Lake Powell Pipeline Project

Final Study Report 15
Vegetation Communities

April 2016

Table of Contents

VEGETATION COMMUNITIES STUDY REPORT EXECUTIVE SUMMARY ES-1
ES.1 Introduction ES-1
ES.2 Methodology ES-1
ES.3 Key Results of the Vegetation Communities Mapping ES-1

CHAPTER 1 INTRODUCTION 1-1
1.1 Introduction 1-1
1.2 Summary Description of LPP Project Alignment Alternatives 1-1
1.2.1 South Alternative 1-1
1.2.2 Existing Highway Alternative 1-8
1.2.3 Southeast Corner Alternative 1-8
1.2.4 Transmission Line Alternatives 1-10
1.2.5 Natural Gas Pipeline and Generators Alternative 1-13
1.2.5.1 1Natural Gas Transmission Line Connection 1-15
1.2.5.2 Natural Gas Supply Line 1-15
1.2.5.3 Natural Gas Generators 1-15
1.3 Summary Description of No Lake Powell Water Alternative 1-18
1.3.1 WCWCD No Lake Powell Water Alternative 1-19
1.3.1.1 Background 1-19
1.3.1.2 WCWCD No Lake Powell Water Alternative Features 1-19
1.3.1.2.1 Re-purposing Potable Water Use. 1-21
1.3.1.2.2 Reverse Osmosis Water Treatment. 1-21
1.3.1.2.3 Secondary Water Storage in Warner Valley Reservoir. 1-22
1.3.1.2.4 Water Distribution to Apple Valley. 1-23
1.3.2 KCWCD No Lake Powell Water Alternative 1-23
1.4 Summary Description of the No Action Alternative 1-23
1.4.1 WCWCD No Action Alternative 1-23
1.4.2 KCWCD No Action Alternative 1-23
1.5 Identified Issues 1-24
1.6 Impact Topics 1-24

CHAPTER 2 STUDY AREA 2-1
2.1 Project Overview 2-1
2.2 Project Alignment 2-1
2.3 Land Ownership 2-1

Table of Contents

2.4 Ecological Setting 2-2
2.5 Climate 2-2
2.5.1 Climactic Effects on Vegetation Field Surveys 2-2
2.6 Study Corridor 2-5

CHAPTER 3 METHODOLOGY 3-1
3.1 Purpose and Approach to Vegetation Community Mapping 3-1
3.2 Pre-survey Preparations, Field Equipment, and Materials 3-1
3.3 Survey 3-2
3.4 50-meter Transects 3-4
3.5 Analysis 3-4
3.6 Classification of the Vegetation of the Lake Powell Pipeline Project 3-6
3.6.1 Plant Communities 3-6
3.6.2 Ecological Systems 3-6
3.6.3 Alliances 3-7
3.6.4 Associations 3-7
3.6.5 Physiognomic Classes 3-7
3.6.6 Understanding Plant Community Names 3-9

CHAPTER 4 VEGETATION COMMUNITIES 4-1
4.1 Ecological Systems 4-1
4.2 Colorado Plateau Region 4-1
4.2.1 Colorado Plateau Active and Stabilized Dune Ecological System 4-2
4.2.1.1 Geographic Distribution 4-2
4.2.1.2 Alliances and Associations 4-2
4.2.1.3 Physiognomy and Composition 4-4
4.2.1.4 Disturbance Regimes 4-4
4.2.2 Colorado Plateau Big Sagebrush Shrubland Ecological System 4-7
4.2.2.1 Geographic Distribution 4-7
4.2.2.2 Alliances and Associations 4-7
4.2.2.3 Physiognomy and Composition 4-9
4.2.2.4 Disturbance Regimes 4-9
4.2.3 Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System 4-12
4.2.3.1 Geographic Distribution 4-12
4.2.3.2 Alliances and Associations 4-12

Table of Contents

4.2.3.3 Physiognomy and Composition 4-13
4.2.3.4 Disturbance Regimes 4-14
4.2.4 Colorado Plateau Grassland Ecological System 4-17
4.2.4.1 Geographic Distribution 4-17
4.2.4.2 Alliances and Associations 4-17
4.2.4.3 Physiognomy and Composition 4-17
4.2.4.4 Disturbance Regimes 4-18
4.2.5 Colorado Plateau Greasewood Flat Ecological System 4-20
4.2.5.1 Geographic Distribution 4-20
4.2.5.2 Alliances and Associations 4-20
4.2.5.3 Physiognomy and Composition 4-20
4.2.5.4 Disturbance Regimes 4-21
4.2.6 Colorado Plateau Gypsum Badland Ecological System 4-23
4.2.6.1 Geographic Distribution 4-23
4.2.6.2 Alliances and Associations 4-23
4.2.6.3 Physiognomy and Composition 4-25
4.2.6.4 Disturbance Regimes 4-25
4.2.7 Colorado Plateau Juniper Savanna Ecological System 4-28
4.2.7.1 Geographic Distribution 4-28
4.2.7.2 Alliances and Associations 4-28
4.2.7.3 Physiognomy and Composition 4-28
4.2.7.4 Disturbance Regimes 4-28
4.2.8 Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System 4-31
4.2.8.1 Geographic Distribution 4-31
4.2.8.2 Alliances and Associations 4-31
4.2.8.3 Physiognomy and Composition 4-32
4.2.8.4 Disturbance Regimes 4-32
4.2.9 Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System 4-34
4.2.9.1 Geographic Distribution 4-34
4.2.9.2 Alliances and Associations 4-34
4.2.9.3 Physiognomy and Composition 4-37
4.2.9.4 Disturbance Regimes 4-37
4.2.10 Colorado Plateau Mixed Desert Scrub Ecological System 4-40
4.2.10.1 Geographic Distribution 4-40

Table of Contents

4.2.10.2 Alliances and Associations 4-40
4.2.10.3 Physiognomy and Composition 4-44
4.2.10.4 Disturbance Regimes 4-45
4.2.11 Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System 4-48
4.2.11.1 Geographic Distribution 4-48
4.2.11.2 Alliances and Associations 4-48
4.2.11.3 Physiognomy and Composition 4-48
4.2.11.4 Disturbance Regimes 4-48
4.2.12 Colorado Plateau Pinyon-Juniper Woodland Ecological System 4-51
4.2.12.1 Geographic Distribution 4-51
4.2.12.2 Alliances and Associations 4-51
4.2.12.3 Physiognomy and Composition 4-54
4.2.12.4 Disturbance Regimes 4-54
4.2.13 Colorado Plateau Shrub-Steppe Ecological System 4-57
4.2.13.1 Geographic Distribution 4-57
4.2.13.2 Alliances and Associations 4-57
4.2.13.3 Physiognomy and Composition 4-60
4.2.13.4 Disturbance Regimes 4-60
4.2.14 Colorado Plateau Volcanic Rock and Cinder Land Ecological System 4-63
4.2.14.1 Geographic Distribution 4-63
4.2.14.2 Alliances and Associations 4-63
4.2.14.3 Physiognomy and Composition 4-63
4.2.14.4 Disturbance Regimes 4-63
4.2.15 Colorado Plateau Wash Ecological System 4-65
4.2.15.1 Geographic Distribution 4-65
4.2.15.2 Alliances and Associations 4-65
4.2.15.3 Physiognomy and Composition 4-67
4.2.15.4 Disturbance Regimes 4-68
4.3 Mojave Desert Region 4-70
4.3.1 Mojave Desert Active and Stabilized Dune Ecological System 4-70
4.3.1.1 Geographic Distribution 4-70
4.3.1.2 Alliances and Associations 4-70
4.3.1.3 Physiognomy and Composition 4-71
4.3.1.4 Disturbance Regimes 4-71
4.3.2 Mojave Desert Bedrock Cliff and Outcrop Ecological System 4-74

Table of Contents

4.3.2.1 Geographic Distribution 4-74
4.3.2.2 Alliances and Associations 4-74
4.3.2.3 Physiognomy and Composition 4-74
4.3.2.4 Disturbance Regimes 4-74
4.3.3 Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System 4-76
4.3.3.1 Geographic Distribution 4-76
4.3.3.2 Alliances and Associations 4-76
4.3.3.3 Physiognomy and Composition 4-76
4.3.3.4 Disturbance Regimes 4-77
4.3.4 Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System 4-79
4.3.4.1 Geographic Distribution 4-79
4.3.4.2 Alliances and Associations 4-79
4.3.4.3 Physiognomy and Composition 4-79
4.3.4.4 Disturbance Regimes 4-80
4.3.5 Mojave Desert Grassland Ecological System 4-82
4.3.5.1 Geographic Distribution 4-82
4.3.5.2 Alliances and Associations 4-82
4.3.5.3 Physiognomy and Composition 4-82
4.3.5.4 Disturbance Regimes 4-82
4.3.6 Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System 4-84
4.3.6.1 Geographic Distribution 4-84
4.3.6.2 Alliances and Associations 4-84
4.3.6.3 Physiognomy and Composition 4-84
4.3.6.4 Disturbance Regimes 4-84
4.3.7 Mojave Desert Mixed Desert Scrub Ecological System 4-87
4.3.7.1 Geographic Distribution 4-87
4.3.7.2 Alliances and Associations 4-87
4.3.7.3 Physiognomy and Composition 4-88
4.3.7.4 Disturbance Regimes 4-88
4.3.8 Mojave Desert Shrub-Steppe Ecological System 4-90
4.3.8.1 Geographic Distribution 4-90
4.3.8.2 Alliances and Associations 4-90
4.3.8.3 Physiognomy and Composition 4-91
4.3.8.4 Disturbance Regimes 4-91
4.3.9 Mojave Desert Volcanic Rock and Cinder Land Ecological System 4-93

Table of Contents

4.3.9.1 Geographic Distribution 4-93
4.3.9.2 Alliances and Associations 4-93
4.3.9.3 Physiognomy and Composition 4-94
4.3.9.4 Disturbance Regimes 4-94
4.3.10 Mojave Desert Wash Ecological System 4-96
4.3.10.1 Geographic Distribution 4-96
4.3.10.2 Alliances and Associations 4-96
4.3.10.3 Physiognomy and Composition 4-96
4.3.10.4 Disturbance Regimes 4-96
4.4 Anthropogenic lands 4-99
4.4.1 Agricultural Land 4-99
4.4.1.1 Geographic Distribution 4-99
4.4.1.2 Acreages 4-99
4.4.1.3 Physiognomy and Composition 4-99
4.4.2 Developed Land 4-101
4.4.2.1 Geographic Distribution 4-101
4.4.2.2 Acreages 4-101
4.4.2.3 Physiognomy and Composition 4-101
4.4.3 Invasive Upland Vegetation 4-103
4.4.3.1 Geographic Distribution 4-103
4.4.3.2 Alliances and Associations 4-103
4.4.3.3 Physiognomy and Composition 4-104
4.4.4 Quarry 4-104
4.4.4.1 Geographic Distribution 4-104
4.4.4.2 Acreages 4-104
4.4.4.3 Physiognomy and Composition 4-104
4.4.5 Reservoir 4-104
4.4.5.1 Geographic Distribution 4-104
4.4.5.2 Acreages 4-104
4.4.5.3 Physiognomy and Composition 4-104
4.4.6 Ruderal Vegetation 4-104
4.4.6.1 Geographic Distribution 4-104
4.4.6.2 Acreages 4-105
4.4.6.3 Physiognomy and Composition 4-105

Table of Contents

CHAPTER 5 CONCLUSION 5-1

References Cited.....R-1
Glossary..... G-1
Abbreviations and Acronyms.....A&A-1
List of Preparers LP-1
Appendix A Data Sheet for Field Surveys A-1
Appendix B Data Sheet for 50-m Transect Surveys.....B-1
Appendix C Lake Powell Pipeline Place Names and Reaches Map C-1
Appendix D Lake Powell Pipeline Ecological Systems Maps D-1

Table of Contents

Tables

Table ES-1 Vegetation Mapping Summary ES-1
Table 1-1 Water Conveyance System Natural Gas Generator Annual Fuel Consumption 1-18
Table 1-2 Available Supply and Projected Demands Under the No Lake Powell Water and Lake Powell Pipeline Project Alternatives 1-21
Table 4-1 Colorado Plateau Region 4-1
Table 4-2 Mojave Desert Region 4-73
Table 5-1 Vegetation Mapping Summary 5-1

Figures

Figure 1-1 Lake Powell Pipeline Proposed Project 1-2
Figure 1-2 Lake Powell Pipeline Intake and Water Conveyance Systems 1-4
Figure 1-3 Pipeline and Penstock Right-of-Way 1-5
Figure 1-4 Lake Powell Pipeline Hydro System South Alternative 1-7
Figure 1-5 Lake Powell Pipeline Hydro System Existing Highway Alternative 1-9
Figure 1-6 Lake Powell Pipeline Hydro System Southeast Corner Alternative 1-11
Figure 1-7 Lake Powell Pipeline Proposed Transmission Lines East 1-12
Figure 1-8 Lake Powell Pipeline Proposed Transmission Lines West 1-14
Figure 1-9 Lake Powell Pipeline Natural Gas Supply Line and Generators West Alternatives 1-16
Figure 1-10 Lake Powell Pipeline Natural Gas Supply Line and Generators East Alternative 1-17
Figure 1-11 No Lake Powell Water Alternative Primary Structure 1-20
Figure 2-1 Land Ownership 2-3
Figure 2-2 Ecological Regions 2-4
Figure 2-3 2008 Average Monthly Maximum Temperatures, as Compared to 30-year Averages 2-5
Figure 2-4 2009 Average Monthly Maximum Temperatures, as Compared to 30-year Averages 2-5
Figure 2-5 2010 Average Monthly Maximum Temperatures, as Compared to 30-year Averages 2-6
Figure 2-6 2008 Average Monthly Precipitation, as Compared to 30-year Averages 2-6
Figure 2-7 2009 Average Monthly Precipitation, as Compared to 30-year Averages 2-7
Figure 2-8 2010 Average Monthly Precipitation, as Compared to 30-year Averages 2-7
Figure 2-9 Vegetation Resources Survey Area 2-9
Figure 3-1 Survey Corridors 3-5
Figure 3-2 Survey Methods 3-6
Figure 3-3 50-meter Transect Locations 3-7
Figure 4-1 Colorado Plateau Active and Stabilized Dune Ecological System 4-4
Figure 4-2 Colorado Plateau Active and Stabilized Dune Ecological System Map 4-6
Figure 4-3 Colorado Plateau Big Sagebrush Shrubland Ecological System 4-9
Figure 4-4 Colorado Plateau Big Sagebrush Shrubland Ecological System Map 4-11
Figure 4-5 Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System 4-14

Table of Contents

Figure 4-6 Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System Map 4-16
Figure 4-7 Colorado Plateau Grassland Ecological System 4-18
Figure 4-8 Colorado Plateau Grassland Ecological System Map 4-19
Figure 4-9 Colorado Plateau Greasewood Flat Ecological System 4-21
Figure 4-10 Colorado Plateau Greasewood Flat Ecological System Map 4-22
Figure 4-11 Colorado Plateau Gypsum Badland Ecological System, Mud Wash 4-25
Figure 4-12 Colorado Plateau Gypsum Badland Ecological System, Cryptobiotic Ridge 4-25
Figure 4-13 Colorado Plateau Gypsum Badland Ecological System Map 4-27
Figure 4-14 Colorado Plateau Juniper Savanna Ecological System 4-29
Figure 4-15 Colorado Plateau Juniper Savanna Ecological System Map 4-30
Figure 4-16 Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System 4-32
Figure 4-17 Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System Map 4-33
Figure 4-18 Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System 4-37
Figure 4-19 Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System Map 4-39
Figure 4-20 Colorado Plateau Mixed Desert Scrub Ecological System 4-45
Figure 4-21 Colorado Plateau Mixed Desert Scrub Ecological System Map 4-47
Figure 4-22 Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System 4-49
Figure 4-23 Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System Map 4-50
Figure 4-24 Colorado Plateau Pinyon-Juniper Woodland Ecological System 4-54
Figure 4-25 Colorado Plateau Pinyon-Juniper Woodland Ecological System Map 4-56
Figure 4-26 Colorado Plateau Shrub-Steppe Ecological System 4-61
Figure 4-27 Colorado Plateau Shrub-Steppe Ecological System Map 4-63
Figure 4-28 Colorado Plateau Volcanic Rock and Cinder Land Ecological System 4-64
Figure 4-29 Colorado Plateau Volcanic Rock and Cinder Land Ecological System Map 4-66
Figure 4-30 Colorado Plateau Wash Ecological System 4-70
Figure 4-31 Colorado Plateau Wash Ecological System Map 4-72
Figure 4-32 Mojave Desert Active and Stabilized Dune Ecological System 4-74
Figure 4-33 Mojave Desert Active and Stabilized Dune Ecological System Map 4-76
Figure 4-34 Mojave Desert Bedrock Cliff and Outcrop Ecological System 4-78
Figure 4-35 Mojave Desert Bedrock Cliff and Outcrop Ecological System Map 4-79
Figure 4-36 Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System 4-81
Figure 4-37 Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System Map 4-82
Figure 4-38 Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System 4-84
Figure 4-39 Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System Map 4-85
Figure 4-40 Mojave Desert Grassland Ecological System 4-86
Figure 4-41 Mojave Desert Grassland Ecological System Map 4-87

Table of Contents

Figure 4-42 Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System 4-88
Figure 4-43 Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System Map 4-90
Figure 4-44 Mojave Desert Mixed Desert Scrub Ecological System 4-92
Figure 4-45 Mojave Desert Mixed Desert Scrub Ecological System Map 4-93
Figure 4-46 Mojave Desert Shrub-Steppe Ecological System 4-95
Figure 4-47 Mojave Desert Shrub-Steppe Ecological System Map 4-96
Figure 4-48 Mojave Desert Volcanic Rock and Cinder Land Ecological System 4-98
Figure 4-49 Mojave Desert Volcanic Rock and Cinder Land Ecological System Map 4-99
Figure 4-50 Mojave Desert Wash Ecological System 4-101
Figure 4-51 Mojave Desert Wash Ecological System Map 4-102
Figure 4-52 Agricultural Land Map 4-104
Figure 4-53 Developed Land Map 4-106
Figure 4-54 Developed Land–Roads Map 4-107
Figure 4-55 Invasive Upland Vegetation Map 4-111
Figure 4-56 Quarries Map 4-112
Figure 4-57 Reservoirs Map 4-113
Figure 4-58 Ruderal Vegetation Map 4-114

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 4,029 classified polygons—2,971 of these classified polygons represented natural communities and 1,058 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	Mojave Desert Region
GIS Classified Polygons	3,722	307
Corridor Acreages	14,487	1163
Ecological Systems	15	10
Alliances	195	35
Associations	490	64

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 Lake Powell Pipeline (LPP) Project alignment alternatives, the No Lake Powell Water Alternative, and the No Action Alternative. It introduces the area studied for environmental resources. It provides an overview of the proposed LPP Project, including each alignment alternative and locator maps.

The LPP Project would deliver Utah's Colorado River water from Lake Powell to the service areas of Washington County Water Conservancy District (WCWCD) and Kane County Water Conservancy District (KCWCD). The LPP Project action alternatives studied include various pipeline and penstock system configurations. Each action alternative would deliver 86,249 acre-feet of municipal and industrial (M&I) use water to the following southwest Utah water conservancy district service areas:

- WCWCD would receive 82,249 acre-feet annually.
- KCWCD would receive up to 4,000 acre-feet annually.

One of the LPP systems previously studied included a conveyance system for the Central Iron County Water Conservancy District (CICWCD), which would have delivered approximately 13,249 acre-feet annually to the Cedar Valley area. The various alternatives were under study when the CICWCD decided to withdraw from the LPP Project, and this conveyance system is no longer being considered.

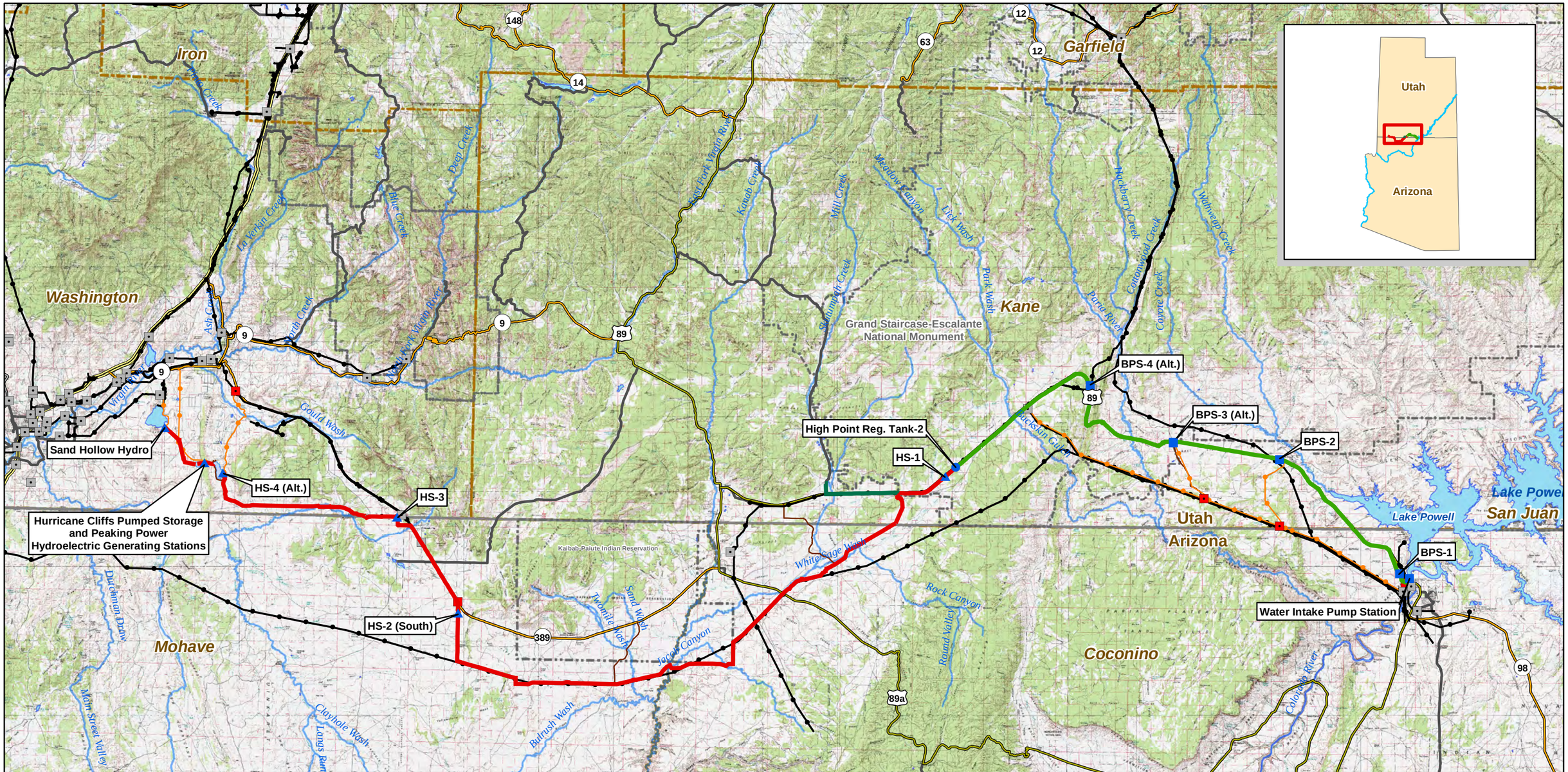
1.2 Summary Description of LPP Project Alignment Alternatives

Three primary pipeline and penstock alignment alternatives are described in this section, along with the electrical power transmission line alignments for providing power to the pump stations and a natural gas supply line alignment alternative. The pipeline and penstock alignment alternatives share common segments between the intake at Lake Powell and delivery at Sand Hollow Reservoir, and they differ spatially in, through and around Kaibab-Paiute Indian Reservation.

The South Alternative (Proposed Action) extends south around Kaibab-Paiute Indian Reservation. The Existing Highway Alternative follows an Arizona state highway through Kaibab-Paiute Indian Reservation. The Southeast Corner Alternative follows the Navajo-McCullough Transmission Line corridor through the southeast corner of Kaibab-Paiute Indian Reservation. The Electric Transmission Line alignments are common to all the pipeline and penstock alignment alternatives. The Natural Gas Supply Line Alignment Alternative is common to all pipeline and penstock alignment alternatives. The natural gas pipeline alignment would be coincident to the buried waterline and would not have a different alignment, as compared to transmission line alignments. Figure 1-1 shows the overall proposed project from Lake Powell near Page, Arizona to Sand Hollow Reservoir, Utah.

1.2.1 South Alternative

The South Alternative consists of four systems: **Water Intake, Water Conveyance, Hydro,** and **KCWCD** (see Figure 1-1).



Project Pump Station
Project Regulating Tank
Project Hydro Station
Substation
Proposed Substation

Water Conveyance System
Hydro System - South Alternative (Penstock Segment)
KCWCD System
Project Transmission Lines
Existing Transmission Lines

Interstate
US Highway
ST Highway
Hwy
Major Road
Access Roads

Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams

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

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

N

0 2.5 5 10 15 20 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-1** MWH

Lake Powell Pipeline Proposed Action

The **Water 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. An enclosed pump station building would house vertical turbine pumps with electric motors, electrical controls, and other equipment at a ground level elevation of 3,745 feet above mean sea level (AMSL).

The **Water Conveyance System** would convey water diverted from Lake Powell at the Intake System through a buried 69-inch diameter pipeline for about 51 miles, parallel with Highway 89 in Coconino County, Arizona and Kane County, Utah, to a buried regulating tank (High Point Regulating Tank-2) along Highway 89 at ground level elevation 5,691 feet AMSL. The pipeline would be a line of connected pipes used for carrying water over a long distance. Figure 1-2 shows the LPP Project Water Intake and Water Conveyance systems. The High Point Regulating Tank-2 would be the LPP Project topographic high point (Figure 1-2). The pipeline would be sited within a utility corridor established by Congress in 1998 that extends 500 feet south and 240 feet north of the Highway 89 centerline on public land administered by Bureau of Land Management (BLM) (U.S. Congress 1998). Figure 1-3 shows the typical 100-foot-wide right-of-way and 20-foot-wide temporary construction easement for the water conveyance system pipeline, adjacent to and away from the highway.

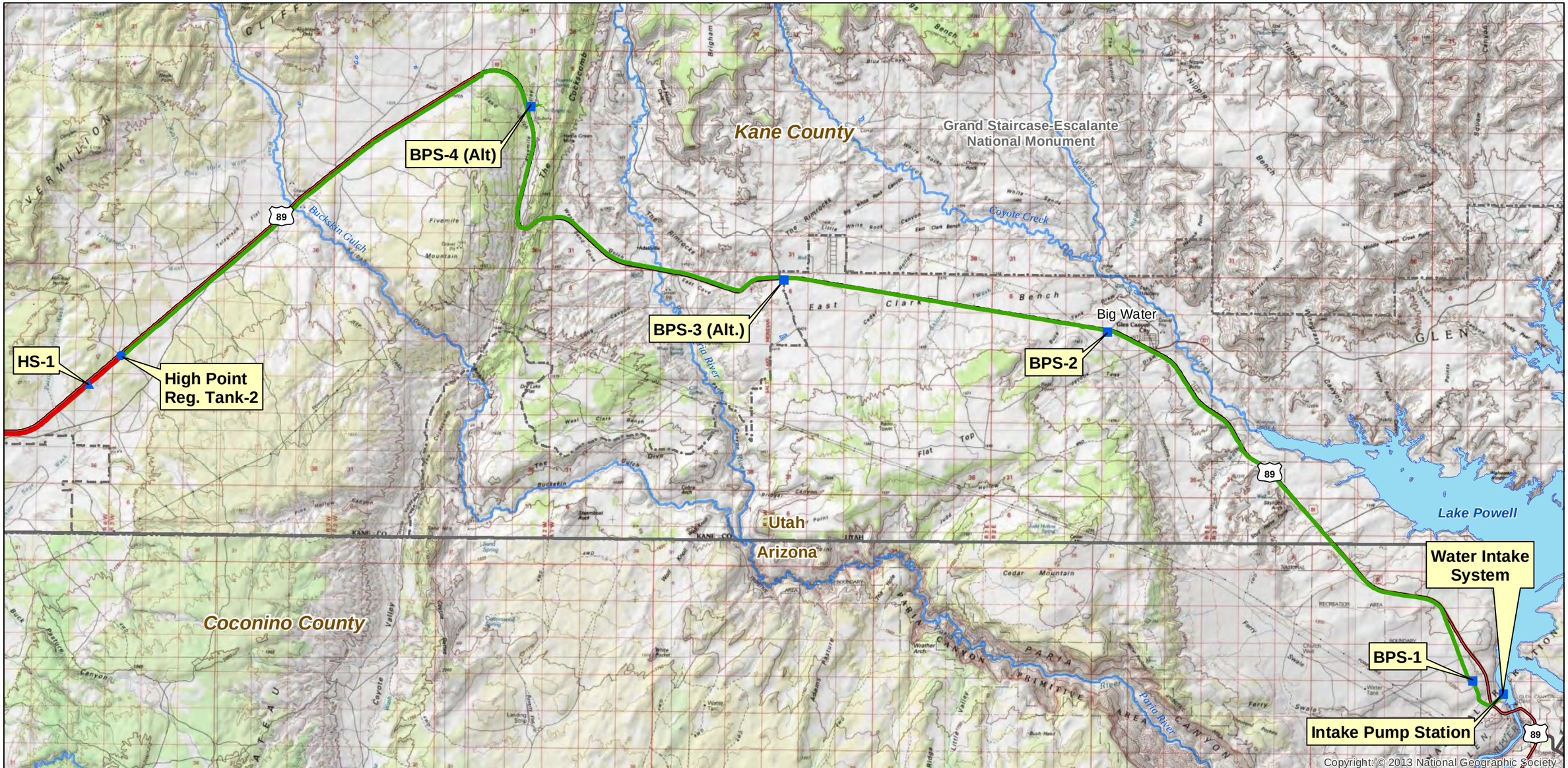
Four booster pump stations (BPS) along the pipeline would pump water to the high point regulating tank. Each BPS would house vertical turbine pumps with electric motors, electrical controls, and other equipment. Additionally, each BPS site would have a buried forebay tank, buried surge tanks, pig retrieval and launching stations, and a surface emergency overflow detention basin. BPS-1 would be located within Glen Canyon National Recreation Area (GCNRA) adjacent to an existing Arizona Department of Transportation maintenance facility, along a segment of abandoned highway, west of Highway 89. The BPS-1 site would cover about six acres and be surrounded by security fencing.

BPS-2 would be on land administered by Utah School and Institutional Trust Lands Administration (SITLA) near Big Water, Utah, on the south side of Highway 89. The BPS-2 site would cover about five acres and be surrounded by security fencing.

BPS-3 (Alt.) would be on land administered by BLM Kanab Field Office, near the east boundary of Grand Staircase-Escalante National Monument (GSENM) on the south side of Highway 89, within the Congressionally-designated utility corridor. The BPS-3 (Alt.) site would cover about five acres and be surrounded by security fencing.

BPS-4 (Alt.) would be located on private land east of Highway 89 and west of the Cockscomb geologic feature (Figure 1-2). The BPS-4 (Alt.) site would cover about six acres and be surrounded by security fencing. The proposed pipeline alignment west of the Cockscomb geologic feature would be situated adjacent to the south boundary of the Congressionally-designated utility corridor.

The proposed pipeline alignment would continue parallel to Highway 89 to the buried High Point Regulating Tank-2 at 5,691 feet AMSL, which would be the topographic high point of the LPP Project (Figure 1-2). The Water Conveyance System would terminate at High Point Regulating Tank-2. The buried High Point Regulating Tank-2 would cover about four acres and be surrounded by security fencing.



- Project Pump Station
- Project Regulating Tank
- Project Hydro Station
- Water Conveyance System
- Hydro System - South Alternative (Penstock Segment)
- KCWCD System
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- Lakes & Reservoirs
- Major Rivers & Streams
- National Park/Monument
- GSENM Boundary
- State Boundaries

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

N

0 0.5 1 2 3 4 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-2** MWH

Lake Powell Pipeline Intake and Water Conveyance System

Figure 1-3 shows the typical 100-foot-wide right-of-way and 20-foot-wide temporary construction easement for the hydro system penstock adjacent to, and away from, the highway. Four in-line hydro generating stations (HS-1, HS-2 [South], HS-3, and HS-4 [Alt.]), with substations located along the penstock, would generate electricity and help control water pressure in the penstock. Each in-line hydro station would consist of a building housing the generator units, an afterbay reservoir, retention basin, pig retrieval and launching stations, switchyard, and maintenance parking area, all surrounded by perimeter security fencing.

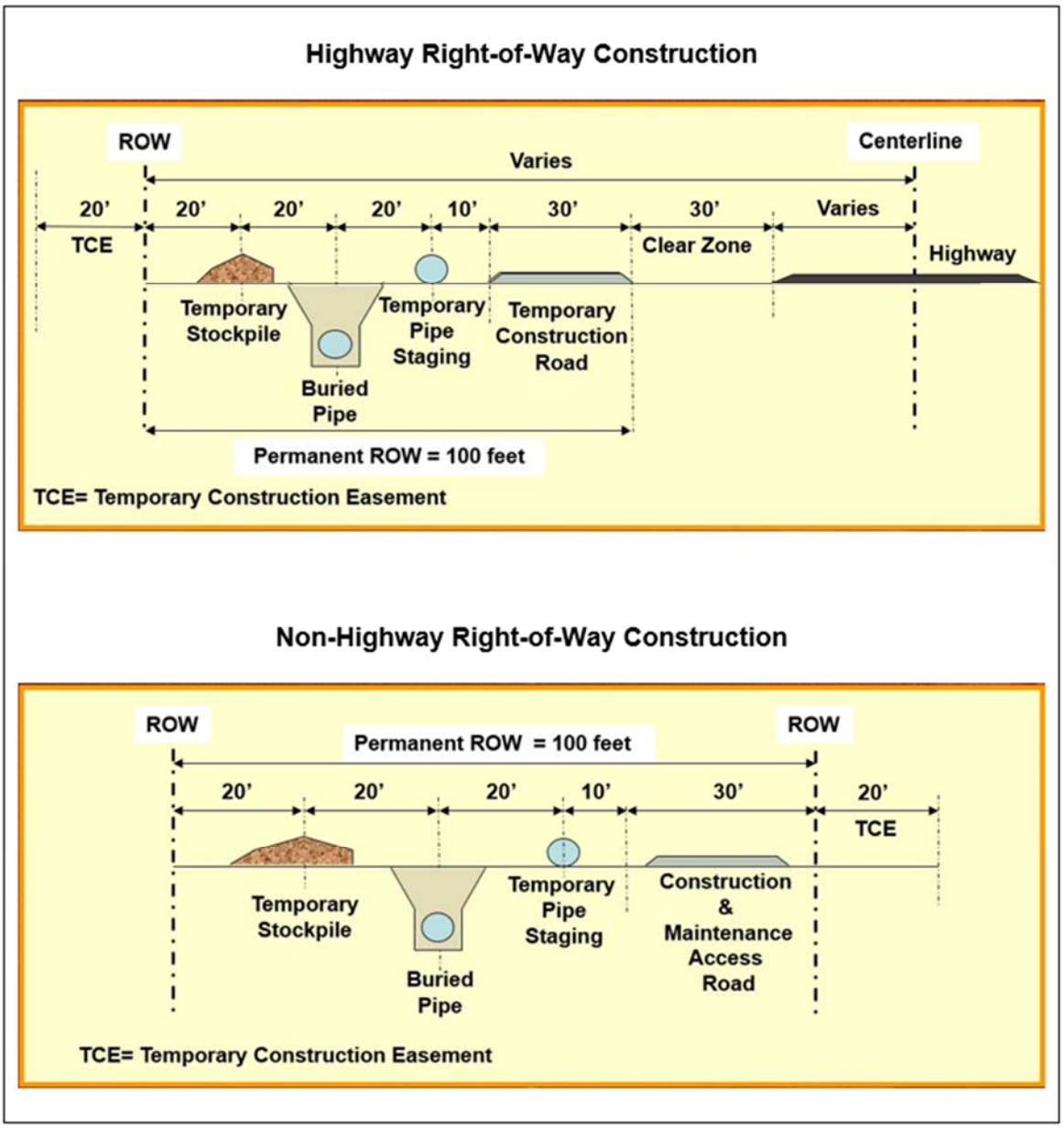


Figure 1-3
Pipeline and Penstock Right-of-Way

The **Hydro System** would convey the water from High Point Regulating Tank-2, at a topographic high point in the LPP Project with ground level elevation 5,691 feet AMSL, for about 87.5 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah, and Coconino and Mohave counties, Arizona, to Sand Hollow Reservoir near St. George, Utah (Figure 1-4). A penstock is an enclosed pipe that delivers water to hydroelectric turbines.

A short penstock segment would convey the water to HS-1. This in-line hydro station would generate up to one megawatt (MW) of electricity at a site along Highway 89 within GSENM, and the penstock would continue west along Highway 89 to the GSENM west boundary. The HS-1 site would cover about five acres.

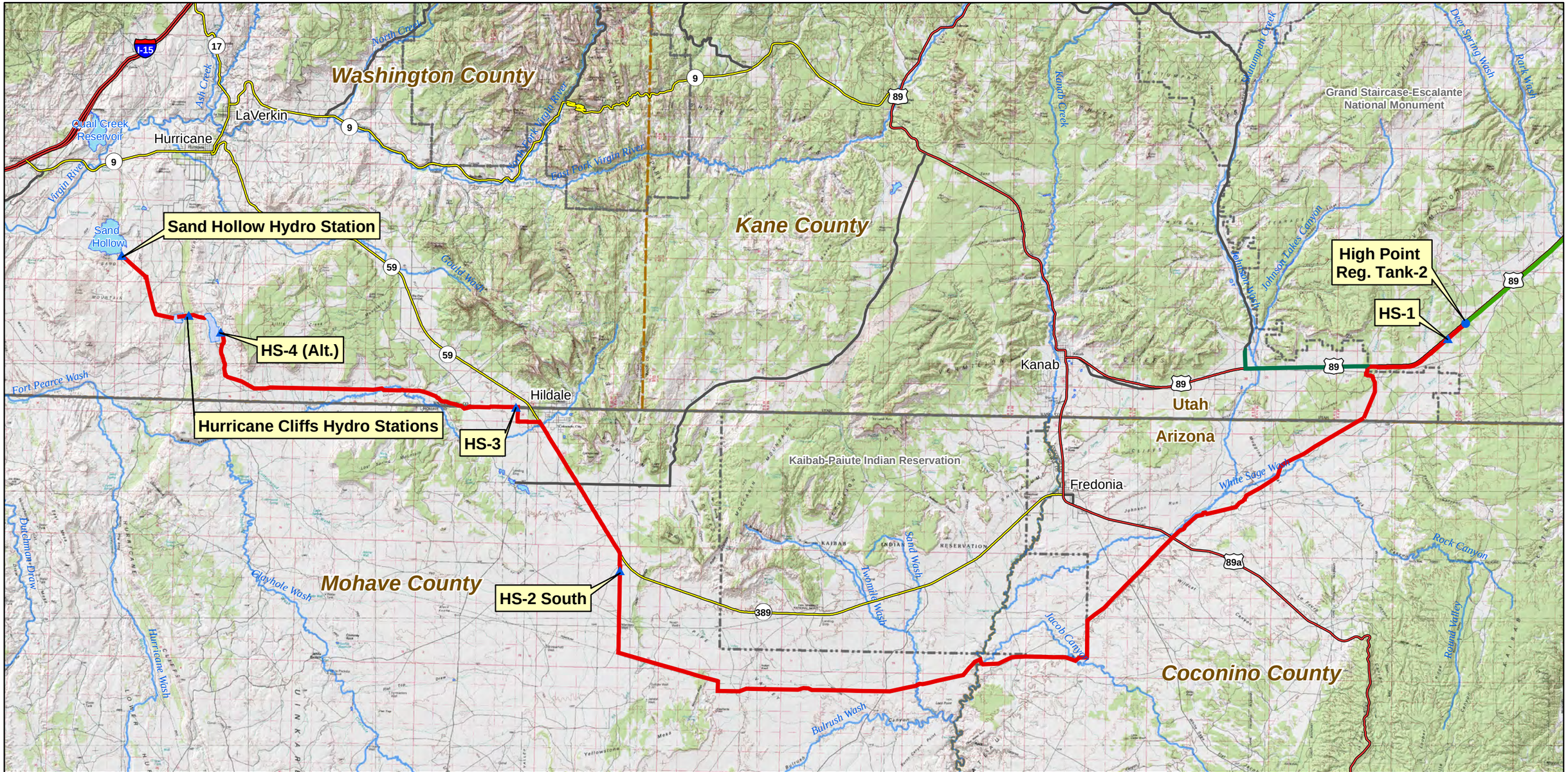
The penstock alignment would turn south from Highway 89 through private land and BLM-administered public lands into White Sage Wash. It would continue across White Sage Wash and then parallel Navajo-McCullough Transmission Line, crossing Highway 89 Alt. and Forest Highway 22 toward the southeast corner of Kaibab-Paiute Indian Reservation. The penstock alignment would run parallel to and south of the Kaibab-Paiute Indian Reservation south boundary, crossing Kanab Creek and Bitter Seeps Wash. It would continue across Moonshine Ridge and Cedar Ridge to Yellowstone Road. At this point, the penstock alignment would run north along Yellowstone Road to Arizona State Route 389 west of Kaibab-Paiute Indian Reservation. HS-2 (South) would be located west of Kaibab-Paiute Indian Reservation on private land east of Yellowstone Road. HS-2 (South) would generate up to one MW of electricity. The HS-2 (South) site would cover about five acres. 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. HS-3 would be located on private land west of Hildale City, Utah, north of and adjacent to Uzona Road. HS-3 would generate up to one MW of electricity. The HS-3 site would cover about five acres. A turnout for future delivery of 13,249 acre-feet of WCWCD's allocation of LPP Project water to Apple Valley would be located immediately west of HS-3.

The penstock alignment would follow Uzona Road west through Canaan Gap and south of Little Creek Mountain, turning north to HS-4 (Alt.) above the proposed Hurricane Cliffs forebay reservoir. HS-4 (Alt.) would be located on about three acres of public land administered by the BLM. HS-4 (Alt.) would generate up to 1.7 MW of electricity and would discharge into the forebay reservoir.

The forebay reservoir would be contained in a valley between two dams (south and north), maintaining active storage of 11,255 acre-feet of water. The forebay reservoir and two dams would cover about 500 acres of public land administered by BLM and would be surrounded by security fencing. 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 35-MW-capacity peaking power hydroelectric generating station and a 300-MW-capacity pumped storage hydroelectric generating station.

The Hurricane Cliffs hydroelectric generating stations and tailrace channel would cover about 50 acres of public land administered by BLM and would be surrounded by security fencing. The tailrace channel would discharge into an afterbay reservoir with 3,551 acre-feet of operating capacity, which is contained by a single dam in the valley below the Hurricane Cliffs. The afterbay reservoir and dam would cover about 200 acres of public land administered by BLM and would be surrounded by security fencing.

Water would be released from the forebay reservoir through the hydro generating system to meet peak power demands. Water would be pumped from the afterbay reservoir into the forebay reservoir during periods of off-peak power demand. The forebay and afterbay reservoirs would not be open to public access because the water levels would fluctuate rapidly during daily operations. A low pressure tunnel would convey the water northwest from the afterbay reservoir to a penstock, continuing to the Sand



Project Pump Station
Project Regulating Tank
Project Hydro Station
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs

Water Conveyance System
Hydro System - South Alternative (Penstock Segment)
KCWCD System
Major Rivers & Streams

Interstate
US Highway
ST Highway
Hwy
Major Road

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

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

N

0 1 2 4 6 8 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-4** MWH

Lake Powell Pipeline Hydro System South Alternative

Hollow Hydro Station, which would generate up to 4.2 MW of electricity. The Sand Hollow Hydro Station would be located on land owned by WCWCD and cover about five acres adjacent to Sand Hollow Reservoir. The LPP Project water would discharge from the Sand Hollow Hydro Station into the existing Sand Hollow Reservoir.

The **KCWCD System** would convey water diverted from Lake Powell through the LPP at the west GSENM boundary for about eight miles through a buried 24-inch diameter pipeline in Kane County, Utah, near the mouth of Johnson Canyon. The pipeline would parallel the south side of Highway 89 across Johnson Wash and then run north for 5000 feet to the mouth of Johnson Canyon (Figure 1-4).

