
Technical Appendix 11

Cultural Resources

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Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Interim Guidelines	Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead
ADOT	Arizona Department of Transportation
APE	area of potential effect
ASPT	Arizona State Parks and Trails
BLM	Bureau of Land Management
CCS	Continued Current Strategies
CFR	Code of Federal Regulations
DEM	digital elevation model
DOE	Department of Energy
EOCY	end-of-calendar year
EOWY	end-of-water year
EPNG	El Paso Natural Gas Company
FWS	United States Fish and Wildlife Service
GCNP	Grand Canyon National Park
HFE	high-flow experiment
LADWP	Los Angeles Department of Water and Power
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
LCRO	Lower Colorado River Office
MWD	Metropolitan Water District of Southern California
NHA	National Heritage Area
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NHT	National Historic Trail
NIB	Northerly International Boundary
NPS	National Park Service
NRA	National Recreation Area
NRHP	National Register of Historic Places
NVCRIS	Nevada Cultural Resources Inventory System

Reclamation	Bureau of Reclamation
SCE	Southern California Edison
SHPO	State Historic Preservation Officer
SIB	Southerly International Boundary
SWGC	Southwest Gas Corporation
TCP	traditional cultural place
THPO	Tribal Historic Preservation Officer
U.S.	United States
USGS	United States Geological Survey
WAPA	Western Area Power Administration
WY	water year

TA 11. Cultural Resources

TA 11.1 Affected Environment

Cultural resources are the physical evidence of past or present cultures, including archaeological sites, historic-era buildings and structures, objects, trails, landforms, and other places of traditional, cultural, or religious importance. Cultural resources can be human-made or natural features and are, for the most part, unique, finite, and nonrenewable.

Of the many laws, regulations, executive orders, and policies concerning cultural resources, the most pertinent to this project is Section 106 of the National Historic Preservation Act (NHPA; 54 United States [U.S.] Code 306108), as amended, and its implementing regulations (36 Code of Federal Regulations [CFR] 800). The NHPA and its implementing regulations require federal agencies to take into account the effects of their undertakings (federal undertakings or federally permitted or funded undertakings) on historic properties. Historic properties are defined as any district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places (NRHP); these include properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization that meet the NRHP criteria (36 CFR 800.16(l)(1)). As such, they are a subset of cultural resources.

Management and ownership of the land through which the Colorado River runs is multifaceted. Bureau of Reclamation (Reclamation) manages river water operations. In southern Utah, northern Arizona, and southeastern Nevada, the river runs through Grand Canyon National Park (GCNP), the Lake Mead National Recreation Area (NRA), and the Glen Canyon NRA, which are managed by the National Park Service (NPS). In western Arizona and eastern California south of Nevada, the river runs through Bureau of Land Management (BLM), Reclamation, U.S. Fish and Wildlife Service (FWS), state, tribal, municipal, and private lands.

Reclamation is consulting with the Arizona, California, Nevada, and Utah State Historic Preservation Officers (SHPOs), land managing agencies, affected tribes, and other consulting parties to develop a project-specific programmatic agreement under Section 106 of the NHPA and its implementing regulations (36 CFR 800.14). As part of the development of the programmatic agreement, Reclamation, the SHPOs, the land managing agencies, the affected tribes, and other consulting parties have defined the area of potential effect (APE). For this analysis, the NEPA study area coincides with the APE, which also mirrors the Class I search area.

The study area for the analysis runs from the northern extent of Lake Powell to the Southerly International Boundary (SIB), and consists of the Colorado River channel from bank to bank except from Glen Canyon Dam to Lake Mead, where it stretches from canyon rim to canyon rim, as well as a 0.5-mile buffer on either side of the riverbank or canyon rim. The study area coincides with the search area used for the Class I records search conducted for this analysis (Tremblay et al. 2024a,

2024b; Eddy et al. 2024; Winslow et al. 2024; Eskenazi 2024). The study area covers a total of 2,735,066 acres in Arizona, California, Nevada, and Utah.

TA 11.1.1 Identification Efforts

A Class I cultural resources record search was conducted for the study area in Arizona, California, Nevada, and Utah (Tremblay et al. 2024a, 2024b; Eddy et al. 2024; Winslow et al. 2024; Eskenazi 2024). Data were collected on archaeological sites, built environment resources, historic-era trails, special designations (National Historic Landmarks [NHLs]), congressionally designated areas (National Heritage Areas [NHAs] and National Historic Trails [NHTs]), traditional cultural places (TCPs), and resources of traditional cultural and religious importance to Native American peoples. Data were provided by the NPS (GCNP, Glen Canyon NRA, Lake Mead NRA, and NPS-managed portions of Grand Canyon-Parashant National Monument [NM]), National and State Registers of Historic Places, NHL and state landmark records, SHPO records, and the NPS Heritage Documentation Programs of the Historic American Building Survey, the Historic American Engineering Record, and the Historic American Landscapes Survey archives. Additionally, historical maps and aerials were checked for all states.

In Arizona, data were obtained from state databases and sources, such as AZSITE, Arizona State Museum Archaeological Records Office, and Arizona Department of Transportation; the Forest Service (Kaibab National Forest); and records searches conducted at BLM field offices or data provided by the BLM (Arizona Strip District Office, including BLM-managed portions of Grand Canyon-Parashant NM, Kingman Field Office, Lake Havasu Field Office, and Yuma Field Office).

In California, data were obtained from the California Historical Resources Information System at three different Information Centers (South Coastal Information Center, South Central Coastal Information Center, and Eastern Information Center). Cultural resource data were also obtained from the California Points of Historical Interest list, the California Historical Landmarks list, the Archaeological Determinations of Eligibility list, and the California State Historic Resources Inventory list.

In Nevada, cultural resources were identified through the Nevada Cultural Resources Inventory System (NVCRIS), Southern Nevada Archaeological Archive, and BLM records. In Utah, Utah Division of State History's (now known as the Utah Historical Society) Sego database and Historic Utah Building database were searched.

Information on TCPs and resources of traditional and religious concern to Native American peoples were gathered through ethnographic research and data provided by Reclamation and NPS. Historic General Land Office and topographic maps were also checked for potential cultural resources. Data on sites on tribal lands was not collected for this effort. Data about ancestral sites located on tribal lands is sensitive and confidential. Reclamation concluded that data collected from state and federal sources would be sufficient to characterize the overall numbers and types of resources that may be affected.

The Class I records search shows that much of the study area has not been surveyed for cultural resources. This is particularly true in the vicinity of Lake Mead and less for Lake Powell, as neither

of these reservoirs were fully surveyed before inundation began behind Hoover Dam in 1934 and behind Glen Canyon Dam in 1963. Because survey coverage for both Lake Powell and Lake Mead is very low, there is high potential for additional yet-to-be identified (that is, undiscovered) sites to exist in the study area. The following discussion concerns only previously recorded archaeological sites and built environment resources, as well as built environment resources found on aerial photographs. Additional resources may be, and are likely to be, present in the areas not covered by previous surveys.

Data were compiled in August 2023, and the 2023 datasets were incorporated into the analysis. Additionally, the NPS provided updated archaeological site counts for Lake Powell and Lake Mead (including Grand Canyon-Parashant NM) in March 2026, which supplemented the August 2023 dataset for the reservoirs. Therefore, the site counts used in the analysis do not reflect later agency database updates in the study area outside the reservoirs.

TA 11.1.2 Section 106 of the National Historic Preservation Act and Tribal Consultation

Per Section 106 of the NHPA and its implementing regulations (36 CFR 800), Reclamation is consulting with the Arizona, California, Nevada, and Utah SHPOs; Tribal Historic Preservation Officers (THPOs); affected tribes without THPOs; and consulting parties regarding the effects of the undertaking on historic properties. Reclamation is developing a project-specific programmatic agreement, in consultation with the SHPOs, THPOs, tribes without THPOs, cooperating agencies, and other consulting parties per 36 CFR 800.14 to outline a process to resolve any adverse effect on historic properties from Reclamation's operation of the Glen Canyon and Hoover dams under the new operating guidelines for annual releases.

TA 11.1.3 Cultural Background

The Colorado River and its surrounding landscape holds significance for many peoples today and has for thousands of years. Indigenous peoples have a strong connection to the river, which plays an important role in their histories and lives. Indigenous peoples' relationship and kinship with the Colorado River is complex and is discussed further in the Tribal Resources (see **TA 13**, Tribal Resources). The following presentation of cultural resources data is from a Western viewpoint and Reclamation acknowledges that this is a partial picture and stems from the viewpoint of Western archaeologists and federal regulations largely promulgated by non-Indigenous peoples. For many Indigenous peoples, archaeological sites are sacred places inhabited in the past and today by ancestors.

Western archaeologists view the human history of the Colorado River and its surrounding landscape in terms of three general temporal components: precontact (including the Paleoindian, Archaic, and Formative cultural periods), ethnohistoric, and postcontact (historic-era). Indigenous concepts of time are also different from Western ideas. For example, the Zuni provided text describing the Zuni concept of time, beginning with their emergence in the Grand Canyon (see **TA 13**, Tribal Resources).

TA 11.1.4 Class I Results

Arizona

Overall, 870 cultural resource investigations (projects) have been conducted in the study area for an overall survey coverage of approximately 4 percent (Tremblay et al. 2024b). This number includes both the non-NPS and NPS datasets and accounts for duplicate records between the datasets. The Class I records search of non-NPS data sources showed that 363 projects have been conducted in the study area in Arizona; however, these projects only cover approximately 2 percent of the study area, and the majority of those projects are over 10 years old. Projects include block and linear surveys, data recovery, and monitoring projects associated with gas pipelines, fiber-optic lines, transmission lines, road and highway construction, mining operations, and numerous development projects, and land transfers. The Class I records search of NPS data sources demonstrated that 521 projects had been conducted resulting in coverage of approximately 3 percent of the study area. Like projects outside the parks, the projects consist of block and linear intensive archaeological surveys, monitoring, and data recovery treatments associated with recreational development, vegetation management, post-fire assessments, land and timber transfers, graffiti removal, and a number of “documentation as preservation” surveys.

California

Within the study area in California, 216 archaeological projects have been conducted (Eddy et al. 2024). Previously conducted projects include survey, data recovery, monitoring, literature reviews, and planning documents. Of the 216 previously conducted archaeological investigations, 161 were surface surveys, covering approximately 11 percent of the study area in California. Projects were conducted in support of a variety of projects including but not limited to transmission lines, water infrastructure, fiber optics installation, pipelines, residential and commercial development, highway projects, prescribed burns and fuel breaks, and agricultural projects.

Nevada

Within the Nevada study area, 605 archaeological projects have been conducted; 408 of the surveys are from the NPS dataset (Winslow et al. 2024). Most of these projects were surveys in support of improvements at Lake Mead NRA, other recreational projects, utility installation, and road improvements. Previous survey covers approximately 5 percent of the study area in Nevada.

Utah

In total, 135 previous survey projects have been conducted within the Utah study area covering 37 percent of the Utah study area (Eskenazi 2024). These surveys were conducted in support of research and improvements to facilities in the Glen Canyon NRA, road improvements, transmission lines, land exchanges, and movie sets.

Archaeological Sites

As discussed above, survey coverage of the study area is variable by state but is overall very low, ranging from 2 or 3 percent in Arizona, 5 percent in Nevada, 11 percent in California, and 37 percent in Utah. Because of the low coverage, the numbers of archaeological sites presented below do not reflect the total number of sites in the study area and are likely only a small fraction of the sites that are present. However, the sites that have been recorded give an overall picture of resources

that may be found in the study area and are used in the analysis as a representative dataset for what may be present in unsurveyed areas.

Arizona

A total of 4,246 archaeological sites were identified in the study area in Arizona based on the 2023 Class I records search (Tremblay et al. 2024b). This number includes both non-NPS and NPS data accounting for duplicates between the two datasets. **Table TA 11-1** summarizes the NRHP status and temporal components of all archaeological sites within the study area in Arizona.

Table TA 11-1
Summary Counts of Previously Recorded Sites in the Study Area in Arizona

		Overall Study Area
Count (Sites)		4,246
NRHP	NRHP Listed	13
	Determined Eligible	3,059
	Recommended Eligible	41
	Determined Ineligible	144
	Recommended Ineligible	92
	Unevaluated	897
Temporal Component	Precontact	3,231
	Ethnohistoric	50
	Postcontact	458
	Multicomponent	282
	Unknown	225

Source: Tremblay et al. 2024b

Note: The information presented in this table incorporates NPS and non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Non-NPS Dataset

The 2023 record search of non-NPS data identified 1,246 archaeological sites in the study area (Tremblay et al. 2024b). Seventeen sites in the study area are listed in the NRHP; 12 of the 17 listed sites are within the Ripley Intaglio Complex Historic District. Of the 1,246 sites, 345 are determined and recommended eligible for the NRHP and 126 are determined or recommended not eligible. The remaining 758 sites are unevaluated for the NRHP or of unknown NRHP status.

Of the 1,246 sites, 985 are precontact sites, 107 are postcontact (historic-era) sites, two are ethnohistoric sites, and 56 are multicomponent sites (i.e., used during more than one temporal period). The temporal affiliations of the remaining 96 sites are unknown. Precontact sites or site components could be attributed to the Paleoindian and Archaic period cultures, as well as the Basketmaker and Ancestral Puebloan cultures. Ethnohistoric sites or site components are affiliated with Mohave, Southern Paiute, Hopi, Diné (Navajo), and indeterminate Indigenous peoples. Postcontact (historic-era) component sites are overwhelmingly associated with Euro-American

culture; however, a few historic-era sites are attributed to Havasupai, Mohave, Diné (Navajo), Pai, Southern Paiute, Ute, and indeterminate Indigenous peoples.

Table TA 11-2 presents a summary of site function for sites in the non-NPS dataset. For precontact sites and site components, limited activity artifact scatters were the most abundant, but both long- and short-term habitation sites, resource procurement and processing sites, lithic reduction sites, and petroglyph/pictograph sites were well-represented. Although in smaller numbers, agricultural and water management sites, storage sites or caches, ceremonial or special-use sites, and trails were also present. Site functions for ethnohistoric sites or site components are similar to those from precontact component sites and include limited activity sites, an agricultural site, temporary camps, long-term habitations, resource processing sites, special-use sites, and a trail. The most common function of historic sites and site components is waste management (refuse piles). Other functions include mining, ranching, agriculture, permanent habitations, temporary camps, public utilities, and water management, as well as numerous transportation features, including roads, trails, and ferry crossings.

Table TA 11-2
Summary of Site Functions within the Study Area in Arizona (Non-NPS Data Only) by Temporal Component

Site Function	Count	Temporal Component		
		Precontact	Ethnohistoric	Postcontact
Limited Activity (Artifact Scatters)	236	233	3	0
Habitation	206	186	2	18
Temporary Habitations/Camps	155	133	2	20
Resource Procurement/Processing	167	163	2	2
Agriculture	52	47	1	4
Lithic Reduction	113	113	0	0
Storage/Cache	36	35	0	1
Ceremonial/Religious/Special Use	28	25	0	3
Petroglyphs/Pictographs	161	150	2	9
Water Management	15	12	0	3
Waste Management (Refuse Piles)	24	0	0	24
Transportation (Roads/Trails/Ferries/etc.)	16	1	0	15
Utility	2	0	0	2
Livestock/Ranching	11	0	0	11
Mining	18	0	0	18
Industrial	2	0	0	2
Government	5	0	0	5

Site Function	Count	Temporal Component		
		Precontact	Ethnohistoric	Postcontact
Military	2	0	0	2
Commerce	4	0	0	4
Unknown	22	16	0	6

Source: Tremblay et al. 2024b

Notes:

- Some sites have multiple functions identified for individual components, such that total site function counts in this table will exceed the total number of individual sites/components within each temporal category.
- The table does not include sites/components where temporal affiliations were not available. The information presented in this table incorporates non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current databases.

NPS Dataset

As stated above, data provided by the NPS will be presented separately where applicable. This means that some sites are found in both the non-NPS and NPS databases. Counts of NPS sites presented below are based on the complete NPS dataset consisting of data acquired in August 2023 and updated in March 2026. Duplicate sites are accounted for above in **Table TA 11-1**.

A total of 4,135 previously recorded archaeological sites are found in the NPS dataset for the study area based on the March 2026 update. Sixteen sites are listed in the NRHP, another 3,315 sites have been determined or recommended eligible, 80 sites have been determined or recommended not eligible, and 678 are unevaluated. There are 46 sites in the Glen Canyon NRA dataset where no NRHP eligibility was given. See **Table TA 11-3** for eligibility by park unit.

Table TA 11-3
Summary Counts of Previously Recorded Sites for NPS Data by Park Unit in Arizona

	Park Unit			Total
	GCNP	Lake Mead NRA	Glen Canyon NRA	
Total Count (Sites)	3,175	790	170	4,135
NRHP	NRHP Listed	3	12	16
	Determined Eligible	3,097	14	3,120
	Recommended Eligible	7	31	195
	Determined Ineligible	20	7	33
	Recommended Ineligible	6	11	47
	Unevaluated	42	49	678
	Unknown/No Status	0	46	46

Source: NPS (including GCNP, Glen Canyon NRA, and Lake Mead NRA staff)

Notes: The information presented in this table incorporates NPS data acquired in March 2026 from current park databases; therefore, the number of sites and/or their corresponding information do not reflect information presented in other tables that rely on the August 2023 Class I records search. Total site counts for Lake Mead NRA also include sites from the NPS-managed portions of Grand Canyon-Parashant NM in Arizona.

Precontact sites or site components from the NPS dataset are attributed to time periods that archaeologists identify as Paleoindian and Archaic period, Basketmaker, Ancestral Puebloan, Cohonina, Patayan, and Cerbat cultures and peoples (**Table TA 11-4**). Ancestral Puebloan sites are most common, and indeterminate Indigenous peoples are second-most common. Ethnohistoric sites or site components are attributed to the Havasupai, Hopi, Diné (Navajo), Pai, and Southern Paiute peoples. For postcontact (historic-era) sites or site components, sites attributed to Euro-American sites are most common; however, several sites are attributed to Havasupai, Hopi, Diné (Navajo), Pai, Southern Paiute peoples, or unspecified Indigenous native cultures.

Table TA 11-4
Summary of Cultural Affiliations in NPS Dataset by Park Unit in Arizona

	Park Unit			Total
	GCNP	Lake Mead NRA	Glen Canyon NRA	
Cultural Affiliation – Precontact				
Paleoindian	2	1	1	4
Archaic	12	0	1	13
Basketmaker	17	0	1	18
Ancestral Puebloan	1,346	8	33	1,387
Patayan	2	13	0	15
Cohonina	302	0	0	302
Cerbat	35	0	0	35
Indigenous Native Culture	759	71	38	868
Unknown	0	2	0	2
Cultural Affiliation – Ethnohistoric				
Pai	29	0	0	29
Southern Paiute	64	0	0	64
Hopi	20	0	0	20
Diné (Navajo)	7	0	0	7
Havasupai	4	0	0	4
Indigenous Native Culture	10	0	0	10
Cultural Affiliation – Postcontact				
Euro-American	401	28	12	441
Diné (Navajo)	24	0	3	27
Havasupai	16	0	0	16
Southern Paiute	8	1	1	10
Pai	2	0	0	2
Hopi	6	0	0	6
Indigenous Native Culture	38	3	0	41
Unknown	7	0	0	7

Source: Tremblay et al. 2024b

Note: The information presented in this table incorporates NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current park unit databases.

