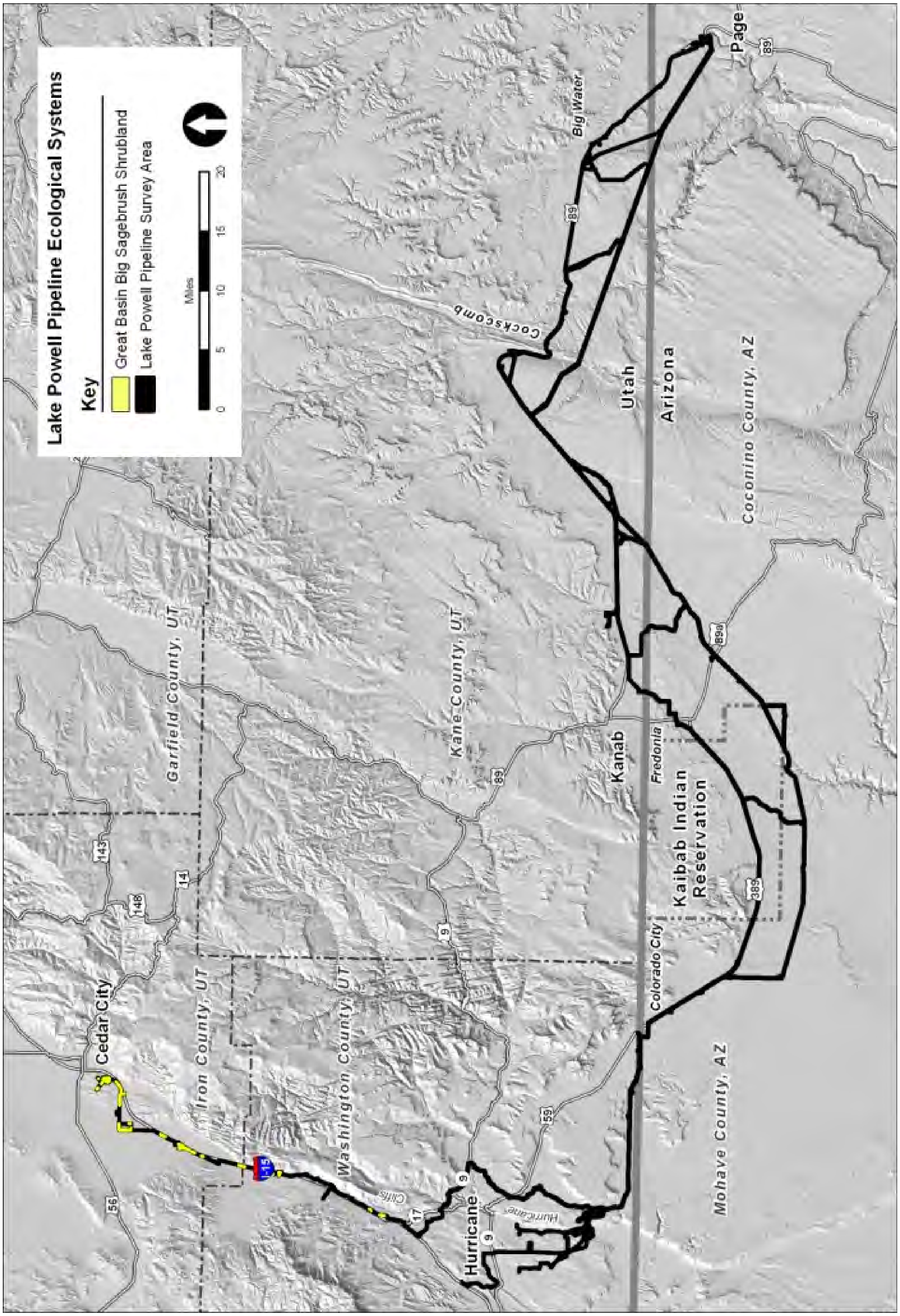
Artemisia tridentata is an increaser under grazing disturbance and fire suppression. It dominates in a long-lived seral stage where shrub cover progressively increases over 75-100 years and shades out the understory. However, it is subject to invasion by *Juniperus osteosperma. Artemisia tridentata* dominated communities represent an intermediate seral stage in disturbed areas of *Pinus monophylla - Juniperus osteosperma* woodlands. These disturbances include logging, land grading, and the peripheral effects of sand and gravel quarry operations.

Artemisia tridentata Shrubland Alliance can be dominated by either subspecies *tridentata* and *vaseyana*, or both, reflecting ensembles in which no differentiation was made in the field. In contrast, the *Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance is dominated solely by that subspecies. Since diagnostic growth form distinctions between the subspecies can overlap, definitive identification required smell - a technique not easily employed outside of transect and rover surveys. *Artemisia tridentata* ssp. *vaseyana* is a preferred browse subspecies among the *Artemisia tridentata* subspecies, although there was no evidence of it decreasing in the survey area from native ungulate browsing. When burned in the region, it can be replaced by *Ericameria nauseosa* or *Quercus* *gambelii*. Large burned area succession by *Quercus gambelii* was not present within the survey area, although it was on mountain slopes above the survey area.

Agropyron cristatum and × *Triticosecale rimpaui* may co-dominate with *Artemisia tridentata* in semi-natural associations which were seeded to increase forage value. *Lolium perenne* and *Triticum aestivum* can co-dominate with *Artemisia tridentata* as a non-native species from local agricultural seedings. *Salsola tragus*, *Erodium cicutarium*, *Chorispora tenella*, *Cardaria draba*, and *Ceratocephala testiculata* are invasive species, any of which co-dominate with *Artemisia tridentata* in highly degraded habitat.

4.3.2.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Big Sagebrush Shrubland Ecological System crosswalks to NatureServe's Inter-Mountain Basins Big Sagebrush Shrubland Ecological Six of the associations in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and 14 associations are new types for the Great Basin Region, not previously described in the national classification. Some of the new semi-natural shrub herbaceous vegetation types are due to including alliances which would otherwise classify to Invasive Upland Vegetation, except for having *Artemisia tridentata* as one to 10 percent cover.



Map 4-17
Great Basin Big Sagebrush Shrubland Ecological System

4.3.3 Great Basin Chaparral Ecological System

4.3.3.1 Geographic distribution

The Great Basin Chaparral Ecological System is found within the southern portion of the Great Basin Region within the LPP survey area along I-15south of the Ash Creek Reservoir. All of the occurrences are found along Ash Creek east of I-15, south of the Ash Creek Reservoir and north of Anderson Junction. Most of the occurrences are found adjacent to Great Basin Pinyon-Juniper Woodlands (Map 4-18).

4.3.3.2 Alliances and associations

Within the survey area, the Great Basin Chaparral Ecological System is comprised of five alliances and nine associations. This ecological system totals 38.8 acres within the survey area. Acreage by alliance and association is as follows:

***Amelanchier utahensis* Shrubland Alliance**		**1.1 acres**
Amelanchier utahensis - Ceanothus greggii var. vestitus Shrubland	0.6 acres	
Amelanchier utahensis Shrubland	0.5 acres	
***Ceanothus greggii* Shrubland Alliance**		**11.0 acres**
Ceanothus greggii Shrubland	6.4 acres	
Ceanothus greggii Sparse Shrubland	3.2 acres	
Juniperus osteosperma / (Ceanothus greggii, Artemisia tridentata) Wooded Shrubland	1.4 acres	
***Eriodictyon angustifolium* Shrubland Alliance**		**2.3 acres**
Eriodictyon angustifolium / Bromus tectorum Semi-natural Shrubland	1.2 acres	
Eriodictyon angustifolium Shrubland	1.2 acres	
***Juniperus osteosperma* Woodland Alliance**		**6.5 acres**
Juniperus osteosperma / (Ceanothus greggii, Artemisia tridentata) Woodland	6.5 acres	
***Quercus turbinella* Shrubland Alliance**		**17.9 acres**
Juniperus osteosperma / Quercus (gambelii, turbinella) Wooded Shrubland	17.9 acres	

4.3.3.3 Physiognomy and composition

The Great Basin Chaparral Ecological System is most commonly a wooded shrubland and occasionally sparse shrubland, woodland, or shrubland (Figure 4-18).

4.3.3.4 Disturbance regimes

The Great Basin Chaparral Ecological System is a mid-successional alliance which typically re-colonizes a site after fire. It excludes sites in which *Artemisia tridentata* is dominant (i.e., Great Basin Big Sagebrush Ecological System). Great Basin Chaparral includes a variety of shrub species which are uniquely adapted to particular site conditions. *Amelanchier utahensis* dominates basalt cliffs, talus and steep slopes of old lava flows. *Ceanothus greggii* is a mid-successional shrub which locally dominates basalt slopes and level ground where fires temporarily eliminated tree cover. *Eriodictyon angustifolium* is a quick to establish, early successional shrub on a wide variety of sites which were very recently burned. *Quercus turbinella* is a late successional shrub co-dominating with *Juniperus osteosperma* in wooded shrublands. It is often an edge effect species, occupying habitats along roads, at the edges of historic burns, or near agricultural land.

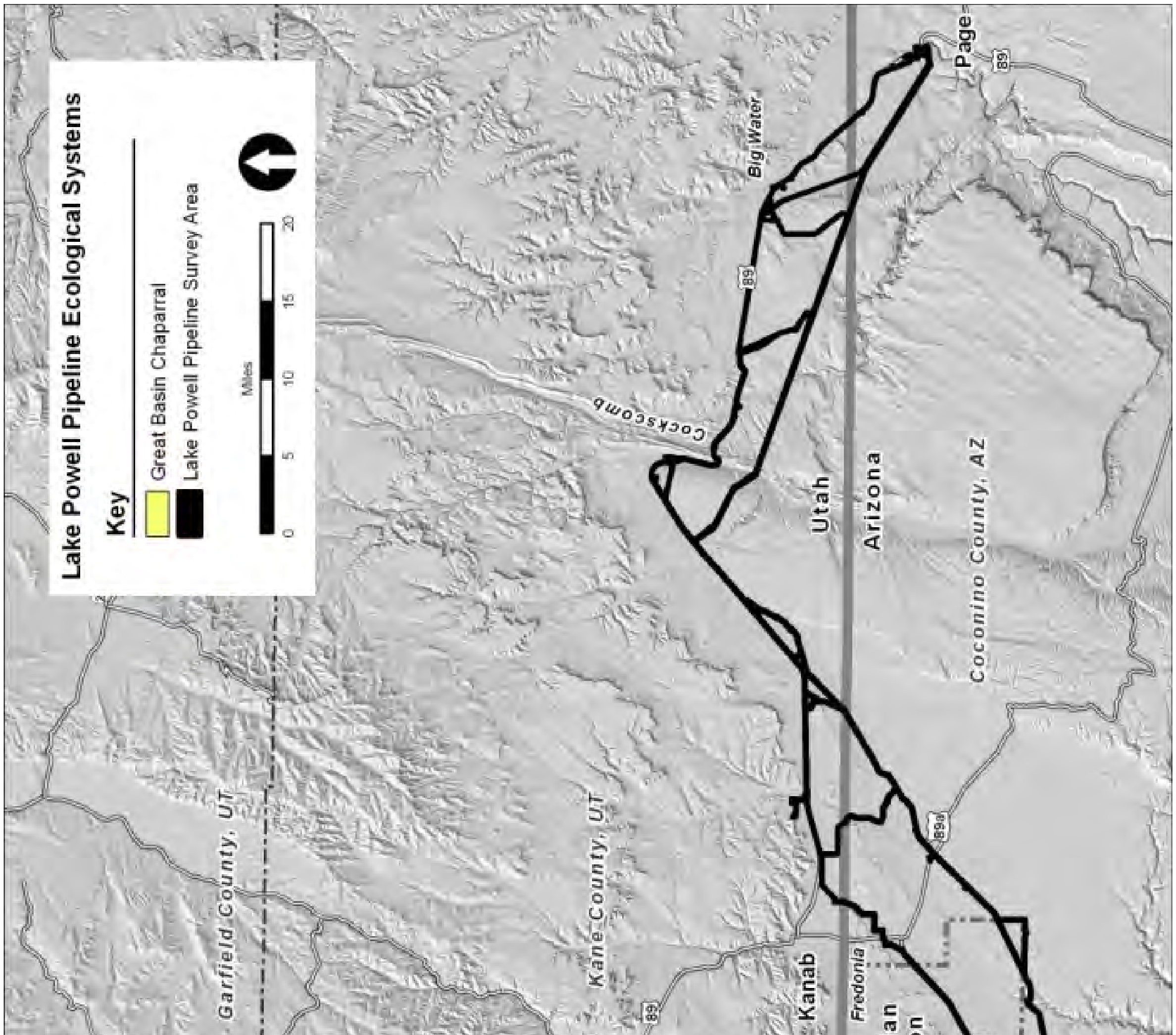
Figure 4-18
Great Basin Chaparral Ecological System

While this ecological system is excellent browse for deer, there was no evidence of over-utilization within the survey area. The system is naturally resistant to livestock grazing, due to difficulty in traversing it. No semi-natural occurrences were noted within the survey area. *Bromus tectorum* is the most common invasive species, although it was rarely a dominant.

4.3.3.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Chaparral Ecological System crosswalks in concept, but not in biogeography to NatureServe's Mogollon Chaparral Ecological System and Rocky Mountain Lower Montane-Foothill Shrubland Ecological System.

Two alliances and eight associations are new types for the Great Basin Region, not previously described in the national classification. Two alliances, *Ceanothus greggii* Shrubland Alliance and *Eriodictyon angustifolium* Shrubland Alliance were created to strengthen the Great Basin Chaparral Ecological System concept.



Map 4-18
Great Basin Chaparral Ecological System

4.3.4 Great Basin Gambel Oak-Mixed Montane Shrubland Ecological System

4.3.4.1 Geographic distribution

The Great Basin Gambel Oak–Mixed Montane Shrubland Ecological System is centrally located within the Great Basin Region of the LPP survey area. Only three occurrences of this ecological system were documented within the survey area. They occur north of Ash Creek Reservoir and south of the community of Kanarraville, west of I-15, near the Harris Gubler Reservoir (Map 4-19).

4.3.4.2 Alliances and associations

Within the survey area, the Great Basin Gambel Oak–Mixed Montane Shrubland Ecological System is comprised of two alliances, *Quercus gambelii* Shrubland Alliance, with two associations, *Quercus gambelii / Artemisia tridentata* Shrubland and *Quercus gambelii* / *Rhus trilobata Sparse* Shrubland, and *Rhus trilobata* Shrubland Alliance, with a single association, *Juniperus osteosperma / Rhus trilobata* Wooded Shrubland. This ecological system totals 5.1 acres within the survey area.

4.3.4.3 Physiognomy and composition

The Great Basin Gambel Oak–Mixed Montane Shrubland Ecological System is predominately a sparse shrubland, wooded shrubland, and shrubland (Figure 4-19). All occurrences were on private property and no data was obtained on vegetation composition.

4.3.4.4 Disturbance regimes

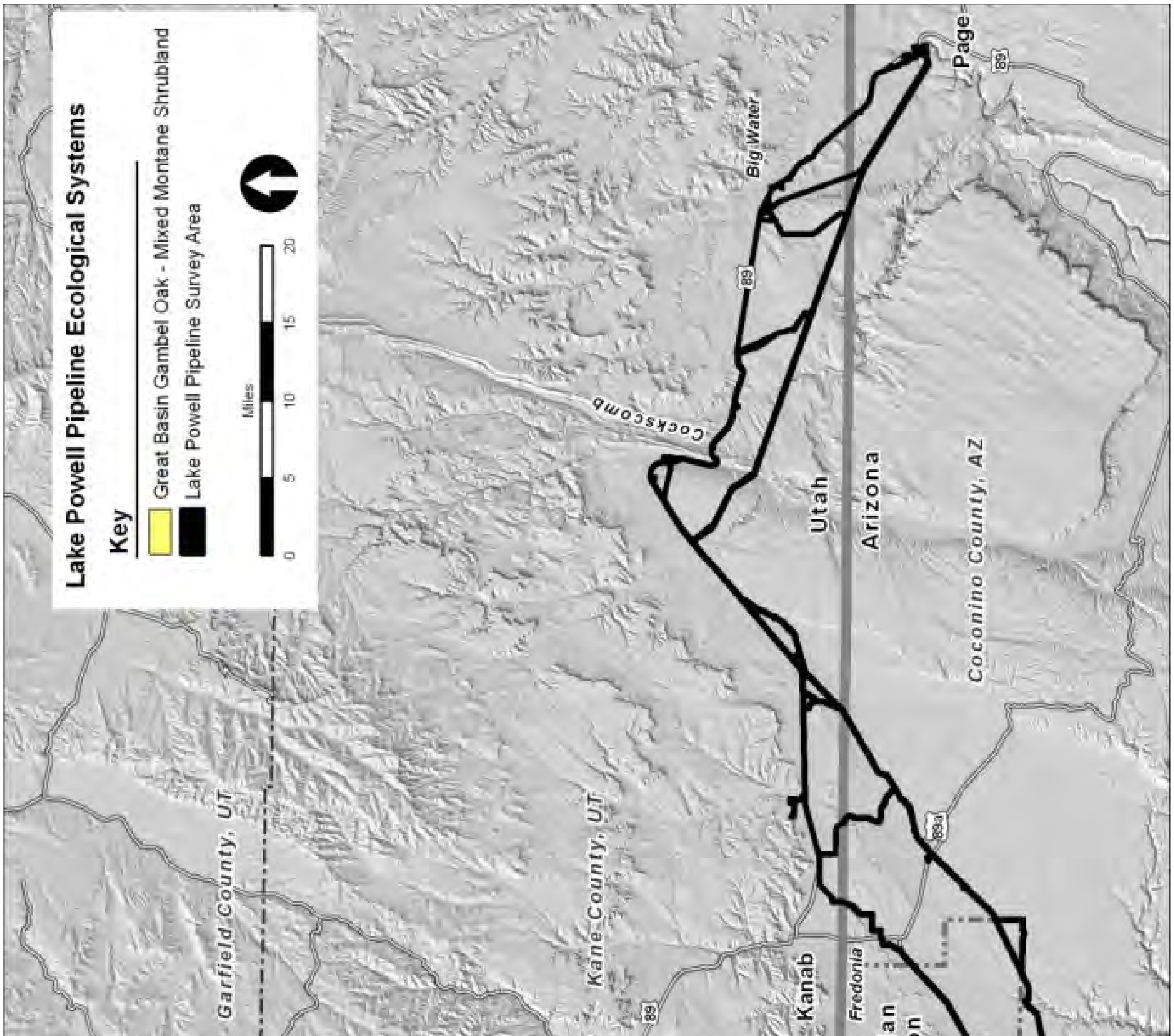
There are insufficient occurrences to determine states, transitions, or disturbance regimes. *Quercus gambelii* is confined within the survey area to small groves between pastures and woodlands.

Figure 4-19
Great Basin Gambel Oak - Mixed Montane Shrubland Ecological System

4.3.4.5 Relationship to the US National Vegetation Classification Systems

Great Basin Gambel Oak–Mixed Montane Shrubland Ecological System crosswalks to NatureServe's *Quercus gambelii* / *Rhus trilobata* Shrubland in the Rocky Mountain Gambel Oak–Mixed Montane Shrubland Ecological System.

Two associations are new types for the Great Basin Region, not previously described in the national classification.



Map 4-19
Great Basin Gambel Oak - Mixed Montane Shrubland Ecological System

4.3.5 Great Basin Greasewood Flat Ecological System

4.3.5.1 Geographic distribution

The Great Basin Greasewood Flat Ecological System is found within the northern portion of the Great Basin Region within the LPP survey area south of the historic community of Hamilton Fort, west of I-15. Occurrences are interspersed with adjacent agricultural lands (Map 4-20).

4.3.5.2 Alliances and associations

Within the survey area, the Great Basin Greasewood Flat Ecological System is comprised of a single alliance, *Sarcobatus vermiculatus* Shrubland Alliance, which includes four associations. This ecological system totals 64.5 acres within the survey area. Acreage by alliance and association is as follows:

***Sarcobatus vermiculatus* Shrubland Alliance**		**64.5 acres**
Sarcobatus vermiculatus - Artemisia tridentata / (× Triticosecale rimpuai, Agropyron cristatum) Semi-natural Shrubland	16.0 acres	
Sarcobatus vermiculatus - Artemisia tridentata / (× Triticosecale rimpuai, Agropyron cristatum) Semi-natural Sparse Shrubland	19.3 acres	
Sarcobatus vermiculatus - Artemisia tridentata Shrubland	5.2 acres	
Sarcobatus vermiculatus Shrubland	24.0 acres	

4.3.5.3 Physiognomy and composition

The Great Basin Greasewood Flat Ecological System is comprised of either shrublands or sparse shrublands (Figure 4-20).

Figure 4-20
Great Basin Greasewood Flat Ecological System

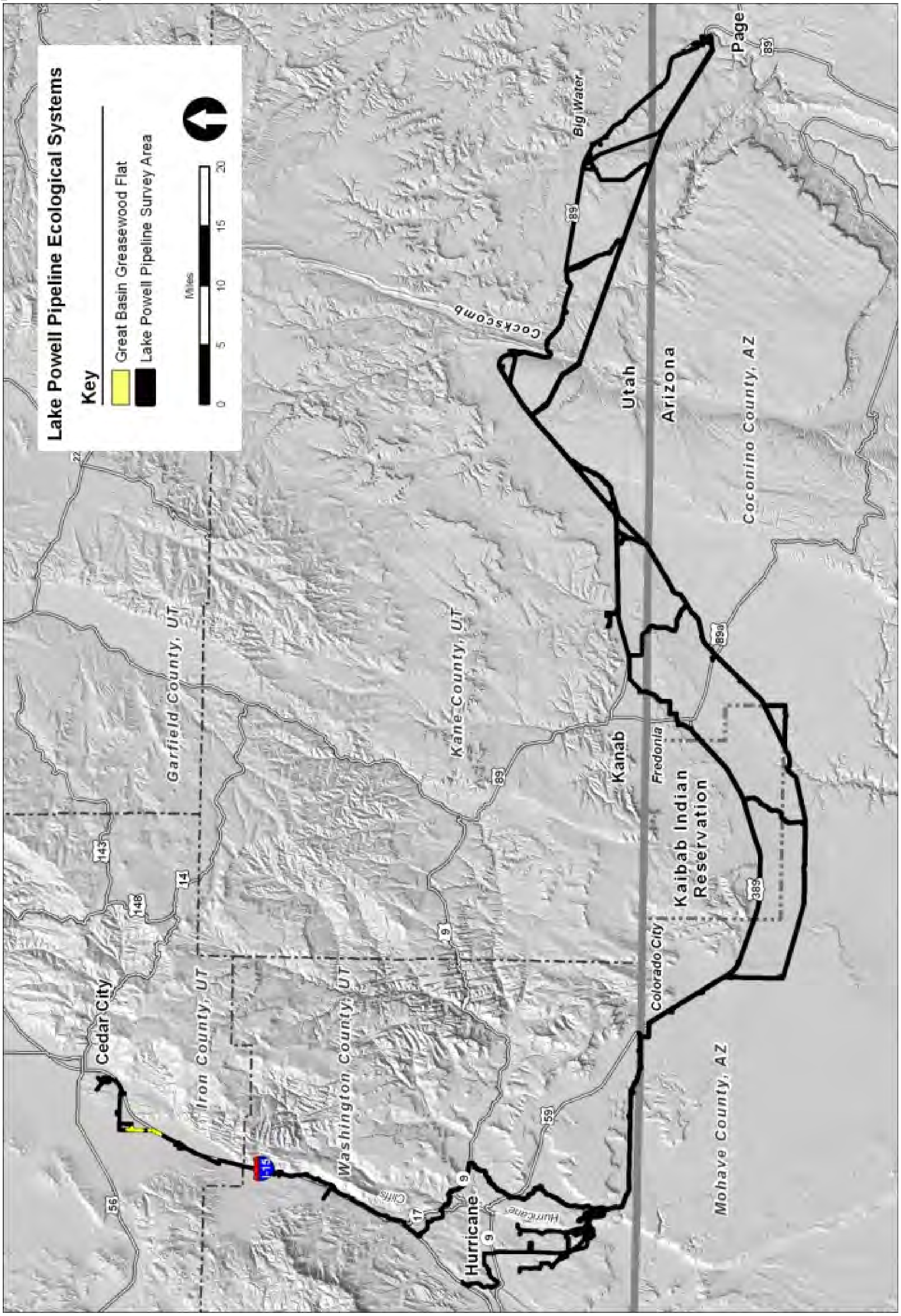
4.3.5.4 Disturbance regimes

The Great Basin Greasewood Flat Ecological System is present within the survey area as three seral stages. The least disturbed is a mix of *Sarcobatus vermiculatus* and *Artemisia tridentata* as a shrubland with over 25 percent cover. Disturbed communities will have low diversity and classify as a monotypic *Sarcobatus vermiculatus* Shrubland. Whether some communities on especially salic soils are naturally low in diversity is not known. With increasing disturbance, the shrub canopy coverage drops to 10-25 percent and the community is subject to stray plants from nearby agriculature. These species include × *Triticosecale rimpuai* (triticale) and *Agropyron cristatum*.

4.3.5.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Greasewood Flat Ecological System directly corresponds to NatureServe's Inter-Mountain Basins Greasewood Flat Ecological System.

Two of the associations in this ecological system required minor name changes from types previously described in the US NVC. Two associations are new types for the Great Basin Region, not previously described in the national classification. The monotypic *Sarcobatus vermiculatus* Disturbed Shrubland Alliance of the US NVCS was not used since it is redundant in concept, but less comprehensive than listing the dominant invasives in semi-natural associations.



Map 4-20
Great Basin Greasewood Flat Ecological System

4.3.6 Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System

4.3.6.1 Geographic distribution

The Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System is found scattered throughout the Great Basin Region of the LPP survey area on both the east and west sides of I-15. The majority of occurrences are concentrated along Ash Creek, south of the Ash Creek Reservoir and east of I-15 (Map 4-21).

4.3.6.2 Alliances and associations

Within the survey area, the Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System is comprised of four alliances, including eight associations. This ecological system totals 17.8 acres within the survey area. Acreage by alliance and association is as follows:

***Fraxinus velutina* Forest Alliance**		**0.4 acres**
Fraxinus velutina Forest	0.2 acres	
Fraxinus velutina Woodland	0.3 acres	
***Populus fremontii* Woodland Alliance**		**13.1 acres**
Populus fremontii - Fraxinus velutina Sparse Woodland	2.8 acres	
Populus fremontii - Fraxinus velutina Woodland	4.5 acres	
Populus fremontii Sparse Woodland	4.5 acres	
Populus fremontii Woodland	1.3 acres	
***Salix* sp. Shrubland Alliance**		**0.4 acres**
Juniperus osteosperma / Salix sp. Wooded Shrubland	0.4 acres	
***Schoenoplectus* sp. Herbaceous Alliance**		**3.8 acres**
Elaeagnus angustifolia / Schoenoplectus sp. Semi-natural Shrub Herbaceous Vegetation	3.8 acres	

4.3.6.3 Physiognomy and composition

The Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System is commonly comprised of either woodland, sparse woodland, (Figure 4-21) or shrub herbaceous vegetation; and rarely forest.

4.3.6.4 Disturbance regimes

Natural communities in this ecological system are dominated by *Populus fremontii* and *Fraxinus velutina*, singly or in combination. There is one semi-natural association in the Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System, where *Elaeagnus angustifolia* is invading a wet pasture dominated by *Schoenoplectus* sp.

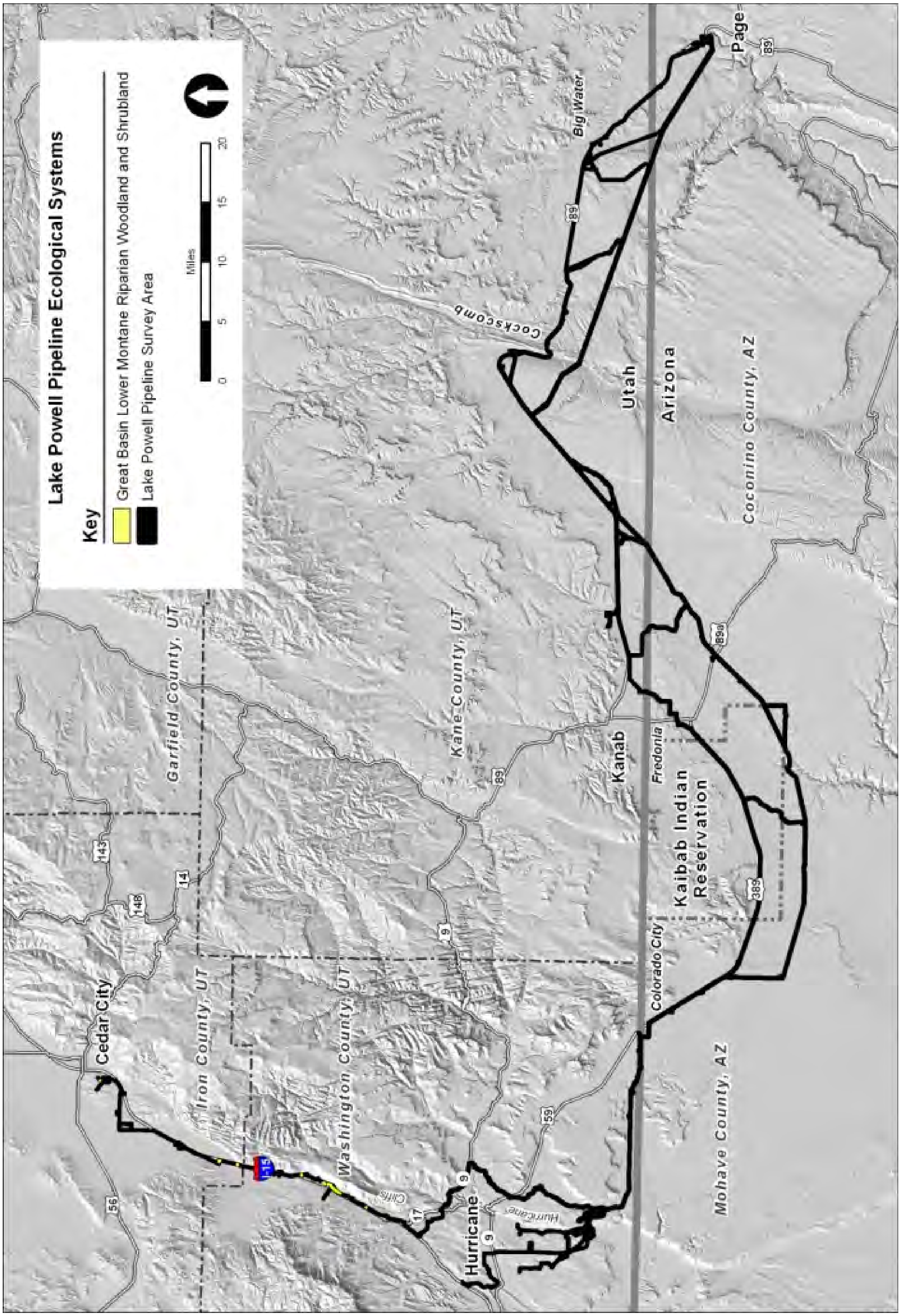
These trees provide shade for livestock, which are often pastured in riparian areas. Early sparse woodland seral stages of *Populus* and *Fraxinus* are technically shrublands (i.e., trees less than 16.5 feet [approximately 5 meters] tall, on average), maturing to woodlands and eventually forests after long periods without major flooding or artificial disturbance. These communities have been subject to logging since settlement of the region in the 1850s. Both *Populus fremontii* and *Fraxinus velutina* can be uprooted by violent flooding – an occasional natural disturbance to streams and rivers in this region.

Figure 4-21
Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System

4.3.6.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System is derived from NatureServe's Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland and the North American Warm Desert Lower Montane Riparian Woodland and Shrubland. Rather than have two overlapping NatureServe regions, riparian woodlands and shrublands are herein split into strict geographical project regions: Great Basin, Mohave Desert, and Colorado Plateau.

One of the alliances and three of the associations in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and three associations are new types for the Great Basin Region, not previously described in the national classification.



Map 4-21
Great Basin Lower Montane Riparian Woodland and Shrubland Ecological System

4.3.7 Great Basin Mixed Desert Scrub Ecological System

4.3.7.1 Geographic distribution

The Great Basin Mixed Desert Scrub Ecological System is located throughout the Great Basin Region within the LPP survey area. It is found northeast of the community of Pintura along I-15 north to to Cedar City; it is interspersed with private property including gricultural land and invasive upland vegetation (Map 4-22).

4.3.7.2 Alliances and associations

Within the survey area, the Great Basin Mixed Desert Scrub Ecological System is comprised of five alliances that include eight associations. This ecological system totals 91.5 acres within the survey area. Acreage by alliance and association is as follows:

***Amaranthus albus* Semi-natural Herbaceous Alliance**		**8.7 acres**
Ericameria nauseosa / Amaranthus albus Semi-natural Shrub Herbaceous Vegetation	8.7 acres	
***Bromus (rubens, tectorum)* Semi-natural Herbaceous Alliance**		**18.6 acres**
Gutierrezia sarothrae / Bromus tectorum Semi-natural Shrub Herbaceous Vegetation	18.6 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**10.5 acres**
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	10.5 acres	
***Ericameria nauseosa* Shrubland Alliance**		**29.2 acres**
Ericameria nauseosa / (Salsola tragus, Erodium cicutarium, Brassica nigra, Agropyron cristatum) Semi-natural Shrubland	3.4 acres	
Ericameria nauseosa / (Salsola tragus, Erodium cicutarium, Brassica nigra, Agropyron cristatum) Semi-natural Sparse Shrubland	9.2 acres	
Ericameria nauseosa Shrubland	9.2 acres	
***Ericameria teretifolia* Shrubland Alliance**		**7.4 acres**
Ericameria teretifolia / (Chorispora tenella, Salsola tragus, Ceratocephala testiculatum) Semi-natural Dwarf-shrubland	7.4 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**24.5 acres**
Gutierrezia sarothrae Dwarf-shrubland	24.5 acres	

4.3.7.3 Physiognomy and composition

The Great Basin Mixed Desert Scrub Ecological System is a mix of shrub herbaceous vegetation, dwarf shrubland, shrubland, and sparse shrubland (Figure 4-22).

Figure 4-22
Great Basin Mixed Desert Scrub Ecological System

4.3.7.4 Disturbance regimes

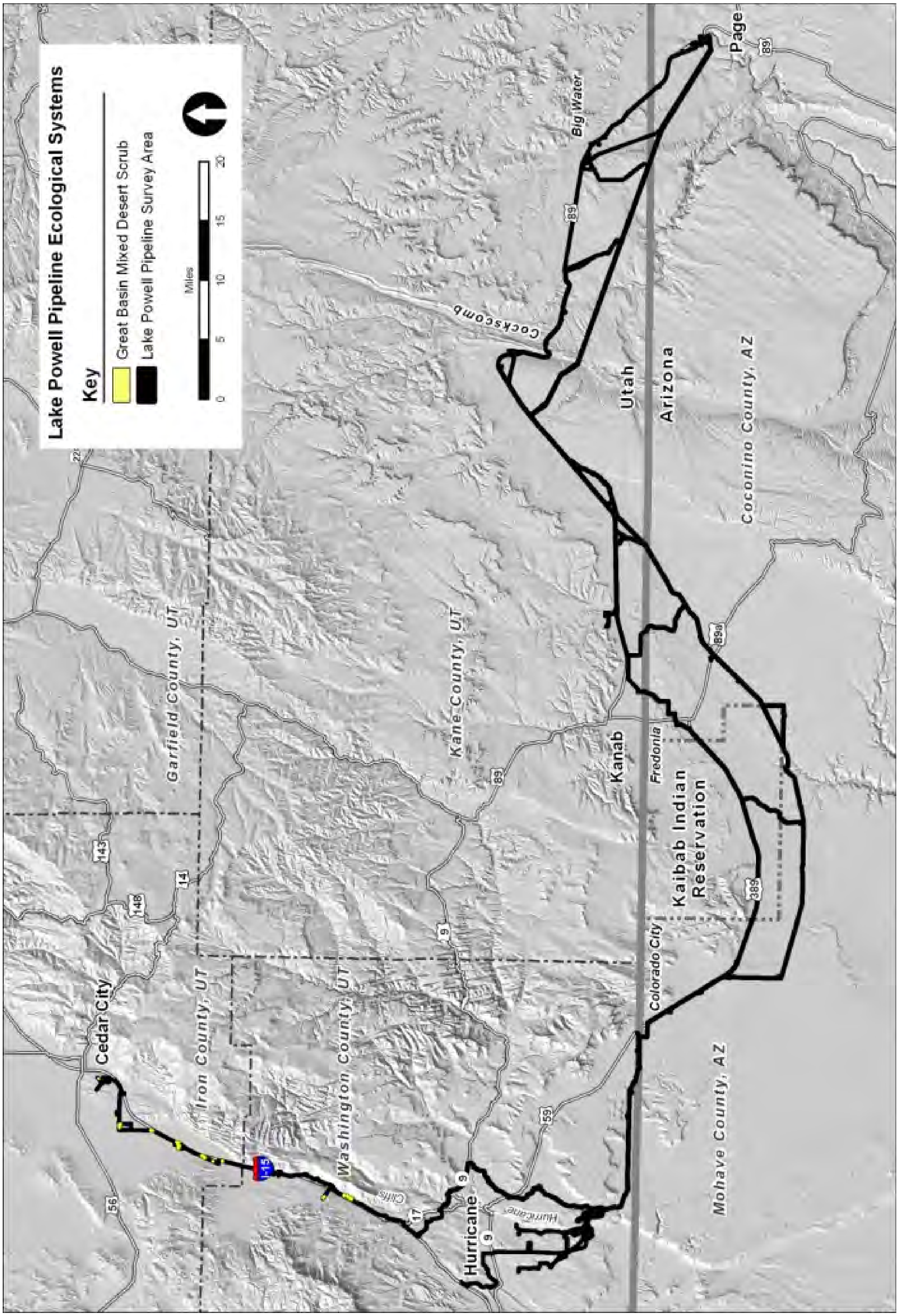
Gutierrezia sarothrae and *Ericameria nauseosa* are increasers under grazing in this ecological system. They dominate in old fields, cleared woodlands, and depleted pastures, and are edaphically adapted to dunes. Both are typical of pastures and woodland clearings. Over time and in the absence of disturbance, they would be replaced by *Coleogyne ramosissima*, *Artemisia tridentata*, or *A. filifolia* on dunes. The dominating invasive species in semi-natural associations are *Amaranthus alba*, *Salsola tragus, Brassica nigra, Chorispora tenella, Ceratocephala testiculatum, Bromus tectorum,* and *Erodium cicutarium*. All occurrences of *Coleogyne ramosissima* Shrublands are degraded and classified as semi-natural.

4.3.7.5 Relationship to the US National Vegetation Classification Systems

There are no existing NatureServe ecological systems in the Great Basin which correlate to the Great Basin Mixed Desert Scrub Ecological System. However, it cross-walks in concept to the Mohave Mid-Elevation Mixed Desert Scrub Ecological System. That system includes the US NVC *Gutierrezia* (*sarothrae*, *microcephala*) - *Ephedra* spp. - *Agave utahensis* Dwarf-shrubland, which is similar to the less broadly defined *Gutierrezia sarothrae* Dwarf-shrubland of the LPP survey area. The US NVC *Coleogyne ramosissima* Shrubland is weakly correlated to the *Coleogyne ramosissima* / (*Erodium cicutarium*, *Bromus* (*rubens*, *tectorum*), *Salsola tragus*) Semi-natural Sparse Shrubland of the survey area. The US NVC *Ericameria teretifolia* Shrubland directly crosswalks to the *Ericameria teretifolia* Dwarf-shrubland of the survey area.

Ericameria nauseosa is placed by NatureServe into different ecological systems depending on if it is a shrubland (Inter-Mountain Basins Big Sagebrush Shrubland) versus a sparse shrubland (Inter-Mountain Basins Shale Badland). Both physiognomic types are found in the LPP survey area in the Great Basin Region, but neither on badlands. Furthermore, *Artemisia tridentata* ssp. *vaseyana* is not listed as an associate of *Ericameria nauseosa* in the US NVC, as might be expected if it had an affinity to NatureServe's Inter-Mountain Basins Big Sagebrush Shrubland Ecological System.

Two of the alliances and one of the associations in this ecological system required minor name changes from types previously described in the US NVC. One alliance and six associations are new types for the Great Basin Region, not previously described in the national classification.



Map 4-22
Great Basin Mixed Desert Scrub Ecological System

4.3.8 Great Basin Pinyon Juniper Woodland Ecological System

4.3.8.1 Geographic distribution

The Great Basin Pinyon Juniper Woodland Ecological System is the most abundant of all the ecological systems within the Great Basin Region of the LPP survey area. It is located throughout the survey area, occurring from Anderson Junction north to Cedar City, on both the east and west sides of I-15 (Map 4-23).

