5.3.5 Groundwater Resources

5.3.5.1 Affected Environment

Groundwater resources in the area of potential effect include managing intake pump station groundwater during construction, shallow groundwater intercepting the ground surface at stream crossings and aquifers characterized by groundwater wells, groundwater recharge, groundwater-surface water interactions, and water quality. The area of potential effect is approximately 200 feet wide along pipeline and penstock alignments and extends 200 feet beyond the defined boundaries of LPP Project facilities.

5.3.5.1.1 Intake Pump Station Construction Dewatering

Water table elevations matched the elevation of Lake Powell during a drilling program at the Water Intake System site. Groundwater is expected to seep from the rock mass into the Intake Pump Station (IPS) shafts and tunnels during construction. Groundwater dewatered from drains, sumps, and dewatering wells would be pumped to the surface where it would be discharged into portable water tanks and particles settled and removed prior to disposal to minimize effects during construction and to protect water quality when discharged in the spillway at Glen Canyon Dam and thus the Colorado River downstream of the dam.

The collected hydrogeologic data provided the basis for an estimate of maximum expected groundwater inflow volume for the intake shafts, forebay connector tunnels and forebay chamber. Groundwater inflows of maximum expected volume are approximated as follows:

- 1000 gpm for one of the 19-ft diameter intake shafts
- 1,500 gpm for two 19-ft diameter intake shafts if shafts are constructed simultaneously
- 200 gpm for one of the forebay connector tunnels
- 400 gpm for the forebay chamber

Therefore the maximum rate of dewatering that would need to occur at any given time would be 1,500 gpm. Dewatering or extraction wells could be constructed around the footprint of the underground construction area. The wells would pump water from the rock mass in the vicinity of the construction area to lower the potentiometric surface and discharge it directly into the temporary holding tanks for settling of suspended solids, thereby reducing the potential groundwater inflow volumes into the shafts and tunnels. The relatively low permeability of the Navajo Sandstone in which the structures would be constructed would require close well spacing.

Discharge of drilling fluids would require treatment to remove solids. Discharge would pass through one or more tanks with sufficient residence time to allow suspended particles to settle; the clarified water would then be conveyed to the Glen Canyon Dam spillway and discharged on the downstream side so no discharge would enter Lake Powell.

It is anticipated that fluids circulated during shaft and tunnel construction will discharge into one end of a trench or rectangular tank. Using typical settling velocities for particles in water (Fifield, J. 2001. Designing for Effective Sediment and Erosion Control on Construction Sites. Forester Press, Santa Barbara, CA) and assuming a particle size of very fine sand (from sandstone), a settling velocity (Vs) of approximately 0.02 ft/sec can be expected. If the tank depth is assumed to be 4 ft deep, a residence time (Tr) of at least 200 seconds would be required to settle a particle at the water surface. For a conservatively high estimate of 1,500 gpm discharge and assuming a tank width of 8 feet (a practical width for transport by truck), the velocity of linear flow from one end of the tank is:

$V_f = Q/A = (1500\ gal/min)(1\ ft^3/7.48\ gal)(1\ min/60\ sec)/((8\ ft)(4\ ft)) = 0.1\ ft/sec$

The minimum length of the settling tank or basin would need to be:

$L = (V_f)(Tr) = (0.1\ ft/sec)(200\ sec) = 20\ ft$

Therefore, a settling tank or basin would be about 8 ft x 20 ft x 4 ft deep to remove very fine sand particles. Settling of solids is likely to involve two tanks or basins in series, with decant from the first tank or basin flowing from the top of the water column into the second tank or basin. Baffles at the end of each tank or basin would help to distribute the flow velocity evenly across the width of the tank or basin. Once clarified, water that is not recirculated would be pumped to the Glen Canyon Dam right spillway and discharged on the downstream side away from Lake Powell into the Colorado River.

5.3.5.1.2 Shallow Groundwater.

5.3.5.1.2.1 Stream Channel Crossings.

The potential to encounter groundwater along most of the Project alignments is low. Most of the alignments are located across areas where groundwater has been historically recorded at low levels, often with few water production wells. Table 5-70 presents stream crossings and washes along the alignments and the estimated probability of encountering groundwater during construction, requiring dewatering. Estimated depths to groundwater were obtained from relevant well water level measurements where available, which are discussed in greater detail in Section 5.3.5.1.1.2. If no direct information was found for determining depth to groundwater at channel crossings, it was assumed that crossings where stream flow occurs much of the year would be at high risk, crossings of infrequent, intermittent-flowing streams would be at medium risk, and crossings of normally-dry washes would be at low risk. The locations where stream channel crossings present a medium to high risk of encountering groundwater during construction are shown in Figure 5-95 for the Water Conveyance System and Figure 5-96 for the Hydro System (all alignments).

