Section 5
Description of Existing Environment

5.1 Geology and Soils

5.1.1 Geology

5.1.1.1 Regional Geology

The proposed Lake Powell Pipeline (Project) alignment traverses physiographic provinces of the western Colorado Plateau into the transition zone between the Plateau and the Basin and Range in Utah and Arizona. These two physiographic provinces define the topographic, geologic, and hydrologic features of much of the western United States.

The Colorado Plateau encompasses most of southern and eastern Utah, western Colorado, northern Arizona, and northwestern New Mexico. Along the Project pipeline alignment, the Colorado Plateau lies east of the Hurricane Cliffs and consists of flat to gently dipping rocks that are regionally uplifted northward. Surface faults exist within the Plateau region and can be locally significant but are generally not dominant surface features on a large scale. However, subsurface faulting and the associated deformation are more common at greater depths, and the same forces have caused gently to steeply inclined folds at the surface, exhibited as anticlines, synclines, and monoclines.

Most of the rocks exposed or in the shallow subsurface of the Colorado Plateau in the vicinity of the Project alignment are sedimentary rocks formed in large, shallow seas, broad river plains, and expansive deserts during the late Permian to the late Cretaceous Periods, roughly 260 to 65 million years ago. Much of the Colorado Plateau has been dissected by erosion to form canyons, cliffs, and other features. Mostly unconsolidated surficial sediments were deposited during the Holocene and Pleistocene Epochs over the past 1.6 million years. Most of the surface deposition was associated with alluvial, fluvial, and eolian deposits, as well as reworked glacial deposits from the last great (Pleistocene) ice age. Basalt flows from cinder cones and fissures of Miocene to Holocene origin (15 million years to present) are exposed at the surface in a number of places, mostly in the western part of the alignment east and west of the Hurricane Cliffs (Boyle, 2003; UGS 1998;USGS 2002a; WCWCD 2005; USGS, 2004a).

The Basin and Range Physiographic Province includes western Utah, most of Nevada, and parts of central and southern Arizona, central and southwestern New Mexico, eastern California, southeastern Idaho, and southeastern Oregon. Basin and Range geology is a result of uplift and crustal extension forces that began during the Miocene Epoch approximately 15 to 16 million years ago and continue today; these forces have caused the region to be broken up into north-south trending mountains and ranges, known as "horst-graben" structures, caused by downthrown blocks "dropping" into the gaps caused by uplift and extension. The up-thrown blocks have been partially eroded to fill much of the valley floors, covering the down-thrown blocks and in many instances depositing several thousand feet of sediments in the intermontane valleys. Localized basalt flows associated with Basin and Range extension are present in the western parts of the Project alignment (Boyle, 2003; UGS 1998; WCWCD 2005; USGS, 2004b).

The province transition zone from the Colorado Plateau to the Basin and Range begins at the Hurricane Cliffs and its associated fault system (the fault zone represents the eastern edge of the Basin and Range horst-graben faulting in this region) and extends westward beyond St. George to approximately the region of Gunlock and Santa Clara, Utah (WCWCD 2005). The transition zone is characterized by an increase in the number and abundance of faults from east to west, with horst-graben type block faulting that forms mountains and valleys not clearly defined but with a significant active fault system (the Hurricane Fault) bounding the eastern edge. The western-most reaches of the pipeline alignment routes from the Hurricane Cliffs westward to Sand Hollow Reservoir are contained within the transition zone because the Project alignment from Lake Powell terminates at Sand Hollow Reservoir, about 10 miles east of St. George. The pipeline alignment from Quail Creek Reservoir (north of Sand Hollow) to Cedar City is aligned parallel to the Hurricane Cliffs and also is contained within the transition zone.

5.1.1.2 Geology of the Project Pipeline Alignment

The following describes major geologic features that occur along the Project alignment. Figures 5-1 and 5-2 show a geologic map along the Project alignment.

Long reaches of sedimentary rocks consisting primarily of sandstone, limestone, siltstone, and shale comprise much of the Project alignment. Beginning at the intake pumping station at Lake Powell and traveling westward to the Cockscomb, the Project pipeline alignment crosses through mostly Jurassic and Cretaceous sandstone, siltstone, and limestone, and overlying Quaternary alluvium and windblown deposits (USGS 1963).

At Big Water City, the Project pipeline alignment crosses the Echo Monocline, a north-south trending, gently east-dipping structural feature associated with Wahweap Creek. The Echo Monocline also is probably associated with minor normal faulting south of the alignment as well as the nearby north-south trending Cedar Mountain Anticline, the latter not crossing the Project pipeline alignment from the south but influencing local surface features (UGS 2006a).

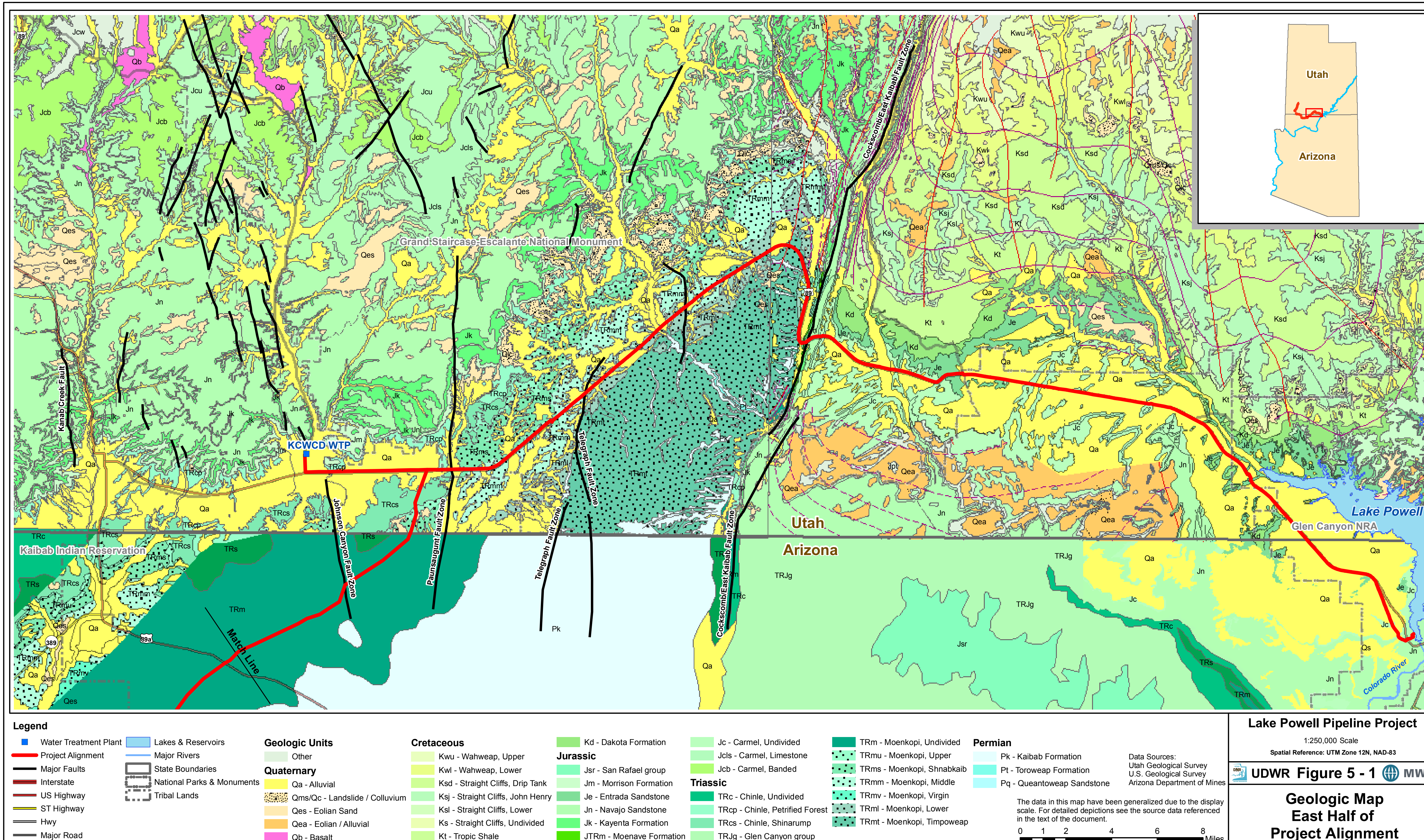
About three miles east of the Paria River, the Project pipeline alignment crosses the Coyote Creek Syncline. The syncline is a long but structurally subtle north-south trending feature that is structurally associated with the Cockscomb several miles further west (UGS 2006a).

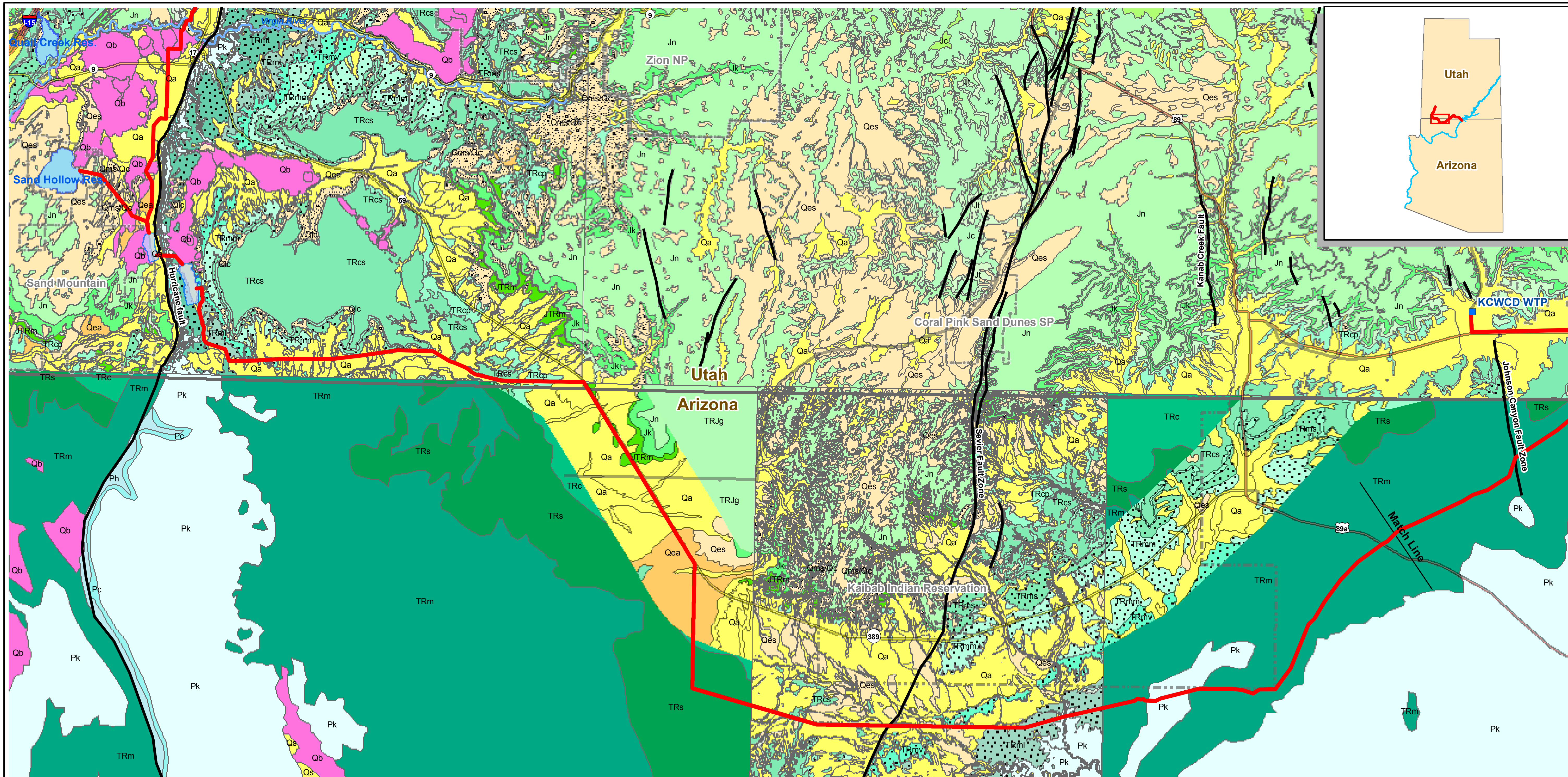
The Cockscomb is a north-south trending ridge that exists because of differential erosion of juxtaposed rocks at the crest of the East Kaibab Monocline, caused by steep vertical and right-lateral faulting at the East Kaibab Monocline as well as the Kaibab Anticline and Fault Zone. Although the Cockscomb ridge is east of the fault, the east side is downthrown relative to the west side (UGS 2006a).

The Project pipeline alignment follows U.S. 89 through the Cockscomb and through Fivemile Valley, just west of the Cockscomb. Further west, the Project pipeline alignment crosses a north-northeast trending, normal, westward downthrown fault designated by Rowley, Dixon, and Brickey (WCWCD 2005) as the Telegraph Fault Zone. This minor fault zone is probably displaced about 100 feet and may be associated with basin-range faulting, and therefore may be active.

The Project pipeline alignment continues toward the southwest, primarily crossing various members of the Triassic Moenkopi Formation and overlying Quaternary alluvial deposits. The Project pipeline alignment crosses several miles of relatively flat terrain known as Telegraph Flat, until heading southwest at Petrified Wash (UGS 2006a; USGS 2004c).

Immediately west of Petrified Wash, the Project alignment crosses the Paunsaugunt Fault Zone at Seaman Wash, which at this location is a north-trending, westward down-thrown fault with about 600 feet of vertical displacement (WCWCD 2005). It is not believed to be active at this location but is known to be active north of Bryce Canyon.


Utah
Arizona
Lake Powell
Glen Canyon NRA
Grand Staircase-Escalante National Monument
Kaibab Indian Reservation
KCWCD WTP
Kanab Creek Fault
Johnson Canyon Fault Zone
Paunsaugunt Fault Zone
Telegraph Fault Zone
Cockscomb/East Kaibab Fault Zone
Match Line
Colorado River
Legend
Water Treatment Plant
Project Alignment
Major Faults
Interstate
US Highway
ST Highway
Hwy
Major Road
Lakes & Reservoirs
Major Rivers
State Boundaries
National Parks & Monuments
Tribal Lands
Geologic Units
Other
Quaternary
Qa - Alluvial
Qms/Qc - Landslide / Colluvium
Qes - Eolian Sand
Qea - Eolian / Alluvial
Qb - Basalt
Cretaceous
Kwu - Wahweap, Upper
Kwl - Wahweap, Lower
Ksd - Straight Cliffs, Drip Tank
Ksj - Straight Cliffs, John Henry
Ksl - Straight Cliffs, Lower
Ks - Straight Cliffs, Undivided
Kt - Tropic Shale
Kd - Dakota Formation
Jurassic
Jsr - San Rafael group
Jm - Morrison Formation
Je - Entrada Sandstone
Jn - Navajo Sandstone
Jk - Kayenta Formation
JTRm - Moenave Formation
Jc - Carmel, Undivided
Jcls - Carmel, Limestone
Jcb - Carmel, Banded
Triassic
TRc - Chinle, Undivided
TRcp - Chinle, Petrified Forest
TRcs - Chinle, Shinarump
TRJg - Glen Canyon group
TRm - Moenkopi, Undivided
TRmu - Moenkopi, Upper
TRms - Moenkopi, Shnabkaib
TRmm - Moenkopi, Middle
TRmv - Moenkopi, Virgin
TRml - Moenkopi, Lower
TRmt - Moenkopi, Timpoweap
Permian
Pk - Kaibab Formation
Pt - Toroweap Formation
Pq - Queantoweap Sandstone
Data Sources:
Utah Geological Survey
U.S. Geological Survey
Arizona Department of Mines
The data in this map have been generalized due to the display scale. For detailed depictions see the source data referenced in the text of the document.
0 1 2 4 6 8 Miles
Lake Powell Pipeline Project
1:250,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 5 - 1 MWH
Geologic Map
East Half of
Project Alignment



Legend

- Water Treatment Plant
- Project Alignment
- Major Faults
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- Lakes & Reservoirs
- Hurricane Cliffs Forebay/Afterbay
- Major Rivers
- State Boundaries
- National Parks & Monuments
- Tribal Lands

Kanab Geol Poly

- Other

Quaternary

- Qa - Alluvial
- Qms/Qc - Landslide / Colluvium
- Qes - Eolian Sand
- Qea - Eolian / Alluvial
- Qb - Basalt

Cretaceous

- Kwu - Wahweap, Upper
- Kwl - Wahweap, Lower
- Ksd - Straight Cliffs, Drip Tank
- Ksj - Straight Cliffs, John Henry
- Ksl - Straight Cliffs, Lower
- Ks - Straight Cliffs, Undivided
- Kt - Tropic Shale
- Kd - Dakota Formation

Jurassic

- Jt - Temple Cap Sandstone
- Jsr - San Rafael group
- Jm - Morrison Formation
- Je - Entrada Sandstone
- Jn - Navajo Sandstone
- Jk - Kayenta Formation
- JTRm - Moenave Formation
- Jc - Carmel, Undivided
- Jcls - Carmel, Limestone
- Jcb - Carmel, Banded

Triassic

- TRc - Chinle, Undivided
- TRcp - Chinle, Petrified Forest
- TRcs - Chinle, Shinarump
- TRJg - Glen Canyon Group
- TRm - Moenkopi, Undivided
- TRmu - Moenkopi, Upper
- TRms - Moenkopi, Shnabkaib
- TRmm - Moenkopi, Middle
- TRmv - Moenkopi, Virgin
- TRml - Moenkopi, Lower
- TRmt - Moenkopi, Timpoweap

Permian

- Ph - Hermit Shale
- Pc - Coconino Sandstone
- Pk - Kaibab Formation
- Pt - Toroweap Formation
- Pq - Queantoweap Sandstone

Data Sources:
Utah Geological Survey
U.S. Geological Survey
Arizona Department of Mines

The data in this map have been generalized due to the display scale. For detailed depictions see the source data referenced in the text of this document.

0 1 2 4 6 8 Miles

Lake Powell Pipeline Project

1:250,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 5 - 2** MWH

Geologic Map
West Half of
Project Alignment

The Project alignment crosses the Johnson Canyon Fault Zone about three to four miles west of Seaman Wash. This fault zone consists of a single fault trace down-thrown to the east (USGS 2004c).

The Kanab Creek Fault Zone near Kanab and in Kanab Canyon has been documented in geologic mapping. Sable and Herford (USGS 2004c) and Doelling (UGS 1999a) identify north-south trending, eastward down-thrown fault zones at and north of Kanab; further south, Rowley, Dixon, and Brickey (WCWCD 2005) observed evidence of faulting near Fredonia that may be associated with the Kanab Creek Fault Zone. It is not clear whether Kanab Creek Fault Zone near Kanab extends as far south as the Project alignment, although Kanab Creek cuts an increasingly deep canyon southward that may be facilitated by faulting.

West of Kanab Canyon and Fredonia, the Project pipeline alignment continues across a largely flat plateau of shallow alluvial and eolian deposits underlain by limestone, siltstone, sandstone, and shale, which are primarily rocks that comprise the various members of the Moenkopi Formation (ABM 1960).

The Project alignment crosses the Sevier Fault, a major, active, north-south trending fault down-thrown to the west with as much as 2,000 feet of vertical displacement (USGS 2004d; WCWCD 2005) south of the Kaibab Paiute Indian Reservation (Reservation) and Pipe Spring National Monument. The east-dipping Moccasin Monocline lies parallel to and just west of the Sevier Fault Zone and appears to be associated with the faulting.

Continuing westward from the Sevier Fault Zone, the Project alignment traverses south of the Reservation, primarily in alluvium and shallow outcrops of Shinarump sandstone and conglomerate. West of the reservation, the Project alignment turns north across alluvial, fluvial, and eolian soils and outcrops of Shinarump sandstone and conglomerate (USGS 2002b; USGS 2004d; ABM 1959). It parallels the Highway 389 corridor west of the reservation boundary, southwest of the Vermillion Cliffs and several miles south of the Utah-Arizona border.

The Project pipeline alignment traverses various alluvial deposits parallel to Highway 389 and Highway 59 as it continues northwestward into Utah. At the Utah border, the Project alignment veers westward through Canaan Gap for approximately 12 miles across mostly eolian and alluvial deposits and short outcrops of Virgin Limestone before turning northward east of the Hurricane Cliffs. The Project alignment continues about five miles northward roughly parallel to the cliffs through a narrow valley of alluvial deposits and outcrops of soft siltstone and sandstone of the Lower Red Member of the Moenkopi Formation, as well as limestone, sandstone, or shale of the Timpoweap Member of the Moenkopi Formation. The Project alignment then crosses through about a mile of basalt flows before discharging to a forebay reservoir near the Hurricane Cliffs.

The Project pipeline would exit the forebay and then drop into a deep vertical shaft that would be used to generate hydropower. The shaft would be bored down through sandstone, siltstone, and limestone of the Timpoweap Member of the Moenkopi Formation, the Kaibab Limestone, the Toroweap Limestone, and the Queantoweap Sandstone. The shaft would connect to a tunnel and pipeline emerging at the base of the Hurricane Cliffs in alluvium and talus, crossing the Hurricane Fault Zone (UGS 2004b). This fault zone is a series of steeply westward-dipping normal faults that trend north-south from the Grand Canyon to north of Cedar City. At this location, the fault offset has more than 5,000 feet and perhaps as much as 6,000 feet of vertical displacement (USGS 2003) and is considered an active fault, with a 5.8 magnitude earthquake occurring in 1992 (UGS, 1997). As the Project pipeline crosses the Hurricane Cliffs and Hurricane Fault Zone, it moves from the Colorado Plateau into the Transition Zone between the Plateau and the Basin and Range.

At the base of the Hurricane Cliffs, the Project pipeline enters an afterbay reservoir. The Project alignment then continues from the base of the cliffs north and west through alluvium and eolian deposits and minor outcrops of basalt. Immediately east of Sand Hollow Reservoir, the Project pipeline drops over a steep slope and crosses through eolian deposits overlying Navajo Sandstone before entering the reservoir, which also overlies eolian sands and Navajo Sandstone (UGS 2004a, 2004b).

The Project pipeline from Quail Creek Reservoir to the Cedar Valley extends north from the reservoir parallel to Interstate 15, initially crossing siltstone and sandstone of the Chinle Formation, parallel to an inactive thrust fault associated with Leeds Reef, before entering a long series of mostly alluvial and eolian deposits south of Leeds (UGS 2003a; 2003b). It continues through alluvium in a north-northeasterly direction roughly parallel to the Hurricane Cliffs for many miles, close to but only occasionally crossing short Basin-and-Range type block faults that typically lie parallel to the Hurricane Cliffs (UGS 2003c).

West of Kolob Arch, the Project pipeline enters an outcrop of Quaternary basalt flows and continues in basalt for approximately five miles before re-emerging into alluvium near Ash Creek Reservoir. Near the Washington County - Iron County boundary, the Project pipeline obliquely crosses an active normal fault that is down-thrown to the west and has displaced recent alluvial deposits (UGS 2002; UGS 2003c; UGS 2006c). Proposed termination of the pipeline would occur at a new regional water treatment plant near the town of Kanarraville.

5.1.2 Soils

Soils along the Project alignment are typically alluvial or eolian or sometimes fluvial deposits and terraces, occasionally including reworked glacial outwash sediments. Soils are generally moderately well drained and shallow, although there are many exceptions.

Most soils in the eastern part of the Project alignment are sands or sandy to gravelly loams from 0 to 5 feet deep (deeper soils tend to occur in larger valleys and deep basins and washes), with large areas of rock outcrop that have little to no soil. Some soils are saline and, when associated with marine parent rocks or non-marine evaporite rocks, have high gypsum content and sometimes moderately high calcium carbonate. More often, soils originating from non-marine, non-evaporite rocks are generally non-saline and low in gypsum but may be relatively high in calcium carbonate (NRCS, 2003, 2007a).

Soils in the Arizona Strip include so-called “clayhole washes” which typically consist of clay, silty loams, silty clay loams, or sandy loams, 0 to 5 feet deep and in some instances deeper. Some clayhole wash soils may be relatively high in gypsum because of gypsiferous parent materials. Soils may be deeper in depressions and other places where deposition is more likely to occur. Outside of the clayhole washes, soils are typically eolian or alluvial sands or gravelly to sandy loams that originate from sandstone parent material. These soils are mostly less than five feet deep but may be deeper, are usually low in gypsum and may be low to moderately high in calcium carbonate (NRCS, 1983, 2007b).

In the western part of the Project alignment, soils are alluvial and eolian fine sands, sandy loams and cobbly loams amid large areas of exposed bedrock. Much of the parent material is limestone and calcareous shale, and as a result soils are often high in calcium carbonate and low in gypsum. Soils are typically thin, often less than two feet deep. Near Sand Hollow Reservoir, eolian and alluvial sandy soils are generally deeper than two feet (NRCS, 1971, 2007c).

The Cedar Valley Pipeline System passes through sandy gravelly loam soils associated with alluvium derived from limestone, sandstone, and shale. It is typically non-saline, high in calcium carbonate, and low in gypsum. Fine eolian sand deposits derived from sandstone are common. Where the Project pipeline passes through sediments deposited over or near volcanic rock, the soil is primarily cobbly sandy loam derived from basalt or from windblown sand deposits. Further north, the soils include cobbly clay loam and silt loam in the southern part of the Cedar Valley. Most soils within the Cedar Valley are in excess of five feet deep and often much deeper away from the valley margins and bedrock outcrops (NRCS, 1996, 2007d).

5.2 Water Resources

5.2.1 Water Supply

Sources of water supplies in the vicinities of Kanab, St. George, and Cedar City include groundwater derived from wells and springs, and from surface water captured in reservoirs and from direct diversion of streams and rivers.

5.2.1.1 Groundwater

Groundwater is used throughout the area and is obtained primarily from wells, with lesser quantities derived from springs. Groundwater is pumped from shallow alluvial aquifers within river valleys, from basalt bedrock, and from shallow to deep fractured and weakly cemented sedimentary rock aquifers, most notably the Navajo Sandstone aquifer system but from others as well. In the vicinity of the Sand Hollow Reservoir, recharge to groundwater from the reservoir occurs to the shallow unconsolidated overburden (alluvial and eolian sand), to the basalt bedrock north of the reservoir, and primarily to the underlying Navajo Sandstone (USGS 2005a). A series of wells near the reservoir captures some of this recharge, which currently originates from water in the Virgin River that is pumped into the reservoir; the groundwater is pumped from the wells for use in St. George and nearby communities west of the reservoir.

Groundwater in the Cedar Valley is a primary source of water for Cedar City and most of the communities in the valley. Groundwater is pumped from the alluvial aquifer. Groundwater quality is variable in the valley aquifer, with high total dissolved solids (TDS) in pockets near the mouth of Cedar Canyon and north of Cedar City, and mostly very good quality further out in the valley. Much of the water used for potable purposes originates from a wellfield near Quichapa Lake and from wells near the City of Enoch (Cedar City Engineer, 2007).

5.2.1.2 Surface Water

Surface water is made available by means of localized streamflow diversions but is primarily captured by reservoirs. Major reservoirs in the vicinity include Quail Creek Reservoir, Sand Hollow Reservoir, and Lake Powell, the latter by far the largest.

5.2.1.2.1 Quail Creek Reservoir. Quail Creek Reservoir is operated by the Washington County Water Conservancy District (WCWCD). The reservoir is supplied with water that gravity flows from Quail Creek, but most of the water in the reservoir is diverted from the nearby Virgin River. It has a full-pool surface area of 590 acres and a capacity of 40,325 acre-feet. The reservoir has an average annual yield of approximately 22,000 acre-feet. The maximum depth of the reservoir is 190 feet and is sustained by two dams. The reservoir provides drinking water to the St. George area and is treated at an on-site water treatment plant (UGS 1999b; UDWQ 2007a).

A U.S. Geological Survey river flow gaging station is located on the Virgin River at Virgin. The gaging station is described below (USGS 2008):

Station Number: 09406000
Station Name: Virgin River at Virgin, UT
Location: Lat 37º 12’ 15”, Long 113º 10’ 48”
Washington County, UT
Hydrologic Unit: 15010008
Drainage Area: 611,840 acres
Period of Record: Annual Flow: Water Years 1910 to 1971, 1979 to 2007
Gage Datum: 3,500 ft above sea level, NGVD29
Restrictions: None
Average annual flow: 199 cfs

Average annual flows for the 97 water years of record that are available from the USGS are shown in Figure 5-3.

5.2.1.2.2 Sand Hollow Reservoir. Sand Hollow Reservoir is operated by WCWCD. The full-pool surface area is approximately 1,300 acres and has a capacity of 50,000 acre-feet (USGS 2005a). The reservoir water supply originates from the Virgin River via the Quail Creek Diversion Dam and Pipeline system and is conveyed by means of a pressure pipeline from the Quail Creek Hydro plant (upstream of Quail Creek Reservoir) to a pump station that lifts the water into Sand Hollow Reservoir. Therefore the Sand Hollow Reservoir watershed is the same as the Quail Creek Reservoir watershed. The WCWCD typically diverts higher quality water (less sediment laden flows) into Sand Hollow Reservoir and diverts lower quality water (higher sediment laden flows) into Quail Creek Reservoir from the Virgin River at the Quail Creek Diversion Dam.

5.2.1.2.3 Lake Powell. Lake Powell is the largest reservoir in Utah. The reservoir has a full-pool surface area of 162,700 acres and a design capacity of 24,322,000 acre-feet. Lake Powell is stored behind the Glen Canyon Dam, built on the Colorado River two miles south of the Utah-Arizona border, with a Colorado River watershed of 65,800,000 acres. The dam is operated by the U.S. Bureau of Reclamation. The watershed above Glen Canyon Dam includes most of eastern and southern Utah, western Colorado, and southwestern Wyoming, as well as relatively smaller areas in the central/southern Rocky Mountains in northeastern Arizona and northwestern New Mexico. The watershed area is largely high desert of the Colorado Plateau but derives much of its runoff from the west slopes of the central Rocky Mountains, as well as the Uintah Mountains along the Utah-Wyoming border and the Wind River Mountains in western Wyoming. Average inflow is approximately 12,000,000 acre/feet per year (Reclamation 2005).

Two U.S. Geological Survey river flow gaging stations are located on the Colorado River downstream of Glen Canyon Dam. The gaging stations are described below (USGS 2007a; 2007b; 2007c):

Station Number: 09379910
Station Name: Colorado River Below Glen Canyon Dam, AZ
Location: Lat 36º 55’ 18”, Long 111º 28’ 58”
Coconino County, AZ
Hydrologic Unit: 14070006
Drainage Area: 71,488,000 acres
Period of Record: Annual Flow: Water Years 1990, 1991, 1992, 2001, 2002, 2003
Monthly Flow: 10/89 to 3/93; 3/01 to 9/02
Gage Datum: 3,100 ft above sea level, NGVD29
Restrictions: The USGS National Water Information System Website indicates that streamflow data from this gaging station is restricted by USGS staff due to special conditions at or near the site
Average annual flow: 11,258 cfs (based on the five water years of record)

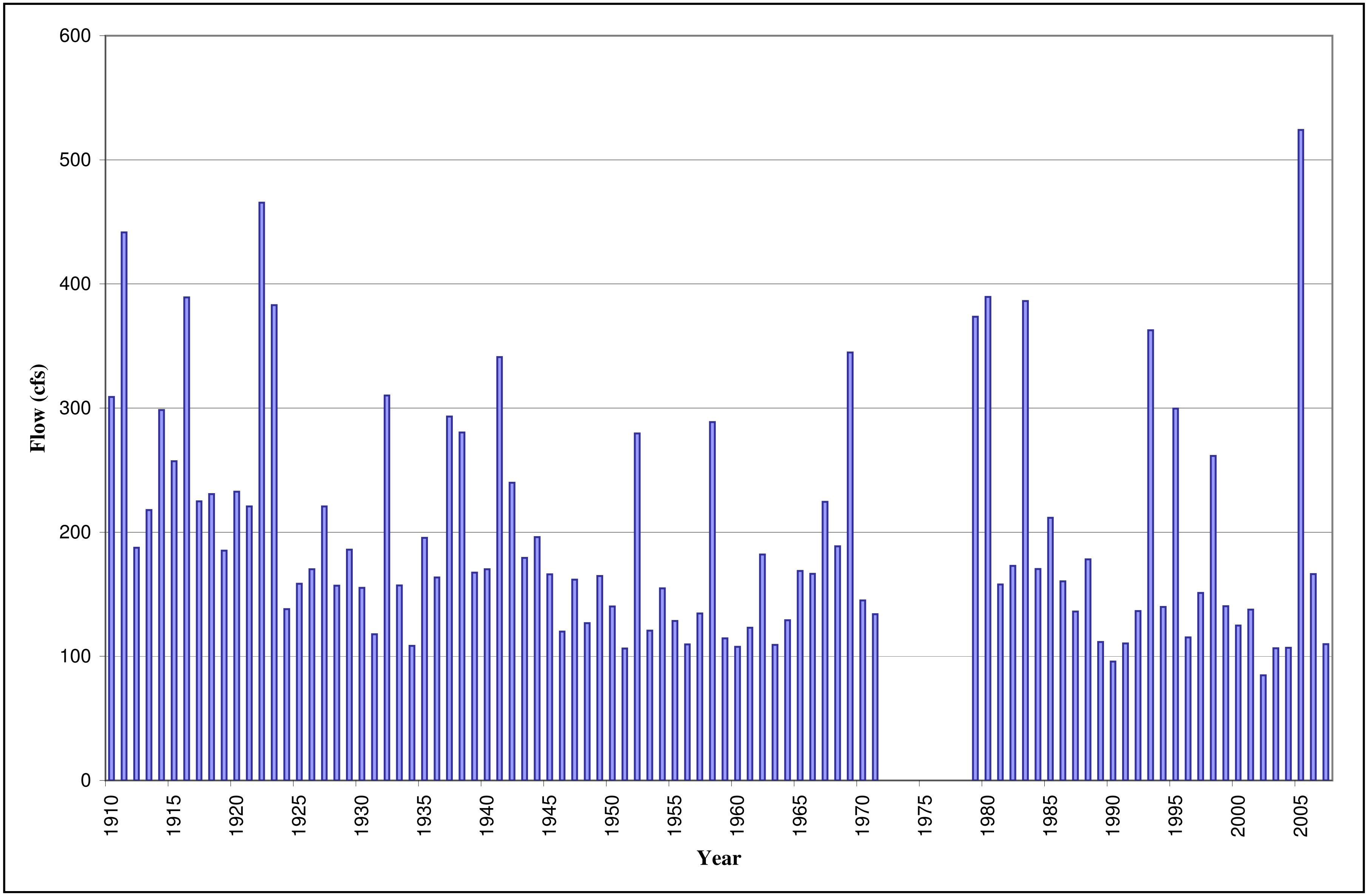


Figure 5-3
Virgin River at Virgin, UT
Annual Average Flow (1910-71, 1979-2007)

Figure 5-4 shows average monthly flows for the six water years of available data.

Station Number:	09380000
Station Name:	Colorado River at Lees Ferry, AZ
Location:	Lat 36º 51' 53", Long 111º 35' 15" Coconino County, AZ
Hydrologic Unit:	14070006
Drainage Area:	71,552,000 acres
Period of Record:	Annual Flow: Water Years 1922 to 2006 Monthly Flow: 10/22 to 8/07
Gage Datum:	3,106.16 ft above sea level, NGVD29
Average annual flow:	14,947 cfs (period of record)

Figure 5-5 shows average annual flows for the Colorado River at Lees Ferry during the period of record that are available from the USGS. Figure 5-6 shows a flow duration curve based on average daily flow for water years 1996 through 2006.

Note that the average annual flow rate for the gaging station at Lees Ferry was calculated using a substantially larger data set than is available for the gaging station below Glen Canyon Dam. Comparisons of average annual flow rates for all years of record for the gaging station at Glen Canyon Dam with comparable water years at the Lees Ferry gaging station indicate that the average annual flow rates are within 1.5 percent of variation. Therefore the calculated average annual flow rate at Lees Ferry should be considered to be more representative of actual flows in the Colorado River than the average annual flow rate calculated for the gaging station below Glen Canyon Dam.

Flows for the Green River are monitored at a USGS gaging station near Jensen, Utah. Information on this gaging station is provided below (USGS 2007a, 2007b):

Station Number:	09261000
Station Name:	Green River near Jensen, UT
Location:	Lat 40º 24' 34", Long 109º 14' 05" Uintah County, UT
Hydrologic Unit:	14060001
Drainage Area:	18,982,400 acres
Period of Record:	Annual Flow: Water Years 1947 to 2006 Monthly Flow: 10/46 to 9/06
Gage Datum:	4,758 ft above sea level, NGVD29
Average annual flow:	4,214 cfs

Figure 5-7 shows average annual flows for the Green River near Jensen, Utah during the period of record that are available from the USGS. Figure 5-8 shows average monthly flows for the water years 1947 to 2006. Figure 5-9 shows a flow duration curve based on the average values for mean daily flow rates for the period of record.

5.2.2 Existing Use of Water

Both surface and groundwater are used for potable (municipal and household domestic) supplies, for industrial applications, for irrigation of crops and for stock watering. Stream, river, lake, and reservoir water supports aquatic life and recreational activities such as boating, fishing, swimming, etc. Glen Canyon Dam is operated for water storage and hydroelectric power generation on the Colorado River.

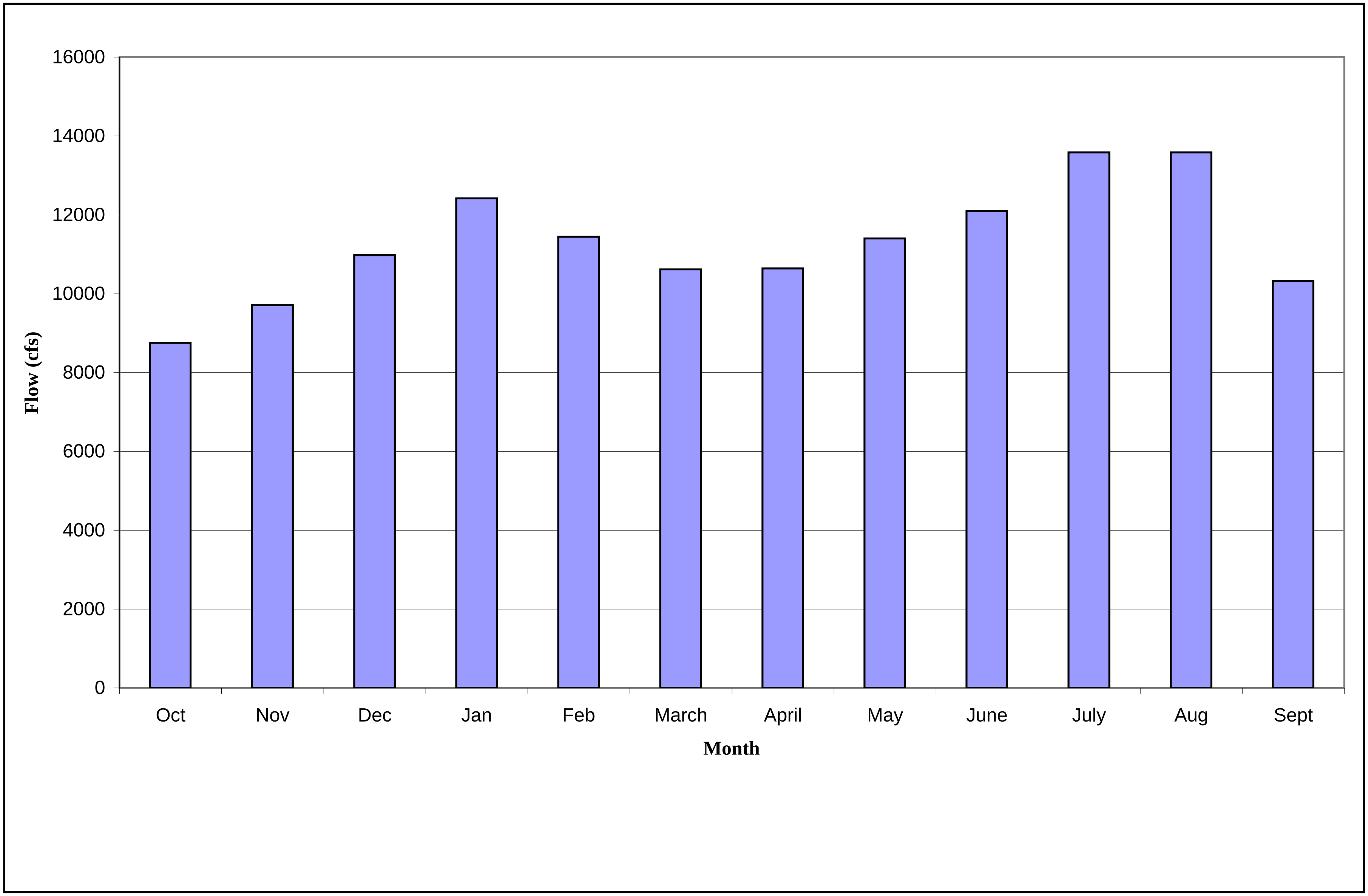


Figure 5-4
Colorado River Below Glen Canyon Dam, Arizona
Average Monthly Flow, 10/1989-3/1993, 3/2000-7/2004

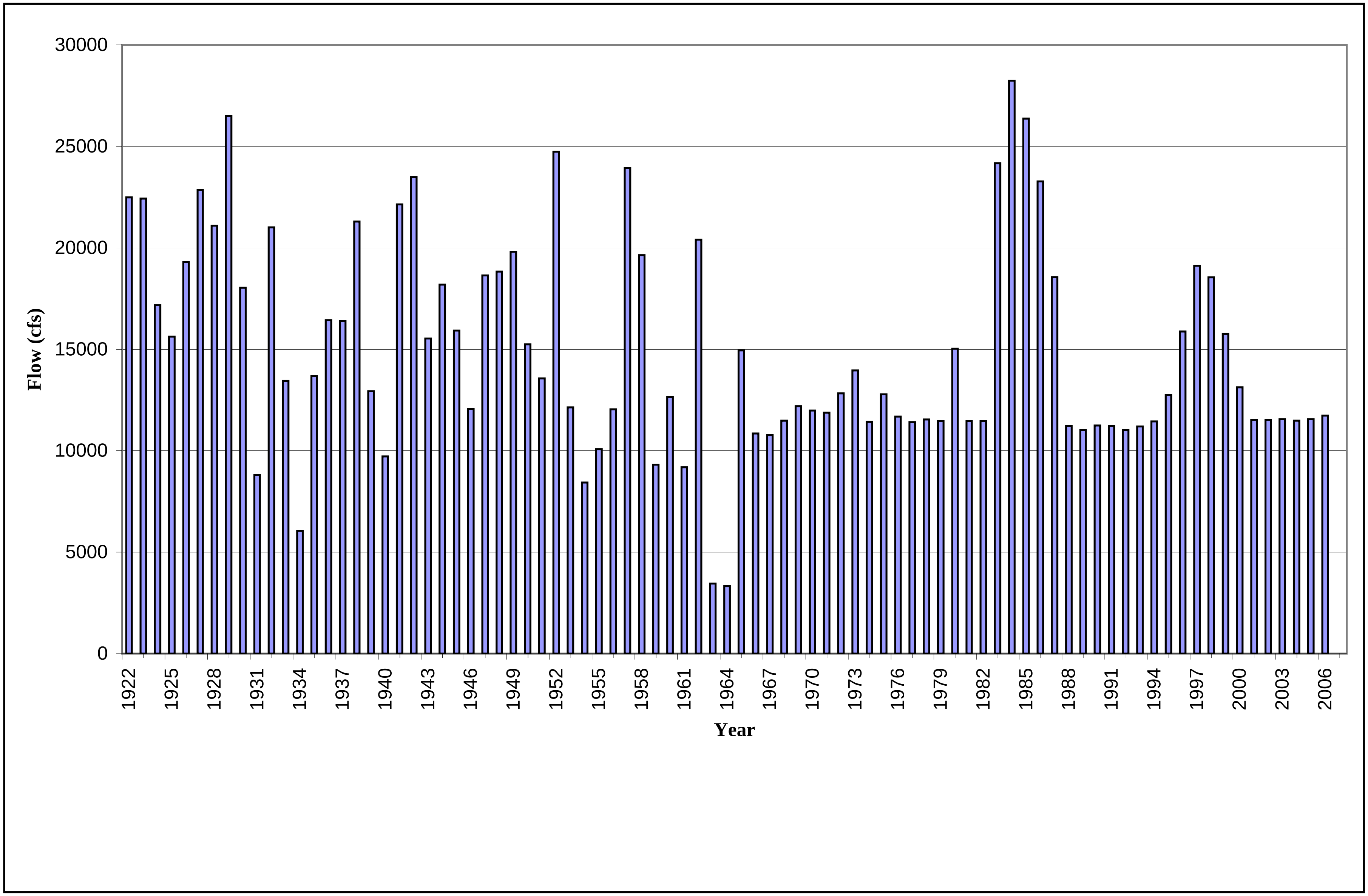


Figure 5-5
Colorado River at Lees Ferry, Arizona
Average Annual Flow, 1922-2007

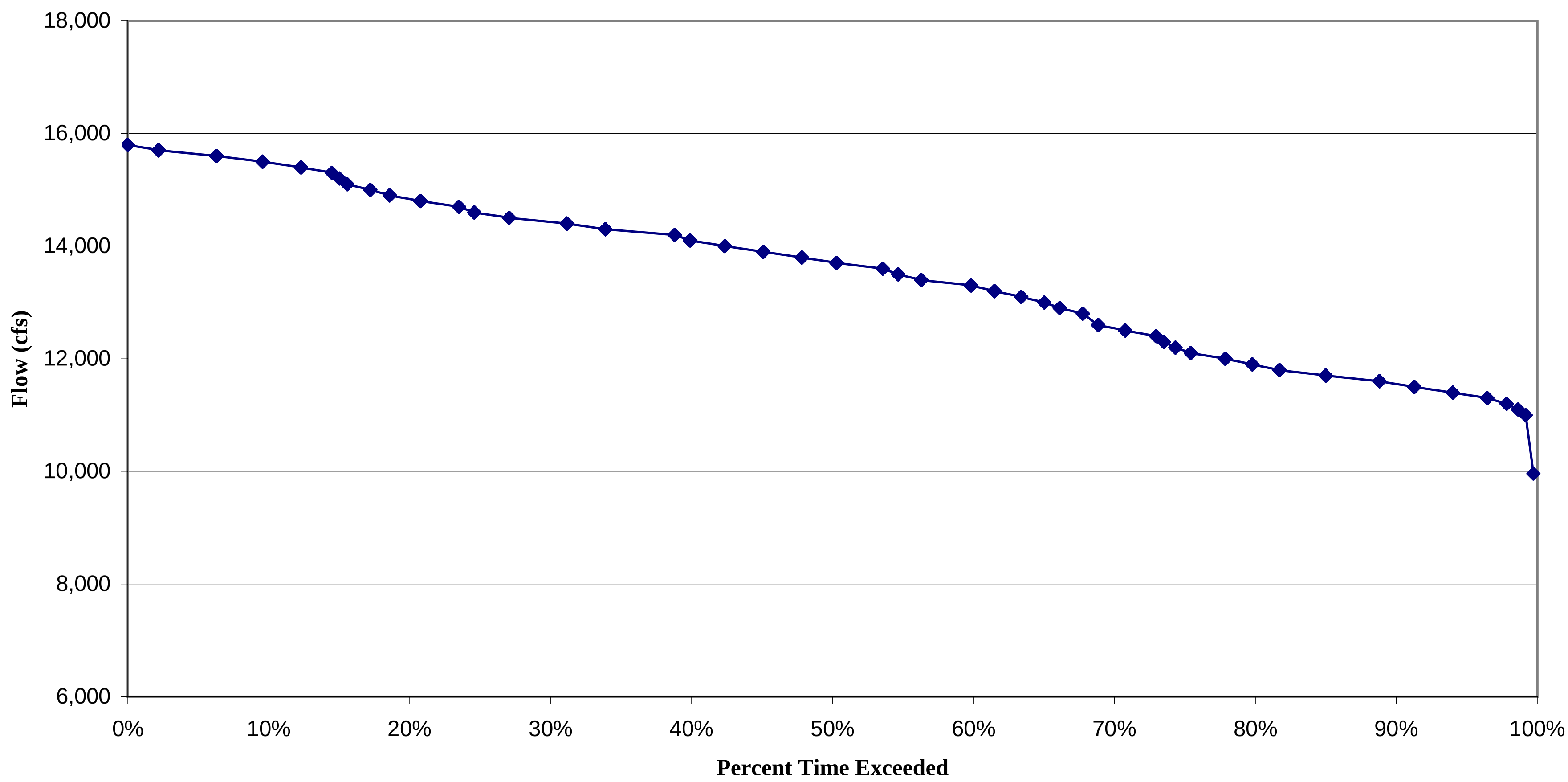


Figure 5-6
Colorado River at Lees Ferry, Arizona
Flow Duration of Means
Average Daily Flow, 10/1996-9/2006