4.3.8.2 Alliances and associations

Within the survey area, the Great Basin Pinyon Juniper Woodland Ecological System is comprised of eight alliances, including 33 associations. This ecological system totals 475.0 acres within the survey area. Acreage by alliance and association is as follows:

Arctostaphylos pungens **Shrubland Alliance**		**16.3 acres**
Juniperus osteosperma / Arctostaphylos pungens Wooded Dwarf-shrubland	16.3 acres	
Artemisia tridentata **Shrubland Alliance**		**1.0 acres**
Artemisia tridentata Shrubland	1.0 acres	
Artemisia tridentata **Shrubland Alliance**		**5.9 acres**
Juniperus osteosperma / Artemisia tridentata Wooded Shrubland	5.9 acres	
Artemisia tridentata ssp. vaseyana **Shrubland Alliance**		**82.2 acres**
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana / Bromus (rubens, tectorum) Semi-natural Wooded Shrubland	2.4 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana / Pleuraphis jamesii Wooded Shrubland	0.2 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Wooded Shrubland	23.6 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Wooded Shrubland	56.1 acres	
Bromus (rubens, tectorum) **Semi-natural Herbaceous Alliance**		**4.5 acres**
Juniperus osteosperma / Gutierrezia sarothrae / Bromus tectorum Semi-natural Wooded Herbaceous Vegetation	4.5 acres	
Juniperus osteosperma **Woodland Alliance**		**292.4 acres**
Juniperus osteosperma / (Bromus tectorum, Salsola tragus, Erodium cicutarium) Semi-natural Woodland	11.5 acres	
Juniperus osteosperma / Arctostaphylos pungens Woodland	1.0 acres	
Juniperus osteosperma / Artemisia tridentata / Sparse Understory Woodland	20.4 acres	
Juniperus osteosperma / Artemisia tridentata Sparse Woodland	1.4 acres	
Juniperus osteosperma / Artemisia tridentata ssp. tridentata Woodland	1.8 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Forest	22.8 acres	
Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Sparse Woodland	22.4 acres	

Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Woodland	40.2 acres	
Juniperus osteosperma / Artemisia tridentata Woodland	50.0 acres	
Juniperus osteosperma / Coleogyne ramosissima Sparse Woodland	11.5 acres	
Juniperus osteosperma / Coleogyne ramosissima Woodland	4.5 acres	
Juniperus osteosperma / Ephedra (nevadensis, viridis) Woodland	4.6 acres	
Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	1.1 acres	
Juniperus osteosperma / Quercus (gambelii, turbinella) / Bromus tectorum Semi-natural Woodland	10.7 acres	
Juniperus osteosperma / Quercus (gambelii, turbinella) Woodland	50.6 acres	
Juniperus osteosperma / Rhus trilobata Woodland	2.2 acres	
Juniperus osteosperma / Sparse Understory Woodland	18.4 acres	
Juniperus osteosperma Forest	6.2 acres	
Juniperus osteosperma Sparse Woodland	7.9 acres	
Juniperus osteosperma Woodland	3.4 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**40.9 acres**
Juniperus osteosperma - Pinus edulis / Artemisia nova Woodland	24.9 acres	
Pinus edulis - Juniperus osteosperma / Artemisia tridentata ssp. vaseyana Woodland	15.9 acres	
***Pinus monophylla - (Juniperus osteosperma)* Woodland Alliance**		**28.5 acres**
Pinus monophylla - Juniperus osteosperma / Artemisia tridentata spp. vaseyana / Sparse Understory Woodland	6.6 acres	
Pinus monophylla - Juniperus osteosperma / Artemisia tridentata Woodland	21.9 acres	
***Quercus turbinella* Shrubland Alliance**		**3.3 acres**
Juniperus osteosperma / Quercus (gambelii, turbinella) Wooded Shrubland	3.3 acres	

4.3.8.3 Physiognomy and composition

The Great Basin Pinyon Juniper Woodland Ecological System includes the greatest number of alliances and associations in the survey area within the Great Basin Region. This ecological system is primarily a woodland (Figure 4-23); occasionally a wooded shrubland or sparse woodland; and rarely a sparse understory woodland, forest, wooded dwarf-shrubland, or shrubland. There is one recently burned occurrence with nearly 100 percent tree mortality. It presently has a wooded herbaceous vegetation physiognomy.

Figure 4-23
Great Basin Pinyon Juniper Woodland Ecological System

4.3.8.4 Disturbance regimes

Seral development in the Great Basin Pinyon Juniper Woodland Ecological System is a predictable progression following disturbances such as wildfire or logging. Depending on site conditions, seed bank, relict vegetation, and adjacent undisturbed vegetation, a community will first develop through the successional stages of one of the region's shrubland ecological systems. *Juniperus osteosperma* will eventually invade the shrubland and can eventually shift canopy dominance away from shrubs such as *Arctostaphylos pungens*, *Artemisia tridentata*, *Coleogyne ramosissima*, *Ephedra nevadensis*, *Quercus gambelii*, *Q. turbinella*,, and *Rhus trilobata*. *Pinus monophylla* establishment may follow *Juniperus* invasion, although not at lower elevations where it cannot tolerate higher drought stresses. As tree cover increases, physiognomy shifts from wooded shrubland to sparse woodland, sparse understory woodland, and eventually woodland. Each of these seral stages classify to the Great Basin Pinyon Juniper Woodland Ecological System. In rare cases succession will progress to a forest. In the absence of fire or logging, *Juniperus osteosperma* / *Artemisia tridentata* Woodland will persist as a state in lower elevations and *Pinus monophylla* - *Juniperus osteosperma* / *Artemisia tridentata* Woodland in higher elevations.

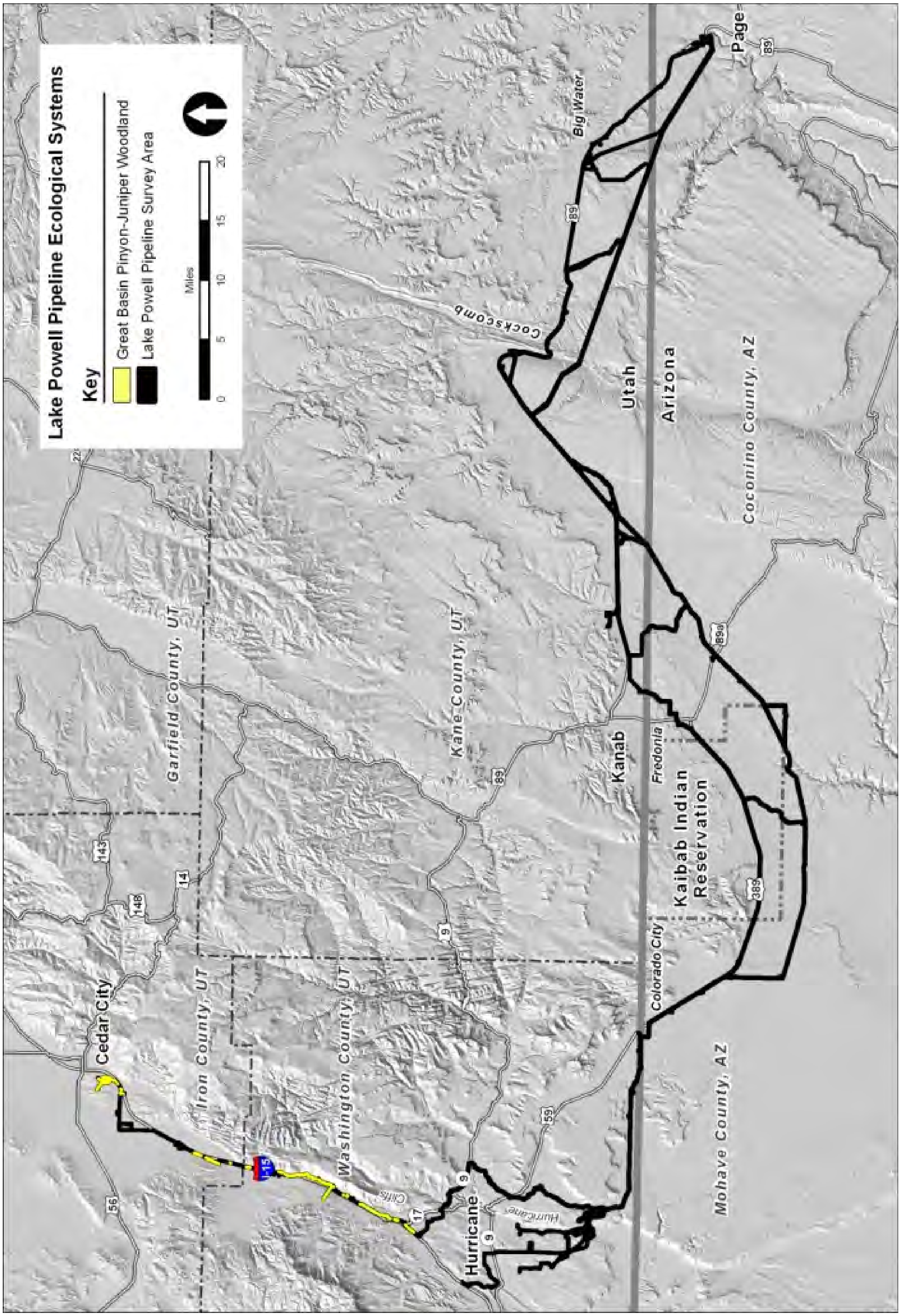
These woodlands become increasingly fire prone as their canopies close. Understory diversity and density decreases under the allelopathic effect of chemicals in the *Juniperus osteosperma* leaf litter. Younger stands may have an understory dominance of *Bromus tectorum* if they have nearby disturbance, edge effect from habitat fragmentation, or are of previous fire origin. Older stands will often have an understory dominated by *Artemisia tridentata*, with *Cordylanthus parviflorus*, a native herb capable of withstanding allelopathic chemicals.

Arctostaphylos pungens and *Quercus turbinella* are mid-successional shrubs, co-dominant with *Juniperus osteosperma* in wooded shrublands. They occupy habitats which show evidence of historic burning or tree cutting.

4.3.8.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Pinyon Juniper Woodland Ecological System mostly crosswalks to NatureServe's Great Basin Pinyon-Juniper Woodland Ecological System. The most conspicuous difference is in how wooded shrubland associations are classified within both alliances and ecological systems. Classification into an ecological system is based on the dominant species in the tallest strata (canopy), versus classification to alliance which is based on species in the strata (sub-canopy) with the greatest vegetal cover.

Two of the alliances and six of the associations in this ecological system required minor name changes from types previously described in the US NVC. Twenty associations are new types for the Great Basin Region, not previously described in the national classification.



Map 4-23
Great Basin Pinyon Juniper Woodland Ecological System

Figure 4-24
Great Basin Semi-Desert Grassland Ecological System

4.3.9 Great Basin Semi-Desert Grassland Ecological System

4.3.9.1 Geographic distribution

The Great Basin Semi-Desert Grassland Ecological System occurs once within the central portion of the Great Basin Region of the LPP survey area. The occurrence is located north of Pintura on the east side of I-15 and is interspersed with Great Basin Pinyon-Juniper Woodland (Map 4-24).

4.3.9.2 Alliances and associations

Within the survey area, the Great Basin Semi-Desert Grassland Ecological System is comprised of one alliance, *Pleuraphis jamesii* Herbaceous Alliance, with one association *Pleuraphis jamesii - (Erodium cicutarium, Bromus tectorum, Salsola tragus)* Semi-natural Herbaceous Vegetation. This ecological system totals 2.8 acres within the survey area.

4.3.9.3 Physiognomy and composition

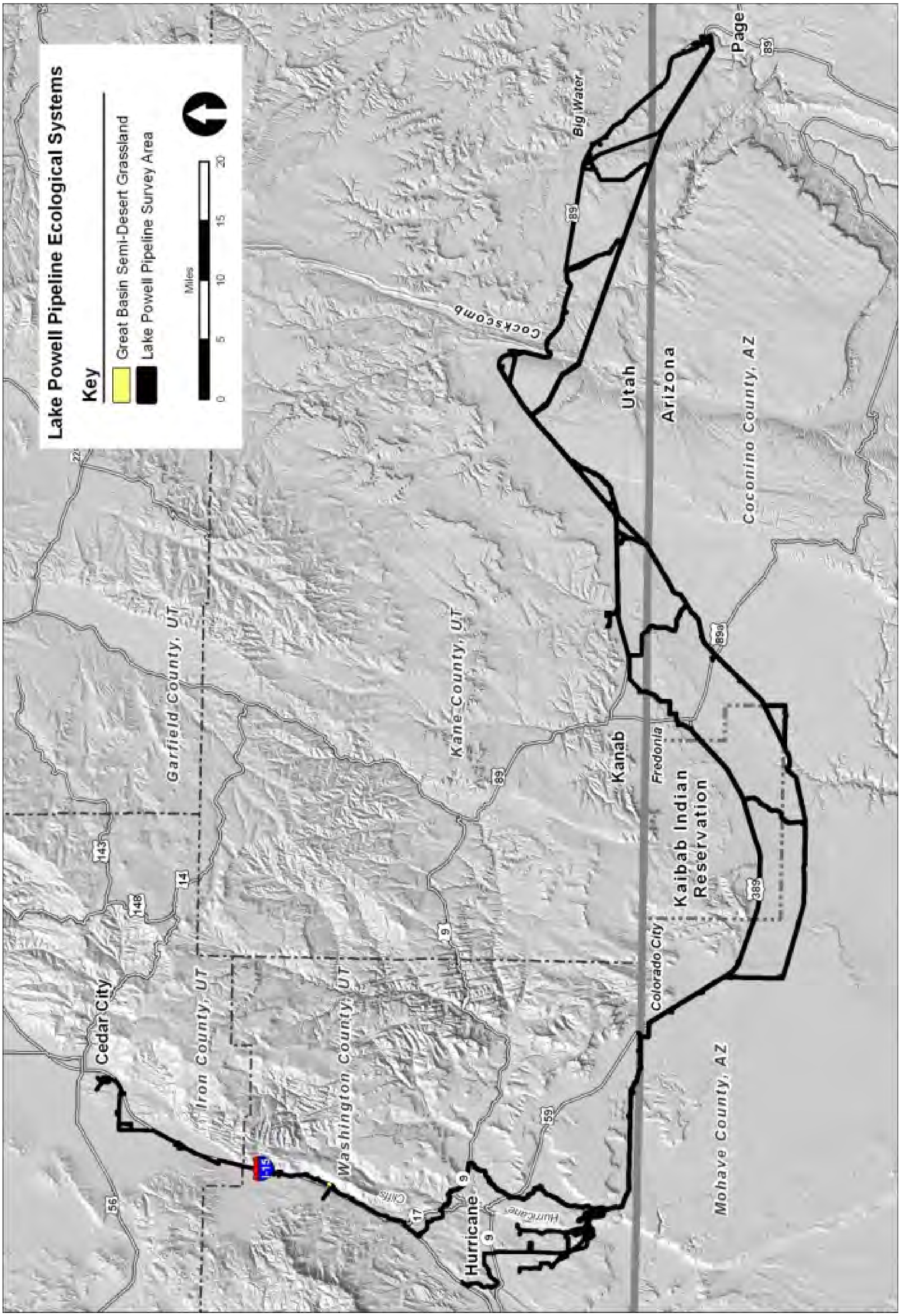
The Great Basin Semi-Desert Grassland Ecological System is strictly herbaceous vegetation (Figure 4-24).

4.3.9.4 Disturbance regimes

The Great Basin Semi-Desert Grassland Ecological System has a single early seral *Pleuraphis jamesii* semi-natural grassland occurrence. That occurrence is recovering from multiple wildfires, with *Pleuraphis jamesii* locally dominate in an otherwise *Bromus tectorum* and *Erodium cicutarium* dominated field.

4.3.9.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Semi-Desert Grassland Ecological System crosswalks to the NatureServe's Inter-Mountain Basins Semi-Desert Grassland Ecological System. The one association is a new type for the Great Basin Region, previously described in the national classification.



Map 4-24
Great Basin Semi-Desert Grassland Ecological System

4.3.10 Great Basin Shrub–Steppe Ecological System

4.3.10.1 Geographic distribution

The Great Basin Shrub-Steppe Ecological System is located at the northern end of the LPP survey area within the Cedar City area (Map 4-25).

4.3.10.2 Alliances and associations

Within the survey area, the Great Basin Shrub-Steppe Ecological System is comprised of one alliance, *Artemisia nova* Shrubland Alliance and two associations, the *Artemisia nova / Poa fendleriana* Dwarf-shrubland and the *Artemisia nova / Poa fendleriana* Sparse Dwarf-shrubland. This ecological system totals 12.3 acres within the survey area.

Figure 4-25
Great Basin Shrub–Steppe Ecological System

4.3.10.3 Physiognomy and composition

The Great Basin Shrub-Steppe Ecological System is dominated by dwarf shrubland and sparse dwarf shrubland (Figure 4-25).

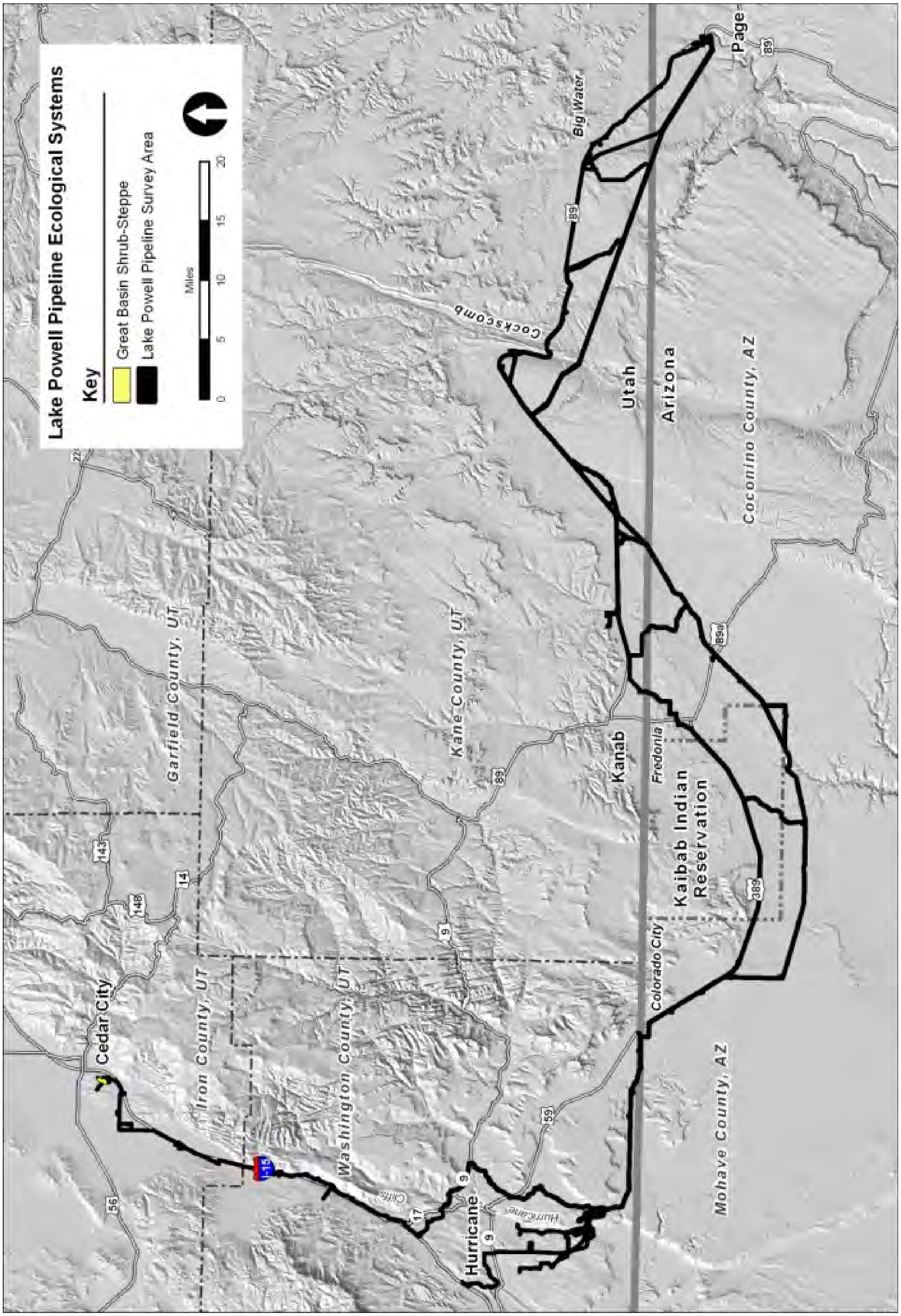
4.3.10.4 Disturbance regimes

The Great Basin Shrub-Steppe Ecological System has historically been grazed by sheep. This would have more impact on forbs than on grasses, which is why the communities do not have a diverse forb component. *Juniperus osteosperma* invades these associations, eventually transforming them into the Great Basin Pinyon-Juniper Woodland Ecological System in the absence of fire, drought kill, or logging.

4.3.10.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Shrub-Steppe Ecological System directly crosswalks to NatureServe's Great Basin Xeric Mixed Sagebrush Shrubland Ecological System, but not the Inter-Mountain Basins Semi-Desert Shrub-Steppe Ecological System. Classifying associations which have grasses dominating the understory as shrub-steppe is more consistent with the way they are treated within Colorado Plateau and Mohave Desert regions of the project.

Two of the associations in this ecological system required minor name changes from types previously described in the national classification.



Map 4-25
Great Basin Shrub–Steppe Ecological System

4.3.11 Great Basin Volcanic Rock and Cinder Land Ecological System

4.3.11.1 Geographic distribution

The Great Basin Volcanic Rock and Cinder Land Ecological System occurs just once within the Great Basin Region of the LPP survey area. It is located north of Pintura on the west side of I-15 and is interspersed with Great Basin Pinyon-Juniper Woodland and invasive upland vegetation (Map 4-26).

4.3.11.2 Alliances and associations

Within the survey area, the Great Basin Volcanic Rock and Cinder Land Ecological System is comprised solely of the *Quercus turbinella Shrubland* Alliance, with a single association, *Juniperus osteosperma / Quercus (gambelii, turbinella)* Wooded Shrubland. This ecological system totals 1.8 acres within the survey area.

Figure 4-26
Great Basin Volcanic Rock and Cinder Land Ecological System

4.3.11.3 Physiognomy and composition

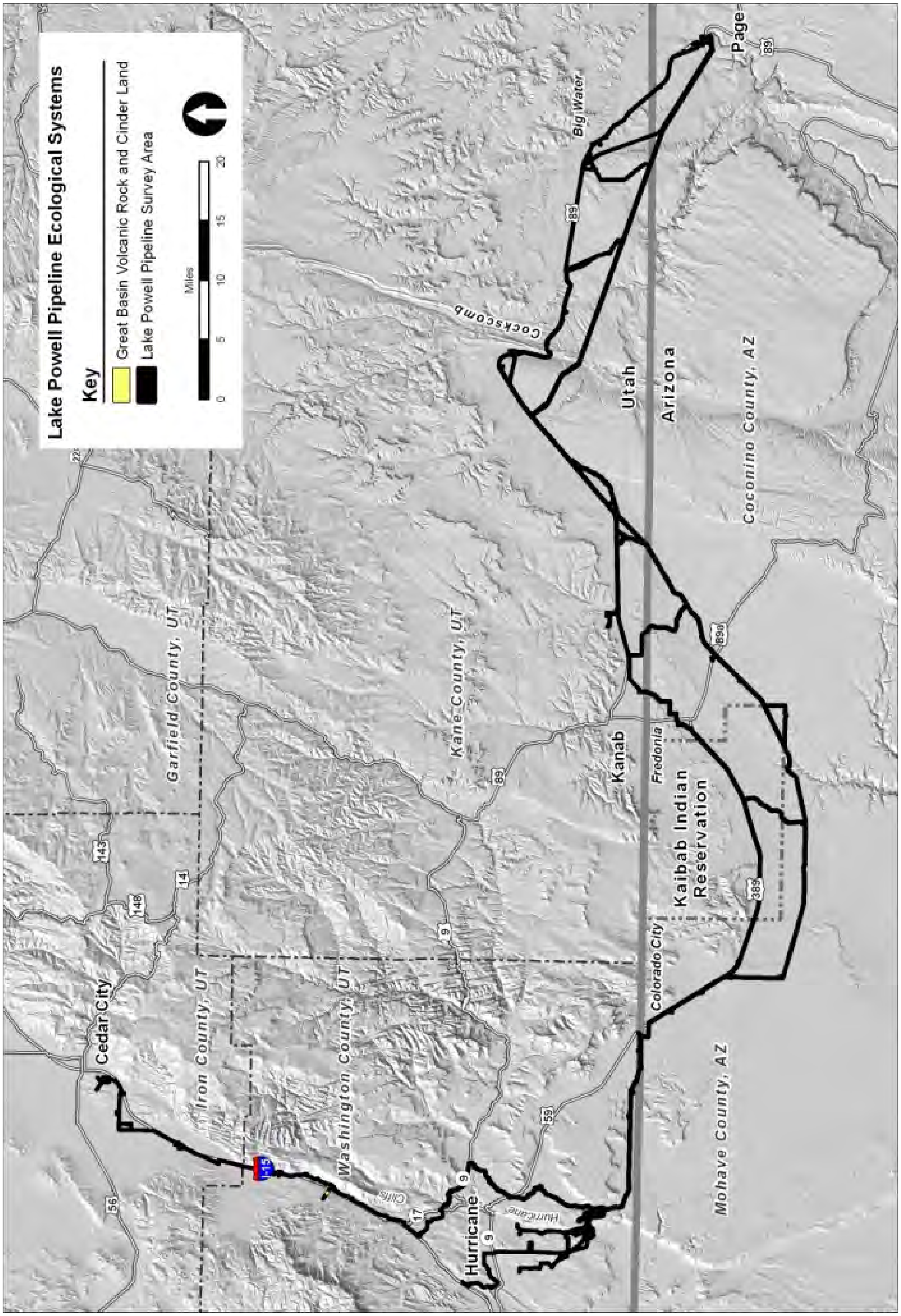
The physiognomy of the Great Basin Volcanic Rock and Cinder Land Ecological System is characterized as a wooded shrubland (Figure 4-26).

4.3.11.4 Disturbance regimes

The sole occurrence is a semi-natural community, arising from a very recent wildfire. All of the following plants colonize after wildfire: *Rhus trilobata*, *Prunus fasciculata*, *Eriodictyon angustifolium*, *Sphaeralcea grossulariifolia,* and *Bromus tectorum*. Recovery would be to a shrubland in the Great Basin Chaparral Ecological System, followed by woodland and perhaps eventually forest in the Great Basin Pinyon-Juniper Woodland Ecological System.

4.3.11.5 Relationship to the US National Vegetation Classification Systems

The Great Basin Volcanic Rock and Cinder Land Ecological System is intended to correlate with NatureServe's Inter-Mountain Basins Volcanic Rock and Cinder Land. Without other basalt substrate communities included, such as *Juniperus osteosperma* dominated woodlands, *Quercus turbinella* Shrubland Alliance is orphaned. The reason more communities were not classified to the Great Basin Volcanic Rock and Cinder Land Ecological System was that they have scant vegetal differences to differentiate them into a system emphasizing a particular landform. An alternate classification would be NatureServe's Great Basin Semi-Desert Chaparral Ecological System. That system has a *Quercus turbinella - Juniperus osteosperma* Shrubland association, but the name doesn't follow conventions used in the US NVC. The single association is a new type for the Great Basin Region, not previously described in the national classification.



Map 4-26
Great Basin Volcanic Rock and Cinder Land Ecological System

4.4 Mohave Desert Region

The Mohave Desert Region (alternately spelled Mojave) comprises 1,904 acres of natural and semi-natural lands within the identified LPP survey area. It includes lands below the Hurricane Cliffs to the west and extends to the north through sand-derived soils immediately south of the lava flows at Anderson Junction (Map 2-2).

Within the Mohave Desert Region of the survey area there are 12 ecological systems, 54 alliances, including 117 associations. Table 4-3 lists the Mohave Desert Ecological Systems and notes the number of alliances, associations, and acreages for each.

Table 4-3
Mohave Desert Region

Ecological System	Number of Alliances	Number of Associations	Acreage
Mohave Desert Active and Stabilized Dune	4	26	193.3
Mohave Desert Bedrock Cliff and Outcrop	4	4	25.8
Mohave Desert Blackbrush-Mormon-tea Shrubland	3	8	119.9
Mohave Desert Creosotebush-White Bursage Desert Scrub	5	18	708.6
Mohave Desert Grassland	1	1	39.4
Mohave Desert Gypsum Badland	2	2	28.8
Mohave Desert Lower Montane Riparian Woodland and Shrubland	4	7	17.9
Mohave Desert Mixed Desert Scrub	12	19	363.6
Mohave Desert Pinyon-Juniper Woodland	1	1	2.2
Mohave Desert Shrub-Steppe	7	13	248.6
Mohave Desert Volcanic Rock and Cinder Land	6	11	143.5
Mohave Desert Wash	4	6	12.9

4.4.1 Mohave Desert Active and Stabilized Dune Ecological System

4.4.1.1 Geographic distribution

The Mohave Desert Active and Stabilized Dune Ecological System is found in two distinct areas within the Mohave Desert Region of the LPP survey area. The northern area is just south and east of the I-15 Toquerville

Exit. The southern area extends north from the Afterbay and contours the southeast edge of Sand Hollow Reservoir (Map 4-27).

4.4.1.2 Alliances and associations

Within the survey area, the Mohave Desert Active and Stabilized Dune Ecological System is comprised of four alliances and includes 26 associations. This ecological system totals 193.3 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**165.6 acres**
Artemisia filifolia - Ephedra (nevadensis, torreyana, viridis) Shrubland	19.0 acres	
Artemisia filifolia - Gutierrezia sarothrae Shrubland	22.4 acres	
Artemisia filifolia - Psorothamnus fremontii / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	32.4 acres	
Artemisia filifolia / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	37.6 acres	
Artemisia filifolia Shrubland	54.3 acres	
***Coleogyne ramosissima - Ephedra nevadensis* Shrubland Alliance**		**5.7 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	5.7 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**20.0 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	4.0 acres	
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	0.01 acres	
Juniperus osteosperma / Coleogyne ramosissima Wooded Shrubland	16.0 acres	
***Larrea tridentata* Shrubland Alliance**		**1.9 acres**
Larrea tridentata - Ambrosia dumosa Sparse Shrubland	1.9 acres	

4.4.1.3 Physiognomy and composition

The Mohave Desert Active and Stabilized Dune Ecological System is typically a shrubland (Figure 4-27); occasionally a dwarf shrubland with *Coleogyne ramosissima* and *Ephedra nevadensis* or a wooded shrubland where *Juniperus osteosperma* has invaded; and rarely a sparse shrubland in the *Larrea tridentata* Shrubland Alliance.

4.4.1.4 Disturbance regimes

Soil stability is a major determinant of vegetal cover and composition in this ecological system. The soil surface crust of these sand dominated soils is easily broken by vehicular traffic, plowing or blading, and the trampling of animals. Once broken, erosional blowouts may occur, exposing roots of the vegetation and eventually uprooting the plants. The blown out soil is carried by winds to depositional areas defined by the topography. There the soil can bury plants, or force the vegetation to grow vertically and stay above the dune surface. In general, stable

Figure 4-27
Mohave Desert Active and Stabilized Dune Ecological System

dunes have plant species which are less able to achieve fast vertical growth. Active dunes have plants which are adapted to quick vertical growth.

Artemisia filifolia is a vertical growth adapted shrub which attains over 25 percent cover in active or disturbed dunelands. This species, along with *Gutierrezia sarothrae*, increases after grazing or burning and is often found on active dunes. Under grazing pressure, or when present in an area of active blowouts, the inter-shrub areas will typically be dominated by early season annual invasive species, especially *Bromus rubens* and *Erodium cicutarium*. Late season annual invasives, such as *Salsola tragus*, are not adapted to the extremely droughty nature of these soils in summer, when dunes have a “burned up” look to their herbaceous vegetation. Never-the-less, *Salsola* is included in the association name since it can locally dominate *Artemisia filifolia* on sandsheets rather than dunes. Sandsheet associations of *Artemisia filifolia* are classified into the Mohave Desert Mixed Desert Scrub Ecological System, although the distinction between dune and sandsheet is hard to determine wherever the two meet.

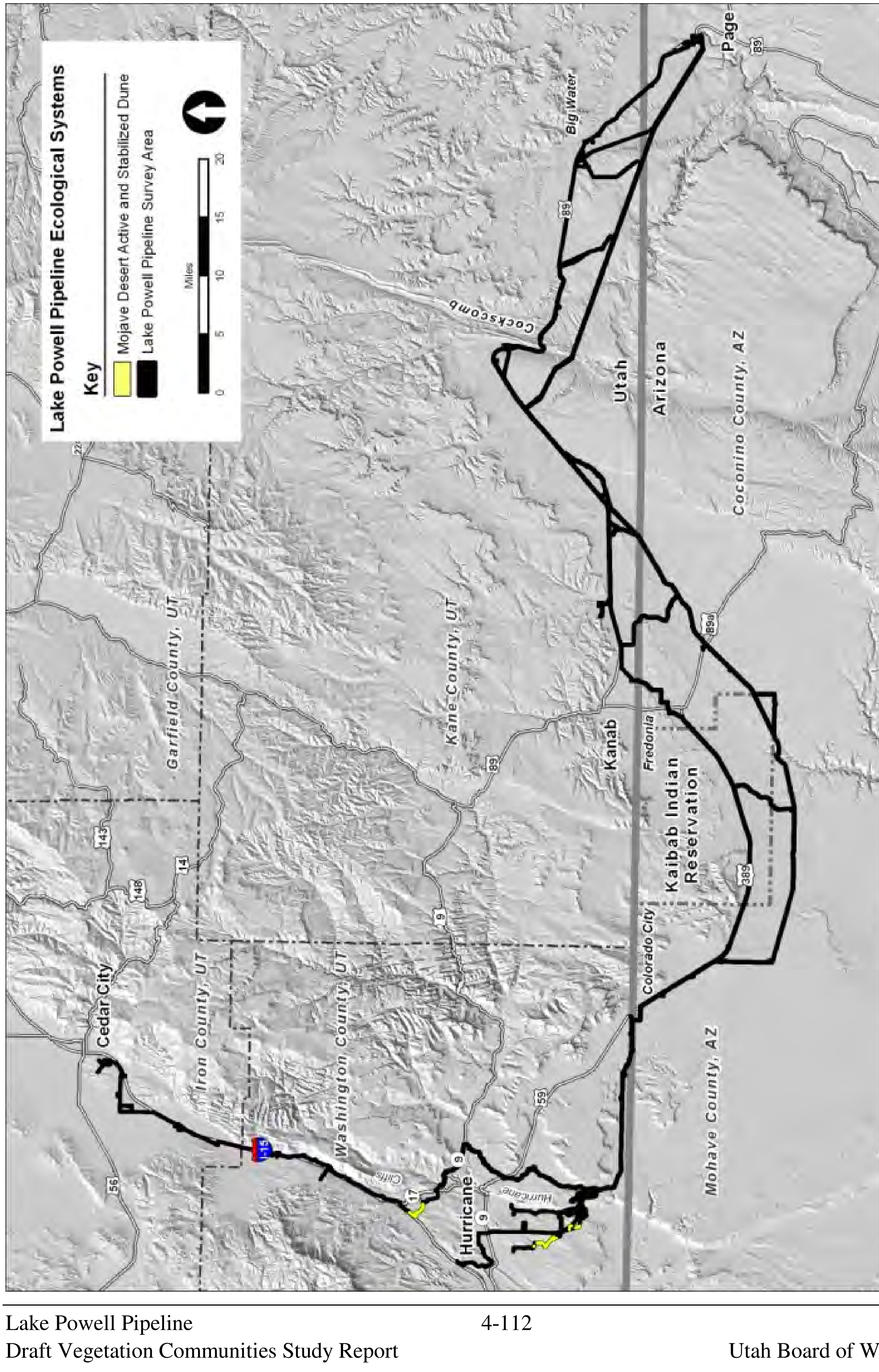
Stable dune soils may be dominated by combinations of *Psorothamnus fremontii*, *Coleogyne ramosissima,* and *Ephedra nevadensis*. *Coleogyne ramosissima* is a slow growing shrub which can persist after root exposure, but is easily overtopped by wind blown sand. *Ephedra nevadensis* is a decreaser species under grazing, but one which can elongate its shoots to stay above a building dune. *Psorothamnus fremontii* is a dominant on stable dunes. Like *Artemisia filifolia*, sandsheet associations of *Coleogyne ramosissima* and *Ephedra nevadensis* are classified into the Mohave Desert Mixed Desert Scrub Ecological System.

4.4.1.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Active and Stabilized Dune Ecological System has no correspondence to NatureServe’s North American Warm Desert Active and Stabilized Dune, even though their elevational limits overlap. Instead, it crosswalks in concept to NatureServe’s Inter-Mountain Basins Active and Stabilized Dune Ecological System. Because the NatureServe system is of higher elevations, *Larrea tridentata* and *Coleogyne ramosissima* dominated communities are absent. They are included here whenever they occur on active or stabilized dunes.

The *Artemisia filifolia* Shrubland Alliance characteristically includes *Psorothamnus fremontii* as a co-dominant shrub. An alternate classification for this type on dunes could be a *Psorothamnus fremontii - Artemisia filifolia* Shrubland Alliance, with a *Psorothamnus fremontii - Artemisia filifolia* / (*Bromus rubens*, *Erodium cicutarium*) Semi-natural Dune Shrubland association.

Two of the associations in this ecological system required minor name changes from types previously described in the US NVC. One alliance and six associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-27
Mohave Desert Active and Stabilized Dune Ecological System

4.4.2 Mohave Desert Bedrock Cliff and Outcrop Ecological System

4.4.2.1 Geographic distribution

The Mohave Desert Bedrock Cliff and Outcrop Ecological System is found in the LPP survey area just east and west of the Afterbay, just west of the Hurricane cliffs (Map 4-28).

4.4.2.2 Alliances and associations

Within the survey area, the Mohave Desert Bedrock Cliff and Outcrop Ecological System is comprised of four alliances and four associations. This ecological system totals 25.8 acres within the survey area. Acreage by alliance and association is as follows:

Coleogyne ramosissima **Shrubland Alliance**		**7.8 acres**
Coleogyne ramosissima / Sandstone Outcrop Sparse Shrubland	7.8 acres	
Lepidium fremontii **Sparsely Vegetated Alliance**		**12.0 acres**
Lepidium fremontii – Coleogyne ramosissima / Pleuraphis rigida – Bromus rubens Semi-natural Shrubland	12.0 acres	
Non-vegetated sandstone Alliance		**1.0 acres**
Non-vegetated sandstone outcrop	1.0 acres	
Purshia (stansburiana, glandulosa, mexicana) **Sparsely Vegetated Alliance**		**5.0 acres**
Purshia (stansburiana, mexicana) / Sandstone Outcrop Sparse Vegetation	5.0 acres	

Figure 4-28
Mohave Desert Bedrock Cliff and Outcrop Ecological System

4.4.2.3 Physiognomy and composition

The Mohave Desert Bedrock Cliff and Outcrop Ecological System occurs in the survey area as shubland (**Error! Reference source not found.**), sparse shrubland, sparse vegetation, and non-vegetated sandstone outcrop.

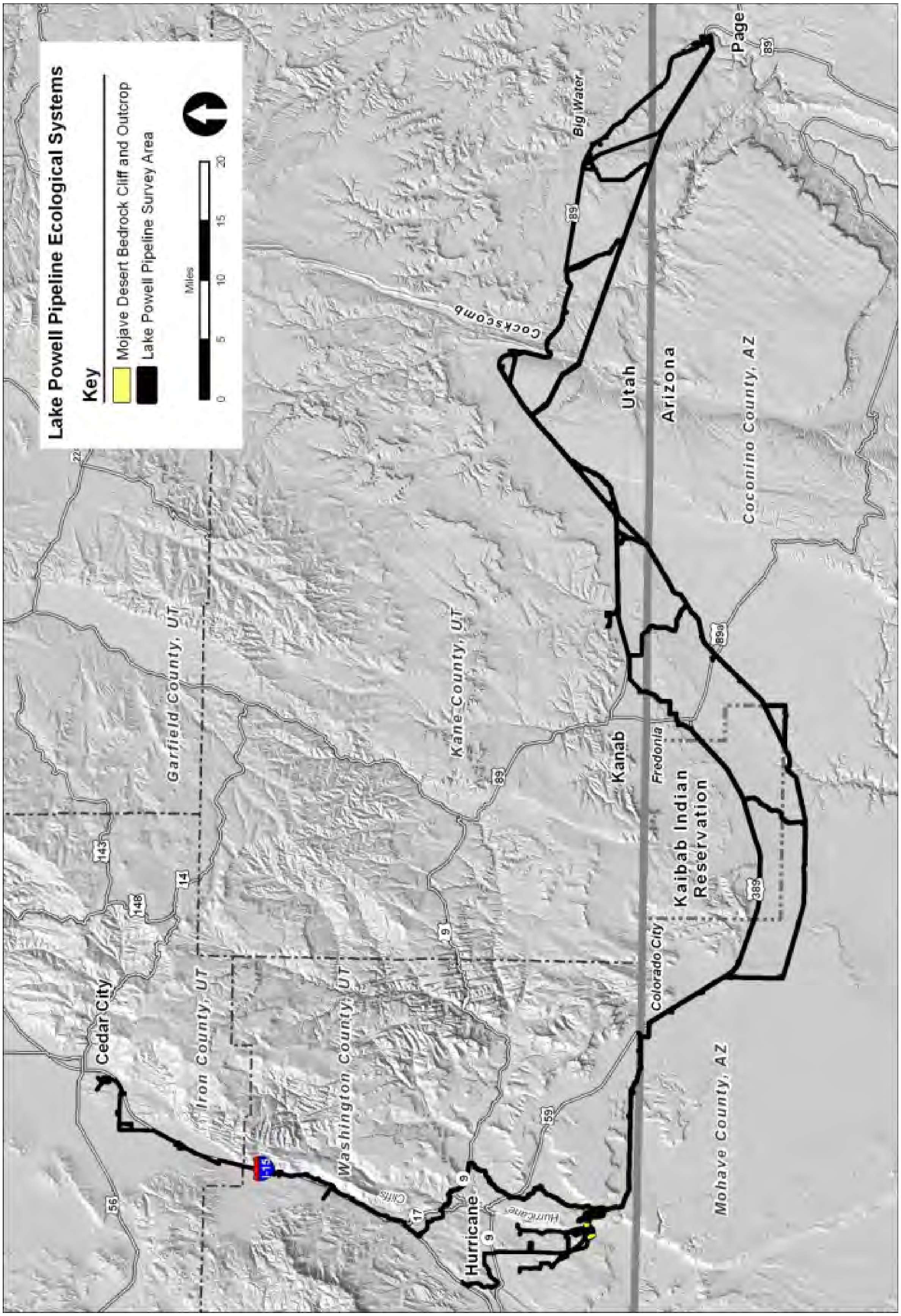
4.4.2.4 Disturbance regimes

The Mohave Desert Bedrock Cliff and Outcrop Ecological System is naturally drought stressed. Plants colonize cracks in bedrock exposures, with largely barren rock between. Colonization appears to be opportunistic and no successional sequences were observed.

