Technical Appendix 9

Vegetation Including Special Status Species

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Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Final EIS	2007 Interim Guidelines Final Environmental Impact Statement
2007 Interim Guidelines	Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead
2024 LTEMP SEIS	Glen Canyon Dam Long-Term Experimental and Management Plan Final Supplemental Environmental Impact Statement
CCS	Continued Current Strategies
cfs	cubic feet per second
DMDU	Decision Making under Deep Uncertainty
FWS	United States Fish and Wildlife Service
HCP	Habitat Conservation Plan
HFE	high-flow experiment
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
maf	million acre-feet
RM	river mile
SIB	Southerly International Boundary
U.S.	United States
WY	water year

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TA 9. Vegetation Including Special Status Species

TA 9.1 Affected Environment

This analysis categorizes vegetation into marsh, woody riparian, and upland habitat types (collectively referred to as terrestrial habitats) throughout the analysis area, which includes Lake Powell, Glen Canyon Dam to Lake Mead, Lake Mead, and Hoover Dam to the Southerly International Boundary (SIB; see **TA 9.2**). Wetlands in the analysis area are typically characterized by marsh habitat, but wetlands could also occur in woody riparian habitats.

Marsh habitats occur in areas that are consistently flooded and are typically found in the transition zone between open water and upland ecosystems. Dominant vegetation in marsh habitat includes graminoids, such as cattails (*Typha* spp.), bulrush (*Schoenoplectus* spp.), and common reed (*Phragmites australis*). Marsh vegetation is sensitive to drought on short timescales, seasonally to annually, and has been found to decrease in cover, species diversity, and productivity when water availability shifts from perennial to intermittent (Stromberg et al. 2005, 2007; Friedman et al. 2022).

Woody riparian habitats occur where water is consistently available and periodic flooding occurs. Dominant vegetation types in woody riparian habitat include woody shrubs and trees, such as cottonwood (*Populus* spp.), mesquite (*Prosopis* spp.), tamarisk (*Tamarix* spp.), arrowweed (*Pluchea* spp.), seep willows (*Baccharis* spp.), and willow (*Salix* spp.). Woody riparian vegetation typically has deeper root systems capable of accessing alluvial groundwater and does not depend on surface water flows (Stromberg et al. 2013). This vegetation type is sensitive to drought on longer timescales, on an annual to decadal scale, depending on the species (Shafroth et al. 2002).

Upland habitats occur in areas without consistent water availability, where vegetation depends on precipitation. Dominant vegetation in the upland habitat is typically desert scrub dominated by various shrub species, such as creosote bush (*Larrea tridentata*) and bursage (*Ambrosia* spp.).

This section also includes special status plant species, defined here as those listed as Bureau of Land Management sensitive species by the overlapping Arizona, California, Utah, and Nevada Bureau of Land Management field offices; species covered in the Lower Colorado River Multi-Species Conservation Program (LCR MSCP); and species listed as threatened or endangered or proposed for listing by the United States (U.S.) Fish and Wildlife Service (FWS; BLM 2017, 2018, 2019, 2023; LCR MSCP 2022; FWS 2025). **TA 9 Attachment 1**, Special Status Plant Species Table, provides a list of the species considered in this document, including their listing status, the river reaches they typically inhabit, and the habitat types they occupy. **TA 9 Attachment 1**, Special Status Plant Species Table, was developed through input from cooperating agencies and local experts.

Culturally important plants are discussed in **TA 13**, Tribal Resources.

TA 9.1.1 Lake Powell

Short-term and long-term fluctuating water elevations influence Lake Powell's shoreline vegetation (**Table TA 9-1**). The median annual water elevation fluctuation between 2008 and 2025, when the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines), were in effect, was 31.45 feet (see **Figure TA 9-1**). The drought-induced drawdown of Lake Powell since 2011 has reduced the lake's perimeter and exposed approximately 59,000 acres of formerly submerged land (Root and Jones 2022).

Table TA 9-1
Approximate Acres of Marsh, Woody Riparian, and Upland Habitat in Each Reach

Reach	Marsh (% of reach)	Woody Riparian (% of reach)	Upland (% of reach)	Total
Lake Powell[1]	1 (<1%)	10,802 (41%)	15,385 (59%)	26,188
Glen Canyon Dam to Lake Mead[2]	96 (3%)	353 (11%)	2,627 (85%)	3,076
Lake Mead[3]	388 (<1%)	6,657 (9%)	64,186 (90%)	71,250
Hoover Dam to the SIB[3]				
Hoover Dam to Davis Dam	36 (5%)	164 (22%)	558 (73%)	758
Davis Dam to Parker Dam	1,069 (20%)	1,990 (38%)	2,195 (42%)	5,254
Parker Dam to Cibola Gage	1,196 (5%)	20,604 (83%)	2,949 (12%)	24,749
Cibola Gage to Imperial Dam	738 (5%)	10,639 (77%)	2,411 (17%)	13,788
Imperial Dam to the Northerly International Boundary	439 (5%)	6,844 (76%)	1,654 (19%)	8,973
Northerly International Boundary to the SIB	10 (<1%)	152 (9%)	1,473 (90%)	1,635
Total	**3,973**	**58,205**	**93,438**	**155,671**

Sources: [1] NPS 2014; [2] Durning et al. 2018; [3] Sound Science 2025
Note: Totals may not equal 100 percent due to rounding.

Historically, marsh and woody riparian vegetation around Lake Powell are restricted due to the natural rocky, desert terrain that extends directly to the water's edge (NPS 2023; Reclamation 2016, 2024). As shown in **Table TA 9-1**, the majority of the reservoir shoreline is upland habitat. Of the 15,385 acres of upland habitat, 7,119 acres were mapped as bare sandstone or slickrock, and 1,044 acres were mapped as sand bar, sand islands, badlands, and other bare dirt areas (NPS 2014). Russian thistle (*Salsola* spp.) is the dominant upland species found along the shores of Lake Powell. Of the 15,385 acres of upland habitat described in **Table TA 9-1**, 1,048 acres were mapped as weedy herbaceous complex, of which Russian thistle is the dominant species (NPS 2014; Tendick et al. 2017). Russian thistle easily takes root on disturbed or bare ground, often establishing before native species (NPS 2023). Recently exposed sites below Lake Powell's full pool showed a higher percentage and cover of nonnative species, with Russian thistle being extremely abundant (Arens 2023).

Long- and short-term fluctuations in reservoir elevations have also had a significant impact on the establishment of marsh and woody riparian vegetation (Reclamation 2016, 2024). Marsh vegetation is extremely limited along Lake Powell, and the 1 acre of marsh vegetation described in **Table TA 9-1** is mapped as spring-supported herbaceous vegetation. Tamarisk is the dominant woody riparian species along the shores of Lake Powell. Of the 10,802 acres of woody riparian habitat described in **Table TA 9-1**, 10,773 acres were mapped as tamarisk shrublands (NPS 2014). Dense stands of tamarisk can displace native plants, degrade wildlife habitat, reduce livestock forage, limit human access, interfere with the natural fluvial processes, alter the ecology and hydrology of riparian systems, and increase the risk of severe wildfires (NPS 2023). Many tamarisk stands were likely established during higher lake elevations and are now showing severe drought stress or mortality as reservoir levels remain low (Arens 2023). The remaining 29 acres of mapped woody riparian habitat were native species vegetation classes, which included coyote willow shrublands, relict spring-supported mixed-deciduous woodlands and shrublands, and Fremont cottonwood (*Populus fremontii*) woodland (NPS 2014). These classes are associated with the major rivers (Colorado, Escalante, and San Juan) and the tributary side canyons (Tendick et al. 2017).

Long-term decreases in water elevations have resulted in standing water and backwater pools in some of the over 90 tributary side canyons of Lake Powell (NPS 2026). Plant surveys were conducted at 20 locations within tributary side canyons along the Escalante River and in exposed areas of Lake Powell bays in 2022 and 2023. At these locations, native shrubs were outcompeting nonnative plants on sites that had been exposed for more than three years, providing diverse ecosystems where natural flow patterns are re-established, including hanging gardens and cryptobiotic crusts (Arens 2023). In these tributary side canyons and along some portions of the major rivers, native woody riparian and marsh vegetation have begun to re-establish. Dominant plants found in areas of canyons include Fremont cottonwood, tamarisk, and cattail (Arens 2023).

In two study areas in the backwaters of Lake Powell, one along the San Juan River and one on the mainstem of the Colorado River, lake water elevations decreased approximately 28 meters between 2009 and 2021 (Kasprak et al. 2026). In these two study areas, a supervised vegetation classification was performed on imagery from 2009, 2014, and 2021, and landcover between these years compared four high-level groupings: water, rock or sand, stressed vegetation, and green vegetation, which included species such as tamarisk, cottonwood, willow, and seepwillow. Green vegetation colonized recently exposed areas, but as water elevations continued to fall, the green vegetation began to show signs of water stress visible in the imagery (such as browning and defoliation).

Two special status plant species are present in the Lake Powell reach and could be affected by operations (**TA 9 Attachment 1**).

TA 9.1.2 Glen Canyon Dam to Lake Mead

Marsh, woody riparian, and upland habitats from Glen Canyon Dam to Lake Mead are influenced by the peak magnitudes, daily fluctuations, and seasonal patterns of river flows. Vegetation composition, structure, distribution, and function are closely tied to ongoing Glen Canyon Dam operations (**Table TA 9-1**; Reclamation 2016; Palmquist et al. 2023).

Hydrologic zone (active channel and active floodplain) was consistently the strongest predictor of vegetation between Glen Canyon Dam and Lake Mead (Palmquist et al. 2023). The active channel, which is inundated by daily fluctuating flows up to 25,000 cubic feet per second (cfs), supports both marsh habitat and woody riparian habitat. Marsh habitat includes species such as bulrushes, rushes (*Juncus* spp.), horsetails (*Equisetum* spp.), and common reed. Woody riparian habitat includes species such as seep willows (*Baccharis* spp.), willow (*Salix* spp.), tamarisk, arrowweed (*Pluchea sericea*), and honey mesquite (*Prosopis glandulosa*). These species occupy the main river margin as well as return-current channels and successional backwaters that are inundated daily for at least part of the year. The active floodplain, inundated by flows up to 45,000 cfs during high-flow experiments (HFEs), supports woody riparian and upland habitat, which includes the woody riparian species as well as upland species, such as mesa dropseed (*Sporobolus flexulosus*), red brome (*Bromus rubens*), and spiny aster (*Chlorocantha spinosa*).

Long-term vegetation monitoring has been conducted since 2014 at two site types: 1) at random locations at sandbars, channel margins, and debris fans and 2) at fixed-site sandbars (Palmquist et al. 2018a). Vegetation dynamics between these two site types vary, including species composition and temporal patterns between years (Palmquist et al. 2023). The fixed-site sandbars are eddy sandbars that have been part of long-term monitoring for geomorphic change and are generally popular camping sites (Palmquist et al. 2018a). At both site types, native species cover and richness were greater than nonnative species cover and richness across all hydrologic zones (Palmquist et al. 2023). The National Park Service has conducted vegetation treatments at a small number of fixed-site sandbars to promote aeolian sand transfer to nearby cultural sites and create campsites for river recreation. These impacts are discussed in **TA 11**, Cultural Resources, and **TA 14,** Recreation.

Marsh and woody riparian vegetation have expanded in this reach since Glen Canyon Dam was completed in 1963 (Sankey et al. 2015). Encroachment of marsh and woody riparian vegetation has decreased the amount of unvegetated areas in the active channel and active floodplain. The greatest area of vegetation expansion between 2002 and 2013 was woody riparian vegetation (tamarisk and seep willow) on sandbars in the active channel (Durning et al. 2021). Encroachment of woody riparian vegetation was most prevalent in the higher elevations of the active channel due to the lower elevation areas being inundated regularly enough to prevent vegetation encroachment. This was despite HFEs in 2004, 2008, and 2012, which aimed to increase unvegetated areas on sandbars for recreation. The effectiveness of HFEs in inhibiting vegetation encroachment is dependent on several factors, including existing vegetation stabilization, geomorphic setting, sandbar elevation, river segment, duration, and flow volume (Mueller et al. 2018; Hazel et al. 2022).

The availability of water at low river elevations (e.g., below 25,000 cfs) from consistent base flows can promote vegetation establishment closer to the river where there were historically bare sand beaches, whereas prolonged periods of peak flow (e.g., above 40,000 cfs during an HFE) may inhibit vegetation establishment closer to the river through scouring action. When inundation frequency increased by five percent or more, vegetation expansion closer to the river was unlikely to occur (Sankey et al. 2015). HFEs may also reduce the narrowing of the riparian zone by inundating the riparian plants that are currently dying back at the upper end of the riparian zone. The Glen Canyon Dam Long-Term Experimental and Management Plan Final Supplemental Environmental Impact Statement (2024 LTEMP SEIS) allows for more spring HFEs to occur in the future, which may allow more HFEs to occur at the historic timing at which peak flows occurred in this system prior the building of the Glen Canyon Dam (Reclamation 2024) which may have benefits for LTEMP vegetation goals both closer to the river and at the upper end of the riparian zone.