Precontact site functions include agricultural, ceremonial/religious/special use, habitation, temporary habitation/camp, limited activity, lithic reduction, resource procurement/processing, petroglyphs/pictographs, storage/cache, transportation (trails), and water management sites (**Table TA 11-5**). Among these, longer-term habitations, resource processing sites, and temporary habitations were the most common. Ethnohistoric site and site component functions are similar to those of precontact sites and include agriculture, habitation, temporary habitation/camp, ceremonial/religious/special use, limited activity, lithic reduction, resources procurement/processing, storage/cache, and petroglyphs/pictographs. Historic site or site component functions consist of temporary habitations/camps, mining, ranching, agriculture, utilities, and water management, as well as numerous sites associated with transportation, such as ferry crossings.

Table TA 11-5
Summary of Site Functions for NPS Dataset by Park Unit in Arizona

	Park Unit			Total
	GCNP	Lake Mead NRA	Glen Canyon NRA	
Site Function – Precontact				
Limited Activity (Artifact Scatters)	231	14	24	269
Habitation	709	23	3	735
Temporary Habitations/Camps	465	21	6	492
Resource Procurement/Processing	535	9	4	548
Agriculture	123	0	0	123
Lithic Reduction	108	16	13	137
Storage/Cache	128	0	1	129
Ceremonial/Religious/Special Use	82	1	1	84
Petroglyphs/Pictographs	98	6	21	125
Water Management	4	1	0	5
Unknown	56	1	7	64
Site Function – Ethnohistoric				
Limited Activity (Artifact Scatters)	4	0	0	4
Habitation	9	0	0	9
Temporary Habitations/Camps	35	0	0	35
Resource Procurement/Processing	48	0	0	48
Agriculture	3	0	0	3
Lithic Reduction	1	0	0	1
Storage/Cache	4	0	0	4
Ceremonial/Religious/Special Use	5	0	0	5
Petroglyphs/Pictographs	17	0	0	17
Water Management	1	0	0	1
Site Function – Postcontact				
Limited Activity (Artifact Scatters)	85	2	0	87
Habitation	48	4	2	54

	Park Unit			Total
	GCNP	Lake Mead NRA	Glen Canyon NRA	
Temporary Habitations/Camps	122	2	1	125
Resource Procurement/Processing	33	0	1	34
Agriculture	5	2	0	7
Lithic Reduction	1	0	0	1
Storage/Cache	7	0	0	7
Ceremonial/Religious/Special Use	38	0	2	40
Petroglyphs/Pictographs	12	3	8	23
Water Management	4	0	1	5
Waste Management (Refuse Piles)	18	3	1	22
Transportation (Roads/Trails/Ferries/etc.)	27	5	2	34
Utility	2	2	0	4
Livestock/Ranching	32	1	0	33
Mining	39	4	1	44
Government	0	2	0	2
Unknown	23	3	2	28

Source: Tremblay et al. 2024b

Note: The information presented in this table incorporates NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current park unit databases.

California

A total of 551 previously recorded archaeological resources were identified within the study area in California as a result of the Class I records search. Of the 551 previously recorded archaeological resources, 493 are classified as archaeological sites, and 58 are classified as isolated occurrences. For the previously recorded archaeological resources (both sites and isolated occurrences), 4 are listed in the NRHP, 22 are recommended or determined eligible for the NRHP, 13 are recommended or determined ineligible or non-significant, and 512 are unevaluated or of unknown NRHP status. Of the 493 archaeological sites, 372 are precontact sites, 78 are postcontact (historic-era) sites, 31 are multicomponent sites with both precontact and postcontact (historic-era) resources, one is a multicomponent site with both precontact and ethnohistoric resources, and 11 sites are unknown.

Site or site component functions within the study area are shown in **Table TA 11-6**. The most common function is lithic reduction followed by transportation (trail). Other common functions include habitation; waste management; ceremonial, religious, and special use; and camps. Some sites or site components are of indeterminate function and are listed in **Table TA 11-6** according to their site type (i.e., potter scatter or rock feature).

Table TA 11-6
Summary of Site or Site Component Functions within the Study Area in California

Function	Numbers of Sites or Site Components
Limited Activity	4
Habitation	71
Camp	26
Resource Procurement/Processing	9
Road	3
Lithic Reduction	264
Storage/Cache	1
Ceremonial, Religious, and Special Use	43
Rock Art	0
Waste Management	48
Water Management	5
Transportation	0
Utility	2
Livestock/Ranching	0
Industrial-Mining	3
Industrial-Other	0
Government	1
Rock Feature	16
Pottery Scatter	38
Trail	98
Quarry	5
Other	9

Source: Eddy et al. 2024

Note: The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Nevada

In the Nevada study area, 664 archaeological sites were identified in the non-NPS and NPS datasets (99 non-NPS [NVCRIS only] and 565 NPS) based on the Class I records search. Four sites are listed in the NRHP (including the B-29 Heavy Bomber Superfortress and the Pueblo Grande de Nevada: Main Ridge Locality); all are in the Lake Mead NRA. Additionally, a total of 29 sites are eligible or contributing for the NRHP (13 non-NPS and 16 NPS), including the St. Thomas historic townsite (ca. 1865). Fifty-five are ineligible (18 non-NPS and 37 NPS), and the remaining 576 resources are either unevaluated or unknown (68 non-NPS and 508 NPS). See **Table TA 11-7** and **Table TA 11-8** for non-NPS and NPS site eligibility, respectively.

Table TA 11-7
Summary Counts of Previously Recorded Sites for Non-NPS Data in Nevada

		Total
Total Count (Sites)		99
NRHP	NRHP Listed	0
	Eligible	13
	Ineligible	18
	Unevaluated/Unknown	68

Source: Winslow et al. 2024

Note: The information presented in this table incorporates non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Table TA 11-8
Summary Counts of Previously Recorded Sites for NPS Data in Nevada

		Total
Total Count (Sites)		565
NRHP	NRHP Listed	4
	Determined Eligible	4
	Recommended Eligible	12
	Determined Ineligible	5
	Recommended Ineligible	32
	Unevaluated	508

Source: NPS (Lake Mead NRA staff)

Notes: The information presented in this table incorporates NPS data acquired in March 2026 from current park databases; therefore, the number of sites and/or their corresponding information do not reflect information presented in other tables that rely on the August 2023 Class I records search. Total site counts presented here include both Lake Mead NRA and NPS-managed portions of Grand Canyon-Parashant NM in Nevada.

Precontact sites include habitation sites, rock shelters, campsites, artifact scatters, tool stone procurement localities, and rock features. Euro-American sites include roads, utility lines, house foundations, mines, recreation facilities, and sites associated with the construction and operation of Hoover and Davis Dams (**Table TA 11-9**).

Table TA 11-9
Summary of Site or Site Component Functions within the Study Area in Nevada

Function	Numbers of Sites or Site Components (NPS Data)	Numbers of Sites or Site Components (non-NPS Data)	Total
Habitation	40	47	87
Lithic Reduction	12	50	62
Lithic Procurement and Testing	1	20	21
Military	1	0	1
Mining	8	3	11
Ranching	0	1	1
Recreation	2	2	4
Resource Processing	0	4	4
Temporary Habitation	0	15	15
Town	1	0	1
Transportation	2	7	9
Unknown/Other	199	51	250
Utility	2	3	5
Waste Management	0	5	5
Water Management	6	31	37

Data source: Winslow et al. 2024

Note: The information presented in this table incorporates NPS and non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Utah

The Class I records search identified 1,384 sites (366 non-NPS and 1,018 NPS) within the Utah study area. Of the 1,384 sites, 2 are listed in the NRHP (non-NPS), 194 are eligible for the NRHP (56 non-NPS and 138 NPS), 143 are not eligible (20 non-NPS and 123 NPS), and 1,045 are unevaluated, undetermined, or have an unknown NRHP eligibility status (288 non-NPS and 757 NPS). See **Table TA 11-10** and **Table TA 11-11** for non-NPS and NPS site eligibility, respectively.

Table TA 11-10
Summary Counts of Previously Recorded Sites for Non-NPS Data in Utah

		Total
Total Count (Sites)		366
NRHP	NRHP Listed	2
	Eligible	56
	Ineligible	20
	Unevaluated/Unknown	288

Source: Eskenazi 2024

Note: The information presented in this table incorporates non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Table TA 11-11
Summary Counts of Previously Recorded Sites for NPS Data in Utah

		Total
Total Count (Sites)		1,018
NRHP	NRHP Listed	0
	Determined Eligible	52
	Recommended Eligible	86
	Determined Ineligible	64
	Recommended Ineligible	59
	Unevaluated	512
	Unknown/No Status	245

Data source: Glen Canyon NRA staff

Note: The information presented in this table incorporates NPS data acquired in March 2026 from current park databases; therefore, the number of sites and/or their corresponding information do not reflect information presented in other tables that rely on the August 2023 Class I records search.

Precontact sites and site components functioned as task-specific sites, domestic sites, unknown or other sites, transportation and communication sites, and special-use sites (**Table TA 11-12**). The postcontact (historic-era) sites and site components are associated with agriculture and subsistence, domestic use, industry, special-use sites, task-specific sites, transportation and communication, and unknown or other.

Table TA 11-12
Summary of Site or Site Component Functions within the Utah Study Area in Utah

Function	Numbers of Sites or Site Components (NPS Data)	Numbers of Sites or Site Components (non-NPS Data)	Total
Agriculture	0	8	8
Ceremonial, Religious, and Special Use	5	4	9
Communication	0	1	1
Defensive	1	0	1
Habitation	148	3	227
Limited Activity	38	96	134
Lithic Reduction	31	101	132
Mining	2	3	5
Ranching	8	2	10
Recreation	0	2	2
Resource Procurement/Processing	20	34	54
Rock Art	41	49	60
Storage	13	22	35

Function	Numbers of Sites or Site Components (NPS Data)	Numbers of Sites or Site Components (non-NPS Data)	Total
Temporary Habitation	62	127	189
Transportation	10	9	19
Unknown	8	47	55

Source: Eskenazi 2024

Note: The information presented in this table incorporates NPS and non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Built Environment Resources

Built environment resources are those human-made and/or intentionally modified components of our world that are shaped by the way we live, work, and play. For the purposes of this analysis, this includes buildings, structures, sites, objects, and districts that are historic in age (at least 50 years old since first constructed) and retain their basic structural elements, configurations, alignments, or patterns of organization (i.e., that are not in ruins and thus categorized as archaeological resources).

It is important to note that the state-specific lists of built environment resources discussed in this section do not include every individual resource or property type of historic age and, collectively, are not intended to represent a comprehensive inventory within the overall study area. Each state has different requirements when it comes to documenting built environment resources, as some state agencies manage such records in continuously maintained databases, while others do not. Arizona does not have a process to track built environment surveys conducted within the state, and at present, such resources are not assigned to any type of unique identifier like archaeological sites. California allocates project numbers to cultural resource investigations and assigns primary numbers to all cultural resources documented during those inventories, but the state's database system (California Historical Resources Information System) does not distinguish between archaeological and built environment (architectural) surveys and/or resources. Nevada maintains its own statewide inventory database where both archaeological and built environment inventories are registered by NVCRIS number and resources documented under the latter are currently assigned state-specific built environment numbers. Lastly, Utah manages information pertaining to previously recorded built environment resources (The HUB) where individual property record numbers are assigned.

Because Arizona, California, Nevada, and Utah each approach the management of built environment resource data in various ways, the types of information presented in this section are specific to each of the four states in the study area. For Arizona, built environment resources have not been documented consistently in the past, and currently, there is no systematic tracking or database managed for these resources. For this reason, the only sources of data that were readily available for historic-era built environment resources in Arizona were the NRHP and Arizona Register of Historic Places; lists encompassing designated NHLs, NHAs, and NHTs; NPS Heritage Documentation Programs (Historic American Building Survey, Historic American Engineering Record, and Historic American Landscapes Survey) databases; and historical aerial imagery. Because of this, only the most important built environment resources (as demonstrated by research) associated with the historic setting of the study area are included for analysis.

The datasets acquired from federal and state agencies were also examined to identify any additional properties that qualified as built environment resources, which were then culled from the archaeological site data; none of the datasets provided included information pertaining to NRHP-ineligible and/or unevaluated built environment resources. For California, all documented cultural resources are assigned a state-specific primary number and built environment resources documented in the study area were identified by their primary numbers from the comprehensive datasets obtained from the California Historical Resources Information System and other registers and lists. Conversely, because Nevada and Utah have (at least to some degree) state-maintained databases for built environment resources, those that are eligible, ineligible, and unevaluated for the NRHP are considered for analysis; however, this is limited to only those resources that have officially been assigned state resource numbers.

Additional details pertaining to identification efforts performed for resources in Arizona, California, Nevada, and Utah are presented in the data-gathering methods summaries in each state-specific volume (Tremblay et al. 2024b; Eddy et al. 2024; Winslow et al. 2024; Eskenazi 2024).

Finally, there is a substantial degree of overlap between designations, particularly involving NHLs and NRHP-listed historic properties, because NHLs are also listed in the NRHP when designated, if they have not been already. For this reason, where historic properties were listed in the NRHP before they were later designated as NHLs (in some cases, many years later), they are included for analysis as NRHP-listed built environment resources and NHLs. NHLs in the study area are discussed in a separate section below (see NHLs, NHAs, and NHTs).

Arizona

In all, a total of 49 previously evaluated built environment resources were identified as part of the Class I records search in the Arizona portion of the study area (Tremblay et al. 2024b). Of these, 43 are NRHP-listed (non-NHL) historic properties (8 districts, 26 buildings, 6 structures, 1 object, and 2 sites) and 6 are NRHP-eligible historic properties (all districts). **Table TA 11-13** provides a summary of NRHP-listed and NRHP-eligible built environment resources identified in the Arizona study area.

Table TA 11-13
NRHP-Listed and NRHP-Eligible Historic Properties in the Study Area in Arizona

DISTRICTS					
Name ^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/Ownership ^b	Administering Agency
Lee's Ferry and Lonely Dell Ranch	Listed	1976, 1978 1997 (combined)	A, C	NPS	Glen Canyon NRA
*North Rim Entrance Road Corridor	Eligible	2011	A, C	NPS	GCNP
*Grand Canyon Inn and Campground	Listed	1982	A, C	NPS	GCNP

DISTRICTS

Name^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/ Ownership^b	Administering Agency
*Grand Canyon North Rim Headquarters	Listed	1982	A, C	NPS	GCNP
*El Tovar Stables	Listed	1974	A	NPS	GCNP
*Grand Canyon National Park Trail System	Eligible	N/A	A	NPS	GCNP
*Transcanyon Water Distribution Pipeline (including Silver Bridge)	Eligible	2016	A, C	NPS	GCNP
*Cross Canyon Corridor	Eligible	2015	A, C	NPS	GCNP
*Grand Canyon Railway	Listed	2000	A	NPS, U.S. Forest Service, Private	GCNP, Kaibab National Forest (federal lands only)
*Horace M. Albright Training Center	Listed	2013	A, C	NPS	GCNP
Temple Bar Developed Area	Eligible	2020	A	NPS	Lake Mead NRA
Katherine's Landing Developed Area	Eligible	2021	A	NPS	Lake Mead NRA
Parker Dam	Eligible	N/A	A, C	Reclamation	Lower Colorado River Office (LCRO)
Brinley Avenue	Listed	1982	A, C	Municipal, Private	City of Yuma (city lands only)
Yuma Main Street	Listed	1994	A	Municipal, Private	City of Yuma (city lands only)

BUILDINGS

Name^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/ Ownership^b	Administering Agency
*Buckey O'Neill Cabin	Listed	1975	A	NPS	GCNP
*Ranger's Dormitory	Listed	1975	A, C	NPS	GCNP
*Superintendent's Residence (First Administration Building)	Listed	1974	A	NPS	GCNP
San Carlos Hotel	Listed	1984	C	Private	N/A
Yuma County Courthouse	Listed	1982	A, C	County	Yuma County

BUILDINGS

Name^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/ Ownership^b	Administering Agency
Yuma Main Post Office	Listed	1985	A, C	Private	N/A
Cactus Press-Plaza Paint Building	Listed	1987	C	Private	N/A
Pauley Apartments	Listed	1982	C	Private	N/A
Methodist Parsonage	Listed	1982	A	Private	N/A
Methodist Episcopal Church	Listed	1982	A, C	Private	N/A
Masonic Temple	Listed	1984	C	Private	N/A
Hotel del Ming	Listed	1982	A, C	Private	N/A
Lee Hotel	Listed	1984	C	Private	N/A
Old Yuma City Hall	Listed	1982	A, C	Municipal	City of Yuma
Dressing Apartments	Listed	1982	C	Private	N/A
Power Apartments	Listed	1982	C	Private	N/A
Named private residences (n=10)	Listed	1982	B and/or C	Private	N/A

STRUCTURES

Name^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/ Ownership^b	Administering Agency
*Navajo Steel Arch Highway Bridge (Navajo Bridge)	Listed	1981	A, C	ADOT	ADOT
*Trans-Canyon Telephone Line	Listed	1986	A, C	NPS	GCNP
Old Trails Bridge (Topock Bridge)	Listed	1988	A, C	FWS, Private	FWS Southwest Region, EPNG
Historic U.S. Route 66 in Arizona	Listed	1989	A, C	FWS, State, County	FWS Southwest Region, ADOT, Mohave County
Ocean-to-Ocean Highway Bridge	Listed	1979	A, C	County	Yuma County
Southern Pacific Passenger Coach Car	Listed	2000	A, C	State	ASPT

SITES

Name ^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/Ownership ^b	Administering Agency
*Grand Canyon Pioneer Cemetery	Listed	1975	A, C	NPS	GCNP
Hardyville Pioneer Cemetery	Listed	2001	A	Municipal	City of Bullhead City

OBJECTS

Name ^a	NRHP Status	Year	Eligibility Criteria	Jurisdiction/Ownership ^b	Administering Agency
Blaisdell Slow Sand Filter Washing Machine	Listed	1979	A	Municipal	City of Yuma

Source: Tremblay et al. 2024b

Notes:

- Resources are listed in order from north to south by type (district, building, structure, site, object).
- The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.
- The Grand Canyon Inn and Campground and the Grand Canyon North Rim Headquarters historic districts are on the North Rim within GCNP, which recently suffered extensive damage from the 2025 Dragon Bravo Fire; therefore, the NRHP status for district components may have changed as a result of wildfire impacts. The Buckey O'Neill Cabin, Ranger's Dormitory, and Superintendent's Residence (First Administration Building) also contribute to the Grand Canyon Village NHL. The Grand Canyon Pioneer Cemetery is listed as part of the Grand Canyon Village Historic District but is not part of the Grand Canyon Village NHL. Parker Dam has not been evaluated as a district in Arizona but was subject to a preliminary assessment in California in 1997, concluding the dam and its components likely qualified as an NRHP-eligible historic district; a formal NRHP nomination is currently in progress for listing.

^a Properties marked with an asterisk (*) are resources in the study area (or portions thereof in terms of linear resources like trails) that are spatially separated from the river corridor because of substantial vertical distance and/or intervening canyon terrain (by several thousand feet in elevation in some instances).

^b Jurisdiction and ownership are given only for the study area, as follows: ADOT = Arizona Department of Transportation; EPNG = El Paso Natural Gas Company; ASPT = Arizona State Parks and Trails; and FWS.