4.4.2.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Bedrock Cliff and Outcrop Ecological System corresponds in concept to NatureServe's North American Warm Desert Bedrock Cliff and Outcrop Ecological System. However, few alliances are presently classified into the NatureServe system and there are none in common with the Lake Powell Pipeline survey area.

Two alliances and two associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-28
Mohave Desert Bedrock Cliff and Outcrop Ecological System

4.4.3 Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System

4.4.3.1 Geographic distribution

The Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System is found in three areas within the Mohave Desert Region of the LPP survey area. The northeastern area is west of the community of Toquerville, just west of Ash Creek (west of SR 17). The southwestern area falls in the vicinity of Quail Creek (west of Hurricane). The southern area estends north and west from the Afterbay toward Sand Mountain (Map 4-29).

4.4.3.2 Alliances and associations

Within the survey area, the Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System is comprised of three alliances and eight associations. This ecological system totals 119.9 acres within the survey area. Acreage by alliance and association is as follows:

***Coleogyne ramosissima - Ephedra nevadensis* Shrubland Alliance**		**17.0 acres**
Coleogyne ramosissima - Ephedra nevadensis / Bromus rubens Semi-natural Dwarf-shrubland	17.0 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**98.9 acres**
Coleogyne ramosissima - Ephedra nevadensis / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	3.3 acres	
Coleogyne ramosissima - Ephedra nevadensis / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	0.4 acres	
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	65.3 acres	
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Sparse Shrubland	9.6 acres	
Coleogyne ramosissima Shrubland	17.2 acres	
***Ephedra nevadensis* Shrubland Alliance**		**7.0 acres**
Ephedra nevadensis - Lycium andersonii Shrubland	0.8 acres	
Ephedra nevadensis Shrubland	6.1 acres	

4.4.3.3 Physiognomy and composition

The Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System occurs commonly in the survey area as either shrubland or sparse shrubland (Figure 4-29); and less frequently as a dwarf-shrubland.

4.4.3.4 Disturbance regimes

The five associations within the *Coleogyne ramosissima* Shrubland Alliance represent various seral stages. The oldest, most stable stands of *Coleogyne ramosissima* are those with the highest cover of that shrub, seemingly to the exclusion of other species. But the seemingly low diversity is deceptive – many herbs and grasses are

Figure 4-29
Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System

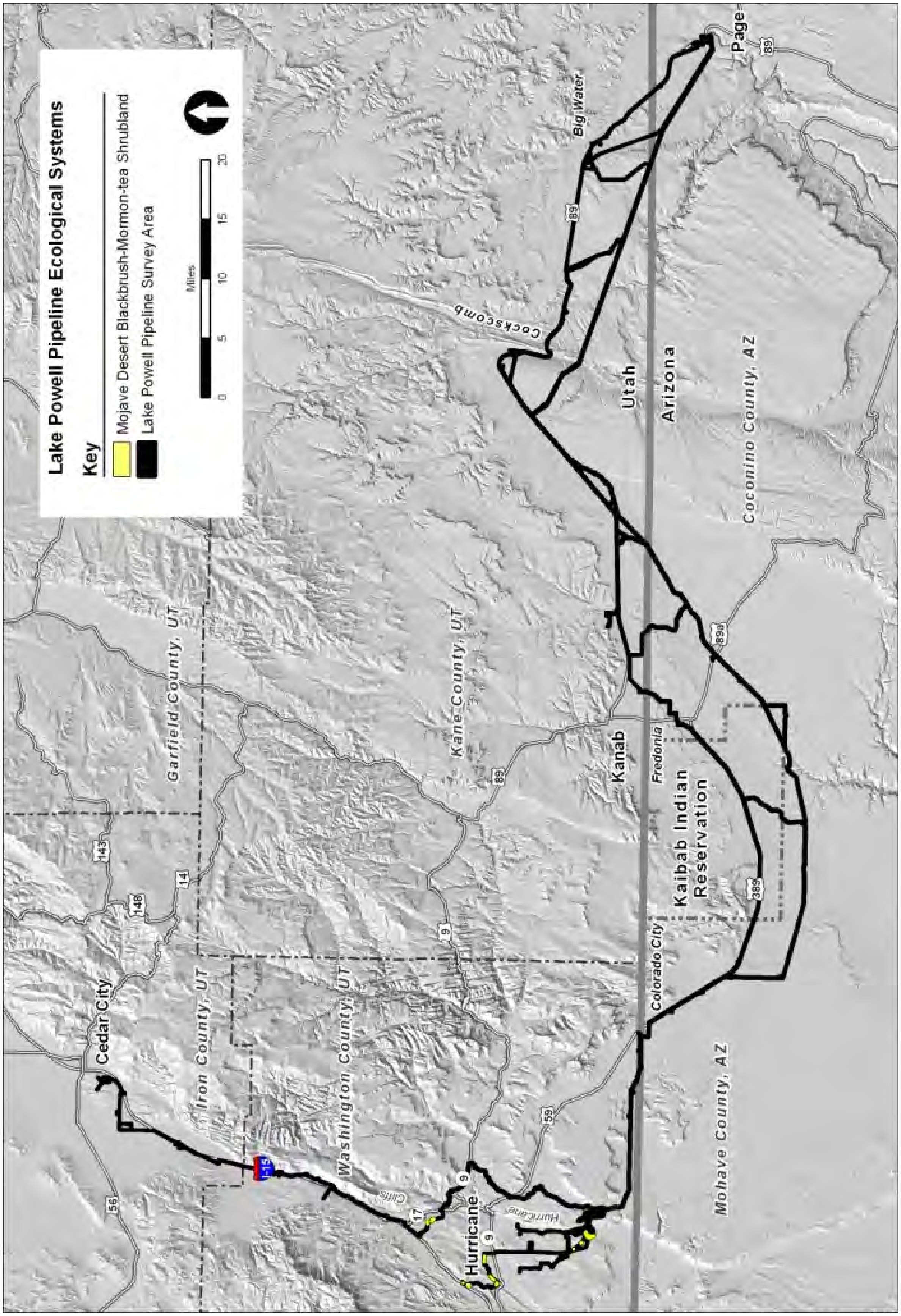
protected from grazing by growing within the dense branches of *Coleogyne ramosissima*. The mechanisms for reducing the canopy cover of shrubs probably include grazing, browsing, and drought mortality. When any of those events occur, *Ephedra nevadensis* may co-dominate. The sparse shrublands will show an increase in invasive species with increasing grazing pressure. *Erodium cicutarium* and *Bromus rubens* are the two most common invasive species.

4.4.3.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System is, in part, NatureServe's Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System. *Coleogyne ramosissima* dominated communities directly crosswalk between the two systems. The only *Ephedra* dominated communities in the Mohave Desert Region of the survey area are on gypsum badlands. These are classified as the Mohave Desert Gypsum Badlands Ecological System. *Artemisia filifolia-Coleogyne ramosissima* communities on dunes are classified as the Mohave Desert Active and Stabilized Dune Ecological System.

Coleogyne ramosissima may share dominance with a variety of other shrubs. These include *Psorothamnus fremontii* and *Larrea tridentata* in the Mohave Desert Creosotebush-White bursage Ecological System, and *Artemisia tridentata* ssp. *vaseyana* in the Mohave Desert Big Sagebrush Ecological System, The larger stature shrub takes precedence in classification decisions.

One alliance and six associations are new types for the Mohave Desert Region, and are not previously described in the national classification.



Map 4-29
Mohave Desert Blackbrush-Mormon-tea Shrubland Ecological System

4.4.4 Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System

4.4.4.1 Geographic distribution

The Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System is found throughout the Mohave Desert Region of the LPP survey area. It is most commonly associated with relatively flat upland habitats. The greatest concentration of this ecological system is within the Afterbay west of the Hurricane Cliffs, and north of the Afterbay toward the Hurricane Airport. It was also documented east of the Sand Hollow Reservoir, adjacent to the Virgin River (west of Hurricane), and adjacent to LaVerkin Creek (north of Hurricane). It is often interspersed with Mohave Desert Shrub-Steppe and Mohave Desert Mixed Desert Scrub Ecological Systems (Map 4-30).

4.4.4.2 Alliances and associations

Within the survey area, the Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System is comprised of five alliances and 18 associations. This ecological system totals 708.6 acres within the survey area. Acreage by alliance and association is as follows:

***Ambrosia dumosa* Shrubland Alliance**		**8.8 acres**
Ambrosia dumosa / (Erodium cicutarium, Bromus rubens) Dwarf-shrubland	2.0 acres	
Ambrosia dumosa Dwarf-shrubland	6.8 acres	
***Ephedra nevadensis* Shrubland Alliance**		**4.6 acres**
Ephedra nevadensis - Ambrosia dumosa / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	4.6 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**86.3 acres**
Larrea tridentata / Erodium cicutarium Semi-natural Shrub Herbaceous Vegetation	86.3 acres	
***Larrea tridentata* Shrubland Alliance**		**560.2 acres**
Larrea tridentata - Ambrosia dumosa / (Erodium cicutarium, Bromus rubens) Semi-natural Shrubland	8.7 acres	
Larrea tridentata - Ambrosia dumosa Shrubland	3.5 acres	
Larrea tridentata - Ambrosia dumosa Sparse Shrubland	10.4 acres	
Larrea tridentata - Coleogyne ramosissima / Bromus rubens Semi-natural Shrubland	42.2 acres	
Larrea tridentata - Coleogyne ramosissima Shrubland	14.4 acres	
Larrea tridentata - Gutierrezia sarothrae / Bromus rubens Semi-natural Sparse Shrubland	10.2 acres	
Larrea tridentata - Gutierrezia sarothrae Shrubland	3.8 acres	
Larrea tridentata - Gutierrezia sarothrae Sparse Shrubland	9.3 acres	
Larrea tridentata / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	41.6 acres	

Larrea tridentata / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Shrubland	379.7 acres	
Larrea tridentata / Bromus rubens Semi-natural Shrubland	5.7 acres	
Larrea tridentata Shrubland	28.7 acres	
Larrea tridentata Sparse Shrubland	2.0 acres	
***Larrea tridentata* Sparsely Vegetated Alliance**		**48.6 acres**
Larrea tridentata / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Vegetation	48.6 acres	

4.4.4.3 Physiognomy and composition

The Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System is commonly a shrubland (**Error! Reference source not found.**); less commonly a sparse shrubland; occasionally sparse vegetation; and rarely dwarf shrubland.

Figure 4-30
Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System

4.4.4.4 Disturbance regimes

A wide diversity of *Larrea tridentata* dominated associations highlights the diversity of seral stages in the Mohave Desert Mixed Desert Scrub Ecological System. *Larrea tridentata* matures in the absence of fire, which is rare in this system. Grazing and light fire will result in co-dominance from the increaser shrub, *Gutierrezia sarothrae*. Over-grazing leads to the loss of the decreaser grass, *Pleuraphis rigida*. Prolonged grazing or wildfire leads to invasive plant dominance in the understory. Invasive species include *Bromus rubens*, *Erodium cicutarium* and *Salsola tragus*. Fire generally kills most of the *Larrea*, leaving at best semi-natural shrub herbaceous vegetation. With total shrub mortality, the community shifts to Invasive Upland Vegetation.

Greater diversity communities in this ecological system will have either *Ambrosia dumosa* or *Coleogyne ramosissima* as co-dominant. This reflects altitudinal gradients and better soils, rather than lack of any particular disturbance. *Bromus rubens* is a widespread invasive species in both the *Larrea tridentata - Coleogyne ramosissima* Shrubland and the *Larrea tridentata - Ambrosia dumosa* Shrubland. However, *Bromus rubens* has become so widespread on the landscape that it has no particular significance to land use history. Like other invasive annuals, *Bromus rubens* dominance varies year to year, based on the amount and timing of rainfall. Seasonally, it may only be visually dominant during spring, making the classification of semi-natural associations problematic.

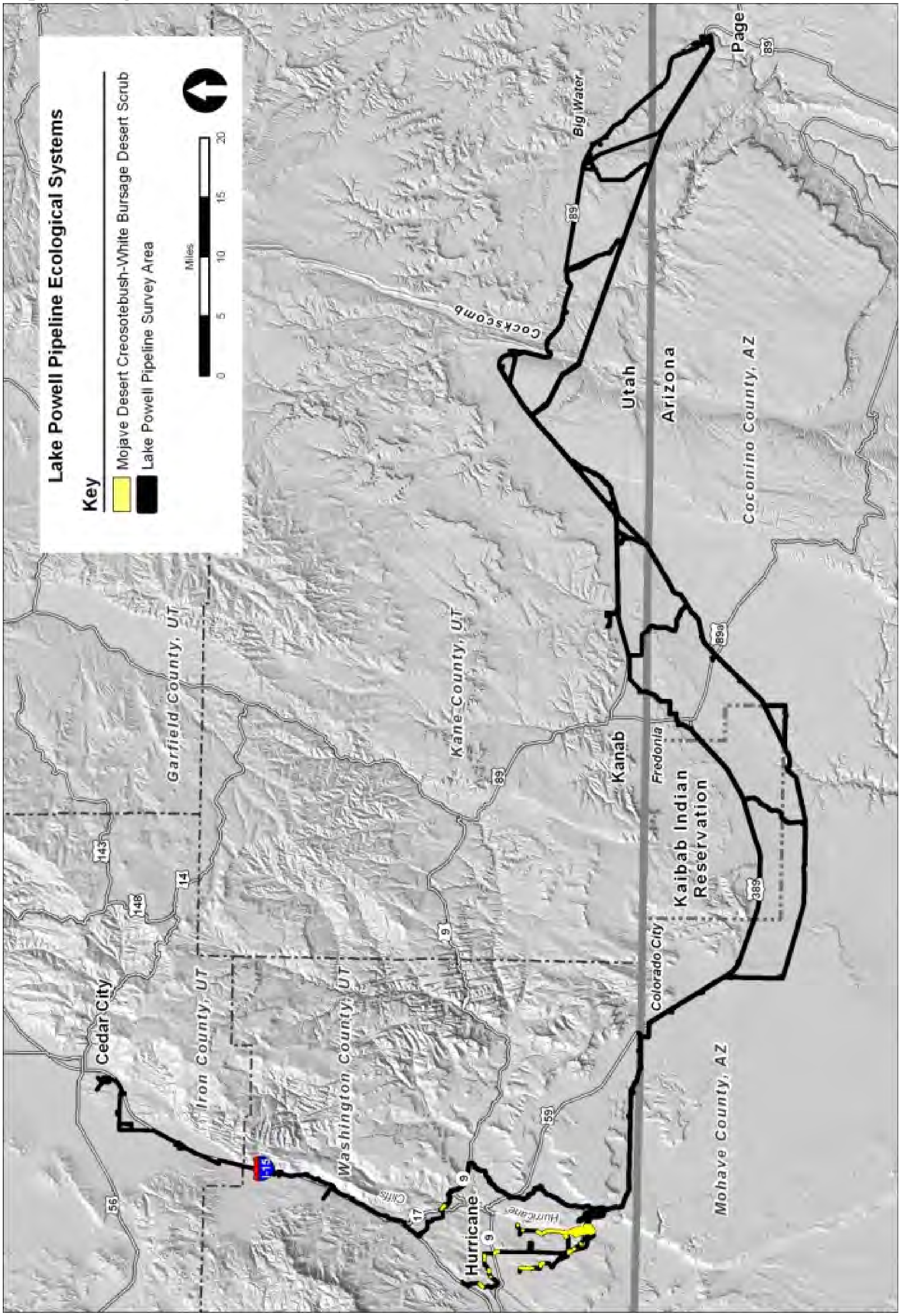
Larrea tridentata rarely co-dominates with *Atriplex canescens*. The sole occurrence is a semi-natural shrubland with additional dominance by *Gutierrezia sarothrae* and *Bromus rubens*. The area was probably grazed, although perhaps not since 1995, based on its appearance in 1995 aerial imagery.

Ambrosia dumosa is a monotypic community where not disturbed. Upon disturbance, it shares dominance with *Ephedra nevadensis*, although not at the expense of a reduction in canopy cover. The herbaceous flora becomes weedy, with dominance by the invasives *Erodium cicutarium* and *Bromus rubens*.

4.4.4.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System slightly expands the concept of NatureServe's Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System. No saline soils were present in Mohave Desert Region of the survey area, thus one occurrence of Atriplex *canescens* with *Larrea tridentata* as co-dominant is simply classified as *Larrea tridentata* Shrubland in the Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System.

Three of the alliances and six of the associations in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and eleven associations are new types for the Mohave Desert Region, not previously described in the national classification. The *Larrea tridentata* Monotype Shrubland association of the US NVC was not used since it is redundant in concept, but less comprehensive than listing the dominant invasives in semi-natural associations.



Map 4-30
Mohave Desert Creosotebush-White Bursage Desert Scrub Ecological System

4.4.5 Mohave Desert Grassland Ecological System

4.4.5.1 Geographic distribution

The Mohave Desert Grassland Ecological System is found northwest of the Afterbay and east of Sand Hollow Reservoir (Map 4-31) within the Mohave Desert of the LPP survey area.

4.4.5.2 Alliances and associations

Within the survey area, the Mohave Desert Grassland Ecological System is comprised of just one alliance *Pleuraphis rigida* Herbaceous Alliance and one association, *Pleuraphis rigida* Herbaceous Vegetation. This ecological system totals 39.4 acres within the survey area.

Figure 4-31
Mohave Desert Grassland Ecological System

4.4.5.3 Physiognomy and composition

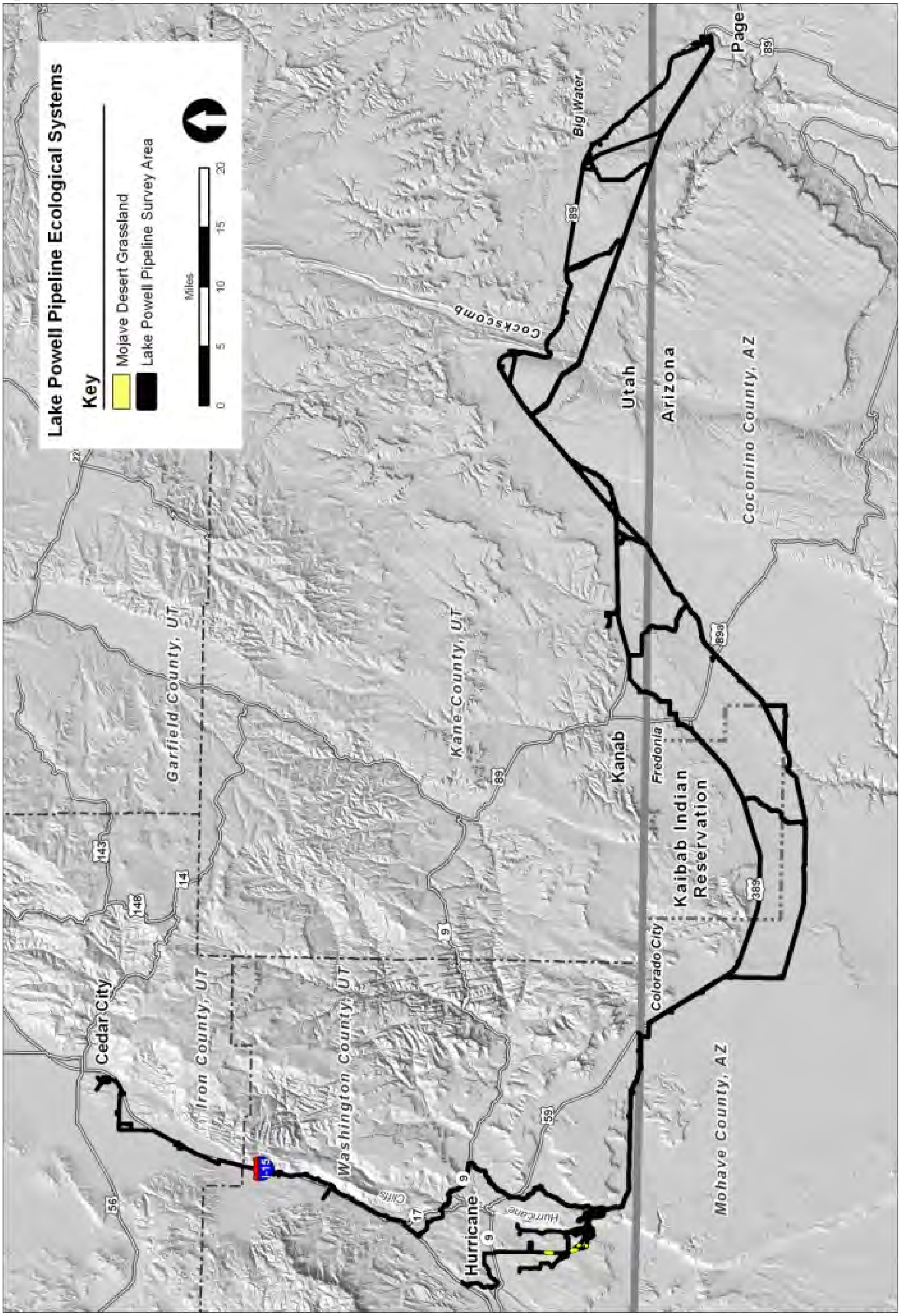
The Mohave Desert Grassland Ecological System occurs in the survey area exclusively as herbaceous vegetation (Figure 4-31).

4.4.5.4 Disturbance regimes

Mohave Desert Grassland appears to be a long persistent ecological system, even under a history of grazing. However, not enough occurrences were sampled in the LPP study area to determine successional stages.

4.4.5.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Grassland Ecological System directly cross-walks to the Inter-Mountain Basins Semi-Desert Grassland, although they differ by region. The *Pleuraphis rigida* Herbaceous Alliance lacks any associations in the US NVC, hence the addition of a *Pleuraphis rigida* Herbaceous Vegetation association.



Map 4-31
Mohave Desert Grassland Ecological System

4.4.6 Mohave Desert Gypsum Badland Ecological System

4.4.6.1 Geographic distribution

The Mohave Desert Gypsum Badland Ecological System is found within the Mohave Desert Region of the LPP survey area along the eastern edge of the Harrisburg Bench (west of the Virgin River in Hurricane; Map 4-32).

4.4.6.2 Alliances and associations

Within the survey area, the Mohave Desert Gypsum Badland Ecological System is comprised of two alliances and two associations. This ecological system totals 28.8 acres within the survey area. Acreage by alliance and association is as follows:

***Ephedra torreyana* Sparsely Vegetated Alliance**		**10.1 acres**
Ephedra torreyana Gypsum Badlands Sparse Vegetation	10.1 acres	
***Psorothamnus fremontii - Hymenoclea salsola - Ambrosia dumosa* Sparsely Vegetated Alliance**		**18.7 acres**
Psorothamnus fremontii - Hymenoclea salsola - Ambrosia dumosa Gypsum Badlands Sparse Vegetation	18.7 acres	

Figure 4-32
Mohave Desert Gypsum Badland Ecological System

4.4.6.3 Physiognomy and composition

The Mohave Desert Gypsum Badland Ecological System is exclusively sparse vegetation (Figure 4-32).

4.4.6.4 Disturbance regimes

The Mohave Desert Gypsum Badland Ecological System is found exclusively along a severely tilted fault line, exposing the Shnabkaib Member of the Moenkopi Formation. The *Psorothamnus fremontii - Hymenoclea salsola - Ambrosia dumosa* Gypsum Badlands Sparse Vegetation is found where the topography is steep and dissected by erosion. The *Ephedra torreyana* Gypsum Badlands Sparse Vegetation association is found where the topography is an eroded basin of the Virgin anticline. It occupies interspersed mounds of soft, grey gypsiferous soils and severely tilted, thin rock outcroppings.

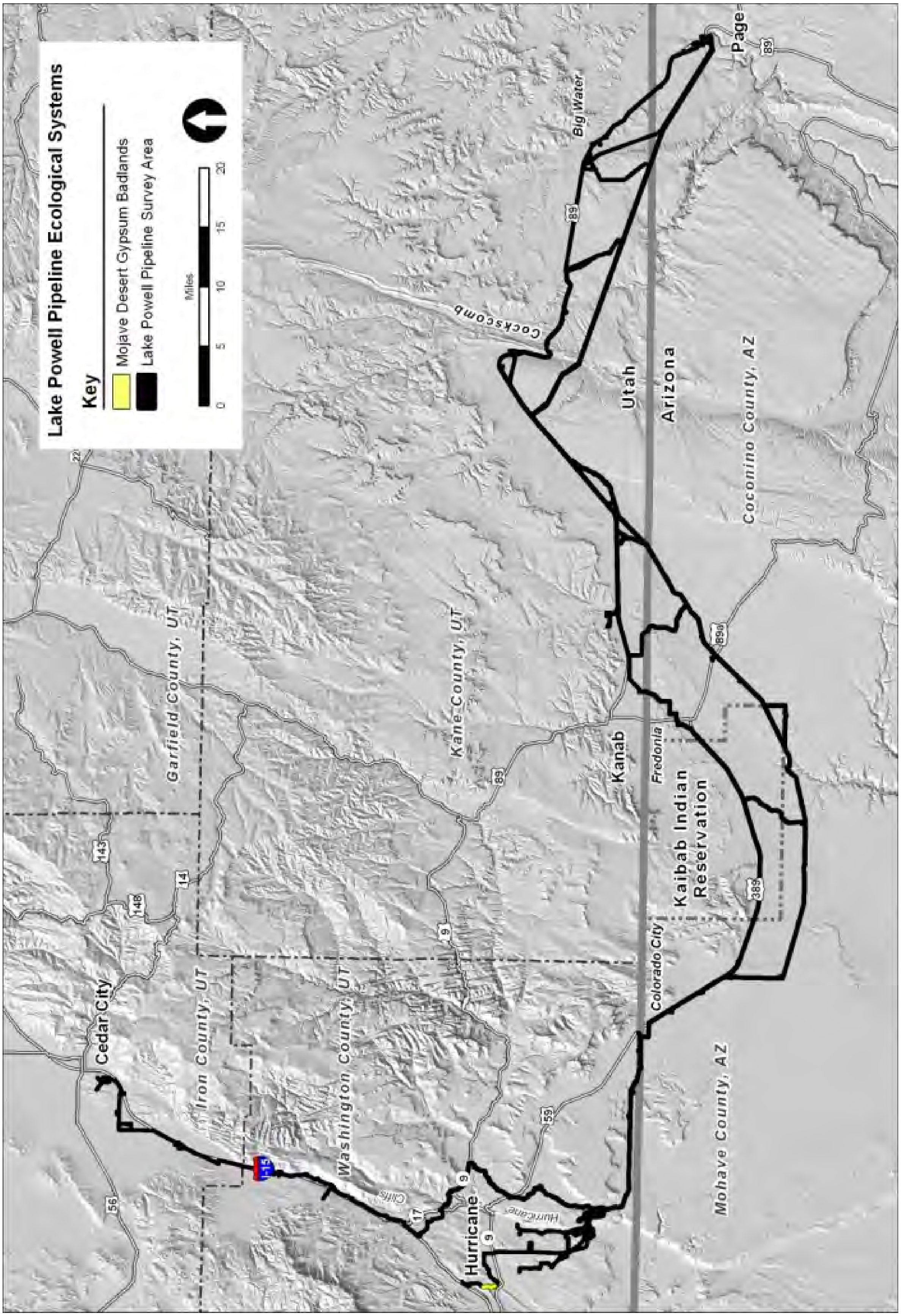
The former association is a vegetation complex variously dominated by *Hymenoclea salsola*, *Psorothamnus fremontii*, or *Ambrosia dumosa*. Dominance depends on topographic position. Successional stages are unknown because all four occurrences are in close proximity to each other and have presumably had the same disturbance history. The sparse nature of the vegetation reduces the threat of wildfire and the steepness of the terrain, adjacent to a road, probably limited historical impacts from grazing. *Bromus tectorum* was common to localized abundant where the ground was disturbed.

In contrast, the *Ephedra torreyana* Gypsum Badlands Sparse Vegetation has been locally impacted by vehicles and grading during the original 1984 and 1990 reconstruction of the Quail Creek south dike. The vegetation tends to be totally graded and non-vegetated, or existing as sparse vegetation with *Ephedra nevadensis* as the single dominant species. The ungraded areas are habitat for *Petalonyx parryi*. Where the uplands are disturbed and the cryptobiotic crust removed, *Halogeton glomeratus* is locally abundant. Very narrow riparian zones dissect the basin, where *Tamarix chinensis* is locally abundant, due to the after effects of scouring from a catastrophic flood when the Quail Reservoir south dike was breeched in 1989.

4.4.6.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Gypsum Badland Ecological System corresponds in concept to NatureServe's Inter-Mountain Basins Shale Badland Ecological System. It differs in being of lower elevations and emphasizing gypsum rather than shale as the dominant geologic influence. It also has alliances which are geographically and geologically more indicative of the survey area than NatureServe's *Ephedra torreyana* Sparsely Vegetated Alliance and the Painted Desert Sparsely Vegetated Alliance.

One alliance and two associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-32
Mohave Desert Gypsum Badland Ecological System

4.4.7 Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System

4.4.7.1 Geographic distribution

The Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is found sporadically throughout the Mohave Desert Region in association with both major and minor drainages within the LPP survey area. Some examples include: Sand Hollow Reservoir, the Virgin River, the outflow from Quail Creek Reservoir, Ash Creek inflow to Quail Creek Reservoir, Ash Creek, as well as areas associated with agricultural water usage (Map 4-33).

4.4.7.2 Alliances and associations

Within the survey area, the Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is comprised of four alliances and seven associations. This ecological system totals 17.9 acres within the survey area. Acreage by alliance and association is as follows:

***Populus fremontii* Woodland Alliance**		**2.3 acres**
Populus fremontii - Fraxinus velutina Woodland	0.7 acres	
Populus fremontii Forest	0.7 acres	
Populus fremontii Sparse Woodland	0.8 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**1.1 acres**
Tamarix chinensis / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	1.1 acres	
***Tamarix chinensis* Semi-natural Shrubland Alliance**		**12.5 acres**
Tamarix chinensis Semi-natural Shrubland	3.9 acres	
Tamarix chinensis Semi-natural Sparse Shrubland	8.5 acres	
***Typha latifolia* Herbaceous Alliance**		**2.1 acres**
Tamarix chinensis / Typha latifolia Semi-natural Shrub Herbaceous Vegetation	2.1 acres	

4.4.7.3 Physiognomy and composition

The Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is commonly sparse shrubland and shrubland; occasionally woodland (Figure 4-33), or shrub herbaceous vegetation; and rarely forest or sparse woodland.

4.4.7.4 Disturbance regimes

Natural communities in the Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System are dominated or co-dominated by the native trees *Populus fremontii* and *Fraxinus velutina*, or the invasive shrub, *Tamarix chinensis*. Early seral stages of *Populus* and *Fraxinus* are shrublands, maturing to woodlands and eventually forests in the absence of disturbance. Semi-natural communities will have the invasive

Figure 4-33
Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System

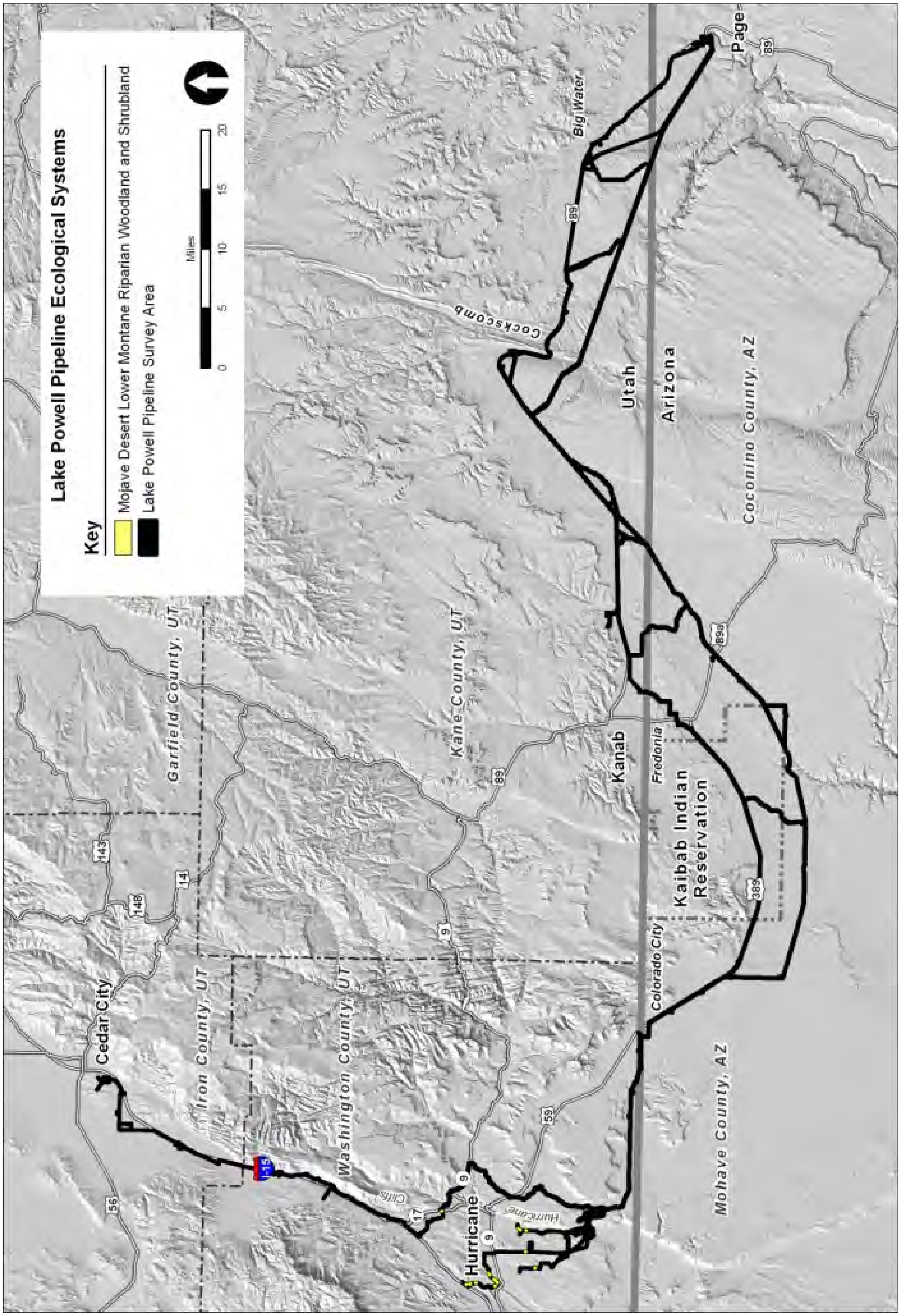
Tamarix chinensis as dominant. There were no examples of *Tamarix chinensis* co-dominating with a native species.

The Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System has been subject to logging since settlement of the region in 1861. Both *Populus fremontii* and *Fraxinus velutina* can be uprooted by violent flooding – an occasional natural disturbance to streams and rivers in this region. These trees provide shade for livestock, which are often pastured in riparian areas. Severe disturbances, such as the dike breeching at Quail Creek Reservoir, as well as habitat fragmentation, can lead to recolonization by *Tamarix chinensis*. These begin as a shrub herbaceous vegetation association, followed by sparse shrubland and eventually shrubland. The seral stages can include *Salsola tragus*, *Typha domingensis*, *T. latifolia,* and *Distichlis spicata* as co-dominants. But once *Tamarix* is established, it soon replaces native and other exotic species in dominance.

4.4.7.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System crosswalks for the most part to NatureServe's North American Warm Desert Lower Montane Riparian Woodland and Shrubland Ecological System. It also has elements of the Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland Ecological System.

Three of the alliances and two of the associations in this ecological system required minor name changes from types previously described in the US NVC. One alliance and four associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-33
Mohave Desert Lower Montane Riparian Woodland and Shrubland Ecological System

4.4.8 Mohave Desert Mixed Desert Scrub Ecological System

4.4.8.1 Geographic distribution

The Mohave Desert Mixed Desert Scrub Ecological System is found throughout the Mohave Desert Region within the LPP survey area. In the north it occurred just west of the community of Toquerville (west of SR 17). Other areas include: south of the Virgin River (east of Quail Creek Reservoir), west of Quail Creek Reservoir, adjacent to the agricultural lands south of Hurricane, portions of Sand Mountain Road, and portions of the Afterbay. It is often interspersed with Mohave Desert Creosotebush-White Bursage Desert Scrub and Mohave Desert Shrub-Steppe Ecological Systems (Map 4-34).

4.4.8.2 Alliances and associations

Within the survey area, the Mohave Desert Mixed Desert Scrub Ecological System is comprised of 12 alliances, including 19 associations. This ecological system totals 363.6 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**8.5 acres**
Artemisia filifolia - Psorothamnus fremontii / (Bromus rubens, Erodium cicutarium, Salsola tragus) Semi-natural Shrubland	8.5 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**40.3 acres**
Chrysothamnus viscidiflorus / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Dwarf-shrubland	20.3 acres	
Chrysothamnus viscidiflorus Sparse Shrubland	20.0 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**3.8 acres**
Atriplex canescens / Erodium cicutarium Semi-natural Shrub Herbaceous Vegetation	3.8 acres	
***Grayia spinosa* Shrubland Alliance**		**23.8 acres**
Grayia spinosa - Lycium andersonii / (Erodium cicutarium, Bromus rubens) Semi-natural Dwarf-shrubland	23.8 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**86.9 acres**
Gutierrezia sarothrae / (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Dwarf-shrubland	51.1 acres	
Gutierrezia sarothrae / (Erodium cicutarium, Bromus (tectorum, rubens), Salsola tragus) Semi-natural Sparse Dwarf-shrubland	0.9 acres	
Gutierrezia sarothrae Dwarf-shrubland	31.6 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	3.2 acres	
***Krascheninnikovia lanata* Shrubland Alliance**		**46.3 acres**
Krascheninnikovia lanata / (Erodium cicutarium, Salsola tragus, Ceratocephala testiculata) Semi-natural Dwarf-shrubland	3.9 acres	
Krascheninnikovia lanata / (Erodium cicutarium, Salsola tragus, Ceratocephala testiculata) Semi-natural Sparse Dwarf-shrubland	0.7 acres	

Krascheninnikovia lanata Dwarf-shrubland	41.7 acres	
***Lepidium fremontii* Sparsely Vegetated Alliance**		**16.1 acres**
Lepidium fremontii Sparsely Vegetated	16.1 acres	
Mixed Desert Shrub Shrubland Alliance		**53.4 acres**
Mixed Desert Shrub / (Bromus rubens, Salsola tragus, Erodium cicutarium) Semi-natural Shrubland	53.4 acres	
***Prunus fasciculata* Shrubland Alliance**		**0.2 acres**
Prunus fasciculata Shrubland	0.2 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**12.7 acres**
Lycium pallidum / Salsola tragus Semi-natural Shrub Herbaceous Vegetation	12.7 acres	
Unclassified		**11.8 acres**
***Yucca baccata* Shrubland Alliance**		**59.8 acres**
Yucca baccata / Bromus rubens Semi-natural Shrubland	33.2 acres	
Yucca baccata / Salsola tragus Semi-natural Sparse Shrubland	26.6 acres	

4.4.8.3 Physiognomy and composition

The Mohave Desert Mixed Desert Scrub Ecological System is commonly dwarf shrubland and shrubland (Figure 4-34); and occasionally sparse dwarf shrubland, sparse shrubland, or shrub herbaceous vegetation.

4.4.8.4 Disturbance regimes

The Mixed Desert Shrub Shrubland Alliance is one of the largest alliances in the Mohave Desert Mixed Desert Scrub Ecological System, It has a mix of shrub species which seemingly change with each step across the landscape. All of the occurrences are semi-natural, with the invasive herbs *Salsola tragus* and *Erodium cicutarium*, or the invasive grass *Bromus rubens* dominating the understory.

Figure 4-34
Mohave Desert Mixed Desert Scrub Ecological System

The alliance with the greatest acreage in the ecological system is *Gutierrezia sarothrae* Dwarf-shrubland. *Gutierrezia sarothrae* is an increaser under grazing and colonizes after fire. This region was subjected to both prescribed and indiscriminate burning with the goal of increasing forage production. *Coleogyne ramosissima* communities were the prime target of these burns. This opened up the range to colonization by invasive species. The major invasive herb in *Gutierrezia sarothrae* dominated communities is *Erodium cicutarium*. Where

Erodium co-dominates, the communities are classified as *Gutierrezia sarothrae* / (*Erodium cicutarum*, *Bromus rubens*, *Salsola tragus*) Semi-natural Dwarf-shrubland or Sparse Dwarf-shrubland associations.

Krascheninnikovia lanata Dwarf-shrubland and *Chrysothamnus viscidiflorus* Shrubland comprise the second and third highest acreage totals, respectively. *Krascheninnikovia lanata* is a decreaser under grazing and provides winter forage, while *Chrysothamnus viscidiflorus* is an increaser. *Erodium cicutarium* is the only major invasive plant, invading under grazing pressure or after wildfire. *Pleuraphis rigida* is the major decreaser and is rarely dominant, indicating the poor range condition typical of these alliances. Where grasses dominate, the communities are classified as shrub-steppe.