1.2.2 Existing Highway Alternative

The Existing Highway Alternative consists of four systems: **Water Intake, Water Conveyance, Hydro,** and **KCWCD**. The **Water Intake** and **Water Conveyance** systems would be the same as described for the South Alternative. The **Hydro System** would convey water diverted at Lake Powell from High Point Regulating Tank 2 at the LPP Project topographical high point (5,691 feet AMSL) for about 80.5 miles through a buried 69-inch diameter penstock in Kane and Washington counties, Utah, and Coconino and Mohave counties, Arizona, to Sand Hollow Reservoir near St. George, Utah (Figure 1-5). The alternative alignment parallels Highway 89 to the west and south boundary of GSENM and continues along Highway 89 to Lost Spring Gap. Four in-line hydro generating stations (HS-1, HS-2 [Hwy], HS-3, and HS-4 [Alt.]) located along the penstock would generate electricity and help control water pressure in the penstock. The HS-1, HS-3 and HS-4 (Alt.) hydro stations would be the same as described for the South Alternative.

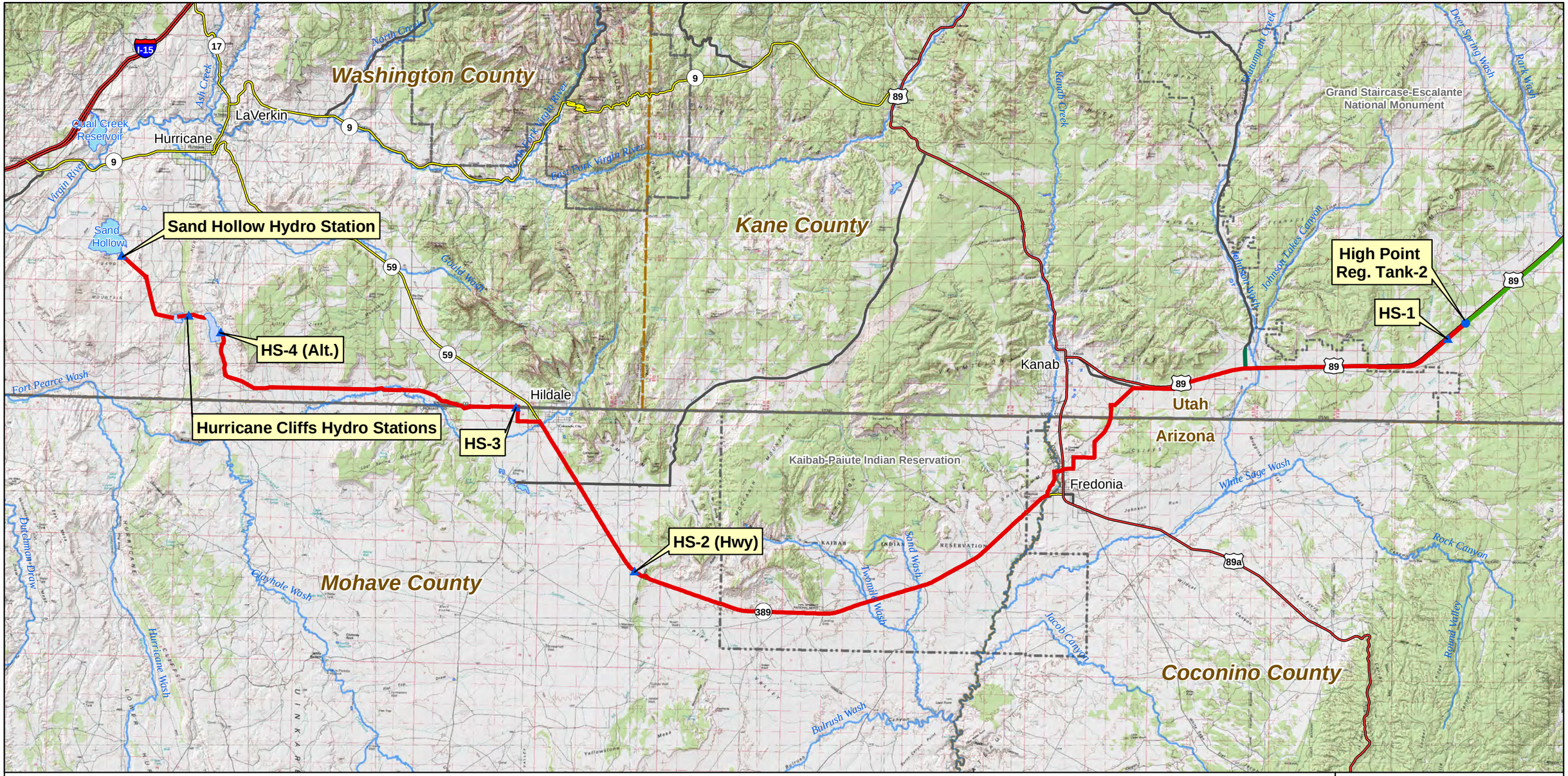
The penstock downstream from the proposed HS-1 would be sited along the south side of Highway 89 within GSENM. The penstock would parallel the south side of Highway 89 west of GSENM, continue past Johnson Wash and follow Lost Spring Gap southwest, crossing Highway 89 Alt. and Kanab Creek in the north end of Fredonia, Arizona. It would continue south, paralleling Kanab Creek to Arizona State Route 389, where it would run west, adjacent to the north side of Route 389 through 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 Kaibab-Paiute Indian Reservation to 1.8 miles west of Cedar Ridge (intersection of Yellowstone Road with Highway 89), where it would then follow the same alignment as the South Alternative to Sand Hollow Reservoir. HS-2 (Hwy) would be sited 0.5 miles west of Cedar Ridge along the north side of Arizona State Route 389. HS-2 (Hwy) would generate approximately 0.8MW of electricity and cover 8.7 acres of private land.

The **KCWCD System** would convey water diverted at Lake Powell from the LPP Project along Highway 89 north along Johnson Canyon Road for 5,000 feet through a buried 24-inch diameter pipeline in Kane County, Utah to the mouth of Johnson Canyon (Figure 1-5).

1.2.3 Southeast Corner Alternative

The Southeast Corner Alternative consists of four systems: **Water Intake, Water Conveyance, Hydro,** and **KCWCD**. The **Water Intake**, **Water Conveyance**, and **KCWCD** systems would be the same as described for the South Alternative.

The **Hydro System** would be the same as described for the South Alternative from High Point Regulating Tank 2 at the LPP Project topographical high point (5,691 feet AMSL) to the east boundary of Kaibab-Paiute Indian Reservation. At the east boundary of 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-Paiute Indian Reservation for about 3.8 miles. The penstock would then follow the South Alternative alignment south of the south boundary of the Kaibab-Paiute Indian Reservation, continuing to Sand Hollow Reservoir (Figure 1-6). The Southeast Corner Alternative would be about 85.7 miles long from High Point Regulating Tank-2 to Sand Hollow Reservoir.



Project Pump Station
Project Regulating Tank
Project Hydro Station
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs

Water Conveyance System
Hydro System - Existing Highway Alternative (Penstock Segment)
KCWCD System
Major Rivers & Streams

Interstate
US Highway
ST Highway
Hwy
Major Road

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

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

N

0 1 2 4 6 8 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-5** MWH

Lake Powell Pipeline Hydro System Existing Highway Alternative

1.2.4 Transmission Line Alignments

Transmission line alignments have been identified to transmit electric power to pump stations in the Water Intake and Water Conveyance systems, and to transmit electric power generated by hydroelectric stations in the Hydro System. The transmission lines that would serve the Water Intake and Water Conveyance systems are located in the east half of the LPP Project. The transmission lines that would serve the Hydro System are located in the west half of the LPP Project.

The proposed new **Water Intake Transmission Line** would begin at Glen Canyon Substation and run parallel to Highway 89 for about 2,500 feet to a new switch station, cross Highway 89 at the Intake access road intersection, and continue northeast to a new electrical substation on the Intake Pump Station site. This 69 kV transmission line would be 0.9 mile long in Coconino County, Arizona (Figure 1-7).

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

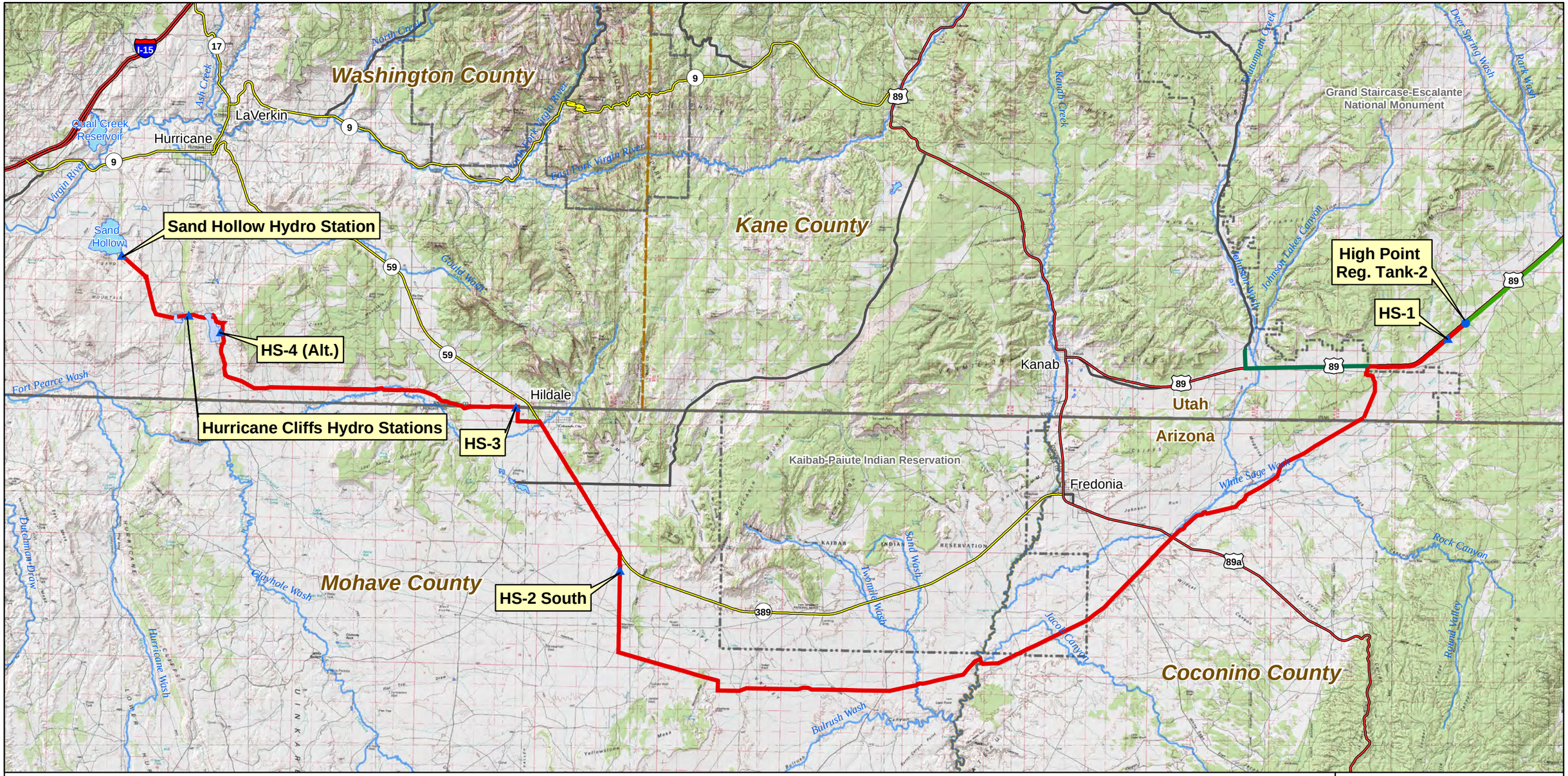
The proposed new **Glen Canyon to Buckskin Transmission Line** would consist of a 230 kV transmission line from the Glen Canyon Substation to the Buckskin Substation, running parallel to the existing 138 kV transmission line. This transmission line upgrade would be about 36 miles long through Coconino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

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

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

The proposed new **BPS-2 Transmission Line** would consist of a new three-ring switch station along the new 230 kV Glen Canyon to Buckskin Transmission Line, 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. 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 alignment would be about seven miles long across Utah SITLA-administered land, with a 138 kV connection to a new electrical substation on the BPS-2 site (Figure 1-7).

The proposed new **BPS-3 Alt. Transmission Line South** would consist of a new three-ring switch station along the new 230 kV Glen Canyon to Buckskin Transmission Line, and a new transmission line from the switch station north along an existing BLM road to a new electrical substation on the BPS-3 (Alt.) site near the GSENM east boundary and within the Congressionally-designated utility corridor. This new 138 kV transmission line alignment would be about 5.9 miles long in Kane County, Utah (Figure 1-7).



- Project Pump Station
- Project Regulating Tank
- Project Hydro Station
- Hurricane Cliffs Forebay/Afterbay
- Lakes & Reservoirs
- Water Conveyance System
- Hydro System - Southeast Corner Alternative (Penstock Segment)
- KCWCD System
- Major Rivers & Streams
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- National Park/Monument
- GSENM Boundary
- Tribal Lands
- State Boundaries
- County Boundaries

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

N

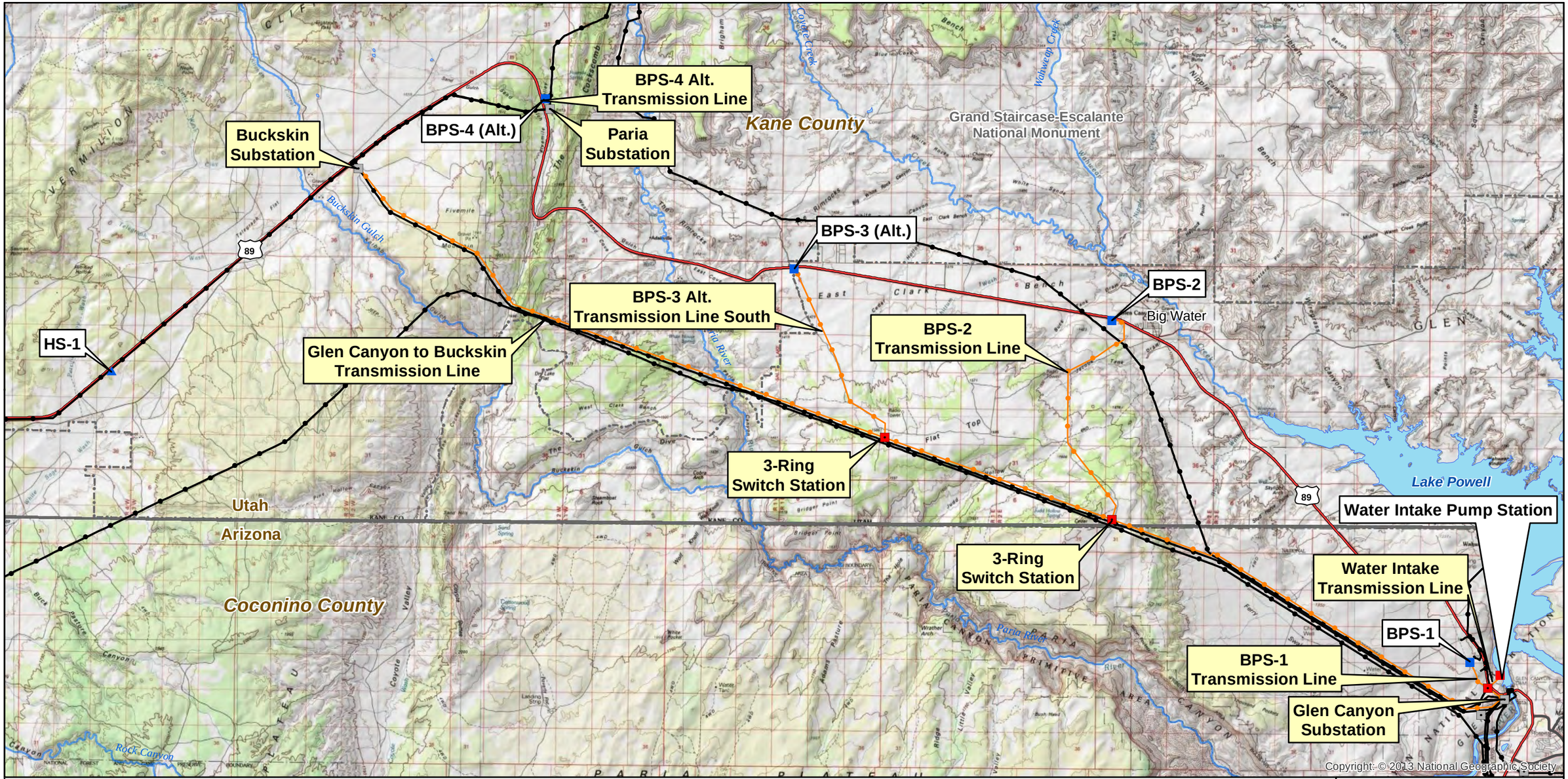
0 1 2 4 6 8 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-6** MWH

Lake Powell Pipeline
Hydro System
Southeast Corner Alternative



Project Intake Pump Station
Project Pump Station
Project Hydro Station
Substation
Proposed Substation
Project Transmission Lines
Existing Transmission Lines
Interstate
US Highway
ST Highway
Hwy
Major Road
Lakes & Reservoirs
Major Rivers & Streams
National Park/Monument
GSENM Boundary
State Boundaries

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

0 0.5 1 2 3 4 Miles

N

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-7** MWH

Lake Powell Pipeline Proposed Transmission Lines East

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

The proposed new **HS-1 Transmission Line** would begin at the new HS-1 and tie into the existing 69 kV transmission line along Highway 89 from the Buckskin Substation to the Johnson Substation. The HS-1 69 kV transmission line would be about 400 feet long in Kane County, Utah (Figure 1-8).

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

The new **HS-2 (Highway) Transmission Line** alternative would directly connect the HS-2 hydroelectric station and substation along the Existing Highway Alternative to an existing 138 kV transmission line paralleling Arizona State Route 389. This new 34.5 kV transmission line would be about 200 feet long in Mohave County, Arizona.

The proposed new **HS-3 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 transmission line would be about 0.6 mile long in Washington County, Utah (Figure 1-8).

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

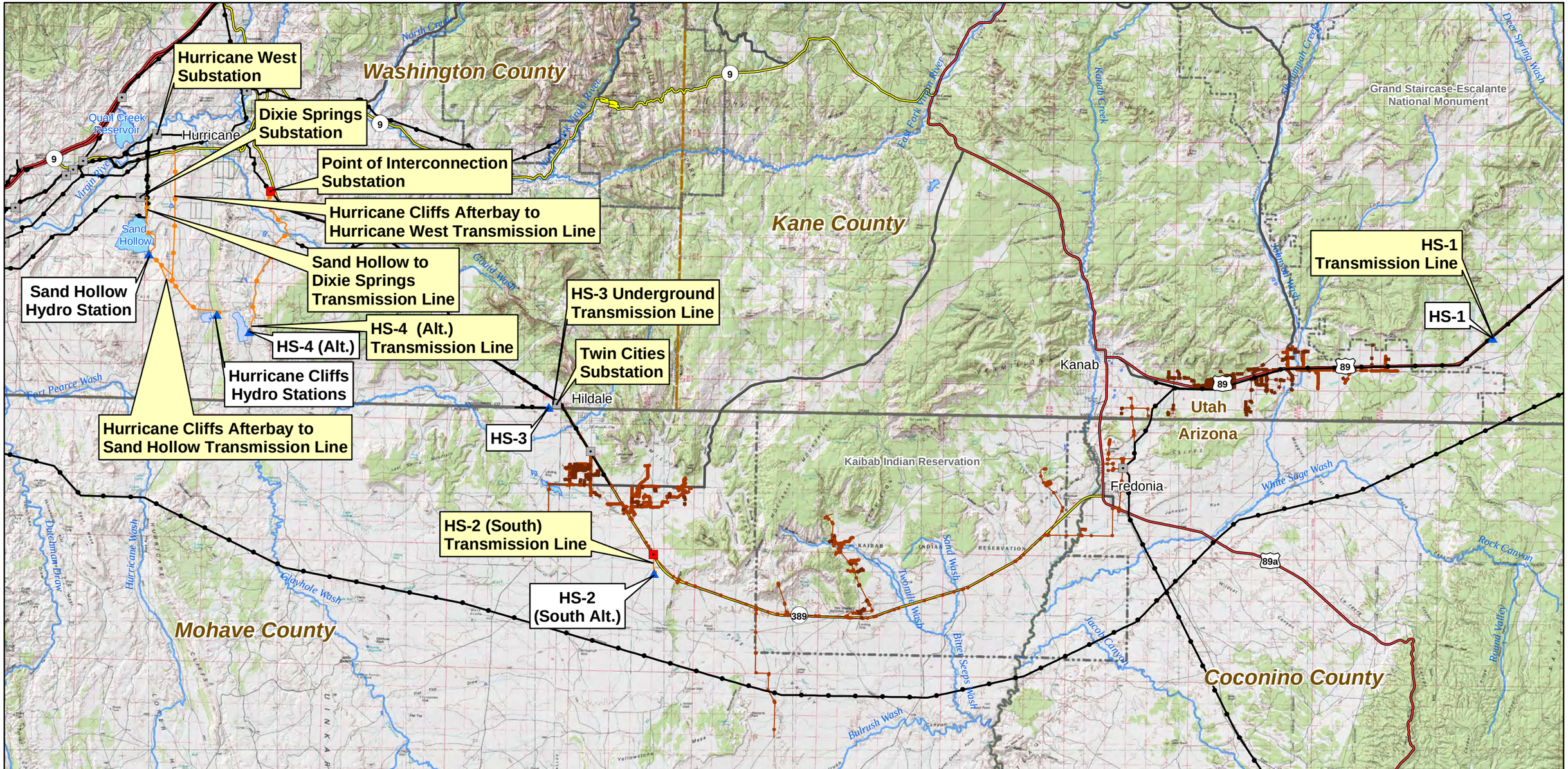
The proposed new **Hurricane Cliffs Afterbay to Sand Hollow Transmission Line** would consist of a new 69 kV transmission line, which would run northwest from the Hurricane Cliffs peaking power plant and substation to the Sand Hollow Hydro substation. This new 69 kV transmission line would be about 4.9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

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

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

1.2.5 Natural Gas Pipeline and Generators Alternative

Natural gas engine-driven generation systems to power electric pumps would be an alternative to powering the LPP Project pump stations by electricity via transmission lines. Recent discussions with Questar Gas Company (local natural gas supplier) indicated that capacity would be available in the Kern River natural gas pipeline, which is located west of St. George, Utah, to supply natural gas for this alternative. Questar Gas Company indicated the company has future plans to extend a high pressure natural gas pipeline from the Kern River line to Hurricane, Utah. The Questar Gas pipeline would be sized to supply natural gas to the LPP Project if it is determined that a single-purpose, dedicated high pressure gas line would be extended to service the LPP pump stations. Based on the preliminary pump



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

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

N

0 1 2 4 6 8 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-8** MWH

Lake Powell Pipeline Proposed Transmission Lines West

selection and fuel requirements, the natural gas supply pipeline would be 12 inches in diameter to provide natural gas supply for the LPP Project pump stations. The pipeline would likely be successively reduced in size as it delivers gas to each of the pump stations.

1.2.5.1 Natural Gas Transmission Line Connection

The natural gas supply line alternative would connect to the proposed Questar Gas Transmission Line from the existing Kern River line to Hurricane City. The natural gas supply line would connect to the high pressure gas transmission line at a proposed gate station southeast of Sand Hollow Reservoir. The proposed gate station would be located adjacent to the alignment of the extension of the Southern Corridor Highway, which is the existing alignment of Sand Hollow Road east of Sand Hollow Reservoir (Figure 1-9).

1.2.5.2 Natural Gas Supply Line

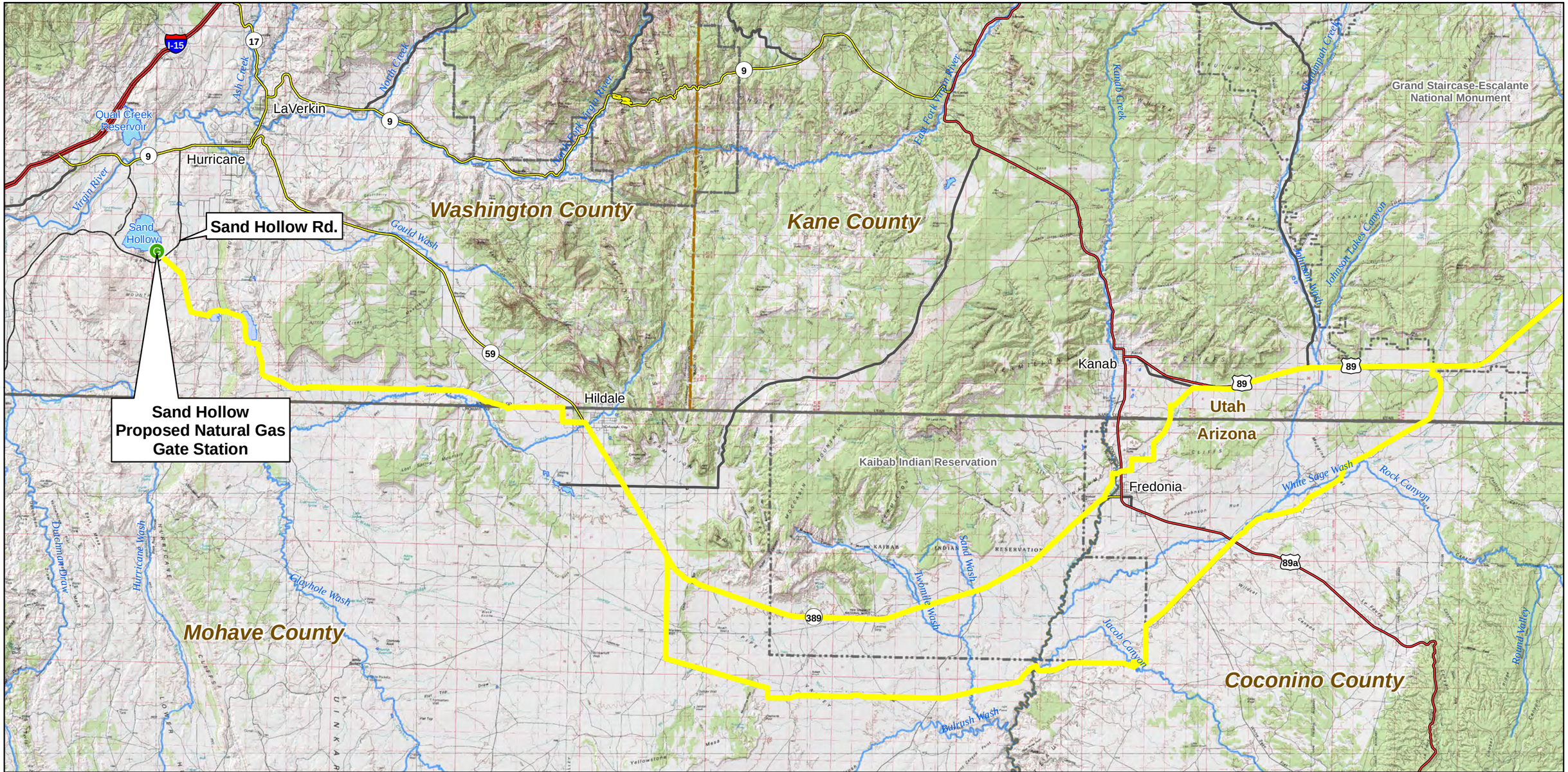
The proposed natural gas supply line would be an intermediate high pressure line and would operate between approximately 250 to 300 psi at the gate station connection. Because of pressure losses in the pipeline it is anticipated that the pressure at each of the LPP pump stations would vary between 50 and 100 psi, which would meet the requirements of the natural gas generators. The pipeline would be constructed of strong carbon steel and have a dielectric coating, such as a fusion bonded epoxy or extruded polyethylene. It would be installed with a minimum four feet of cover and be provided withcathodic protection (a technique that involves inducing an electric current through the pipe to ward off corrosion and rusting). The pipeline would be designed, constructed, tested, and operated at a minimum in accordance with all applicable requirements included in the U.S. DOT regulations in 49 CFR Part 192, “Transportation of Natural Gas and other Gas by Pipeline: Minimum Federal Safety Standards,” and other applicable federal and state regulations.

The natural gas supply line would follow the proposed LPP ROW from the Sand Hollow Gate Station to the intake pump station near Page, Arizona. The line would be about 138.5 miles long and installed a minimum of 10 feet from the edge of the proposed water pipeline in a separately excavated trench within the LPP ROW. Figure 1-9 shows the west alignment of the natural gas supply line as proposed and an alternative alignment along Arizona State Route 389 and through Fredonia, Arizona, parallel to the Existing Highway Alternative alignment, both to the west GSENM boundary. Figure 1-10 shows the east alignment of the natural gas supply line as proposed from the west GSENM boundary to the water intake pump station.

Sectionalizing valves would be required along the natural gas supply line alignment. These valves are safety devices used for emergency shut down or maintenance. The natural gas supply line sectionalizing valves would be required at approximately 20-mile intervals because of the gas line’s remoteness. The main line valve sites would cover a 40-foot by 40-foot area surrounded by a chain link fence within the confines of the permanent LPP pipeline ROW. The valves would be above ground and connected to the buried natural gas supply line. Additionally, pig launching or receiving equipment would be installed within the fenced areas. Pigs are devices that are placed into a natural gas supply line to clean the inside walls or to monitor its internal and external condition. Launching and receiving equipment is connected to the natural gas supply line to enable pigs to be inserted into or removed from the pipeline.

1.2.5.3 Natural Gas Generators

Natural gas generators would be used to supply power to operate the electric pumps at the LPP pump stations. The size of the electric pumps is approximately 18 feet from center to center when configured. The overall pump station building size would be 14 feet wider and 18 feet longer than the pump stations which are powered by electricity from transmission lines.



Natural Gas Gate Station
Natural Gas Supply Line Alignment
Hurricane Cliffs Forebay/Afterbay
Lakes & Reservoirs
Major Rivers & Streams
Interstate
US Highway
ST Highway
Hwy
Major Road
National Park/Monument
GSENM Boundary
Tribal Lands
State Boundaries
County Boundaries

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

N

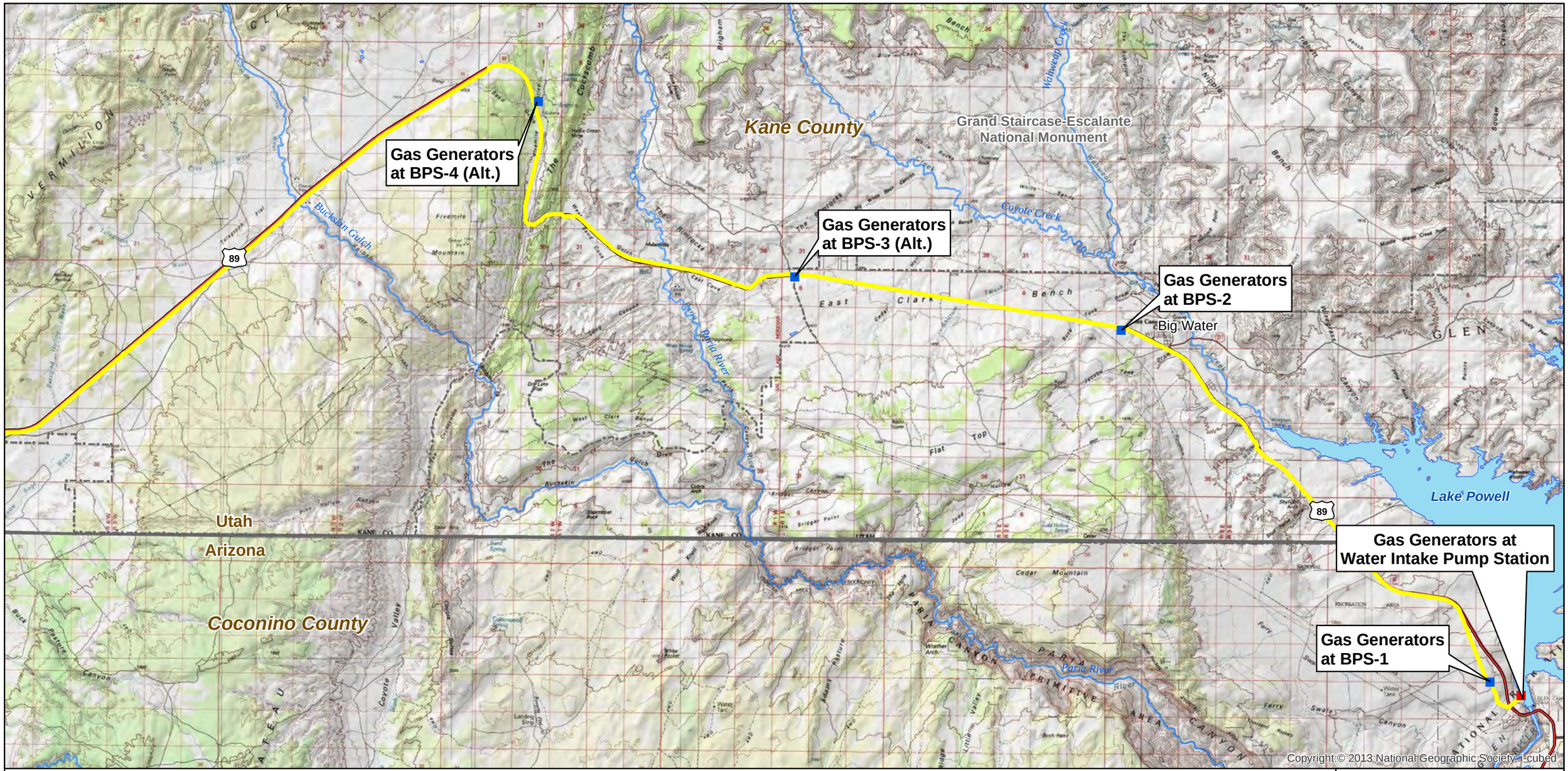
0 2 4 6 8 10 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-9** MWH

Lake Powell Pipeline
Natural Gas Supply Line and Generators West Alternatives



Project Water Intake Pump Station
Gas Generators at Booster Pump Station
Natural Gas Supply Line Alignment

Interstate
US Highway
ST Highway
Hwy
Major Road

Lakes & Reservoirs
Major Rivers & Streams
National Park/Monument
GSENM Boundary
State Boundaries

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

N

0 1 2 3 4 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-10** MWH

Lake Powell Pipeline Natural Gas Supply Line and Generators East Alternative

The natural gas generators would be approximately 35 feet long by eight feet wide by nine feet high. The intake pump station building size for the natural gas generators would be approximately 65 feet wide by 170 feet long by 50 feet high, and located adjacent to the pump station electrical room within the five-acre site designated for each pump station. The booster pump station building size for the natural gas generators would be 65 feet wide and 39 feet high, with lengths ranging from 114 feet to 162 feet long. Each natural gas generator would require a 24-inch diameter stack, with guide wires, extending above the building roof to disperse the exhaust gases. The five stacks (four operating natural gas generators plus one standby natural gas generator) at the intake pump station would extend 20 feet above the top of the 55-foot tall building. The stacks at BPS-1, BPS-2, BPS-3 (Alt.), and BPS-4 (Alt.) would extend 61 feet above the top of the buildings to a total height of 100 feet above the ground surface. The natural gas generators at the intake pump station and BPS-4 (Alt.) would require emission control systems to meet air quality standards.

The natural gas generators alternative at the LPP pump stations would require an annual natural gas supply of 2,855,400 million British thermal units (MMBtu). Table 1-1 shows the annual natural gas consumption at the proposed project intake pump station and booster pump stations 1 through 4.

Table 1-1
Water Conveyance System Natural Gas Generator Annual Fuel Consumption

Pump Station	Site Elevation Feet MSL	Number of Pumps	Motor (HP)	Total Motor (kW)	Natural Gas Generator GE Model	# of Units[1]	Emission Control Required	Generator Total kW[2]	Annual Fuel Consumption (MMbtu)[3]
IPS	3,750	5	3000	11,190	JGS 620 F09	4+1	Yes	12,120	729,000
BPS-1	4,111	5	1500	5,595	JGS 620 F09	2+1	No	5,992	364,500
BPS-2	4,311	5	1750	6,530	JGS 620 F09	3+1	No	8,895	425,400
BPS-3 Alt.	4,657	5	2500	9,325	JGS 620 F09	4+1	No	11,652	607,500
BPS-4 Alt.	5,001	5	3000	11,190	JGS 620 F09	5+1	Yes	14,430	729,000
Total		**25**		**43,830**		**18+5**		**53,089**	**2,855,400**

Notes:
[1] Number of operating units plus standby generator
[2] Total generator capacity without standby generator
[3] The annual fuel consumption is based on all pumps operating at rated motor horsepower, 8400 hours/year operation with generators loaded at 87 percent on the average.

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 eliminating residential outdoor water use in the WCWCD service area. This alternative could provide a total of 86,249 acre-feet of water annually to WCWCD and KCWCD for M&I use without diverting Utah's water from Lake Powell.

1.3.1 WCWCD No Lake Powell Water Alternative

1.3.1.1 Background

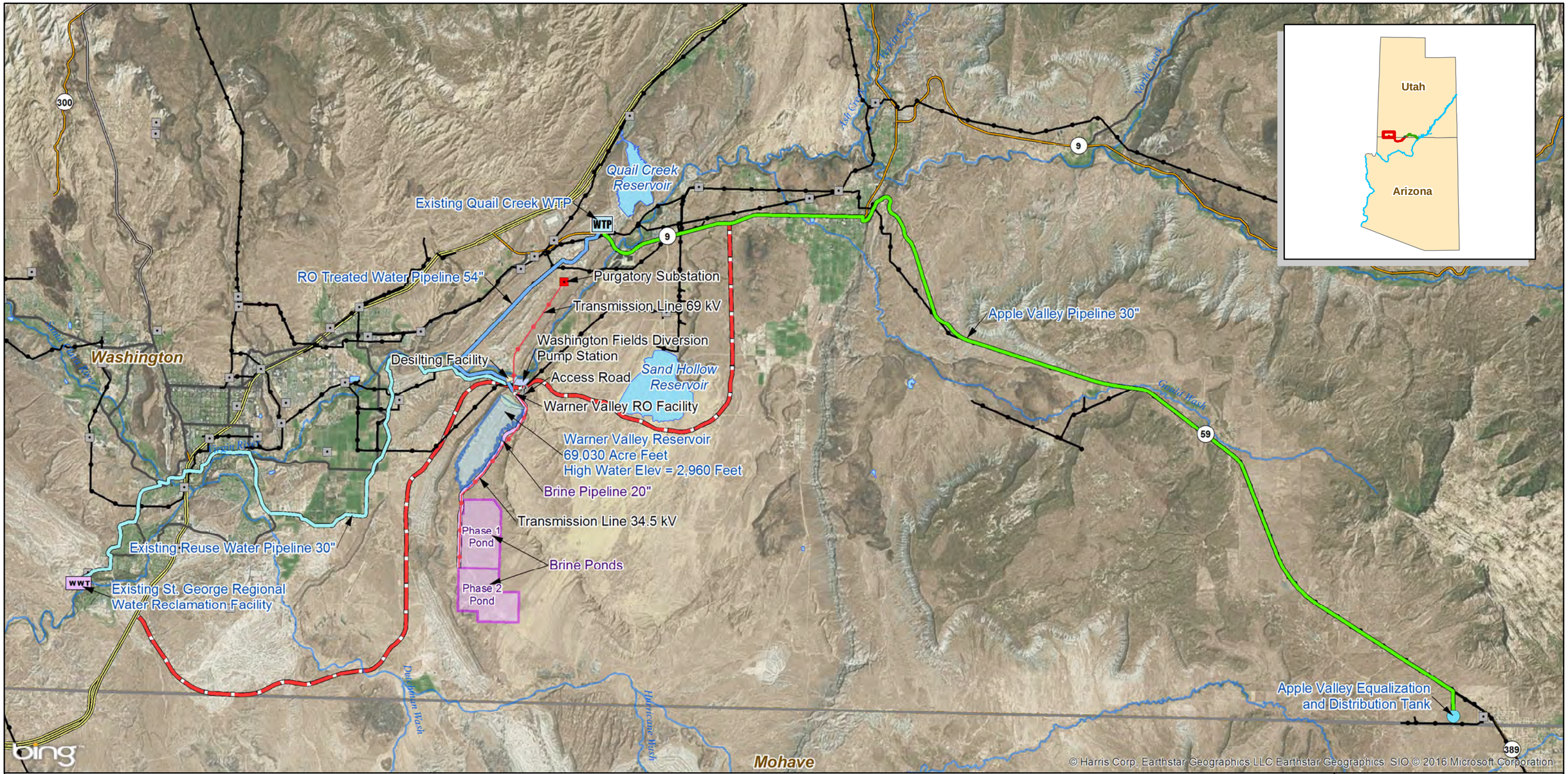
The WCWCD LPP allocation would be 82,249 acre-feet per year, and the WCWCD No Lake Powell Water alternative would need to supply 82,249 acre-feet per year to meet the same future water demands. In addition to the direct supply from Utah's Colorado River water, the water supplied by the LPP Project would provide additional wastewater reuse supply provided that sufficient storage is available.

The No Lake Powell Water Alternative would serve the same population as the LPP Project. WCWCD would implement other future water development projects currently planned by the District, develop additional water reuse/reclamation programs, continue to implement new water conservation measures, and convert additional agricultural water use to M&I use as a result of urban development in agricultural areas through 2028. Remaining planned and future water supply projects include the Ash Creek Pipeline (2,840 acre-feet per year), Sand Hollow recharge/recovery (3,000 acre-feet per year), Westside groundwater wells arsenic treatment (5,000 acre-feet per year), and development/yield increase of existing groundwater wells (2,830 acre-feet per year). Along with existing supplies, these future water supplies would yield an estimated 72,842 acre-feet per year of potable water and 8,505 acre-feet per year secondary water by 2028.

Under the No Lake Powell Water Alternative, actions in addition to the currently planned WCWCD projects would be taken to meet the water demand that would have been supplied by the Lake Powell Pipeline, as described below.

1.3.1.2 WCWCD No Lake Powell Water Alternative Features

Beginning in 2025, Washington County residential outdoor potable water use would be permanently re-purposed to indoor potable water use to help meet increasing indoor potable water demands. 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 50,000 acre-feet per year of diverted Virgin River water, which has a high total dissolved solids (TDS) concentration, mixed with an additional 19,030 acre-feet per year of reuse water. WCWCD would develop the Warner Valley Reservoir to store the reuse water and diverted Virgin River water prior to RO treatment. A water distribution pump station and pipeline would be constructed to convey 13,249 acre-feet of potable water from Quail Creek Water Treatment Plant to the Apple Valley area of Washington County. Figure 1-11 shows the primary conceptual components of the No Lake Powell Water Alternative. Table 1-2 summarizes available supplies and projected demands under the No Lake Powell Water Alternative and the LPP Project alternatives.



WTP Quail Creek WTP (Existing)
WWT St. George Regional Water Reclamation Facility (Existing)
Substation
Substation (Future)
Warner Valley Transmission Line
Existing Transmission Lines
Desilting Facility
RO WTP
Washington Fields Diversion Pump Station
Lakes & Reservoirs
Brine Evaporation Ponds
Access Road
Apple Valley Pipeline 30"
Brine Pipeline 20"
Existing Reuse Water Pipeline 30"
RO Treated Water Pipeline 54"
Major Rivers & Streams
Interstate
US Highway
ST Highway
Hwy
Major Road
Southern Corridor Highway
State Boundaries
County Boundaries

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

N

0 0.75 1.5 3 4.5 6 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 1-11** MWH

No Lake Powell Water Alternative Primary Infrastructure

Table 1-2 Available Supplies and Projected Demands Under the No Lake Powell Water and Lake Powell Pipeline Project Alternatives		
	No Lake Powell Water Alternative	**Lake Powell Pipeline Project Alternative**
Existing Supplies	67,677	67,677
Planned Projects	13,670	13,670
Lake Powell Pipeline Project	0	82,249
RO Treatment of Virgin River and Reuse Water	57,883	0
Agricultural Conversion	0[1]	10,080
Reuse	17,100[2]	36,130
2060 Total Supply	156,330	209,806
2060 Total Demand	133,119[3]	185,285
Surplus in 2060	**23,211**	**24,521**

Notes:
[1]Agricultural conversion water included in RO treatment.
[2]19,030 acre-feet per year additional reuse included in RO treatment.
[3]Demand reduced 52,166 acre-feet per year from elimination of residential outdoor watering.