Additionally, 16 unevaluated but notable built environment resources (five districts, one building, nine structures, one site) were also identified as important resources that may be eligible for the NRHP based on extensive research. **Table TA 11-14** summarizes these resources identified in the Arizona portion of the study area.

Table TA 11-14
Unevaluated But Notable Built Environment Resources in the Study Area in Arizona
Listed from North to South

Name ^a	Property Type	Location/Vicinity ^b
Glen Canyon Dam	District	Glen Canyon NRA
*Glen Canyon Dam Bridge	Structure	Glen Canyon NRA
*Greenland Lake Salt Cabin	Building	GCNP

Name ^a	Property Type	Location/Vicinity ^b
Black Suspension Bridge (Kaibab Suspension Bridge)	Structure	GCNP
Davis Dam	District	Laguna
London Bridge	Structure	Lake Havasu City
Ehrenberg Pioneer Cemetery	Site	Ehrenberg
Palo Verde Diversion Dam	Structure	Yuma
Yuma Levee System (Yuma Project)	District	Yuma
Fisher's Landing	District	Yuma
Imperial Dam	Structure	Yuma
Gila Project	District	Yuma
Laguna Dam	Structure	Yuma
Southern Pacific Railroad ^c	Structure	Yuma
Southern Pacific Railroad Bridge (Colorado River) ^c	Structure	Yuma
Morelos Dam	Structure	Northerly International Boundary

Source: Tremblay et al. 2024b

Note: The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

^a Properties marked with an asterisk (*) are resources in the study area (or portions thereof in terms of linear resources) that are spatially separated from the river corridor because of substantial vertical distance and/or intervening canyon terrain (by several thousand feet in elevation in some instances).

^b Location and vicinity do not imply jurisdiction, ownership, or administrative responsibilities.

^c The Southern Pacific Railroad has been recorded in other locations in Arizona, but the route as aligned through Yuma has not yet been documented and/or evaluated for the NRHP, nor has the Southern Pacific Railroad Bridge across the river.

California

A total of nine built environment investigations have been conducted within the California portion of the study area based on the Class I records search, which involved inventory and evaluation for components of the All-American Canal, the Imperial Dam, the Imperial Irrigation District, land ports of entry, and masonry arch bridges. In all, 63 historic-era built environment properties were identified from archival records searches, including three districts (Picacho Squatters Settlement District, Topock Compressor Station District, and Parker Dam), a regional park (Moabi Regional Park), and various buildings, structures, roads, and transmission lines (Eddy et al. 2024). **Table TA 11-15** summarizes the general categories of built environment resources (based on function and/or use) established for the literature review.

Table TA 11-15
Built Environment Resource Categories in the Study Area in California

Category	Number of Resources
Bridge	3
Building	12
District	3
Historic/Survey Marker	3
Other Structure	8

Category	Number of Resources
Park	1
Railroad	2
Road	21
Single Family Dwelling	2
Transmission	3
Water Conveyance/Management	5
Totals	63

Source: Eddy et al. 2024

Notes:

- Sixteen individual resources are within the Topock Compressor Station District, which is counted as one of three districts in this table.
- The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

For the 63 built environment resources identified in the study area, two are listed in the NRHP (the Old Trails Bridge near Topock and the Ocean-to-Ocean Highway Bridge in Yuma), six were recommended as eligible for the NRHP, 17 were recommended/determined ineligible (including the Topock Compressor Station District and Moapi Regional Park), while 38 have either not yet been evaluated (including the Picacho Squatters Settlement District), or NRHP status was not reported (Eddy et al. 2024). Parker Dam and its associated facilities were subject to a 1997 preliminary evaluation that concluded the dam complex is likely eligible as a district, therefore it is considered an NRHP-eligible historic district for the purposes of this Final Environmental Impact Statement (see Arizona above). The eight NRHP-listed/-eligible historic properties are summarized in **Table TA 11-16**.

Table TA 11-16
NRHP-Listed/-Eligible Historic Properties in the Study Area in California Listed from North to South

Resource Name/Type	Category	Property Type	NRHP Status	Criteria
National Trails Highway (Bat Cave Wash)	Transportation	Structure	Eligible	A
Historic U.S. Route 66	Transportation	Structure	Eligible	A
Old Trails Bridge (Topock Bridge)	Transportation	Structure	Listed	A, C
Parker Dam ^a	Water conveyance/management	District	Eligible	A, C
All-American Canal	Water conveyance/management	Structure	Eligible	A, C
Transmission Line (near Fort Yuma Riviera)	Electric Power	Structure	Eligible	D
Southern Pacific Railroad	Transportation	Structure	Eligible	D

Resource Name/Type	Category	Property Type	NRHP Status	Criteria
Ocean-to-Ocean Highway Bridge	Transportation	Structure	Listed	A, C

Source: Eddy et al. 2024

Note: The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

^a As previously mentioned, Parker Dam was subject to a preliminary assessment in California in 1997; a formal NRHP nomination is currently in progress for listing; therefore, the dam complex is included here as an NRHP-eligible district.

Nevada

In all, the Class I records search identified 22 built environment inventories that have been completed within the Nevada portion of the study area; these inventories were undertaken for several Lake Mead NRA improvements, transmission line construction, roadway improvements, resource evaluations, and NRHP eligibility determinations. Research identified 159 previously documented built environment resources, consisting mostly of properties (districts [i.e., groupings of resources], along with individual buildings, structures, sites, and objects) associated with the construction and ongoing operation of Hoover Dam on the Nevada side of the Colorado River (Winslow et al. 2024). As previously mentioned, the Hoover Dam Historic District was listed in the NRHP in 1981 and later designated an NHL in 1985. Because of the substantial number of district resources present on the Nevada side of the Colorado River, nearly all of which were given individual state-specific numbers, Hoover Dam is discussed in detail in this section as an NRHP-listed historic district.

In all, 98 individual built environment resources were documented as part of Hoover Dam, of which 66 are contributing (eligible), and 29 are noncontributing (ineligible) components of the NRHP-listed historic district, with the remaining 3 having no information pertaining to NRHP status. These include dam operational components (diverter towers, spillways, intakes, tunnels, penstocks, diversion channels, concrete support structures, and anchor foundations), cableway components (hoist house, crane towers, tower bases, and cable lines), electric power-related components (power plants, switchyards, transformers, and transmission lines), visitor services components (modern visitor facilities [not housed in operational buildings], parking lots and structures, food/beverage/gift shop facilities, historical monuments and interpretive installations, walking trail systems, and scenic overlooks), transportation components (access roads, gates, railroads and associated features, and bridges), and other components (unique and unclassifiable resources like spoils piles, survey markers, and memorials).

In addition to the Hoover Dam Historic District, there is one additional NRHP-listed historic property within the boundaries of Lake Mead NRA in the study area: Willow Beach Gauging Station (listed in the NRHP in 1986). Elsewhere in the Nevada study area, a total of 26 built environment resources associated with the development of recreation around Lake Mead and Lake Mohave within Lake Mead NRA have been given state-specific built environment resource numbers, consisting of 10 NRHP-eligible properties (including Echo Bay Developed Area, Cottonwood Cove Developed Area, and the Las Vegas Wash Developed Area) and 16 ineligible properties (including Boulder Beach Developed Area District, Callville Bay Developed Area, and Overton Beach

Developed Area District). At the south end of Lake Mohave is Davis Dam, and because most of the dam complex is on the Arizona side of the river, only three components of the dam have been documented and given inventory numbers, and all are eligible for the NRHP (Winslow et al. 2024).

Furthermore, 23 built environment resources identified in the Nevada study area were documented on an individual basis (apart from Hoover and Davis Dams and established recreation areas in Lake Mead NRA), including 11 NRHP-eligible properties and five NRHP-ineligible properties, leaving eight properties where NRHP status information was absent in the archival record (Winslow et al. 2024). Half of these resources represent individual overhead powerlines that are owned and maintained by various utility entities (federal, state, municipal, private), bringing electricity generated at both Hoover and Davis Dams to their respective service areas primarily in Southern California. The other half consists of transportation (road segments), non-electric power utility (the Boulder City water supply line, a telephone line), science and research (U.S. Geological Survey [USGS] monitoring facilities), resources that have been given state-specific built environment numbers. Lastly, there are six built environment resources for which no information (e.g., resource category, property type, NRHP status, and jurisdiction/ownership) was available from corresponding archives. **Table TA 11-17** summarizes the built environment resources by category (i.e., function and/or use) along with corresponding property types and NRHP status as identified in the Nevada portion of the study area.

Table TA 11-17
Built Environment Resources Documented in the Study Area in Nevada

HOOVER DAM					
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/Ownership	Administering Agency
Dam Operations	Building	Eligible (A and/or C)	4	Reclamation	LCRO
		Ineligible	3	Reclamation	LCRO
	Structure	Eligible (A and/or C)	19	Reclamation	LCRO
		Ineligible	1	Reclamation	LCRO
	Total		27	—	—
Cableway	Building	Eligible (A and/or C)	1	Reclamation	LCRO
	Structure	Eligible (A and/or C)	4	Reclamation	LCRO
	Total		5	—	—
Electric Power	Building	Eligible (A and/or C)	2	Reclamation	LCRO
	Structure	Eligible (A and/or C)	15	DOE, Reclamation, Municipal	WAPA, LCRO, LADWP
		Ineligible	19	Unknown	Unknown
	Total		36	—	—

HOOVER DAM						
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/ Ownership	Administering Agency	
Visitor Services	Building	Eligible (A and/or C)	1	Reclamation	LCRO	
		Ineligible	2	Reclamation	LCRO	
	Structure	Eligible (A and/or C)	4	Reclamation	LCRO	
		Ineligible	2	Reclamation	LCRO	
	Object	Eligible (A and/or C)	1	Reclamation	LCRO	
		Ineligible	1	Reclamation	LCRO	
		Unknown	1	Reclamation	LCRO	
	Total		12	—	—	
Transportation	Structure	Eligible (A and/or C)	12	Reclamation	LCRO	
		Ineligible	1	Reclamation	LCRO	
	Total		13	—	—	
Other	Structure	Ineligible	1	Reclamation	LCRO	
	Site	Eligible (A and/or C)	2	Reclamation	LCRO	
		Unknown	1	Reclamation	LCRO	
	Object	Eligible (A and/or C)	1	Reclamation	LCRO	
	Total		5	—	—	
HOOVER DAM RESOURCE TOTAL			98			
LAKE MEAD / LAKE MOHAVE						
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/ Ownership	Administering Agency	
Recreation	District	Eligible	3	NPS	Lake Mead NRA	
		Ineligible	3	NPS	Lake Mead NRA	
	Building	Eligible (A and/or C)	5	NPS	Lake Mead NRA	
		Ineligible	11	NPS	Lake Mead NRA	
	Structure	Eligible (A and/or C)	2	NPS	Lake Mead NRA	
	Site	Ineligible	2	NPS	Lake Mead NRA	
	LAKE MEAD / LAKE MOHAVE RESOURCE TOTAL			26		

DAVIS DAM					
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/ Ownership	Administering Agency
Transportation	Structure	Eligible (A and/or C)	1	Reclamation	LCRO
	Total		1		
Other	Site	Eligible (A and/or C)	2	Reclamation	LCRO
	Total		2		
DAVIS DAM RESOURCE TOTAL			3		
INDIVIDUAL					
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/ Ownership	Administering Agency
Electric Power	Structure	Eligible (A and/or C)	7	DOE, State, Municipal, Private	WAPA, MWD, LADWP, SCE
		Ineligible	3	DOE, Private	WAPA, NV Energy, SWGC
		Unknown	2	Private	SCE
		Total		12	
Recreation	Building	Unknown	5	NPS	Lake Mead NRA
		Total		5	
Transportation	Structure	Eligible (A and/or C)	1	NPS	Lake Mead NRA
		Ineligible	1	Reclamation	LCRO
		Total		2	
Utility (Non-Electric)	Structure	Eligible (A and/or C)	1	Reclamation	LCRO
		Unknown	1	Unknown	Unknown
		Total		2	
Science/Research	Building	Eligible (A and/or C)	1	Unknown	Unknown
	Structure	Eligible (A and/or C)	1	Unknown	Unknown
	Total		2		
INDIVIDUAL RESOURCE TOTAL			23		

UNKNOWN					
Category	Property Type	NRHP Status (Criteria)	Resource Count	Jurisdiction/ Ownership	Administering Agency
Unknown	Unknown	N/A	6	Unknown	Unknown
UNKNOWN RESOURCE TOTAL			6		

Source: Winslow et al. 2024

Notes:

- Jurisdiction is given only for the study area and is based on ownership information in NVCRIS; WAPA (Western Area Power Administration) is under the DOE (Department of Energy); the Southern Nevada Fish and Wildlife Office is part of the FWS. Other administering entities include MWD (Metropolitan Water District of Southern California), LADWP (Los Angeles Department of Water and Power), SWGC (Southwest Gas Corporation), SCE (Southern California Edison), and Nevada Department of Wildlife. For transmission lines, shared jurisdictional responsibility is not uncommon; however, this is not reflected in this table. For components of the Hoover Dam Historic District, resources noted as eligible are contributing components of the district, while ineligible resources are noncontributing components. For Lake Mead and Lake Mohave—two districts (Boulder Beach [ineligible] and Las Vegas Wash Campground [eligible]), each encompasses a share of the buildings, structures, and sites listed separately.
- The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Utah

The Class I records search identified one built environment resource within the Utah portion of the study area—Hite Crossing Bridge—which was previously documented and recommended as eligible for the NRHP under Criterion C (Eskenazi 2024). Also known as the Colorado River Arch Bridge, it spans the river connecting Utah State Route 95 near Hite Marina within the boundaries of Glen Canyon NRA. Part of the Trail of the Ancients National Scenic Byway and the Utah Bicentennial Highway Scenic Byway, the Hite Crossing Bridge is under the management of the Utah Division of Transportation.

Specially Designated Cultural Resources

As previously mentioned, there are three different types of special designations identified in the study area—that of the NHL, as well as the congressionally designated NHA and the NHT. NHLs are historic properties that illustrate U.S. heritage, while NHAs are nationally important landscapes encompassing unique natural, cultural, and scenic values. NHAs are not managed by the federal government, rather, they are managed by state governments, non-profit organizations, or private entities. Lastly, NHTs follow past routes of exploration, migration, trade, struggle, and/or military action representing historic corridors of national significance, which may or may not have a present physical manifestation. With some exceptions, administration of an NHT is generally assigned to a single federal agency (NPS, BLM, or U.S. Forest Service), with on-site jurisdiction belonging to various governmental agencies or private entities that own or manage the lands along each NHT.

The specially designated areas intersecting the study area are briefly summarized below by state, with more detailed discussions presented in the respective state volumes prepared to support this Final Environmental Impact Statement (Eddy et al. 2024; Eskenazi 2024; Tremblay et al. 2024b; Winslow et al. 2024). It should be noted that there are five specially designated areas crossing the study area in

more than one state including two NHLs and three NHTs—Hoover Dam NHL (Arizona and Nevada within Lake Mead NRA), Yuma Crossing NHL (Arizona and California), the Armijo Route (Arizona and Utah within Glen Canyon NRA) and the Mojave Road route (Nevada within Lake Mead NRA) of the Old Spanish NHT, as well as the Juan Bautista de Anza NHT and the recently designated Butterfield Overland NHT (Arizona and California).

Arizona

The Class I records search identified nine NHLs that intersect the Arizona portion of the study area—five districts and four individual buildings (Tremblay et al. 2024b). Most of the NHLs in the study area are within GCNP, including two districts and four buildings on the South Rim and one on the North Rim, all of which are administered by the NPS. The remaining two NHLs outside of GCNP are Hoover Dam and Yuma Crossing. Hoover Dam is under the jurisdiction of Reclamation and is situated within the boundaries of Lake Mead NRA but is not part of the NPS-administered park. The NHL designation encompasses infrastructure in both Arizona and Nevada, with the majority of components on the latter side of the river. Yuma Crossing NHL is unique in that it is composed of five distinct individual areas (including two state parks) that are collectively also designated as an NHA. The NHL designation encompasses portions of the study area in both Arizona and California while the NHA boundary only includes Arizona. The NHA is managed by a non-profit organization.

For the Arizona study area, the Armijo Route of the Old Spanish NHT crosses portions of Lake Powell within Glen Canyon NRA, while both the Juan Bautista de Anza NHT and the recently designated Butterfield Overland NHT traverse the river corridor in the Yuma area. There are no known physical remnants of the Old Spanish NHT in Arizona and if present, such evidence would be under the waters of Lake Powell. The routes of the Juan Bautista de Anza NHT and the Butterfield Overland NHT are approximate through the study area and, likewise, there is no known physical evidence of any original trail sections for either NHT. Therefore, there are no known NRHP-eligible segments of any of the three NHTs (Tremblay et al. 2024b).

Table TA 11-18 summarizes the specially designated areas (NHLs, NHAs, and NHTs) in the Arizona study area.

Table TA 11-18
National Historic Landmarks, National Heritage Areas, and National Historic Trails in the Study Area in Arizona

NATIONAL HISTORIC LANDMARKS				
Name	Year Designated	Property Type	Jurisdiction/Ownership	Administering Agency
*M.E.J. Colter Buildings	1987	District	GCNP	NPS
*El Tovar Hotel	1987	Building	GCNP	NPS
Grand Canyon Lodge (North Rim)	1987	District	GCNP	NPS
*Grand Canyon Depot	1987	Building	GCNP	NPS
*Grand Canyon Park Operations Building	1987	Building	GCNP	NPS

NATIONAL HISTORIC LANDMARKS

Name	Year Designated	Property Type	Jurisdiction/Ownership	Administering Agency
*Grand Canyon Power House	1987	Building	GCNP	NPS
Grand Canyon Village	1997	District	GCNP	NPS
Hoover Dam	1985	District	Federal	Reclamation
Yuma Crossing and Associated Sites	1966	District	Multiple (tribal, state, city)	N/A

NATIONAL HERITAGE AREAS

Name	Year Designated	Property Type	Jurisdiction/Ownership	Administering Agency
Yuma Crossing	2000	N/A	Multiple (state, city)	Non-profit

NATIONAL HISTORIC TRAILS

Name	Year Designated	Property Type	Jurisdiction/Ownership	Administering Agency
Old Spanish Trail (Armijo Route)	2002	N/A	Glen Canyon NRA	NPS
Juan Bautista de Anza Trail	1990	N/A	Multiple (tribal, state, city, private)	NPS
Butterfield Overland Trail	2023	N/A	Multiple (tribal, state, city, private)	NPS

Source: Tremblay et al. 2024b

Notes:

- Jurisdiction and ownership are given only for the study area.
- NHLs, when designated, are automatically listed in the NRHP if not already. NHLs in this table that also contribute to other NRHP-listed historic districts are indicated with an asterisk (*) and may also be repeated in subsequent applicable table(s). The M.E.J. Colter Buildings NHL consists of four isolated buildings on the South Rim (Lookout Studio, Hopi House, Desert View Watchtower, and Hermit's Rest), of which two (Lookout Studio and Hopi House) contribute to the significance of the Grand Canyon Village NHL. NHLs in GCNP are spatially separated from the river corridor because of substantial vertical distance and intervening terrain in Grand Canyon. Yuma Crossing NHA encompasses Yuma Territorial Prison State Park, Colorado River State Park, Yuma East Wetlands, Yuma West Wetlands, and Pivot Point Plaza. The Grand Canyon (North Rim) Lodge was designated as an NHL in 1987 along with its associated cabins; however, the main lodge was recently lost during the 2025 Dragon Bravo Fire, along with several cabins. While it is still designated as an NHL, it has been mostly destroyed by wildfire and its status is likely to change; therefore, this NHL has been removed from consideration.
- The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

California

The Class I records search identified one NHL—Yuma Crossing—which extends across the Colorado River into California to encompass the site of Fort Yuma, a former nineteenth century U.S. military post now on the Fort Yuma-Quechan Reservation (Eddy et al. 2024). There are no NHAs in the California portion of the study area because the Yuma Crossing NHA designation only

includes the portion of the NHL on the Arizona side of the river. For the portions of the Juan Bautista de Anza NHT and Butterfield Overland NHT that cross the study area in California, there is no physical evidence of original trail segments known to exist.