5.3.5.1.2.2 Groundwater Wells.

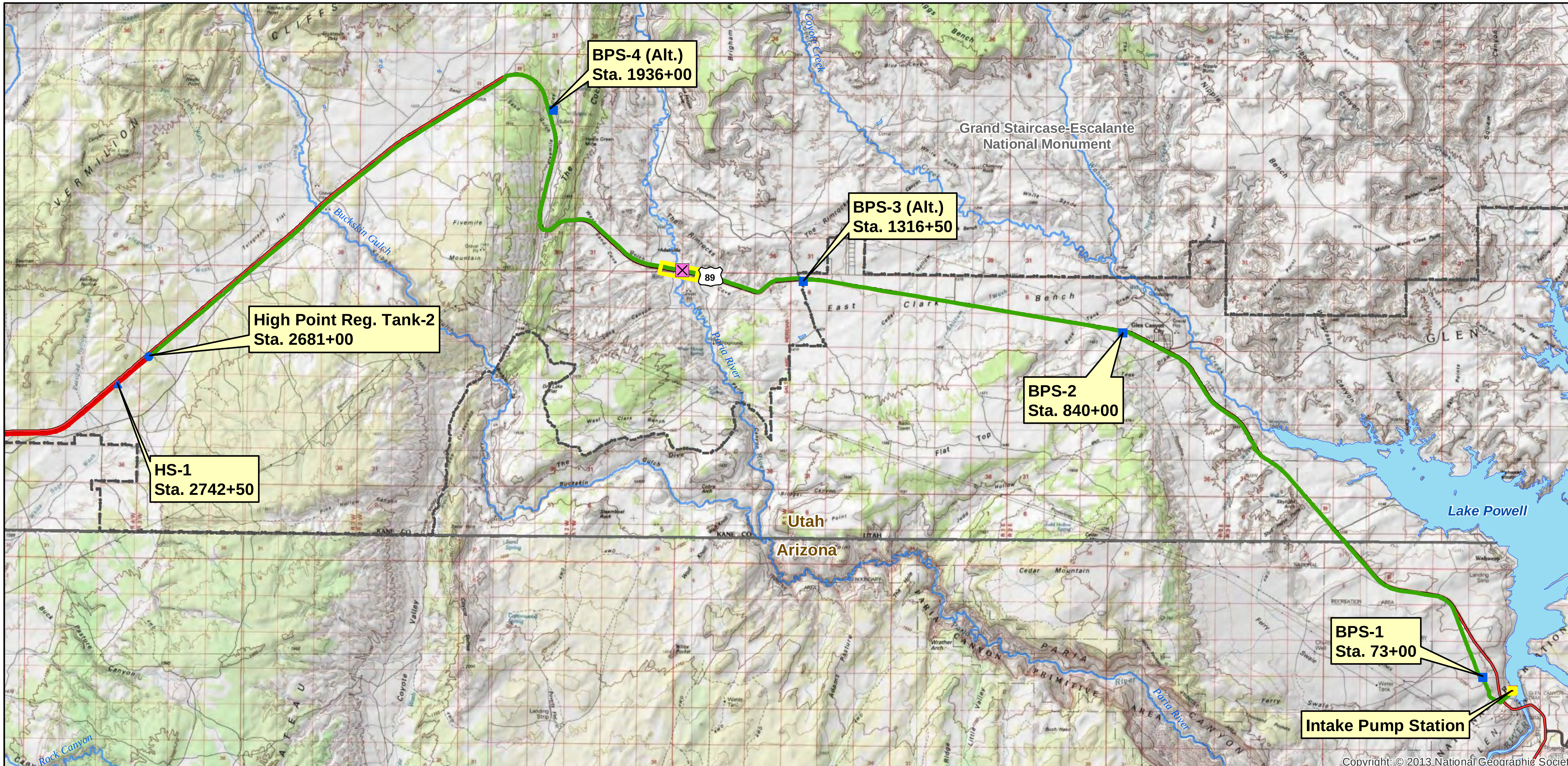
Depth to groundwater away from stream channel crossings was determined from well logs and USGS water level measurement records. These were used to identify areas where there is a medium to high risk of encountering groundwater during Project construction. The locations where there is a medium to high risk of encountering groundwater are shown in Figure 5-95 for the Water Conveyance System and Figure 5-96 for the Hydro System.

5.3.5.1.3 Forebay and Afterbay Recharge.

Two open-air reservoirs could be constructed as part of the LPP Project, including the Hurricane Cliffs Hydro Station forebay reservoir and the Hurricane Cliffs Hydro Station afterbay reservoir. Both reservoirs are located near the Hurricane Cliffs, as shown in Figure 5-97. Only the afterbay reservoir would not be lined to prevent substantial seepage.

