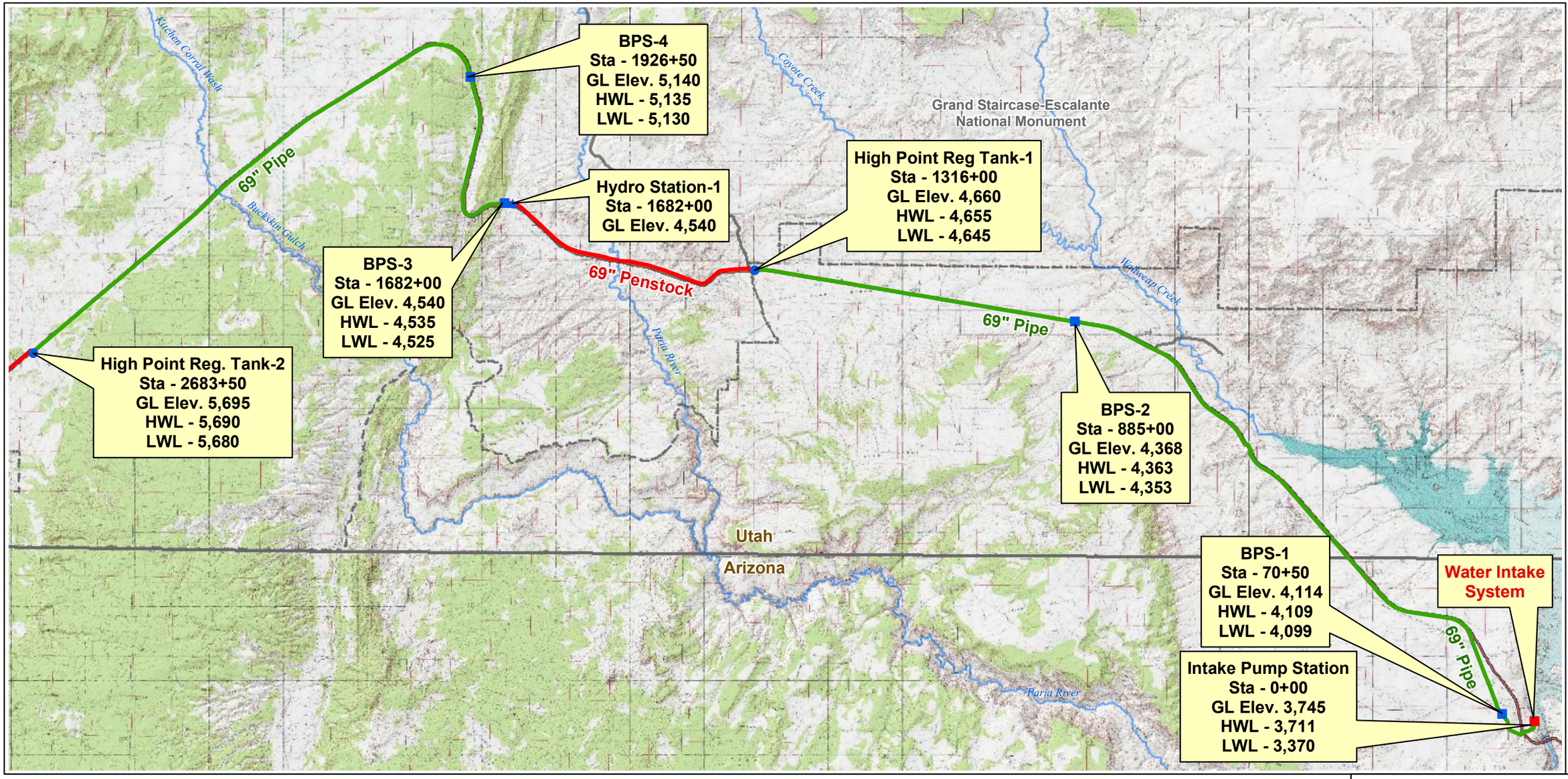
Section 4
Description of the Proposed Project

4.1 Project Overview

The Project concept consists of constructing and operating 139 miles of 69-inch diameter pipeline and penstock; 35 miles of 48- to 30-inch diameter pipeline; 6 miles of 24-inch diameter pipeline; a combined conventional peaking and pumped storage hydro station; and six conventional in-line hydro stations on Federal, state, and private lands in Kane, Washington and Iron counties, Utah and in Coconino and Mohave counties, Arizona. Figure 4-1 shows the eastern 44-miles of the Lake Powell Pipeline, which is comprised primarily of the Water Intake System and Water Conveyance System moving water from Lake Powell up to a topographical high point within the Grand Staircase-Escalante National Monument (GSENM). Figure 4-2 shows the western 95-miles of the Lake Powell Pipeline that would primarily serve as the Hydro System where water is conveyed through a series of penstock pipelines and turbine generators. The Hydro System begins at the topographical high point within the GSENM and would generate power through gravity flow at several locations as it passes through northern Arizona and southwest Utah ending at Sand Hollow Reservoir, near St. George, Utah. Figure 4-3 shows the alignment of the Cedar Valley Pipeline System from the Hurricane Cliffs afterbay reservoir to Cedar Valley in Iron County, Utah. The Project would operate 350 days annually, with 15 days annually for facility inspection and maintenance. The Project's four systems would involve constructing and operating the following primary facilities:

- The Water Intake System on the west side of Lake Powell in Coconino County, Arizona
- Four booster pump stations along the 44-mile long water conveyance pipeline alignment, three in Kane County, Utah and one in Coconino County, Arizona and 6.6 miles of power transmission line to supply electricity to the pump stations (Water Conveyance System)
- 44-miles of 69-inch diameter buried pipeline from Lake Powell to two regulating tanks at high points in the Grand Staircase-Escalante National Monument (GSENM) along a 60-foot wide operational right-of-way in Kane County, Utah (Water Conveyance System)
- 6.3-miles of 24-inch diameter buried pipeline from the 69-inch diameter penstock west of the GSENM boundary to the mouth of Johnson Canyon, terminating at a proposed regional water treatment plant serving KCWCD in Kane County, Utah (Water Conveyance System)
- 95-miles of 69-inch diameter buried penstock which includes 88 miles of continuous penstock pipeline from the two regulating tanks at high points in the GSENM to the existing Sand Hollow Reservoir along a 60-foot wide operational right-of-way in Kane and Washington counties, Utah and Coconino and Mohave counties, Arizona (Hydro System)
- Five in-line hydro stations utilizing impulse type turbine units along the pipeline and penstock alignment, ranging in capacity from 1.0 MW to 3.5 MW; two in Kane County, Utah, one in Mohave County, Arizona, and two in Washington County, Utah (Hydro System)
- Hurricane Cliffs Pumped Storage Hydro consisting of two generating units with combined capacity of 300 MW alongside a single 35 MW peaking generating unit in Washington County, Utah (Hydro System)



Legend

- Project Intake Pump Station
- Project Pump Station
- Project Regulating Tank
- Project Hydro Station
- Project Pipeline Alignment
- Project Penstock Alignment
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- Major Rivers & Streams
- National Park/Monument
- GSENM Boundary
- State Boundaries

0 0.5 1 2 3 4 Miles

Lake Powell Pipeline Project

1:161,394 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-1** MWH

Water Intake System & Water Conveyance System

Sand Hollow Hydro Station - 7
Sta - 7349+00
GL Elev. 3,075
TWL - 3,060

Hydro Station - 5
Sta - 6960+00
GL Elev. 4,749
HWL - 4,740

69" Penstock

Hurricane Cliffs Hydro Station - 6
Sta - 7067+50
GL Elev. 3,700
HWL - 3,660
LWL - 3,560

69" Penstock

Hydro Station - 4
Sta - 6020+00
GL Elev. 5,074
HWL - 5,069
LWL - 5,059

69" Penstock

Hydro Station - 3
Sta - 5519+00
GL Elev. 5,182
HWL - 5,177
LWL - 5,167

69" Penstock

High Point Reg. Tank-2
Sta - 2683+50
GL Elev. 5,695
HWL - 5,690
LWL - 5,680

69" Pipe

KCWCD WTP

24" Pipe

Hydro Station - 2
Sta - 2820+50
GL Elev. 5,479
HWL - 5,474
LWL - 5,464

69" Penstock

Virgin River
North Fork Virgin River
Kanab Creek
Grand Staircase-Escalante National Monument
Deer Spring Wash
Kaibab Indian Reservation
Utah
Arizona
White Sage Wash
Sand Wash
Rabbit Wash
Bitter Seep Wash
Jacob Canyon
Round Valley
Hurricane Wash
Clayhole Wash

Legend

- Water Treatment Plant
- Project Pump Station
- Project Regulating Tank
- Project Hydro Station
- Project Pipeline Alignment
- Project Penstock Alignment
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- Hurricane Cliffs Forebay/Afterbay
- National Park/Monument
- GSENM Boundary
- Tribal Lands
- State Boundaries
- County Boundaries
- Lakes & Reservoirs
- Major Rivers & Streams

0 1.25 2.5 5 7.5 10 Miles

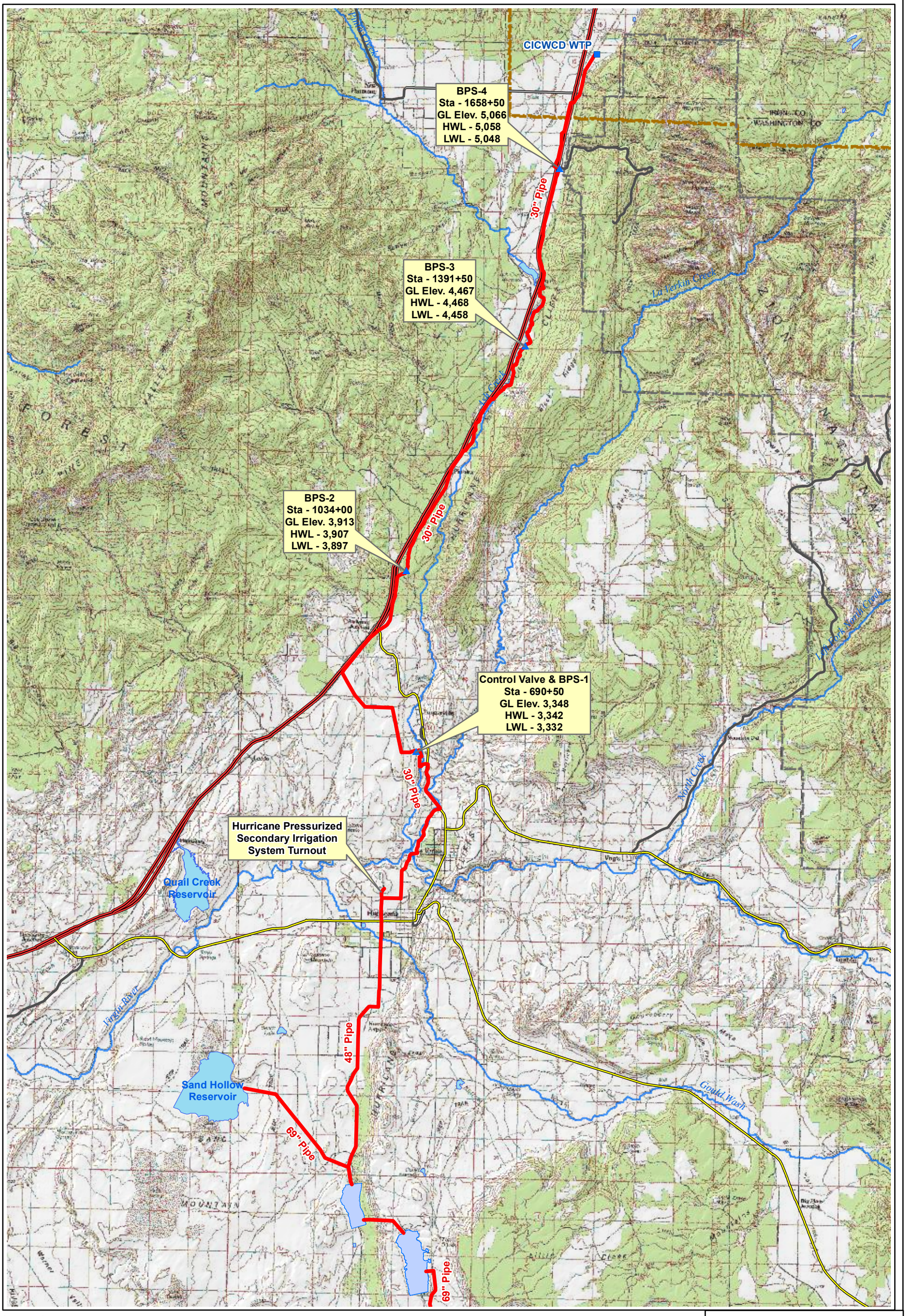
Lake Powell Pipeline Project

1:300,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-2** MWH

Hydro System


CICWCD WTP
BPS-4
Sta - 1658+50
GL Elev. 5,066
HWL - 5,058
LWL - 5,048
30" Pipe
BPS-3
Sta - 1391+50
GL Elev. 4,467
HWL - 4,468
LWL - 4,458
Ash Creek
Lt Creek
BPS-2
Sta - 1034+00
GL Elev. 3,913
HWL - 3,907
LWL - 3,897
30" Pipe
Control Valve & BPS-1
Sta - 690+50
GL Elev. 3,348
HWL - 3,342
LWL - 3,332
30" Pipe
Hurricane Pressurized
Secondary Irrigation
System Turnout
Quail Creek
Reservoir
Virgin River
48" Pipe
Sand Hollow
Reservoir
69" Pipe
69" Pipe
North Creek
Gould Wash
Legend
Pump Stations
Water Treatment Plant
Project Pipeline Alignment
Hurricane Cliffs Forebay/Afterbay
Reservoirs
Major Rivers & Streams
National Park/Monument
Interstate
US Highway
ST Highway
Hwy
Major Road
0 0.5 1 2 3 4
Miles
Lake Powell Pipeline Project
1:150,000 Scale
Spatial Reference: UTM Zone 12N, NAD-83
UDWR Figure 4-3 MWH
Cedar Valley
Pipeline System

- Sand Hollow Hydro consisting of a turbine generating system with a single generating unit of approximately 3.5 MW capacity at the terminus of the Lake Powell Pipeline along the shoreline of the existing Sand Hollow Reservoir in Washington County, Utah (Hydro System)

- 42-miles of power transmission line, including about 35 miles of 138-kV line connecting in-line hydro stations to the existing power grid and about 7 miles of 345 kV line from the Hurricane Cliffs Pumped Storage Hydro and Sand Hollow Hydro to the planned Hurricane West 345 kV substation (Hydro System)

- 35-miles of 48- to 30-inch diameter buried pipeline from the Hurricane Cliffs afterbay to the Hurricane pressurized secondary irrigation system and to a regional water treatment plant in the Cedar Valley near Kanarraville along a 50-foot wide operational right-of-way in Washington and Iron counties, Utah and 2.2 miles of power transmission line to supply electricity to the four booster pump stations (Cedar Valley Pipeline System)

4.2 Water Intake System

The Water Intake System would be situated on the west shore of Lake Powell approximately 2,000 feet northwest of Glen Canyon Dam. It would be located on federal land managed by the Bureau of Reclamation (Reclamation) that was previously used as a staging area during construction of Glen Canyon Dam. Figure 4-4 shows the Water Intake System site within the Reclamation management area.

The Water Intake System would consist of four multiple-level horizontal intake tunnels connecting to Lake Powell at various elevations, two vertical intake shafts, an intake pump station with six vertical turbine intake pumps connected to a discharge header pipe leading to the 69-inch diameter buried water conveyance pipeline. Figure 4-5 shows a conceptual cross section of the intake pump station, which would have a ground level elevation of 3,745 feet MSL. The intake pump station site would have six buried steel surge tanks connected to the buried water conveyance pipeline to absorb potential pipeline hydraulic surges during Project operation. The vertical turbine pumps would be housed in a pump station building with an electrical room and a bridge crane for pump and motor maintenance. The vertical turbine pumps would have a total dynamic rated head of 747 feet and a combined rated total 19,200 horsepower (hp). A power transmission line would be constructed to supply electricity to operate the intake pump station.

4.3 Water Conveyance System

The Water Conveyance System would generally run alongside and parallel to U.S. Highway 89 from the intake pumping station to the topographical high point in the GSENM. Most of it would occupy Federal lands managed by Reclamation, the National Park Service, the Bureau of Land Management (BLM), and on State of Utah land managed by the School and Institutional Trust Lands Administration (SITLA). Figure 4-1 shows the Water Conveyance System alignment that also includes a 6.9-mile-long penstock section that is part of the Hydro System. Most of the buried pipeline and penstock would be within the U.S. Highway 89 right-of-way, except for a short segment on land managed by the National Park Service near Lake Powell. The U.S. Congress established a utility corridor for the pipeline along Highway 89 as part of Public Law 105-355 in 1998. The utility corridor runs from the west boundary of Glen Canyon National Recreation Area through the GSENM, and extends 240 feet north and 500 feet south of the highway centerline. The pipeline would be situated within the established utility corridor to a point west of the GSENM boundary.

