Technical Appendix 14

Recreation

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Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Final EIS	2007 Interim Guidelines Final Environmental Impact Statement
°C	degrees Celsius
°F	degrees Fahrenheit
CCS	Continued Current Strategies
cfs	cubic feet per second
DMDU	decision making under deep uncertainty
Draft EIS	Draft Environmental Impact Statement
FWS	United States Fish and Wildlife Service
GCNP	Grand Canyon National Park
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
LTEMP	Long-Term Experimental and Management Plan
NIB	Northerly International Boundary
NPS	National Park Service
NRA	National Recreation Area
NWR	National Wildlife Refuge
Reclamation	Bureau of Reclamation
RM	river mile
SEIS	supplemental environmental impact statement
SIB	Southerly International Boundary
UDOT	Utah Department of Transportation

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TA 14. Recreation

TA 14.1 Affected Environment

This Draft Environmental Impact Statement (Draft EIS) identifies and describes in detail the following key recreation resources or issues:

- Shoreline public use
- Reservoir boating
- River and whitewater boating
- Sport fishing

TA 14.1.1 Shoreline Public Use

The following sections describe shoreline public use associated with boating facilities (marinas, boat docks, and boat launch ramps), access to points of interest, and other opportunities within each Colorado River reach. Recreational boating in the study area depends on these major shoreline access points. While fluctuations in pool elevations are a normal aspect of reservoir operations, increased frequency or severity of these variations could result in changes in recreational facility operation costs and temporary closures. Below critical pool elevations and river flows, certain facilities may be rendered inoperable or require relocation to maintain operation.

Lake Powell and Glen Canyon Dam

Lake Powell is entirely within the Glen Canyon National Recreation Area (NRA), which receives approximately three to five million visitors each year (NPS 2025a). **Table TA 14-1** summarizes visitation to Glen Canyon NRA from 2019 through 2024.

Table TA 14-1
Glen Canyon NRA Recreational Visitors

Year	Recreational Visitors
2019	4,330,563
2020	2,553,392
2021	3,144,318
2022	2,842,776
2023	5,206,934
2024	4,725,610

Source: NPS 2025a

Table TA 14-2 summarizes the total number of recreation visits to Glen Canyon NRA by district for 2024, the most recent year for which data are available.

Table TA 14-2
Glen Canyon NRA Visits by District for 2024

District	Recreational Visitors
Wahweap District	1,612,518
Antelope Point District	532,202
Bullfrog District	101,627
Halls Crossing District	139,234
Hite District	261,725
Lees Ferry District	2,065,278
Horseshoe Bend District	831,631
Escalante District	13,029

Source: NPS 2025b

Lake Powell, with its many side canyons and related natural, cultural, and geologic resources, is the primary recreation feature of Glen Canyon NRA. Recreation that occurs at Lake Powell includes swimming and sunbathing, power boating, waterskiing, fishing, off-beach activities associated with boat trips (such as hiking and exploring archaeological sites), house boating, personal watercraft use, canoeing, kayaking, sailing, wildlife viewing, photography, sightseeing, and other activities. Visitors can enjoy a wide range of camping options, from remote and undeveloped campsites to fully developed campgrounds. Visitors can also see archaeologically and culturally important sites throughout the Glen Canyon NRA.

Boating Facilities

Recreational boating is the most important recreational activity on Lake Powell, with nearly two million visitors accessing the reservoir by either private boat or rental (NPS 2025c). **Table TA 14-3** lists critical lake elevations for Lake Powell, identified by the National Park Service (NPS), below which certain marinas, boat docks, or boat launch ramps become inoperable. Water-based recreational facilities at Lake Powell include the marinas at Wahweap, Halls Crossing, Bullfrog, and Antelope Point. Declining water levels have rendered the Dangling Rope Marina inoperable since 2021, which was once the busiest gas station in Utah despite having no roads that led there because it was the only place to refuel in the middle of the lake. The Hite Launch Ramp has also been closed since 2012 due to the ramp being out of the water as a result of low reservoir levels (NPS 2025d).

Changes to the shoreline affect the usability of boat launch ramps throughout the year, especially in warmer months. Launch ramp closures due to declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks (NPS 2025d).

Table TA 14-3
Critical Elevations for Lake Powell by Boating Facility

Lake Elevation (feet)	Impact and Facility
3,700	Full pool
3,650	Hite Public Launch Ramp closed
3,520	Wahweap Stateline Auxiliary Launch Ramp closed
3,588	Antelope Point Public Launch Ramp closed
3,583	Castle Rock Cut closed
3,565	Utah Department of Transportation (UDOT) Ferry and Launch Ramp closed
3,578	Bullfrog Main Launch Ramp closed
3,564	Wahweap Stateline Launch Ramp closed
3,540	Antelope Point Business Ramp closed
3,556	Hall's Crossing Main Launch Ramp closed
3,550	Wahweap Main Launch Ramp closed
3,578	Bullfrog Main Launch Ramp Spur closed
3,550	Rainbow Bridge National Monument closed
3,529	Bullfrog North Launch Ramp closed
3,515	Antelope Marina closed; Bullfrog Marina closed; Hall's Crossing Marina closed
3,430	Wahweap Boat Rental closed; Wahweap Boat Tour Dock closed

Source: Nicole Gibney, Assistant Colorado River Coordinator, NPS, personal communications, May 15, 2024

In 2022, the NPS received $26 million in Disaster Supplemental Funding to provide additional boating access at Lake Powell. Design work is underway for a North Lake Powell ramp that provides access down to an elevation of 3,450 feet in the Stanton Creek area, near Bullfrog. The NPS is also working to develop schematic designs for the Antelope Point Public Ramp, Halls Crossing Public Ramp, and a primitive ramp and take-out area at the Hite Marina. The NPS continues to seek funding necessary for potential reconstruction. The NPS is also continuing to seek funds to replace the services previously offered at Dangling Rope Marina, and a Navigable Waterway Congestion Study in South Lake Powell (NPS 2023a).

State Route 276 runs through Glen Canyon NRA and crosses Lake Powell via the Charles Hall Ferry, which is operated by UDOT. The ferry's southern port is at Hall's Crossing and the northern port is at Bullfrog. The ferry does not operate if Lake Powell elevation levels drop below 3,565 feet in elevation (UDOT 2025).

Access to Points of Interest

Since 2021, the courtesy dock access to the Rainbow Bridge National Monument trail has been intermittently unavailable due to changes in water level. When water levels fall below 3,544 feet, visitors have to leave boats and small vessels at the shoreline and traverse through mud, debris, sand, and water before reaching the established trail. While no longer connected to the shoreline, the Rainbow Bridge dock system is accessible with restroom facilities. The concessionaire-operated

tours to the monument are no longer able to access the area, thus removing access for most Glen Canyon NRA visitors. Visitors can also access Rainbow Bridge National Monument by obtaining a permit from the Navajo Nation Parks and Recreation Department to backpack for multiple days on Navajo Tribal lands from Navajo Mountain; however, this is not possible for many visitors (NPS 2021).

Harmful Algal Blooms

Warming water temperatures and increased inputs of nutrients from monsoonal storms create conditions that are more conducive to harmful algal bloom growth. Harmful algal blooms produce toxins that pose serious health risks to humans and animals (NPS 2019). Harmful algal blooms may necessitate temporary closures of water-based recreation in order to protect public health (Deemer et al. 2023). Water quality concerns are described in detail in **TA 6**, Water Quality.

Quagga Mussel Shells on Shorelines

Quagga mussels were first detected at Lake Powell in 2012. Quagga mussels have colonized practically all areas of the lake, as indicated by water sampling for veligers (NPS 2023b). Seasonally low water levels are now exposing mussel-encrusted shoreline. Sharp Quagga mussel shells eventually wash up on beaches and can cut through skin, clothing, and pet paws (NPS 2016).

Hiking and Sightseeing in Glen Canyon

Declining water levels have exposed approximately 100,000 acres of Glen Canyon that were previously inundated by Lake Powell, creating new opportunities to view landscapes that have been underwater since the late 1960s (Baker 2022; Kolbert 2021). These include arches, side canyons, other rock formations, and lush desert ecosystems. This has created new hiking and sightseeing opportunities for Glen Canyon NRA visitors over the last several years. At the same time, these landscapes and archaeological sites are fragile, and exposure could result in their degradation and vandalism.

TA 14.1.2 Glen Canyon Dam to Lake Mead

The 15.5-mile river reach downstream of Glen Canyon Dam to Lees Ferry is within Glen Canyon NRA; it is used by anglers, campers, commercial float trip operators, kayakers, and other boaters. Fishing opportunities for rainbow and brown trout also occur downstream of this reach. In the last five years, warming water temperatures have made this reach more attractive for day and overnight use by paddle boarders, kayakers, and canoeists, resulting in increased visitation.

The NPS manages most of the reach, except where it is bordered on the east by the Navajo Indian Reservation and on the south by the Hualapai Indian Reservation. Grand Canyon National Park (GCNP) staff regulates visitor use of the Colorado River downstream of Lees Ferry in accordance with the Colorado River Management Plan (NPS 2006a, 2006b).