Nevada

The Class I records search identified two specially designated cultural resources intersecting the study area—Hoover Dam NHL and the Mojave Road route of the Old Spanish NHT (Winslow et al. 2024). Hoover Dam NHL was designated in 1985, spanning two states, encompassing half the dam along with extensive electrical infrastructure on the Nevada side of the river, including primary visitor services. The Old Spanish NHT corridor enters the Nevada study area along the Virgin River and is submerged under the Overton Arm of Lake Mead. It exits the study area near Boulder Wash Cove and reenters at Callville Bay before exiting again at Las Vegas Bay. There are no known original segments of the Old Spanish NHT within the Nevada portion of the study area, and if remnants do exist, they were submerged when Lake Mead was impounded and would be underwater.

Utah

Based on the Class I records search, there is only one congressionally designated area in the Utah portion of the study area—the Armijo Route of the Old Spanish NHT—which crosses into the study area within Glen Canyon NRA (Eskenazi 2024). There are no known segments of the original trail documented within the Utah portion of the study area. Like Lake Mead, if such do exist, they are inundated under the waters of Lake Powell.

Cultural Landscapes

There are different definitions for what constitutes a cultural landscape, however, at its basic level, a cultural landscape is a geographic area, encompassing both cultural and natural resources, that illustrates evidence of human interaction with the physical environment. The only defined cultural landscapes in the study area are within GCNP, where NPS has identified 16 cultural landscape areas in the park, representing historically or culturally significant designed, vernacular, and ethnographic landscapes, which allows land managers to assess how these landscapes should be managed and interpreted (NPS 2024). Most of the cultural landscapes identified in GCNP are spatially separated from the river corridor because of vertical distance and/or intervening canyon terrain. The Colorado River and its associated uplands represent a cultural landscape with both tangible and intangible attributes for many Indigenous peoples. Natural resources, such as animals, plants, springs, rivers, land formations, and human-made elements, such as ancestral homes and trails, fields, prayer objects enshrined in travertine and salt, are all important aspects of a cultural landscape. Tribal perspectives on cultural landscapes are summarized in **TA 13**, Tribal Resources.

The historic landscape at Lees Ferry, a recreation site at the confluence of the Colorado and Paria rivers in Glen Canyon NRA, is an example of a managed cultural landscape encompassing the NRHP-listed Lee's Ferry and Lonely Dell Ranch Historic District, which represents over 60 years of non-Indigenous cultural use of the Colorado River beginning with the establishment of the first ferry crossing by John D. Lee in 1871 up to 1909 when the Church of Jesus Christ of Latter-day Saints divested itself from both the ferry and farmstead. Lee's Ferry was the only ferry crossing of the Colorado River within 700 miles because, here, the river was not bound by steep canyon walls,

allowing wagons to be driven to the river's edge. Historically, Lee's Ferry operated as a ferry crossing and farmstead with an extensive irrigation system, which today are represented by several historic-era buildings, a cemetery, an orchard, trails, and fields. The Lee's Ferry and Lonely Dell landscape is an interpretative site that is still used today by day visitors, river runners, campers, and the USGS for their river gauging stations.

Traditional Cultural Places

A TCP, which is a type of historic property, is "a building, structure, object, site, or district that may be eligible for inclusion in the National Register for its significance to a living community because of its association with cultural beliefs, customs, or practices that are rooted in the community's history and that are important in maintaining the community's cultural identity" (NPS 2024). Because the TCPs of concern are those of Indigenous peoples, the analysis of impacts on TCPs is found in **TA 13**, Tribal Resources.

TA 11.2 Environmental Consequences

TA 11.2.1 Methodology

Direct and indirect impacts on cultural resources could result from changes in lake levels or river flows from the annual releases. Of greatest concern are effects on historic properties (i.e., resources eligible for or listed in the NRHP) that alter the characteristics of the properties in a way that would diminish the integrity of its location, design, setting, materials, workmanship, feeling, or association (36 CFR 800.5). Direct impacts may be from processes such as wave action and wet-dry cycling, but include any impact that is immediate in place and time, including visual, auditory, and atmospheric impacts; indirect impacts, such as from increased ease of access to previously inundated sites, are those that occur farther away in distance and/or later in time.

Impacts on cultural resources analyzed in this section only include those impacts resulting from Reclamation's management of annual releases from Glen Canyon and Hoover dams. The analysis emphasizes cultural resources within 20 meters (66 feet) of the river corridor because they are the most likely to be affected by changes in river flows.

Archaeological Sites

Three types of analyses are used to discuss potential impacts on archaeological resources: known site counts by elevation and modeled lake elevations/known sites counts within 20 meters (66 feet) of the river corridor, preservation risk modeling developed by the USGS and NPS, and aeolian transport modeling also developed by the USGS. Elevations for sites identified in the Class I records search at Lake Powell and Lake Mead were calculated and used to identify those sites that are at elevations subject to changes in water levels. However, due to the low Class III survey coverage, there are doubtless more sites to be found. Archaeological data over broad areas are, by virtue of how and when the data were collected, variable in coverage and documentation. For example, areas around Lake Powell have a higher cultural resource survey coverage and therefore, more archaeological data are available, while areas around Lake Mead do not. Also, there is very limited data on archaeological sites below the water line due to a lack of studies prior to inundation in Lake Mead NRA.

Along the river corridor, the analysis focuses on sites identified within 20 meters (66 feet) of the river corridor (bank to bank). A 20-meter (66-foot) distance is used because the variability of elevation along the river corridor is too great to efficiently sort thousands of sites by elevation; this distance corresponds to the most likely impacted zone from the Class I report (Tremblay et al. 2024b; Winslow et al. 2024).

Inundated Resources and Water Levels

Fluctuating water levels at Lake Powell and Lake Mead can impact the preservation of archaeological sites, especially for those that are currently or previously inundated. The NPS prepared an initial study of how inundation and fluctuating water levels at Lake Powell affect resources (Morgan and Conlin 2023), which generally parallel the findings of earlier archaeological inundation studies (e.g., Lenihan et al. 1981a, 1981b; Ware 1989). Archaeological resources are more vulnerable to disturbance and degradation when water levels fluctuate. Fluctuating water levels can result in increased wave impacts, wet-dry cycling, freeze-thaw cycling, and erosion.

Differences in topography and elevation in the lake reservoirs, as well as the length of exposure, affect the impact on sites. The reservoirs, in the cross section, are wide at the higher elevations and narrow at the lower elevations, where the lake fills what were steep-sided and deep canyons. In areas where the topography is flatter, at higher elevations, changes in lake elevation take longer, and the reservoir volume fluctuation exposes more horizontal area, while in the steeper areas, like canyons, changes in lake elevation may be faster and reservoir volume fluctuation occurs in a much more volatile fashion. In the lower reaches of the narrow canyons, removal or addition of a small amount of water will raise or lower the lake significantly; this may occur multiple times due to normal reservoir operations and will be relatively rapid. Higher in the canyons, removal or addition of water will raise or lower the lake by a smaller amount, leading to more extended periods of impacts due to wave actions and freezing and thawing.

Changes in temperature, water chemistry, pH, salinity, and sedimentation as water levels rise and fall can also be detrimental to the preservation of resources. While inundation is also not ideal, as it can displace artifacts and disturb and damage site components sensitive to water or moisture (like mud mortar), inundation can protect resources through sedimentation, if it is consistent over time. Inundation can also prevent weathering and provide a low oxygen environment that can protect artifacts. Resources that have previously been inundated and are exposed through fluctuating water levels are particularly vulnerable to wave action, etc., as well as to impacts from visitation. Like fluctuating lake levels, changes in river flows may impact archaeological sites through erosion, wet-dry cycling, exposure to the elements, and increased visitation of exposed resources. Discussion of lake elevations is based on minimum water-year (WY) and end-of-water-year (EOWY) elevations for Lake Powell, and minimum calendar-year (CY) and end-of-calendar-year (EOCY) elevations for Lake Mead (see **TA 3**, Hydrologic Resources). The analysis references applicable tables presented in **TA 3** for corresponding elevations (in feet) at Lake Powell (minimum WY and EOWY) and Lake Mead (minimum CY and EOCY) for each of the different hydrological conditions under different modeled scenarios. These include the maximum, 90th percentile, 75th percentile, median (50th percentile), 25th percentile, 10th percentile, and minimum elevations. The analysis also references applicable figures in **TA 3** that visualize the elevation data for Lake Powell and Lake Mead using side-by-side conditional box plots where the bold lines through each box represents the median

elevation (50th percentile), the top and bottom of each box captures the 25th and 75th percentile of the modeled results (the interquartile range), the lines extend to the 10th and 90th percentiles, and the outliers are represented as dots beyond these lines (maximum and minimum elevation ranges for the modeled results). Specific tables and figures from **TA 3**, Hydrologic Resources, are called out as appropriate in each section below.

Preservation Risk Modeling

The USGS, in cooperation with NPS, developed a model to assess “preservation risk” for archaeological resources at or below full pool elevation at Lake Powell and Lake Mead (Caster et al. 2026). This Preservation Risk model is a spatial model that considers several landscape characteristics, locations of previously recorded cultural resources, and potential for water-related impacts, such as wave action and erosion. The lake landscape was gridded off into 10-meter resolution cells, and each 10-meter resolution grid cell within the model was categorically ranked 1 to 5 based on low (1) to high (5) potential for site preservation to be negatively affected by water at a given reservoir elevation. The Preservation Risk model incorporates two other models: the Site Distribution model, which identifies where archaeological resources are more likely or less likely to be found, and the Preservation Hazard model, which identifies where site impacts related to lake fluctuations will likely occur.

Specific for archaeological sites, the Site Distribution model is based on landscape characteristics (geologic and geomorphic context-geologic maps and digital elevation models [DEMs]), topographic position-DEMs/bathymetry, proximity to major runoff flow concentrations seen in National Hydrology Dataset flowlines and DEMs, and known locations of archaeological sites (precontact and postcontact). As mentioned above, not all of Lake Powell was surveyed prior to the completion of Glen Canyon Dam construction, and very little of Lake Mead prior to when filling began in 1934, so this model allows for the prediction of site distribution based on the correlation of landscape characteristics to known site location. However, the known site distribution was used within Lake Powell (a larger percent surveyed) to help define the distribution ranks (Rank 1 – no known archaeological sites, Rank 2 – known site density less than 1.5 per square mile (2.6 square kilometer), Rank 3 – known site density greater than and equal to 1.5 per square mile and less than 3 per square mile, Rank 4 – known site density greater than and equal to 3 per square mile and less than 4.5 per square mile, and Rank 5 – known site density greater than and equal to 4.5 per square mile).

The Preservation Hazard model is based on the simplified physical factors influencing lake shore geomorphic change. Like with coastal environments, wave action is a major player in erosion, but reservoirs have the added risk of large, rapid, and sustained changes in water level that affect runoff base level conditions, soil deformation, and chemical weathering with submersion and exposure. These aspects were incorporated into the model using available USGS topography and bathymetric data and the known relationships between slope-wave interactions/baselevel adjustments, lake fetch lengths (distance wind travels over water surfaces to help build waves), and lake shoreline area change, as well as a given change in elevation. In this model, the highest rank (5) correlates to a higher potential for impacts, and the lowest rank (1) correlates to a lower risk from these factors.

When combining the Site Distribution and Preservation Hazard models, a simple rule set was used based on the assumptions that: 1) regardless of hazard rank, areas likely to contain resources have

potential to be affected by dam management operations; 2) even where archaeological resource likelihood is low, hazards from water levels can impact a potentially significant site; 3) areas with very high likelihood of containing archaeological sites and very high potential for impacts are at the highest risk of resource condition changes; and 4) areas with very low likelihood of containing archaeological sites and very low potential for impacts are at the lowest risk of resource condition changes.

The above concepts allow for each grid cell in the reservoir footprint to be ranked. For the analysis, the Preservation Risk model was summarized for greater than 60 units of 10-foot elevation bins at and below full pool. The summaries represent statistics of the Preservation Risk rank at the lake shoreline between the upper and lower reservoir elevations, defining each 10-foot bin (i.e., each bin represents a different summary area). Monthly modeled reservoir values are used in this model. In this way, each monthly modeled reservoir level will fall into one of the 10-foot summary bins and can be assigned a preservation risk rank summary statistic, such as the mean risk rank, that represents generalized potential impacts along the lake shoreline for that reservoir level. Monthly risk values, based on reservoir elevations, can then be used to evaluate differences between scenarios and traces within the modeling period.

Wind-deposited Sediment

Research conducted by the USGS and NPS has demonstrated that wind-deposited (aeolian) sediment can help stabilize and preserve archaeological sites along the Colorado River over long periods of time (East et al. 2016; Sankey et al. 2023). Fine sand or sediment can be blown from flow-deposited source areas and deposited on cultural sites (East et al. 2016). The effects of deposition or erosion may be negative or positive depending on the nature of the site. One important recent finding is that sandbars created by high-flow events at Glen Canyon Dam can provide sources of windblown sand that can cover archaeological sites (East et al. 2016) as well as anneal, or reverse, the formation of gullies (Sankey and Draut 2014). In this context, changes in dam operations can affect erosion rates on archaeological sites (East et al. 2016; Collins et al. 2016). Sediment is generally deposited via wind on nearby terraces with archaeological sites at an average rate of a few millimeters a year; however, operations of the Glen Canyon Dam can inhibit the formation of sand bars from which the sediment is blown. Management of the Colorado River influences the supply of windblown river sand in two ways: (1) the reduction of river flows below current average baseflow levels causes sand in the river channel to be exposed subaerially and, given sufficient time, can dry out and become available for wind transport (Sankey et al. 2022); and (2) when high-flow experiments (HFEs) are successfully implemented to rebuild river sandbars, the sand in the subaerial portion of the sandbars becomes available for wind transport in the Grand Canyon (Caster et al. 2022; Sankey et al. 2018). However, riparian vegetation can block the windblown transport of sand; when vegetation cover decreases, the potential for wind transport increases (Sankey et al. 2023).

The analysis integrated three independent models: the aeolian sand availability model (hereafter referred to as the “Sand Area model”; Kasprak et al. 2024; Kelley et al. 2026), the Vegetation Habitat Suitability model (Butterfield et al. 2018; Butterfield and Palmquist 2026), and the Sandbar Volume model (initially modified from Mueller and Grams 2021; Salter and Grams 2026). The Sand Area model was specifically developed to predict the supply of river-sourced, windblown sand as a function of river discharge and subaerial exposure time; however, the Sand Area model used here

does not incorporate changes in vegetation cover that occur as a function of river hydrology or geomorphic changes (deposition and erosion of sand) that would also affect sand area. Therefore, the Sand Area model was then coupled with the outputs with those from the Marble Canyon Vegetation Habitat Suitability model. Scenarios were assessed in which modeled sand availability exceeded a defined threshold while vegetation suitability remained below a specified benchmark—conditions presumed to favor increased aeolian transport.

To further capture the dynamic influence of high-flow events, which can increase sandbar volume and enhance future sand supply, the Sandbar Volume model output was then included in the evaluation framework. In this analysis, a future is defined as a “preferred minimum performance” if one of the following logical criteria was met: (1) the Sand Area model exceeded and the Vegetation Habitat Suitability model simultaneously fell below their respective thresholds (suggesting favorable conditions for aeolian transport), or (2) the Sandbar Volume model exceeded the threshold, indicating enhanced sand supply via fluvial-related deposition. Previous work suggests that dam releases that allow for these conditions to be met at least once every 1–3 years may slow the rate of degradation to enable time for proactive mitigation and planning (Sankey et al. 2018). Considering temporal variability of future preferred minimum performance, it is a preferred minimum performance if these conditions are met at least once every 3 years.

Model thresholds were derived from recent historical baselines: the sand area and vegetation (Marble Canyon only) thresholds reflect the 50th percentile of model outputs from 2000 to 2023, while the sandbar volume threshold is set at 1.5 times the modeled initial condition beginning in 2027. For sandbars to grow in volume and provide a continuous supply of river sand for aeolian transport to protect cultural resources, HFEs must be conducted on a frequent basis (e.g., every 1–3 years). However, the frequency of HFE occurrence, and thus sandbar volume growth, is likely overpredicted in the modeling, as the decision for an HFE to occur or not in a given year is a policy decision based on environmental conditions and other factors.

Built Environment Resources

No modeling was conducted specifically for built environment resources. Recalling that built environment resources are those human-made and/or intentionally modified components of our environment, these types of resources are much less vulnerable to impacts compared to archaeological resources. The most prominent of the built environment resources identified in the study area also constitute critical infrastructure, constructed as part of major Reclamation projects like Glen Canyon Dam, Hoover Dam, as well as Davis and Parker dams. This also includes the smaller dams like the Palo Verde Diversion Dam, Imperial Dam, Laguna Dam, and Morelos Dam, along with the various canals and levee systems in the lowest reaches. Collectively, these facilities are key to Colorado River operations, and none of the alternatives would result in the decommissioning or substantial alteration of such critical infrastructure, so the historic importance of these resources would not be jeopardized. Therefore, it is assumed there would be no direct or indirect impacts on this critical infrastructure, and they are not carried forward for analysis.

In terms of built environment resources around the reservoirs and immediately along the river corridor that are not considered critical infrastructure for river operations, these properties were developed in response to either the creation of both Lake Powell and Lake Mead or to provide

access to and/or across the river itself. Historic-era transportation roadway and railway networks spanned the river via bridges, while trails were established to provide river access. Recreation areas like those identified in Lake Mead NRA were intentionally placed in locations that took advantage of proximity to water. Other tourist facilities, like those in GCNP, were designed to accommodate visitors near the river and provide safe crossing between the North and South Rims. As such, for most built environment resources in the study area, these types of properties were designed or located in consideration of fluctuating water levels both around the reservoirs and the river corridor. They are not considered vulnerable to inundation or varying water levels, increased wave impacts, wet-dry cycling, or erosion like archaeological sites because they were designed to withstand or avoid those impacts historically. Therefore, impacts on NRHP-listed and NRHP-eligible built environment resources would occur where uncharacteristic water levels and river flows exceed historical ranges.

Specially Designated Cultural Resources

No modeling was undertaken for NHLs, NHAs, or NHTs. The one NHA identified in the study area (Yuma Crossing) coincides with the Arizona portion of the Yuma Crossing and Associated Sites NHL; therefore, it is analyzed as an NHL. There are no confirmed segments of the original trail in the study area for the three NHTs. Impacts on NHLs, as the only specially designated cultural resources identified in the study area, could occur only if river flows are outside the historical ranges.