Legend

- Project Pipeline Alignment
- Bureau of Reclamation Management Area
- Intake Pump Station
- Curb Lines
- Landscape Berm

0 100 200 400 600 800 Feet

N

Lake Powell Pipeline Project

1:4,800 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-4** MWH

Water Intake System Site

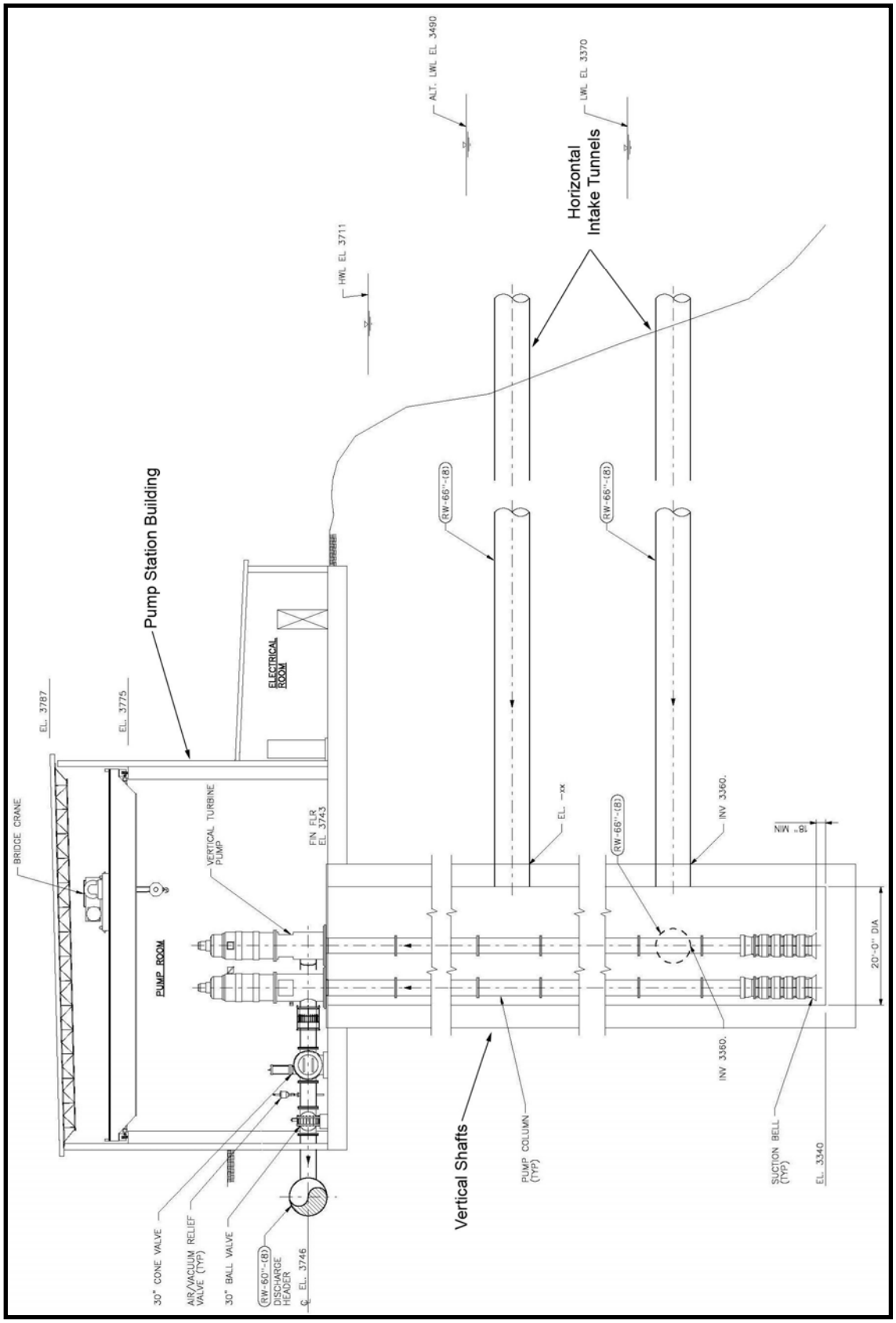


Figure 4-5
Lake Powell Pipeline Project
Conceptual Cross Section of Intake Pump Station

The Water Conveyance System would consist of 44 miles of 69-inch inside diameter buried pipeline, four booster pump stations, two regulating tanks sited at topographical high points along the pipeline alignment, and power transmission lines to supply electricity to the booster pump stations. Figure 4-6 shows the hydraulic grade line for the components of the Water Conveyance System including In-Line Hydro No. 1 and its corresponding 6.9-mile-long penstock section, part of the Hydro System. The pipeline would be designed for operating pressures ranging from 200 to 250 psi. The four booster pump stations would be designed to operate at pressures ranging from 200 to 300 psi. Figure 4-7 shows a conceptual cross section of a typical booster pump station, including a 1 million gallon forebay reservoir, six vertical turbine pumps, valves, electrical room, bridge crane for pump and motor maintenance, and connection to a discharge header. Each booster pump station site would have six buried steel surge tanks connected to the buried water conveyance pipeline to absorb potential pipeline hydraulic surges during Project operation. The regulating tanks would be buried concrete reservoirs, each with 1 million gallon capacity.

Booster Pump Station 1 would be situated on 5 acres of Federal land managed by the National Park Service, about 1.3 miles from the Water Intake System. The existing ground level at the pump station site is 4,114 feet MSL. The pumps would operate to provide 200 psi discharge line pressure. The vertical turbine pumps would have a total dynamic rated head of 350 feet and a combined total rated power of 12,000 hp.

Booster Pump Station 2 would be situated on 5 acres of state land managed by SITLA about 16.8 miles from the Water Intake System. The existing ground level at the pump station site is 4,368 feet MSL. The pumps would operate to provide 200 psi discharge line pressure. The vertical turbine pumps would have a total dynamic rated head of 350 feet and a combined total rated power of 12,000 hp.

High Point Regulating Tank 1 would be situated on 5 acres of Federal land managed by the BLM about 25 miles from the Lake Powell intake facility. The 1 million gallon capacity buried concrete tank would have a ground level elevation of 4,660 feet MSL.

Booster Pump Station 3 would be situated on 5 acres of Federal land managed by the BLM at the east side of The Cockscomb (a sandstone ridge formation in the GSENM) about 31.8 miles from the Water Intake System. The existing ground level at the pump station site is 4,540 feet MSL. The pumps would operate to provide 300 psi discharge line pressure. The vertical turbine pumps would have a total dynamic rated head of 642 feet and a combined total rated power of 21,000 hp.

Booster Pump Station 4 would be situated on 5 acres of Federal land managed by the BLM on the west side of The Cockscomb about 36.5 miles from the Water Intake System. The existing ground level at the pump station site is 5,043 feet MSL. The pumps would operate to provide 300 psi discharge line pressure. The vertical turbine pumps would have a total dynamic rated head of 642 feet and a combined total rated power of 21,000 hp.

High Point Regulating Tank 2 would be situated on 5 acres of Federal land managed by the BLM about 51 miles from the Lake Powell intake facility. The 1 million gallon capacity buried concrete tank would have a ground level elevation of 5,695 feet MSL.

The water conveyance pipeline would have appurtenances including vacuum relief valves, air release valves, and blowoff discharge valves at specific points along the alignment. All appurtenant valves would be housed in buried concrete vaults with a manhole access at the ground surface elevation. Blowoff valves would discharge to natural drainages crossed by the pipeline. The water conveyance system would have a Supervisory Control and Data Acquisition (SCADA) control feature that would allow pump

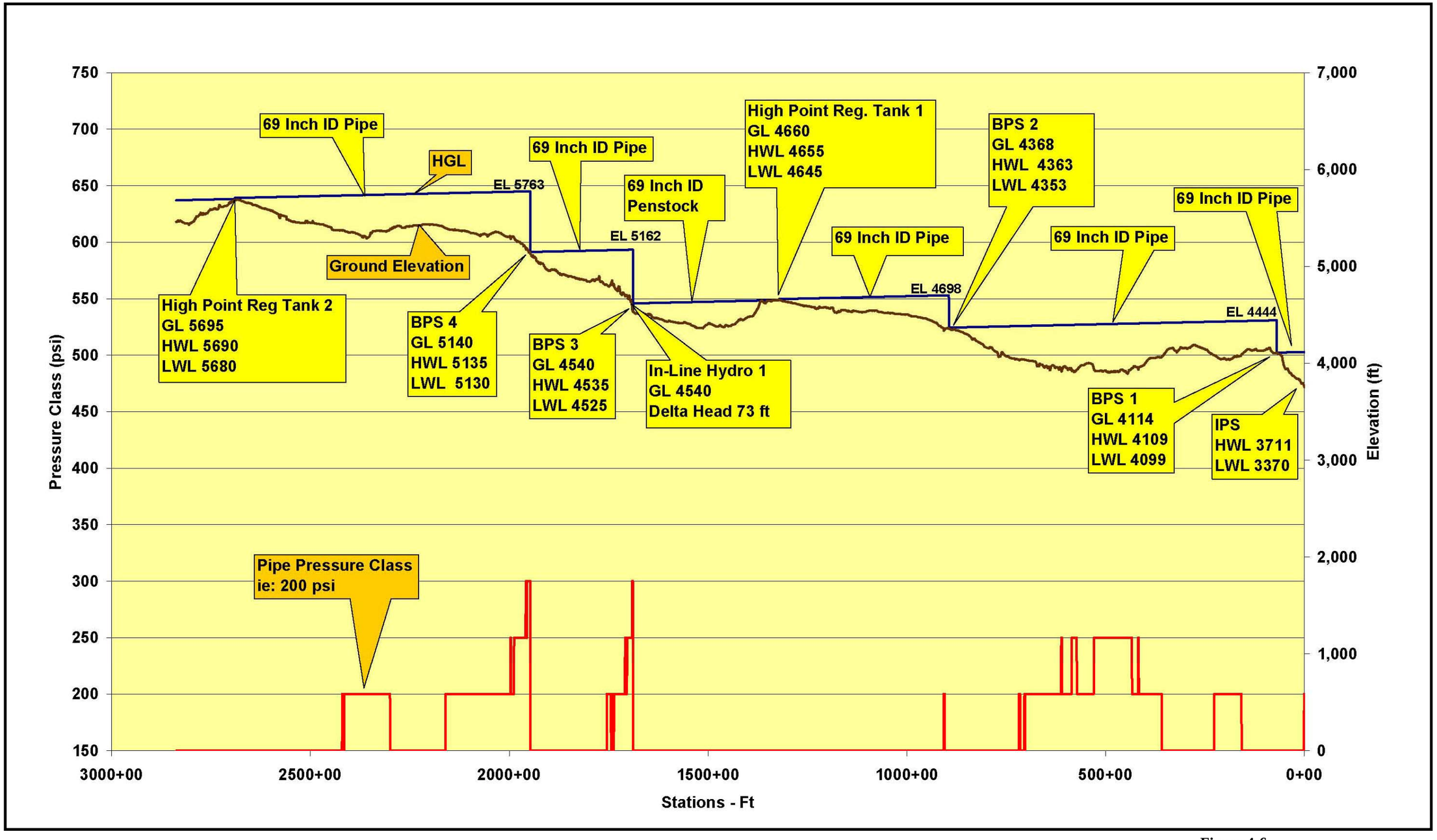


Figure 4-6
Lake Powell Pipeline Project
Water Conveyance System Hydraulic Grade Line

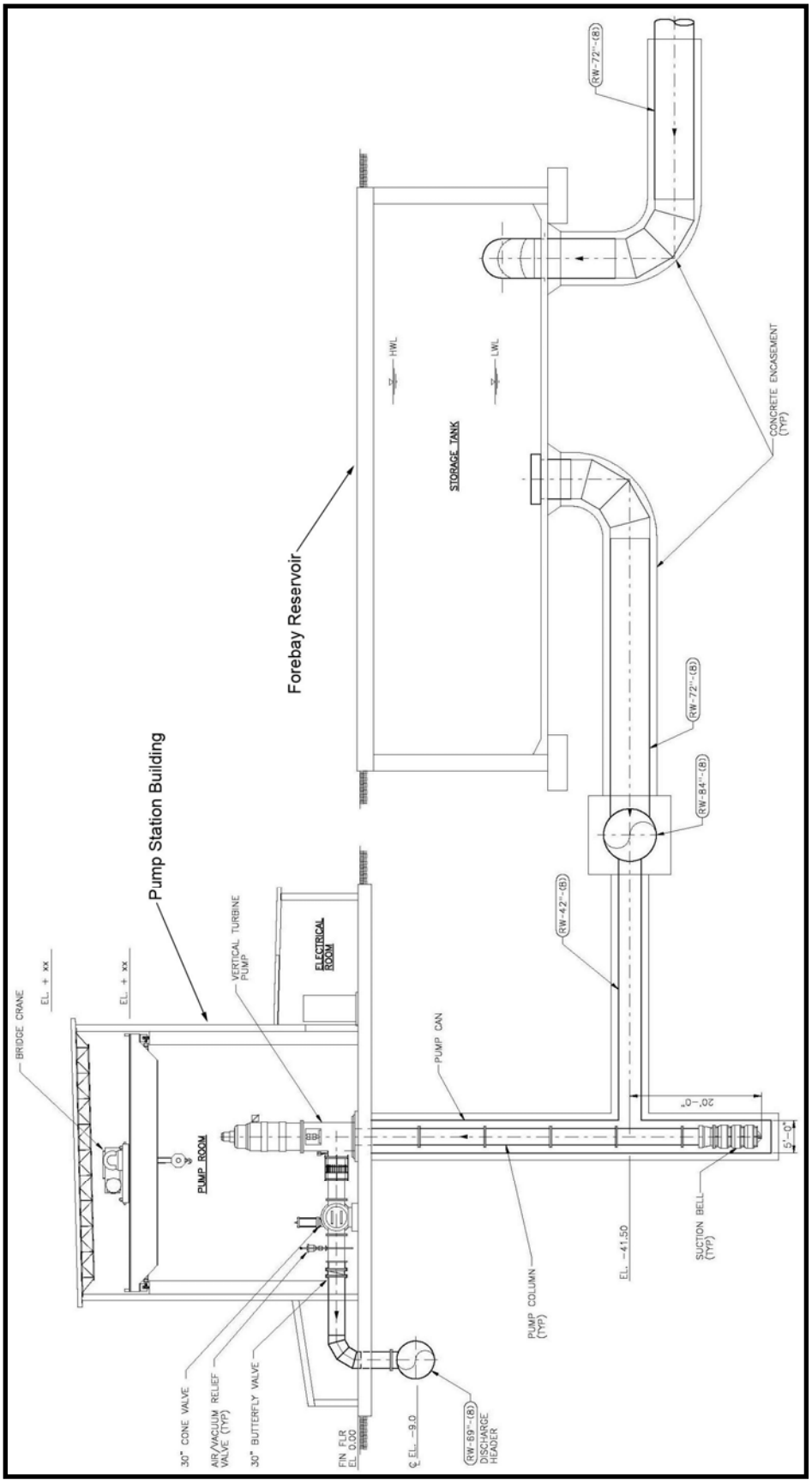


Figure 4-7
Lake Powell Pipeline Project
Conceptual Cross Section of Intake Pump Station

stations, valves and regulating tanks to be remotely monitored and operated from a control building in St. George.

The KCWCD would divert their portion of the Project water from the penstock pipeline immediately west of the GSENM boundary into a 24-inch diameter pipeline (see Figure 4-2). The buried pipeline would parallel U.S. Highway 89 for about 5.3 miles to the mouth of Johnson Canyon, where it would extend north for one mile to an existing water tank. A proposed regional water treatment plant would be located at an elevation above the existing tank. The Project water treated in the new treatment plant would be conveyed by gravity flow to the existing tank for distribution through an existing piping system.

4.4 Hydro System

4.4.1 Overview

The Hydro System, which the Applicant proposes to be licensed, would generally run alongside and parallel to portions of U.S. Highway 89, the Navajo-McCullough Transmission Line, and Arizona State Highway 389 from topographical high point 2 in the GSENM to Sand Hollow Reservoir. It also includes the 6.9-mile-long penstock and power station associated with In-line Hydro Station 1 west of the first topographical high point, also in the GSENM. The Hydro System facilities would be sited on lands managed by the BLM, SITLA, the Arizona State Land Department, and private land owners. Figure 4-2 shows most of the Hydro System components and proposed alignments. The buried penstock sections would extend across Federally recognized utility corridors where possible, including the U.S. Highway 89 utility corridor and the Navajo-McCullough Transmission Line corridor. The Navajo-McCullough Transmission Line corridor extends 0.5-mile north and south of the current existing electric transmission line alignment, which follows the centerline of the larger corridor.

The Hydro System capacity and energy storage options described within this document will be carried forward into the analysis phase, and will need to be optimized to best suit the physical site and electrical system conditions. At the present time the following energy generation components are being studied: 1) a single unit, 2.8 MW in-line turbine-generator at The Cockscomb (In-Line Hydro Station 1); 2) a single unit, 2.3 MW in-line turbine-generator near the west boundary of the GSENM (In-Line Hydro Station 2) ; 3) a single unit, 2.8 MW in-line turbine-generator near Arizona State Highway 389 west of the Kaibab Indian Reservation (In-Line Hydro Station 3); 4) a single unit, 1.0 MW in-line turbine-generator at Hildale, Utah (In-Line Hydro Station 4); 5) a single unit, 3.5 MW in-line turbine-generator at the Hurricane Cliffs forebay (In-Line Hydro Station 5); 6) a 2-unit, 300 MW (150 MW each unit) pumped storage hydro station at the Hurricane Cliffs, with the forebay and afterbay sized to provide ten hours of continuous 300 MW output; 7) a single unit, 35 MW peaking energy recovery generation unit built within the Hurricane Cliffs hydro station; and 8) a single unit, 3.5 MW hydro station at the existing Sand Hollow Reservoir (see Figures 4-1 and 4-2).