1.3.1.2.1 Re-Purposing Potable Water Use. The No Lake Powell Water Alternative would permanently eliminate residential outdoor potable water use in Washington County, re-purposing the portion of potable water used for residential outdoor watering to indoor potable use. Projections of future water use through 2060 account for population growth, climate change (projected 6 percent reduction of Virgin River flows by 2050 [Reclamation 2014]), and water conservation (35 percent reduction in per capita water use from 2000 to 2060). Potable water in Washington County is consumed for residential indoor and outdoor uses, commercial uses, institutional uses, and industrial uses. These potable water uses would total 130,245 acre-feet per year by 2052, the year the LPP Project water is anticipated to be fully utilized (UDWRe 2015). Gradually eliminating residential outdoor potable water use starting in 2025 would provide the growing population with potable water for indoor use through 2045; however, re-purposing residential outdoor potable water use to indoor use would not increase the water supply and would have to be accompanied by adding another water supply to meet the growing demand. Re-purposing residential outdoor potable water use to indoor potable use would require converting traditional residential outdoor landscapes and uses to either landscaping requiring no irrigation or desert landscapes compatible with the local climate. Residential water users would be responsible for converting their traditional outdoor landscapes to non-irrigated or desert landscapes. If no additional water supply was added in Washington County after 2025 and potable water use continued to meet residential indoor and outdoor purposes, then the projected population would completely utilize the potable water supply of 72,842 acre-feet per year by 2028.

1.3.1.2.2 Reverse Osmosis Water Treatment. Washington County's additional future water supply under the No Lake Powell Water Alternative would be dependent on two water sources: 1) Virgin River water diverted at the Washington Fields Diversion; and 2) reuse water from an expanded St. George Regional Water Reclamation Facility. WCWCD would develop a RO advanced water treatment facility near Washington Fields Diversion in Washington County, Utah. The RO facility would be designed to treat 50,000 acre-feet of de-silted water per year diverted from the Virgin River at Washington Fields Diversion. St. George Regional Wastewater Reclamation Facility would provide an additional 19,030 acre-feet of water per year to be treated at the RO facility. The RO facility would be necessary to remove the high concentrations of TDS present in both the Virgin River and the effluent from the St. George Regional Wastewater Reclamation Facility. The reuse facility has a current capacity of approximately 7,800 acre-feet per year, with a future design capacity of 11,760 acre-feet per year. An additional 7,830 acre-feet per year of future wastewater reclamation capacity would need to be added to meet the

total reuse water requirement of 19,030 acre-feet per year for RO processing inflow. The RO process would separate the TDS from the water, resulting in two products: 1) a treated water product; and 2) a brine product consisting of highly concentrated salts. A two-stage RO process would be applied to the brine solution to recover additional water and reduce the brine volume for enhanced evaporation. The RO-treated water product would be pH-adjusted to neutral pH, dosed with sodium silicate, mixed with conventionally-treated water from the Quail Creek Water Treatment Plant, and disinfected for distribution throughout the WCWCD service area. The RO advanced water treatment facility would process up to 64,313 acre-feet per year and produce up to 57,883 acre-feet per year of water suitable for M&I potable indoor use. The two-stage RO process would remove 90 percent of the TDS. The remaining 10 percent rejection (6,430 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 RO water treatment plant would process approximately 64,313 acre-feet per year of inflow water from Warner Valley Reservoir storage to meet the 2052 water demand under the No Lake Powell Water Alternative.

The RO water treatment plant processes would consist of pressurized, parallel ultra-filtration units, an influent storage tank with acid added to adjust the pH, pressurized cartridge filtration to remove additional particles from the water, high pressure pumping to pass the water through the parallel RO membrane units, a product water storage tank with saturated lime solution added to adjust the pH of the treated product water prior to disinfection and distribution as potable water, and brine storage tanks in series with the two-stage RO process units for further brine reduction. These water treatment processes would be housed in a water treatment building with electrical, mechanical, chemical storage and metering, heating/air conditioning/ventilation, and SCADA systems. A seven-mile long buried 54-inch diameter pipeline would convey the product water from a pump station at the RO water treatment plant to the Quail Creek Water Treatment Plant. The RO water treatment plant would add RO membrane units in phases as necessary to meet the growing water demand. The RO water treatment plant would be powered by electricity, requiring a 2.8-mile long 69-kV power transmission line from the proposed Purgatory Substation.

The concentrated brine product (6,430 acre-feet per year) would be pumped from the brine tanks through a pipeline to an evaporation apron, spray system and double-lined pond, and then pumped into spray headers over a series of double-lined ponds with leak detection and recovery systems. The enhanced evaporation ponds would be located south of Warner Valley Reservoir and would cover approximately 2,000 acres, developed in two phases. A buried brine conveyance pipeline approximately 4.4 miles long would convey the concentrated brine to the enhanced evaporation ponds. A 4.4-mile long 34.5-kV power transmission line would be extended from the RO water treatment plant to the enhanced evaporation ponds to provide electricity for the pumps spraying the brine solution. The brine solids would be evaporated for approximately 25 years in the Phase 1 ponds, and then dried, collected and disposed in an approved solid waste landfill. The Phase 2 enhanced evaporation ponds would be used during the following 25 years to continue evaporating the brine by-product. Additional infrastructure would be required as part of this alternative, including a de-silting facility, pump stations, pipelines, switch stations and substations, blending and storage tanks, and other associated earthwork.

1.3.1.2.3 Secondary Water Storage in Warner Valley Reservoir. WCWCD would develop the Warner Valley Reservoir to store diverted Virgin River water and reuse water from the St. George Regional Water Reclamation Facility, which would be delivered as inflow to the RO advanced water treatment facility. Warner Valley Reservoir would be located south-southwest of the Washington Fields Diversion. An earth-fill embankment with a clay core and rock-riprap facing would be constructed across the north entrance to the natural valley. The reservoir would have a maximum active storage volume of 69,030 acre-feet and would cover approximately 1,130 acres, including the earth-fill embankment. A large pump station would be constructed at the Washington Fields Diversion to pump the diverted Virgin River water into the Warner Valley Reservoir. The pump station would be powered by electricity via the 69-kV transmission line from the Purgatory Substation to the RO water treatment plant. The reservoir would store Virgin River water diverted at the Washington Fields Diversion (50,000 acre-feet per year) mixed with St. George Regional Water Reclamation Facility effluent (19,030 acre-feet per year), accounting for annual average evaporation (4,717 acre-feet per year), to produce up to 57,883 acre-feet of RO product water (assuming 90 percent recovery). The brine product from RO treatment would total approximately 6,430 acre-feet per year.

1.3.1.2.4 Water Distribution to Apple Valley. The largest remaining contiguous land area available for development in Washington County would be in Apple Valley. WCWCD would develop a pump station and 28-mile long pipeline to deliver 13,249 acre-feet per year of potable water from the Quail Creek Water Treatment Plant near Hurricane City to the Apple Valley area to meet future residential and commercial water demands.

1.3.2 KCWCD No Lake Powell Water Alternative

The KCWCD No Lake Powell Water Alternative would rely on existing water supplies, water conservation measures resulting in reduced water use, and future water development projects consisting of new groundwater production. Reliable water supplies (projected to be 2,170 acre-feet per year in 2035) for the area served by KCWCD (Kanab City and Johnson Canyon), adjusted for projected stream flow reductions (4.2 percent in 2035) resulting from climate change and a planning reserve (10 percent), would be exceeded by projected M&I water demands by 27 acre-feet per year within the KCWCD service area in 2035. KCWCD projected potable water demand in 2060 would be 3,435 acre-feet per year, with a potable water deficit of 1,334 acre-feet per year. Additional groundwater in the Kanab Creek drainage basin could be developed to provide up to 6,615 acre-feet per year of potable water within the aquifer's estimated safe yield. The quality of this water would likely require advanced water treatment. The developed groundwater from the Kanab Creek drainage basin would be pumped and conveyed through an eight-mile long pipeline to the Johnson Canyon drainage basin. The Johnson Canyon drainage basin comprises the potable water supply service area served by KCWCD in the area that could be served by the LPP Project.

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. FERC would not issue a license for the LPP Project. 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.

1.4.1 WCWCD No Action Alternative

Under the No Action Alternative, WCWCD would complete the Ash Creek Project, planned groundwater development and continue to implement planned conservation programs. Wastewater reuse would be utilized to the maximum extent storage allows. Existing and future water supplies totaling 72,840 acre-feet per year potable and 8,505 acre-feet per year secondary would meet projected M&I water demand within the WCWCD service area through approximately 2028, exhausting all water planning reserves. Each supply source would be phased in to meet the M&I potable and secondary water 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). The No Action Alternative would not provide adequate water supply to meet projected water demands beyond 2028. There would be a projected water shortage of approximately 102,903 acre-feet per year in 2060 within the WCWCD service area under the No Action Alternative.

1.4.2 KCWCD No Action Alternative

KCWCD would use existing water supplies to meet potable water demands through 2035. Reliable water supplies are projected to be 2,101 acre-feet per year in 2060.

The No Action Alternative would not provide KCWCD with any reserve water supply (e.g., water to meet annual shortages because of drought, emergencies, and other losses). The No Action Alternative would not provide adequate water supply to meet projected water demands beyond 2035. There would be a projected water shortage

of approximately 1,334 acre-feet per year in 2060 within the KCWCD service area under the No Action Alternative.

1.5 Identified Issues

The following vegetation community issues were raised during the public and agency scoping and informational process:

- What vegetation community types would be affected by the pipeline and transmission line alternative alignments?
- What unique vegetation communities or habitat types and other sensitive vegetation areas would be affected by the pipeline and transmission line alternative alignments?

1.6 Impact Topics

The following impact topics are analyzed in this study report:

- Vegetation communities
  - Ecological systems
  - Regions
  - Alliances
  - Associations
- Anthropogenic lands

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 (formerly, Logan Simpson Design Inc. [LSD)]). The proposed LPP project is a water conveyance system designed to deliver 86,249 acre-feet of water annually from Lake Powell in the vicinity of Glen Canyon Dam to portions of Washington and Kane counties, Utah. The project includes water intake facilities at Lake Powell; approximately 270 miles of proposed and alternative 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; . The proposed and alternative corridor alignments analyzed is as configured in April 2009 and amended in 2010 and 2015 (AppendixA; 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 and Washington counties in Utah (Figure 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 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-Paiute Indian Reservation within the Utah State Route 389 transportation corridor, also within Arizona. The southern alignment occurs south of the Kaibab-Paiute 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 the Virgin River. The pipeline alignment also continues northward from the forebay, to Utah State Route 59 (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

Two main ecological regions—the Colorado Plateau and Mojave Desert—are represented within the project area (Figure 2-2). The vast majority of the project area, from Lake Powell to Hurricane, occurs within the Colorado Plateau Ecological Region. The Mojave 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) and the City of St. George, Utah (elevation 3,000 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 2-3, Figure 2-4, and Figure 2-5 (USU 2010 and Weather Underground 2010).

Average total precipitation in the communities near the project area ranges from 6.46 inches in Page to 13.37 inches in Kanab, Utah annually (U.S. Climate Data 2016). The 2008, 2009 and 2010 average annual precipitation for urban centers across the LPP corridor, as compared to 30-year averages, are provided inFigure 2-6, Figure 2-7, and Figure 2-8, 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 continued to see lower-than-average temperatures. By July and August, temperatures in all four cities exceeded 30-year averages.

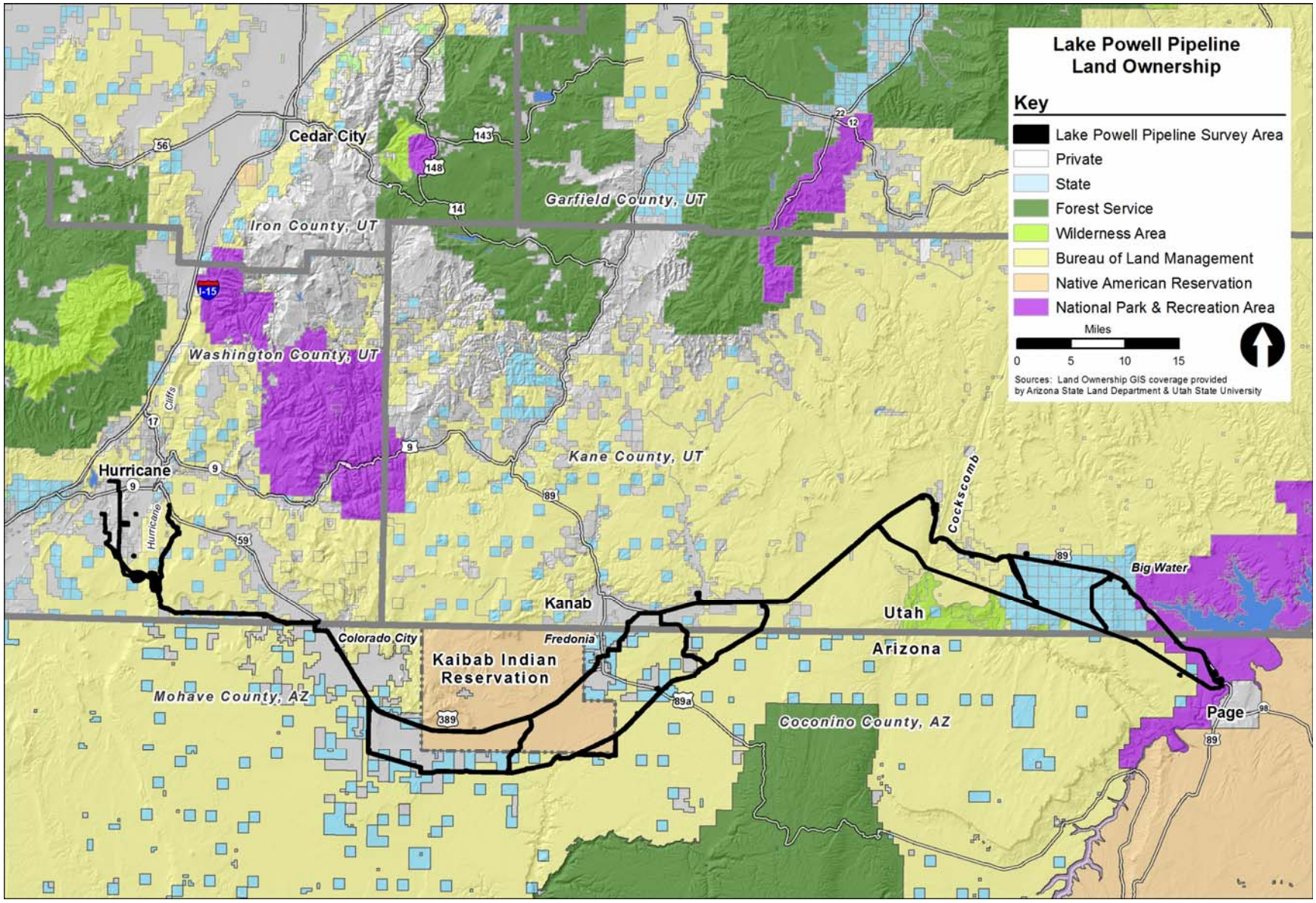


Figure 2-1
Land Ownership

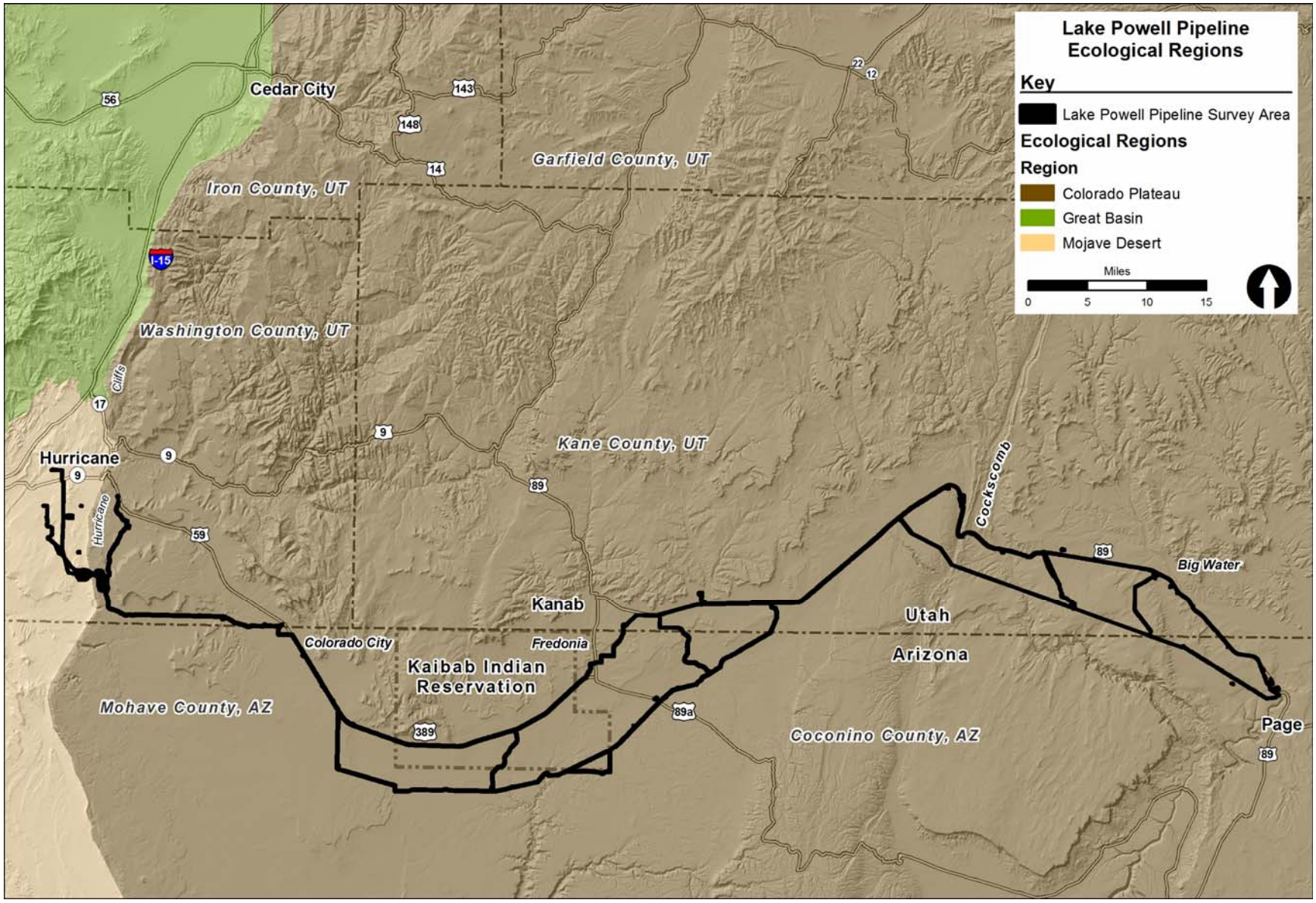


Figure 2-2
Ecological Regions

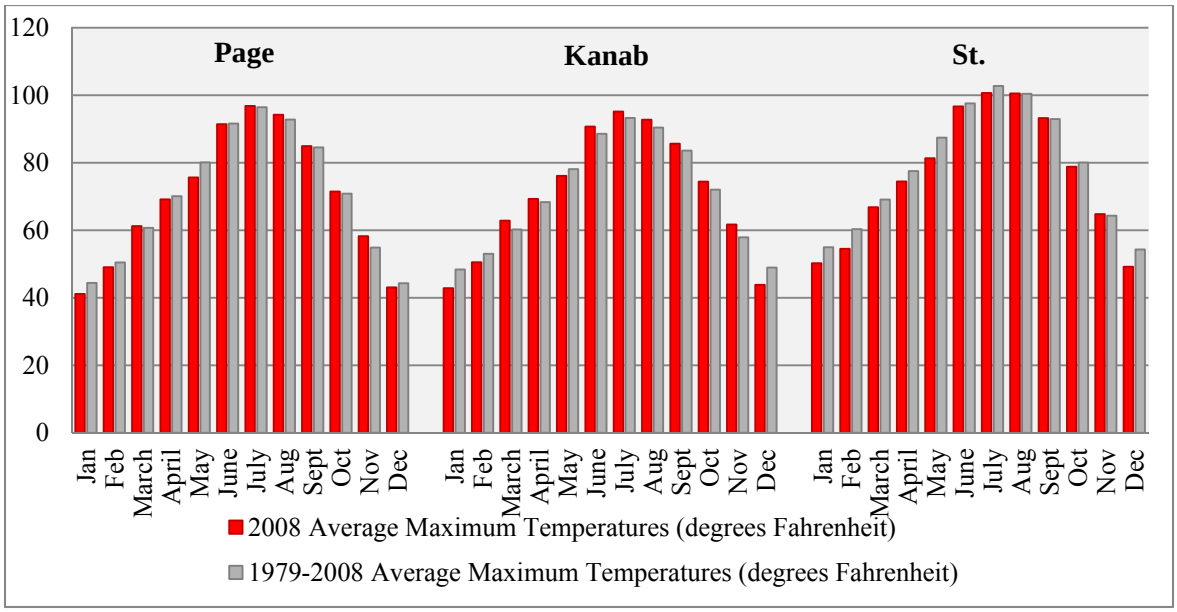


Figure 2-3
2008 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

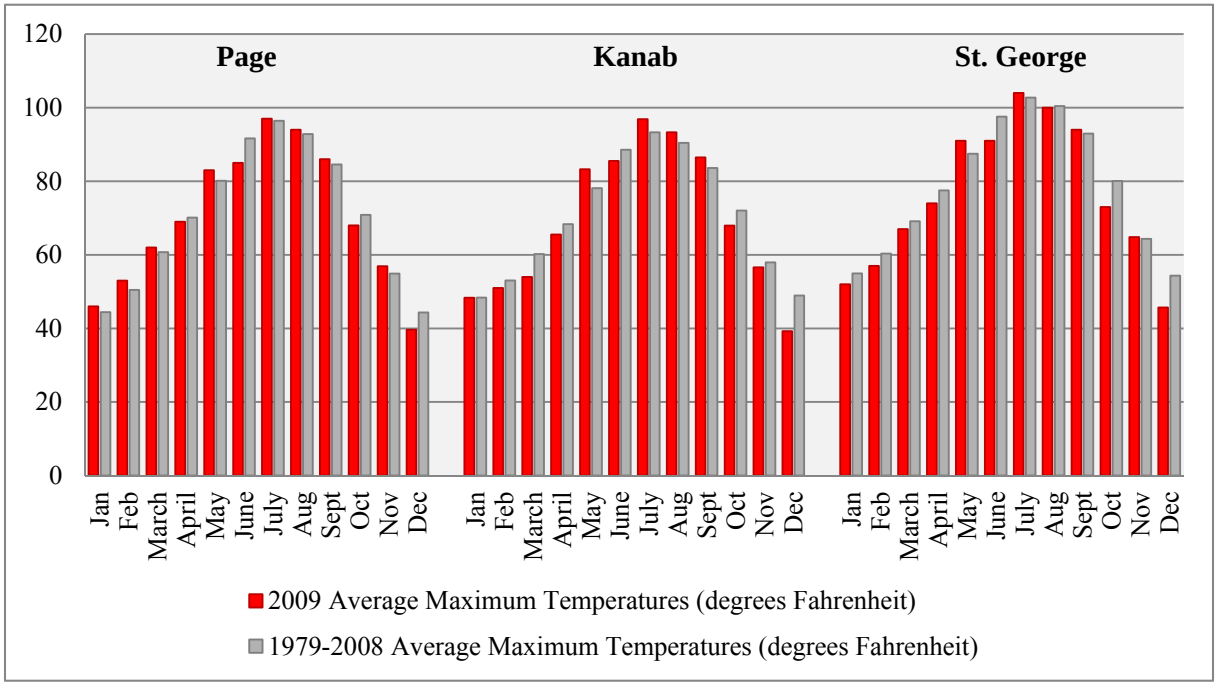


Figure 2-4
2009 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

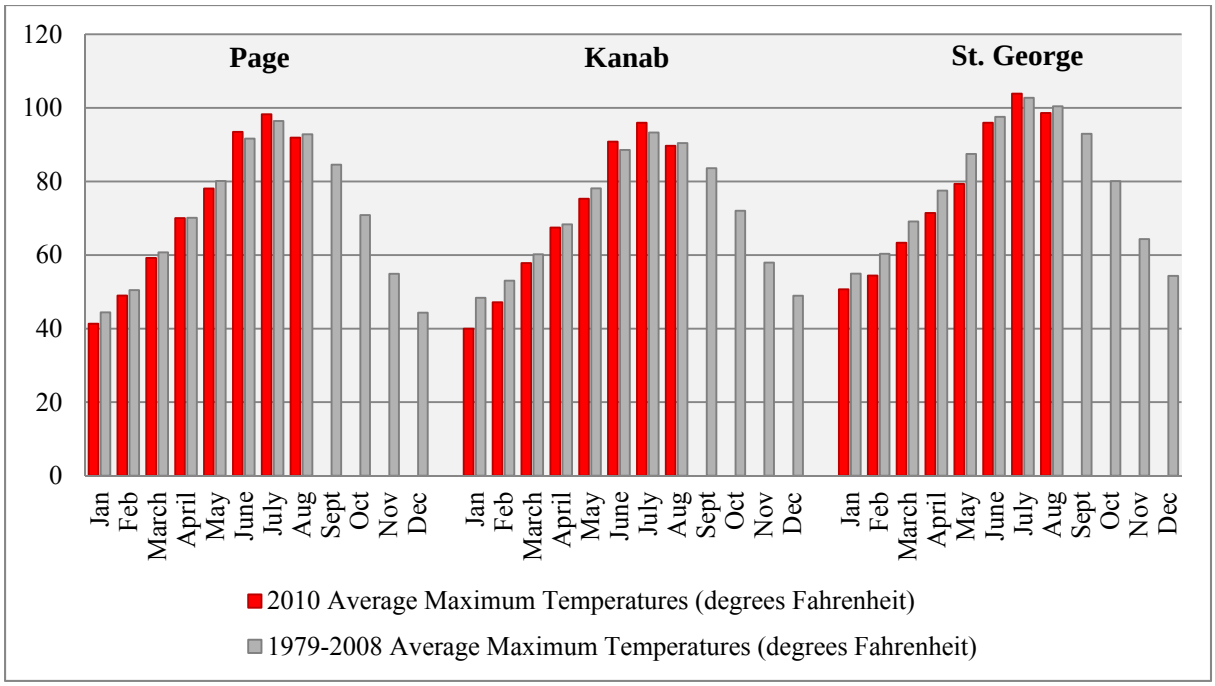


Figure 2-5
2010 Average Monthly Maximum Temperatures, as Compared to 30-year Averages

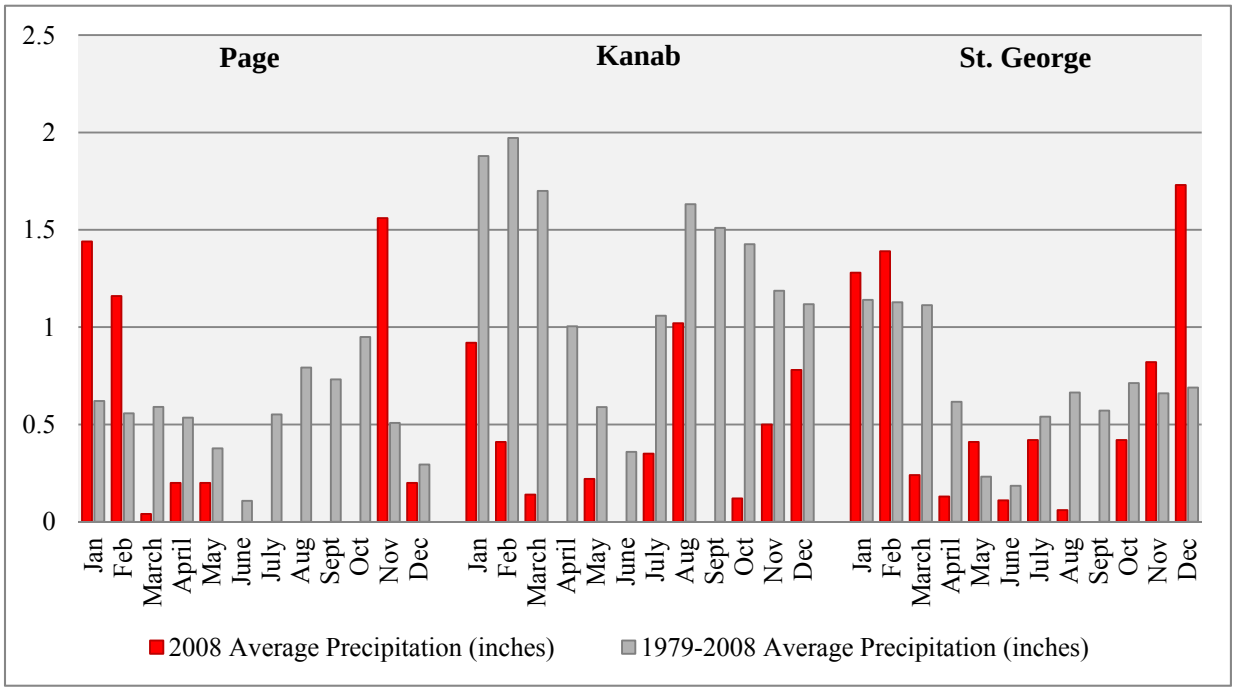


Figure 2-6
2008 Average Monthly Precipitation, as Compared to 30-year Averages

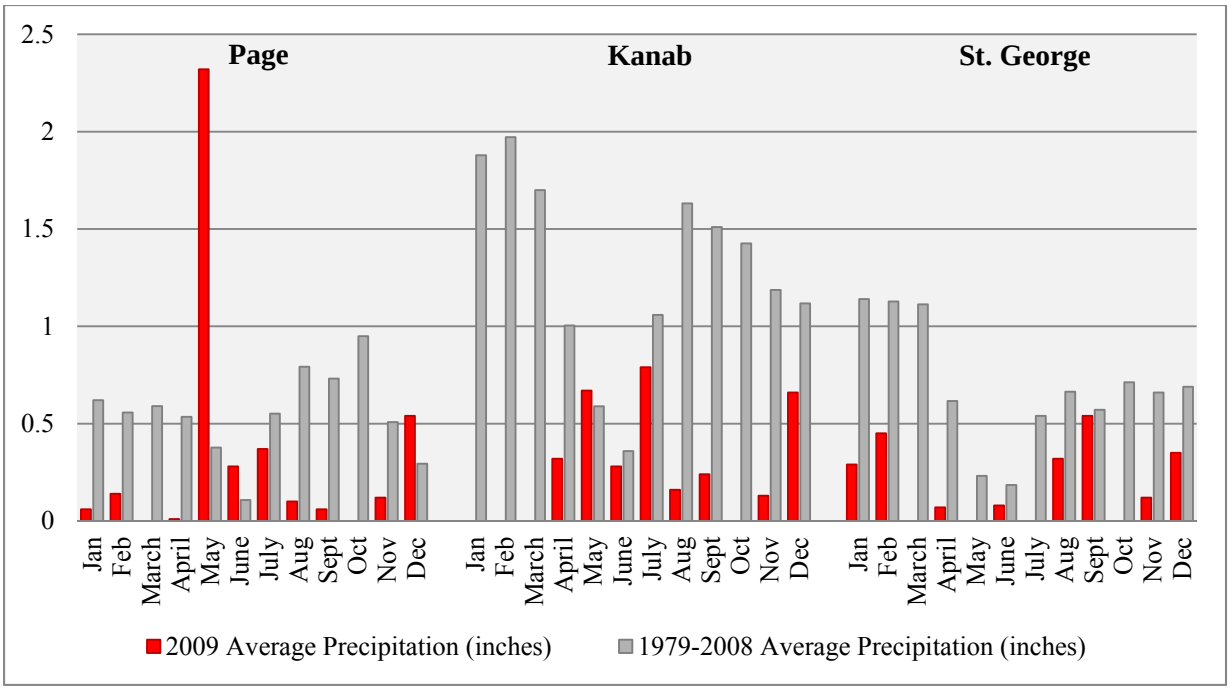


Figure 2-7
2009 Average Monthly Precipitation, as Compared to 30-year Averages

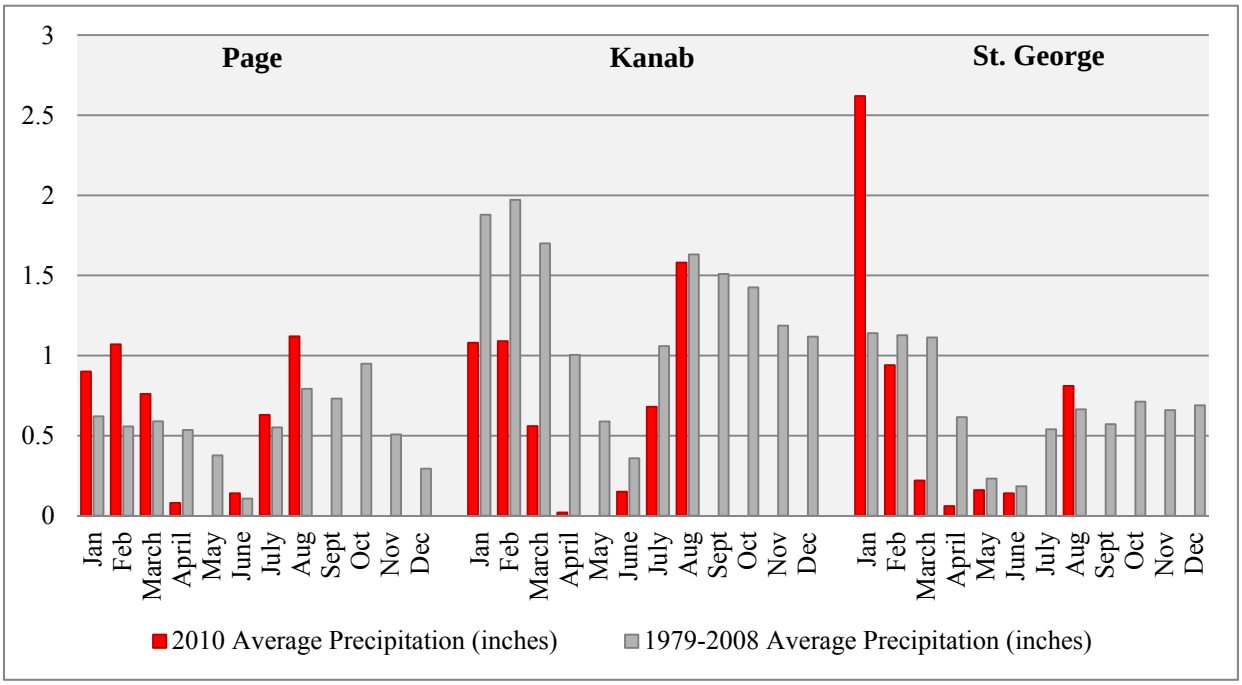


Figure 2-8
2010 Average Monthly Precipitation, as Compared to 30-year Averages

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 and St. George, 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 three 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. At the end of the 2010 survey, lower than average precipitation was experienced in Kanab, 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 and St. George, 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 5th. 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.

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 alignment. Generally, the 300-foot-wide corridors occurred between Lake Powell and the Cockscomb, and west of the Hurricane Cliffs extending northward to Hurricane. All other linear elements had a 600-foot-wide survey corridor (Figure 2-9). Vegetation community mapping was undertaken concurrently with surveys for noxious weeds and special status plant species.

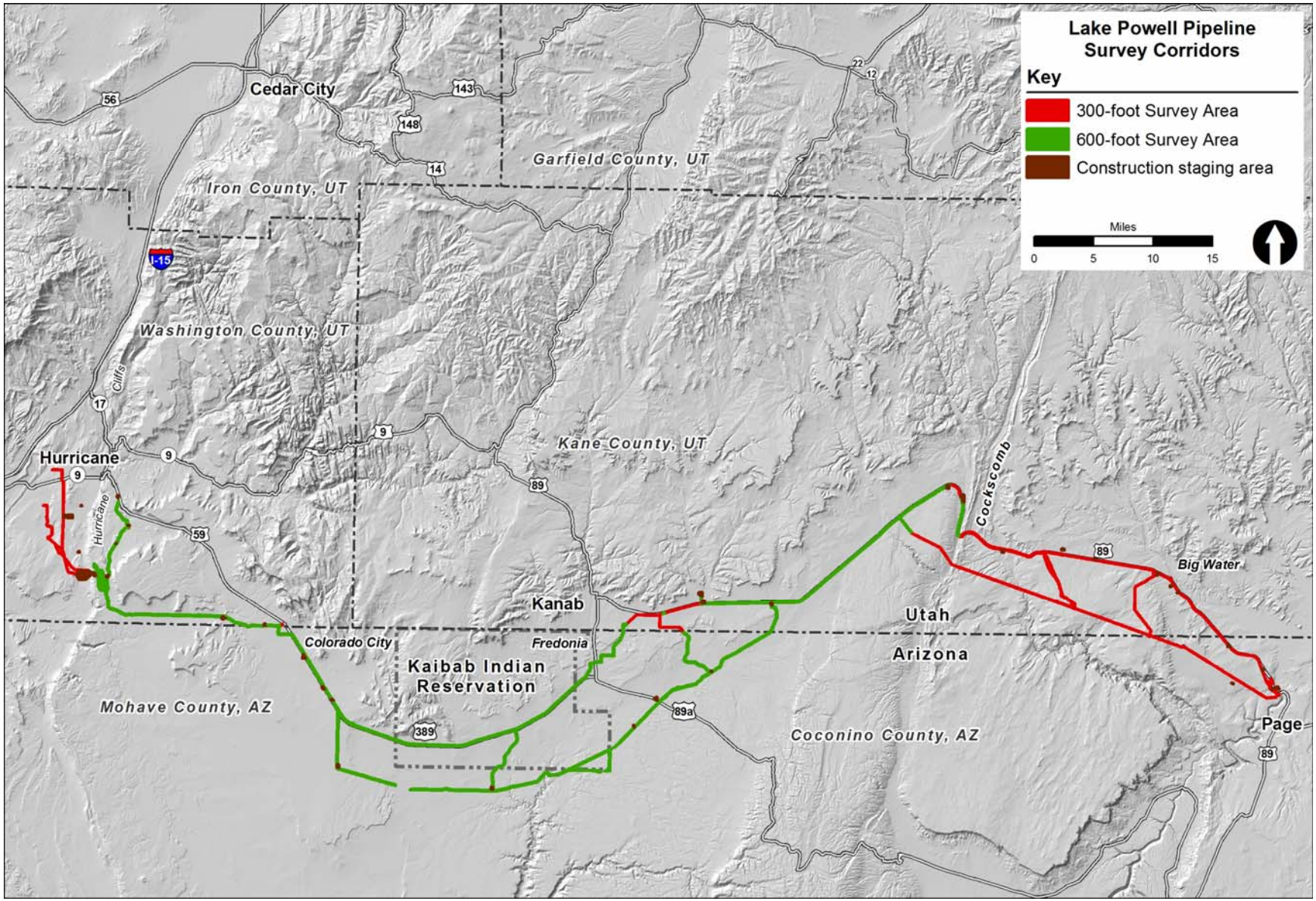


Figure 2-9
Vegetation Resources Survey Area

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 across 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 dominance, 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 species composition; and alliances are grouped into ecological systems that reflect major geographic regions (e.g., Colorado Plateau and Mojave Desert). The completed vegetation community mapping of the LPP survey area uses terminology and classification standards consistent with the U.S. 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 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. 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 (157.4 miles) was achieved using a combination of pedestrian surveys (77 percent) and windshield/binocular surveys (23 percent) (Figure 3-1 and Figure 3-2). Approximately 9 percent of the 300-foot-wide corridor (110.9 miles) was surveyed either on foot (5276 percent) or by windshield/binocular surveys (1839 percent), with sixnine percent of the 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 rights-of-way 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 (Figure 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 U.S. 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 A). 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 (Figure 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.

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 B).

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 U.S. 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 U.S. NVC were 0-10 percent, 10-25 percent, 25-60 percent and over 60 percent.