Impact Analysis Area

The impacts analysis area consists of the Colorado River corridor from the upper limits of Lake Powell in Utah, through the Grand Canyon in Arizona, and Lake Mead in Arizona, and from Hoover Dam to the SIB.

Assumptions

- Once a resource has been inundated by a reservoir, being continuously inundated thereafter is more conducive to preservation than repeated cycles of inundation and exposure (i.e., wet-dry cycling and wave action).
- Repeating cycles of inundation and exposure of resources by the reservoirs and/or the river are damaging to archaeological resources.
- The covering of resources by wind-deposited, river-sourced sediment is conducive to preservation.
- While HFEs were considered in the aeolian transport model as part of the individual vegetation and sandbar models, actual HFE frequency may differ from that assumed or predicted in the modeling.
- Impacts on cultural resources can be characterized based on projected minimum and end-of-year lake elevations for very wet through very dry conditions and river flow volumes.
- Cultural resources that have not been previously inundated would not be inundated under the Continued Current Strategies (CCS) Comparative Baseline, the No Action Alternative, or any action alternatives (i.e., no cultural resources located above reservoir spillway elevations or above the level of current river flows would be inundated).

- The limit of physical impacts on cultural resources by the river is constrained to resources within the river corridor (bank to bank) or within 20 meters (66 feet) of the river.
- Where previous survey coverage is absent within the study area, there may be sites that have not yet been identified (i.e., undiscovered) that could be affected under the CCS Comparative Baseline, the No Action Alternative, or any action alternatives.
- The Class I records search conducted for the study area in Arizona, California, Nevada, and Utah serves as a representative dataset for the purposes of analysis.
- Lake Mohave and Lake Havasu would continue to follow their target end-of-the-month elevation schedules (“rule curve”) (see **TA 3**, Hydrologic Resources), therefore, no cultural resource impacts are expected at these reservoirs.

Impact Indicators

- Projected monthly and end-of-year lake elevations that may expose cultural resources to damage from wave action, wet-dry cycling, or increased ease of access
- Projected WY and CY dam releases resulting in potential river-flow changes that leave cultural resources susceptible to damage from erosion, wet-dry cycling, or increased ease of access
- Projected availability of sediments along the river, which may be transported by wind and deposited on archaeological sites

TA 11.2.2 Issue 1: How will any changes in dam operations affect (1) lake elevations at Lake Powell and Lake Mead and (2) river flows downstream, which may affect cultural resources?

Lakes

As water levels in Lake Powell and Lake Mead fluctuate, archaeological sites that were previously inundated become vulnerable to several hazards. Direct impacts from wave action, wet-dry cycling, and erosion are more likely to occur as water levels drop to expose previously inundated resources; indirect impacts may occur from increased visitor traffic as access to exposed resources becomes easier. This section discusses the potential for archaeological resources to be exposed, and therefore potential impacts from exposure, using the distribution by elevation of cultural resources and the hydrologic modeling results for Lake Powell and Lake Mead elevations. However, please note that more data was available for Lake Powell than for Lake Mead because of variable archaeological survey coverage. The following discussion incorporates the discussion of hydrological modeling as presented in **TA 3**, Hydrologic Resources.

Because survey coverage varies across the study area and much of the locational data for recorded sites predates modern technology, precise site counts are not feasible for analysis. Instead, site counts should be considered a representative sample used to understand the overall level of sensitivity within the study area. Representative site counts by elevation were compiled from Class I data using associated elevations based on critical conditions for each lake, which are discussed in **TA 3**, Hydrologic Resources. For Lake Powell, the associated elevations for critical conditions pertinent to this analysis are 3,700 feet (top of the Glen Canyon Dam spillway) down to 3,490 feet (minimum power pool; see **Table TA 3-2** in **Section TA 3.2.1** of **TA 3**, Hydrologic Resources). For

Lake Mead, these associated elevations for critical conditions pertinent to this analysis are 1,221 feet (top of the Hoover Dam Spillway) down to 950 feet (minimum power pool; see **Table TA 3-5** in **Section TA 3.2.1** of **TA 3**, Hydrologic Resources).

Archaeological sites identified in the Lake Powell dataset are presented by elevation range in **Table TA 11-19**, while those identified in the Lake Mead dataset are presented (also by elevation range) in **Table TA 11-20**. Overall survey coverage for both lakes is very low (around 3 percent), which means the numbers in **Table TA 11-19** and **Table TA 11-20** greatly underrepresent the total number of sites present.

Table TA 11-19
Recorded Archaeological Sites in the Lake Powell Dataset by Elevation Range (Arizona and Utah)

Elevation Range (feet)	Elevation Range (meters)	No. of Sites (NPS)	No. of Sites (non-NPS)	Total
3,700–3,680	1,128–1,122	66	N/A	66
3,680–3,660	1,122–1,116	40	N/A	40
3,660–3,640	1,116–1,109	32	N/A	32
3,640–3,620	1,109–1,103	59	N/A	59
3,620–3,600	1,103–1,097	52	N/A	52
3,600–3,580	1,097–1,091	31	N/A	31
3,580–3,560	1,091–1,085	36	N/A	36
3,560–3,540	1,085–1,079	34	N/A	34
3,540–3,520	1,079–1,073	31	N/A	31
3,520–3,500	1,073–1,067	34	N/A	34
<3,500	<1,067	442	N/A	442
Total Sites in the Lake Powell Dataset				857

Source: Glen Canyon NRA staff

Notes:

- N/A = not applicable; all lands within Glen Canyon NRA are NPS lands.
- Glen Canyon NRA staff provided updated NPS site counts by elevation in March 2026, stating that lands within the study area under 3,580 feet are NPS lands and should be accounted for in the updated data; therefore, the non-NPS data acquired during the Class I records search (which relies on agency data acquired in August 2023) have been omitted. Therefore, this table does not correlate with the NPS site counts (or the total number of sites) identified by the Class I records search.
- Survey coverage at Lake Powell is calculated to be 3.3 percent of the area below full pool meaning the number of sites in the Lake Powell data set represents a fraction of the total number of sites present.

Table TA 11-20
Recorded Archaeological Sites in the Lake Mead Dataset by Elevation Range (Arizona and Nevada)

Elevation Range (feet)	Elevation Range (meters)	No. of Sites (NPS)	No. of Sites (non-NPS)	Total
1,221–1,201	372–366	75	10	85
1,201–1,181	366–360	49	8	57
1,181–1,161	360–354	52	2	54
1,161–1,141	354–348	27	4	31
1,141–1,121	348–342	13	5	18
1,121–1,101	342–336	17	3	20
1,101–1,081	336–329	8	2	10
1,081–1,061	329–323	5	ND	5
1,061–1,041	323–317	6	ND	6
1,041–1,021	317–311	5	ND	5
1,021–1,001	311–305	5	ND	5
1,001–981	305–299	5	ND	5
981–961	299–293	5	ND	5
<961	<293	4	ND	4
Total Sites in the Lake Mead Dataset				310

Sources: Lake Mead NRA staff; Tremblay et al. 2024b; Winslow, et al. 2024

Notes:

- ND = no data available; site counts for elevations below 1,081 feet were lacking for the non-NPS dataset.
- Lake Mead NRA staff provided updated NPS site counts by elevation in March 2026, acknowledging that the park's database may contain errors. For this reason, non-NPS data acquired in August 2023 for the Class I records search have been retained for analysis. Therefore, this table does not correlate with the NPS and non-NPS site counts (or the total number of sites) identified by the Class I records search.
- Survey coverage at Lake Mead is calculated to be 2.8 percent of the area below full pool meaning the number of sites in the Lake Mead data set represents a fraction of the total number of sites present.

There are no NRHP-listed or NRHP-eligible built environment resources within the elevation range for Lake Powell (3,700–3,490 feet), but there is one NRHP-eligible district within the elevation range for Lake Mead (1,221–950 feet): the Echo Bay Developed Area in Lake Mead NRA. The historic-era boat ramp within the district boundary falls between 1,221 and 1,100 feet.

Lake Powell

This section references **Figure TA 3-6** in **Section TA 3.2.1**, Issue 1, and **Table TA 3-3** and **Table TA 3-4** at the end of **TA 3**, Hydrologic Resources.

The following discussion uses the known number of sites within the Lake Powell dataset provided by NPS staff. Survey coverage at Lake Powell is calculated to be 3.3 percent of the area below full pool, meaning the number of sites in the Lake Powell dataset represents a fraction of the total number of sites present.

In general, where water-level elevations are at the top of the Glen Canyon Dam spillway (3,700 feet), all 857 archaeological sites in the Lake Powell dataset would be inundated, while water levels dropping to minimum power pool could expose up to all 857 archaeological sites (depending on how many of those in the Lake Powell dataset remain above 3,490 feet), leaving them vulnerable to impacts. A total of 442 sites (equating to around 52 percent of the sites in the Lake Powell dataset) are below 3,500 feet; thus, where any of the modeled scenarios result in reservoir levels below this elevation, a greater proportion of archaeological sites would be left vulnerable to impacts. Additionally, it is important to note that because some areas at Lake Powell have not been surveyed, any of the modeled scenarios have the potential to impact undiscovered archaeological resources. Based on these parameters, this section will focus on median and interquartile elevations for analysis as presented in **TA 3**, Hydrologic Resources, where appropriate.

As presented in **Table TA 3-3** and **Table TA 3-4** at the end of **TA 3**, Hydrologic Resources, the CCS Comparative Baseline and the No Action, Basic Coordination, Enhanced Coordination, and Maximum Operational Flexibility Alternatives all perform similarly under the Wet Flow Category with minimum WY median elevations around or just below 3,670 feet and EOWY median elevations around 3,680 feet. Therefore, based on these median elevations, any of these modeled scenarios could expose at least 66 archaeological sites, as well as any undiscovered sites that may be present above the EOWY median within the 3,680-3,660-foot zone. The Supply Driven Alternative (both Lower Basin [LB] Priority and LB Pro Rata approaches) has a minimum WY median elevation around 3,640 feet, which could potentially expose up to 138 sites above this elevation while up to 106 sites could be exposed (impacting 32 fewer sites) relative to an EOWY median elevation of around 3,660 feet. The Representative Preferred Alternative has a minimum WY median elevation of around 3,650 feet, which could potentially expose at least 106 archaeological sites and any additional sites above this elevation within the 3,660–3,640-foot zone along with any undiscovered sites that may be present. The EOWY median elevation for the Representative Preferred Alternative is at just above 3,660 feet, similar to the same elevation for the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), also exposing up to 106 sites above this elevation. Sites exposed at higher elevations may be less vulnerable to impacts from wet-dry cycling and wave action, but may have increased ease of access depending on their location.

As conditions move toward average, the sites affected by wet-dry cycling are found at lower elevations in the lake, while sites exposed at higher elevations would see less of those impacts but may have increased ease of access. In the Average Flow Category, the modeled scenarios begin to perform differently compared to wetter hydrological conditions. Minimum WY median elevations for the CCS Comparative Baseline, and the No Action Alternative fall around and just below 3,550 feet, which could expose at least 316 archaeological sites as well as those above this elevation within the 3,540–3,560-foot zone along with any undiscovered sites that may be present. EOWY median elevations for the CCS Comparative Baseline and the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) are around 3,570 feet and just above 3,580 feet for the No Action Alternative under average hydrological conditions. This would leave at least 280 known sites (and any undiscovered sites) present as well as those above 3,570 feet in the 3,580-3,560-foot zone vulnerable to impacts if elevations drop that low. Additional sites would continue to be exposed as water levels drop, depending on elevation (see **Table TA 11-19** above).

For the Average Flow Category, the Basic Coordination Alternative and the Representative Preferred Alternative both perform slightly better with a minimum WY median elevation of around 3,560 feet and around 3,570 feet, respectively, potentially exposing up to 316 sites (and any undiscovered sites present), leaving them vulnerable to impacts. The EOWY median elevation for these two alternatives is higher, around 3,590 feet for the Basic Coordination Alternative and just below 3,600 feet for the Representative Preferred Alternative, potentially leaving at least 249 known sites exposed as well as those above 3,590 feet in the 3,600-3,580-foot zone. The Enhanced Coordination and Maximum Operational Flexibility Alternatives perform the best with minimum WY median elevations around 3,610 feet to around, 3,600 feet, respectively, which would expose at between 197 and 249 known sites (and any undiscovered sites). The EOWY median elevations are around 3,630 feet for the Enhanced Coordination Alternative and around 3,620 feet for the Maximum Operational Flexibility Alternative, with the Enhanced Coordination Alternative exposing at least 138 sites (plus any additional sites present above 3,630 feet within the 3,640-3,620-foot zone) and the Maximum Operational Flexibility Alternative exposing up to 197 known sites. Both the Enhanced Coordination and the Maximum Operational Flexibility Alternatives also have the narrowest interquartile ranges for these median elevations (see **Figure TA 3-6** in **TA 3**, Hydrologic Resources).

As hydrological conditions become critically dry, the CCS Comparative Baseline, No Action Alternative, and all action alternatives struggle to reach key elevations for Lake Powell (see **Table TA 3-3** and **Table TA 3-4** at the end of **TA 3**, Hydrologic Resources). For the Critically Dry Flow Category, the CCS Comparative Baseline, and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives have flows for minimum WY and EOWY median elevations as well as interquartile ranges that are below 3,490 feet (minimum power pool), dropping down even lower to just below 3,440 feet for the No Action Alternative. Therefore, there is the potential for at least 415 archaeological sites (around 48 percent of the sites in the Lake Powell dataset), along with any undiscovered sites that may be present, to be left exposed and vulnerable under critically dry flow conditions. Additional sites could be left vulnerable as water levels drop below 3,490 feet (minimum power pool), depending on the elevations of the 442 sites recorded below 3,500 feet. As discussed in **Section TA 3.2.1**, Issue 1, in **TA 3**, Hydrologic Resources, the 3,500-foot elevation is important because it provides a 10-foot buffer for water supply and hydropower to stay above minimum power pool. These are also the elevations where sites are vulnerable to wet-dry cycling and wave action would be the lowest for all scenarios because more of the sites would be above the inundation line as water levels drop, but would also have the potential for increased ease of access.

For the Critically Dry Flow Category, the Representative Preferred Alternative fares slightly better with a minimum WY median elevation just above 3,490 feet, which would leave at least 415 sites exposed above 3,500 feet but would protect more sites if they are present above the minimum power pool elevation. The Representative Preferred Alternative performs even better relative to its EOWY median elevation just below 3,510 feet, which would inundate more sites below this elevation in the 3,520-3,500-foot zone. The Enhanced Coordination and Maximum Operational Flexibility Alternatives perform better with the minimum WY elevations at around 3,520 feet and 3,510 feet, respectively. EOWY median elevations are higher at around 3,560 feet and around 3,550 feet, respectively. This means that, relative to EOWY median elevations, both alternatives have the

potential to expose at least 316 known sites (and any undiscovered sites present) down to 3,560 feet with the Maximum Operational Flexibility Alternative exposing more sites if any are present above 3,550 feet within the 3,560-3,540-foot zone. The interquartile ranges for the Enhanced Coordination Alternative indicates that this is the only alternative that has the potential to expose the fewest sites of all modeled scenarios relative to critically dry conditions with an that have the potential to expose the fewest sites (up to 249 sites) as the uppermost limit of the EOWY median elevation (75th percentile) for this action alternative reaches around 3,600 feet.

Lake Mead

This section references **Figure TA 3-11** in **Section TA 3.2.1**, Issue 1, and **Tables TA 3-6** and **TA 3-7** at the end of **TA 3**, Hydrologic Resources. Like Lake Powell, this section focuses on median and interquartile elevations for analysis.

The following discussion uses the known number of sites within the Lake Mead dataset provided by NPS staff. Survey coverage at Lake Mead is calculated to be 2.8 percent of the area below full pool meaning the number of sites in the Lake Mead data set represents a fraction of the total number of sites present. For Lake Mead generally, when water-level elevations are at or above 1,221 feet, all 310 archaeological sites in the datasets (and any undiscovered sites present) would be inundated. Conversely, if water levels drop to 950 feet, up to 310 sites in the Lake Mead datasets (and any undiscovered sites above this elevation) would be exposed, depending on the elevations of sites below 961 feet (see **Table TA 11-20**). The archaeological sites recorded at Lake Mead are distributed relatively evenly across the uppermost elevation ranges of the reservoir, with 275 sites (around 89 percent of sites in the Lake Mead datasets) recorded above 1,081 feet. Therefore, if any of the modeled scenarios result in reservoir levels below 1,081 feet, a greater proportion of archaeological sites would be exposed. However, sites exposed at higher elevations may be less vulnerable to impacts from wet-dry cycling and wave action, but they may have increased ease of access depending on their location.

To reiterate, very little of Lake Mead was surveyed prior to the construction of the Hoover Dam in the early 1930s; as a result, undiscovered archaeological resources are likely to be present in unsurveyed areas that could be affected under any of the modeled scenarios.

Although Wet Flow Category conditions as modeled for Lake Mead are less likely to occur based on conditions in recent years, the CCS Comparative Baseline and No Action Alternative perform similarly for minimum CY and EOCY median elevations and interquartile ranges. As presented in **Table TA 3-6** and **Table TA 3-7** at the end of **TA 3**, Hydrologic Resources, even under the wettest hydrological conditions for the modeled scenarios, elevations for the CCS Comparative Baseline and No Action Alternative for both the minimum CY and EOCY median scenarios are between around 1,150 feet and 1,100 feet, exposing between 196 and 265 known archaeological sites and any undiscovered sites at or above these median elevations.

For the Basic Coordination Alternative in the Wet Flow Category, the minimum CY and EOCY median elevations are around 1,170 feet and 1,180 feet, respectively, exposing a minimum of 142 known sites and any undiscovered sites present above these elevations. The Enhanced Coordination and Maximum Operational Flexibility Alternatives perform better, with median elevations around

1,200 to 1,210 feet for both minimum CY and EOCY elevations. This would expose up to 85 known sites (and any undiscovered sites) present down to 1,200 feet; fewer sites would be exposed as water levels rise (see **Table TA 11-20** above). The Representative Preferred Alternative performs similarly, with a minimum CY median elevation of just below 1,200 and an EOCY median elevation of around 1,210 feet under the wettest conditions, potentially exposing the same number of known sites (and any undiscovered sites present) as the Enhanced Coordination and Maximum Operational Flexibility Alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) performs only slightly better compared to all the modeled scenarios in this flow category, with minimum CY and EOCY median elevations above 1,210 feet, which would expose fewer than 85 sites depending on their elevations within the 1,221-1,201-foot zone. As mentioned above for Lake Powell, sites exposed at higher elevations at Lake Mead may be less vulnerable to impacts from wet-dry cycling and wave action, but at the same time they may have increased ease of access depending on their location.

In the Average Flow Category, the modeled scenarios result in a variable range of performance respective to minimum CY and EOCY median elevations (refer to **Table TA 3-6** and **Table TA 3-7** at the end of **TA 3**, Hydrologic Resources). The No Action Alternative performs the poorest with median values for both minimum CY and EOCY elevations just below 970 feet and just below 980 feet, respectively, which would expose at least 301 known archaeological sites in the Lake Mead dataset as well as those below this elevation in the 981–961-foot zone (including any undiscovered sites that may be present). The CCS Comparative Baseline has higher median elevations than the No Action Alternative, with a minimum CY median elevation of 1,030 feet and an EOCY median elevation of around 1,040 feet, but it would still leave a minimum of 286 archaeological sites and any additional undiscovered archaeological sites present vulnerable from exposure.