4.4.2 Penstock and In-Line Hydro Stations

The Hydro System would consist of 95-miles of 69-inch inside diameter buried penstock, five in-line hydro units at specific low points along the Project alignment, a pumped storage hydro station at the Hurricane Cliffs, a continuous operation hydro station at Sand Hollow Reservoir, and power transmission lines and substations to deliver generated hydroelectric power into the existing power grid. Figure 4-8 shows the hydraulic grade line for In-Line Hydro Stations 2 through 5, the Hurricane Cliffs Pumped Storage Hydro, and Sand Hollow Hydro. Penstocks would be designed for operating pressures ranging from 200 to 500 psi. The in-line hydro stations would utilize impulse-type units at specific points in the

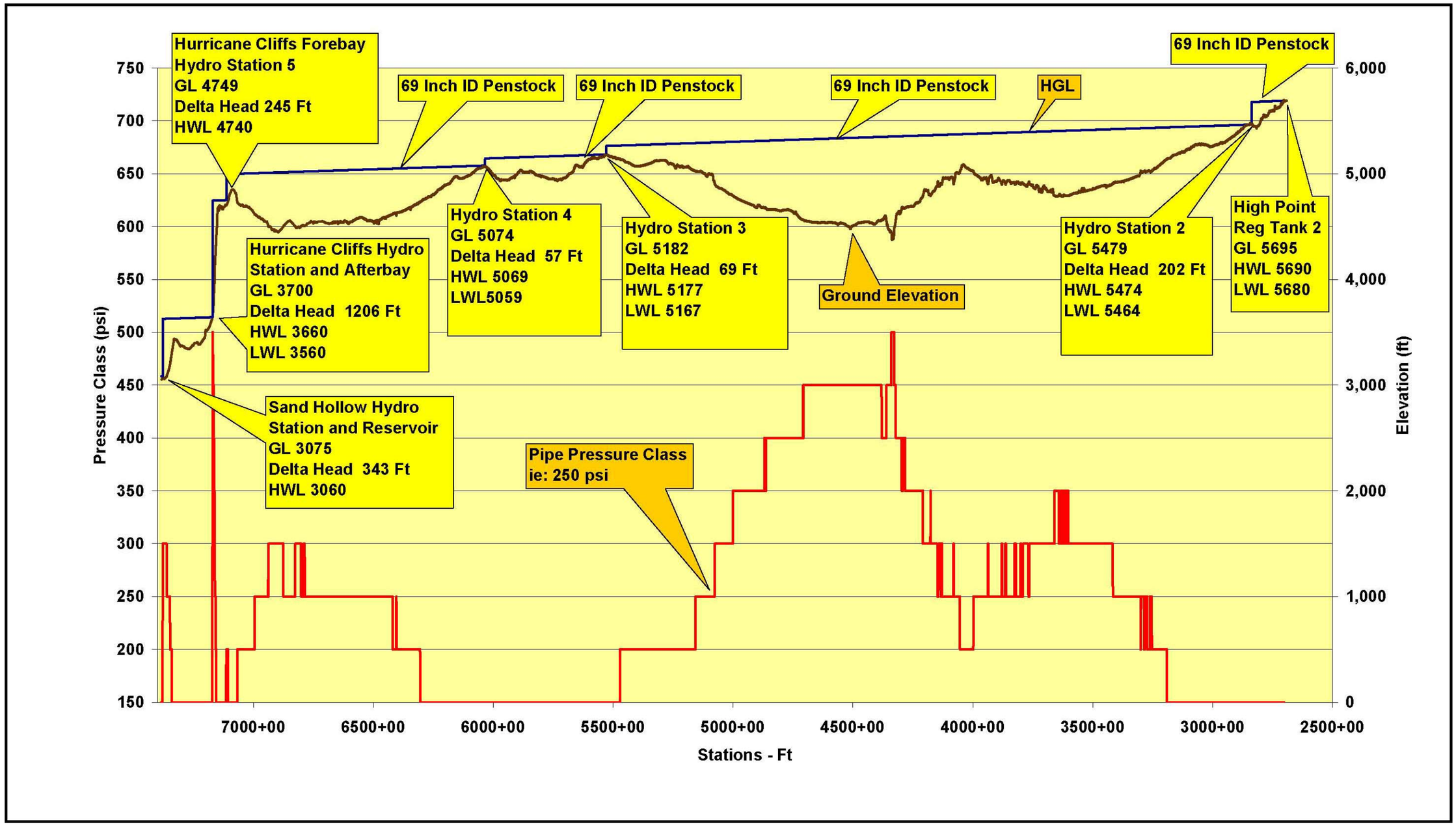


Figure 4-8
Lake Powell Pipeline Project
Hydro System Hydraulic Grade Line

continuous penstock sections where there is sufficient elevation differential to generate power and move water by gravity into the forebay at the Hurricane Cliffs Pumped Storage Hydro station. Figures 4-9, 4-10 and 4-11 show a plan and cross sections, respectively, of a typical in-line hydro station powerhouse, including an afterbay chamber to control surge. The impulse-type units are the only feasible generating turbine unit because of the long pressurized segment upstream of each in-line unit. Penstock appurtenances would include vacuum relief valves, air release valves and blowoff discharge valves at specific points along the alignments. All appurtenant valves would be housed in buried concrete vaults with a manhole access at the ground surface elevation. Blowoff valves would discharge to natural drainages crossed by the penstock. The Hydro System would have a SCADA control feature that would allow hydro stations, valves and reservoirs to be remotely monitored and operated from a control building in St. George.

In-Line Hydro Station 1 would have a 6.9-mile long 69-inch inside diameter buried penstock and a powerhouse with a 2.8 MW turbine-generator unit. The existing ground surface elevation at the powerhouse is 4,540 feet MSL. The powerhouse would be co-located with Booster Pump Station 3, located just east of The Cockscomb (see Figure 4-1). The hydro power generated from this unit would be used to supplement the Booster Pump Station 3 power requirements.

In-Line Hydro Station 2 would have a 2.6-mile long 69-inch inside diameter buried penstock and a powerhouse with a 2.3 MW turbine-generator unit. The existing ground surface elevation at the powerhouse is 5,479 feet MSL near the west boundary of the GSENM. If connected to the existing 138 kV power transmission system, about 10 miles of new transmission line would be required to connect to the existing 138 kV substation in the GSENM (see Figure 4-20).

In-Line Hydro Station 3 would have a 51.1-mile long 69-inch inside diameter buried penstock and a powerhouse with a 2.8 MW turbine-generator unit. The existing ground surface elevation at the powerhouse is 5,182 feet MSL near Arizona State Highway 389 west of the Kaibab Indian Reservation. If connected to the existing 138 kV power transmission system, about 10 miles of new transmission line would be required to connect to the existing 138 kV substation in Hildale (see Figures 4-24 and 4-25).

In-Line Hydro Station 4 would have a 9.5-mile long 69-inch inside diameter buried penstock and a powerhouse with a 1.0 MW impulse-type turbine-generator unit. The existing ground surface elevation at the powerhouse is 5,055 feet MSL in Hildale, Utah. If connected to the existing 138 kV power transmission system, about 0.5 mile of new transmission line would be required to connect to the existing 138 kV substation in Hildale (see Figure 4-25).

In-Line Hydro Station 5 would have a 19.7-mile long 69-inch inside diameter buried penstock and a powerhouse with a 3.5 MW impulse-type turbine-generator unit. The powerhouse would be situated adjacent to the Hurricane Cliffs Pumped Storage Hydro forebay reservoir, with the tailrace extending into the reservoir at elevation 4,730 feet MSL. If connected to the existing 138 kV power transmission system, about 7 miles of new transmission line would be required to connect to a new 138 kV substation west of Apple Valley (see Figures 4-26 and 4-27).

4.4.3 Hurricane Cliffs Pumped Storage Hydro

The Hurricane Cliffs Pumped Storage Hydro would be comprised of the following facilities: 1) a forebay along the Hurricane Cliffs ridgeline where the ground elevation is above 4,700 feet MSL; 2) an afterbay along the base of the Hurricane Cliffs where ground surface elevations are below 3,700 feet MSL; 3) a waterway of approximately 2,500-feet connecting the forebay, pump-turbines and the afterbay; 4) a steel and concrete powerhouse structure containing the pump-turbines and motor-generators to be located

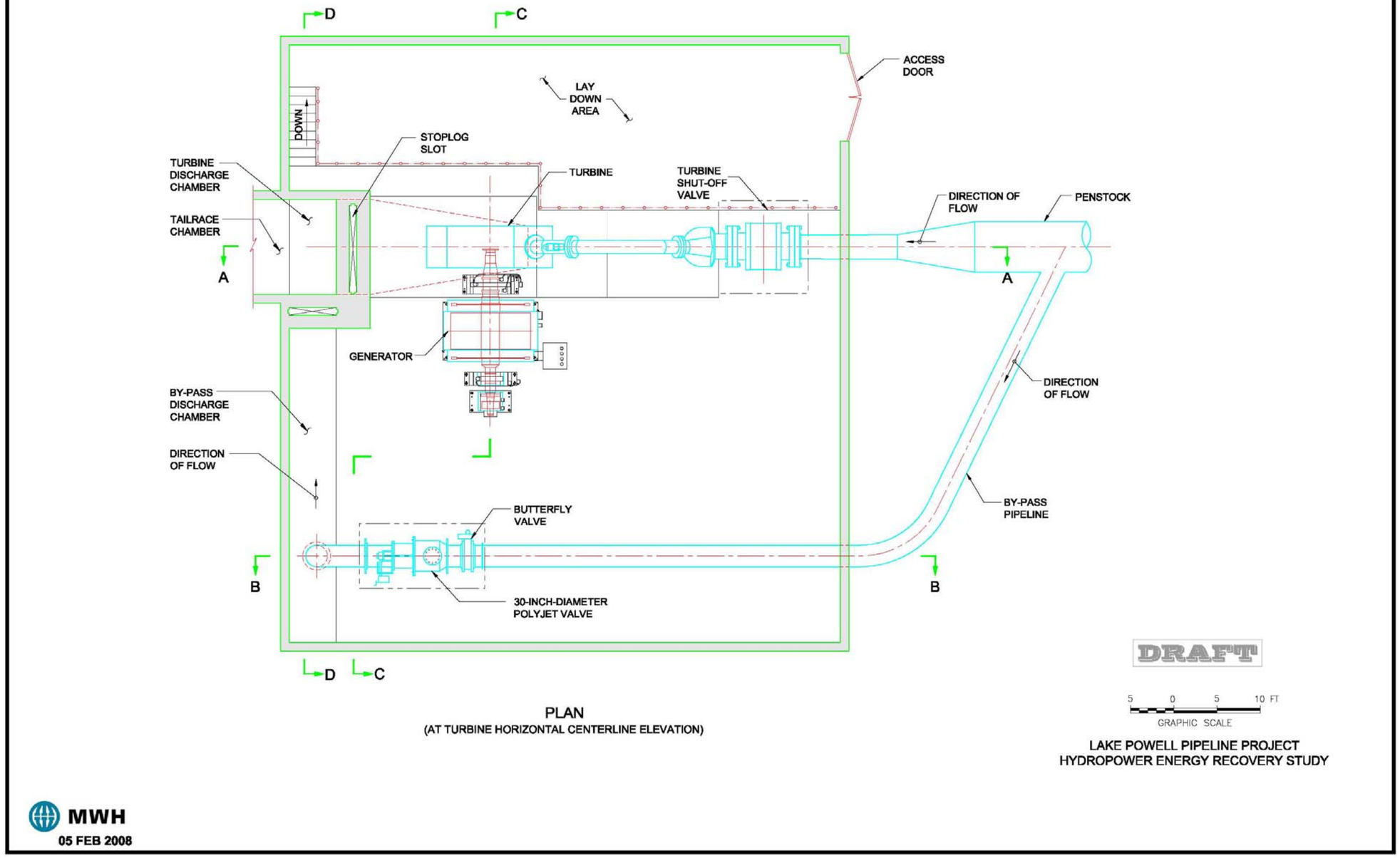
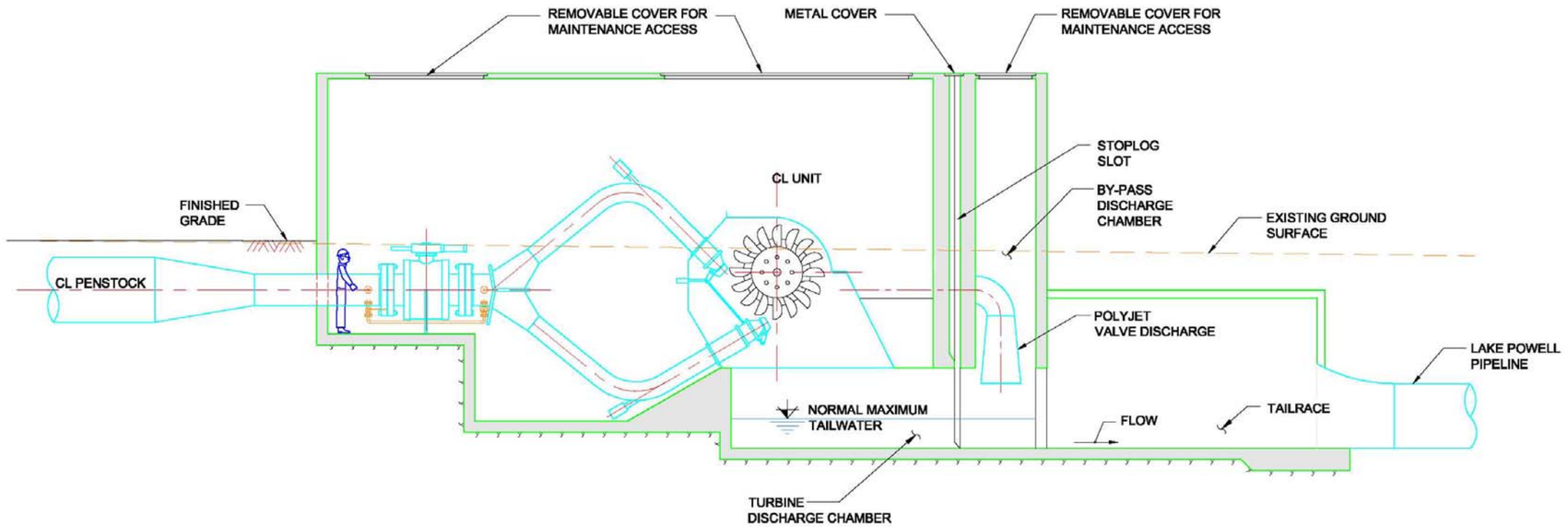
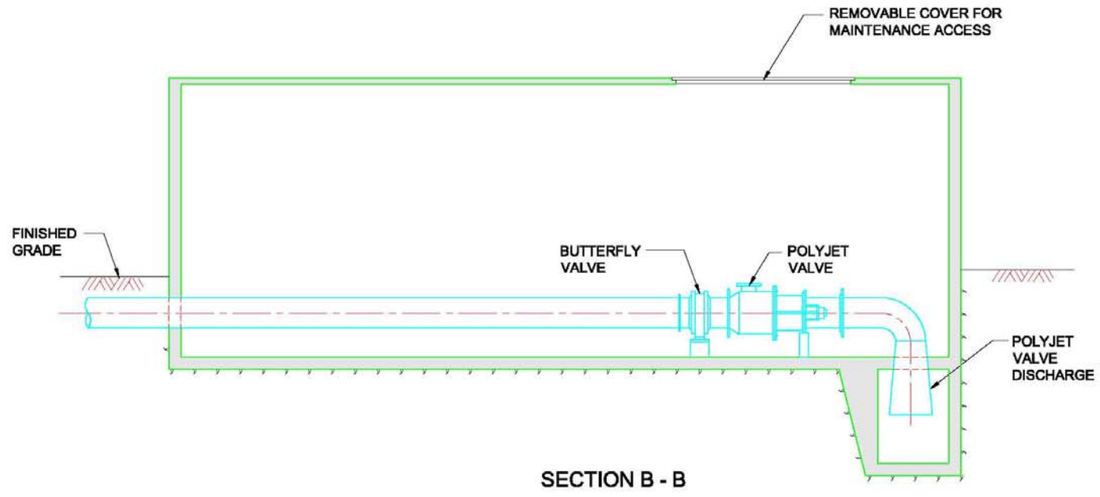


Figure 4-9
Lake Powell Pipeline Project
Typical In-Line Hydro Powerhouse Plan



SECTION A - A



SECTION B - B

DRAFT

5 0 5 10 FT
GRAPHIC SCALE

LAKE POWELL PIPELINE PROJECT
HYDROPOWER ENERGY RECOVERY STUDY

MWH
05 FEB 2008

Figure 4-10
Lake Powell Pipeline Project
Typical In-Line Hydro Powerhouse Sections (1 of 2)

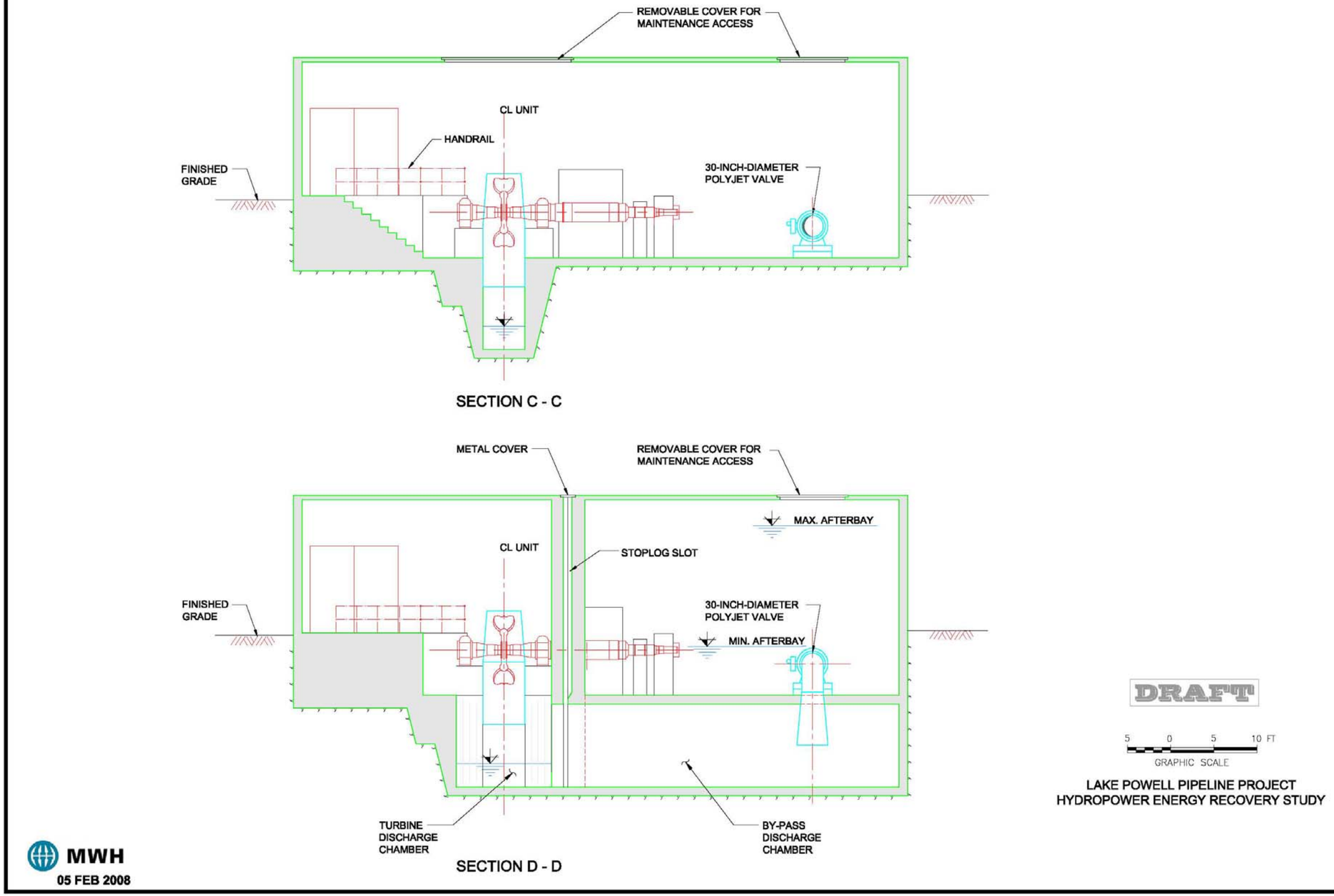


Figure 4-11
Lake Powell Pipeline Project
Typical In-Line Hydro Powerhouse Sections (2 of 2)

along they waterway alignment with a turbine generating system consisting of two generating units of combined capacity of 300 MW alongside a single 35 MW peaking generating unit; and 5) an electrical interconnection with the existing high-voltage regional transmission system.