GCNP begins downstream of the Lees Ferry boat ramp at the confluence of the Colorado and Paria Rivers. Designated as a United Nations Educational, Scientific and Cultural Organization World Heritage Site in 1979, the GCNP is valued for its superlative natural and cultural resources as well as its varied recreational experiences. Approximately 94 percent of GCNP (1,143,918 acres) qualifies as wilderness, as described in the 1964 Wilderness Act (Public Law 88-577) and NPS Management

Policies 2006 (NPS 2006b). This includes 10,919 acres of potential wilderness along the Colorado River corridor.

The Colorado River corridor borders tribal lands for nearly half the distance from the put-in at Lees Ferry to the last takeout at Pearce Ferry. The Navajo Indian Reservation borders GCNP along the eastern bank of the Colorado River from near Lees Ferry to the confluence with the Little Colorado River at river mile (RM) 61.8. The Hualapai Indian Reservation borders the river corridor for approximately 108 miles from upstream of National Canyon (RM 167) to approximately RM 274. The Hualapai Indian Reservation offers camping, fishing, hiking, and big game hunting. Tribal enterprises offer rafting trips on the Colorado River between Diamond Creek and Pearce Ferry. The NPS coordinates with tribal neighbors to address resource management and visitor use concerns along shared boundaries. Access permits from the Navajo Nation, Havasupai Tribe, or Hualapai Tribe are required by each respective Tribe to access and recreate on Tribal lands.

GCNP receives 4 to 6 million visitors each year (NPS 2025e). **Table TA 14-4** summarizes visitation to GCNP for the most recent 6 years.

Table TA 14-4
GCNP Recreational Visitors

Year	Recreational Visitors
2019	5,974,411
2020	2,897,098*
2021	4,532,677
2022	4,732,101
2023	4,733,705
2024	4,919,163

Source: NPS 2025e
*Park closure April–May due to the COVID-19 pandemic

The Lees Ferry to Diamond Creek reach has relatively low use densities (attributed to the competitive lottery system) and low levels of development, providing opportunities for solitude on the Colorado River, as well as at many camps and attraction sites. This section of the Colorado River is where the majority of whitewater boating occurs. Takeouts are at Diamond Creek and Pearce Ferry. The reach downstream of Diamond Creek offers different recreational opportunities than the upstream reach, as it transitions to a more populated, developed setting. Whitewater boating trips become intermingled with very high levels of general boating and recreation use in the Quartermaster area (RM 260). **TA 16**, Socioeconomics, describes the social and economic importance of whitewater boating in the Grand Canyon.

Helicopter operations authorized by the Hualapai Tribe transport people into the Grand Canyon and connect them with motorized pontoon boats that give 20-minute tours of the Quartermaster area. These same helicopters provide a dual service in flying out boaters who have traveled from Diamond Creek on commercial motor day trips.

Boating Facilities

No boating facilities are within GCNP. Development along the Colorado River within the park is limited to the development at Phantom Ranch (RM 88) and Pipe Creek (RM 89.5). Other focal points include the launch ramp at Lees Ferry (within Glen Canyon NRA), the helipad near Whitmore Wash (RM 187) on the Hualapai Reservation, road access and minor structures operated by the Hualapai Tribe at Diamond Creek (RM 226), and the tourist area near Quartermaster Canyon (RM 260).

Camping between the Lees Ferry boat ramp and Lake Mead occurs in GCNP on undeveloped sandbars along the Colorado River. The number and usability of campsites diminish between depositional High Flow Experiments, due to vegetation encroachment; sandbar erosion from hydropeaking operations, erosion from tributary flooding, aeolian sand remobilization, and recreation use. Sites can also be closed to protect sensitive resources (NPS 2006a). Further information on sedimentation and beach building can be found in **TA 5**, Geomorphology and Sediment. Of the 276 campsites referenced in Section 3.12.1.1 of the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement (2007 Final EIS), 195 sites (71 percent) are still classified as "camps"; 68 sites (25 percent) have been classified as "noncamps" due to sand erosion, vegetation overgrowth, or both; 2 sites could not be ascertained based on the float-by methodology used during the November 2022 NPS Colorado River Management Plan monitoring trip; and 10 campsites were not evaluated (Kearsley 2023).

TA 14.1.3 Lake Mead and Hoover Dam

Lake Mead NRA encompasses 1.5 million acres. It encompasses the 110-mile-long Lake Mead, the 67-mile-long Lake Mohave, the surrounding desert, and the isolated Shivwits Plateau in Arizona. Recreation such as camping, boating, fishing, and hiking occurs on upper Lake Mead. The Overton Wildlife Management Area provides opportunities for wildlife viewing and photography, waterfowl and upland game bird hunting, hiking, and fishing. The Overton Wildlife Management Area averages 4,226 annual visitor use days (Nevada Department of Wildlife, personal communication, 2023).

Lake Mead NRA extends along the lower Colorado River from the western border of GCNP to Davis Dam. Primary recreational activities on Lake Mead include cruising/sailing, personal watercraft usage, waterskiing, fishing, and swimming. A number of campgrounds and picnic areas, including Boulder Beach, Calville Bay, Echo Beach, Las Vegas Bay, and Temple Bar, provide additional recreational opportunities. Lake Mead NRA had approximately 6.4 million visitors in 2024 (NPS 2025f).

Table TA 14-5 summarizes recreational visits to LMNRA for the last 6 years.

Table TA 14-5
Lake Mead NRA Recreational Visitors

Year	Recreational Visitors
2019	7,499,049
2020	8,016,510
2021	7,603,474
2022	5,578,226
2023	5,798,541
2024	6,412,854

Source: NPS 2025f

Water quality concerns are increasing and are described in detail in **TA 4**, Water Quality. In the spring and summer of 2015, Lake Mead experienced notable concentrations of harmful blue-green algae, which triggered harmful algal bloom advisories for various locations across the lake (NPS 2023b). In 2022, a swimmer was fatally infected with a brain-eating amoeba (*Naegleria fowleri*) at Lake Mead. Brain-eating amoebas are commonly found in bodies of warm freshwater, such as lakes, rivers, and geothermal water (NPS 2022). These trends may continue to increase as water temperatures warm.

Declining reservoir elevations at Lake Mead in recent years have exposed mudflats along several areas of the shoreline. These have created dangerous conditions where recreationists have periodically become stuck in wet, muddy deposits. Some of these areas have access roads that previously enabled visitors to drive close to the shoreline when reservoir elevations were higher. As reservoir elevations have declined over recent years, visitors have often attempted to chase the shoreline both in their vehicles and on foot to gain access to the changing shoreline for such purposes as fishing, hiking, and other recreational activities. In doing so, they and their vehicles have created unauthorized vehicle routes toward the lowering water levels, and become stuck in these muddy conditions, requiring assistance from NPS personnel and others to extract themselves and/or their vehicles.

Boating Facilities

Lake Mead NRA is considered one of the nation's premier water-based recreation areas. Most visitors participate in water-based recreational activities, primarily between May and September. These recreational activities are supported by marina and launch ramp facilities developed along the Lake Mead shoreline. On average, the majority of boats are personal watercraft. Water-based recreational facilities at Lake Mead are located at Callville Bay, Hemenway Harbor, Temple Bar, Echo Bay, South Cove, and Pearce Ferry boat ramps. Pearce Ferry is used as a take-out by Colorado River boaters. **Table TA 14-6** shows critical elevations identified by the NPS for Lake Mead, below which marinas, boat docks, or boat launch ramps become inoperable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, is closed at 1,175 feet. This results in rafts and other whitewater boats having to continue downstream to South Cove, an additional 16 miles.

Table TA 14-6
Critical Elevations for Lake Mead by Boating Facility

Lake Elevation (feet)	Impact and Facility
1,221	Full pool
1,075	Boulder Harbor closed
1,035	South Cove Ramp closed
1,000	Echo Bay public launch ramp closed
950	Hemenway Harbor public launch ramp closed; Callville Bay public launch ramp closed; Temple Bar public launch ramp closed

Source: Source: Nicole Gibney, Assistant Colorado River Coordinator, NPS, personal communications, May 15, 2024, December 3, 2024, and December 10, 2025

Since the publication of the 2007 Final EIS, the Echo Bay, Boulder Harbor, and South Cove boat ramps have closed due to low water levels. The NPS facilities at the Temple Bar Marina are also inoperable; however, the concessionaire launch operations remain operable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, previously closed at elevation 1,175 feet. Access to Lake Mead was closed at Pearce Ferry in 2001 when the water elevation dropped to 1,175 feet. In 2010, the NPS extended Pearce Ferry Road 2 miles to the Colorado River to provide for river take-out operations for private and commercial river runners (NPS 2010).

Changes to water levels affect the usability of the remaining boat launch ramps throughout the year, especially in warmer months. Launch ramp closures due to declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks. In addition, ongoing maintenance and construction at ramps have resulted in temporary closures.