Additional factors related to flow that influence marsh and woody riparian vegetation include characteristics of deposited sediments (e.g., water-holding capacity, aeration, and nutrient levels), depth to groundwater, and anoxia in the root zone. Sand and silt particles are critical for supporting riparian species, and continual erosion may ultimately result in the loss of large stands of riparian plants (Palmquist et al. 2025). The export of sediments (particularly silts, clays, and organic matter) was observed to coarsen substrates, affect nutrient concentrations, and reduce opportunities for subsequent recruitment of tamarisk and native shrubs such as coyote willow (*Salix exigua*) and Emory seep willow (*Baccharis emoryi*; Reclamation 2016).

Twenty special status plant species are present in the Grand Canyon to Lake Mead reach and could be affected by operations (**TA 9 Attachment 1**).

TA 9.1.3 Lake Mead

Similar to Lake Powell, short- and long-term fluctuations in water elevation affect the shoreline vegetation of Lake Mead (**Table TA 9-1**) and are described in detail in Section 3.4 and Section 3.8.1 of the LCR MSCP Habitat Conservation Plan (HCP; Reclamation 2004a) and 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; Reclamation 2016). The median annual water elevation fluctuation between 2008 and 2025 was approximately 16.19 feet (**Figure TA 9-3**). The drawdown of Lake Mead from 1998 to 2011 reduced the lake's perimeter by more than 400 kilometers (249 miles) and exposed more than 61,776 acres of formerly submerged land (Engel et al. 2014). Water levels have continued to decline since 2012 (see **Figure TA 3-5**, in **TA 3**, Hydrologic Resources), further reducing the lake's perimeter and exposing additional shoreline.

Historically, Lake Mead has undergone large changes in elevation that create and subsequently flood both marsh and woody riparian habitat. From 1990–1996, Lake Mead reservoir levels remained within a relatively narrow range (**Figure TA 3-5, TA 3**, Hydrologic Resources), creating dense stands of willow habitat (approximately 1000 acres; McKernan and Braden 1998). When the water levels rose, then dropped from 2000–2004, a delta at the Virgin River was created that changed habitat conditions, resulting in a subsequent die off of willow (Reclamation 2004b).

Riparian vegetation that does develop within the range of Lake Mead elevation fluctuations is temporary, as fluctuating lake elevations either dewater or inundate these areas through time. Vegetation that develops within the range of short-term (interannual) Lake Mead elevation fluctuations is likely temporary, as frequent inundation and dewatering prevent long-term establishment. Long-term fluctuations allow the establishment of woody riparian vegetation (primarily tamarisk); however, as lake levels continue to fall, tamarisk may begin to show drought stress and mortality when water levels fall below their roots. The decline of tamarisk has been correlated with increased root exposure above the waterline; cover and density of tamarisk were substantially reduced after 6 years of exposure (Engel et al. 2014). Overall, native species cover has been found to be greatest on surfaces that have been exposed for a longer period of time (Engel et al. 2014).

Sediment deposition and associated vegetation growth at the Lake Mead delta have been ongoing for decades. Historically, both marsh and woody riparian habitats were limited, even along much of the historic Colorado River corridor now inundated by Lake Mead (Engel et al. 2014). The highest concentration of vegetated habitat occurs in the Colorado and Virgin River deltas.

Native vegetation at Lake Mead has also been positively influenced by defoliation from the tamarisk leaf beetle (*Diorhabda* spp.; beetle). Beetles were released along the Virgin River in St. George, Utah, in 2006, and widespread defoliation of tamarisk was first observed in St. George in 2008. The area of tamarisk defoliation on the Virgin River expanded downstream annually, encompassing the entire stretch of the Virgin River to Lake Mead, Nevada, by the end of 2012 (Gonzalez et al. 2020). Arrowweed was found to replace defoliated tamarisk stands as the dominant species along the Virgin River floodplain, increasing native species cover (Gonzalez et al. 2020). Additional control efforts by the National Park Service Lake Mead Inter-Regional Invasive Plant Management team have contributed to controlling tamarisk in the Lake Mead National Recreation Area (NPS 2022).

Twenty-one special status plant species are present in the Lake Mead reach and could be affected by operations (**TA 9 Attachment 1**).

TA 9.1.4 Hoover Dam to SIB

Vegetation in this reach is described in detail in Section 3.4 and Section 3.8.1 of the LCR MSCP HCP and 2007 Final EIS (Reclamation 2004a; Reclamation 2016). The LCR MSCP planning area identifies fourteen land-cover types, including five woody riparian types that are divided into multiple structural types, and the marsh land cover type is divided into seven compositional types based on plant composition and vegetation structure (**Table TA 9-2**). The LCR MSCP HCP further describes the extent of these habitat types by river reach in Table 3-8 and Figures 3-2 through 3-8 (Reclamation 2004a), which are incorporated by reference.

Table TA 9-2
Summary of Vegetation Cover Types from Lake Mead to the SIB

Vegetation Type	Characteristics
Marsh	Cattail/bulrush, little common reed, trees and grasses, and open water
Woody Riparian	Cottonwood-willow, tamarisk, honey mesquite, tamarisk-screwbean mesquite, arrowweed, atriplex
Upland	Desert scrub, agriculture, developed

Source: Reclamation 2004a

Marsh and woody riparian vegetation can be formed through either direct connection to the river and river-dependent groundwater or along reservoirs and impoundments (e.g., Lake Havasu and Mittry Lake). The dams in this reach and their resultant reservoirs and flood control structures, including levees, have altered the extent and quality of marsh and woody riparian vegetation along the river and have converted large areas of riverine habitat to lacustrine habitat behind dams and diversion facilities (Reclamation 2004a). Habitats at wildlife refuges and management areas, restoration areas, and LCR MSCP conservation areas are dependent on water diversions from the river and existing groundwater levels supported by the river's surface elevation to establish and maintain woody riparian and marsh habitat.

Since the beetle's release in 2006, its range has expanded downstream from Lake Mead along the lower Colorado River, and by 2019, large beetle populations were detected along the Imperial stretch of the lower Colorado River. In 2020, beetles were present, and defoliation was documented in or around all LCR MSCP study areas (Reclamation 2021), and in 2024 beetles have been documented to the SIB (McLeod and Pellegrini 2021; Mahoney et. al 2022; RiversEdge West 2025).

The LCR MSCP HCP and subsequent BOs set habitat creation goals to mitigate for predicted impacts from covered river operations, including flow reductions, water delivery and diversion, changes in point of diversion, generation of hydropower, and operation and maintenance activities in the LCR MSCP planning area (Reclamation 2004a; FWS 2005, 2018, 2022, 2024). A summary of the habitat creation goals and habitat created towards those goals as of 2025 (LCR MSCP 2025) is included as **Table TA 10-1**, in **TA 10**, Terrestrial Wildlife Including Special Status Species. Habitat creation goals assumed the predicted habitat impacts from reductions in flow and changes in points of diversion up to 2.083 maf per year may occur annually until 2055 and would be permanent, even if impacts never actually occur. Habitat would be created to replace it in LCR MSCP conservation areas. This includes a prediction that all existing cottonwood-willow land cover supported by the river and river connected groundwater would be lost due to flow-related covered activities (with the exception of habitat at Topock Marsh and Lake Havasu). Impacts on marsh from flow reductions from 2.083 maf per year to 3 maf per year were predicted to be short term in duration, and the habitat would recover when inundated again (FWS 2024).

Table TA 9-3
Summary of Habitat Creation Goals and Acres Created from Lake Mead to the SIB

Habitat Type	Habitat Creation Goal[1]	Acres Created through 2025[2]
Marsh	568	362
Woody Riparian (cottonwood-willow only)	5,940	4,954
Woody Riparian (honey mesquite only)	1,320	2,046
Woody Riparian (total)	7,260	7,000

Source: [1]Reclamation 2004a; FWS 2005, 2022, 2024; [2]LCR MSCP 2020, 2025

In 2024, the Bureau of Reclamation (Reclamation) contracted RiverRestoration.Org, LLC to map backwater areas (water, marsh, and non-marsh) in the LCR MSCP planning area and to conduct a change analysis between the 2024 effort and a previous 2000 backwater mapping effort. The study found an overall decrease in marsh between Davis Dam and Morelos Dam from 2000 to 2024. The change from marsh to non-marsh was most common and is likely a response to prolonged drought conditions (RiverRestoration.Org 2025). Non-marsh includes woody riparian and upland vegetation types, as well as a broader range of dry and vegetated features that would not typically be considered "upland" in a geomorphic or ecological sense, such as dry arroyos, cleared ground, and fringe riparian areas.

Nine special status plant species are present in the Hoover Dam to SIB reach and could be influenced by operations (**TA 9 Attachment 1**).

TA 9.2 Environmental Consequences

TA 9.2.1 Methodology

Lake Powell

Ground-based vegetation mapping has not been conducted for all of Lake Powell's shoreline (NPS 2023). To estimate the extent of marsh, woody riparian, and upland habitats within the full pool area of Lake Powell, mapping data from the vegetation classification and mapping project for Glen Canyon National Recreation Area and Rainbow Bridge National Monument was used (NPS 2014; Tendick et al. 2017). This vegetation classification map was created using 1,164 vegetation classification plots, 51 observation points, and aerial photointerpretation using 2009 and 2010 National Agriculture Imagery Program imagery (Tendick et al. 2017). Woody riparian vegetation classes included coyote willow shrublands, Fremont cottonwood woodland, relict spring-supported mixed deciduous woodlands and shrublands, and tamarisk shrublands. The only marsh vegetation class present was spring-supported herbaceous vegetation. As noted in **TA 9.1.1**, since 2011, approximately 59,000 additional acres of formerly submerged land has been exposed in addition to 26,188 acres of terrestrial habitats described in **Table TA 9-2**.

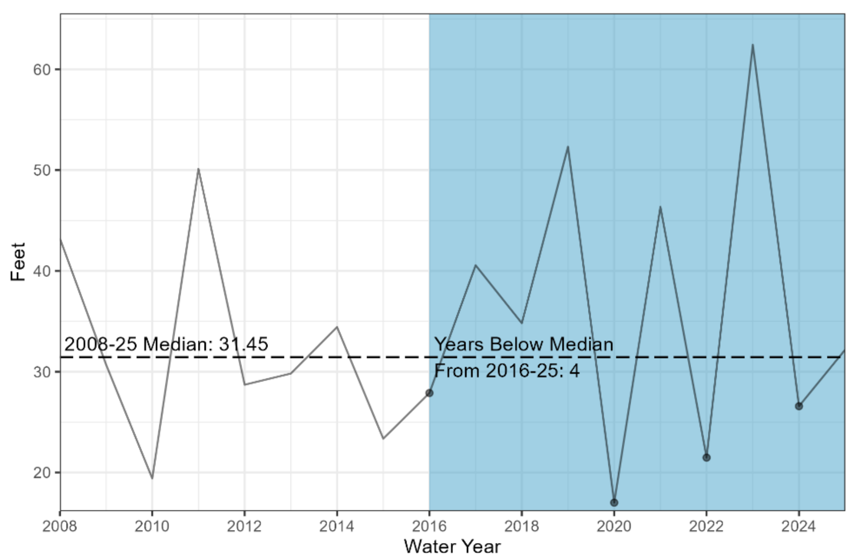
There are no long-term vegetation monitoring datasets available for Lake Powell that would support quantitative habitat modeling for this reach, as was done for the Glen Canyon to Lake Mead section; therefore, a qualitative approach was used to determine the predicted differences in marsh and woody riparian vegetation among the alternatives. As noted in **TA 9.1**, marsh and woody riparian vegetation are affected by water level fluctuations on short (annual) and long (5-year) time scales. Therefore, changes in water elevation over one-year and five-year periods were used as proxies to represent potential changes to marsh and woody riparian vegetation. In the Lake Powell reach, potential changes to marsh and native woody riparian vegetation would be primarily restricted to tributary side canyons and emerging riverine habitats along the major rivers, while non-native woody riparian vegetation (tamarisk) would be expected to continue to establish along the reservoir shoreline.

To determine the changes in water elevation under each alternative, the Colorado River Simulation System model was applied within the Decision Making under Deep Uncertainty (DMDU) framework to show maximum variability within 1 year and over 5 years in robustness heat map figures. A 5-year period was selected to represent longer-term variability in water level fluctuations. The modeled variability from the CRSS model and the DMDU framework were then compared to historic conditions to determine whether variability would remain the same, increase, or decrease for each alternative. For the purposes of this analysis, historic conditions extend from water year (WY) 2008–2025 (the 2007 Interim Guidelines period). Refer to **Section 3.2**, Analysis Methods, for additional information on DMDU and **Appendix E**, DMDU Overview and Approach, for an overview of how to interpret the DMDU robustness heatmaps.