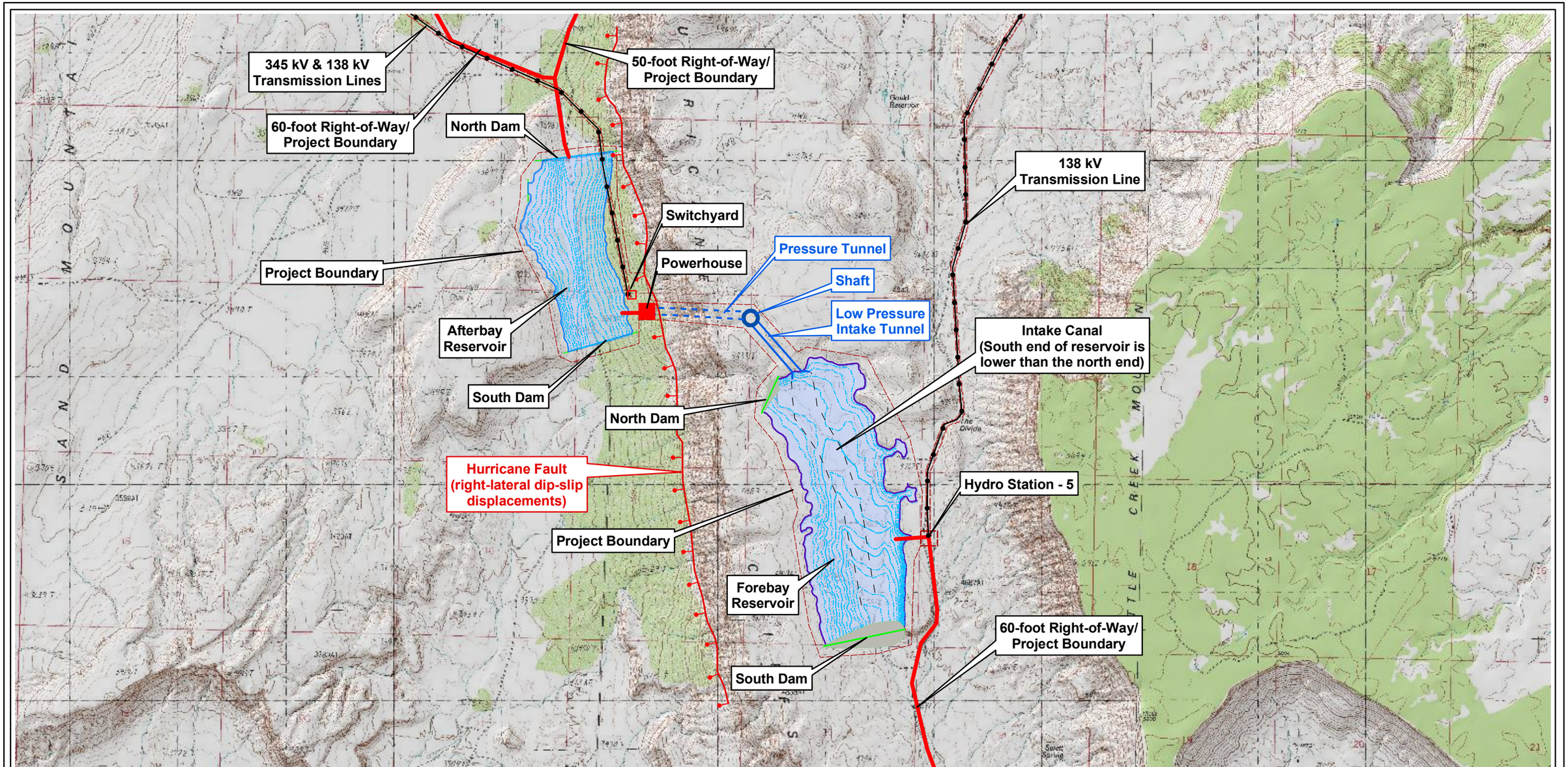
The Hurricane Cliffs Pumped Storage Hydro forebay would be located above the north-south trending Hurricane Ridge and the afterbay would be located along a lower bench at the base of the cliffs, northwest of the forebay site (see Figure 4-12). The anticipated maximum water level of the forebay would be at elevation 4,740 feet MSL and the afterbay would be at elevation 3,660 feet MSL (see Figure 4-13). The forebay at full supply level is estimated to cover 537 acres and the afterbay at full supply would cover approximately 290 acres. The forebay would store approximately 20,000 acre-feet and the afterbay would be sized to contain approximately 4,000 acre-feet of water storage, sufficient to support the desired 10 hours of continuous operation. The forebay and afterbay would be formed by the construction of embankment structures making use of natural topographic depressions where possible. Subsurface investigations will be required to establish the technical feasibility of the forebay and afterbay concepts. The locations and configuration of the forebay and afterbay reservoirs for the Hurricane Cliffs Pumped Storage Hydro would be optimized as part of the studies envisioned during the licensing process.

The Hurricane Cliffs Pumped Storage Hydro waterway would consist of a low-pressure horizontal tunnel, vertical shaft and access shaft, sloped pressure tunnel, and an above-ground penstock. The low-pressure horizontal tunnel would have a diameter of 17.5 feet and extend about 780 feet, connecting the forebay reservoir to the vertical shaft. The vertical shaft would be 715 feet deep and 17.5-feet diameter, with a vertical access shaft extending 103 feet above the vertical shaft to about elevation 4,750 feet MSL. The pressure tunnel would be sloped at 8 percent, have a diameter of 17.5 feet, and extend about 2,040 feet from the bottom of the vertical shaft to the tunnel portal. The above-ground penstock would have a diameter of 17.5 feet and extend about 750 feet, connecting the pressure tunnel portal to the pumped storage powerhouse. The penstock would cross over the Hurricane Fault above-ground between the pressure tunnel portal and the connection to the powerhouse structure (see Figure 4-13).

The Hurricane Cliffs Pumped Storage Hydro powerhouse would be primarily a subsurface structure, with a total depth of about 300 feet. The penstock would connect to twin unit penstocks, each with 12.8-feet diameter leading to spherical valves and vertical Francis pump-turbine units near the bottom of a pit-type powerhouse (see Figure 4-14). The Francis pump-turbine units would connect to a tailrace channel that extends into the afterbay reservoir (see Figure 4-14). The powerhouse shaft would have a large bridge crane within the powerhouse building at the ground surface. A switchyard containing the two transformers would be adjacent to the powerhouse structure at about elevation 3,700 feet MSL.

4.4.4 Sand Hollow Hydro

The Sand Hollow Hydro would consist of 3.9-mile long 69-inch inside diameter buried penstock, a single impulse-type turbine and a 30-inch diameter polyjet-type bypass valve, both contained within a single reinforced steel and concrete powerhouse structure. The powerhouse would be situated adjacent to Sand Hollow Reservoir, with the tailrace extending into the reservoir at elevation 3,055 feet MSL. The powerhouse structure would be located above the maximum design flood level of 3,060 feet MSL for Sand Hollow Reservoir. Figure 4-15 shows a conceptual plan view of the powerhouse, and Figure 4-16 shows a conceptual section view of the powerhouse. The impulse-type turbine would have a 3.5 MW continuous generating capacity. The Sand Hollow Hydro station would include a switchyard for interconnection to a power transmission line.



Legend

- Faults
- Transmission Lines
- Project Alignment
- Pump Storage Project Boundary
- Hurricane Cliffs Forebay/Afterbay

0 1,000 2,000 4,000 6,000 8,000 Feet

The project features indicated on this map are intended to provide only a general indication of a possible development concept. Studies performed during the term of the permit would lead to a definite layout

Lake Powell Pipeline Project

1:36,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-12** MWH

Hurricane Cliffs Pumped Storage Layout

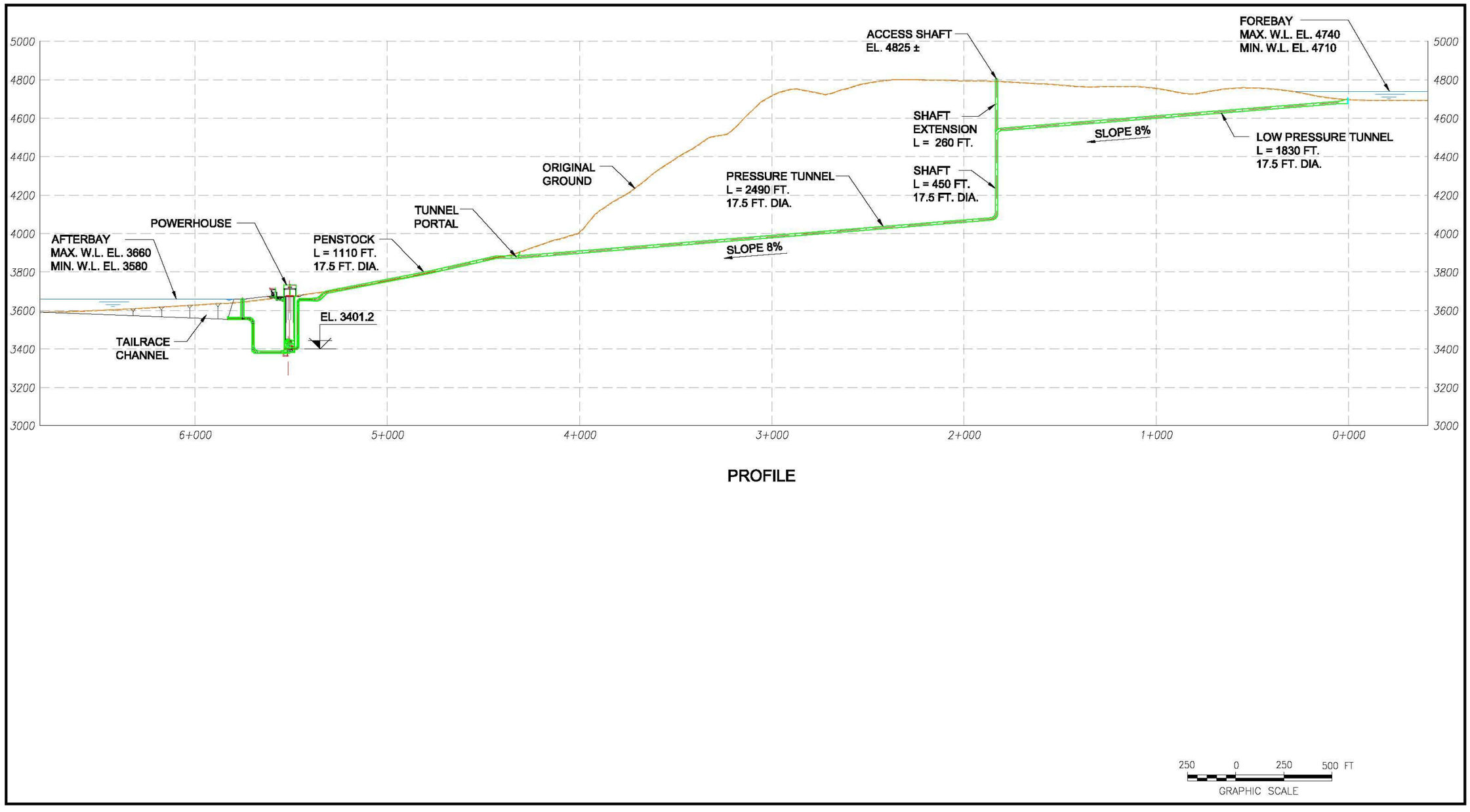


Figure 4-13
Lake Powell Pipeline Project
Hurricane Cliffs Pumped Storage (South Forebay) Waterway Profile

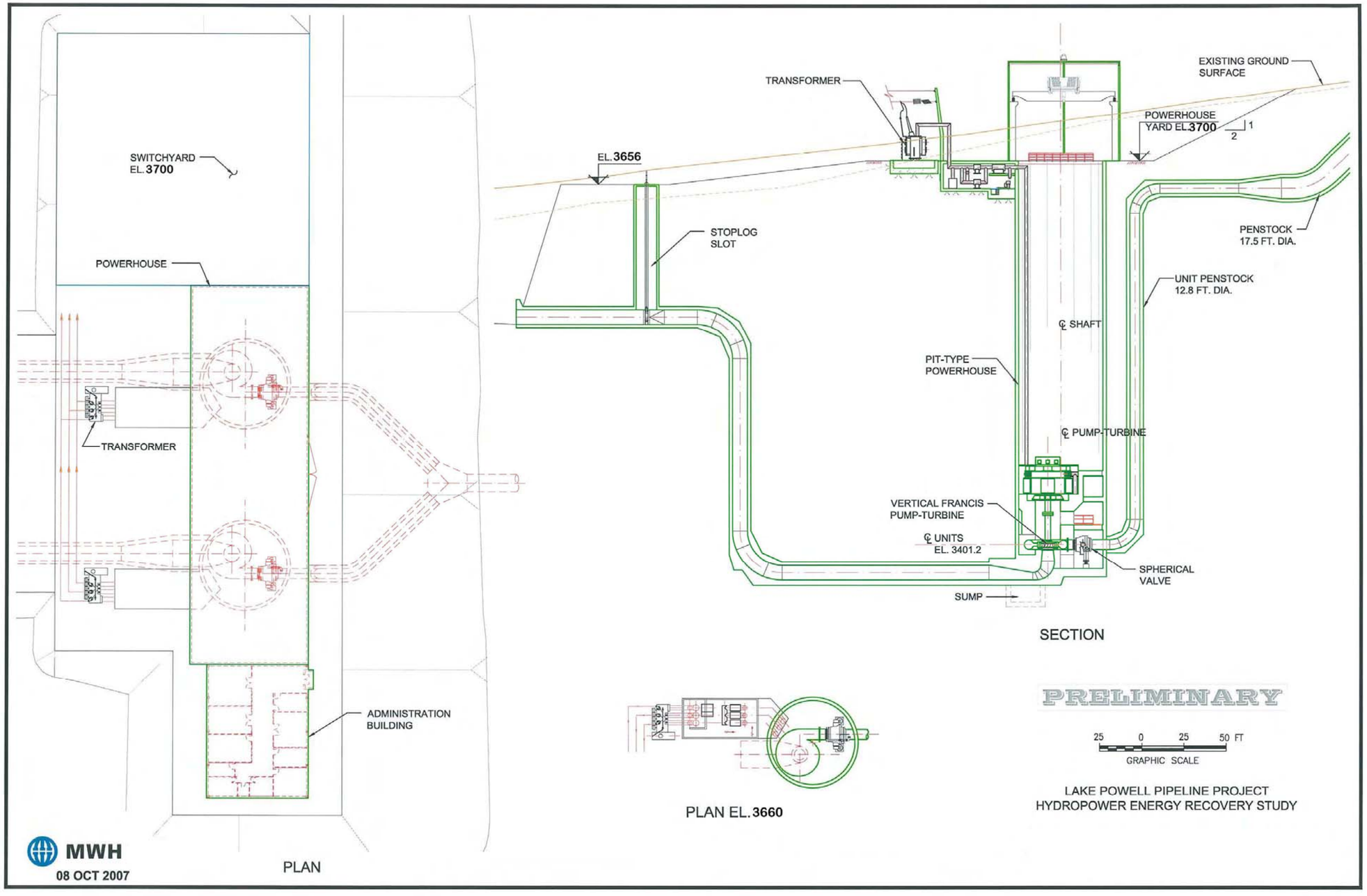


Figure 4-14
Lake Powell Pipeline Project
Hurricane Cliffs Pumped Storage Powerhouse Plan and Section