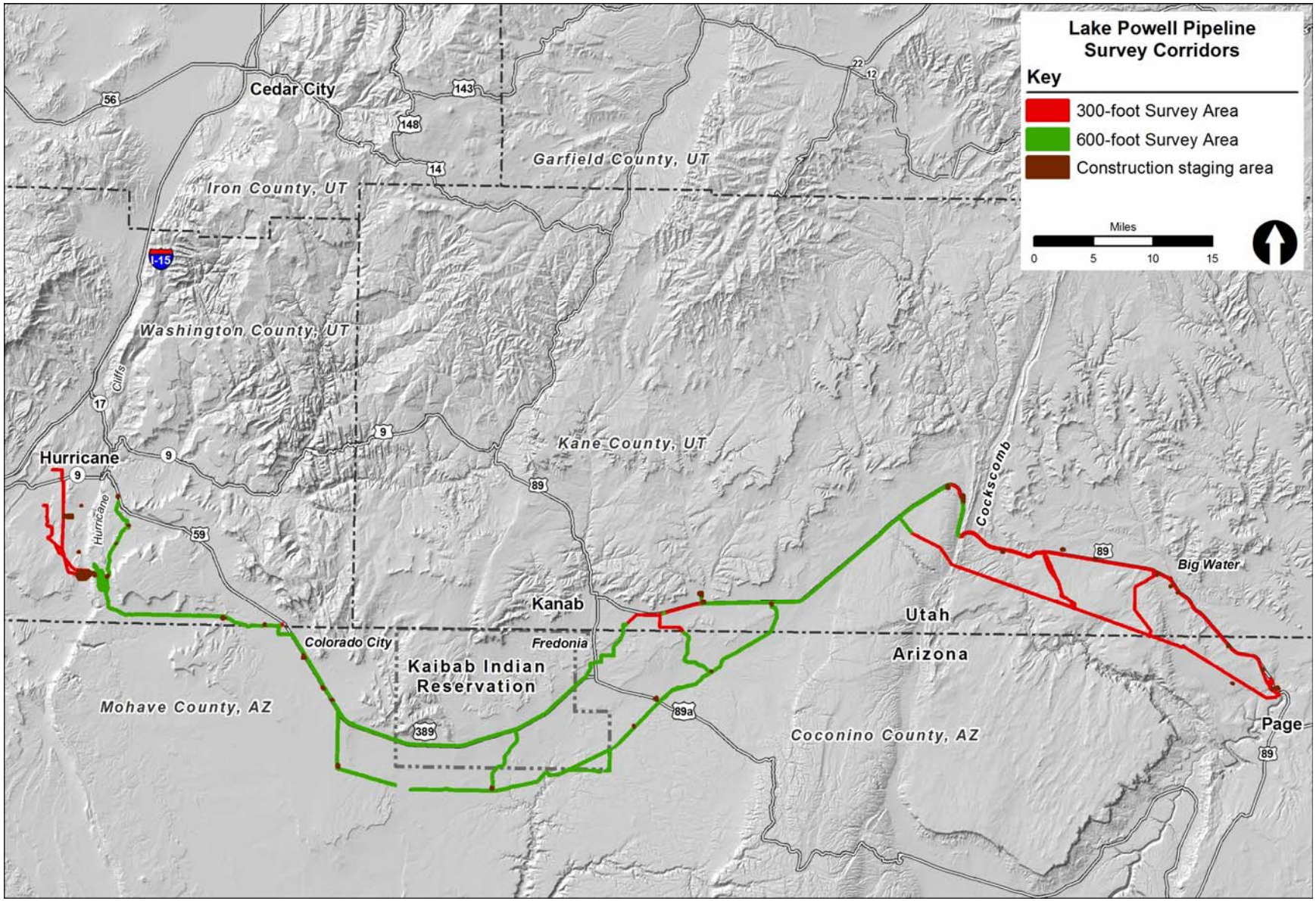


Figure 3-1
Survey Corridors

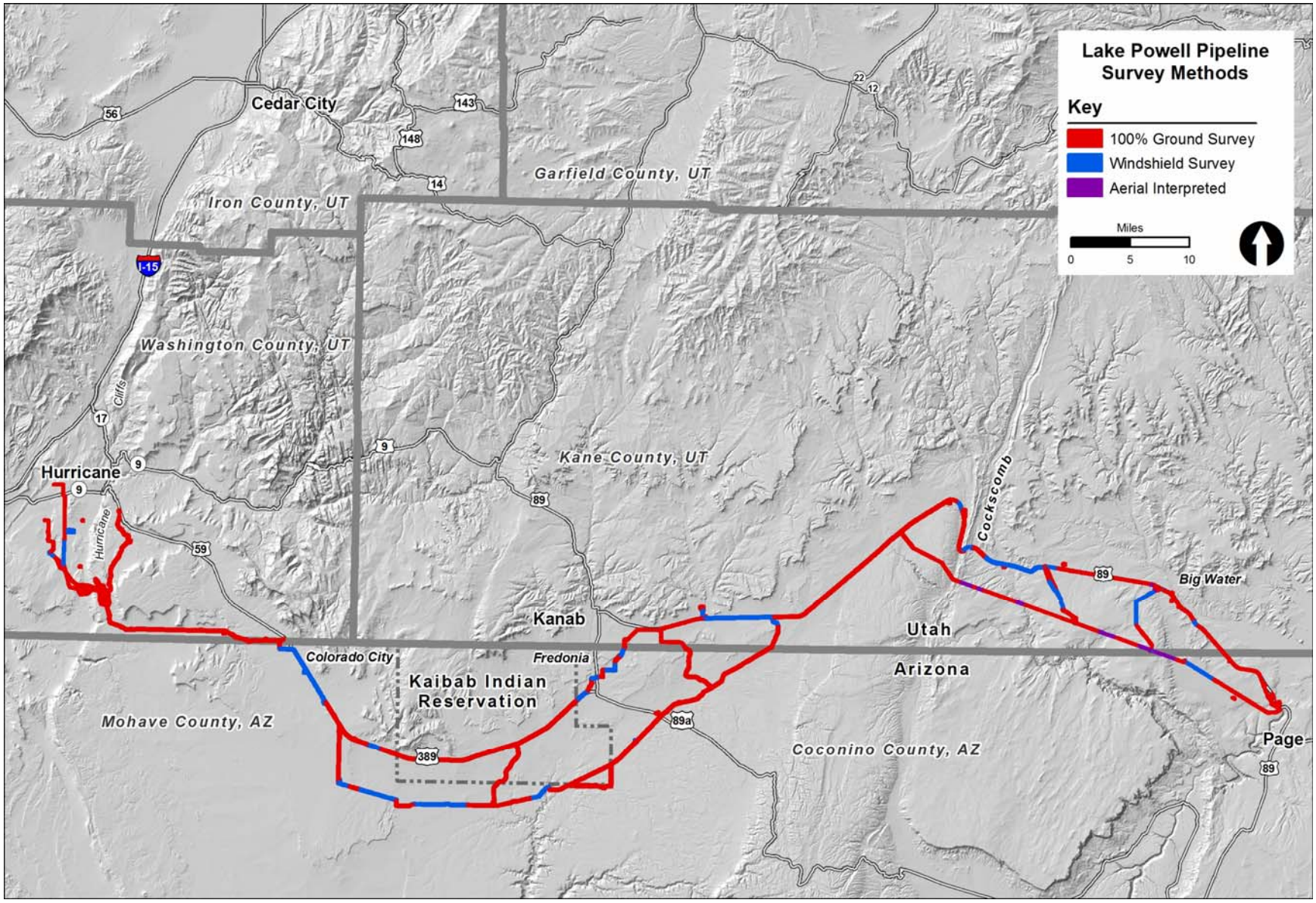


Figure 3-2
Survey Methods

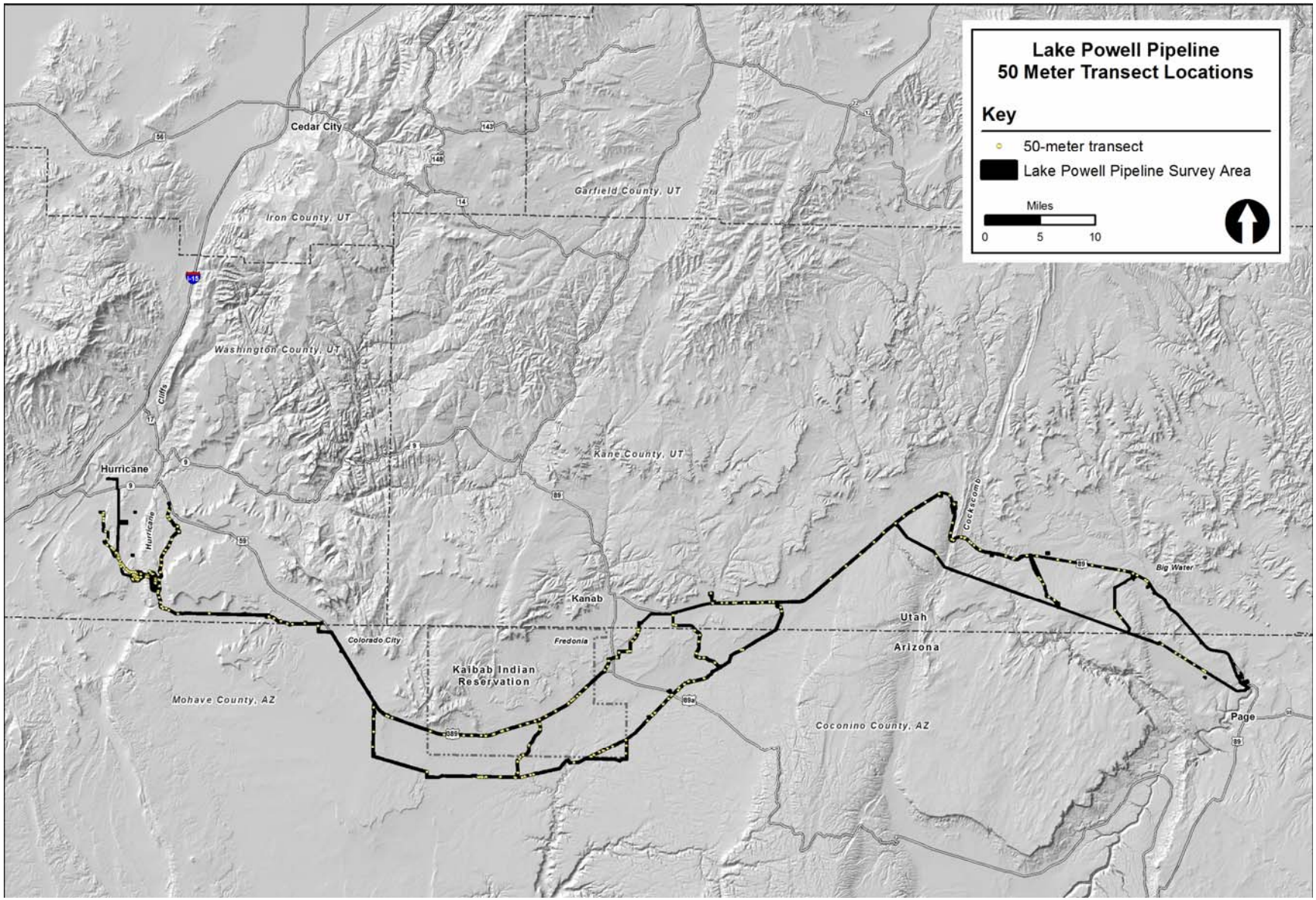


Figure 3-3
50-meter Transect Locations

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 U.S. National Vegetation Classification System (U.S. 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 U.S. 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.

U.S. 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 may be 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.

Logan Simpson 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, Logan Simpson chose to constrain each ecological system to a single, widely recognized region. These include the Mojave Desert Ecological Region and the Colorado Plateau Ecological Region. For example, active and stabilized dunelands are herein recognized as two regionalized ecological systems: Mojave Desert Active and Stabilized Dunes and Colorado Plateau Active and Stabilized Dunes. Nevertheless, the NatureServe and Logan Simpson ecological systems retain correspondences which can be crosswalked. In this case, both 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. Logan Simpson 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). Logan Simpson 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.

Logan Simpson 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 ..... **Substrate Term**

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 Mojave 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 U.S. 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 4,029 typed polygons within the survey area, the gaps in the NVC 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, 2010, and 2012 field seasons. These ecological systems are first organized by ecological region – Colorado Plateauand Mojave 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, and a map depicting the location of the ecological system in relation to the entire LPP survey area. For reference, a map of the two ecological regions is included above in Chapter 2 (Figure 2-2). A map that includes all place names and MWH reaches referenced in the descriptions below is provided in Appendix C. Appendix D 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 (14,487 acres of the 18,231 total acres surveyed). The Colorado Plateau extends from Lake Powell west to the Hurricane Cliffs east of Hurricane, Utah (Figure 2-2). Here, in the Hurricane area, the Colorado Plateau Region meets up with the Great Basin Region to the north and the Mojave Desert Region to the south.

Within the Colorado Plateau Region of the LPP survey area there are 15 ecological systems, 195 alliances, and 490 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	10	30	615.3
Colorado Plateau Big Sagebrush Shrubland	6	45	3069.2
Colorado Plateau Blackbrush-Mormon-tea Shrubland	8	30	1582.2
Colorado Plateau Grassland	5	6	547.1
Colorado Plateau Greasewood Flat	1	10	184.1
Colorado Plateau Gypsum Badland	19	33	662.5
Colorado Plateau Juniper Savanna	3	2	30.5
Colorado Plateau Lower Montane Riparian Woodland and Shrubland	7	10	82.8
Colorado Plateau Mixed Bedrock Canyon and Tableland	24	49	464.1
Colorado Plateau Mixed Desert Scrub	28	92	3671.2
Colorado Plateau Mixed Low Sagebrush Shrubland	3	5	69.9
Colorado Plateau Pinyon-Juniper Woodland	18	60	1774.2

Table 4-1 Colorado Plateau Region Page 2 of 2			
Ecological System	**Number of Alliances**	**Number of Associations**	**Acreage**
Colorado Plateau Shrub-Steppe	25	61	1858.9
Colorado Plateau Volcanic Rock and Cinder Land	2	3	37.3
Colorado Plateau Wash	8	46	159.3

4.2.1 Colorado Plateau Active and Stabilized Dune Ecological System

4.2.1.1 Geographic Distribution

The active and stabilized dune community is predominantly found within the eastern portion of the Colorado Plateau Region; however, there are four exceptions: an occurrence along Arizona State Route 389 west of Mount Trumbull Road, two areas along U.S. Highway 89 with one just west of Fredonia and a second just east of Pipe Springs National Monument, and a single occurrence west of Yellowstone Road. Within the pipeline corridor this system was found scattered along U.S. Highway 89 from the Glen Canyon Dam area to west of Big Water, as well as near the Paria Canyon area, the Cockscomb area, Five mile Valley, and Kimball Valley. Within the transmission line corridor this system was found scattered from the Glen Canyon Dam area to the Cockscomb (Figure 4-2).

4.2.1.2 Alliances and Associations

Within the survey area, the Colorado Plateau Active and Stabilized Dune Ecological System is comprised of 10 alliances. The *Artemisia filifolia* Shrubland Alliance is the most common alliance. It consists of 13 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 615.3 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**	**405.8 acres**
Artemisia filifolia - Atriplex canescens - Vanclevea stylosa Shrubland	0.03 acres
Artemisia filifolia - Atriplex canescens Shrubland	2.903 acres
Artemisia filifolia - Ephedra (*nevadensis*, *torreyana*, *viridis*) Shrubland	84.703 acres
Artemisia filifolia - Ephedra (*nevadensis*, *torreyana*, *viridis*) Sparse Shrubland	70.403 acres
Artemisia filifolia - Ephedra nevadensis - Vanclevea stylosa Shrubland	45.803 acres
Artemisia filifolia - Tamarix chinensis Semi-natural Shrubland	3.003 acres
Artemisia filifolia - Vanclevea stylosa Shrubland	48.103 acres
Artemisia filifolia / (*Bromus rubens*, *Erodium cicutarium*, *Salsola tragus*) Semi-natural Shrubland	2.603 acres
Artemisia filifolia Colorado Plateau Shrubland	98.503 acres

Artemisia filifolia Sparse Shrubland	5.903 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	38.7 acres	
***Artemisia filifolia* Sparsely Vegetated Alliance**		**6.0 acres**
Artemisia filifolia Sparse Vegetation	6.0 acres	
***Artemisia tridentata* Shrubland Alliance**		**0.3 acres**
Juniperus osteosperma / *Artemisia filifolia* Wooded Shrubland	0.3 acres	
***Coleogyne ramosissima - Ephedra nevadensis* Shrubland Alliance**		**19.3 acres**
Coleogyne ramosissima - *Ephedra nevadensis* Dwarf-shrubland	19.3 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**2.4 acres**
Coleogyne ramosissima Dwarf-shrubland	2.4 acres	
***Ephedra nevadensis* Shrubland Alliance**		**133.8 acres**
Ephedra nevadensis - *Vanclevea stylosa* / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Shrubland	26.8 acres	
Ephedra nevadensis - *Vanclevea stylosa* Shrubland	69.9 acres	
Ephedra nevadensis Shrubland	3.8 acres	
Ephedra nevadensis Sparse Shrubland	1.7 acres	
Juniperus osteosperma / *Ephedra* (*torreyana*, *nevadensis*) - *Gutierrezia sarothrae* Wooded Shrubland	13.1 acres	
Juniperus osteosperma / *Ephedra* (*torreyana*, *nevadensis*) Wooded Shrubland	18.5 acres	
***Ephedra nevadensis* Sparsely Vegetated Alliance [Provisional]**		**7.9 acres**
Ephedra nevadensis Sparse Vegetation	7.9 acres	
***Gutierrezia sarothrae* Dwarf-shrubland Alliance**		**2.1 acres**
Gutierrezia sarothrae Dwarf-shrubland	2.1 acres	
***Juniperus osteosperma* Woodland Alliance**		**23.6 acres**
Juniperus osteosperma / *Artemisia filifolia* Sparse Woodland	1.6 acres	
Juniperus osteosperma / *Artemisia filifolia* Woodland	7.1 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	

Sparse Vegetation	**2.4 acres**
Unclassified	**11.7 acres**

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. A variety of vegetation exists within this ecological system, which may consist of: *Achnatherum hymenoides*, *Artemisia fililfolia*, *Artemisia tridentata ssp. tridentata*, *Atriplex canescens*, *Ephedra* spp., *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ericameria nauseosa*, *Hesperostipa comata*, *Leymus flavenscens*, *Muhlenbergia pungens*, *Psoralidium laneolatum*, *Purshia tridentata*, *Redfieldia flexuousa*, *Sporobolus airoides*, *Sarcobatus vermiculatus*, *Tetradymia tetramers*, or *Tiquilia* spp.

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

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 fourth 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 greene*i. 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* 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 Dwarf-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.

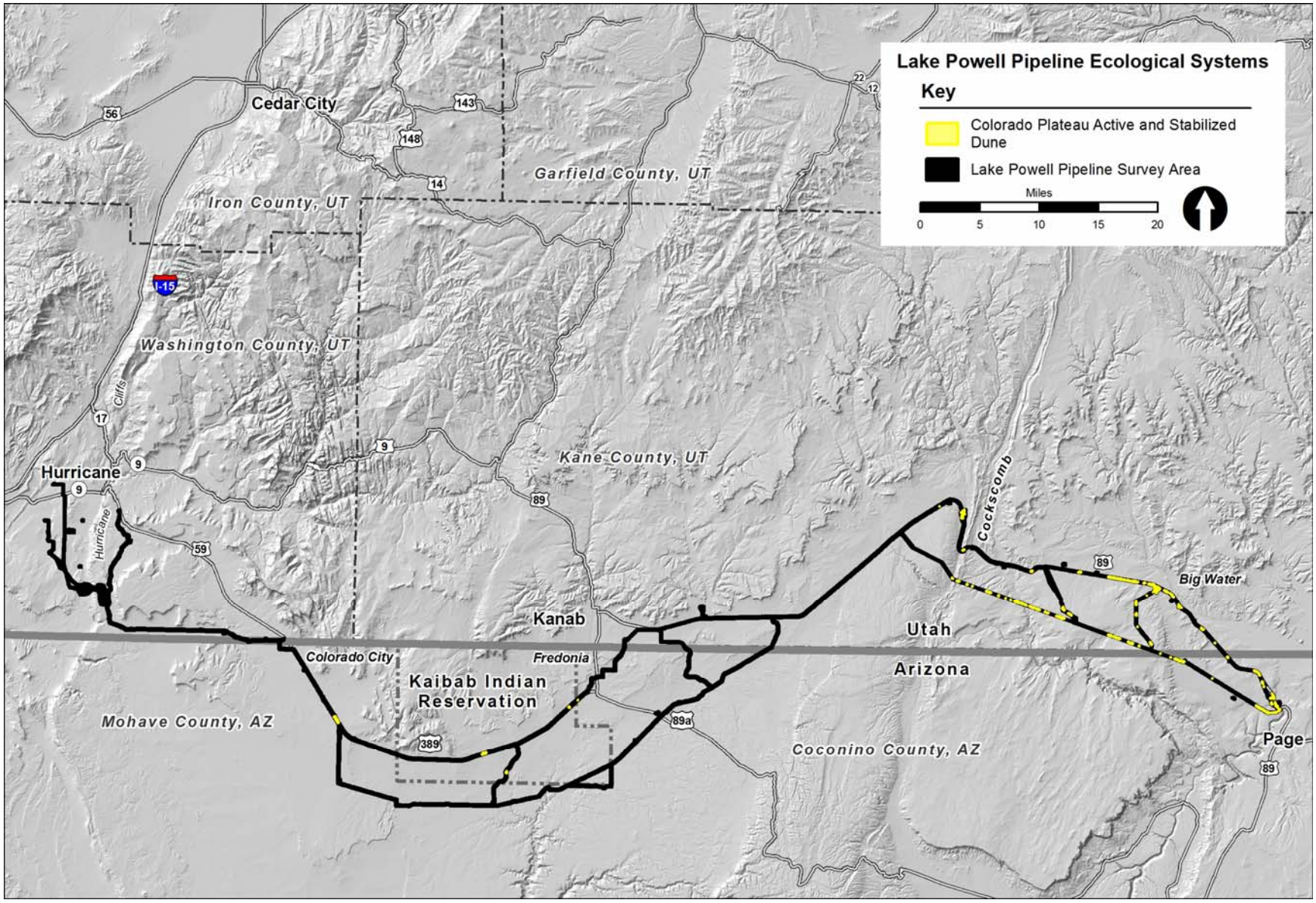


Figure 4-2
Colorado Plateau Active and Stabilized Dune Ecological System Map

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 U.S. Highway 89 from just west of the Cockscomb to Fredonia and the southest corner of the Kaibab-Paiute Indian Reservation.There are other more minor occurrences near Colorado City and just east of the Hurricane Cliffs (Figure 4-4).

4.2.2.2 Alliances and Associations

Within the survey area, the Colorado Plateau Big Sagebrush Shrubland Ecological System is comprised of six 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 3,069.2 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 [Provisional]	26.6 acres	
Artemisia filifolia - *Artemisia tridentata* ssp. *vaseyana* – *Gutierrezia sarothrae* Shrubland	22.7 acres	
***Artemisia tridentata* Shrubland Alliance**		**743.8 acres**
Artemisia (*filifolia*, *tridentata*) / *Pleuraphis jamesii* Shrubland	112.2 acres	
Artemisia tridentata - *Atriplex confertifolia* Shrubland	1.5 acres	
Artemisia tridentata - *Ephedra viridis* Shrubland	6.7 acres	
Artemisia tridentata - *Ericameria nauseosa* Shrubland	31.4 acres	
Artemisia tridentata - *Gutierrezia sarothrae* / Sparse Understory Shrubland	3.3 acres	
Artemisia tridentata - *Gutierrezia sarothrae* Shrubland	25.2 acres	
Artemisia tridentata - *Gutierrezia sarothrae* Sparse Shrubland	16.5 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	15.0 acres	
Artemisia tridentata / Sparse Understory Shrubland	345.2 acres	
Artemisia tridentata Shrubland	66.6 acres	
Artemisia tridentata ssp. *vaseyana* / (*Erodium cicutarium*, *Salsola tragus*, *Lolium perenne*) Semi-natural Sparse Shrubland	7.7 acres	
***Artemisia tridentata* ssp. *tridentata* Shrubland Alliance**		**527.8 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	5.4 acres	
Artemisia tridentata ssp. *tridentata* / Sparse Understory Shrubland	367.2 acres	
Artemisia tridentata ssp. *tridentata* Shrubland	93.5 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**		**1667.9 acres**
Artemisia tridentata ssp. *tridentata* Shrubland	1.1 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	11.2 acres	
Artemisia tridentata ssp. *vaseyana* - *Ericameria nauseosa* Shrubland	8.4 acres	
Artemisia tridentata ssp. *vaseyana* - *Gutierrezia sarothrae* / (*Pleuraphis jamesii*, *Sporobolus cryptanthus*) Shrubland	39.7 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	90.9 acres	
Artemisia tridentata ssp. *vaseyana* - *Gutierrezia sarothrae* Shrubland	107.4 acres	
Artemisia tridentata ssp. *vaseyana* / (*Erodium cicutarium*, *Salsola tragus*, *Lolium perenne*) Semi-natural Shrubland	102.8 acres	
Artemisia tridentata ssp. *vaseyana* / (*Erodium cicutarium*, *Salsola tragus*, *Lolium perenne*) Semi-natural Sparse Shrubland	39.2 acres	
Artemisia tridentata ssp. *vaseyana* / (*Pleuraphis jamesii*, *Heterostipa comata* ssp. *comata*) Shrubland	75.1 acres	

Artemisia tridentata ssp. *vaseyana* / *Pleuraphis jamesii* Shrubland	37.9 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	22.0 acres	
Artemisia tridentata ssp. *vaseyana* / Sparse Understory Shrubland	409.2 acres	
Artemisia tridentata ssp. *vaseyana* Shrubland	633.7 acres	
Artemisia tridentata ssp. *vaseyana* Sparse Shrubland	29.4 acres	
***Salsola tragus* Semi-natural Herbaceous Alliance**		**79.3 acres**
Artemisia tridentata / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	38.9 acres	
Artemisia tridentata ssp. *tridentata* / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	26.1 acres	
Artemisia tridentata ssp. *vaseyana* / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	14.3 acres	

4.2.2.3 Physiognomy and Composition

The Colorado Plateau Big Sagebrush Shrubland Ecological System is primarily shrubland or sparse shrubland (Figure 4-3). 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. Typical plant species that occur in this ecological system include the following: *Artemisia tridentata* ssp. *tridentata* and/or *Artemisia tridentata* ssp. *wyomingensis*, *Juniiperus* spp., *Sarcobatus vermiculatus*, *Atriplex* spp., *Ericameria nauseosa*, *Chrysothamnus viscidiflorus*, *Purshia tridentate*, *Achnatherum humenoides*, *Bouteloua gracilis*, *Elymus lanceolatus*, *Festuca idahoensis*, *Hesperostipa comate*, *Leymus cinereus*, and *Pleuraphis jamesii*.

Figure 4-3
Colorado Plateau Big Sagebrush Shrubland
Ecological System

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. *tridentat*a 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 2007) and prevent tree encroachment on transmission lines, respectively.

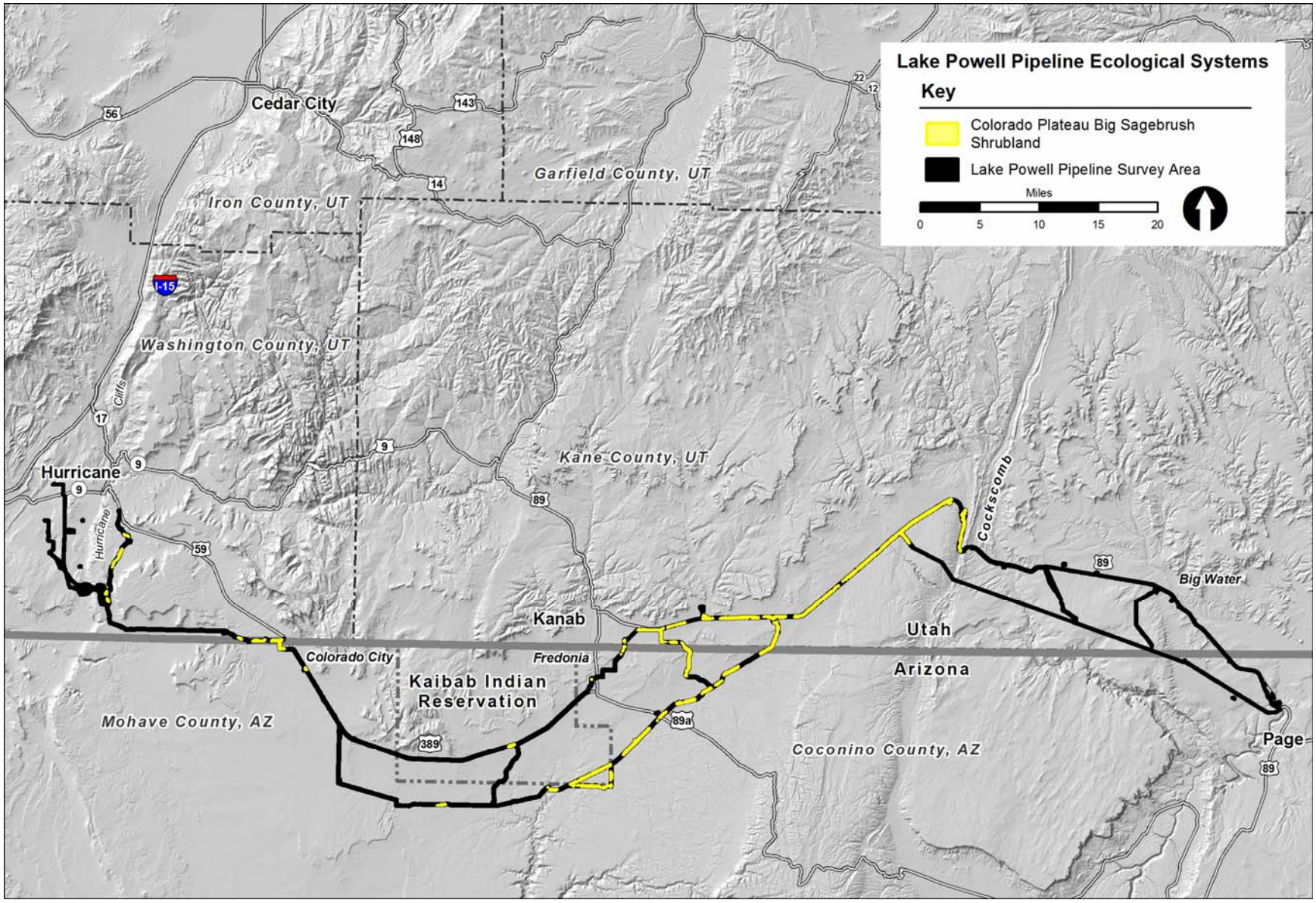


Figure 4-4
Colorado Plateau Big Sagebrush Shrubland Ecological System Map

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 Arizona State Route 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, the forebay and north to Hurricane (Figure 4-6).

4.2.3.2 Alliances and Associations

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

Various Ephedra dominated alliances are as the second most common; the Ephedra nevadensis Shrubland Alliance is most abundant, including nine 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. This ecological system totals 1,260.3 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**66.3 acres**
Artemisia filifolia - Ephedra (*nevadensis*, *torreyana*, *viridis*) Shrubland	45.0 acres	
Artemisia filifolia - Ephedra (*nevadensis*, *torreyana*, *viridis*) Sparse Shrubland	21.3 acres	
***Coleogyne ramosissima - Ephedra nevadensis* Shrubland Alliance**		**1.5 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	1.5 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**544.7 acres**
Coleogyne ramosissima - Artemisia filifolia Shrubland	14.9 acres	
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	7.2 acres	
Coleogyne ramosissima - Ephedra nevadensis Shrubland	90.1 acres	
Coleogyne ramosissima - Ephedra viridus Shrubland	5.1 acres	
Coleogyne ramosissima - Ephedra viridus Sparse Shrubland	9.2 acres	
Coleogyne ramosissima - Gutierrezia sarothrae Shrubland	72.4 acres	
Coleogyne ramosissima - Gutierrezia sarothrae Sparse Shrubland	15.3 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	6.2 acres	
Coleogyne ramosissima Dwarf-shrubland	56.2 acres	
Coleogyne ramosissima Shrubland	254.2 acres	
Coleogyne ramosissima Sparse Dwarf-shrubland	5.7 acres	
Juniperus osteosperma / *Coleogyne ramosissima* Wooded Shrubland	2.6 acres	
***Ephedra* (*nevadensis, torreyana*) Shrubland Alliance**		**173.1 acres**
Ephedra nevadensis - *Ephedra torreyana* Shrubland	106.0 acres	
Ephedra nevadensis - *Ephedra torreyana* Sparse Shrubland	67.1 acres	
***Ephedra nevadensis* - *Ephedra viridis* Shrubland Alliance**		**677.5 acres**
Ephedra nevadensis - *Ephedra viridis* Shrubland	33.6 acres	
Ephedra nevadensis Shrubland Alliance	322.0 acres	
Ephedra nevadensis - *Gutierrezia sarothrae* Dwarf-shrubland	13.0 acres	
Ephedra nevadensis - *Gutierrezia* sarothrae Shrubland	15.0 acres	
Ephedra nevadensis - *Gutierrezia sarothrae* Sparse Shrubland	30.9 acres	
Ephedra nevadensis / (*Erodium cicutarium*, *Bromus rubens*) Semi-natural Sparse Shrubland	107.1 acres	
Ephedra nevadensis / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Shrubland	40.4 acres	
Ephedra nevadensis Shrubland	84.0 acres	
Ephedra nevadensis Sparse Shrubland	31.5 acres	
***Ephedra torreyana* Shrubland Alliance**		**16.7 acres**
Ephedra torreyana Shrubland	7.9 acres	
Ephedra torreyana Sparse Shrubland	8.8 acres	
Salsola tragus Semi-natural Herbaceous Alliance		**5.2 acres**
Coleogyne ramosissima / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	5.2 acres	
Unclassified		**97.2 acres**

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 4-5). It is rarely wooded shrubland, shrub herbaceous vegetation, or a mosaic of shrubland/dwarf-shrubland. This ecological system is dominated by *Coleogyn ramosissima* often with *Ephedra viridis*, *Ephedra torreyana*, or *Grayia spinosa*. *Artemisia filifolia* is a co-dominant. The herbaceous layer may include *Achnatherum hymenoides*, *Pleuraphis jamesii*, or *Sporobolus cryptandrus*.

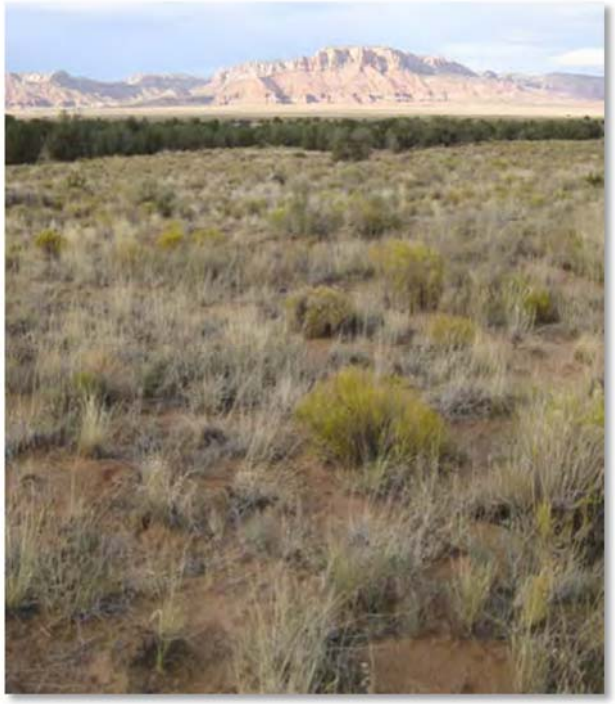


Figure 4-5
Colorado Plateau Blackbrush-Mormon-tea
Shrubland Ecological System

4.2.3.4 Disturbance Regimes

Within the LPP survey area, *Artemisia filifolia* is an increaser species under prolonged grazing disturbance in the Colorado Plateau Blackbrush- Mormon-tea Shrubland Ecological System. *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.

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 dominates 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.

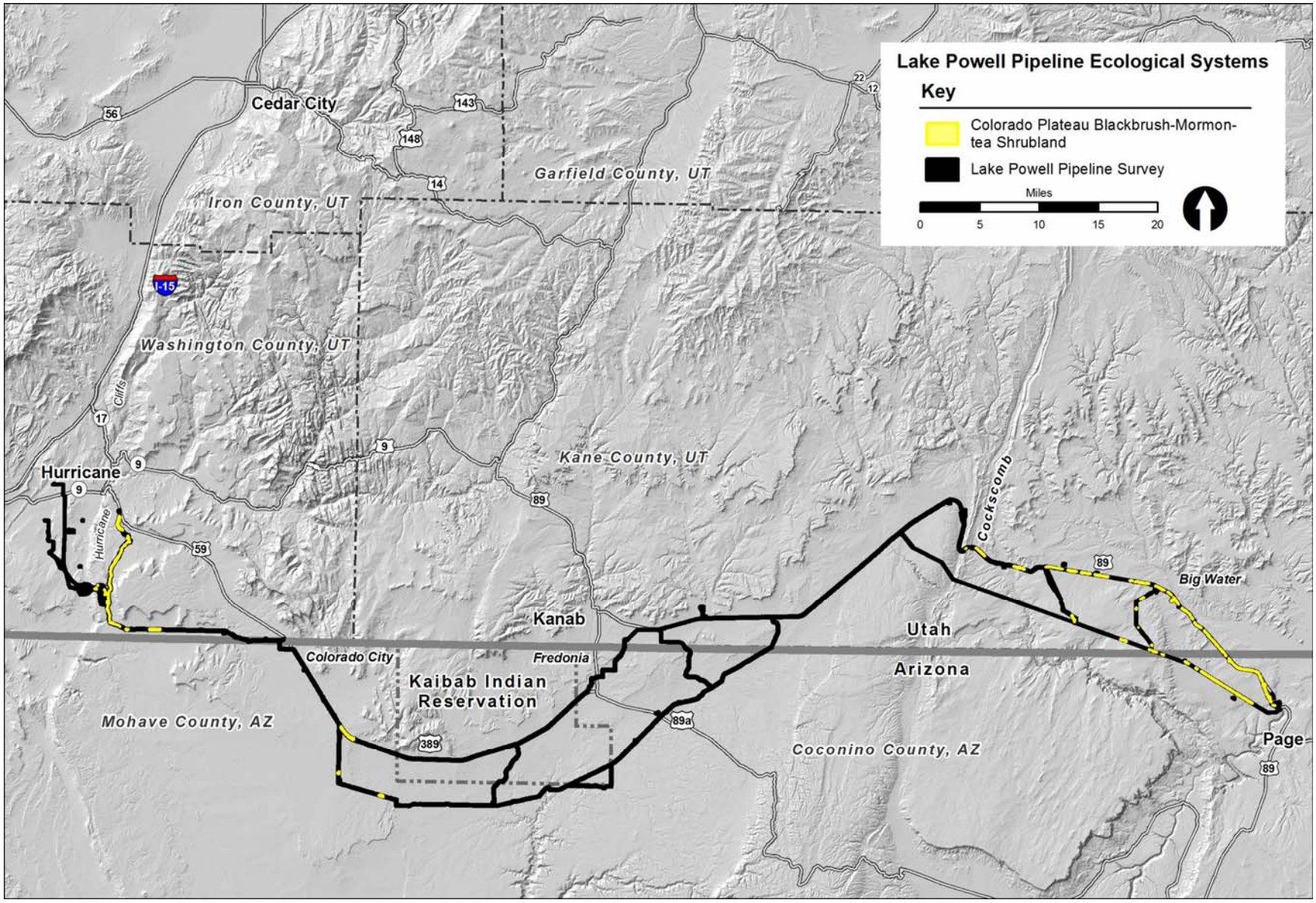


Figure 4-6
Colorado Plateau Blackbrush-Mormon-tea Shrubland Ecological System Map

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 U.S. Highway 89 and both east and west of Mount Trumbull Road along the transmission line corridor south of the Kaibab-Paiute Indian Reservation (Figure 4-8).

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 547.1 acres within the survey area. Acreage by alliance and association is as follows:

***Achnatherum hymenoides* Herbaceous Alliance**		**287.7 acres**
Achnatherum hymenoides Colorado Plateau Herbaceous Vegetation	287.7 acres	
***Bouteloua barbata* Herbaceous Alliance**		**20.1 acres**
Bouteloua barbata - *Erodium cicutarium* Semi-natural Herbaceous Vegetation	20.1 acres	
Herbaceous Vegetation		**13.0 acres**
Herbaceous Vegetation	13.0 acres	
***Hesperostipa comata* Herbaceous Alliance**		**1.3 acres**
Hesperostipa comata Herbaceous Vegetation	1.3 acres	
***Pleuraphis jamesii* Herbaceous Alliance**		**225.0 acres**
Pleuraphis jamesii - (*Erodium cicutarium*, *Bromus tectorum*, *Salsola tragus*) Semi-natural Herbaceous Vegetation	41.6 acres	
Pleuraphis jamesii Herbaceous Vegetation	183.5 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 4-7). Typical plant species occurring in this ecological system include the following: *Artemisia tridentata ssp. tridentata*, *Artemisia tridentata* ssp. w*yomingensis*, *Atriplex* spp. *Coleogyne* spp., *Ephedra* spp., *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Achnatherum hymenoides*, *Aristida* spp., *Bouteloua gracilis*, *Hesperostipa comata*, *Muhlenbergia* spp., *Pleuraphis jamesii*, and *Sporobolus* spp.

Figure 4-7
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.

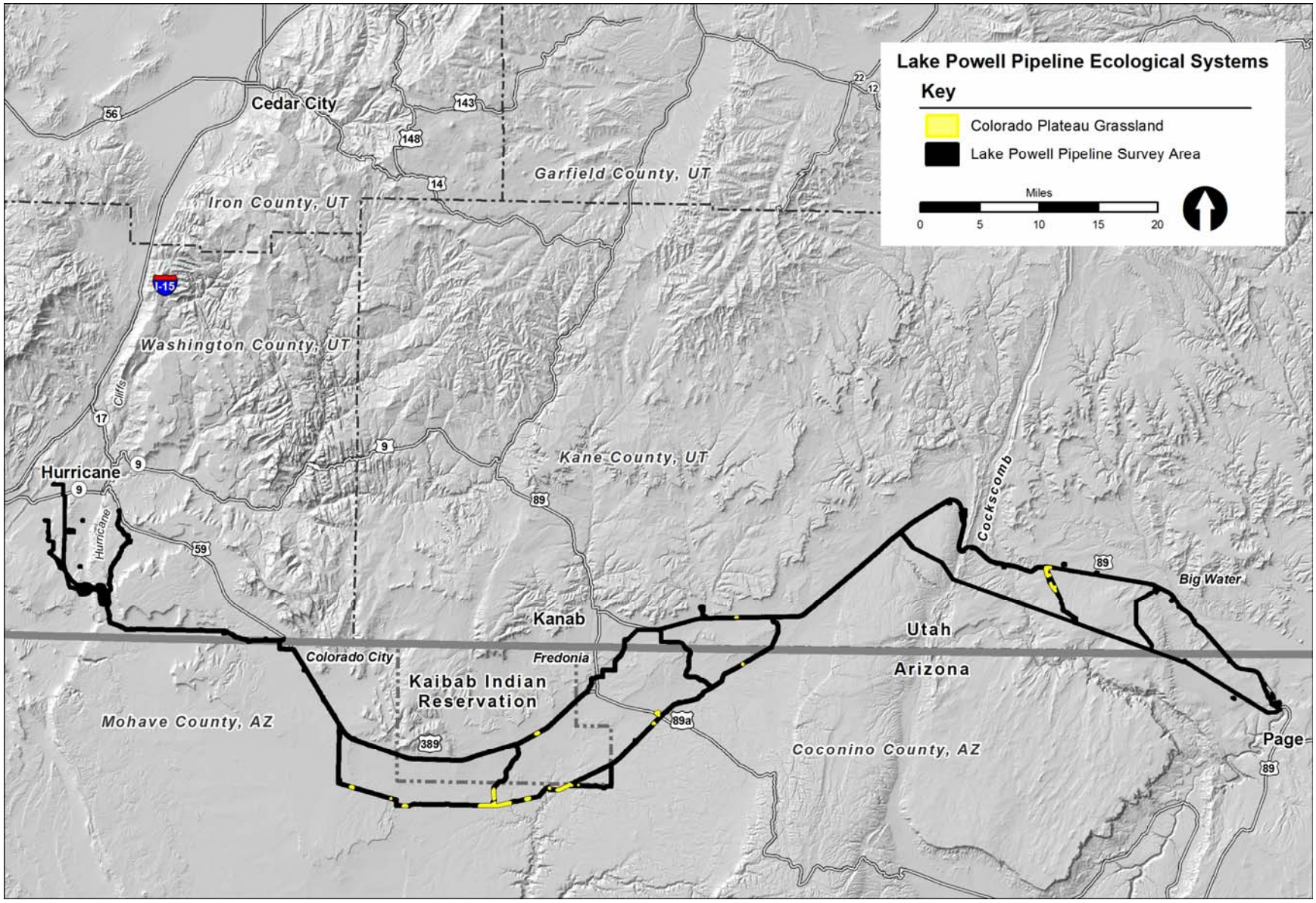


Figure 4-8
Colorado Plateau Grassland Ecological System Map

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 U.S. Highway 89, where the proposed pipeline crosses the highway (Figure 4-10).

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 184.1 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	18.7 acres
Sarcobatus vermiculatus - *Artemisia tridentata* Sparse Shrubland	0.9 acres
Sarcobatus vermiculatus - *Atriplex confertifolia* / (*Salsola tragus*, *Ceratophylla testulata*) Semi-natural Shrubland	13.2 acres
Sarcobatus vermiculatus - *Gutierrezia sarothrae* / *Salsola tragus* Semi-natural Shrubland	42.6 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	70.3 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 4-9). Typical vegetation occurring within this ecological system includes the following: *Sarcobatus vermiculatus*, *Atriplex canescens*, *Atriplex confertifolia*, *Atriplex gardneri*, *Artemisia tridentata* ssp. *Wyomingensis*, *Artemisia tridentata ssp. tridentata Artemisa cana* ssp. *cana*, and *Krascheninnikovia lanata*.

Figure 4-9
Colorado Plateau Greasewood Flat Ecological System

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.

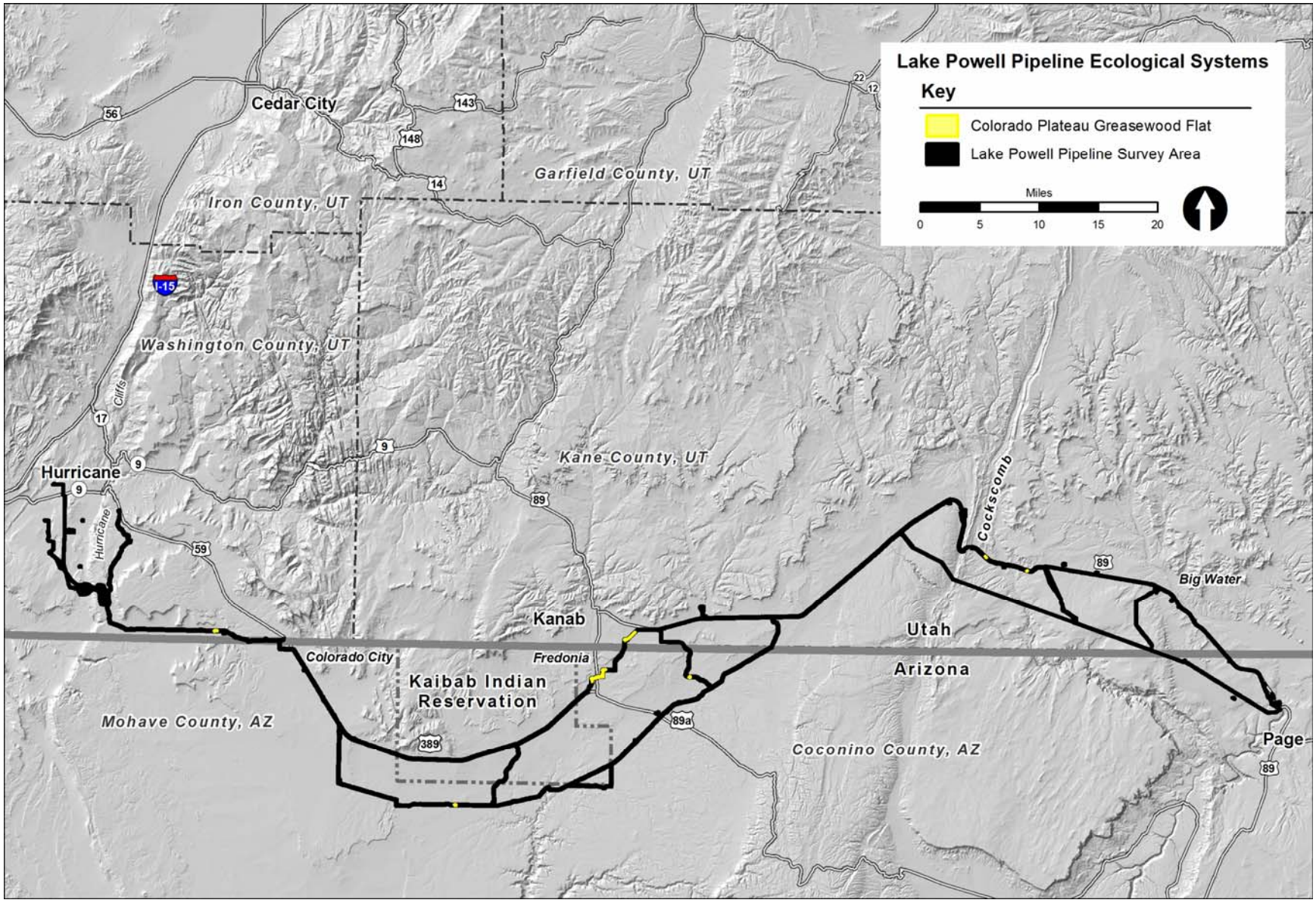


Figure 4-10
Colorado Plateau Greasewood Flat Ecological System Map

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 Petrified Hollow Wash along U.S. Highway 89 to Seaman Wash and sporadically to the Johnson Wash area. It dominates the landscape from east of Fredonia across the Kaibab-Paiute Indian Reservation to the Pipe Springs National Monument turnoff along Arizona State Route 389. Another large area dominated by this System is located along the Honeymoon Trail north past The Divide to Utah State Route 59(Figure 4-13).