The DMDU calculations are based on alternatives meeting a preferred minimum performance, defined by a threshold applied to model output values and a frequency over time. If a modeled future meets both the threshold and frequency, it is considered a successful future. For Lake Powell vegetation, the thresholds correspond to the median observed variability in water elevation over 1-year (for marsh vegetation) and 5-year (for woody riparian vegetation), representing historic conditions (**Figure TA 9-1** and **Figure TA 9-2**). The Continued Current Strategies (CCS) Comparative Baseline data displayed on each figure represents the modeled outcome if current management strategies were continued into the future. This information is included for comparative purposes between the alternatives and the modeled future of the analysis area.

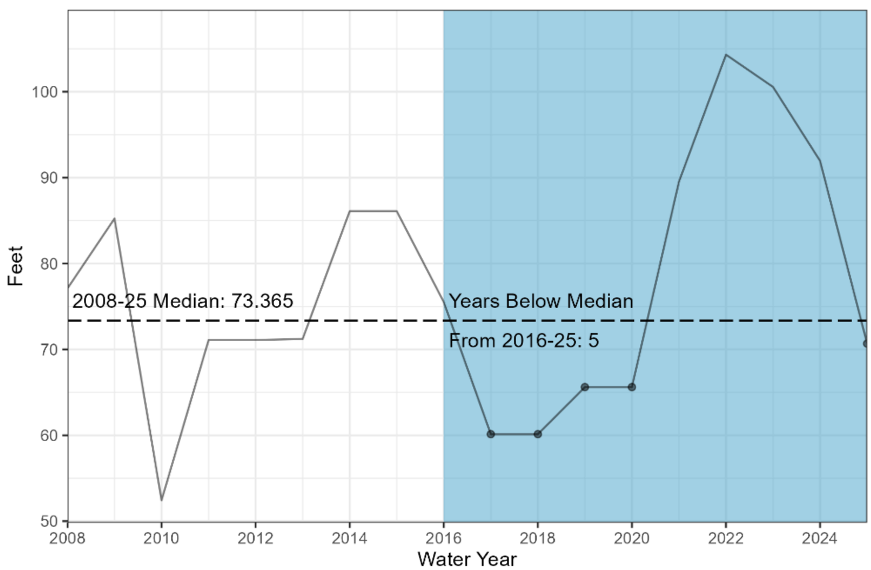
Since vegetation can tolerate a range of environmental conditions, failing to meet the threshold criteria once over the full modeling period is not necessarily detrimental to the habitat's establishment or growth over the long-term. Therefore, the analysis focuses on the number of times that the model meets the criteria over a 10-year window for marsh and a rolling 10-year window for woody riparian vegetation.

Figure TA 9-1
Historical Maximum Annual Water Elevation Change in Lake Powell



Note: The median of the maximum annual change was calculated for the 2007 Interim Guidelines period from 2008 to 2025. The number of years in which the maximum annual change was below that median (31.45 feet) in the last 10 years (2016–2025) was counted to determine the historical frequency. The full time period on **Figure TA 9-1** shows the entire 2007 Interim Guidelines period, while the shaded area indicates the last 10 years.

Figure TA 9-2
Historical Maximum 5-year Elevation Change in Lake Powell



Note: The maximum 5-year elevation change for each year was calculated using the minimum and maximum change from the previous 5 years. For example, the 5-year change for 2021 was calculated by using the minimum and maximums from 2016-2021. The median of the maximum 5-year change was calculated for the 2007 Interim Guidelines period from 2008 to 2025. The number of years in which the maximum 5-year change was below that median (73.365 feet) in the last 10 years (2016–2025) was counted to determine the historical frequency. The full time period on **Figure TA 9-2** shows the entire 2 Interim Guidelines period, while the shaded area indicates the last 10 years.

Glen Canyon Dam to Lake Mead

Riparian species classification data from Durning et al. (2018) was used to quantify existing land cover of marsh, woody riparian, and upland habitats in the analysis area of this reach. Durning et al. used remote sensing to delineate 33 species assemblages, which were consolidated based on the dominant species into marsh, woody riparian, and upland. Using the modeled and estimated 45,000 cfs stage elevation, there are approximately 3,076 acres of terrestrial habitat present in the analysis area (**Table TA 9-1**).

The Grand Canyon Monitoring and Research Center conducted hydrological niche modeling for several species on the fixed site sandbars for each alternative and used these models to estimate the acres of habitat suitability for each species (**Figure TA 9-9** and **Figure TA 9-10**; Butterfield and Palmquist 2026). The data used for this modeling was collected from 2014 to 2019 (Palmquist et al. 2018a) and can be accessed in the associated data release (Palmquist et al. 2022). In addition to habitat suitability, changes to native species richness (**Figure TA 9-12**), proportion native cover (**Figure TA 9-13**), and total vegetation cover (**Figure TA 9-14**) were estimated by combining the modeled habitat suitability. The hydrological niche modeling includes HFEs. For a detailed analysis of frequency and duration of HFEs under each alternative, see **TA 5**, Geomorphology and Sediment Resources.

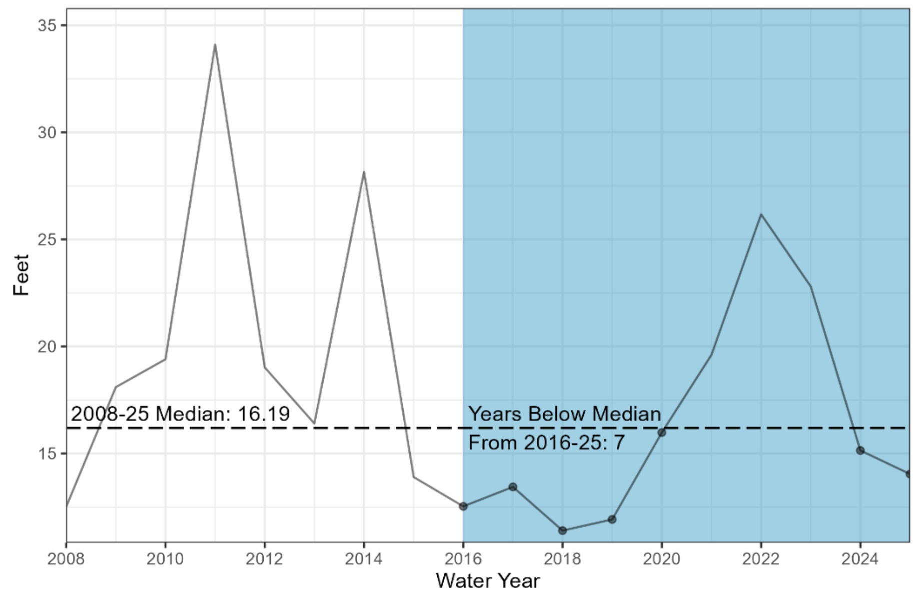
Figures presented for this reach are conditional box plots. Refer to **Section 3.2**, Analysis Methods, for additional information on DMDU and **Appendix E**, DMDU Overview and Approach, for an overview of how to interpret the DMDU conditional box plots. The hydrological niche modeling results used to create these figures can be accessed in the associated data release (Butterfield and Palmquist 2026). Habitat suitability is modeled in **Figure TA 9-9** and **Figure TA 9-10**, species included were consolidated by marsh (*Schoenoplectus* spp., *Juncu*s spp., *Equisetum arvense*, and *Phragmites australis*; **Figure TA 9-9**) and woody riparian (*Baccharis* spp., *Pluchea sericea*, *Prosopis glandulosa*, and *Salix exigua*; **Figure TA 9-10**). Upland species were not modeled because upland habitat is considered ubiquitous within and surrounding the analysis area (**Table TA 9-1**). Since multiple species can have similar habitat suitability characteristics, the acres presented in **Figure TA 9-9** and **Figure TA 9-10** are likely an overestimate and should be used to compare alternatives relatively in terms of increasing or decreasing habitat rather than as a prediction of actual acres under each alternative. The dashed lines included in **Figure TA 9-9** through **Figure TA 9-14** are reference lines to the 50th percentile of the modeled 'historical' period, which were modeled using 2000-2025 hydrology under CCS Comparative Baseline using a dry-initial condition (see **Section 3.2.6**, Decision Making under Deep Uncertainty for an explanation of initial conditions).

Lake Mead

In 2018, Reclamation contracted Sound Science, LLC, to classify and map riparian vegetation along the lower Colorado River, including Lake Mead (Sound Science 2025). Publicly available aerial imagery and Google Earth Engine were used to classify the imagery into eight classes: Cottonwood/Willow, Tamarisk, Mesquite, Marsh, other (sparsely vegetated), other (densely vegetated), water, and bare ground. Agricultural and developed areas were excluded from this classification. These classes were consolidated into woody riparian (Cottonwood/Willow, Tamarisk, Mesquite, other [densely vegetated]), marsh, and upland (other [sparsely vegetated], bare ground). Within the full pool area of Lake Mead, there are approximately 71,250 acres of terrestrial habitats present (**Table TA 9-1**).

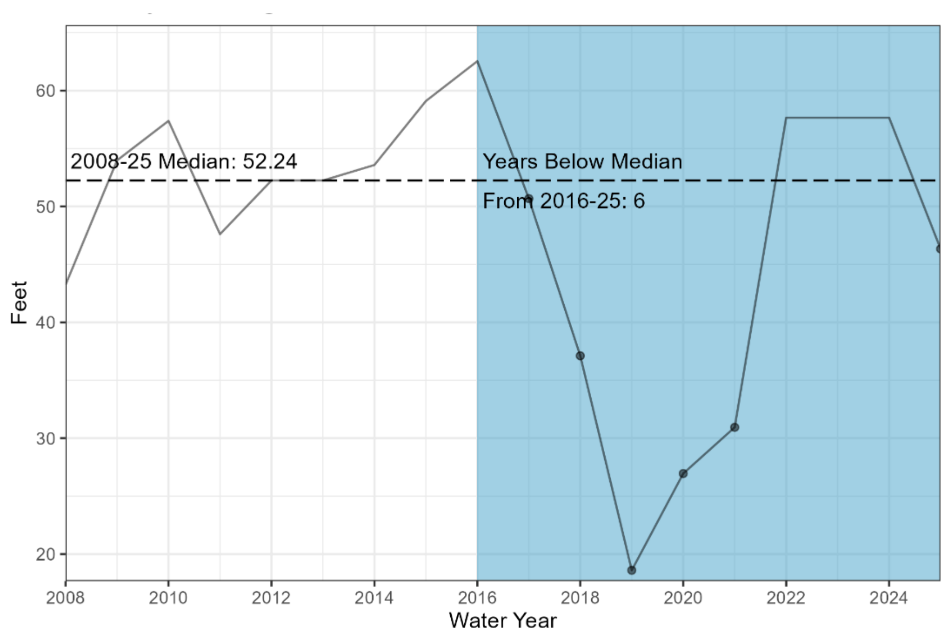
Similar to Lake Powell, changes in water elevation from historical conditions were used as a proxy to determine potential impacts on marsh and woody riparian vegetation under each alternative (**Figure TA 9-3** and **Figure TA 9-4**). The same methods for Lake Mead were used as described for Lake Powell.

Figure TA 9-3
Historical Maximum Annual Water Elevation Change in Lake Mead



Note: The median of the maximum annual change was calculated for the 2007 Interim Guidelines period from 2008 to 2025. The number of years where the max annual change was below that median (16.19 feet) in the last 10 years (2016–2025) was counted to determine the historical frequency. The full time period on **Figure TA 9-3** shows the entire Interim Guidelines period, while the shaded area indicates the last 10 years.

Figure TA 9-4
Historical Maximum 5-year Elevation Change in Lake Mead



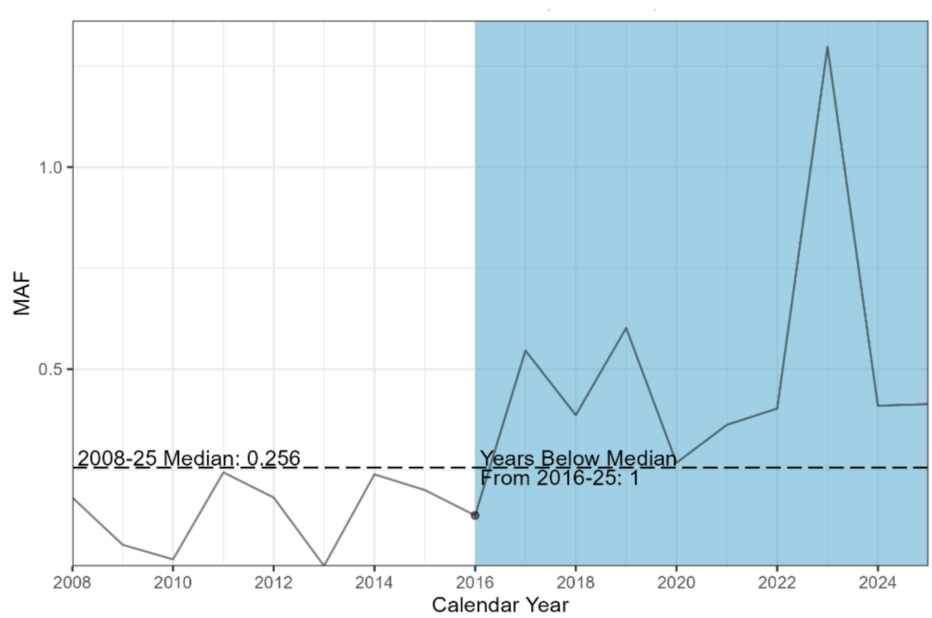
Note: The maximum 5-year elevation change for each year was calculated using the minimum and maximum change from the previous 5 years. For example, the 5-year change for 2021 was calculated by using the minimum and maximums from 2016 to 2021. The median of the maximum 5-year change was calculated for the 2007 Interim Guidelines period from 2008 to 2025. The number of years where the maximum 5-year change was below that median (52.24 feet) in the last 10 years (2016–2025) was counted to determine the historical frequency. The full time period on **Figure TA 9-4** shows the entire Interim Guidelines period, while the shaded area indicates the last 10 years.