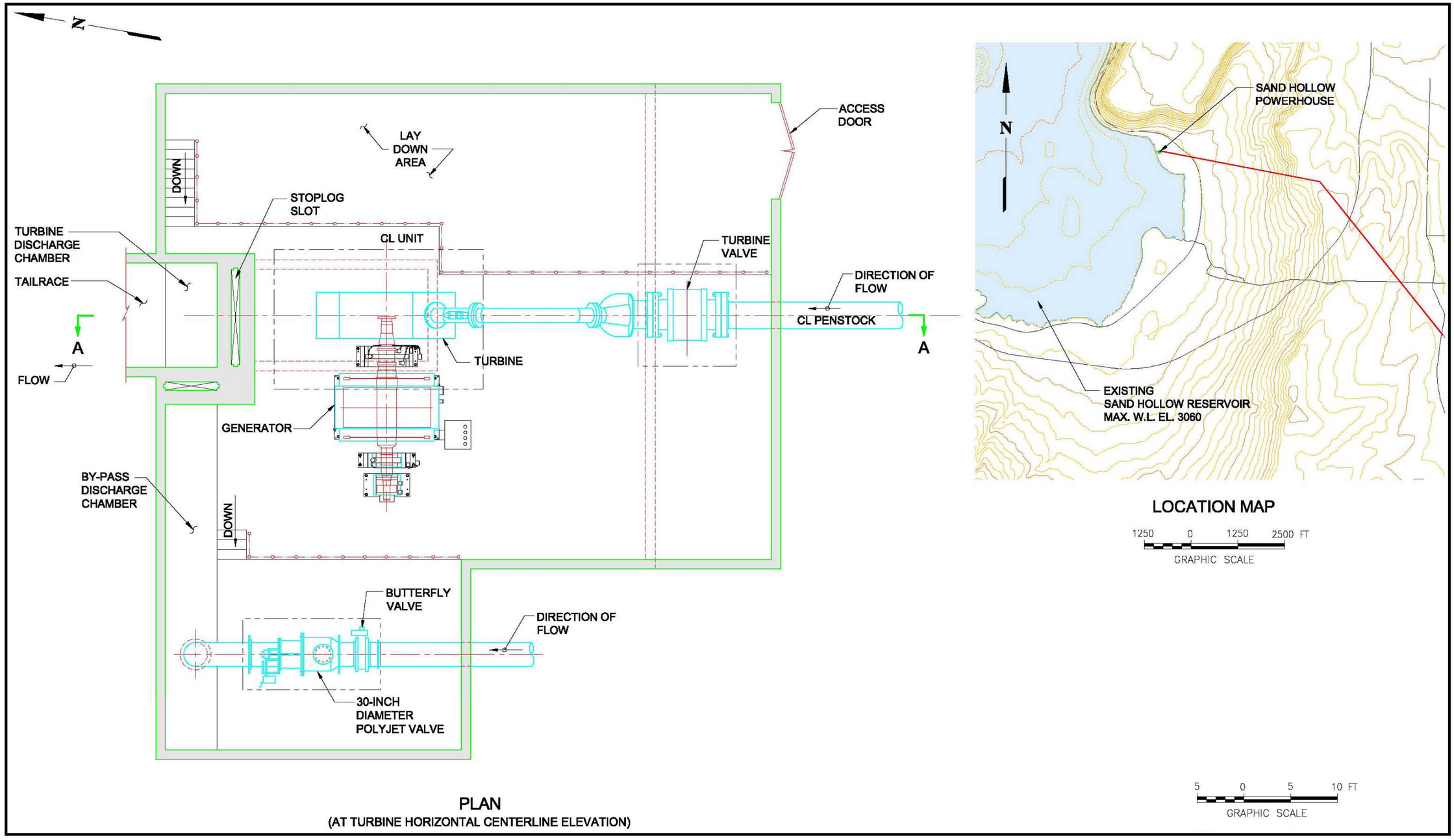
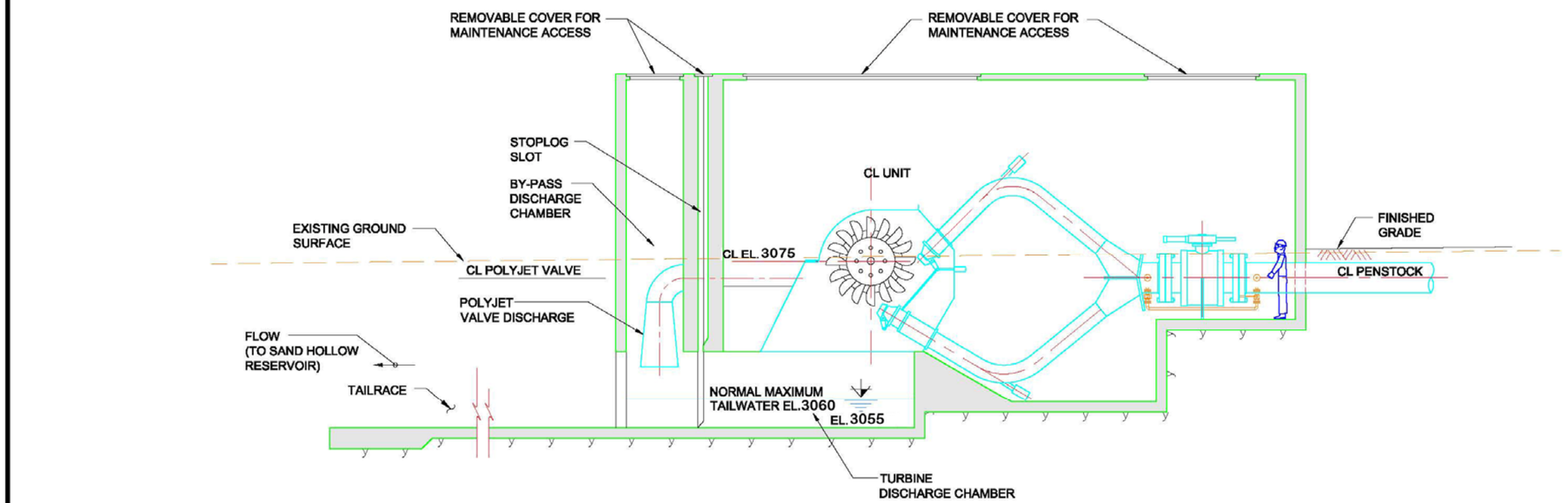


Figure 4-15
Lake Powell Pipeline Project
Sand Hollow Hydro Powerhouse Plan



SECTION A - A

DRAFT

5 0 5 10 FT
GRAPHIC SCALE

LAKE POWELL PIPELINE PROJECT
HYDROPOWER ENERGY RECOVERY STUDY

MWH
05 FEB 2008

Figure 4-16
Lake Powell Pipeline Project
Sand Hollow Hydro Powerhouse Section

4.4.5 Power Transmission Lines

The location, number of circuits, voltage, and configuration of the Project's hydroelectric generation interconnections with the regional electric utility network will be established as part of the studies to be carried out during the licensing process. It is currently anticipated that the Hurricane Cliffs Pumped Storage Hydro would interconnect to the planned Hurricane West 345-kV substation located near the Quail Creek Hydroelectric Plant. A double circuit 345-kV transmission line would start at the Hurricane Cliffs powerhouse switchyard, run northwest to the Sand Hollow Hydro station, continue north and then west for a total of about 7 miles to the planned Hurricane West Substation (see Figures 4-26, 4-27, 4-30, and 4-31). A 345 kV power transmission line serving the east side of Washington County is planned for construction in 2012 to increase system reliability on the west side of the county and avoid system-wide outages during the height of the summer season.

Power transmission lines connecting the in-line hydro units into the existing power grid would be 138 kV lines (or lower voltage lines) of various lengths and locations that are currently under study. There may be some opportunities to upgrade existing power transmission lines or utilize un-used capacity in existing power transmission lines. If interconnected to a 138 kV power grid, new power transmission lines for interconnecting the in-line hydro units to the existing power grid would total an estimated 35 miles in length (see Figures 4-20, 4-24, 4-25, 4-26, 4-27, 4-30 and 4-31). However, selection of interconnection locations and voltages is subject to further study and coordination with the local electrical utility companies.

Power transmission lines connecting the pump stations into the existing power grid would be 138 kV lines of various lengths and locations that are currently under study. The new power transmission lines for interconnecting the pump stations to the existing power grid would total an estimated 8.8 miles in length (see Figures 4-18, 4-19, 4-20, 4-21, 4-27, and 4-28). These estimates will be refined as studies proceed.

4.4.6 Planned Installed Capacity and Average Annual Energy

The planned installed capacity of the seven hydroelectric developments would be approximately 351 MW (300 MW of pumped storage hydroelectric generating capacity and approximately 51 MW of conventional hydro generating capacity), although this may change as studies proceed and the Applicant performs transmission system studies and power market investigations.

The Hurricane Cliffs Hydro and Sand Hollow Hydro stations would have planned installed capacities ratings of 35 and 3.5 MW, respectively. The combined capacity of the remaining in-line hydro stations would be 12.4 MW. Approximately 179 GWh would be produced annually through the hydro energy recovery operations.

For the Hurricane Cliffs Pumped Storage Hydro station, a pumped storage concept is being studied with two pump-turbine motor-generator sets, each with a nominal rating of 150 MW. Assuming a 15 percent plant factor, typical for pumped storage hydro, the average annual electricity production would be 394 GWh. Assuming a cycle efficiency of 76 percent, which is typical for hydro pumped storage, the pumping energy requirement is 557 GWh annually.

On a preliminary basis, the Hurricane Cliffs Pumped Storage Hydro would use approximately 1,206 feet of maximum gross hydraulic head, and the Sand Hollow Hydro would use an additional 343 feet of gross maximum head. The combined in-line hydro stations 1 through 5 would use a maximum gross hydraulic head of approximately 646 feet. These estimates will be refined as studies proceed.

4.4.7 Power Consumed by Pump Stations

Power consumed by the intake pump station and Water Conveyance System booster pump stations is estimated at 445 GWh annually. Power consumed by the Cedar Valley Pipeline System booster pump stations is estimated at 91 GWh annually. These estimates will be refined as studies proceed.

4.5 Cedar Valley Pipeline System

The Cedar Valley Pipeline System would start at the Hurricane Cliffs afterbay reservoir and run approximately 35 miles to the Cedar Valley in Iron County, Utah, terminating at a regional water treatment plant south of Kanarraville and east of Interstate 15. Additional studies are currently being performed to determine the final delivery points for Project water in the Cedar Valley. The Cedar Valley Pipeline System also would deliver secondary irrigation water into the Hurricane Secondary Irrigation System during the irrigation season, depending on Virgin River flows. Therefore, the first segment of the Cedar Valley Pipeline System would be used jointly to convey 12,000 acre-feet to the pressurized irrigation system serving the Hurricane Valley and 20,000 acre-feet to Cedar Valley. A 48-inch diameter buried pipeline would convey the combined flows and would reduce to a 30-inch diameter buried pipeline near 600 North in Hurricane City. The 48-inch diameter pipeline would run north from the afterbay reservoir along existing roads to Hurricane City where a turnout would be connected to the pressurized secondary irrigation system, and the 30-inch diameter buried pipeline would continue across the Virgin River into LaVerkin, along a portion of Highways 9 and 17, northwest to Anderson Junction and northeast along the Interstate 15 corridor (see Figure 4-3). The pipeline would run parallel to Interstate 15 until 1.5 miles north of the Washington County – Iron County boundary. The pipeline alignment would be situated on a combination of lands managed by the BLM, land managed by the state through SITLA, and on private lands.

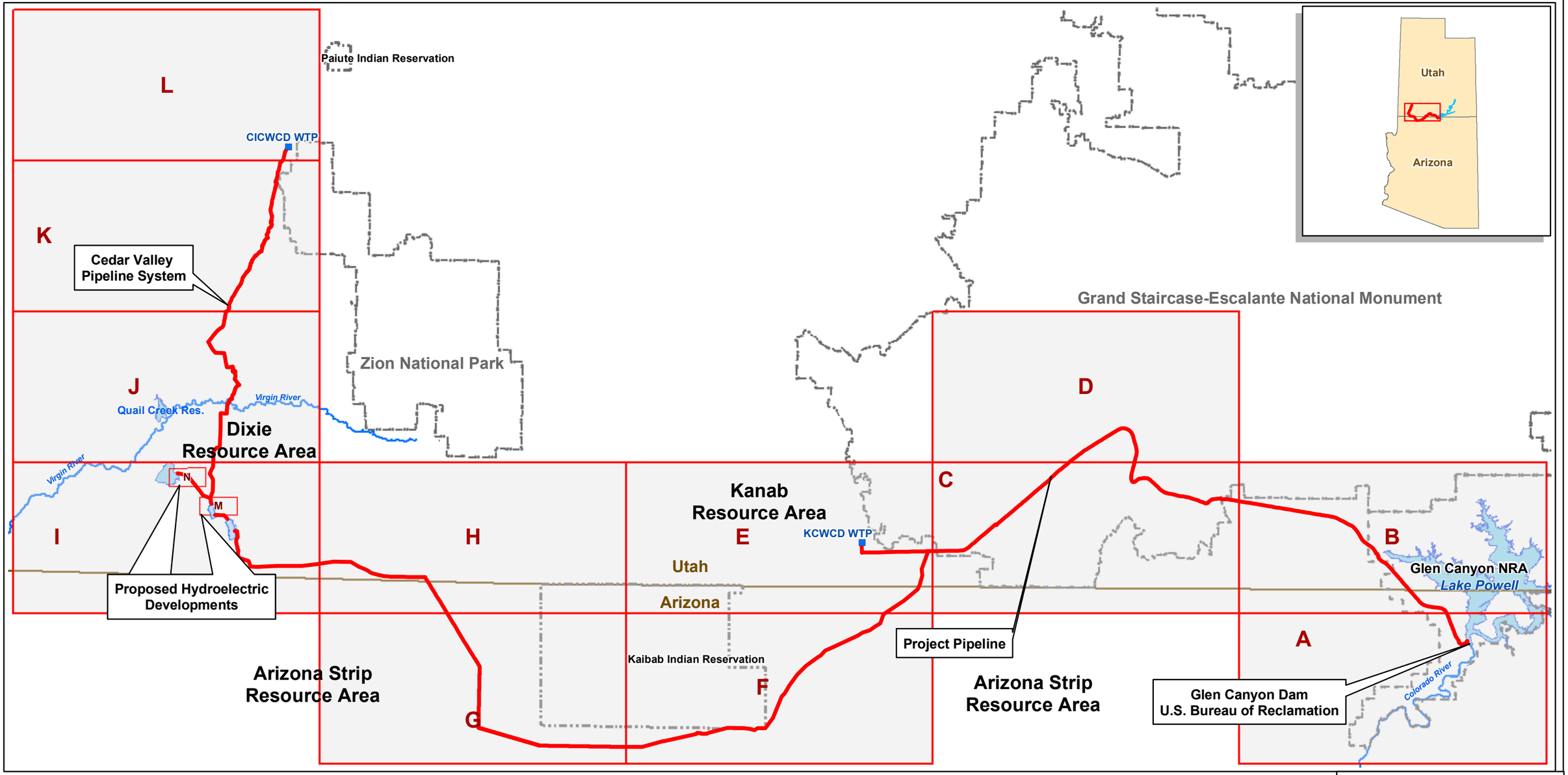
The Cedar Valley Pipeline System would be initially pressurized by the pressure head leading out of the Hurricane Cliffs afterbay reservoir. After crossing the Virgin River, the Cedar Valley Pipeline System would include four booster pump stations situated along the pipeline alignment, pipeline appurtenances, and power transmission lines to supply electricity to the booster pump stations. The hydraulic analysis of the pipeline and booster pump stations is currently being performed to refine potential locations of each pump station facility. Power transmission line requirements will be determined after the booster pump stations are located.

4.6 Lands of the United States

All of the lands of the United States that are enclosed within the Project boundary are shown on Figures 4-17 through 4-31.

4.7 Additional Information

The Project would develop, conserve, and utilize, in the public interest, the water resources of the southwest Utah region. The Project would allow the growing municipalities of southwest Utah and adjoining areas within the southwest Utah water conservancy district's service areas to meet projected water and power needs through about 2040. The Project would provide opportunities for additional benefits such as enhanced management of stream flows potentially benefiting native and endangered fish species and their habitats, and reducing sediment loads in existing pressurized secondary irrigation systems.



Legend

- Water Treatment Plant
- Project Alignment
- Grid Sheets
- Grid Sheets
- Tribal Lands
- National Park/Monument
- State Boundaries
- Major Rivers
- Lakes/Reservoirs
- Hurricane Cliffs Forebay/Afterbay

0 2 4 8 12 16 Miles

Lake Powell Pipeline Project

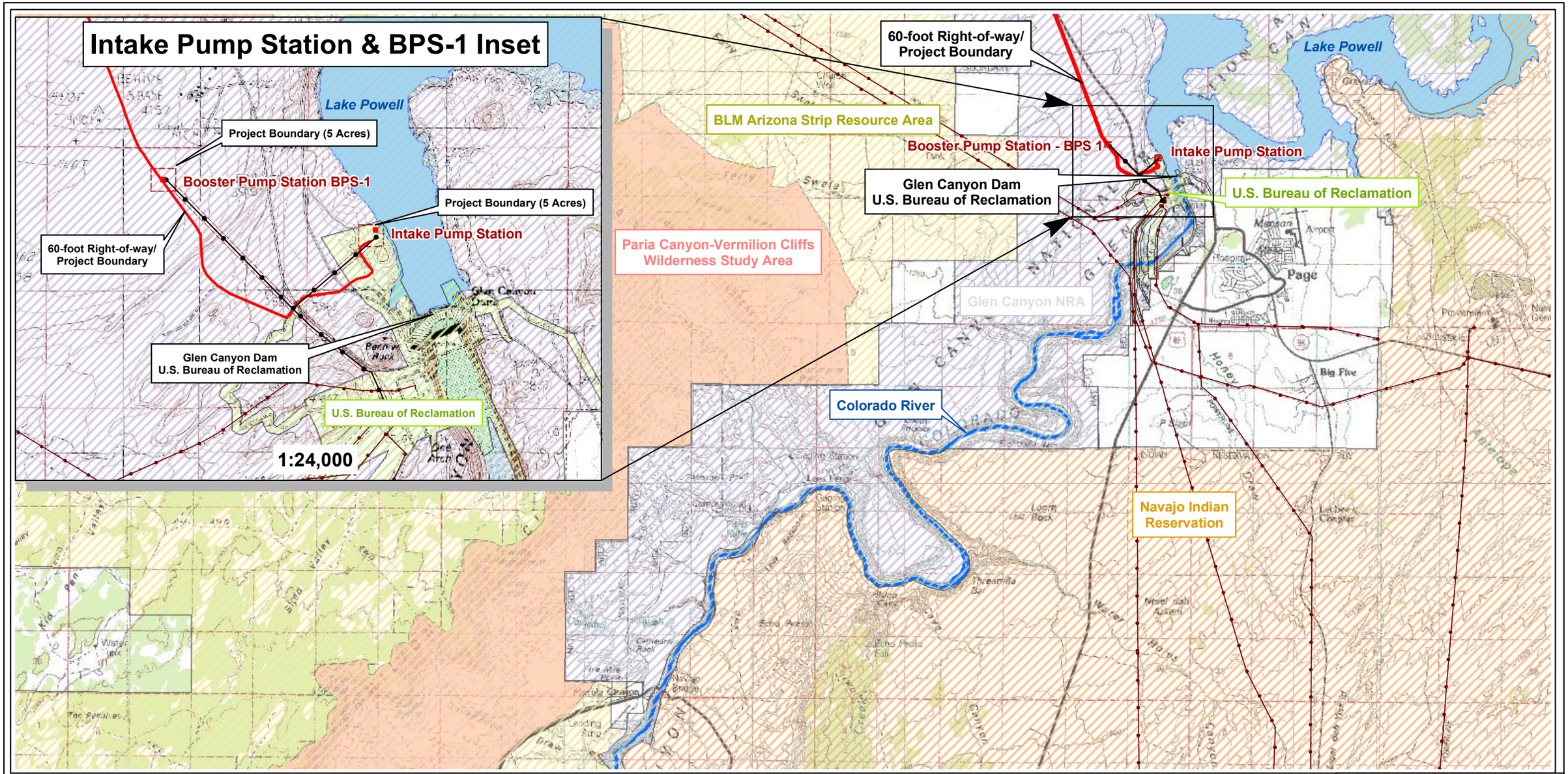
1:500,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-17** MWH

Index to Map Series
Sheets A - N



Legend

- Proposed Transmission Lines
- Existing Transmission Lines
- Project Pump Stations
- Project Boundary
- Project Alignment
- Bureau of Reclamation