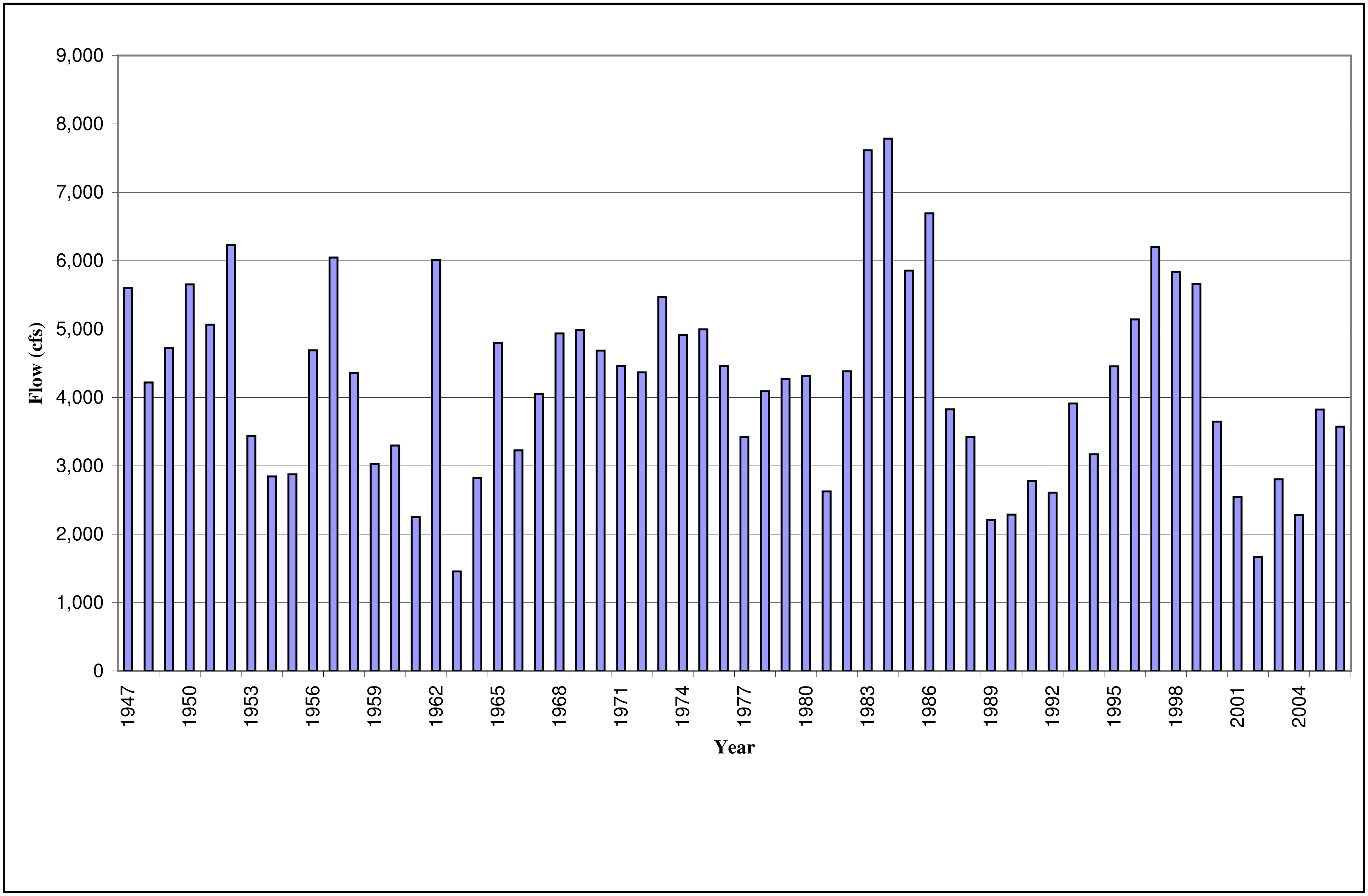


Figure 5-7
Green River near Jensen, UT
Average Annual Flow (1947-2006)

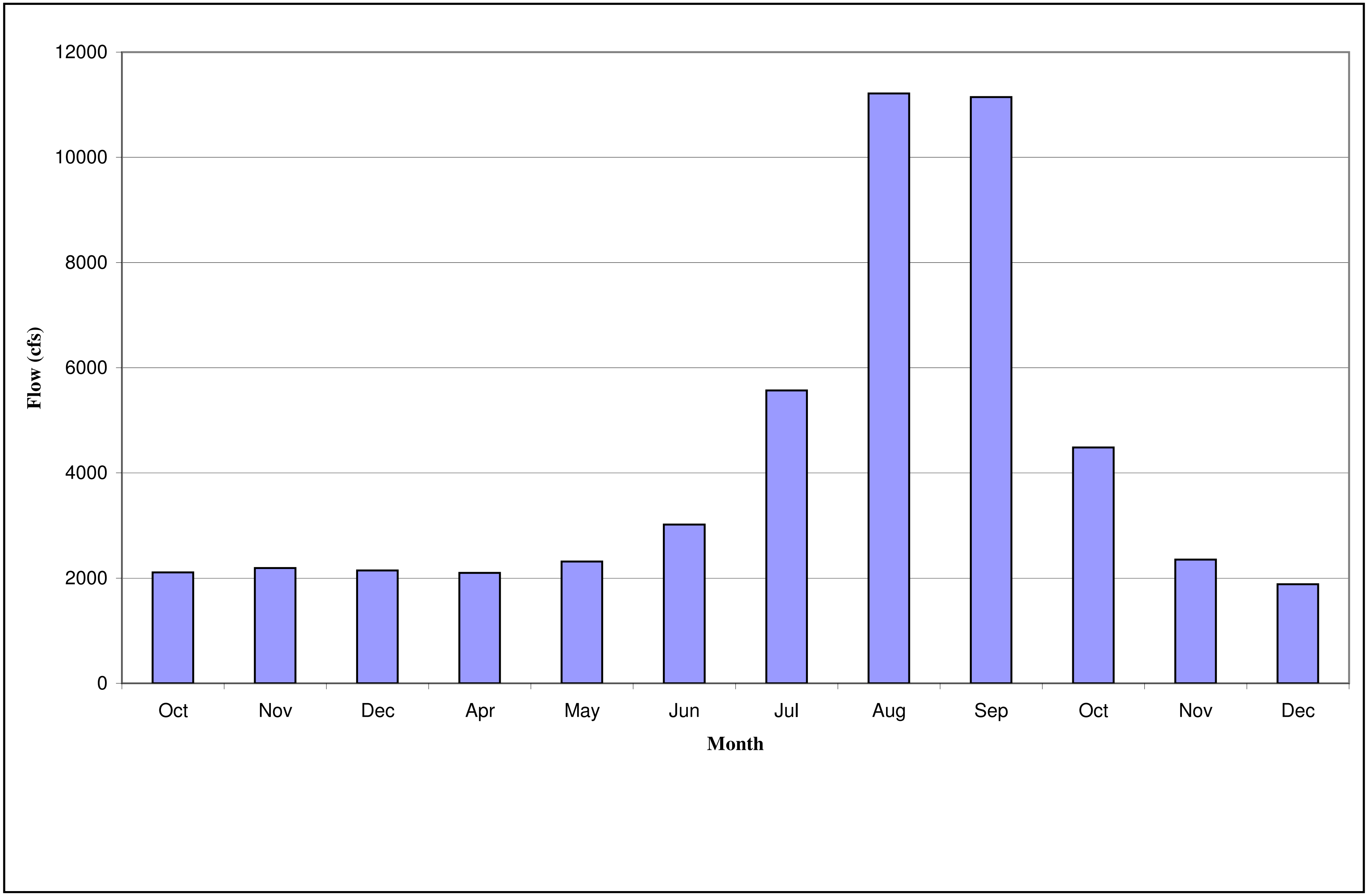


Figure 5-8
Green River near Jensen, UT
Average Monthly Flow (1947 - 2006)

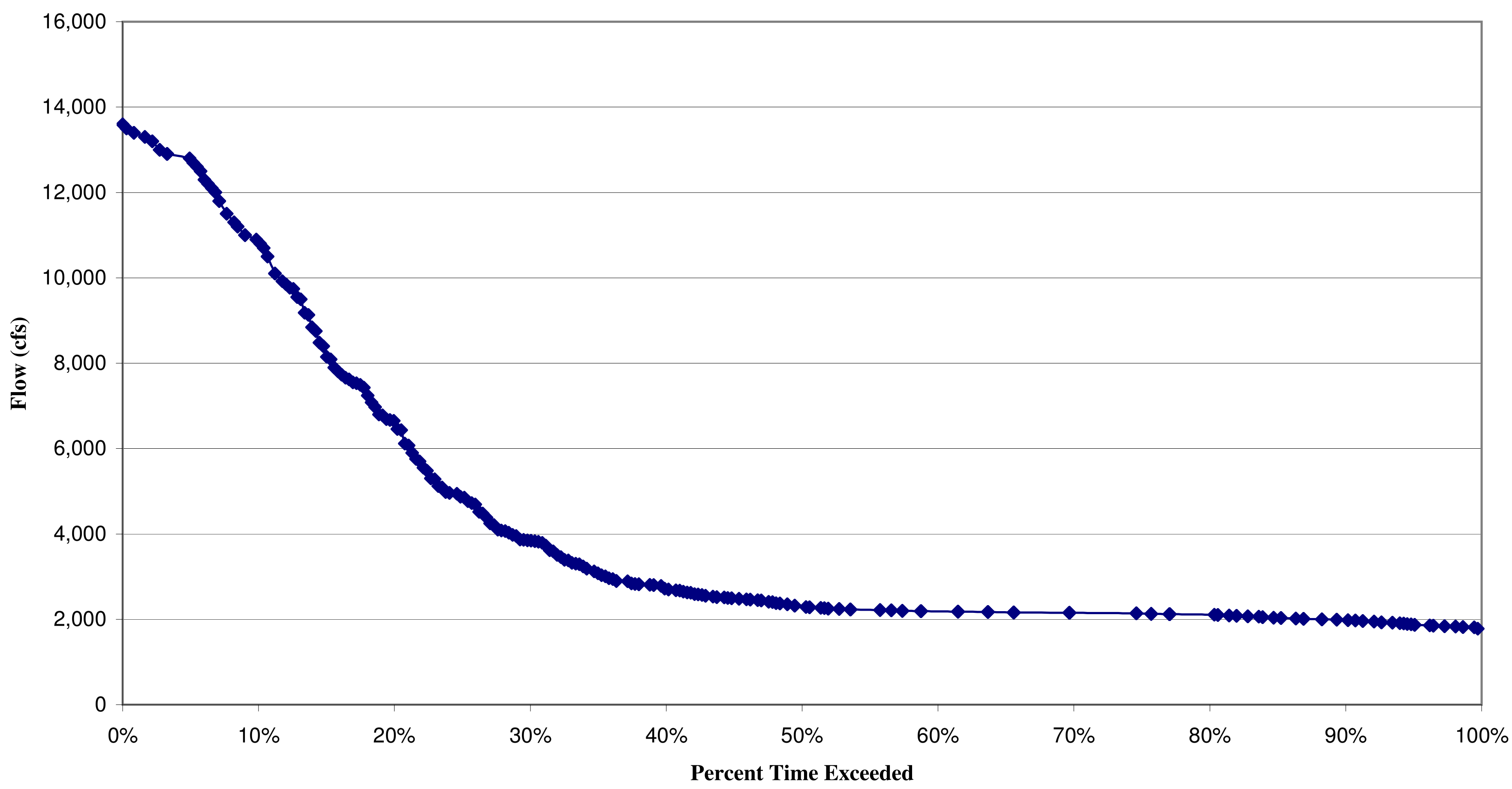


Figure 5-9
Green River near Jensen, UT
Flow Duration of Means
Average Daily Flow (10/1946 - 9/2006)

5.2.3 Existing Instream Flow Uses

Instream flows on the Colorado and Virgin Rivers are used for recreational and native fisheries. Hydropower generation from Glen Canyon Dam is an important in-stream use of Colorado River water and is relied upon for power in several southwestern states. Water discharged from Glen Canyon Dam is regulated to provide storage and aquatic habitat.

Groundwater is used primarily for domestic and municipal drinking water supplies, for agricultural applications including irrigation and stock watering, and to a limited extent for industrial facilities.

5.2.4 Colorado River Basin Climate – Effects on Water Resources

5.2.4.1 Current Factors Affecting Moisture and Temperature

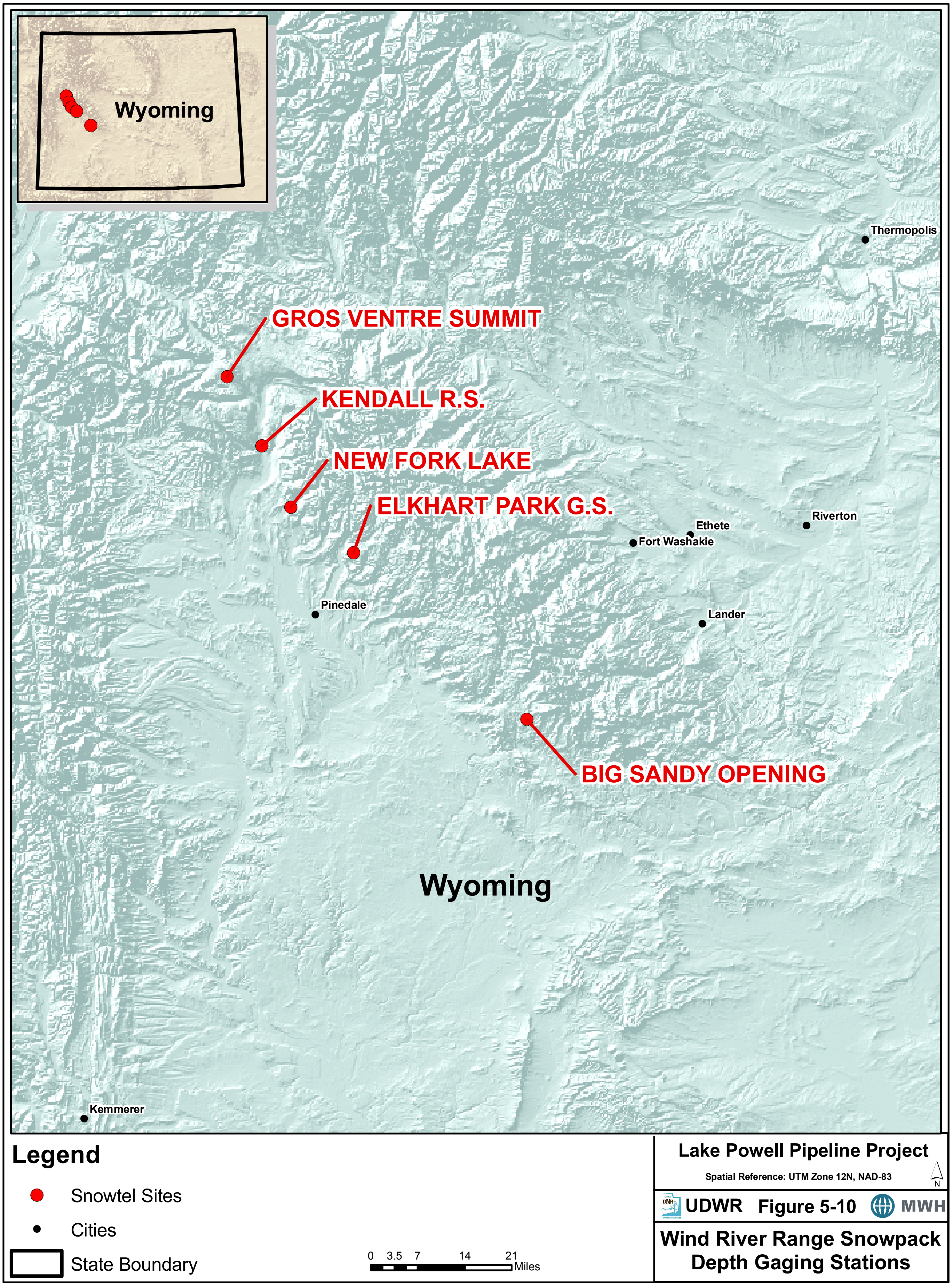
Most of the flow in the Colorado River system is derived from precipitation in high mountain ranges in Colorado, Utah, and Wyoming. Most of the precipitation occurs as snow, and flow in the river system comes largely from spring snowmelt and from groundwater discharge associated with infiltration of snowmelt.

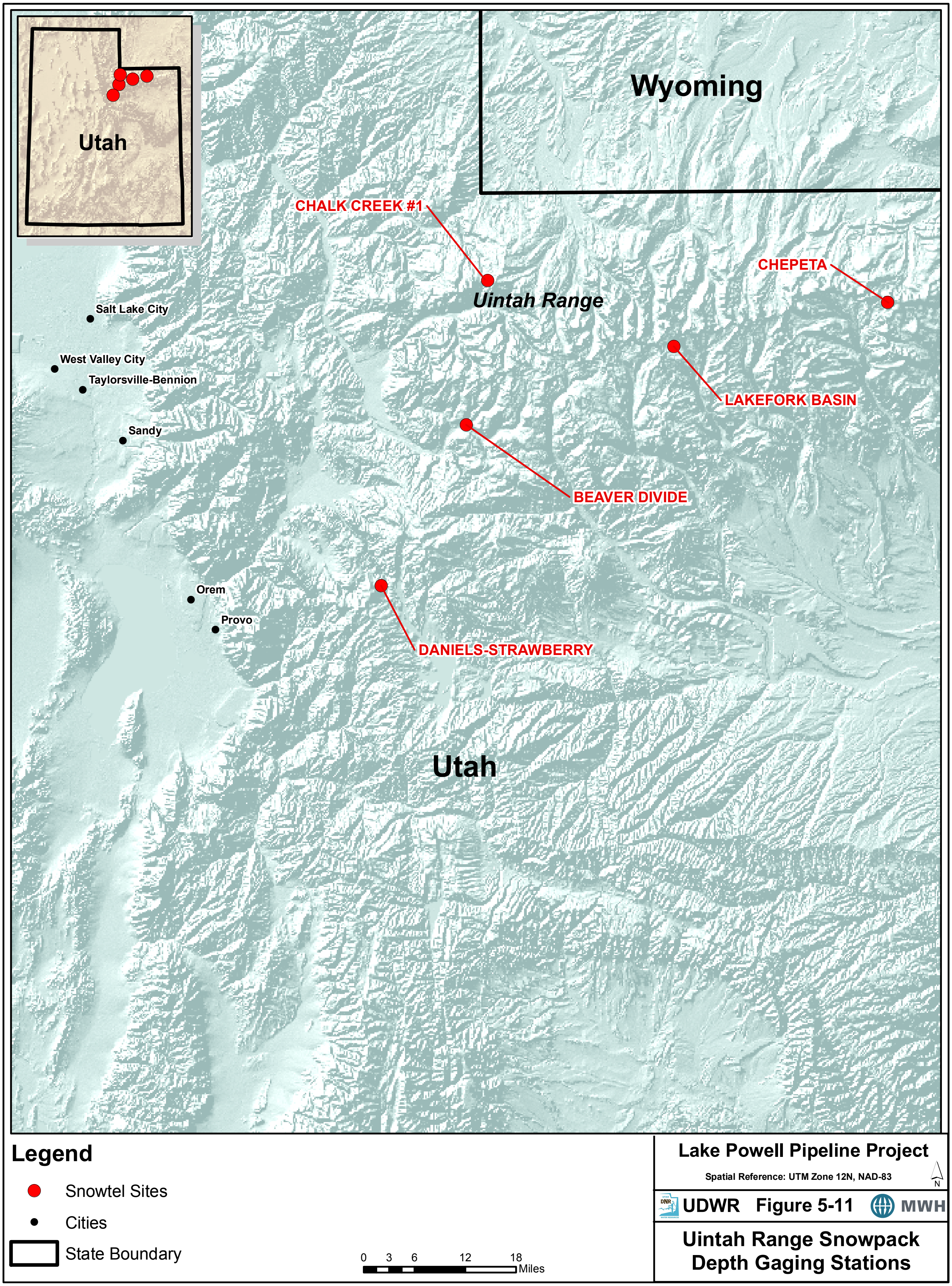
Peak runoff in the Colorado River and it main tributaries occurs in late spring as a result of snowmelt runoff, which in turn supplies water for storage in Lake Powell and further downstream at Lake Mead, these two reservoir systems comprising most of the in-stream storage on the Colorado River. Most of the snowpack originates from winter and spring frontal systems moving eastward from the central and northern Pacific Ocean. The release of moisture as precipitation from these frontal systems occurs as a result of the orographic effect caused by the major mountain systems of the Upper Basin (Rocky, Uintah, and Wind River Mountains). Additional, but lesser, amounts of precipitation occur in winter as a result of relatively warm winter storms from the southeastern Pacific Ocean associated with tropical cyclones, and from summer monsoons originating from the Gulf of Mexico, the Gulf of California, and the eastern Pacific. The latter of these may result in locally significant precipitation events but generally contributes relatively little to the Colorado River system flows and therefore to storage in Lake Powell (USGS, 2004e).

5.2.4.2 Snowpack and Runoff in the Upper Colorado River Basin

Historical springtime snowpack was evaluated for the Wind River mountain range (Wyoming), Uintah mountain range (Utah), and Rocky Mountain range (Colorado) to assess snowpack impacts on snowmelt runoff river flows. These three mountain ranges represent the highest ranges in the Upper Colorado River Basin and therefore capture most of the snow precipitation in the basin. Data was obtained from the NRCS Snowpack Telemetry (SNOTEL) website which contains snowpack data for numerous snow depth stations where the NRCS gathers snow depth data, including snow water equivalent (the equivalent depth of melted water present in a vertical column of snowpack) (NRCS, 2007e). March 1 of each year was selected as the point of reference for this analysis because it is late enough in winter to capture most of the snowpack for a given season but generally before snowmelt begins at high elevations.

Data were compiled from selected sites distributed throughout the different mountain ranges that had 25 years of data or more. Five sites were chosen for the Wind River and Uintah ranges and ten sites were chosen for the Rocky Mountains. For the Wind River and Rocky Mountain ranges, only sites on the western slope were chosen because the western slopes contribute to runoff in the Upper Colorado River Basin. The sites chosen for analysis are shown in Table 5-1. The locations for the snow depth gaging stations in the Wind River Range, Uintah Range, and Central Rocky Mountains are shown in Figures 5-10, 5-11, and 5-12, respectively.


Wyoming
Thermopolis
GROS VENTRE SUMMIT
KENDALL R.S.
NEW FORK LAKE
ELKHART PARK G.S.
Ethete
Riverton
Fort Washakie
Pinedale
Lander
BIG SANDY OPENING
Wyoming
Kemmerer
Legend
Snowtel Sites
Cities
State Boundary
0 3.5 7 14 21 Miles
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR
Figure 5-10
MWH
Wind River Range Snowpack Depth Gaging Stations


Wyoming
Utah
CHALK CREEK #1
Uintah Range
CHEPETA
Salt Lake City
West Valley City
Taylorsville-Bennion
Sandy
LAKEFORK BASIN
BEAVER DIVIDE
Orem
Provo
DANIELS-STRAWBERRY
Utah
Legend
Snowtel Sites
Cities
State Boundary
0 3 6 12 18
Miles
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR Figure 5-11 MWH
Uintah Range Snowpack
Depth Gaging Stations

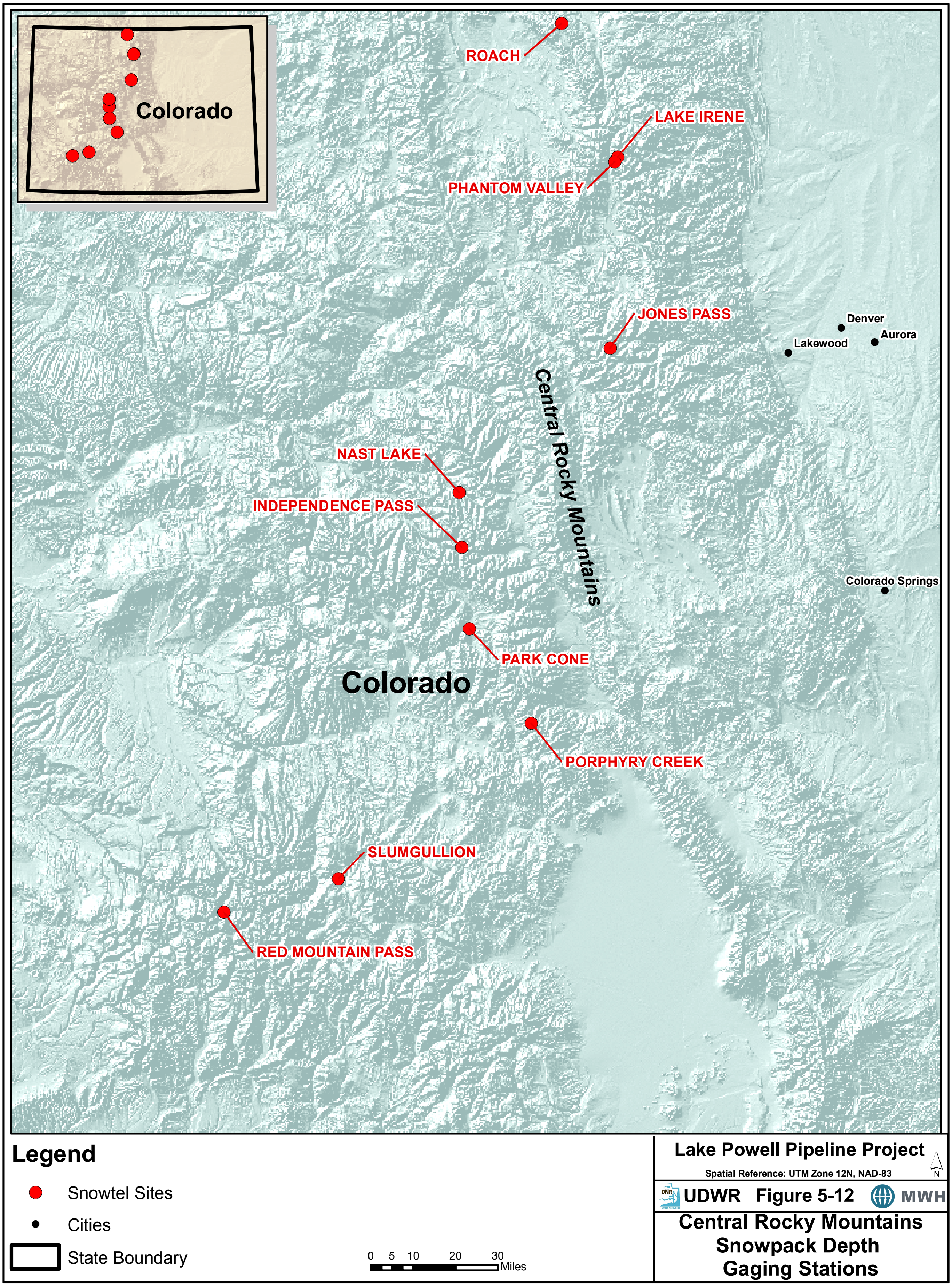

Colorado
ROACH
LAKE IRENE
PHANTOM VALLEY
JONES PASS
Denver
Aurora
Lakewood
Central Rocky Mountains
NAST LAKE
INDEPENDENCE PASS
Colorado Springs
PARK CONE
Colorado
PORPHYRY CREEK
SLUMGULLION
RED MOUNTAIN PASS
Legend
Snowtel Sites
Cities
State Boundary
0 5 10 20 30
Miles
Lake Powell Pipeline Project
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR Figure 5-12
MWH
Central Rocky Mountains
Snowpack Depth
Gaging Stations

Table 5-1
Snow Depth Gaging Stations Site Information

Mountain Range	Name	Elevation (ft msl)
Wind River Range	Gros Ventre Summit	8,750
Wind River Range	Kendall R.S.	7,740
Wind River Range	New Fork Lake	8,340
Wind River Range	Big Sandy Opening	9,080
Wind River Range	Elkhart Park	9,400
Uintah Range	Chalk Creek #1	8,993
Uintah Range	Chepeta	10,592
Uintah Range	Lake Fork Basin	10,966
Uintah Range	Beaver Divide	8,280
Uintah Range	Daniels Strawberry	8,037
Central Rocky Mountains	Roach	9,700
Central Rocky Mountains	Phantom Valley	9,030
Central Rocky Mountains	Jones Pass	10,400
Central Rocky Mountains	Nast Lake	10,700
Central Rocky Mountains	Independence Pass	10,600
Central Rocky Mountains	Park Cone	9,600
Central Rocky Mountains	Porphyry Creek	10,760
Central Rocky Mountains	Slumgullion	11,440
Central Rocky Mountains	Red Mountain Pass	11,200

5.2.4.2.1 Wind River Range. Historic snowpack depths, expressed as inches of snow-water equivalent (SWE), over the periods of record for each of the snowpack stations in the Wind River Range are shown in Figures 5-13 through 5-17. Also shown in these figures are the historical trends for the period of record, as well as the 10-year and 30-year moving average SWE depths and the 30-year average from 1971 to 2000 as determined by the NRCS.

Of the five Wind River Range sites chosen, all of the sites show a decreasing trend in snow pack over the past 35 years or more. For each of the sites, snowpack has been lower during the past six to seven years, reflecting recent drought conditions.

5.2.4.2.2 Uintah Range. Historic snowpack depths, expressed as inches of SWE, over the periods of record for each of the snowpack stations in the Uintah Range are shown in Figures 5-18 through 5-22. Also shown in these figures are the historical trends for the period of record, as well as the 10-year and 30-year moving average SWE depths and the 30-year average from 1971 to 2000 as determined by the NRCS.

Three of the five sites have a moderate downward trend in snowpack SWE over the period of record. The Chepeta station showed a slightly increasing trend in snowpack during the period of record. The data include a high snowpack SWE depth in 2005. Overall, as with the others, there is no clear indication of a historically increasing or decreasing trend. The NRCS has qualified the Utah snowpack station data by noting that many changes affecting snowpack have occurred at the stations during the period of record.

5.2.4.2.3 Central Rocky Mountain Range. Historic snowpack depths, expressed as inches of SWE,

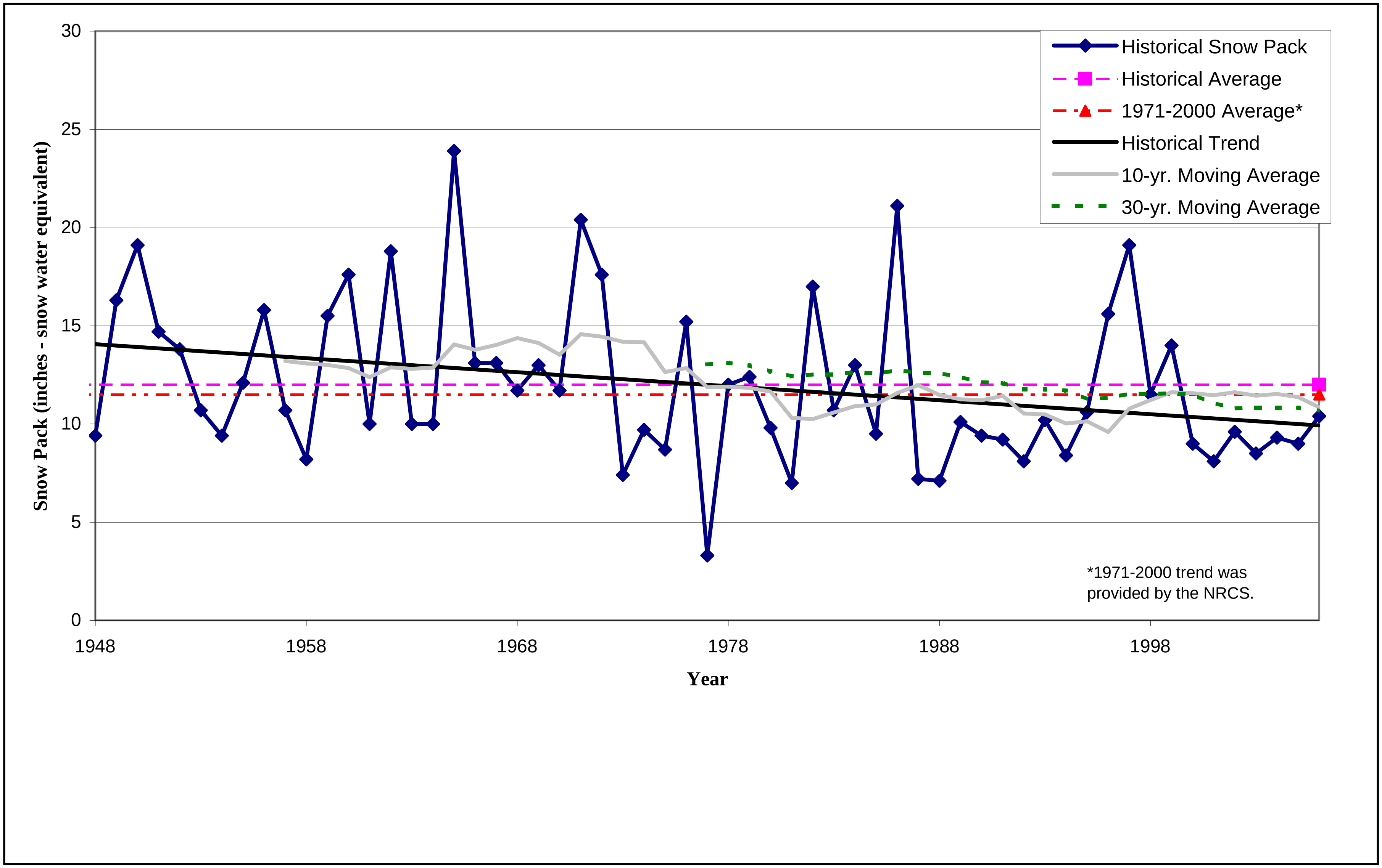


Figure 5-13
Snowpack Depths as Snow-Water Equivalent
Wind River Range, Wyoming
Gros Ventre Summit Station

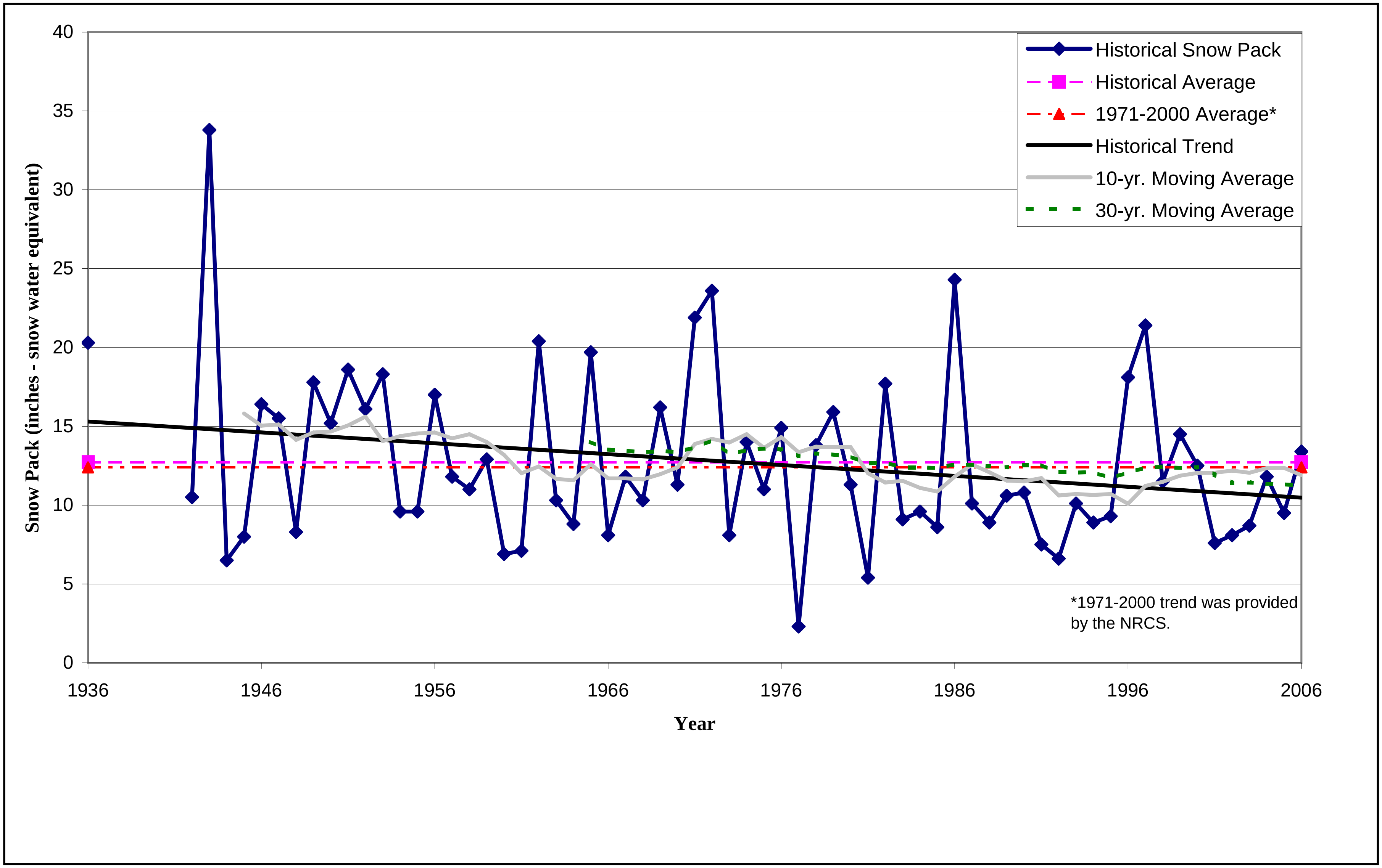


Figure 5-14
Snowpack Depths as Snow-Water Equivalent
Wind River Range, Wyoming
Kendall R.S.

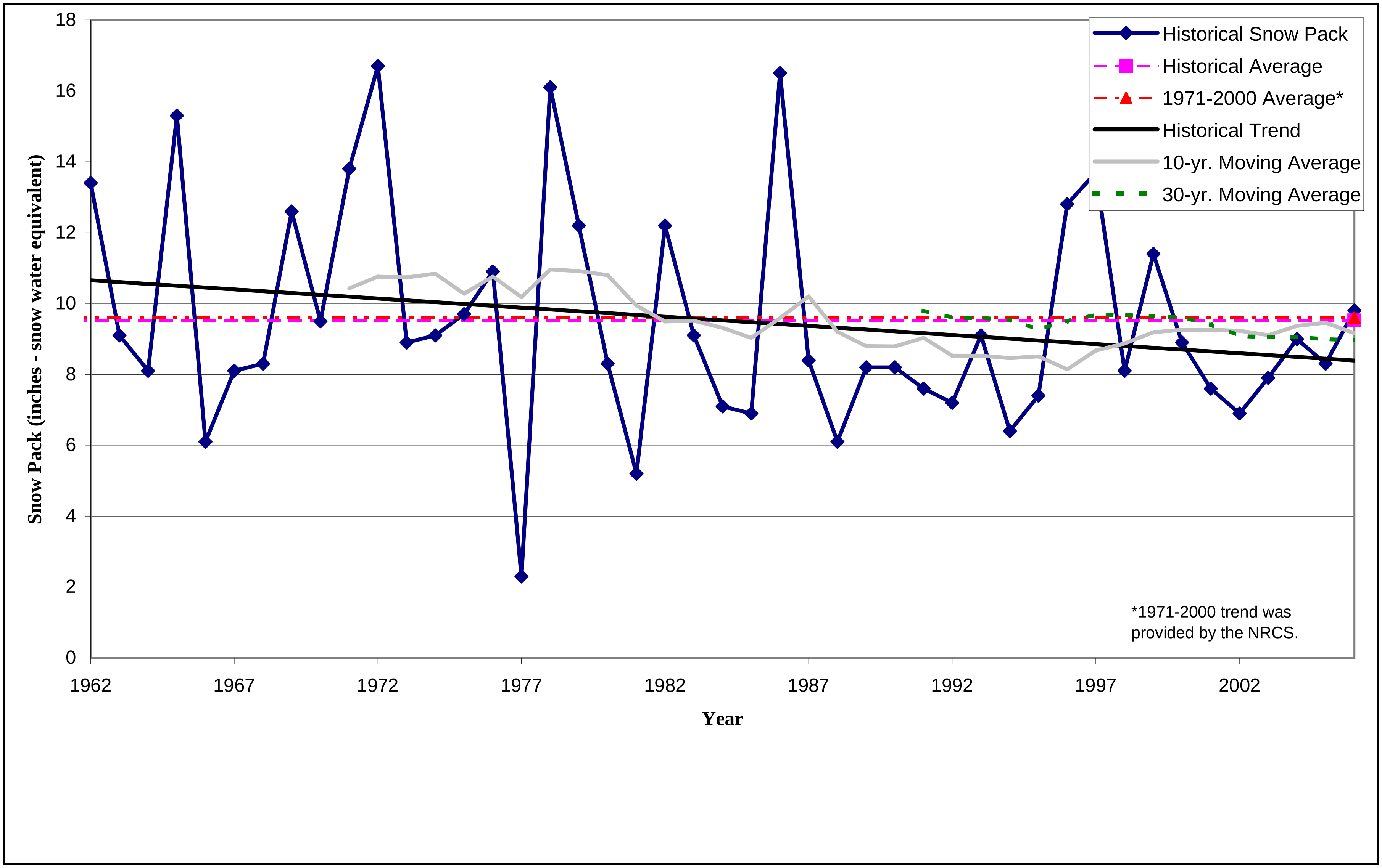


Figure 5-15
Snowpack Depths as Snow-Water Equivalent
Wind River Range, Wyoming
New Fork Lake Station

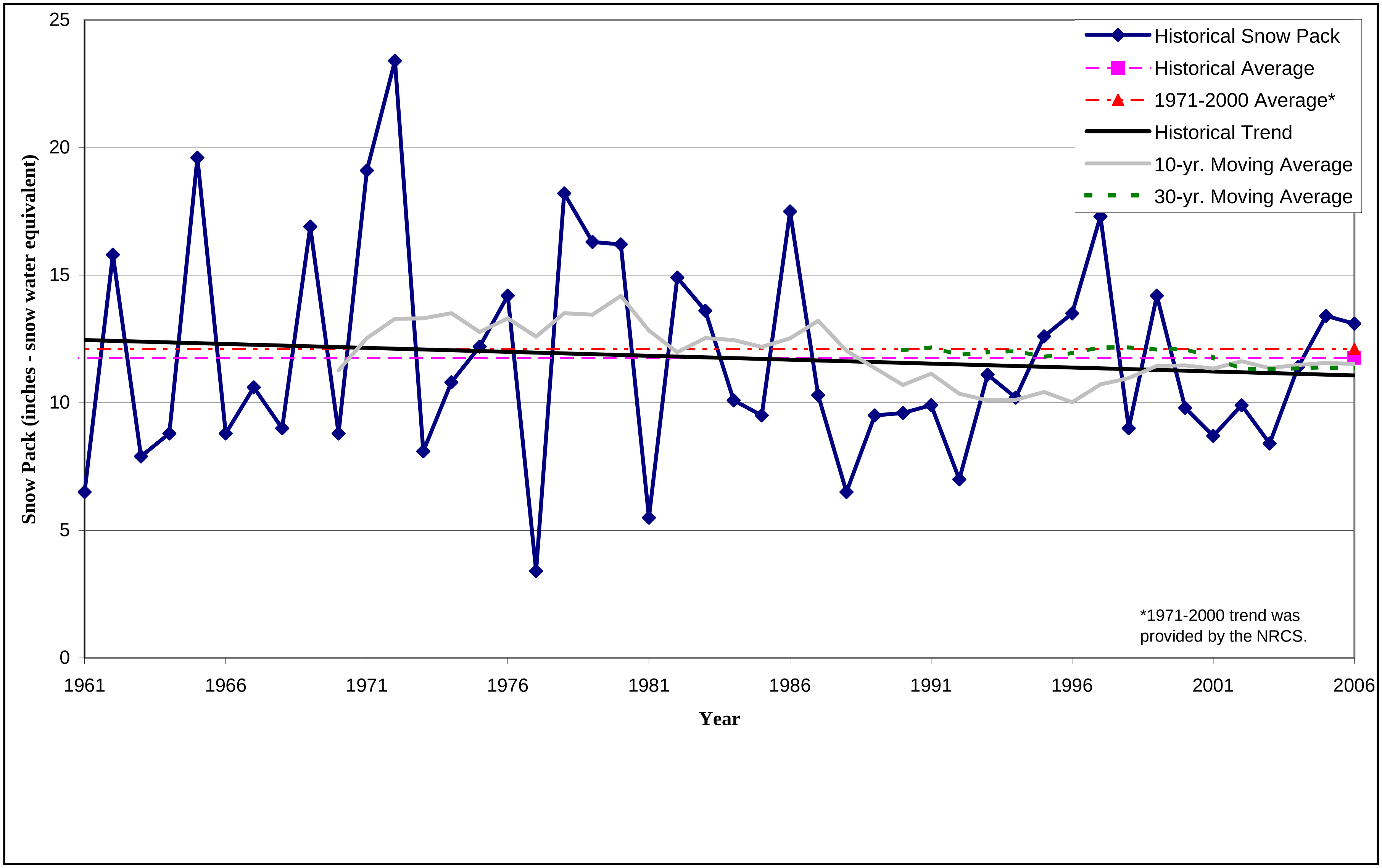


Figure 5-16
Snowpack Depths as Snow-Water Equivalent
Wind River Range, Wyoming
Big Sandy Opening Station

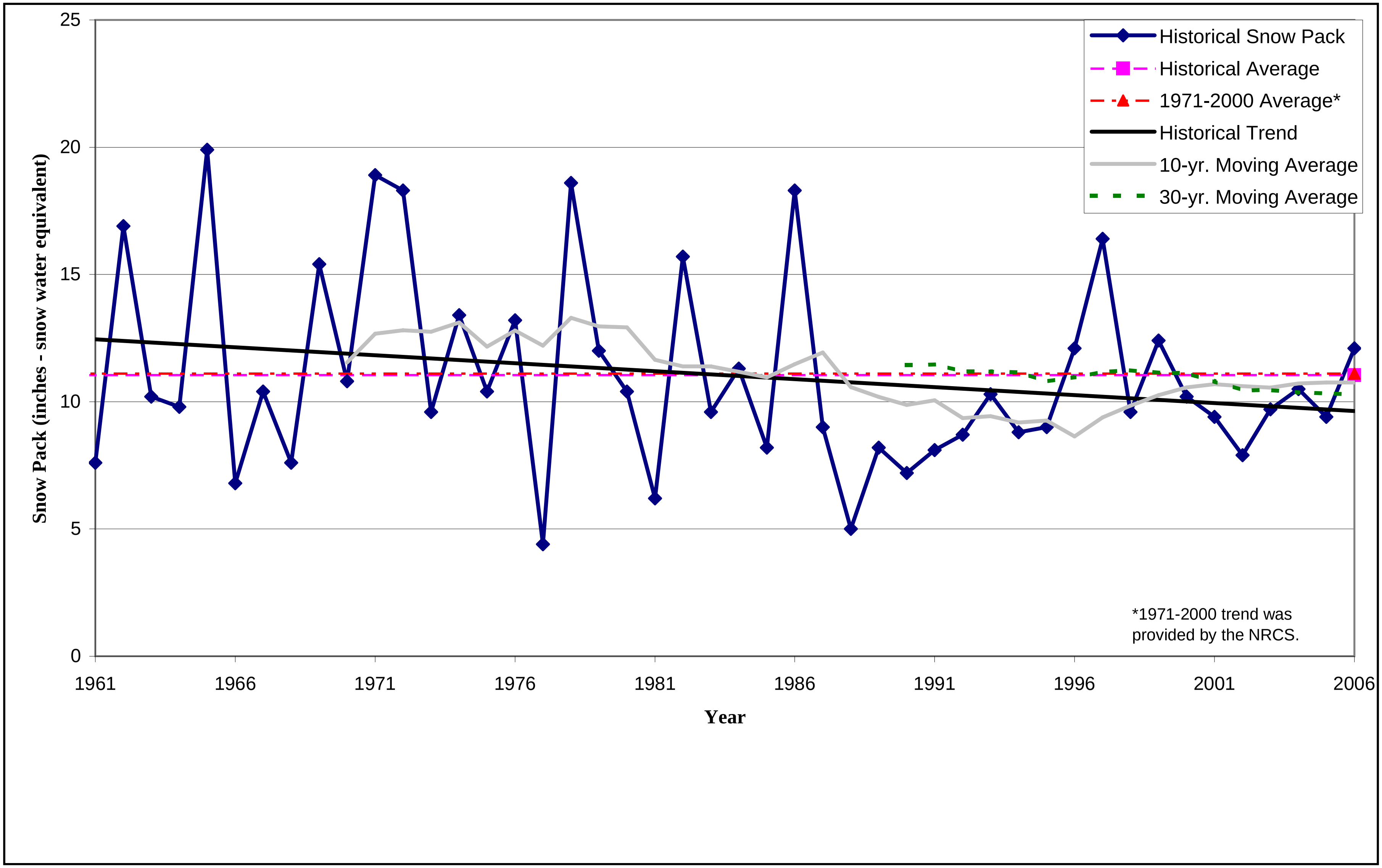


Figure 5-17
Snowpack Depths as Snow-Water Equivalent
Wind River Range, Wyoming
Elkhart Park G.S.