4.2.6.2 Alliances and Associations

Within the survey area, The Colorado Plateau Gypsum Badland Ecological is comprised of 19 alliances, including 33 associations. This ecological system totals 662.5 acres. Acreage by alliance and association is as follows:

***Artemisia biglovii* Shrubland Alliance**		**46.2 acres**
Artemisia bigelovii - *Chrysothamnus greenei* Gypsum Badlands Sparse Dwarf-shrubland	15.0 acres	
Artemisia bigelovii - *Ephedra torreyana* / Cryptobiotic Gypsum Badlands Sparse Shrubland	31.2 acres	
***Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance**		**86.9 acres**
Artemisia tridentata ssp. *vaseyana* / *Pleuraphis jamesii* Gypsum Badlands Shrubland	61.8 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	11.8 acres	
Pinus edulis - *Juniperus osteosperma* / *Artemisia tridentata* ssp. *vaseyana* Gypsum Badlands Wooded Shrubland	2.3 acres	
***Atriplex confertifolia* Shrubland Alliance**		**84.1 acres**
Atriplex confertifolia / *Salsola tragus* Semi-natural Gypsum Badlands Dwarf-shrubland	3.1 acres	
Atriplex confertifolia Gypsum Badlands Dwarf-shrubland	60.7 acres	
Atriplex confertifolia Gypsum Badlands Sparse Dwarf-shrubland	20.3 acres	
***Atriplex confertifolia* Sparsely Vegetated Alliance**		**7.3 acres**
Atriplex confertifolia Gypsum Badlands Sparse Vegetation	7.3 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**16.4 acres**
Chrysothamnus viscidiflorus Gypsum Badlands Sparse Dwarf-shrubland	16.4 acres	
***Ephedra* (*nevadensis, torreyana*) Shrubland Alliance**		**28.5 acres**
Ephedra (*nevadensis*, *torreyana*) Gypsum Badlands Sparse Shrubland	26.7 acres	

Ephedra torreyana - (*Atriplex* spp.) / Cryptobiotic Gypsum Badlands Sparse Shrubland	1.8 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**		**31.1 acres**
Eriogonum corymbosum - *Artemisia tridentata* ssp. *vaseyana* Gypsum Badlands Sparse Shrubland	26.2 acres	
Eriogonum corymbosum Gypsum Badlands Shrubland	2.9 acres	
Eriogonum corymbosum Gypsum Badlands Sparse Vegetation	2.0 acres	
***Eriogonum corymbosum* Sparsely Vegetated Alliance**		**0.4 acres**
Eriogonum corymbosum Gypsum Badlands Sparse Vegetation	0.4 acres	
***Eriogonum thompsoniae* var. *atwoodii* Sparsely Vegetated Alliance**		**16.0 acres**
Eriogonum thompsoniae var. *atwoodii* Gypsum Badlands Sparse Vegetation	16.0 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**		**10.0 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**		**15.7 acres**
Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Gypsum Badlands Woodland	15.6 acres	
Juniperus osteosperma Gypsum Badlands Sparse Woodland	0.1 acres	
***Mahonia fremontii* Shrubland Alliance**		**3.3 acres**
Mahonia fremontii Gypsum Badlands Sparse Shrubland	3.3acres	

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 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**		**18.7 acres**
Pleuraphis jamesii Gypsum Badlands Herbaceous Vegetation	12.1 acres	
Pleuraphis jamesii Gypsum Badlands Sparse Vegetation	6.6 acres	
***Purshia* (*stansburiana, glandulosa, mexicana*) Sparsely Vegetated Alliance**		**4.2 acres**
Purshia glandulosa Gypsum Badlands Sparse Vegetation	4.2 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 4-11 and Figure 4-12); 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. Typical vegetation in this ecological system includes the following: *Artemisia bigelovii*, *Ephedra torreyana*, *Ericameria nauseosa*, *Eriogonum corymbosum*, *Achnatherum hymenoides*, *Sporobolus airoides*, and *Pleuraphis jamesii*.

Figure 4-11
Colorado Plateau Gypsum Badland Ecological System, Mud Wash

Figure 4-12
Colorado Plateau Gypsum Badland Ecological System, Cryptobiotic Ridge

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 gypsophiles (Meyer 1986). The vegetal strata from ground level to 6.5 feet (2 meters) tall are 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 are 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.

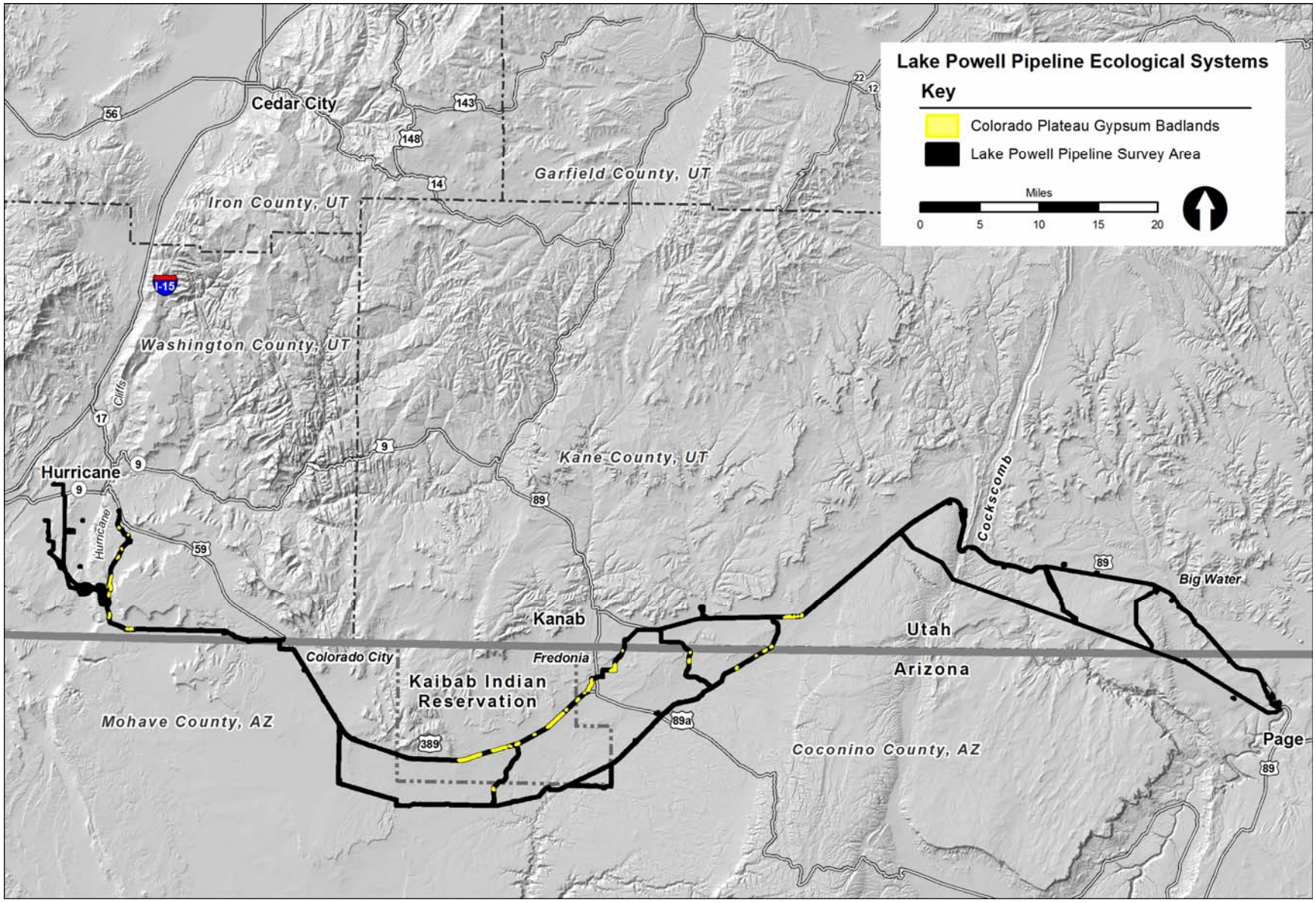


Figure 4-13
Colorado Plateau Gypsum Badland Ecological System Map

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 Arizona State Route 389 (Figure 4-15).

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 4-14). Typical vegetation associated with this ecological system includes *Juniperus osteosperma*, *Artemisia* spp., *Bouteloua gracilis*, and *Pleuraphis jamesii*.

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.

Figure 4-14
Colorado Plateau Juniper Savanna
Ecological System

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.

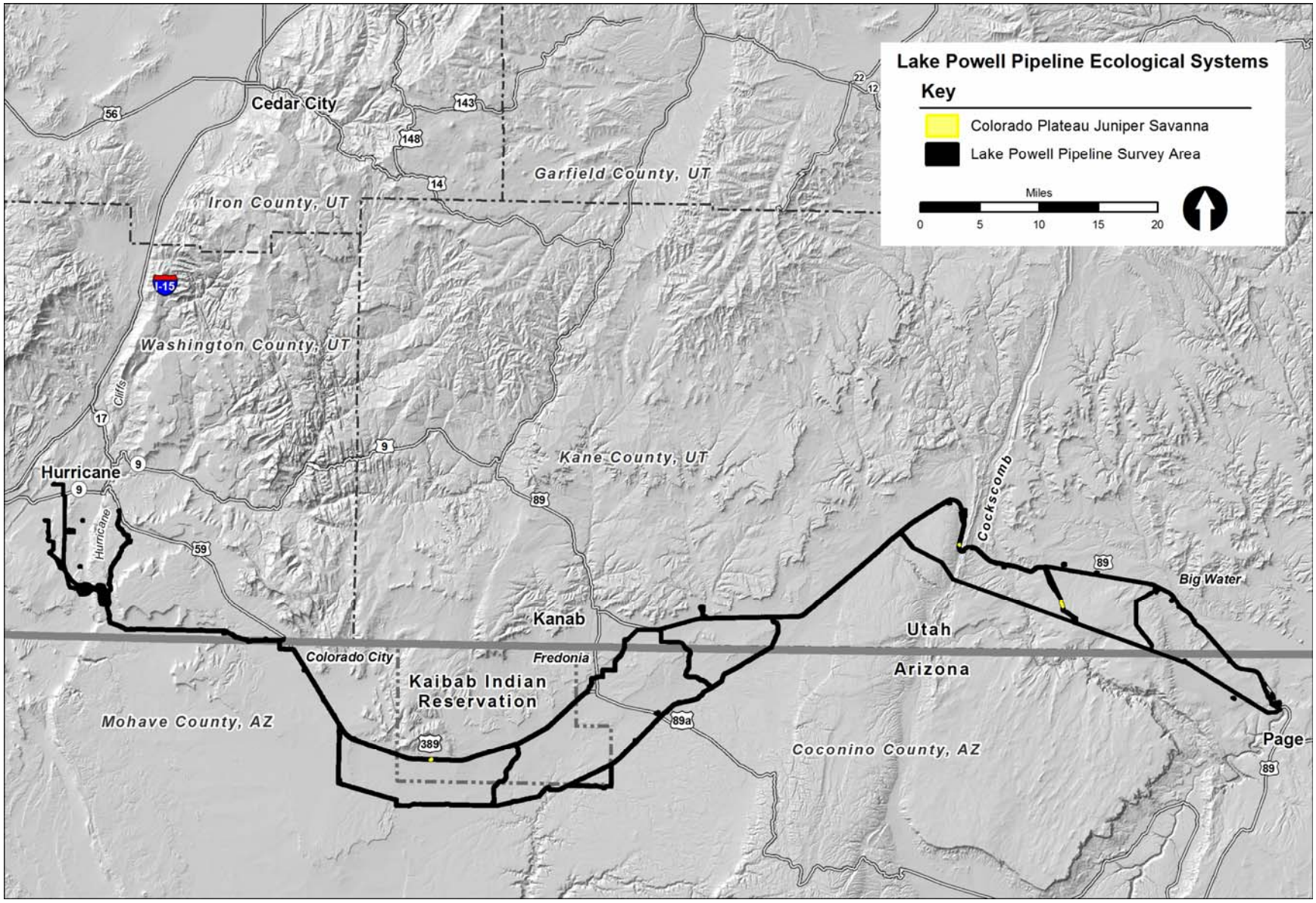


Figure 4-15
Colorado Plateau Juniper Savanna Ecological System Map

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 the following: Lower Blue Pool Wash, Upper Paria River, Seaman Wash, Whitesage Wash, Johnson Wash, Kanab Creek, Cottonwood Wash, Bitter Seep Wash, Twomile Wash, Short Creek, and Gould Wash (Figure 4-17).

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 seven alliances and 10 associations. This ecological system totals 82.8 acres within the survey area. Acreage by alliance and association is as follows:

***Elaeagnus angustifolia* Semi-natural Woodland Alliance**		**4.8 acres**
Elaeagnus angustifolia Semi-natural Woodland	4.8 acres	
***Juniperus osteosperma* Woodland Alliance**		**1.8 acres**
Juniperus osteosperma / *Tamarix chinensis* Semi-natural Woodland	1.8 acres	
***Populus fremontii* Woodland Alliance**		**23.1 acres**
Populus fremontii / *Elaeagnus angustifolia* Semi-natural Sparse Woodland	6.6 acres	
Populus fremontii / *Tamarix chinensis* Semi-natural Woodland	16.5 acres	
***Salix exigua* Shrubland Alliance**		**2.0 acres**
Salix exigua / *Tamarix chinensis* Semi-natural Shrubland	2.0 acres	
***Salix* sp. Shrubland Alliance**		**1.3 acres**
Salix sp. Shrubland	1.3 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**		**48.9 acres**
Tamarix chinensis Semi-natural Shrubland	45.6 acres	
Tamarix chinensis Semi-natural Sparse Shrubland	2.0 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 4-16), occasionally sparse shrubland, and rarely woodland, shrub herbaceous vegetation, or sparse vegetation. A mosaic of shrubland and sparse vegetation is also rare. Typical plant species associated with this ecological system include *Populus fremontii*, *Fraxinus velutina*, *Salix exigua*, *Prunus* spp., and *Baccharis salicifolia*.

Figure 4-16
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.

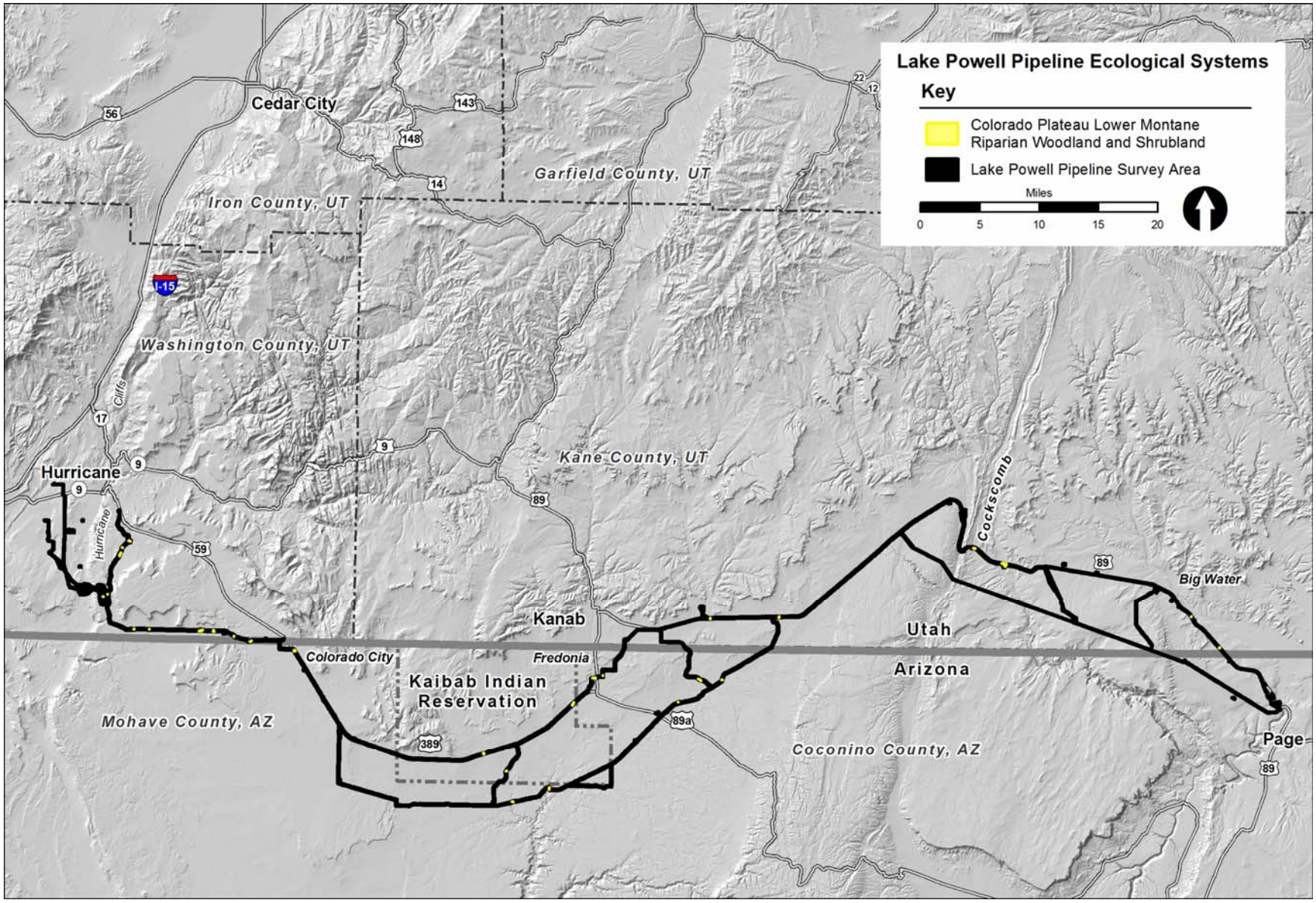


Figure 4-17
Colorado Plateau Lower Montane Riparian Woodland and Shrubland Ecological System Map

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 U.S. 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-Paiute Indian Reservation. Three 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 and one north of The Divide (Figure 4-19).

4.2.9.2 Alliances and Associations

Within the survey area, the Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System is comprised of 25 alliances, including 50 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**		**1.5 acres**
Pinus edulis - Juniperus osteosperma / Shepherdia routundifolia – Amelanchier utahensis Sandstone Bedrock Wooded Shrubland	1.5 acres	
***Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance**		**1.1 acres**
Artemisia tridentata ssp. *vaseyana* Shrubland	1.1 acres	
***Chrysothamnus greenei* Shrubland Alliance**		**8.0 acres**
Coleogyne ramosissima - Gutierrezia sarothrae Shrubland	8.0 acres	
***Coleogyne ramosissima* Sparsely Vegetated Alliance**		**8.8 acres**
Coleogyne ramosissima - Ephedra nevadensis Sparse Vegetation	3.0 acres	
Coleogyne ramosissima Sparse Vegetation	5.8 acres	
***Ephedra nevadensis* Sparsely Vegetated Alliance**		**29.9 acres**
Ephedra nevadensis Sandstone Slickrock Sparse Vegetation	7.1 acres	
Ephedra nevadensis Sparse Vegetation	16.1 acres	
Eriogonum corymbosum - Ephedra nevadensis - Coleogyne ramosissima Sandstone Slickrock Sparse Vegetation	6.8 acres	
***Ericameria nauseosa* Shrubland Alliance**		**1.3 acres**
Ericameria nauseosa / (Nonvascular) Shrubland	1.3 acres	
***Ericameria nauseosa* Sparsely Vegetated Alliance**		**3.8 acres**
Ericameria nauseosa - Artemisia biglovii Sandstone Bedrock Sparse Vegetation	1.4 acres	

Ericameria nauseosa Sandstone Bedrock Sparse Vegetation	2.4 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**47.1 acres**
Eriogonum corymbosum - *Chrysothamnus greenei* Shrubland	10.1 acres	
Eriogonum corymbosum - *Ephedra nevadensis* - *Coleogyne ramosissima* Sandstone Slickrock Sparse Vegetation	8.8 acres	
Eriogonum corymbosum - *Ephedra nevadensis* Sandstone Slickrock Sparse Shrubland	2.0 acres	
Eriogonum corymbosum - *Ericameria nauseosa* Sandstone Bedrock Sparse Shrubland	5.3 acres	
Eriogonum corymbosum Shrubland	19.6 acres	
Eriogonum corymbosum Sparse Shrubland	1.2 acres	
***Eriogonum corymbosum* Sparsely Vegetated Alliance**		**66.5 acres**
Eriogonum corymbosum - *Ephedra nevadensis* - *Coleogyne ramosissima* Sandstone Slickrock Sparse Vegetation	62.1 acres	
Eriogonum corymbosum - *Ericameria nauseosa* Sandstone Bedrock Sparse Shrubland	3.0 acres	
Eriogonum corymbosum Sparse Vegetation	1.4 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**4.3 acres**
Gutierrezia sarothrae Dwarf-shrubland	2.1 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	2.3 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**14.71 acres**
Gutierrezia sarothrae Sandstone Slickrock Sparse Vegetation	8.3 acres	
Gutierrezia sarothrae Sparse Vegetation	6.5 acres	
***Juniperus osteosperma* Sparsely Vegetated Alliance**		**34.2 acres**
Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Sparse Vegetation	1.2 acres	
Juniperus osteosperma / *Chrysothamnus greenei* Sandstone Bedrock Sparse Vegetation	6.8 acres	
Juniperus osteosperma / *Gutierrizia sarothrae* Sandstone Bedrock Sparse Vegetation	7.5 acres	
Juniperus osteosperma / Sandstone Outcrop Sparse Vegetation	14.2 acres	
Juniperus osteosperma Sandstone Slickrock Sparse Vegetation	4.5 acres	
***Juniperus osteosperma* Woodland Alliance**		**84.1 acres**
Juniperus osteosperma / *Artemisia filifolia* Sparse Woodland	7.9 acres	
Juniperus osteosperma / *Ephedra nevadensis* Sparse Woodland	5.5 acres	
Juniperus osteosperma / *Purshia tridentata* Sandstone Bedrock Sparse Woodland	16.3 acres	

Juniperus osteosperma / *Shepherdia rotundifolia* / Sandstone Outcrop Sparse Vegetation	1.6 acres	
Juniperus osteosperma / *Shepherdia rotundifolia* Sparse Woodland	47.9 acres	
Juniperus osteosperma Sparse Woodland	1.8 acres	
Juniperus osteosperma Woodland	3.1 acres	
Non-vegetated		**1.5 acres**
Non-vegetated SandstoneOutcrop	0.4 acres	
Sandstone Bedrock Non-vegetated	1.1 acres	
Non-vegetated Sandstone		**28.7 acres**
Non-vegetated SandstoneOutcrop	28.7 acres	
***Pinus edulis - Juniperus osteosperma* Sparsely Vegetated Alliance**		**12.9 acres**
Pinus edulis - Juniperus osteosperma Sandstone Slickrock Sparse Vegetation	5.7 acres	
Pinus edulis - Juniperus osteosperma Sparse Vegetation	7.2 acres	
***Pinus edulis - Juniperus osteosperma* Woodland Alliance**		**19.8 acres**
Pinus edulis - Juniperus osteosperma / *Artemisia bigelovii* Sandstone Bedrock Sparse Woodland	6.2 acres	
Pinus edulis - Juniperus osteosperma / *Coleogyne ramosissima* Sparse Woodland	5.1 acres	
Pinus edulis - Juniperus osteosperma / *Coleogyne ramosissima* Woodland	1.5 acres	
Pinus edulis - Juniperus osteosperma / *Shepherdia rotundifolia* Sparse Woodland	7.0 acres	
***Pinus edulis* Woodland Alliance**		**9.6 acres**
Pinus edulis / *Coleogyne ramosissima* Sparse Woodland	9.6 acres	
***Purshia glandulosa* Mixed Shrubland Alliance**		**16.1 acres**
Purshia glandulosa Mixed Shrubland	16.1 acres	
***Quercus* x *pauciloba* Shrubland Alliance**		**2.1 acres**
Quercus x *pauciloba* Shrubland	2.1 acres	
Sandstone Bedrock Sparse Vegetation		**1.0 acres**
Sandstone Bedrock Sparse Vegetation	1.0 acres	
***Shepherdia rotundifolia* Shrubland Alliance**		**16.0 acres**
Pinus edulis - Juniperus osteosperma / *Shepherdia routundifolia – Amelanchier utahensis* Sandstone Bedrock Wooded Shrubland	6.2 acres	
Shepherdia rotundifolia / Sandstone Outcrop Sparse Shrubland	5.9 acres	
Shepherdia rotundifolia Shrubland	3.9 acres	

Sparse Vegetation		**11.3 acres**
***Sphaeralcea* (*ambigua, coccinea, parviflora*) Herbaceous Alliance**		**10.6 acres**
Ephedra viridis / *Sphaeralcea parviflora* Shrub Herbaceous Vegetation	10.6 acres	
Unclassified		**19.6 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 4-18); 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. Typical vegetation associated with this ecological system includes *Pinus edulis*, *Pinus ponderosa*, *Juniperus* spp., *Cercocarpus intricatus*, *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, and *Ephedra torreyana*.

Figure 4-18
Colorado Plateau Mixed Bedrock Canyon
and Tableland Ecological System

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.

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 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.

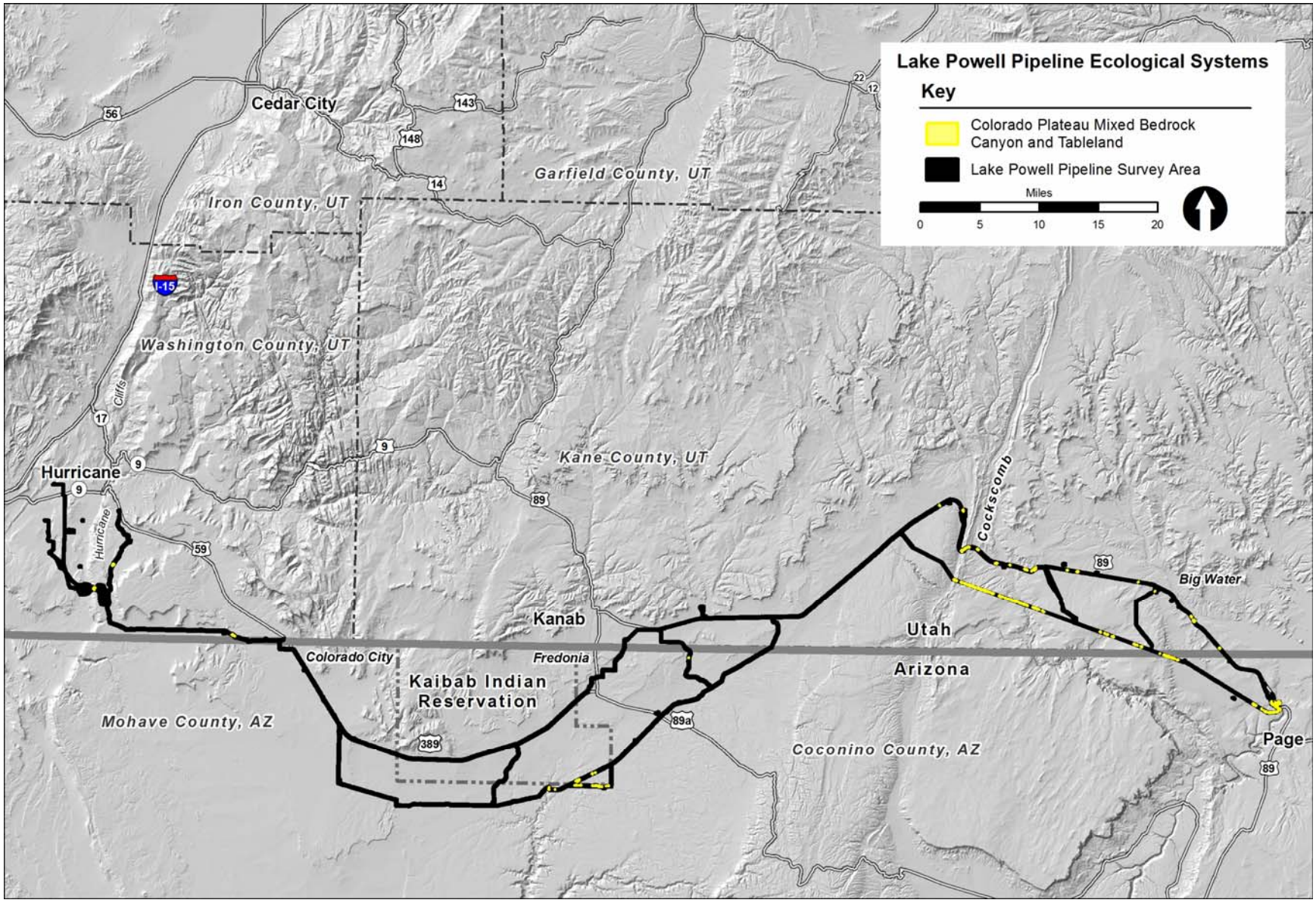


Figure 4-19
Colorado Plateau Mixed Bedrock Canyon and Tableland Ecological System Map

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 Gould Wash in the north (Figure 4-21).

4.2.10.2 Alliances and Associations

Within the survey area, the Colorado Plateau Mixed Desert Scrub Ecological System ecological system is comprised of 28 alliances, including 92 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 3,666.4 acres. Acreage by alliance and association is as follows:

***Aristida purpurea* Herbaceous Alliance**		**11.2 acres**
Lycium pallidum / *Aristida purpurea* Shrub Herbaceous Vegetation	11.2 acres	
***Artemisia filifolia* Shrubland Alliance**		**351.9 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* Shrubland	3.1 acres	
Artemisia filifolia - *Ericameria nauseosa* Shrubland	16.3 acres	
Artemisia filifolia - *Eriogonum corymbosum* Shrubland	36.9 acres	
Artemisia filifolia - *Gutierrezia sarothrae* Shrubland	20.3 acres	
Artemisia filifolia - *Psorothamnus fremontii* Sparse Shrubland	2.2 acres	
Artemisia filifolia / (*Bromus rubens*, *Erodium cicutarium*, *Salsola tragus*) Semi-natural Shrubland	38.7 acres	
Artemisia filifolia / (*Bromus rubens*, *Erodium cicutarium*, *Salsola tragus*) Semi-natural Sparse Shrubland	12.0 acres	
Artemisia filifolia Colorado Plateau Shrubland	173.6 acres	
Artemisia filifolia Sparse Shrubland	24.5 acres	
Juniperus osteosperma / *Artemisia filifolia* Wooded Shrubland	1.6 acres	
***Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance**		**43.3 acres**
Artemisia tridentata ssp. *vaseyana* - *Gutierrezia sarothrae* Shrubland	43.3 acres	
***Atriplex canescens* Shrubland Alliance**		**796.3 acres**
Artemisia filifolia - *Atriplex canescens* / (*Erodium cicutarium*, *Bromus* (*rubens*, *tectorum*), *Salsola tragus*) Semi-natural Sparse Shrubland	112.2 acres	
Atriplex canescens - *Artemisia filifolia* Shrubland	25.4 acres	

Atriplex canescens - *Artemisia tridentata* / *Pleuraphis jamesii* Sparse Shrubland	2.7 acres
Atriplex canescens - *Artemisia tridentata* / *Salsola tragus* Semi-natural Shrubland	16.5 acres
Atriplex canescens - *Artemisia tridentata* / *Tamarix chinensis* Semi-natural Shrubland	13.0 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	6.5 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	10.0 acres
Atriplex canescens - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Shrubland	28.2 acres
Atriplex canescens - *Gutierrezia sarothrae* Shrubland	3.5 acres
Atriplex canescens - *Krascheninnikovia lanata* Shrubland	10.2 acres
Atriplex canescens / (*Erodium cicutarium*, *Bromus* (*rubens*, *tectorum*), *Salsola tragus*) Semi-natural Sparse Shrubland	198.98 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	81.1 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	8.1 acres
Atriplex canescens / *Pleuraphis jamesii* Shrubland	70.6 acres
Atriplex canescens / *Pleuraphis jamesii* Sparse Shrubland	8.9 acres
Atriplex canescens / *Sporobolus cryptandrus* Sparse Shrubland	10.5 acres
Atriplex canescens Shrubland	55.2 acres
Atriplex canescens Sparse Shrubland	48.7 acres
***Atriplex confertifolia* Shrubland Alliance**	**49.6 acres**
Atriplex confertifolia - *Krascheninnikovia lanata* / (*Salsola tragus*, *Bromus* (*rubens*, *tectorum*)) Semi-natural Sparse Shrubland	10.8 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**		**192.3 acres**
(*Purshia tridentate*) - *Chrysothamnus greenei* Sparse Shrubland	24.9 acres	
Chrysothamnus greenei - *Gutierrezia sarothrae* Dwarf-shrubland	22.6 acres	
Chrysothamnus greenei Dwarf-shrubland	137.4 acres	
Chrysothamnus greenei Sparse Dwarf-shrubland	7.5 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**8.4 acres**
Chrysothamnus viscidiflorus Shrubland	8.4 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**		**29.1 acres**
Ericameria linearifolia Dwarf-shrubland	29.1 acres	
***Ericameria nauseosa* Shrubland Alliance**		**123.1 acres**
Ericameria nauseosa - *Gutierrezia sarothrae* Shrubland	57.8 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	18.0 acres	
Ericameria nauseosa Sparse Shrubland	6.9 acres	
***Ericameria nauseosa* Sparsely Vegetated Alliance**		**45.5 acres**
Ericameria nauseosa Sparse Vegetation	45.5 acres	
***Eriogonum corymbosum* Shrubland Alliance**		**55.4 acres**
Eriogonum corymbosum - *Artemisia nova* Sparse Shrubland	16.9 acres	
Eriogonum corymbosum - *Ericameria nauseosa* Shrubland	33.2 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**		**3.4acres**
Fallugia paradoxa Shrubland	3.4 acres	
***Gutierrezia sarothrae* Dwarf-shrubland Alliance**		**420.0 acres**
Gutierrezia sarothrae / (*Erodium cicutarium*, *Bromus* (*tectorum, rubens*), *Salsola tragus*) Semi-natural Dwarf-shrubland	105.7 acres	
Gutierrezia sarothrae / (*Erodium cicutarium*, *Bromus* (*tectorum*, *rubens*), *Salsola tragus*) Semi-natural Sparse Dwarf-shrubland	24.1 acres	
Gutierrezia sarothrae - *Grindelia squarrosa* Sparse Dwarf-shrubland	8.8 acres	
Gutierrezia sarothrae Dwarf-shrubland	236.8 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	44.6 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**5.8 acres**
Gutierrezia sarothrae Sparse Vegetation	5.8 acres	
***Juniperus osteosperma* Woodland Alliance**		**8.7acres**
Juniperus osteosperma / *Artemisia filifolia* Sparse Woodland	8.7 acres	
***Krascheninnikovia lanata* Shrubland Alliance**		**165.3 acres**
Krascheninnikovia lanata / (*Erodium cicutarium*, *Salsola tragus*, *Ceratocephala testiculata*) Semi-natural Dwarf-shrubland	95.0 acres	
Krascheninnikovia lanata Dwarf-shrubland	67.0 acres	
Krascheninnikovia lanata Sparse Dwarf-shrubland	3.2 acres	
***Lycium pallidum* Shrubland Alliance**		**82.3 acres**
Lycium pallidum Shrubland	14.5 acres	
Lycium pallidum Sparse Shrubland	67.8 acres	
Mixed Desert Shrub Shrubland Alliance		**274.5 acres**
Mixed Desert Scrub / (*Bromus rubens*, *Salsola tragus*, *Erodium cicutarium*) Semi-natural Shrubland	6.7 acres	
Mixed Desert Scrub Shrubland	258.1 acres	
Mixed Desert Scrub Sparse Shrubland	9.6 acres	
***Pleuraphis jamesii* Herbaceous Alliance**		**220.8 acres**
Atriplex canescens - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Shrub Herbaceous Vegetation	52.6 acres	
Atriplex canescens / *Pleuraphis jamesii* Shrub Herbaceous Vegetation	168.2 acres	

***Psorothamnus fremontii* Shrubland Alliance**		**46.1 acres**
Psorothamnus fremontii - *Gutierrezia sarothrae* Shrubland	7.3 acres	
Psorothamnus fremontii Shrubland	38.9 acres	
***Purshia tridentata* Mixed Shrubland Alliance**		**1.2 acres**
Purshia tridentata Mixed Shrubland	1.2 acres	
Ruderal Vegetation		**0.4 acres**
***Salsola tragus* Semi-natural Herbaceous Alliance**		**436.9 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	133.9 acres	
Chrysothamnus greenei / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	25.2 acres	
Gutierrezia sarothrae / *Salsola tragus* Semi-natural Shrub Herbaceous Vegetation	80.4 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	18.1 acres	
Sparse Vegetation		**0.6 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		**219.1 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 4-20); 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 such as wooded dwarf shrubland/dwarf shrubland, sparse woodland/dwarf shrubland, or sparse shrubland/herbaceous vegetation. These areas have indistinct boundaries between types. Plant species associated with this ecological system include the following: *Atriplex confertifolia*, *Atriplex canescens*, *Grayia spinosa*, *Krascheninnikovia lanata*, *Lycium* spp., *Achnatherum hymenoides*, *Bouteloua gracilis*, and *Pleuraphis rigida*.

Figure 4-20
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-dominants.

Other increaser shrubs which form alliances in this ecological system include the following: *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 dominant but only in mosaics with semi-natural areas dominated by *Salsola tragus*.

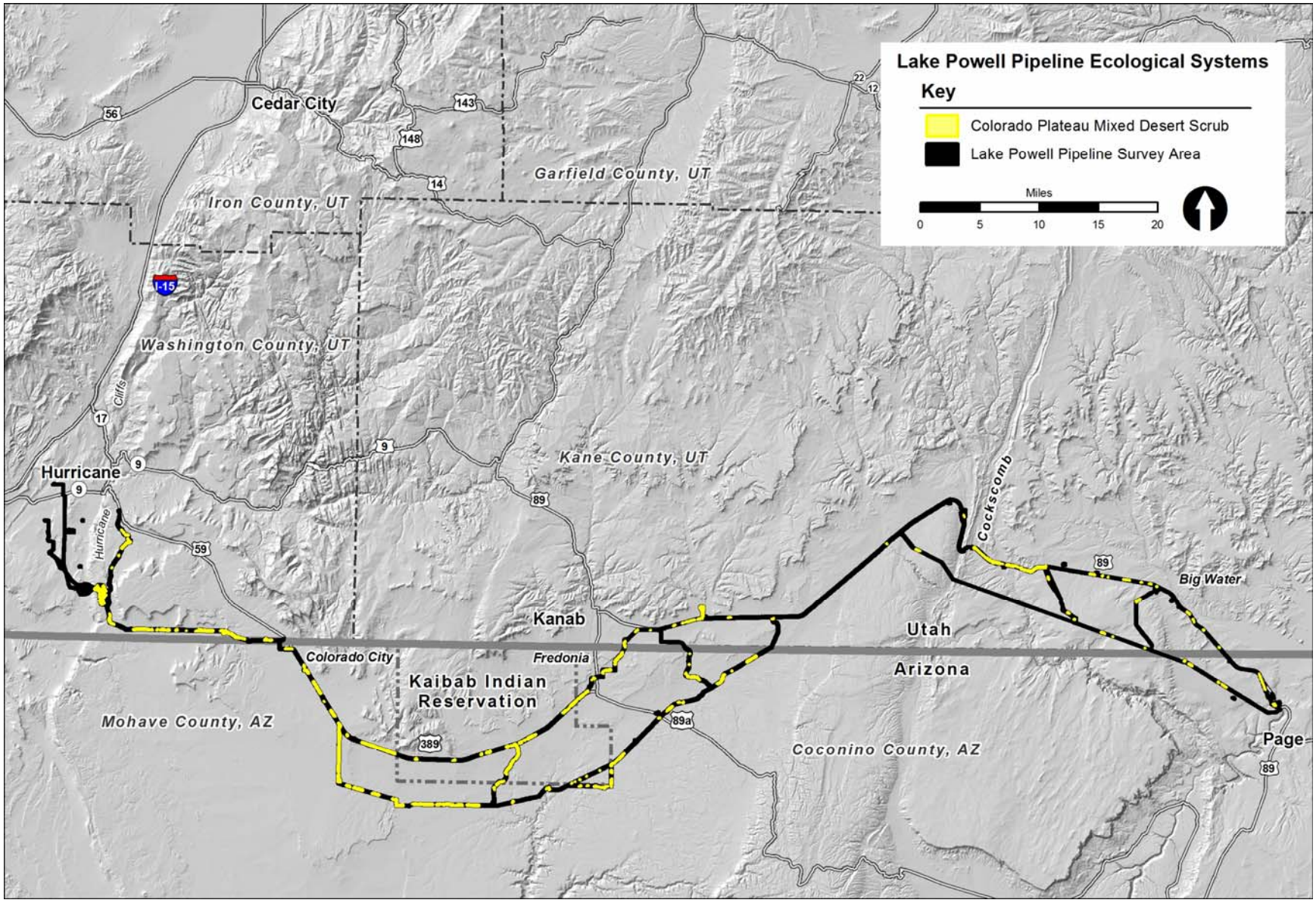


Figure 4-21
Colorado Plateau Mixed Desert Scrub Ecological System Map

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 on both the east and west side of Buckskin Gulch along U.S. Highway 89, across the southwest corner of the Kaibab-Paiute Indian Reservation, and along Mount Trumbull Road (Figure 4-23).

4.2.11.2 Alliances and Associations

Within the survey area, the Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System is comprised of three alliances and six associations. This ecological system totals 69.9 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia bigelovii* Shrubland Alliance**		**4.2 acres**
Artemisia bigelovii Dwarf-shrubland	4.2 acres	
***Artemisia nova* Dwarf-shrubland Alliance**		**9.0 acres**
Artemisia (*nova*, *bigelovii*) Dwarf-shrubland	9.0 acres	
***Artemisia nova* Shrubland Alliance**		**56.7 acres**
Artemisia (*nova*, *bigelovii*) Dwarf-shrubland	19.8 acres	
Artemisia (*nova*, *bigelovii*) Sparse Dwarf-shrubland	5.8 acres	
Artemisia nova Dwarf-shrubland	14.3 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 4-22). Typical vegetation includes *Artemisia nova*, *Artemisia bigelovii*, *Achnatherum hymenoides*, *Bouteloua gracilis*, *Hesperostipa comate*, and *Pleuraphis jamesii*.

Figure 4-22
Colorado Plateau Mixed Low Sagebrush Shrubland
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.