TA 14.1.4 Hoover Dam to Davis Dam

Visitation and recreational use at Lake Mohave have increased in response to more variable Lake Mead levels and the closure of associated boating infrastructure. Recreational opportunities at Lake Mohave include boating, canoeing on the northern parts of the lake, camping, exploring, fishing, photography, picnicking, swimming, parasailing, and water skiing. There are also hundreds of beaches accessible only by boat. As with Lake Mead, harmful blue-green algal blooms occurred at Lake Mohave in 2015, leading to advisories for multiple locations across the lake (NPS 2023b).

The main shoreline access points for Lake Mohave are Katherine Landing, Cottonwood Cove, and Willow Beach. Facilities for public use and boat launching are located at Katherine's Landing in Arizona near Davis Dam, and at Cottonwood Cove, east of Searchlight, Nevada. Boats and jet skis can be rented at both locations. Public campgrounds are available at both locations, where concessionaires provide trailer parks, restaurants, lodging, docking facilities, boat and fishing tackle equipment, and fishing licenses. Facilities for public use and boat launching are also located at Willow Beach, 31 miles upstream on the Arizona shore.

TA 14.1.5 Davis Dam to Parker Dam

The Davis Dam to Parker Dam reach includes several recreational areas along the Colorado River, including Laughlin, Bullhead City, Davis Camp, Needles, Havasu National Wildlife Refuge (NWR),

Lake Havasu State Park, and Bill Williams River NWR. Relevant recreation areas are briefly described in the following sections.

Davis Camp. Davis Camp contains a campground and day use area, has boat launching facilities, picnic areas, numerous campsites, and recreational vehicle hookups. Davis Camp offers many river-oriented recreational opportunities, including fishing and water sports.

Havasu NWR. The Havasu NWR, managed by the United States Fish and Wildlife Service (FWS), covers 30 RMs (300 miles of shoreline) from Lake Havasu City, Arizona, to Needles, California. Typical activities include canoeing, fishing, boating through the scenic Topock Gorge, and hiking in the Havasu Wilderness Area. The 4,000-acre Topock Marsh offers excellent canoeing, fishing, and birdwatching. Other activities offered by the Havasu NWR include camping and hunting.

Lake Havasu State Park. Lake Havasu, formed by Parker Dam, contains several coves and inlets, and is a popular spot for fishing. The waters of Lake Havasu are also used for canoeing, houseboating, jet-skiing, kayaking, sailing, speedboating, swimming, and water-skiing. Camping and hiking also occur along the more than 400 miles of the lake's shoreline. Additional visitor opportunities include viewing the London Bridge. Lake Havasu is a popular spring break and family vacation destination.

Lake Havasu is the premier attraction area within the Davis Dam to Parker Dam reach. **Table TA 14-7** lists the visitation for the last six years at Arizona's Lake Havasu and Cattail Cove State Parks.

Table TA 14-7
Visitation at Arizona's Lake Havasu and Cattail Cove State Parks

Year	Lake Havasu State Park Visitation	Cattail Cove State Park Visitation
2019	488,597	111,262
2020	598,403	116,822
2021	492,074	95,179
2022	494,318	86,385
2023	484,716	79,978
2024	468,535	83,992

Source: Arizona Hospitality Research and Resource Center, 2025

Bill Williams River NWR. The Bill Williams River NWR, managed by the FWS, is located along the Bill Williams River near its confluence outlet into Lake Havasu. The refuge offers a variety of recreational opportunities, including hiking, birdwatching, and other wildlife viewing. Hunting is permitted for dove, cottontail, quail, and desert bighorn sheep. Other activities include boating and fishing.

Boating Facilities. The Davis Dam to Park Dam reach includes shoreline public use facilities at Laughlin, Bullhead City, Davis Camp, Needles, Havasu NWR, Lake Havasu State Park, and Bill

Williams NWR. Recreational activities within this reach include canoeing, fishing, houseboating, jet-skiing, kayaking, sailing, speed-boating, swimming, and water-skiing.

TA 14.1.6 Parker Dam to Cibola Gage

The Parker Dam to Cibola Gage reach includes several recreational areas, including Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and Cibola NWR. Brief descriptions of relevant recreational areas located on this reach are below.

Parker Strip Recreation Area. The Parker Strip Recreation Area includes an 11-mile road along the Colorado River. Recreational activities include boating, camping, fishing, hiking, rock hounding, swimming, and wildlife viewing.

Palo Verde Diversion Dam. There are approximately 95 miles of navigable waters between Imperial Dam downstream of Yuma and Palo Verde Diversion Dam upstream of Blythe. Activities include canoeing, fishing, hunting, power boating, and other water sports.

Cibola NWR. The Cibola NWR, including Cibola Lake, is managed by the FWS and located about 15 miles south of Blythe. Visitors to the refuge engage in canoeing, fishing, hiking, hunting, photography, and wildlife viewing.

Boating Facilities. The Parker Dam to Cibola Gage reach includes shoreline public use facilities at Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and Cibola NWR. Typical water activities within this reach include canoeing, power boating, fishing, swimming, and other water sports.

TA 14.1.7 Cibola Gage to Imperial Dam

The Cibola Gage to Imperial Dam reach includes a few recreational areas: Picacho State Recreation Area, Imperial NWR, and Martinez Lake. Brief descriptions of these recreational areas follow.

Picacho State Recreation Area. This area is popular for camping, desert exploring, river running, and sport fishing. It received approximately 10,763 visitors in 2022 (including day and overnight use) (California State Parks 2024), and has a group boat-in area, three individual boat-in camp areas, and large group camping areas. Birdwatching and small-game hunting for doves, ducks, and quail are among other recreation opportunities.

Imperial NWR. Recreational opportunities at the Imperial NWR include canoeing, fishing, and hunting. Boaters value the refuge for its remote scenery.

Martinez Lake. Martinez Lake, which adjoins the Imperial NWR, offers opportunities for fishing, birdwatching, boating, hunting, rock hounding, sightseeing, and water skiing.

Boating Facilities. The Cibola Gage to Imperial Dam reach includes shoreline public use facilities at Picacho State Recreation Area, Imperial NWR, and Martinez Lake. Typical water activities within this reach include river running, boating, canoeing, water-skiing, and sport fishing.

TA 14.1.8 Imperial Dam to NIB

The Imperial Dam to the Northerly International Boundary (NIB) reach includes a few recreational areas along the Colorado River, including Betty's Kitchen and Mittry Lake Wildlife Area. Brief descriptions of these recreation areas are included below.

Betty's Kitchen. This 10-acre wildlife interpretative area provides birdwatching and fishing opportunities.

Mittry Lake Wildlife Area. Mittry Lake, within the Mittry Lake Wildlife Area, covers approximately 600 acres and provides small game hunting and sportfishing opportunities. There is a three-lane boat launch ramp for motorized boating on the lake. The area is also popular for birdwatching and nature study.

Boating Facilities. The Imperial Dam to the NIB reach includes shoreline public use facilities, including a public fishing pier at Betty's Kitchen and a boat launch ramp for motorized boating and fishing jetties at Mittry Lake Wildlife Area. Typical water activities within this reach include boating, swimming, and sport fishing.

NIB to SIB

The NIB to the Southerly International Boundary (SIB) reach includes shoreline public use facilities in the city of Yuma, Arizona. Typical water activities within this reach, which is located on the edge of the historical floodplain to the east of the Colorado River, include boating, swimming, and sport fishing.

TA 14.1.9 Reservoir Boating

Reservoir boating is affected by fluctuating reservoir elevations; these fluctuations specifically alter exposure to boating navigation hazards and safer boating capacities. Hazards such as exposed rocks may become more evident, and changes in navigation patterns may be necessary as reservoir elevations decline. At low-pool elevations, special buoys or markers may be placed within reservoirs to warn boaters of navigation hazards. In addition, signs may be posted in areas deemed unsuitable for navigation.

Near Hite, a delta has formed that can affect river boaters coming into Lake Powell at low-pool elevations. River boaters from the Colorado River row or motor through Lake Powell to a location where a boat transports them 20 to 25 miles to the Hite Marina. At low elevations, the river boaters must travel further downstream to reach a location accessible to the transport company's boat. Although this results in more miles to the take-out, there is usually enough current in the river to carry the boats. At lower elevations, additional rapids are exposed in Cataract Canyon. Lower Lake Powell elevations may create additional navigational hazards due to restricted channel widths and subsurface conditions.

Lake Powell

Safe boating navigation. The navigation system on Lake Powell utilizes regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface

obstructions or changes in subsurface conditions that could be hazardous for safer passage. Placement of many of these marking devices depends on the lake elevation.

Safe boating capacity. Recreational boating is the most frequent type of boating activity on Lake Powell. One of the most popular activities at Lake Powell is taking out houseboats and motorboats for multiple day excursions to explore the reservoir. At full pool elevation for Lake Powell (3,700 feet), its operating surface area is 160,782 acres. Using boating capacity at full pool elevation is approximately 17,865 boats at one time. As the pool elevation decreases, the surface area suitable for boats and navigability also decreases.

Lake Mead

Safe boating navigation. Regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels.