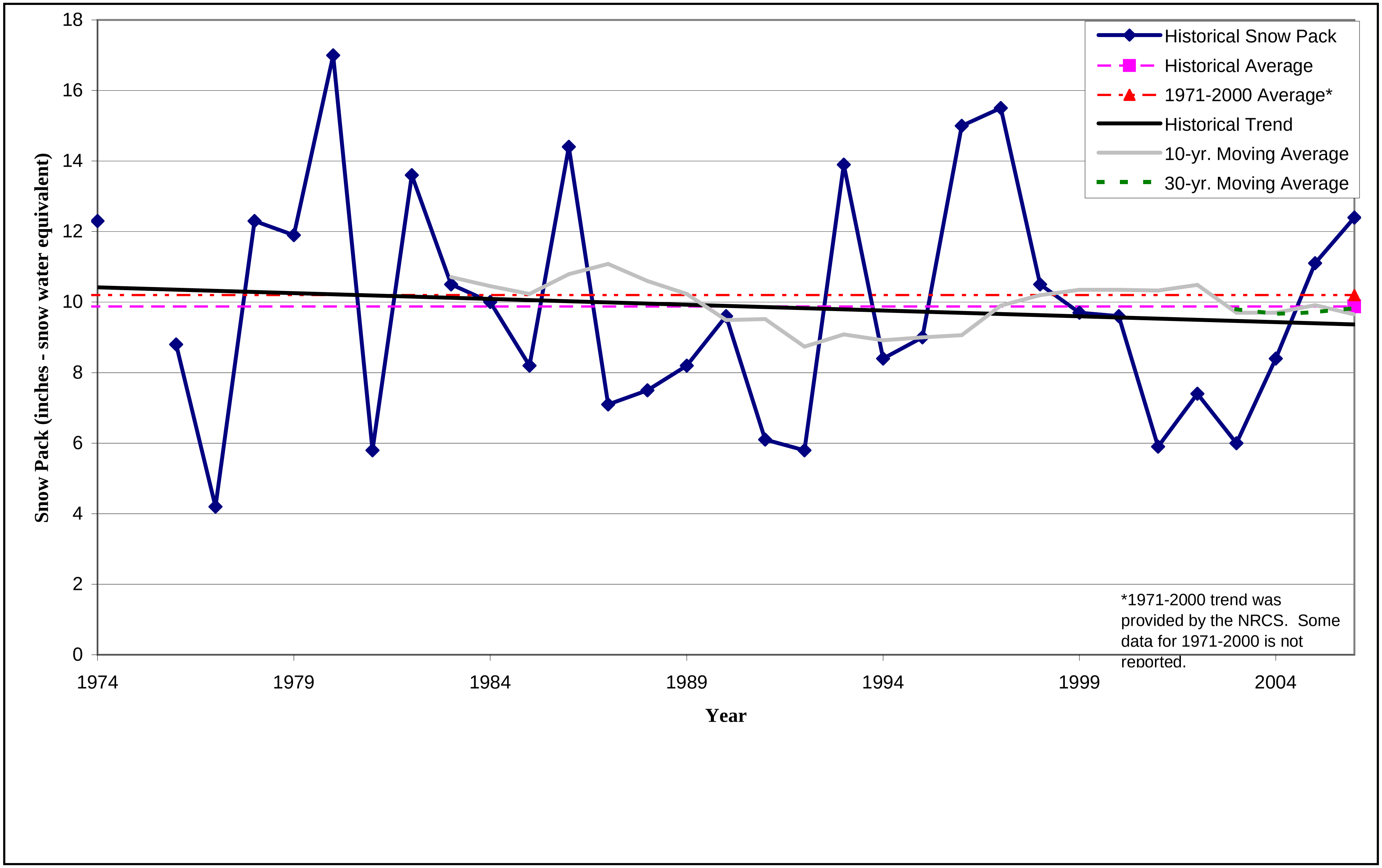


Figure 5-18
Snowpack Depths as Snow-Water Equivalent
Uintah Range, Utah
Beaver Divide Station

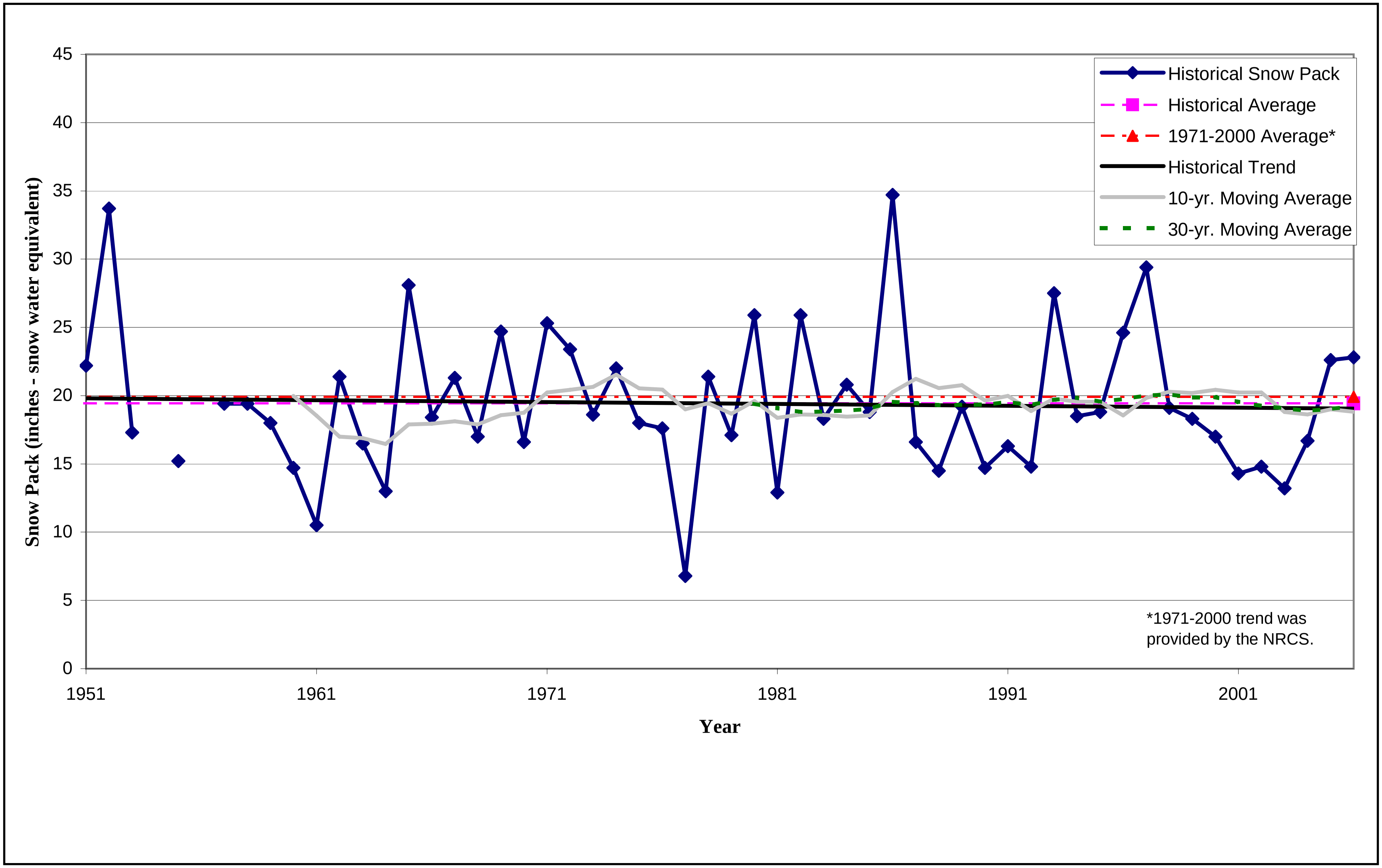


Figure 5-19
Snowpack Depths as Snow-Water Equivalent
Uintah Range, Utah
Chalk Creek Station #1

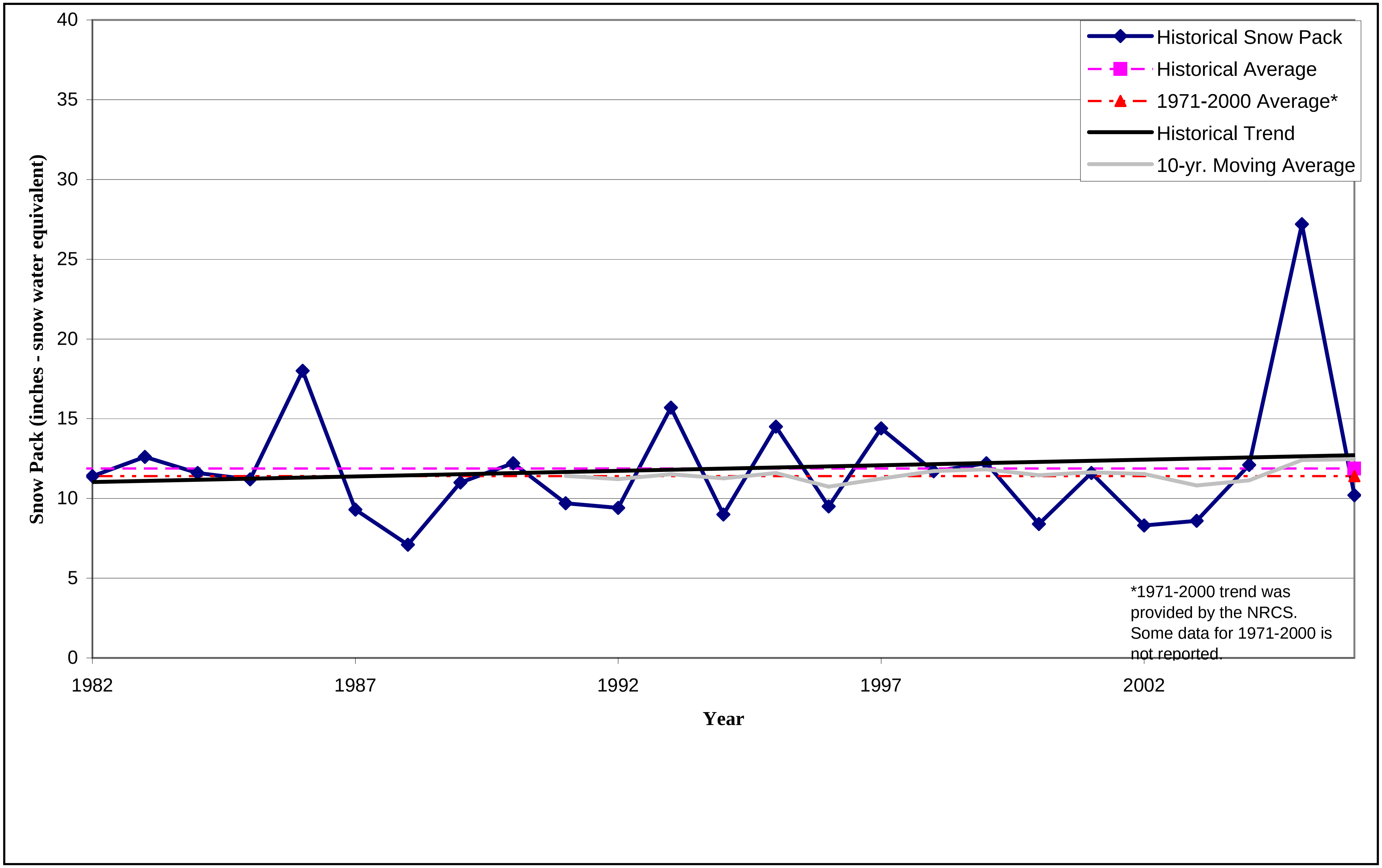


Figure 5-20
Snowpack Depths as Snow-Water Equivalent
Uintah Range, Utah
Chepeta Station

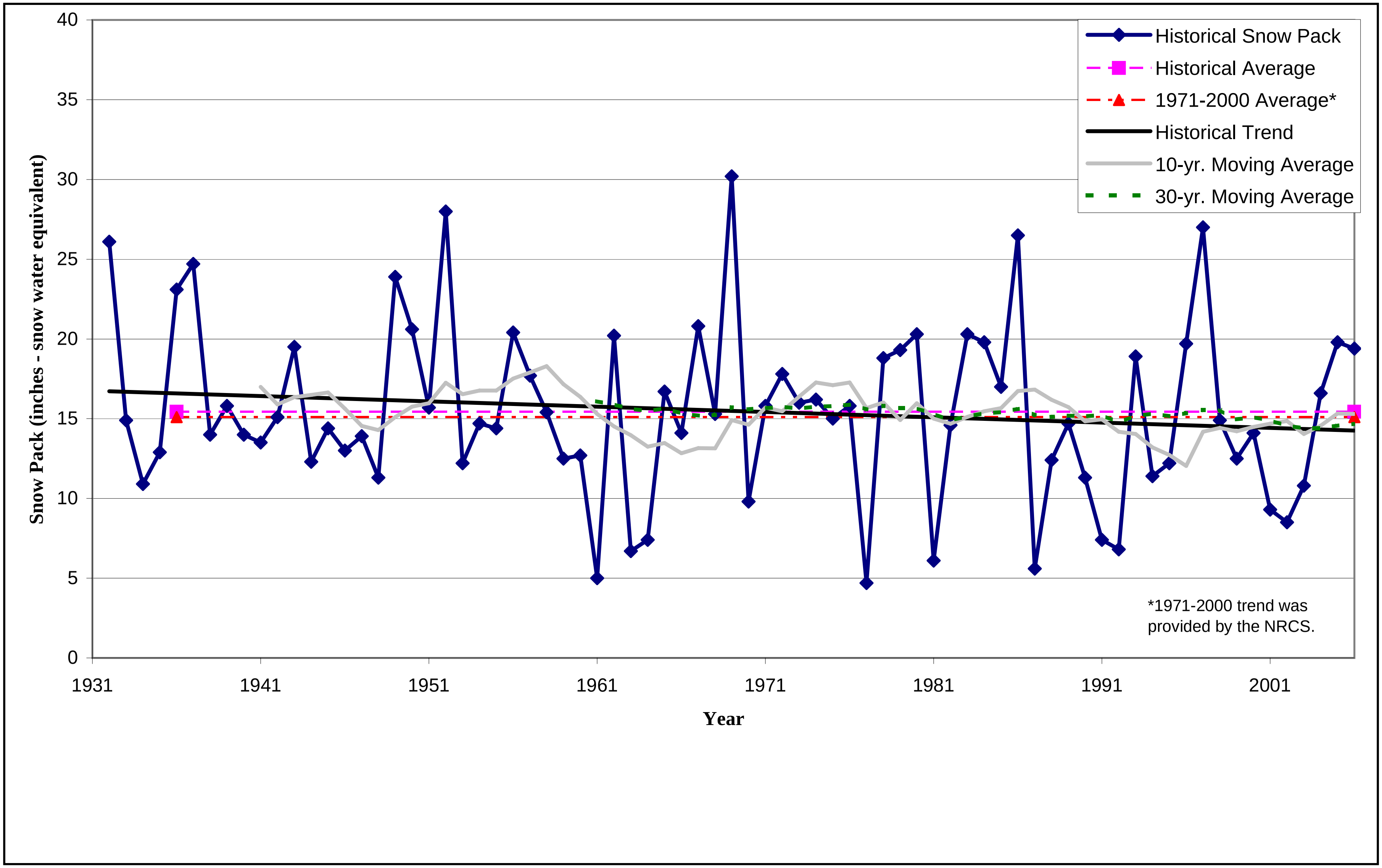


Figure 5-21
Snowpack Depths as Snow-Water Equivalent
Uintah Range, Utah
Daniels Strawberry Station

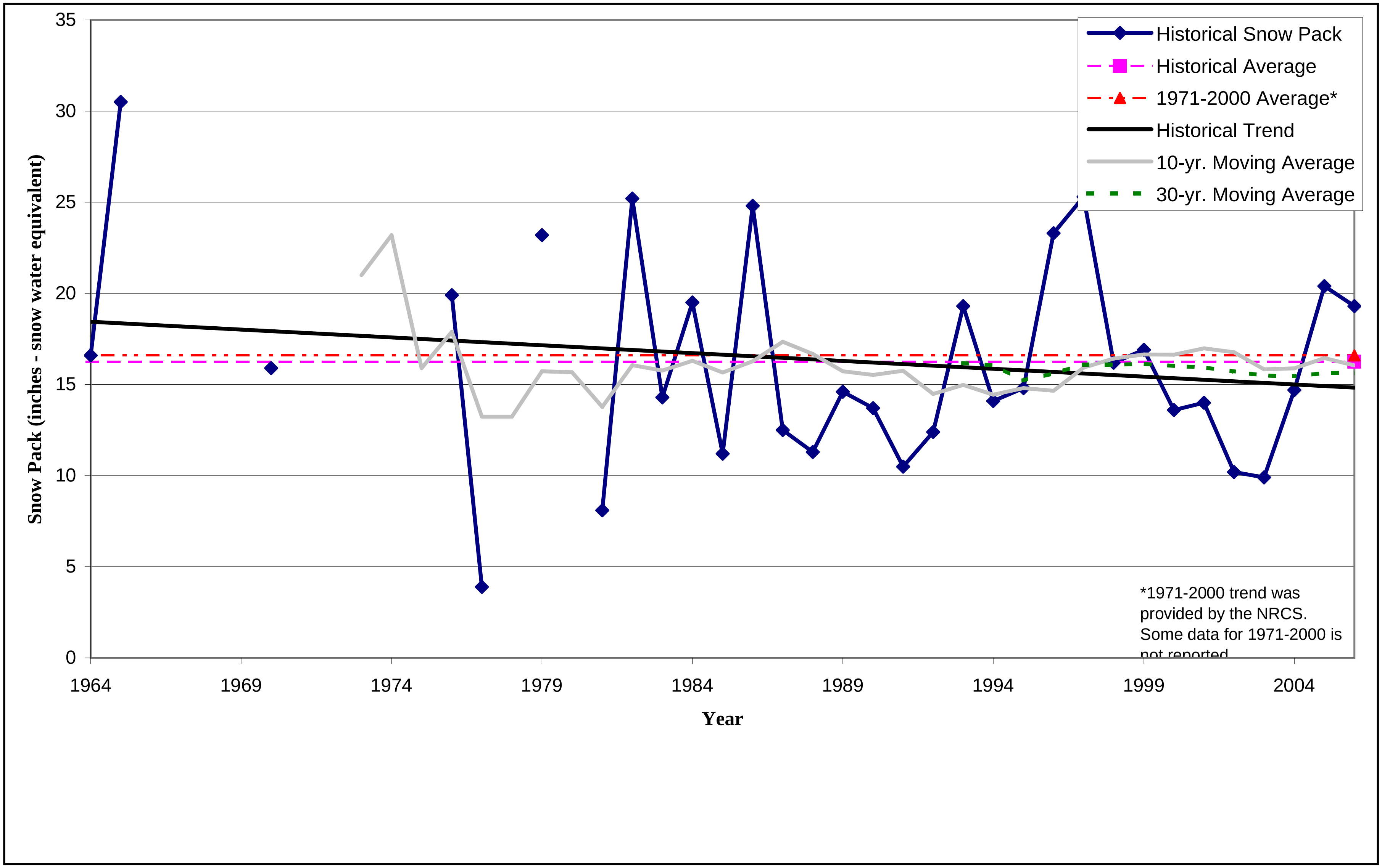


Figure 5-22
Snowpack Depths as Snow-Water Equivalent
Uintah Range, Utah
Lakefork Basin Station

during the periods of record for each of the snowpack stations in the Central Rockies are shown in Figures 5-23 through 5-32. Also shown in these figures are the historical trends for the period of record, as well as the 10-year and 30-year moving average SWE depths and the 30-year average from 1971 to 2000 as determined by the NRCS.

Of the ten sites selected, five show decreasing trends in snowpack SWE depths, three show increasing trends, and two show no change. Of those sites that show an apparent decreasing trend, Red Mountain Pass, Independence Pass, Lake Irene, and Park Cone stations all show a decreasing trend over the past 40 to 50 years. Roach Station shows a decreasing trend over a period of more than 25 years. In each case, the decreasing trend is gradual.

Jones Pass, Nast Lake, and Phantom Valley stations all show increasing snowpack SWE depth trends during the last 50 years or more. For each of these sites, the average snowpack SWE depth from 1971 – 2000 was higher than the historical snow pack. The trend for each of these sites is gradual and in each case, the most recent data may show that the upward trend is either flattening out or slightly decreasing, probably reflecting recent drought conditions.

Both Slumgullion and Porphyry Creek stations show consistent cyclical snow pack trends indicating consistency in annual snow pack. There is no evident correlation showing either an increase or decrease.

Overall, the selected snowpack stations show a majority sites that have a decreasing trend in snowpack SWE depths, with 13 of 20 stations showing moderate to substantial declines in SWE depths over the period of record. This is most apparent in the Wind River Range and least definitive in the Uintah Range, and with about half the sites in the Central Rocky Mountains showing a decreasing trend. This suggests an overall decline in SWE accumulation and associated availability for runoff in the Upper Colorado River Basin over time. However, some sites showed no clear trend, and some sites showed an overall upward trend in snowpack SWE; therefore a definitive trend for the entire basin cannot be drawn from this analysis.

5.2.4.3 Potential Causes of Climate Variability

Considerable variability in precipitation from snowfall in the Colorado River Basin and elsewhere in the western United States can occur from year to year, and over periods of several years or even decades. Much of this variability results from phenomena in the Pacific and Atlantic Oceans. These include the El Nino Southern Oscillation (ENSO), the La Nina Southern Oscillation (LNSO), The Pacific Decadal Oscillation (PDO), and the Atlantic Multidecadal Oscillation (AMO) (USGS, 2002c, 2004e; Edwards and Redmond, 2005).

The ENSO is caused by occurrences of warmer-than-normal equatorial waters in the eastern Pacific Ocean, which typically result in wetter and cooler winters in the Southwest (including the Lower Basin) and drier and warmer winters in the Pacific Northwest; the effect in the Upper Colorado River Basin is somewhat less well understood. The LNSO results from cooler-than-normal equatorial waters in the eastern Pacific Ocean, usually resulting in warmer, drier winters in the Southwest and wetter, cooler winters in the Pacific Northwest; again, the effects in the Upper Colorado River Basin are not well understood. ENSO and LNSO events can last for six to 18 months (USGS, 2004e; Edwards and Redmond, 2005).

The PDO is caused by anomalous sea-surface temperatures, air pressure, and wind along the Pacific Coast. This can result in effects similar to the ENSO and LNSO conditions, but the cycle (wetter-drier to cooler-warmer) may occur over a period of 30 to 50 years. As with the El Nino and La Nina phenomena, the effects in the Southwest and Pacific Northwest are well documented, but the effects in the Upper Basin are less well characterized (USGS, 2004e).

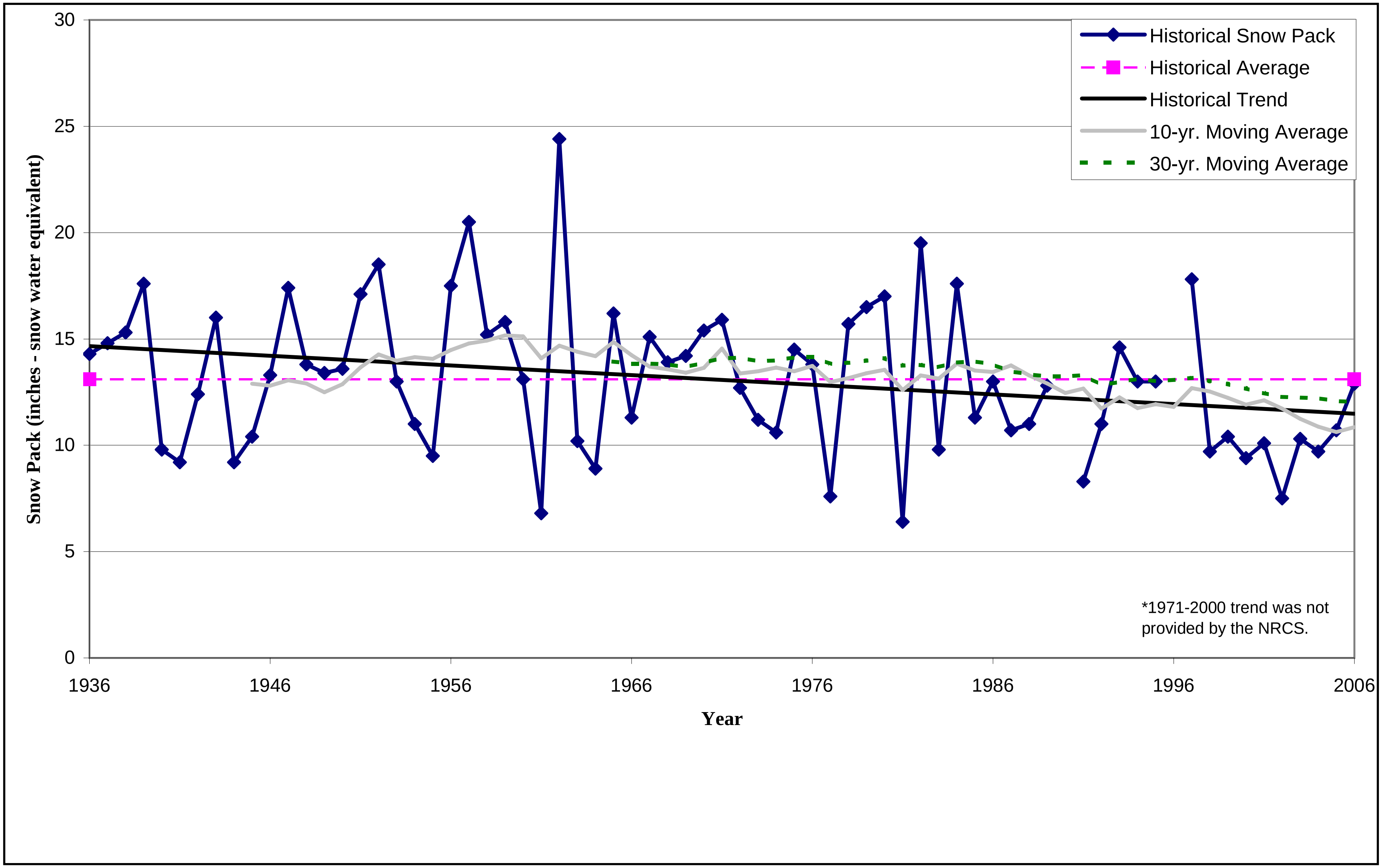


Figure 5-23
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Independence Pass Station

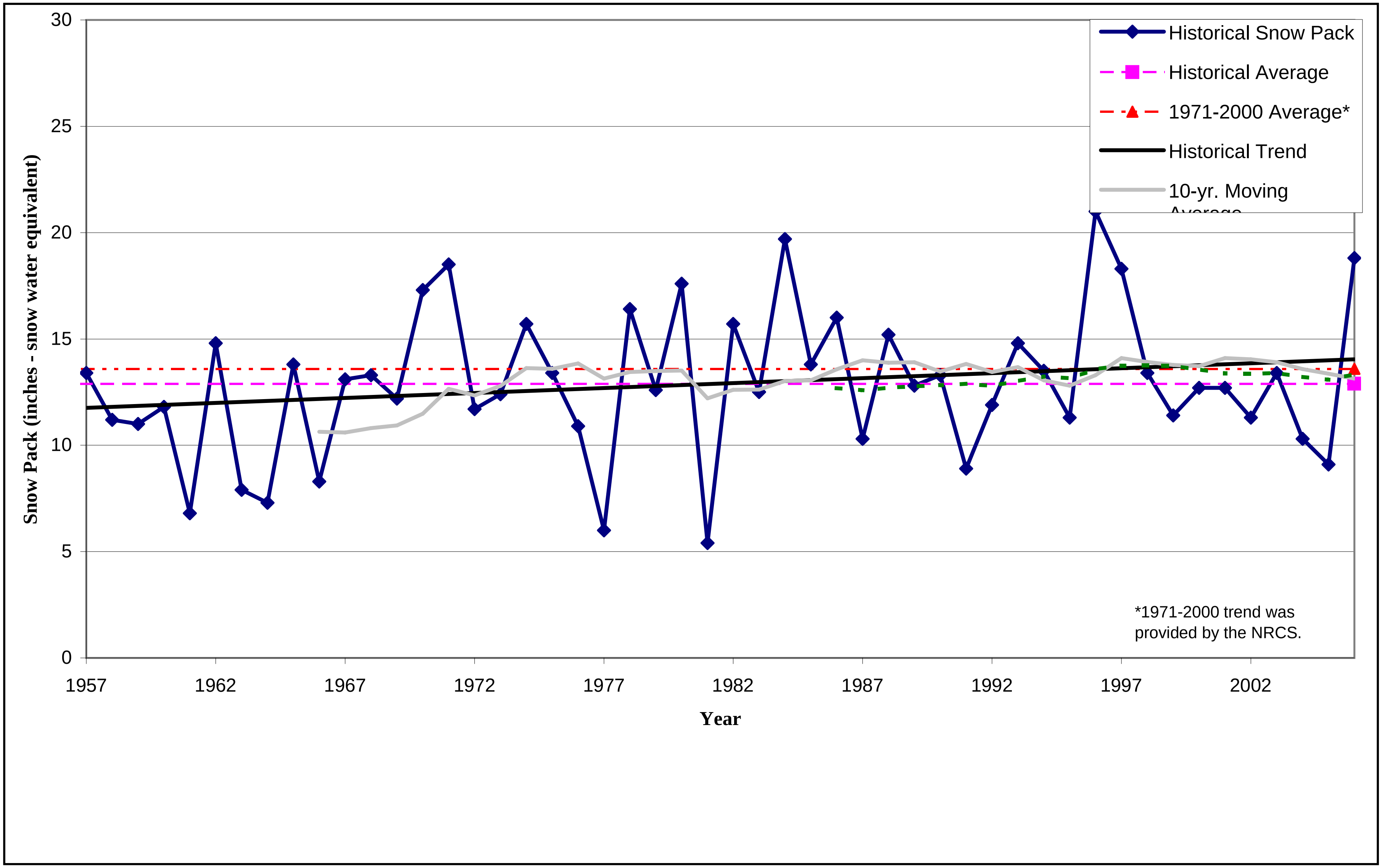


Figure 5-24
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Jones Pass Station

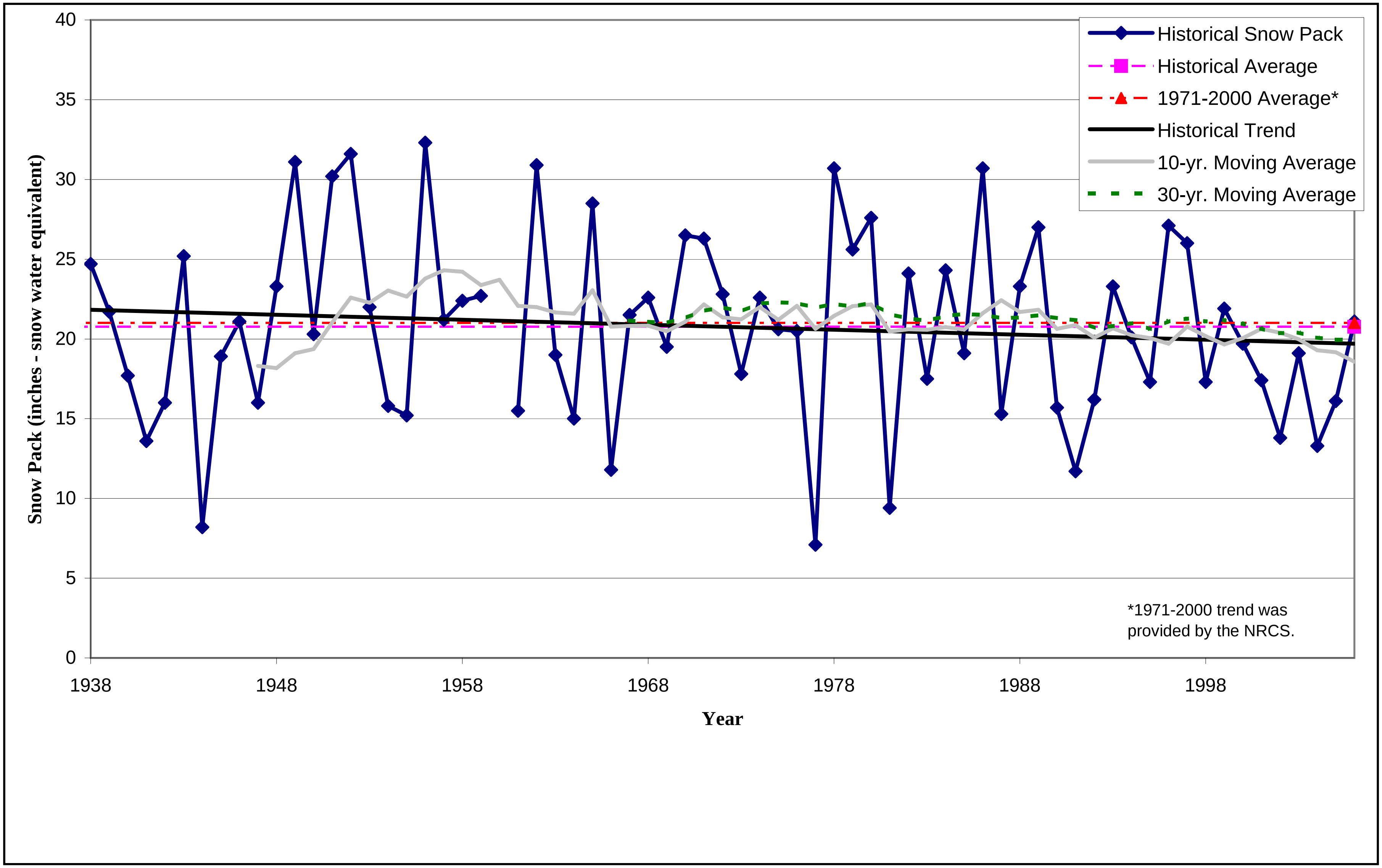


Figure 5-25
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Lake Irene Station

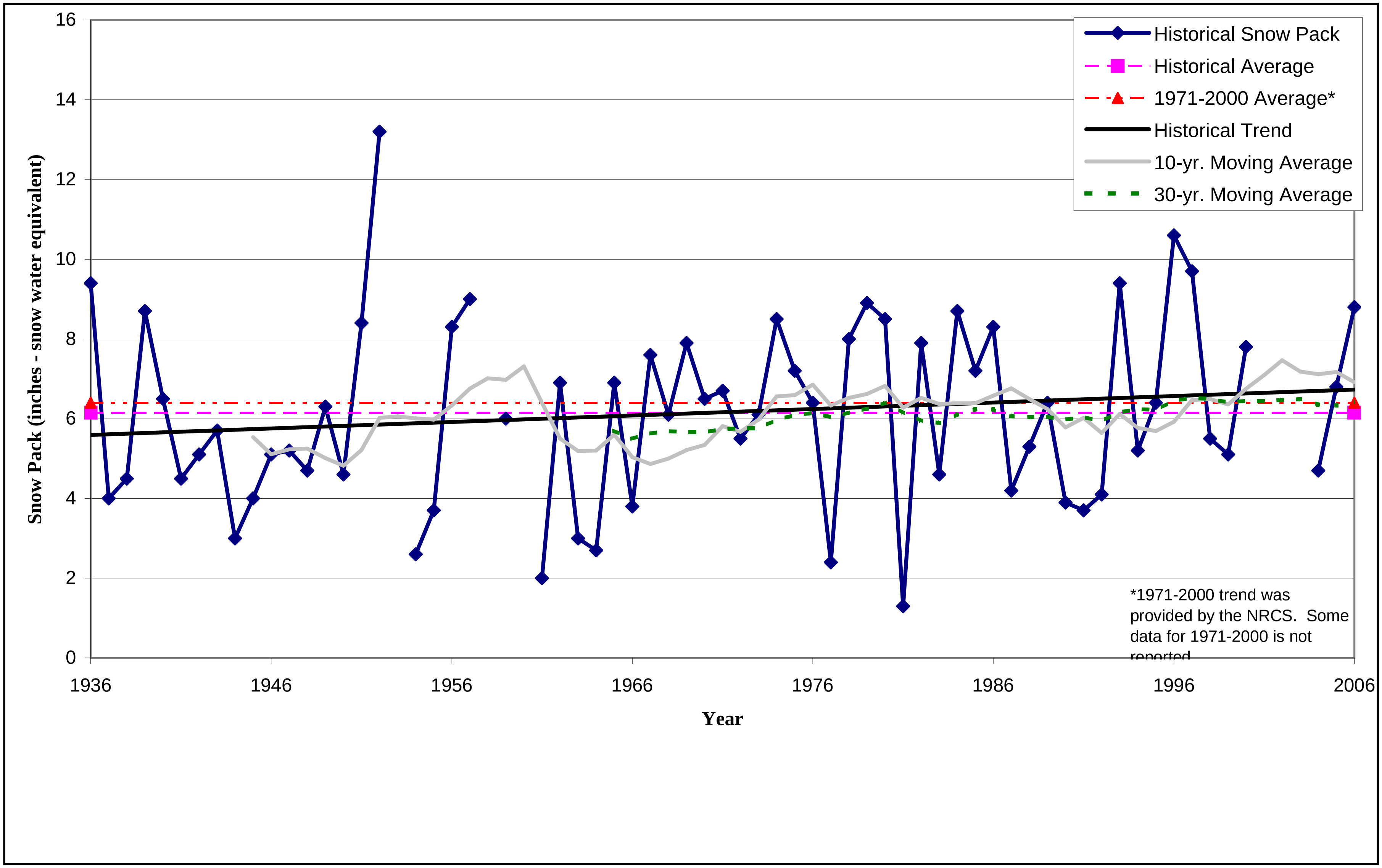


Figure 5-26
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Nast Lake Station

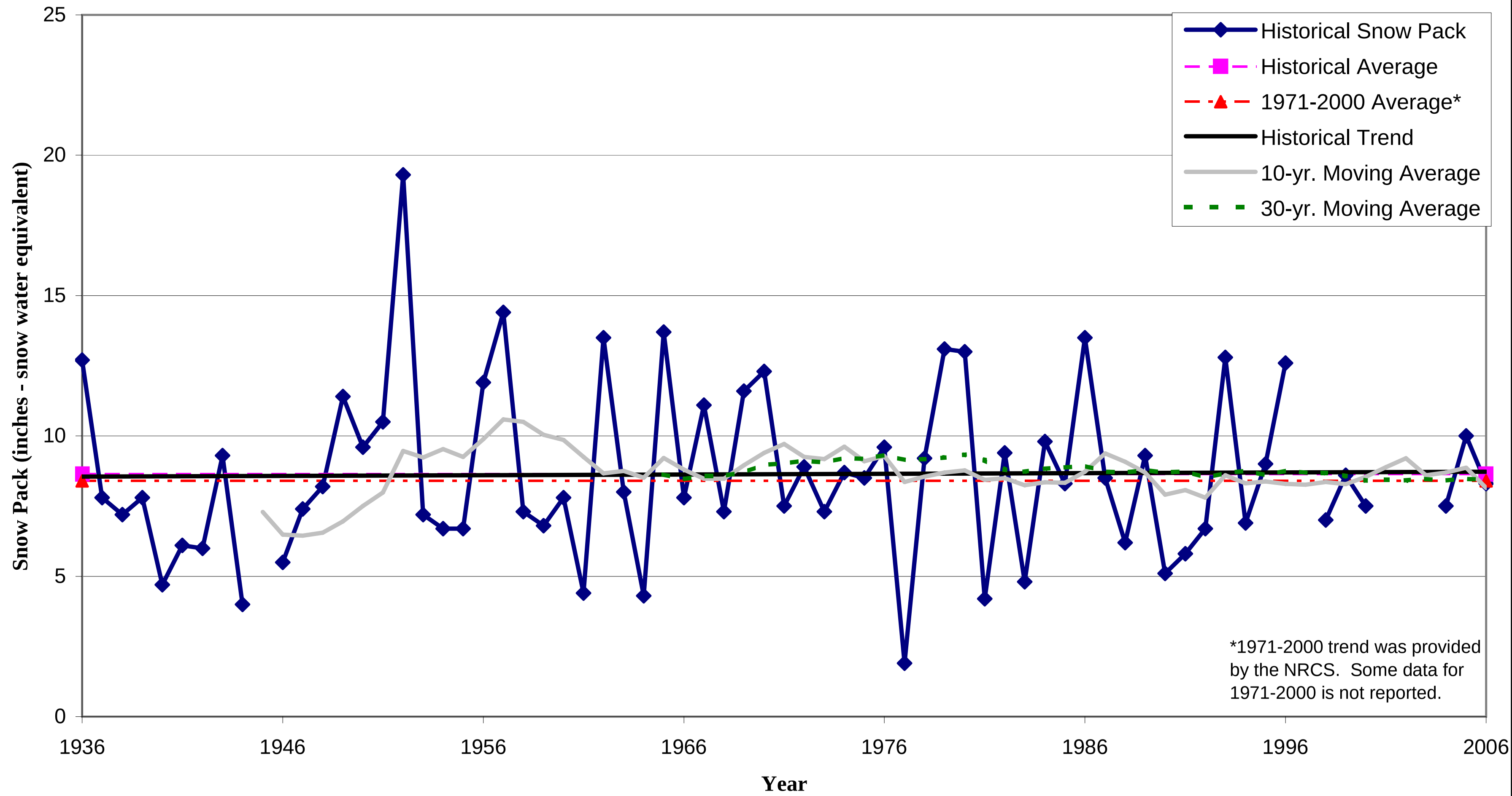


Figure 5-27
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Park Cone Station

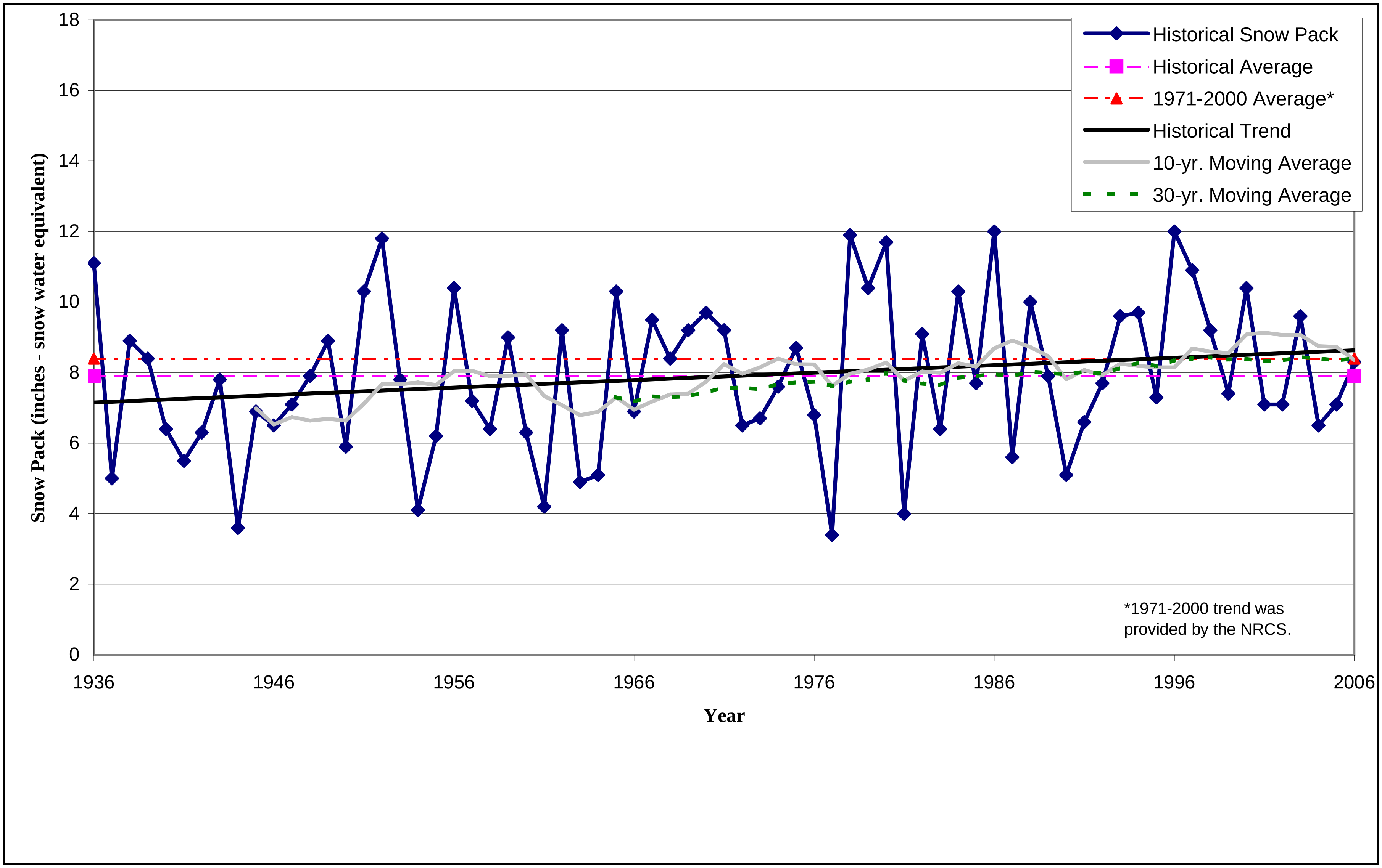


Figure 5-28
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Phantom Valley Station

