Lake Powell Pipeline Project
FERC Additional Information Request Schedule B – Item 15

Exhibit E

15. In your response to our comment 9 on the PLP, you state that a summary discussion is provided in Final Study Report 4, *Geology and Soil Resources*, and exhibit E identifying locations, estimated lengths, and (as supported by available data) rock quality for all proposed project tunnels. We could not locate this summary. Please identify the location of this summary information or provide a summary table.

UBWR Response:

Table 2-1 provides a summary of tunnel and shaft information for the Lake Powell Pipeline (LPP) project Water Intake Pump Station, Hurricane Cliffs Hydropower waterway features, and Sand Hollow tunnel. The Water Intake Pump Station would be located immediately upstream of Glen Canyon Dam. The Hurricane Cliffs Hydropower waterway features would be located between the proposed forebay reservoir at the top of the Hurricane Cliffs and the Hurricane Cliffs Hydropower Station at the bottom of the Hurricane Cliffs. The Sand Hollow tunnel would be located on the west side of the afterbay reservoir. The information provided in the attached Table 2-1 includes the identifying locations, approximate lengths, and rock quality (as supported by available data) for all proposed LPP project tunnels and shafts.

Table 2-1
Summary of Tunnel and Shaft Information

Tunnel/Shaft	Approximate Total Length (ft.)	Geologic Unit	Hardness[1]	Unconfined Compressive Strength[2] (psi)	RMR/Rating[3, 5]	Q/Rating[4, 5]	Possible Stabilization Methods	Probable Impacts and Mitigation	Comments
Water Intake Pump Station	1,615 ft. horizontal 1,050 ft. vertical (total of multiple shafts and tunnels)	Navajo Sandstone	MH/H	1,810 to 7,250/ 7,250 to 14,500	73/Good	30/Good	Light to medium steel sets as required	Impacts: Excavation spoils; construction dewatering discharge Mitigation: Use spoils as bedding and backfill; remove suspended solids from dewatering discharge under permit	Includes 8 horizontal tunnels, 6 for intake and 2 to pump chamber; includes 3 vertical shafts; 1 forebay chamber
HCH[6] Intake Shaft	20	Alluvium; Moenkopi Fm – Lower Red Member (highly weathered)	NA	NA	NA	NA	Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	Weathered lower Moenkopi rocks are expected to be of low strength
HCH[6] Intake Shaft	30	Moenkopi Fm – Rock Canyon Conglomerate Member	MH/H	1,810 to 7,250/ 7,250 to 14,500	44/Fair to Good	2.5/Poor	Pattern post-tension bolting, with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as bedding and backfill	
HCH[6] Intake Shaft	150	Kaibab Fm – Harrisburg Member	VH	14,500 to 36,250	64/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Low Pressure Tunnel	700	Kaibab Fm – Harrisburg Member	VH	14,500 to 36,250	64/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Low Pressure Tunnel	800	Kaibab Fm – Fossil Mountain Member	M	725 to 1,810	59/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Surge Shaft	20	Alluvium	NA	NA	NA	NA	Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Surge Shaft	10	Moenkopi Fm – Rock Canyon Conglomerate Member	MH/H	1,810 to 7,250/ 7,250 to 14,500	44/Fair to Good	2.5/Poor	Pattern post-tension bolting, with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as bedding and backfill	
HCH[6] Surge Shaft	150	Kaibab Fm – Harrisburg Member	VH	14,500 to 6,250	64/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Surge Shaft	120	Kaibab Fm – Fossil Mountain Member	M	725 to 1,810	59/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Cast-in-place reinforced concrete liner	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Pressure Shaft	50	Kaibab Fm – Fossil Mountain Member	M	725 to 1,810	59/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	

Table 2-1
Summary of Tunnel and Shaft Information

Tunnel/Shaft	Approximate Total Length (ft.)	Geologic Unit	Hardness[1]	Unconfined Compressive Strength[2] (psi)	RMR/Rating[3, 5]	Q/Rating[4, 5]	Possible Stabilization Methods	Probable Impacts and Mitigation	Comments
HCH[6] Pressure Shaft	350	Toroweap Fm – Woods Ranch Member	M	725 to 1,810	48/Poor	0.25 Extremely Poor+	Systematic bolting with wire mesh; Fiber-reinforced shotcrete; Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] Pressure Shaft	150	Toroweap Fm – Brady Canyon Member	M	725 to 1,810	59/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] High Pressure Tunnel	50	Toroweap Fm – Brady Canyon Member	M	725 to 1,810	59/Good	9.3/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Steel penstock liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] High Pressure Tunnel	1150	Toroweap Fm – Seligman Member	S/M	180 to 725/ 725 to 1,810	48/Poor	0.25/ Extremely Poor	Systematic bolting with wire mesh; Fiber-reinforced shotcrete (crown and sides); Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	
HCH[6] High Pressure Tunnel	150	Queantoweap Sandstone	MH/H	1810 to 7250/ 7,250 to 14,500	59/Good	5/Fair	Post-tension bolts in crown with wire mesh; Fiber-reinforced shotcrete; Steel penstock liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as bedding and backfill	
Sand Hollow Tunnel	4,200	Navajo Sandstone	MH	1,810 to 7250	50/Fair	1/Poor	Systematic bolting with wire mesh; Fiber-reinforced shotcrete (crown and sides); Light to medium steel sets as required; Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as backfill	More friable than at LPP Water Intake Pump Station construction
Sand Hollow Tunnel	100	Kayenta Fm	MH/H	1810 to 7250/ 7,250 to 14,500	NA	NA	Systematic bolting with wire mesh; Fiber-reinforced shotcrete (crown and sides); Light to medium steel sets as required; Steel liner with structural reinforced concrete backfill	Impacts: Excavation spoils Mitigation: Use spoils as bedding and backfill	May or may not be encountered during tunnel construction

Notes:
1) USBR 1998. Hardness: VH=Very Hard, H=Hard, MH=Medium Hard, M=Medium, S=Soft, VS=Very Soft.
2) U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). National Engineering Handbook. Part 631, Geology. Chapter 4, Engineering Classification of Rock Materials. 2012. Table 4-3, Unconfined Compressive Strength of Rock Materials.
3) RMR = Rock Mass Index (Bieniawski, Z. T. 1989).
4) Tunneling Quality Index (Barton et al., 1974).
5) MWH 2011. Lake Powell Pipeline Phase II – Preliminary Engineering and Environmental Studies, Task 6 – Preliminary Design Report, Appendix 4.D, Hurricane Cliffs Waterways Features. Table 4D.1, Estimated Excavation Methods, Initial Support and Final Lining for Waterway.
6) Hurricane Cliffs Hydropower Waterway (intake shaft, low pressure tunnel, surge shaft, pressure shaft, and high pressure tunnel).