Under average flow conditions, the Basic Coordination Alternative has minimum CY median elevation just above 1,050 feet and EOCY median elevation of just above 1,060 feet, leaving at least 280 archaeological sites (along with any undiscovered sites present) exposed, while the corresponding interquartile ranges from 1,130 feet at the upper limit down to around 1,000 feet could leave, at a minimum, between 227 to 296 known sites (and any undiscovered sites) left vulnerable to impacts from exposure, depending on elevation. The Representative Preferred Alternative performs slightly better with a minimum CY median elevation of just above 1,090 feet and a EOCY median elevation just above 1,100 feet, exposing at least 265 known archaeological sites as well as any undiscovered sites present. Additional sites would be exposed as water levels drop (refer to **Table TA 11-20** above). Additionally for the Average Flow Category, the Enhanced Coordination Alternative has a minimum CY median elevation around 1,100 feet and an EOCY median elevation of around 1,110 feet, which has the potential to at least 245 sites and up to 265 sites (and any undiscovered sites present) depending on elevation. The interquartile range for this alternative is similar for both minimum CY and EOCY elevations, from around 1,130 feet to around 1,060 feet, and around 1,140 feet to around 1,070 feet, respectively, which may expose at least 227 known sites above 1,140 feet and up to 280 known sites (and any undiscovered sites present in the study area at Lake Mead), depending on elevation. The Maximum Operational Flexibility Alternative has a minimum CY median elevation of just below 1,120 feet and an EOCY median elevation of just below 1,130 feet, potentially exposing at least 227 known sites and up to 245 known sites, along with

any undiscovered sites present. The interquartile range for the Maximum Operational Flexibility Alternative is the largest of all modeled scenarios for both minimum CY and EOCY elevations, from around 1,180 feet, leaving up to 142 known sites exposed, down to just above 1,040 feet, which would leave up to 286 archaeological sites (and any undiscovered sites present) vulnerable to impacts.

The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) performs the best in the Average Flow Category. The Supply Driven Alternative (LB Priority approach) minimum CY and EOCY median elevations of around 1,140 feet and 1,150 feet, respectively, would expose between 196 known sites up to 227 sites as well as any undiscovered sites present in those elevation ranges. The Supply Driven Alternative (LB Pro Rata approach) has a minimum CY median elevation of just above 1,150 feet and an EOCY median elevation of 1,160 feet, which has the potential to expose at least 196 known sites (and any undiscovered sites) down to 1,160 feet as well as those present above 1,150 feet within the 1,161-1,141-foot zone, leaving them vulnerable to impacts. The interquartile ranges for the Supply Driven Alternative vary, with the range for the LB Pro Rata approach performing the best from just below 1,190 feet (75th percentile) down to just below 1,070 feet (25th percentile) and around 1,180 feet (75th percentile) down to just below 1,060 feet (25th percentile for the LB Priority approach. This has the potential to leave (at minimum) between 85 and 275 known sites vulnerable to exposure under the LB Pro Rata approach and (at minimum) between 142 and 280 known sites exposed under the LB Pro Rata approach (and any undiscovered sites present) during average hydrological conditions.

As conditions grow drier, the modeled scenarios remain the same in relation to one another relative to minimum CY and EOCY median elevations, but they shift downward collectively in elevation about 100 feet in the Critically Dry Flow Category. As discussed in **Section TA 3.2.1**, Issue 1, in **TA 3**, Hydrologic Resources, the 975-foot elevation is important for Lake Mead because it provides a 25-foot buffer for water supply and hydropower to stay above minimum power pool. Like Lake Powell, as conditions for Lake Mead become drier, the sites affected by wet-dry cycling are found at lower elevations in the lake, while sites exposed at higher elevations would see less of those impacts but may have increased ease of access.

Under critically dry hydrological conditions, the elevation where sites are vulnerable to wet-dry cycling and wave action would be the lowest for all scenarios. The CCS Comparative Baseline has a minimum CY median elevation of around 930 feet, while the No Action Alternative drops to around 900, both of which are well below minimum power pool (950 feet). The EOCY median elevation for the CCS Comparative Baseline is around 960 feet; with the No Action Alternative EOCY median elevation dropping below that to around 930 feet. Both would potentially leave all 310 archaeological sites in the Lake Mead datasets (and any undiscovered sites present) vulnerable from exposure, depending on the elevations of the four sites below 961 feet. For the Critically Dry Category, the Basic Coordination Alternative fares slightly better with a minimum CY median elevation of just above 970 feet and an EOCY median elevation of around 980 feet. The Representative Preferred Alternative performs slightly better with a minimum CY median elevation of around 980 feet and an EOCY median elevation of just above 990 feet. Despite having slightly higher median elevations, these two action alternatives still have the potential to leave a minimum of 296 known archaeological sites (over 95 percent of sites in the Lake Mead dataset) and any

undiscovered sites present) exposed during critically dry conditions. The Enhanced Coordination Alternative, which has minimum CY and EOYC median elevations of around or just above 1,000 feet and interquartile ranges from 1,050 feet down to around 950 feet, would have the potential to leave up to all 310 known sites (and any undiscovered sites) exposed, depending on the elevations of the four known sites (and any undiscovered sites present) below 961 feet. The Maximum Operational Flexibility Alternative has similar median elevations of just above 1,010 feet down to around 1,000 feet, which would still leave between 291 and 296 known sites vulnerable to impacts. The interquartile ranges for this alternative are from around 1,060 feet down to around 970 feet, potentially exposing (at minimum) between 280 and 301 known sites at or above 981 feet as well as those down to 970 feet if any of the four known archaeological sites (and any undiscovered sites) in the 981–961-foot zone are present above that elevation.

The LB Priority approach under the Supply Driven Alternative has similar minimum CY and EOYC median elevations of around 1,010 feet, while the Supply Driven Alternative (LB Pro Rata approach) has median elevations at or just below around 1,030 feet, the latter of which is the highest median elevation for any of the modeled scenarios in the Critically Dry Flow Category. Regardless of this, a minimum of 286 to 291 known sites (and any undiscovered sites) have the potential to be exposed based on median elevations under the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches). The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) does have the potential to protect some sites through inundation when examining the upper limits of their interquartile ranges for both minimum CY and EOYC median elevations, which are at or just above 1,070 feet for the LB Priority approach (exposing at least 275 known sites) and around 1,090 feet for the LB Pro Rata approach (exposing at least 265 sites); however, both scenarios would still leave at least 85 percent of the sites in the Lake Mead dataset, in addition to any undiscovered sites present, exposed above the water level and thus vulnerable to impacts.

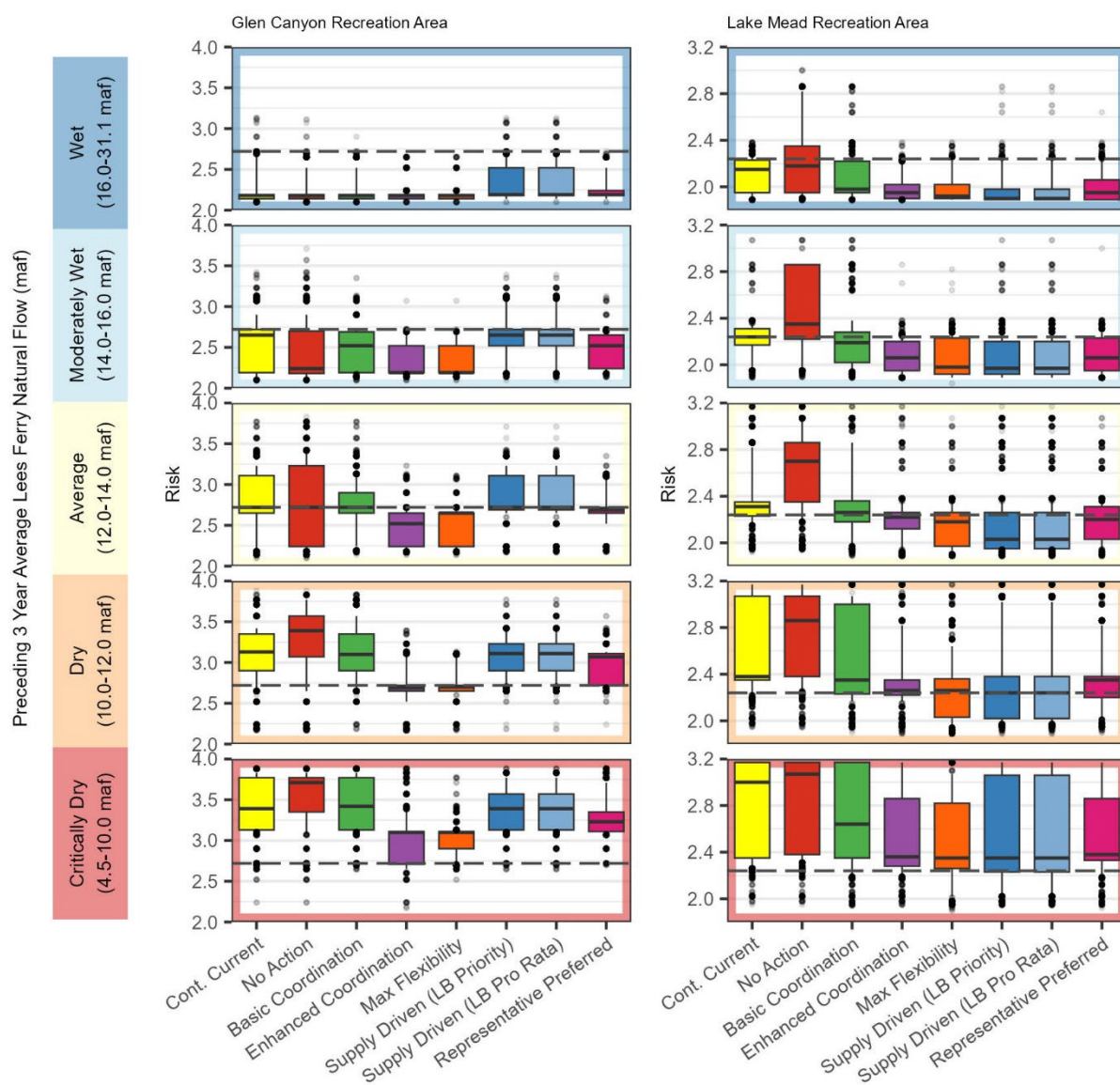
For the Echo Bay Developed Area, modeled scenarios with minimum CY and EOYC median elevations below 1,100 feet expose additional portions of the boat ramp; however, this would occur outside the NRHP-eligible district boundary toward the receding lakeshore. Conversely, modeled scenarios with elevations above 1,100 feet could partially inundate the ramp, with full submersion occurring at higher elevations along the ramp, which extends up to approximately 1,221 feet. These conditions would be more likely under the Supply Driven Alternative, as the interquartile ranges for minimum CY and EOYC elevation for the LB Priority approach extends to around 1,090 feet. Reservoir elevations exceeding 1,221 feet, would begin to impact recreation area infrastructure within the district boundary.

Preservation Risk Modeling

Preservation risk modeling results were compared to the 90th percentile values of modeled values for WY 2008 to 2025 (i.e., the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead [2007 Interim Guidelines] period); the 90th percentile risk value for Lake Powell is 2.72 and for Lake Mead is 2.24 (Caster et al. 2026). If preservation risk exceeds these threshold values, impacts on archaeological sites may occur at levels beyond those expected under historical conditions for the specific reservoir. For the purposes of this analysis, “historical conditions” coincide with the 2007 Interim Guidelines period (WY 2008–2025).

Figure TA 11-1 shows the WY maximum archaeological preservation risk for Lake Powell and Lake Mead.

Figure TA 11-1
Water Year Maximum Archaeological Preservation Risk at Glen Canyon NRA and Lake Mead NRA



For both Lake Powell and Lake Mead, the WY maximum preservation risk median is lowest in the Wet Flow Category for the CCS Comparative Baseline, No Action Alternative, and all action alternatives. The median for Lake Powell is 2.18 for all except for the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) and the Representative Preferred Alternative, which are slightly higher at 2.19. All the median risk values remain below 2.72 during wet flow periods for Lake Powell, meaning that impacts on archaeological sites, if they occur, would like those anticipated under similar historical conditions. At Lake Mead, the median risk value in the Wet Flow Category is at or below 2.0 for all alternatives (including the Representative Preferred Alternative at 1.95), except for the No Action Alternative at 2.18 and the CCS Comparative Baseline at 2.15. None of the

median risk values are above 2.24 for Lake Mead, which means impacts to archaeological sites, if they occur, would not be at levels greater than expected under similar historical conditions. However, the interquartile range for the No Action Alternative does reach up to 2.35 (75th percentile), the highest of any of the modeled scenarios.

In the Average Flow Category, the CCS Comparative Baseline, and the No Action, Basic Coordination, and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives all have preservation risk median values at the 2.72 threshold for Lake Powell. The Representative Preferred Alternative has a median value of 2.69, followed by the Maximum Operational Flexibility Alternative at 2.65 and the Enhanced Coordination Alternative at 2.52. The preservation risk median for the Enhanced Coordination Alternative is 2.52 and for the Maximum Operational Flexibility Alternative at 2.65; both have the same interquartile ranges from 2.65 to 2.24 under average hydrological conditions. The Representative Preferred Alternative has the narrowest interquartile range from 2.72 (75th percentile) to 2.65 (25th percentile) while the No Action Alternative has the greatest variation in risk in the interquartile range from 3.23 (75th percentile) down to 2.24 (25th percentile). Therefore, under average flow periods as modeled, if impacts on archaeological sites occur, they would not be at levels beyond those otherwise expected under similar average conditions historically.

For Lake Mead in the Average Flow Category, the preservation risk median value is highest for the No Action Alternative at 2.70. The CCS Comparative Baseline is the second highest at 2.31 while the Basic Coordination Alternative is at 2.26, which remains above the preservation risk value threshold of 2.24. This means that, during average flows, the risk to archaeological sites is greater than would otherwise be expected under similar historical conditions. The Enhanced Coordination Alternative has a preservation risk median of just below 2.24 at 2.22 followed by the Representative Preferred Alternative at 2.20 and the Maximum Operational Flexibility Alternative at 2.18. The interquartile ranges for the CCS Comparative Baseline, the No Action Alternative as well as all the action alternatives have upper preservation risk values above 2.24, including the Representative Preferred Alternative at 2.31. The lower extent of these interquartile ranges drops below 2.24 except for the No Action Alternative, which remains above it at 2.35 in the Average Flow Category. The median risk value for the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the lowest at 2.03.

In the Critically Dry Flow Category for Lake Powell, the preservation risk median values for CCS Comparative Baseline and all the alternatives are over the 2.72 threshold. The No Action Alternative has the median highest preservation risk for Lake Powell, which is well over 2.72 at 3.71, followed by the Basic Coordination Alternative at 3.42, and the Supply Driven (both LB Priority and LB Pro Rata approaches) Alternative at 3.39. The Representative Preferred Alternative has a preservation risk median value of 3.23 while both the Maximum Operational Flexibility and Enhanced Coordination Alternatives have at 3.10; however, the interquartile range of the Enhanced Coordination drops to 2.71. Again, the lower the preservation risk value, the better the performance and where these median values fall below 2.72 at Lake Powell, impacts to archaeological sites, if they occur, would not be beyond those anticipated under similar historical conditions.

The preservation risk median values for Lake Mead in the Critically Dry Flow Category for all scenarios are well above the 2.24 preservation risk value threshold. The No Action Alternative performs the worst at 3.07 followed by the No Action Alternative at 3.0. All of the action alternatives thus fall below 3.0, with the Basic Coordination Alternative at 2.64, the Representative Preferred Alternative at 2.38, the Enhanced Coordination Alternative at 2.36, and the Maximum Operational Flexibility and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives at 2.35. Because neither the CCS Comparative Baseline, the No Action Alternative, nor the action alternatives have preservation risk median values below 2.24, impacts to archaeological sites would be at levels beyond those anticipated under critically dry conditions historically.

Figure TA 11-2 and **Figure TA 11-3** compare alternatives by showing the percentage of futures in which the preservation risk is below 2.72 for Lake Powell and 2.24 for Lake Mead in at least 90 percent of months. The 2.72 and 2.24 preservation risk values represent the 90th percentile of modeled historical values for WY 2008–2025 (the 2007 Interim Guidelines period), which includes the period of significant reservoir storage loss. To reiterate, if preservation risk exceeds these value thresholds for the reservoirs, impacts on archaeological sites may occur at levels greater than those expected under historical conditions. The highlighted row shows the percentage of futures at that preferred minimum performance.