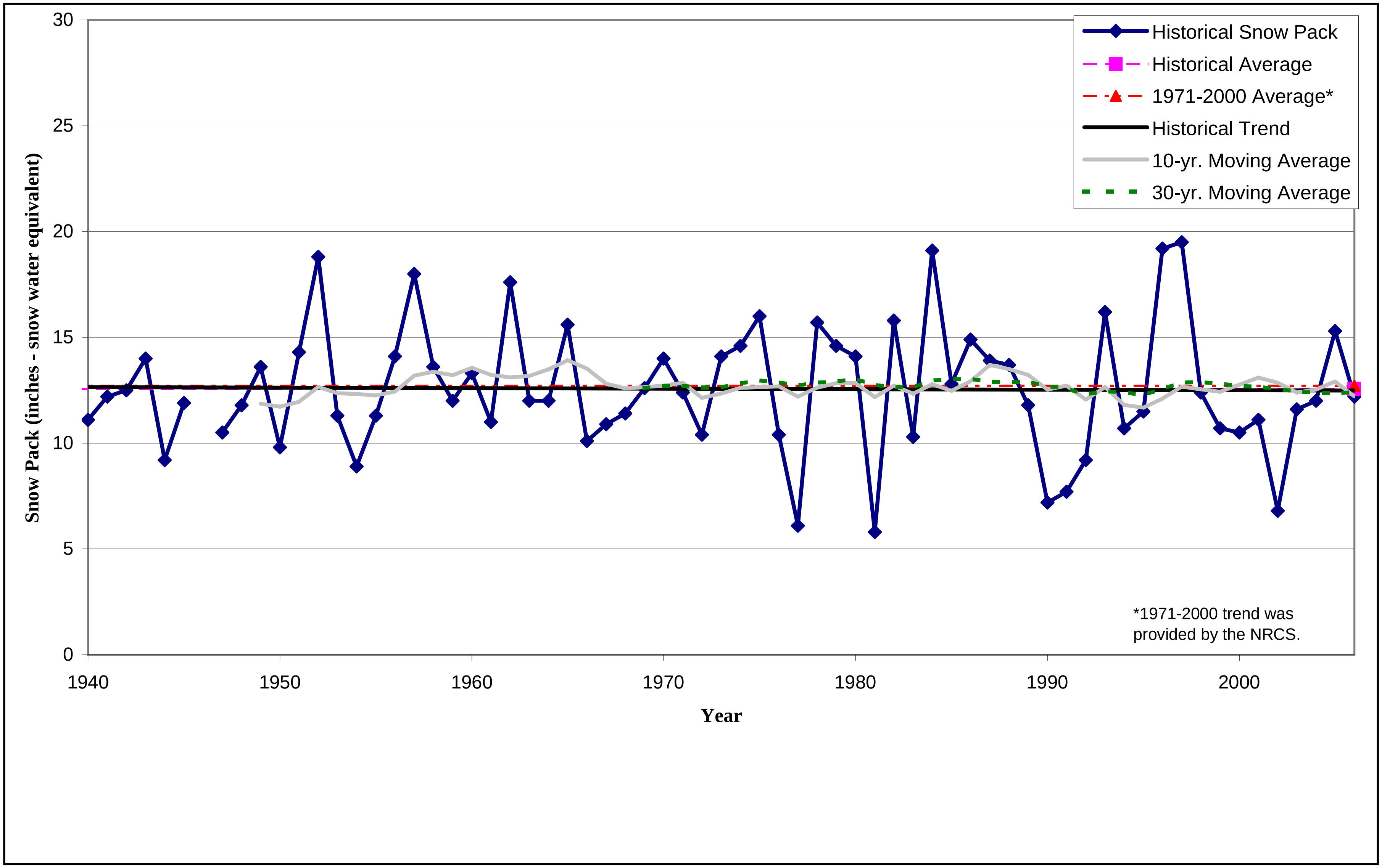


Figure 5-29
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Porphyry Creek Station

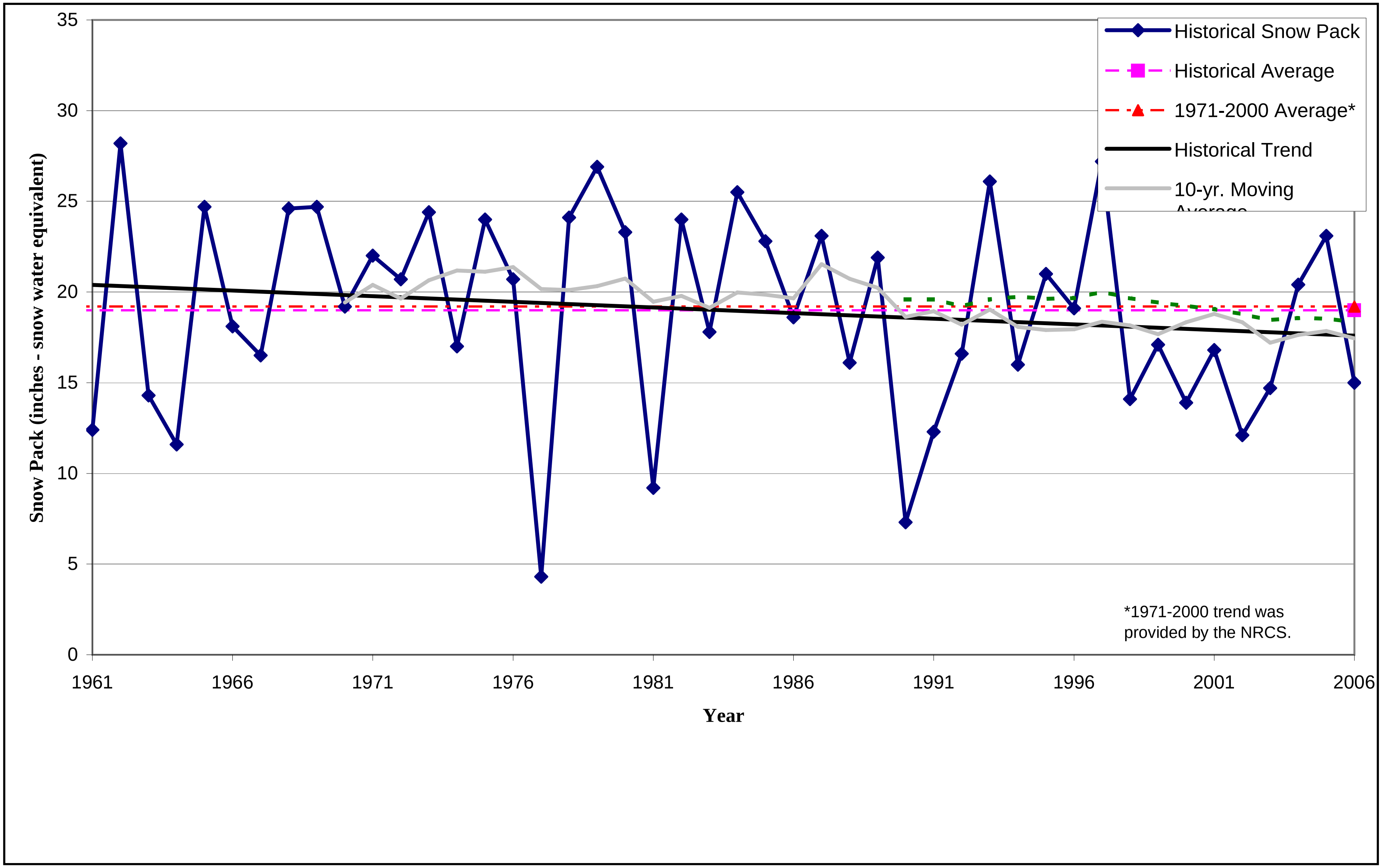


Figure 5-30
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Red Mountain Pass Station

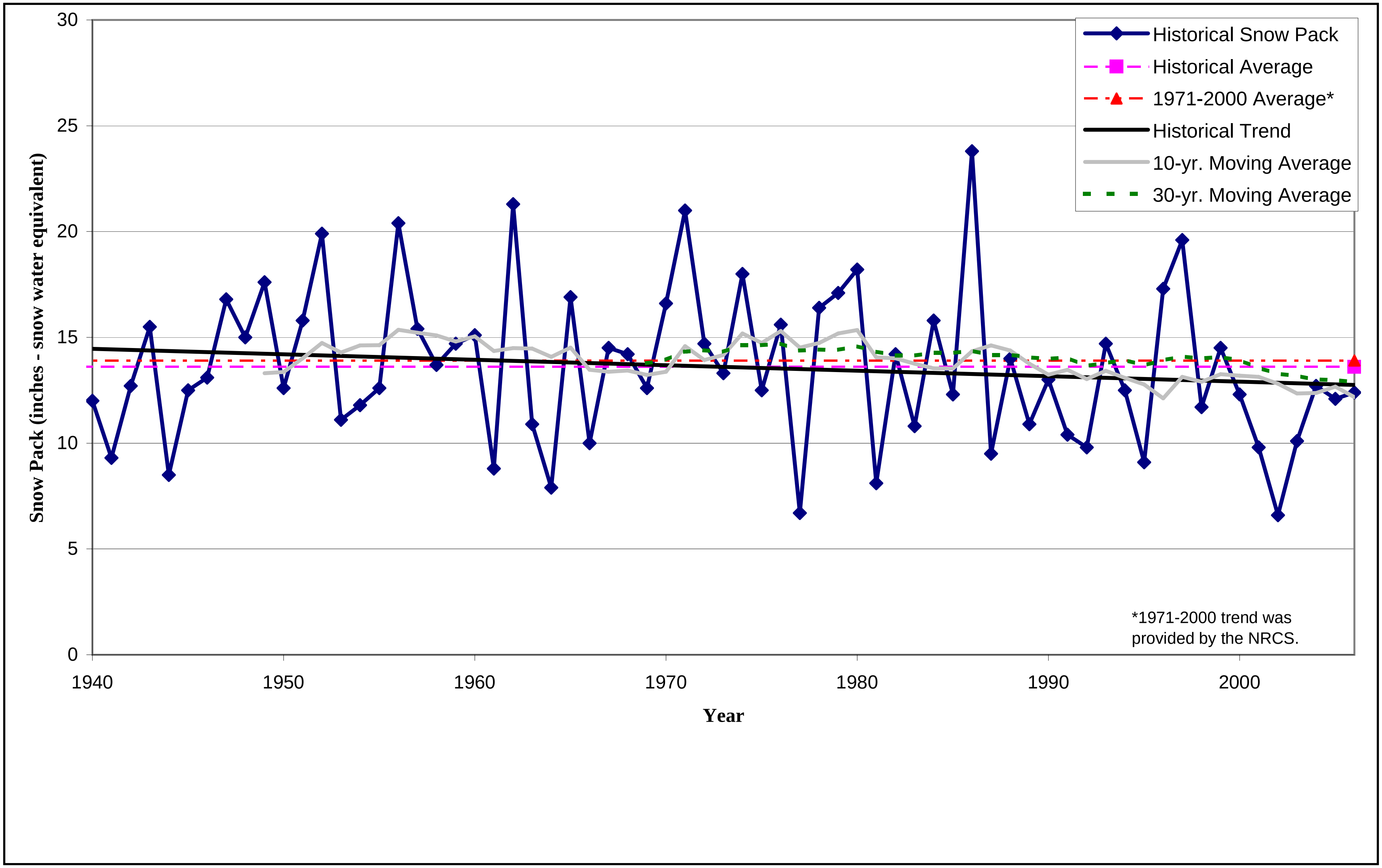


Figure 5-31
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Roach Station

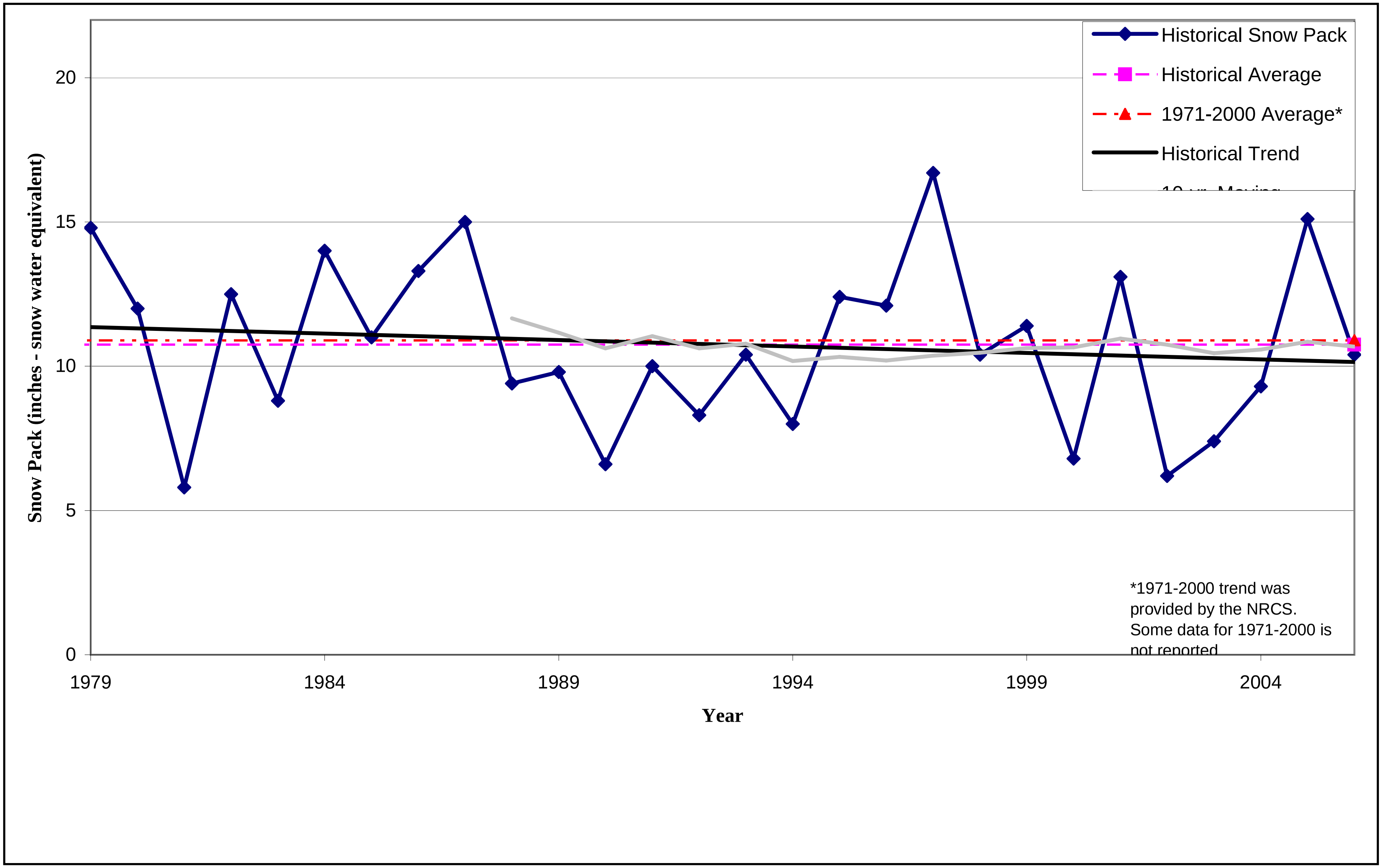


Figure 5-32
Snowpack Depths as Snow-Water Equivalent
Central Rocky Mountains, Colorado
Slumgullion Station

The AMO is caused by multi-decadal cycles of warmer or cooler Atlantic Ocean surface temperatures. These cycles apparently influence easterly atmospheric flows from the Atlantic and Gulf of Mexico, with warmer waters causing atmospheric flows to be further southward and thereby missing much of the Basin (USGS, 2004e).

Thus, several documented factors affect precipitation and temperature in the western U.S. from year to year and over periods of several years. ENSO and LNSO are responsible for much of the annual variation in climate, but PDO and AMO conditions affect climate over cycles of many years or even decades. Although the role of each of these phenomena are less well understood in the Upper Basin than in other parts of the western U.S., all are likely to play a role in climate conditions there (Garfin, 2005).

In addition to these natural phenomena that contribute to normal variations in climate change, climate scientists have indicated that global climate change is occurring as a result of human-introduced greenhouse gases that trap energy from the sun in the atmosphere (Christensen et al. 2007). The extent to which anthropogenic climate change has affected climate conditions and associated snowpack and runoff in the Upper Colorado River Basin is not known.

5.2.4.4 Climate Trends and Climate Change

Overall, long-term climate trends in the western U.S., including the Colorado River Basin, show a warming trend that occurred throughout most of the 20th century and has accelerated since the mid-1970s. This warming trend is reflected globally. In most of the western U.S., this has included much drier conditions since the late 1990s. Drought cycles of several years or decades are not unusual in the western U.S., contributing to a substantial decline in storage in Lake Powell and Lake Mead.

Climate scientists studying global climate change are somewhat uncertain about the veracity of regional climate models that encompass the Colorado River Basin, as opposed to more global models where confidence is higher. According to reporting by the Intergovernmental Panel on Climate Change (IPCC), most regional climate models have projected increases in both summer and winter temperatures in the Colorado River Basin during the 21st century. This may be partly offset by possible increases in precipitation in some areas, although the overall snowpack is expected to continue to decline in most years (Christensen, et al. 2007).

The relationship between ENSO and LNSO occurrences and global climate change is not well understood. ENSO and LNSO are known to have occurred long before the current global climate change phenomenon and are not caused by global climate change. However, the occurrence of ENSO episodes has been more frequent since about 1976, and it has been hypothesized that well-documented warmer sea surface temperatures throughout most of the world’s oceans and associated with global climate change may enhance the effects of ENSOs (NOAA 2007). Whether the conditions that drive global climate change have had an impact on ENSO effects in the Upper Basin are not yet known (Garfin, 2005).

5.2.5 Water Quality Standards

5.2.5.1 Surface Water

In Utah, water quality protection standards are based on designated state beneficial uses, which are defined and classified in the Utah Administrative Code R317-2. Use designations are provided in R317-2-6 and include the classifications shown in Table 5-2.

Table 5-2 **Beneficial Use Protection Classifications for Surface Waters of the State of Utah, UAC R317-2-6**	
Classification	**Definition**
1C	Raw water source for domestic purposes with prior treatment
2A	Primary contact recreation such as swimming
2B	Secondary contact recreation such as boating, wading, and similar uses
3A	Cold water species of game fish and cold water aquatic life
3B	Warm water species of game fish and warm water aquatic life
3C	Nongame fish and other aquatic life
3D	Waterfowl, shore birds and other water-oriented wildlife
3E	Severely habitat-limited waters
4	Agricultural uses including irrigation and stock watering
5	Special category for the waters of the Great Salt Lake

Beneficial use protection classifications for major rivers and reservoirs in the vicinity of the Project pipeline alignment are provided in Table 5-3. Note that no specific designation is assigned to Sand Hollow Reservoir in UAC R317-2, although it is used or may be used for groundwater recharge and for the purposes designated in Table 5-2 as 1C, 2A, 2B, 3B, 3D, and 4.

Table 5-3 **Beneficial Use Protection Classifications Designated for Major Rivers and Reservoirs in the Vicinity of the Lake Powell Pipeline Project Alignment, UAC 317-2-13**	
Water Body	**Classifications**
Colorado River	1C, 2B, 3B, 4
Quail Creek	1C, 2B, 3A, 4
Virgin River (above Quail Creek Diversion)	1C, 2B, 3C, 4
Virgin River (below Quail Creek Diversion)	2B, 3B, 4
Kanab Creek (lower)	2B, 3C, 4
Paria River	2B, 3C, 4
Lake Powell	1C, 2A, 2B, 3B, 4
Quail Creek Reservoir	1C, 2A, 2B, 3B, 4

Surface water quality numeric criteria for the most stringent protection classification, Domestic Source (Class 1C) are specified in UAC R317-2-14 and are summarized in Table 5-4. Other beneficial use protection classifications are available in the Utah Administrative Code and are too voluminous to present here.

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)
Page 1 of 6

Constituent	Parameter	Footnote
Bacteria (*E. coli*)		
30-Day Geometric Mean (#/100 mL)	206	a
Maximum (#/100 mL)	940	a
Physical		
pH (Range)	6.5-9.0	
Turbidity Increase (NTU)	-	
Metals (Dissolved, Max. - mg/L)		b
Antimony	5.6	
Arsenic	0.01	c
Barium	1	
Beryllium	<0.004	d
Cadmium	0.01	d
Chromium	0.05	d
Copper	1300	
Lead	0.015	d
Mercury	0.002	c
Nickel	100 MCL	
Selenium	0.05	c
Silver	0.05	
Thallium	0.24	
Zinc	7,400	
Inorganics (Max. - mg/L)		
Asbestos (fibers/L)	7000000	
Bromate	0.01	
Boron	-	
Chlorite	<1.0	
Cyanide	140	
Fluoride	1.4-2.4	e
Nitrates as N	10	
Total Dissolved Solids	-	f
Radiological (Max. - pCi/L)		
Gross Alpha	15	
Gross Beta (mrem/yr)	4	
Radium 226, 228 (Combined)	5	
Strontium 90	8	
Tritium	20000	
Uranium	30	

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)
Page 2 of 6

Constituent	Parameter	Footnote
Organics (Max. - µg/L)		
Acrolein	190	
Acrylonitrile	0.051	g
Alachlor	2	
Atrazine	3	
Benzene	2.2	g
Bromoform	4.3	g
Carbofuran	40	
Carbon Tetrachloride	0.23	g
Chlorobenzene	100 MCL	
Chlorodibromomethane	0.4	g
Chloroethane	-	
2-Chloroethylvinyl Ether	-	
Chloroform	5.7	g
Dalapon	200	
Di(2ethylhexl)adipate	400	
Dibromochloropropane	0.2	
Dichlorobromomethane	0.55	g
1,1-Dichloroethane	-	
1,2-Dichloroethane	0.38	g
1,1-Dichloroethylene	7 MCL	
Dichloroethylene (cis-1,2)	70	
Dinoseb	7	
Diquat	20	
1,2-Dichloropropane	0.5	g
1,3-Dichloropropene	0.34	
Endothall	100	
Ethylbenzene	530	
Ethylene Dibromide	0.05	
Glyphosate	700	
Haloacetic acids	60	
Methyl Bromide	47	
Methyl Chloride	-	
Methylene Chloride	4.6	g
Ocamyl (vidate)	200	
Picloram	500	
Simazine	4	
Styrene	100	

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)

Constituent	Parameter	Footnote
1,1,2,2-Tetrachloroethane	0.17	g
Tetrachloroethylene	0.69	g
Toluene	1,000	
1,2 -Trans-Dichloroethylene	100 MCL	
1,1,1-Trichloroethane	200 MCL	
1,1,2-Trichloroethane	0.59	g
Trichloroethylene	2.5	g
Vinyl Chloride	0.025	
Xylenes	10,000	
2-Chlorophenol	81	
2,4-Dichlorophenol	77	
2,4-Dimethylphenol	380	
2-Methyl-4,6-Dinitrophenol	13	
2,4-Dinitrophenol	69	
2-Nitrophenol	-	
4-Nitrophenol	-	
3-Methyl-4-Chlorophenol	-	
Penetachlorophenol	0.27	g
Phenol	21,000	
2,4,6-Trichlorophenol	1.4	g
Acenaphthene	670	
Acenaphthylene	-	
Anthracene	8,300	
Benzidine	0.000086	g
BenzoaAnthracene	0.0038	g
BenzoaPyrene	0.0038	g
BenzobFluoranthene	0.0038	g
BenzoghiPerylene	-	
BenzokFluoranthene	0.0038	g
Bis2-ChloroethoxyMethane	-	
Bis2-ChloroethylEther	0.03	g
Bis2-Chloroisopropy1Ether	1,400	
Bis2-EthylhexylPhthalate	1.2	g
4-Bromophenyl Phenyl Ether	-	
Butylbenzyl Phthalate	1,500	
2-Chloronaphthalene	1,000	
4-Chlorophenyl Phenyl Ether	-	
Chrysene	0.0038	g

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)
Page 4 of 6

Constituent	Parameter	Footnote
Dibenzoa, hAnthracene	0.0038	g
1,2-Dichlorobenzene	420	
1,3-Dichlorobenzene	320	
1,4-Dichlorobenzene	63	
3,3-Dichlorobenzidine	0.021	g
Diethyl Phthalate	17,000	
Dimethyl Phthalate	270,000	
Di-n-Butyl Phthalate	2,000	
2,4-Dinitrotoluene	0.11	g
2,6-Dinitrotoluene	-	
Di-n-Octyl Phthalate	-	
1,2-Diphenylhydrazine	0.036	g
Fluoranthene	130	
Fluorene	1,100	
Hexachlorobenzene	0.00028	g
Hexachlorobutedine	0.44	g
Hexachloroethane	1.4	g
Hexachlorocyclopentadiene	40	
Ideno 1,2,3-cdPyrene	0.0038	g
Isophorone	35	g
Naphthalene	-	
Nitrobenzene	17	
N-Nitrosodimethylamine	0.00069	g
N-Nitrosodi-n-Propylamine	0.005	g
N-Nitrosodiphenylamine	3.3	g
Phenanthrene	-	
Pyrene	830	
1,2,4-Trichlorobenzene	35	
Aldrin	0.000049	g
alpha-BHC	0.0026	g
beta-BHC	0.0091	g
gamma-BHC (Lindane)	0.2 MCL	
delta-BHC	-	
Chlordane	0.0008	g
2,4-D	70	
4,4-DDT	0.00022	g
4,4-DDE	0.00022	g
4,4-DDD	0.00031	g

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)
Page 5 of 6

Constituent	Parameter	Footnote
2,4,5-TP	10	
2,3,7,8-TCDD Dioxin	5.00E-09	g
Dieldrin	0.000052	g
alpha-Endosulfan	62	
beta-Endosulfan	62	
Endosulfan Sulfate	62	
Endrin	0.059	
Endrin Aldehyde	0.29	
Heptachlor	0.000079	g
Heptachlor Epoxide	0.000039	g
Methoxychlor	40	
Polychlorinated Biphenyls	0.000064	g, h
PCB's	-	
Toxaphene	0.00028	g

Table 5-4
Surface Water Numeric Standards for Domestic Source (Class 1C)

Constituent	Parameter	Footnote
Pollution Indicators (mg/L)	i	
BOD	-	
Nitrate as N	-	
Total Phosphorus as P	-	j

* This table consists of data from the Utah Administrative Code R317-2, Tables 2.14.1 and 2.14.6. The table lists numeric criteria for water associated with domestic sources, including human health criteria for consumption. The data presented in this table represent the most stringent beneficial use water quality criteria. Consult UAC R317-2 for other beneficial use classifications.

Footnotes:

a) Where the criteria are exceeded and there is a reasonable basis for concluding that the indicator bacteria are primarily from natural sources (wildlife), e.g., in National Wildlife Refuges and State Waterfowl Management Areas, the criteria may be considered attained. Exceedences of bacteriological numeric criteria from nonhuman nonpoint sources will generally be addressed through appropriate Federal, State, and local nonpoint source programs.

b) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by atomic absorption or inductively coupled plasma (ICP) spectrophotometry.

c) See Table 2.14.2 of the Utah Administrative Code R317-2.

d) EPA has not calculated a human criterion for this contaminant. However, permit authorities should address this contaminant in NPDES permit actions using the State's existing narrative criteria for toxics.

e) Maximum concentration varies according to the daily maximum mean air temperature. See table below.

Temp. (C)	mg/L
12	2.4
12.1-14.6	2.2
14.7-17.6	2
17.7-21.4	1.8
21.5-26.2	1.6
26.3-32.5	1.4

f) TDS limits may be adjusted if such adjustment does not impair the designated beneficial use of the receiving water. The total dissolved solids (TDS) standards shall be at background where it can be shown that natural or un-alterable conditions prevent its attainment. In such cases rulemaking will be undertaken to modify the standard accordingly. For site specific TDS standards, see footnote 4 in Table 2.14.1 of the Utah Administrative Code R317-2. The Virgin River has site-specific TDS criteria downstream of Pah Tempe springs.

g) Based on carcinogenicity of 10-6 risk.

h) This standard applies to total PCBs.

i) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

j) Total Phosphorus as P (mg/L) indicator for lakes and reservoirs shall be 0.025.

5.2.5.2 Groundwater

Groundwater quality protection standards in Utah are specified in UAC 317-6 and are based on established groundwater quality numerical standards as well as on beneficial uses, similar to the surface water standards. Aquifers are assigned a protection standard based upon the designated beneficial uses; however, only a limited number of aquifers in the State of Utah have been assigned a groundwater class. Groundwater classes are presented in Table 5-5. Numerical groundwater quality standards are found in UAC R317-6-2 and are presented in Table 5-6.

Table 5-5
Groundwater Classes for the State of Utah UAC R317-6-3

Classification	Title	Definition
IA	Pristine Groundwater	Meets groundwater quality standards with TDS <500 mg/L
IB	Irreplaceable Groundwater	Meets groundwater water quality standards with no comparable replacement source
IC	Ecologically Important Groundwater	Important to wildlife habitat
II	Drinking Water Quality Groundwater	Meets groundwater quality standards with TDS >500 mg/L but <3,000 mg/L
III	Limited Use Groundwater	Does not meet groundwater standards and/or TDS >3,000 mg/L but <10,000 mg/L
IV	Saline Groundwater	TDS >10,000 mg/L

Note: TDS = Total dissolved solids

Table 5-6
Utah Numerical Groundwater Quality Standards
Page 1 of 4

Parameter Description	Value
Physical Characteristics	
Color (units)	15.0
Corrosivity (characteristic)	Non-corrosive
Odor (threshold number)	3.0
pH (units)	6.5-8.5
Inorganic Chemicals (mg/L)	
Bromate	0.01
Chloramine (as Cl_2)	4
Chlorine (as Cl_2)	4
Chlorine Dioxide	0.8
Chlorite	1.0
Cyanide (free)	0.2
Fluoride	4.0
Nitrate (as N)	10.0
Nitrite (as N)	1.0
Total Nitrate/Nitrite (as N)	10.0

Table 5-6
Utah Numerical Groundwater Quality Standards

Parameter Description	Value
Metals (mg/L)	
Antimony	0.006
Asbestos (fibers/l and > 10 microns in length)	7.0×10^6
Arsenic	0.05
Barium	2.0
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Copper	1.3
Lead	0.015
Mercury	0.002
Selenium	0.05
Silver	0.1
Thallium	0.002
Zinc	5.0
Organic Chemicals (mg/L)	
Pesticides and PCBs	
Alachlor	0.002
Aldicarb	0.003
Aldicarb sulfone	0.002
Aldicarb sulfoxide	0.004
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
Dalapon (sodium salt)	0.2
Dibromochloropropane (DBCP)	0.0002
2, 4-D	0.07
Dichlorophenoxyacetic acid (2, 4-) (2,4D)	0.07
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylene Dibromide (EDB)	0.00005
Glyphosate	0.7
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Lindane	0.0002
Methoxychlor	0.04
Oxamyl (Vydate)	0.2
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated Biphenyls	0.0005
Simazine	0.004
Toxaphene	0.003
2, 4, 5-TP (Silvex)	0.05
Volatile Organic Chemicals (mg/L)	
Benzene	0.005
Benzo (a) pyrene (PAH)	0.0002

Table 5-6
Utah Numerical Groundwater Quality Standards
Page 3 of 4

Parameter Description	Value
Carbon tetrachloride	0.005
1, 2 - Dichloroethane	0.005
1, 1 - Dichloroethylene	0.007
1, 1, 1-Trichloroethane	0.200
Dichloromethane	0.005
Di (2-ethylhexyl) adipate	0.4
Di (2-ethylhexyl) phthalate	0.006
Dioxin (2,3,7,8-TCDD)	0.00000003
para - Dichlorobenzene	0.075
o-Dichlorobenzene	0.6
cis-1,2 dichloroethylene	0.07
trans-1,2 dichloroethylene	0.1
1,2 Dichloropropane	0.005
Ethylbenzene	0.7
Hexachlorobenzene	0.001
Hexachlorocyclopentadiene	0.05
Monochlorobenzene	0.1
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1
Trichlorobenzene (1,2,4-)	0.07
Trichloroethane (1,1,1-)	0.2
Trichloroethane (1,1,2-)	0.005
Trichloroethylene	0.005
Vinyl chloride	0.002
Xylenes (Total)	10
Other Organic Chemicals (mg/L)	
Five Haloacetic Acids (HAA5) (Monochloroacetic acid) (Dichloroacetic acid) (Trichloroacetic acid) (Bromoacetic acid) (Dibromoacetic acid)	0.06
Total Trihalomethanes (TTHM)	0.08

Table 5-6
Utah Numerical Groundwater Quality Standards
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Parameter Description	Value
Radionuclides	
Radium-226 + Radium-228	5pCi/L
Gross alpha, including Radium-226 but excluding Radon and Uranium	15pCi/L
Uranium	0.030 mg/L
Beta particle and photon radioactivity	4 millirem/year[a]

Notes:
a) Except for the radionuclides listed below, the concentration of man-made radionuclides causing four millirem total body or organ dose equivalents shall be calculated on the basis of a two liter per day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burden and Maximum Permissible Concentration Exposure", NBS Handbook 69 as amended August 1962, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed four millirem/year. Average annual concentrations assumed to produce a total body or organ dose of four millirem/year:

Radionuclide	Critical Organ	pCi per liter
Tritium	Total Body	20,000
Strontium-90	Bone Marrow	8

b) A permit specific ground water quality standard for any pollutant not specified above may be established by the State at a level that will protect public health and the environment. This permit limit may be based on U.S. Environmental Protection Agency maximum contaminant level goals, health advisories, risk based contaminant levels, standards established by other regulatory agencies and other relevant information.

Two aquifers have been classified within the vicinity of the Project alignment, the Cedar Valley aquifer near Cedar City and the Navajo Sandstone aquifer near Sand Hollow Reservoir. For classification purposes, the Cedar Valley aquifer has been subdivided into three areas. Most of the aquifer has been designated Class IA. The area around Cedar City from the eastern edge of the valley to about four miles west, five miles north, and six miles south of Cedar City is designated as Class II. A relatively small area north of Cedar City and south of Enoch, mostly west of Interstate 15, is designated as Class III (UDWQ 2007c). The Navajo Sandstone aquifer around Sand Hollow Reservoir has been classified into two areas. Most of the aquifer has been designated Class IA. An area immediately southeast of Quail Creek Reservoir and west of Hurricane has been designated Class II. The application for aquifer classification was approved by the Utah Division of Water Quality in 2006.

Class IA protection levels, in addition to the requirements of Table 5-5 and Table 5-6, also require compliance with the following degradation requirements when discharging to groundwater:

- TDS may not exceed 1.25 times background concentrations, or background plus two standard deviations
- When a contaminant is not detectable in background, the affected groundwater may not exceed the greater of 0.1 times the numerical groundwater quality standard value, or the limit of analytical detection
- When a contaminant is detectable in background, the affected groundwater may not exceed the greater of 1.25 times the background concentration or 0.25 times the numerical groundwater quality standard value or background plus two standard deviations

- In no case will the concentration of a contaminant in affected groundwater be allowed to exceed the numerical groundwater quality standard

Class II protection levels, in addition to the requirements listed in Table 5-5, require compliance with the following degradation requirements when discharging to groundwater:

- TDS may not exceed 1.25 times background concentrations, or background plus two standard deviations
- When a contaminant is not detectable in background, the affected groundwater may not exceed the greater of 0.25 times the numerical groundwater quality standard value, or the limit of analytical detection
- When a contaminant is detectable in background, the affected groundwater may not exceed the greater of 1.25 times the background concentration, or 0.25 times the numerical groundwater quality standard value, or background plus two standard deviations
- In no case will the concentration of a contaminant in affected groundwater be allowed to exceed the numerical groundwater quality standard

Class III protection levels, in addition to the requirements of Table 5-5, require compliance with the following degradation requirements when discharging to groundwater:

- TDS may not exceed 1.25 times background concentrations, or background plus two standard deviations
- When a contaminant is not detectable in background, the affected groundwater may not exceed the greater of 0.5 times the numerical groundwater quality standard value, or the limit of analytical detection
- When a contaminant is detectable in background, the affected groundwater may not exceed the greater of 1.5 times the background concentration, or 0.5 times the numerical groundwater quality standard value, or background plus two standard deviations
- In no case will the concentration of a contaminant in affected groundwater be allowed to exceed the numerical groundwater quality standard. If the background concentration exceeds the numerical groundwater quality standard, no increase will be allowed.

5.2.6 Existing Water Quality in Lake Powell and Sand Hollow Reservoir

5.2.6.1 Lake Powell

Lake Powell water quality has been monitored at various locations. The U.S. Geological Survey water quality sampling location nearest to the proposed pipeline intake and pump station is at Wahweap Bay, just south of the Utah-Arizona state boundary at 2.4 miles from Glen Canyon Dam and 2.1 miles from the proposed intake. Samples used for this evaluation were taken at various depths throughout the water column at approximately monthly or bi-monthly intervals from June 1995 to March 2004 for laboratory analyses. Profile sampling (field parameters, including temperature, pH, electrical conductivity, dissolved oxygen (DO), turbidity, oxygen reduction potential (ORP) and TDS were collected for various depths at approximately monthly intervals from January 2002 to March 2007. Not all samples were analyzed at each sampling event, but enough samples were collected to provide some characterization. The average, minimum, and maximum concentrations determined from sampling at the Wahweap Bay sampling site are presented in Table 5-7. Samples collected from various water depths have been placed into groups (0-5 m, 5-50 m, 50-100 m, >100 m). Concentrations are presented in mg/L unless noted otherwise.

Table 5-7
Water Quality for Lake Powell at Wahweap Sampling Station, Arizona
Page 1 of 3

Parameter	Depth (m)	Average	Minimum	Maximum	Remarks
Temperature (ºC)	0-5	17.3	8.3	27.4	
	5-50	12.6	7.3	27.0	
	50-100	8.0	6.5	11.0	
	>100	7.7	6.4	8.7	
	Overall	10.7	6.4	27.4	
pH (S.U.)	0-5	8.1	7.5	9.0	
	5-50	7.7	2.1[a]	9.1	a) Single day, 4/7/04; all other sample events >6.9
	50-100	7.4	2.2[a]	8.1	a) Single day, 4/7/04; all other sample events >6.9
	>100	7.5	6.2	8.0	
	Overall	7.6	2.1[a]	9.1	a) Single day, 4/7/04; all other sample events >6.9
Conductivity (µS)	0-5	786	650	892	
	5-50	806	569	1018	
	50-100	949	716	1074	
	>100	987	880	1084	
	Overall	878	569	1084	
Dissolved Oxygen	0-5	8.1	5.9	10.7	
	5-50	6.5	1.7	12.1	
	50-100	4.3	1.9	8.2	
	>100	4.2	0.5	8.4	
	Overall	5.6	0.5	12.1	
Turbidity (NTU)	0-5	2.3	0[b]	34.2	[b]Turbidity recorded at 0 NTU - uncommon in natural waters, presumably <0.1 NTU
	5-50	2.5	0[b]	16.4	[b]Turbidity recorded at 0 NTU - uncommon in natural waters, presumably <0.1 NTU
	50-100	3.7	0[b]	17.9	[b]Turbidity recorded at 0 NTU - uncommon in natural waters, presumably <0.1 NTU
	>100	3.9	0[b]	20.3	[b]Turbidity recorded at 0 NTU - uncommon in natural waters, presumably <0.1 NTU
	Overall	3.1	0	34.2	[b]Turbidity recorded at 0 NTU - uncommon in natural waters, presumably <0.1 NTU
TDS (field)	0 ft[c]	468	371	563	[c] 1991-2007 monthly
	50 ft[d]	459	360	556	[d] 1990-2007 monthly
	100 ft[d]	464	371	593	
	150 ft[d]	488	371	640	
	200 ft[d]	528	372	694	
	250 ft[d]	562	411	697	
	300 ft[d]	580	454	702	
	350 ft[d]	583	471	696	
	400 ft[d]	594	478	696	
	Overall[d]	519	360	702	

Table 5-7
Water Quality for Lake Powell at Wahweap Sampling Station, Arizona

Parameter	Depth (m)	Average	Minimum	Maximum	Remarks
TSS (lab)	0-5	4.1	4.0	7.8	
	5-50	4.1	4.0	5.8	
	50-100	4.2	3.9	14.2	
	>100	5.9	4.0	15.3	
	Overall	4.3	3.9	15.3	
Ca	0-5	56.8	45.4	69.4	
	5-50	60.7	47.3	79.5	
	50-100	64.3	45.5	82.6	
	>100	74.7	53.3	95.9	
	Overall	64.3	45.4	95.9	
Mg	0-5	20.0	15.8	23.4	
	5-50	20.5	15.0	24.6	
	50-100	21.3	15.8	27.9	
	>100	24.7	17.9	29.5	
	Overall	21.7	15.0	29.5	
Na	0-5	54.4	39.4	69.0	
	5-50	57.2	41.0	76.4	
	50-100	60.2	39.8	85.7	
	>100	74.4	46.3	97.5	
	Overall	61.7	39.4	97.5	
K	0-5	2.6	1.0	7.0	
	5-50	2.5	1.0	4.0	
	50-100	2.3	1.0	4.3	
	>100	2.7	1.0	4.7	
	Overall	2.5	1.0	7.0	
CO3	0-5	0.8	0.0	2.2	
	5-50	0.9	0.0	1.8	
	50-100	0.7	0.0	1.0	
	>100	0.8	0.0	1.0	
	Overall	0.8	0.0	2.2	
HCO3	0-5	152	116	182	
	5-50	160	127	209	
	50-100	163	133	186	
	>100	178	141	214	
	Overall	163	116	214	
Alkalinity	0-5	126	95	164	
	5-50	132	113	171	
	50-100	136	109	184	
	>100	147	115	239	
	Overall	135	95	239	
Cl	0-5	35.0	26.4	51.8	
	5-50	38.1	24.9	59.2	
	50-100	42.6	25.6	74.8	
	>100	58.5	31.8	81.9	
	Overall	43.8	24.9	81.9	

Table 5-7
Water Quality for Lake Powell at Wahweap Sampling Station, Arizona
Page 3 of 3

Parameter	Depth (m)	Average	Minimum	Maximum	Remarks
SO4	0-5	176	140	221	
	5-50	184	124	232	
	50-100	190	136	272	
	>100	228	170	292	
	Overall	195	124	292	
SiO2	0-5	7.5	6.2	8.8	
	5-50	7.7	6.4	8.7	
	50-100	8.4	7.0	9.4	
	>100	8.5	7.1	9.9	
	Overall	8.1	6.2	9.9	
Fe	0-5	4.2	4.0	10.6	
	5-50	4.0	4.0	4.2	
	50-100	4.0	4.0	5.9	
	>100	4.1	4.0	8.7	
	Overall	4.1	4.0	10.6	
Total P as P	0-5	0.0	0.0	0.1	
	5-50	0.0	0.0	0.1	
	50-100	0.0	0.0	0.1	
	>100	0.0	0.0	0.1	
	Overall	0.0	0.0	0.1	
Orthophosphate as P	0-5	0.0	0.0	0.0	
	5-50	0.0	0.0	0.5	
	50-100	0.0	0.0	0.0	
	>100	0.0	0.0	0.1	
	Overall	0.0	0.0	0.5	
NH3 as N	0-5	0.0	0.0	0.2	
	5-50	0.0	0.0	0.1	
	50-100	0.0	0.0	0.3	
	>100	0.0	0.0	0.2	
	Overall	0.0	0.0	0.3	
NO2+NO3 as N	0-5	0.1	0.0	0.4	
	5-50	0.2	0.0	0.4	
	50-100	0.3	0.0	0.5	
	>100	0.4	0.2	0.5	
	Overall	0.3	0.0	0.5	
TKN as N	0-5	0.2	0.1	0.9	
	5-50	0.2	0.1	0.9	
	50-100	0.3	0.1	6.3	
	>100	0.2	0.1	0.6	
	Overall	0.2	0.1	6.3	

Source: Reclamation 2007.

5.2.6.2 Sand Hollow Reservoir

Limited water quality parameters for water in Sand Hollow Reservoir have been collected and analyzed from 10 samples collected by the U.S. Geological Survey during the period when Sand Hollow Reservoir was being filled, from September 2002 to January 2006 (USGS 2005a; 2007d). (The 2006 sample was analyzed for only a very limited suite of parameters.) In general, the water quality is good, with slightly elevated specific conductance (from 710 to 1,000 μS/cm) and pH ranging from 7.6 to 8.8, the highest readings being slightly above standards for drinking water, aquatic biota and primary recreational contact, but generally meeting those standards. The analytical suites are insufficient to undertake a complete evaluation of compliance with standards for current uses, although no classifications have been published for Sand Hollow Reservoir as of September 2007.

5.2.7 Existing Groundwater Quality near St. George and Cedar City

5.2.7.1 St. George Area Groundwater Quality

Groundwater quality in St. George area was characterized by the U.S. Geological Survey (UDNR 2000) in connection with a hydrogeologic modeling study. Additional characterization in the vicinity of Sand Hollow was performed by the USGS (USGS 2005a; 2007d) as part of a study evaluating recharge of groundwater from Sand Hollow Reservoir. The former study evaluated the three major aquifers in the St. George area, whereas the latter study was limited to the Navajo/Kayenta aquifer region near Sand Hollow Reservoir in connection with an evaluation of groundwater recharge from the reservoir. Because this current document primarily addresses issues affected by the Lake Powell Pipeline, consideration of groundwater quality in the St. George area will be restricted to the vicinity of Sand Hollow and Quail Creek Reservoirs.

5.2.7.1.1 Sand Hollow. Sand Hollow Reservoir, 10 miles east of St. George, overlies primarily Navajo Sandstone and Quaternary basalt flows on top of the Navajo Sandstone. A thin veneer of sandy eolian soils covers part of the rock outcrop. Prior to construction and filling of Sand Hollow Reservoir, groundwater flowed northward. Since the filling of Sand Hollow Reservoir, the direction of groundwater flow is still primarily northward, but mounding as a result of recharge has created a local outward flow component in all directions (USGS 2005a). Volumetrically, the primary flow remains northward toward the Virgin River and away from the groundwater table mound. The dominant northward flow direction precludes recharge from the Pine Valley Mountains, northwest of the reservoir area, considered the primary source of regional groundwater recharge (UDNR 2000), the Hurricane Cliffs to the east, and the Virgin River to the north and west. This suggests that natural recharge in the vicinity of the reservoir occurs largely as a result of local precipitation within Sand Hollow. This is consistent with oxygen isotope analysis on groundwater in the Sand Hollow area, which is more similar to oxygen isotope analytical results for local precipitation than it is to groundwater elsewhere in the region that is recharged at a higher altitude in the Pine Valley Mountains (USGS 2005a). This controls the aquatic chemical characteristics of the natural groundwater prior to construction of Sand Hollow Reservoir.