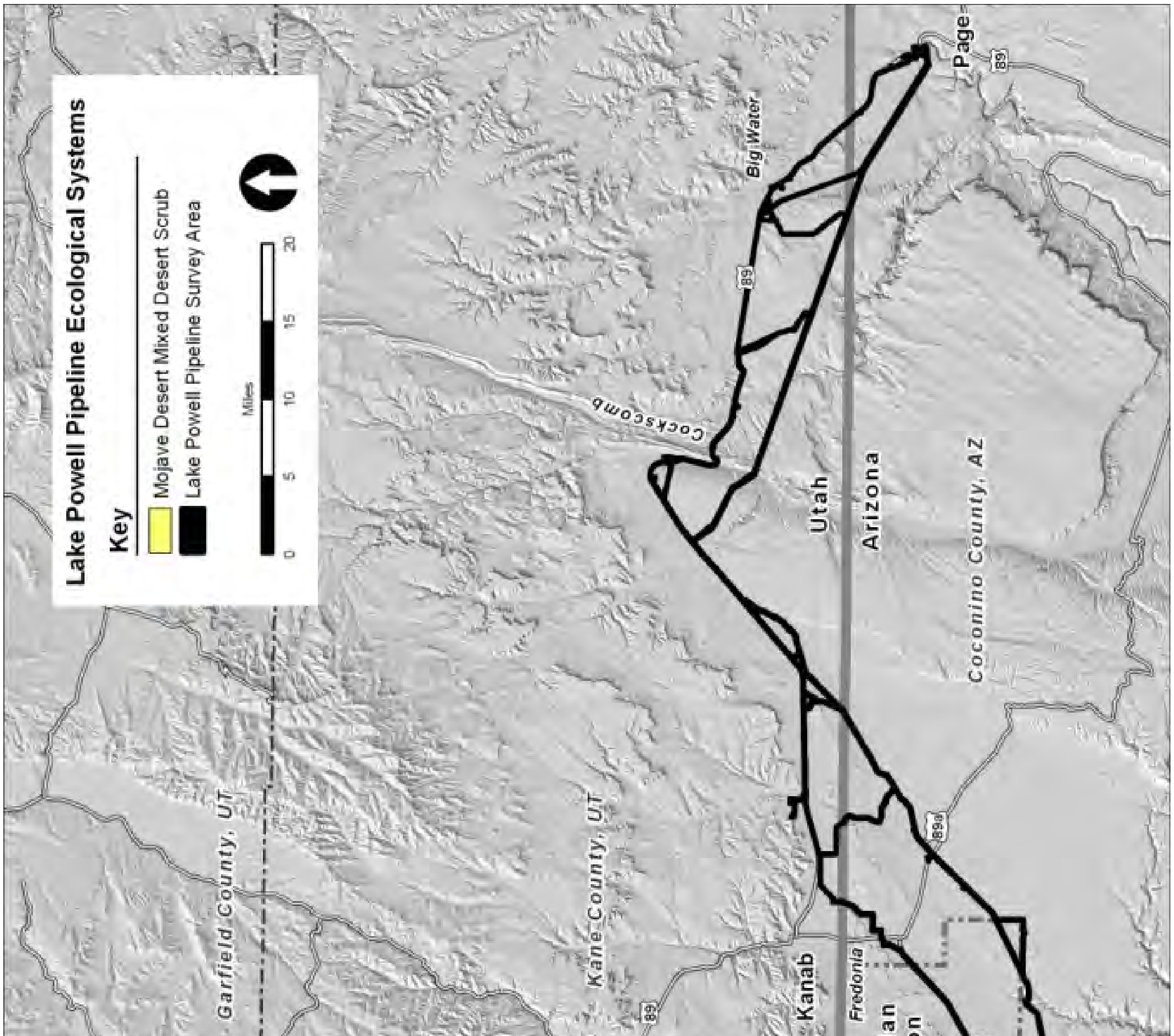
Grazed sandsheet topography typically supports *Artemisia filifolia* dominated communities. This habitat has shallower sand dominated soil horizons than the soils in the Mohave Desert Active and Stabilized Dune Ecological System. All occurrences of the *Artemisia filifolia* Shrubland Alliance are semi-natural, with *Erodium cicutarium* and *Bromus rubens* as co-dominant invasives. There are insufficient occurrences to determine increaser or decreaser species, or other seral stages.

Communities which are severly disturbed are classified as either *Salsola tragus* Semi-natural Herbaceous Alliance or *Erodium cicutarium* Semi-natural Herbaceous Alliance. While these are typically alliances within Invasive Upland Vegetation, they also have shrub herbaceous vegetation seral stages with *Lycium pallidum* and *Atriplex canescens*, respectively.

4.4.8.5 Relationship to the US National Vegetation Classification Systems

Mixed desert scrub ecological system is recognized at the ecological system level as NatureServe's Mohave Mid-Elevation Mixed Desert Scrub Ecological System. However, it is much more restrictive of included alliances versus the Colorado Plateau Mixed Desert Scrub Ecological System described here. This ecological system incorporates parts of NatureServe's Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System, Inter-Mountain Basins Mixed Salt Desert Scrub Ecological System, and Sonora-Mohave Mixed Salt Desert Scrub.

The minor *Prunus fasciculata* Shrubland Alliance occurs in basalt canyons where streams have dissected lava flows. It occupies the riparian area, as well as lower canyon slopes. Alternately that alliance could be classified in the Mohave Desert Volcanic Rock and Cinder Land Ecological System. Currently, that ecological system has no riparian alliances in it. NatureServe recognizes a *Prunus fasciculata* Intermittently Flooded Shrubland Alliance, but does not list it under any ecological system. Three of the alliances and five of the associations in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and twelve associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-34
Mohave Desert Mixed Desert Scrub Ecological System

4.4.9 Mohave Desert Pinyon-Juniper Woodland Ecological System

4.4.9.1 Geographic distribution

The Mohave Desert Pinyon-Juniper Woodland Ecological System is found in just one area within the LPP survey area, west of the community of Toquerville (west of SR 17; Map 4-35).

4.4.9.2 Alliances and associations

Within the survey area, the Mohave Desert Pinyon-Juniper Woodland Ecological System is comprised of just one alliance, *Coleogyne ramosissima* Shrubland Alliance, and one association, *Juniperus osteosperma / Coleogyne ramosissima* Wooded Shrubland. This ecological system totals 2.2 acres within the survey area.

Figure 4-35
Mohave Desert Pinyon-Juniper Woodland Ecological System

4.4.9.3 Physiognomy and composition

The Mohave Desert Pinyon-Juniper Woodland Ecological System occurs in the survey area exclusively as a wooded shrubland (Figure 4-35).

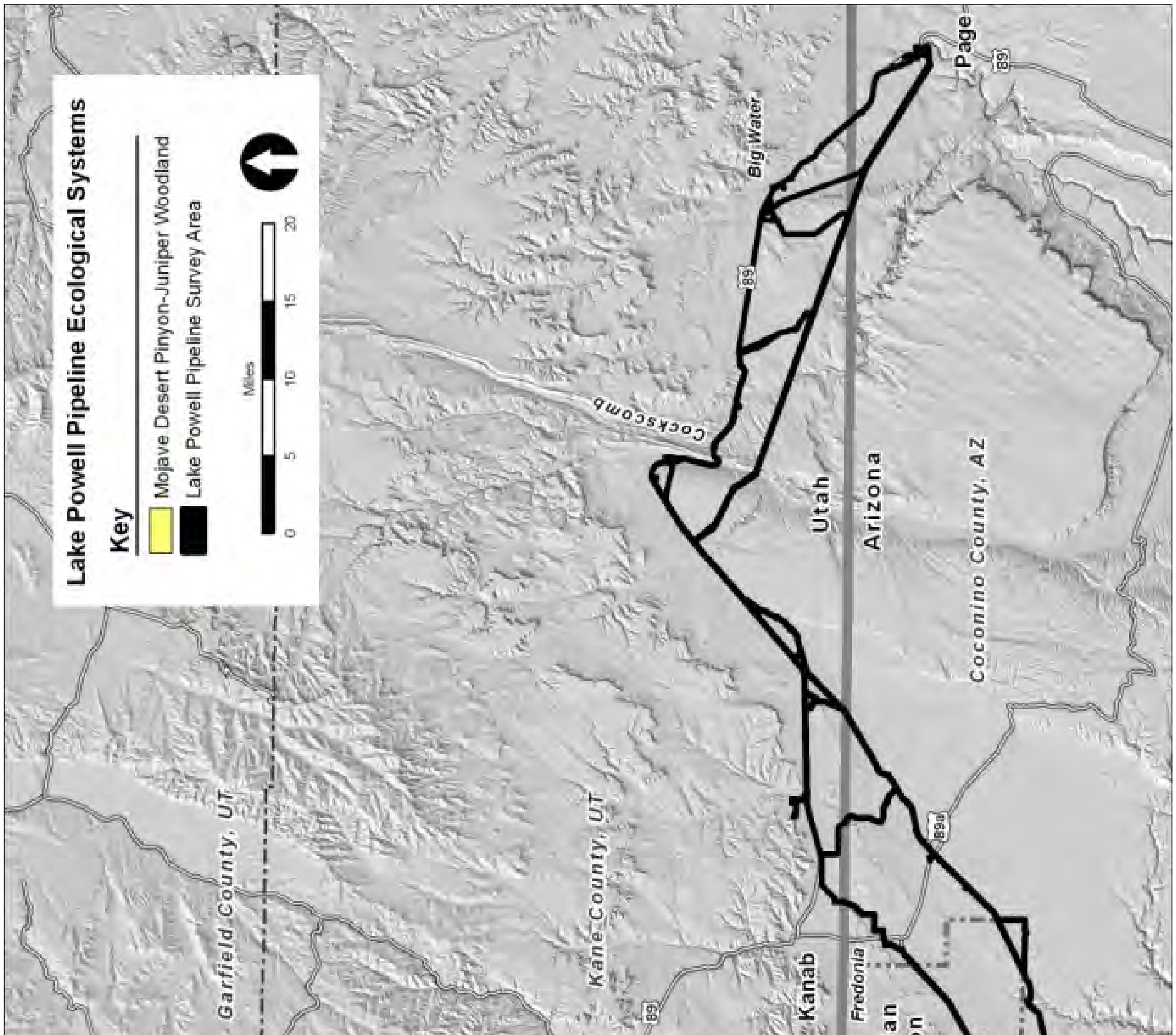
4.4.9.4 Disturbance regimes

At higher elevations of the Mohave Desert. *Juniperus osteosperma* may invade shrublands. Where *Juniperus osteosperma* has less cover than the shrubs, the communities are classified as wooded shrubland, with *Juniperus osteosperma* as the dominant canopy species. Where these areas are dominated in the sub-canopy by *Coleogyne ramosissima*, and are classified as the *Juniperus osteosperma* / *Coleogyne ramosissima* Woodland. Present climatic conditions are too harsh or fire regimes too frequent to allow *Juniperus osteosperma* to attain a greater cover than the shrub strata, thus there are no woodland seral stages present in the survey area.

4.4.9.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Pinyon-Juniper Woodland Ecological System crosswalks to NatureServe's Great Basin Pinyon-Juniper Woodland or Colorado Plateau Pinyon-Juniper Woodland Ecological Systems. Classification of the one wooded shrubland association into the Mohave Desert Pinyon-Juniper Woodland Ecological System is based on the dominant species in the tallest strata (canopy), versus classification to alliance which is based on species in the strata (sub-canopy) with the greatest vegetal cover.

The single association in this ecological system is a new type for the Mohave Desert Region, and is not previously described in the national classification.



Map 4-35
Mohave Desert Pinyon-Juniper Woodland Ecological System

4.4.10 Mohave Desert Shrub-Steppe Ecological System

4.4.10.1 Geographic distribution

The Mohave Desert Shrub-Steppe Ecological System is found predominantly near Hurricane, extending south to the Hurricane Cliffs within the Mohave Desert Region of the LPP survey area. It is often interspersed with Mohave Desert Creosotebush-White Bursage Desert Scrub and Mohave Desert Mixed Desert Scrub Ecological Systems (Map 4-36).

4.4.10.2 Alliances and associations

Within the survey area, the Mohave Desert Shrub-Steppe Ecological System is comprised of seven alliances and 13 associations. This ecological system totals 248.6 acres within the survey area. Acreage by alliance and association is as follows:

***Ambrosia dumosa* Shrubland Alliance**		**3.9 acres**
Ambrosia dumosa / Pleuraphis jamesii Dwarf-shrubland	3.9 acres	
***Ericameria linearifolia* Shrubland Alliance**		**18.0 acres**
Ericameria linearifolia / Pleuraphis rigida Dwarf-shrubland	18.0 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**8.4 acres**
Gutierrezia sarothrae / Pleuraphis rigida Dwarf-shrubland	8.4 acres	
***Larrea tridentata* Shrubland Alliance**		**73.4 acres**
Larrea tridentata / Pleuraphis rigida - (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Shrubland	7.9 acres	
Larrea tridentata / Pleuraphis rigida Shrubland	46.4 acres	
Larrea tridentata / Pleuraphis rigida Sparse Shrubland	19.1 acres	
***Lycium andersonii* Shrubland Alliance**		**30.8 acres**
Lycium andersonii / Pleuraphis rigida - (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Shrubland	5.1 acres	
Lycium andersonii / Pleuraphis rigida Shrubland	25.7 acres	
***Pleuraphis rigida* Herbaceous Alliance**		**93.7 acres**
Ephedra nevadensis / Pleuraphis rigida - Bromus rubens Semi-natural Shrub Herbaceous Vegetation	15.4 acres	
Gutierrezia sarothrae / Pleuraphis rigida - Erodium cicutarium Semi-natural Shrub Herbaceous Vegetation	5.7 acres	
Gutierrezia sarothrae / Pleuraphis rigida - Erodium cicutarium Shrub Herbaceous Vegetation	0.2 acres	
Gutierrezia sarothrae / Pleuraphis rigida Shrub Herbaceous Vegetation	72.5 acres	
***Psorothamnus fremontii* Sparsely Vegetated Alliance**		**20.4 acres**
Psorothamnus fremontii / Pleuraphis rigida Sparse Vegetation	20.4 acres	

4.4.10.3 Physiognomy and composition

Figure 4-36
Mohave Desert Shrub-Steppe Ecological System

The Mohave Desert Shrub-Steppe Ecological System is commonly dominated by herbaceous vegetation with less than10 percent shrub cover (i.e., shrub herbaceous vegetation; Figure 4-36). It is also commonly a dwarf shrubland or shrubland and rarely sparse shrubland or herbaceous vegetation without shrubs.

4.4.10.4 Disturbance regimes

The Mohave Desert Shrub-Steppe Ecological System is a mix of late succession shrub dominated shrublands, dwarf-shrublands, and early succession shrub herbaceous vegetation communities. Alternately, the shrub herbaceous vegetation can be viewed as slightly degraded, but otherwise nearly steady state desert grasslands, dominated by *Pleuraphis rigida* with shrub cover between one and ten percent. Where shrubs are absent, *Pleuraphis rigida* Herbaceous Vegetation is classified into the Mohave Desert Grassland Ecological System.

Gutierrezia sarothrae is an increaser shrub under grazing or burning. Heavy disturbance results in co-dominance with *Gutierrezia sarothrae* of the invasive annual forb, *Erodium cicutarium*. *Pleuraphis rigida* is a decreaser under grazing. The successional pathway from excellent to poor range condition is *Pleuraphis rigida* Herbaceous Vegetation, followed by *Pleuraphis rigida* Shrub Herbaceous Vegetation, then *Gutierrezia sarothrae / Pleuraphis rigida* Shrub Herbaceous Vegetation, and finally the degraded *Gutierrezia sarothrae* / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Dwarf-shrubland. Initial recovery in the absence of a seed bank would probably be to a *Gutierrezia sarothrae* Dwarf-shrubland Alliance. Full loss of native shrubs leads to Invasive Upland Vegetation, an anthropogenic system discussed in the next section.

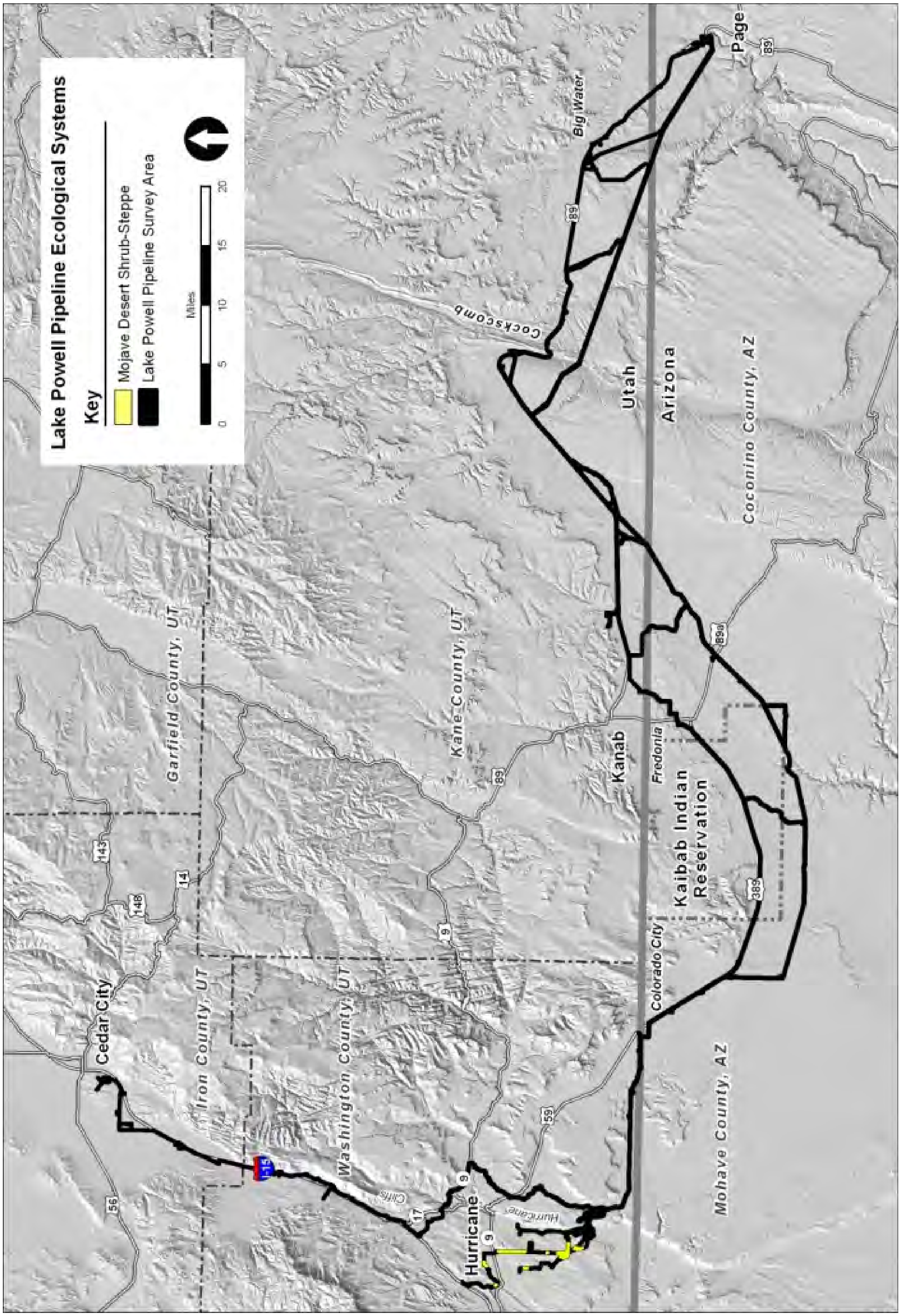
Psorothamnus fremontii is a long-lived shrub indicative of later seral stages. It is adapted to natural disturbance from debris deposition on steep slopes. Stable seral stages may have large individuals with a mixed age structure to the population. *Pleuraphis rigida* is a decreaser grass in the *Psorothamnus fremontii* Shrubland association. *Larrea tridentata* is an increaser shrub under disturbance.

Other shrubs which can dominate this ecological system are *Ambrosia dumosa*, *Ericameria linearifolia,* and *Lycium andersonii*. *Pleuraphis rigida* is a decreaser grass in the *Ambrosia dumosa* Dwarf-shrubland Alliance and the *Ericameria linearifolia* Dwarf-shrubland Alliance. The latter may also have *Lycium andersonii* as locally dominate.

4.4.10.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Shrub-Steppe Ecological System is most closely related to NatureServe's Inter-Mountain Basins Semi-Desert Shrub-Steppe Ecological System. However, NatureServe's type is typically higher elevation and apparently more encompassing of shrublands and dwarf-shrublands associations without co-dominating grasses in their names.

Two of the alliances and one association in this ecological system required minor name changes from types previously described in the US NVC. Three alliances and 12 associations are new types for the Mohave Desert Region, not previously described in the national classification.



Map 4-36
Mohave Desert Shrub-Steppe Ecological System

4.4.11 Mohave Desert Volcanic Rock and Cinder Land Ecological System

4.4.11.1 Geographic distribution

The Mohave Desert Volcanic Rock and Cinder Land Ecologial System is found scattered throughout the Mohave Desert Region of the LPP survey area. As the name implies it is found in association with rock outcrops and rock lands, within the Mohave Desert Region these include the Winkel-Rock outcrop complex and the Bermesa-Rock land association, as well as Stony colluvial land (Map 4-37).

4.4.11.2 Alliances and associations

Within the survey area, the Mohave Desert Volcanic Rock and Cinder Land Ecologial System is comprised of six alliances, including 11 associations. This ecological system totals 143.5 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia ludoviciana* Herbaceous Alliance**		**4.1 acres**
Artemisia ludoviciana Herbaceous Vegetation	4.1 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**50.3 acres**
Coleogyne ramosissima - Ephedra nevadensis Shrubland	17.5 acres	
Coleogyne ramosissima / (Erodium cicutarium, Bromus (rubens, tectorum), Salsola tragus) Semi-natural Shrubland	25.7 acres	
Coleogyne ramosissima Shrubland	7.1 acres	
***Ephedra nevadensis* Shrubland Alliance**		**0.9 acres**
Ephedra nevadensis - Lycium andersonii Shrubland	0.9 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**4.4 acres**
Gutierrezia sarothrae / Artemisia ludoviciana Dwarf-shrubland	4.4 acres	
***Larrea tridentata* Shrubland Alliance**		**47.6 acres**
Larrea tridentata - Ambrosia dumosa Shrubland	18.5 acres	
Larrea tridentata - Coleogyne ramosissima Shrubland	27.2 acres	
Larrea tridentata Sparse Shrubland	1.8 acres	
Mixed Desert Shrub Shrubland Alliance		**36.2 acres**
Mixed Desert Shrub / *(Bromus rubens, Salsola tragus, Erodium cicutarium)* Semi-natural Dwarf-shrubland	12.5 acres	
Mixed Desert Shrub / *(Bromus rubens, Salsola tragus, Erodium cicutarium)* Semi-natural Shrubland	23.7 acres	

4.4.11.3 Physiognomy and composition

The Mohave Desert Volcanic Rock and Cinder Land Ecologial System is either herb or shrub dominated (Figure 4-37). The latter are typically shrublands and dwarf shrublands, and rarely sparse shrublands.

4.4.11.4 Disturbance regimes

Figure 4-37
Mohave Desert Volcanic Rock and Cinder Land Ecological System

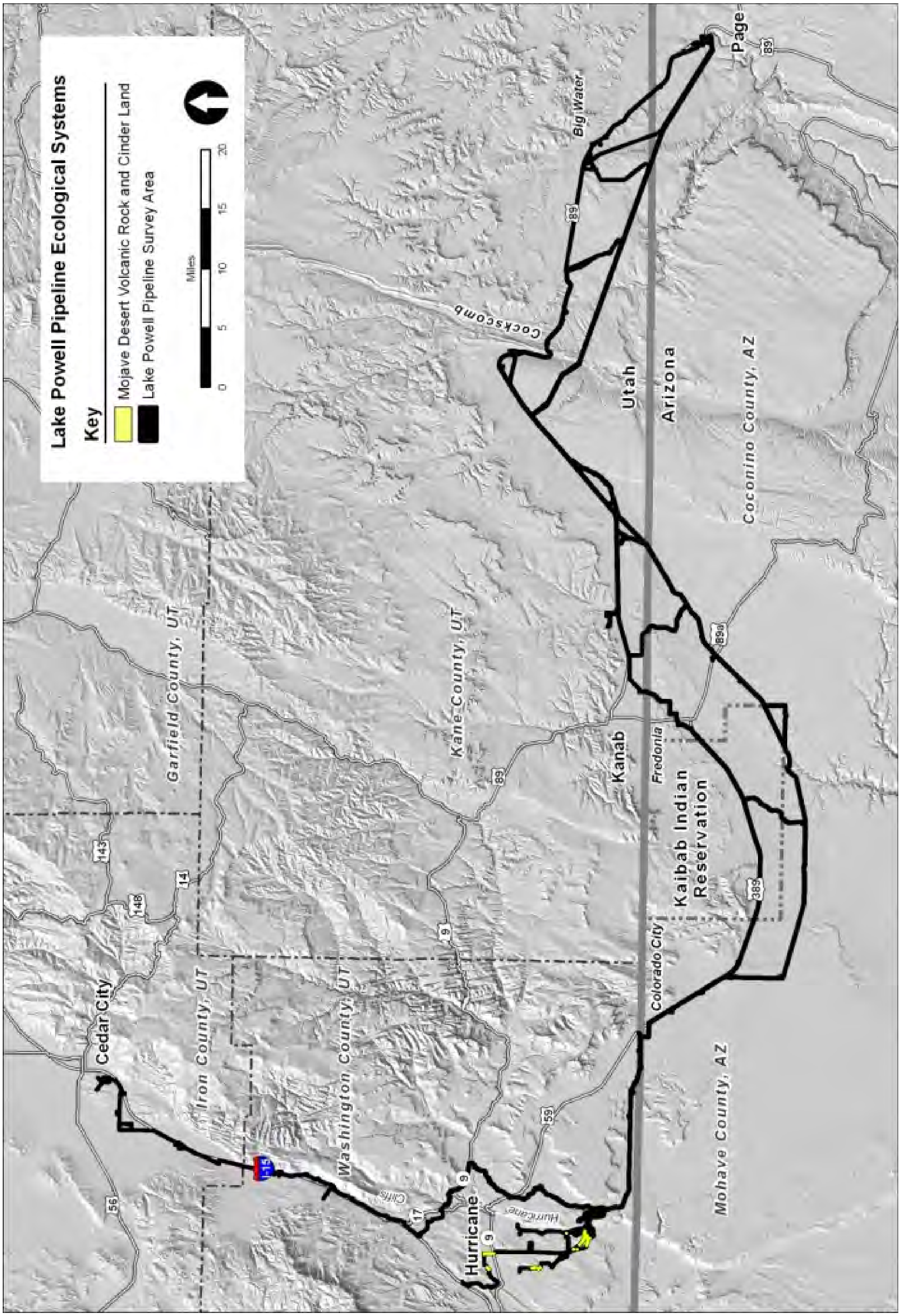
The *Coleogyne ramosissima* Shrubland Alliance is a long-lived seral stage on the rugged basalt soils of the Mohave Desert Volcanic Rock and Cinder Land Ecologial System. Where degraded, they are a semi-natural sparse shrubland, with *Bromus rubens* and *Erodium cicutarium* as invasives. Shrub density may decrease with disturbance, although mortality due to climatic warming could also reduce shrub density.

Artemisia ludoviciana is particularly adapted to north-facing basalt cliffs and talus habitat. Here the *Artemisia ludoviciana* Herbaceous Vegetation dominates, to the exclusion of shrubbier associations. *Larrea tridentata* dominates basalt soils on level ground, with or without *Ambrosia dumosa* or *Coleogyne ramosissima* as co-dominants. Where burned, *Larrea tridentata* overwhelmingly dominates the flora, but with a sparse cover. An increaser under disturbance is the annual grass, *Vulpia octoflora*. There were not enough occurrences to determine invasive species.

4.4.11.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Volcanic Rock and Cinder Land Ecologial System best fits NatureServe's Inter-Mountain Basins Volcanic Rock and Cinder Land Ecological System, rather than the North American Warm Desert Volcanic Rockland Ecological System. The latter is comprised of alliances found primarily at elevations lower than the survey area. However, the former has many alliances of higher elevations than the survey area, thus there is little one to one correspondence between Mohave Desert Volcanic Rock and Cinder Land Ecological System and NatureServe's Inter-Mountain Basins Volcanic Rock and Cinder Land Ecological System.

One alliance and two of the associations in this ecological system required minor name changes from types previously described in the US NVC. Two alliances and seven associations are new types for the Mohave Desert Region, not previously described in the national classification. Some areas were classified as Mixed Desert Scrub Shrubland Alliance because it was impossible to determine a dominant shrub among the many species which were common and widespread in the communities.



Map 4-37
Mohave Desert Volcanic Rock and Cinder Land Ecological System

4.4.12 Mohave Desert Wash Ecological System

4.4.12.1 Geographic distribution

While washes are characteristic of the Mohave Desert topography, many are too small to be mapped on the 1:3,780 scale aerial imagery most commonly used in the survey area Thus, the six occurrences of the Mohave Desert Wash Ecological System represent washes wide enough to accurately delineate, across a 300 foot or 600 foot survey area, this is equal to an average minimum mapping area of 0.3 acre. These occurrences are located in the Afterbay, north of the Afterbay, and west of the community of Toquerville (west of SR 17; Map 4-38).

4.4.12.2 Alliances and associations

Within the survey area, the Mohave Desert Wash Ecological System is comprised of four alliances and their six associations. This ecological system totals 12.9 acres within the survey area. Acreage by alliance and association is as follows:

***Fallugia paradoxa* Shrubland Alliance**		**5.4 acres**
Fallugia paradoxa Desert Wash Shrubland	5.4 acres	
***Hymenoclea salsola* Shrubland Alliance**		**6.0 acres**
Hymenoclea salsola / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Shrubland	1.5 acres	
Hymenoclea salsola / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Shrubland	0.8 acres	
Hymenoclea salsola Shrubland	3.7 acres	
Non-vegetated sandstone		**0.7 acres**
Non-vegetated Sandstone Outcrop	0.7 acres	
Sparse Vegetation		**0.7 acres**

4.4.12.3 Physiognomy and composition

The Mohave Desert Wash Ecological System occurs in the survey area as either a shrubland or a sparse shrubland (Figure 4-38).

4.4.12.4 Disturbance regimes

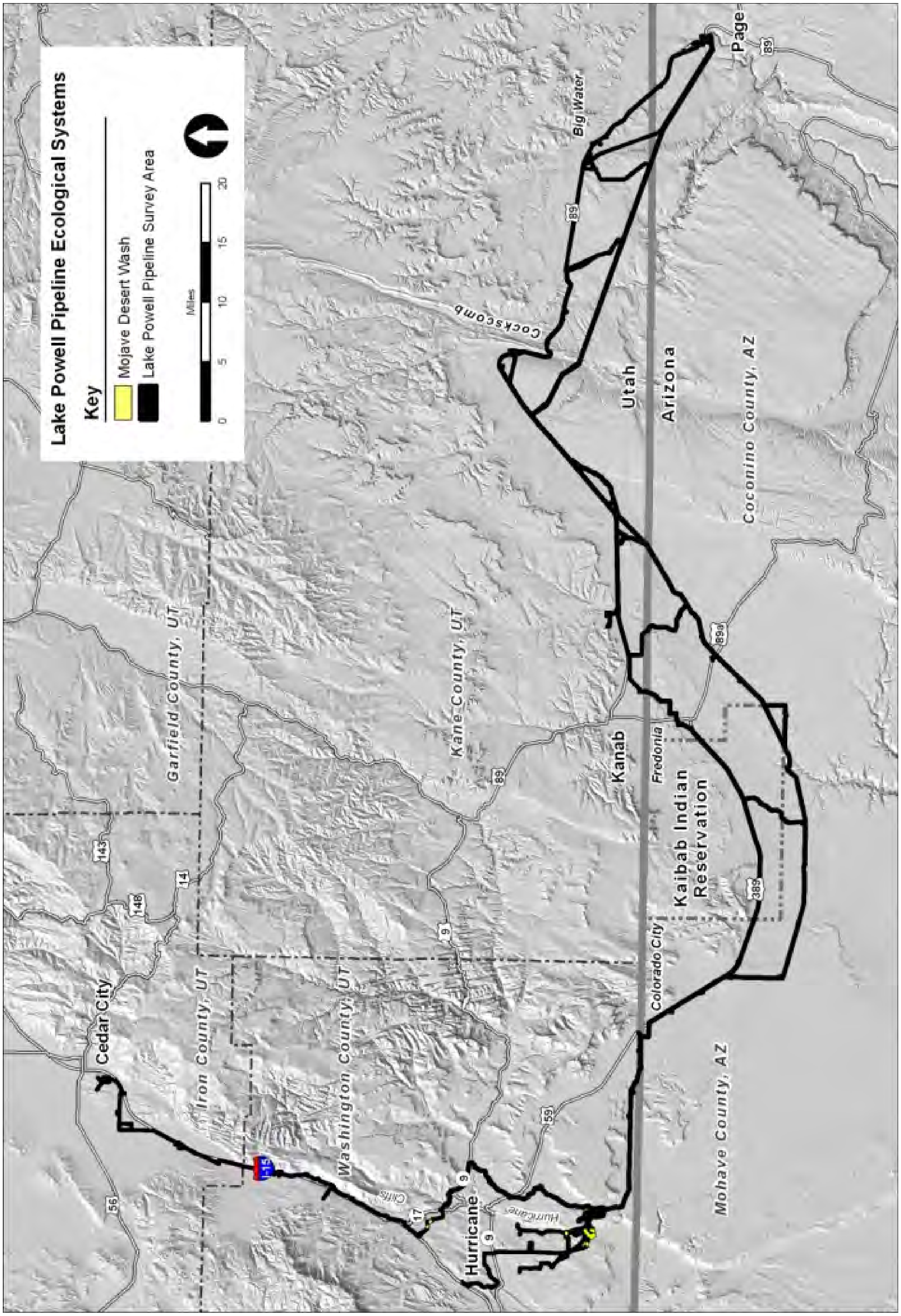
The Mohave Desert Wash Ecological System is subject to periodic flash flooding which scours the generally dry wash channels and removes vegetation which isn't strongly rooted. Thus, non-vegetated conditions would be expected immediately after catastrophic disturbance. *Gutierrezia sarothrae* will invade the newly exposed soil surfaces, as well as ground trampled by livestock. *Hymenoclea salsola* is also a characteristic shrub of this system. It has a spreading root system and is capable of rapid growth onto more stable soils following flood events. Because of the frequent natural disturbance regime, the invasive *Bromus rubens* is a common co-dominating grass.

4.4.12.5 Relationship to the US National Vegetation Classification Systems

The Mohave Desert Wash Ecological System corresponds in concept to NatureServe's North American Warm Desert Wash, although with geographical constraints to just the Mohave Desert Region of the survey area. While NatureServe classifies the *Gutierrezia sarothrae* Dwarf-shrubland Alliance in the Inter-Mountain Basins Semi-Desert Shrub-Steppe, it is typically a wide spread, non-characteristic species in the survey area. Thus *Gutierrezia sarothrae* is classified under many different ecological systems.

Figure 4-38
Mohave Desert Wash Ecological System

Two associations in this ecological system required minor name changes from types previously described in the US NVC. Two associations are new types for the Mohave Desert Region, not previously described in the national classification. Non-vegetated Sandstone Outcrop is technically not part of the US NVC, which excludes lands with one percent cover or less. They are discussed under anthropogenic lands.



Map 4-38
Mohave Desert Wash Ecological System

4.5 Anthropogenic lands

A variety of vegetated and unvegetated land use types were mapped within the LPP survey area. These are types which are neither natural nor semi-natural plant communities. They include agricultural lands, developed lands with various predominant land uses, invasive upland vegetation where the original plant community is no longer extant, ruderal vegetation, and non-vegetated lands. A total of 3,828 acres are classified in the anthropogenic lands category. Except for Introduced Upland Vegetation and Ruderal Vegetation, these types are not included in the US NVC system, or within NatureServe ecological systems.

4.5.1 Agricultural land

For the purposes of the project, agricultural land designation requires the land to either be in current use/production, or in very recent use/production. Often times older agricultural lands could be identified both on the ground and by historical aerial photograph interpretation. Generally historic agricultural lands have since been vegetated by invasive plants and are identified as ruderal vegetation, introduced upland vegetation, or invasive upland vegetation. Also included under the general heading of Agricultural lands are stock ponds. Fifteen stock ponds were documented as occurring within the survey area. Stock ponds may have the invasive tall shrub *Tamarix chinensis* present, but are not classified under any other type.

4.5.1.1 Geographic distribution

Agricultural lands are found throughout the LPP survey area. The greatest concentration occurs within the Great Basin Region, along the I-15 corridor. Further to the south, within the Mohave Desert Region, far less agricultural land was documented. Notable exceptions are adjacent to the Virgin River in Toquerville and south of the Virgin River in Hurricane. Agricultural lands are found sporadically across the Colorado Plateau Region, often associated with nearby drainages. Some examples include Gould Wash, Short Creek at Canaan Gap and Short Creek adjacent to Colorado City, Kanab Creek south of Fredonia, Johnson's Wash, and the Paria River where it is crossed by Highway 89 (Map 4-39).

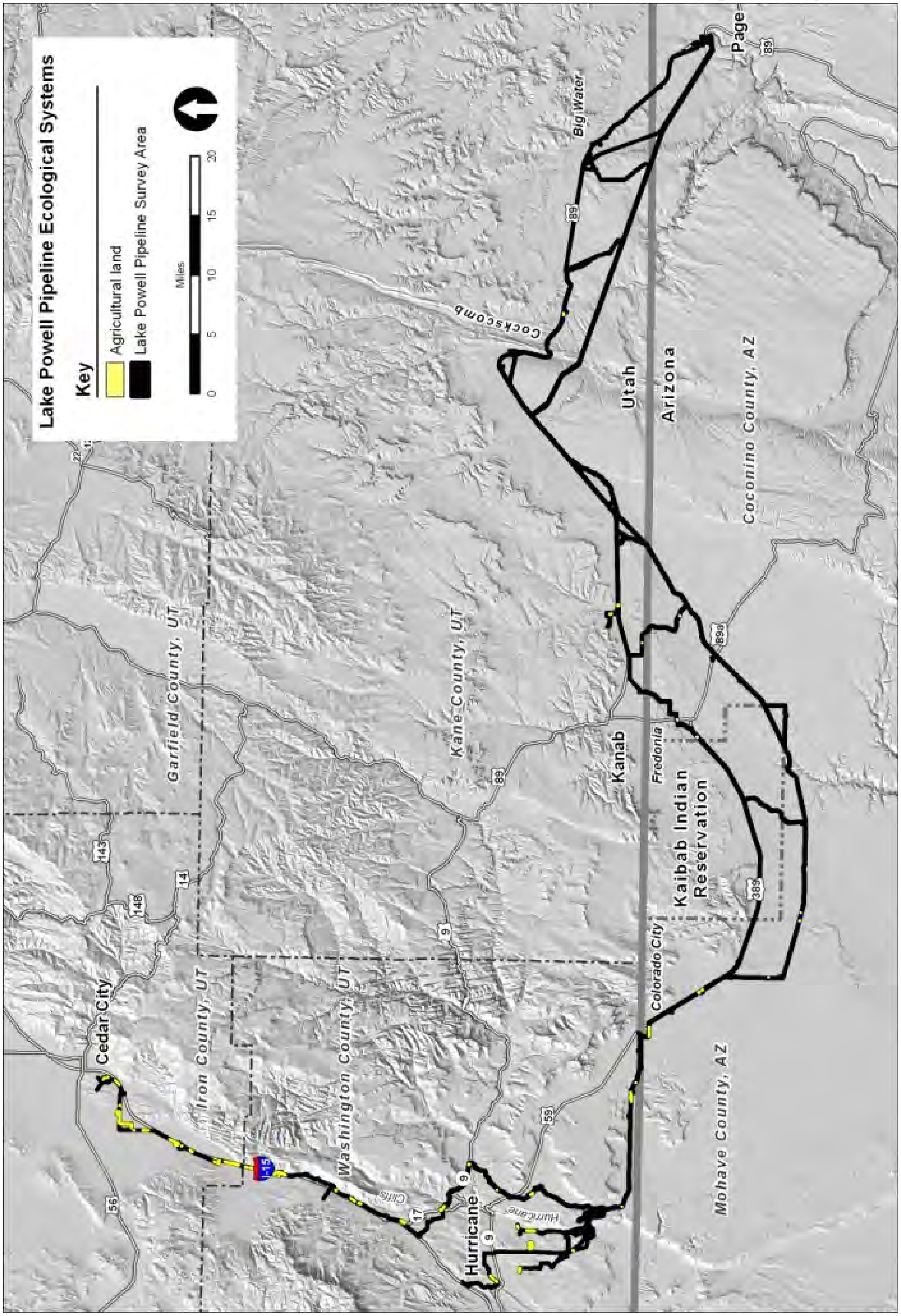
4.5.1.2 Acreages

Agricultural land totals 653.7 acres within the survey area.

Agricultural land		**615.5 acres**
***Agropyron cristatum* Semi-natural Herbaceous Alliance**		**6.9 acres**
Agropyron cristatum Semi-natural Herbaceous Vegetation	6.9 acres	
***Elymus trachycaulus* Herbaceous Alliance**		**20.7 acres**
Elymus trachycaulus / Gutierrezia sarothrae Shrub Herbaceous Vegetation	19.0 acres	
Elymus trachycaulus Herbaceous Vegetation	1.7 acres	
Stock Pond		**10.7 acres**

4.5.1.3 Physiognomy and composition

Since agricultural lands have crops planted on an annual basis, no effort was made to determine what crop was present on any particular tract. If desired, this information is available from the US Department of Agriculture, Farm Security Agency, for those farms participating in federal government agricultural programs.