Table 5-70
LPP Stream Channel Crossings

Stream Channel	Probability of Encountering Groundwater	Rationale
Existing Highway Alternative		
Paria River	High	Streamflow occurs in all seasons of the year
Buckskin Gulch	Medium	Typically dry but flows in wet periods
Johnson Wash	Low	Typically dry
Kanab Creek	High	Streamflow occurs in all seasons of the year; high water table in wells
Cottonwood Creek	Low/Medium	Anecdotal account of flow other than after storm events
Sand Wash	Low/Medium	Anecdotal account of flow other than after storm events
Two Mile Wash	Low/Medium	Anecdotal account of flow other than after storm events
Short Creek	High	Flows part of the year; medium to high measured water table in wells
Proposed Action		
Paria River	High	Streamflow occurs in all seasons of the year
Buckskin Gulch	Medium	Typically dry but flows in wet periods
White Sage Wash	Low	Typically dry
Jacob Canyon Wash	Low	Typically dry
Kanab Creek	High	Streamflow occurs part of the year
Bitter Seeps Wash	Low	Typically dry
Short Creek	High	Flows part of the year; medium to high measured water table in wells
Southeast Corner Alternative		
Jacob Canyon Wash	Low	Typically dry



- Shallow Ground Water Stream Crossings
- Probable Groundwater Areas
- Water Conveyance System
- Hydro System - South Alternative
- KCWCD System
- Project Intake Pump Station
- Project Pump Station
- Project Regulating Tank
- Project Hydro Station
- Interstate
- US Highway
- ST Highway
- Hwy
- Major Road
- Lakes & Reservoirs
- Major Rivers & Streams
- National Park/Monument
- State Boundaries

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

N

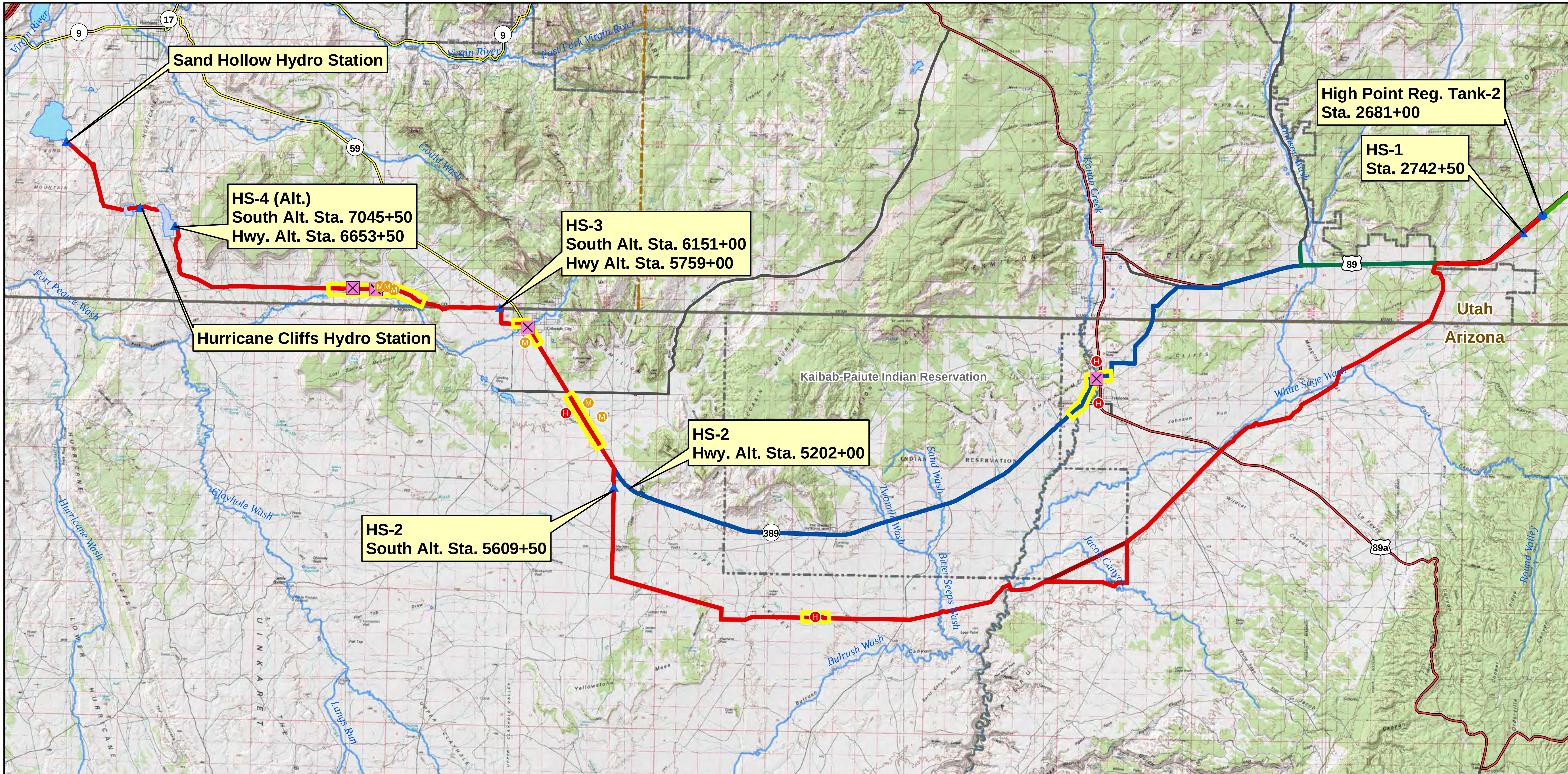
0 0.5 1 2 3 4 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe Figure 5-95 MWH