Groundwater sampling collected prior to the construction of Sand Hollow Reservoir from wells and springs open to the Navajo Aquifer and in the vicinity of the reservoir indicate two general types of water quality. Samples from most locations have generally low TDS (less than 500 mg/L), relatively cool temperature (less than 20ºC), and are classified as a calcium-magnesium-carbonate type. This water quality is generally consistent with water quality elsewhere in the Navajo Aquifer, with slightly lower TDS probably because of local (Sand Hollow) recharge that would be unaffected by transport over or through other formations (UDNR 2000; USGS 2005a).

A cluster of samples north of the current location of the Sand Hollow Reservoir, south and east of the Virgin River and west of the City of Hurricane, have higher TDS (greater than 500 mg/L); samples from these wells tend to be warmer than at other locations, with some samples measured at greater than 20ºC. The warmer, higher TDS wells are generally of the calcium-sodium-sulfate type and are believed to represent a blending with deeper geothermal groundwater migrating up into the Navajo Aquifer through faults and fractures associated with the Hurricane Fault Zone a few miles to the west (UDNR 2000).

Sampling of monitoring and production wells in the immediate vicinity of Sand Hollow Reservoir was performed by the U.S. Geological Survey as part of a study of the effects of artificial recharge of Virgin River water on the Navajo Sandstone Aquifer in Sand Hollow. The groundwater sampling wells in the Sand Hollow Reservoir vicinity are shown in Figure 5-33. Sampling began at some locations between 1999 and 2001, before construction and filling of the reservoir with Virgin River water. Periodic or one-time sampling of selected wells occurred up through 2006, and reflects the effects, if any, caused by aquifer recharge. Analytical results of this sampling, as well as samples collected from the Virgin River and from Sand Hollow Reservoir, are shown in Table 5-8. A complete discussion of this study is provided by the USGS (USGS 2005a; 2007d).

Table 5-8
Pre- and Post-Filling Groundwater Quality Conditions at Sand Hollow Reservoir
Page 1 of 4

Map Number	Well Name	Date Sampled	Specific Conductance (µS/cm)	pH (standard units)	Total Dissolved Solids (mg/L)
5	WD 10	[1]06/12/2001	375	7.8	202
		09/13/2001	365	7.8	---
		05/07/2003	350	7.8	---
		10/13/2003	350	7.7	---
6	Well 4	08/29/2001	480	8.0	---
		09/11/2002	495	8.1	297
		10/15/2003	475	7.9	---
8	WD 4	04/02/1999	355	8.2	---
		12/18/2002	350	7.7	205
		01/19/2006	345	8.0	---
9	WD 6	05/15/2001	130	7.6	88
		08/28/2001	185	7.7	---
		09/09/2002	290	7.7	167
		12/17/2002	400	7.6	---
		03/19/2003	425	7.5	251
		05/07/2003	450	7.5	276
		06/09/2003	390	7.8	---
		08/04/2003	350	7.5	234
		10/06/2003	400	7.6	239
		01/08/2004	300	7/7	172
		05/03/2004	700	7.4	446
		02/09/2005	445	7.9	269
		04/05/2005	460	7.6	---
		01/19/2006	684	7.6	---

Table 5-8
Pre- and Post-Filling Groundwater Quality Conditions at Sand Hollow Reservoir

Map Number	Well Name	Date Sampled	Specific Conductance (μS/cm)	pH (standard units)	Total Dissolved Solids (mg/L)
10	Well 8	10/08/2002	550	7.5	323
		10/09/2003	430	7.6	242
		09/21/2004	530	7/7	312
28	North Dam 3A	10/08/2002	4,430	8.0	3,020
		12/18/2002	2,830	8.0	1,890
		03/19/2003	1,200	7.9	750
		06/10/2003	1,330	7.8	842
		08/04/2003	1,130	7.8	677
		10/09/2003	1,230	7.8	723
		01/08/2004	1,220	8.2	779
		05/03/2004	1,300	7.7	828
		09/21/2004	980	7.7	610
		10/29/2004	905	7.9	---
		12/14/2004	960	8.0	---
		02/10/2005	960	7.7	614
		04/05/2005	960	7.8	---
		01/19/2006	835	8.0	---
30	North Dam Drain	09/11/2002	2,090	8.0	1,450
		12/18/2002	1,530	8.1	1,070
		03/19/2003	1,400	8.0	923
		05/08/2003	1,250	8.0	810
		06/10/2003	430	8.1	829
		08/06/2003	920	8.1	659
		01/08/2004	980	8.3	624
		05/03/2004	1,050	7.9	637
32	WD RJ	04/02/1999	560	8.2	---
		12/17/2002	530	7.7	309
		01/18/2006	550	7.7	---
33	WD 5	[1]04/03/1999	540	8.3	---
		12/17/2002	530	7.8	311
		01/18/2006	528	7.9	---
34	WD 3	12/19/2000	465	---	---
		01/18/2006	460	7.9	---
36	WD 11	[1]06/14/2001	420	7.8	232
		12/16/2002	455	7.6	---
		06/09/2003	650	7.9	386
		08/05/2003	700	7.8	482
		10/07/2003	800	7.8	460
		01/06/2004	770	7.8	450
		05/03/2004	680	7.7	440
		09/20/2004	920	8.2	---

Table 5-8
Pre- and Post-Filling Groundwater Quality Conditions at Sand Hollow Reservoir

Map Number	Well Name	Date Sampled	Specific Conductance (µS/cm)	pH (standard units)	Total Dissolved Solids (mg/L)
		02/09/2005	960	8.1	667
		01/18/2006	977	7.9	---
37	WD 9	[1]05/23/2001	335	7.7	---
		09/14/2001	280	7.4	---
		09/11/2002	335	7.9	189
		05/07/2003	315	7.8	---
		06/09/2003	350	7.7	230
		08/05/2003	720	7.5	344
		10/07/2003	740	7.5	445
		01/06/2004	630	7.7	405
		05/03/2004	545	7.4	240
		09/20/2004	750	7.8	480
		02/09/2005	780	7.6	50.3
		04/09/2005	815	7.7	---
		01/18/2006	1,233	7.9	---
38	Basin 1	[1]07/22/1999	---	---	---
		09/10/2001	620	7.6	---
39	Slope 1a	[1]04/28/1999	270	8.1	000
		09/12/2001	240	7.9	000
		09/09/2002	270	8.0	150
		03/20/2003	265	7.8	---
43	Hole O	[1]06/11/2001	465	7.6	---
		09/11/2001	425	8.0	000
44	WD 8	[1]05/21/2001	300	7.7	168
		09/12/2001	305	7.7	---
		09/09/2002	305	7.9	173
		05/08/2003	340	7.5	---
		10/16/2003	355	7.4	---
46	Basin 2	[1]07/21/1999	295	8.1	---
		08/27/2001	290	7.8	---
47	WD 13	08/30/2001	275	8.1	000
		10/16/2003	225	8.2	000
50	WD 7	09/10/2001	380	7.8	---
		05/07/2003	390	7.9	---
		10/08/2003	395	7.8	230
[2]VR	Virgin River	08/29/2001	850	8.4	---
		10/03/2001	820	8.2	---
		11/27/2001	850	8.1	---
[3]RES	Reservoir	09/10/2002	1,000	8.8	669
		03/20/2003	830	8.2	525
		06/10/2003	850	8.2	---

Table 5-8
Pre- and Post-Filling Groundwater Quality Conditions at Sand Hollow Reservoir
Page 4 of 4

Map Number	Well Name	Date Sampled	Specific Conductance (µS/cm)	pH (standard units)	Total Dissolved Solids (mg/L)
		08/06/2003	920	7.6	568
		10/07/2003	910	8.4	569
		01/08/2004	870	8.4	523
		05/05/2004	710	8.2	442
		09/22/2004	765	8.5	---
		02/10/2005	855	8.4	546
		01/18/2006	815	8.5	---

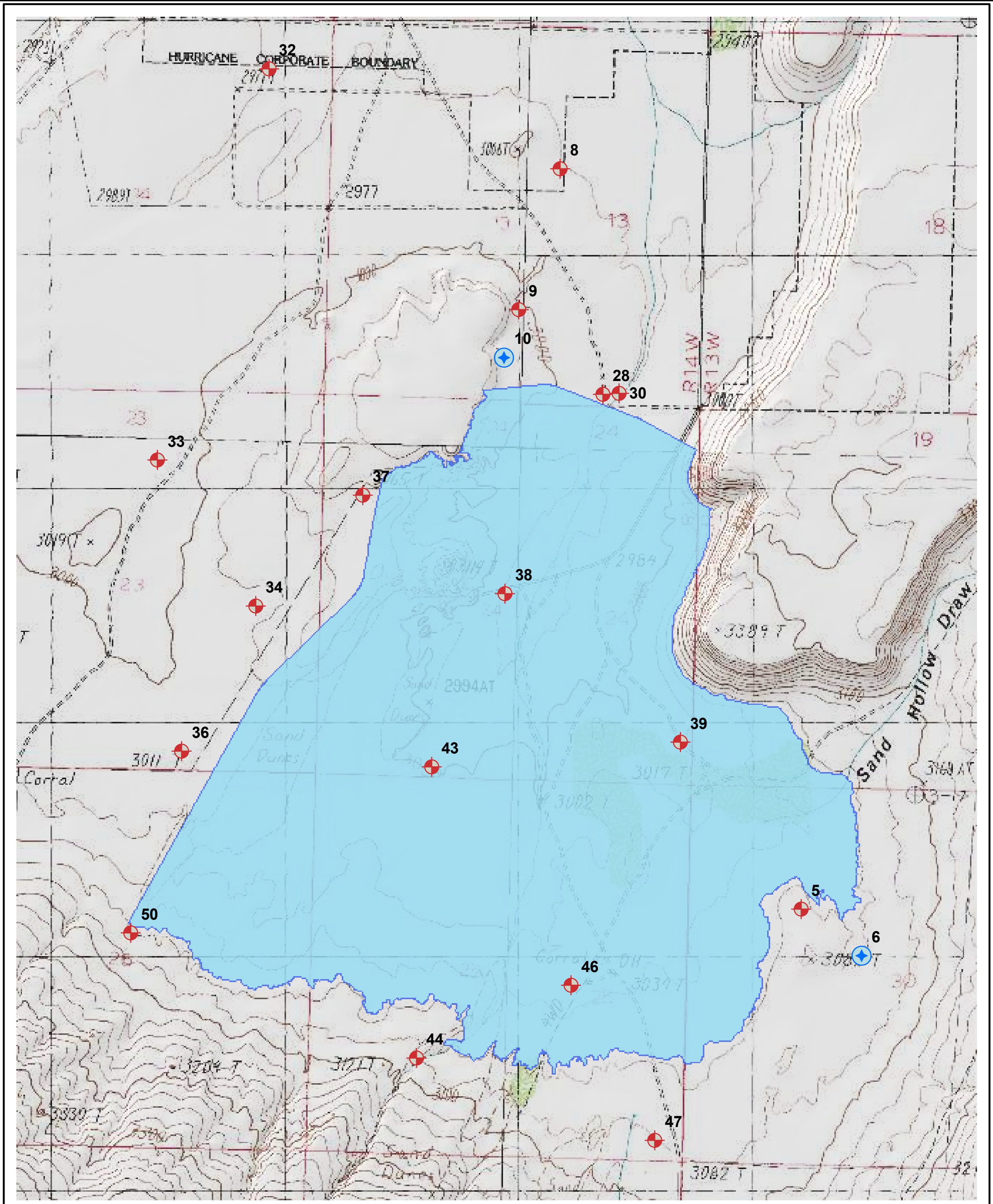
Notes:
[1]Sample collected in open hole prior to well installation.
[2]Surface water measured or sampled at Virgin River near Virgin, Utah.
[3]Surface water measured or sampled in Sand Hollow Reservoir, Utah.

Nine samples were collected prior to filling the reservoir from shallow wells (less than or equal to 250 feet deep) in late August or early September 2001, and therefore could be expected to represent similar shallow groundwater conditions. The sampled wells were from locations all around the perimeter of the current reservoir footprint as well as from within its interior. Specific conductance for samples from this sampling event ranged from a low of 185 µS/cm to a high of 620 µS/cm, with only one sample below 240 µS/cm and one sample above 380 µS/cm. The median value was 290 µS/cm. By comparison, specific conductance for the Virgin River during that sampling period was 850 µS/cm, which is generally consistent with sampling analyses collected before and after that date.

Only limited TDS data are available for wells sampled prior to filling Sand Hollow Reservoir, although many wells have TDS data collected during and after filling. Measured TDS in wells prior to filling the reservoir ranged from 88 mg/L in well #9 to 232 mg/L in well #36. No TDS analyses were conducted for the August-September 2001, pre-reservoir sampling event.

Hem (USGS 1985) has identified a linear relationship between specific conductance and TDS. Although the relationship is not universally applicable, it generally holds true that the ratio of the concentration of TDS to specific conductance is typically between 0.55 and 0.75. A comparison of ratios of TDS to specific conductance for data collect at various wells at Sand Hollow confirms this relationship, with most ratios between about 0.60 and 0.68. Assuming that a ratio of 0.65 is reasonably representative, the median TDS value for shallow groundwater from the August to September 2001 pre-reservoir sampling event can be derived from the median value for specific conductance and is estimated to be approximately 190 mg/L. Using the Virgin River specific conductance of 850 µS/cm for the August to September 2001 sampling event, the estimated TDS for Virgin River water is approximately 550 mg/L. Measurements for both specific conductance and TDS in samples collected from Sand Hollow Reservoir water have generally been consistent with the measured specific conductance and estimated TDS for the Virgin River, as expected since the river water is the source of water in the reservoir.

The results of the USGS study show that recharge of the Navajo Aquifer from Virgin River water at Sand Hollow Reservoir is affecting some groundwater quality parameters at some locations but seems to have limited effect at other locations. Samples collected closer to the reservoir generally show more influence



Legend

- Ground-water monitoring well
- Production Well
- Lakes/Reservoirs

0 500 1,000 2,000 3,000 Feet

Lake Powell Pipeline Project

1:24,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 5-33** MWH

Groundwater Sampling Wells - Sand Hollow Reservoir Vicinity

than samples collected from wells further away, presumably because reservoir water hadn't migrated outward as far as the outer wells at the time of sampling and/or because mingling with natural aquifer water had diluted the effects of reservoir recharge water further from the point of recharge. Both water quality and the lateral range of influence from reservoir water generally have increased over time.

One indication of groundwater quality changes associated with recharge may be observed by looking at trends in the specific conductance of samples collected at selected locations on multiple dates. By looking at changes in specific conductance over time, beginning with samples collected prior to filling of the reservoir (initiated in March 2002), the influence of Virgin River water on Navajo Aquifer groundwater quality can be observed. Most wells closer to the reservoir show a greater change in specific conductance (and presumably also TDS) than wells further away. In most instances where specific conductance has been influenced by recharge, this change is upward. Samples from well #9, for example, located immediately north of the reservoir, had a measured specific conductance of 185 µS/cm when sampled in August 2001. This increased over time to 684 µS/cm when sampled in January 2006, an increase of more than 300 percent. Similarly, groundwater sampled from well #36, immediately west of the reservoir, showed an increase in specific conductance from 420 µS/cm in June 2001 to 977 µS/cm in January 2006, more than doubling. Other wells further from the reservoir have shown lower increases or no change (USGS 2005a; 2007d). Specific conductance in some well samples is actually higher than in reservoir water, suggesting that some initial leaching of salts may have occurred from vadose zone soils.

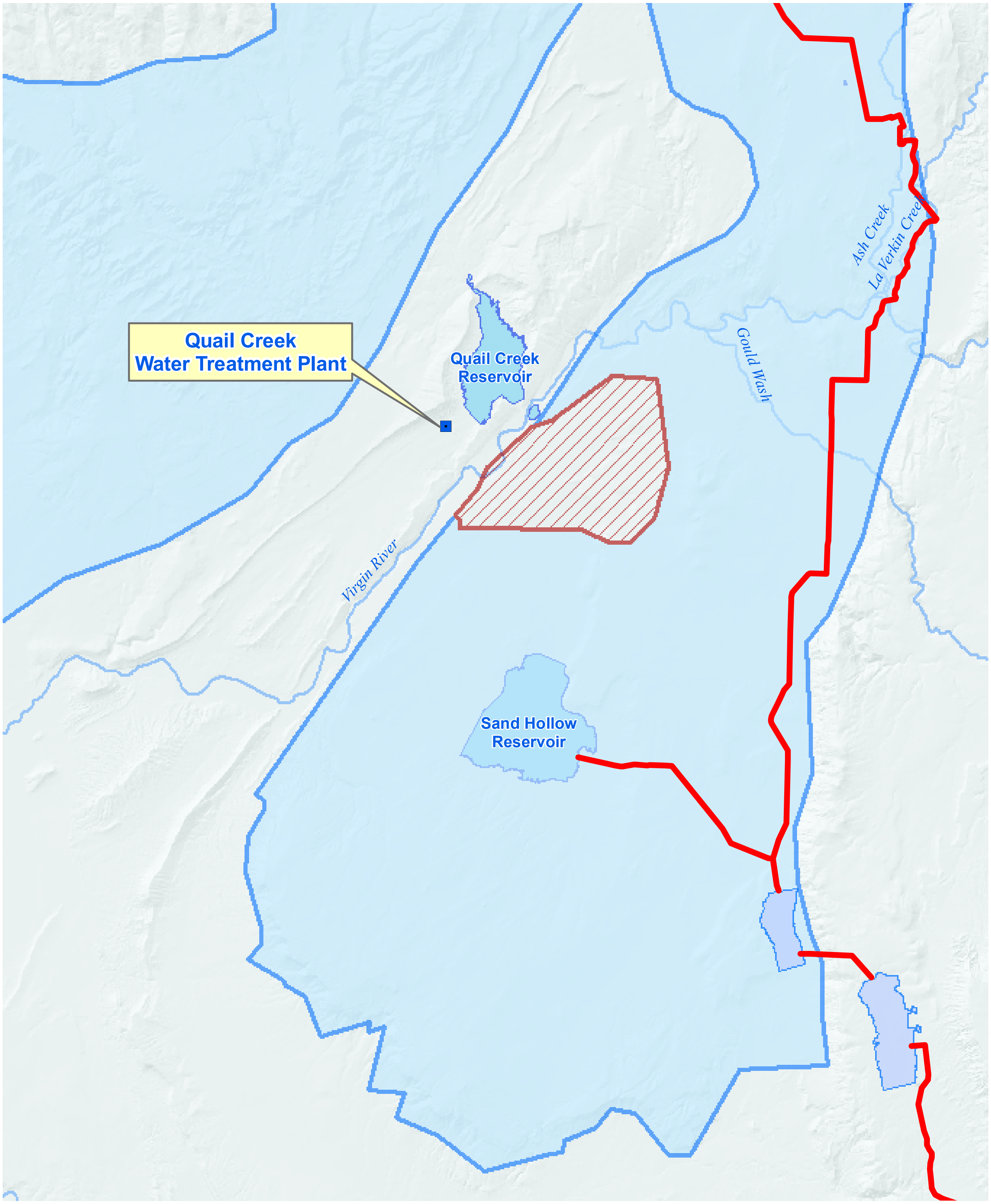
The Navajo Sandstone aquifer around Sand Hollow Reservoir has been classified under the State Groundwater Quality Classification System. A map of the classification areas is shown in Figure 5-34.

5.2.7.1.2 Quail Creek Reservoir. Quail Creek Reservoir is constructed in the hogsback depression created by the Virgin River Anticline, immediately north of the Virgin River. The reservoir is underlain by mudstone and evaporite/shale of the Shnabkaib Member of the Moenkopi Formation. It is highly fractured in places because of its association with the Virgin River Anticline, and a high gypsum content causes the rock to be very soluble, especially in fracture zones which contributed to failure of one of the dams in 1989 (UGA 2000). The Shnabkaib Member is normally considered to be of low permeability and therefore not a point of recharge to underlying groundwater, although extensive fracturing and dissolution of gypsum may result in some limited local recharge. Although locally important from a dam safety perspective, overall groundwater movement through the Moenkopi Formation is small, and the recharge contribution from Quail Creek Reservoir is unlikely to be an important factor in groundwater quantity or quality.

5.2.7.2 Cedar Valley Groundwater Quality

The aquifer system in the Cedar Valley occurs primarily in unconsolidated sediments associated with erosion of upthrown blocks of crust rock, typical of Basin and Range intermontane valleys. Sediments in the valley floor are derived from erosion of the mountains east and west of the valley, with most sediments originating in the mountains formed by the Hurricane Cliffs. Sediments tend to be coarser and more homogeneous near the margins of the valley, particularly on the eastern margin, and finer grained and more layered toward the center of the valley. As a result, both confined and unconfined aquifer conditions exist in the valley and tend to be more pronounced toward the center of the valley floor. In general, three primary aquifers have been identified, including an upper, unconfined aquifer and two deeper aquifers that behave as confined or semiconfined systems.

Recharge to the upper, unconfined aquifer occurs both as direct precipitation and from losing streams originating in the mountains, primarily in the higher elevations associated with the Hurricane Cliffs and Markagunt Plateau on the east, with Coal Creek near Cedar City being the largest single source of recharge from a losing stream as it crosses the alluvial fan near the mouth of Cedar Canyon. Irrigation



Legend

- Water Treatment Plants
- Project Alignment
- Hurricane Cliffs Forebay/Afterbay
- Major Rivers & Streams
- Lakes/Reservoirs

Aquifer Class

- Class 1A - Pristine Aquifer
- Class II - Drinking Water Aquifer

0 2,650 5,300 10,600 15,900 21,200 Feet

Lake Powell Pipeline Project

1:130,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 5-34** MWH

Sand Hollow Reservoir Area Groundwater Quality Classification

water derived both from deeper groundwater and from surface water diversions also provides an important component of recharge to the upper, unconfined aquifer. Recharge to the deeper, confined or semiconfined aquifers is believed to occur primarily from infiltration of streamflow and precipitation along the eastern valley margin, and to a lesser extent from bedrock discharge at depth associated with deep circulating groundwater in the mountains. A primary influence in groundwater quality in most locations is the water quality of streams that flow from the eastern mountains westward into the valleys and recharge the aquifers; also of importance is the geochemical nature of the porous media through which groundwater flows. Some limited recharge to the shallow, unconfined aquifer system also occurs from surface flow from streams originating in the Harmony Mountains and the Black Mountains, located west and north, respectively, of the Cedar Valley (USGS 2005b). Because these mountains are smaller in aerial extent and of lower elevation than the highland areas east of the valley, they contribute somewhat less to recharge of the valley aquifer system.

A collection of water quality data reported by Howells, Mason, and Slaugh (USGS 2002c) includes measurements of specific conductance, TDS, temperature, and other parameters in surface and groundwater samples from many locations in the Cedar Valley at irregular sampling intervals between 1961 and 2001. The water quality data sets provided in that report are too large to be included herein. The data presented by Howells, Mason, and Slaugh (USGS 2002c) as well as other studies are summarized in USGS (2005b).

Specific conductance measurements in Coal Creek, a major source of recharge for groundwater, are generally less than 1,000 µS/cm; the estimated TDS of Coal Creek water is calculated to be less than 650 mg/L. The water is classified as a calcium-magnesium-bicarbonate type. Shurtz (or Shirts) Creek, which flows westward into the valley from Cedar Mountain about five miles southwest of Coal Creek, is another surface source of recharge (but substantially smaller than Coal Creek). Shurtz Creek water is a calcium-bicarbonate-sulfate type water (USGS 2005b).

Groundwater quality varies considerably throughout the Cedar Valley. At Cedar City, high TDS (greater than 1,500 mg/L in the alluvial fan near the mouth of Cedar Canyon, greater than 1,000 mg/L in other parts of Cedar City) makes groundwater unsuitable for potable use. Cedar City gets its groundwater primarily from wells west of Quichapa Lake in the south central part of the valley, and from the City of Enoch area to the north (USGS 2005b). Springs in Shurtz Canyon and other springs located in mountain canyons east of the valley also are used for potable water. Most of the wells and springs used by Cedar City for potable purposes report average TDS concentrations between 110 and 280 mg/L, with combined average annual concentrations between 165 and 217 mg/L from 1998 to 2006. These potable water sources are from the Quichapa Lake Wellfield west of Quichapa Lake, two wells south of the City of Enoch, and springs in Shurtz Canyon and Cedar Canyon, as well as Spillsbury Spring in Quichapa Canyon, located in the Harmony Mountains southwest of the Quichapa Wellfield. High TDS is reported for groundwater samples from two production wells just north of Cedar City, with TDS at or greater than 1,000 mg/L in one well and at or greater than 2,000 mg/L in the other well in samples collected from 2003 to 2006 (Cedar City Engineer, 2007).

Cedar Valley aquifers have been classified under the State Groundwater Quality Classification System. A map of the Cedar Valley groundwater classification areas is shown in Figure 5-35. The classified areas include a classification of 1A (Pristine Aquifer) for most of the valley from Kanarraville in the south to the Black Mountains in the north. Most of the area in the southeast part of the valley, from a few miles south of the City of Enoch to Kanarraville Creek, is classified as Class 2 (Drinking Water Aquifer). Class 2 designation also is applied to a small area northwest of the City of Enoch near Rush Lake, as well as a very small area at Mud Spring Wash about 15 miles northwest of Enoch. Class 3 (Limited Use Aquifer) is assigned to a portion of the valley in the north central part of Cedar City and continuing northward to about two miles south of the City of Enoch.

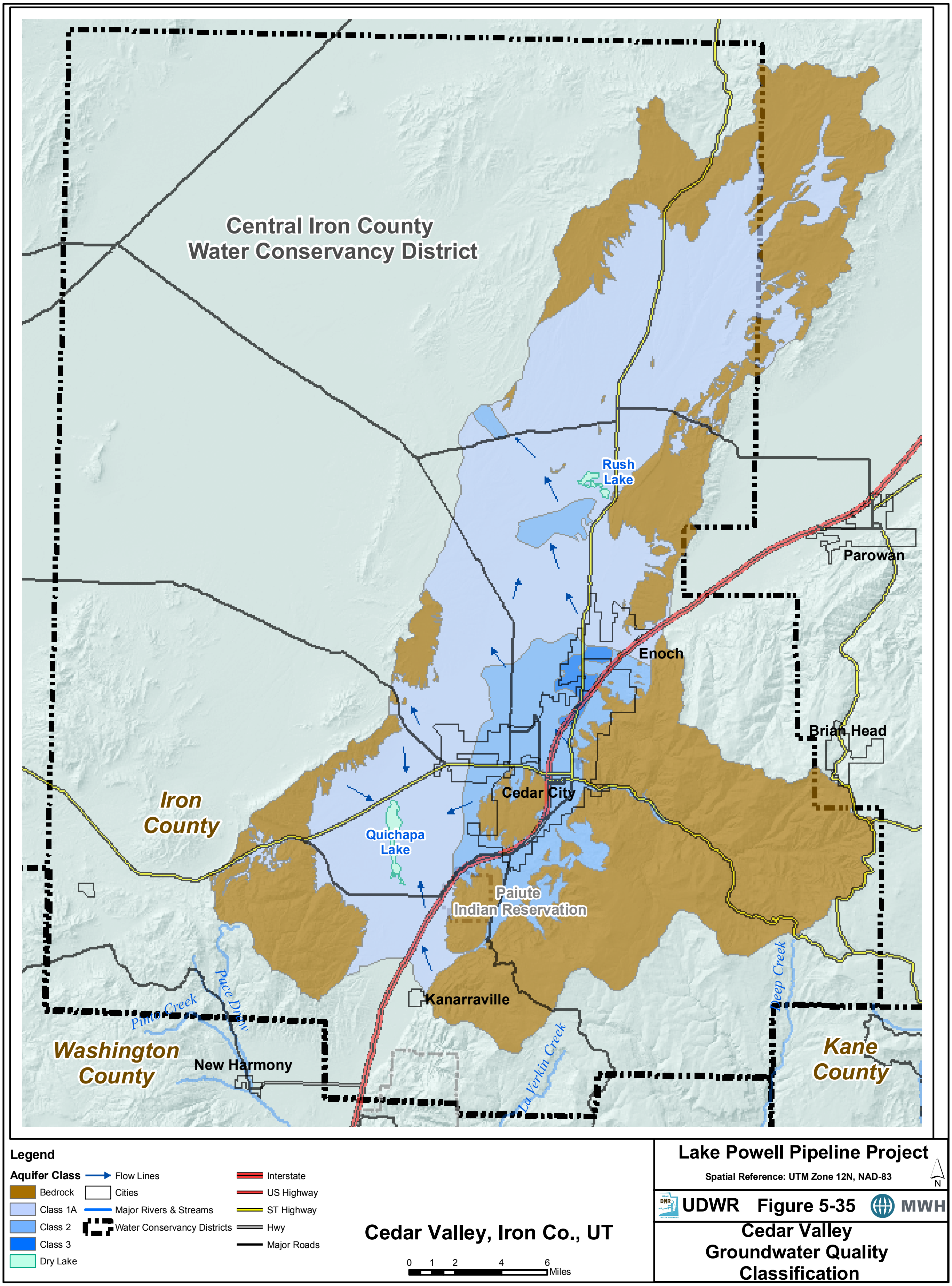


Figure 5-35
Cedar Valley Groundwater Quality Classification

5.3 Fish and Aquatic Resources

5.3.1 Watershed Fish Resources

There are numerous drainages within the Project area that convey water intermittently or during storm events. The Paria River and the Virgin River are the only drainages that convey perennial flow across the Project alignment.

The Paria River originates in Utah and flows south for 30 miles, from the Utah border through Paria Canyon, to its terminus at Lees Ferry on the Colorado River. It has been considered as suitable for inclusion into the National Wild and Scenic Rivers system. The river is turbid much of the year and carries large quantities of suspended sediment. Meaning “muddy water” in the Paiute Indian language, the Paria River at the Project crossing location is a muddy, shallow, perennial stream and potentially provides habitat for a variety of fish and wildlife species. The Paria River, along with the Little Colorado River, currently contributes to sediment loads in the Colorado River through the Grand Canyon, and paints the Colorado River red even during relatively low runoff. The runoff is high in TDS, mostly consisting of sulfates (BLM 2007a).

The Paria River provides habitat for Flannelmouth sucker (*Catostomus latipinnis*), Bluehead sucker (*Catostomus discobolus*), Razorback sucker (*Xyrauchen texanus*), Rainbow trout (*Oncorhynchus mykiss*) and Speckled dace (*Rhinichthys osculus*). These fish, with the exception of Rainbow trout and Speckled dace, are considered sensitive by the State of Utah. The Razorback sucker is federally listed as endangered and is discussed in further detail in the Rare, Threatened, Endangered and Special Status Species Section 5.7 of this document. The Bluehead sucker feeds on algae from the bottom of stream substrate and typically inhabits large rivers and mountain streams with variable turbidity and temperature. The Flannelmouth sucker is a bottom feeder consuming algae, other fragmented vegetation, seeds and invertebrates. The species lives within moderate to large rivers and is typically affected by nonnative species, hybridization, habitat alteration and blockage of migration routes. Rainbow trout is a game fish common in Utah reservoirs and rivers and can be found in water bodies associated with the Project area. The Speckled dace is a minnow common in many western waters. It is a bottom-dwelling species and is an important forage fish.

Kanab Creek north of Kanab has perennial flow through the narrow, rock canyon upstream of the Project pipeline alignment. Kanab Creek supports no large populations of sport fish because of the intermittent flows associated with the water feature (Utah Outdoors 2007). Flannelmouth sucker, a sensitive species, may be present in Kanab Creek upstream of the Project alignment (Speas 2003). Upstream users of the Kanab Creek in Utah divert flows for municipal and irrigation purposes, leaving it mostly dry in the summer season where the Project alignment would cross the creek (BLM 2007a).

The Virgin River provides perennial flow habitat for native, non-native and endangered fish species including the Woundfin minnow (*Plagopterus argentissimus*) and Virgin River chub (*Gila seminude*). The endangered fish species are discussed in the Rare, Threatened, Endangered and Special Status Species Section 5.7 of this document.

5.3.2 Reservoir Fish Resources

Sand Hollow Reservoir and Quail Creek Reservoir are off-stream, managed waters that were completed in 2002 and 1985, respectively. Fish species diversity in each of the reservoirs is fairly low, and predominantly is associated with introduced stock game fish. Game fish in Sand Hollow Reservoir include Bluegill (*Lepomis macrochirus*), Largemouth bass (*Micropterus salmoides*), and Bullhead catfish

(*Ictalurus melas*) (Angler Guide 2007). The Quail Creek Reservoir supports populations of Rainbow trout (*Oncorhynchus mykiss*), Largemouth bass (*Microptereus salmoides*), Bluegill (*Lepomis macrochirus*), and Threadfin shad (*Dorosoma petenense*). As of August, 2006, the reservoir had not been chemically treated to control rough fish competition, so the reservoir could contain some of the original fish populations of Quail Creek and the Virgin River (Quail Creek Reservoir 2006).

Lake Powell is a much larger reservoir and is older than Sand Hollow Reservoir or Quail Creek Reservoir with the Glen Canyon Dam construction completed and reservoir fill initiating in 1963. Hence, fish species diversity in this reservoir is much greater. The lake supports approximately 20 species of fish, the majority of which are introduced game fish. Game fish in Lake Powell include Rainbow trout (*Oncorhynchus mykiss*), Striped bass (*Morone saxatilis*), Largemouth bass (*Micropterus salmoides*), Smallmouth bass (*Micropterus dolomieui*), Walleye (*Stizostedion vitreum*), Channel catfish (*Ictalurus punctatus*), Bullhead catfish (*Ictalurus melas*), Black crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), and Green sunfish (*Lepomis cyanellus*) (Blue Ribbon Fisheries 2006). Open water habitats in Lake Powell are dominated by bass; however Lake Powell is a highly productive fishery for all above-listed species.

5.3.3 Watershed Aquatic Resources

In 1979, the BLM reported that natural channeling of stream bottoms associated with the Paria River system and repeated over-utilization of forage by livestock had reduced the acreage and quality of riparian habitat along the Paria River and had impaired, and in some cases, nearly eliminated aquatic habitat in the river (BLM 1979). The BLM found that water quality in the Paria River declined with the impairment of the riparian habitat, particularly that resulting from adverse impacts of flooding and livestock grazing. As a result, BLM management practices changed and livestock have not grazed the upper 20 miles of the river for decades, although the lower 7 miles of the Paria River above Lees Ferry continued to be grazed.

BLM management practices on the lower segment of the Paria River changed in the 1980s from year-long grazing to seasonal (winter - spring) use under a three-pasture, rest-rotation system (BLM 2007a). This grazing system brought changes to vegetation along the Paria River such as increased growth of perennial grasses, cottonwoods, tamarisk, and willows. In turn, the aquatic habitats associated with the riparian vegetation improved. By 1998, cattle were completely removed from the lower segment and livestock grazing has not occurred since then (BLM 2007a). Aquatic habitat in the Paria River now supports aquatic invertebrates and amphibians, evidenced by the presence of Rainbow trout and sensitive fish species.

Species such as tadpoles, wire worms, and salamanders can be found in association with the vernal pools of Coral Pink Sand Dunes State Park, UT and may be found in other Project areas as well (UDP&R 2004).

The invasive New Zealand mudsnail (*Potamopyrgus antipodarum*) has recently been found in several trout streams in Utah and throughout the West, however this species has not been reported within the Paria River or Kanab Creek and has not been reported within the Project area. New Zealand mudsnails are very hardy, are capable of surviving several days out of water, reproduce asexually, and can flourish in most waters (Utah Fishing Proclamation 2006).

The Virgin River is home to various aquatic resources. The Virgin River Resource Management and Recovery Program has been established to help recover various sensitive and listed species within the river including the Woundfin minnow (*Plagopterus argentissimus*) and the Virgin River chub (*Gila seminuda*), which are both federally listed as endangered species and are discussed in further detail in the

Rare, Threatened, Endangered, and Sensitive Species, Section 5.7. The Virgin River Resource Management and Recovery Program also aims to provide habitat to other native fish while allowing for continued use of the water resources. Woundfin minnow and Virgin River chub rely on substantial water flows on a year-round basis, and part of the habitat protection goals for these species include eliminating reaches of dry channel during parts of the year to support habitat critical for these species as well as others (USFWS 2000).

5.3.4 Reservoir Aquatic Resources

Quail Creek Reservoir is not considered eutrophic because sediments have not yet accumulated in quantity (Quail Creek Reservoir 2006). Aquatic diversity is fairly low in Quail Creek Reservoir as well as in Sand Hollow Reservoir. Quail Creek Reservoir and Sand Hollow Reservoir have been planted with trout, bluegill, and largemouth bass. Threadfin shad (*Dorosoma petenense*) are an abundant food base for larger predatory fish in Quail Creek Reservoir.

There are approximately 35 species of fish, reptiles and amphibians in the Lake Powell area (NPS 2005). Threadfin shad (*Dorosoma petenense*) are very abundant and form the food base for larger predatory fish, especially striped bass (NPS 2005). Other species present include Flannelmouth sucker (*Catostomus latipinnis*), Razorback sucker (*Xyrauchen texanus*), Redside shiner (*Richardsonius balteatus*), Colorado pikeminnow (*Ptychocheilus lucius*), Speckled dace (*Rhinichthys osculus*), and Fathead minnow (*Pimephales promelas*). Crayfish also are commonly found in Lake Powell.

Zebra mussels (*Dreissena polymorpha*), quagga mussels (*Dreissena rostriformis bugensis*) and Asian clams (*Corbicula fluminea*) are exotic mollusk species whose occurrence is slowly moving west. Recent findings indicate “the presence of an extremely small number of individual, larval quagga or zebra mussels in Lake Powell” (USFWS et al. 2007). The extent to which Lake Powell has been influenced to date by these mussels remains minimal. Measures to prevent the spread and infestation of mussels in Lake Powell include boat decontamination stations available in Glen Canyon National Recreation Area marinas. Quagga and zebra mussels and Asian clams are present in Lake Mead and have been documented to foul water intake structures. The Utah Division of Wildlife Resources has hired aquatic resource biologists and technicians, and has purchase mobile sprayers for use in decontaminating boats. The Utah Division of Wildlife Resources is preparing a plan to help control the spread of invasive mussel and clam species.

The Spiny water flea (*Bythotrephes cederstroemi*), a small, invasive, nearly microscopic crustacean from Australia, was recently found in Lake Powell. The species is very prolific and can cause food cycle changes in reservoirs that can be detrimental to sport fisheries. Native zooplanktons are a more desirable food source for game fish than the Spiny water flea. Biologists believe that the Spiny water flea may displace native zooplanktons in Lake Powell (Trophy 2007).

5.4 Wildlife Resources

This section discusses the various general wildlife species present within various locations of the project area. It does not discuss threatened, endangered, sensitive or special status species that may be within the Project area. These species are discussed within the Rare, Threatened, Endangered, and Special Status Species, Section 5.7.

5.4.1 Lake Powell Area

There are approximately 80 species of mammals, 35 species of reptiles and amphibians, and 200 species of birds within the Lake Powell area (NPS 2005). Common small mammals in the Project vicinity include Jackrabbit (*Lepus californicus*), Ord kangaroo rat (*Dipodomys ordi*), Deer mouse (*Peromyscus maniculatus*), Pocket mouse (*Chaetodipus spp.* and *Perognathus spp.*), and Woodrat (*Neotoma spp.*). Large mammals such as Coyote (*Canis latrans*) and Mule deer (*Odocoileus hemionus*) are occasionally observed. Plateau striped whiptail lizard (*Cnemidophorus velox*) are abundant. Other common reptiles include Gopher snake (*Pituophis catenifer*), Western rattlesnake (*Crotalus viridis*), Desert spiny lizard (*Sceloporus magister*), and Side-blotched lizard (*Uta stansburiana*). The Common raven (*Corvus corax*) is the most evident resident bird; other large birds that are regularly present include Golden eagle (*Aquila chrysaetos*) and Red- tailed hawk (*Buteo jamaicensis*). The Golden eagle is federally protected under the Bald Eagle Act of 1962, is of concern to the State of Arizona, and is discussed further in Section 5.7 of this document. The Great-tailed grackle (*Quiscalus mexicanus*) is ubiquitous around the campgrounds and marinas of Lake Powell, while the Canyon wren (*Catherpes mexicanus*) is frequently seen and heard in the canyon country surrounding the lake. Common waterfowl include Mallard (*Anas platyrhynchos*), Coot (*Fulica americana*), and Western grebe (*Aechmophorus occidentalis*). Yellow warbler (*Dendroica petechia*), Say's phoebe (*Sayornis saya*), and Blue-grey gnatcatcher (*Polioptila caerulea*) are among the various species of migratory birds found in the Lake Powell area (NPS 2005).

5.4.2 Pipeline Alignment

The Project alignment is situated within wildlife habitats for various species. The following subsections identify wildlife habitats and provide descriptions of habitats present within the Project area.

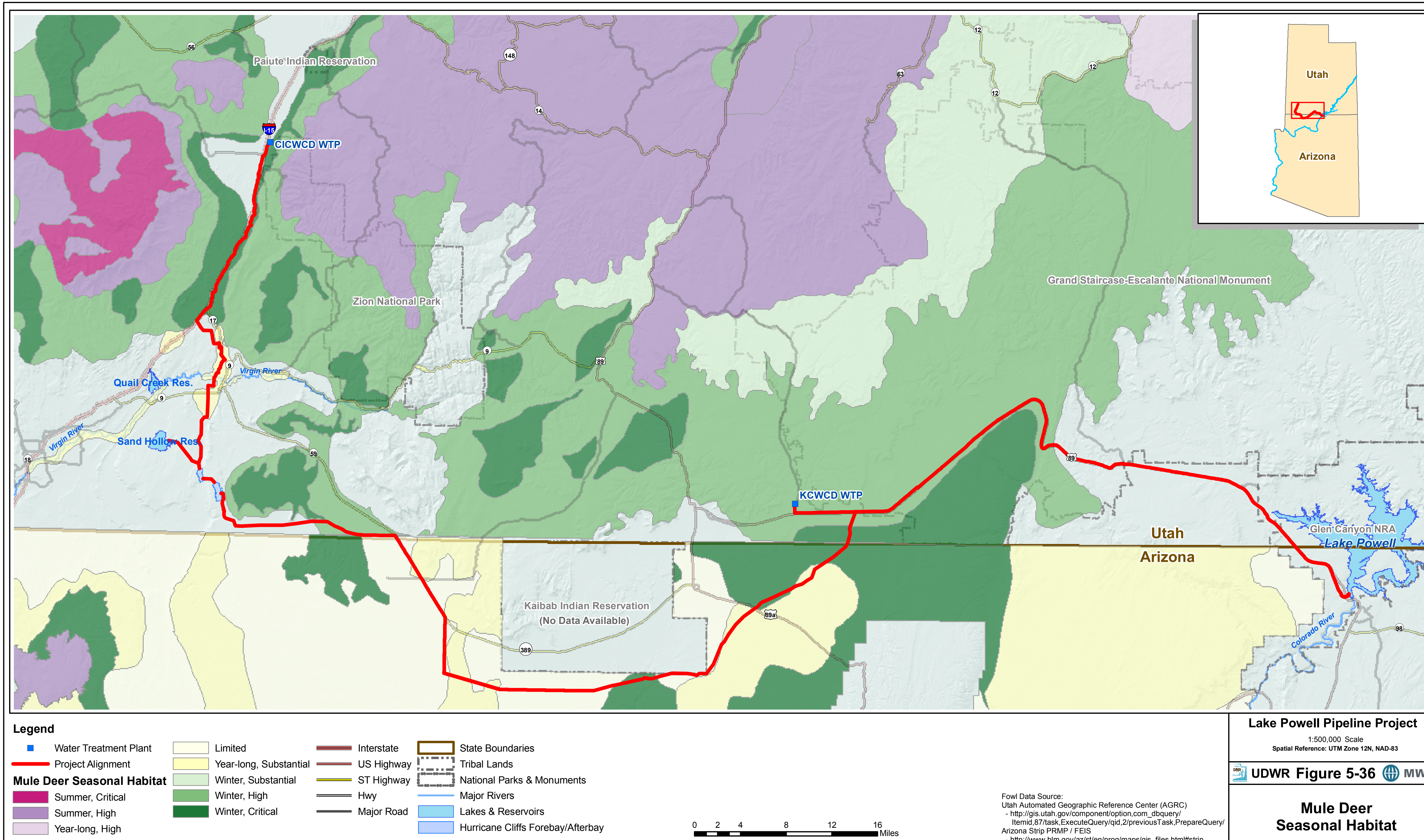
5.4.2.1 Mule Deer

Mule deer habitat occurs along most segments of the Project alignment (see Figure 5-36). Mule deer were not common in the Project area prior to the arrival of early settlers, but populations began increasing during the early 1900s. Populations peaked during the 1960s following decades of intensive predator control measures. Since that time, Mule deer herds have cycled through several decline and recovery periods. The current Mule deer population is considered by the State of Arizona to be low but stable (BLM 2007b). Northern Arizona and southern Utah provide winter habitat range for Mule deer. Mule deer are documented to use the Little Creek Mountain area during winter months and are generally found in association with open, rough, sparsely vegetated canyons or grasslands. Mule deer frequently bed in juniper or shrubby areas (BLM 2007b).