Map 4-39
Agricultural land

4.5.2 Developed land

For the purpose of the project, a developed lands designation requires that the land typically be either unvegetated and occupied with a structure, or has been bladed for future use. Three additional break-outs were included within the Developed lands grouping: Developed lands – Roads Paved, Developed Land – Roads Graded, and Developed Land – Roads Unimproved.

4.5.2.1 Geographic distribution

Developed lands are found throughout the LPP survey area. Concentrations of such lands are generally found in association with private property and around established towns such as Glen Canyon City, Fredonia, Pipe Springs, Colorado City, Hurricane, Toquerville, and Cedar City. They are also in areas with a high percentage of private land; specifically along portions of Highway 89 between Fredonia and Johnson's Wash (Map 4-40).

Developed lands – Roads Paved is a sub category which includes paved roads as found throughout the LPP survey area. The vast majority of these occur along the existing highway systems that parallel the survey area; a prime example of this is Highway 89 east of Kanab. Other smaller portions of paved roads include the frontage road to the east of I-15 near Pintura and Anderson Junction, along Highway 9 east of La Verkin, adjacent to Quail Creek Reservoir and San Hollow Reservoir, and through residential areas south of Hurricane (Map 4-41).

Developed lands – Roads Graded is a sub category which includes graded roads as found throughout the LPP survey area. Within the northwest portion of the survey area, graded roads occur as frontage roads and as agricultural access roads adjacent to I-15. The entire length of road from Highway 9 east of La Verkin south to Highway 59 is a graded road and from there south along the Honeymoon Trail is also a graded road. The access road running the length of the Afterbay is a graded road. The entire length of both Yellowstone Road and Mount Trumbull Roads are graded. 8 Mile Gap Road from Highway 89 to the Utah state border is also a graded road.

Developed lands – Roads Unimproved is a sub category which includes ungraded two-track roads as found throughout the LPP survey area. These roads are unmaintained and ungraded and have parallel tracks as created and perpetuated by four wheeled off the road vehicles. Excluded from mapping are single-track trails, typically created by foot, bicycle, or motor bike use, even when designated as recreational routes. Trail bike routes such as the GEM Trail near Hurricane, are too new to identify in the aerial imagery used for mapping.

4.5.2.2 Acreages

Developed land totals 358.1 acres within the survey area.

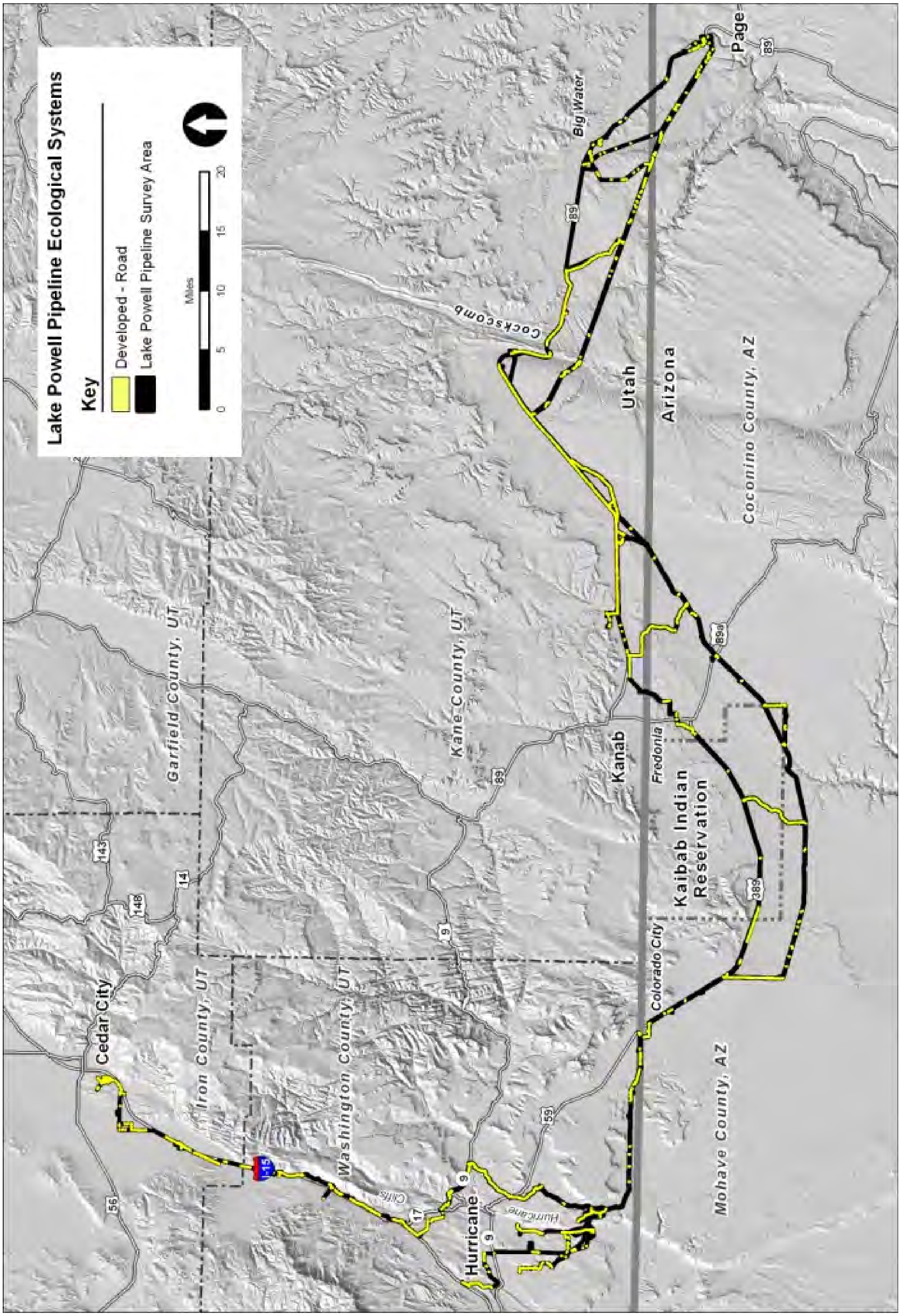
Developed land – Roads Paved totals 300.5 acres within the survey area.

Developed land – Roads Graded totals 285.9 acres within the survey area.

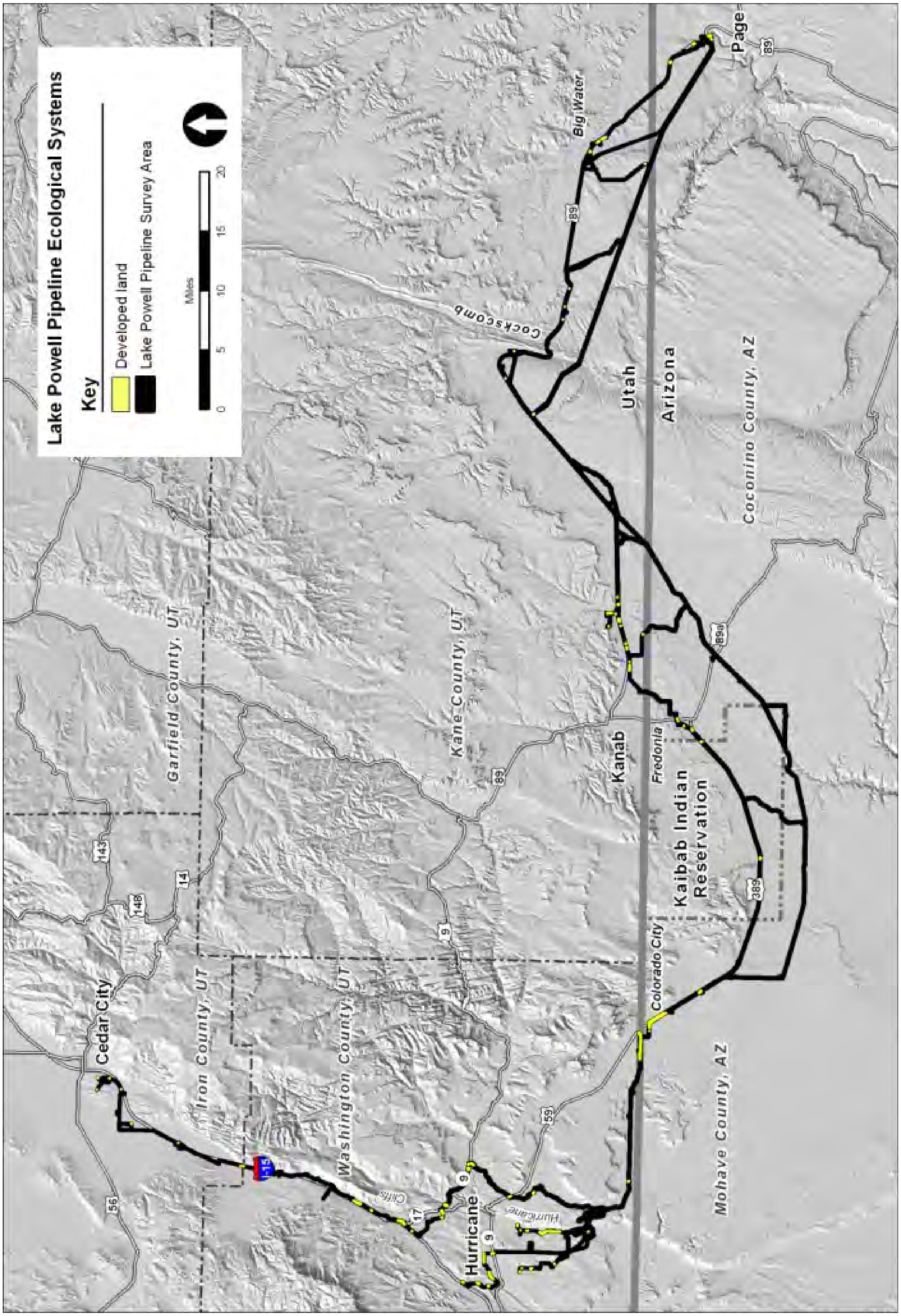
Developed land – Roads Unimproved totals 126.5 acres within the survey area.

4.5.2.3 Physiognomy and composition

Not applicable.



Map 4-40
Developed land



Map 4-41
Developed land - Roads

4.5.3 Invasive Upland Vegetation

4.5.3.1 Geographic distribution

Invasive Upland vegetation is found scattered throughout the entire LPP survey area (Map 4-42).

4.5.3.2 Alliances and associations

Within the survey area, this ecological system is comprised of 15 alliances including 14 associations. This ecological system totals 1,156.3 acres within the survey area. Acreage by alliance and association is as follows:

***Agropyron cristatum* Semi-natural Herbaceous Alliance**		**66.7 acres**
Agropyron cristatum Semi-natural Herbaceous Vegetation	66.7 acres	
***Bromus (rubens, tectorum)* Semi-natural Herbaceous Alliance**		**57.0 acres**
Bromus rubens Semi-natural Herbaceous Vegetation	26.5 acres	
Bromus tectorum Semi-natural Herbaceous Vegetation	30.5 acres	
***Cardaria draba* Semi-natural Herbaceous Alliance**		**2.1 acres**
Cardaria draba Semi-natural Herbaceous Vegetation	2.1 acres	
***Ceratocephala testiculata* Semi-natural Herbaceous Alliance**		**0.7 acres**
Ceratocephala testiculata Semi-natural Herbaceous Vegetation	0.7 acres	
***Chorispora tenella* Semi-natural Herbaceous Alliance**		**39.1 acres**
Chorispora tenella Semi-natural Herbaceous Vegetation	39.1 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**206.5 acres**
Erodium cicutarium Semi-natural Herbaceous Vegetation	206.5 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**12.2 acres**
Gutierrezia sarothrae / (Erodium cicutarium, Bromus rubens, Salsola tragus) Semi-natural Sparse Vegetation	12.2 acres	
***Halogeton glomeratus* Semi-natural Herbaceous Alliance**		**0.6 acres**
Halogeton glomeratus Semi-natural Herbaceous Vegetation	0.6 acres	
***Helianthus annuus* Semi-natural Herbaceous Alliance**		**91.9 acres**
Helianthus annuus Semi-natural Herbaceous Vegetation	91.9 acres	
Invasive Upland Vegetation		**103.1 acres**
Ruderal Vegetation		**0.8 acres**
***Salsola tragus* Semi-natural Herbaceous Alliance**		**551.6 acres**
Salsola tragus Semi-natural Herbaceous Vegetation	551.6 acres	
***Salsola tragus* Semi-natural Sparsely Vegetated Alliance**		**23.6 acres**
Salsola tragus Semi-natural Sparse Vegetation	23.6 acres	

***Tamarix chinensis* Semi-natural Shrubland Alliance**		**0.3 acres**
Tamarix chinensis Semi-natural Shrubland	0.3 acres	
***Xanthium strumarium* Semi-natural Herbaceous Alliance**		**0.1 acres**
Xanthium strumarium Semi-natural Herbaceous	0.1 acres	

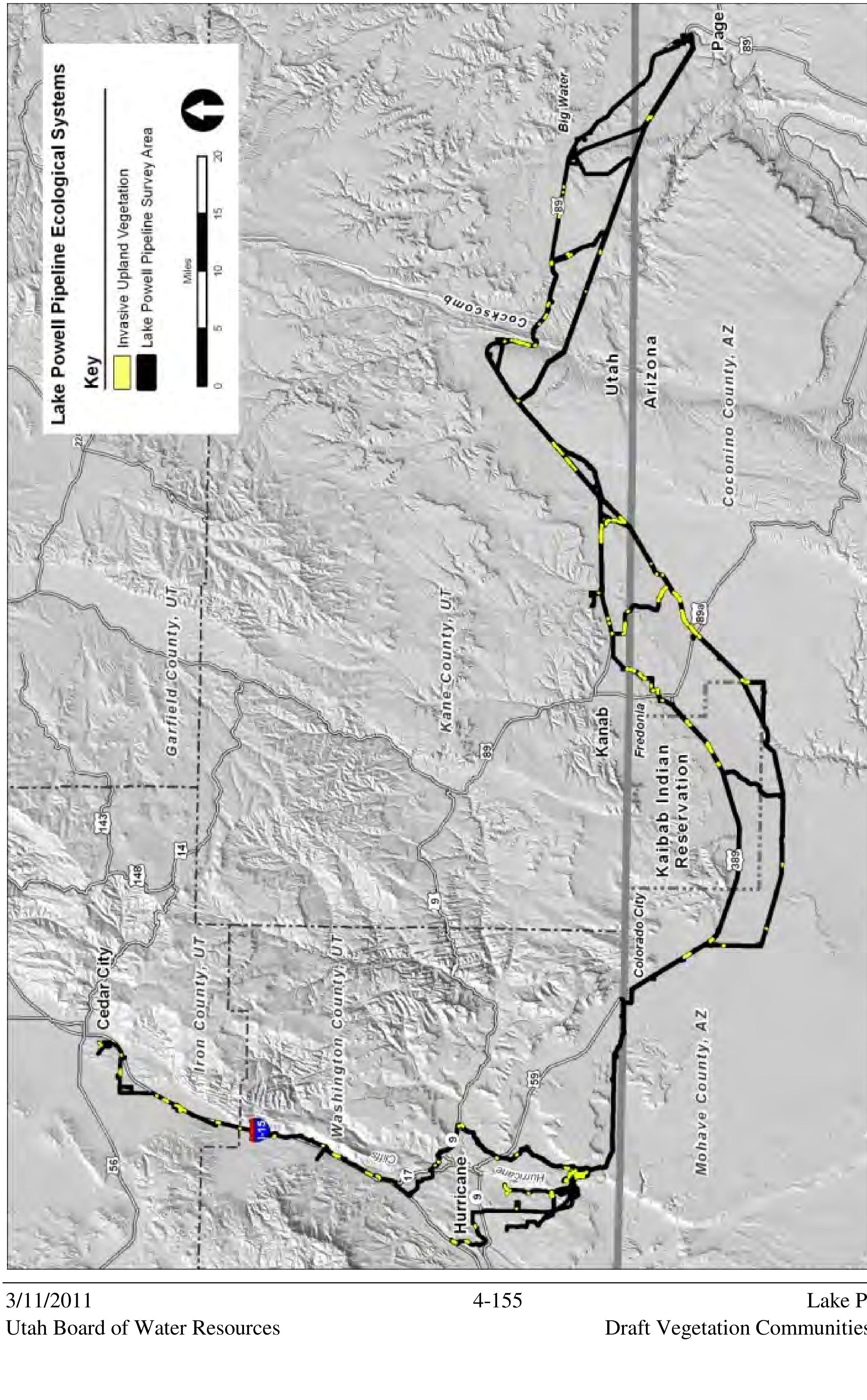
4.5.3.3 Physiognomy and composition

These alliances are nearly all herbaceous vegetation, occasionally sparse vegetation and rarely shrubland. The *Gutierrezia sarothrae* / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Sparse Vegetation within the *Gutierrezia sarothrae* Sparsely Vegetated Alliance could alternately be classified in the Colorado Plateau Mixed Desert Shrub Ecological System.

4.5.3.4 Relationship to the US National Vegetation Classification Systems

In the US NVC, Introduced Upland Vegetation includes Annual and Biennial Forbland, Annual Grassland, and Perennial Grassland and Forbland. In this report, the *Agropyron cristatum* Semi-natural Herbaceous Alliance is retained under Introduced Upland Vegetation Perennial Grassland and Forbland. The *Bromus tectorum* Semi-natural Herbaceous Alliance is classified under Invasive Upland Vegetation rather than NatureServe's which does not place it into any ecological system. Semi-natural alliances are not classified by NatureServe into ecological systems. They tend to extend over broad geographic areas and do not have compositional affinities to any ecoregion or ecological system. In this study, semi-natural alliances and associations are classified with ecological systems where there is remnant or recolonizing native vegetation. They are classified into Invasive Upland Vegetation when exotic vegetation is dominant and native vegetation is either absent or strictly ruderal. Erodium cicutarium Semi-natural Herbaceous Alliance is classified as a semi-natural type under Invasive Upland Vegetation, rather than as a natural type in NatureServe's Introduced Upland Vegetation-Annual and Biennial Forbland.

Two of the alliances and three of the associations in Invasive Upland Vegetation required minor name changes from types previously described in the US NVC. One alliance and two associations are new types, not previously described in the national classification.



Map 4-42
Invasive Upland Vegetation

4.5.4 Quarry

4.5.4.1 Geographic distribution

Seven quarries were documented as occurring within the LPP survey area. Three are within the Mohave Desert Region, and two each are in the Great Basin and Colorado Plateau regions (Map 4-43).

4.5.4.2 Acreages

Quarries total 47.7 acres within the survey area.

4.5.4.3 Physiognomy and composition

Not applicable.

4.5.5 Reservoir

4.5.5.1 Geographic distribution

Two reservoirs were documented as occurring within the LPP survey area, both within the Mohave Desert Region. These include the Sand Hollow Reservoir, southwest of Hurricane and the Quail Creek Reservoir, west of Hurricane (Map 4-44).

4.5.5.2 Acreages

Reservoirs total 4.8 acres within the survey area.

4.5.5.3 Physiognomy and composition

Not applicable.

4.5.6 Ruderal Vegetation

4.5.6.1 Geographic distribution

Ruderal Vegetation occurs throughout the LPP survey area. It is most often associated with paved roads and areas of recent development activities. This includes: Highway 89 from the Glen Canyon Dam area to the community of Glen Canyon City, Highway 89 west of the Cockscomb and east of Fredonia, Highway 389 across the Kaibab Piute Reservation, Highway 9 east of LaVerkin, and the I-15, as well as around Quail Creek Reservoir and Sand Hollow Reservoir, and adjacent to the agricultural lands south of Hurricane (Map 4-45).

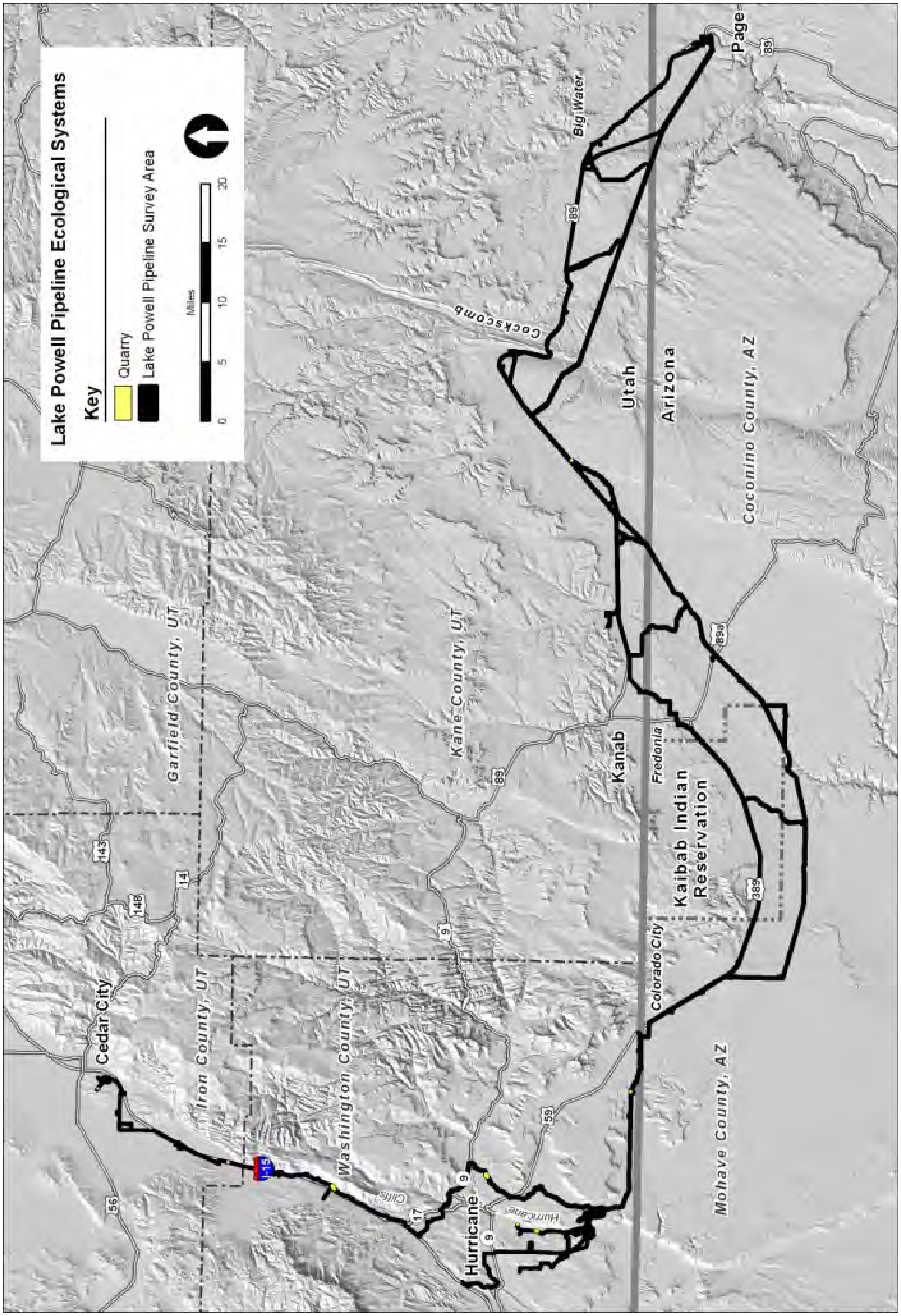
4.5.6.2 Acreages

Ruderal Vegetation totals 894.4 acres within the survey area.

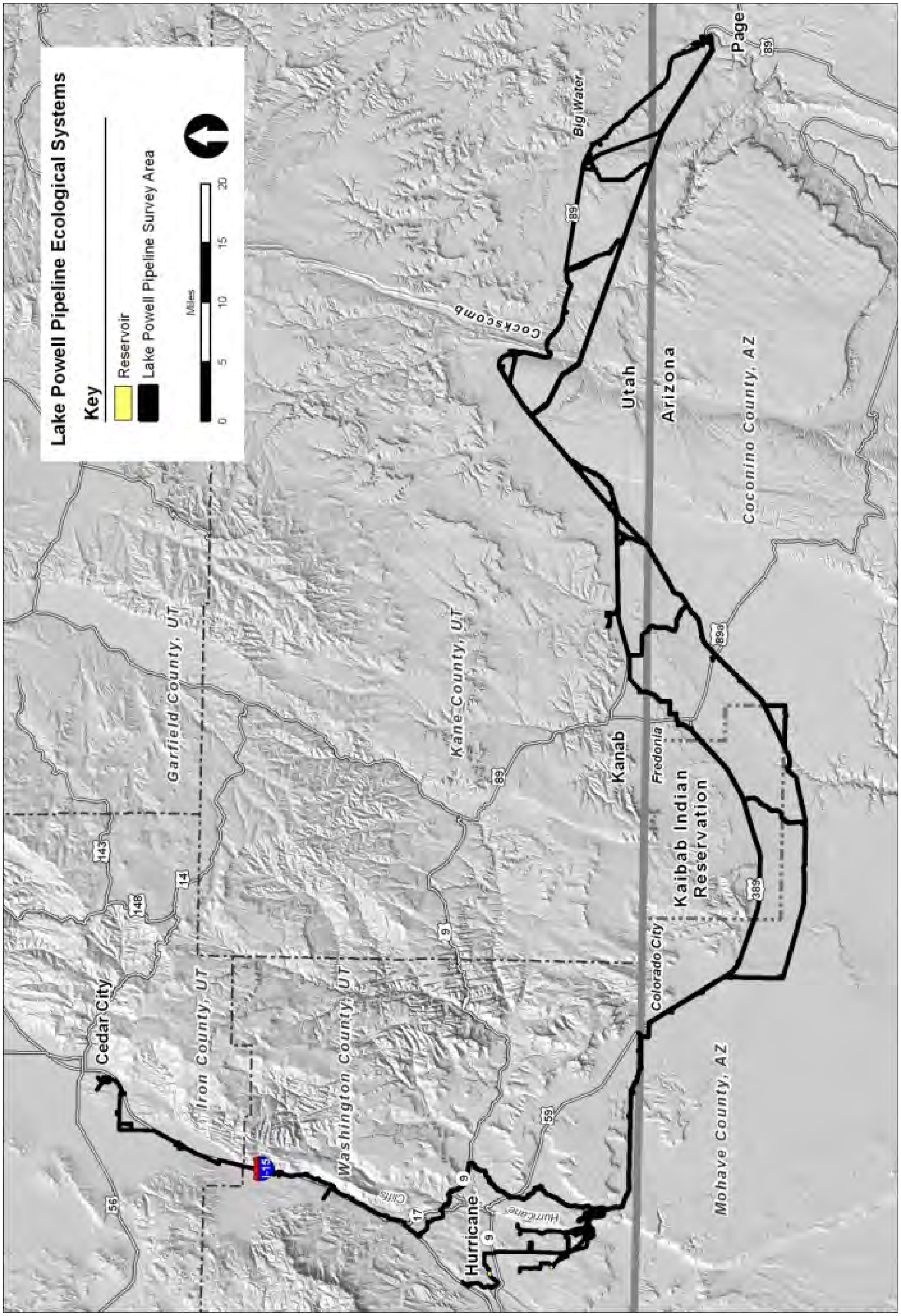
***Agropyron cristatum* Semi-natural Herbaceous Alliance**		**1.7 acres**
Artemisia tridentata ssp. vaseyana / Agropyron cristatum Semi-natural Shrub Herbaceous Vegetation	1.7 acres	
***Bromus (rubens, tectorum)* Semi-natural Herbaceous Alliance**		**1.7 acres**
Bromus rubens Semi-natural Herbaceous Vegetation	1.7 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**5.0 acres**
Erodium cicutarium Semi-natural Herbaceous Vegetation	2.3 acres	
Erodium cicutarium Semi-natural Sparse Vegetation	2.7 acres	
Ruderal Vegetation		**885.8 acres**
× *Triticosecale rimpaui* Semi-natural Herbaceous Alliance		**0.2 acres**
× *Triticosecale rimpaui* Semi-natural Herbaceous Vegetation	0.2 acres	

4.5.6.3 Physiognomy and composition

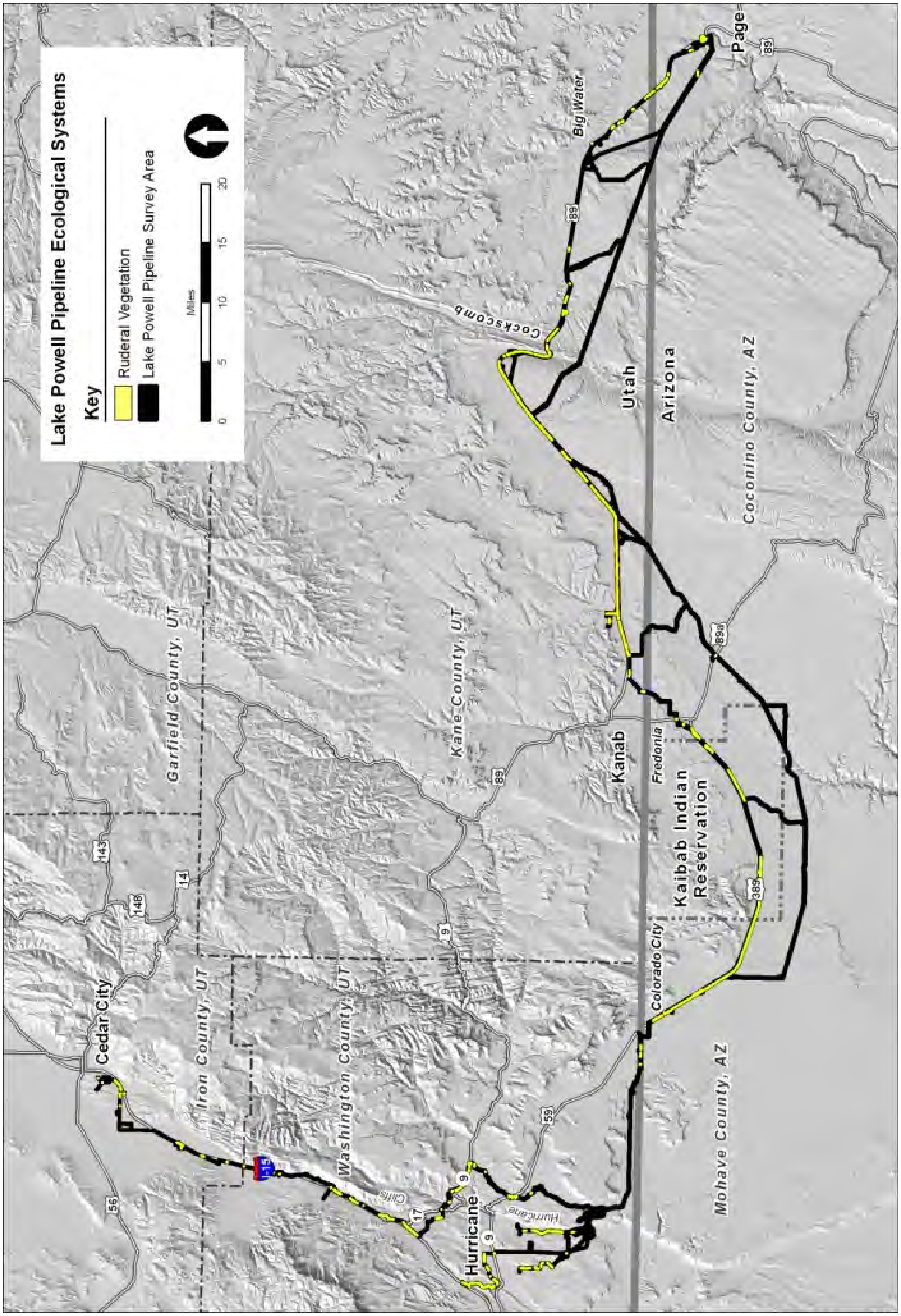
This type is exclusively herbaceous vegetation.



Map 4-43
Quarrys



Map 4-44
Reservoirs



Map 4-45
Ruderal Vegetation

Chapter 5
Conclusion

This report presents the results of vegetation community classification and mapping within the project area, and provides documentation of existing vegetation conditions. Vegetation mapping identifies areas of high biodiversity and unique plant assemblages, provides information regarding infestations of noxious and invasive plant species, and can be used to assess the impacts of potential management actions and the application of restoration activities.

GIS based vegetation mapping, typically to a minimum mapping unit between 0.2 and 0.3 acre, resulted in a total of 4,726 classified polygons--3,443 of these classified polygons represented natural communities and 1,283 represented anthropogenic types. Table 5-1 details by Ecological Region the numbers of classified polygons, ecological systems, alliances, associations, and acreage. Over 340 plant species were identified during field surveys to the species level or finer.

Table 5-1
Vegetation Mapping Summary

	Colorado Plateau Region	Great Basin Region	Mohave Desert Region
GIS Classified Polygons	2,817	316	310
Corridor Acreages	18,045	1,072	1,904
Ecological Systems	15	11	12
Alliances	208	35	53
Associations	567	92	116

By mapping the vegetation communities at this scale, the ecological hierarchy is presented from Ecological Region to alliance, and association representing species presence, vegetation densities, and plant physiognomy. The understanding of the distribution and successional development of vegetation communities can contribute to an accurate assessment of the consequences of land disturbances, and development of on-site management actions and restoration practices.

The study area had previously been mapped by SWReGAP from a supervised classification of multispectral LandSat TM imagery at 30 meter resolution. Ecological systems were the mapping units presented in SWReGAP final products. In comparison, the mapping for this study was first mapped based on ground surveys, and then aided by aerial interpretation using 9 inch resolution, 3 band color digital imagery for Iron County and much of Washington County, Utah south to the Afterbay. The remaining area was at 1 meter accuracy, with additional 1 meter, 4 band (includes near infrared) coverage for the entire area. Thus, this study benefitted from much higher resolution imagery versus SWReGAP, as well as extensive ground observation of the vegetation being classified and mapped. The many differences between SWReGAP and LPP mapping show the limitations of the former in applications such as predictive modeling of rare plant habitat, identifying areas of greater biodiversity, and conducting project-related impact assessments.

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Glossary

Agricultural vegetation — a vegetation type that exhibits a) rapid turnover in structure, typically at least on an annual basis, either through comprehensive manipulation of physiognomy and floristics by harvesting and/or planting, or by continual removal of above ground structure (e.g., cutting, haying); or b) strong linear (planted) features. The herbaceous layer may be bare at various times of the year.

Abiotic — pertaining to the nonliving parts of an ecosystem, such as soil particles, bedrock, air, and water.

Abundance — the total number of individuals of a taxon or taxa in an area, volume, population, or community; often measured as cover in plants.

Allelopathic — a property of certain biochemicals (allelochemicals) produced by some highly competitive plants and toxic to other plants.

Alliance — a vegetation classification unit containing one or more associations. The grouping of associations by the physiognomy, the diagnostic plant species (including dominants and co-dominants), similar species compositions, the diagnostic growth forms, and the disturbance regimes.

Anthropogenic — vegetation and soils that are the result of man's direct impact, sustained or not, upon the environment.

Anticline — a geologic feature in which formations are compressed and form a convex fold where the oldest formation in centrally exposed and younger strata are exposed to either side.

Association — a vegetation classification unit defined on the basis of a diagnostic species occurring from multiple growth forms or layers, a characteristic range of species composition, substrates, hydrology, disturbance regimes, and physiognomy.

Belt Transects — a survey method in which two lines are laid out, usually 1 meter apart, and all individuals of a species are recorded. Depending on the data collected, it can provide information on presence/absence, density, or cover of a species.

Biotic — pertaining to the living parts of an ecosystem, such as plants, animals, fungi, insects, etc.

Badlands — a landscape in which severe erosion plays a predominant role in limiting the density and diversity of plant species, often by exposing various soil horizons and geological strata which may be droughty, offer poor rooting support, lack nutrients, or have a toxic level of a chemical.

Canopy Cover — the percentage of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings in the canopy are included.

Chain (chaining) — removal of vegetation by dragging a chain between two bulldozers and tearing woody plants out of the soil.

Character species — a species that shows a distinct maximum concentration (quantitatively and by presence) in a well-definable vegetation types, sometimes recognized at local, regional, and general geographic scales. Character species may also be viewed as very strong differential species.

Classification — the grouping of similar types (in this case – vegetation types) according to criteria (in this case - physiognomic and floristic). The rules for classification shall be clarified prior to delineation of the types within the classification standard. Classification methods should be clear, precise, and based upon objective criteria so that the outcome is theoretically independent of who applies the classification.

Co-dominance — when more than one plant shares dominance in a vegetal community, such as an alliance or association.

Colluvial — materials deposited by gravity.

Community — a group of organisms living together and linked together by their effects on one another and their responses to the environment they share.

Cover Type — a vegetation type defined on the basis of the plant species forming a plurality of composition and abundance.

Cross-walk — to describe and document the relationships between members of one set or series and members of another set or series. These relationships may be one-to-one, one-to many, or many-to-many.

Cryptobiotic — cyanobacteria, lichens, and mosses which colonize undisturbed or relatively undisturbed soil and rock surfaces in desert environments. The cover of such organisms are established over long periods of time and help the soil resist wind and water erosion.

Diagnostic Species — any species or group of species whose relative constancy or abundance differentiates one vegetation type from another. It can include Character, Differential, and Dominant species.

Differential Species — a plant species that is distinctly more widespread or successful in one or a pair of plant communities than in the other, although it may be still more successful in other communities not under discussion.

Disturbance regime — analysis of the observed vegetative states of an ecological system, alliance, or association, as responses to a multi-variate set of natural and artificial perturbations (transitions) affecting vegetation composition and structure, as well as soils. Vegetation after a disturbance.

Decreaser species — plants which decrease in abundance with livestock grazing. Can also be applied to species which decrease in abundance when browsed by wildlife. See also: increaser species.

Dominance — the extent to which a given taxon or growth form has a strong influence in a community because of its size, abundance, or cover.

Dominance Type — a class of communities defined by the dominance of one or more species, which are usually the most important ones in the uppermost or dominant layer of the community, but sometimes of a lower layer of higher coverage.

Dominant Species — species with the highest percent of cover, usually in the uppermost dominant layer (in other contexts dominant species can be defined in terms of biomass, density, height, coverage, etc).

Ecological system —in a general sense: a biological environment of interacting living and non-living components, such as organisms, air, soil, water, climate, etc.. Developed as a classification scheme by NatureServe and closely related to the formation level of classification in the US National Vegetation Classification system, as revised in 2008.

Edaphic — plant communities which are primarily influenced by soil, landform, or geologic factors, as opposed to external factors like climate or disturbance.

Endemic — restricted or peculiar to a locality or region (Merriam-Webster 2010).

Forebay — a reservoir or canal from which water is taken to run equipment (as a waterwheel or turbine) (Merriam-Webster 2010).

Forest — a plant community dominated by trees over 5 meters tall, as opposed to herbs, grasses, or shrubs. Technically a type of woodland with over 60 percent canopy cover of trees. See also: woodland.

Grassland — a plant community dominated by grasses, as opposed to trees, shrubs, or herbs.

Gypsiferous — the quality of bearing gypsum; generally with regard to a soil horizon which is exposed by erosion.

Gypsophile — a plant species which is restricted to, or shows a strong affinity to gypsum-bearing soils (Meyer 1986).

Gypsum — a water soluble layer or layers in a soil or geologic formation laid down by ancient salt water (marine) seas.

Habitat — a general term referring to the locality, site, and particular type of local environment occupied by an organism or community.

Halophyte – plants which can live under high levels of salinity.

Increaser species — plants which increase in abundance directly as the result of livestock grazing. See also: decreaser species.

Invasive species — non-indigenous (non-native) species that adversely affect the habitats they invade, economically, environmentally, or ecologically.

Layer (vegetation) — a structural component of a community consisting of plants of approximately the same height and growth form (e.g., tree overstory, tree regeneration). See also: Stratum.

Native — used in a botanical context to indicate a plant which was present in a geopolitical region since the dawn of written history. The opposite of an exotic or non-native plant, for which there is a written record or hypothesis that it was introduced by man into a geopolitical region.

Natural Vegetation — vegetation where ecological processes primarily determine species and site characteristics; that is, vegetation comprised of a largely spontaneously growing set of plant species that are shaped by both site and biotic processes.

Noxious weeds — plants are generally considered to be noxious if they are non-native, and negatively impact agriculture, navigation, fish, wildlife, or public health.

Occurrence — a spatially continuous unit of vegetation with uniform composition, structure, and environmental conditions. A particular example of a plant community (e.g., stand). See also: polygon.

Penstock — a conduit or pipe for conducting water (Merriam-Webster 2010)

Physiognomy — the visible structure or outward appearance of a plant community as expressed by the dominant growth forms, such as their leaf appearance or deciduousness.

Plant Community — a group of plant species living together and linked together by their effects on one another and their responses to the environment they share. Typically the plant species that co-occur in a plant community show a definite association or affinity with each. Alliances and association are specific types of plant communities.

Polygon — for attributes with area, the finest level of mapping in a Geographical Information System layer; as in an occurrence of a cover type in vegetation mapping.

Ruderal Vegetation — a suite of stray plant species that colonize an area by chance following disturbance by man. These suites are random in plant composition and have no resemblance to the original vegetation, thus are not natural or semi-natural communities.

Salic — of, relating to, or being relatively light rock that is rich in silica and alumina and is typical of the outer layers of the earth (also sialic); generally restricted to bottomland soils where such minerals accumulate to toxic levels, thus inhabiting the growth of many plant species. See also: halophyte, sodic.

Savanna — a plant community dominated by grasses, with trees as a visual dominant but technically less than 10% canopy cover.

Seed bank — the store of viable plant seed in a plant community and available to recolonize the community after disturbance.