Hoover Dam to Southerly International Boundary

The Sound Science, LLC riparian vegetation mapping effort described above under Lake Mead also includes the analysis areas within the Hoover Dam to SIB reach (Sound Science 2025). Within the full pool of Lake Mohave and Lake Havasu, and the historical floodplain of the Colorado River from Hoover Dam to the SIB, there are approximately 55,121 acres of terrestrial habitat (**Table TA 9-1**).

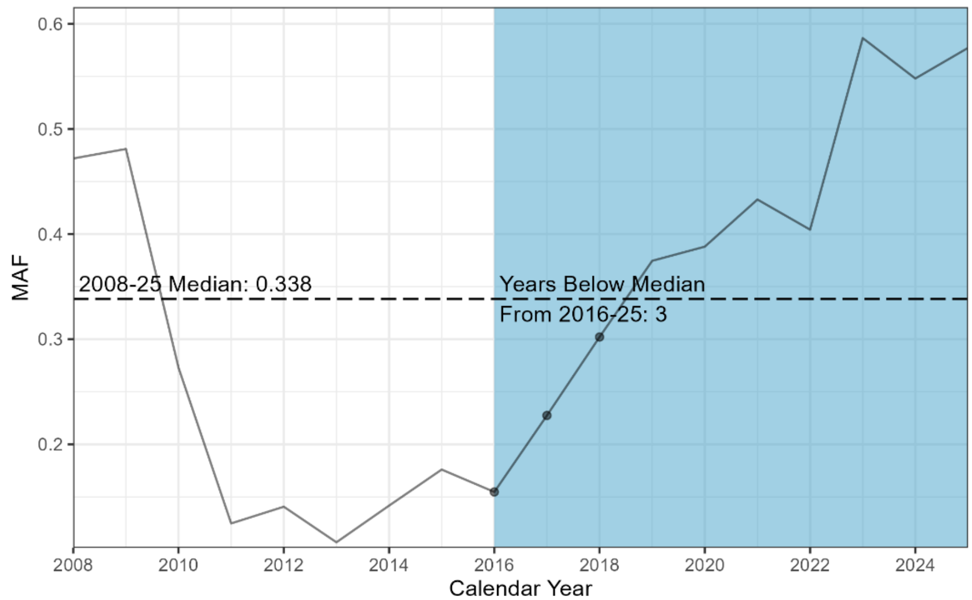
Similar to Lake Powell and Lake Mead, changes in water elevation were used as a proxy to determine potential impacts on marsh and woody riparian vegetation under each alternative. However, for this reach, water releases were used to represent changes from historic conditions rather than water elevation (**Figure TA 9-5** and **Figure TA 9-6**). Releases from Hoover Dam, Davis Dam, and Parker Dam were modeled, as releases from these dams determine the amount of water available downstream. Davis Dam and Parker Dam were found to have similar trends as Hoover Dam; therefore, only Hoover Dam results are discussed in detail (see **TA 9 Attachment 2** for Davis and Parker Dam results). The impacts as described in the Hoover to SIB section apply to the entire reach.

Figure TA 9-5
Historical Change in Annual Water Releases from Hoover Dam



Note: The median annual change was calculated from 2008 to 2025, whereas the number of years in which the change was below that median was calculated for the prior 10 years (shaded).

Figure TA 9-6
Historical Change in the Average 5-year Water Releases from Hoover Dam



Note: The median 5-year water release was calculated from 2008 to 2025, whereas the number of years in which the change was below that median was calculated for the prior 10 years (shaded).

Impact Analysis Area

Lake Powell

The Lake Powell reach includes Lake Powell up to full pool (water surface elevation 3,700 feet).

Glen Canyon Dam to Lake Mead

The Glen Canyon Dam to Lake Mead reach extends from Glen Canyon Dam (river mile [RM] -15.6) to RM 240. This reach includes the Colorado River through the Grand Canyon and ends where Lake Mead at full pool occurs at RM 240. The analysis area for this reach extends to the 45,000 cfs modeled stage elevation, corresponding to the maximum controlled flood releases under the current HFE protocol, and is considered the active floodplain of the Colorado River in this reach (LTEMP 2016). The modeled 45,000 cfs stage elevation from Magirl et al. (2008) was used for Lees Ferry (RM 0) to Diamond Creek (RM 226) and was estimated using the maximum height of the modeled stage elevation for RM 15.6 to RM 0 and RM 226 to RM 240.

Riparian vegetation composition changes from Glen Canyon Dam to Lake Mead and is related to decreasing elevation, increases in temperature, and shifts in precipitation (Palmquist et al. 2018b). The section from Glen Canyon Dam to Lake Mead is divided into three sub-reaches to account for these vegetation community changes: Marble Canyon (RM -15.6 to RM 60), Eastern Grand Canyon (RM 60 to RM 161), and Western Grand Canyon (RM 161 to RM 240).

Lake Mead

The Lake Mead reach extends from RM 240 in Grand Canyon to Hoover Dam. The analysis area for this reach includes full pool of Lake Mead (water surface elevation 1,229 feet).

Hoover Dam to SIB

The Hoover Dam to SIB reach is aligned with the LCR MSCP planning area. As described in **TA 8**, Biological Resources – Fish and Other Aquatic Species, there are seven reaches within the LCR MSCP planning area. For vegetation analysis, the analysis area includes LCR MSCP reaches 2-7 (Reclamation 2004a). Reach 1 in the LCR MSCP planning area includes Lake Mead up to full pool, which is addressed in the section above under Lake Mead. The analysis area includes the full pool of Lake Mohave and Lake Havasu and the historical floodplain of the Colorado River.

Assumptions

- A change of 10 percent between/among alternatives is considered a notable difference for the DMDU analysis.
- Upland, marsh, and woody riparian vegetation are suitable representatives for the major vegetation types found throughout the analysis area.
- A change in water elevations or releases greater than what has been observed over the past 10 years would result in changes to marsh and woody riparian vegetation compared to existing conditions.

Impact Indicators

- A change in the median and interquartile ranges from modeled historic conditions (Glen Canyon Dam to Lake Mead reach).
- Changes in water fluctuations within a single year compared to historic conditions (Lake Powell, Lake Mead, and Hoover Dam to SIB reaches).
- Changes in water fluctuations in the preceding 5 years compared to historic conditions (Lake Powell, Lake Mead, and Hoover Dam to SIB reaches).

TA 9.2.2 Issue 1: How would changes in the management of the Colorado River impact vegetation, including for special status species

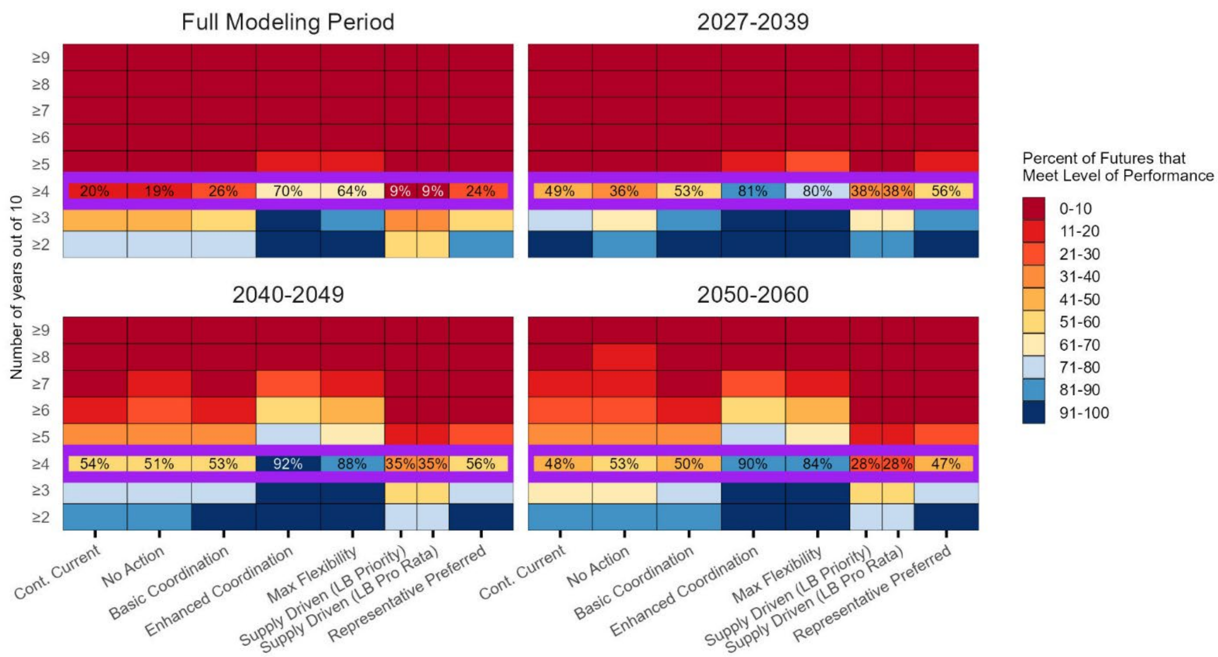
Lake Powell

Marsh Vegetation

As described above in **TA 9.2.1**, there are no long-term vegetation monitoring datasets available for Lake Powell that would support quantitative habitat modeling, therefore, changes in water elevation over one-year and five-year periods were used as proxies to represent potential changes to marsh and woody riparian vegetation. The median of the maximum annual change in water surface elevation from water year (WY) 2008–2025 was 31.45 feet (**Figure TA 9-1**). Over the past 10 years (WY 2016–2025) the maximum annual change in water surface elevation was less than 31.45 feet in 4 of 10 years (**Figure TA 9-1**). These data were used to characterize the existing variability in Lake Powell that has led to the current extent of marsh vegetation in the Lake Powell analysis area and are collectively referred to as historic conditions. As described above in **TA 9.1.1** and **TA 9.2.1**, marsh vegetation in Lake Powell is primarily restricted to tributary side canyons and emerging riverine habitats along the major rivers, so potential changes to marsh vegetation would be expected to be limited to those areas. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, an alternative must have a maximum annual change in water surface elevation of less than 31.45 feet in 4 or more years out of 10. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 4 years row is the alternative most similar to historic conditions. **Figure TA 9-7** compares the similarity of each alternative to the historic maximum annual change in Lake Powell elevation.

The other rows outside the greater than or equal to 4 years row demonstrate how many times the alternative had a maximum annual change in water surface elevation of less than 31.45 feet for X number of years, where the value of X varies by row (displayed on the y-axis). This information demonstrates whether the alternatives would meet the criterion for more or fewer years compared to historic conditions. For comparative purposes, each alternative is compared relative to historic conditions, which are outlined in the greater than or equal to 4 years row for reference. The percentages are provided in the greater than or equal to 4 years row to differentiate between alternatives, with a difference greater than 10 percent considered notable.

Figure TA 9-7
Lake Powell Marsh Riparian Vegetation: Robustness.
Percent of futures in which the maximum annual change in Lake Powell elevation is less than 31.45 feet in the number of years specified by each row during any 10-year period



The maximum annual change in water elevation for marsh over any 10-year period was calculated using historical data for the first 9 years of modeling on a rolling basis. After the 9th year, all data used to calculate the max annual change in water elevation included only modeled outputs. Since the years 2016 through 2019 included 3 years where the elevation change was greater than 31.45 feet (**Figure TA 9-1**), the early years of the first decade (2026–2029) had limited ability to reach the desired level of performance, as they could only fail one more time over the decade before failing to reach the desired level of performance. Once the years 2016 through 2019 were excluded (2030 and beyond), it became easier for the modeled alternatives to meet the desired level of performance.

For all alternatives except for the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative, increased variability in the first decade (2027–2039; **Figure TA 9-7**) compared to modeled historic conditions, indicated by a lower percentage of futures meeting the level of performance, would result in changes in marsh vegetation. Whether an area experiences an increase or a decrease in marsh habitat in response to changed conditions is mostly dependent on local topography, but generally, an increase in variability is expected to result in a decrease in marsh vegetation due to more frequent dewatering and inundation. In the first decade, the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative are the most robust, meeting the minimum level of performance in 81 percent and 80 percent of futures, respectively. The CCS Comparative Baseline and No Action Alternative meet it in 49 percent and 36 percent of futures, respectively.