Excursions from Lake Mead into the Grand Canyon are a popular activity. Boats entering the Grand Canyon usually launch at Pearce Ferry, South Cove, or Temple Bar. Many boaters include overnight camping on these excursions.

The upper arms and inflow areas of Lake Mead may be difficult to navigate due to shifting subsurface sediments. Over the years, sediment has built up in the section of the reservoir between Grand Wash and Pearce Ferry. When Lake Mead elevations drop below 1,170 feet, the sediment is exposed as mud flats, and there is no well-defined river channel. As a result, the area is too shallow for motorboats to navigate upstream and into the lower reaches of the Grand Canyon. With fluctuating flows, even smaller crafts may have difficulty accessing the area due to the shifting channel. Based on this information, elevation 1,170 feet is considered a threshold elevation for safer boating navigation for the upper end of Lake Mead.

Since the publication of the 2007 Final EIS, the NPS has extended the Pearce Ferry launch ramp to provide river take-out operations for private and commercial river runners. However, due to the close proximity of the developing Pearce Ferry Rapid, the public launch of boats is prohibited (NPS 2010).

Safe boating capacity. Since the pool elevation has decreased since the publication of the 2007 Final EIS, the safer boating capacity at Lake Mead has subsequently decreased.

Lake Mohave and Lake Havasu

Because Lake Mohave and Lake Havasu will continue to be operated to meet monthly target elevations, reservoir boating, safer navigation, and capacity in these reaches will not be affected by the alternatives beyond trends previously described.

TA 14.1.10 River and Whitewater Boating

Whitewater boating is the key recreational activity in the Grand Canyon from Lees Ferry to the Diamond Creek or Pearce Ferry takeouts. Other reaches are not predominantly whitewater localities; therefore, they will not be discussed in this section.

Glen Canyon Dam to Lake Mead

Grand Canyon whitewater boating trips launch at Lees Ferry in Glen Canyon NRA and take out at Diamond Creek on the Hualapai Indian Reservation or at Pearce Ferry in Lake Mead NRA. River trips are conducted using a variety of boats and rafts; group sizes can range up to 32 people (including guides). Trip lengths range up to 25 days and can be run by commercial companies or by private individuals. There are various ways to join trips, including launching from Lees Ferry, hiking into or out of the canyon to join and leave a trip, and gaining limited access by vehicle and helicopter (commercial use only) to join trips in the western portion of the Grand Canyon.

GCNP regulates recreational boating in accordance with the Colorado River Management Plan (NPS 2006a). The Colorado River Management Plan prescribes recreational use management by establishing limits on the number of daily launches, group size, trip length, and motorized and nonmotorized use periods. Motorized use is permitted between April 1 and September 15. In general, whitewater navigability can be affected by river flows and by large amounts of side canyon debris washed into the river channel. Due to reduced water levels in Lake Mead, rapids like Separation Rapid have returned, and new rapids have formed from the Colorado River scouring a new path in the deltaic sediments, making it more challenging to navigate. While most of the river still follows the old river channel, a new channel has developed near Pearce Ferry, creating a new impassible class VI rapid known as the Pearce Ferry Rapid (Joel 2016). Intermittent, larger-volume and higher-magnitude flows could improve navigability at some of these rapids.

River flow levels and fluctuations are important for whitewater boaters (Bishop et al. 1987; Shelby et al. 1992; Hall and Shelby 2000; Stewart et al. 2000; Neher et al. 2017). Past studies have polled commercial and private whitewater trip leaders for their preferences on the minimum levels for running the river safely with passengers. Preferences may vary by experience level and equipment types for different boaters, but a majority have reported that flows below 10,000 cubic feet per second (cfs) and above about 45,000 cfs are considered less than optimal; flows between 20,000 cfs and 26,000 cfs are considered optimum (Shelby et al. 1992; Bishop et al. 1987; Neher et al. 2017). Flows of above 8,000 cfs have been identified by commercial guides as the minimum level necessary to safely run the river with passengers (Bishop et al. 1987). At low flows (5,000 cfs or less), it often becomes necessary to either walk passengers around some rapids or wait for higher water. The risk of accidents varies by the type of boat employed. At extremely low flows (less than 5,000 cfs), motor rigs have the highest incidence of accidents, followed by small (typically private group) rafts (Jalbert 1992). At flows higher than powerplant capacity, smaller craft, such as small rafts, dories, kayaks, and canoes/inflatables, experience more accidents (Brown and Hahn 1987).

Hoover Dam to SIB

The alternatives are not expected to adversely affect river and whitewater boating between Hoover Dam and the SIB.

TA 14.1.11 Sport Fishing

No specific reservoir elevation thresholds or river stages related to sport fishing were identified in the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat, including water quality. Please refer to **TA 8**, Biological Resources – Fish and Other Aquatic Resources, for more information regarding impacts on fish habitat, and **TA 6**, Water

Quality, for impacts on water quality. Fishing satisfaction is assumed to be directly related to 1) the general recreation issues of boating access to water via shoreline facilities, and 2) the boating navigation potential for hazards or reservoir detours due to low reservoir elevations.

Lake Powell and Glen Canyon Dam

Lake Powell supports a popular warmwater sport fishery composed mainly of striped and smallmouth bass. The striped bass depend on threadfin shad for a significant portion of their diet. The threadfin shad in Lake Powell are at the northernmost portion of their range, and they are sensitive to fluctuations in water temperature. Gizzard shad may become an important forage fish for striped bass. In addition to striped and smallmouth bass, Lake Powell supports other non-native fish species including largemouth bass, walleye, channel catfish, bluegill, and black crappie. Angler use in 2018 was at a 40-year low, mainly attributed to a decline in the percentage of boat days that were spent angling (Blommer and Gustaveson 2021).

Glen Canyon Dam to Lake Mead

The 15.5-mile Glen Canyon reach of the Colorado River supports a Blue Ribbon recreational rainbow trout fishery that attracts local, national, and international anglers. The NPS, in coordination with the Arizona Game and Fish Department and the FWS, manages fish in all waters within the Glen Canyon NRA and GCNP. The intention of Blue Ribbon management is to provide a quality fishing opportunity where anglers can catch larger-than-average trout, at a relatively high catch rate, in a unique recreational setting. Most angling is done from boats or is facilitated by boat access, often provided by guide services. Some anglers also wade or fish from shore.

Fishing in the Glen Canyon reach occurs year-round. Peak usage is in April and May; however, substantial fishing has occurred from March through October in most years (Rogowski and Boyer 2023). An estimated total of 5,095 anglers used the rainbow trout fishery in 2022; of these, 3,594 were boat anglers, and 1,501 were walk-in anglers (Rogowski and Boyer 2023). Boat and walk-in angler use decreased in 2022 relative to 2021 (Rogowski and Boyer 2023).

The quality of the rainbow trout fishery at Lees Ferry is highly dependent on water quality within the reach, which is a proxy for catch (Bishop et al. 1987). Prior to 2022, fish species from Lake Powell have been periodically entrained and have survived passage through the dam; however, water temperatures within the Glen Canyon reach were generally cold enough to impede growth and cease reproduction. In 2022, water temperatures within the Glen Canyon reach were the highest on record, which led to higher survival of entrained warmwater and coolwater fish through the dam (Rogowski and Boyer 2023). There is concern that as Lake Powell continues to decline and warm water is subsequently discharged, coupled with low dissolved oxygen, there will be an increase in warmwater fish, successful recruitment of the highly invasive smallmouth bass, and a decrease in rainbow trout (Rogowski and Boyer 2023). The Long-Term Experimental Management Plan (LTEMP) Supplemental Environmental Impact Statement (SEIS) was developed to implement water management actions to temporarily control smallmouth bass populations downstream of Glen Canyon Dam from 2024–2027 (Reclamation 2024). The Bureau of Reclamation (Reclamation) is planning to continue coordination with stakeholders for future control of smallmouth bass populations. **TA 8**, Biological Resources – Fish and Other Aquatic Resources, provides further information on rainbow trout dynamics in the Glen Canyon reach.

Lake Mead and Hoover Dam

Lake Mead has an excellent warmwater sport fishery composed of largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Fishing is generally better in the fall months of September, October, and November. Larger fish are caught by deepwater trolling in spring from March through May.

The Lake Mead Fish Hatchery, operated by the Nevada Department of Wildlife, historically raised rainbow trout, endangered razorback suckers, and bonytail chub. Since the publication of the 2007 Final EIS, the Lake Mead Fish Hatchery ceased operations in 2022 in response to Lake Mead declining below 1,060 feet, the point at which the hatchery drew its water (Peterson 2022). The Nevada Department of Wildlife and the Southern Nevada Water Authority are currently developing a project to replace the hatchery's water supply line to draw deeper in the water column.

Hoover Dam to Davis Dam

Lake Mohave's fishery is similar to Lake Mead's fishery. In Lake Mohave, there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Largemouth and striped bass are in deep water in the winter and move into shallow water to spawn in the spring. Fishing is open year-round, but the best fishing generally occurs in September, October, and November. For deepwater trolling, March through May tends to provide the best conditions.