Seral — in the classical, linear response model to an ecosystem perturbation, a vegetation type (or component species) that is nonclimax; a community demonstrably susceptible to replacement by another suite of species. See also: state.

Semi-Natural Vegetation — vegetation in which past or present human activities significantly influences composition or structure such that one or more non-native species dominate the vegetation.

Shrub — a woody plant that generally has several erect, spreading, or prostrate stems which give it a bushy appearance. In instances where growth form cannot be determined, woody plants less than 5 meters in height at maturity shall be considered shrubs. Includes tall shrubs, dwarf-shrubs, and low or short woody vines.

Shrubland — a plant community dominated by shrubs, rather than herbs or trees.

Shrub Stratum — the layer of vegetation consisting of woody plants more than 0.5 meters tall but less than 5 meters in height, such as shrubs, tree seedling and saplings, and lianas. Epiphytes may also be included in this stratum. Rooted herbs are excluded even if they are over 0.5 meters in height.

Siltation — the act of creating or perpetuating areas where water transported soil materials are deposited.

Sodic — of, relating to, or containing sodium, such as a sodic horizon in a soil which may limit plant diversity to only halophytes. See also: salic, halophytes.

Special Status Species — plant or animal species which are listed by biodiversity organizations, resource management and government regulatory agencies as being of special interest or concern, typically due to rarity or endemism, or lack of available information to determine the same. See also: endemic, rare plants.

State — multiple, non-equilibrium expressions of plant communities, or seral stages of plant communities, among which reversible relationships are maintained. Changes in states require crossing a threshold, in which a return to the previous state is not possible without significant management inputs.

Stratum — a structural component of a community consisting of plants.

Structure (vegetation) — (1) the spatial pattern of growth forms in a plant community, especially with regard to their height, abundance, or coverage within the individual layers; (2) the spatial arrangement of the components of vegetation resulting from plant size and height, vertical stratification into layers, and horizontal spacing of plants. See also: physiognomy.

Substrate type — a description of the geologic formation, rock type, or soil exposure dictating the plant species, or lack of plant species, present in an area. Typically, the surface of barren land as sand, rock, exposed subsoil, or salt affected soils. Types include sandstone/limestone/basalt outcrops, sandstone/limestone slickrock, gypsum badlands, dry wash, and desert pavement.

Talus — a sloping area formed especially by an accumulation of rock rubble; rock debris at the base of a cliff (Merriam-Webster 2010).

Transition — a process (e.g., fire) which causes a state to change from one to another. Different combinations of transitions, coupled with differing intensities and timing often result in different states.

Tree — a woody plant that generally has a single main stem and a more or less definite crown. In instances where growth form cannot be determined, woody plants equal to or greater than 5 meters in height at maturity shall be considered trees. Includes dwarf trees.

Tree Stratum — the layer of vegetation consisting of woody plants more than 5 meters in height, including mature trees, shrubs over 5 meters tall, and lianas.

Ungulate — A group of mammals which walk on hoofed feet. Used in botany to group together browsing animals which lack upper incisors and instead have a dental pad to assist in browsing woody plant material as part of their diet.

Vascular — of or relating to a channel for the conveyance of a body fluid (e.g. sap of a plant) or to a system of such channels (Merriam-Webster 2010)

Vegetation — the collective plant cover of an area.

Vegetation type — a named category of plant community or vegetation defined on the basis of shared floristic and/or physiognomic characteristics that distinguish it from other kinds of plant communities or vegetation. This term can refer to units in any level of the US NVC hierarchy, or even finer, ad hoc levels such as community, cover, or dominance type.

Woodland — plant communities dominated by trees, as opposed to exclusively herbs, grasses, or shrubs. Technically a plant community with over 25 percent cover of trees. See also: forest.

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Abbreviations and Acronyms

AGFD	Arizona Game and Fish Department
BLM	Bureau of Land Management
BMP	Best Management Practice
BPS	Booster Pump Station
CICWCD	Central Iron County Water Conservancy District
DRG	Digital raster graphics
ESA	Endangered Species Act
FGDC	Federal Geographic Data Committee
GCNRA	Glen Canyon National Recreation Area
GIS	Geographic Information System
GOPB	Governor's Office of Planning & Budget
gpcd	Gallons per capita per day
GPS	Global Positioning System
GSENM	Grand Staircase - Escalante National Monument
I-15	Interstate 15
KCWCD	Kane City Water Conservancy District
LPP	Lake Powell Pipeline
LSD	Logan Simpson Design Inc.
M&I	Municipal and Industrial
MSL	Mean Sea Level
NISC	National Invasive Species Council
NPS	National Park Service
NRA	National Recreation Area
NVC	National Vegetation Classification
NVCS	National Vegetation Classification System
OHV	Off-highway vehicle
Reclamation	Bureau of Reclamation

Abbreviations and Acronyms

RO	Reverse Osmosis
SITLA	School Institutional Trust Lands Administration
SR	State Route
SWReGAP	Southwest Regional Gap Analysis Program
TDS	Total Dissolved Solids
UDWR	Utah Division of Water Resources
U.S.	United States
USFWS	United States Fish and Wildlife Service
US 89	United States Highway 89
UTM	Universal Transverse Mercator
VRM	Visual Resource Management
WCWCD	Washington County Water Conservancy District

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Appendix A
Lake Powell Pipeline Plant Species Data Sheet

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Appendix B
Data Sheet for Field Surveys

Field Data Sheet for Lake Powell Pipeline Rare Plant, Noxious Weed, and Veg. Community Surveys

Logan Simpson Design Project #065276 Page 1 of 2

General Information

Date: _________________ Beginning Time: ________________ Ending Time: ______________

Surveyor's Names: ____

□ Team A □ Team B □ Team C

Location Information

State: ________ County: ________________

Corridor Width: __________________ or Other Facility: _______________________________________

Topo Map Number(s) _______________ Aerial Map Number(s) ________________________________

GPS Information

File Name: __________________________

Corner #	Direction (SW, SE, etc.)	Photo #	Easting	Northing	Elev.
1					
2					
3					
4					

Soils Information

Geologic Formation per USGS: ____

Notes (cryptogamic crust, rock outcrops, sand dunes, lenses of different soils, exposed gypsum): _______

____

____

Recorder's Initials: ______

Vertebrates Sighted

Species: ____

Species: ____

Species: ____

Species: ____

Notes: ____

____

Recorder's Initials: _______

Appendix B. Data Sheet for Field Surveys

Field Data Sheet for Lake Powell Pipeline Rare Plant, Noxious Weed, and Veg. Community Surveys

Logan Simpson Design Page 2 of 2

Date: ___________________

GPS File Name: _______________________

Rare Plants (Record condition, blooming, fruiting, GPS pt. number, quantity, photo #)

Target Species:
____
____

Species sighted: ____
____
____
____

Notes:
____
____

Recorder's Initials: _______

Noxious Weeds (gen. abundance, location, blooming, fruiting, GPS pt. number, quantity, photo #)

Species:
____

Species:
____

Species:
____

Species:
____

Species:
____

Species:
____

Notes: ____
____

Recorder's Initials: _______

Vegetative Community Information

Community Type per ReGAP: ____

Variation to ReGAP noted on aerial map: ____

Dominant Species: ____
____
____
____
____

Notes (include land use such as grazing, off-road vehicles, dumping): _________________________________
____

Recorder's Initials: ______

Appendix C
Data Sheet for 50-m Transect Surveys

Field Data Sheet for Lake Powell Pipeline Vegetation Transects (50 m x 1 m)

Logan Simpson Design Project #065276 Page 1 of 2

General Information

Date: ____________ Beginning Time: ________________ Ending Time: ______________

Surveyor's Names (Recorder listed first): ____

Location Information

State: ________ County: _______________________

Transect Orientation (N-S, E-W): ________________ Notes: ______________________________

Corridor Width: __________________ or Other Facility: _________________________________

Topo Map Number(s): _______________ Aerial Map Number(s): ________________

GPS Information

File Name: ___________________________________

Point	Photo #	Easting	Northing	Elev.
Start				
End				

Soils & Topography Information

Geologic Formation per USGS: ____

Notes (cryptogamic crust, rock outcrops, sand dunes, lenses of different soils, exposed gypsum):

____

Aspect: _________________________

Slope: __________________________

Vegetation Community Information

Community Type: ____

Percent Cover: __________________

Hydrology (check one)

□ Upland (above and away from floodplains)

□ Riparian (along rivers or stream channels)

□ Wetland (saturated soil for majority of growing season)

□ Playa lakebed (poorly drained depressions)

Land Use

Apparent land use: ____

Distance from nearest road (two-track or larger): ______________________

Disturbance (check one)

□ No disturbance apparent

□ Light to moderate disturbance

□ Site heavily disturbed

If disturbed, cause: ____

Appendix C. Data Sheet for 50-m Transects Surveys

Field Data Sheet for Lake Powell Pipeline Vegetation Transects (50 m x 1 m)

Logan Simpson Design Project #065276 — Page 2 of 2

Date: ____________________

GPS File Name: ________________________

Species	Tabulation	Total		Species	Tabulation	Total
AGRO CRIS				KRAM EREC		
AMBR ACAN				KRAS LANA		
AMBR DUMO				LARR TRID		
AMEL UTAH				LEPI FREM		
ARCT PUNG				LYCI ANDE		
ARIS PURP				LYCI PALL		
ARTE BIGE				LYGO		
ARTE FILI				MAHO FREM		
ARTE LUDO				MENO SPIN		
ARTE NOVA				MIRA BIGE		
ARTE TRID				OPUN ERIN		
ASTR				OPUN POLY		
ATRI CANC				ORYZ HYME		
ATRI CONF				PINU EDUL		
BERB FREM				PINU MONO		
BOUT GRAC				PORT OLER		
BRAS TOUR				PRUN FASF		
BROM INER				PSOR FREM		
BROM RUBE				PURS GLAN		
CEAN GREG				PURS TRID		
CERC LEDI				QUER GAMB		
CHRY NAUS				QUER TURB		
CHRY VISC				RHUS TRIL		
CIRS				SALS TRAG		
COLE RAMO				SALV DORR		
COMA UMBE				SITA HYST		
CONV ARVE				SPHA AMBM		
CYLI WHIP				STAN PINN		
ECHI ENGE				STEP EXIG		
ECHI TRIG				TAMA CHIN		
ELAE ANGU				TETR AXIL		
ENCE VIRG				THAM MONT		
EPHE NEVA				TRIB TERR		
EPHE TORR				YUCC ANGU		
EPHE VIRI				YUCC BACC		
ERIO CORY						
ERIO INFL						
ERIO PULC						
ERIO UMBE						
FALL PARA						
GARR FLAV						
GUTI MICR						
GUTI SARO						
HAPL LINI						
HILA JAME						
HILA RIGI						
HYME SALS						
JUNI OSTE						

Appendix D
Lake Powell Pipeline Place Names and Reaches Map

Appendix D. Lake Powell Pipeline Place Names and Reaches Map

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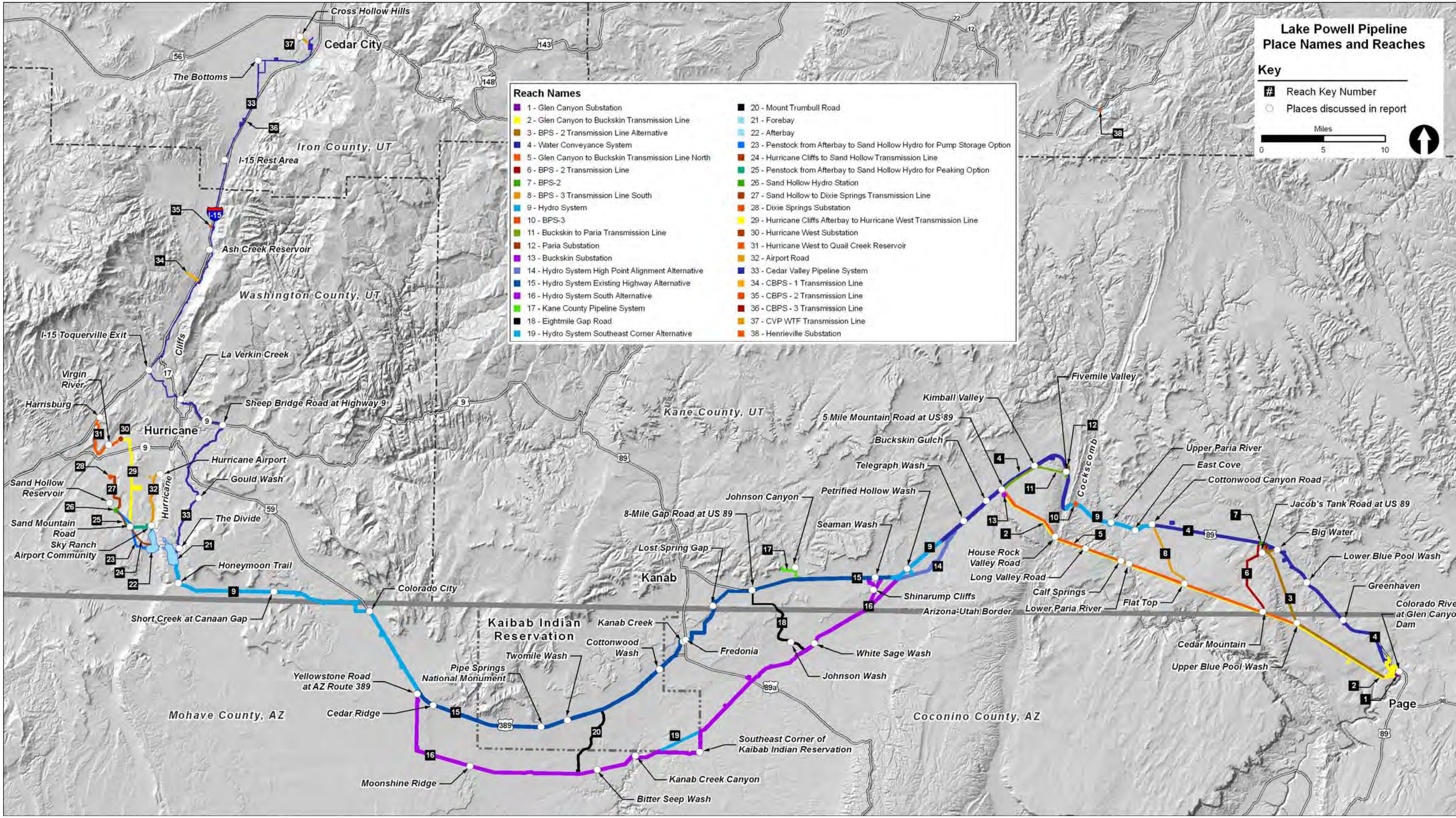

Map D-1
Lake Powell Pipeline Place Names and Reaches

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Appendix E
Lake Powell Pipeline Ecological Systems Maps

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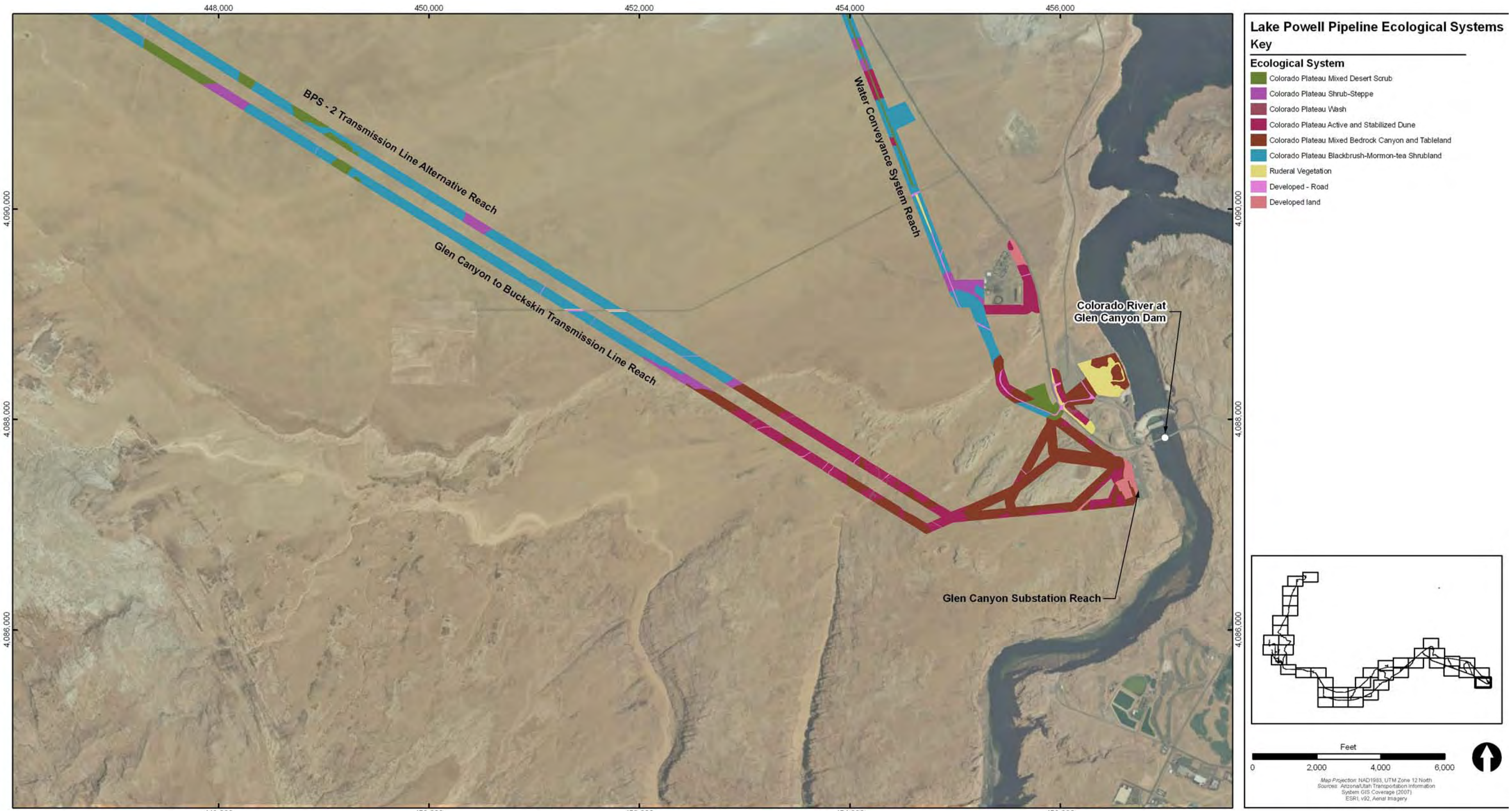

Map E-1
Lake Powell Pipeline Ecological Systems

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Map E-2
Lake Powell Pipeline Ecological Systems

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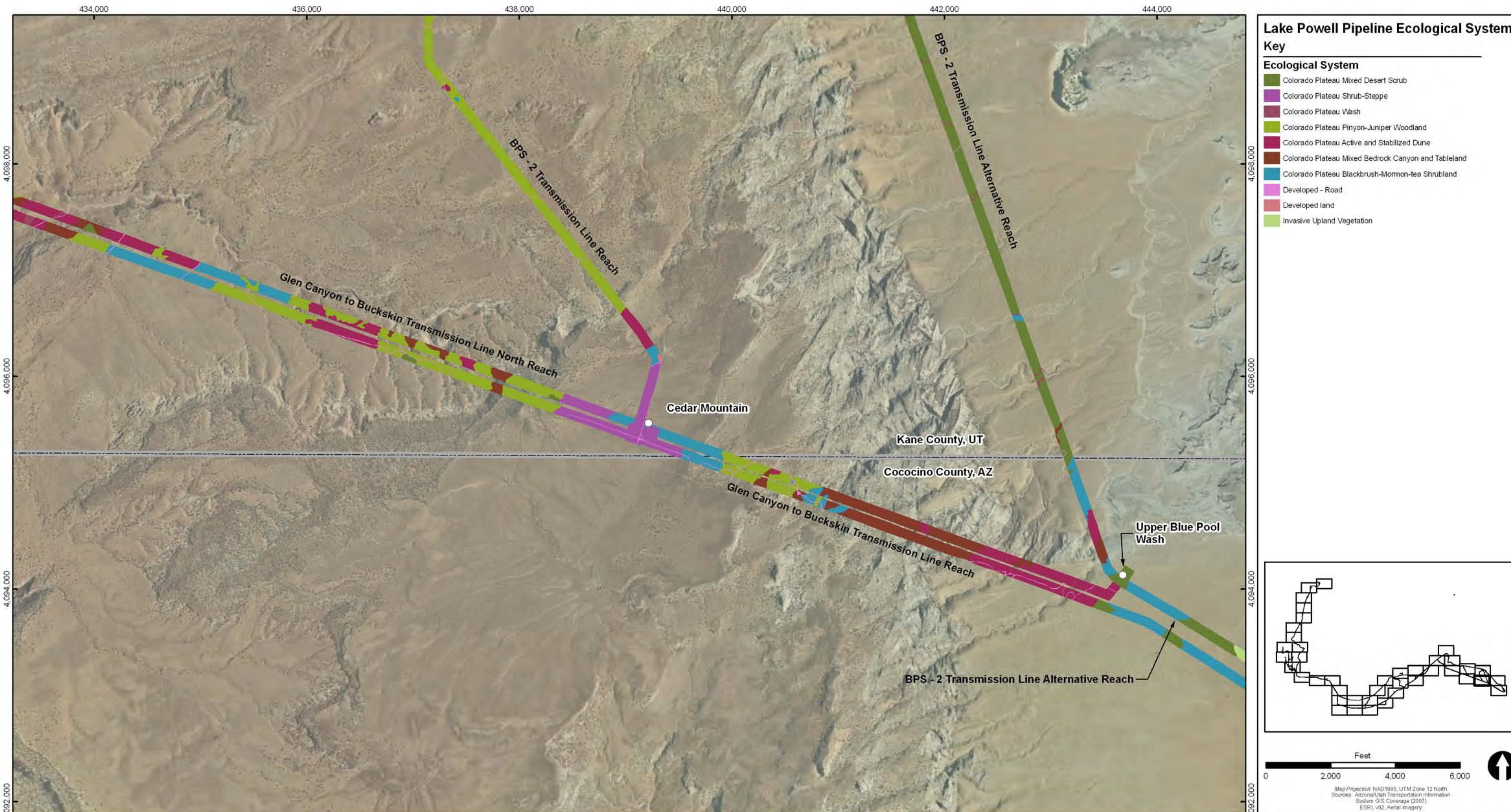

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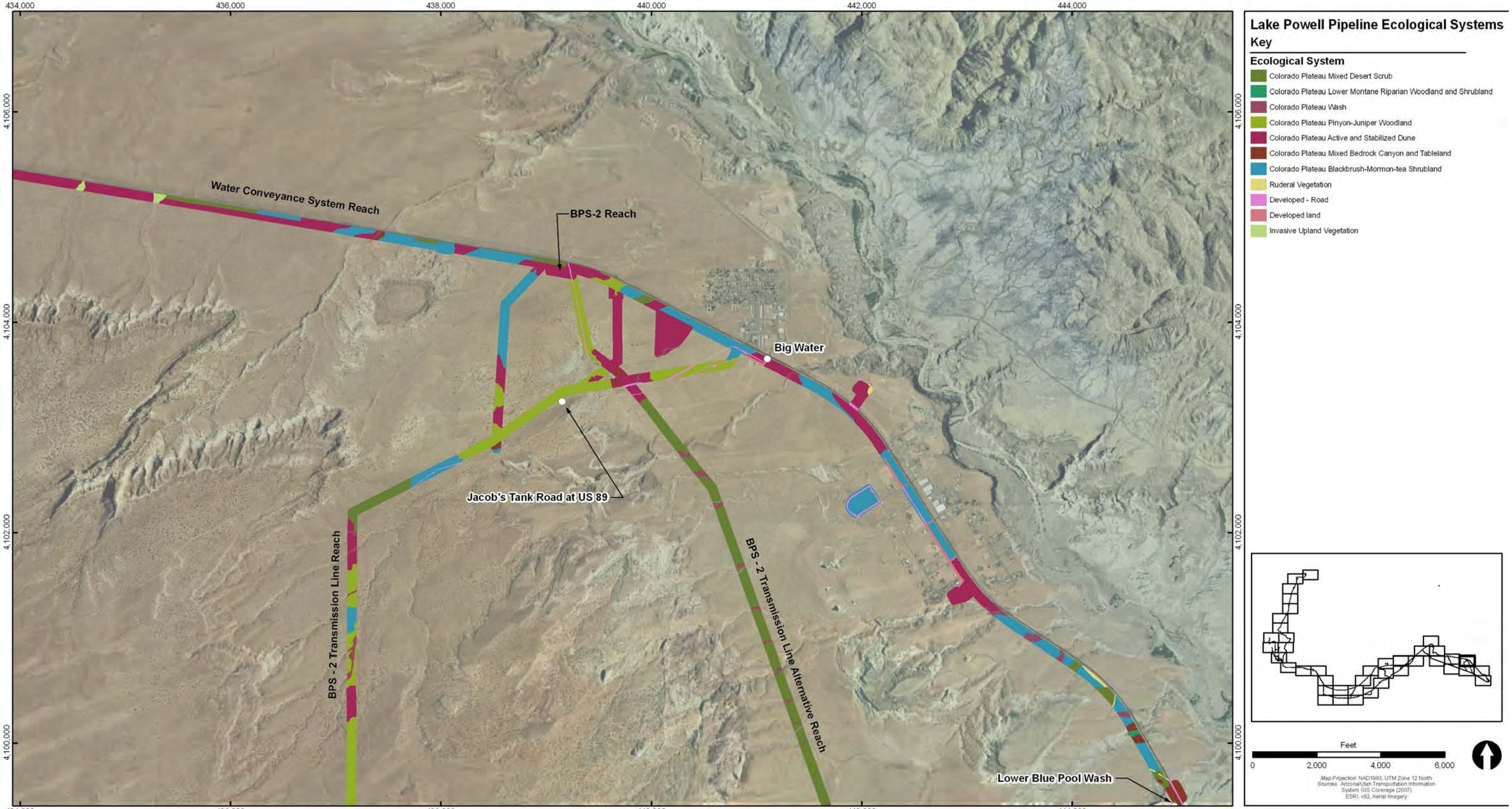

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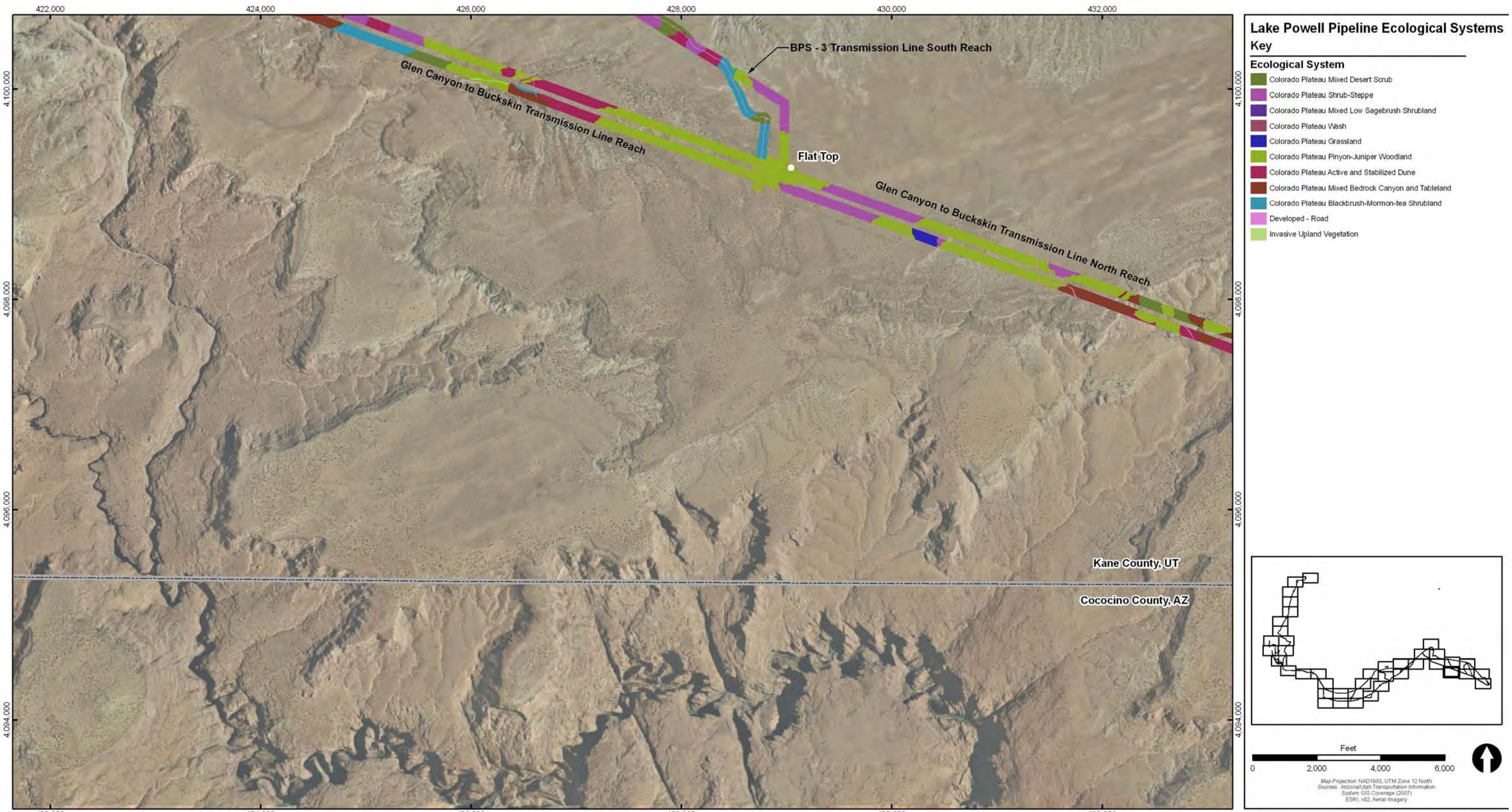

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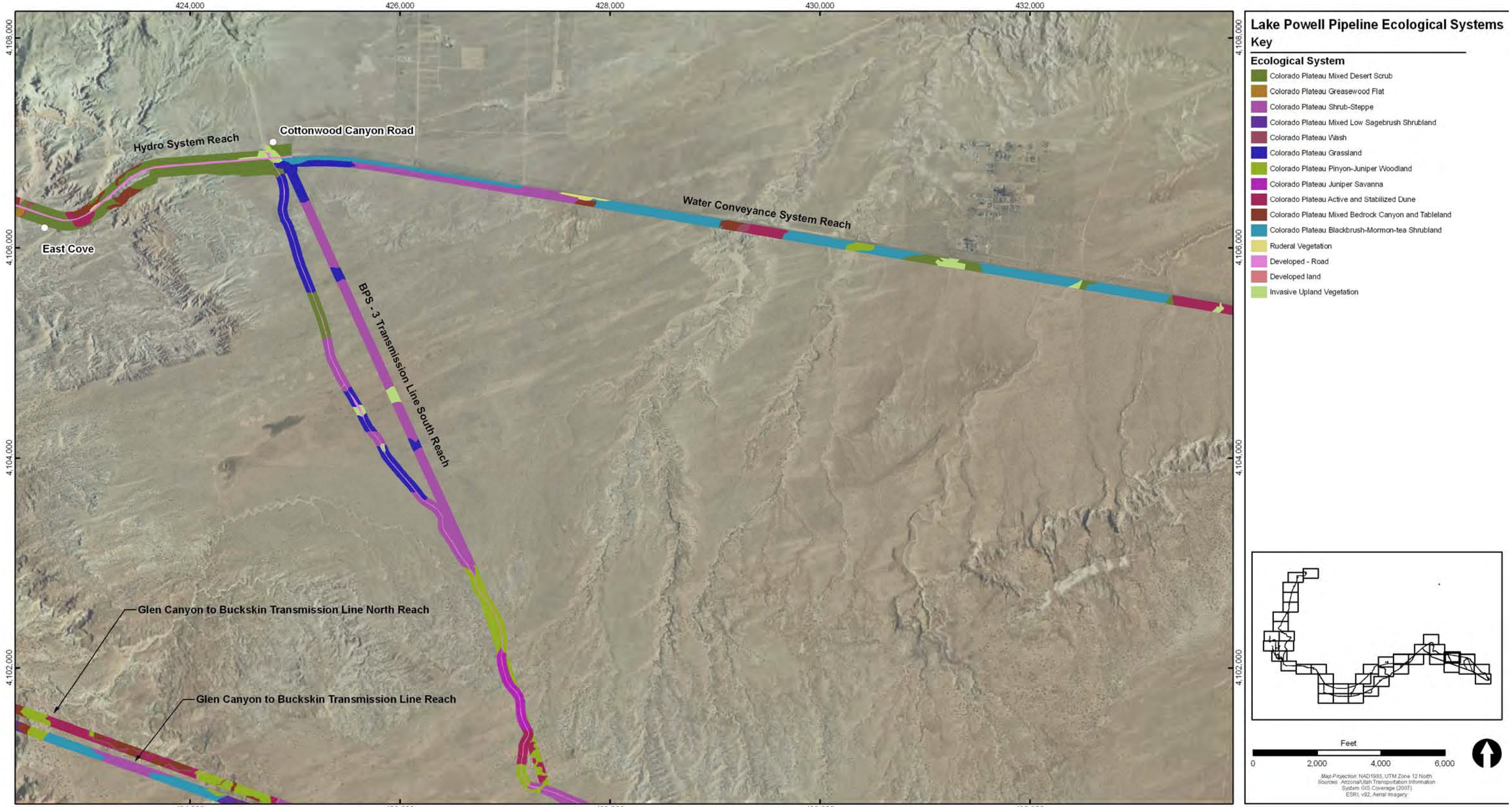

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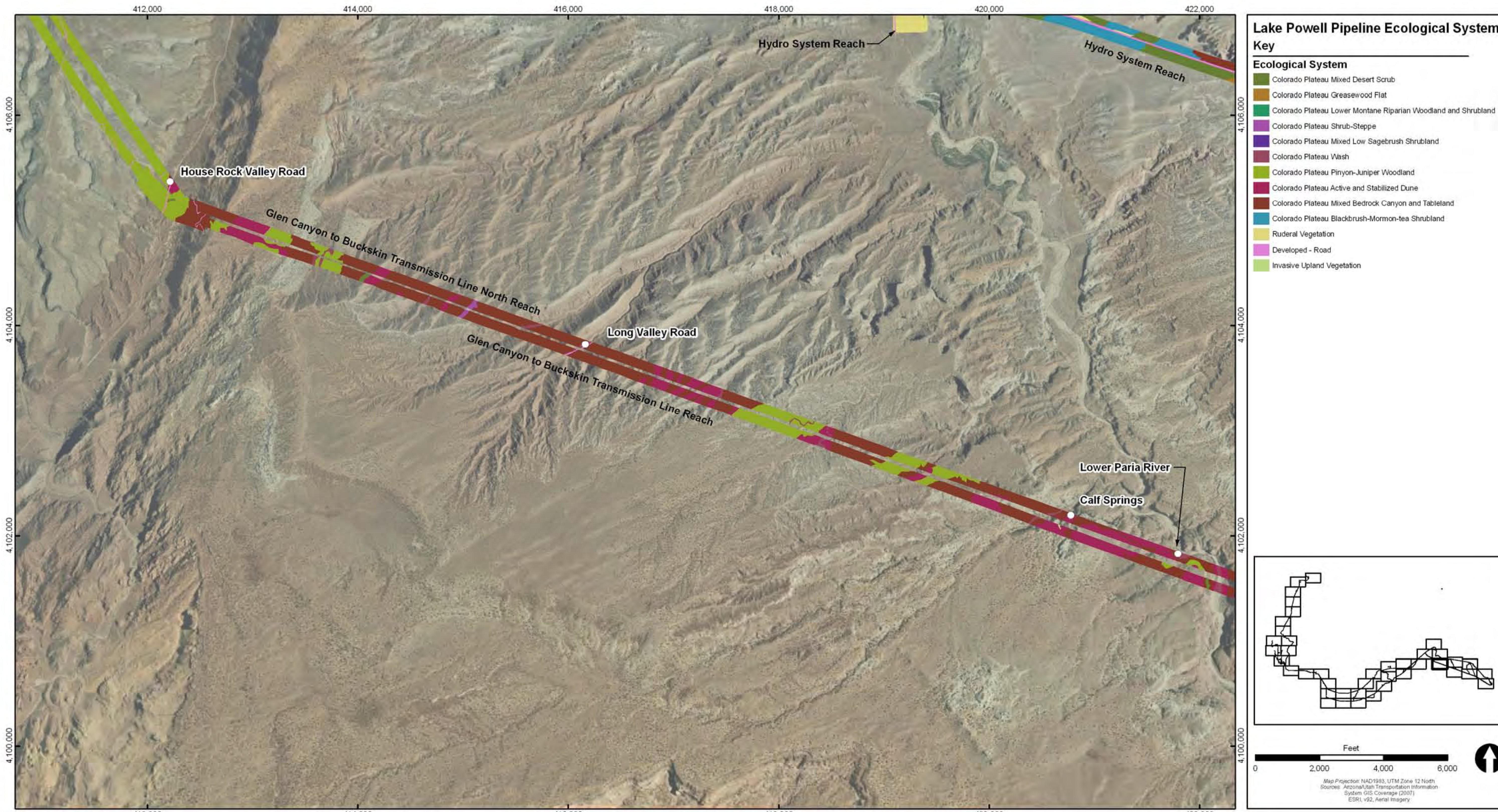

Map E-7
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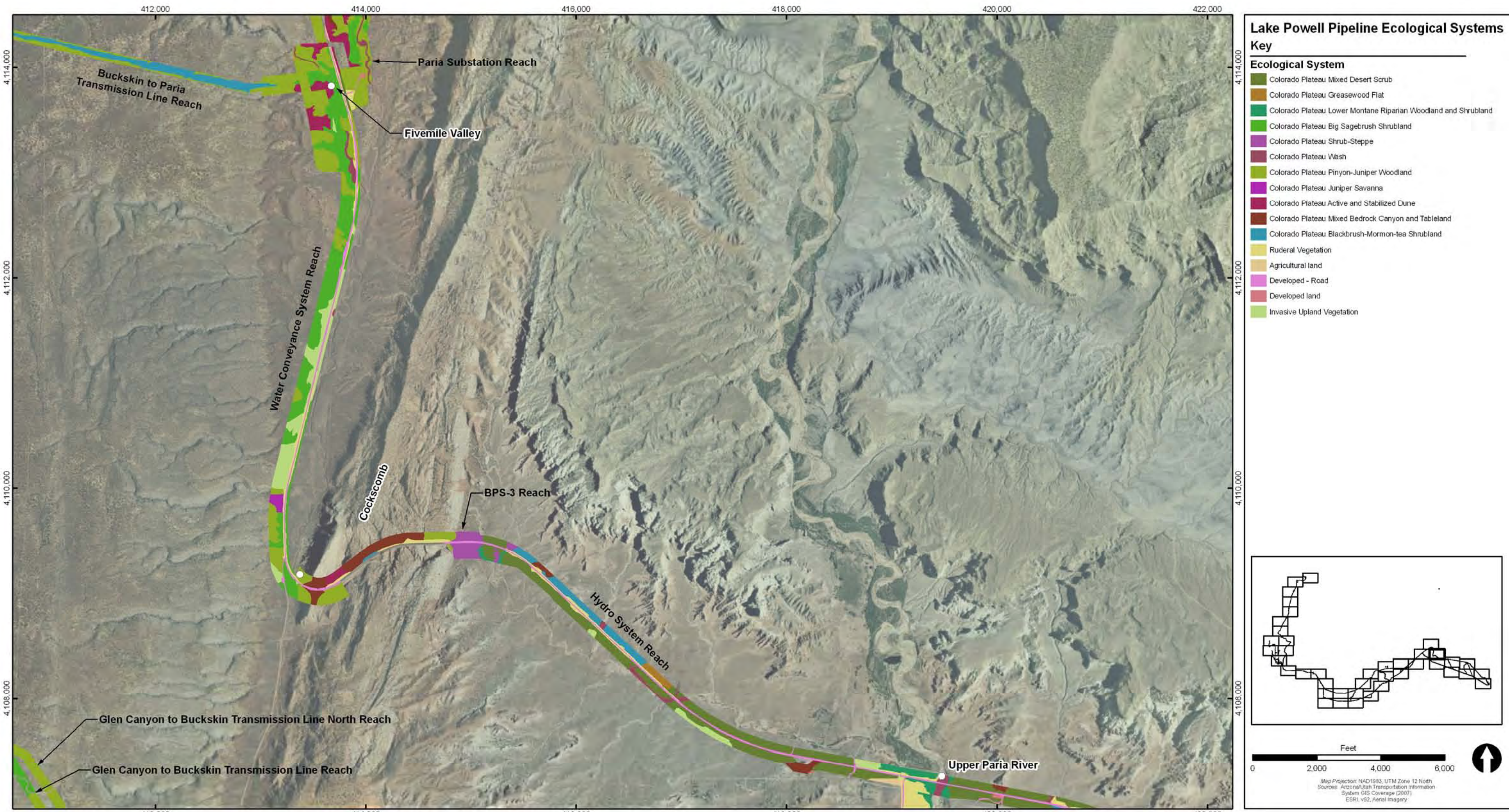

Map E-8
Lake Powell Pipeline Ecological Systems

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Map E-9
Lake Powell Pipeline Ecological Systems