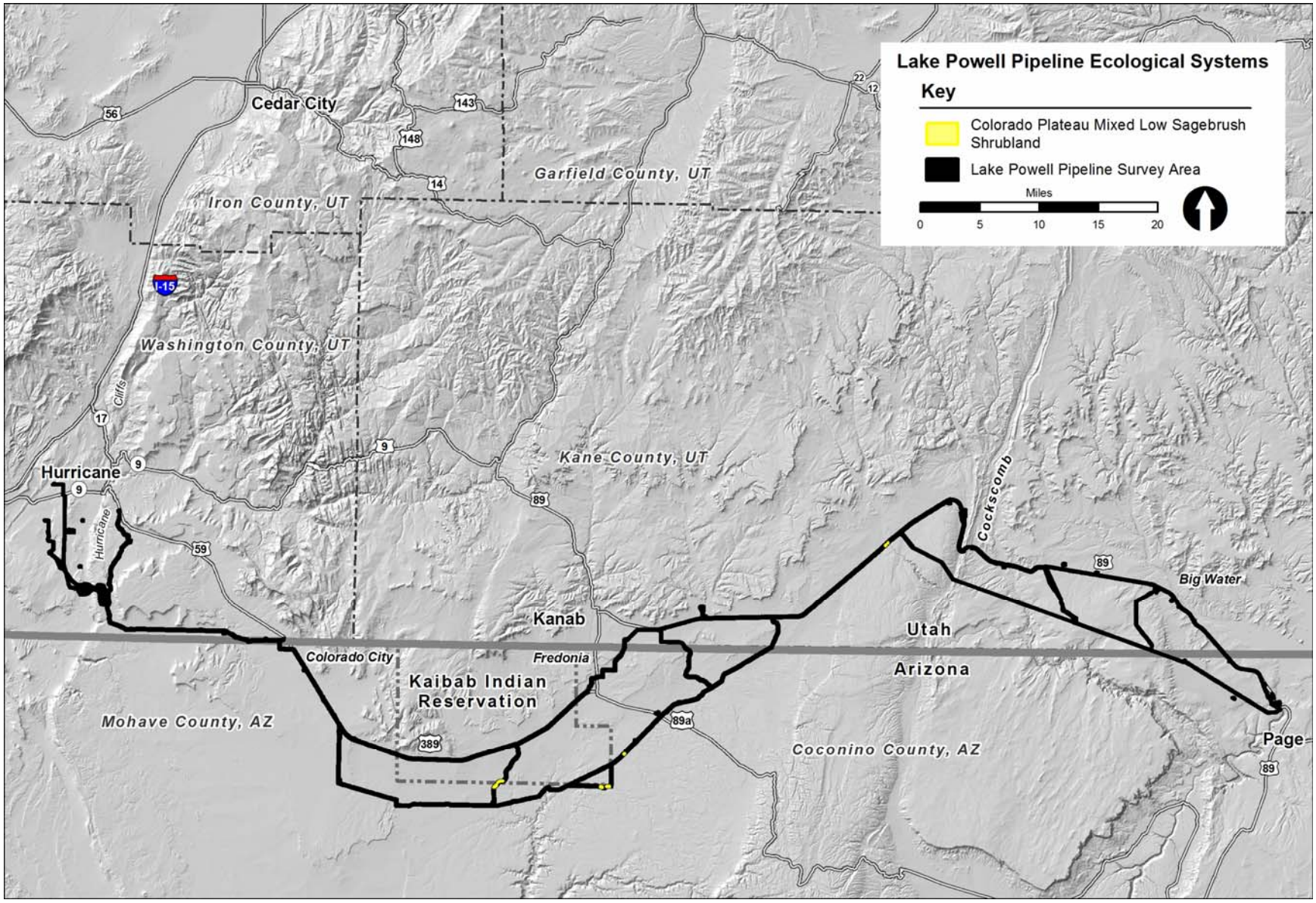


Figure 4-23
Colorado Plateau Mixed Low Sagebrush Shrubland Ecological System Map

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 U.S. Highway 89 and along the northern pipeline corridor along U.S. Highway 89 from the Cockscomb west almost to Fredonia, as well as along the north/south transmission line corridor just east 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 proposed existing highway alignment along Arizona State Route 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 Utah State Route 59 along the Honeymoon Trail to The Divide, adjacent to the forebay area (Figure 4-25).

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 60 associations. This ecological system totals 1774.2 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**53.0 acres**
Juniperus osteosperma / *Artemisia filifolia* Wooded Shrubland	53.0 acres	
***Artemisia nova* Shrubland Alliance**		**81.1 acres**
Juniperus osteosperma / *Artemisia nova* Wooded Dwarf-shrubland	81.1 acres	
***Artemisia tridentata* Shrubland Alliance**		**79.7 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	55.4 acres	
Pinus monophylla - *Juniperus osteosperma* / *Ephedra viridus* Wooded Shrubland	5.3 acres	
***Artemisia tridentata* ssp. *tridentata* Shrubland Alliance**		**19.2 acres**
Juniperus osteosperma / *Artemisia tridentata* ssp. *tridentata* Wooded Shrubland	19.2 acres	
***Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance**		**97.3 acres**
Artemisia tridentata ssp. *vaseyana* Shrubland	1.6 acres	
Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Wooded Shrubland	55.4 acres	
Pinus edulis - *Juniperus osteosperma* / *Artemisia tridentata* ssp. *vaseyana* Wooded Shrubland	5.3 acres	
***Chrysothamnus greenei* Shrubland Alliance**		**91.4 acres**
Juniperus osteosperma / *Chrysothamnus greenei* Wooded Shrubland	91.4acres	

***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**		**92.4 acres**
Juniperus osteosperma / *Ephedra* (*torreyana*, *nevadensis*) - *Gutierrezia sarothrae* Wooded Shrubland	11.1 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	77.3 acres	
Juniperus osteosperma / *Ephedra nevadensis* / (*Bouteloua gracilis*, *Pleuraphis jamesii*, *Hesperostipa comata*) Wooded Herbaceous Vegetation	1.6 acres	
Juniperus osteosperma / *Ephedra nevadensis* Wooded Shrubland	0.3 acres	
***Ephedra torreyana* Shrubland Alliance**		**66.3 acres**
Juniperus osteosperma / *Ephedra* (*torreyana*, *nevadensis*) / *Pleuraphis jamesii* Wooded Shrubland	66.3 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**		**57.3 acres**
Juniperus osteosperma / *Gutierrezia sarothrae* Wooded Dwarf-shrubland	57.3 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**		**682.5 acres**
(*Pinus monophylla*) - *Juniperus osteosperma* / *Quercus* x *pauciloba* Woodland	1.2 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 filifolia* Sparse Woodland	14.5 acres	
Juniperus osteosperma / *Artemisia tridentata* / Sparse Understory Woodland	0.7 acres	
Juniperus osteosperma / *Artemisia tridentata* Sparse Woodland	48.6 acres	
Juniperus osteosperma / *Artemisia tridentata* ssp. *tridentata* Sparse Woodland	6.9 acres	
Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Sparse Woodland	38.1 acres	
Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Woodland	155.5 acres	
Juniperus osteosperma / *Artemisia tridentata* Woodland	41.6 acres	
Juniperus osteosperma / *Coleogyne ramosissima* Sparse Woodland	60.6 acres	
Juniperus osteosperma / *Coleogyne ramosissima* Woodland	3.3 acres	
Juniperus osteosperma / *Ephedra* (*nevadensis*, *viridis*) Woodland	16.1 acres	
Juniperus osteosperma / Ephedra nevadensis Sparse Woodland	70.3 acres	
Juniperus osteosperma / *Fallugia paradoxa* Sparse Woodland	1.1 acres	
Juniperus osteosperma / *Gutierrezia sarothrae* Sparse Woodland	5.9 acres	
Juniperus osteosperma / *Gutierrezia sarothrae* Woodland	4.2 acres	
Juniperus osteosperma / *Salsola tragus* Semi-natural Sparse Woodland	24.6 acres	
Juniperus osteosperma / *Shepherdia rotundifolia* Sparse Woodland	27.1 acres	
Juniperus osteosperma / Sparse Understory Woodland	25.4 acres	
Juniperus osteosperma Sparse Woodland	18.2 acres	
Juniperus osteosperma Woodland	103.8 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**		**163.3 acres**
Pinus edulis - Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana – Gutierrezia sarothrae* Woodland	36.2 acres	
Pinus edulis - Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Sparse Woodland	40.0 acres	
Pinus edulis - Juniperus osteosperma / *Artemisia tridentata* ssp. *vaseyana* Woodland	9.7 acres	
Pinus edulis - Juniperus osteosperma / *Coleogyne ramosissima* Sparse Woodland	16.6 acres	
Pinus edulis - Juniperus osteosperma / *Coleogyne ramosissima* Woodland	1.1 acres	
Pinus edulis - Juniperus osteosperma / *Ephedra nevadensis* Sparse Woodland	12.7 acres	
Pinus edulis - Juniperus osteosperma / *Ephedra nevadensis* Woodland	12.7 acres	
Pinus edulis - Juniperus osteosperma / *Gutierrezia sarothrae* Sparse Woodland	5.1 acres	
Pinus edulis - Juniperus osteosperma / *Pleuraphis jamesii* Sparse Woodland	27.4 acres	
Pinus edulis - Juniperus osteosperma Woodland	14.5 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**	**5.4 acres**
Juniperus osteosperma / *Purshia glandulosa* Wooded Shrubland	5.4 acres

4.2.12.3 Physiognomy and Composition

The Colorado Plateau Pinyon-Juniper Woodland Ecological System is most commonly a woodland (Figure 4-24); 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. Typical plant species associated with this ecological system include the following: *Pinus edulis*, *Juniperus osteosperma*, *Aretmisia tridentata*, *Coleogyn ramosissima*, *Purshia stansburiana*, *Purshia tridenttata*, *Bouteloua gracilis*, and *Pleuraphis jamesii*.

Figure 4-24
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 toward 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.

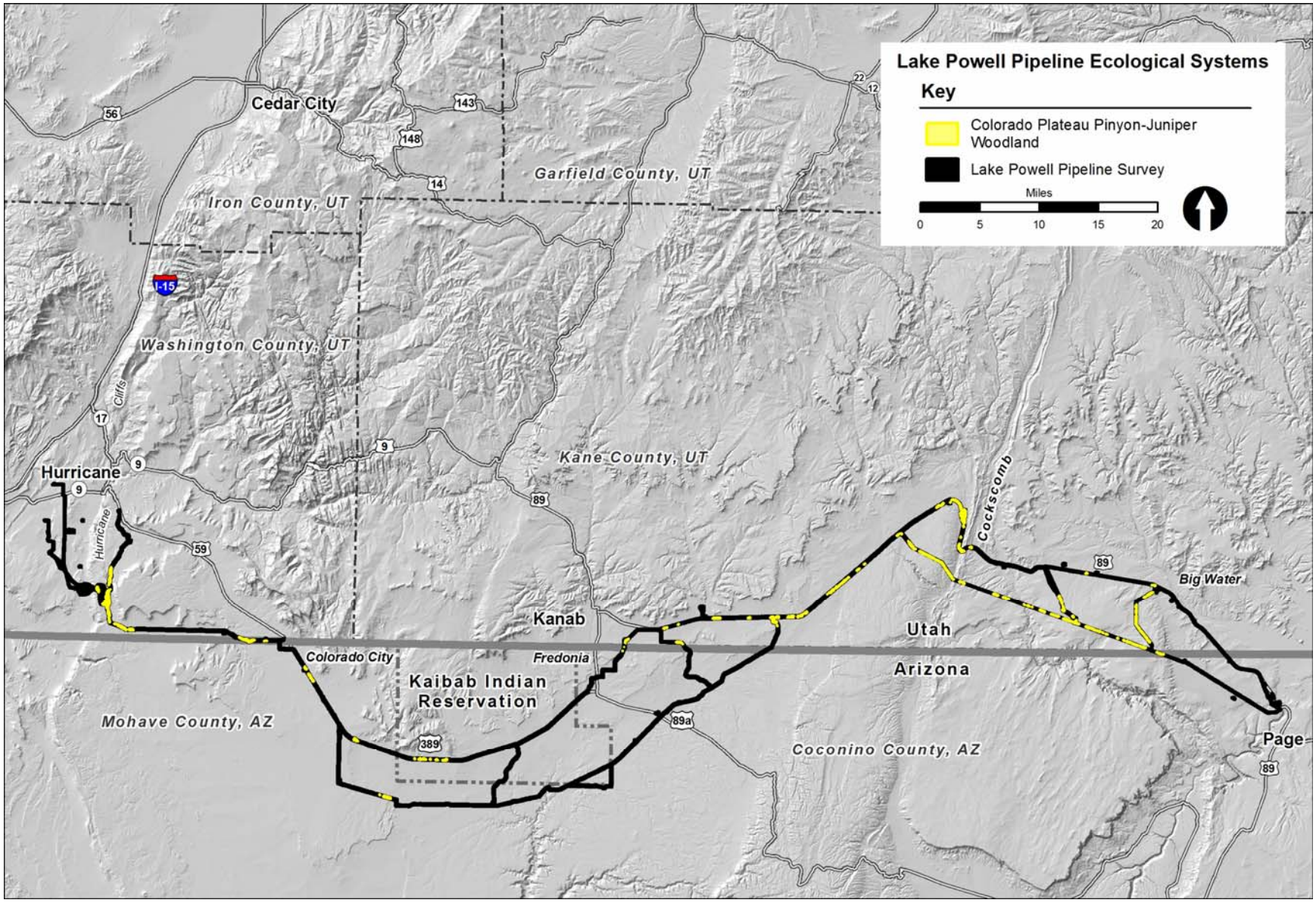


Figure 4-25
Colorado Plateau Pinyon-Juniper Woodland Ecological System Map

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 U.S. Highway 89 to the Cockscomb, along the transmission line corridor from the Glen Canyon Dam area to the Cockscomb, from just east of 8-Mile Gap Road (U.S. Highway 89) to Cedar Ridge (Arizona State Route 389), and from Short Creek at Canaan Gap north to Utah State Route 59 (Figure 4-27).

4.2.13.2 Alliances and Associations

Within the survey area, the Colorado Plateau Shrub-Steppe Ecological System is comprised of 26 alliances that include 62 associations. This ecological system totals 1,858.9 acres within the survey area. Acreage by alliance and association is as follows:

***Achnatherum hymenoides* Herbaceous Alliance**		**82.4 acres**
Ephedra nevadensis / *Achnatherum hymenoides* Shrub Herbaceous Vegetation	34.8 acres	
Gutierrezia sarothrae / (*Pleuraphis jamesii*, *Achnatherum hymenoides*) Shrub Herbaceous Vegetation	47.6 acres	
***Artemisia filifolia* Shrubland Alliance**		**11.3 acres**
Artemisia filifolia / *Achnaterum hymenoides* Sparse Shrubland	2.2 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. *wyomingensis* Shrubland Alliance**		**9.7 acres**
Artemisia tridentate ssp. *wyomingensis* Shrubland	9.7 acres	
***Atriplex canescens* Shrubland Alliance**		**2.7 acres**
Atriplex canescens - *Krascheninnikovia lanata* / *Pleuraphis jamesii* Shrubland	2.7 acres	
***Atriplex confertifolia* Shrubland Alliance**		**81.7 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	79.7 acres	

***Chrysothamnus greenei* Shrubland Alliance**		**195.2 acres**
Chrysothamnus greenei - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Sparse Dwarf-shrubland	11.2 acres	
Chrysothamnus greenei / *Achnatherum parishii* Dwarf-shrubland	7.4 acres	
Chrysothamnus greenei / *Pleuraphis jamesii* - (*Erodium cicutarium*, *Salsola tragus*) Semi-natural Dwarf-shrubland	66.4 acres	
Chrysothamnus greenei / *Pleuraphis jamesii* Dwarf-shrubland	77.6 acres	
Chrysothamnus greenei / *Pleuraphis jamesii* Sparse Dwarf-shrubland	32.5 acres	
***Chrysothamnus viscidiflorus* Shrubland Alliance**		**1.3 acres**
Chrysothamnus viscidiflorus / (*Pleuraphis jamesii*, *Hesperostipa comata* ssp. *comata*) Shrubland	1.3 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**27.1 acres**
Coleogyne ramosissima - *Ephedra viridus* / *Sporobolus cryptandrus* Shrubland	11.8 acres	
Coleogyne ramosissima / (*Sporobolus cryptandrus*, *Pleuraphis rigida*) Sparse Shrubland	15.3 acres	
***Ephedra* (*nevadensis, torreyana*) Shrubland Alliance**		**3.5 acres**
Ephedra nevadensis - *Ephedra torreyana* / *Pleuraphis rigida* Shrubland	3.5 acres	
***Ephedra nevadensis* Shrubland Alliance**		**251.8 acres**
Ephedra nevadensis - *Gutierrezia sarothrae* / (*Pleuraphis jamesii*, *Bouteloua gracilis*) Shrubland	46.1 acres	
Ephedra nevadensis - *Gutierrezia sarothrae* / (*Pleuraphis jamesii*, *Bouteloua gracilis*, *Hesperostipa comata* ssp. *comata*) Shrubland	36.5 acres	
Ephedra nevadensis - *Gutierrezia sarothrae* / (*Pleuraphis jamesii*, *Sporobolus cryptandrus*, *Bouteloua gracilis*) Dwarf-shrubland	14.1 acres	
Ephedra nevadensis - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Sparse Dwarf-shrubland	27.2 acres	
Ephedra nevadensis / (*Bouteloua gracilis*, *Sporobolus cryptandrus*, *Achnatherum hymenoides*) Shrubland	28.3 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**		**42.5 acres**
Ephedra torreyana / *Pleuraphis jamesii* Sparse Shrubland	42.5 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	
***Eriogonum corymbosum* Shrubland Alliance**		**133.0 acres**
Eriogonum corymbosum - *Gutierrezia sarothrae* / (*Pleuraphis jamesii*, *Achnatherum hymenoides*) Shrubland	126.5 acres	
Eriogonum corymbosum - *Gutierrezia sarothrae* / *Pleuraphis jamesii* Sparse Shrubland	6.5 acres	
***Gutierrezia sarothrae* Dwarf-shrubland Alliance**		**296.8 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	26.7 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	48.5 acres	
Gutierrezia sarothrae / (*Pleuraphis jamesii*, *Achnatherum hymenoides*) Dwarfshrubland	9.2 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	49.5 acres	
Gutierrezia sarothrae / *Pleuraphis jamesii* Dwarf-shrubland	5.6 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**1.5 acres**
Gutierrezia sarothrae / *Pleuraphis rigida* - *Salsola tragus* Semi-natural Dwarf-shrubland	1.5 acres	
***Hesperostipa comata* Herbaceous Alliance**		**12.4 acres**
Ephedra nevadensis / *Hesperostipa comata* ssp. comate Shrub Herbaceous Vegetation	12.4 acres	
***Krascheninnikovia lanata* Shrubland Alliance**		**157.2 acres**
Krascheninnikovia lanata / (*Pleuraphis jamesii*, *Achnatherum hymenoides*) – (*Erodium cicutarium*, *Salsola tragus*) Semi-natural Dwarf-shrubland	117.5 acres	
Krascheninnikovia lanata / *Pleuraphis jamesii* Dwarf-shrubland	39.7 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**		**149.2 acres**
Atriplex confertifolia / *Pleuraphis jamesii* Shrub Herbaceous Vegetation	3.9 acres	
Chrysothamnus greenei / *Pleuraphis jamesii* Dwarf-shrubland Alliance	4.2 acres	
Chrysothamnus greenei / *Pleuraphis jamesii* Shrub Herbaceous Vegetation	75.2 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	3.7 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* Seminatural Shrub Herbaceous Vegetation	2.6 acres	
***Sarcobatus vermiculatus* Shrubland Alliance**		**58.8 acres**
Atriplex confertifolia - Sarcobatus vermiculatus / *Pleuraphis jamesii* Shrubland	58.8 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 (Figure 4-26). It is infrequently a sparse dwarf shrubland and rarely a sparse shrubland, or mosaic of shrubland and herbaceous vegetation. Typical vegetation associated with this ecological system includes the following: *Atriplex canescens*, *Chrysothamnus greenei*, *Chrysothamnus viscidiflorus*, *Ephedra* spp., *Ericameria nauseosa*, *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Achnatherum hymenoides*, *Bouteloua gracilis*, *and Hesperostipa comata*.

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.

Figure 4-26
Colorado Plateau Shrub-Steppe Ecological System

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.

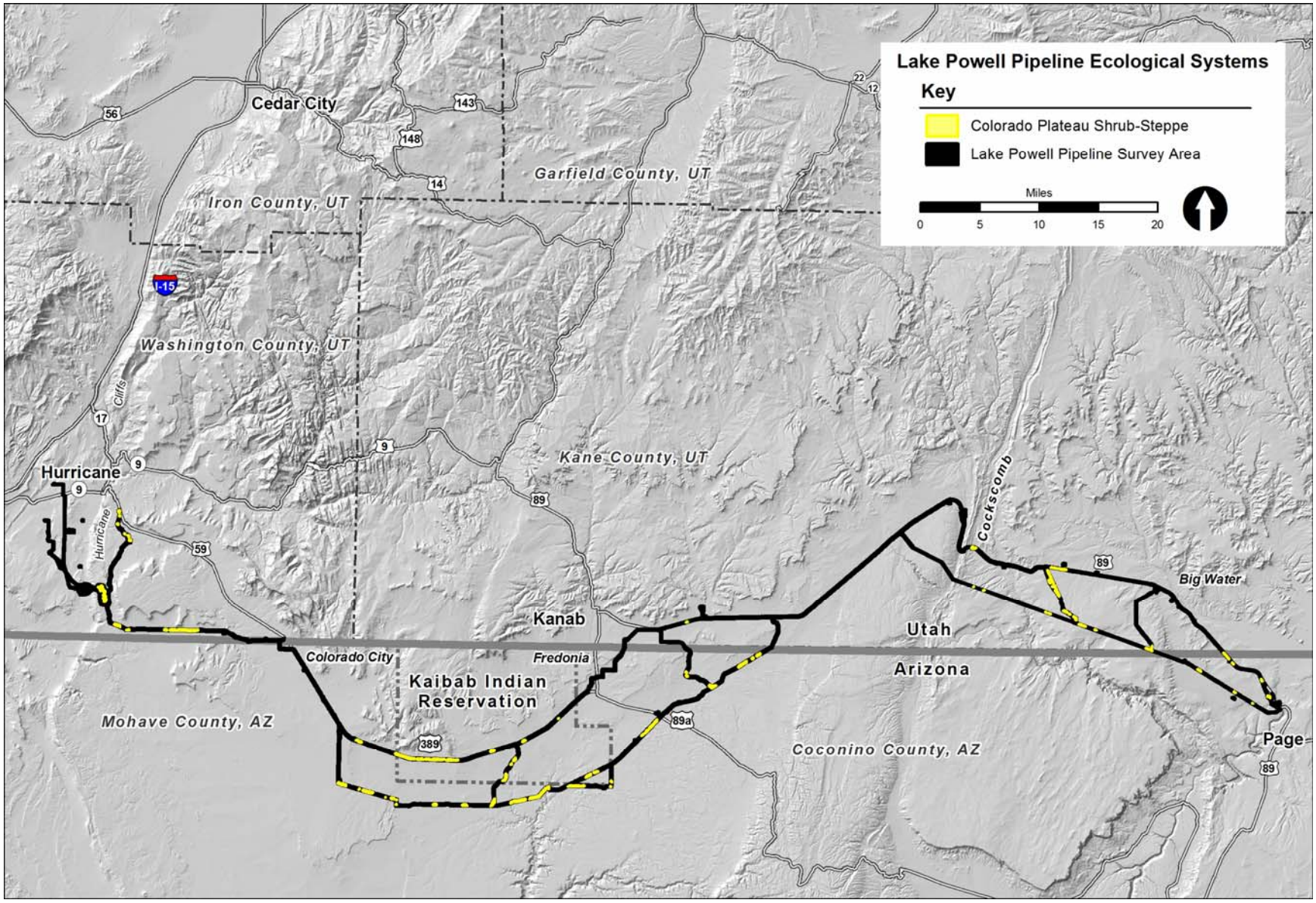


Figure 4-27
Colorado Plateau Shrub-Steppe Ecological System Map

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 Utah State Route 59 near The Divide and within the northern area of the forebay, just west of the Honeymoon Trail (Figure 4-29).

4.2.14.2 Alliances and Associations

Within the survey area, the Colorado Plateau Volcanic Rock and Cinder Land Ecological System is comprised of two alliances and three associations. This ecological system totals 37.3 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**		**20.5 acres**
Eriogonum fasciculatum / *Erodium cicutarium* Semi-natural Shrub Herbaceous Vegetation	20.5 acres	

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 4-28). Typical plant species associated with this ecological system include *Ephedra* spp., *Atriplex canescens*, *Eriogonum corymbosum*, and *Fallugia paradoxa*.

Figure 4-28
Colorado Plateau Volcanic Rock and Cinder Land Ecological System

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 severely burned areas in this ecological system.

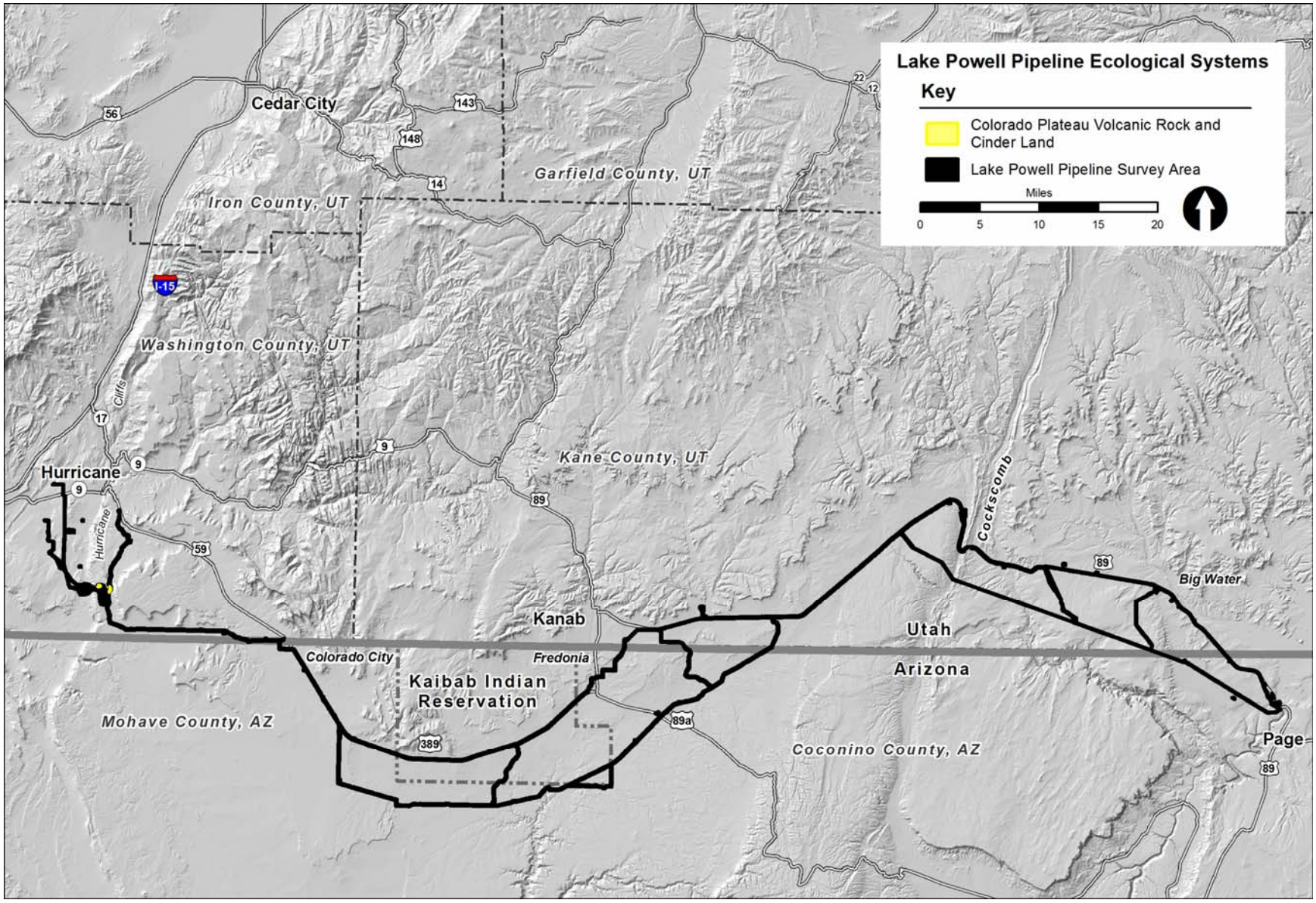


Figure 4-29
Colorado Plateau Volcanic Rock and Cinder Land Ecological System Map

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, which 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 Gould Wash south of Utah State Route 59 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 (Figure 4-31).

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 (29) and associations (47).This ecological system totals 159.3 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**		**15.2 acres**
Artemisia filifolia - Atriplex canescens Sparse Shrubland	1.8 acres	
Artemisia filifolia Shrubland	8.1 acres	
Artemisia filifolia Sparse Shrubland	5.3 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**		**17.2 acres**
Artemisia tridentata ssp. *tridentata - Ericameria nauseosa* Shrubland	4.4 acres	
Artemisia tridentata ssp. *tridentata - Tamarix chinensis* Semi-natural Shrubland	3.5 acres	
Artemisia tridentata ssp. *tridentata* Shrubland	8.2 acres	
Artemisia tridentata ssp. *tridentata* Sparse Shrubland	1.1 acres	
***Artemisia tridentata* ssp. *vaseyana* Shrubland Alliance**		**21.4 acres**
Artemisia tridentata ssp. *vaseyana - Ericameria nauseosa* Shrubland	0.7 acres	
Artemisia tridentata ssp. *vaseyana* Shrubland	20.6 acres	

***Atriplex canescens* Shrubland Alliance**		**19.8 acres**
Atriplex canescens - *Gutierrezia sarothrae* Desert Wash Shrubland	6.2 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	6.1 acres	
***Atriplex confertifolia* Shrubland Alliance**		**1.6 acres**
Atriplex confertifolia - *Krascheninnikovia lanata* Dwarf-shrubland	1.6 acres	
***Ericameria nauseosa* Shrubland Alliance**		**15.5 acres**
Ericameria nauseosa - *Gutierrezia sarothrae* Shrubland	2.9 acres	
Ericameria nauseosa - *Tamarix chinensis* Semi-natural Desert Wash Shrubland	3.3 acres	
Ericameria nauseosa / (*Bromus tectorum*, *Salsola tragus*) Semi-natural Desert Wash Shrubland	2.1 acres	
Ericameria nauseosa Desert Wash Shrubland	7.2 acres	
***Ericameria nauseosa* Sparsely Vegetated Alliance**		**1.9 acres**
Ericameria nauseosa Sparse Vegetation	1.9 acres	
***Fallugia paradoxa* Temporarily Flooded Shrubland Alliance**		**1.5 acres**
Fallugia paradoxa Desert Wash Shrubland	1.5 acres	
***Fraxinus anomala* Sparsely Vegetated Alliance**		**2.5 acres**
Amelanchier utahensis - *Fraxinus anomala* Sparse Vegetation	0.7 acres	
Fraxinus anomala - *Tamarix chinensis* Semi-natural Sparse Vegetation	0.7 acres	
Unclassified	1.1 acres	
***Gutierrezia sarothrae* Shrubland Alliance**		**4.3 acres**
Gutierrezia sarothrae Dwarf-shrubland	4.3 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**		**1.8 acres**
Juniperus osteosperma / *Purshia glandulosa* Sparse Vegetation	1.8 acres	
***Juniperus osteosperma* Woodland Alliance**		**16.7 acres**
Juniperus osteosperma / *Fallugia paradoxa* Sparse Woodland	2.7 acres	
Juniperus osteosperma Sparse Woodland	11.9 acres	
Juniperus osteosperma Woodland	2.1 acres	

Mixed Desert Shrub Shrubland Alliance		**0.7 acres**
Mixed Desert Scrub / *Pleuraphis jamesii* Shrubland	0.7 acres	
Non-vegetated		**1.7 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**		**0.9 acres**
Juniperus osteosperma / *Purshia glandulosa* Wooded Shrubland	0.9 acres	
***Purshia tridentata* Mixed Shrubland Alliance**		**0.9 acres**
Purshia glandulosa Mixed Shrubland	0.9 acres	
***Rhus trilobata* Shrubland Alliance**		**0.5 acres**
Rhus trilobata Sparse Shrubland	0.5 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		**6.1 acres**
***Sphaeralcea* (*ambigua, coccinea, parviflora*) Herbaceous Alliance**		**1.5 acres**
Sphaeralcea (*ambigua, coccinea*, *parviflora*) - (*Salsola tragus*, *Erodium cicutarium*) Semi-natural Herbaceous Vegetation	1.5 acres	
***Tamarix chinensis* Semi-natural Shrubland Alliance**		**1.9 acres**
Tamarix chinensis Semi-natural Shrubland	0.1 acres	
Tamarix chinensis Semi-natural Sparse Shrubland	1.8 acres	
Unclassified		**7.4 acres**

4.2.15.3 Physiognomy and Composition

The Colorado Plateau Wash Ecological System is commonly shrubland (Figure 4-30); 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. This ecological system includes plant species such as *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Fallugia paradoxa*, *Artemisia tridentata ssp. tridentata*, *and Grayia spinosa*.

Figure 4-30
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.

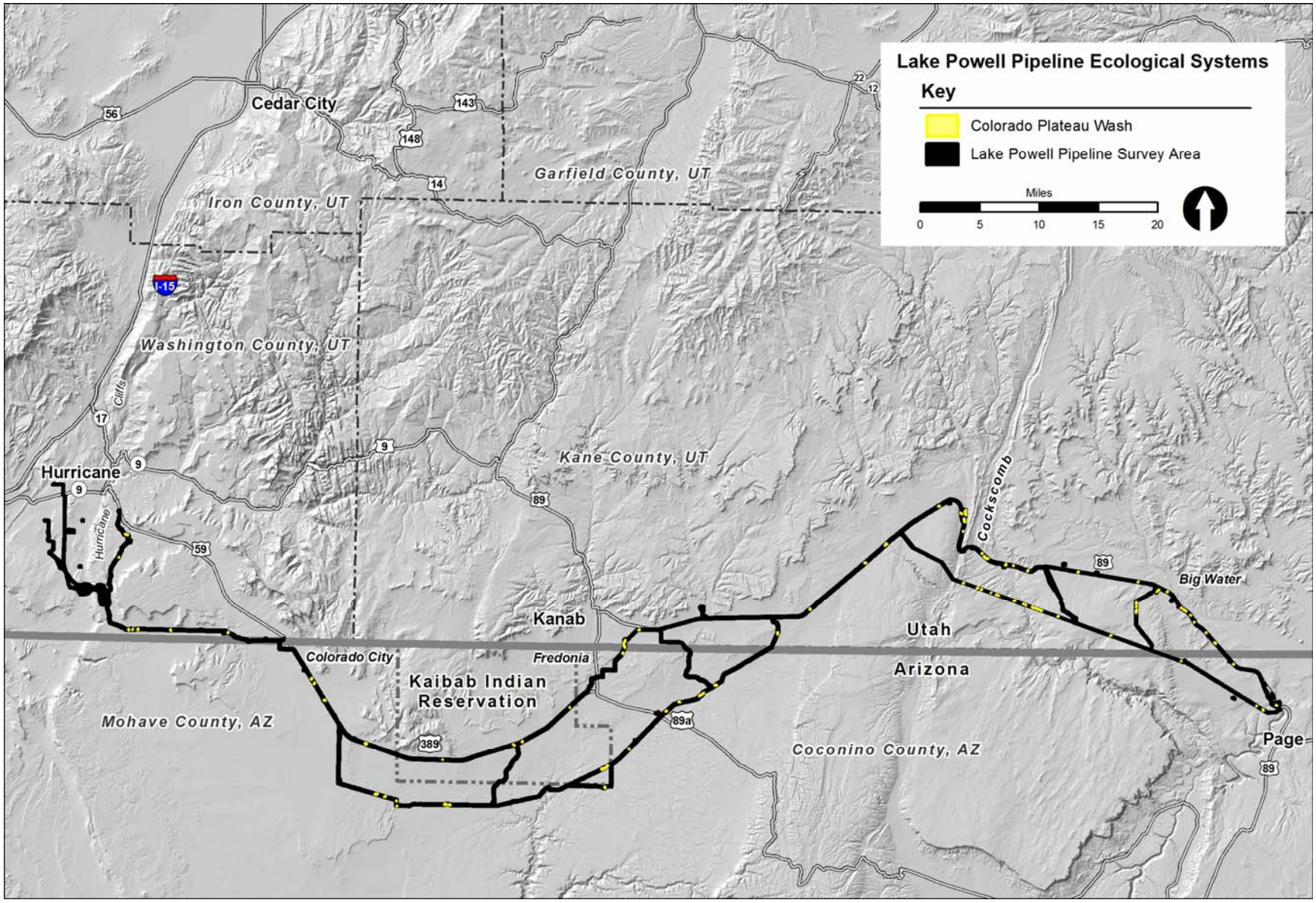


Figure 4-31
Colorado Plateau Wash Ecological System Map

4.3 Mojave Desert Region

The Mojave Desert Region comprises 1,163 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 (Figure 2-2).

Within the Mojave Desert Region of the survey area there are 10 ecological systems, 35 alliances, including 64 associations. Table 4-2 lists the Mojave Desert Ecological Systems and notes the number of alliances, associations, and acreages for each.

Table 4-2
Mojave Desert Region

Ecological System	Number of Alliances	Number of Associations	Acreage
Mojave Desert Active and Stabilized Dune	4	6	106.4
Mojave Desert Bedrock Cliff and Outcrop	4	4	25.8
Mojave Desert Blackbrush-Mormon-tea Shrubland	3	6	80.5
Mojave Desert Creosotebush-White Bursage Desert Scrub	4	10	307.4
Mojave Desert Grassland	1	1	39.4
Mojave Desert Lower Montane Riparian Woodland and Shrubland	2	2	2.9
Mojave Desert Mixed Desert Scrub	6	9	249.7
Mojave Desert Shrub-Steppe	5	10	200.5
Mojave Desert Volcanic Rock and Cinder Land	5	10	139.4
Mojave Desert Wash	3	4	11.3

4.3.1 Mojave Desert Active and Stabilized Dune Ecological System

4.3.1.1 Geographic Distribution

The Mojave Desert Active and Stabilized Dune Ecological System is found in one distinct area within the Mojave Desert Region of the LPP survey area. The Mojave Desert Active and Stabilized Dune Ecological System extends north from the afterbay and contours the southeast edge of Sand Hollow Reservoir (Figure 4-33).

4.3.1.2 Alliances and Associations

Within the survey area, the Mojave Desert Active and Stabilized Dune Ecological System is comprised of four alliances and includes seven associations. This ecological system totals 106.4 acres within the survey area. Acreage by alliance and association is as follows:

***Artemisia filifolia* Shrubland Alliance**	**95.2 acres**
Artemisia filifolia - *Ephedra* (*nevadensis*, *torreyana*, *viridis*) Shrubland	18.9 acres
Artemisia filifolia - *Gutierrezia sarothrae* Shrubland	22.4 acres
Artemisia filifolia - Sandsheet Shrubland	28.2 acres
Artemisia filifolia Shrubland	25.7 acres

***Coleogyne ramosissima - Ephedra nevadensis* Shrubland Alliance**		**5.3 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	5.3 acres	
***Coleogyne ramosissima* Shrubland Alliance**		**4.0 acres**
Coleogyne ramosissima - Ephedra nevadensis Dwarf-shrubland	4.0 acres	
***Larrea tridentata* Shrubland Alliance**		**1.9 acres**
Larrea tridentata - Ambrosia dumosa Sparse Shrubland	1.9 acres	

4.3.1.3 Physiognomy and Composition

The Mojave Desert Active and Stabilized Dune Ecological System is typically a shrubland (Figure 4-32); 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. Common vegetation in this ecological system includes the following: *Artemisia fililfolia*, *Artemisia tridentata* ssp. *tridentata*, *Atriplex canescens*, *Ephedra* spp., *Chrysothamnus viscidiflorus*, *Coleogyne ramosissima*, *Ericameria nauseosa*, *Hesperostipa comata*, *Leymus flavenscens*, *Purshia tridentata*, *Redfieldia flexuousa*, *Sporobolus airoides*, and *Sarcobatus vermiculatus*.

Figure 4-32
Mojave Desert Active and Stabilized Dune
Ecological System

4.3.1.4 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 trampling by animals. Once the soil is 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 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. Nevertheless, *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 Mojave 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 Mojave Desert Mixed Desert Scrub Ecological System.

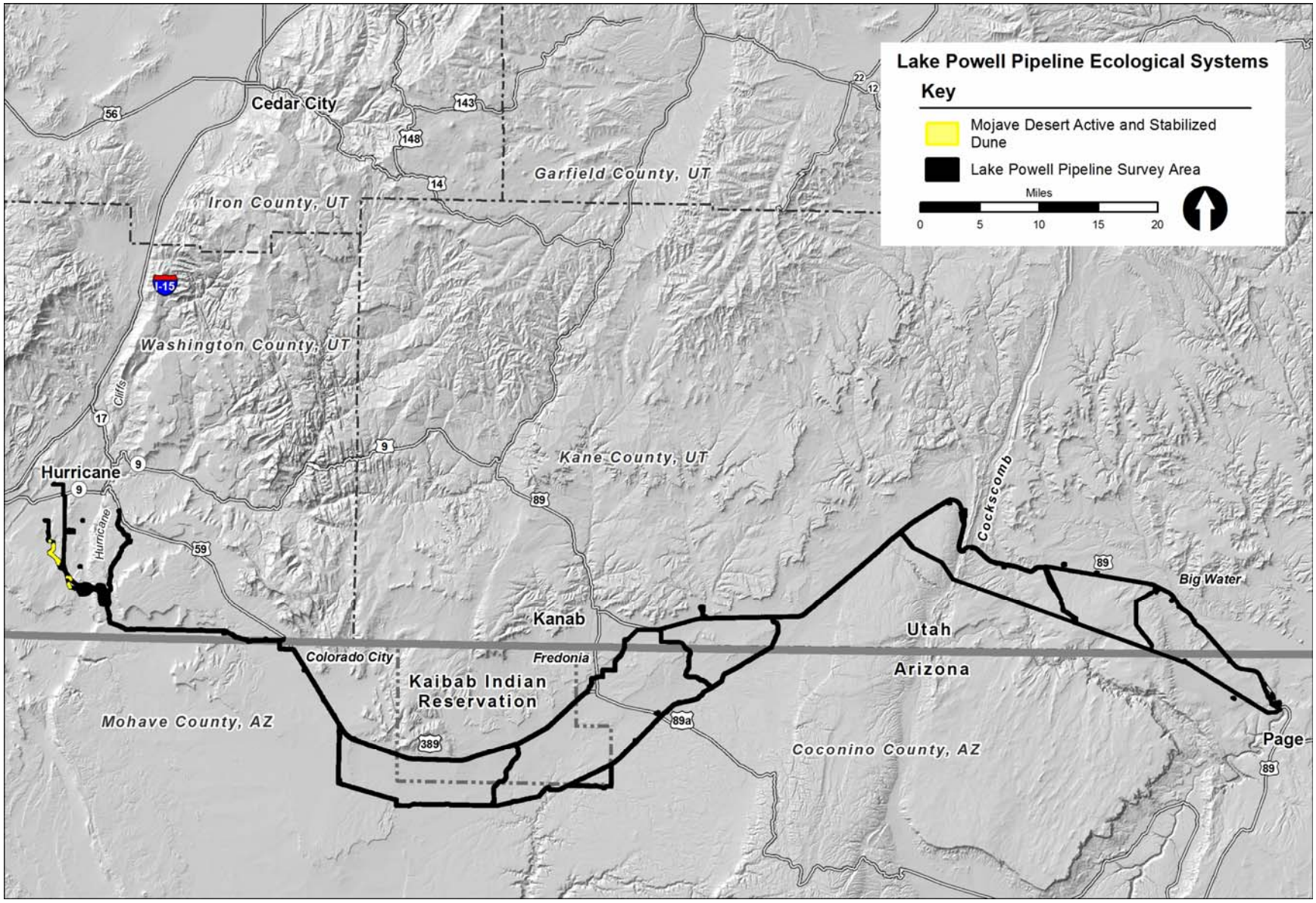


Figure 4-33
Mojave Desert Active and Stabilized Dune Ecological System Map

4.3.2 Mojave Desert Bedrock Cliff and Outcrop Ecological System

4.3.2.1 Geographic Distribution

The Mojave 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 (Figure 4-35).

4.3.2.2 Alliances and Associations

Within the survey area, the Mojave 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	

4.3.2.3 Physiognomy and Composition

The Mojave Desert Bedrock Cliff and Outcrop Ecological System occurs in the survey area as shrubland (Figure 4-34), sparse shrubland, sparse vegetation, and non- vegetated sandstone outcrop. Plant species common in this ecological system include *Bursera microphylla*, *Opuntia bigelovii*, and *Larrea tridentata*.

4.3.2.4 Disturbance Regimes

The Mojave 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.