Lake Powell Pipeline
Potential Shallow
Groundwater Locations
Water Conveyance System



Shallow Ground Water Stream Crossings	Probable Groundwater Areas
High Water Table Risk - 16'-30'	Hurricane Cliffs Forebay/Afterbay
Medium Water Table Risk - 0'-16'	Water Conveyance System
Project Pump Station	Hydro System - South Alternative
Project Regulating Tank	Hydro System, Existing Highway Alternative
Project Hydro Station	KCWCD System
	Hydro System, Southeast Corner Alternative

Interstate	National Park/Monument
US Highway	Tribal Lands
ST Highway	State Boundaries
Hwy	County Boundaries
Major Road	Lakes & Reservoirs
Major Rivers & Streams	

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

0 1.25 2.5 5 7.5 10 Miles

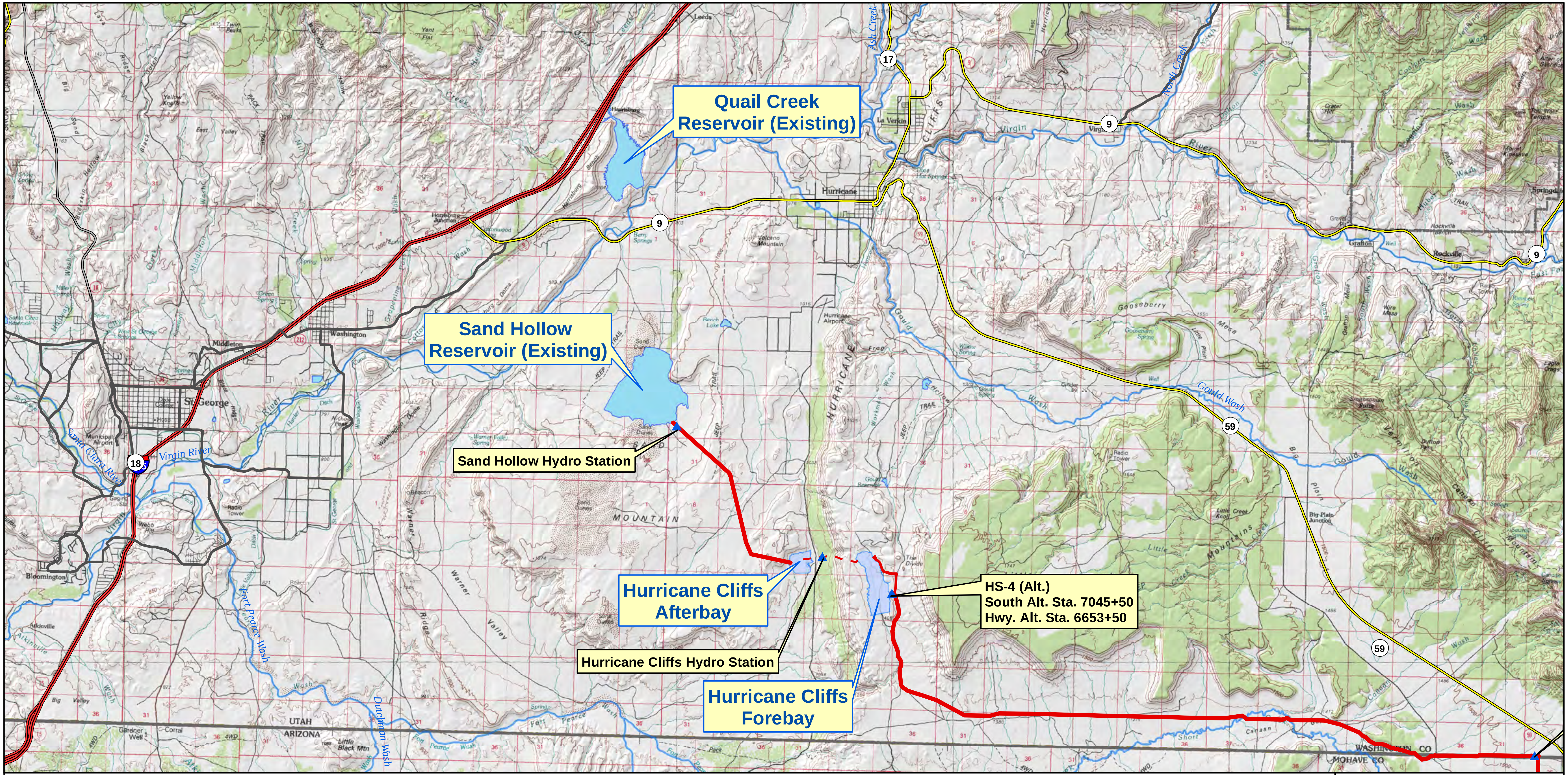
N

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 5-96** MWH

Lake Powell Pipeline Potential Shallow Groundwater Locations Hydro System



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

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

N

0 0.5 1 2 3 4 Miles

Lake Powell Pipeline Project

Spatial Reference: UTM Zone 12N, NAD-83

UDWRe **Figure 5-97** MWH

Lake Powell Pipeline Project Reservoirs

The forebay reservoir would be located above the Hurricane Cliffs. Underlying strata includes the Lower Red Member of the Moenkopi Formation, the Timpoweap Member of the Moenkopi Formation, the Harrisburg Member of the Kaibab Formation, and the Fossil Mountain Member of the Kaibab Formation, as well as some basalt flows. Vertical fractures within these formations could result in relatively high infiltration rates, and discharge to the face of Hurricane Cliffs would be a concern. However, the forebay reservoir may be partially lined to prevent substantial amounts of seepage and reduce the possibility of discharge to the face of the cliffs. Furthermore, the strata dip gently toward the east, away from the cliffs. Zones of little or no fractures present within the formations would tend to direct seepage from the forebay reservoir away from the cliffs rather than toward it.

Seepage from the pumped storage afterbay reservoir is likely because the reservoir would overlie generally coarse-grained alluvial sediments with moderate to high rates of permeability. However, well measurements in the vicinity of the pumped storage afterbay reservoir show that groundwater is deep, and few, if any, existing groundwater users are currently in the area. Recharge from the pumped storage afterbay reservoir may result in localized groundwater mounding. No known wells are currently located within one mile of the pumped storage afterbay reservoir. If mounding eventually extends out from the pumped storage afterbay reservoir to existing or future production wells or if the water table rises as a result of recharge from the pumped storage afterbay reservoir, it would provide a positive hydraulic benefit to groundwater resource users. However, because no drilling geologic data that extends to the water table are available at this location, it is not known whether any impermeable layers may exist that would impede recharge to the deep aquifer.

5.3.5.1.4 Groundwater – Surface Water Interactions.