For alternatives with increased variability, in the first decade, cover of prickly Russian thistle may increase due to the increased area of upland habitat created during water elevation fluctuations. Cover of prickly Russian thistle would be expected to decrease in the later decades if variability also decreases, indicated by a higher percentage of futures meeting the level of performance, reducing areas vulnerable to invasive species establishment on an annual basis. Native vegetation can re-establish over time, particularly in areas exposed for more than 3 years (Arens 2023).

In the later decades (2040–2049 and 2050–2060; **Figure TA 9-7**), the Enhanced Coordination Alternative is the most robust, meeting the minimum level of performance in 92 percent and 90 percent of futures, respectively. The CCS Comparative Baseline and No Action Alternative meet it in 54 percent and 48 percent, and 51 percent and 53 percent of futures, respectively. As variability becomes closer to historic conditions for Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative (as indicated by a higher percentage of futures meeting the level of performance), marsh vegetation may re-establish to a similar historical extent under those alternatives.

For the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative under the Critically Dry Flow Category Lake Powell has a modeled WY minimum median elevation of approximately 3,520 feet and 3,512 feet above mean sea level, respectively (see **TA 3**, Hydrologic Resources, **Table TA 3-3**), which are 38 and 46 feet below, respectively, the minimum 2024 water elevation of 3,558 feet (see **TA 3**, Hydrologic Resources, **Figure TA 3-1**). Under the Average Flow Category, Lake Powell has a WY modeled minimum median elevation of approximately 3,613 and 3,605 feet for the Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative, respectively (see **TA 3**, Hydrologic Resources, **Table TA 3-4**), which are approximately 55 and 47 feet higher than the minimum 2024 water elevation. This suggests higher modeled elevations under the Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative under all but the driest hydrologic conditions. If water elevations gradually rise with similar levels of variability to historic conditions (**Figure TA 9-7**), marsh vegetation is expected to continue to re-establish along the new water line over time. If water elevations rise, some of the side canyons that were exposed as Lake Powell receded may reflood, inundating native plant communities that had reemerged.

If water elevations stay the same or gradually fall with similar variability to historic conditions (**Figure TA 9-7**), marsh vegetation may re-establish to a similar extent along the new water line over time. Under these alternatives, plant communities in side canyons would remain exposed.

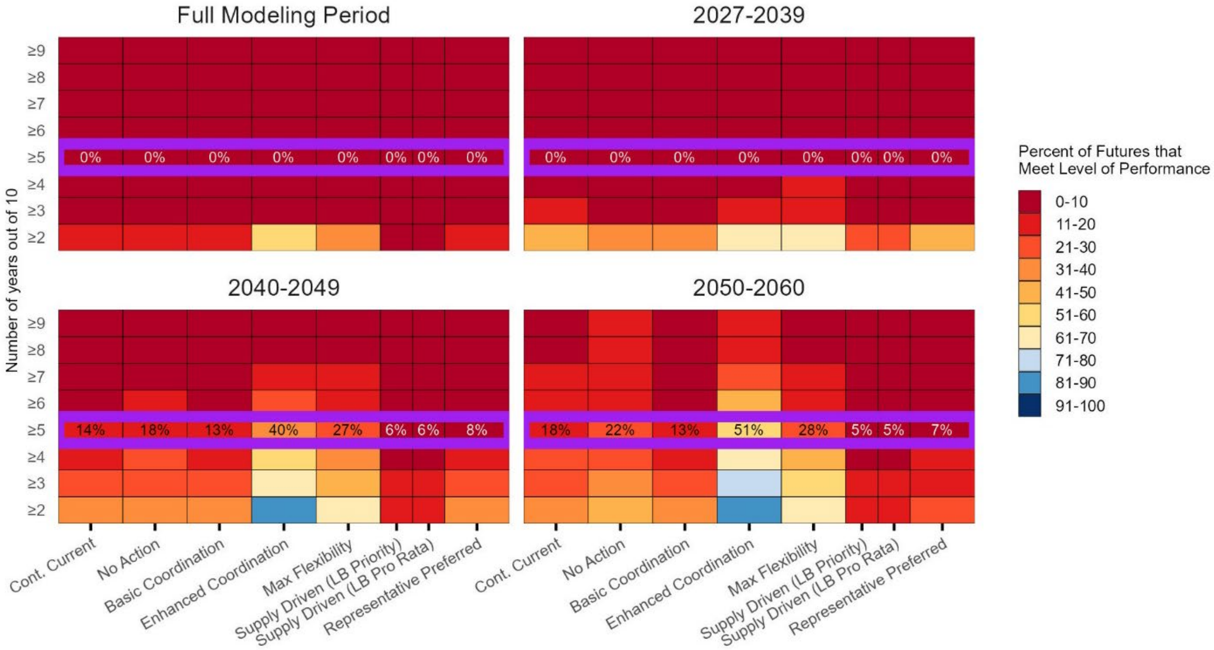
Whether water elevations rise, fall, or remain the same, if variability resembles historic conditions under the Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative in the later decades (**Figure TA 9-7**), marsh vegetation is expected to continue to re-establish along the new water line over time. For alternatives that have more variability than historic conditions (**Figure TA 9-7**), marsh vegetation may re-establish to a smaller extent along the new water line over time. Where variability eliminates or prevents the establishment of marsh habitat, woody riparian or upland habitat may become the dominant habitat type.

Woody Riparian Vegetation

The median of the maximum 5-year change in water surface elevation from WY 2008–2025 was 73.365 feet (**Figure TA 9-8**). Over the past 10 years (WY 2016–2025), the maximum 5-year change was less than 75.51 feet in 5 of 10 years (**Figure TA 9-8**). These data were used to characterize the existing variability that has led to the current extent of woody riparian vegetation in the Lake Powell analysis area and are collectively referred to as historic conditions. As described above in **TA 9.1.1** and **TA 9.2.1**, native woody riparian vegetation is primarily restricted to tributary side canyons and emerging riverine habitats along the major rivers, while non-native woody riparian vegetation (tamarisk) is abundant in these areas as well as the reservoir shoreline. Potential changes to woody riparian vegetation would be expected to occur in both of these areas, depending on species. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, an alternative must have a maximum 5-year change in water surface elevation of less than 73.365 feet in 5 or more years during every 10-year period. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 5 years row is the alternative most similar to historic conditions. **Figure TA 9-8** compares the similarity of each alternative to the historic maximum 5-year change in Lake Powell elevation.

The trends and types of impacts on woody riparian vegetation are the same as those described for marsh vegetation for Lake Powell (**Figure TA 9-7** and **Figure TA 9-8**). Similar to marsh vegetation, the historical trend for the maximum 5-year change includes historical data for the first 9 years, which influenced the ability for the model to reach the level of performance in the first decade (2027–2039). From 2021 to 2024, all 4 years were over the median of 73.365 (**Figure TA 9-8**). Once the years 2021–2024 were no longer a part of the calculation (2034 and beyond), it became easier for the model to hit the desired level of performance, which is reflected in the second and third decades of modeling having higher percentages. In the first decade, all alternatives are equally non-robust, meeting the minimum level of performance in 0 percent of futures.

Figure TA 9-8
Lake Powell Woody Riparian Vegetation: Robustness.
Percent of futures in which the maximum 5-year change in in Lake Powell elevation is less than 73.365 feet in the number of years specified by each row during any 10-year period



In the later decades, the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative are the most robust, meeting the minimum level of performance in 40 percent and 51 percent, and 27 percent and 28 percent of futures, respectively. The CCS Comparative Baseline and No Action Alternative meet the minimum level of performance in 14 percent and 18 percent, and 18 percent and 22 percent of futures, respectively. The Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative would have vegetation most similar to historic conditions in the later decades (2040–2060 and 2050–2060; **Figure TA 9-8**).

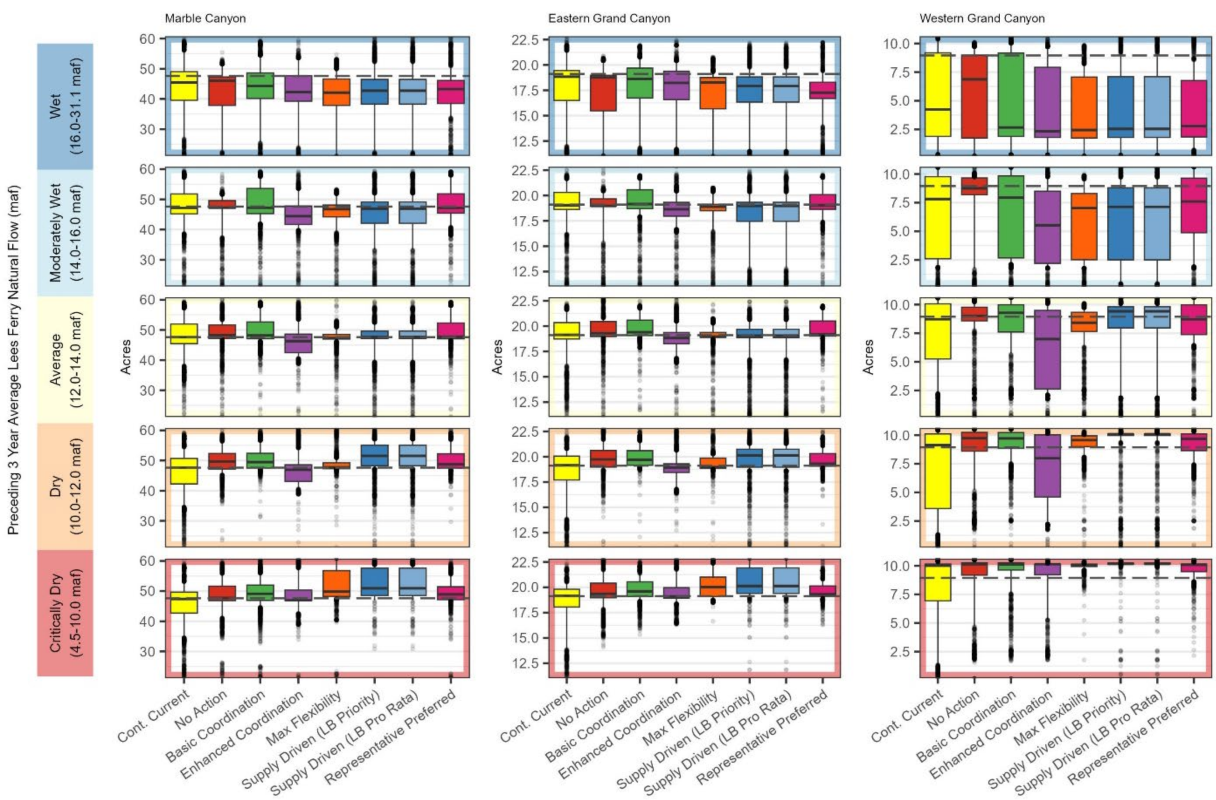
Also similar to marsh vegetation, whether water elevations rise, fall, or stay the same, if there are similar levels of variability to historic conditions under the Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative in the later decades (**Figure TA 9-8**), then woody riparian vegetation is expected to reestablish along the new water line over time. For alternatives that have more variability than historic conditions (**Figure TA 9-8**), woody riparian vegetation may re-establish to a smaller extent along the new water line over time. Where variability eliminates or prevents the establishment of woody riparian habitat, upland habitat may become the dominant habitat type. Whether an area experiences an increase or a decrease in woody riparian habitat in response to changed conditions is largely dependent on local topography, but generally an increase in variability is expected to result in a decrease in woody riparian vegetation.

Glen Canyon Dam to Lake Mead

Suitable Habitat Area

Marsh. Figure TA 9-9 compares the amount of modeled marsh habitat for each alternative by Grand Canyon sub-reach. Marsh vegetation includes bulrushes, rushes, field horsetail (*Equisetum arvense*), and common reed. Since multiple marsh vegetation species can have similar habitat suitability characteristics, the acres presented in **Figure TA 9-9** are likely an overestimate and should be used to compare alternatives in terms of relative increases or decreases in suitable habitat area rather than as a prediction of actual acres under each alternative. The hydrological niche modeling data used to create **Figure TA 9-9** can be found in Butterfield and Palmquist (2026).

Figure TA 9-9
Suitable Modeled Marsh Habitat for each Alternative by Sub-reach



In Marble Canyon and Eastern Grand Canyon, under the Average Flow Category, Moderately Wet Flow Category, and Dry Flow Category, the medians are near modeled historic conditions (dashed line) and the interquartile ranges are relatively restricted and overlap the modeled historic conditions (**Figure TA 9-9**) for all alternatives, indicating that the amount of habitat suitable for marsh species would likely be similar to historic conditions under these categories. Under the Critically Dry Flow Category, the Maximum Operational Flexibility Alternative, Supply Driven Alternative (both Lower Basin Priority [LB Priority] and Lower Basin Pro Rata [LB Pro Rata] approaches), and Representative Preferred Alternative medians and interquartile ranges are completely above modeled historic conditions (dashed line), indicating that suitable habitat for marsh species may increase under the Critically Dry Flow Category for those alternatives. Under the Wet Flow Category, the medians and interquartile ranges are mostly below modeled historic conditions (dashed line) for all alternatives, suggesting there would likely be less suitable marsh habitat under all alternatives.