Figure 4-34
Mojave Desert Bedrock Cliff and Outcrop Ecological System

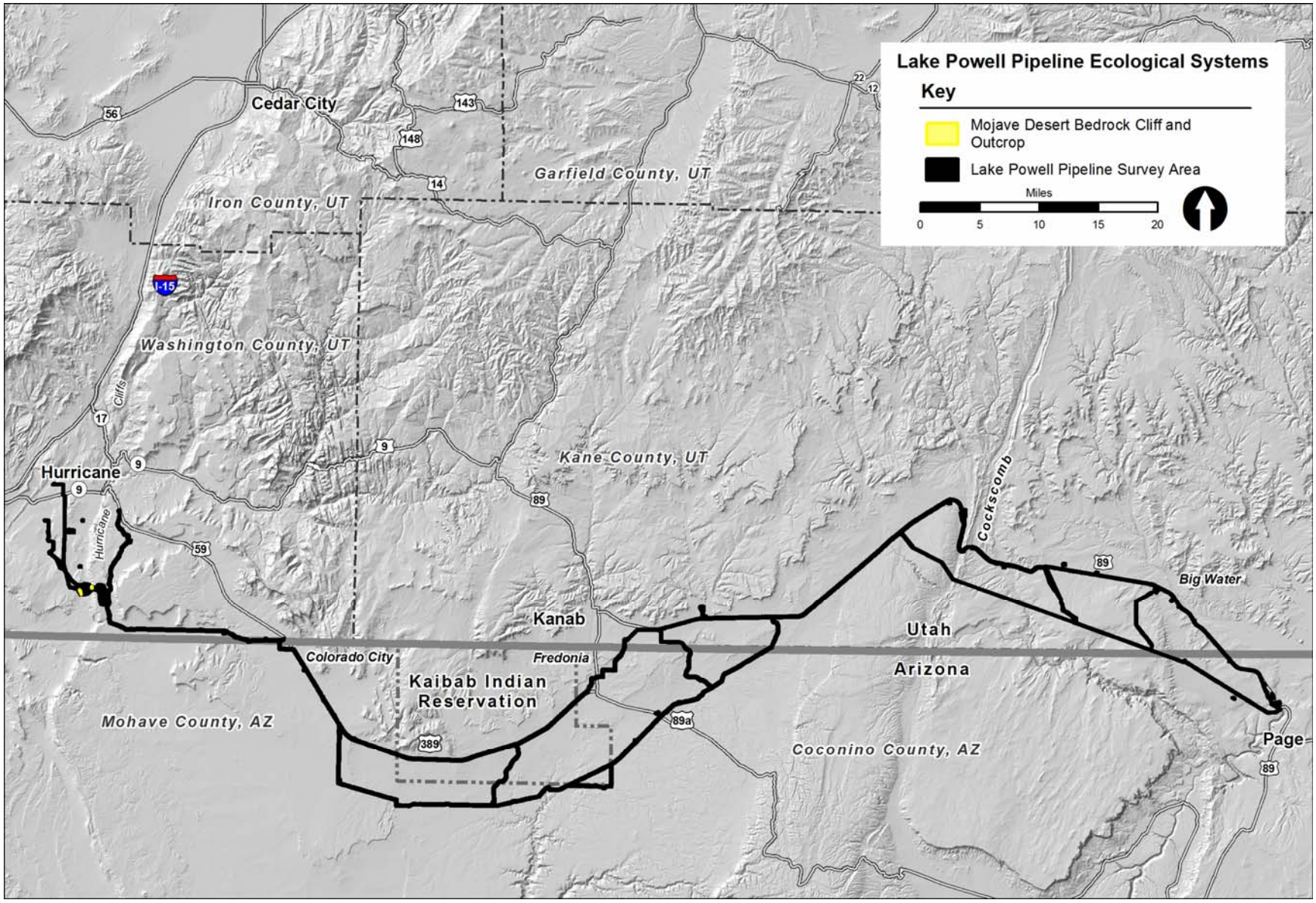


Figure 4-35
Mojave Desert Bedrock Cliff and Outcrop Ecological System Map

4.3.3 Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System

4.3.3.1 Geographic Distribution

The Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System is found in two areas within the Mojave Desert Region of the LPP survey area. The northern area is west of Hurricane near the Virgin River. The southern area extends north and west from the afterbay toward Sand Mountain (Figure 4-37).

4.3.3.2 Alliances and Associations

Within the survey area, the Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System is comprised of three alliances and six associations. This ecological system totals 80.5 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**		**56.6 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	52.9 acres	
***Ephedra nevadensis* Shrubland Alliance**		**7.0 acres**
Ephedra nevadensis - Lycium andersonii Shrubland	0.8 acres	
Ephedra nevadensis Shrubland	6.1 acres	

4.3.3.3 Physiognomy and Composition

The Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System occurs commonly in the survey area as either shrubland or sparse shrubland (Figure 4-36); and less frequently as a dwarf-shrubland. This ecological system is dominated by *Coleogyn ramosissima* often with *Ephedra viridis*, *Ephedra torreyana*, or *Grayia spinosa*. *Artemisia filifolia* is a co-dominant. The herbaceous layer may include *Achnatherum hymenoides*, *Pleuraphis jamesii*, or *Sporobolus cryptandrus*.

Figure 4-36
Mojave Desert Blackbrush-Mormon-tea Shrubland
Ecological System

4.3.3.4 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 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.

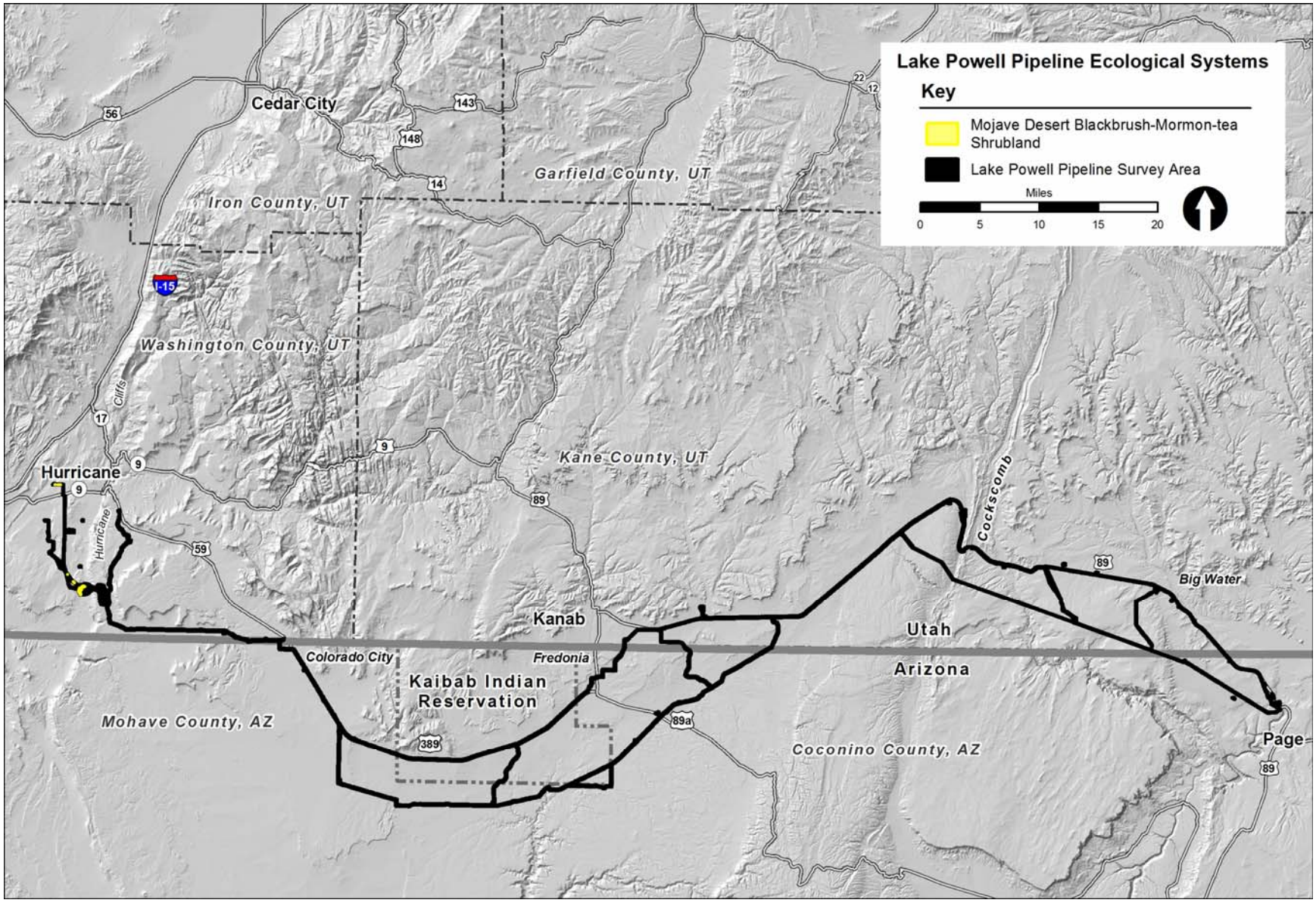


Figure 4-37
Mojave Desert Blackbrush-Mormon-tea Shrubland Ecological System Map

4.3.4 Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System

4.3.4.1 Geographic Distribution

The Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System is found throughout the Mojave 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). It is often interspersed with Mojave Desert Shrub-Steppe and Mojave Desert Mixed Desert Scrub Ecological Systems (Figure 4-39).

4.3.4.2 Alliances and Associations

Within the survey area, the Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System is comprised of four alliances and 10 associations. This ecological system totals 307.4 acres within the survey area. Acreage by alliance and association is as follows:

***Ambrosia dumosa* Shrubland Alliance**		**4.2 acres**
Ambrosia dumosa / (*Erodium cicutarium*, *Bromus rubens*) Dwarf-shrubland	2.0 acres	
Ambrosia dumosa Dwarf-shrubland	2.2 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**		**211.3 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	20.2 acres	
Larrea tridentata / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Shrubland	38.9 acres	
Larrea tridentata / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Sparse Shrubland	99.8 acres	
Larrea tridentata Shrubland	24.0 acres	
***Larrea tridentata* Sparsely Vegetated Alliance**		**5.7 acres**
Larrea tridentata / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Sparse Vegetation	5.7 acres	

4.3.4.3 Physiognomy and Composition

The Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System is commonly a shrubland (Figure 4-38), less commonly a sparse shrubland, occasionally sparse vegetation, and rarely dwarf shrubland. Typical plants in this ecological system may include the following: *Larrea tridentata*, *Ambrosia dumosa*, *Atriplex canescens*, *Ephedra nevadensis*, *Lycium andersonii*, *Cryptantha* spp., and *Phacelia* spp.

Figure 4-38
Mojave Desert Creosotebush-White Bursage
Desert Scrub Ecological System

4.3.4.4 Disturbance Regimes

A wide diversity of *Larrea tridentata* dominated associations highlights the diversity of seral stages in the Mojave 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*.

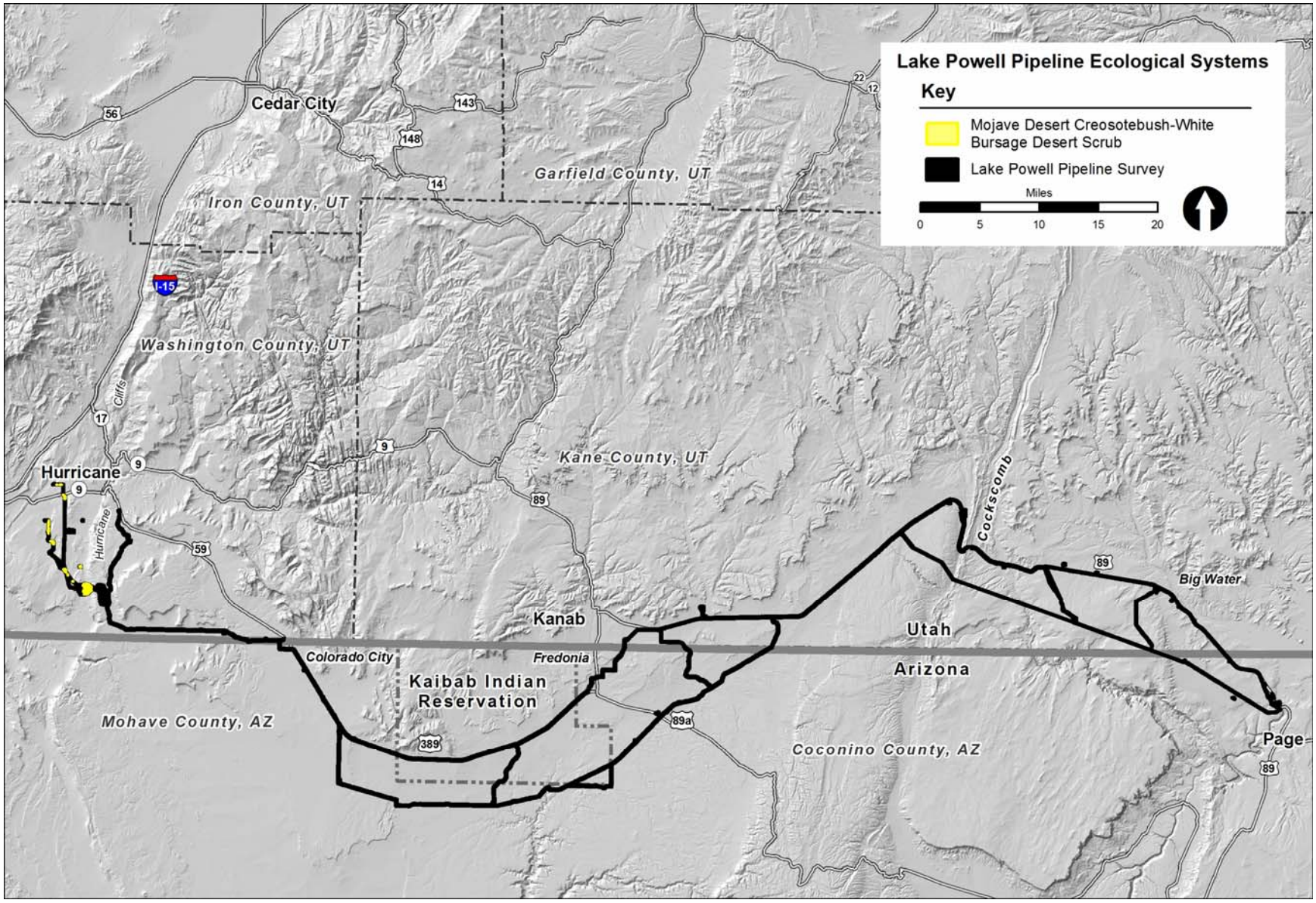


Figure 4-39
Mojave Desert Creosotebush-White Bursage Desert Scrub Ecological System Map

4.3.5 Mojave Desert Grassland Ecological System

4.3.5.1 Geographic Distribution

The Mojave Desert Grassland Ecological System is found northwest of the afterbay and east of Sand Hollow Reservoir (Figure 4-41) within the Mojave Desert of the LPP survey area.

4.3.5.2 Alliances and Associations

Within the survey area, the Mojave 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.

4.3.5.3 Physiognomy and Composition

The Mojave Desert Grassland Ecological System occurs in the survey area exclusively as herbaceous vegetation. Typical plant species occurring in this ecological system include the following: *Artemisia tridentata ssp. tridentata*, *Artemisia tridentata* ssp. w*yomingensis*, *Atriplex* spp. *Coleogyne* spp., *Ephedra* spp., *Gutierrezia sarothrae*, *Krascheninnikovia lanata*, *Achnatherum hymenoides*, *Aristida* spp., *Bouteloua gracilis*, *Hesperostipa comata*, *Muhlenbergia* spp., *Pleuraphis jamesii*, and *Sporobolus* spp. (Figure 4-40).

Figure 4-40
Mojave Desert Grassland Ecological System

4.3.5.4 Disturbance Regimes

Mojave 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.

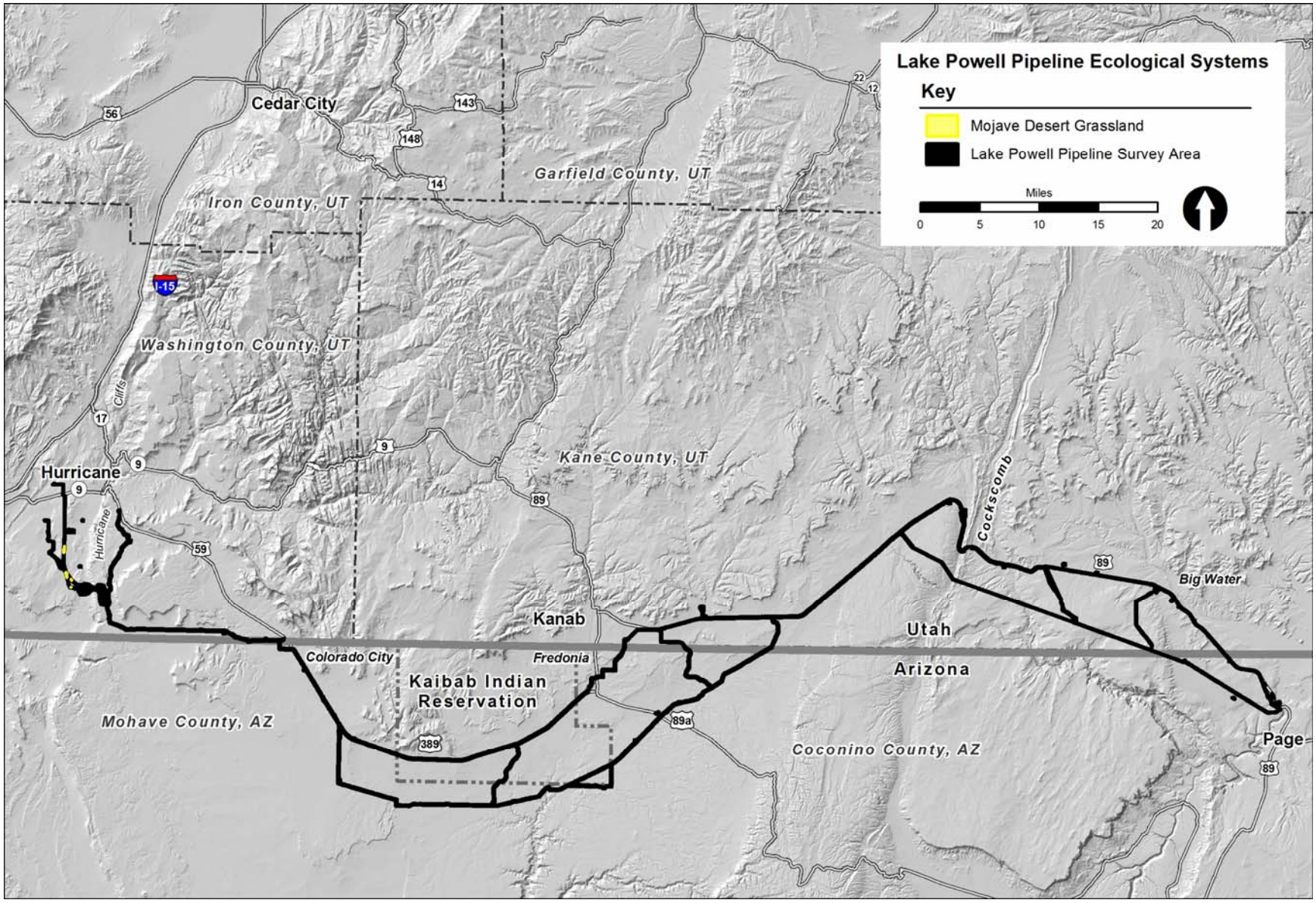


Figure 4-41
Mojave Desert Grassland Ecological System Map

4.3.6 Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System

4.3.6.1 Geographic Distribution

The Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is found in two distinct areas in the Mojave Desert Region in association with both major and minor drainages within the LPP survey area. The first occurrence is located near Sand Hollow Reservoir, and the second occurs in an area associated with agricultural water usage (Figure 4-43).

4.3.6.2 Alliances and Associations

Within the survey area, the Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is comprised of two alliances and two associations. This ecological system totals 2.9 acres within the survey area. Acreage by alliance and association is as follows:

***Tamarix chinensis* Semi-natural Shrubland Alliance**		**0.8 acres**
Tamarix chinensis Semi-natural Sparse Shrubland	0.8 acres	
***Typha latifolia* Herbaceous Alliance**		**2.1 acres**
Tamarix chinensis / *Typha latifolia* Semi-natural Shrub Herbaceous Vegetation	2.1 acres	

4.3.6.3 Physiognomy and Composition

The Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System is commonly sparse shrubland and shrubland, occasionally woodland (Figure 4-42) or shrub herbaceous vegetation, and rarely forest or sparse woodland. Typical plant species occurring in this ecological system include a mix of riparian woodlands and shrublands. Dominant trees include *Acer negundo*, *Populus fremontii*, *Fraxinus velutina*, and *Sapindus saponaria*. Occasionally, *Populus angustifolia* may come in from higher elevations. Shrub dominants include *Salix* spp., *Shepherdia argentea*, *Prunus* spp., *Alnus oblongifolia*, and *Baccharis salicifolia*.

Figure 4-42
Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System

4.3.6.4 Disturbance Regimes

Natural communities in the Mojave 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 *Tamarix chinensis* as dominant. There were no examples of *Tamarix chinensis* co-dominating with a native species.

The Mojave 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.

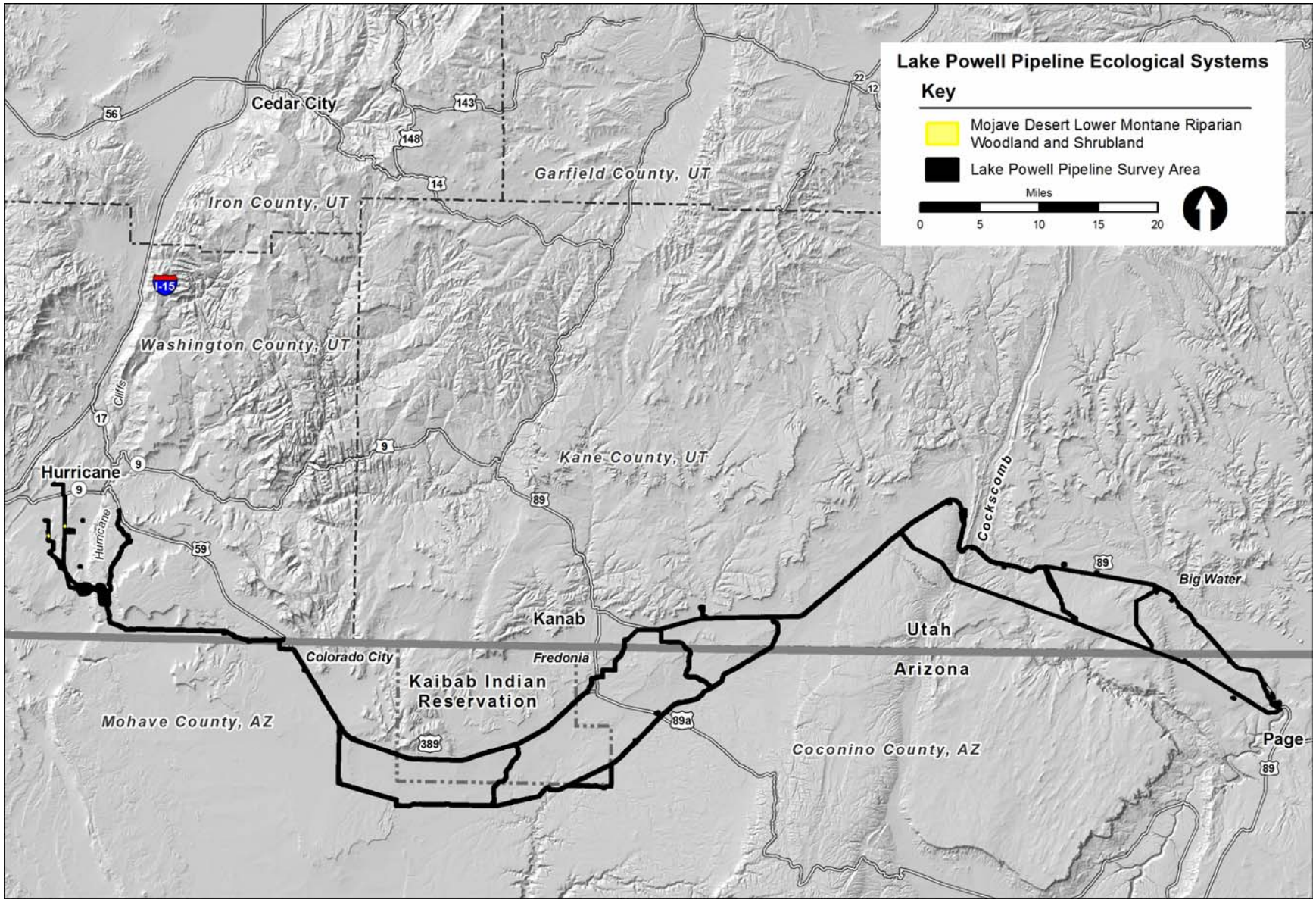


Figure 4-43
Mojave Desert Lower Montane Riparian Woodland and Shrubland Ecological System Map

4.3.7 Mojave Desert Mixed Desert Scrub Ecological System

4.3.7.1 Geographic Distribution

The Mojave Desert Mixed Desert Scrub Ecological System is found throughout the Mojave Desert Region within the LPP survey area. In the north it occurrednear the Virgin River, adjacent to the agricultural lands south of Hurricane, portions of Sand Mountain Road, and portions of the afterbay. It is often interspersed with Mojave Desert Creosotebush-White Bursage Desert Scrub and Mojave Desert Shrub-Steppe Ecological Systems (Figure 4-45).

4.3.7.2 Alliances and Associations

Within the survey area, the Mojave Desert Mixed Desert Scrub Ecological System is comprised of six alliances, including 9 associations. This ecological system totals 249.7 acres within the survey area. Acreage by alliance and association is as follows:

***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**		**59.3 acres**
Gutierrezia sarothrae / (*Erodium cicutarium*, *Bromus* (*tectorum*, *rubens*), *Salsola tragus*) Semi-natural Dwarf-shrubland	36.4 acres	
Gutierrezia sarothrae / (*Erodium cicutarium*, *Bromus* (*tectorum*, *rubens*), *Salsola tragus*) Semi-natural Sparse Dwarf-shrubland	0.9 acres	
Gutierrezia sarothrae Dwarf-shrubland	19.2 acres	
Gutierrezia sarothrae Sparse Dwarf-shrubland	2.8 acres	
***Krascheninnikovia lanata* Shrubland Alliance**		**41.7 acres**
Krascheninnikovia lanata Dwarf-shrubland	41.7 acres	
Mixed Desert Shrub Shrubland Alliance		**53.4 acres**
Mixed Desert Shrub / (*Bromus rubens*, *Salsola tragus*, *Erodium cicutarium*) Semi-natural Shrubland	53.4 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	

4.3.7.3 Physiognomy and Composition

The Mojave Desert Mixed Desert Scrub Ecological System is commonly dwarf shrubland and shrubland (Figure 4-44) and occasionally sparse dwarf shrubland, sparse shrubland, or shrub herbaceous vegetation. Typical plant species occurring in this ecological system include the following: *Coleogyne ramosissima*, *Eriogonum fasciculatum*, *Ephedra nevadensis*, *Grayia spinosa*, *Lycium* spp., *Menodora spinescens*, *Nolina* spp., *Opuntia acanthocarpa*, *Salazaria mexicana*, and *Yucca brevifolia*.

Figure 4-44
Mojave Desert Mixed Desert Scrub
Ecological System

4.3.7.4 Disturbance Regimes

The Mixed Desert Shrub Shrubland Alliance is one of the largest alliances in the Mojave 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.

The alliance with the second 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 comprises the third highest acreage total. *Krascheninnikovia lanata* is a decreaser under grazing and provides winter forage. *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 Mojave 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.

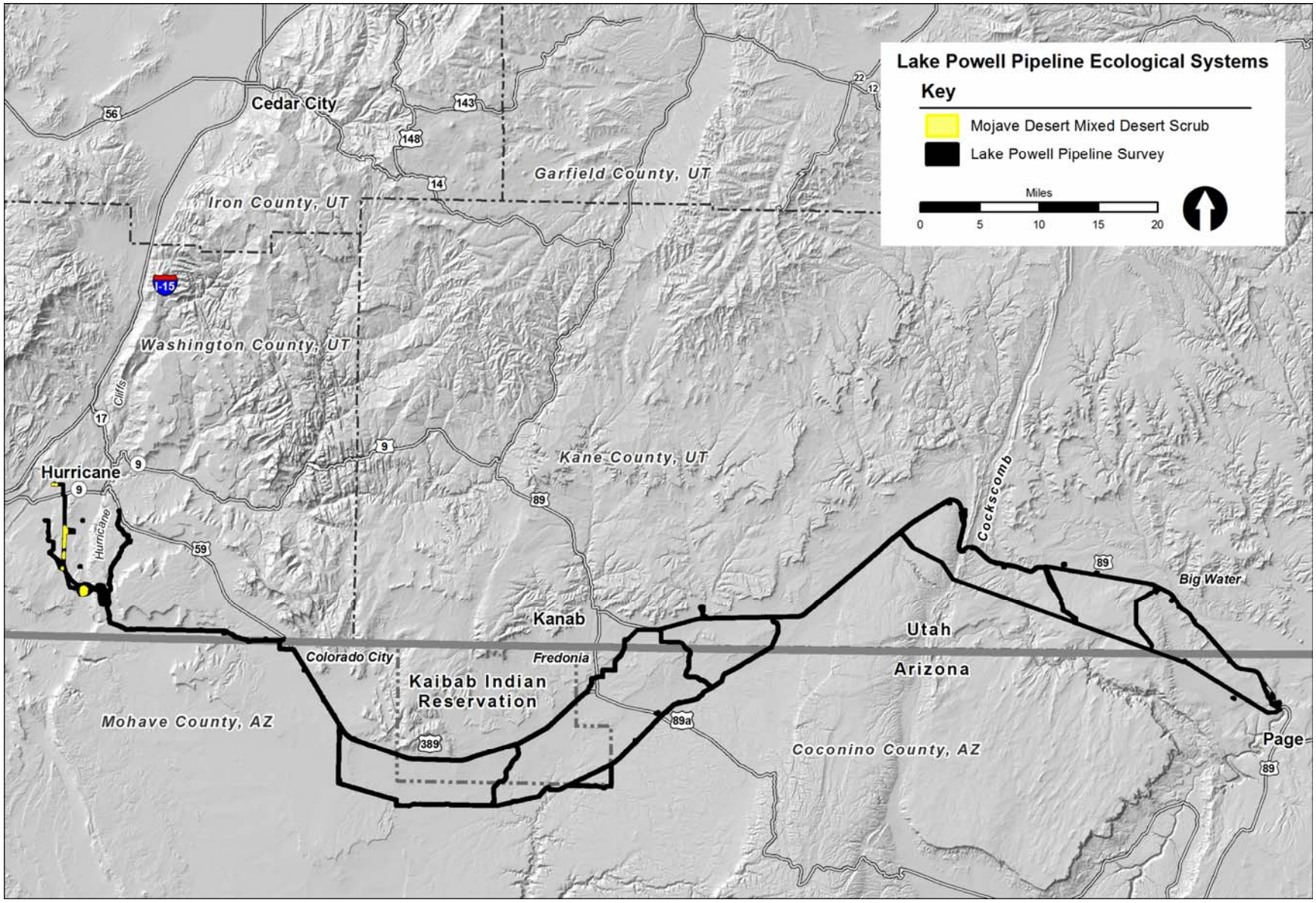


Figure 4-45
Mojave Desert Mixed Desert Scrub Ecological System Map

4.3.8 Mojave Desert Shrub-Steppe Ecological System

4.3.8.1 Geographic Distribution

The Mojave Desert Shrub-Steppe Ecological System is found from the Virgin River south of Sand Mountain Road within the Mojave Desert Region of the LPP survey area. It is often interspersed with Mojave Desert Creosotebush-White Bursage Desert Scrub and Mojave Desert Mixed Desert Scrub Ecological Systems (Figure 4-47).

4.3.8.2 Alliances and Associations

Within the survey area, the Mojave Desert Shrub-Steppe Ecological System is comprised of five alliances and 10 associations. This ecological system totals 200.5 acres within the survey area. Acreage by alliance and association is as follows:

***Ericameria linearifolia* Shrubland Alliance**		**18.0 acres**
Ericameria linearifolia / *Pleuraphis rigida* Dwarf-shrubland	18.0 acres	
***Larrea tridentata* Shrubland Alliance**		**64.7 acres**
Larrea tridentata / *Pleuraphis rigida* - (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Sparse Shrubland	2.7 acres	
Larrea tridentata / *Pleuraphis rigida* Shrubland	46.4 acres	
Larrea tridentata / *Pleuraphis rigida* Sparse Shrubland	15.7 acres	
***Lycium andersonii* Shrubland Alliance**		**25.7 acres**
Lycium andersonii / *Pleuraphis rigida* Shrubland	25.7 acres	
***Pleuraphis rigida* Herbaceous Alliance**		**71.7 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	2.8 acres	
Gutierrezia sarothrae / *Pleuraphis rigida* - *Erodium cicutarium* Shrub Herbaceous Vegetation	0.2 acres	
Gutierrezia sarothrae / *Pleuraphis rigida* Shrub Herbaceous Vegetation	53.3 acres	
***Psorothamnus fremontii* Sparsely Vegetated Alliance**		**20.4 acres**
Psorothamnus fremontii / *Pleuraphis rigida* Sparse Vegetation	20.4 acres	

4.3.8.3 Physiognomy and Composition

The Mojave Desert Shrub-Steppe Ecological System is commonly dominated by herbaceous vegetation with less than 10 percent shrub cover (i.e., shrub herbaceous vegetation; Figure 4-46). It is also commonly a dwarf shrubland or shrubland and rarely sparse shrubland or herbaceous vegetation without shrubs. Typical plant species occurring in this ecological system include *Atriplex canescens*, *Artemisia tridentata*, *Psorothamnus fremontii*, *Chrysothamnus greenei*, *Chrysothamnus viscidiflorus*, *Ephedra* spp., *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. *Artemisia tridentata* or *Atriplex canescens* may be present but usually do not dominate; *Bromus tectorum*, may be present to abundant.

Figure 4-46
Mojave Desert Shrub-Steppe Ecological System

4.3.8.4 Disturbance Regimes

The Mojave 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 1 and 10 percent.

Where shrubs are absent, *Pleuraphis rigida* Herbaceous Vegetation is classified in the Mojave Desert Grassland Ecological System.

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 dominant.

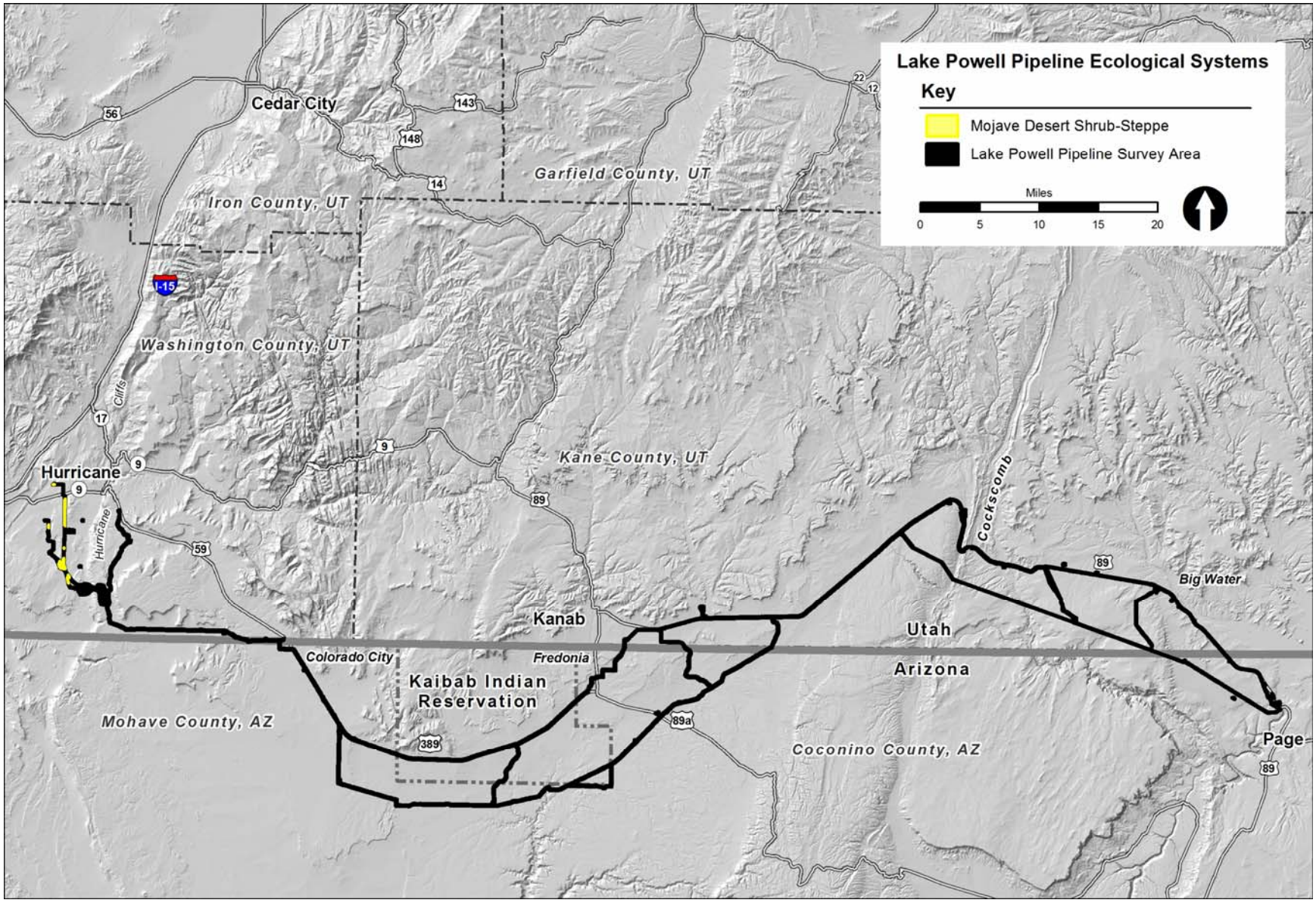


Figure 4-47
Mojave Desert Shrub-Steppe Ecological System Map

4.3.9 Mojave Desert Volcanic Rock and Cinder Land Ecological System

4.3.9.1 Geographic Distribution

The Mojave Desert Volcanic Rock and Cinder Land Ecologial System is found in three distinct areas: near the Virgin River, near Sand Hollow Reservoir, and along the afterbay north to Sand Mountain Road. As the name implies it is found in association with rock outcrops and rock lands, within the Mojave Desert Region these include the Winkel-Rock outcrop complex and the Bermesa-Rock land association, as well as Stony colluvial land (Figure 4-49).

4.3.9.2 Alliances and Associations

Within the survey area, the Mojave Desert Volcanic Rock and Cinder Land Ecologial System is comprised of five alliances, including 10 associations. This ecological system totals 139.45 acres within the survey area. Acreage by alliance and association is as follows:

***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	

4.3.9.3 Physiognomy and Composition

The Mojave Desert Volcanic Rock and Cinder Land Ecologial System is either herb or shrub dominated (Figure 4-48). The latter are typically shrublands and dwarf shrublands, and rarely sparse shrublands. Typical plant species occurring in this ecological system, at montane and foothill elevations, are scattered *Juniperus* spp. trees. Shrubs such as *Ephedra* spp., *Atriplex canescens*, *Eriogonum corymbosum*, and *Fallugia paradoxa* may also be present.

Figure 4-48
Mojave Desert Volcanic Rock and Cinder Land
Ecological System

4.3.9.4 Disturbance Regimes

The *Coleogyne ramosissima* Shrubland Alliance is a long-lived seral stage on the rugged basalt soils of the Mojave Desert Volcanic Rock and Cinder Land Ecological System. Where soils are degraded, the alliance is 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.

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.

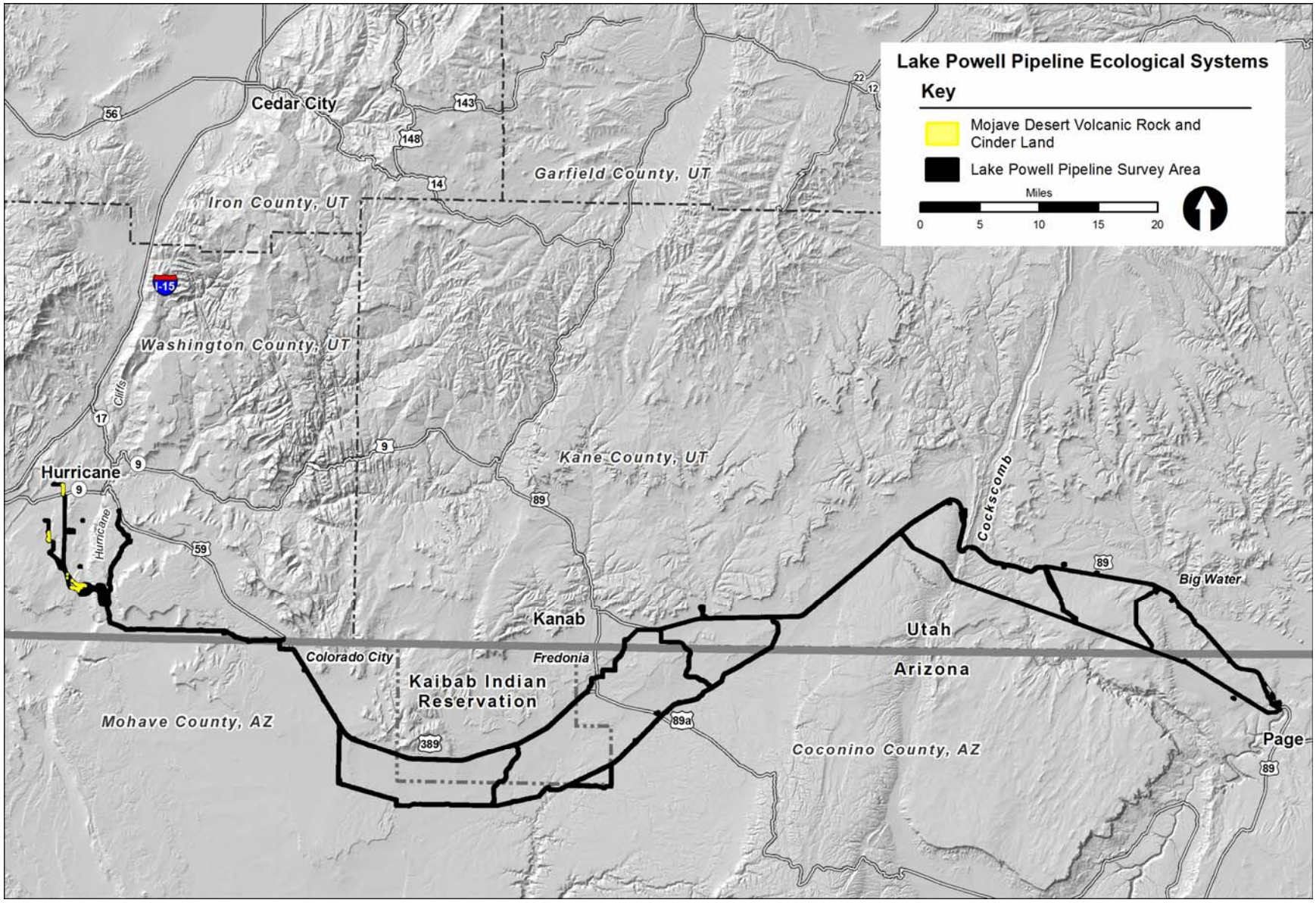


Figure 4-49
Mojave Desert Volcanic Rock and Cinder Land Ecological System Map

4.3.10 Mojave Desert Wash Ecological System

4.3.10.1 Geographic Distribution

While washes are characteristic of the Mojave 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 Mojave 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 and north of the afterbay (Figure 4-51).

4.3.10.2 Alliances and Associations

Within the survey area, the Mojave Desert Wash Ecological System is comprised of three alliances and their four associations. This ecological system totals 11.3 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**		**5.2 acres**
Hymenoclea salsola / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Shrubland	1.5 acres	
Hymenoclea salsola Shrubland	3.7 acres	
Non-vegetated sandstone		**0.7 acres**
Non-vegetated Sandstone Outcrop	0.7 acres	

4.3.10.3 Physiognomy and Composition

The Mojave Desert Wash Ecological System occurs in the survey area as either a shrubland or a sparse shrubland (Figure 4-50). Typical plant species occurring in this ecological system include a woody layer dominated by shrubs and small trees such as *Acacia greggii*, *Baccharis sarothroides*, *Chilopsis linearis*, *Fallugia paradoxa*, *Hymenoclea salsola*, *Hymenoclea monogyra*, *Psorothamnus spinosus*, and *Prunus fasciculata*. Common upland shrubs such as *Larrea tridentata* and *Ambrosia dumosa* are often present along the edges of these washes.

Figure 4-50
Mojave Desert Wash Ecological System

4.3.10.4 Disturbance Regimes

The Mojave 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.