Federal Land

- BLM
- National Park Service
- Tribal Trust

- Wilderness Study Area
- ACEC
- Lakes/Reservoirs
- Major Rivers

0 0.5 1 2 3 4 Miles

The project features indicated on this map are intended to provide only a general indication of a possible development concept. Studies performed during the term of the permit would lead to a definite layout

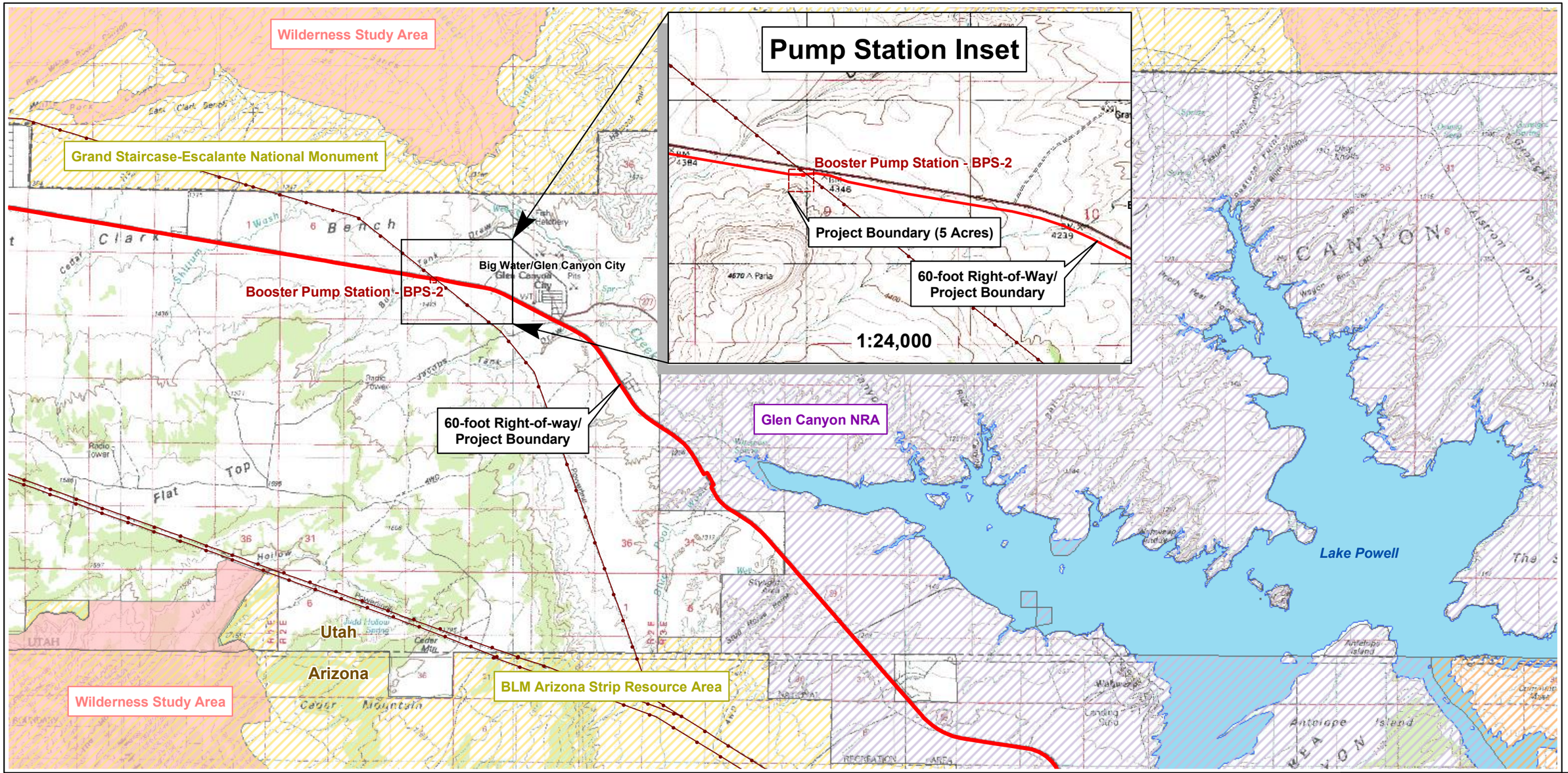
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 4-18 MWH

Sheet - A
Water Intake System, Arizona



Legend

- Existing Transmission Lines
- Project Pump Stations
- Project Boundary
- Project Alignment

Federal Land

- BLM
- National Park Service
- Tribal Trust
- Wilderness Study Area

- ACEC
- Lakes/Reservoirs
- Major Rivers
- National Park/Monument

0 0.5 1 2 3 4 Miles

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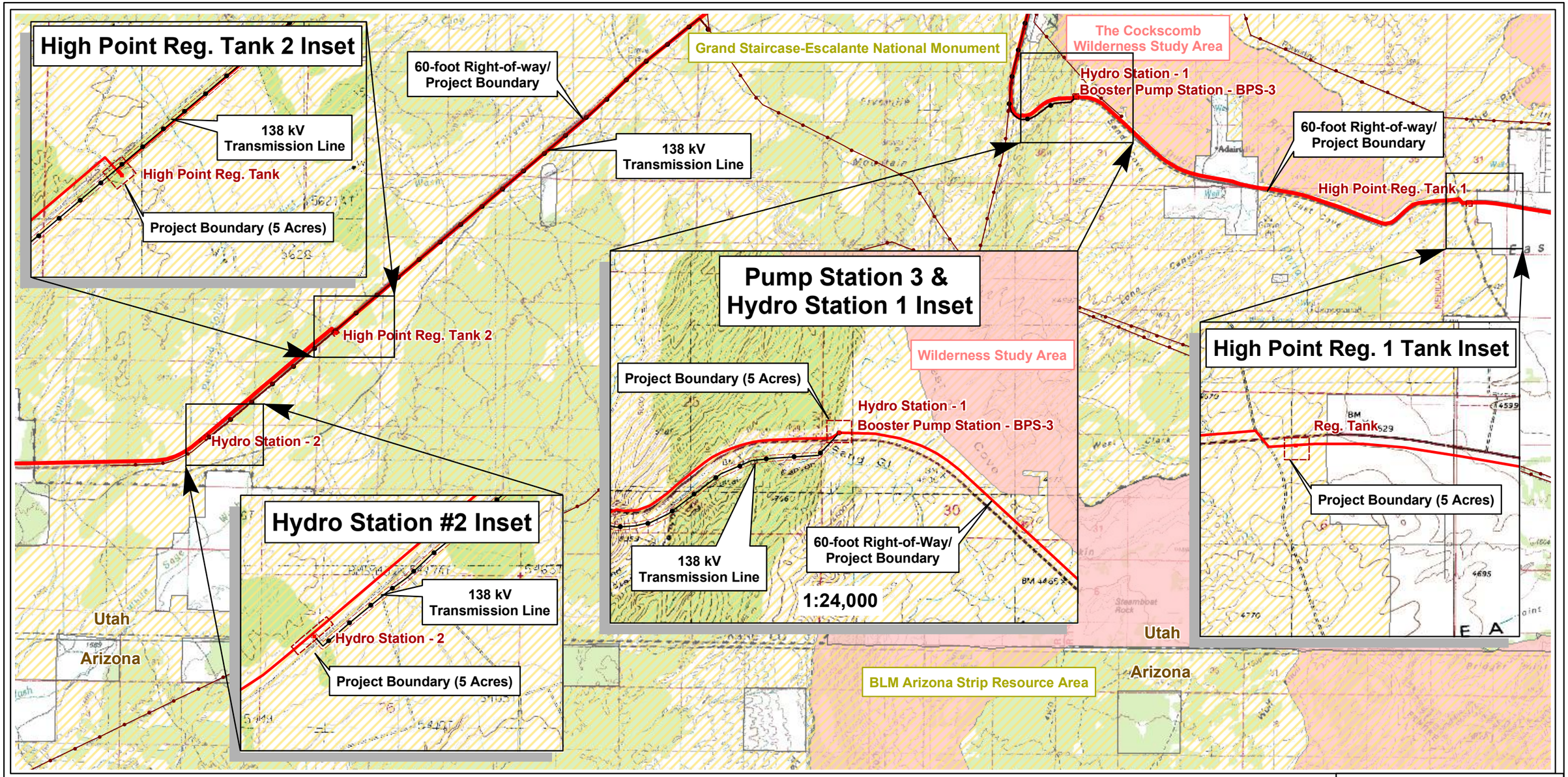
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 4-19 MWH

Sheet - B - Big Water Booster Pump Station



Legend

- Proposed Transmission Lines
- Existing Transmission Lines
- Project Pump Stations
- Project Alignment
- Project Boundary

Federal Land

- BLM
- National Park Service
- Tribal Trust

- National Park/Monument
- Wilderness Study Area
- ACEC
- Lakes/Reservoirs
- Major Rivers

0 0.5 1 2 3 4 Miles

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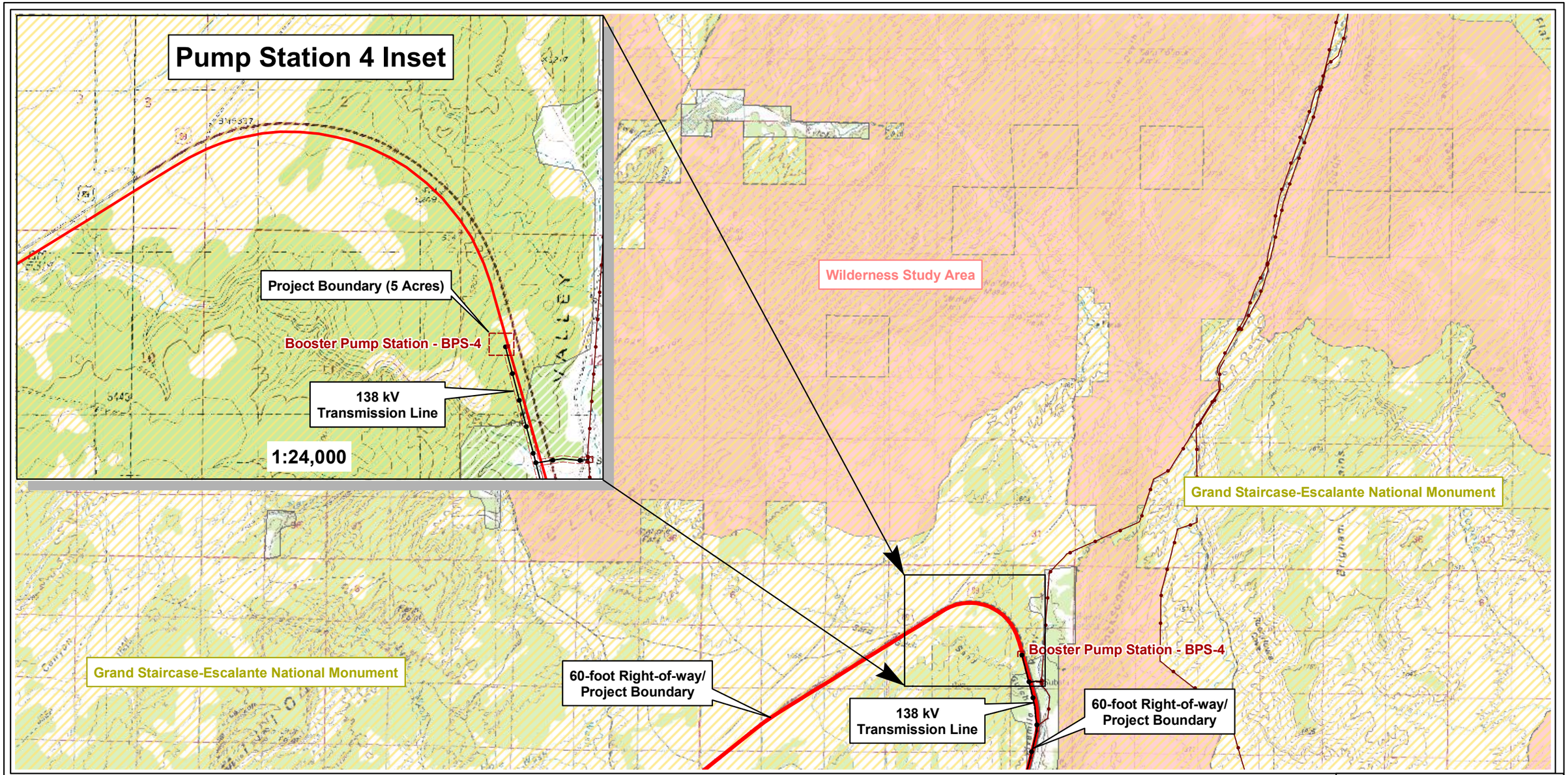
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 4-20 MWH

Sheet C - The Cockscomb Booster Pump Station



Legend

- Proposed Transmission Lines
- Existing Transmission Lines
- Project Pump Stations
- Project Boundary
- Project Alignment

Federal Land

- BLM
- National Park Service
- Tribal Trust

- Wilderness Study Area
- ACEC
- Lakes/Reservoirs
- Major Rivers
- National Park/Monument

0 0.5 1 2 3 4 Miles

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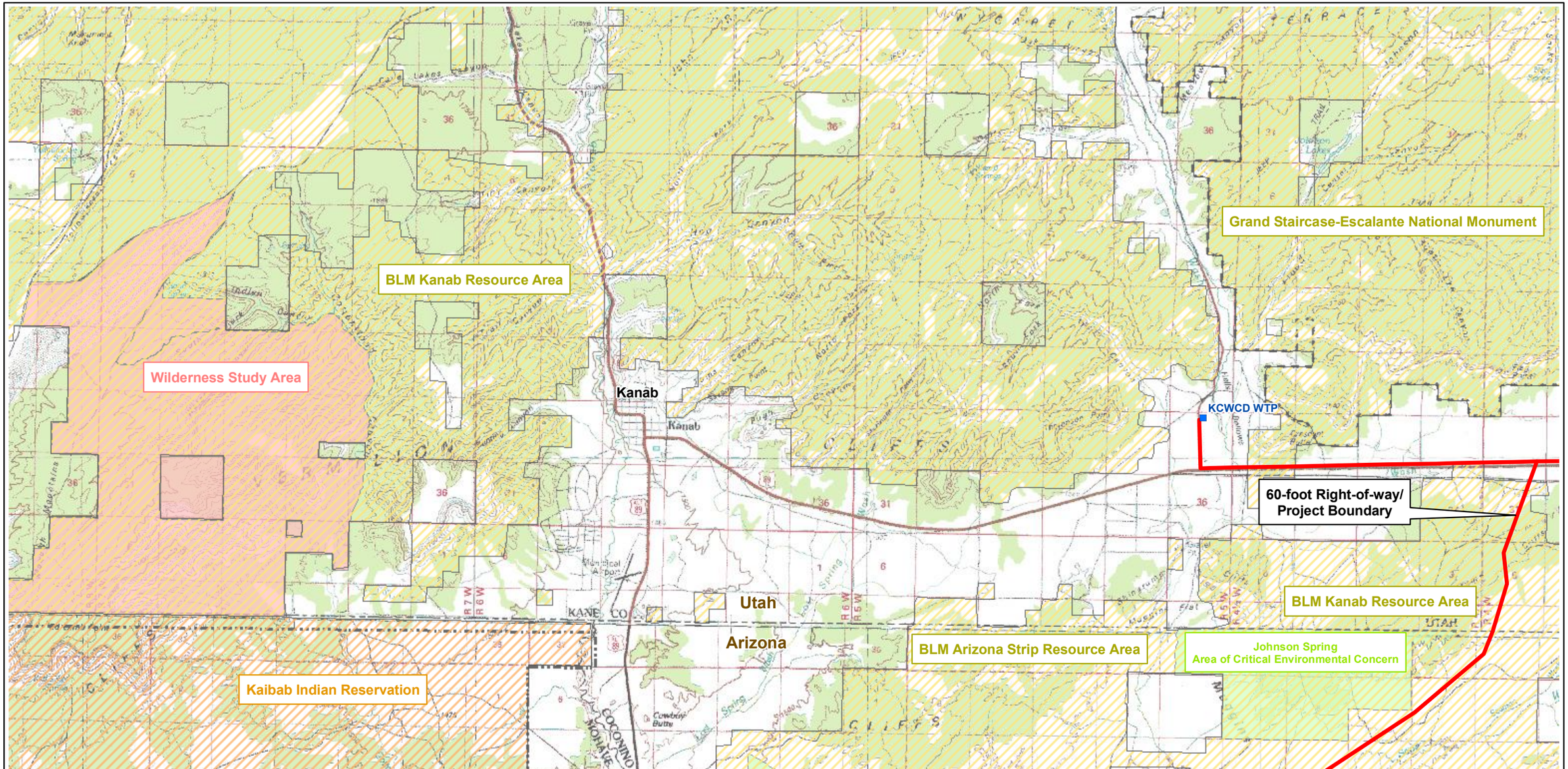
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-21** MWH