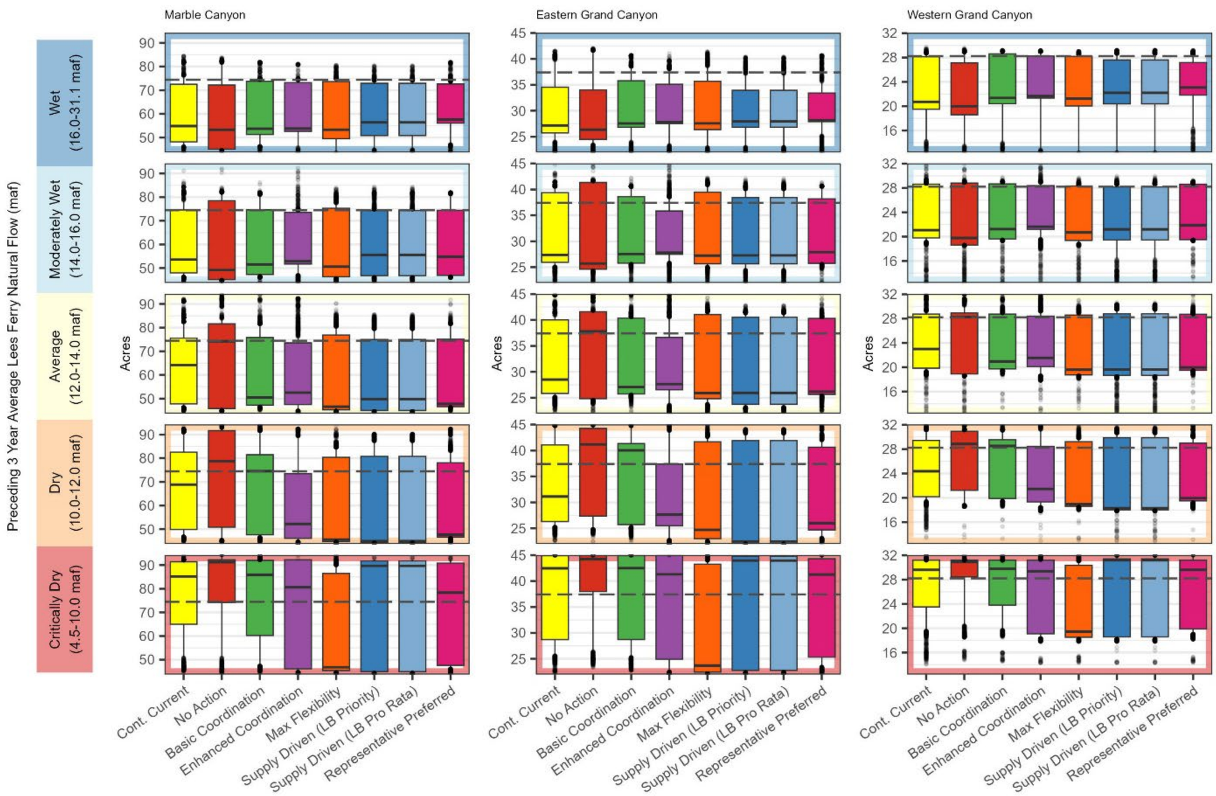
Further downstream in Western Grand Canyon, wider interquartile ranges suggest greater uncertainty in the amount of modeled suitable marsh habitat. The general trends follow that of Marble Canyon and Eastern Grand Canyon, but with more differentiation in the Moderately Wet and Dry Flow Categories; there would likely be similar levels of marsh habitat under the Average Flow Category, less marsh habitat under the Wet and Moderate Wet Flow Categories, and more marsh habitat under the Dry and Critically Dry Flow Categories. Under the Average, Dry, and Critically Dry Flow Categories, the CCS Comparative Baseline and Enhanced Coordination Alternative have wider interquartile ranges than the other alternatives, suggesting greater uncertainty.

The decrease in suitable habitat for marsh species under the Wet Flow Category for all sub-reaches and all alternatives may be because higher water levels may reduce the overall available terrestrial habitat in the active channel of the river (Sankey et al. 2015). The similarity or increase in suitable habitat for marsh species under the Dry and Critically Dry Flow Categories for all sub-reaches and all alternatives may be because decreasing water levels increase the amount of exposed shoreline habitat.

Woody Riparian. Figure TA 9-10 compares the amount of modeled woody riparian habitat for each alternative by Grand Canyon sub-reach. Woody riparian vegetation includes seep willow, arrowweed, honey mesquite, and coyote willow. Since multiple woody riparian species can have similar habitat suitability characteristics, the acres presented in **Figure TA 9-10** are likely an overestimate and should be used to compare alternatives in terms of relative increases or decreases in suitable habitat area rather than as a prediction of actual acres under each alternative. The hydrological niche modeling data used to create **Figure TA 9-10** can be found in Butterfield and Palmquist (2026).

Across all three sub-reaches, similar interquartile ranges would suggest that woody riparian suitable habitat would respond in a similar way across all alternatives under each flow category. However, the wide interquartile ranges suggest a high amount of uncertainty about how vegetation would respond under each of the modeled conditions and alternatives in all three sub-reaches.

Figure TA 9-10
Suitable Modeled Woody Riparian Habitat for each Alternative by Sub-reach



Similar to marsh habitat, under the Average, Moderately Wet Flow, Wet Flow, and Dry Flow Categories, there is less suitable habitat for woody riparian species, as indicated by the median remaining below the modeled historic conditions under all sub-reaches and across all alternatives except for the No Action Alternative and Enhanced Coordination Alternative in the Dry Flow Category. For some alternatives, the interquartile range expands above the modeled historic conditions (dashed line), indicating uncertainty about how vegetation would respond. Under the Critically Dry Flow Category, the medians are typically above the modeled historic conditions (dashed line), indicating a likely increase in suitable habitat for woody riparian vegetation under all alternatives except for the Maximum Flexibility Alternative. However, the large interquartile ranges extend far above as well as below the modeled historic conditions (dashed line) under all reaches and for all alternatives except for the No Action Alternative, indicating the variability is too high to predict whether there would be more or less suitable habitat for woody riparian species under these alternatives. The No Action Alternative remains above the modeled historic conditions for all three sub-reaches. This may be because under the No Action Alternative, there would be less water available compared to the other alternatives, and thus more exposed shoreline that can support woody riparian species.

Similar to marsh habitat, the decrease in suitable habitat for woody riparian species under the Moderately Wet Flow Category and Wet Flow Category for all sub-reaches and all alternatives may be because higher water levels reduce the overall available terrestrial habitat (Sankey et al. 2015).

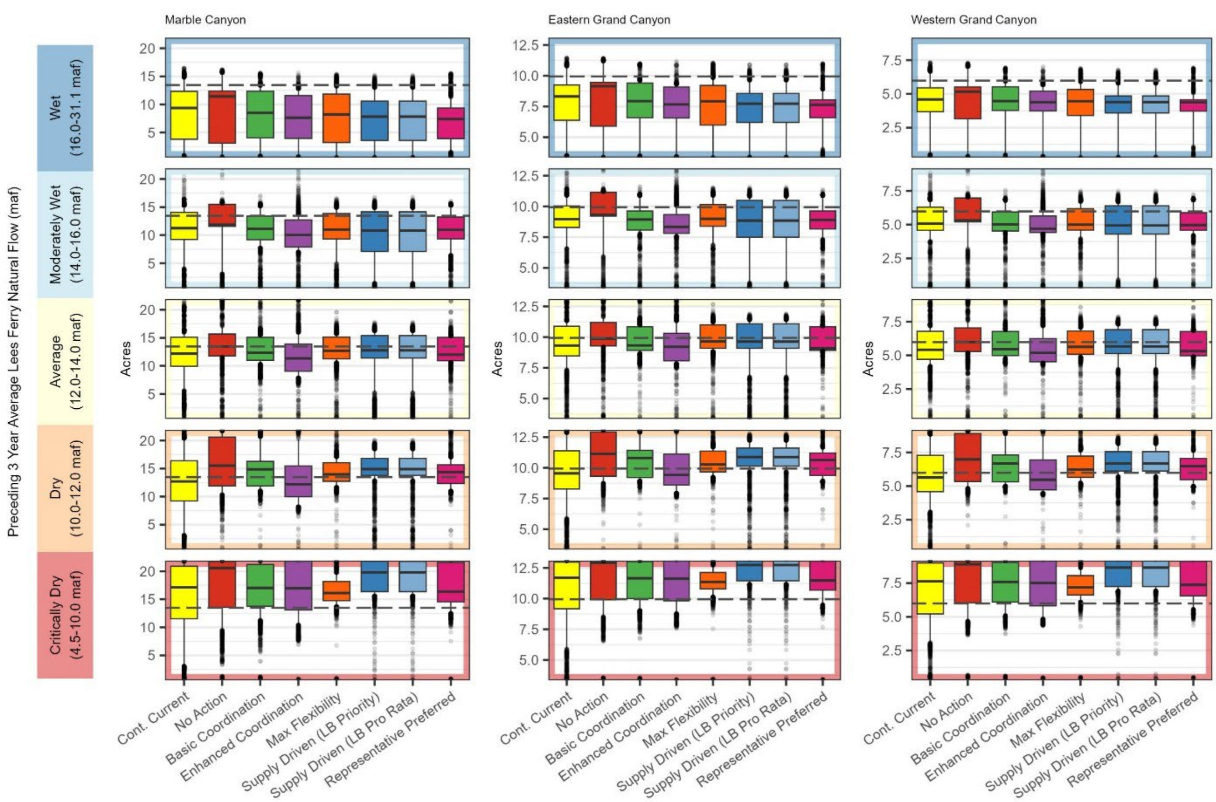
Whereas suitable habitat for woody riparian species may increase under the Critically Dry Flow Category, this expansion would occur near river level on areas recently exposed by lower water levels. Suitable habitat for both woody riparian and marsh species may overlap in these recently exposed areas, where these habitat types would compete near the river. In areas near the top of the active floodplain, decreasing water levels may provide an opportunity for an increase in upland habitat due to disconnection from the river.

Arrowweed

Figure TA 9-11 compares arrowweed suitable habitat under each alternative by Grand Canyon sub-reach. Across all three reaches, all alternatives show similar trends: the generally similar and overlapping interquartile ranges suggest arrowweed would respond in a similar way across all alternatives. The hydrological niche modeling data used to estimate changes to annual total vegetation cover and create **Figure TA 9-11** can be found in Butterfield and Palmquist (2026).

Under the Average Flow Category, across all three sub-reaches, the median for each alternative overlaps or nearly overlaps the modeled historic conditions (dashed line), and the interquartile ranges are relatively small. This indicates that arrowweed suitable habitat may be similar to historic conditions under the Average Flow Category.

Figure TA 9-11
Suitable Modeled Arrowweed (Pluchea sericea) Habitat for each Alternative by Sub-reach



Across all three sub-reaches, under the Wet Flow Category and Moderately Wet Flow Category, the median and interquartile ranges are below the modeled historic conditions (dashed line) for all alternatives except for the interquartile ranges of the No Action Alternative and Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) in the Moderately Wet Flow Category. This suggests that there would be less arrowweed suitable habitat under the Wet and Moderately Wet Flow Categories under all sub-reaches and all alternatives. Under the Dry Flow Category, the median and interquartile ranges are above historic conditions (dashed line), for all alternatives except the CCS Comparative Baseline and Enhanced Coordination Alternatives. Under the Critically Dry Flow Category, the median and interquartile ranges are above the modeled historic conditions (dashed line) for all sub-reaches and all alternatives except for the CCS Comparative Baseline, although the median remains above historic conditions. This indicates that there may be more arrowweed suitable habitat under the Critically Dry Flow Category for all alternatives across all sub-reaches.