Only one location within the LPP Project has the potential to be affected by groundwater-surface water interactions. This would be at Sand Hollow Reservoir and the nearby Virgin River. Recharge from the existing Sand Hollow Reservoir, which began filling in 2002, affects groundwater levels near Sand Hollow Reservoir by causing mounding of the groundwater table. This mound now extends from the underlying water table to the bottom of the reservoir, and therefore cannot get much larger. Some of the recharge is recovered by production wells. Flow within the Navajo Sandstone aquifer system underlying Sand Hollow Reservoir is northward and westward, and intercepts the Virgin River both north and west of the reservoir. Ongoing studies by the USGS (USGS 2005; 2007; 2009; 2012) suggest that the water levels within the aquifer are no longer changing substantially as a result of recharge from Sand Hollow Reservoir. Therefore rates of discharge to the Virgin River are assumed to be approximately stabilized and are unlikely to change substantially as a result of recharge from the reservoir, regardless of the source of water filling the reservoir.

5.3.5.1.5 Water Quality.

Groundwater quality within the LPP Project area of potential effect may only be affected at the Hurricane Cliffs Hydropower afterbay reservoir and at Sand Hollow Reservoir because discharges into unlined reservoirs would only occur at these two locations. No water quality data were identified for groundwater in the vicinity of the afterbay reservoir. Therefore it is not possible to identify baseline conditions at this location.

Water quality at Sand Hollow Reservoir has been characterized by ongoing USGS investigations (USGS 2005; 2007; 2009; 2012). The recharge effects of using Virgin River water have been documented by the USGS. Virgin River water is very similar in concentrations of TDS and most individual constituents compared with Lake Powell water. Current recharge at Sand Hollow Reservoir has resulted in a trend toward higher TDS, caused in part by the higher TDS of Virgin River water as it blends with underlying groundwater, as well as a probable leaching effect of salts within the soil. This leaching appears to be diminishing, because groundwater quality near the reservoir appears to be improving after an initial increase in TDS. If current trends continue, groundwater underlying Sand Hollow Reservoir will become similar to the recharge water.

5.3.5.2 Environmental Effects

5.3.5.2.1 Significance Criteria.

The following criteria were used in this evaluation to determine whether effects associated with any of the alternatives would be significant. Significance criteria were established based on the study topics identified herein, which were identified in the Study Plan. Effects are considered significant only if they would occur within the design life of the Project (75 years), and could not be mitigated by design.

5.3.5.2.1.1 Intake Pump Station Construction Dewatering.

Dewatering associated with construction of the IPS would be a significant effect on groundwater resources if dewatering would result in a measurable, long-term depletion of groundwater resources to resource users, relative to baseline conditions.

5.3.5.2.1.2 Shallow Groundwater.

Dewatering of shallow groundwater to facilitate construction along any of the LPP Project alignments would have a significant effect on groundwater resources if dewatering would result in a measurable, long-term depletion of groundwater resources to resource users, relative to baseline conditions.

5.3.5.2.1.3 Groundwater Recharge.

Groundwater recharge associated with the LPP Project or any of the alternatives would have a significant effect on groundwater resources if resulting recharge would result in a measurable, long-term change in availability of groundwater resources to resource users, relative to baseline conditions.