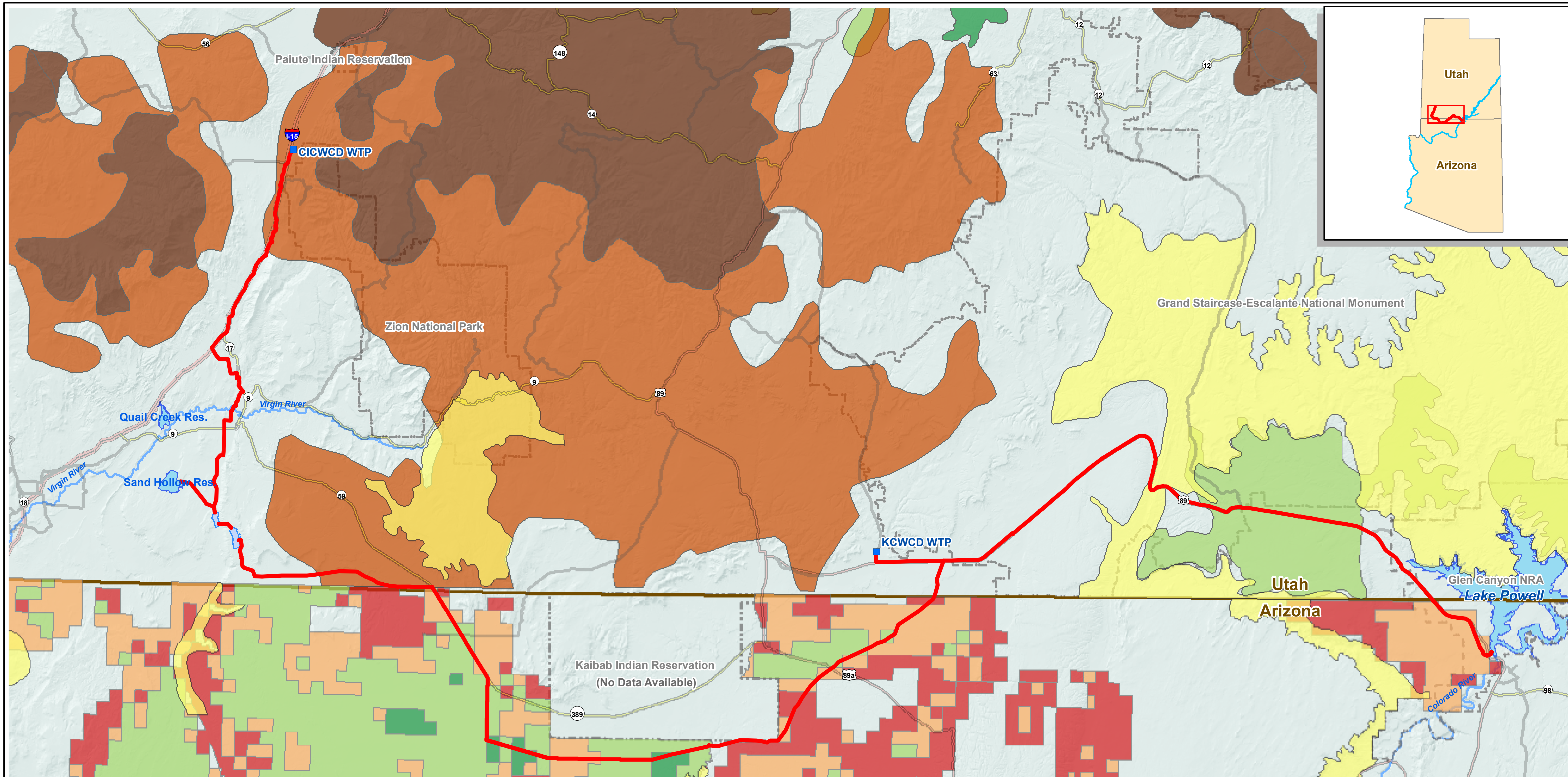
5.4.2.2 Pronghorn Antelope

Pronghorn antelope habitat occurs along segments of the Project alignment except for the Cedar City pipeline (see Figure 5-37). Pronghorn antelope are native to the project area, with early residents having reported that antelope were common. However, the species was eliminated from the area in the early 1900s but reintroduced beginning in 1961; re-introduction efforts continue today. Populations since the 1980s have been low, but stable. Management actions to help restore pronghorn to their former ranges include modifying fences to allow pronghorn antelope movement and access to water, improving forage species composition and diversity, and developing or making other water sources available for Pronghorn antelope (BLM 2007c).

Rangelands in northern Arizona and southern Utah are utilized by Pronghorn antelope and are comprised of some of the greater vicinity's best Pronghorn antelope habitat. Forbs and shrubby growth with open



Paiute Indian Reservation
CICWCD WTP
I-15
Zion National Park
Grand Staircase-Escalante National Monument
Quail Creek Res.
Virgin River
Virgin River
Sand Hollow Res.
KCWCD WTP
Glen Canyon NRA
Lake Powell
Utah
Arizona
Kaibab Indian Reservation
(No Data Available)
Colorado River
56
148
14
63
12
12
12
17
9
9
9
89
89
59
18
89a
389
98
Utah
Arizona
Legend
Water Treatment Plant
Project Alignment
Mule Deer Seasonal Habitat
Summer, Critical
Summer, High
Year-long, High
Limited
Year-long, Substantial
Winter, Substantial
Winter, High
Winter, Critical
Interstate
US Highway
ST Highway
Hwy
Major Road
State Boundaries
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
Hurricane Cliffs Forebay/Afterbay
0 2 4 8 12 16
Miles
Fowl Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://gis.utah.gov/component/option,com_dbquery/
Itemid,87/task,ExecuteQuery/qid,2/previousTask,PrepareQuery/
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip
Lake Powell Pipeline Project
1:500,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR Figure 5-36 MWH
Mule Deer
Seasonal Habitat



Legend

Water Treatment Plant	**UT Desert Bighorn Sheep**	Interstate	State Boundaries
Project Alignment	Year-long, Critical	US Highway	Tribal Lands
UT Black Bear	**AZ Pronghorn Habitat**	ST Highway	National Parks & Monuments
Year-long, High	High	Hwy	Major Rivers
Year-long, Substantial	Moderate	Major Road	Lakes & Reservoirs
UT Pronghorn	Low Quality		Hurricane Cliffs Forebay/Afterbay
Year-long,Critical	Poor Quality		
Year-long, High			

0 2 4 8 12 16
Miles

Fowl Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://gis.utah.gov/component/option,com_dbquery/Itemid,87/task,ExecuteQuery/qid,2/previousTask,PrepareQuery/
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip

Lake Powell Pipeline Project

1:500,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 5-37** MWH

Pronghorn Antelope, Bighorn Sheep & Black Bear Habitat

landscapes are ideal for Pronghorn antelope as they rely on their sense of vision and unobstructed views to detect predators. Pronghorn antelope habitat is further typified by sparsely vegetated flatlands and low hills with stands of various grasses and prickly pear cactus. The greatest mortality of Pronghorn antelope occurs during the first two months of life, with most fawns born in June. This mortality is largely attributed to coyote, bobcats, and golden eagles that prey on fawns (BLM 2007c). Pronghorn antelope are highly mobile and can cover a large range throughout the year (BLM 2007c), though several highways in northern Arizona and southern Utah impede their mobility.

5.4.2.3 Wild Turkey

A wild turkey habitat corridor is perpendicular to the Project pipeline alignment. The corridor intersects a portion of the Project alignment near Grand Staircase-Escalante National Monument (GSENM). Wild turkey habitat within the Project area is shown on Figure 5-38.

5.4.2.4 Gambel's Quail

Gambel's quail habitat is present in the westernmost portion of the Project pipeline alignment and along the Cedar City pipeline alignment. Gambel's quail are found near Sand Hollow Reservoir and Quail Creek Reservoir. Gambel's quail habitat within the Project area is shown on Figure 5-38.

5.4.2.5 Desert Bighorn Sheep

A Desert bighorn sheep habitat corridor intersects the Project alignment, extending perpendicular to the Project area for approximately two miles of the pipeline alignment. The habitat corridor is west of the Lake Powell intake area and shown on Figure 5-37. Desert bighorn sheep habitat is not present along the Cedar City pipeline alignment. Bighorn sheep habitat is typically comprised of rocky, rough terrain near canyons and washes. Often found in blackbrush habitats as well as grasslands, Bighorn sheep also are known to utilize pinyon-juniper woodlands (BLM 2007d). Bighorn sheep can be found in woodland habitats or canyon rims throughout the year near in northern Arizona and southern Utah.

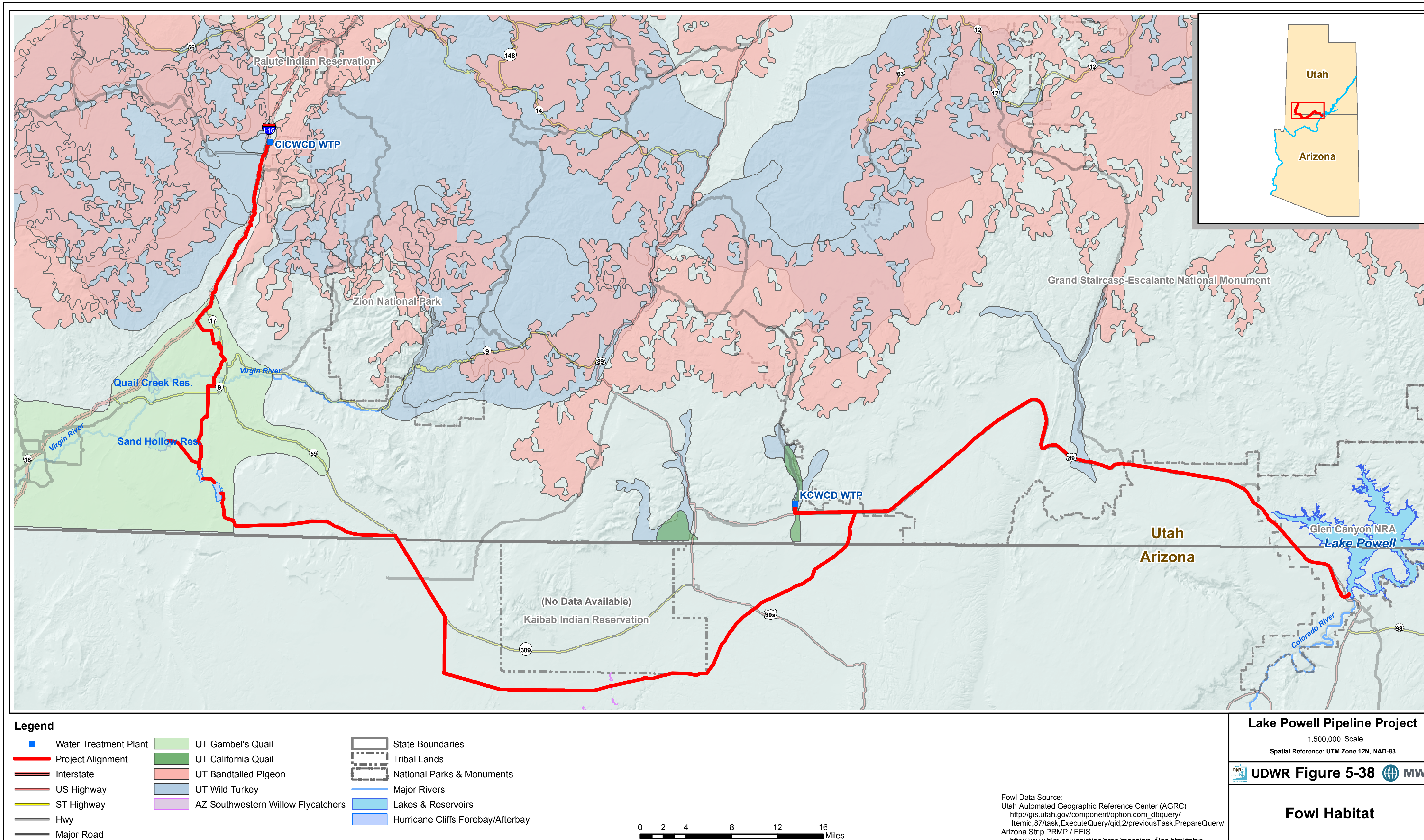
With the exception of occasional sightings, Bighorn sheep were believed to have been eliminated from this habitat location around the turn of the century. In a cooperative effort between the BLM and Arizona Game and Fish beginning in 1979, Bighorn sheep were re-introduced into the suitable habitat areas. These successful reintroduction and reproduction efforts have resulted in a gradual increase in the populations of Desert Bighorn sheep. Bighorn sheep populations now appear to be stable (BLM 2007d).

5.4.2.6 Black Bear

Black bear habitat intersects the Project alignment on the westernmost part of the pipeline and also intersects a portion of the Cedar City alignment as shown in Figure 5-37. This habitat has been determined by the State of Utah to be "high to substantial" in value for Black bears.

5.4.3 Quail Creek Reservoir and Sand Hollow Reservoir Areas

The areas around Quail Creek Reservoir and Sand Hollow Reservoir provide habitat for birds, waterfowl, migratory birds and raptors. Mule deer utilize areas near Quail Creek Reservoir throughout all seasons of the year (Utah Division of Wildlife Resources 2007a), and both reservoirs provide habitat for Gambel's quail (Utah Division of Wildlife Resources 2007b). Reptiles and amphibians found include snakes, toads, frogs, lizards, and tortoises. The majority of wildlife associated with the reservoir areas are associated with game fish (Section 5.3).


Paiute Indian Reservation
CICWCD WTP
Zion National Park
Grand Staircase-Escalante National Monument
Quail Creek Res.
Virgin River
Sand Hollow Res.
KCWCD WTP
Utah
Arizona
Glen Canyon NRA
Lake Powell
(No Data Available)
Kaibab Indian Reservation
Colorado River
Legend
Water Treatment Plant
Project Alignment
Interstate
US Highway
ST Highway
Hwy
Major Road
UT Gambel's Quail
UT California Quail
UT Bandtailed Pigeon
UT Wild Turkey
AZ Southwestern Willow Flycatchers
State Boundaries
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
Hurricane Cliffs Forebay/Afterbay
0 2 4 8 12 16 Miles
Fowl Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://gis.utah.gov/component/option,com_dbquery/Itemid,87/task,ExecuteQuery/qid,2/previousTask,PrepareQuery/
Arizona Strip PRMP / FEIS
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Lake Powell Pipeline Project
1:500,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR Figure 5-38 MWH
Fowl Habitat

5.5 Botanical Resources

5.5.1 Vegetation Along the Project Pipeline Alignment

The Project pipeline alignment is dominated by grassland and sagebrush typical of Great Basin plant communities. In smaller, more isolated areas generally east of the Kaibab Indian Reservation, mixed shrub and Great Basin blackbrush vegetation are also prominent. Dominant plant species within project grassland areas include gramma, muhly, needlegrass, wheatgrass, brome, galleta, fescue, and dropseed (BLM 2007e). Basin big sagebrush is a common species found within sagebrush vegetation zones, while sand sage dominates on sandy soils. Sagebrush communities along the pipeline alignment may include shadscale, which is usually found between sagebrush and greasewood-dominated communities and is also associated with harsh, cold deserts on dry plains, foothills, valley bottoms, or dried alkali lakes. Common associates to shadscale include black greasewood, big sagebrush, winterfat, spiny hopsage, blue gramma, needle-and-thread, wild ryes, cheatgrass, Indian ricegrass, and alkali sacaton (BLM 2007e). Communities of pinyon-juniper are also present east of the Kaibab Indian Reservation.

Within the Project vicinity, blackbrush communities are found in localized areas east of the Reservation along the penstock alignment. Blackbrush communities are typically found on gentle slopes above creosote bush communities and below big sagebrush/pinyon-juniper communities. Blackbrush communities are characterized by low stature evergreen woody shrubs dominated by blackbrush, which can comprise up to 90 to 95 percent of the total plant cover (BLM 2007e). Blackbrush may take over 100 years to re-establish itself when killed, which typically occurs because of fire. It is co-dominant with other native species such as creosote, juniper, desert almond, Anderson wolfberry, and yucca. Dominant invasive species include cheatgrass and filaree, but blackbrush communities are known to change little over several decades, exhibiting very low reproductive rates and slow growth.

Pinyon-juniper occurs in isolated areas along the Project alignment at higher elevations. Pinyon and juniper are the dominant tree species of the pinyon-juniper vegetation zone. Common pinyon, called either two-leaf or Colorado pinyon, is more dominant than the single leaf pinyon, which is occasionally found. Utah juniper is the most common juniper present, with one-seed juniper occasionally found. One-seed juniper is a climax species in a number of pinyon-juniper, sagebrush, grassland, and shrub-steppe communities. The understories of pinyon-juniper and dense mature juniper woodlands can be considered species-poor, containing only widely scattered shrubs, forbs, and small clumps of grass (BLM 2007e).

Though sparse, grasses comprise the most common understory component of the pinyon-juniper communities. Predominant grasses include grama, Arizona fescue, prairie junegrass, Indian ricegrass, needlegrass, dropseed, and squirreltail. Shrubs may include sagebrush, cliffrose, serviceberry, rabbitbrush, shadscale, and winterfat. Understory plants are most common along the edges of the zone, though bare ground is also very common (BLM 2005).

5.5.2 Vegetation Along the Cedar City Alignment

Undeveloped areas are comprised predominantly of sagebrush and pinyon-juniper woodland vegetation types. Precipitation along the Cedar City Alignment area averages 11.6 inches per year (Iron County Commission 1998) and mainly occurs during winter months with occasional summer storms contributing to the annual precipitation average (NRCS 2007). The moisture derived from this precipitation combined with higher elevations with cooler temperatures results in more woody vegetation communities compared with the Project pipeline alignment. The predominant land use within the Cedar City alignment is agriculture with the remainder of the land mostly undeveloped, though some conversion to urbanized landscape has occurred in recent years. Agricultural lands along the Cedar City corridor are considered by the State of Utah as “farmland of statewide importance” and “prime farmland if irrigated” (NRCS 2007). Local agriculturists have expressed concerns related to the invasion of unwanted and unproductive plant species on rangelands and farm fields such as pinyon-juniper encroachments and invasion of cheatgrass and other noxious weeds that can decrease productivity of farm areas (NRCS 2007).

5.5.3 Invasive Species

Weed infestations present problems for agriculturalists as well as land managers within the Project area. Infestations most frequently occur in areas where soil and native vegetation has been disturbed or totally removed (i.e. road sides, livestock trails, reservoir sites, and flood damaged areas). Noxious weeds and invasive plant species often exclude other vegetation, reducing species diversity and changing habitats. If unrestricted, noxious weeds and invasive species often begins to occupy additional public and private lands. The BLM is required by law to control noxious weeds in areas they manage (BLM 2005).

Various invasive plant species designated as restricted noxious weeds have been identified as likely occurring within the Project area. These include Russian knapweed (*Acroptilon repens*), camelthorn (*Alhagi maurorum*), globed-podded hoary cress/whitetop (*Cardaria draba*), diffuse knapweed (*Centaureau diffusa*), spotted knapweed (*Centaureau maculosa*), halogeton (*Halogeton glomeratus*), three-lobed morning glory (*Ipomoea triloba*), and scotch thistle (*Onopordum acanthium*) (BLM 2007e). Iron County, Utah has declared the poison western whorled milkweed (*Asclepias subverticillata*) to be a noxious weed in their county (NRCS 2007). According to the NRCS Rapid Watershed Assessment for Iron County, the following weeds were officially designated and published as noxious for the State of Utah, as per the Utah Noxious Weed Act. These identified species may occur within the Project area (NRCS 2007):

- Bermudagrass (*Cynodon dactylon*)
- Canada thistle (*Cirsium arvense*)
- Diffuse knapweed (*Centaurea diffusa*)
- Dyers woad (*Isatis tinctoria L*)
- Field bindweed (Wild Morning Glory) (*Convolvulus arvensis*)
- Hoary cress (*Cardaria drabe*)
- Johnsongrass (*Sorghum halepense*)
- Leafy spurge (*Euphorbia esula*)
- Medusahead (*Taeniatherum caput-medusae*)
- Musk thistle (*Carduus mutans*)
- Perennial pepperweed (*Lepidium latifolium*)
- Perennial sorghum (*Sorghum halepense L* & *Sorghum almum*)
- Purple loosestrife (*Lythrum salicaria L.*)
- Quackgrass (*Agropyron repens*)
- Russian knapweed (*Centaurea repens*)
- Scotch thistle (*Onopordum acanthium*)
- Spotted knapweed (*Centaurea maculosa*)
- Squarrose knapweed (*Centaurea squarrosa*)
- Yellow starthistle (*Centaurea solstitialis*)

Field analysis is necessary to determine the presence of these and/or other invasive plants along the Project alignment.

5.5.4 Vegetation near Lake Powell

At the Project intake area, Lake Powell is located on the Colorado Plateau and lies within the Great Basin desert scrub biotic community (NPS 2005). Blackbrush (*Coleogyne ramosissima*) and shadscale (*Atriplex confertifolia*) are known to be dominant vegetation near the Project alignment. Other species known to be in the Project vicinity include Mormon tea (*Ephedra torreyana*), yucca (*Yucca angustissima*), snakeweed (*Gutierrezia microcephala*), and sand sagebrush (*Artemesia filifolia*). Sparsely distributed vegetation with bare ground and sandstone rock are known to be common in the area (NPS 2005).

5.5.5 Non-Vegetated Areas

There are various locations within the Project area that can be considered non-vegetated. Non-vegetated lands consist of areas with less than 30 percent vegetation cover and generally include lava outcrops, canyon cliffs, and sparsely vegetated sand dunes (BLM 2005). Colorado Plateau cliffs, talus slopes, and canyons occur near Lake Powell and the Paria River and include sparsely vegetated landscapes with steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary rocks. The Colorado Plateau cliffs and canyons are largely composed of exposed bedrock (usually sedimentary) and scree (BLM 2005).

5.6 Wetlands and Riparian Resources

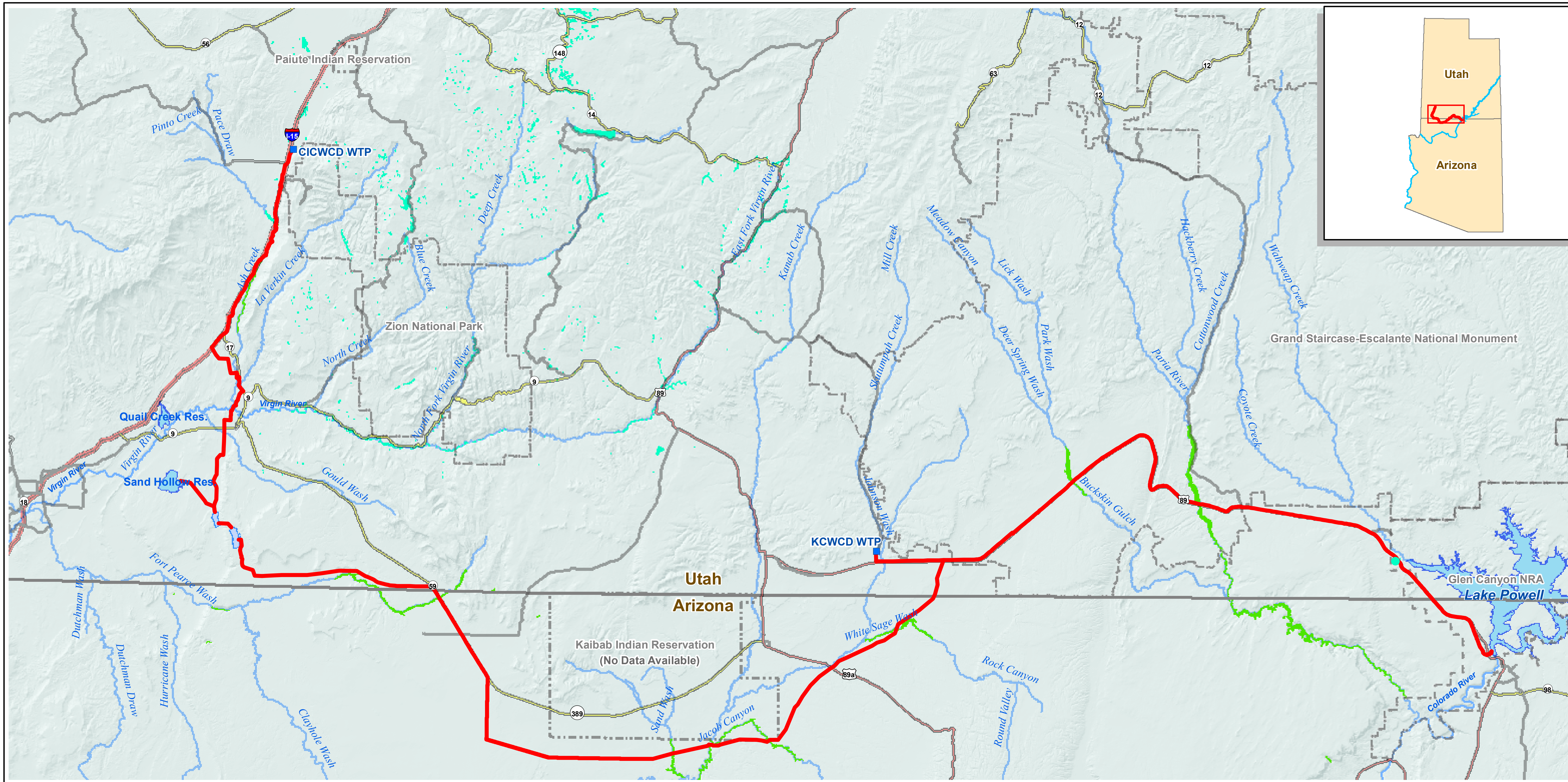
5.6.1 Wetlands

Wetland areas are defined by federal policy as areas inundated or saturated by surface or groundwater at a duration and frequency sufficient to support vegetation typically adapted for saturated soil conditions. Wetland areas typically comprise marshes, shallow swamps, lakeshores, wet meadows, and riparian areas and are often along or adjacent to perennial or intermittent water bodies. Ephemeral streams or washes often do not exhibit the presence of vegetation dependant on saturated soils and are infrequently considered wetlands under Federal policy (BLM 2005). Wetland and riparian areas have been identified as the two top habitats of priority within the Utah state-wide area as theses resources provide vital habitat for various species of greatest conservation need (NRCS 2007).

Few wetland areas exist within the Project area because of the arid climate generally associated with the Project. Mapping from the State of Utah and Arizona BLM indicates that there are two designated wetland areas that could intersect with the Project alignment. One area is situated along the Cedar City pipeline alignment in Iron County, parallel to Interstate 15. The other wetland area occurs along Highway 89 in Kane County within the Glen Canyon National Recreation Area. Wetlands occurring within the Project area are shown on Figure 5-39.

5.6.2 Riparian Resources

Riparian areas form a transition between permanently saturated and upland areas and typically exhibit vegetation and physical characteristics associated with permanent sources of surface or subsurface water. The Project alignment would cross several riparian areas along, adjacent to, or contiguous with perennial and intermittent rivers or water bodies (see Figure 5-39). Although accounting for a small percentage of the overall Project area, riparian areas are among the most productive and important ecosystems in the Project vicinity; as a general rule riparian areas have a greater diversity of flora and fauna than adjacent uplands. Riparian systems filter and purify water, reduce sediment loads, enhance soil stability, provide



Legend

Water Treatment Plant	Interstate	Wetlands
Project Alignment	US Highway	Riparian Areas
State Boundaries	ST Highway	Streams and Ephemeral Channels
Tribal Lands	Hwy	Lakes & Reservoirs
National Parks & Monuments	Major Road	Hurricane Cliffs Forebay/Afterbay

0 2 4 8 12 16 Miles

Fowl Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://gis.utah.gov/component/option,com_dbquery/Itemid,87/task,ExecuteQuery/qid,2/previousTask,PrepareQuery/
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip

Lake Powell Pipeline Project

1:500,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 5-39** MWH

Wetland & Riparian Areas

microclimatic moderation when contrasted with extremes in adjacent areas, and can contribute to groundwater recharge and base flow.

Native riparian-associated vegetation in the project area includes cottonwoods, willows, seep willows, arrowweed, ash, cattails, rushes, and sedges as well as a variety of grasses and forbs. Most of the riparian areas also contain invasive weeds. Tamarisk and Russian olive are considered woody invasive species; rabbit foot, dallisgrass, Bermuda grasses, cocklebur, and thistles are considered herbaceous invasive species. These common riparian vegetation species are likely to be found within riparian zones crossed by the Project pipeline alignment.

The Project alignment would cross riparian resources along the Paria River, Buckskin Gulch, White Sage Wash, Jacob Canyon, Kanab Creek, Bitter Seeps Wash, Short Creek, Ash Creek, and along highway crossings of unnamed tributary drainages. The Paria River riparian ecological zone is known for low base flows with seasonal flash floods of sizeable proportions (BLM 2007a). Historically degraded because of over-grazing, the Paria River's riparian system has substantially recovered as grazing practices have been modified and in some cases, eliminated from the area. Positive changes in riparian vegetation along the Paria River are evident in the growth and proliferation of perennial grasses, cottonwoods, and willows (BLM 2007a). The history of grazing management changes in the area is discussed further in the Aquatic Watershed Resources, Section 5.3. The Kanab Creek riparian zone is currently in proper, functioning condition with typical riparian vegetation present. Kanab Creek is open to livestock grazing from October to mid-April (BLM 2005).

5.7 Rare, Threatened, Endangered and Special Status Species

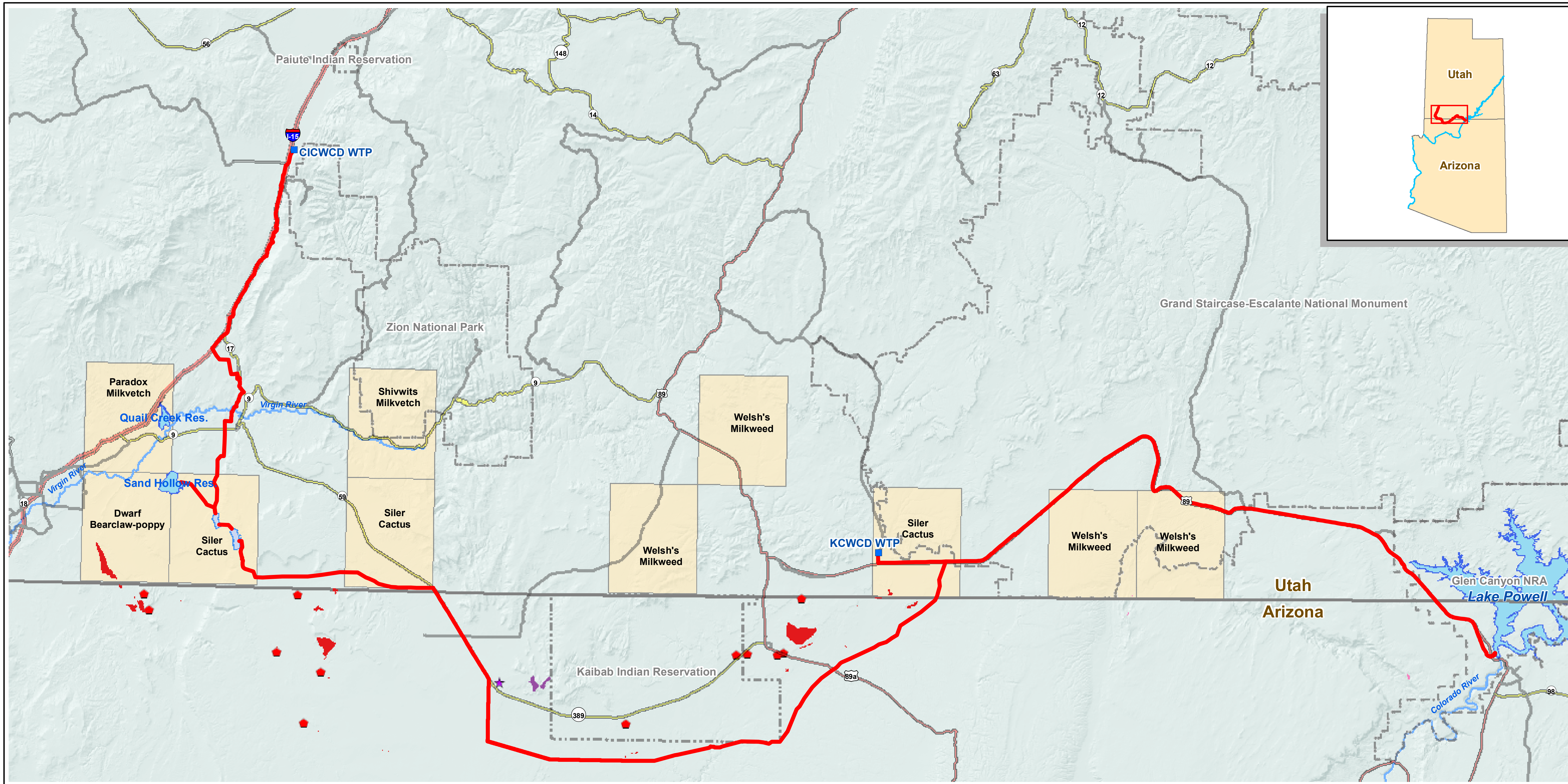
Special status species include those federally listed as threatened or endangered under the Endangered Species Act (ESA); those proposed for or that are candidates for federal listing; species considered as wildlife of special concern by the State of Arizona or State of Utah; and those species identified by the BLM as sensitive or rare. All species identified as sensitive must be managed proactively to minimize the need for future listing as threatened or endangered under the ESA.

5.7.1 Special Status Plants

There is a high potential that seven sensitive plants occur within the Project area, though others also may be present within the Project area. Those with high potential include Dwarf bearclaw poppy (*Arctomecon califonica*), Siler's pincushion cactus *(Pediocactus sileri)*, Jones cycladenia (*Cycladenia humilis var. jonesii*), Welch's milkweed (*Asclepias welshii*), Yellow beavertail (*Opuntia basilaris var. aurea*) Holmgren milkvetch (*Astragalus homgrenorium*), and Gumbo milk-vetch (*Astragalus ampullarius*). Figure 5-40 shows species habitats, and special status plants likely occurring within the Project area are addressed in the following sections.

5.7.1.1 Jones Waxy-Dogbane

Jones cycladenia (*Cycladenia humilis var. jonesii*) Apocynaceae, also known as Jones waxy-dogbane, is federally listed as threatened. Its habitat often includes mixed desert scrub, juniper or wild buckwheat-mormon tea plant communities and is found on gypsiferous, saline soils. Exacting soil requirements and low fruit set typify the species (Arizona Game and Fish 2007).



Legend

- Water Treatment Plant
- Project Alignment
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road

Federal T&E Plants in AZ

- Siler pincushion
- Jones cyclad
- Welsh's milkweed
- Siler's Pincushion Cactus
- Jones Cycladenia
- Federal T&E Plants in UT by Quad

- State Boundaries
- Tribal Lands
- National Parks & Monuments
- Major Rivers
- Lakes & Reservoirs
- Hurricane Cliffs Forebay/Afterbay

0 2 4 8 12 16 Miles

T & E Plant Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://dwrcdc.nr.utah.gov/ucdc/ViewReports/plantrpt.htm
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip

Lake Powell Pipeline Project

1:500,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 5-40** MWH

Federally Listed Threatened & Endangered Plants

5.7.1.2 Holmgren Milkvetch

Holmgren milkvetch (*Astragalus homgrenorium*) Fabacae, commonly known as Paradox milkvetch, is federally listed as endangered and has a narrow habitat area. Two known populations exist near St. George and the plant has been found in Mohave County, Arizona on Arizona State Lands. The species establishes itself at elevations ranging from 2,700 feet to 2,800 feet just under limestone ridges and along draws in gravelly clay hills (USFWS 2006).

5.7.1.3 Welch's Milkweed

Welch's milkweed (*Asclepias welshii*) is a tall, herbaceous plant in the milkweed family listed as threatened under the ESA. When a recovery plan was developed in 1992, the species was known in three population areas including the Coral Pink Sand Dunes, Sand Hills (8 miles north of Kanab), and in Sand Cove, about 28 miles east of Kanab. No other historic populations are known to have existed (USFWS 1992). The species is vulnerable to habitat destruction from off-road vehicles and potentially natural factors such as disease, competition, and grazing by native species.

5.7.1.4 Yellow Beavertail

Yellow beavertail (*Opuntia basilaris var. aurea*), also known as Yellow prickly pear cactus or Creeping beavertail prickly pear cactus, is found in northern Arizona and southern Utah between 5,200 and 5,500 feet elevation, typically in red sandy soils. This cactus is a species of concern in the State of Arizona.

5.7.1.5 Dwarf Bearclaw Poppy

Dwarf bearclaw poppy (*Arctomecon califonica*) was listed as endangered under the ESA in 1979. The plant grows on gypsum-rich soil and occupies restricted land on the eastern edge of the Mohave Desert in Washington County, Utah, in the vicinity of St. George. Dwarf bearclaw poppy is characterized by several unique features including its stature, leaf morphology and floral parts (USFWS 1985). Its short, leafy peduncles are 4.5 to 6 inches tall. White flowers appear to float above the cluster of leaves, accentuating the plant's low stature. Dwarf bearclaw poppy usually has four petals, while other similar poppies commonly possess six petals (USFWS 1985).

5.7.1.6 Siler's Pincushion Cactus

Siler's pincushion cactus *(Pediocactus sileri)* was first listed on October 26, 1979 and is currently federally listed as threatened under the ESA. This small, solitary, or occasionally clustered cactus grows to about 5 inches tall and 3 to 4 inches in diameter, although some have been known to grow up to 18 inches tall. Flowers are yellowish with maroon veins that bloom in spring. The species is found exclusively on gypsiferous clay to sandy soils high in soluble salts, derived from the Moenkopi formation, with a restricted range in desert shrub communities (USFWS 2007). This species is known to occur primarily on BLM lands in Arizona and within Kane County and Washington County, Utah. Threats to this species include disturbance from off-road vehicle use, livestock, insecticide spraying, and possibly mining. Species decline also has resulted from private and commercial collection of the plant (BLM 2005).

When recovery and habitat management plans were written and implemented in the early 1990s, it was determined that the cactus was more abundant and widespread than believed at the time of listing. Trend studies, first undertaken in the 1980s, have demonstrated relatively stable populations with some fluctuations caused by precipitation and rodent depredations. The species was consequently down-listed in 1993 and a petition for de-listing was submitted in 2002, though today the plant is still listed as threatened (USFWS 2007).

5.7.1.7 Gumbo Milkvetch

Gumbo milk-vetch (*Astragalus ampullarius*) is a herbaceous, flowering perennial of concern in the State of Arizona. The species is endemic to clay soils in the Chinle Formation in western Kane and Washington counties, Utah, and adjacent northern Mohave and Coconino counties, Arizona (Arizona Game and Fish 2005). The plant occurs in small populations in narrowly restricted locations.

5.7.2 Special Status Mammals and Birds

Several sensitive birds and mammals are likely within the project area. Those highly likely or known to be within the Project area include the Utah prairie dog (*Cynomys parvidens*), Ferruginous hawk (*Buteo regalis*), American peregrine falcon (*Falco peregrinus anatum*), Bald eagle (*Haliaeetus leucocephalus*), Golden eagle (*Aquila chrysaetos*), Desert tortoise (*Gopherus agassizii*) and Southwestern willow flycatcher (*Empidonax traillii extimus*). These special status species are addressed in the following sections.

5.7.2.1 Utah Prairie Dog

The Utah prairie dog is listed as a federally threatened species that occurs only in southwestern Utah. The majority of this species occurs in Iron County on private lands along the Interstate 15 corridor (Iron County Commission 1998). There have been past conflicts between the Utah prairie dog and the development of private lands. The Utah Division of Wildlife Resources has developed a Habitat Conservation Plan to protect the species (NRCS 2007). Prairie dog recovery areas are present within the project area, predominantly along the I-15 corridor (NRCS 2007).

5.7.2.2 Ferruginous Hawk

Ferruginous hawks *(Buteo regalis)* are currently federally listed as a species of concern and are found in locations throughout most of the state of Utah. Ferruginous hawks are likely found along the Project alignment including the Cedar City pipeline as the hawk can be associated with prairie dog colonies. Productivity in Ferruginous hawks can be directly correlated with the availability of prey base such as jackrabbits and/or prairie dogs. As jackrabbit populations are known to be cyclical, Ferruginous hawk populations can undergo similar booms and crashes. Breeding Ferruginous hawks rely on grassland or shrubsteppe terrain and, in many parts of Utah, they nest on the ecotone between these habitats and pinyon-juniper woodlands (BLM 2005).

5.7.2.3 American Peregrine Falcon

The American peregrine falcon (*Falco peregrine anatum*) is a medium-sized raptor that occurs across much of North America and inhabits rocky, steep cliffs, preferably near open water (USFWS 1994). The falcon may inhabit areas within or near the project area during the entire year. The arid southwestern U.S. supports breeding peregrine falcons and the bird has been documented as occurring in Paria Canyon, Vermillion Cliffs, Kanab Creek Canyon, Hurricane Cliffs, the Virgin Mountains, as well as in other areas not associated with the Project. The American peregrine falcon was one of the first species protected under the Endangered Species Act. In 1999, it was officially declared recovered and removed from the endangered species list. The USFWS, states, and other groups continue to monitor peregrine falcon populations to ensure the species' long-term survival (USFWS 2007).

5.7.2.4 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*), which were recently delisted federally as a threatened species, winter throughout Utah and Arizona and are generally known to roost in large cottonwood trees associated with open, agricultural fields. It is likely that Bald eagle roosts are present along the I-15 corridor area associated with the Project.

5.7.2.5 Golden Eagle

The Golden eagle is federally protected under the Bald Eagle Act of 1962. The species is of concern in the State of Arizona and is likely found within the Project area.

5.7.2.6 Desert Tortoise

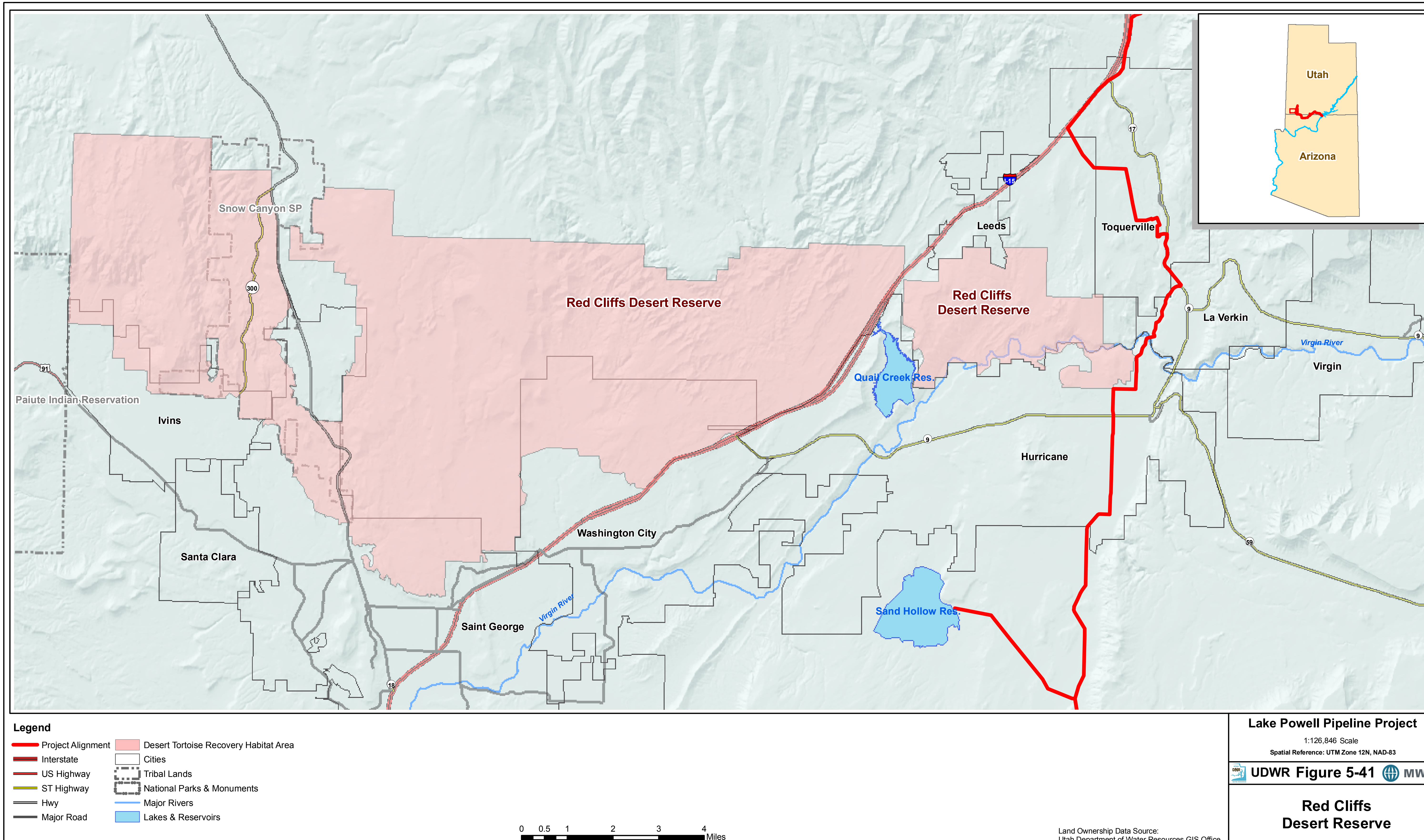
The Desert tortoise (*Gopherus agassizii*) has been listed as a threatened species under the ESA since 1990. Within the Project vicinity habitat recovery units are located between St. George and Leeds in an area known as the Red Cliffs Desert Preserve and the population within this habitat is considered a part of the Upper Virgin River Mojave population. Figure 5-41 shows the relationship between Desert tortoise habitat recovery units (habitat) and the Cedar Valley Pipeline System alignment. The Cedar Valley Pipeline System alignment would be located east of Desert tortoise habitat. A Habitat Conservation Plan has been in place since 1995 to address specific recovery actions (Washington County Commission 1995).

Though Desert tortoise can occupy variable terrain and slopes and typically prefer flats and alluvial fan areas with sand or sandy-gravel soils and herbaceous plant growth, individuals in the Upper Virgin River population are often found in sandstone crevices or rock caves and tend to burrow in sand (FWS 1994). The Upper Virgin River population is known to prefer transitional vegetation habitat such as Sagebrush scrub, Sand sage, and Blackbush scrub and feed on perennial grasses, cacti, and summer and winter annuals (FWS 1994).

Desert tortoise population decline is attributed to human-caused mortality associated with direct take and destruction, degradation and habitat fragmentation. The tortoise also is threatened by an upper respiratory tract disease that causes mortality in the species (FWS 1994). Although population density of Upper Virgin River Desert tortoise is high in comparison to other recovery units, the degree of threat to the species is the highest of all recovery units for this population as well.

5.7.2.7 Southwestern Willow Flycatcher

The Southwestern willow flycatcher is federally listed as endangered and is primarily found in lowland riparian habitats, but may be found in mountain riparian habitats in southwestern North America. Its breeding range includes, but is not limited to, portions of Utah and Arizona. The Virgin River basin is the northern extreme of the species' range, with 3 known pairs in southwest Utah. The subspecies was listed as endangered effective March 29, 1995, and approximately 900 to 1,100 pairs existed as of 2002 (USFWS 2002a). Critical habitat established in 2004 includes the Virgin River floodplain from the Utah/Arizona state line to the Washington Fields diversion. Wetlands comprise the flycatcher's habitat and breeding areas. Shrubby clearings, pastures, and woodlands near water likely comprise winter habitat for the species, though requirements for wintering are not well understood. Destruction and modification of riparian habitats has been thought to reduce population levels. Parasitism by the Brown-headed cowbird (*Molothrus ater*) has been known to further reduce population levels. The Southwestern willow flycatcher may occupy riparian areas, wetlands, and lake-side reservoir habitats near the Project area


Snow Canyon SP
Red Cliffs Desert Reserve
Red Cliffs
Desert Reserve
Paiute Indian Reservation
Ivins
Santa Clara
Washington City
Saint George
Leeds
Toquerville
La Verkin
Virgin
Hurricane
Quail Creek Res.
Sand Hollow Res.
Virgin River
Virgin River
Utah
Arizona
Legend
Project Alignment
Interstate
US Highway
ST Highway
Hwy
Major Road
Desert Tortoise Recovery Habitat Area
Cities
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
0 0.5 1 2 3 4 Miles
Land Ownership Data Source:
Utah Department of Water Resources GIS Office
Lake Powell Pipeline Project
1:126,846 Scale
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 5-41 MWH
Red Cliffs
Desert Reserve

(USFWS 2004).Southwestern willow flycatcher recovery in Utah is addressed in the Virgin River Resource Management and Recovery Program.

5.7.3 Special Status Invertebrates and Fish

One rare invertebrate has a remote potential of being located within the Project area. The Desert spring snail (*Pyrgulopsis deserta*) was found in specific spring habitats in Washington County, Utah. Endangered fish species that may be associated with the Project area including the Woundfin minnow (*Plagopterus argentissimus*), Virgin River chub (*Gila seminude*), and the Razorback sucker (*Xyrauchen texanus*). Several species including the Flannelmouth sucker *(Catostomus latipinnis)*, and Bluehead sucker (*Catostomus discobolus*) may be within the Project area

and are considered sensitive by the State of Arizona and the State of Utah. Speckled dace (*Rhinichthys osculus reliquus*) is considered a sensitive species by BLM only in Arizona. Although there are a variety of threatened, endangered, and sensitive fish species associated with the Colorado River and Lake Powell area, there are no known sensitive fish species present near the Project intake site on Lake Powell. Special status invertebrate and fish species are addressed in the following sections.