Sheet D - Sand Gulch Booster Pump Station



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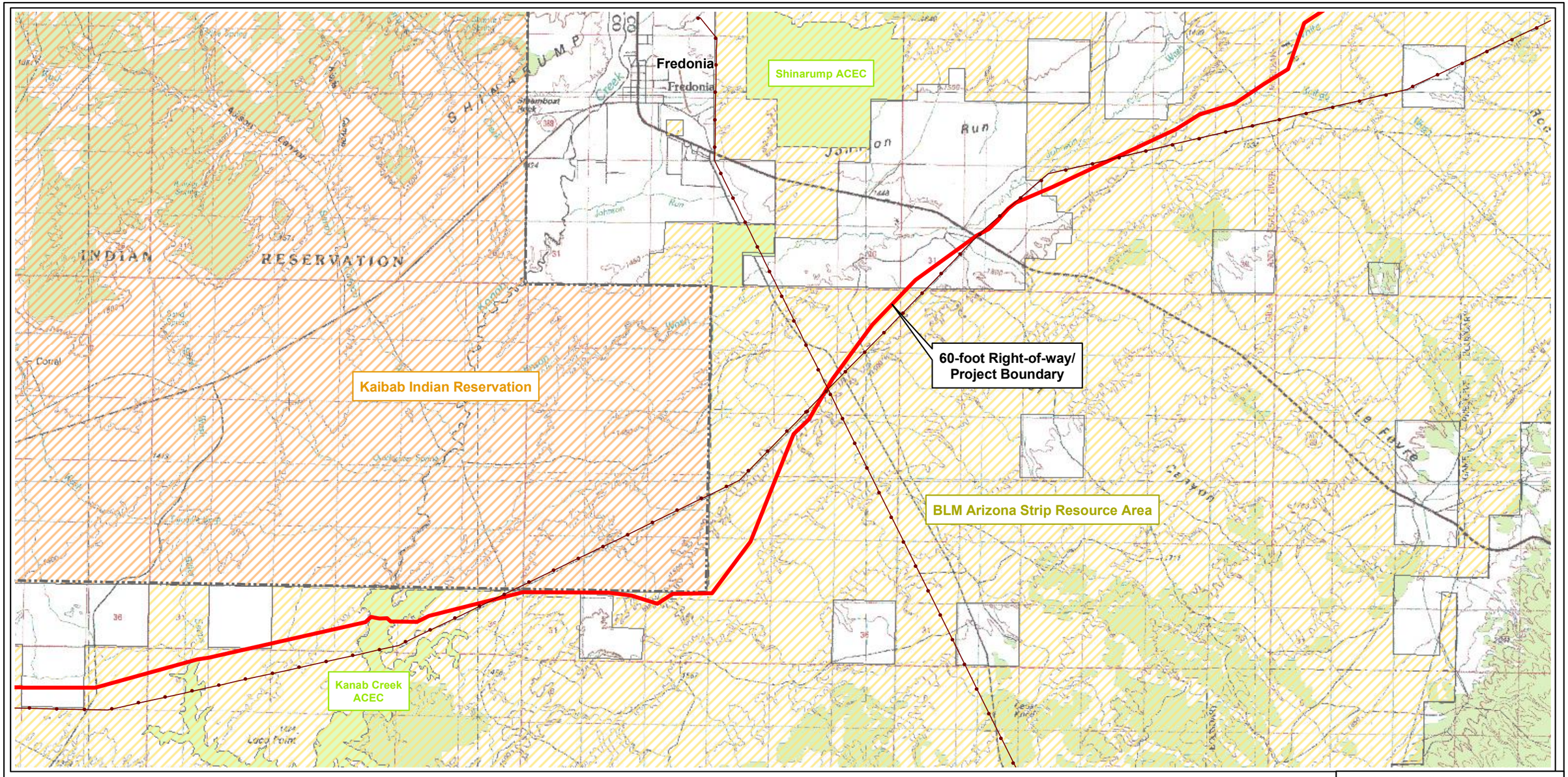
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-22** MWH

Sheet E
Kanab, Utah



Legend

- Existing Transmission Lines
- Project Pump Stations
- Project Boundary
- Project Alignment
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

Federal Land

- BLM
- National Park Service
- Tribal Trust
- ACEC

0 0.5 1 2 3 4 Miles

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Lake Powell Pipeline Project

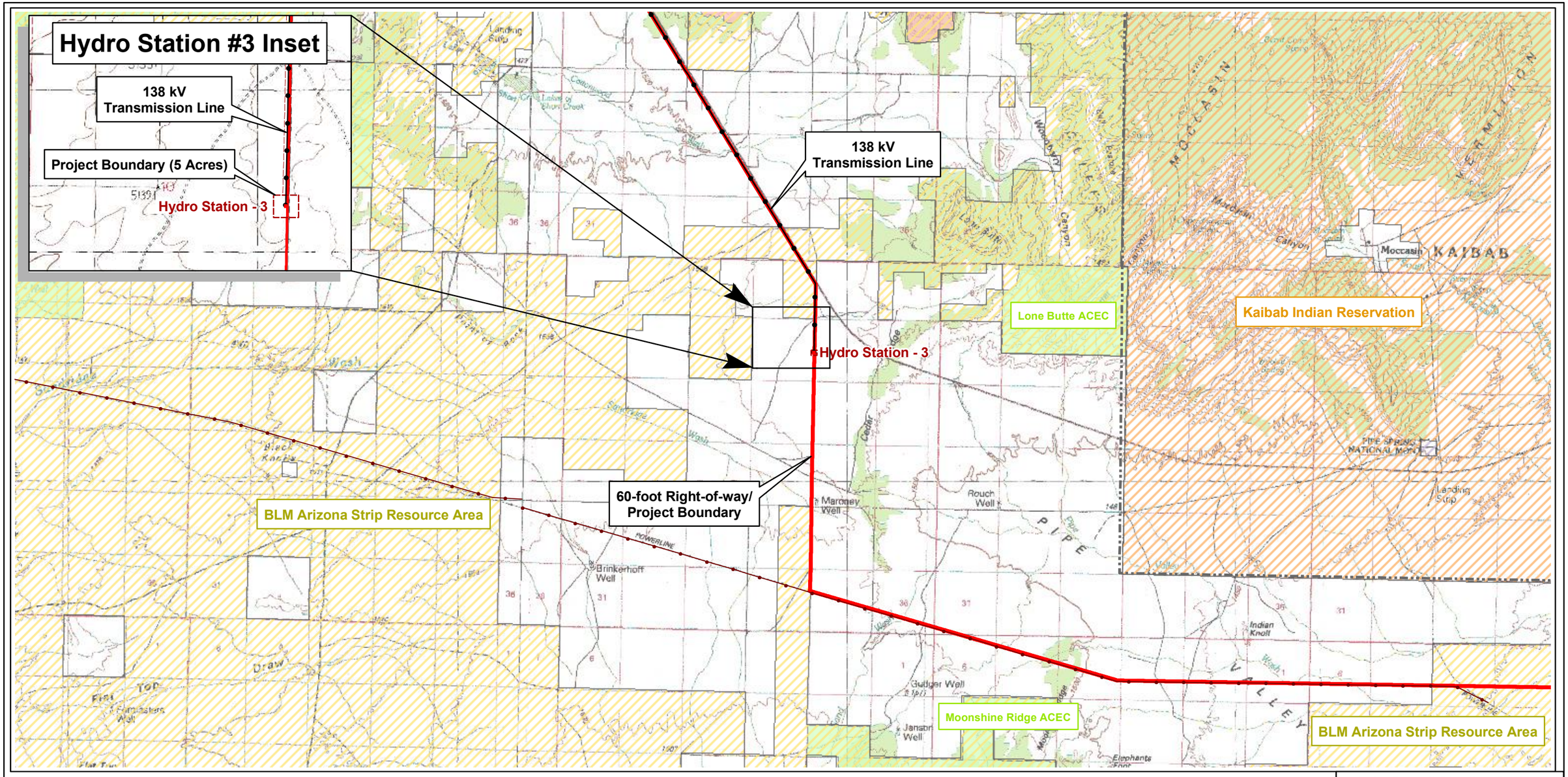
1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-23** MWH

Sheet F
Fredonia, Arizona



Legend

- Project Pump Stations
- Proposed Transmission Lines
- Existing Transmission Lines
- Project Boundary
- Project Alignment
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

Federal Land

- BLM
- National Park Service
- Tribal Trust
- ACEC
- Wilderness Study Area

0 0.5 1 2 3 4 Miles

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Lake Powell Pipeline Project

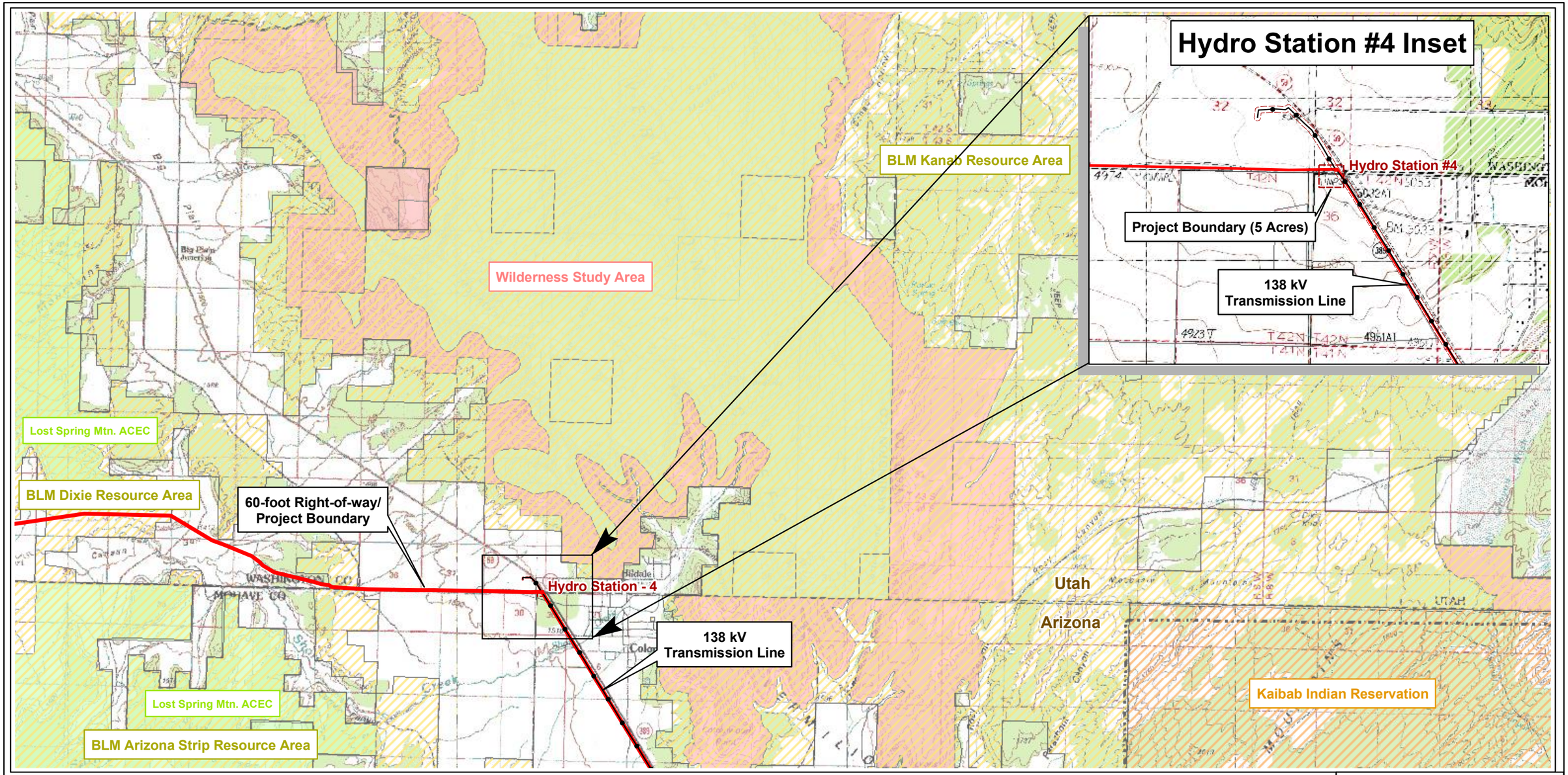
1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-24** MWH

Sheet G
Pipe Springs, Arizona



Legend

- Project Pump Stations
- Proposed Transmission Lines
- Project Alignment
- Project Boundary

Federal Land

- BLM
- National Park Service
- Tribal Trust

- ACEC
- Wilderness Study Area
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

0 0.5 1 2 3 4 Miles

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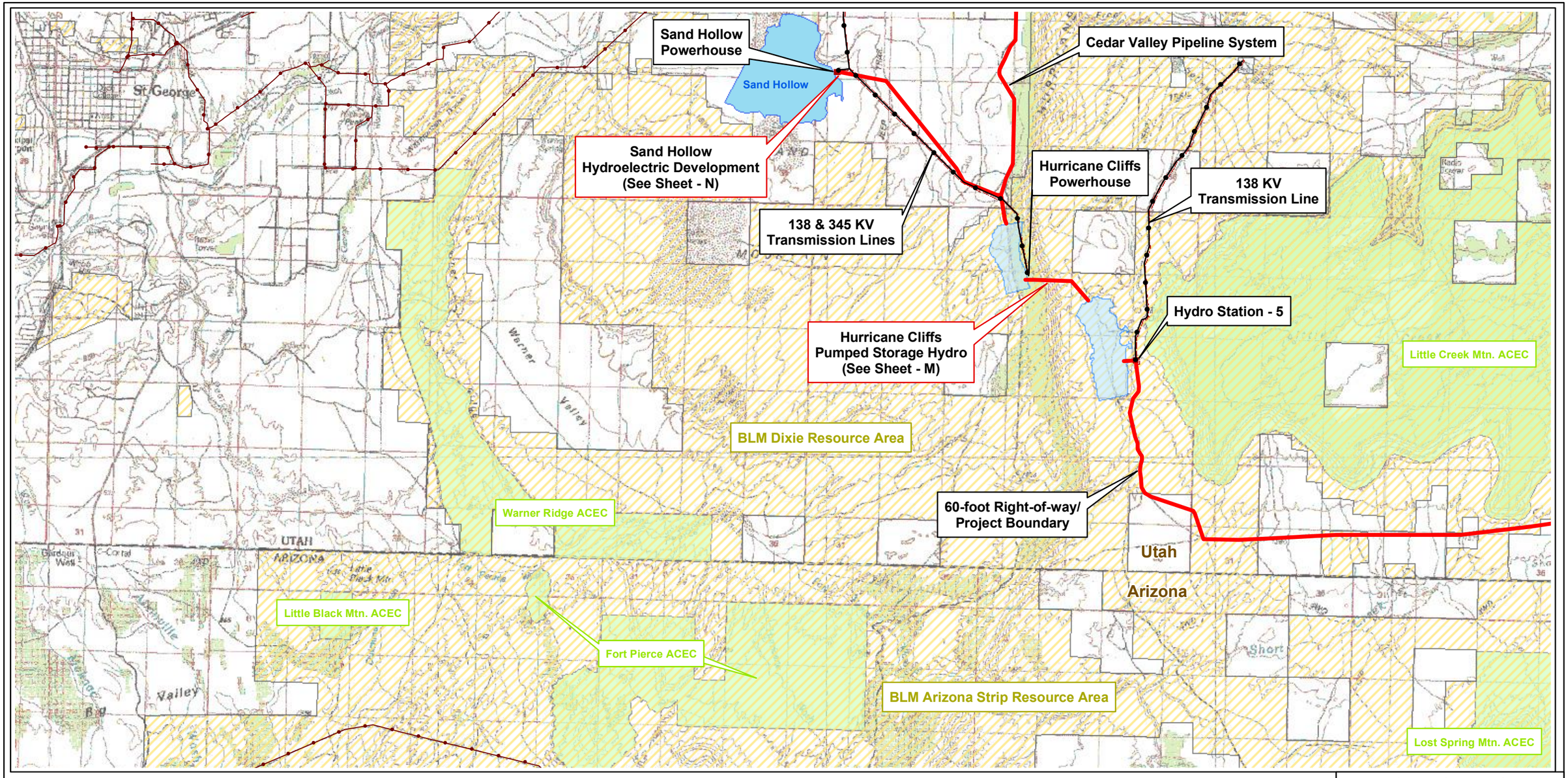
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-25** MWH

Sheet H
Colorado City, Arizona



Legend

- Existing Electrical Lines
- Proposed Transmission Lines
- Project Pump Stations
- Project Alignment
- Wilderness Study Area
- ACEC
- Hurricane Cliffs Forebay/Afterbay
- Project Boundary
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

Federal Land

- BLM
- National Park Service
- Tribal Trust

0 0.5 1 2 3 4 Miles

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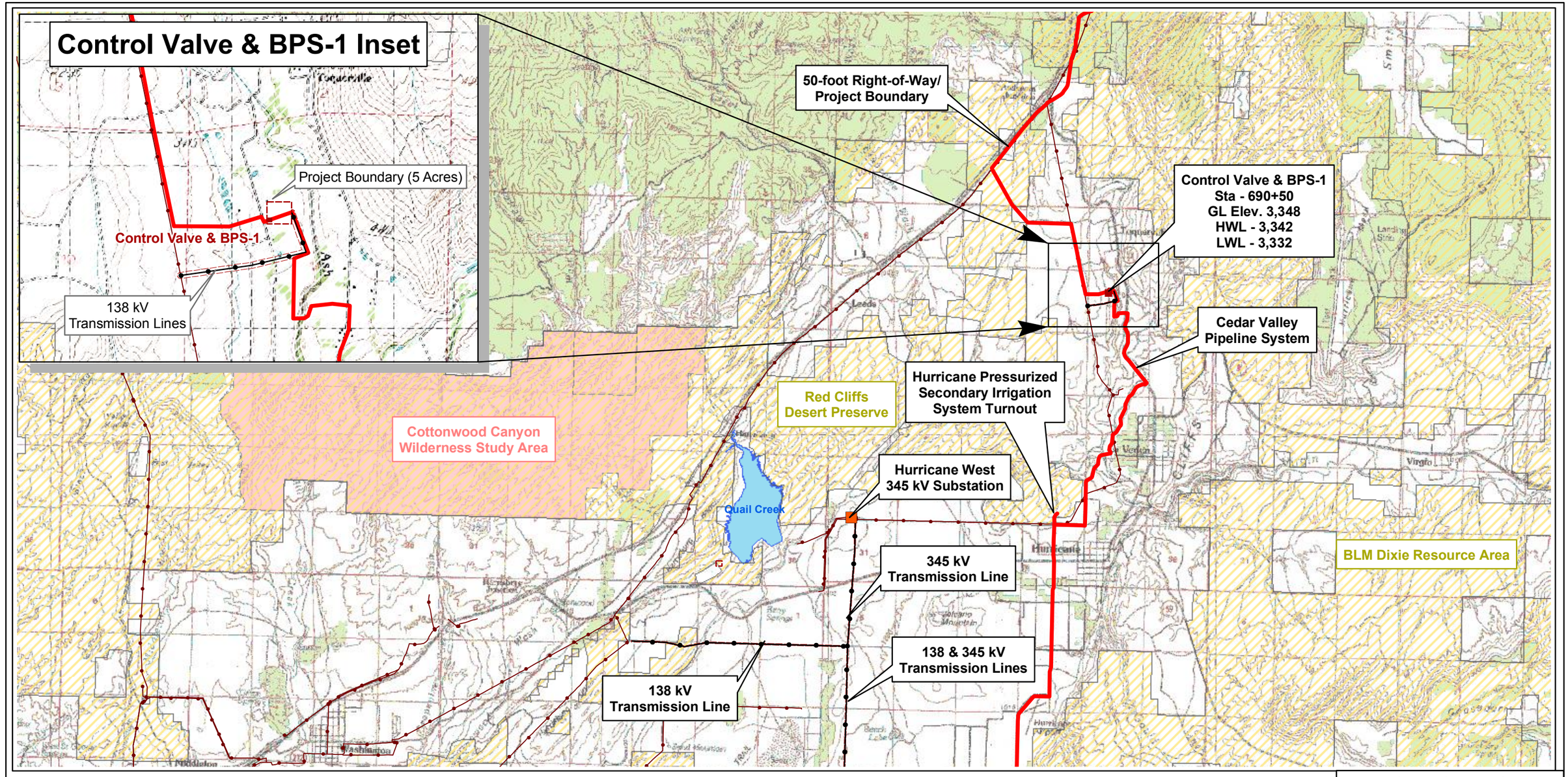
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR **Figure 4-26** MWH