5.3.5.2.1.4 Groundwater-Surface Water Interactions.

Groundwater-surface water interactions associated with recharge that would occur as part of the LPP Project or any of the alternatives would have a significant effect on groundwater resources if the recharge would result in measurable, long-term changes in the rates or locations of groundwater-surface water interactions, relative to baseline conditions.

5.3.5.2.1.5 Water Quality.

Changes in water quality associated with the alternatives would have a significant effect on groundwater resources if the changes would degrade groundwater quality, either by changing the state aquifer classification or by increasing concentrations of constituents such that they would exceed state numerical standards for drinking water.

5.3.5.2.2 Proposed Action.

5.3.5.2.2.1 Construction Effects.

Intake Pump Station Construction Dewatering

Construction dewatering for the IPS would be of a duration of potentially numerous months. This would result in a cone of depression of the water table around the IPS to the north, west and south. The water table in boreholes at the IPS location indicate that groundwater in the Navajo Sandstone at that location is in hydraulic connection with Lake Powell, so the lake would serve as a recharge boundary which would limit the cone of depression eastward and would provide much of the water that would be pumped over the long term. The relatively low permeability of the Navajo Sandstone aquifer matrix would result in a steep groundwater gradient within the cone of depression that would limit the extent of drawdown around the IPS facility during construction dewatering. A review of Arizona Department of Water Resources Well Registry identified no production wells within one mile of the proposed IPS site. Because of the isolation of the proposed IPS facility, no production wells would be affected. No measurable effects would occur and no significant effect would occur.

Shallow Groundwater

Shallow groundwater would be encountered at the Paria River and possibly at the Cane Beds and near Short Creek in the Colorado City area. Shallow groundwater probably would be encountered at the Sand Hollow Hydro Station tailrace adjacent to Sand Hollow Reservoir. Although possible, it is unlikely that shallow groundwater would be encountered elsewhere. BMPs would be incorporated to limit drawdown during construction dewatering to the minimum drawdown necessary for safe and effective construction. BMPs such as trench-blockers would be utilized to prevent groundwater migration along trench bedding where shallow groundwater is encountered. Drawdown would be temporary, no longer than necessary for construction purposes, which would not cause long-term or extensive depletion of groundwater levels or available supplies. Disposal of dewatered groundwater would be performed using BMPs to prevent excessive erosion. Therefore, no measurable effects on groundwater would occur and there would be no significant effects on groundwater.

Groundwater Recharge

No effects would occur.

Groundwater-Surface Water Interactions

Dewatering disposal during construction would be performed using BMPs to prevent erosion or other effects on surface water. Therefore, no effects are expected and no significant effects would occur on groundwater as a result of construction dewatering. No other effects would occur.

Water Quality

No effects would occur and no significant effects would occur on groundwater quality.

5.3.5.2.2.2 Operational Effects.

Intake Pump Station Long-Term Operation

The shafts and tunnels would be lined which would minimize or eliminate groundwater inflow. After construction is completed, the groundwater table would stabilize at or near the water level elevation of Lake Powell. No measurable effects on groundwater would occur.

Shallow Groundwater

Occasional water releases from pipeline and penstock drains would occur at low points in the profile. These temporary drain releases to streams and dry washes would have no measurable effects on shallow groundwater. If released surface water recharged to the ground in these streams and dry washes, the resulting effects on shallow groundwater would be positive and intermittent. No significant effects would occur on shallow groundwater.

Groundwater Recharge

Substantial groundwater recharge would only occur at the afterbay reservoir and at Sand Hollow Reservoir. At the afterbay reservoir, recharge would be to a deep aquifer in the Navajo sandstone utilized by very few groundwater resource users. If any recharge reaches the aquifer, it would result in an increase in groundwater levels. This would be a positive, long-term effect on groundwater resources.

Recharge at Sand Hollow Reservoir from LPP water would continue the hydraulic recharge conditions similar to baseline conditions where recharge of Virgin River water occurs. Therefore, no distinguishable effects and no significant effects would occur on groundwater resources.

Groundwater-Surface Water Interactions

Groundwater-surface water interactions would be the same as baseline conditions. Therefore, no effects and no significant effects would occur on groundwater resources.

Water Quality

Water quality effects associated with the LPP Project would be similar to baseline conditions because of the similarity of Virgin River water quality to the Lake Powell water that would be delivered to Sand Hollow Reservoir. Therefore, no measurable effects and no significant effects would occur on groundwater resources.

Recharge at the afterbay reservoir is of unknown quantity into an aquifer of unknown quality; however, recharge would be into a deep aquifer with few or no groundwater users. Therefore, no effects and no significant effects are expected to occur on groundwater resources.

5.3.5.2.3 Existing Highway Alternative.

Construction and operations effects on groundwater resources would be the same as described for the Proposed Action in Section 5.3.5.2.2.

5.3.5.2.4 Southeast Corner Alternative.

Construction and operations effects on groundwater resources would be the same as described for the Proposed Action in Section 5.3.5.2.2.