5.7.3.1 Desert Spring Snail

The Desert spring snail (*Pyrgulopsis deserta*) is known to be located in six springs in Washington County, based on specimens collected in the 1970s. The current status of known populations, not reported since material was collected in the 1970s, is yet to be determined. Potential threats to this species include disturbance and degradation of springs by livestock trampling or by human recreation, rapid urban and agricultural development, and modifications of the springs this species may inhabit (Arizona Game and Fish 2004).

5.7.3.2 Woundfin Minnow

The Woundfin minnow (*Plagopterus argentissimus)* is federally listed as endangered and is a small, silver minnow that inhabits shallow runs and riffles. The species is found only in the Virgin River below the La Verkin Hot Springs. Recovery efforts for the Woundfin minnow are addressed through the Virgin River Resource Management and Recovery Program, which was established in January of 1995 to implement actions to recover, conserve, enhance and protect native species in the Virgin River Basin and to enhance the ability to provide adequate water supplies for sustaining human needs (Utah Department of Natural Resources, 2002). The Recovery Actions include: describe baseline conditions, provide and protect instream flows, protect and enhance habitat, protect and enhance native species communities, maintain genetically appropriate brood stocks, determine ecological factors limiting abundance of native species, monitor habitat conditions and populations, and improve education and communication on resource issues (UDNR, 2002).

5.7.3.3 Virgin River Chub

The Virgin River chub (*Gila seminude*) is federally listed as endangered and is a silvery, medium-sized minnow that averages 8 inches in length. The chub is endemic to the Virgin River in southwest Utah, northwest Arizona and southeast Nevada (USFWS 1990). Virgin River chub prefer deep, protected areas of swift water. The Virgin River Resource Management and Recovery Program was established in January of 1995 to implement actions to recover, conserve, enhance and protect native species, including the Virgin River chub, in the Virgin River Basin and to enhance the ability to provide adequate water supplies for sustaining human needs (Utah Department of Natural Resources, 2002). The Recovery

Action Plan includes objectives including: describe baseline conditions, provide and protect instream flows, protect and enhance habitat, protect and enhance native species communities, maintain genetically appropriate brood stocks, determine ecological factors limiting abundance of native species, monitor habitat conditions and populations, and improve education and communication on resource issues (UDNR, 2002).

5.7.3.4 Razorback Sucker

The Razorback sucker (*Xyrauchen texanus*) is one of the largest suckers in North America and was federally listed as endangered in 1991. It has been protected in the State of Utah since 1973. Small numbers of Razorback sucker have been found in Lake Powell, typically at the mouths of the Colorado, Dirty Devil, and San Juan Rivers. In the upper Colorado River Basin, Razorback sucker typically spawn between mid-April and mid-June and reportedly migrate long distances to spawn and congregate in relatively large populations for spawning activity. Habitats required by adults in rivers include deep runs, eddies, backwaters, and flooded off-channel or wetland environments. Razorback sucker young require nursery environments with quiet, warm, shallow water such as tributary mouths or backwaters. Threats to the species include streamflow alterations, habitat modification, predation by nonnative fish, and chemical pollutants (USFWS 2002b).

5.7.3.5 Paria River Sensitive Fish Species

The Paria River provides habitat for the Flannelmouth sucker (*Catostomus latipinnis*) and Bluehead sucker, *(Catostomus discobolus*), which are listed in Utah and Arizona as sensitive. The Bluehead sucker feeds on bottom of stream substrate and algae and typically inhabits large rivers and mountain streams in variable turbidity and temperature. The Flannelmouth sucker is also a bottom feeder, consuming algae, other fragmented vegetation, seeds and invertebrates. Flannelmouth sucker live within moderate to large rivers and are typically threatened by nonnative species, hybridization, habitat alteration and blockage of migration routes. Speckled dace (*Rhinichthys osculus reliquus*) is listed only in Arizona as a state sensitive species and inhabits the lower Paria River in Arizona. The Speckled dace is a minnow common in many western waters. It is a bottom-dwelling species and is an important forage fish.

5.7.4 Other Sensitive Wildlife Species Potentially in the Project Area

Based on the general topography and ecosystems along the Project pipeline alignment, various sensitive species may be present within the Project area. The species addressed in the following sections are considered sensitive by the State of Arizona or the State of Utah and have been identified within counties associated geographically with the Project.

5.7.4.1 Arizona Toad

Arizona toad *(Bufo microscaphus)* is found within Kane County and Mohave and Coconino counties. This species inhabits streams, washes, irrigated crop lands, reservoirs, and uplands adjacent to water and may be present at the Kanab Creek crossing area of the Project alignment (BLM 2005). The Arizona toad lays eggs on the bottoms of shallow, slow-moving streams. The adult diet consists mainly of insects and snails, whereas larvae (tadpoles) consume plant matter and organic debris.

5.7.4.2 Greater Sage Grouse

Greater sage-grouse *(Centrocercus urophasianus)* populations are documented in Kane County (UDNR 2006). Greater sage-grouse inhabit sagebrush plains, foothills, and mountain valleys. The Greater sage-grouse is an herbivore and insectivore, and is associated with both tall and short sagebrush types. Sagebrush, understory of grasses and forbs, and associated wet meadow areas are essential for optimum habitat. Sage-grouse use the same breeding ground or "leks" for several consecutive breeding seasons. Habitat within the Project area could contain leks (BLM 2005).

5.7.4.3 Burrowing Owl

Burrowing owl *(Speotyto cunicularia)* prefer open areas within deserts, grasslands, and sagebrush steppe communities. Both primary and secondary breeding habitat exists in Kane County (UDNR 2006). Habitat consists of well-drained, level to gently sloping areas characterized by sparse vegetation and bare ground such as moderately or heavily grazed pasture. Burrowing owls breed in pastures, hay fields, fallow fields, road and railroad rights-of-way, and in a number of urban habitats. They mainly eat terrestrial invertebrates, but also consume a variety of small vertebrates, including small mammals, birds, frogs, toads, lizards, and snakes (BLM 2005).

Burrowing owls are found in open, dry grasslands, agricultural areas, rangelands, and desert habitats often associated with burrowing animals, particularly prairie dogs. They also can inhabit grass, forb, and shrub stages of pinyon and ponderosa pine habitats. They commonly perch on fence posts or on top of mounds outside the burrow. Burrowing owls consume a variety of prey animals, including young desert tortoise. Rangewide, their populations have declined in many areas because of human-caused habitat loss or alteration. The species also uses burrows excavated by ground squirrels and badgers (BLM 2007e).

5.7.4.4 Fringed Myotis

Fringed myotis *(Myotis thysanodes)* is a bat that occurs in Kane County. Fringed myotis use caves, mine tunnels and buildings for day and night roosts; they roost in tightly packed clusters. They are sensitive to human disturbances, especially when in maternity colonies. Important habitat areas for this species are lowland riparian areas and water courses (BLM 2005).

5.7.4.5 Western Red Bat

The Western red bat *(Lasiurus blossevillii)* is very rare in Utah and is sparsely distributed within the northcentral, central, and southwestern regions of the state. The Western red bat roosts in the foliage of cottonwood trees and is dependent on broad leaf shrubs and trees in lowland riparian zones below 5,700 feet elevation. Loss of riparian habitat is the main threat to Western red bat (BLM 2005).

5.7.4.6 Spotted Bat

The Spotted bat *(Euderma maculatum)* is considered rare in Utah. Spotted bat can occupy many habitats but is most frequently found in dry, rough, desert terrain with roosts in rock crevices and under loose rocks or boulders (BLM 2005).

5.7.4.7 Allen's Big-Eared Bat

Allen's big-eared bat *(Idionycteris phyllotis)* occurs in Kane County in riparian woodlands of cottonwood and willow and in forested mountain areas of pine and oak. The species is also found in pinyon-juniper habitat or salt-cedar. Breeding colonies are generally located in mine tunnels and boulder piles and are susceptible to human disturbance (BLM 2005).

5.7.4.8 Pygmy Rabbit

Pygmy rabbit *(Brachylagus idahoensis)* occurs in isolated patches in the western half of Utah. The species requires deep soils for burrowing, and tall, dense sagebrush for cover and food. Threats to pygmy rabbit include increased fire frequency, agriculture, human encroachment, overgrazing and sagebrush removal projects (BLM 2005).

5.8 Recreation and Land Use

5.8.1 Existing Recreation Facilities and Opportunities

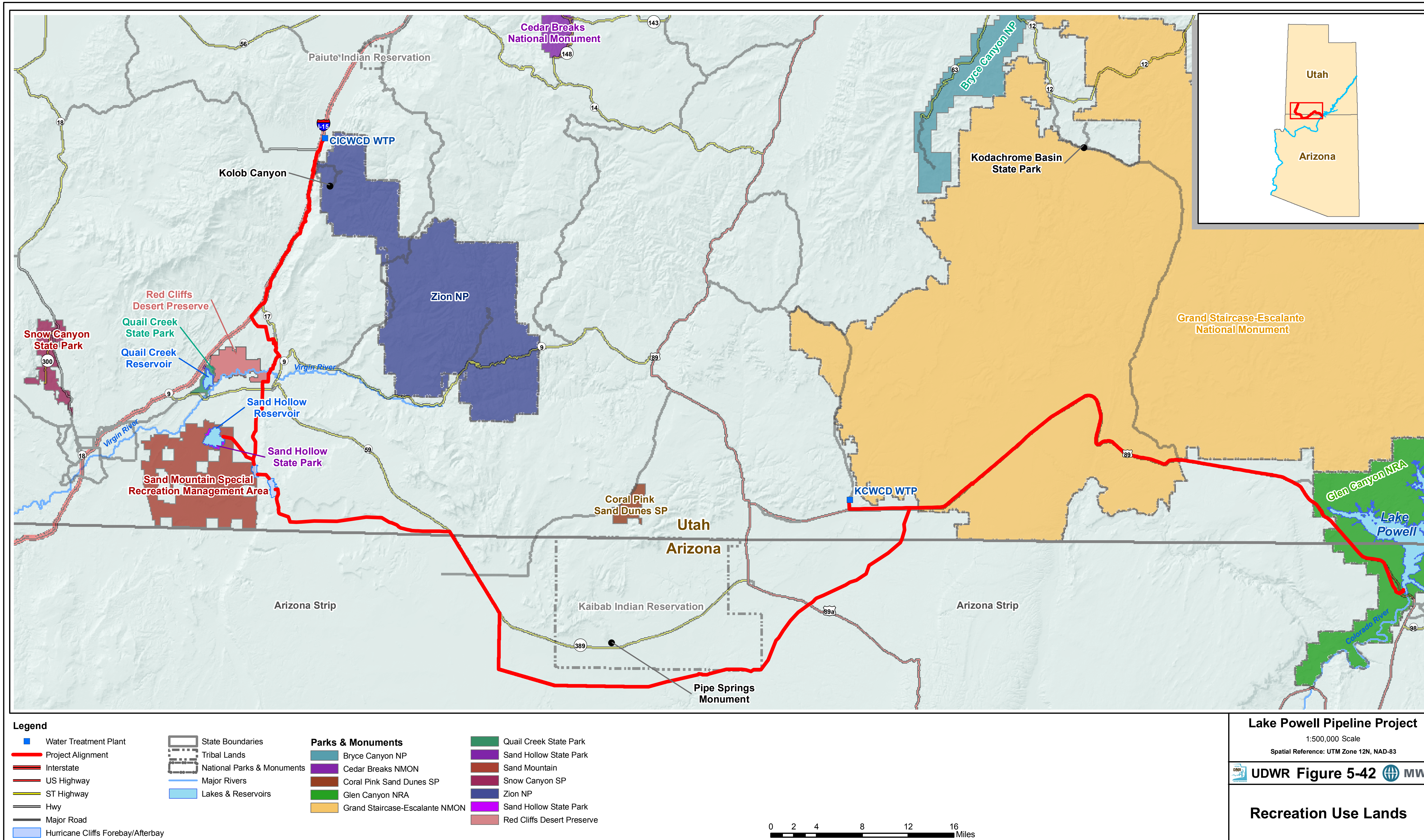
The Project pipeline and penstock segments would traverse a variety of public use lands, crossing five counties, eight municipalities, and two states; Arizona and Utah. The Project would occupy lands managed by with the USBR at Lake Powell, the NPS at the Glen Canyon National Recreation Area, and the BLM at the Grand Staircase-Escalante National Monument, BLM Kanab, Arizona Strip, and Dixie Resource Areas. The Project also would occupy State-managed lands including Sand Hollow Reservoir and Quail Creek State Park in Utah. Many other special use lands, which are used or highly valued for recreation, are situated in the vicinity of the Project, but would not have any Project facilities placed within them. The Project area is considered to be within the "Golden Circle" which is a term coined for the four-corners scenic region, encompassing parks and monuments from Mesa Verde to the Grand Canyon. The following sections describe existing federal and state designated lands, most supporting multiple uses including recreation facilities, backcountry areas and related recreation opportunities. Figure 5-42 shows the some of the major recreational use lands in the Project region.

5.8.1.1 Glen Canyon National Recreation Area

The initial segment of the Project pipeline and one pumping station would be located within the Glen Canyon National Recreation Area (NRA) (see Figure 5-42). The Project intake facility would be located on the western shoreline of Lake Powell. The Project pipeline and pumping station would parallel U.S. Highway 89 in the NRA through northern Arizona and into Utah.

Congressionally established in 1972 to "provide for public outdoor recreation use and enjoyment of Lake Powell and lands adjacent thereto in the states of Arizona and Utah and to preserve scenic, scientific, and historic features contributing to public enjoyment of the area" (Public Law 92-593). The NRA is comprised of approximately 1.25 million acres of mostly desert and encompasses Lake Powell. The NRA spans the border of Arizona and Utah and also borders Capitol Reef National Park and Canyonlands National Park on the north, Grand Staircase-Escalante National Monument on the west, and Grand Canyon National Park on the south (Wikipedia 2007b). The NRA and Lake Powell have proven to be premier attractions for millions of visitors from all over the world. The NPS reported that nearly 1.9 million people visited Glen Canyon NRA in 2006. Glen Canyon Dam is operated and managed by Reclamation and the NRA is managed by the National Park Service (Reclamation 2007a).

Lake Powell was formed in 1964 when construction of Glen Canyon Dam was completed on the Colorado River. Lake Powell is the second largest human-made lake in the United States, with a design storage capacity of 24.3 million acre-feet at a surface water elevation of 3,700 feet (Reclamation 2007b). At full capacity the lake has a surface area of 163,000 acres (Reclamation 1995). The lake straddles the state border of Arizona and Utah and is a popular summertime vacation destination and is well-known for its recreational activities, fishing opportunities, and scenic beauty.



Cedar Breaks National Monument
Paiute Indian Reservation
Bryce Canyon NP
CICWCD WTP
Kolob Canyon
Kodachrome Basin State Park
Zion NP
Red Cliffs Desert Preserve
Quail Creek State Park
Quail Creek Reservoir
Snow Canyon State Park
Virgin River
Sand Hollow Reservoir
Sand Hollow State Park
Sand Mountain Special Recreation Management Area
Grand Staircase-Escalante National Monument
Coral Pink Sand Dunes SP
KCWCD WTP
Glen Canyon NRA
Lake Powell
Colorado River
Utah
Arizona
Arizona Strip
Kaibab Indian Reservation
Pipe Springs Monument
Legend
Water Treatment Plant
Project Alignment
Interstate
US Highway
ST Highway
Hwy
Major Road
Hurricane Cliffs Forebay/Afterbay
State Boundaries
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
Parks & Monuments
Bryce Canyon NP
Cedar Breaks NMON
Coral Pink Sand Dunes SP
Glen Canyon NRA
Grand Staircase-Escalante NMON
Quail Creek State Park
Sand Hollow State Park
Sand Mountain
Snow Canyon SP
Zion NP
Sand Hollow State Park
Red Cliffs Desert Preserve
0 2 4 8 12 16 Miles
Lake Powell Pipeline Project
1:500,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 5-42 MWH
Recreation Use Lands

Situated in red-rock desert country, Lake Powell is considered by many to be one of the most scenic reservoirs in the United States. Lake Powell's recreational activities include boating swimming, fishing, camping, hiking, and photography. There are five major marinas with boat docks, facilities, and launch ramps associated with Lake Powell. Additional rudimentary docking and launch ramp locations are available, but they vary in accessibility associated with the lake water levels. Lake Powell is a popular destination for fishermen as the lake has nearly 2,000 miles of shoreline and is well stocked with various game fish including largemouth bass, smallmouth bass, striped bass, crappie and walleye. Further discussion of fish and wildlife of Lake Powell is provided in Section 5.3. Lake Powell is part of Glen Canyon National Recreation Area and is managed by the National Park Service (NPS).

Glen Canyon NRA recreational activities are predominantly associated with Lake Powell. Popular recreational activities within the NRA around the lake include mountain biking and environmental education. Below Glen Canyon Dam, there are many additional recreational opportunities. Species of trout, mainly brown and rainbow trout, have flourished below the dam resulting from a fish stocking program established in 1964 and the cold, highly oxygenated water released from reservoir behind the dam. Recreational angling downstream from the dam primarily occurs from boats because the canyon walls are steep and rugged. White water rafting also occurs below the dam within the NRA (Reclamation 1995).

5.8.1.2 Grand Staircase-Escalante National Monument

About 31 miles of the Project pipeline and penstock, two pumping stations, two regulating tanks, one hydro station, and a transmission line would be located within the Grand Staircase-Escalante National Monument (GSENM) (see Figure 5-42). These Project features would be constructed and operated entirely within the utility corridor established by Congress in P.L. 105-355 on November 6, 1998. This utility corridor is parallel to U.S. Highway 89 and extends 240 feet north of the highway centerline and 500 feet south of highway centerline in Kane County, Utah from the west boundary of the NRA to Mt. Carmel Junction (the junction of U.S. Highway 89 and State Route 9)..

The GSENM was established in 1996 under authority of the 1906 Antiquities Act by President Clinton. Managed and administered by the BLM, GSENM is located entirely within southeastern Utah and spans nearly 1.87 million acres. GSENM is primarily surrounded by federal lands with Dixie National Forest bordering on the north, Capitol Reef National Park on the east, Glen Canyon NRA on the east and southeast, Bryce Canyon National Park on the northwest, and other BLM administered lands on the south and west (BLM 2000). Kodachrome Basin State Park and Utah lands administered by State Institutional Trust Lands Administration also adjoin the GSENM.

GSENM was created primarily to protect an array of historic, biological, geological, paleontological, and archaeological resources. All other monument activities, including recreation, are secondary to this primary goal (BLM 2000). GSENM recreational activities include hiking, backpacking, mountain biking, camping, river running, equestrian activities, hunting, and off highway vehicle (OHV) usage (BLM 2000). Major facilities and services generally lie outside of the monument boundaries in neighboring communities. Approximately 695,866 people visited GSENM in 2006.

The GSENM management plan establishes various zones and multiple use areas that designate particular and permitted activities within prescribed areas. GSENM provides opportunities for public discovery and education, recreation, scientific research activities, and transportation access, though opportunities vary within different zones, depending on the sensitivity and category of the zone. Facilities within GSENM range from primitive to modest and certain zones limit the number of individuals, type of activities, and frequency of visitors allowed within designated areas. Camping and water resources are limited and carefully managed. In all zones, GSENM is managed to provide pristine, minimally disturbed natural areas for public view and interpretation.

The Project would traverse through the GSENM front country management zone along the of U.S. Highway 89 utility corridor. The front country management zone is the focal point for monument visitation, providing day use opportunities adjacent to Highways 12 and 89. This zone accommodates primary interpretation areas, overlooks, trails, and associated facilities. The front country management zone is the least sensitive zone within the monument in terms of preserving GSENM's primary focus of protecting monument resources. This zone is most frequented by the public and is the most utilized for recreation activities; group size is not restricted in the front country zone.

Utility rights-of-way are allowed uses within the front country management zone, and future planning for the Project was explicitly recognized within the GSENM management plan. The management plan acknowledged that the Project would tentatively parallel Highway 89 for its length within the monument (BLM 2000). Both the Project alignment and Highway 89 parallel the Cockscomb Wilderness Study Area, however neither the highway nor the Project pipeline would overlap into study area. The Project alignment would cross the Paria River within the GSENM, and the river has been found eligible for Wild and Scenic River designation and is currently designated as a recreational river at the crossing location (BLM 2000).

5.8.1.3 Arizona Strip

The Arizona Strip refers to the "strip" of northern Arizona that lies north of the Colorado River. Approximately 55 miles of the Project pipeline alignment would traverse portions of the Arizona Strip (see Figure 5-42). The Arizona Strip is managed and administered by the BLM Arizona Strip Field office. The Arizona Strip spans Mohave and Coconino Counties in Arizona and is comprised of the lands between and including the Vermillion Cliffs National Monument and Grand-Canyon Parashant National Monument (Parashant), which are managed by the BLM with some lands of the Parashant also managed by the NPS. The Grand Canyon National Park boundary is adjacent to the south boundary of the Arizona Strip.

The BLM portion of the Arizona Strip covers 1.68 million acres and offers numerous opportunities for various recreational activities including OHV riding, hiking, backpacking, biking, camping, hunting, sightseeing and photography (BLM 2007). It is rugged and isolated and is one of the largest, continuous stretches of minimally developed lands in the lower 48 states. It is geographically separated from the rest of Arizona by the deep canyons of the Colorado River, particularly the Grand Canyon.

In addition to public lands, the Arizona Strip encompasses state, local, and private lands that are concentrated around small communities in extreme northern Arizona, including Fredonia, Marble Canyon, Colorado City, Centennial, Littlefield, Beaver Dam, and Scenic. Few paved roads extend into interior sections of the Arizona Strip, but three highways (U.S. 89, Arizona 389, and Interstate 15) cross the extreme northern end of these public lands, linking several communities to the managed area. Together with easily accessible, unpaved roads, these highways allow the northernmost area near communities to receive the majority of human use associated with the Arizona Strip (BLM 2007).

The limited and low quality of motorized access to the Arizona Strip constitutes a large part of the appeal to visitors that venture into the backcountry and near-community settings in a rugged environment with endless mesas, canyons, mountains, and plateaus. Remote, natural, and historic settings are managed by the BLM to preserve landscapes. High quality, night sky viewscapes occur across the Arizona Strip. In addition to rugged and scenic recreation opportunities, the Arizona Strip contains an abundant fossil record, wildlife viewing opportunities, ecological and physiographic diversity, undisturbed archaeological sites, areas of importance to local and regional Indian tribes, and historic resources remnant from early European exploration and Mormon settlement. Rich in historical significance, the Arizona Strip provides opportunity for public interpretation, study, and preservation of these resources.

Mining and grazing activities are permitted in most areas of the Arizona Strip as part of BLM's multiple use management strategy. Increased management of recreational activities because of increasing visitation and population surrounding the Arizona Strip is likely so that the BLM can balance other Arizona Strip uses including resource use and extraction, cultural interests, and health and diversity of unique flora and fauna (BLM 2007). Further management of general exploring, OHV use, mountain biking, sightseeing, hiking, camping, and hunting is likely to occur as the Arizona Strip receives more public use.

5.8.1.4 Sand Hollow Recreation Area and Reservoir

Project facilities within Sand Hollow Recreation Area and Sand Hollow State Park (see Figure 5-42) would include a penstock, a hydro station, switchyard, transmission line, and tailrace structure extending into Sand Hollow Reservoir.

Sand Hollow Recreation Area comprises 16,564 acres of land within the Sand Mountain Special Recreation Management Area (SRMA). Sand Hollow Recreation Area is adjacent to Sand Hollow State Park, which includes Sand Hollow Reservoir. Sand Hollow State Park is comprised of 20,611 acres of property administered by Washington County Water Conservation District (WCWCD), but operated by the State of Utah under a lease agreement. Combined, the recreation area and park serve as one of the premier state recreation areas in Utah and consists of two key attractions, Sand Hollow Reservoir and Sand Mountain. The Sand Hollow Reservoir is often filled above 90 percent capacity, with full capacity being 50,000 acre feet (WCWCD 2005b, WCWCD 2006, and WCWCD 2007). The reservoir is the largest of local reservoirs in Washington County and is located 5.5 miles southwest of Hurricane City, 12.5 miles northeast of St. George and is located several miles south of Quail Creek Reservoir. Approximately 187,000 people visited Sand Hollow in 2006.

Water-based recreation such as swimming, fishing, boating and cliff jumping are popular activities. Walking paths and camping facilities are available. One-hundred fifty boats are allowed on the reservoir at one time and abundant largemouth bass, bluegill, and occasional catfish attract anglers to the area. Section 5.3 provides more detailed discussion of fish and aquatic resources associated with Sand Hollow Reservoir.

The Sand Mountain area is comprised of 16,564 acres of red, sculpted dunes and is managed cooperatively by the BLM, WCWCD and Utah Division of Parks and Recreation. The dunes are popular with OHV enthusiasts; equestrian activities, hiking, camping and sightseeing are also popular within the dune and cliff environment.

5.8.1.5 Quail Creek State Park

The Project would deliver water to Quail Creek Reservoir in Quail Creek State Park via an existing 60-inch diameter water conveyance pipeline that connects Sand Hollow Reservoir with Quail Creek Reservoir.

Quail Creek State Park was established in 1985 and the Quail Creek Reservoir, which is the dominant feature associated with the park, offers many recreational activities and also provides drinking water for the St. George metropolitan area. Approximately 108,000 people visited Quail Creek State Park in 2006.

The Park is located on Utah Highway 9 about 3 miles east of Interstate 15 and 4 miles west of Hurricane (Go-Utah.com 2007) and is managed by Utah State Parks.

Recreational activities include boating, fishing, swimming, camping, and picnicking. Fish species in the reservoir include rainbow trout, largemouth bass, bluegill, and threadfin shad. Section 5.3 provides more detailed discussion of fish and aquatic resources associated with Quail Creek Reservoir. Winter temperatures at the park are mild because of the reservoir's low elevation and southern location, and the recreation season extends from early spring to late fall. Reservoir water levels are generally maintained between 60 to 90 percent capacity with design capacity 40,325 acre-feet (WCWCD 2005b, WCWCD 2006, and WCWCD 2007). The area surrounding the reservoir is mostly comprised of bare rock and desert soils.

5.8.1.6 Regional Recreation Facilities and Opportunities

Regional recreational facilities play a significant and dominant role in local and regional economies and abound in the area surrounding the Project. These regional recreation facilities and recreation opportunities they offer influence traffic and seasonal population flucuations in the Project vicinity. Washington, Kane, and Iron County estimates indicate that nearly 11 million people visit the region annually, often staying in accommodations within regional communities. Section 5.12.2 presents more detailed information regarding tourism, temporary populations, and the socioeconomics of tourism in the Project vicinity.

Southern Utah and northern Arizona contain parks, monuments and other attractions associated with the Southwest region's scenic beauty, cultural resources, and diverse, unique landforms. Visitors from around the world recognize the southern Utah and northern Arizona as a tourist destination and well known American attraction. Visitors often make the region a destination, coming to view and visit many of the area's attractions within a trip, often by automobile. Figure 5-42 shows the recreational facilities and opportunities in the Project region.

The Project region exhibits diverse topography and climate over a wide range of elevations, generally characterized by a desert landscape. Scenery and outdoor activities near the Project have promoted a high population growth rate and thriving tourist industry in St. George and the surrounding area in recent years. The Project area's arid climate and relatively mild winters and hot summers that include over 300 days of sunshine per year make it an ideal vacation destination for many people.

Of national significance in the area near St. George is Zion National Park (see Figure 5-42), which was established as a national park in 1919 and currently comprises 148,031 acres of land (Watson 2004). The park is renowned for its tall red cliffs, slot canyons, geologic uniqueness, and endless hiking possibilities. The Virgin River flows through the park and is a natural corridor for recreationists to view and experience park features. Recreation activities include hiking, backpacking, camping, rock climbing, sight seeing, picnicking and OHV use. The park receives approximately 2.5 million visitors annually and is Utah's most visited and oldest national park (Utah National Parks 2007). The main entrance is located at the south end of the park, near St. George, making St. George's accommodations attractive to many visitors. The park is managed by the National Park Service.

Bryce Canyon National Park is located north of both the Project and GSENM between the towns of Escalante and Panguitch (see Figure 5-42). This park was established in 1928 and is comprised of 37,277 acres of land managed by the National Park Service. The Bryce Canyon area is filled with red rock formations, pink cliffs, limestone hoodoos and forests. Well known viewpoints within the park make for popular driving destinations, and hiking, photography, biking, sightseeing, pleasure car riding, and horseback riding are popular recreation activities. The National Park Service estimated that approximately 891,000 people visited Bryce Canyon in 2006 (NPS 2007a).

Managed by the NPS, Cedar Breaks National Monument, also in the Project vicinity, located east of Cedar City (see Figure 5-42). The monument was established in 1933 by President Franklin D. Roosevelt and is comprised of 6,154 acres. The monument is situated on the Colorado plateau formations and provides scenic views of a three-mile, 2,000 feet deep natural amphitheater (NPS 2007b). Often characterized as a miniature Bryce Canyon or Grand Canyon, Cedar Breaks provides varied hues of sedimentary rocks and displays a colorful vista for sightseeing and photography. Camping, hiking, picnicking, are popular summer activities and the area is popular with cross-country skiers in winter months. Dixie National Forest surrounds Cedar Breaks, also providing recreation opportunities. The National Park Service estimated that approximately 488,000 people visited the monument in 2006 (NPS 2007b).

Coral Pink Sand Dunes State Park was established in 1959, is located approximately 22 miles northwest of Kanab in Kane County, and is managed by Utah State Parks (see Figure 5-42). The park is best known for its 1,500-acre coral colored dune field and scenery associated with the dunes. The park land was acquired from the BLM to protect dune resources and provide access to the dunes for recreation (Desert USA 2007). The park functions to protect and enhance the scenic beauty and natural geologic, biologic, historic, and cultural attributes of the park while providing recreation opportunities to the public. The park encompasses 3,730 acres and is situated within easy access to other parks, monuments, and national recreation and wilderness areas (UDP&R 2004). The park provides interpretive and educational programs to raise awareness of the park's unique flora and fauna, distinct geology, sensitive and endangered species, and recreation opportunities found in and near the park. Today the park is a popular vacation destination for off-highway vehicle (OHV) enthusiasts as well as day and overnight users who utilize the park for horseback riding, hiking, photography, nature study, and camping. Park visitation has dramatically increased in the last decade, and visitation exceeds 125,000 annually. The park is most heavily visited during the months of May through September (UDP&R 2004). The park and other surrounding tourist attractions play a critical role in Kane County's economy. Existing facilities are planned to be expanded and improved (UDP&R 2004).

Snow Canyon State Park was established as a Utah state park in 1964 and is located 11 miles northwest of St. George (see Figure 5-42). The park provides camping facilities, canyon hiking trails, sightseeing and rock climbing opportunities and is managed by Utah State Parks (UDP&R 1998). It is estimated that approximately 256,000 people visited Snow Canyon State Park in 2006.

Other recreational opportunities present in the region include Brian Head Resort(a popular winter sports resort and summertime mountain biking destination), Capitol Reef National Park, Anasazi Indian Village State Park, Escalante Petrified Forest State Park, Kodachrome Basin State Park, Kolob Canyon, the north rim of Grand Canyon National Park, Pipe Springs National Monument, Gunlock State Park, Panguitch Lake, and Scenic Byway 12.

5.8.2 Recreation Needs Identified in Management Plans

Management plans associated with recreational areas, national parks, national monuments, state parks, managed lands and other areas of interest generally show a trend in increasing need for facility upkeep, improvement, and expansion. Though some managed areas have experienced decreased visititation in the past several years, management plans indicate the regions recreational areas, in general, are increasing in popularity throughout the region and that the numbers of people visiting recreation areas are as a whole are increasing annually. As a result, many management plans dedicate focus on addressing current and anticipated increases in visitation so that facilities, natural features, and resources do not become overly utilized, disturbed, or rundown (Grass 2007, BLM 2000, BLM 2005, USFWS 1990, and Reclamation 2005).

Plans emphasize the need to control trail access, uses, and maintenance as there are needs to keep visitors within trail limits and on designated trails, whether trails are utilized for hiking, horseback, or motorized (OHV) use. Several management plans, including those associated with the Arizona Strip, Coral Pink Sand Dunes State Park, and Quail Creek State Park identify needs to keep OHV users within various areas and out of other areas (UDP&R and UDNR 2004, BLM 2007, and Utah Travel Industry 2007). Increased signage and interpretation for trails as well as environmental and conservation education at facilities are also identified needs that stem from desire to preserve existing conditions for future and increasing numbers of recreation users.

In recreation areas and parks where boating and personal watercraft activities are available, improvement of existing ramps and the installation of additional boat and watercraft ramps are identified as needs. In particular, a recreation need at Lake Powell is to extend and modify boat ramps to better accommodate users at lower water levels. The spread of quagga mussels and other invasive aquatic species is a concern of reservoir managers in the region (USFWS 2007). Boat washing and disinfection facilities have been identified as a measure to prevent spread of invasive aquatic species. Section 5.3 provides more detailed discussion of invasive aquatic species.

Generally, management plans identify needs to maintain existing facilities as a minimum goal, however needs to expand and improve existing facilities to accommodate increased numbers of visitors is common to all plans. Maintaining and improving day use and camping facilities are frequently identified as needs with the exception of GSENM and Zion National Park where new camping facilities not are allowed based on their respective resource management plans (BLM 2000 and NPS 2001).

5.8.3 Land Uses and Management

Although public lands are the most common type of land with the Project area, other land ownership types and related uses are found in the area as well. Federal lands near and within the Project alignment are also utilized for recreation, grazing, mineral exploration and mining, resource harvesting, wildlife habitat, and scientific research. These same uses also take place on private lands within the project boundaries. Agricultural, urban and rural developed uses, and utility rights-of-way, and open space are common uses within Project area.

The primary land use in the Arizona Strip, which constitutes a large portion land associated with the Project, is livestock grazing, which occurs on both private and public land. South of the Utah border, the Project would traverse lands south of the Kaibab Indian Reservation, where the landscape includes a mix of high desert and open range with pinyon pine, juniper, natural springs, and ephemeral washes found in certain locations. In Utah, land use consist of urban and rural developed uses, agricultural uses (mainly irrigated farmland), livestock grazing, and other public lands including state and national parks and monuments. As development in southern Utah continues to increase and urban areas grow, some land now used for grazing and agriculture is likely to convert to urban land use (NRCS 2007 and Utah Division of Water Resources 2007).

In areas not irrigated for agricultural use or used as urban and rural uses , or in existing right-of-ways, the land cover generally consists of desert scrub, desert grassland, desert shrub, pinion-juniper shrub lands, and pinion-juniper woodlands. Section 5.5 provides more detailed discussion of botanical resources within the Project area. The Project alignment crosses a variety of topography including flat open areas, canyon lands, and steep cliffs. As shown in Figures 5-36, 5-37 and 5-38, these lands provide habitat for various game and non-game species including mule deer, pronghorn antelope, desert bighorn sheep, elk, black bear, pheasant, quail, band tailed pigeon, and wild turkey. Section 5.4 provides more detailed discussion of wildlife resources in the Project area.

Several wilderness areas and wilderness study areas are located near the Project alignment, however the Project would not any facilities located within any designated wilderness or wilderness study area (see Figure 5-43). Nearby Wilderness and Wilderness Study Areas include Paria Canyon-Vermilion Cliffs, The Cockscomb, Paria-Hackberry, Moquith Mountain, Parunuweap Canyon, Cottonwood Point, Canaan Mountain, Cottonwood Canyon, Red Butte, and Spring Creek Canyon (BLM 2007 and BLM 2000). The Project alignment would cross the Kanab Creek Area of Critical Environmental Concern (ACEC) and would be sited near to several other ACECs (see Figure 5-43). ACECs are designated by the BLM to protect specific resources.

5.9 Aesthetic Resources

5.9.1 Overview

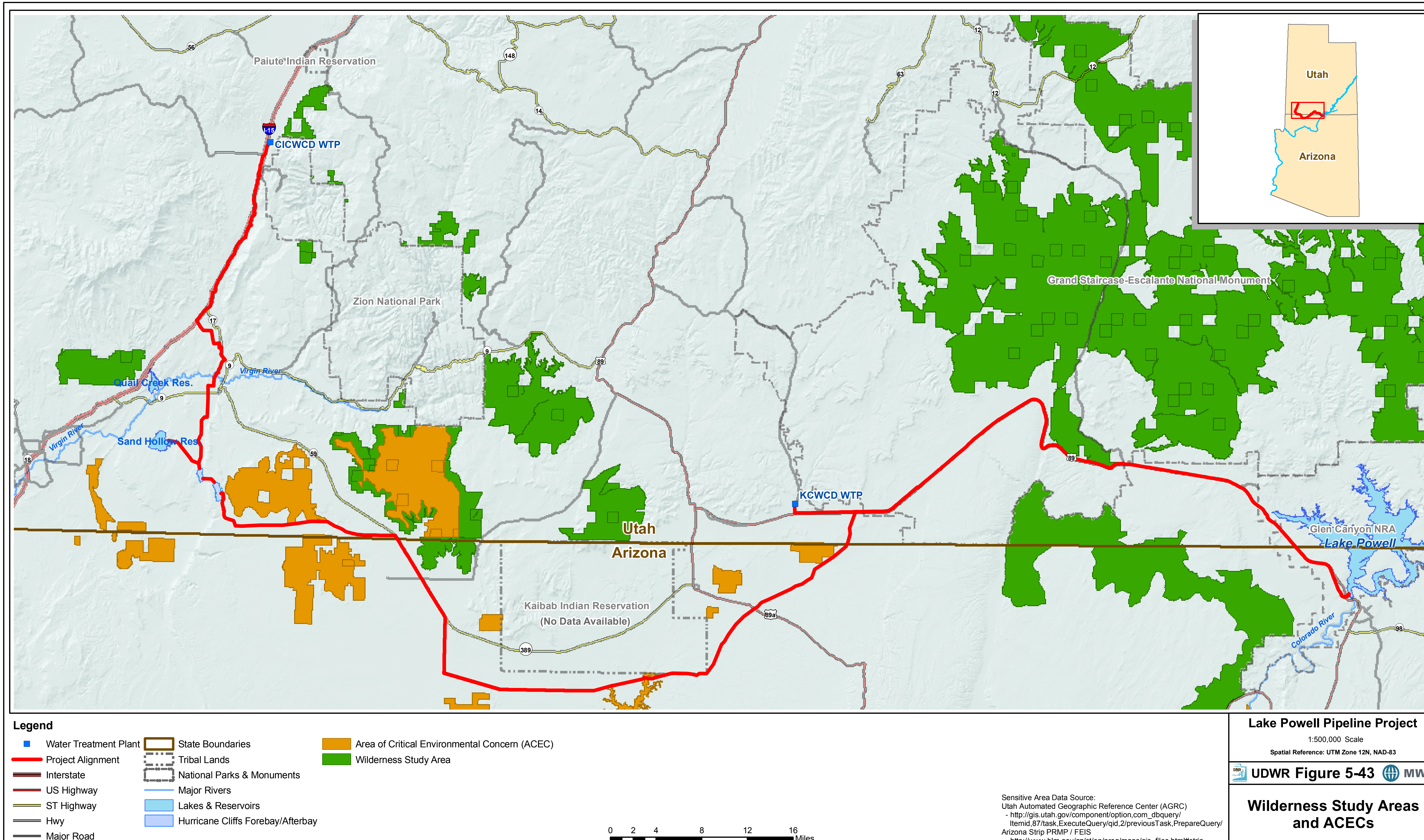
The landscape in the Project vicinity is well known for its scenic and aesthetic beauty. Sightseers and photographers tour southern Utah and northern Arizona vicinity to take in and enjoy the visual marvels offered by the region. Often, the southern Utah and northern Arizona area is described as breathtaking, magnificent, spectacular, amazing, and incredible by those who visit the area's many scenic vistas, parks, recreation areas, and lands. The landscape is noted for scenic cliffs, canyons, multi-color striated rock monoliths, big, clear skies, starry nights with little light pollution, desert vistas, and dramatic changes in topographic relief. The existing recreation areas, state and national parks and monuments offer many varieties of unique scenic beauty that draw millions of visitors each year for recreation and relaxation. Likewise, the general expanses of land outside of federally and state designated areas between Lake Powell, St. George and Cedar City offer distinctive examples of natural settings from desert grasslands and scrubland to cliffs and canyons to pinyon-juniper forests.

Much of the Project pipeline alignment is situated along highway rights-of-way and typical views include vast, open expanses of land, with few visual highlights. Scenic view points are more predominant where the Project alignment nears or traverses recreation areas. Specific areas of aesthetic value occur at different locations along the Project alignment. The Hurricane Cliffs are a prominent scenic feature with cliff faces and dramatic topographic relief. Between St. George and Cedar City, the alignment parallels the Hurricane Cliffs, Interstate 15 and the boundary of Zion National Park.

5.9.2 Visual Character of Project Lands and Waters

The area surrounding the Project is a land of contrasts, with riparian areas, reservoirs and forests providing dramatic contrast to the dominant desert scenery. High desert plains consisting of desert grassland, desert scrub and desert sagebrush at lower elevations and pinyon-juniper desert woodlands at higher elevations are common along the Project alignment. The majority of the land, both public and private, within Project construction easement areas can be characterized predominantly as open, protected space, utility rights-of-way, and grazing and agricultural lands.

The BLM utilizes a Visual Resource Management (VRM) system to classify and manage visual resources on the public lands they administer. Visual resources are defined in foreground, middle ground and background by distance, with characteristics describing form, line, texture and color. The VRM system includes designation of Key Observation Points (KOPs) where the landscape is most likely to be viewed


Paiute Indian Reservation
CICWCD WTP
Zion National Park
Quail Creek Res.
Virgin River
Sand Hollow Res.
Virgin River
Grand Staircase-Escalante National Monument
KCWCD WTP
Utah
Arizona
Kaibab Indian Reservation
(No Data Available)
Glen Canyon NRA
Lake Powell
Colorado River
Utah
Arizona
Legend
Water Treatment Plant
Project Alignment
Interstate
US Highway
ST Highway
Hwy
Major Road
State Boundaries
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
Hurricane Cliffs Forebay/Afterbay
Area of Critical Environmental Concern (ACEC)
Wilderness Study Area
0 2 4 8 12 16
Miles
Sensitive Area Data Source:
Utah Automated Geographic Reference Center (AGRC)
- http://gis.utah.gov/component/option,com_dbquery/Itemid,87/task,ExecuteQuery/qid,2/previousTask,PrepareQuery/
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip
Lake Powell Pipeline Project
1:500,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 5-43 MWH
Wilderness Study Areas and ACECs

by the public. The BLM has established the following VRM classes with specific management prescriptions to manage and protect visual resources:

- Class 1 – Preservation. Class 1 VRM areas are managed for no change in visual characteristics of form, line, texture and color of the landscape. Class 1 visual resources are managed for preservation in their natural state.

- Class 2 – Retention. Class 2 VRM areas are managed for minimal change in visual characteristics of form, line, texture and color of the landscape. Class 2 visual resources are managed for minimal change from their natural state and to retain the visual context, with any changes subordinate to the primary landscape characteristics.

- Class 3 – Partial Retention. Class 3 VRM areas are managed to allow moderate change in visual characteristics of form, line, texture and color of the landscape. Class 3 visual resources are managed to achieve partial retention of the visual context and some changes in primary landscape characteristics are allowed.

- Class 4 – Modification. Class 4 VRM areas are managed to allow modifications in visual characteristics of form, line, texture and color of the landscape. Class 4 visual resources are managed to allow modification of the visual context and complete change in the primary landscape characteristics.

The Project alignment traverses through VRM Class 2, 3 and 4 areas as shown on Figure 5-44. There are no VRM Class 1 areas along the Project alignment.

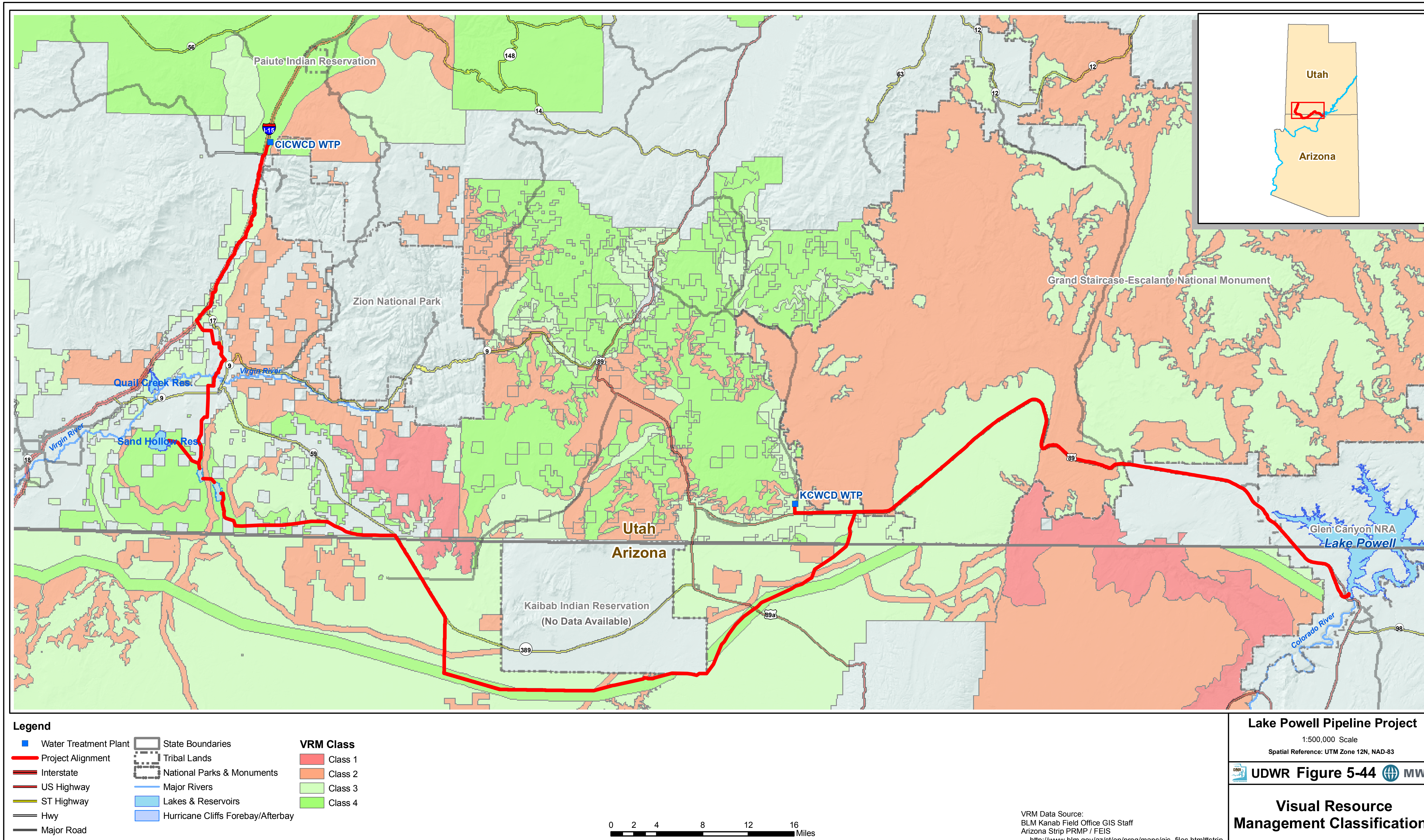
The reservoirs associated with the Project are noted for their beauty and visual contrast with the surrounding desert landscape. When the Colorado River was impounded by Glen Canyon Dam and Lake Powell was formed, it provided unique lake and canyon scenery with scenic cliff faces and striated canyons that became more accessible for public viewing. Red sand dunes at Sand Hollow Reservoir provide contrast with the blue waters of the reservoir. Similarly, the Quail Creek Reservoir area is picturesque.