Sheet I
St. George, Utah



Legend

- Pump Stations
- Substation
- Proposed Transmission Lines
- Existing Transmission Lines
- Project Alignment
- Project Boundary

Federal Land

- BLM
- National Park Service
- Tribal Trust

- ACEC
- Wilderness Study Area
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

0 0.5 1 2 3 4 Miles

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Lake Powell Pipeline Project

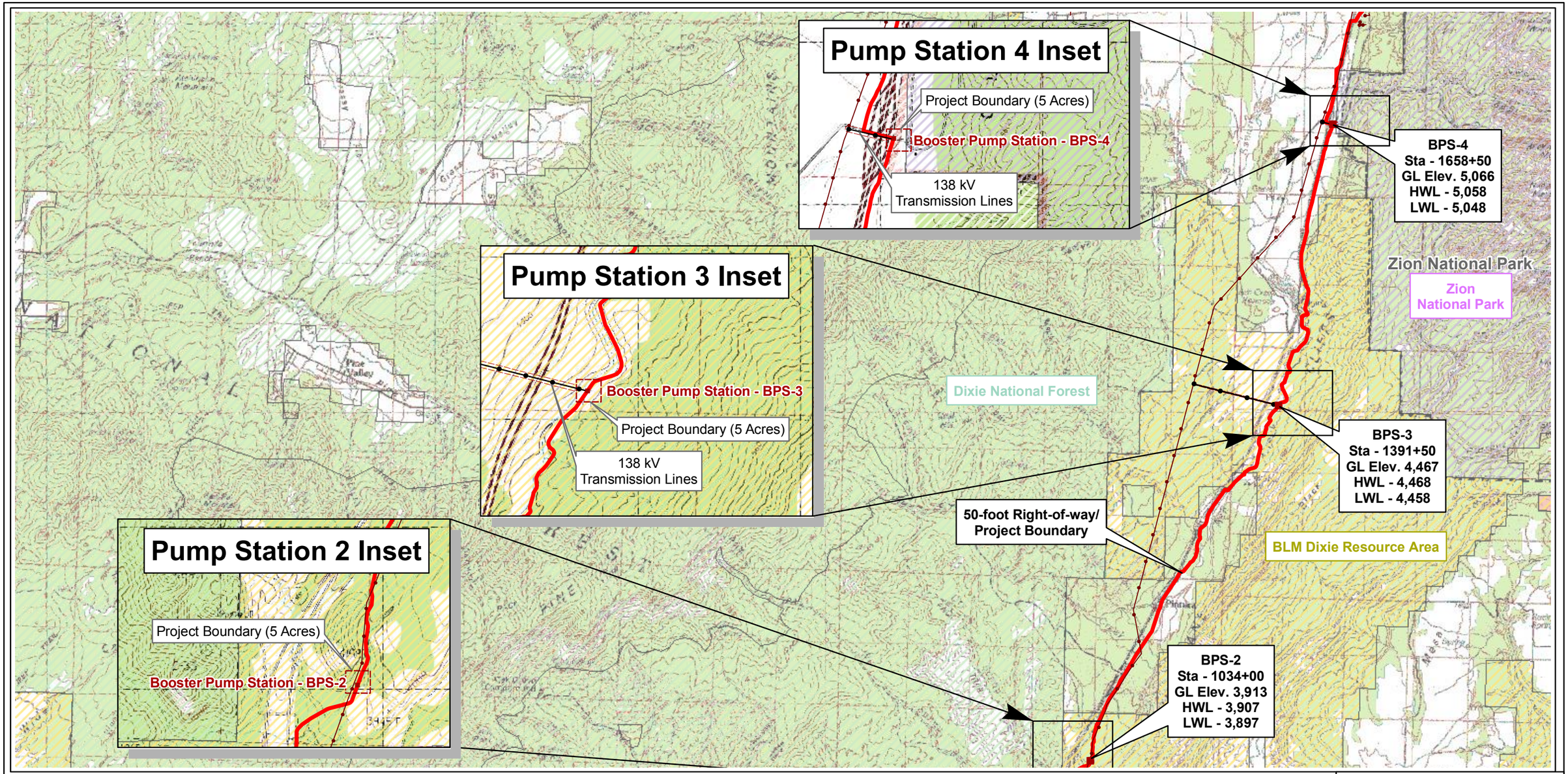
1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-27** MWH

Sheet J
Cedar Valley Pipeline, Utah



Legend

- Pump Stations
- Existing Transmission Lines
- Proposed Transmission Lines
- Project Alignment

Federal Land

- BLM
- National Park Service
- Tribal Trust
- USFS
- Wilderness Study Area

- ACEC
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

0 0.5 1 2 3 4 Miles

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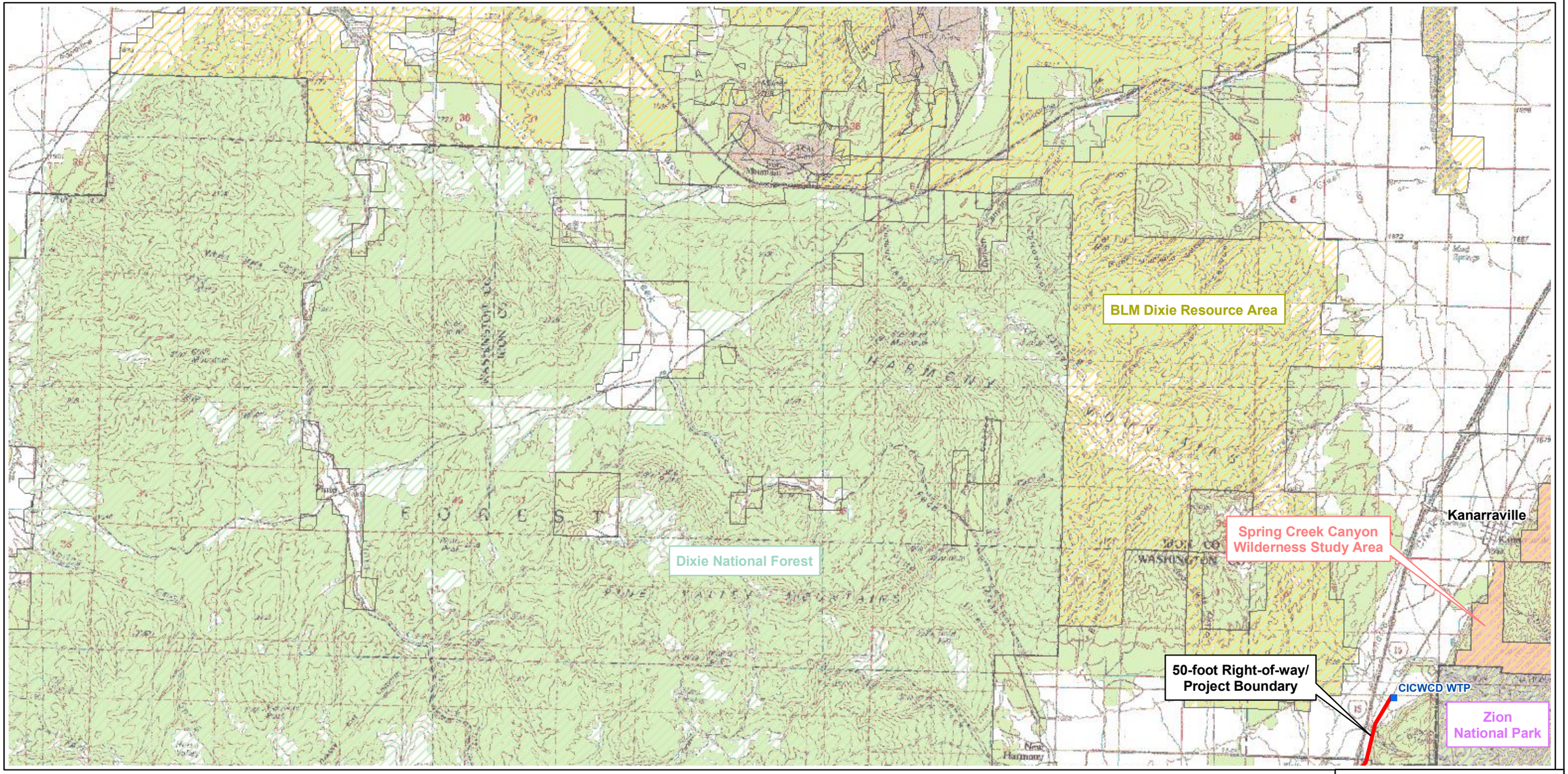
Lake Powell Pipeline Project

1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

UDWR Figure 4-28 MWH

Sheet K
New Harmony, Utah



Legend

- Water Treatment Plant
- Project Alignment

Federal Land

- BLM
- National Park Service
- Tribal Trust
- USFS
- Wilderness Study Area

- ACEC
- Lakes/Reservoirs
- Major Rivers
- Tribal Lands
- National Park/Monument

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Lake Powell Pipeline Project

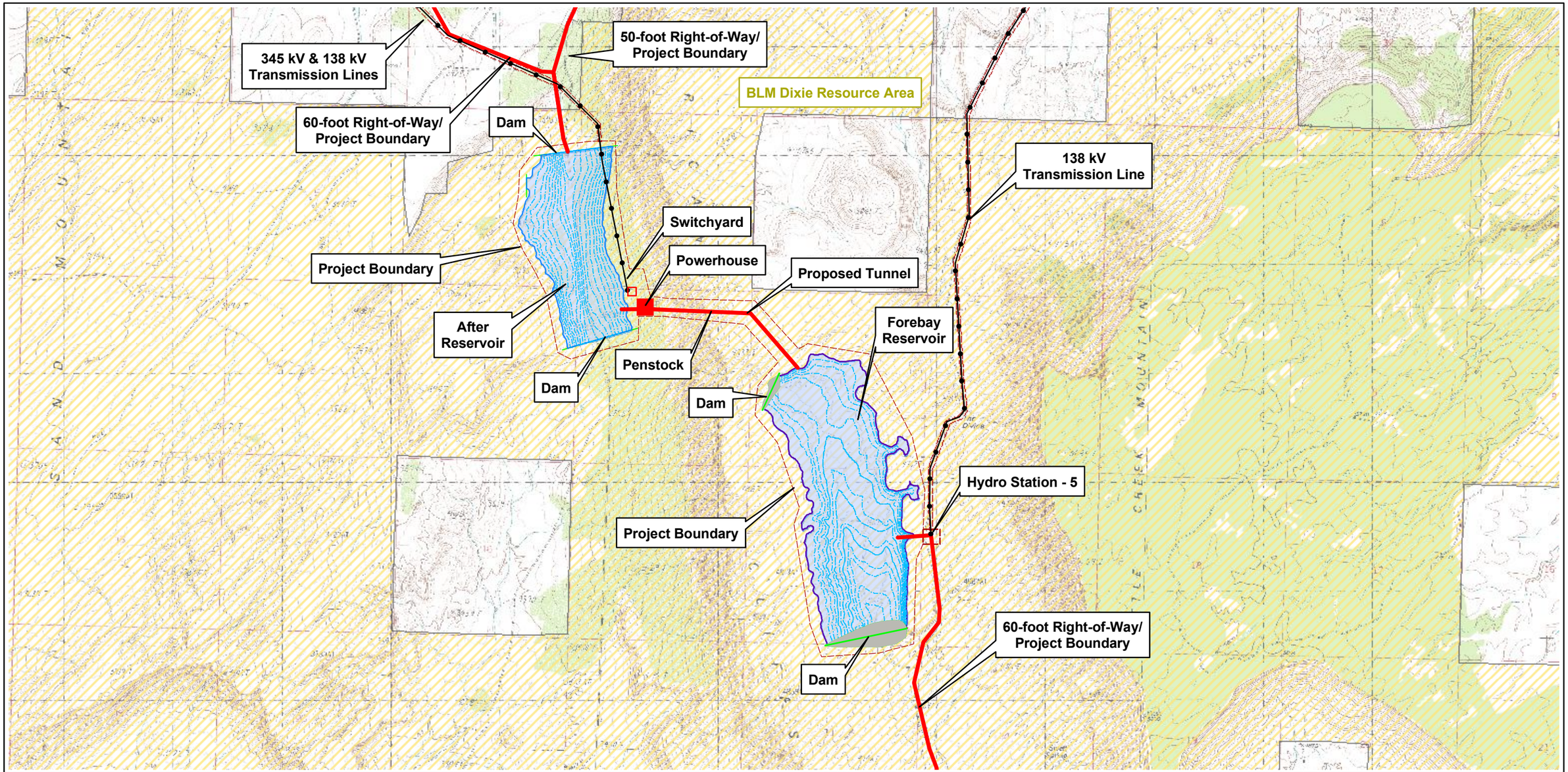
1:100,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-29** MWH

Sheet L
Kanarraville, Utah



Legend

- Transmission Lines
- Project Alignment
- Pump Storage Project Boundary
- Hurricane Cliffs Forebay/Afterbay

Federal Land

- BLM
- National Park Service
- Tribal Trust

0 750 1,500 3,000 4,500 6,000 Feet

The project features indicated on this map are intended to provide only a general indication of a possible development concept. Studies performed during the term of the permit would lead to a definite layout

Lake Powell Pipeline Project

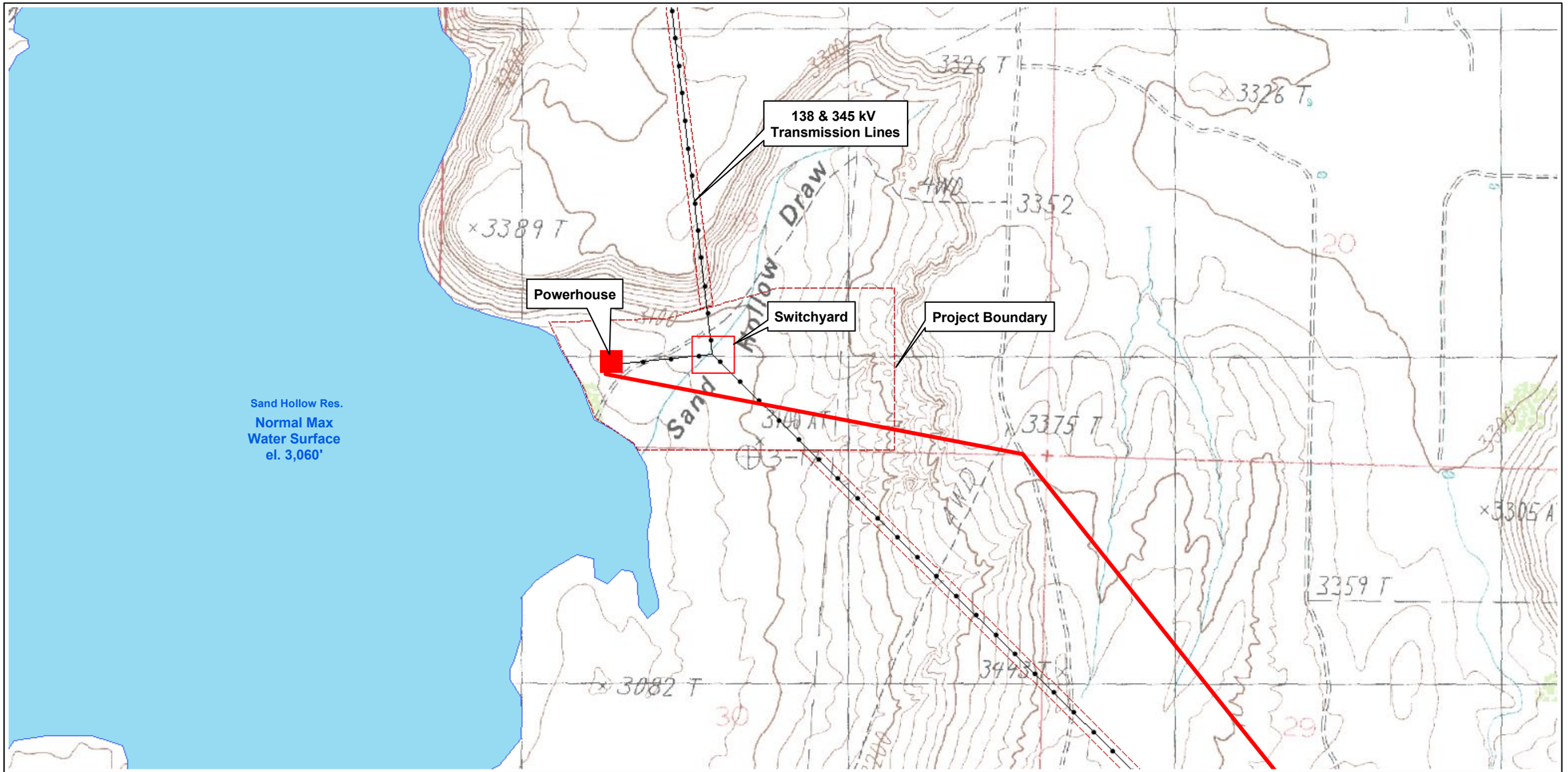
1:36,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-30** MWH

Sheet M - Hurricane Cliffs Pumped Storage Hydro



Legend

- Project Alignment
- Project Boundary
- Proposed Transmission Lines
- Reservoirs

Federal Land

- BLM
- National Park Service
- Tribal Trust

0 250 500 1,000 1,500 2,000 Feet

The project features indicated on this map are intended to provide only a general indication of a possible development concept. Studies performed during the term of the permit would lead to a definite layout

Lake Powell Pipeline Project

1:12,000 Scale

Spatial Reference: UTM Zone 12N, NAD-83

N

UDWR **Figure 4-31** MWH

Sheet N - Sand Hollow Hydro