5.3.5.2.5 No Lake Powell Water Alternative.

5.3.5.2.5.1 WCWCD.

Intake Pump Station Construction Dewatering

The IPS would not be constructed so no dewatering would be needed. No effects would occur.

Shallow Groundwater

Shallow groundwater resources would be affected as water supplies become increasingly scarce. Increasing demands for water supply would maximize groundwater resource usage. Shallow groundwater recharged to the Navajo sandstone aquifer beneath and around Sand Hollow Reservoir would be reserved for use during dry periods to compensate for any deficit between annual supply and demand.

Groundwater Recharge

The No Lake Powell Water Alternative would eliminate residential outdoor landscape watering with potable water. Elimination of outdoor landscape watering with potable water would greatly reduce groundwater recharge in the St. George metropolitan area. The estimated reduction in residential outdoor potable water use by 2052 (the projected year when all LPP Proposed Action water would be utilized) would be between 51,633 acre-feet per year and 56,724 acre-feet per year when compared to the Proposed Action. UDWRe estimates that approximately 50 percent of current residential potable water used for outdoor residential irrigation is consumed by evapotranspiration, and the remaining 50 percent is recharged to groundwater. Non-sewered return flows of potable water are projected by UDWRe to decrease from 50 percent to 30 percent between 2010 and 2050 resulting from increased water conservation measures and more efficient use of potable water for outdoor watering. UDWRe estimates that approximately 20 percent of commercial potable water use is used for outside watering, and approximately 80 percent of institutional potable water use is used for outside watering (UDWRe 2016). This would be a long-term adverse effect and would be a significant long-term adverse effect on groundwater recharge in the St. George metropolitan area.

Groundwater-Surface Water Interactions

No effects would occur.

Water Quality

The No Lake Powell Water Alternative could adversely affect groundwater quality in the St. George metropolitan area through recharge only with lower quality secondary surface water for outdoor irrigation. Groundwater quality could gradually decrease from increased concentration of TDS associated with the secondary irrigation water. Moderate adverse effects on groundwater quality could occur. These effects could be significant on groundwater quality in the St. George metropolitan area.

5.3.5.2.5.2 KCWCD.

Intake Pump Station Construction Dewatering

The IPS would not be constructed so no dewatering would be needed. No effects would occur.

Shallow Groundwater

The Kanab Creek aquifer would be further developed to meet demands for M&I water in the KCWCD service area for Kanab and Johnson Canyon. The shallow aquifer associated with Kanab Creek would be further depleted. This depletion would have a minor effect on groundwater resources in the Kanab area.

Groundwater Recharge

No effects would occur.

Groundwater-Surface Water Interactions

No effects would occur.

Water Quality

The No Lake Powell Water Alternative does not change baseline conditions for groundwater quality, so no effects would occur as a result of the alternative. No effects would occur.

5.3.5.2.6 No Action Alternative.

5.3.5.2.6.1 WCWCD.

Intake Pump Station Construction Dewatering

Construction of the IPS would not occur. No effects from groundwater dewatering would occur.

Shallow Groundwater

Shallow groundwater resources would be affected as water supplies become increasingly scarce. Increasing demands for water supply would maximize groundwater resource usage. Shallow groundwater recharged to the Navajo sandstone aquifer beneath and around Sand Hollow Reservoir would be reserved for use during dry periods to compensate for any deficit between annual supply and demand.

Groundwater Recharge

No effects would occur.

Groundwater-Surface Water Interaction

No effects would occur.

Water Quality

No effects would occur.

5.3.5.2.3.2 KCWCD.

Intake Pump Station Construction Dewatering

Construction of the IPS would not occur. No effects from groundwater dewatering would occur.

Shallow Groundwater

Shallow groundwater resources would be affected as the projected shortage of available water would require maximization of the groundwater resource usage. Eventually, the capacity of the aquifers would be exceeded and depletion would occur, limiting the availability of water for use. This would cause a significant long term effect.

Groundwater Recharge

No effects would occur.

Groundwater-Surface Water Interaction

No effects would occur.

Water Quality

No effects would occur.

5.3.5.3 Protection, Mitigation and Enhancement Measures

The following protection, mitigation and enhancement measures would be implemented to protect and mitigate potential effects on groundwater resources.

5.3.5.3.1 LPP Project Proposed Action and Action Alternatives

5.3.5.3.1.1 Planning.

UDWRe would prepare site specific groundwater BMPs and implement a Spill Prevention, Control and Countermeasures Plan (SPCCP) to minimize the potential for groundwater contamination from uncontrolled or unmitigated releases of hazardous materials. The SPCCP would include measures such as using portable containment pads for refueling and servicing construction equipment to prevent hazardous material spills on the ground surface where it could come into contact with surface and/or groundwater. BMPs would be utilized during construction to prevent accidental releases of fuel or chemicals and to minimize disposal of turbid water that could affect groundwater quality.

5.3.5.3.1.2 Site Stabilization and Erosion Control.

UDWRe in consultation with federal land management agencies would specify hydroseeding, mulching, soil stabilizers (binders), silt fences, geotextiles, and erosion control blankets as necessary on disturbed soils to protect against soil erosion, excessive surface water runoff, and ponding that could transfer construction-related contaminants into the soil and/or groundwater.