Davis Dam to Parker Dam

Striped bass is the dominant sport fish in Lake Havasu. They can be caught throughout the year, but the best fishing locations change with the seasons and water temperature. The largemouth bass population supports tournaments nearly every weekend from September through May. The smallmouth bass population has increased in numbers over the past couple of years. Channel catfish are abundant and average 2 to 4 pounds in size. Flathead catfish grow to large sizes in Lake Havasu. Only a limited number of anglers fish specifically for catfish. Black crappie numbers are limited due to overharvesting and a lack of habitat.

Parker Dam to SIB

Fishing in Cibola NWR is available in Pretty Water, Cibola Lake, the Colorado River, and the Old River channel. Cibola NWR is managed to protect wintering waterfowl that use Cibola Lake. Fishing is permitted March 15 – October 1, unless otherwise stated. Sport fishing in Cibola Lake includes largemouth, smallmouth, and striped bass; channel and flathead catfish; crappie; sunfish; tilapia; and common carp.

The Imperial NWR is managed as a refuge and breeding area for migratory birds and other wildlife. Hunting and fishing are permitted in some areas, according to state regulations, and fishing by boat is allowed in the mainstream Colorado River at any time of the year.

TA 14.2 Environmental Consequences

TA 14.2.1 Methodology

Reclamation used similar methods for the analysis of potential impacts on recreation as were used in the 2007 Final EIS and LTEMP SEIS to assess the effects on shoreline public use facilities, reservoir boating and navigation hazards, whitewater boating, and sport fishing. This analysis also incorporates additional decision making under deep uncertainty (DMDU) concepts, specifically robustness heat maps and vulnerability bar plots, developed to provide an indicator of an alternative's performance across many possible hydrologic futures. Refer to **TA 3.2.6** for an overview of interpreting the DMDU robustness heat maps and vulnerability bar plots.

Method Used to Assess Shoreline Public Use Facilities

This section analyzes the impacts that reservoir elevations decreasing below critical thresholds would have on selected marinas, boat docks, and launch ramps, as well as whether these elevations could impact access to or use of attraction features. The NPS provided threshold reservoir elevations included in this analysis. The DMDU analysis uses the subset of reservoir elevations utilized in the regional economic modeling (see **TA 16**, Socioeconomics). The DMDU analysis for shoreline public use facilities analyzes the percentage of selected marinas, boat docks, and launch ramps. Threshold elevations were used as indicators of recreational facilities that might be rendered inoperable or require relocation or modification to remain operational. The narrative of the alternatives' effects is provided below for selected facilities at both Lake Powell and Lake Mead. These facilities are representative of the alternatives' potential effects on shoreline recreational opportunities at each reservoir.

Method Used to Assess Reservoir Boating and Navigation Hazards

This analysis assesses the effects of reservoir elevations falling below critical thresholds, which would result in boating navigation hazards and changing navigable areas and passageways. This methodology is consistent with the 2007 Final EIS and LTEMP SEIS, but with the addition of new modeling and DMDU concepts, it assesses the percentage of futures in which reservoir elevations never drop below identified thresholds. Threshold pool elevations were determined using the methodology identified in the 2007 Final EIS.

Method Used to Assess Whitewater Boating

The assessment of effects on whitewater boating used a similar methodology identified in the 2007 Final EIS and LTEMP SEIS by using river flow data from **TA 3**, Hydrologic Resources, to analyze whether there would be increased exposures to boating navigation hazards, changes in access or use of rest areas and take-outs, or changes in trip durations resulting from the alternatives. The analysis additionally incorporates DMDU concepts and analyzes the percentage of futures in which daytime flows of the Colorado River would not drop below an identified minimum threshold, previously identified as the minimum preferred flow (Bishop et al. 1987; Stewart et al. 2000).

Methods Used to Assess Sportfishing

This analysis assesses the effects on fishing opportunities by river reach under the alternatives, using similar methods identified in the 2007 Final EIS and LTEMP SEIS. There are no specific reservoir elevation thresholds related to sportfishing; therefore, DMDU concepts are not used in the reservoir

sportfishing analysis. A general discussion of changes in flow and salinity, and the possible effects on sportfish is also provided.

A more detailed analysis of effects on rainbow trout based on changes in water temperature is used for the Lees Ferry reach of the Colorado River, which incorporates DMDU concepts. Rainbow trout were chosen for the analysis based on the importance of their recreational fishery in the Colorado River reach below Glen Canyon Dam.

TA 14.2.2 Impact Analysis Area

The impact analysis area for recreation aligns with the general analysis area, which encompasses the Colorado River corridor from the full pool elevation of Lake Powell to the SIB.

Assumptions

- The analysis assumes that the demand for recreational opportunities will either remain constant or increase over time, forming the basis for evaluating impacts on activities such as reservoir recreation, fishing, and whitewater boating.
- The analysis considers 5,000 cfs and 8,000 cfs as two levels at which commercial and private boaters may experience navigability challenges (Shelby et al. 1992).
- Additional assumptions related to modeling are considered in the analysis, contributing to the accuracy and reliability of the hydrologic models used to anticipate impacts resulting from various actions.

Impact Indicators

- Threshold reservoir elevations
- Threshold river flows
- Water temperatures

TA 14.2.3 Issue 1: How would the management of reservoir elevations affect recreation?

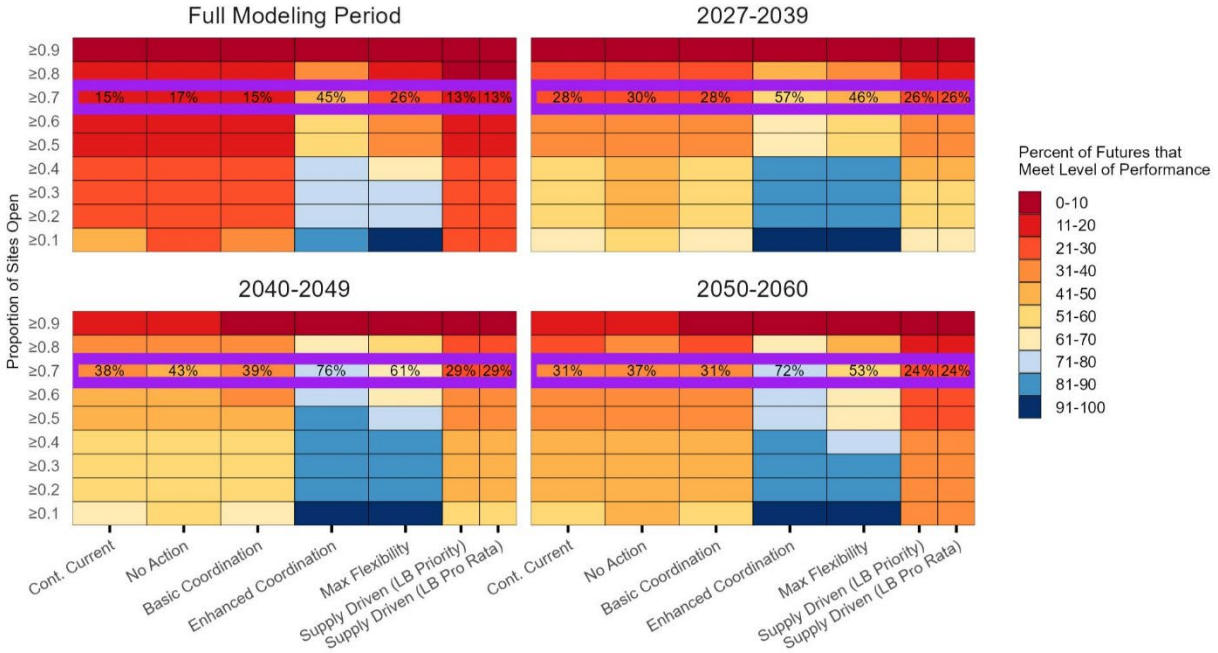
This issue examines how different reservoir elevations (Lake Powell and Lake Mead) resulting from different operational strategies would impact shoreline recreational facilities, reservoir boating activities, sportfishing opportunities, and the ferry and taxi boat services at Lake Powell. This analysis first presents and analyzes DMDU figures, and then assesses qualitative impacts on selected recreation activities resulting from changes in reservoir elevations.

Lake Powell

Table TA 14-3 identifies the threshold elevations below which shoreline recreational facilities at Lake Powell could be affected. Below these elevations, facility adjustments or capital improvements would be required, creating potential impacts on recreation at Lake Powell. **Figure TA 14-1** below depicts the performance of each alternative with regard to keeping a specified proportion of Lake Powell recreational sites open over every summer month, which corresponds to peak visitation (May 31 – August 31). The figure is divided into four heat maps, each showing a different time period across the analysis. The highlighted row represents the percentage of futures that an alternative achieves maintaining a 0.7 proportion of Lake Powell recreational sites open between May 31 and

August 31. The 0.7 proportion row was chosen to be highlighted because it corresponds to approximately the 10th percentile from the historical analysis that informed the thresholds.