Figure TA 11-2
Cultural Resources in Glen Canyon NRA: Robustness
Percentage of futures in which monthly preservation risk stays below the value specified in each row in at least 90 percent of months

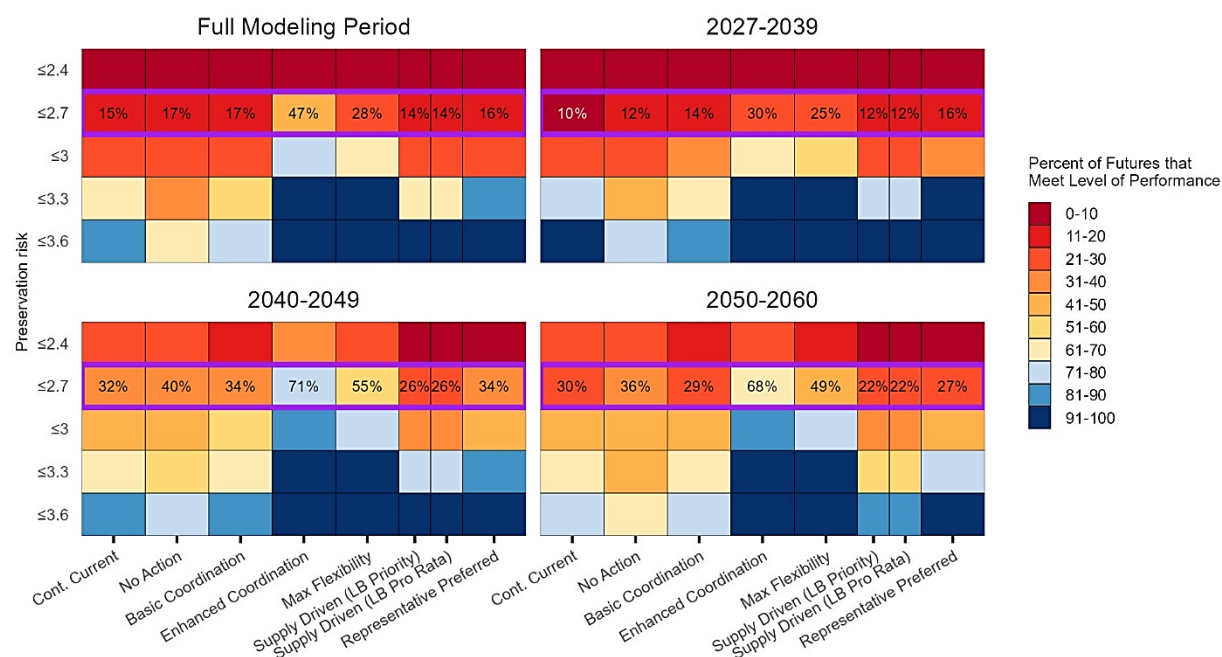
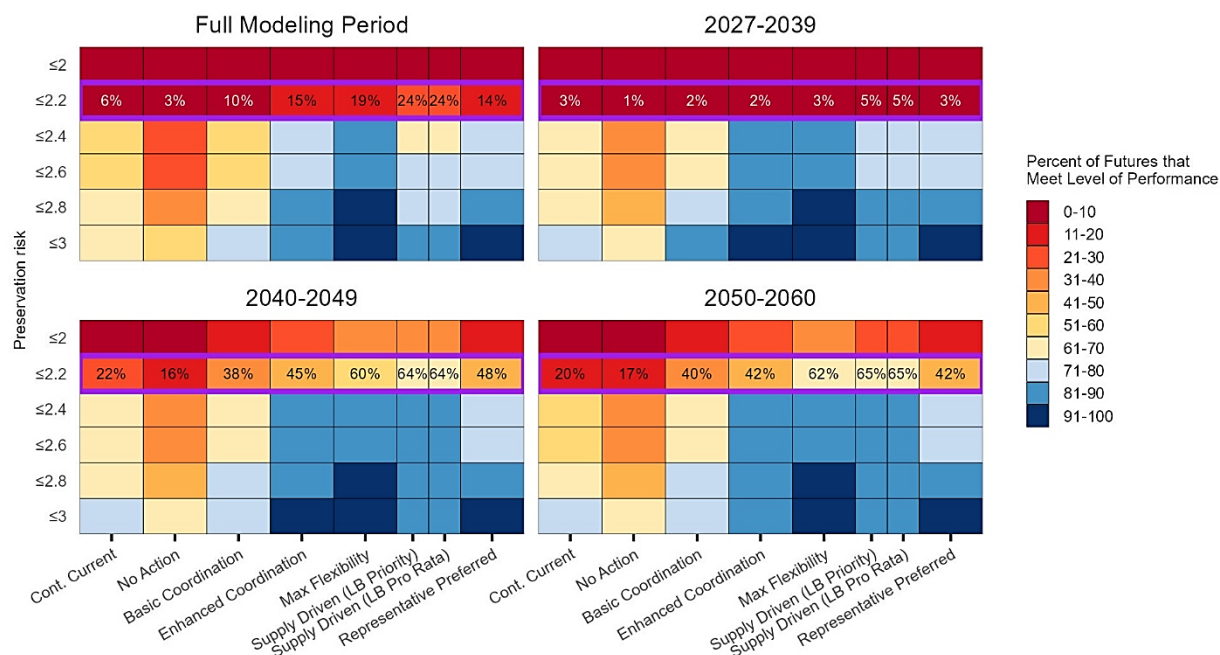


Figure TA 11-3
Cultural Resources in Lake Mead NRA: Robustness
Percentage of futures in which monthly preservation risk stays below the value
specified in each row in at least 90 percent of months



For Lake Powell, over the full modeling period, the Enhanced Coordination Alternative is the most robust, meeting the 2.72 risk threshold in 47 percent of futures. The Maximum Operational Flexibility Alternative is less robust, meeting the 2.72 threshold in 28 percent of futures, followed by the No Action and Basic Coordination Alternatives at 17 percent, the Representative Preferred Alternative at 16 percent, and the CCS Comparative Baseline at 15 percent. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) meets the preferred level of performance in 14 percent of futures. This relational pattern is consistent if the full modeling period is broken out into shorter periods, including the first decadal period from 2027–2039 where the Enhanced Coordination Alternative also performs the best at 30 percent whereas the CCS Comparative Baseline performs the worst at 10 percent. It is important to note that 2027, as the beginning of the first 10-year interval, is anticipated to have low reservoir elevations and, therefore, the modeling for this breakout (2027–2039) shows very low percentages of futures met for the preferred minimum of performance across the CCS Comparative Baseline, the No Action Alternative, and all other action alternatives. See **Figure TA 11-2** above for robustness modeled for 2040–2049 and 2050–2060 at Lake Powell.

For Lake Mead, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust by meeting the 2.24 risk threshold in 24 percent of futures over the full modeling period. The CCS Comparative Baseline and No Action Alternative meet the preferred minimum of performance in only 6 and 3 percent of futures, respectively. The Maximum Operational Flexibility Alternative meets the threshold in 19 percent of futures, followed by the Enhanced Coordination

Alternative at 15 percent, the Representative Preferred Alternative at 14 percent, and the Basic Coordination Alternative at 10 percent. If the modeling period is broken out, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) can be seen to meet the threshold for only 5 percent of futures in the first decadal period (2027–2039), followed by the CCS Comparative Baseline, the Maximum Operational Flexibility Alternative, and the Representative Preferred Alternative, all three of which meet the preferred level of performance in only 3 percent of futures. The Basic Coordination and Enhanced Coordination Alternatives meet the threshold 2 percent of the time while the No Action Alternative is at 1 percent for the 2027–2039 modeling period. It is important to note that, when examining the first decadal period (2027–2039) at Lake Mead, the percentage of futures meeting the preferred minimum of performance drops drastically because the anticipated water levels for Lake Mead in 2027 are expected to be low. Therefore, the robustness modeling shows a substantial drop in performance compared to the full modeling period. See **Figure TA 11-3** above for robustness modeled for 2014–2049 and 2050–2060 at Lake Mead.

Overall, the Enhanced Coordination Alternative is the most robust for Lake Powell for the full modeling period and the first decadal modeling period (2027–2039), followed by the Maximum Operational Flexibility Alternative. For Lake Mead, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust for, followed by the Maximum Operational Flexibility Alternative for the full modeling period. Looking at only the 2027–2039 modeling period, while the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) still remains the most robust at 5 percent, the CCS Comparative Baseline, Representative Preferred Alternative, and Maximum Operational Flexibility Alternative are all equally, but lesser, robust for the first 10-year period at 3 percent.

River Flows

This section references the discussion presented in **Section TA 3.2.4**, Issue 4, as presented in **TA 3**, Hydrologic Conditions, with additional references to other sections as appropriate.

For the purposes of analyzing potential impacts related to changes in river flow, archaeological sites that may be physically affected are those located along or immediately adjacent to the river, where erosion caused by moving water may occur. As with the lake site data discussed above, variable survey coverage and older locational data must be taken into account. To identify a representative number of sites that may be affected by changes in flow, sites with all or portions of their boundaries in the river corridor or within 20 meters (66 feet) of the river corridor (bank to bank) were identified from the overall datasets using a geographic information system. **Table TA 11-21** lists the number of sites along the river.

Like archaeological sites, built environment resources, and specially designated cultural resources that may be most affected by river flow changes are those immediately along the river corridor. As previously mentioned, built environment resources along the river tend to be more resilient to changes in river flow because they were designed to avoid impacts from shifts in conditions. Using elevations from DEM and other data sources, NRHP-listed and NRHP-eligible built environment resources and specially designated cultural resources that are all or in part within 20 meters (66 feet) of the riverbank and/or above the river itself (such as in the case of bridges) were identified.

Unevaluated built environment resources are treated as eligible for the purposes of analysis. **Table TA 11-22** summarizes these properties.

Table TA 11-21
Representative Number of Sites within 20 Meters (66 Feet) of the River by Reach

Reach	No. of NPS Sites	No. of Sites (non-NPS)	Total
Glen Canyon Dam to Lake Mead	128	43	171
Hoover Dam to Davis Dam	180	78	258
Davis Dam to Parker Dam	N/A	64	64
Parker Dam to Imperial Dam	N/A	16	16
Imperial Dam to the SIB	N/A	2	2

Source: Eddy et al. 2024; Eskenazi 2024; Tremblay et al. 2024b; Winslow et al. 2024

Note: The information presented in this table incorporates NPS and non-NPS data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Table TA 11-22
Built Environment and Specially Designated Cultural Resources within 20 Meters (66 Feet) of the River by Reach

Reach	Resource Name	Status	Property Type
Glen Canyon Dam to Lake Mead	Lee's Ferry and Lonely Dell Historic District	NRHP (Listed)	District
Hoover Dam to Davis Dam	Willow Beach Gauging Station	NRHP (Listed)	Structure
Davis Dam to Parker Dam	Historic U.S. Route 66	NRHP (Listed)	Structure
	National Old Trails Arch Bridge (Topock Bridge)	NRHP (Listed)	Structure
Parker Dam to Imperial Dam	Fisher's Landing	Unevaluated	District
Imperial Dam to the SIB	Southern Pacific Railroad Bridge	Unevaluated	Structure
	Ocean-to-Ocean Highway Bridge	NRHP (Listed)	Structure
	Yuma Crossing and Associated Sites	NHL, NRHP (Listed)	District

Source: Eddy et al. 2024; Eskenazi 2024; Tremblay et al. 2024b; Winslow et al. 2024

Notes: The Hoover Dam to Davis Dam and Davis Dam to Parker Dam reaches exclude Lake Mohave and Lake Havasu, respectively, because these two reservoirs would continue to be operated under their same rule curves for target end-of-month elevations, regardless of modeled scenario. The information presented in this table incorporates data acquired in August 2023 for the Class I records search; therefore, the number of sites and/or their corresponding NRHP status do not reflect current agency databases.

Glen Canyon Dam to Lake Mead

This section references the median and interquartile WY release volumes (in maf) from Glen Canyon Dam illustrated in **Figure TA 3-21** in **Section TA 3.2.3**, Issue 3, with the full statistical

summary presented in **Table TA 3-14** at the end of **TA 3**, Hydrologic Resources. In all categories except the Critically Dry Flow Category, the high end of the results range has been cut off to improve comparisons in the average and drier flow conditions.

Since 2008, WY release volumes from Glen Canyon Dam have been from around 7.0 maf to around 12.5 maf, averaging around 8.7 maf. The annual average release of around 8.7 maf is just over 1.0 maf lower than the average annual releases from 1996 to 2007 of 9.8 maf, which is the result of both hydrologic conditions in the Colorado River Basin and operations under the 2007 Interim Guidelines (see **Section TA 3.1.3**, Lake Powell and Glen Canyon Dam, in **TA 3**, Hydrologic Resources). In general, WY releases from Glen Canyon Dam deviate that fall outside the historical range of around 7.0–12.5 maf have greater potential to impact known cultural resources within 20 meters (66 feet) of the river as well as to undiscovered resources that may be present along the river corridor. In addition, higher WY release volumes can increase erosion along the river corridor, even when releases remain in this historical range. As stated above, impacts from changes in river flow would include water erosion from river currents during higher releases, but may also include exposure from lower water levels where dam release volumes are reduced; however, these impacts are only be considered in terms of this analysis when these volumes are outside past releases or flows.

River flows from Lake Powell to Lake Mead primarily consist of controlled releases from Glen Canyon Dam. WY releases from Glen Canyon Dam under the Wet Flow and Average Flow Categories would generally fall within the range of past annual release volumes for all modeled scenarios. Under wet flow conditions, the median volumes of WY releases range from around 8.4 maf for the CCS Comparative Baseline up to 12.0 maf for the Representative Preferred Alternative. Neither the CCS Comparative Baseline, No Action Alternative, nor the action alternatives (including the Representative Preferred Alternative) have median volumes that fall below 7.9 maf in the Average Flow Category. In terms of interquartile ranges under wetter hydrological conditions, none of the modeled scenarios exceed past release volumes (7.0–12.5 maf). For sites within 20 meters (66 feet) of the river in this reach, it is anticipated that, under wetter conditions, there would be no additional impacts because none of the modeled scenarios deviate outside the established range. This is also true for the one NRHP-listed built environment resource found along this reach because the boundary of the Lees Ferry and Lonely Dell Historic District extends into the river channel.

For the Average Flow Category, the interquartile range for the Enhanced Coordination Alternative is the only modeled scenario that has the potential to deviate the most from the range of past release volumes (7.0 maf up to 12.5 maf), as it is modeled as potentially dropping to around 6.9 maf (25th percentile). Reductions in the volume of WY releases would affect river flows, thereby potentially exposing the Steamboat Charles Spencer. The same drops in river flows, resulting from reduced WY releases from Glen Canyon Dam, would not be detrimental to the only known historic property within 20 meters (66 feet) of the river, as lower water levels would protect the Lee's Ferry and Lonely Dell Historic District from river currents.

For the Critically Dry Flow Category, median WY release volumes for the CCS Comparative Baseline, No Action Alternative, and all action alternatives (including the Representative Preferred Alternative) fall below 7.0 maf, down as low as around 5.1 maf for the Enhanced Coordination

Alternative. Under the critically dry hydrological conditions, the No Action Alternative performs better than the others relative to the upper limits of the interquartile range (75th percentile), which is 8.2 maf, followed by the CCS Comparative Baseline at around 7.7 maf. The Representative Preferred Alternative has one of the narrowest interquartile ranges under critically dry hydrological conditions, with an upper limit around 6.0 maf, which is still below the bottom of the range of past flow volumes at 7.0 maf. All the modeled scenarios could expose the Steamboat Charles Spenser if the reduced volumes of these WY releases cause the river to drop below previous water levels. On the other hand, these same potential drops in river water level would protect the only NRHP-listed property within 20 meters (66 feet) of the river (the Lee's Ferry and Lonely Dell Historic District), as previously discussed.

Hoover Dam to Davis Dam

This section references the median and interquartile CY release volumes from Hoover Dam illustrated in **Figure TA 3-25** in **Section TA 3.2.3**, Issue 3, with the full range of statistical data presented in **Table TA 3-19** at the end of **TA 3**, Hydrologic Resources. In all categories, the high end of the results range has been cut off to improve comparisons in the average and drier flow conditions.

Since 2008, CY releases from Hoover Dam have been from around 8.5 maf to around 9.6 maf, averaging around 9.2 maf (see **TA 3.1.7**, Hoover Dam to Lake Mohave, in **TA 3**). Since the implementation of the 2007 Interim Guidelines, releases from Hoover Dam have decreased to meet monthly elevation targets, resulting in lower river flows through this reach. The 2007 Interim Guidelines have reduced average CY releases from Hoover Dam by approximately 1.0 maf (averaging 9.2 maf). In general, CY releases from Hoover Dam occurring outside the historical range of around 8.5–9.6 maf have greater potential for impacts on known cultural resources within 20 meters (66 feet) of the river as well to undiscovered resources that may be present along the river corridor. The impacts from changes in river flow would include water erosion from river currents during higher releases, but may also include exposure from lower water levels where dam release volumes are reduced; however, these impacts are only considered in terms of this analysis when these volumes are outside past releases that in turn change river flows. Based on these parameters, this section will focus on median and interquartile release volumes (in maf) for analysis and frequently refers to **TA 3**, Hydrologic Resources, where appropriate.

River flows below Lake Mead primarily consist of controlled releases from Hoover Dam. Median CY releases under the Wet Flow Category would remain within the range of past volumes except for the Supply Driven Alternative, with the LB Priority approach around 10.2 maf and the LB Pro Rata approach around 10.4 maf. Under this alternative, the median CY release volumes would exceed 9.6 maf by up to 0.8 maf, potentially causing erosion to sites along the river. Interquartile ranges for the CCS Comparative Baseline and the No Action Alternative are narrow, with the upper range (75th percentile) for both exceeding past CY release ranges at around 10.1 maf while the lower range (25th percentile) stays within past conditions. Similarly for the action alternatives, while the interquartile ranges vary, the upper limits (75th percentile) of all (including the Representative Preferred Alternative) exceed CY releases of 9.6 maf with the LB Pro Rata approach under the Supply Driven Alternative being the highest at around 11.4 maf. Exceeding the range of past CY release volumes (i.e., above 9.6 maf) risks impacting archaeological sites within 20 meters (66 feet) of the river that

have not been previously affected by river flows if releases from Hoover Dam that are above 9.6 maf cause river water levels to also rise within this reach. Depending on these river levels, the substructure of the one NRHP-listed built environment resource (Willow Beach Gaging Station) identified within this reach could be affected, but this structure was designed to withstand changes in historical river flows and was built directly above the river's surface; therefore, impacts are unlikely even under the wet hydrological conditions presented under the different modeled scenarios.

For the Average Flow Category, median CY release volumes for the No Action Alternative is the only modeled scenario that remains within the 8.5–9.6 maf range for previous release volumes below Hoover Dam in this reach at around 8.6 maf. The CCS Comparative Baseline falls just under previous release volumes at around 8.3 maf. The action alternatives do not perform as well, with the median CY release volume for the Basic Coordination Alternative in the Average Flow Category around 8.0 maf, followed by the Representative Preferred Alternative at around 7.9 maf, the Maximum Operational Flexibility Alternative at around 7.8 maf, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) at around and just below 7.7 maf, and the Enhanced Coordination Alternative at just below 7.6 maf. Where impacts on archaeological sites result from erosion caused by moving water, these may be less likely to occur if the reduced CY release volumes cause the river to drop below previous water levels. The same drops in river water levels below Hoover Dam would not be detrimental to NRHP-listed Willow Beach Gaging Station.

For the Critically Dry Flow Category, median CY release volumes would be well below previous volume ranges (i.e., below 8.5 maf) for the CCS Comparative Baseline, No Action Alternative, and all action alternatives, which fall below 8.0 maf, down as low as 6.4 maf for the Maximum Operational Flexibility Alternative, with the Enhanced Coordination Alternative slightly higher at around 6.5 maf. Under the driest hydrological conditions, the No Action Alternative, followed by the CCS Comparative Baseline, performs better than the others relative to the upper limits of their interquartile ranges (75th percentile), which are around 8.6 maf for the No Action Alternative and around 8.3 maf for the CCS Comparative Baseline. The Representative Preferred Alternative has an upper interquartile range limit of around 7.9 maf, which again is below the range past flow volumes (8.5–9.6 maf). Again, relative to impacts to archaeological sites that may be subject to erosion caused by moving water, the modeled scenarios may be less likely to physically affect archaeological sites if the reduced CY release volumes cause the river to drop below previous water levels. Likewise, these same potential drops in river water level would not affect the NRHP-listed Willow Beach Gaging Station previously discussed.

Within this reach is Lake Mohave, which is operated under a rule curve that maintains end-of-month target elevations between 630 feet up to around 646 feet, has been kept relatively constant at around 641 feet since 2008 (see **Section TA 3.1.7**, Hoover Dam to Lake Mohave, in **TA 3**, Hydrologic Resources). Because Lake Mohave would continue to be operated under this rule curve, regardless of scenario, there are no anticipated impacts on any known cultural resources around the reservoir in this portion of the reach.

Davis Dam to Parker Dam

The 84-mile-long reach from Davis Dam to Parker Dam forms Lake Havasu. Davis and Parker Dams are operated under the same rule curve that determines end-of-month target elevations, which are between 445 and 450 feet for Lake Havasu (see **Section TA 3.1.8**, Davis Dam to Lake Havasu, in **TA 3**, Hydrologic Resources). Therefore, no impacts from the CCS Comparative Baseline, the No Action Alternative, nor any of the action alternatives (including the Representative Preferred Alternative) to 64 known archaeological sites within 20 meters (66 feet) of the river between Davis Dam and Parker Dam are anticipated. This is also true for the portions of NRHP-listed Historic U.S. Route 66 or the NRHP-listed National Old Trails Bridge (Topock Bridge) as the only two built environment resources within 20 meters (66 feet) of the river.