5.3.5.3.1.3 Dewatering.

If dewatering is necessary, water would be pumped to an acceptable, properly designed dewatering basin. The stored water can be used for onsite construction activities, discharged into evaporation/infiltration basins or land-applied on adjacent land with prior permission. Pumping would be limited to the flow rate necessary to achieve dewatering for safe and stable trench construction activities and would occur no longer than necessary to complete construction within the open trench interval.

5.3.5.3.1.4 Pollutant Removal and Peak Runoff Control.

UDWRe would require construction contractors to manage and control all sediment from dewatered groundwater using earth dikes, drainage swales, ditches, velocity dissipation devices, slope drains and/or similar methods. At the IPS, settling tanks or basins would be used to remove suspended solids from discharge. The treated water would be pumped to the Glen Canyon Dam spillway to be discharged and would flow from there into the Colorado River downstream of the dam.

5.3.5.3.1.5 Streambank Stabilization and Antidegradation.

Construction locations with severe channel instability problems would be avoided. Stabilization and erosion control measures would be implemented to prevent any increase in sedimentation, siltation and turbidity to the stream as a result of construction activity. Runoff and contaminants from staging areas would be prevented from entering stream and dry washes by using secondary containment structures. Directional drilling may be used in geologically sensitive locations to minimize potential for groundwater contamination. All drilling fluids would be captured and accounted for during drilling activities.

5.3.5.3.1.6 Stormwater Percolation.

Infiltration trenches would be used to percolate uncontaminated run-on and runoff stormwater as applicable. All infiltration trenches would be reclaimed to approximate original contour following construction completion of each segment.

5.3.5.3.1.7 Waste Management.

All construction waste generated would be handled, stored and disposed of under prevailing codes and regulations. Lined containment structures would be used where applicable to prevent groundwater contamination from construction waste.

5.3.5.3.2 No Lake Powell Water Alternative.

Regular monitoring of groundwater levels would be required to determine trends and rates of depletion to maintain adequate groundwater supply for future growth under the No Lake Powell Water Alternative.

5.3.5.3.3 No Action Alternative.

Regular monitoring of groundwater levels would be required to determine trends and rates of depletion to maintain adequate groundwater supply for future growth under the No Action Alternative.

5.3.5.4 Cumulative Effects

5.3.5.4.1 Proposed Action.

The Proposed Action would have no short-term cumulative effects on groundwater resources. The Proposed Action would have positive, long-term cumulative effects on groundwater resources resulting from LPP water recharge into the Navajo sandstone aquifer under Sand Hollow Reservoir.

5.3.5.4.2 Existing Highway Alternative.

The Existing Highway Alternative would have the same cumulative effects as the Proposed Action described in Section 5.3.5.4.1.

5.3.5.4.3 Southeast Corner Alternative.

The Southeast Corner Alternative would have the same cumulative effects as the Proposed Action described in Section 5.3.5.4.1.

5.3.5.4.4 No Lake Powell Water Alternative.

The No Lake Powell Water Alternative would have no short-term or long-term cumulative effects on groundwater resources.

5.3.5.4.5 No Action Alternative.

The No Action Alternative would have no short-term or long-term cumulative effects on groundwater resources.

5.3.5.5 Unavoidable Adverse Effects

5.3.5.5.1 Proposed Action.

The Proposed Action would have unmeasurable short-term unavoidable adverse effects on groundwater resources. Construction effects would include groundwater dewatering at the water intake system site and potential groundwater dewatering and disposal in areas near the Paria River, Kane Beds and Short Creek. The Proposed Action would have no long-term unavoidable adverse effects on groundwater resources.

5.3.5.5.2 Existing Highway Alternative.

The Existing Highway Alternative would have the same unavoidable adverse effects on groundwater resources as the Proposed Action described in Section 5.3.5.5.1.

5.3.5.5.3 Southeast Corner Alternative.

The Southeast Corner Alternative would have the same unavoidable adverse effects on groundwater resources as the Proposed Action described in Section 5.3.5.5.1.

5.3.5.5.4 No Lake Powell Water Alternative.

The No Lake Powell Water Alternative would have no short-term unavoidable adverse effects on groundwater resources. It would have major long-term unavoidable adverse effects on groundwater resources in the St. George metropolitan area resulting from eliminating outdoor irrigation with potable water. The elimination of shallow groundwater recharge from outdoor irrigation with potable water would reduce groundwater discharge to the Virgin River and could indirectly reduce stream flows, increase water temperature, and decrease DO concentrations during summer months. Depletion of groundwater supplies would result in reduced availability of water and higher pumping costs. Agricultural irrigation ultimately would not occur and groundwater recharge would not occur as a result of agricultural irrigation.

5.3.5.5.5 No Action Alternative.

Depletion of groundwater supplies would result in reduced availability of water and higher pumping costs. Agricultural irrigation ultimately would not occur and groundwater recharge would not occur as a result of agricultural irrigation.

5.3.5.6 References

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