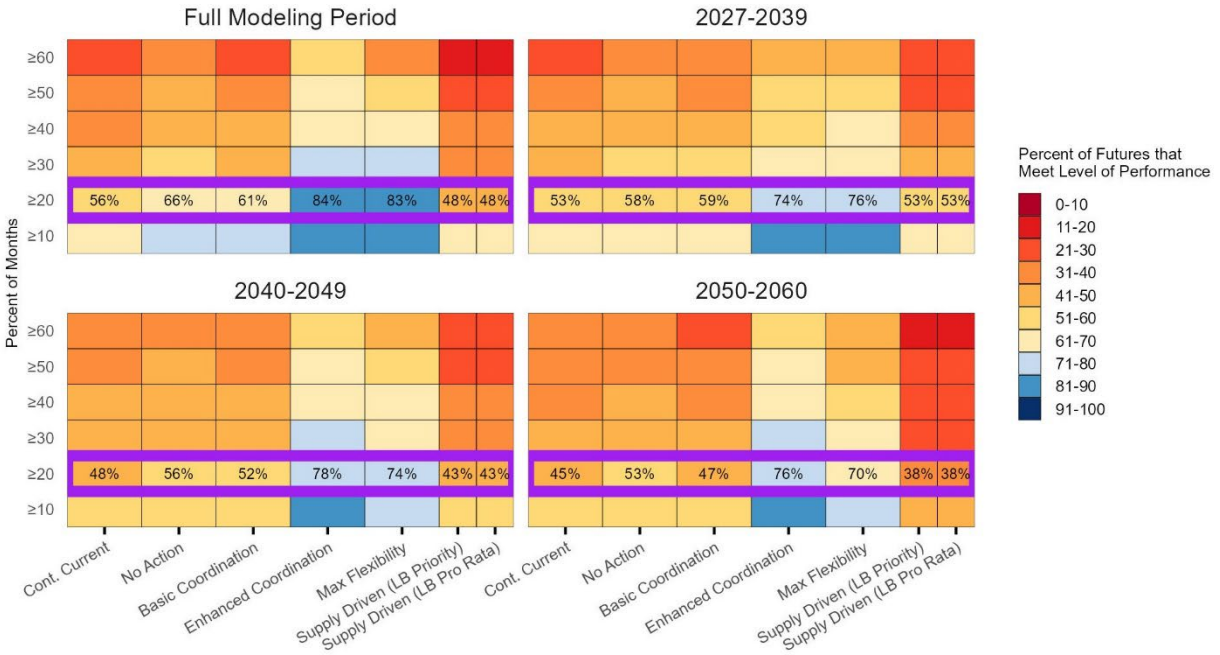
Figure TA 14-1
Lake Powell Recreation Sites: Robustness.
Percent of futures in which the proportion of open Lake Powell sites stays above the value specified by each row in every summer month (May 31 – August 31)



The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust at maintaining a 0.7 proportion of Lake Powell recreational sites open during the summer months over the full modeling period, doing so in 45 percent and 26 percent of futures, respectively. The Continued Current Strategies (CCS) Comparative Baseline and the No Action Alternative perform similarly, succeeding in 15 percent and 17 percent of futures, respectively, over the full analysis period. The Basic Coordination, Supply Driven (both Priority and Pro Rata approaches) Alternatives have the worst performance, ranging from a 13 percent to 15 percent success rate over the full analysis period.

Figure TA 14-2 below depicts the performance of each alternative with regard to keeping Lake Powell above elevation 3,620 feet, which corresponds to the critical threshold for most boat launch facilities and for safely navigating the Castle Rock Cut. The figure is divided into four heat maps, each showing a different time period across the analysis. Rows of the heat map show different frequency ranges (percent of months) for keeping Lake Powell above an elevation of 3,620 feet. The highlighted row shows the percentage of futures that an alternative achieves in maintaining Lake Powell above this elevation in 20 percent or more of months. This row was chosen to be highlighted because, from October 2007 through May 2025, Lake Powell was at or above 3,620 feet in 24.5 percent of months.

Figure TA 14-2
Lake Powell Boating Hazards: Robustness.
Percent of futures in which the elevation of Lake Powell is at least 3,620 feet in the percent of months specified by each row



The Enhanced Coordination and Maximum Operational Flexibility Alternatives are the most robust at maintaining or exceeding a Lake Powell elevation of 3,620 feet in 20 percent or more of months over the full modeling period, as shown in the upper-left heat map. These alternatives perform similarly to one another, doing so in 84 percent and 83 percent of futures, respectively. Over the full modeling period, the Basic Coordination Alternative performs similarly to the No Action Alternative and CCS Comparative Baseline, succeeding in 61 percent, 66 percent, and 56 percent of futures, respectively. These alternatives are slightly more robust than the Supply Driven Alternative (both Priority and Pro Rata approaches), which only meet the preferred minimum performance (maintain an elevation of 3,620 feet in 20 percent or more of months) in 48 percent of futures.

Across the full modeling period, all alternatives exhibit poor performance for the upper rows. Under all alternatives, projected Lake Powell elevations for much of the analysis period would be below the critical thresholds for most boat launch facilities and for safely navigating the Castle Rock Cut. This would result in a reduction in the quality of or the loss of reservoir boating opportunities on Lake Powell. Under all alternatives, dock access would continue to be unavailable from the Rainbow Bridge National Monument shoreline, which would continue until a long-term access solution is developed. Similarly, under all alternatives, projected Lake Powell elevations for much of the analysis period would be below the critical threshold for the Charles Hall Ferry, which would therefore be unable to operate.

Sportfishing

There are no specific reservoir elevation thresholds or river stages related to sportfishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat. Generally, lower reservoir elevation also reduces lake habitat for sportfish, which may have a negative impact on recreational sportfishing. Higher lake levels tend to favor popular sportfish, like largemouth bass, bluegill, and crappie, whereas lower levels favor smallmouth bass (Gustaveson 2018). The general trend for the alternatives indicates that the Maximum Operational Flexibility and Enhanced Coordination Alternatives have higher, less variable results centered around 3,600 feet, while the Supply Driven (both Priority and Pro Rata approaches), Basic Coordination, and No Action Alternatives, and the CCS Comparative Baseline have median elevations around 3,560 feet. Therefore, the Maximum Operational Flexibility and Enhanced Coordination Alternatives would likely be more beneficial for reservoir sportfishing.

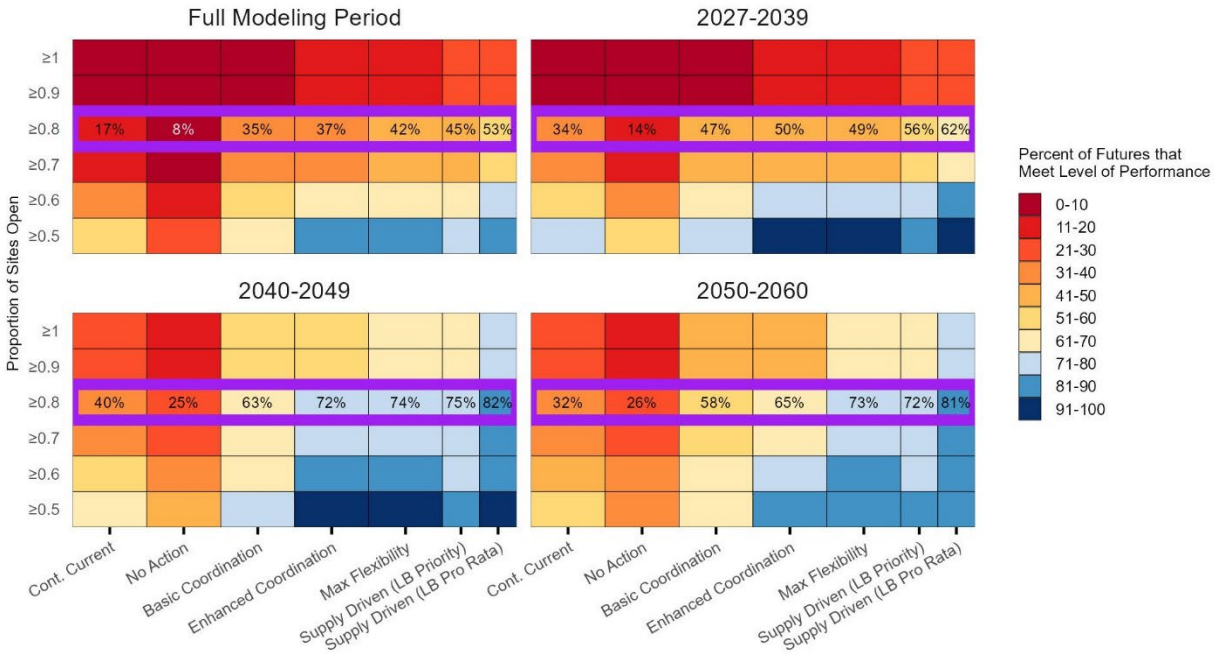
Lake Mead

Table TA 14-6 identifies the threshold elevations below which shoreline recreational facilities at Lake Mead could be affected. Below these elevations, facility adjustments or capital improvements would be required, potentially impacting recreation at Lake Mead.