The region is known for wildlife viewing as herds of game and non-game species utilize habitats throughout the Project area and provide popular attraction for the many people who visit this region's well known vacation destinations. Section 5.4 provides more detailed discussion regarding wildlife resources.

5.9.3 Noise

Much of the Project alignment is considered fairly remote in location, however, various existing human-caused sources of noise currently occur along and adjacent to the Project area. Significant portions of the Project alignment would be within the rights-of-way of existing highways, including U.S. Highway 89, Arizona Highway 389, Utah Highway 59 and Interstate 15. Ambient noise from traffic is common within the rights-of-way, particularly as these highways are utilized frequently by semi-truck and recreation vehicles (RVs) as well as lighter passenger vehicles.

Urban areas along and near the Project alignment produce noise. Noise levels increase from sounds generated in human-populated areas as the Project alignment nears communities such as Kanab, Cedar City, Colorado City, Hildale, and the St. George metropolitan area. These sounds are generated by vehicles, aircraft, building cooling and heating systems, and other human activities.


Paiute Indian Reservation
CICWCD WTP
Zion National Park
Grand Staircase-Escalante National Monument
Quail Creek Res.
Virgin River
Sand Hollow Res.
KCWCD WTP
Utah
Arizona
Kaibab Indian Reservation
(No Data Available)
Glen Canyon NRA
Lake Powell
Colorado River
Utah
Arizona
Legend
Water Treatment Plant
Project Alignment
Interstate
US Highway
ST Highway
Hwy
Major Road
State Boundaries
Tribal Lands
National Parks & Monuments
Major Rivers
Lakes & Reservoirs
Hurricane Cliffs Forebay/Afterbay
VRM Class
Class 1
Class 2
Class 3
Class 4
0 2 4 8 12 16
Miles
VRM Data Source:
BLM Kanab Field Office GIS Staff
Arizona Strip PRMP / FEIS
- http://www.blm.gov/az/st/en/prog/maps/gis_files.html#strip
Lake Powell Pipeline Project
1:500,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
N
UDWR
Figure 5-44
MWH
Visual Resource
Management Classifications

The Project pipeline would parallel the existing Navajo-McCullough 500 kV transmission line for about 24 miles. This transmission line often creates a buzzing sound that emanates laterally for short distances from the facility.

Noise is common near reservoir areas as people, traffic, OHVs, power boats, and personal watercrafts are in use near reservoir recreation areas. Wildlife sounds also occur near and around reservoirs. When reservoir waters are managed and diverted by existing infrastructure, some noise can be attributed to intake and outtake structures associated with the water control features.

Portions of the Project alignment would be located far from human activities (i.e., areas that are off-highway, away from the transmission lines, and away from urban and reservoir areas). These areas are considered remote with little human-induced noise sources. For example, the Project alignment diverges from paralleling the Navajo-McCullough Transmission Line, and the buried pipeline would be largely situated within remote areas of the Arizona Strip in lands used primarily by livestock as part of grazing allotments. In this area, there are few sounds other than those associated with aircraft, wildlife, livestock, occasional vehicle noise, and the natural elements. Other remote areas generally have similar wildlife, livestock, and elemental sounds as well. Aircraft, both commercial and smaller, sightseeing planes, and helicopters produce temporary noise in remote areas. Zion National Park management has noted in several publications concern regarding airplane traffic and associated noise within and near park areas (Watson 2004 and NPS 2001).

5.10 Cultural Resources

5.10.1 Identification of Historic and Archaeological Sites in the Project Vicinity

Many known historic and archaeological sites occur in the Project vicinity, however a formal Class I Cultural Resources Review has yet to be conducted to determine what, if any, historic and archaeological sites lie within disturbance areas associated with the Project alignment. The Project alignment likely contains historic or archaeological sites because of the large number of sites recorded in the Project vicinity. A Class I Cultural Resources Review would reveal what, if any, historic and cultural resources are listed by or are eligible for federal or state listing. The following paragraphs provide a brief summary of known historic and archaeological sites near the Project vicinity.

Approximately 2,300 archeological sites have been recorded downstream of Lake Powell and Glen Canyon Dam in Glen Canyon. There are many documented areas in the GSENM that show evidence of extensive use by ancient cultures and many more undocumented sites that exist within the monument that are worthy of preservation for future study according to the Monument's current management plan (BLM 2000). Sites are valued by Native American Indian tribes, local communities, scientists and other interested parties worldwide, and by private organizations. In the BLM Kanab Resource Management Area there are 1,023 cultural resource sites listed in the State Historic Preservation Office (SHPO) database. In the BLM Arizona Strip resource area, less than five percent of the management area has been inventoried for cultural resources thus far, which has resulted in the recording of 3,500 cultural resources (BLM 2007).

There are three listed trails considered historic resources near the Project alignment managed by the Arizona Strip field office: Honeymoon Trail, Temple Trail and the Dominguez/Escalante Trail. These trails are currently accessible for public use and interpretation to encourage socio-historical understanding of the area (BLM 2007). Cultural sites have been identified in Snow Canyon (UDP&R 1998). Sites document the use of Snow Canyon by Archaic populations, western Anasazi, Paiute, and historic ranchers. Existing inventories indicate that more cultural resources are likely present than what is currently known in Snow Canyon State Park.

The Coral Pink Sand Dunes State Park includes 23 sites that are recorded with SHPO (UDP&R 2004). Of these sites, eight were determined as significant and were nominated to the National Register of Historic Places. The other non-significant sites document sporadic use of the area by Ancestral Puebloan people (UDP&R 2004).

Zion National Park has numerous cultural resources that are currently regulated and managed under the Zion National Park General Management Plan (NPS 2001). The BLM Dixie Resource Area estimates that there are over 10,000 archeological sites on public lands within their management area (Reclamation 1998).

Cultural resource sites represent an important record of prehistoric and historic cultures and events that have value to contemporary Native Americans as well as other interested individuals. Prehistoric sites also provide opportunities within recreation, parks, and monument areas for education.

5.10.2 Traditional Cultural Properties

Traditional cultural properties are those sites recognized by contemporary Native American Indians as important to their cultural continuity. Sites within the Project alignment have yet to be definitively identified, however a preliminary literature evaluation regarding areas within and adjacent to the Project has been performed. Management plans and other documents were reviewed to determine what, if any traditional cultural or religious properties were listed and identified in managed areas and other areas near the Project vicinity. The Paria Management Plan, GSENM Management Plan, Virgin River Management Plan, Virgin River Watershed Management Plan, Navajo Generating Station Water Intake Project Environmental Assessment, Escalante Valley-Iron County Rapid Watershed Assessment, Sand Hollow Recreation Area Recreation Management Plan, and Dixie Resource Area Management Plan all indicated that no traditional cultural properties have been identified or designated within these areas.

The Arizona Strip EIS and Management Plan indicates that the entire Arizona Strip and also smaller sections of the Arizona Strip are of value to various Native American Indian groups including Navajo, Hualapai and Havasupai, Hopi, and Southern Paiutes. These groups, either currently or historically living in or adjacent to the Arizona Strip, have cultural ties to the area. The Navajo Nation has traditional hunting rights within the Arizona Strip (BLM 2007). Traditional cultural properties and Native American religious sites have been documented in the Arizona Strip.

The Glen Canyon Dam FEIS indicates that traditional cultural properties exist in the corridor of the Colorado River between Glen Canyon Dam and Separation Canyon, a 255-mile section of the Colorado River within Grand and Glen canyons (Reclamation 1995). This area has importance and traditional significance to six Native American tribes. The Colorado River is also important to these tribes.

The Kanab Field Office Resource Management Plan indicates that no specific Native American religious concerns or traditional cultural properties have been identified in the Kanab decision area (Reclamation 2005). However, the Kanab Management Plan also indicates that a recent ethnography of the Paiute Tribe was performed for GSENM, and one of its key findings was that water plays an important part in the Paiute’s life and beliefs and therefore, any water source can be viewed as a potential Native American religious concern. Further consultation is needed to identify specific water sites or areas of potential concern with respect to the Project.

The Coral Pink Sand Dunes General Management Plan does not indicate any specific religious or traditional cultural properties within the park. However, the park area has a long history of Native American use by Ancestral Paiutes and Ancestral Puebloans (UDP&R 2004).

5.11 Paleontological Resources

Fossils are recognized as non-renewable resources protected under federal law that possess both scientific and educational values. The scientific value of fossils, especially vertebrate fossils, often drives management decisions in managed areas within southern Utah and northern Arizona, given the predominance of fossiliferous resources in the region. A survey of paleontological resources within Utah's national parks, monuments, and recreational areas was conducted in 2000 (Stantucci 2000). The survey revealed that most of the parks and monuments in Utah, including those traversed by or adjacent to the Project alignment, were established for or are recognized for their significant geologic features and abundance of fossil records (Stantucci 2000). Given the vicinity of the Project alignment being situated between and within many park, recreation, and monument areas recognized to have significant paleontological resources of value, it is possible that paleontological resources lie within the Project alignment. Of those areas analyzed in the 2000 survey, the following parks, monuments and areas associated with the Project alignment were recognized as having considerable paleontological resources with scientific significance: Cedar Breaks National Monument, Glen Canyon National Recreation Area, GSENM, and Zion National Park. Comprehensive resource inventories are underway in several National Parks Service areas in Utah (Stantucci 2000).

The GSENM, which was established as a monument in part because of its recognized paleontological value, is considered rich in paleontological resources. Much research is currently being performed in the GSENM. Dinosaur bones, footprints and skin impressions and plant and animal fossils, petrified wood, trace fossils and other paleontological resources have been identified and become popular items of interest within the GSENM. The Kanab Resource Management Plan indicates that GSENM contains one of the best terrestrial fossil records for Mesozoic period, which is informally called the "Age of Dinosaurs." The Mesozoic Era saw the rise of mammals, modern reptiles, amphibians, dinosaurs, birds, flowering plants, and many types of insects (Reclamation 2005). Recent inventory by researchers associated with the Utah Geological Association provides compilation of 168 collections of predominantly marine and brackish-water invertebrate fossils from Late Cretaceous rocks within GSENM. This indicates a clear presence of valuable paleontologic records present within the GSENM that provides information on the geologic age, lithologic characteristics, and depositional environments of rock units (Cobban et al. 2000).

The Kanab Management Area of the BLM contains 19 identified formations that are known to be or are likely to be fossiliferous. Extensive paleontological field research has not been completed within the Kanab Management Area, however the Kanab BLM area office has determined that highly valuable paleontological resources are likely present in various regions within the managed area. This determination was based on published literature, known occurrences within GSENM with similarities to formations in Kanab, and review of unpublished literature. Mapping provided in the Kanab Management Plan indicates there is medium potential (on a scale of high, medium, low, or no data) for paleontological sensitivity in areas within and adjacent to the Project alignment (Reclamation 2005). Similar rock strata to those found in GSENM occur in the Kanab Management Area, indicating that the Kanab region may have similar potential to the GSENM for understanding ancient Mesozoic and/or Late Cretaceous ecosystems (Reclamation 2005).

An abundant fossil record is noted in the Arizona Strip resource management plan for this managed area. Caves and karst features may also be considered significant resources within the Arizona Strip (BLM 2007).

Zion National Park and geologically related areas of southern Utah contain eolian dune system deposits preserved in Jurassic Navajo Sandstone. This sandstone provides record of valuable paleoclimatic information in its sedimentary record (Chan and Archer 2000).

Evaluation by the Utah State Paleontologist indicates that there are no recorded paleontological sites in Snow Canyon State Park (Utah Division of Parks and Recreation 1998). The Coral Pink Sand Dunes State Park management plan does not indicate presence of recorded paleontological sites in the park (UDP&R 2004). Geologic summary of Quail Creek State Park indicates that Jurassic fossils of Pentacrinus (or sea lily) are common in river boulder deposits at the north end of the reservoir (Biek 1999). The Sand Mountain Special Recreation Management Area is adjacent to the Dinosaur Trackway paleontologic site, though this area is outside of the Sand Hollow Recreation Area (WCWCD et al. 2001). The Navajo Generating Station Water Intake Project Environmental Assessment does not indicate presence of recorded paleontological sites in relation to this facility (NPS 2005).

5.12 Socioeconomic Resources

5.12.1 Existing Communities

The Project would be situated within the counties of Washington, Kane, and Iron in Utah and Mohave and Coconino in Arizona. The Project would be near or within existing communities in Arizona including Page, Fredonia and Colorado City and in Utah including Big Water, Church Wells, Kanab, Hildale City, Apple Valley, Hurricane, St. George, Washington City, La Verkin, Virgin, Leeds, Toquerville, Kanarraville, and Cedar City.

The Project would deliver water from Lake Powell to communities in southwest Utah in the Washington County Water Conservancy District (WCWCD), the Central Iron County Water Conservancy District (CICWCD), and the Kane County Water Conservancy District (KCWCD). The Project would deliver power to communities in Washington and Kane counties. WCWCD has executed a Regional Water Supply Agreement with five municipalities in Washington County. The supply agreement provides the structure by which WCWCD will provide water to customers in St. George, Washington, Ivins, Hurricane, and La Verkin, and eventually throughout the county (Utah Division of Water Resources 2007). KCWCD has a relatively small customer base served by existing water supplies. Existing customers are rural developments located in the Cedar Mountain and Johnson Canyon areas. CICWDC serves customers in the central portion of Iron County, primarily including the unincorporated areas around Cedar City, Enoch City and Kanarraville. CICWCD is building its customer base and currently has limited water supply because of this small but growing customer base (Utah Division of Water Resources 2007).

Southwest Utah historically has had a predominantly resourced-based economy, relying on agriculture, cattle ranching, and some mining to support ways-of-life. The establishment of national parks and construction of Interstate 15 throughout the 20th century has made Utah increasingly known for its unique natural beauty and recreation opportunities. Today, southwest Utah still maintains agricultural and other resource-based land uses and much land is dedicated to public use. However, in recent years, southwest Utah has increasingly become a destination for suburban and urban people to reside and retire (Utah Division of Water Resources 2007). Tourism, retirement facilities, information technology, and other entrepreneurial and innovation-based businesses have become common. The many recreational opportunities, pleasant climate, and growth opportunities in the area have attracted many newer residents to the area (Wikipedia 2007c).

The Cedar Valley area, located in Iron County, is one of the fastest growing regions in the country and is nearby the fastest growing metropolitan area in the country: St. George, Utah. St. George is located in Washington County and this county's population has nearly doubled in the last three decades (Utah Division of Water Resources 2007), largely around the greater St. George area, which is locally referred to as "Dixie." Given the mild winters in the Dixie area and throughout southern Utah, the area has become a popular destination for "snow birds" or retirees who live in the area for part of the year to avoid harsh winters elsewhere. Hence, many retiree "residents" in southern Utah are part-time residents who own homes that they use only during winter months. A portion of the southern Utah part-time resident population is comprised of university students who live on or near campuses throughout the school year (Utah Division of Water Resources 2007).

Today, tourism is a major industry in southern Utah with many national parks and other recreational and scenic attractions primarily supporting the industry. Secondary tourism attractions and facilities, such as urban attractions and resort and retiree-based facilities, are becoming more common to make the region more robust and attractive to visitors. Research and service based industries are emerging components of southwest Utah's economy (Wikipedia 2007c). Together, the transitions in the southern Utah economy and population have changed ways of life for many and have spawned more urban-based development (NRCS 2007).

Recent trends indicate that the population within Iron County is increasing particularly along the Interstate 15 corridor. New landowners in this area typically maintain non-agricultural and non-resourced based ways of life, seeing natural resources in the vicinity as recreational opportunities, not as a direct means for making a living (NRCS 2007). The ability to maintain more traditional ways of life associated with farming and other resource-based livelihoods is diminishing and has created great concerns from resource-based sectors of the population. Areas previously utilized for farming around the greater Cedar City area have begun to be converted to housing and business developments.

The use and distribution of water is changing and becoming more challenging to manage because of the increase in urban populations (Utah Division of Water Resources 2007). For example, water use can be correlated with population and urbanization in southwest Utah. Demands are anticipated to continue with projected population increases and the increased development moving into the sub-basins of the Escalante Valley basin and the St. George metropolitan area. Water use for agriculture in the southwest Utah remains a primary use of basin water and is critical to the economic fabric of the rural communities surrounding the urban developments (NRCS 2007).

5.12.2 Recent Population and Economic Growth

The southwest Utah population has experienced rapid growth during the past 40 years. Much of this population growth has occurred in the St. George metropolitan area (including St. George, Washington City, Hurricane City, Santa Clara, Ivins, Virgin, La Verkin, Leeds, Toquerville, Rockville, and Springdale) and the Cedar Valley areas. Table 5-9 provides a population growth and per capita income overview for the Project vicinity. Table 5-10 provides an overview of the rapid expansion of housing developments in the Project vicinity. Table 5-11 provides an overview of the increase in non-farming related enterprises emerging in the Project area. Together, these tables demonstrate the rapidly changing social and economic fabric of the Project vicinity population and communities.

Table 5-9
Southern Utah and Northern Arizona
Change in Population from 2000 to 2006 & Per Capita and Poverty Level Data from 2000

County or Municipality	Population as of 2006	Percent increase from 2000 to 2006	Per Capita Income (as of 2000)[1]	Percent of Families Below Poverty Level (2000)[2]
Kane County, UT	6,532	8.0%	$15,455	5.5%
Washington County, UT	126,312	39.8%	$13,568	7.7%
Iron County, UT	40,544	20.0%	$13,568	13.1%
Big Water, UT	413	-1.0%	$15,026	11.0%
Kanab, UT	3,754	5.8%	$16,128	4.0%
Hildale City, UT	1,950	2.9%	$ 4,782	37.0%
Hurricane, UT	12,084	46.5%	$13,353	10.8%
St. George, UT	67,614	36.1%	$17,022	7.4%
Cedar City, UT	25,665	25.0%	$14,057	14.5%
Fredonia, AZ	1,062	2.5%	$13,309	12.3%
Colorado City, AZ	4,607	38.1%	$ 5,293	29.0%

Notes:
1) PCPI U.S. Average in 2000 was $21,587
2) 2000 National Average of Families below Poverty Level was 9.2%

Source: U.S. Census Bureau (2000 and 2006)

Table 5-10
Housing Increases Between 2000 and 2005 in Southern Utah

County or Municipality	Number of Housing Units as of 2005	Percent Increase in Number of Housing Units between 2000 and 2005	Median Owner Occupied Value 2000
Kane County, UT	4,374	13.8%	$103,900
Washington County, UT	48,777	25.0%	$139,800
Iron County, UT	16,137	15.6%	$112,000

Source: U.S. Census Bureau (2000 and 2006)

Table 5-11
Increase in Non-Farm Establishments in the Project Area

County or Municipality	Number of Non-Farm Establishments in 2005	Percent Increase in Non-Farm Establishments from 2000 to 2005	Number of People Employed by Non-Farm Establishments in 2005
Kane County, UT	240	28.6%	1,837
Washington County, UT	3,686	38.6%	36,929
Iron County, UT	1,196	11.9%	11,172

Source: U.S. Census Bureau (2000 and 2006)

These tables reflect the rapid transition occurring within the Project vicinity. Urban and suburban lifestyles are growing and increasing, housing developments are expanding, and population has increased at a rapid pace in some metropolitan areas.

5.12.2.1 Population Forecasts

Forecasts for the assessment were based on officially adopted forecasts provided by the Utah Governor's Office of Planning and Budget (GOPB). Population and water needs for the three southwest Utah water conservancy districts were forecast to 2050, the adopted planning horizon for studies associated with the Project. Population projections were obtained from the GOPB, and information on the type of residences (e.g., permanent and non-permanent) and the tourism population were obtained from cities where the data were available. Table 5-12 presents a summary of the GOPB projections related to permanent population in the Project area.

Table 5-12
Permanent Population Projections in the Project Area

District	Population Projection for 5 to 10 Year Intervals (Annual Growth Rate)						2005 to 2050 Annual Growth Rate
	2005	2010	2020	2030	2040	2050	
WCWCD[1]							
Population	127,127	168,078	279,864	415,510	559,670	709,674	--
Annual Growth Rate	--	5.58%	5.10%	3.95%	2.98%	2.37%	3.82%
CICWCD[2]							
Population	37,108	45,358	61,236	78,563	98,833	123,020	--
Annual Growth Rate	--	4.02%	3.00%	2.49%	2.30%	2.19%	2.66%
KCWCD[3]							
Population	6,211	6,893	8,746	10,394	12,034	14,267	--
Annual Growth Rate	--	2.08%	2.38%	1.73%	1.47%	1.70%	1.85%

Notes:
[1] WCWCD - total Washington County population.
[2] CICWCD - total Iron County population less the population served by water suppliers that are not located within the district's boundary (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit Sanitary Sewer District)
[3] KCWCD - total Kane County population (population projections were given for total Kane County population, and were also determined separately for the four subbasins within the KCWCD service area
Source: (Population projections from GOPB 2008; 2005 population estimated from GOPB 2007)

The base population within the Project area has recently increased and is projected to continue to increase. In Washington County, the population is projected to increase almost 6 times the current population by 2050. In the Central Iron County Water Conservation District area, the population is anticipated increase by more than 3 times the current population. In Kane County Water Conservation District, the population is anticipated to almost double by 2050.

5.12.2.2 Temporary Residents

Temporary residents, including second-home owners and college students, contribute to economic generation and variability in annual population fluctuations in areas associated with the Project, however, these residents are not included in base population statistics. The Washington County temporary resident population is estimated at approximately 34,300 people or 27 percent of the total 2005 population. Washington County's economy is dominated by tourism and business travel, with St. George as the primary business center of the area drawing a significant temporary population for conventions. An estimated 16 million people visit Washington County annually. Temporary residents also are a significant part of the population in Iron County and Kane County as a result of tourist attractions, with approximately 600,000 people visiting Iron County and 465,000 people visiting Kane County annually (Utah Water Resources Division 2007). The Iron County temporary resident population is estimated at approximately 7,400 people or 20 percent of the total 2005 population. The Kane county temporary resident population is estimated at approximately 5,100 people or 82 percent of the total 2005 population.

The St. George metropolitan area hosts a significant tourism population associated with conventions, golfing, and visits to nearby national parks and other recreation areas. Cedar City is influenced by tourism population associated with conventions and visits to nearby scenic destinations and recreation areas. Kane County is a gateway to Lake Powell and the Grand Staircase-Escalante National Monument. Average annual tourist visits for each of the three counties within the Project area are summarized in Table 5-13.

Table 5-13
Average Annual Tourist Information for Southwest Utah Counties

County	Average Annual Tourist Estimate[1]
Washington County	16,013,000
Iron County	632,000
Kane County	465,000

Notes:
[1] Average annual tourists = (# hotel rooms) * (occupancy rate) * (1.5 people per room) * (365 days per year).
Source: (Utah Division of Water Resources 2007).

Southwest Utah experiences temporary population increases above the base population because there are a high percentage of part-time home owners that reside in second homes in the area during the winter months or other short durations during the year. These second home owners are not included in the base population records shown in Table 5-12, however they add to water needs and to temporary population increases.

College students temporarily reside at or near universities for part of the year contribute to population dynamics in the Project area. There are several colleges and universities within the Project area. The average annual student population is summarized in Table 5-14 based on information collected from the following universities: Dixie State College, Dixie Applied Technology College, Southwest Applied Technology College, Southern Utah University, and Utah State University (satellite campus).

Table 5-14 Average Annual Student Population for Southwest Utah Counties	
County	**Average Annual Student Population**
Washington County	10,100
Iron County	9,700
Kane County	0
Source: (Utah Division of Water Resources 2007).	

5.12.3 Water Supporting Population and Economic Growth

Water supplies in southwest Utah have been developed during the past 150 years to meet agricultural, municipal and industrial demands. Supplies have been derived through diversions from surface streams such as the Virgin River in Washington County, Coal Creek in Iron County, Kanab Creek in Kane County, and through pumping from groundwater sources such as the Navajo Sandstone aquifer in Kane County and Washington County and Cedar Valley aquifer in Iron County.

Recent population and tourism growth in the area has utilized most of the existing water supplies, and has forced communities to plan and pursue new water projects and develop comprehensive water conservation programs. Growing water demands are increasing the use of local water sources in some areas to a level that is approaching or surpassing the sustainable yield of available resources. This condition is causing water providers to pursue water sources outside of their respective basins to meet the projected demands of future growth. Execution of water conservation programming has been calculated into anticipated water demands for the water conservation districts, however future demands are anticipated to significantly increase because of increasing population

It is the intent of Washington County planners that urban growth should occur within the corporate boundaries of existing cities. This has resulted in policies to encourage development/infill within existing city boundaries, and to annex areas of pending development into existing cities.

5.12.3.1 Water Resources in WCWCD Service Area

Surface water and groundwater sources within the WCWCD service area are considered by the Utah Division of Water Rights to be fully appropriated at this time (UDWR 2008). Currently, Washington County’s total reliable potable water supply is estimated to be 71,300 acre-feet per year. Current water demands for WCWCD customers are estimated at approximately 47,000 acre-feet per year. Projected water demands in the WCWCD service area are anticipated to increase up to five times their current amounts by 2050.

5.12.3.2 Water Resources in CICWCD Service Area

CICWCD currently provides culinary M&I water to multiple customers and is planning on extending an existing secondary water use system into an area of new development. Existing M&I water supply within the CICWCD service area consists of groundwater supply from the Cedar Valley groundwater basin. CICWCD is building its customer base and currently has limited water supply because of this small but growing customer base. The Cedar Valley groundwater basin is currently considered to be over-appropriated. Current water demand by CICWCD customers is approximately 10,000 acre-feet per year. Projected future water demands are anticipated to increase to 25,000 to 35,000 acre-feet per year by 2050.

5.12.3.3 Water Resources in KCWCD Service Area

The total reliable potable supply in Kane County including water rights owned by KCWCD is 5,270 acre-feet per year. Reliable secondary water supply comprises 564 acre-feet per year, for a total reliable water supply of approximately 5,800 acre-feet per year. The demand forecast for KCWCD indicates that total M&I demand for KCWCD would increase from 3,000 acre-feet per year in 2005 to 4,400 to 5,500 acre-feet per year in 2050. A combination of existing and new groundwater supplies in KCWCD is sufficient to meet all future needs within the planning horizon.

5.13 Transportation Resources

Transportation resources within the Project area are primarily comprised of existing federal, state, county, city, and private roads (see Figure 5-45). Interstate 15 (I-15) is the primary north-south interstate highway in Utah. It passes through the St. George metropolitan area as well as Cedar City; the Project's Cedar Valley pipeline would parallel I-15 from the Quail Creek Reservoir area to the Cedar City area.

The Project alignment would parallel a portion of U.S. Highway 89. Although the highway is a U.S. Highway that predominantly runs north-south, the section within the Project area is oriented mostly east-west. The highway, along with Arizona and Utah state highways, functions as a main transportation route between Lake Powell and the St. George metropolitan area and provides a transportation corridor through the Grand Staircase-Escalante National Monument.

The Project pipeline would parallel U.S. Highway 89, Arizona State Highway 389 and Utah State Highway 59. It would cross U.S. Highway 89A and State Highway 237. The Project is planned to be situated outside of the running surface of the roads and within the established road rights-of-way.

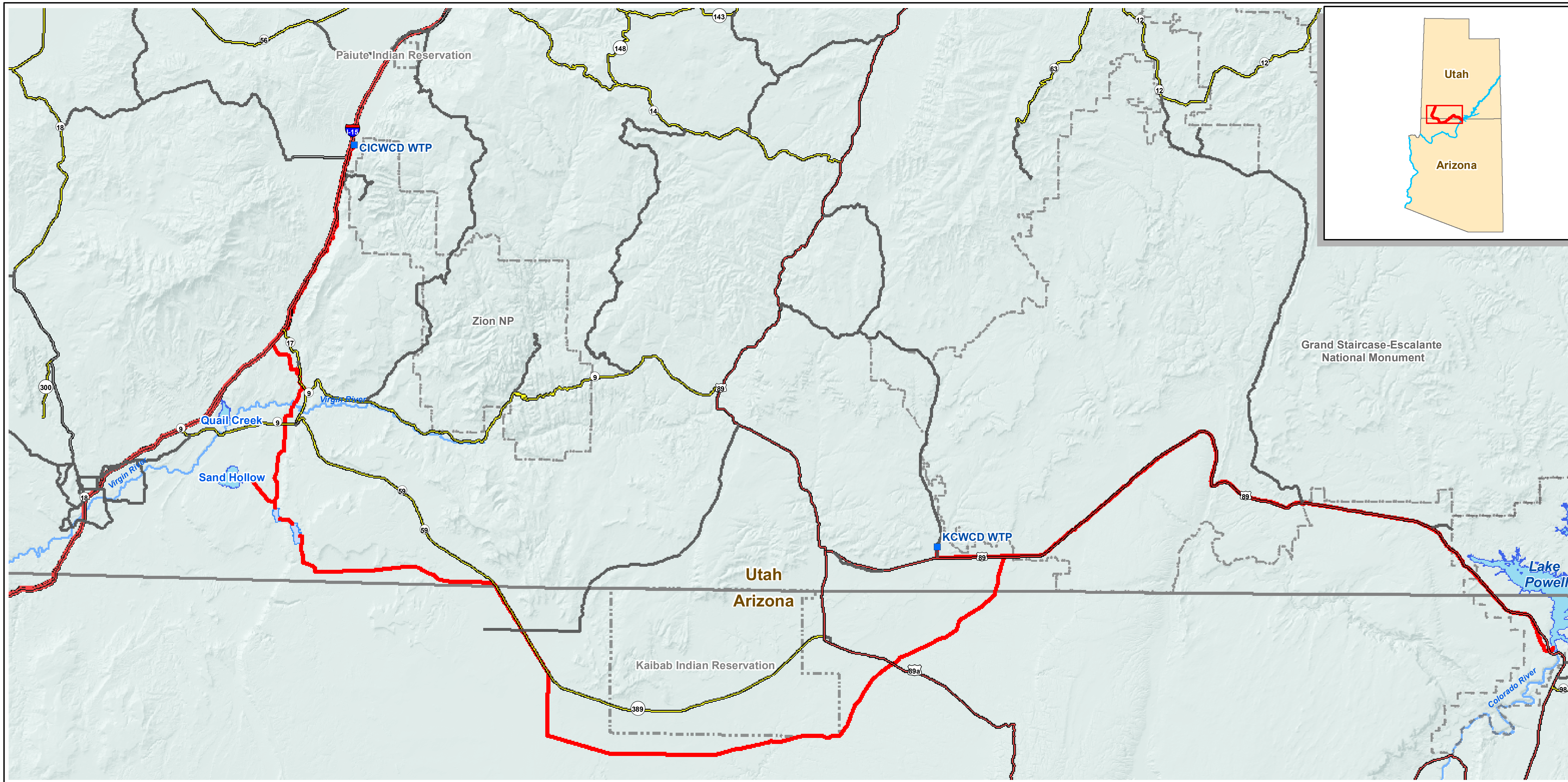
Commercial air travel is fairly limited in the Project vicinity. The closest international airport is located in Las Vegas, approximately 160 miles from the Project area. The second closest international airport is in Salt Lake City, approximately 290 miles from the Project area. St. George Municipal and Cedar City Regional Airport are closer to the Project area and provide commuter airline service. A large regional airport is anticipated to be completed in 2010 to serve the rapidly-growing population in the St. George metropolitan area. Page, Arizona has a small, municipal airport approximately 5 miles from Glen Canyon Dam that provides scheduled air service to Denver, Colorado and Phoenix, Arizona.

No existing off-street trail systems have been identified within the Project area. There are a number of 4-wheel drive roads and trails within the Project area.

No rail or water transportation is available within the Project area. St. George and Cedar City have local bus companies that serve these metropolitan areas.

5.14 Air Quality

Fugitive dust has been identified as a threat to air quality in the St. George metropolitan area (Southern Utah Air Quality Task Force 2007). The recent Central Iron County Rapid Watershed Assessment also identified air quality associated with fugitive dust as a current issue that will likely become even more of



Legend

- Water Treatment Plant
- Project Alignment
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- State Boundaries
- Tribal Lands
- National Parks & Monuments
- Major Rivers
- Lakes & Reservoirs
- Hurricane Cliffs Forebay/Afterbay

Lake Powell Pipeline Project
Transportation Routes

0 2 4 8 12 16 Miles

Lake Powell Pipeline Project

1:500,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 5-45** MWH

Transportation Resources

an issue in the future (NRCS 2007). Fugitive dust is known to cause health problems, often in combination with other air pollutants. Various population sectors including infants, the elderly, and people with respiratory problems can be affected by dust. Intensive residential and commercial development in southwest Utah, primarily associated with population growth, has increased fugitive dust problems in the area. Although dust storms have long been common in the southwest Utah region, more fugitive dust has been produced by human-caused sources in recent years because of development activities. Fugitive dust producing activities include land clearing of vegetation to prepare for housing and other construction, vehicle use of dirt and gravel roads for construction equipment access and materials transport, mineral extraction and processing, and recreational access. Once fugitive dust is generated from a site, it can be transported and dispersed by high winds across the valley areas. Air pollution problems associated with fugitive dust have gained more attention in recent years (Southern Utah Air Quality Task Force 2007).

5.15 Tribal Resources

5.15.1 Identified Native American Tribes and Nations

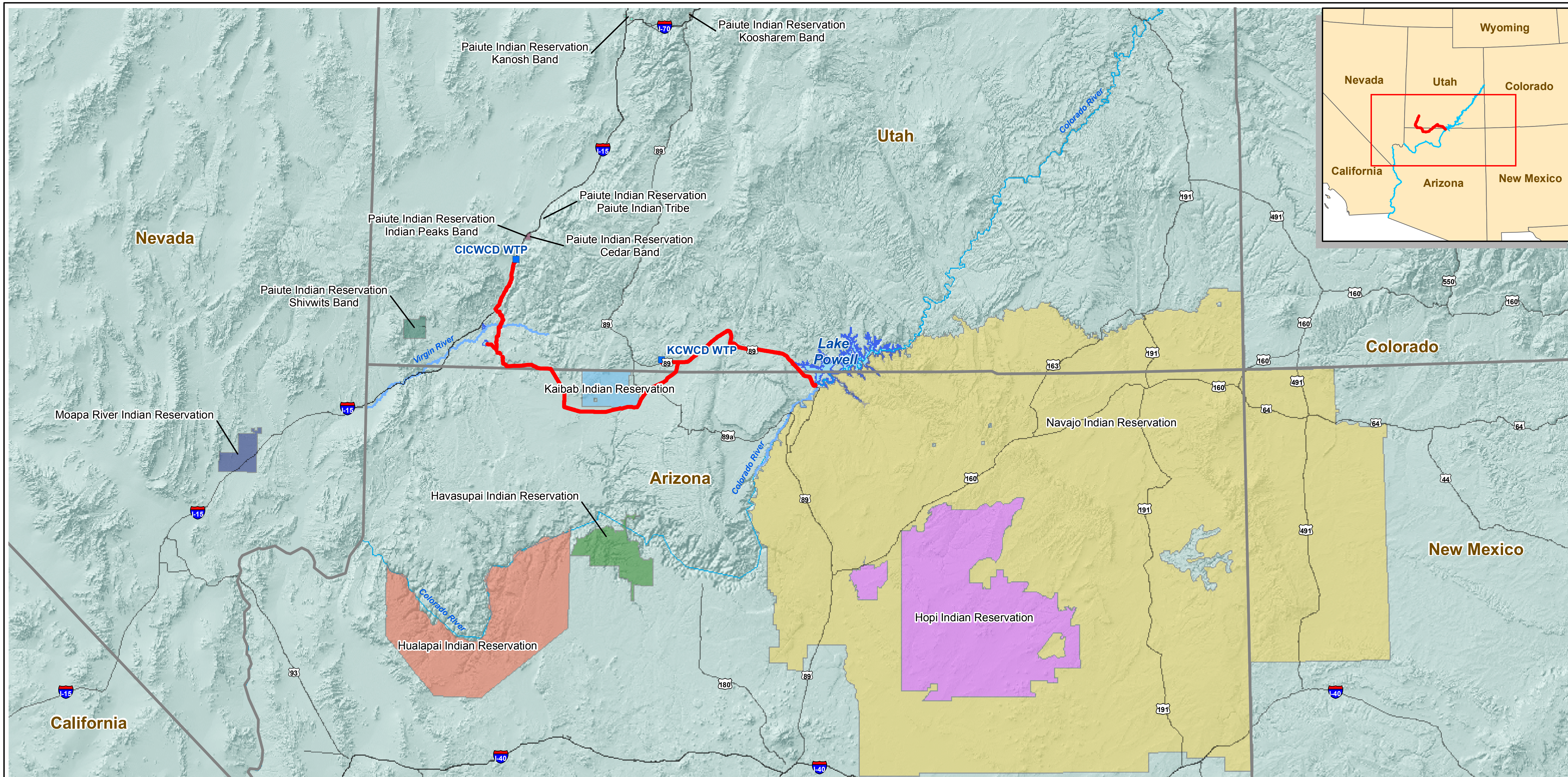
Native American tribes and nations in the Project region include the Paiute Indian Tribe of Utah, the Kaibab-Paiute Tribe, the Navajo Nation, and the Hopi Indian Tribe. The following briefly describes the localities of tribes and nations in the Project region.

5.15.1.1 Paiute Indian Tribe of Utah

The modern-day Paiute Indian Tribe of Utah consists of five constituent bands: Cedar, Indian Peaks, Kanosh, Koosharem, and Shivwits. The five bands were reorganized as the Paiute Indian Tribe of Utah by an act of Congress (25 U.S.C. §761) on April 3, 1980. The federal government formally recognizes both the Paiute Indian Tribe of Utah and its five constituent bands as Indian Tribal entities located within the boundaries of the Paiute Indian Tribe of Utah Tribal Reservation (Reservation). The Reservation consists of ten separate land parcels located in four southwestern Utah counties. Figure 5-46 shows the locations of the Reservation lands. The Paiute Indian Tribe of Utah holds a 45-acre parcel in Iron County near Cedar City. The Cedar Band holds a 2,047-acre parcel in Iron County along Interstate 15 southwest of Cedar City. The Indian Peaks Band holds a 425-acre parcel in Iron County west of Cedar City. The Kanosh Band holds three parcels totaling 1,342 acres in Millard County near Interstate 15. The Koosharem Band holds three parcels totaling 1,274 acres in Sevier County near Interstate 70, Joseph, and Richfield. The Shivwits Band holds a 28,229-acre parcel in Washington County northwest of St. George. There were 840 tribal members recorded among the five bands in 2006.

5.15.1.2 Kaibab-Paiute Tribe

The Kaibab-Paiute Tribe is a member of the Southern Paiute Nation, the latter of which covers lands along the southern Great Basin and San Juan-Colorado River drainage. The Kaibab Paiute Indian Reservation (Reservation) was established by two Executive Orders signed by President Woodrow Wilson, the first on June 11, 1913 and the second on July 17, 1917. The Reservation consists of 120,431 acres located in Mohave and Coconino counties, Arizona (see Figure 5-46). The Reservation's north boundary is the Arizona-Utah border, and Kanab Creek runs north to south through the Reservation. The communities of Kanab and Fredonia are situated northeast and east of the Reservation; Colorado City is situated west of the Reservation. Arizona State Highway 389 runs east-west across the Reservation, and the Navajo-McCullough Transmission Line crosses the southeast corner of the Reservation. Most of the Reservation land is undeveloped. The Kaibab-Paiute Tribe has 240 members. The Project pipeline and penstock alignment would be located south of the Reservation.



Legend

- Water Treatment Plant
- Project Alignment
- States
- Interstate
- US Highway
- Major Rivers
- Colorado_River
- Lakes & Reservoirs

Native American Boundaries

- Havasupai Indian Reservation
- Hopi Indian Reservation
- Hualapai Indian Reservation
- Kaibab Indian Reservation
- Moapa River Indian Reservation
- Navajo Indian Reservation
- Paiute Indian Reservation, Cedar Band
- Paiute Indian Reservation, Kanosh Band
- Paiute Indian Reservation, Koosharem Band
- Paiute Indian Reservation, Paiute Indian Tribe
- Paiute Indian Reservation, Shivwits Band

0 5 10 20 30 40
Miles

Lake Powell Pipeline Project

1:2,000,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 5-46 MWH

Native American Reservations & Nations

5.15.1.3 Navajo Nation

The Navajo Nation extends into southern Utah, northern Arizona and western New Mexico, covering more than 27,000 square miles (Figure 5-46). The Colorado River downstream of Glen Canyon Dam, Lake Powell and the San Juan River form the north boundary of the Navajo Nation. The Navajo Nation covers parts of San Juan County in Utah, Coconino, Navajo and Apache counties in Arizona, and San Juan, McKinley, Cibola, Socorro, and Bernalillo counties in New Mexico. Interstate 40, U.S. Highways 89, 160, 191, and 491 cross portions of the Navajo Nation land. The Navajo Nation population now surpasses 250,000. The Project intake and water conveyance system would be located north of the Navajo Nation and Lake Powell.

5.15.1.4 Hopi Indian Tribe

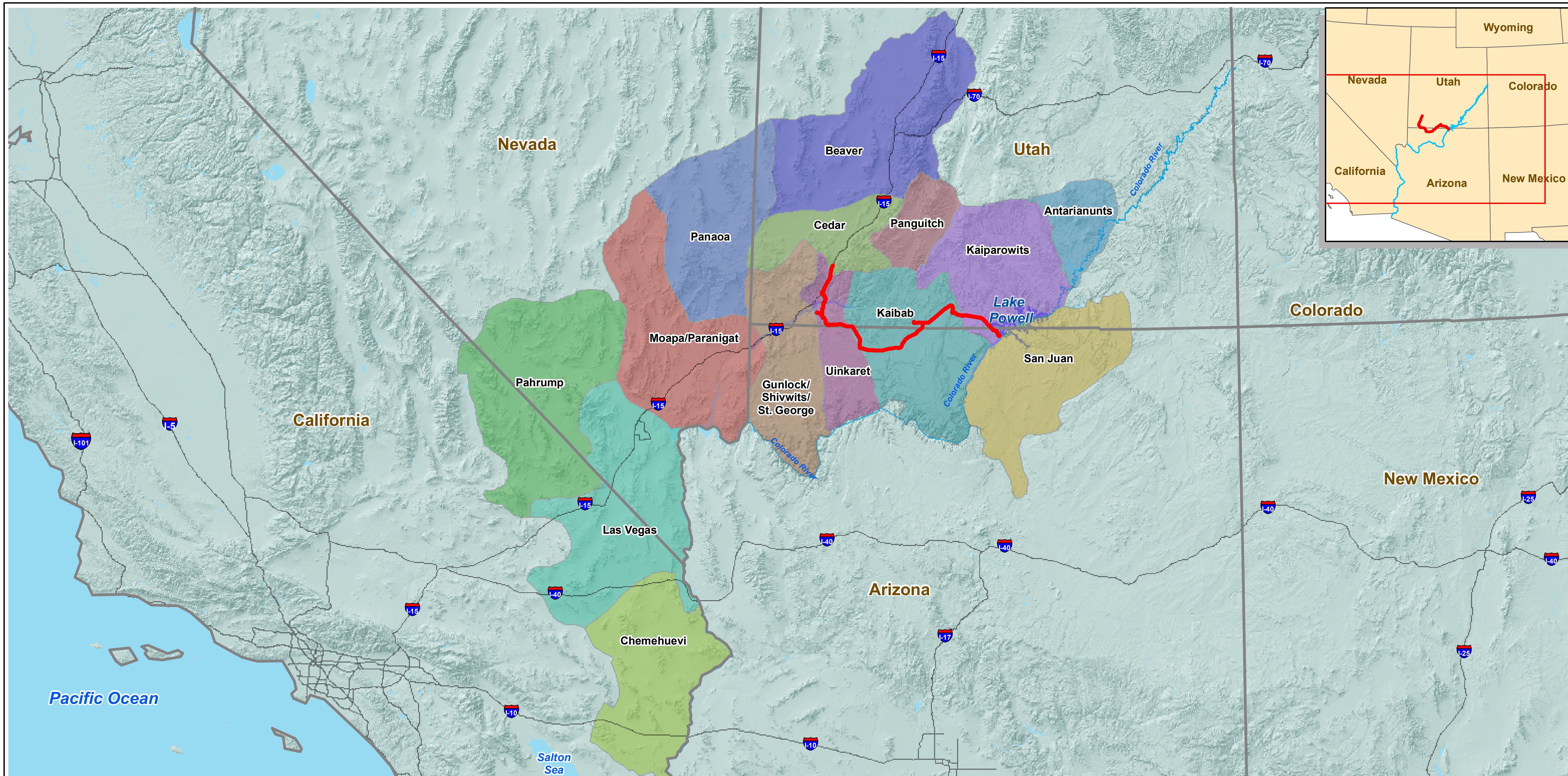
The Hopi Indian Tribe is a gathering of Native American people that live in the arid highlands and mesas of northeast Arizona. The Hopi Indian Reservation, which covers 2,532 square miles, is the home of the Hopi Indians and the reservation is completely surrounded by the Navajo Nation. Arizona State Highway 264 runs east-west across the Hopi Indian Reservation. The Hopi Indian Tribe has a population of about 7,000. The Project intake and water conveyance system would be located north of the Hopi Indian Reservation and Lake Powell.

5.15.1.5 Traditional Southern Paiute Territory

The Traditional Southern Paiute Territory refers to areas traditionally associated with Southern Paiute entities such as tribes, communities and kinship units during the past 40 years or at least 2 generations in and around national parks. The term *traditionally associated* is used by the National Park Service to define cultural entities that regard a park's resources as essential to their development and continued identity as a culturally distinct people. Figure 5-47 shows the traditional Southern Paiute Territory in the area around the Project (Stoffle 2005). Traditional Southern Paiute Territory divisions that would be crossed by Project features include the Kaiparowits Band, Kaibab Band, Unikaret Band, Gunlock/Shivwits/St. George Bands, and Cedar Band.

5.15.2 Tribal Interests Affected by the Project

The region in and around the Project is considered to contain resources, properties, sites and areas important to Native American tribes and nations. The range of elevations and areas associated with riverine, riparian, and pinyon-juniper habitats along the Project alignment includes many potential types of interests that could be affected by the Project. These tribal interests could include Traditional Cultural Properties, sacred sites, petroglyphs, other rock art sites, and traditional hunting, foraging and gathering areas. The resources, properties, sites and areas are expected to be situated on and off reservation lands. The Project area also may include Indian Trust Assets (lands, natural resources, other assets held by the Federal Government in trust or that are restricted against alienation for Indian Tribes and individual Indians) or affect other treaty-based rights. Specific information regarding the potential for the Project to affect any of these rights will be developed through consultation with the identified Tribes and the Navajo Nation.



Legend

- Project Alignment
- Interstates
- States
- Major Rivers
- Lakes & Reservoirs

Territory

- Antarianunts
- Beaver
- Cedar
- Chemehuevi
- Gunlock/Shivwits/St. George
- Kaibab
- Kaiparowits
- Las Vegas
- Moapa/Paranigat
- Pahrump
- Panaoa
- Panguitch
- San Juan
- Uinkaret

0 25 50 100 150 Miles

Lake Powell Pipeline Project

1:3,600,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 5-47** MWH

Traditional Southern Paiute Territory