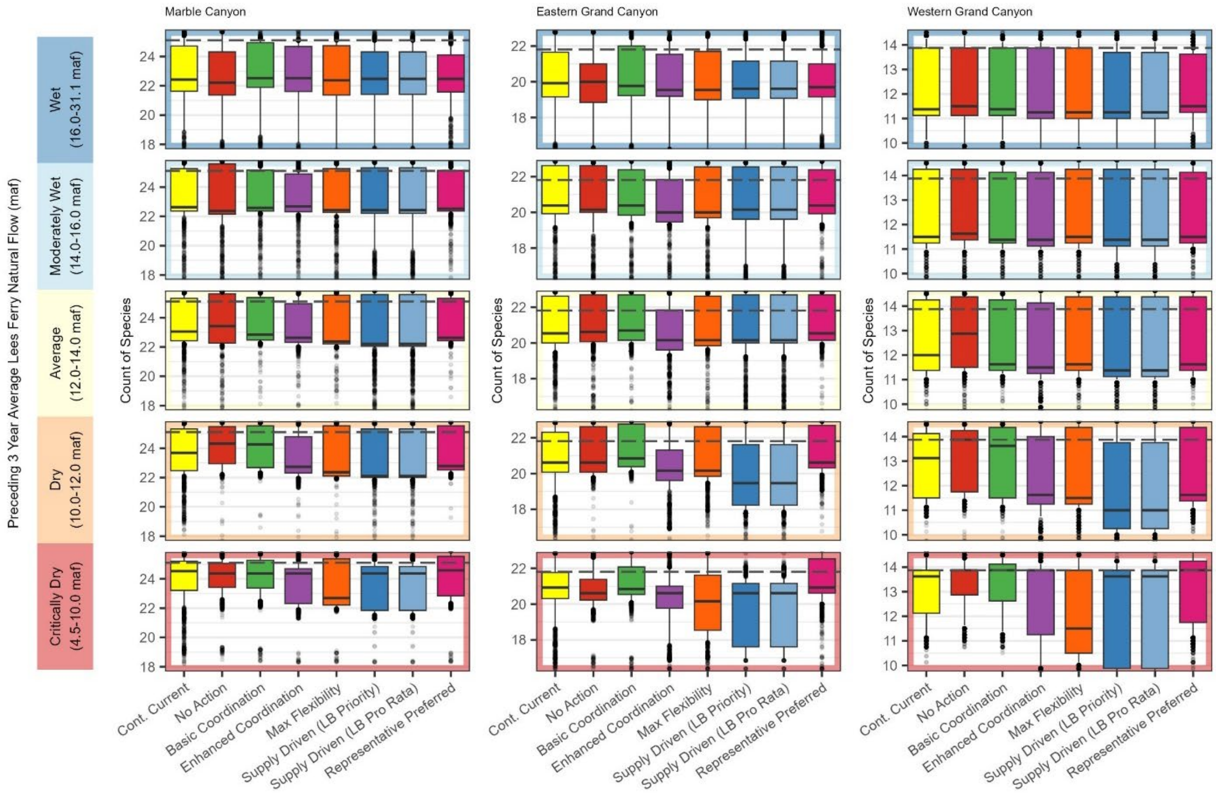
Similar to the discussions under *Marsh* and *Woody Riparian*, the decrease in arrowweed suitable habitat under the Moderately Wet and Wet Flow Categories for all sub-reaches and all alternatives may be because higher water levels reduce the overall available terrestrial habitat (Sankey et al. 2015). HFEs would also have an influence on suitable habitat, with more frequent and longer HFEs impacting vegetation encroachment in various ways depending on geomorphic setting, duration, and flow volume. Conversely, arrowweed suitable habitat may increase under the Dry and Critically Dry Flow Categories, potentially in areas recently exposed by lower water levels. Fewer to no HFEs under the Dry and Critically Dry Flow Categories could also lead to higher vegetation encroachment.

Native Species Richness

Figure TA 9-12 compares the predicted count number of native species (native species richness) under each alternative by Grand Canyon sub-reach. Native species richness includes all habitat types, and does not distinguish between marsh, woody riparian, and upland. Across all three sub-reaches, all alternatives show similar trends: the wide and generally similar interquartile ranges suggest native species richness would respond in a similar way across all alternatives. The hydrological niche modeling data used to estimate changes to native species richness and create **Figure TA 9-12** can be found in Butterfield and Palmquist (2026).

Under all alternatives, sub-reaches, and flow categories, the median is below the modeled historic conditions (dashed line). For some modeled conditions, the interquartile range is above the modeled historic conditions, indicating uncertainty in how vegetation would respond. Since most of the interquartile range is still below the modeled historic conditions, native species richness may decrease under all modeled conditions. However, given the large interquartile ranges, it is difficult to predict how each alternative may respond. Similar to marsh habitat, the Western Grand Canyon reach has larger interquartile ranges than Marble Canyon and Eastern Grand Canyon, indicating greater uncertainty further downstream.

Figure TA 9-12
Native Vegetation Species Richness for each Alternative by Sub-reach



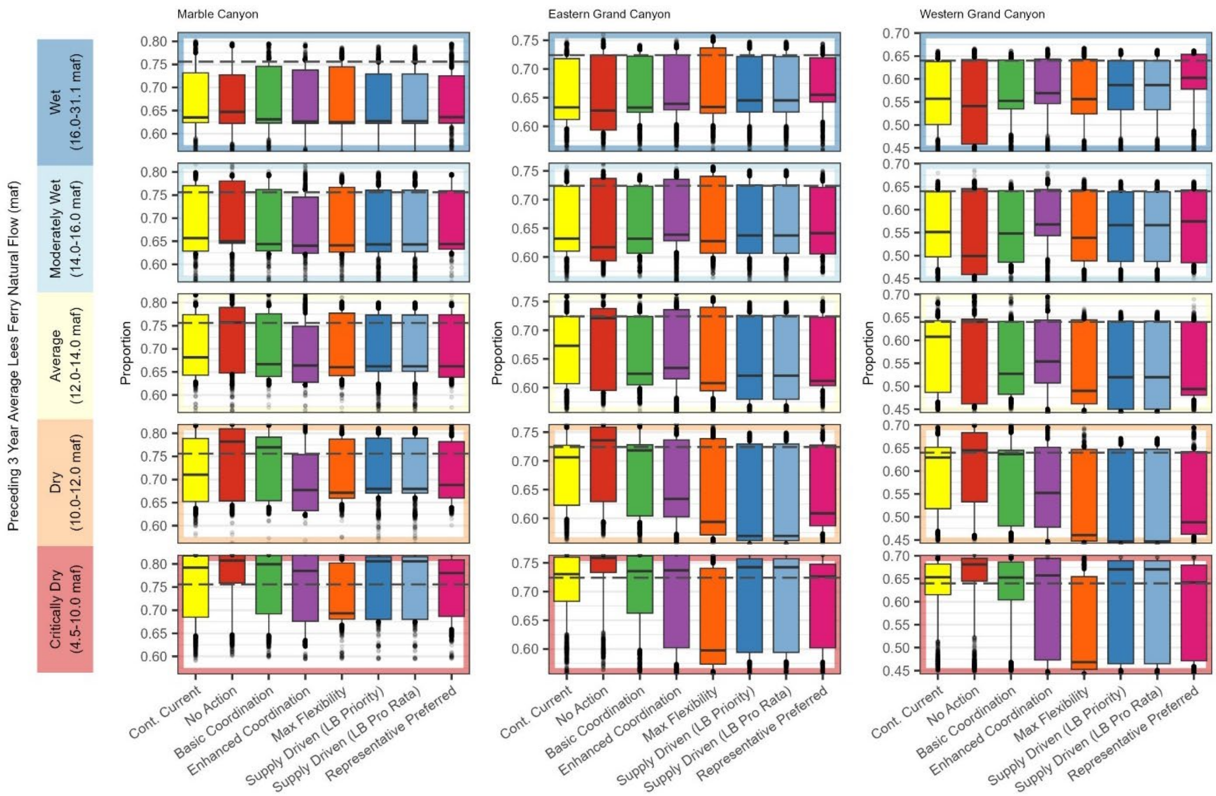
Species richness at the fixed site sandbars declined from 2014-2019, a trend that was driven by low species richness in 2019 (Palmquist et al. 2023). The low species richness in 2019 was likely caused by the HFE that occurred in fall 2018 and the lack of monsoon precipitation in summer 2019. Native species richness may decrease under wet hydrologic conditions as HFEs would be a more frequent occurrence and may decrease under the Critically Dry Flow Category due to a lack of precipitation. Disturbance created by HFEs can also positively impact native species richness, as some species require periodic disturbance. Native species richness may also decrease under the Critically Dry Flow Category due to a lack of HFEs.

Under all conditions, a combination of these hydrological and climatic factors may be driving the variable interquartile ranges.

Proportion Native Species Cover

Figure TA 9-13 compares the proportion of native species cover under each alternative by Grand Canyon sub-reach. Proportion of native species cover includes all habitat types and does not distinguish between marsh, woody riparian, and upland. Across all three sub-reaches, all alternatives show similar trends: the generally wide and similar interquartile ranges in each sub-reach suggest that the proportion of native cover would respond in a similar way across all alternatives. The hydrological niche modeling data used to estimate changes to the proportion of native species cover and create **Figure TA 9-13** can be found in Butterfield and Palmquist (2026).

Figure TA 9-13
Proportion of Native Species Cover for each Alternative by Sub-reach



Similar to native species richness, the proportion of native species cover has large interquartile ranges across all modeled conditions and all alternatives. This indicates a large amount of uncertainty in how vegetation would respond under various conditions.

Within all reaches, under the Wet, Moderately Wet, Average, and Dry Flow Categories modeled conditions, the median is below the modeled historic conditions (dashed line) for all alternatives except for the No Action Alternative and Basic Coordination Alternative under Average and Dry Flow Categories. Since most of the interquartile ranges are below the modeled historic conditions, the proportion of native cover may decrease under Wet, Moderately Wet, Average, and Dry Flow Category conditions under all alternatives and all sub-reaches. However, given the large interquartile ranges, it is difficult to predict how vegetation may respond under each of the modeled conditions, alternatives, and sub-reaches.

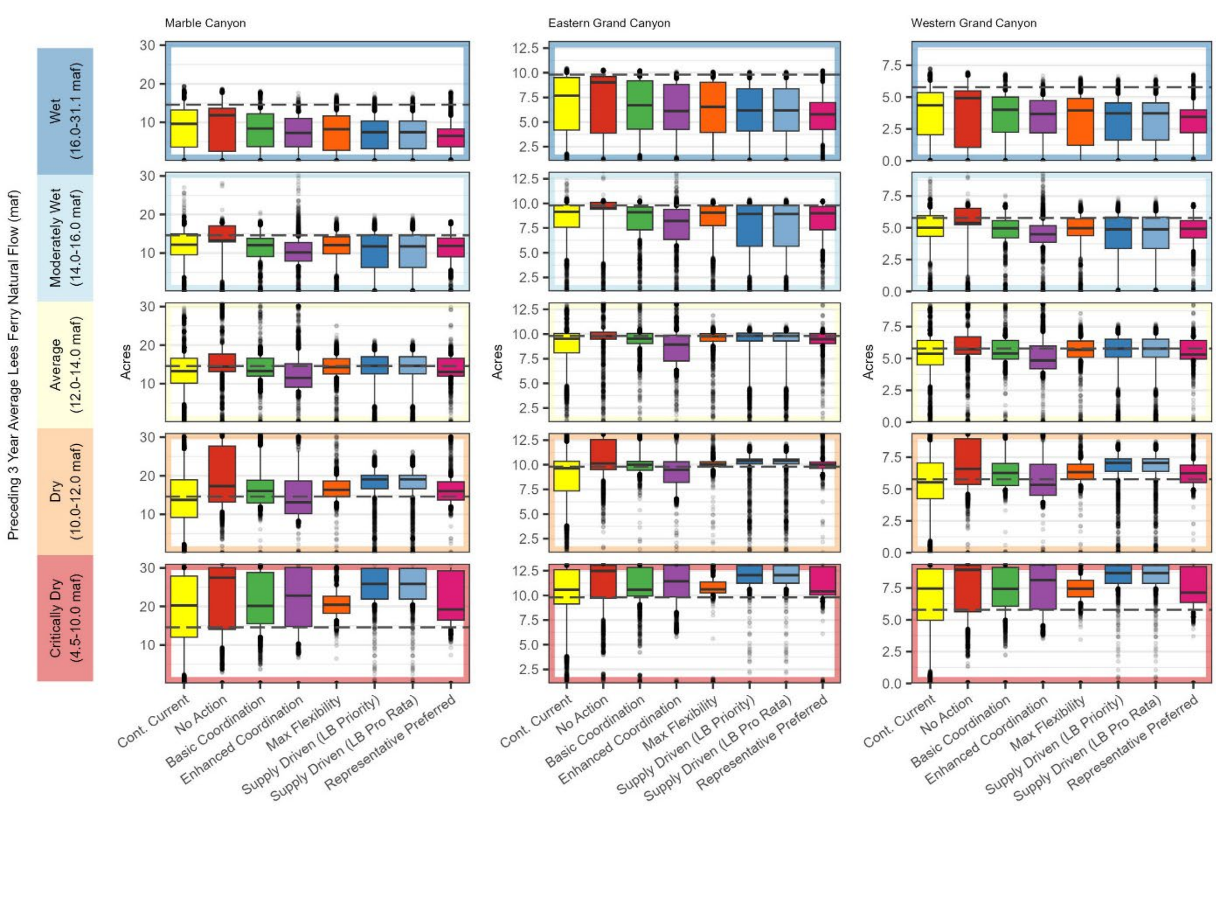
For all sub-reaches, under the Critically Dry Flow Category modeled conditions, the median and interquartile range is above the modeled historic conditions (dashed line) under all alternatives except for the Maximum Operational Flexibility Alternative. This suggests that under the Critically Dry Flow Category modeled conditions, the proportion of native cover may stay similar to historic conditions or increase under most alternatives. However, given the large interquartile ranges, it is difficult to predict how vegetation may respond under each alternative.