Figure TA 14-3 below depicts the performance of each alternative with regard to keeping a specified proportion of Lake Mead recreational sites open over every summer month, which corresponds to peak visitation (May 31 – August 31). The figure is divided into four heat maps, each showing a different time period across the analysis. The highlighted row shows the percentage of futures in which an alternative achieves maintaining a 0.8 proportion of Lake Mead recreational sites open between May 31 and August 31. The 0.8 proportion row was highlighted because it corresponds to approximately the 10th percentile from the historical analysis that informed the thresholds.

The Supply Driven Alternative (Lower Basin Pro Rata [LB Pro Rata] approach) is the most robust at maintaining a 0.8 proportion of Lake Mead recreational sites open during the summer months over the full modeling period, doing so in 53 percent of futures. The Supply Driven (Lower Basin Priority [LB Priority] approach) and Maximum Operational Flexibility Alternatives perform similarly, succeeding in 45 percent and 42 percent of futures, respectively, over the full analysis period. The Enhanced Coordination and Basic Coordination Alternatives also perform similarly, succeeding in 37 percent and 35 percent of futures, respectively, over the full analysis period. The CCS Comparative Baseline Alternative succeeds in only 17 percent of futures, and the No Action Alternative, which has the worst performance at an 8 percent success rate over the full analysis period.

Figure TA 14-3
Lake Mead Recreation Sites: Robustness.
Percent of futures in which the proportion of open Lake Mead sites stays above the value specified by each row in every summer month (May 31 – August 31)

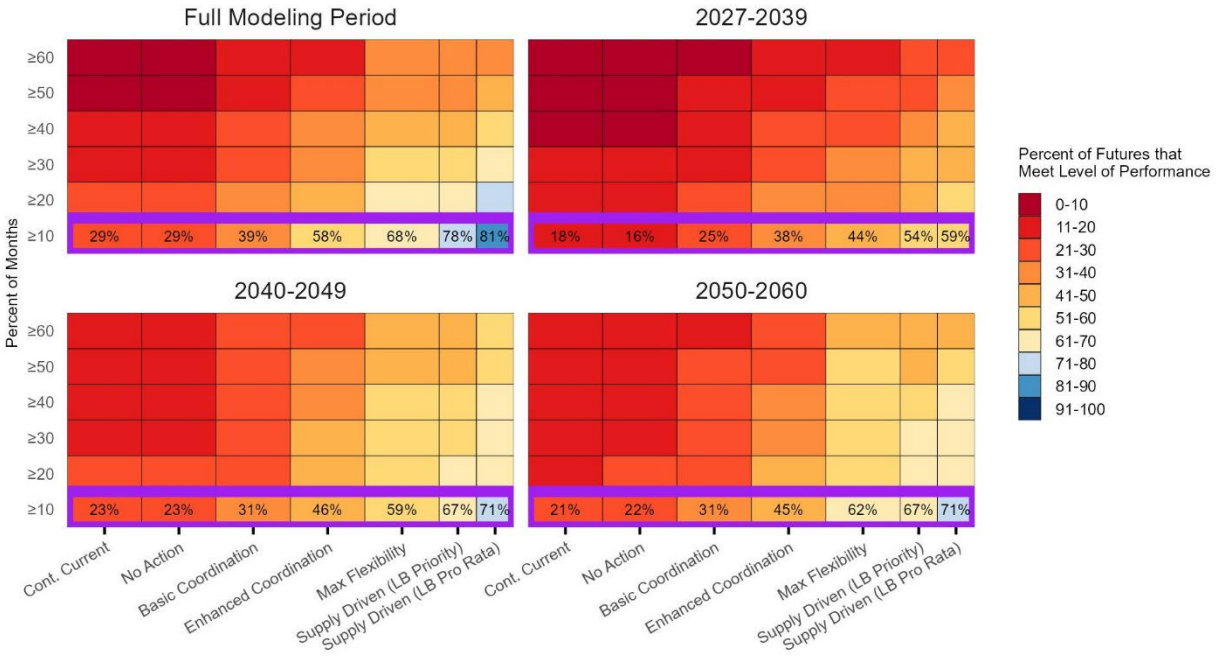


Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water)

Figure TA 14-4 depicts the performance of each alternative with regard to the percent of futures in which the Lake Mead elevation is 1,170 feet or above in the specified minimum percent of months across the full modeling period (2027–2060). Rows of the heat map show different frequency ranges for keeping Lake Mead above this elevation for a specified percentage of months throughout the full modeling period. Lake Mead has not been at or above an elevation of 1,170 feet between October 2007 and May 2025; therefore, the 10 percent row was chosen to be highlighted.

The Supply Driven Alternatives (both LB Pro Rata and Priority approaches) are the most robust at maintaining or exceeding a Lake Mead elevation of 1,170 feet in 10 percent or more of months over the full modeling period, as shown in the upper-left heat map. These alternatives perform similarly to one another, doing so in 81 percent and 78 percent of futures, respectively. Over the full modeling period, performance is followed by the Maximum Operational Flexibility Alternative, the Enhanced Coordination Alternative, and the Basic Coordination Alternative, which succeed in 68 percent, 58 percent, and 39 percent of futures, respectively. The No Action Alternative and CCS Comparative Baseline are the least robust, succeeding in 29 percent of futures.

Figure TA 14-4
Lake Mead Boating Hazards: Robustness.
Percent of futures in which the elevation of Lake Mead is at least 1,170 feet in the percent of months specified by each row



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water)

Across the full modeling period, all alternatives exhibit poor performance in the upper rows. The analysis suggests that it is difficult to achieve a Lake Mead elevation above which boating navigational hazards would not occur.

TA 14.2.4 Issue 2: How would the management of releases from Glen Canyon Dam affect recreation, including water temperature?

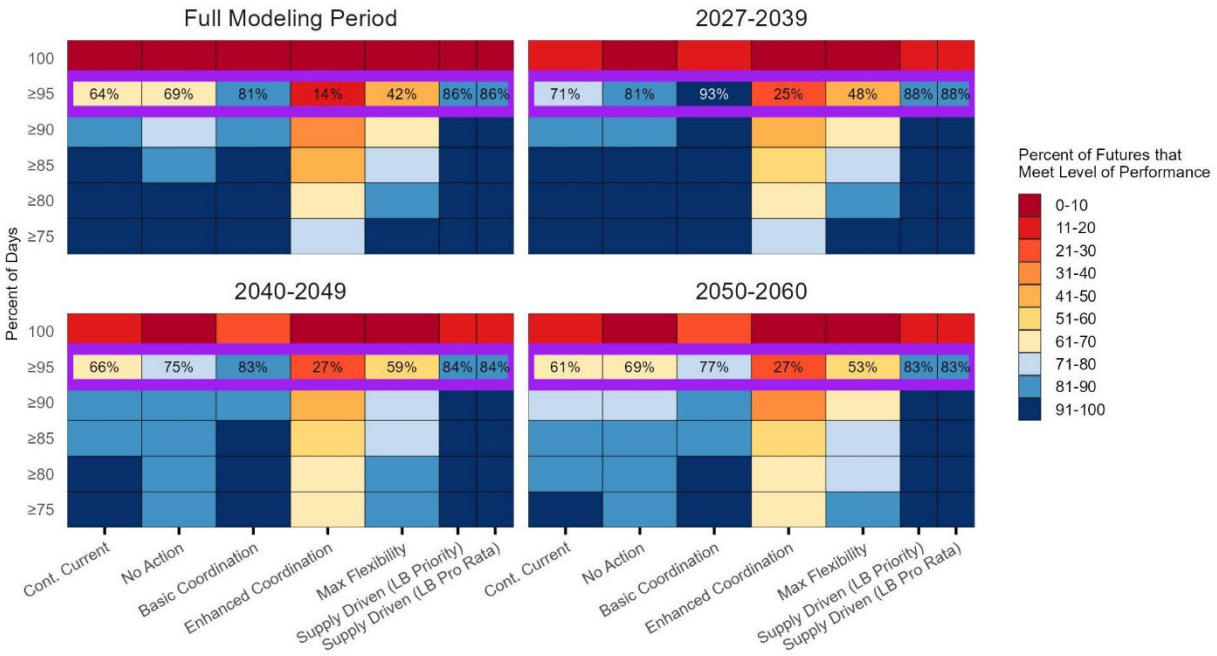
Whitewater Boating

River flow levels and fluctuations are important for whitewater boaters. The minimum daily flow levels of 8,000 cfs were set under the 2016 LTEMP as the minimally adequate daytime levels for Grand Canyon boating. Levels lower than this may present increasing navigability challenges for the use of large (often 35 feet long) rafts equipped with motors. Extended low flows of 5,000 cfs would adversely affect navigability and trip management because of a greater risk of boating incidents. In September 2023, the NPS received several reports of boating incidents, including several life-threatening injuries to boaters and damaged equipment across all types of watercraft, when flows were reduced to 5,000 cfs after trips had launched. Commercial and private whitewater trip leaders have reported a preference for steady flows (flows that do not fluctuate by more than 10,000 cfs per

day) in the 20,000-26,000 cfs range (Bishop et al. 1987; Neher et al. 2017); thus, there would likely be greater perceived value to rafters when flows are within this range. However, the historical and projected volume range under the alternatives may not align with these preferences, and the exact impacts on recreation would continue to depend on water availability for releases.