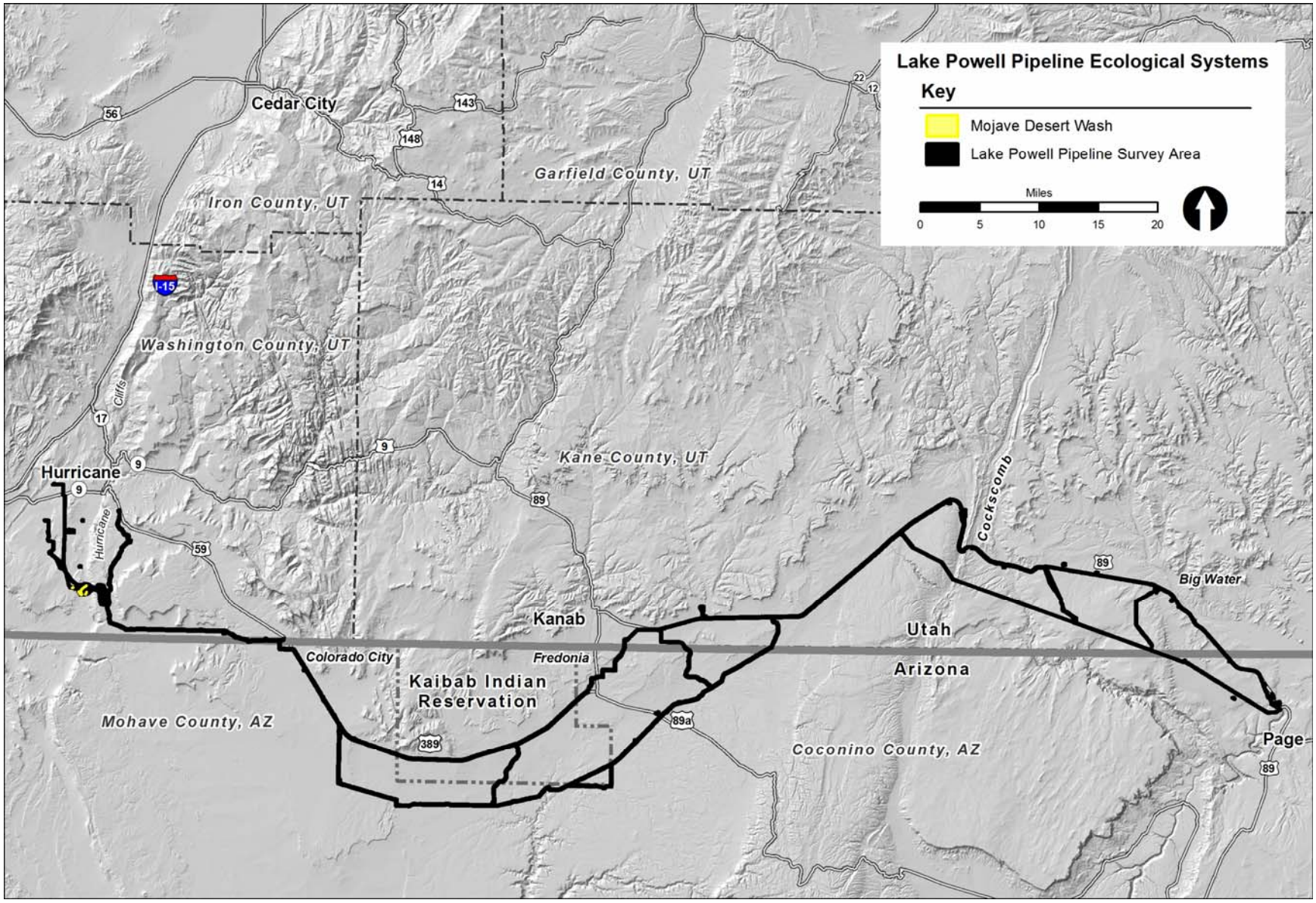


Figure 4-51
Mojave Desert Wash Ecological System Map

4.4 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 2,581 acres are classified in the anthropogenic lands category. Except for Introduced Upland Vegetation and Ruderal Vegetation, these types are not included within NatureServe ecological systems.

4.4.1 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. Twelve 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.

4.4.1.1 Geographic Distribution

Agricultural lands are found throughout the LPP survey area. The greatest concentration occurs within the Mojave Desert Region, just west of the Hurricane Cliffs.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 U.S. Highway 89 (Figure 4-52).

4.4.1.2 Acreages

Agricultural land totals 191.5 acres within the survey area.

Agricultural land	**182.9 acres**
Stock Pond	**8.6 acres**

4.4.1.3 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 U.S. Department of Agriculture, Farm Security Agency, for those farms participating in federal government agricultural programs.

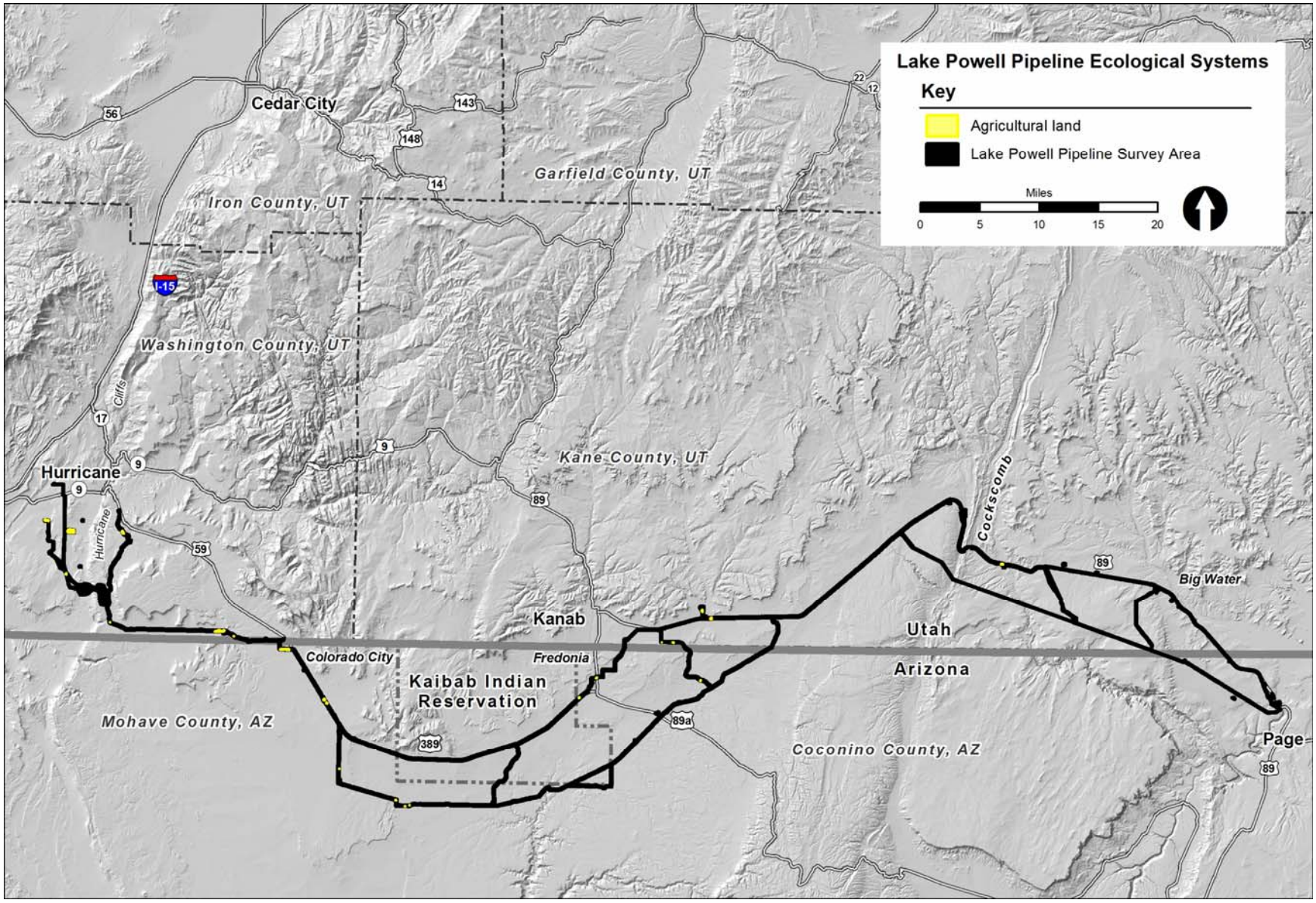


Figure 4-52
Agricultural Land Map

4.4.2 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.

4.4.2.1 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, and Hurricane. They are also in areas with a high percentage of private land; specifically along portions of U.S. Highway 89 between Fredonia and Johnson's Wash (Figure 4-53).

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 U.S. Highway 89 east of Kanab. Other smaller portions of paved roads include areas near Sand Hollow Reservoir and through residential areas south of Hurricane (Figure 4-54).

Developed lands – Roads Graded is a sub category which includes graded roads as found throughout the LPP survey area. The road south from Utah State Route 59 along the Honeymoon Trail is a graded road. The access road running the length of the afterbay is also a graded road. The entire length of both Yellowstone Road and Mount Trumbull Roads are graded. 8-Mile Gap Road from U.S. 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.

4.4.2.2 Acreages

Developed land totals 247.7 acres within the survey area.

Developed land – Roads Paved totals 236.3 acres within the survey area. Developed land – Roads Graded totals 154.7 acres within the survey area. Developed land – Roads Unimproved totals 78.5 acres within the survey area.

4.4.2.3 Physiognomy and Composition

Not applicable.

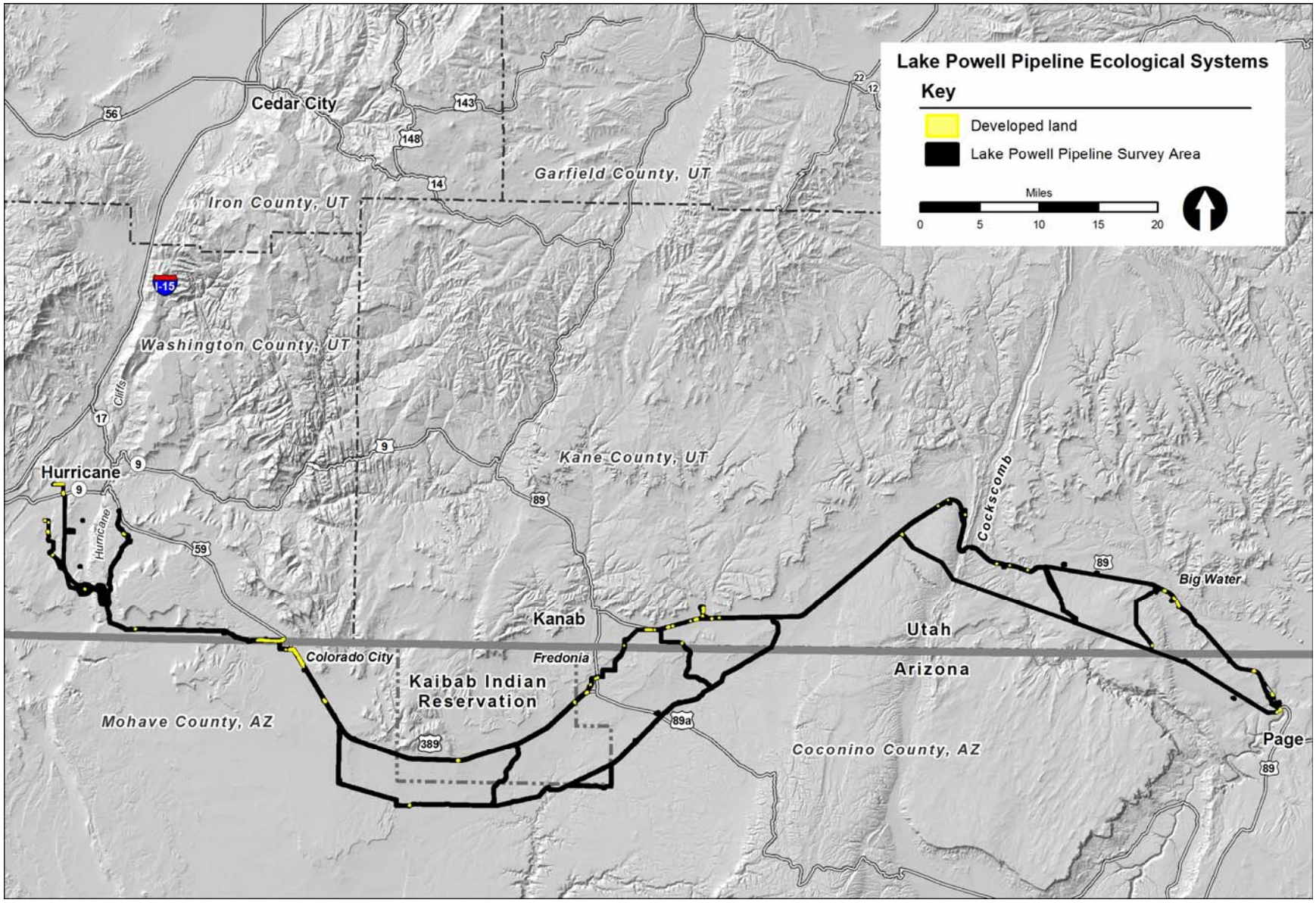


Figure 4-53
Developed Land Map

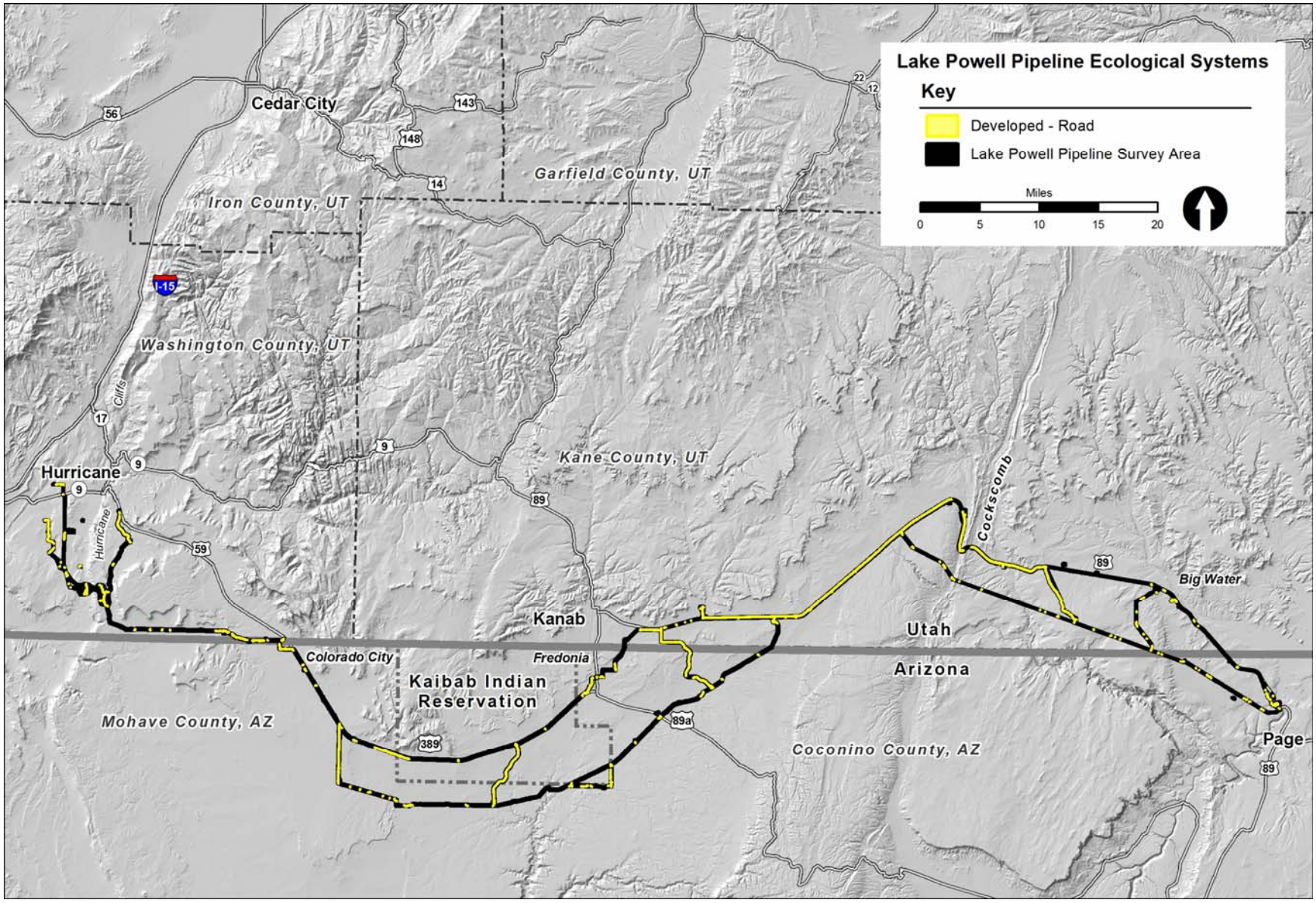


Figure 4-54
Developed Land–Roads Map

4.4.3 Invasive Upland Vegetation

4.4.3.1 Geographic Distribution

Invasive Upland vegetation is found scattered throughout the entire LPP survey area (Figure 4-55).

4.4.3.2 Alliances and Associations

Within the survey area, this ecological system is comprised of 12 alliances including 11 associations. This ecological system totals 970.5 acres within the survey area. Acreage by alliance and association is as follows:

***Agropyron cristatum* Semi-natural Herbaceous Alliance**		**17.3 acres**
Agropyron cristatum Semi-natural Herbaceous Vegetation	17.3 acres	
***Bromus* (*rubens, tectorum*) Semi-natural Herbaceous Alliance**		**6.2 acres**
Bromus rubens Semi-natural Herbaceous Vegetation	4.2 acres	
Bromus tectorum Semi-natural Herbaceous Vegetation	2.0 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**		**20.2 acres**
Chorispora tenella Semi-natural Herbaceous Vegetation	20.2 acres	
***Erodium cicutarium* Semi-natural Herbaceous Alliance**		**190.8 acres**
Erodium cicutarium Semi-natural Herbaceous Vegetation	190.8 acres	
***Gutierrezia sarothrae* Sparsely Vegetated Alliance**		**12.2 acres**
Gutierrezia sarothrae / (*Erodium cicutarium*, *Bromus rubens*, *Salsola tragus*) Semi-natural Sparse Vegetation	12.2 acres	
***Helianthus annuus* Semi-natural Herbaceous Alliance**		**77.4 acres**
Helianthus annuus Semi-natural Herbaceous Vegetation	77.4 acres	
Invasive Upland Vegetation		**96.3 acres**
Ruderal Vegetation		**0.7 acres**
***Salsola tragus* Semi-natural Herbaceous Alliance**		**529.2 acres**
Salsola tragus Semi-natural Herbaceous Vegetation	529.2 acres	
***Salsola tragus* Semi-natural Sparsely Vegetated Alliance**		**19.1 acres**
Salsola tragus Semi-natural Sparse Vegetation	19.1 acres	
***Tamarix chinensis* Semi-natural Shrubland Alliance**		**0.3 acres**
Tamarix chinensis Semi-natural Shrubland	0.3 acres	

4.4.3.3 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.

4.4.4 Quarry

4.4.4.1 Geographic Distribution

Two quarries were documented as occurring within the LPP survey area. Both are in the Colorado Plateau region (Figure 4-56).

4.4.4.2 Acreages

Quarries total 2.0 acres within the survey area.

4.4.4.3 Physiognomy and Composition

Not applicable.

4.4.5 Reservoir

4.4.5.1 Geographic Distribution

One reservoir was documented as occurring within the LPP survey area, within the Mojave Desert Region. This includes the Sand Hollow Reservoir, southwest of Hurricane (Figure 4-57).

4.4.5.2 Acreages

Reservoirs total 1.9 acres within the survey area.

4.4.5.3 Physiognomy and Composition

Not applicable.

4.4.6 Ruderal Vegetation

4.4.6.1 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: U.S. Highway 89 from the Glen Canyon Dam area to the community of Glen Canyon City, U.S. Highway 89 west of the Cockscomb and east of Fredonia, Arizona State Route 389 across the Kaibab-Paiute Reservation, as well as around Sand Hollow Reservoir, and adjacent to the agricultural lands south of Hurricane (Figure 4-58).

4.4.6.2 Acreages

Ruderal Vegetation totals 697.8 acres within the survey area.

***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**		**2.3 acres**
Erodium cicutarium Semi-natural Herbaceous Vegetation	2.3 acres	
Ruderal Vegetation		**693.8 acres**

4.4.6.3 Physiognomy and Composition

This type is exclusively herbaceous vegetation.

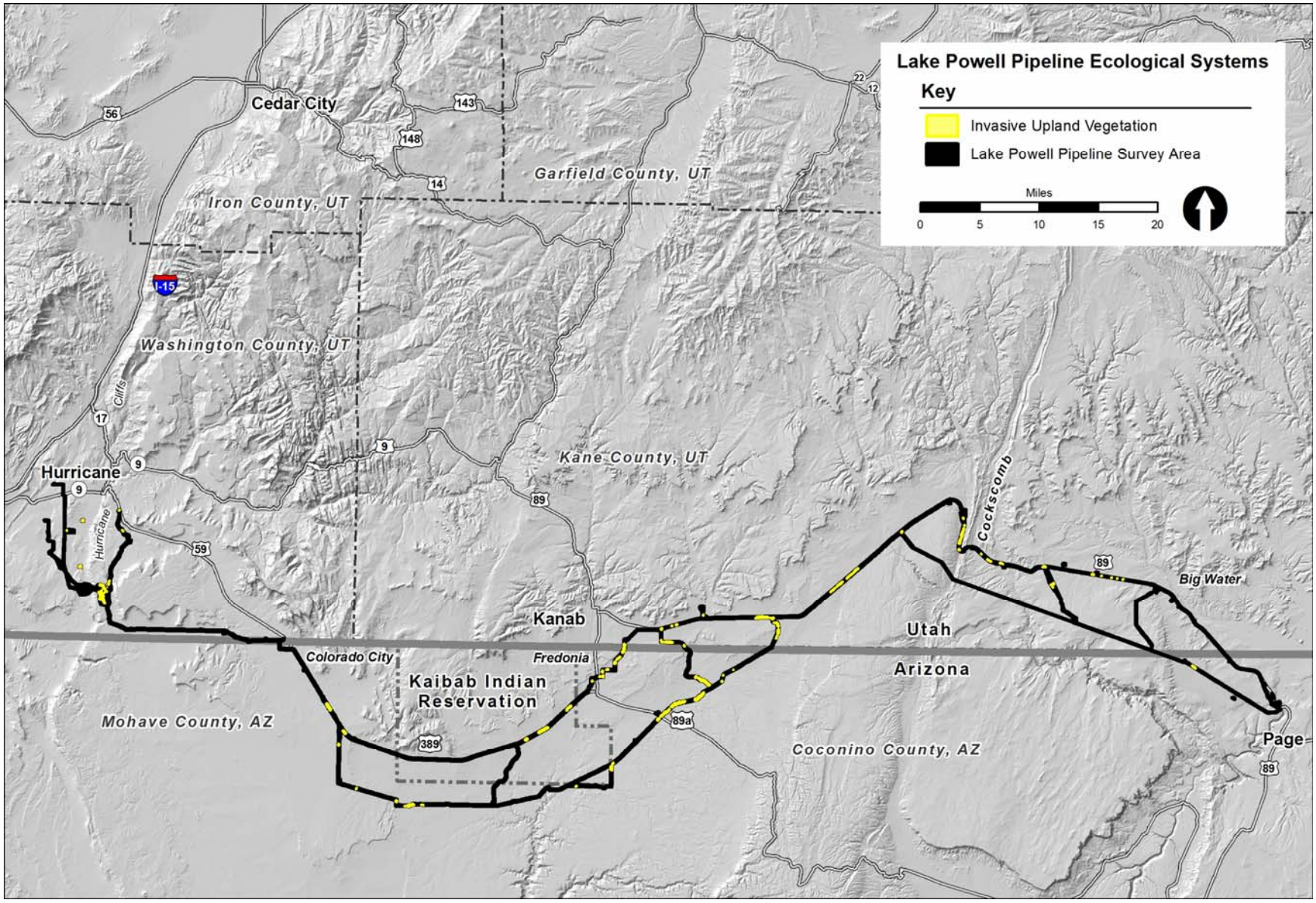


Figure 4-55
Invasive Upland Vegetation Map

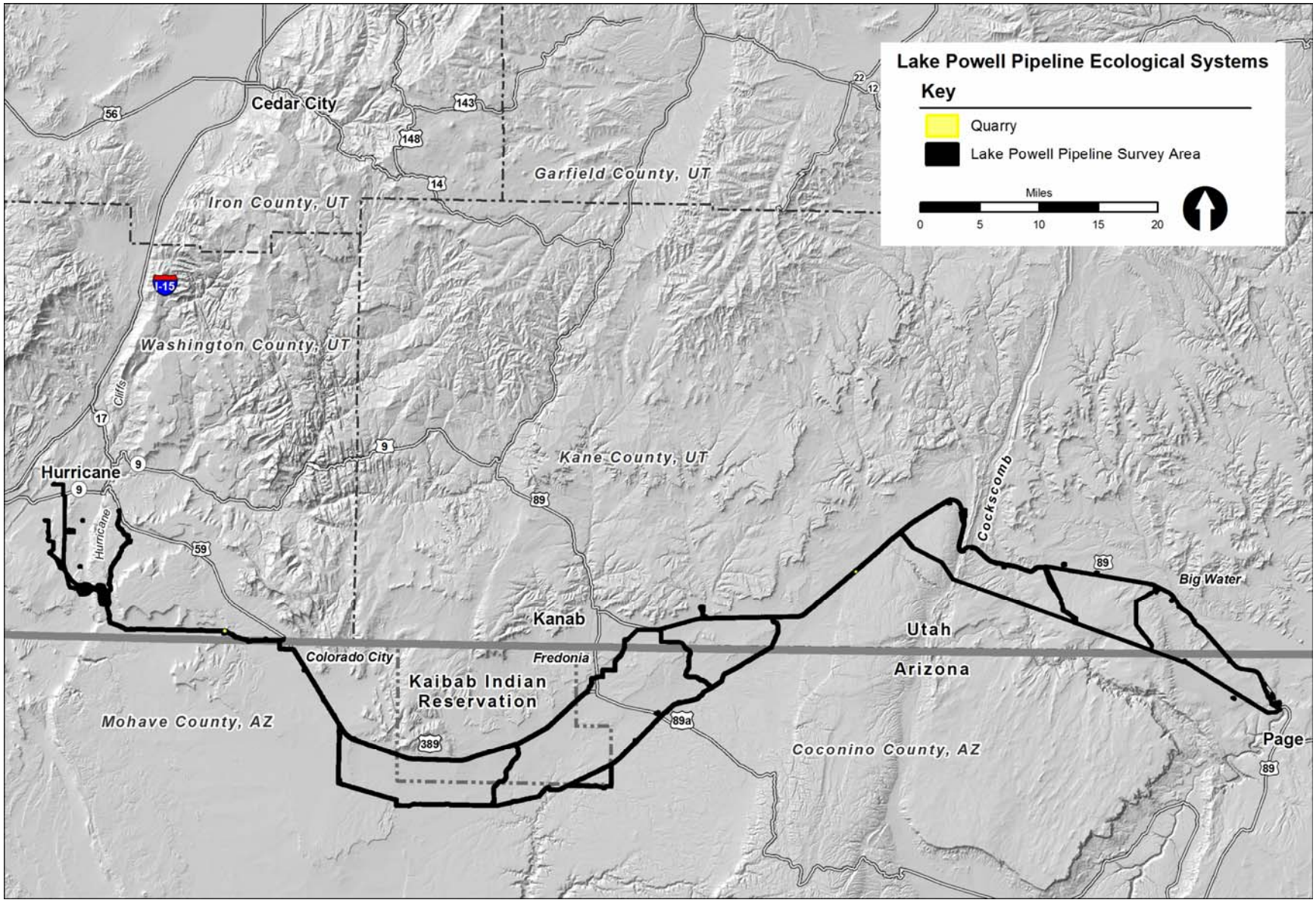


Figure 4-56
Quarries Map

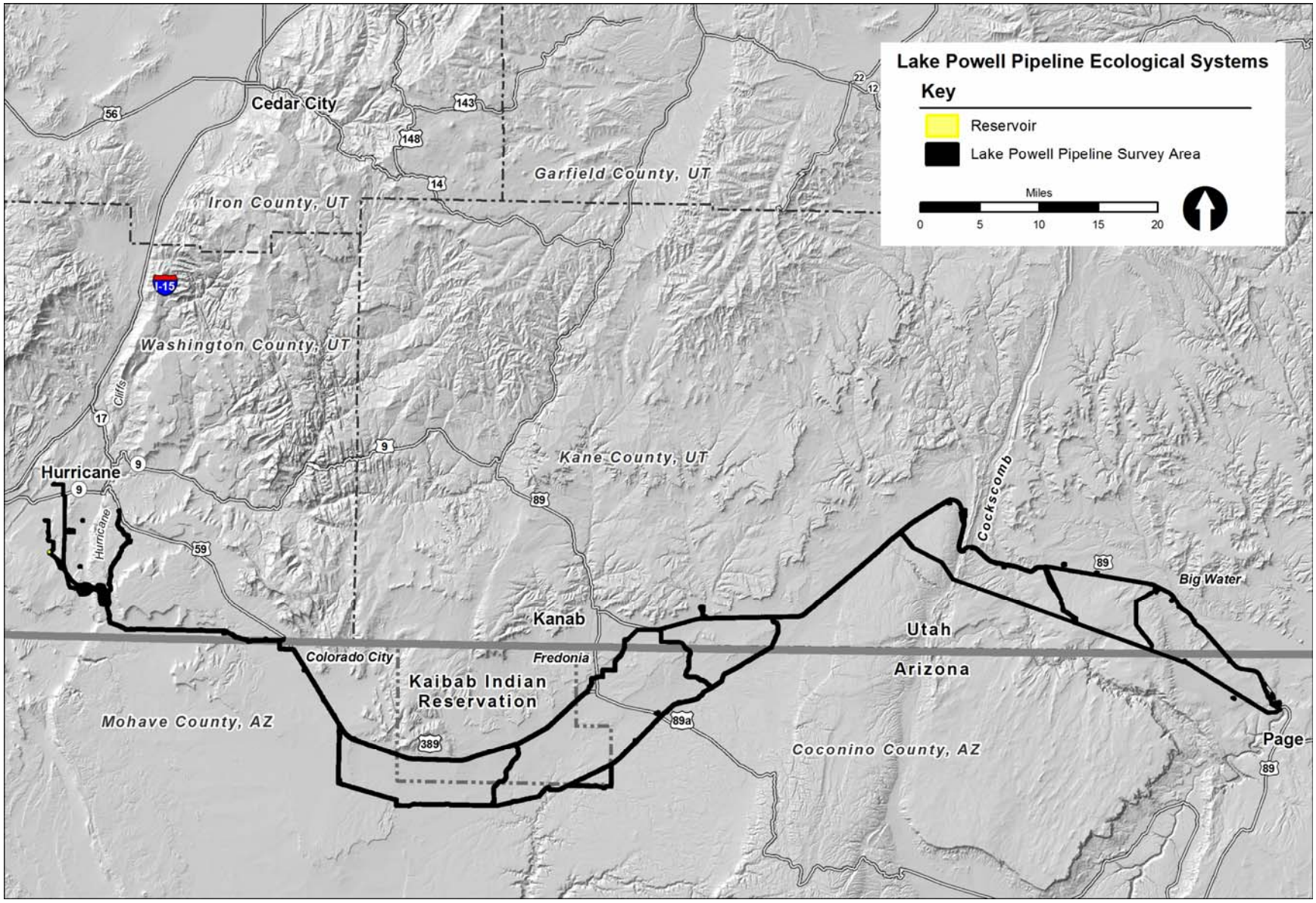


Figure 4-57
Reservoirs Map

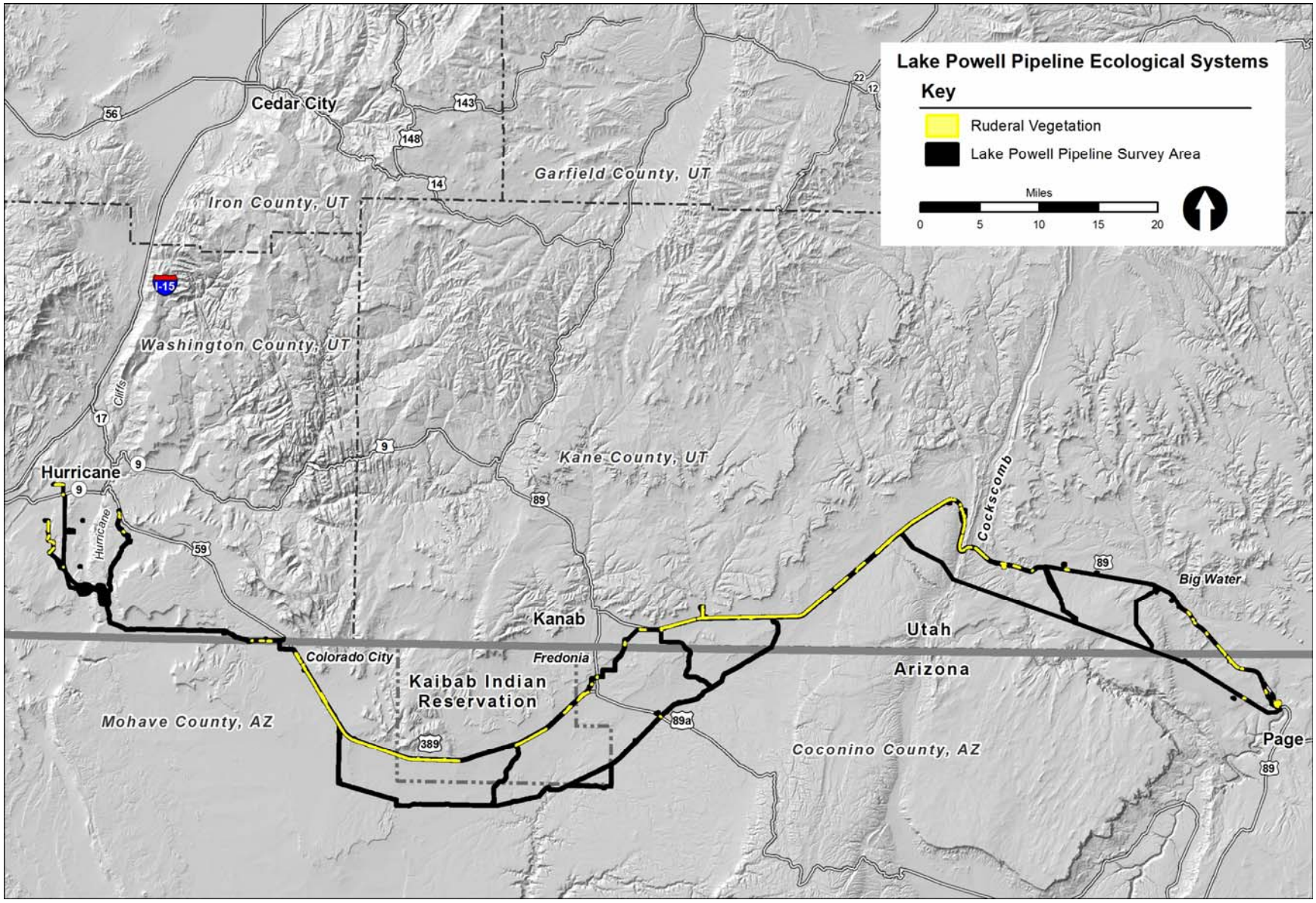


Figure 4-58
Ruderal Vegetation Map

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 4,029 classified polygons—2,971 of these classified polygons represented natural communities and 1,058 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	Mojave Desert Region
GIS Classified Polygons	3,722	307
Corridor Acreages	14,487	1,163
Ecological Systems	15	10
Alliances	195	35
Associations	490	64

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 (USGS 2004) 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.

THIS PAGE INTENTIONALLY LEFT BLANK

References Cited

Anderson, M. F. 1998. *Living at the Edge: Explorers, Exploiters and Settlers of the Grand Canyon Region*. Arizona: Grand Canyon Association.

Arizona Game and Fish Department (AGFD). 2007. Buckskin Mountain Mule Deer Habitat Improvement. Arizona Game and Fish Department. Accessed: http://www.azgfd.gov/pdfs/w_c/hpc/proposals/Mule%20Deer/07-220-Buckskin%20chaining%20HPC.pdf (October 7, 2010).

Merriam-Webster, Incorporated. Merriam-Webster Online Dictionary. 2010. www.merriam-webster.com (accessed: September 28, 2010).

Meyer, S. E. 1986. The Ecology of *Gypsophile Endemism* in the Eastern Mojave Desert. *Ecology* 67(5): 1303-1313.

U.S. Climate Data. 2016. Availible on the World Wide Web at http://www.usclimatedata.com/climate/kanab/utah/united-states/usut0127.

U.S. Congress. 1998. Public Law 105-355. Title II – Grand Staircase-Escalante National Monument. Section 202, Utility Corridor Designation, U.S. Route 89, Kane County, Utah. November 6, 1998.

U.S. Geologic Services (USGS). 2004. U.S. Geological Survey's Gap Analysis Program (GAP)'Provisional' Southwest Regional Landcover Data. September, 2004

Utah State University (USU). 2010. Cooperative Observer Program. Utah Climate Center, Logan, UT. http://climate.usurf.usu.edu/products/data.php?tab=coop (accessed January 14, 2010 and September 27, 2010).

Weather Underground. 2010. http://www.wunderground.com/ (Accessed: January 11, 2009 and September 27, 2010).

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 U.S. 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 U.S. 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.

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
KCWCD	Kane City Water Conservancy District
LPP	Lake Powell Pipeline
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
RO	Reverse Osmosis
SITLA	School Institutional Trust Lands Administration
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
UTM	Universal Transverse Mercator
VRM	Visual Resource Management
WCWCD	Washington County Water Conservancy District

List of Preparers

Logan Simpson

Project Manager

Bruce Palmer
Senior Biologist

Authors

Heather English
Biologist, Vegetation Community Report Author

Gary Reese
Botanist, Vegetation Community Report Author

Judy Mielke
Technical Review of the Vegetation Community Report

Richard Remington
Senior Biologist

Field Crew

Kurt Bahti
Jennifer Cleland
Harry Cooper
Ada Davis
Heather English
Jeffrey Ensing
Grant Fahrni
John Ginter
Sara Gregory
Will Hayes
Jenni James
Rebecca Kipp
Judy Mielke
John Millican
Bruce Palmer
Art Pizzo
Eric Poirier
Gary Reese
Richard Remington
Nikolas Smilovsky
Thomas Staudt
Shaylon Stump
Jared Wahlberg
James Warnecke
Yumi Yoshino

Appendix A
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: _____

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 B
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: _____

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

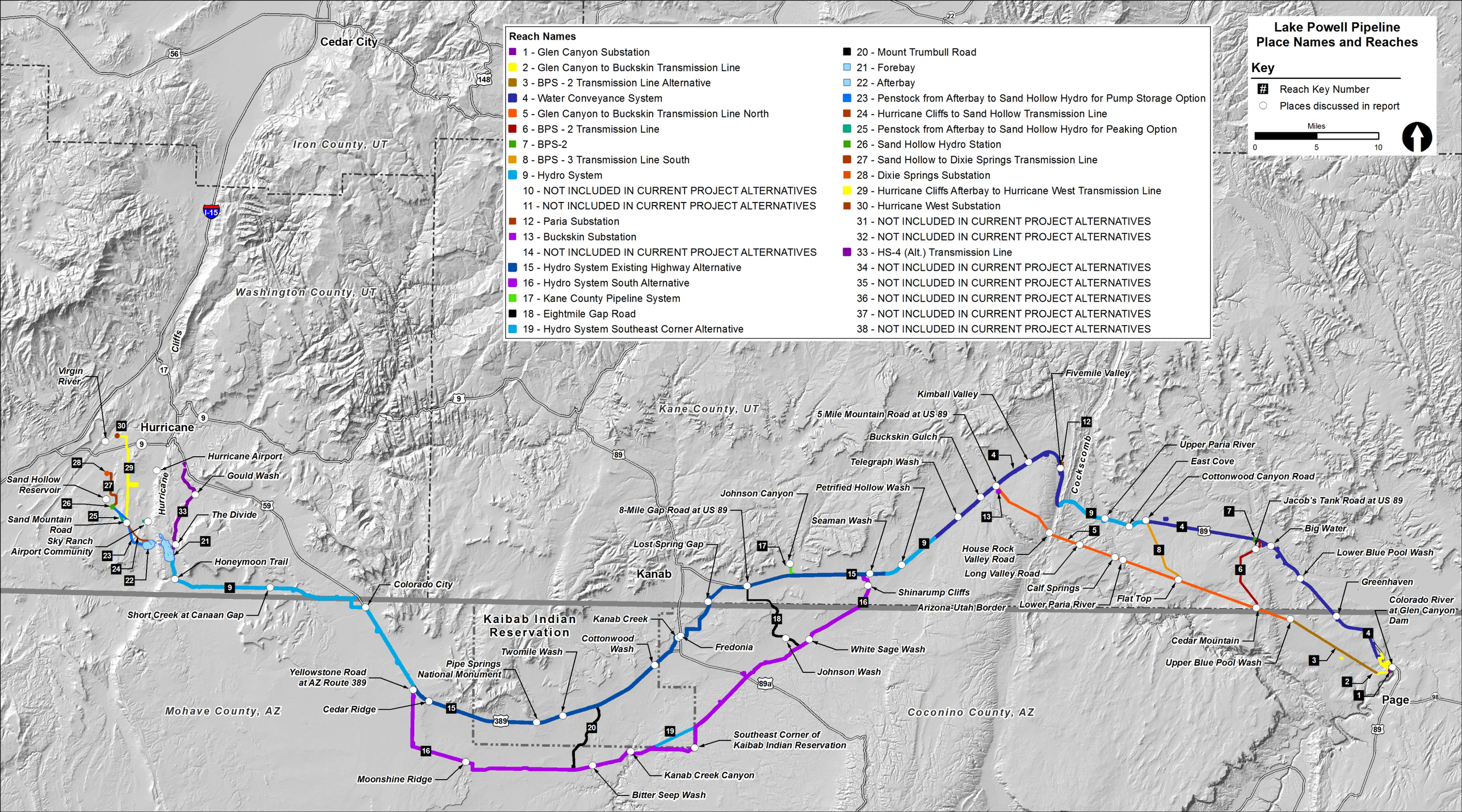
Logan Simpson Design Project #065276 Page 2 of 2

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 C
Lake Powell Pipeline Place Names and Reaches Map


Lake Powell Pipeline
Place Names and Reaches
Key
Reach Key Number
Places discussed in report
Miles
0
5
10
Reach Names
1 - Glen Canyon Substation
2 - Glen Canyon to Buckskin Transmission Line
3 - BPS - 2 Transmission Line Alternative
4 - Water Conveyance System
5 - Glen Canyon to Buckskin Transmission Line North
6 - BPS - 2 Transmission Line
7 - BPS-2
8 - BPS - 3 Transmission Line South
9 - Hydro System
10 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
11 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
12 - Paria Substation
13 - Buckskin Substation
14 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
15 - Hydro System Existing Highway Alternative
16 - Hydro System South Alternative
17 - Kane County Pipeline System
18 - Eightmile Gap Road
19 - Hydro System Southeast Corner Alternative
20 - Mount Trumbull Road
21 - Forebay
22 - Afterbay
23 - Penstock from Afterbay to Sand Hollow Hydro for Pump Storage Option
24 - Hurricane Cliffs to Sand Hollow Transmission Line
25 - Penstock from Afterbay to Sand Hollow Hydro for Peaking Option
26 - Sand Hollow Hydro Station
27 - Sand Hollow to Dixie Springs Transmission Line
28 - Dixie Springs Substation
29 - Hurricane Cliffs Afterbay to Hurricane West Transmission Line
30 - Hurricane West Substation
31 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
32 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
33 - HS-4 (Alt.) Transmission Line
34 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
35 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
36 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
37 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
38 - NOT INCLUDED IN CURRENT PROJECT ALTERNATIVES
Cedar City
Iron County, UT
Washington County, UT
Kane County, UT
Mohave County, AZ
Coconino County, AZ
Hurricane
Hurricane Cliffs
Virgin River
Hurricane Airport
Gould Wash
The Divide
Sand Hollow Reservoir
Sand Mountain Road
Sky Ranch Airport Community
Honeymoon Trail
Colorado City
Short Creek at Canaan Gap
Kaibab Indian Reservation
Kanab
Kanab Creek
Cottonwood Wash
Twomile Wash
Pipe Springs National Monument
Yellowstone Road at AZ Route 389
Cedar Ridge
Moonshine Ridge
Fredonia
Lost Spring Gap
8-Mile Gap Road at US 89
Johnson Canyon
Seaman Wash
Petrified Hollow Wash
Telegraph Wash
Buckskin Gulch
5 Mile Mountain Road at US 89
Kimball Valley
Fivemile Valley
Cockscomb
Shinarump Cliffs
Arizona-Utah Border
White Sage Wash
Johnson Wash
Southeast Corner of Kaibab Indian Reservation
Kanab Creek Canyon
Bitter Seep Wash
House Rock Valley Road
Long Valley Road
Calf Springs
Lower Paria River
Flat Top
Upper Paria River
East Cove
Cottonwood Canyon Road
Jacob's Tank Road at US 89
Big Water
Lower Blue Pool Wash
Greenhaven
Colorado River at Glen Canyon Dam
Cedar Mountain
Upper Blue Pool Wash
Page