Map E-10
Lake Powell Pipeline Ecological Systems

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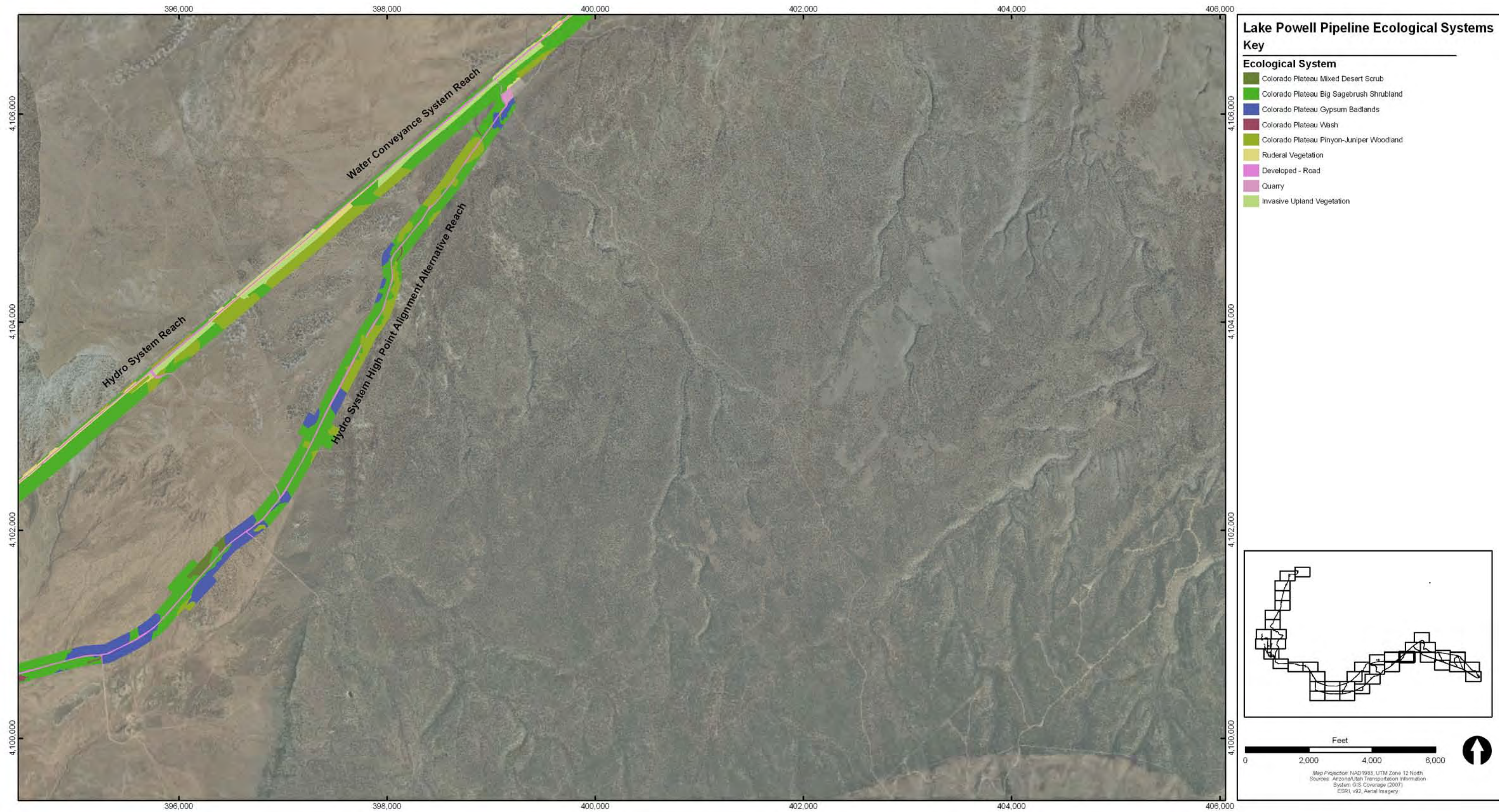

Map E-11
Lake Powell Pipeline Ecological Systems

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Map E-12
Lake Powell Pipeline Ecological Systems

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Map E-13
Lake Powell Pipeline Ecological Systems

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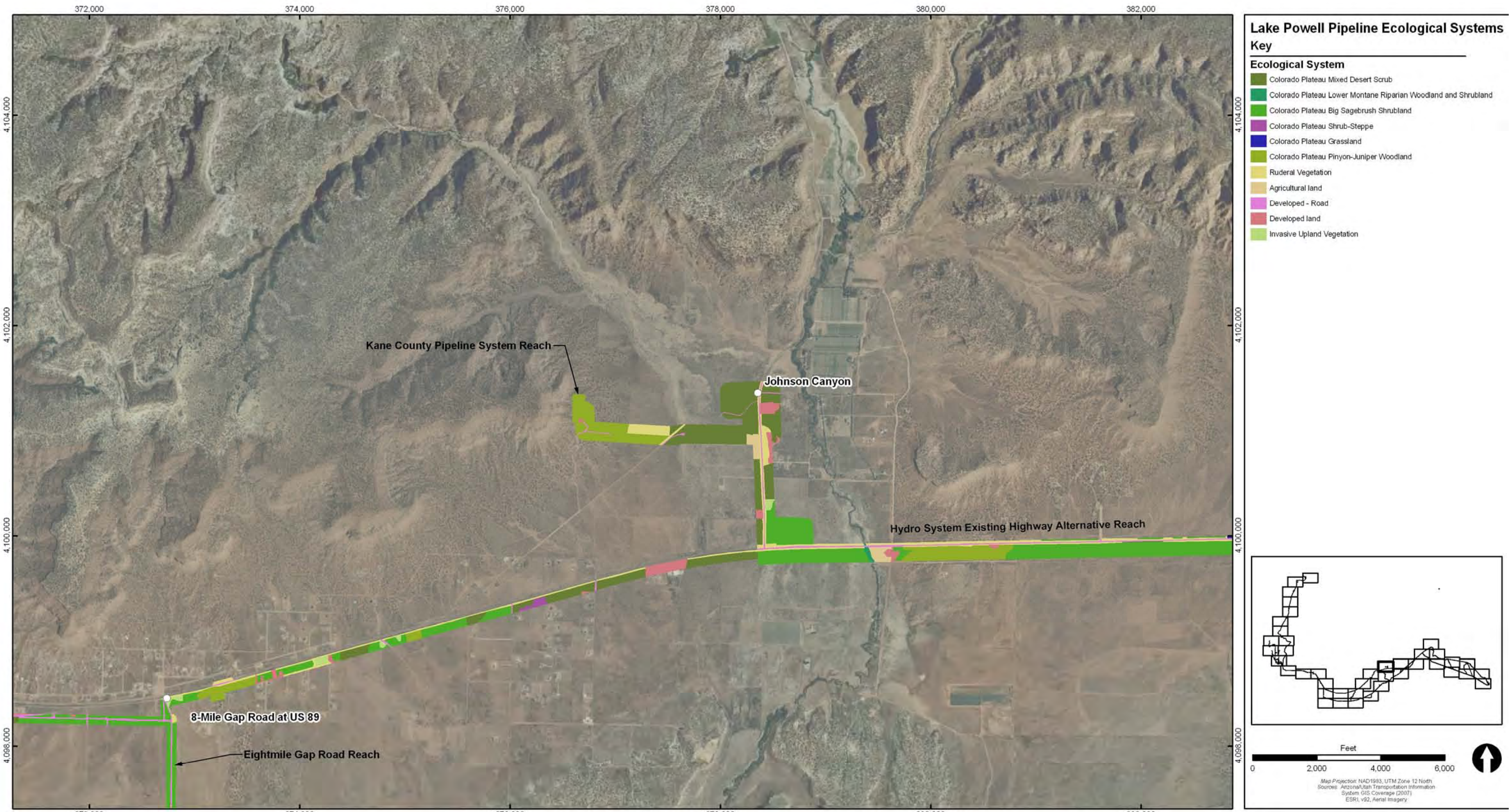

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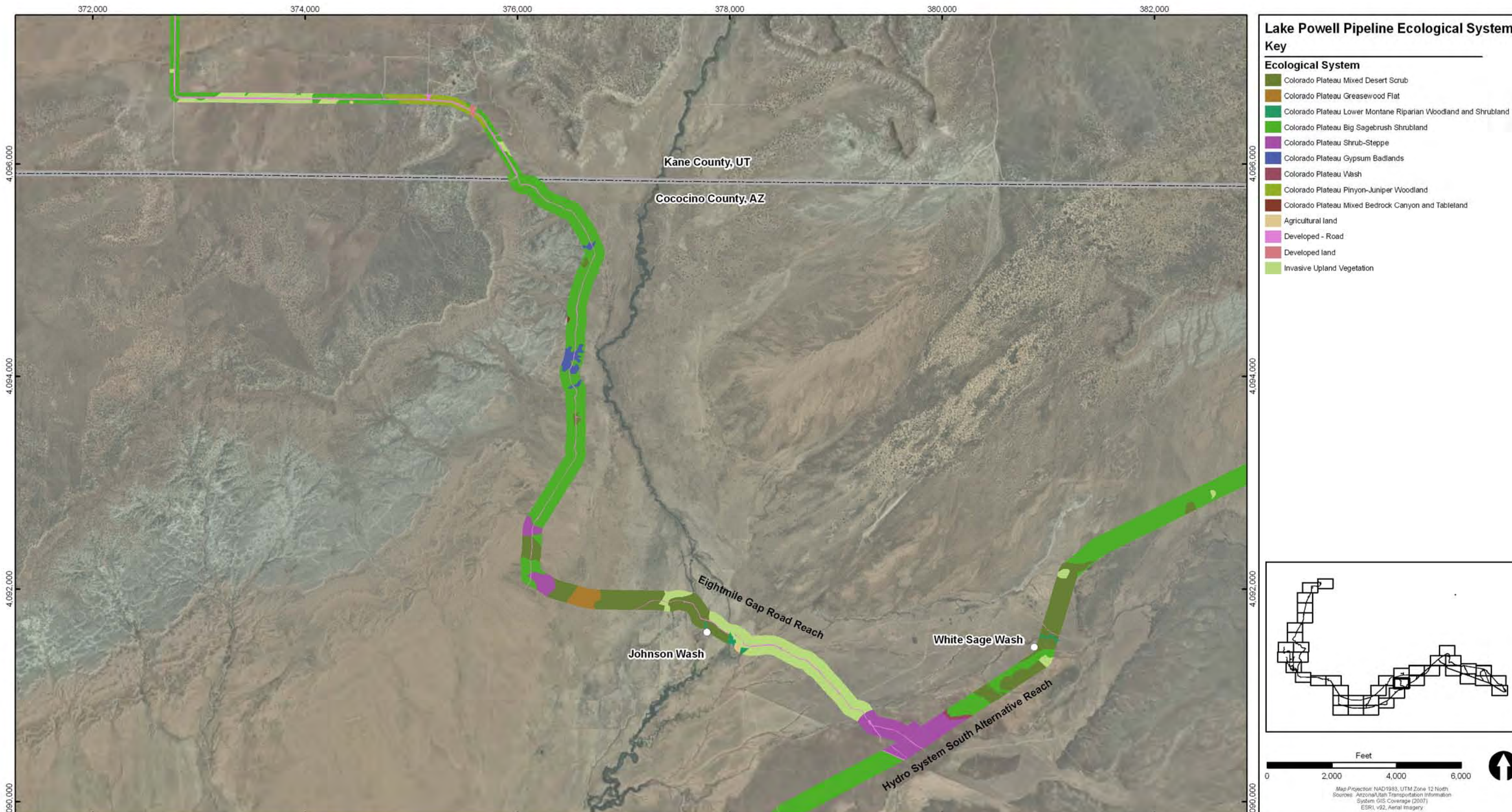

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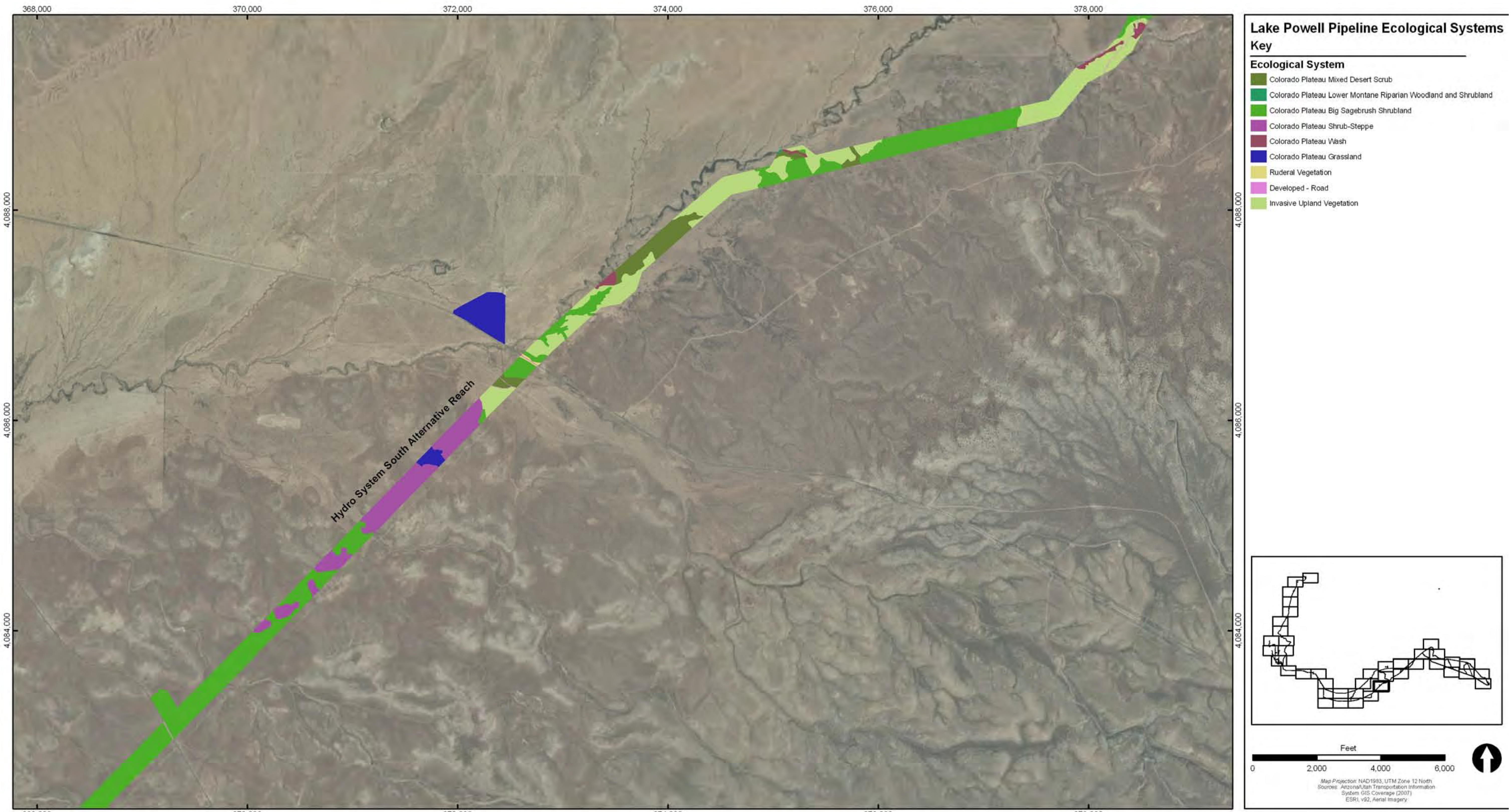

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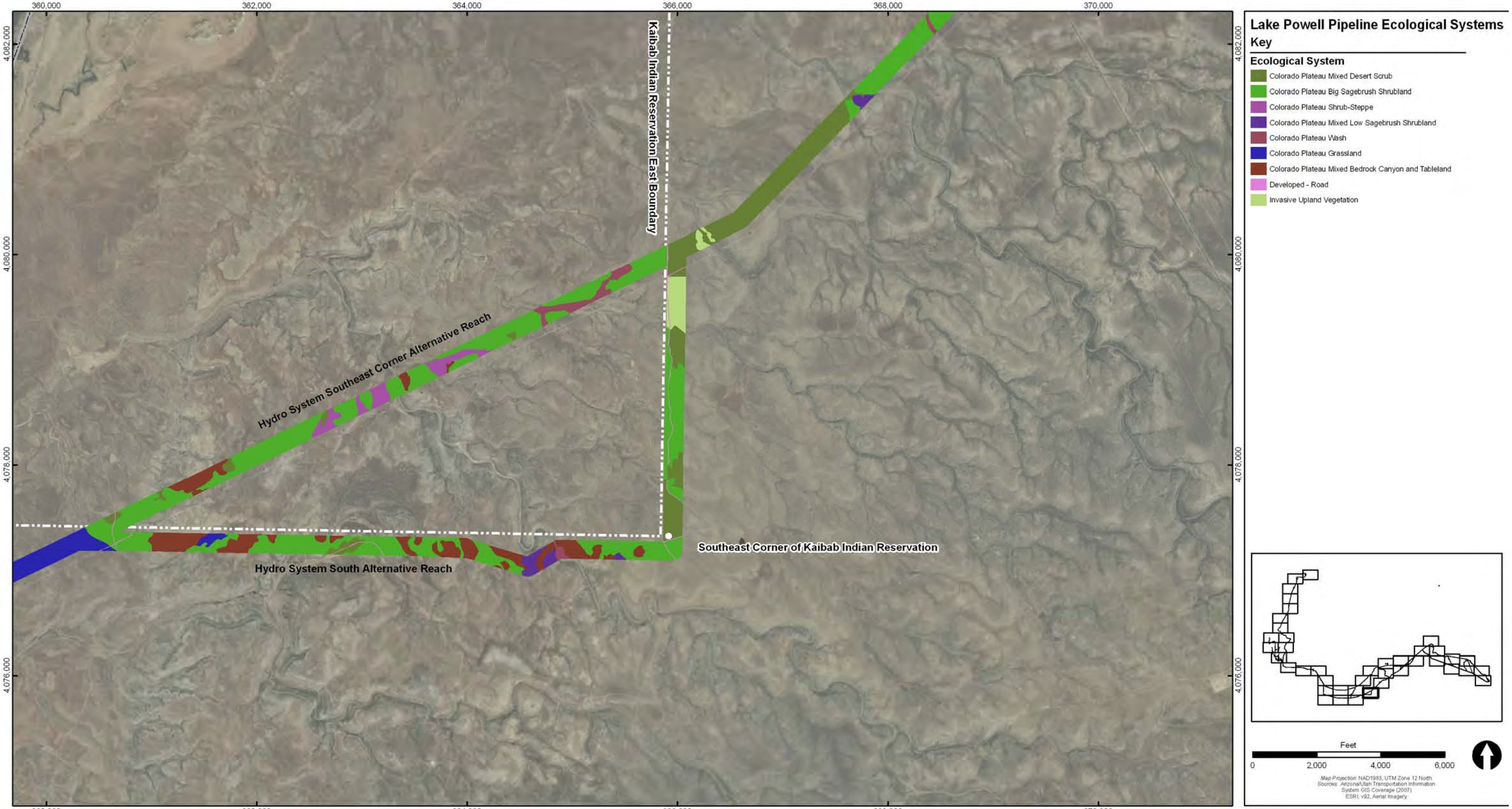

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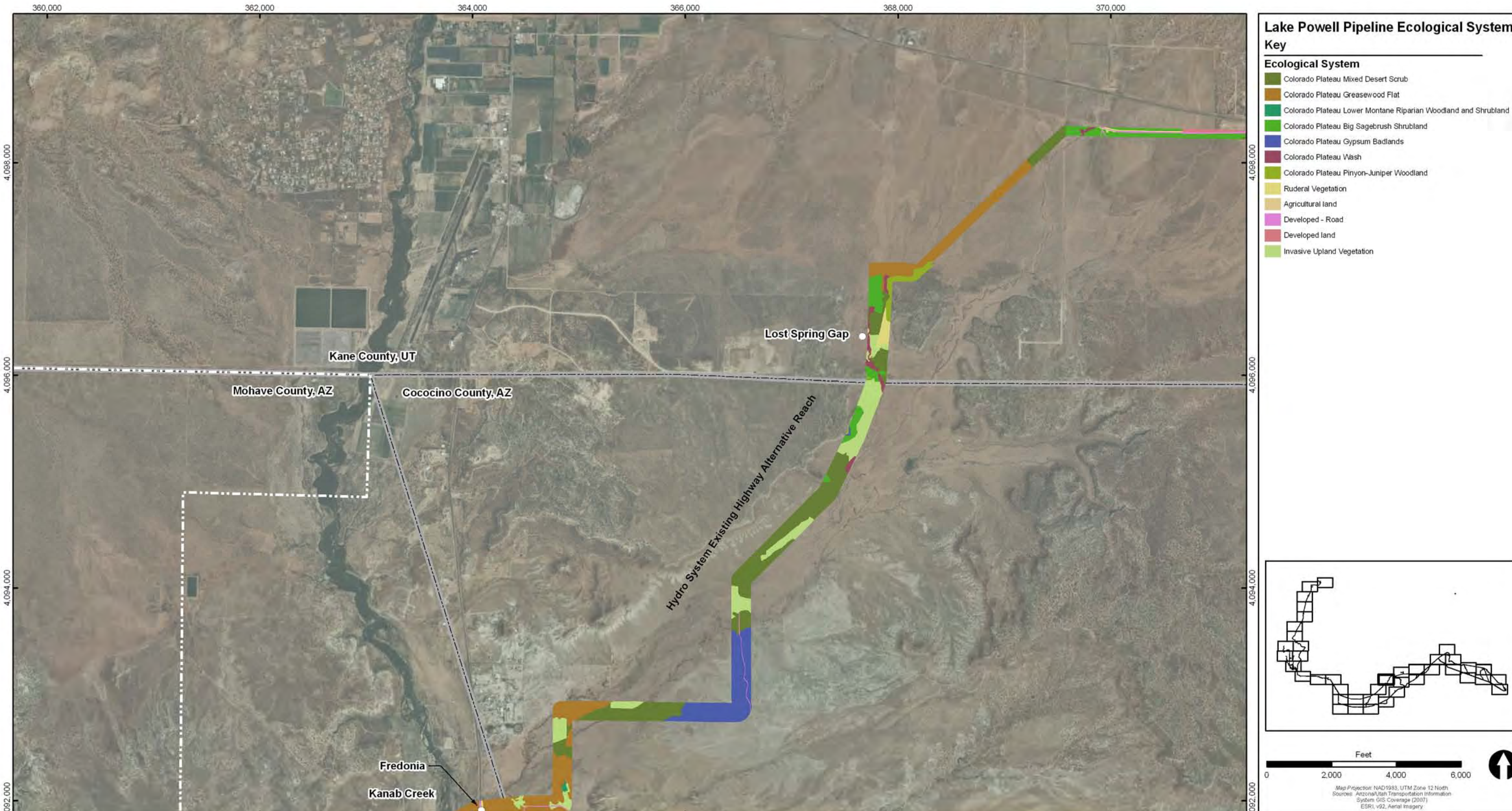

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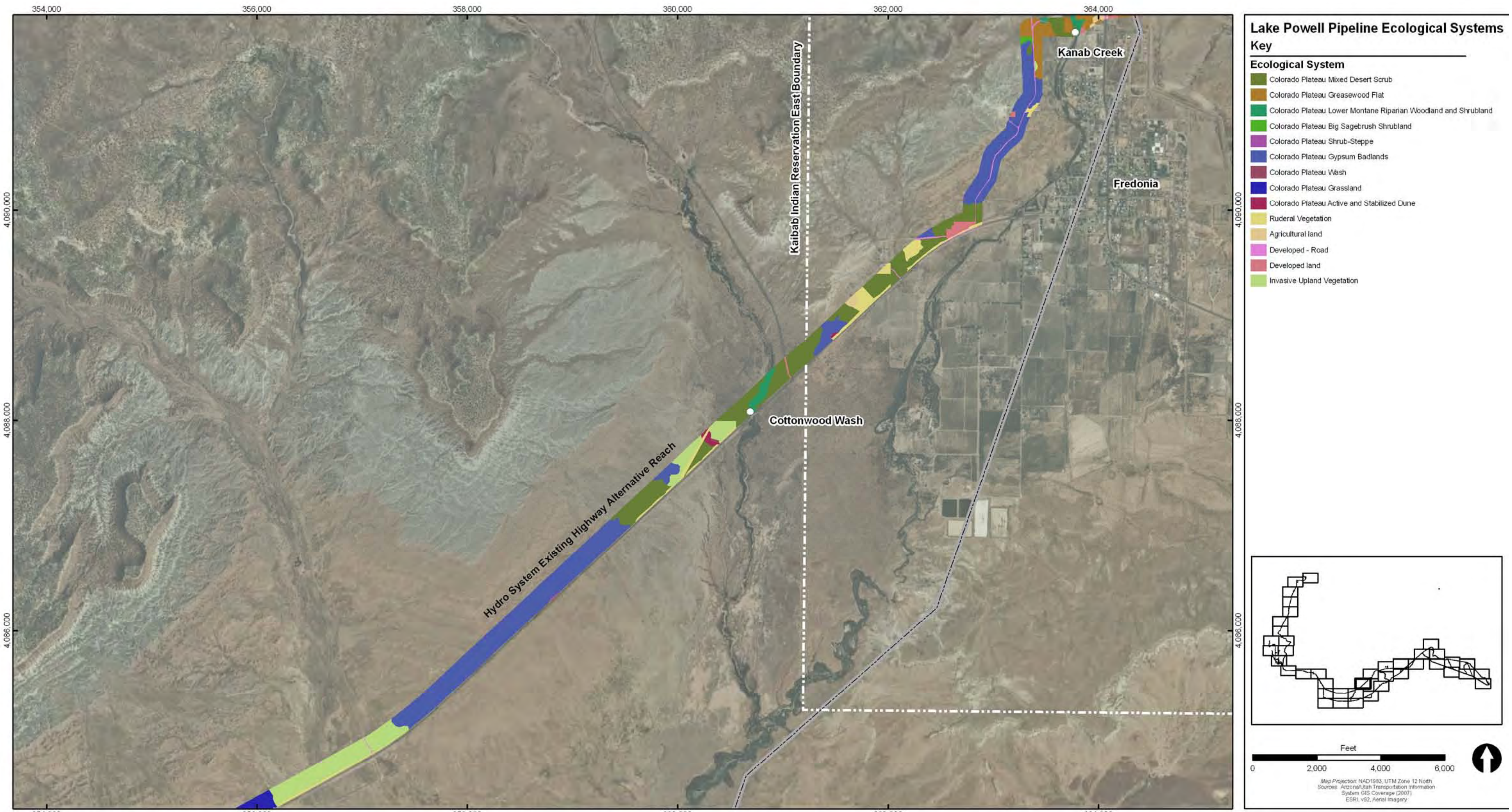

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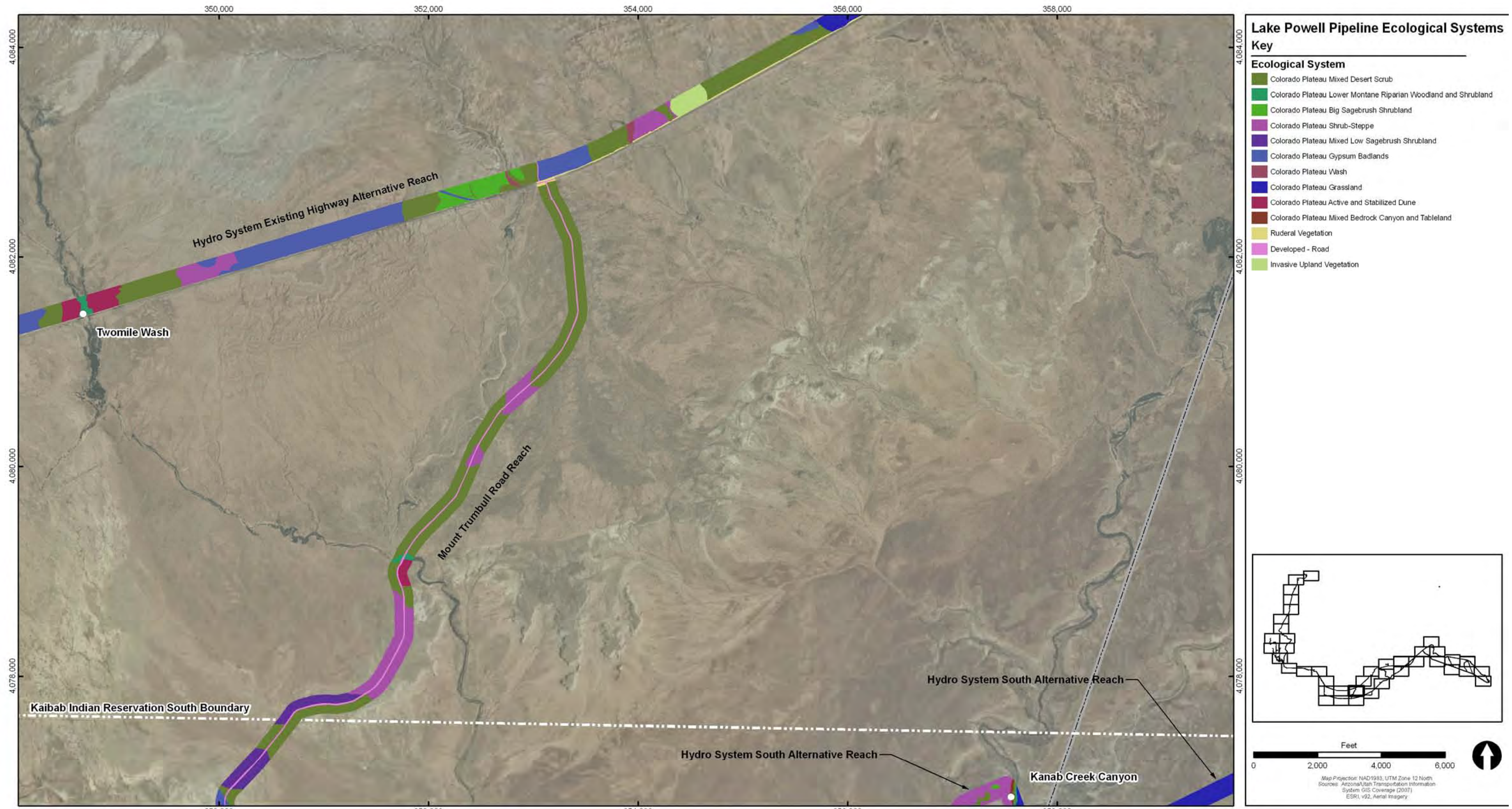

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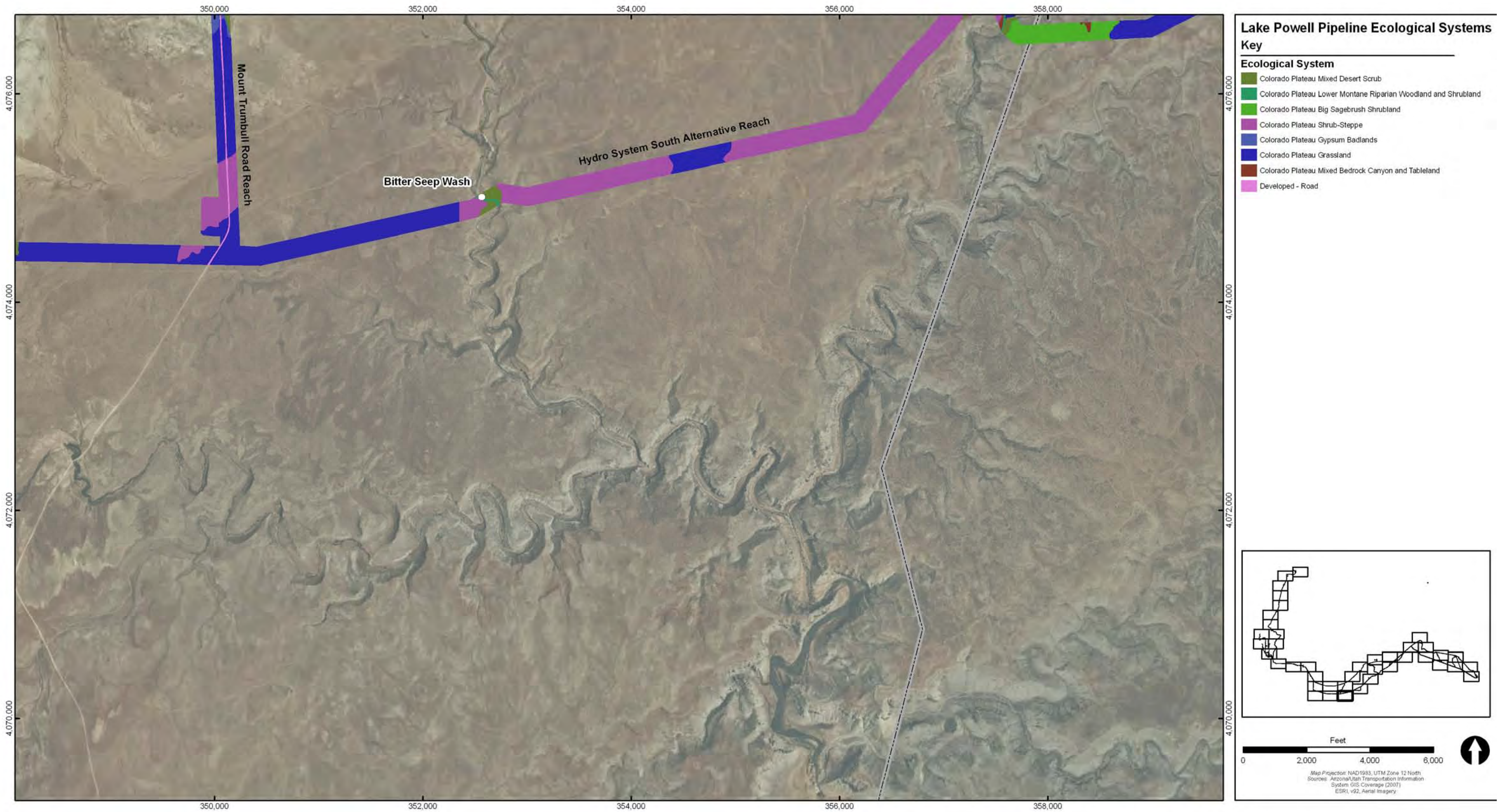

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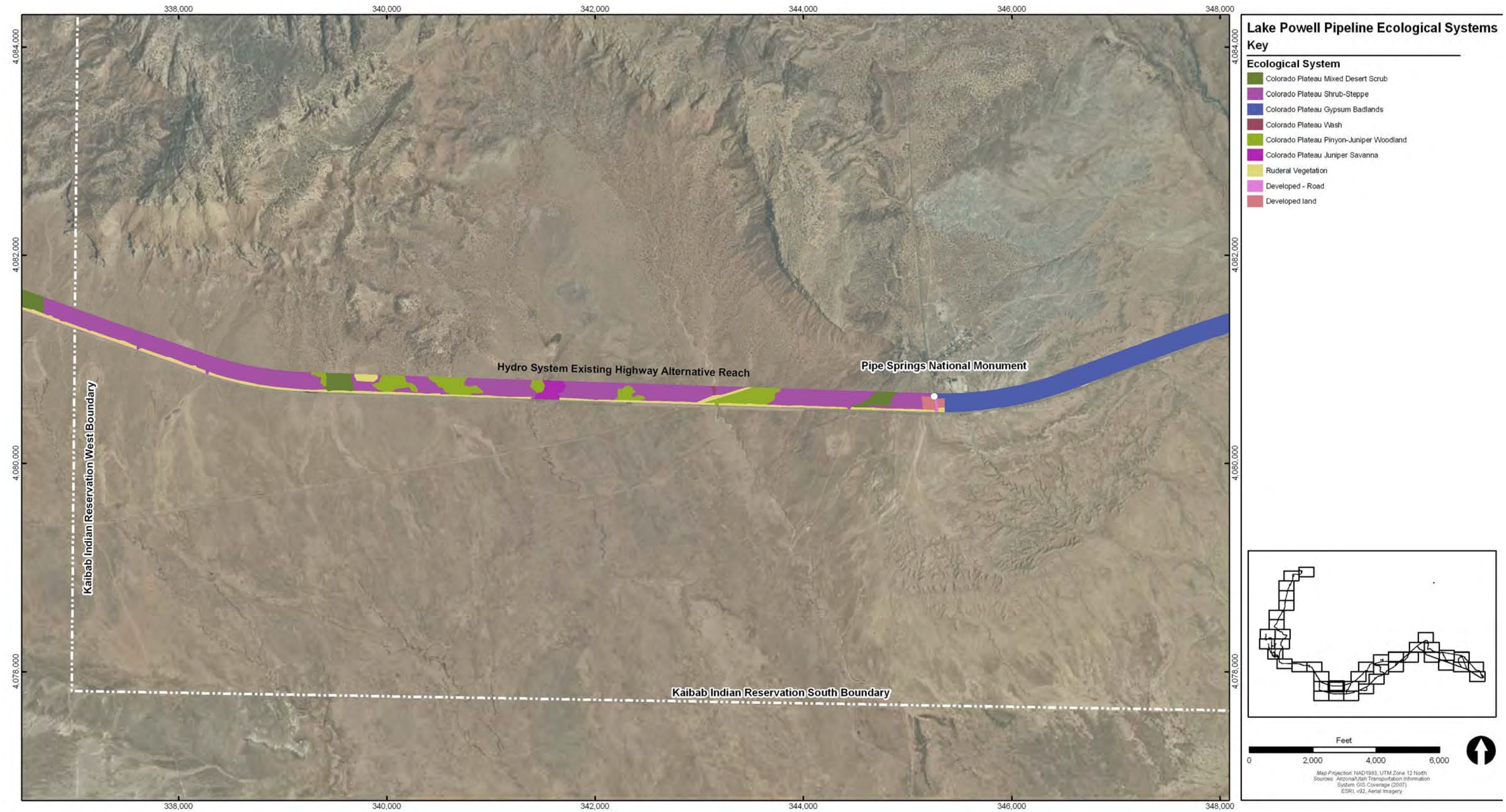

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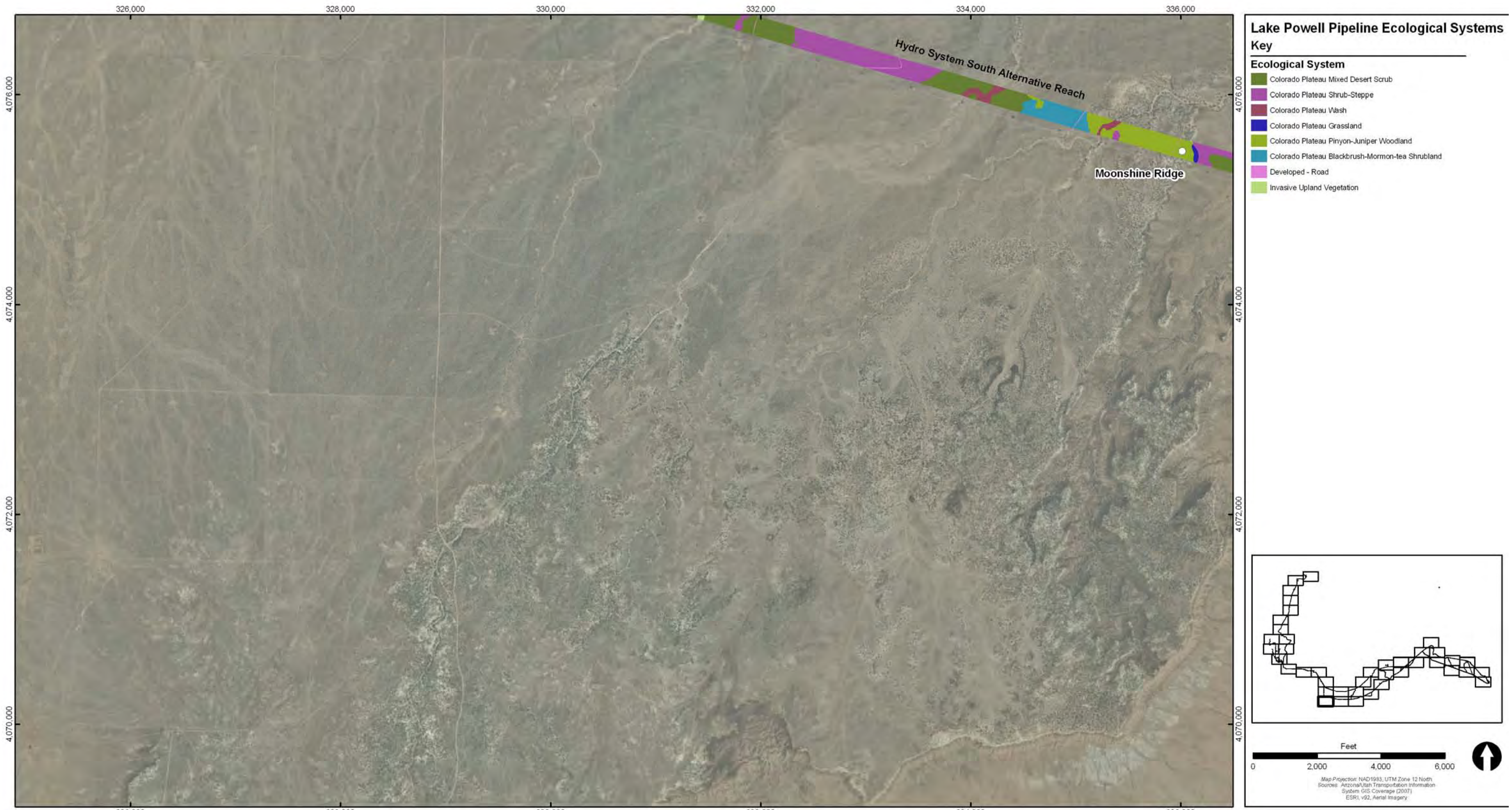