Parker Dam to Imperial Dam

Parker Dam releases are scheduled on both a daily and hourly basis, and while the 2007 Interim Guidelines did not specifically target operations of this dam, implementation of these guidelines has resulted in reduced annual release rates (see **Section TA 3.1.9**, Parker Dam to Cibola Gage, in **TA 3**, Hydrologic Resources). Parker Dam annual releases since 2008 have ranged from 6.2 maf to 6.7 maf, averaging 6.4 maf, which represents an average annual decrease of 1.0 maf in volume from the previous pre-2008 average of 7.4 maf. At the end of this reach is Imperial Dam and the Imperial Reservoir, which is operated to maintain a nearly constant elevation to meet water delivery requirements for major diversions to California (All-American Canal) and Arizona (Gila Main Canal) (see **Section TA 3.1.10**, Cibola Gage to Imperial Dam, in **TA 3**, Hydrologic Resources).

Additionally, this reach is characterized by several stretches of mechanically channelized river corridor (particularly through wildlife refuges) and no impacts on the 16 known archaeological sites or the one built environment resource (Fisher's Landing) within 20 meters (66 feet) of the river are expected regardless of flow volume through these areas.

Imperial Dam to SIB

The Colorado River channel is reinforced by a system of levees from Imperial Dam south to the Northerly International Boundary (NIB) and flows through this first portion of this reach are influenced primarily by Imperial Dam releases made for water deliveries. Other factors, like the Laguna Dam and the confluence with the Gila River, also influence river flows in this reach. Implementation of the 2007 Interim Guidelines did not affect the operations or flows in the upper portion of the reach between Imperial Dam and the NIB (see **Section TA 3.1.11**, Imperial Dam to Northerly International Boundary, in **TA 3**, Hydrologic Resources). Because of the levee system from Imperial Dam south to the NIB, there are no anticipated impacts on the two archaeological sites, two built environment resources (Southern Pacific Railroad Bridge and the NRHP-listed Ocean-to-Ocean Highway Bridge) or the Yuma Crossing NHL (also NRHP listed) located within 20 meters (66 feet) of the river.

Just downstream of the NIB is Morelos Dam, which impounds most of the water supply to be diverted to the United Mexican States (Mexico), and is owned, operated, and maintained by Mexico per the 1944 United States-Mexico Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande. Most of the remaining Colorado River water supply that makes it to the Morelos Dam is diverted to Mexico via the Reforma Canal. Thus, the remaining river flows below Morelos Dam to the SIB consist of excess water volumes above Mexico's scheduled delivery

due to Flood Control operations at Hoover Dam, seepage from Morelos Dam and other return/inflows. Morelos Dam operations did not change with the implementation of the 2007 Interim Guidelines because of the required 1.5 maf annual water delivery (see **Section TA 3.1.12**, NIB to SIB, in **TA 3**, Hydrologic Resources). There are no other known cultural resources (aside from Morelos Dam, which is excluded from analysis) between the lower portion of this reach from the NIB to the SIB.

TA 11.2.3 Issue 2: How will changes in dam operations affect sediment availability for aeolian transport to protect archaeological sites in the Grand Canyon?

As discussed above in **Section TA 11.2.1**, the aeolian transport model looks at favorable conditions for wind-born sand to be present to protect archaeological sites over long periods of time using projected vegetation cover and exposed sand area or sandbar volume (Butterfield and Palmquist 2026; Kelley et al. 2026; Salter and Grams 2026). The vegetation and sandbar volume modeling used is from the Marble Canyon sub-reach from Lees Ferry Gaging Station to the Little Colorado River. The exposed sand modeling was conducted for the portion of the river from Lees Ferry to Bright Angel Creek. While these analyses are limited to those reaches, the results provide general insight into sediment and vegetation responses that may also be relevant to other portions of the river corridor with similar geomorphic and hydrologic conditions.

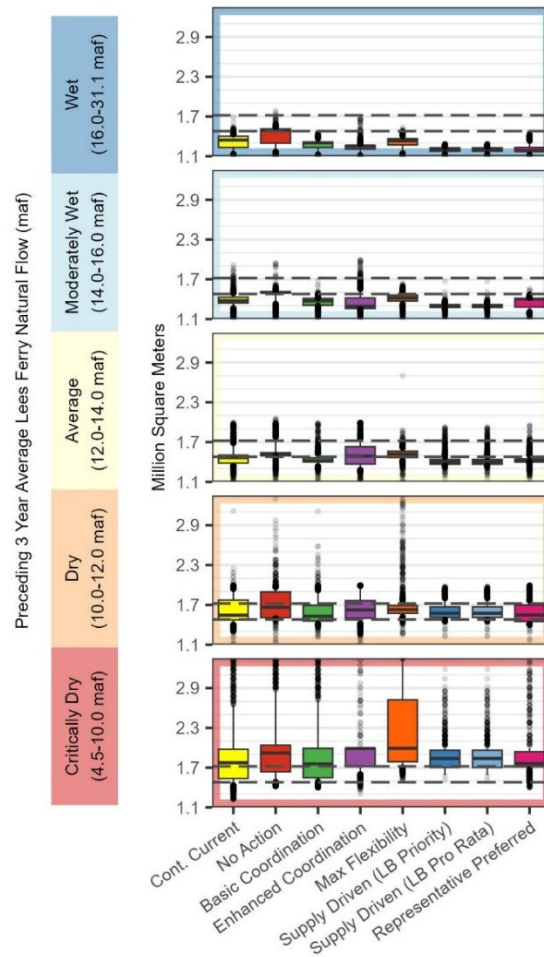
The results of the annual vegetation cover modeling are presented in **TA 9**, Vegetation, Including Special Status Species. Overall, less vegetation is better for aeolian sand transport because it leaves available sand exposed to be picked up by the wind. As discussed in **Section TA 9.2.2**, Issue 1, and seen in **Figure TA 9-14** (see **TA 9**, Vegetation, Including Special Status Species), for all modeled scenarios under the wet and moderately wet conditions, there would be less annual total vegetation cover (below modeled historical conditions, indicated by the dashed line in **Figure TA 9-14**) from higher water levels and longer HFEs. As conditions grow drier, water flows diminish, and HFEs are shorter, annual total vegetation cover thereby increases (see **Figure TA 9-14** in **TA 9.2.2** of **TA 9**, Vegetation, Including Special Status Species). For the Average Flow Category, the median for the CCS Comparative Baseline, the No Action Alternative and all action alternatives (including the Representative Preferred Alternative) is at or just below the modeled historical conditions (i.e., the 2007 Interim Guidelines period [WY 2008–2025]) and the interquartile ranges are relatively small. This indicates that the annual total vegetation may be similar to historical conditions under average flows. Conversely, under the dry and critically dry conditions, annual total vegetation cover increases, and differentiation between alternatives can be seen. For the Critically Dry Flow Category, the medians and interquartile ranges are above the modeled historical conditions (dashed line) for all sub-reaches and all alternatives except the interquartile range for the CCS Comparative Baseline, which drops just below the dashed line (see **Figure TA 9-14** in **TA 9**). This indicates that there may be more annual total vegetation cover, especially under critically dry flows.

The results of the sandbar volume modeling are presented in **TA 5**, Geomorphology and Sediment. As discussed in **TA 5**, for an HFE to be triggered, enough sand needs to be available in Marble Canyon and enough water needs to be available in Lake Powell (as measured by water level), with both the required amounts of sand and water being dependent on the selected HFE duration. Additionally, HFE releases can only be implemented when Lake Powell water levels are at or above

3,500 feet, with sandbar deposition occurring most rapidly during the first 4 days of an HFE event. Lastly, sandbar volume modeling uses the assumption that HFEs are implemented as often as possible (see **TA 5.2.1**, Modeling Criteria and Assumptions). For the aeolian transport model, increased exposed sandbar volume (or the amount of “useable” sand) means more sand is available to protect archaeological sites. In general, as conditions get drier and the amount of water flowing through the river decrease, exposed sandbar volume increases (see **Section TA 5.2.5**, Issue 4, in **TA 5**, Geomorphology and Sediment). Differences in performance among the alternatives also increase as hydrological conditions become drier, with the Enhanced Coordination and Maximum Operational Flexibility Alternatives performing the best for the Critically Dry Flow Category (see **Figure TA 5-12** in **Section TA 5.2.5**).

Figure TA 11-4 shows the results of the WY average of exposed sand area modeling, with the 90th percentile and median (50th percentile) of modeled sand areas depicted as the two dashed lines. As with exposed sandbar volume, increased exposed sand area is beneficial for the aeolian transport of sand to protect archaeological sites. In the Average Flow Category, median exposed sand area is

Figure TA 11-4
Water Year Average of Exposed Sand Area



around the 90th percentile (upper dashed line) and the median (50th percentile, lower dashed line) of modeled sand area (in million square meters). As conditions become drier, all modeled scenarios perform similarly with modeled median exposed sand area above the observed median, with the No Action, Enhanced Coordination, and Maximum Operational Flexibility Alternatives having slightly higher median values than the CCS Comparative Baseline and the other action alternatives, particularly in the Critically Dry Flow Category. Under critically dry conditions, the Maximum Operational Flexibility Alternative has the most variability with the greatest interquartile range.

Figure TA 11-5 shows the results of the aeolian sand modeling in which the percentage of futures meet one of two criteria: either the annual sand area is greater than the median observed sand area over the last 20 years and the vegetation cover area is less than the median observed area over the last 20 years, or the sandbar volume is greater than 1.5 times the initial condition. The highlighted row shows when those conditions are met at least 1 out of every 3 years, which is the optimal time frame for enough sand to be available for aeolian transport based on previous studies.

Figure TA 11-5
Multi-model Aeolian Transport Condition: Robustness
Percent of futures in which annual sand area is >50th and vegetation cover is <50th percentile or sandbar volume is >1.5 times initial condition in the frequency specified in each row



Over the full modeling period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust; they meet the preferred minimum of performance in 19 and 18 percent of futures, respectively, followed by the No Action Alternative only in 14 percent of futures. The Basic Coordination Alternative meets the preferred minimum of performance in only 9 percent of futures, with the Representative Preferred Alternative meeting it in only 6 percent of futures. The

Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the least robust, meeting the preferred minimum of performance in only 3 percent of futures with the CCS Comparative Baseline only slightly higher at 4 percent of futures. If the year interval is lengthened (i.e., to 1 out of 4, 5, or 6 years), the models perform in a similar overall pattern with the Enhanced Coordination Alternative performing the best until reaching the 1-out-of-6-year interval when the No Action Alternative performs the best over the full modeling period.

If the modeling period is broken out for the first 10 years, the No Action Alternative performs the best, meeting the preferred minimum performance in 38 percent of futures for the highlighted interval, followed by the Enhanced Coordination Alternative at 35 percent of futures in the first decadal period (2027–2039), followed by the Maximum Operational Flexibility Alternative at 30 percent of futures. The Basic Coordination Alternative and the CCS Comparative Baseline meet the preferred minimum of performance in 18 percent and 19 percent of futures, respectively, followed by the Representative Preferred Alternative at 17 percent. The Supply Driven Alternative (both the LB Priority and LB Pro Rata approaches) performs with only 9 percent of futures meeting the minimum preferred performance. Due to aeolian transport favoring drier conditions because more useable sand is available and the beginning of the first decadal period (2027–2039) is anticipated to have low reservoir elevations, the modeling for this breakout (2027–2039) depicts more modeled futures meeting the preferred minimum of performance across the CCS Comparative Baseline, the No Action Alternative, and all action alternatives than over the full modeling period. See **Figure TA 11-5** above for robustness modeled for 2040–2049 and 2050–2060 relative to multi-model aeolian transport condition.

The overall results seem to indicate an increase in the percentage of futures over time, which may correlate to increased available sand over time; however, the perceived increase is driven by an increase in sandbar volume over time in the modeling with the understanding that HFEs would continue as planned. In reality, the decision to conduct HFEs depends on annual review and the actual HFE frequency may differ from that assumed or predicted in the modeling.

TA 11.2.4 Summary Comparison of Alternatives

Issue 1: How will any changes in dam operations affect (1) lake elevations at Lake Powell and Lake Mead and (2) river flows downstream, which may affect cultural resources?

Lake Powell and Lake Mead

Because the continual inundation of archaeological sites is more conducive to preservation than repeating cycles of inundation and exposure due to the risks of wave action, changes in lake elevations that may expose previously inundated resources is the biggest concern. As water elevations drop, the elevation at which sites become vulnerable to wet-dry cycling and wave action becomes lower; however, while sites exposed at higher elevations may be less vulnerable to impacts from wet-dry cycling and wave action, they may also have increased ease of access depending on their location. Based on the hydrological models, during the wet hydrological conditions, median elevations at Lake Powell are projected to stay around or above 3,640 feet for all modeled scenarios. As conditions become drier, the Enhanced Coordination and Maximum Operational Flexibility Alternatives perform the best in the Average Flow Category, with median water elevations from around 3,600 feet to around 3,630 feet relative to average hydrological conditions. They also

perform best in the Critically Dry Flow Category; however, the projected medians are between 3,510 feet and 3,560 feet for these two action alternatives, potentially leaving (at minimum) between 316 and 381 archaeological sites and any undiscovered sites above these elevations exposed. Under critically dry conditions, the Representative Preferred Alternative has median water levels from just above 3,490 feet (minimum WY), up to just below 3,510 feet (EOWY), which has the potential to leave up to 415 sites exposed above 3,500 feet, but would inundate more sites if they are present above the minimum power pool elevation of 3,490 feet.

For Lake Mead, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) performs best over in both the Average Flow and Critically Dry Flow Categories, followed by the Enhanced Coordination and Maximum Operational Flexibility Alternatives. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) have projected median elevations between 1,140 feet and 1,160 feet under average hydrological conditions, while the Enhanced Coordination and Maximum Operational Flexibility Alternatives have median elevations between 1,100 feet and 1,130 feet, respectively. Higher reservoir levels means that more sites are inundated as opposed to exposed at lower reservoir levels. The Representative Preferred Alternative has median water levels of around 1,080 to 1,090 feet, exposing between 265 and 275 known archaeological sites as well as any undiscovered sites present above these elevations relative to average hydrological conditions. For the Critically Dry Flow Category, all scenarios would result in the exposure of at least 306 archaeological sites (all but four in the Lake Mead dataset) and any undiscovered sites that may be present based on median water levels; however, the LB Pro Rata approach under the Supply Driven Alternative has the potential to expose the fewest number of known sites (286) with median elevations up to around 1,030 feet. The Representative Preferred Alternative has median water levels from around 980 feet to around 990 feet, potentially leaving up to 301 archaeological sites (and any undiscovered sites present) exposed during critically dry conditions.

For preservation risk, the Enhanced Coordination Alternative is the most robust for Lake Powell, with 47 percent of the modeled futures over the full modeling period meeting the 2.72 threshold, followed by the Maximum Operational Flexibility Alternative with 28 percent of futures. This relational pattern is consistent if the full modeling period is broken out into shorter ranges, including the first decadal period (2027–2039) where the Enhanced Coordination Alternative also performs the best at 30 percent of futures, followed again by the Maximum Operational Flexibility Alternative at 25 percent of futures. The Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is the most robust for Lake Mead, meeting the 2.24 risk threshold in 24 percent of the modeled futures over the full modeling period, followed by the Maximum Operational Flexibility Alternative with 19 percent of futures. When examining the first decadal period (2027–2039) at Lake Mead, the percentage of futures meeting the preferred minimum of performance drops drastically. This is because the anticipated water levels for Lake Mead in 2027 are expected to be low and for this reason, robustness modeling shows a substantial drop in performance. For this first 10-year period, the Supply Driven Alternative (both LB Priority and LB Pro Rata) continues to perform the best, but only at 5 percent of futures, followed by the CCS Comparative Baseline, the Maximum Operational Flexibility Alternative, and the Representative Preferred Alternative, all three of which meet the preferred level of performance in only 3 percent of futures.

Overall, for Lake Powell, the Enhanced Coordination and the Maximum Operational Flexibility Alternatives perform better in drier conditions and have the greatest potential to expose fewer archaeological sites and protect more through inundation. For the preservation risk model results, this is true for the full modeling period or for the first decadal period (2027–2039); however, the percentage at which the threshold of 2.72 for Lake Powell is met declines drastically approaching critically dry conditions for the first 10-year period.

For Lake Mead overall, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) followed by the Enhanced Coordination and Maximum Operational Flexibility Alternatives perform better in drier conditions. This can be seen in the results from the preservation risk model for the full modeling period; however, for the first 10-year period (2027–2039) the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) is followed closely by the CCS Comparative Baseline, the Maximum Operational Flexibility Alternative, and the Representative Preferred Alternative under critically dry conditions. Overall, preservation risk for the Representative Preferred Alternative falls in the middle for both lakes compared to the other modeled scenarios as conditions become drier. The No Action and Basic Coordination Alternatives have the greatest potential to expose the most archaeological sites (thereby protecting the fewest sites) at both lakes.

River Flows

For the reaches between Glen Canyon Dam and Lake Mead and Hoover Dam to Lake Mohave, in the Wet and Average Flow Categories, all modeled scenarios generally fall within the ranges of past release volumes. However, in the Critically Dry Flow Category, the median WY release volumes all fall below 7.0 maf for the reach below Glen Canyon Dam, with the Enhanced Coordination Alternative falling to 5.1 maf. The Representative Preferred Alternative has the narrowest interquartile range under critically dry hydrological conditions, with the upper limit at around 6.6 maf, which is still below the bottom of the range of past flow volumes at 7.0 maf. Below Hoover Dam, median CY release volumes all fall at or below 8.0 maf, with the Representative Preferred Alternative at around 7.2 maf. The Enhanced Coordination and Maximum Operational Flexibility Alternatives have the poorest performance, falling as low as 6.4 maf for CY releases. Therefore, under the Critically Dry Flow Category, there is greater potential for sites to be impacted by fluctuating water levels; however, any impacts, if they occur, would be to those sites closest to the riverbanks.

Below Davis Dam, little to no impacts, regardless of flow category, are expected. This is because the dams below Lake Mohave are operated under guidelines that maintain lake elevations or target water deliveries. Also, they have several stretches of channelized banks.

Issue 2: How will changes in dam operations affect sediment availability for aeolian transport in the Grand Canyon?

Based on the aeolian transport model for the full modeling period, the Enhanced Coordination and Maximum Operational Flexibility Alternatives would have the best outcome for increasing the availability of sand for wind transport to protect archaeological sites. Both alternatives have a similar percentage of futures meeting the minimum preferred performance in at least 1 out of every 3 years at 19 and 18 percent, respectively. Although this is a small percentage, the two alternatives perform

better than the No Action, Basic Coordination, the Representative Preferred, and the Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives as well as the CCS Comparative Baseline, which all have values at 9 percent or lower. This changes, however, when examining the first decadal period (2027–2039) where the No Action Alternative performs the best, meeting the preferred minimum performance in 38 percent of futures, followed by the Enhanced Coordination Alternative at 35 percent and the Maximum Operational Flexibility Alternative at 30 percent in 1 out of every 3 years. The Basic Coordination Alternative, CCS Comparative Baseline, and Representative Preferred Alternative perform similarly at 19 percent, 18 percent, and 17 percent, respectively, but all still notably perform more poorly than the No Action and Enhanced Coordination Alternatives. The Supply Driven Alternative (both the LB Priority and LB Pro Rata approaches) performs the worst, meeting the preferred minimum performance in only 9 percent of futures.

TA 11.3 References

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