Figure TA 14-5 depicts the performance of each alternative with regard to the percent of futures in which daytime flows (7 a.m. – 7 p.m.) below Glen Canyon Dam are at least 8,000 cfs in the specified percent of days over the full modeling period (2027–2060). Rows of the heat map show different frequency ranges for keeping daytime flows above this threshold in the specified percentage of days throughout the full modeling period.

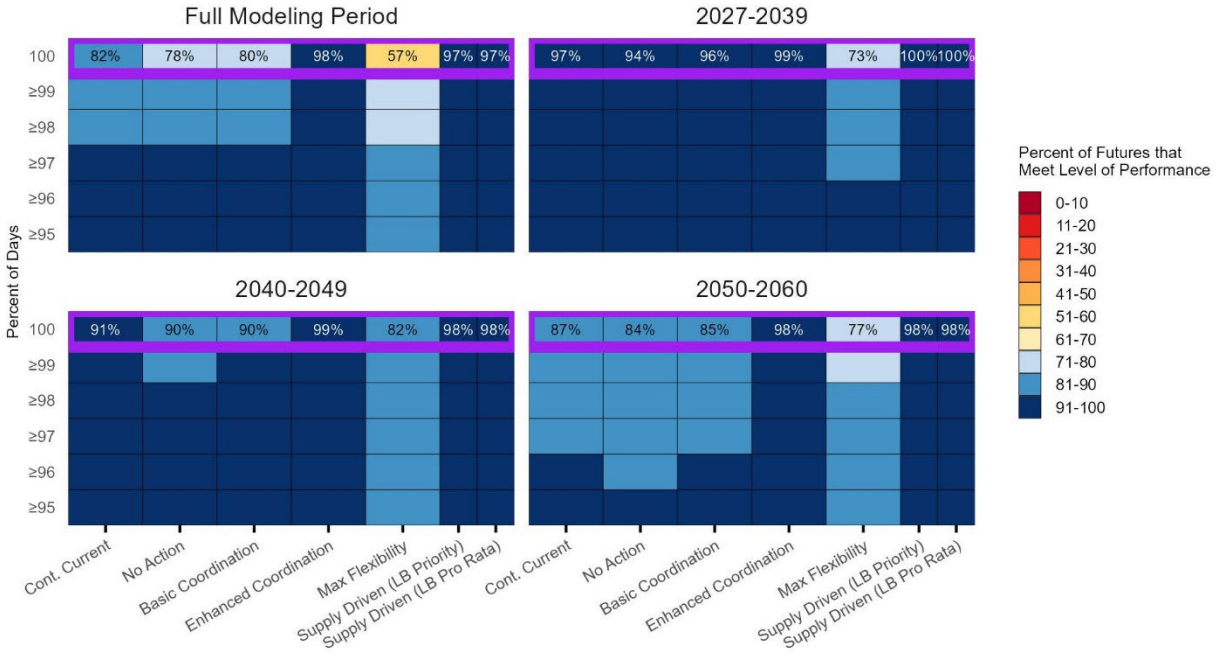
Figure TA 14-5
Whitewater Boating Below Glen Canyon Dam, 8,000 cfs: Robustness. Percent of futures in which daytime flows below Glen Canyon Dam are ≥8,000 cfs in the percent of days specified by each row



The Supply Driven Alternative (both Priority and Pro Rata approaches) is the most robust at maintaining or exceeding daytime flows of 8,000 cfs below Glen Canyon Dam over the full modeling period, as shown in the upper-left heat map. Both alternatives would succeed in 86 percent of futures. The Basic Coordination Alternative achieves a similar robustness of 81 percent. Over the full modeling period, performance is followed by the No Action Alternative, which would succeed in 69 percent of futures, and the CCS Comparative Baseline, which would succeed in 64 percent of futures. The Maximum Operational Flexibility Alternative would succeed in 42 percent of futures, and the Enhanced Coordination Alternative would be the least robust, succeeding in only 14 percent of futures.

Figure TA 14-6 depicts the performance of each alternative with regard to the percent of futures in which daytime flows (7 a.m. – 7 p.m.) below Glen Canyon Dam are at least 5,000 cfs in the specified percent of days over the full modeling period (2027–2060). Rows of the heat map show different frequency ranges for keeping daytime flows above this threshold in the specified percentage of days throughout the full modeling period.

Figure TA 14-6
Whitewater Boating Below Glen Canyon Dam, 5,000 cfs: Robustness.
Percent of futures in which daytime flows below Glen Canyon Dam are ≥5,000 cfs in the percent of days specified by each row



The Enhanced Coordination and Supply Driven Alternatives (both Priority and LB Pro Rata approaches) are the most robust at maintaining or exceeding daytime flows of 5,000 cfs below Glen Canyon Dam over the full modeling period, as shown in the upper-left heat map. These alternatives would succeed in 98 percent and 97 percent of futures, respectively. The CCS Comparative Baseline would succeed in 82 percent of futures across the full modeling period, followed by the Basic Coordination Alternative (80 percent), then the No Action Alternative (78 percent), and finally, the Maximum Operational Flexibility Alternative (57 percent).

When flows are above 5,000 cfs, there would generally be fewer navigation challenges and boating incidents caused by a change in river levels. Minor changes in exposure to boating navigation hazards caused by a change in river velocity; changes in access or use of rest areas and take-out points; changes in trip duration caused by changes in river velocity; or the ability to use sportfishing sites caused by changes in flows, may occur under all alternatives.

Sportfish Populations

While different water temperature thresholds were considered for native and invasive fish species, this section focuses on impacts on the rainbow trout fishery at Lees Ferry. Water temperatures exceeding 20 °C (degrees Celsius; 68 °F [degrees Fahrenheit]) can cause thermal stress and mortality of rainbow trout while creating conditions more favorable for the growth of nonnative fish and smallmouth bass. Additionally, warmer water temperatures may increase the competitive advantage for brown trout, as this species is more tolerant of elevated temperatures. The percentage of futures for each alternative in which water temperature at Lees Ferry exceeds 20 °C (68 °F) is presented in **Figure TA 8-10** under **TA 8**, Biological Resources – Fish and Other Aquatic Resources.

Over the full modeling period, the Enhanced Coordination Alternative is the most robust, meeting the preferred minimum performance in 71 percent of futures. The Enhanced Coordination Alternative is the most robust for maintaining cooler water temperatures at Lees Ferry, which would benefit rainbow trout. Since a greater than 10 percent difference would be considered significant, the Maximum Operational Flexibility Alternative performs significantly lower than the Enhanced Coordination at 59 percent, but is significantly higher than the other three alternatives. The No Action Alternative and Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) perform similarly and are the least robust (21–26 percent), and perform slightly worse than the CCS Comparative Baseline.

Alternatives that support higher Lake Powell elevations and greater river flows generally perform better at maintaining cooler water temperatures. However, under extended drought (low average flows and lower Lake Powell elevation), all alternatives become more vulnerable to undesirable temperature increases, affecting fish habitat and species composition. Please refer to **TA 8**, Biological Resources – Fish and Other Aquatic Resources, Issue 2, for more detailed information on changes in water temperature and quality from Glen Canyon Dam downstream through the Grand Canyon to Pearce Ferry and impacts on rainbow trout, native Grand Canyon fishes, and nonnative predatory fish.

TA 14.2.5 Summary Comparison of Alternatives

The alternatives vary in their potential to affect recreational resources, including shoreline public use facilities, reservoir boating, river and whitewater boating, and sportfishing. The general trend for the alternatives indicates that the Maximum Operational Flexibility and Enhanced Coordination Alternatives have higher, less variable Lake Powell reservoir elevations; therefore, these alternatives would likely be more beneficial for all Lake Powell recreational activities. The general trend for the alternatives indicates the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) has higher, less variable Lake Mead reservoir elevations, followed by the Maximum Operational Flexibility and Enhanced Coordination Alternatives; therefore, these alternatives would likely be more beneficial for all Lake Mead recreational activities.

However, across the full modeling period, all alternatives have poor levels of performance for maintaining higher elevations for a greater percentage of futures. Under all alternatives, projected Lake Powell and Lake Mead elevations for much of the analysis period would be below the critical thresholds for most boat launch facilities and safer boat navigation, which would result in a reduction in the quality of or the loss of reservoir boating opportunities.

Under the Basic Coordination Alternative, projected flows would be the highest in the Critically Dry Flow Category; however, river flows generally decrease as flow categories get drier. Higher flows would generally yield the greatest benefits to whitewater boating in the Grand Canyon. The Enhanced Coordination and the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) are the most robust at achieving daytime flows of 5,000 cfs or greater, which is above the safer whitewater boating minimum for large, motorized watercraft.

The Enhanced Coordination Alternative is the most robust at maintaining cooler water temperatures at Lees Ferry, which would confer the greatest benefits to the rainbow trout fishery.

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