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Map E-25
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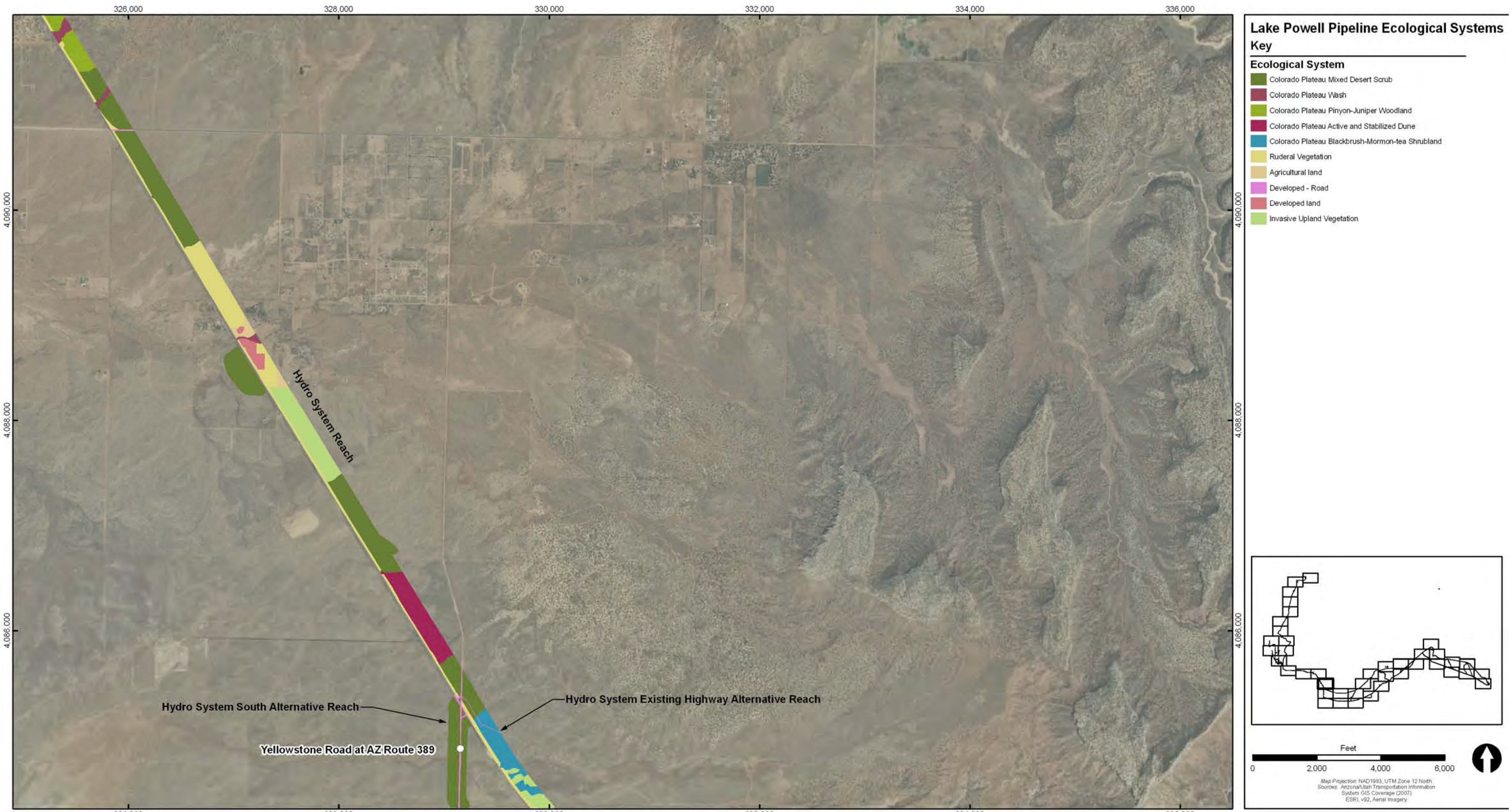

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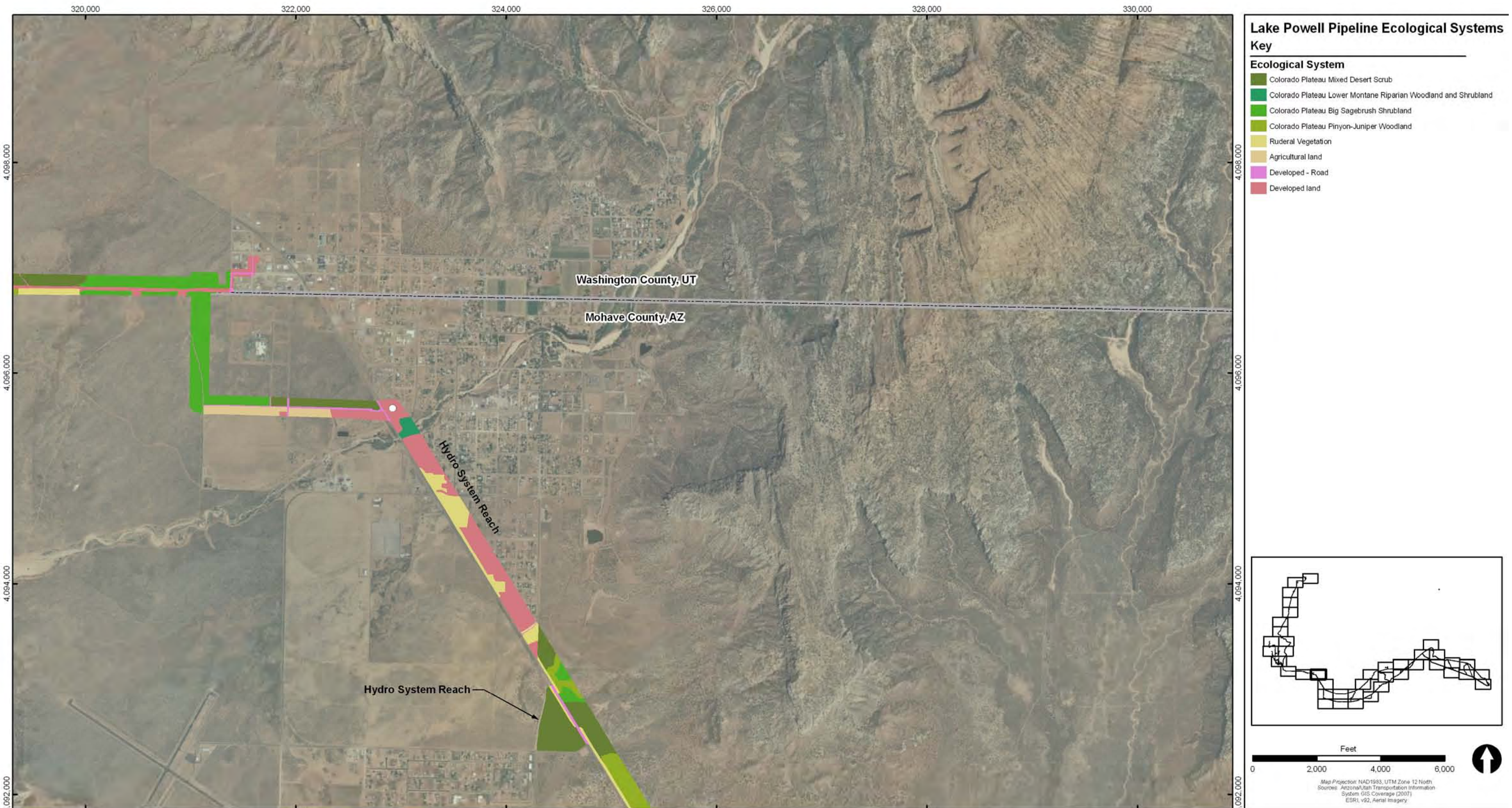

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Map E-28
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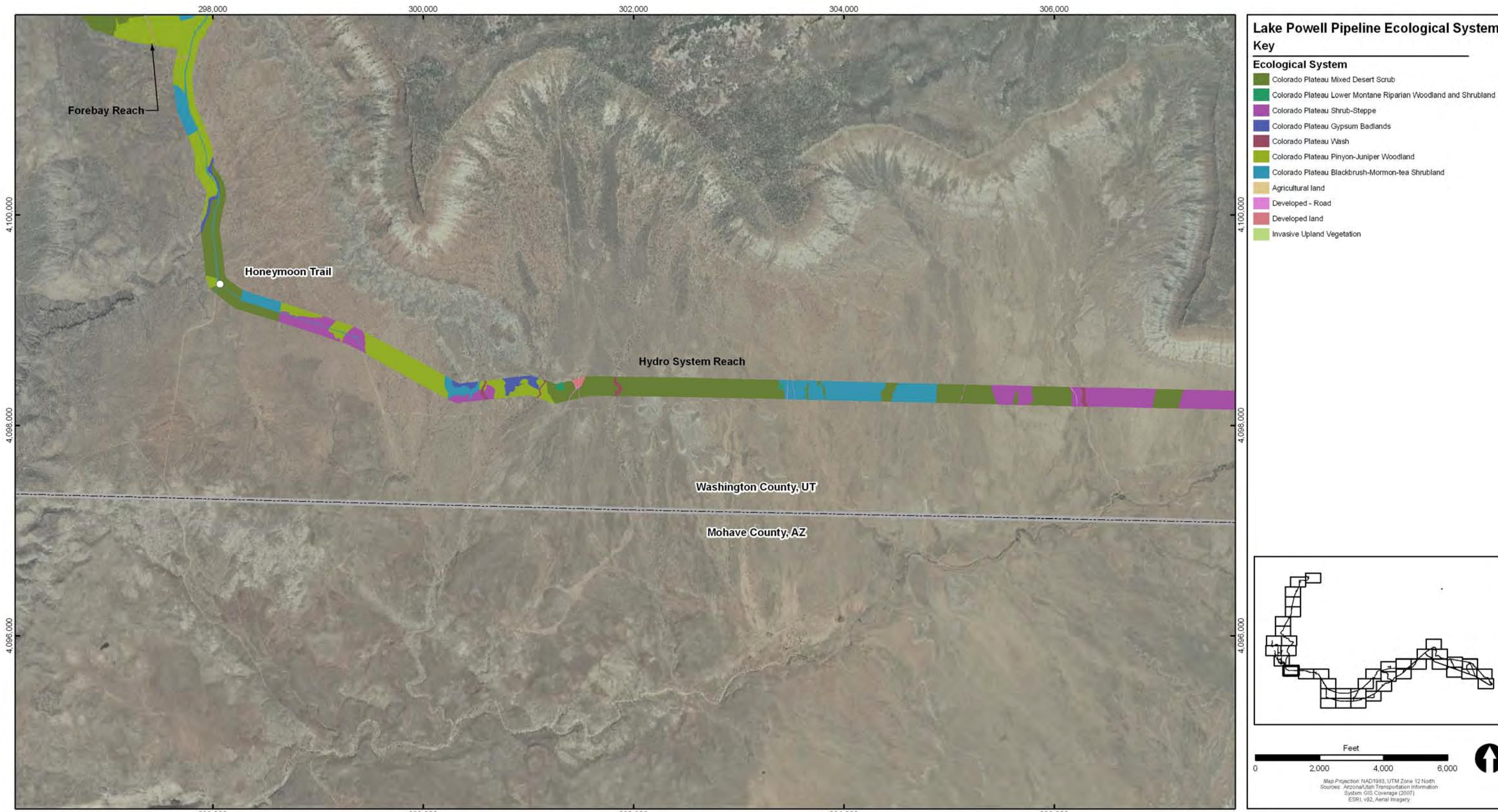

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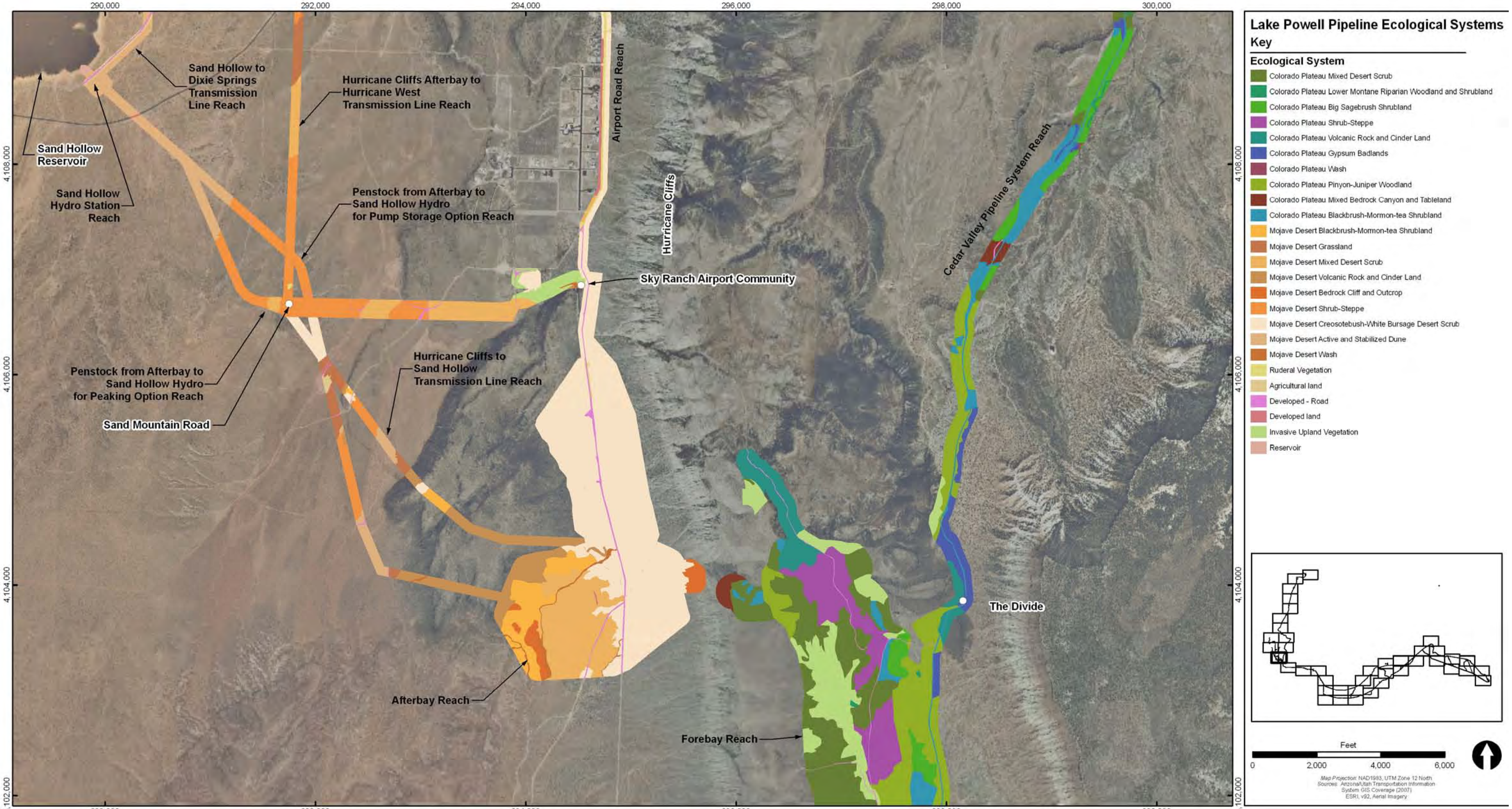

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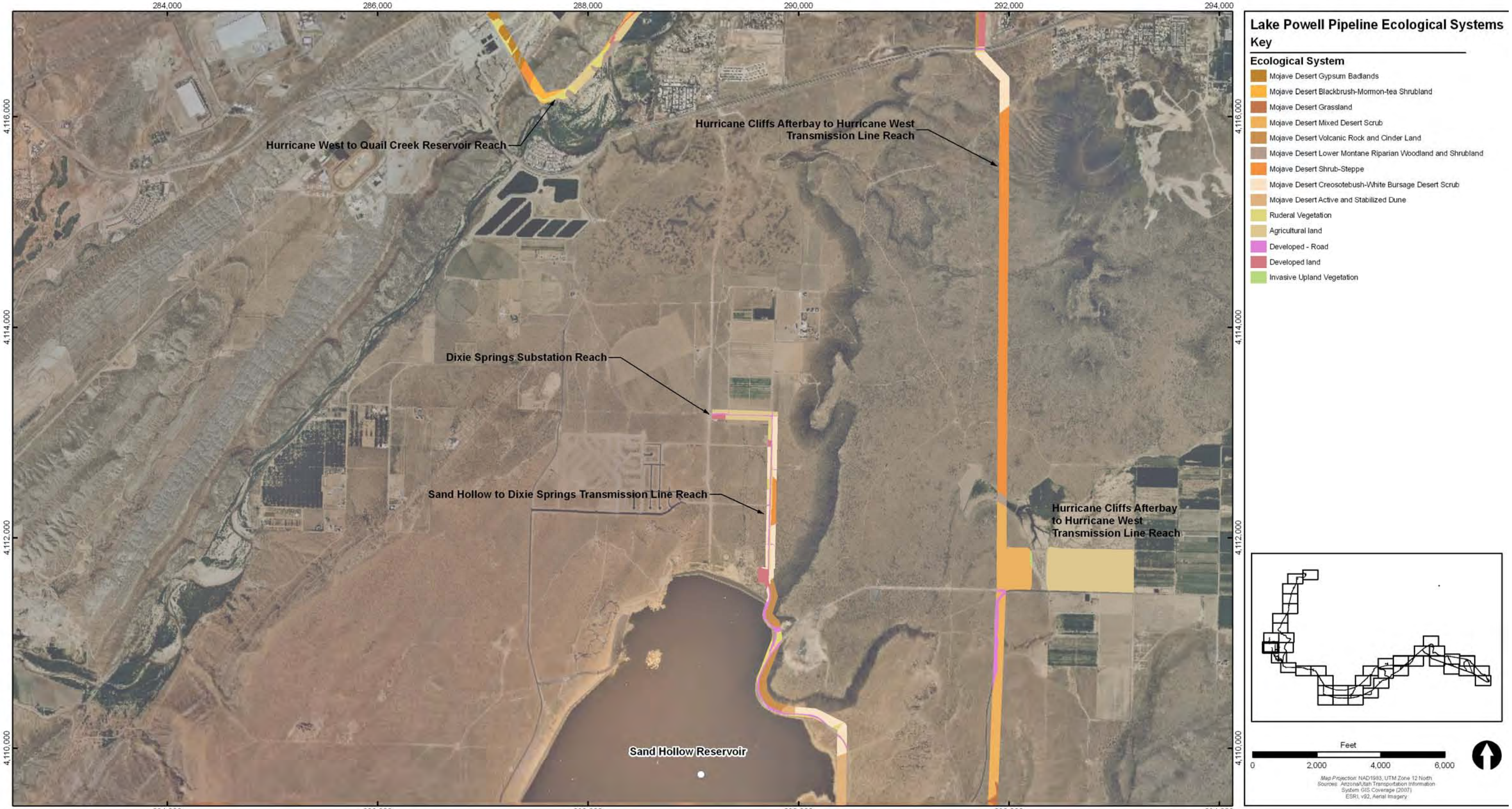

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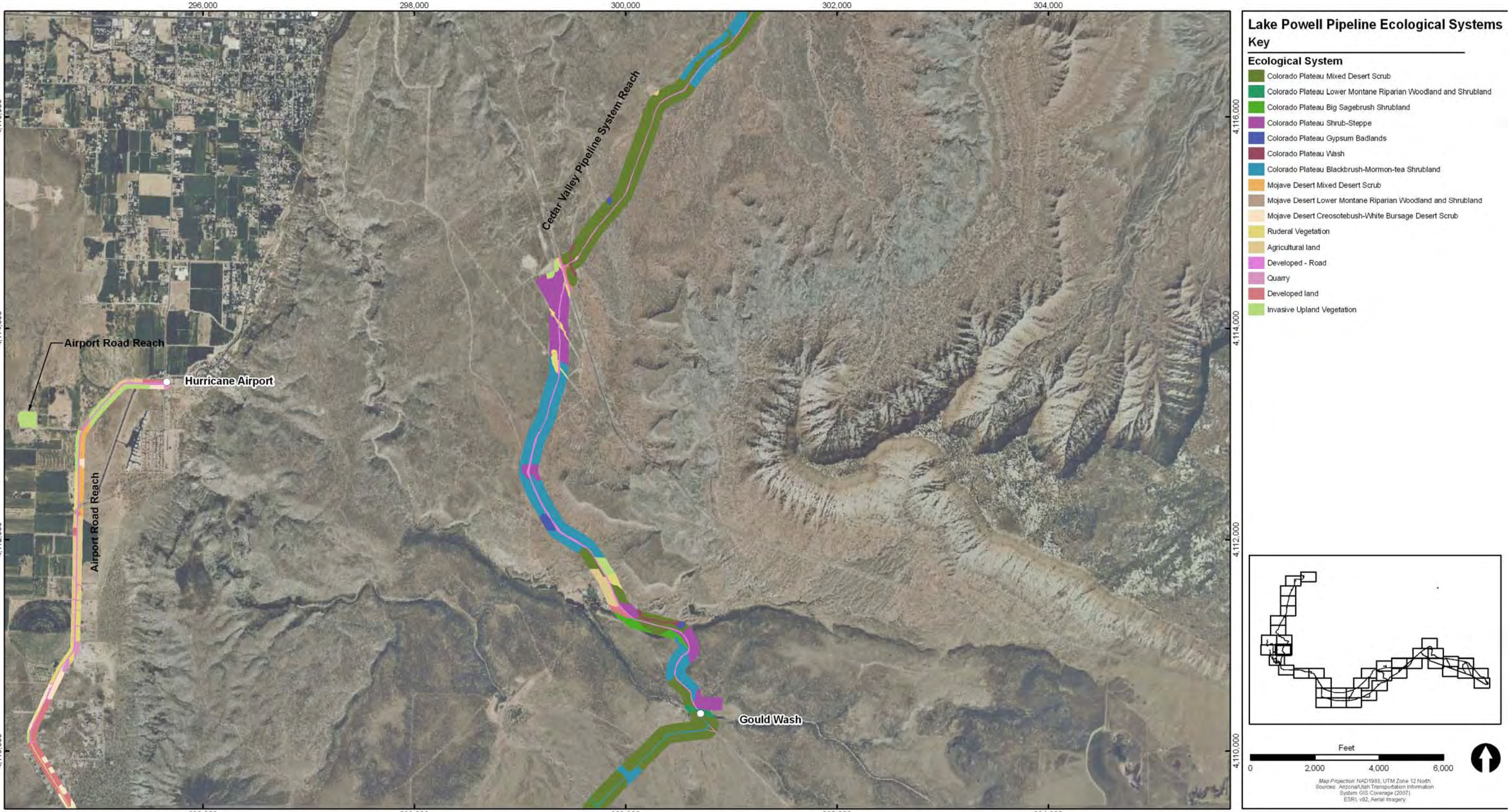

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Lake Powell Pipeline Ecological Systems

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Map E-33
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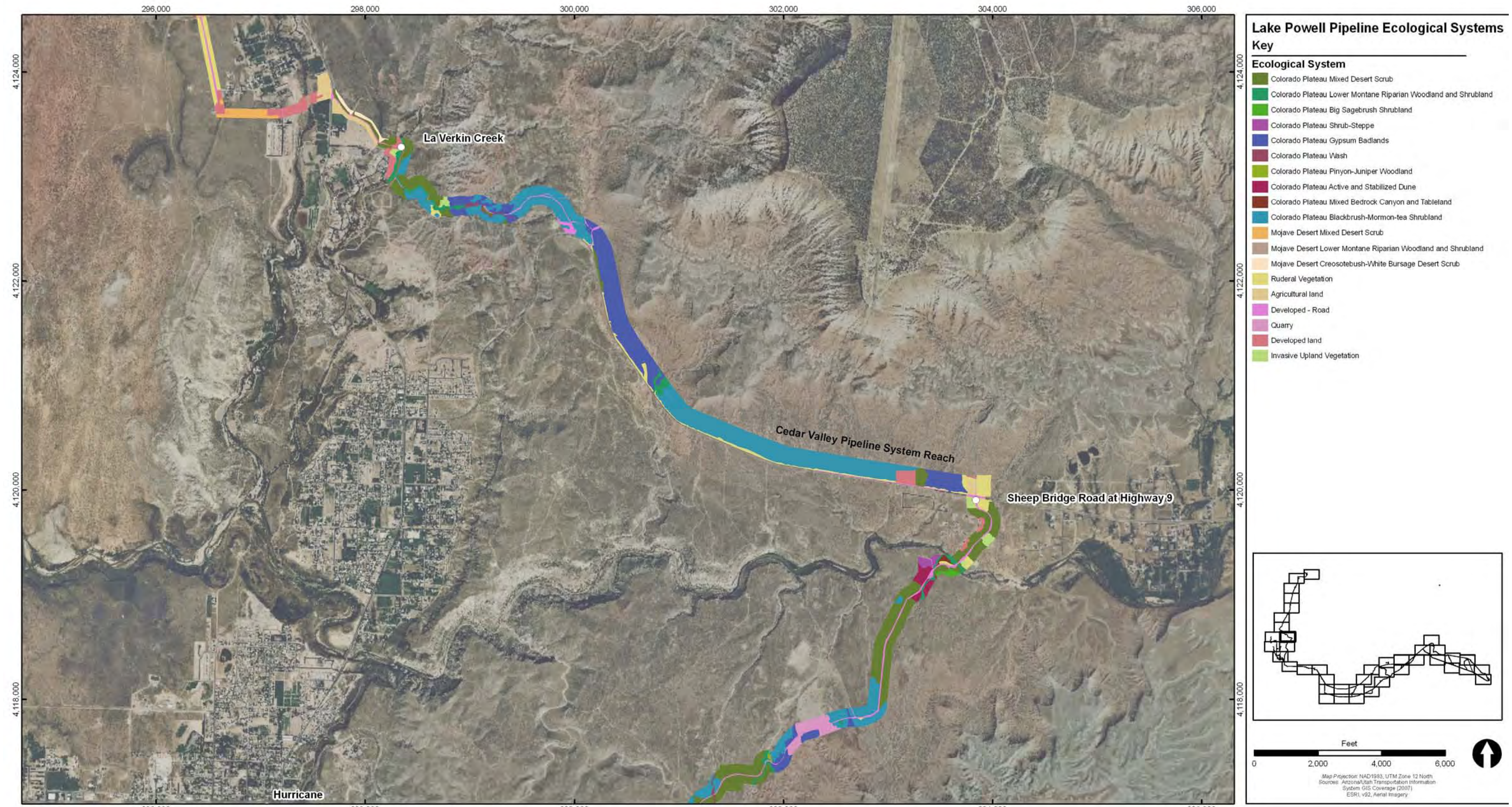

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Lake Powell Pipeline Ecological Systems

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Map E-35
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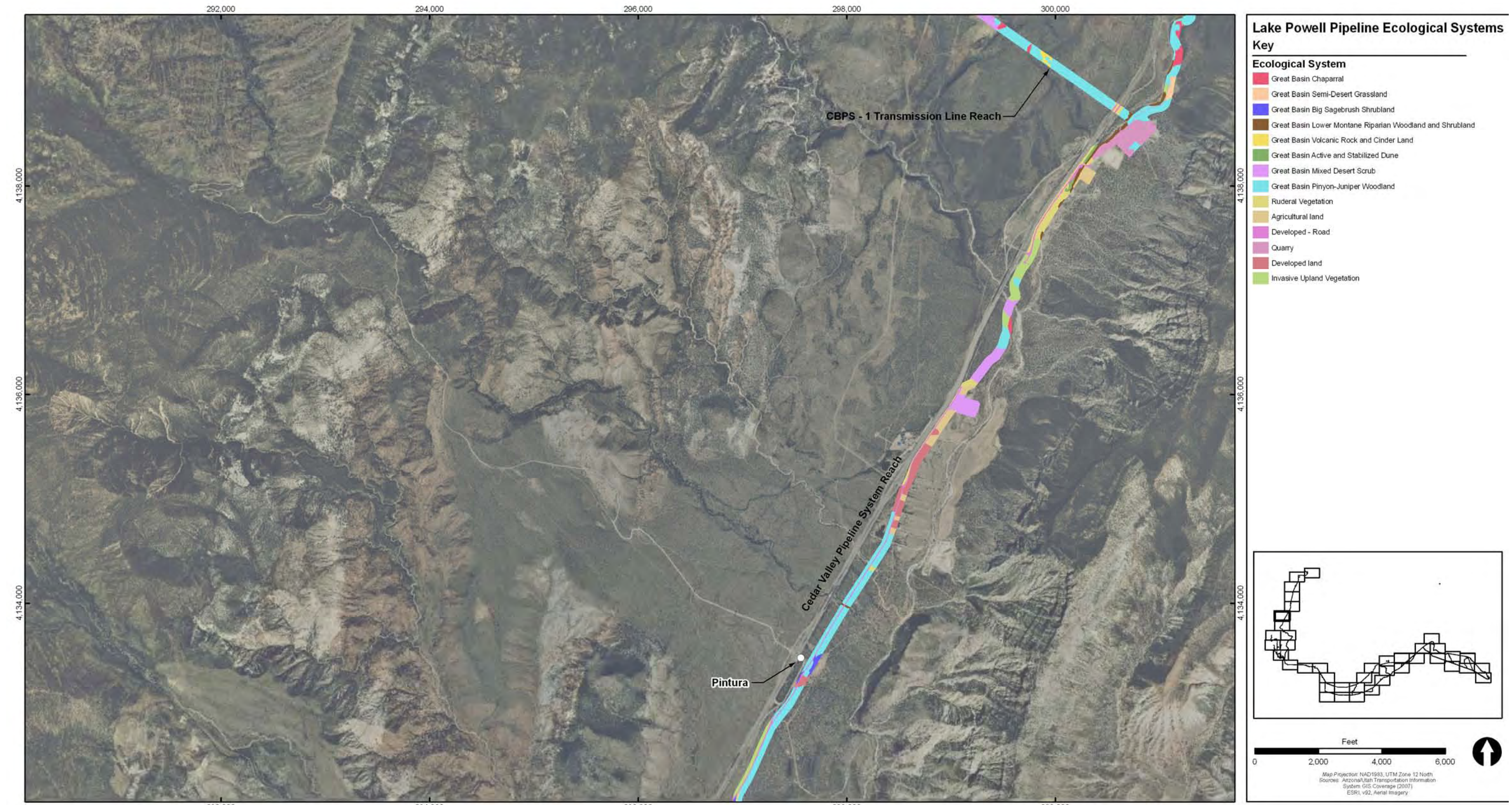

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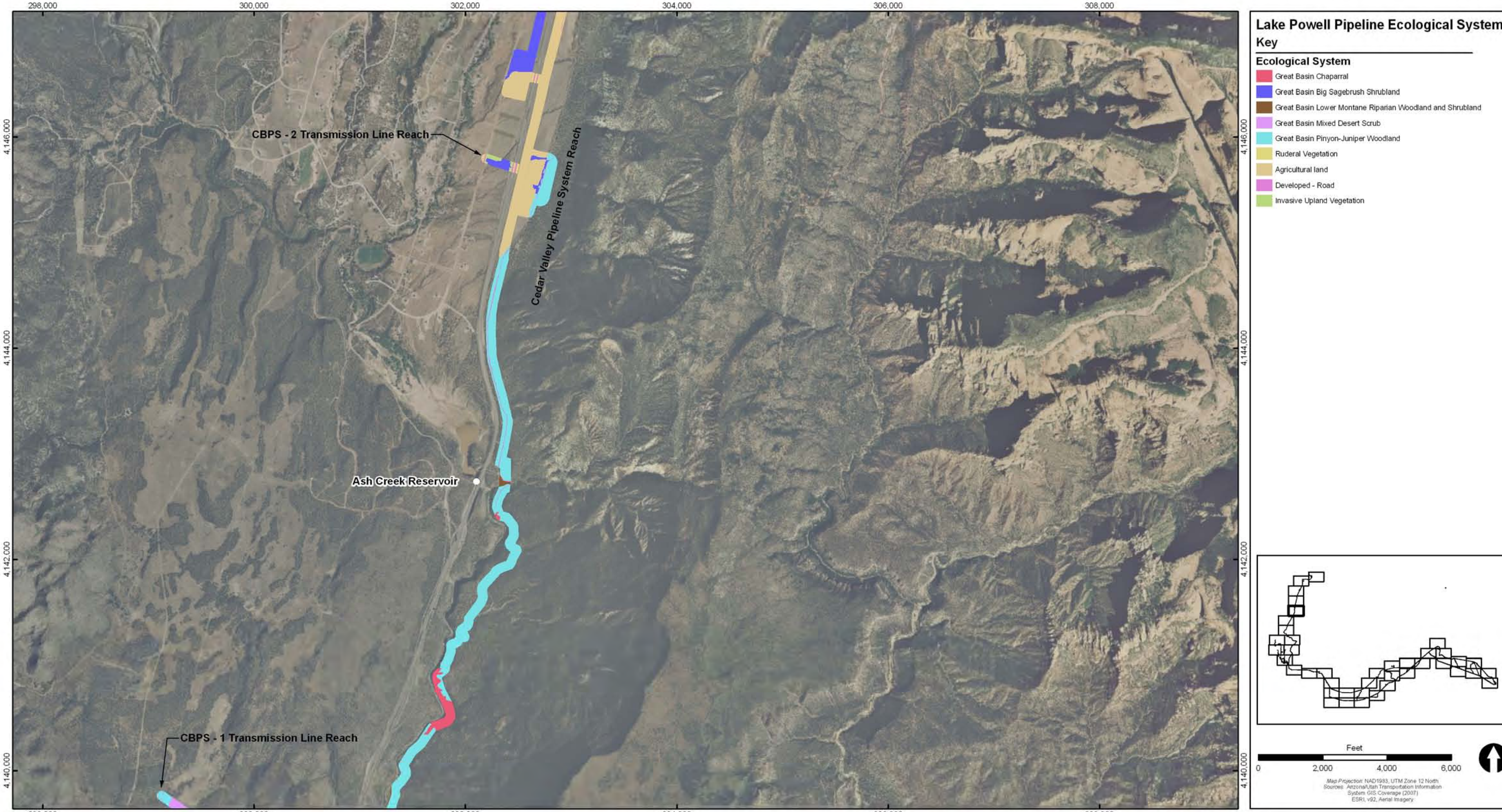

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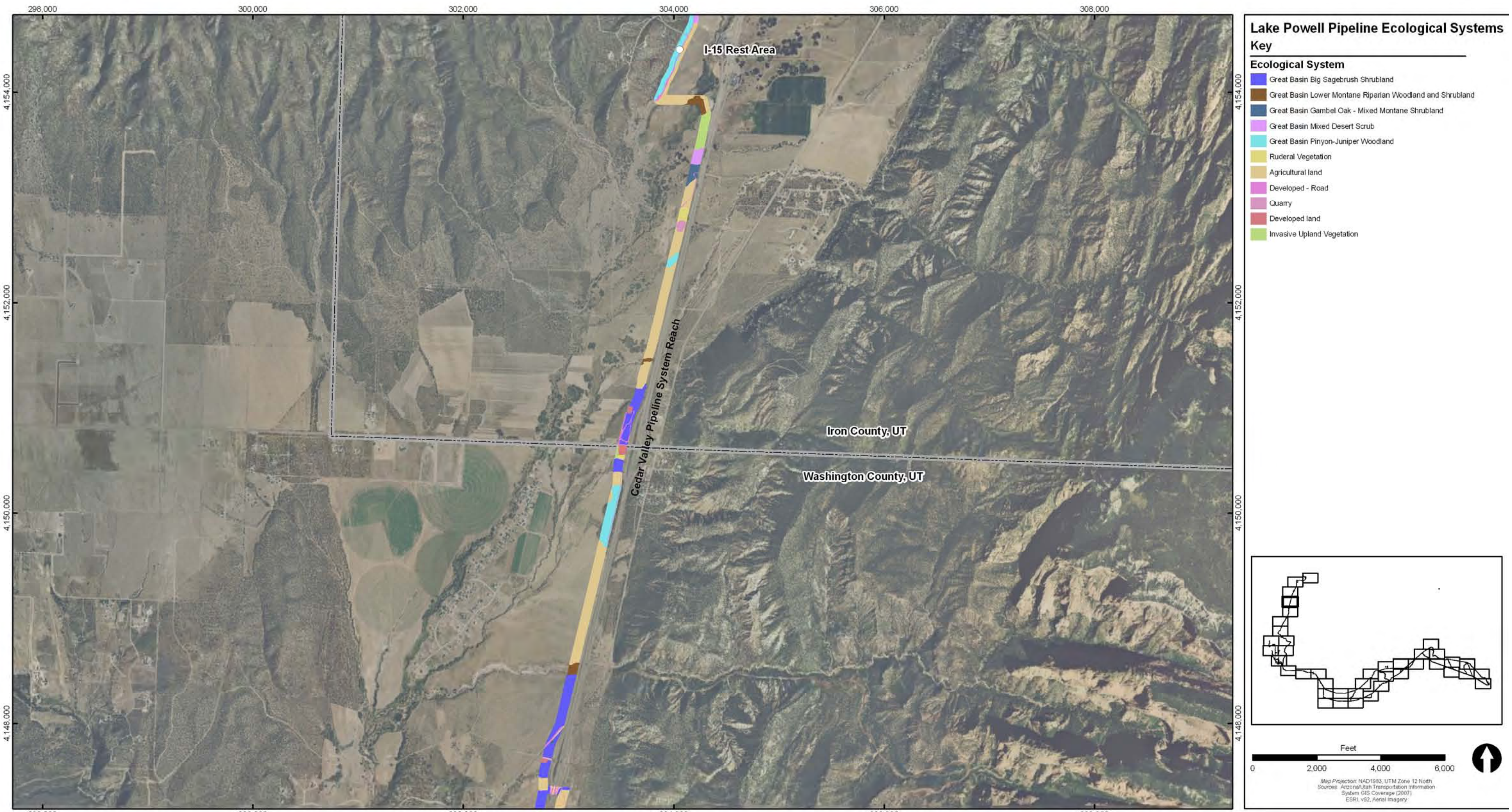

Map E-38
Lake Powell Pipeline Ecological Systems

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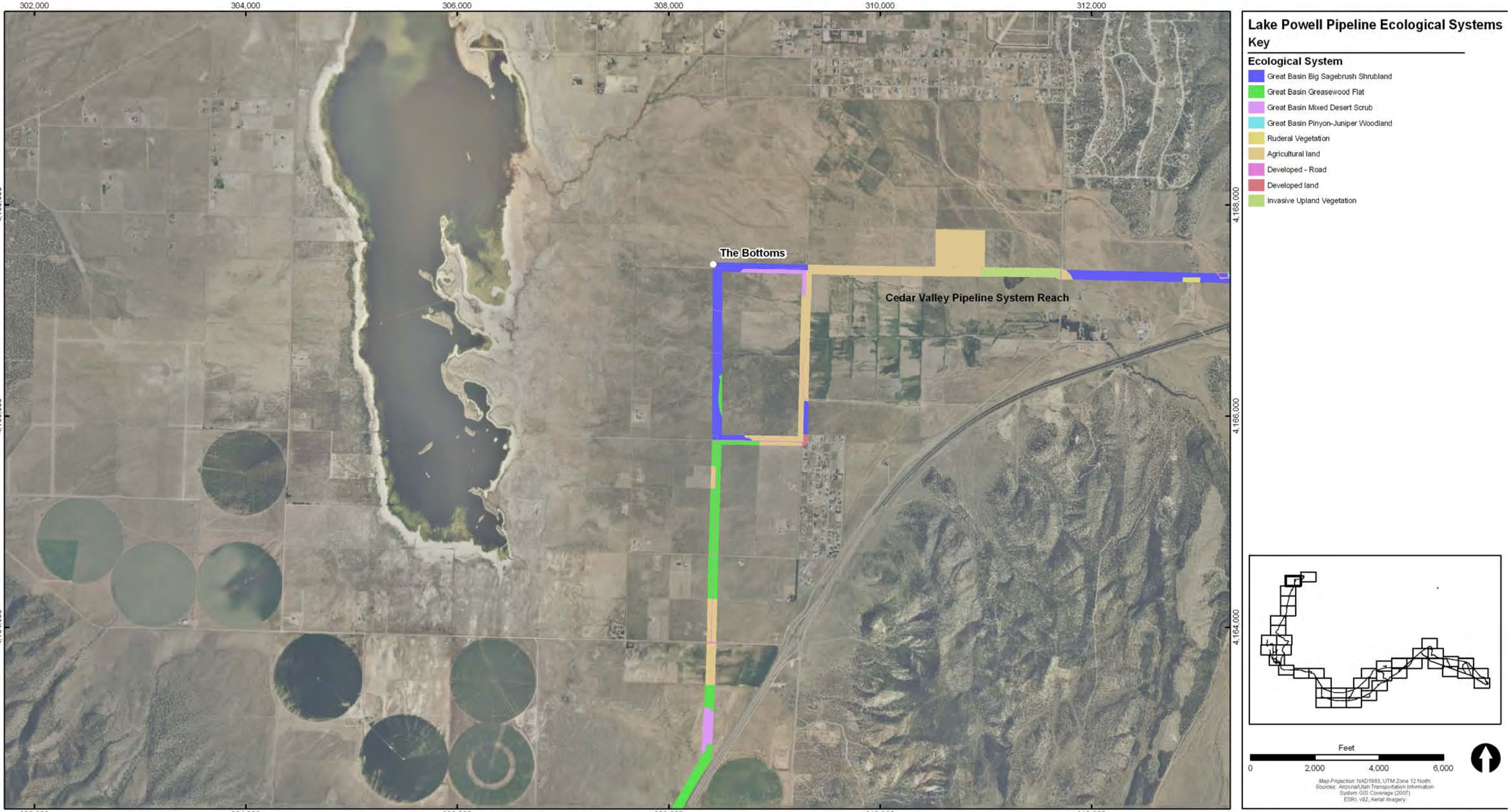
Map E-39
Lake Powell Pipeline Ecological Systems



Map E-40
Lake Powell Pipeline Ecological Systems

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Map E-41
Lake Powell Pipeline Ecological Systems