Encroachment of riparian vegetation into the exposed active channel and bare sand of sandbars has been found to be driven by seep willows, which are native species (Durning et al. 2021). The proportion of native species cover may decrease under all conditions except for the Critically Dry Flow Category due to a lack of bare sand available for native species, particularly seep willows, to colonize. Seep willows are also less flood tolerant than other species, so the increase in HFE frequency and duration could decrease their suitable area under the Moderately Wet Flow Category. The proportion of native cover may increase under the Critically Dry Flow Category because of receding water levels and subsequent increase in available sand.

Annual Total Vegetation Cover

Figure TA 9-14 compares the annual total vegetation cover under each alternative by Grand Canyon sub-reach. Annual total vegetation cover includes all habitat types and does not distinguish between marsh, woody riparian, and upland. Across all three reaches, all alternatives show similar trends: the generally similar and overlapping interquartile ranges suggest annual total vegetation cover would respond in a similar way across all alternatives. The hydrological niche modeling data used to estimate changes to annual total vegetation cover and create **Figure TA 9-14** can be found in Butterfield and Palmquist (2026).

Figure TA 9-14
Annual Total Vegetation Cover for each Alternative by Sub-reach



Under the Average Flow Category, across all three sub-reaches, the median for each alternative overlaps or nearly overlaps the modeled historic conditions (dashed line), and the interquartile ranges are relatively small. This indicates that annual total vegetation may be similar to historic conditions under the Average Flow Category.

Across all three sub-reaches, under the Wet Flow Category and Moderately Wet Flow Category, the median and interquartile ranges are at or below the modeled historic conditions (dashed line) for all alternatives except for the interquartile range of the No Action Alternative in the Moderately Wet Flow Category, although the median remains below historic conditions. This suggests that there would be less annual total vegetation cover under the Wet and Moderately Wet Flow Categories under all sub-reaches and all alternatives. Under the Dry Flow Category, the medians are above historic conditions (dashed line) for all alternatives except the CCS Comparative Baseline and Enhanced Coordination Alternative. Under the Critically Dry Flow Category, the median and interquartile ranges are above the modeled historic conditions (dashed line) for all sub-reaches and all alternatives except for the CCS Comparative Baseline. This indicates that there may be more annual total vegetation cover under the Dry and Critically Dry Flow Categories.

Similar to the discussions under *Suitable Habitat Area*, the decrease in annual total vegetation cover under the Moderately Wet and Wet Flow Categories for all sub-reaches and all alternatives may be because higher water levels reduce the overall available terrestrial habitat (Sankey et al. 2015). HFEs would also have an influence on annual total vegetation cover; more frequent and longer HFEs would result in lower vegetation encroachment. Conversely, annual total vegetation cover may increase under the Dry and Critically Dry Flow Categories, potentially on areas recently exposed by lower water levels. Fewer to no HFEs under the Dry and Critically Dry Flow Categories could also lead to higher vegetation encroachment.

High Flow Experiments

HFEs influence vegetation dynamics in this reach depending on geomorphic setting, duration, and flow volume. HFEs are dependent on sufficient storage and sediment conditions at Lake Powell. Alternatives that prioritize retaining higher levels in Lake Powell are more likely to result in HFEs, which could influence modeled vegetation responses in this reach. The role of HFEs in shaping vegetation in this reach is described in greater detail in the 2024 LTEMP SEIS (Reclamation 2024).

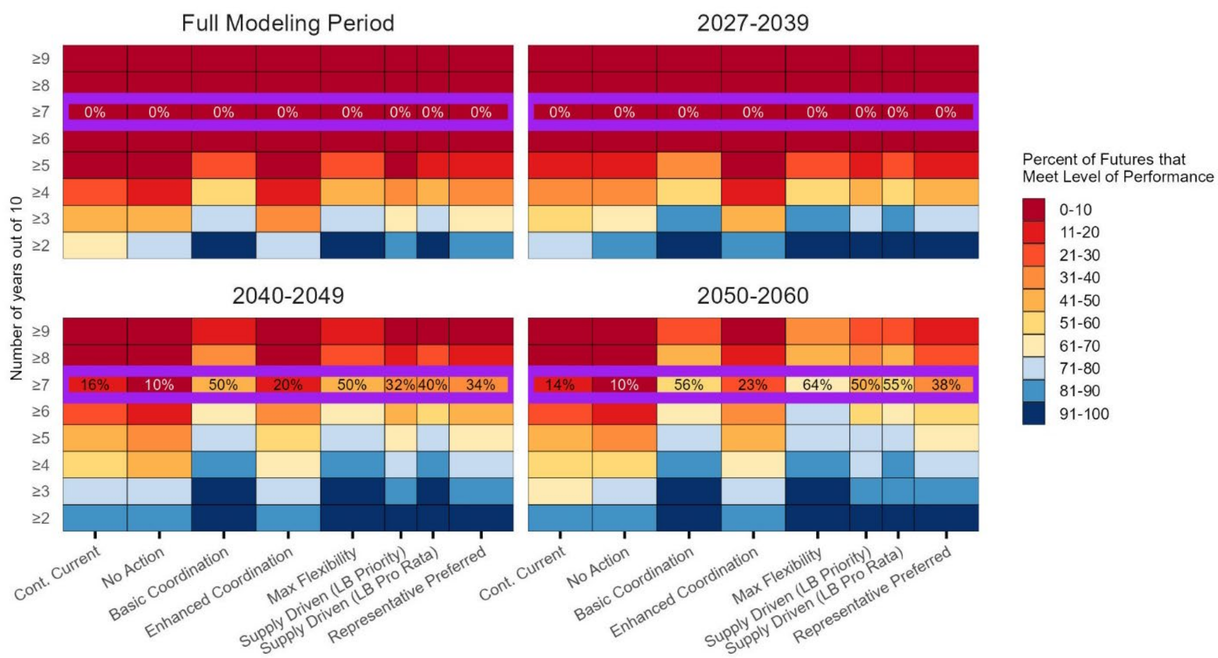
Lake Mead

Marsh Vegetation

The median of the maximum annual change in water surface elevation from WY 2008–2025 was 16.19 feet (**Figure TA 9-15**). Over the past 10 years, WY 2016–2025, the maximum annual change was less than 16.19 feet in 7 of 10 years (**Figure TA 9-15**). These data were used to understand the existing variability in Lake Mead that has led to the current extent of marsh vegetation in the Lake Mead analysis area and are collectively referred to as historic conditions. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, the alternative must have a maximum annual change in water surface elevation of less than 16.19 feet in 7 or more years. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 7 years row is the alternative most similar to historic conditions. **Figure**

TA 9-15 compares the similarity of each alternative to historic maximum annual change in Lake Mead elevation.

Figure TA 9-15
Lake Mead Marsh Riparian Vegetation: Robustness.
Percent of futures in which the maximum annual change in Lake Mead elevation is less than 16.19 feet in the number of years specified by each row during any 10-year period



Note: Supply Driven Lower Basin (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).

Similar to Lake Powell, the first decade of modeling for marsh habitat in Lake Mead is influenced by historical data (**Figure TA 9-15**). In the first decade, all alternatives are equally non-robust, meeting the minimum level of performance in 0 percent of futures. For all alternatives, the increased variability from historic conditions in the first decade (2027–2039; **Figure TA 9-15**) of the analysis may result in decreased cover of marsh vegetation.

In later decades (2040–2049 and 2050–2060; **Figure TA 9-15**) when variability becomes closer to historic conditions for the Basic Coordination Alternative and Maximum Operational Flexibility Alternative, marsh vegetation may re-establish to a more similar extent compared to the other alternatives. Both of these alternatives are more robust than the CCS Comparative Baseline and No Action Alternative, which meet the minimum level of performance in 16 percent and 14 percent, and 10 percent and 10 percent of futures, respectively. Similar to Lake Powell, when conditions are more variable, cover of nonnative species such as prickly Russian thistle may increase, and if variability decreases, native cover may reestablish.

As shown in **Figure TA 3-11** (see **TA 3**, Hydrologic Resources), the interquartile ranges for all alternatives for the Average Flow Category are above the 2024 WY minimum of 1,061 feet except for the No Action Alternative. The interquartile ranges under the Dry Flow Category are closer to the 2024 WY minimum compared to the Average Flow Category, and the interquartile ranges overlap with the 2024 WY minimum for all alternatives under the Critically Dry Flow Category. This suggests that Lake Mead is likely to lower under drier conditions. Conversely, under the Moderately Wet and Wet Flow Categories, the interquartile ranges shift to be higher than the 2024 WY minimum of 1,061 feet (**Figure TA 3-11**, see **TA 3**, Hydrologic Resources), suggesting that Lake Mead would rise under wetter conditions.

Similar to Lake Powell, whether water elevations rise, fall, or remain the same, if there are similar levels of variability to historic conditions under the Basic Coordination Alternative, Maximum Operational Flexibility Alternative, and Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) in the later decades (**Figure TA 9-15**), marsh vegetation is expected to continue to reestablish along the new water line over time. For alternatives with greater variability than historic conditions (**Figure TA 9-15**), marsh vegetation may re-establish to a smaller extent along the new water line over time. Where variability eliminates or prevents establishment of marsh habitat, woody riparian or upland habitat may become the dominant habitat type.

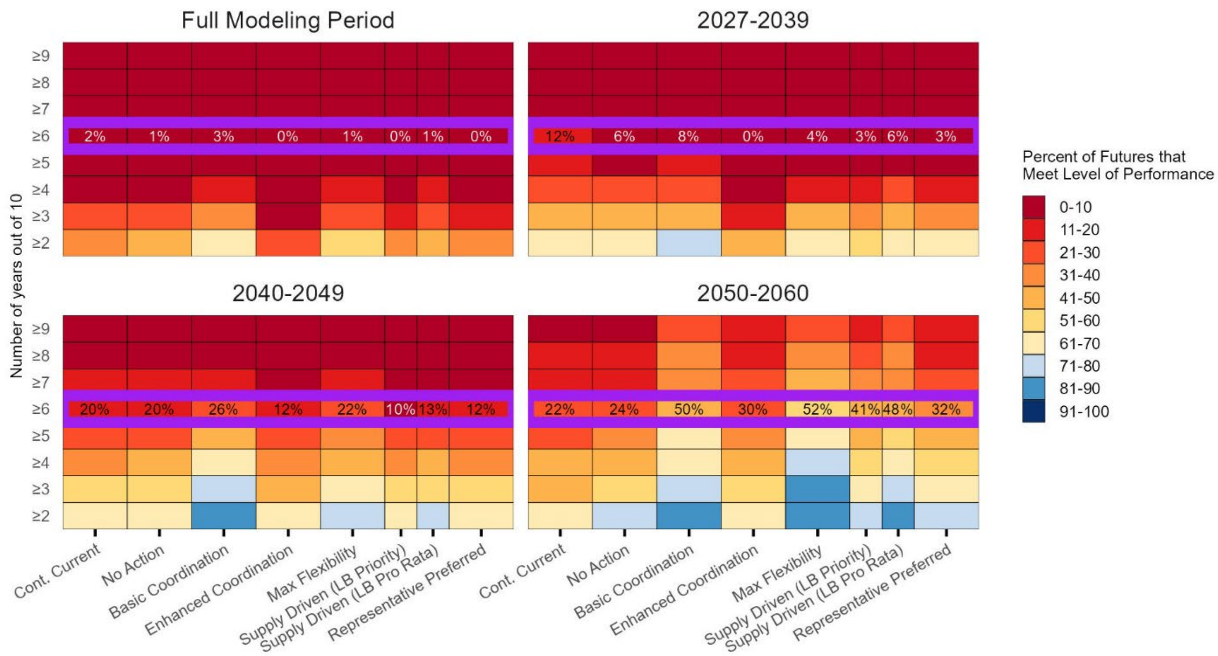
Woody Riparian Vegetation

The median 5-year change in water surface elevation from WY 2008–2025 was 52.24 feet (**Figure TA 9-16**). Over the past 10 years, WY 2016–2025, the 5-year change was less than 52.24 feet in 6 years out of 10 (**Figure TA 9-16**). These data were used to understand the existing variability in Lake Mead that has led to the current extent of woody riparian vegetation in the Lake Mead analysis area and are collectively referred to as historic conditions. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, the alternative must have a maximum 5-year change in water surface elevation of less than 52.24 feet in 6 or more years during every 10-year period. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 6 years row is the alternative most similar to historic conditions. **Figure TA 9-16** compares the similarity of each alternative to the historic maximum 5-year change in Lake Mead elevation.

Similar to Lake Powell, the first decade of modeling for woody riparian vegetation is influenced by historical data (**Figure TA 9-16**). All alternatives meet the minimum level of performance in 12 percent or less of futures.

The later decades (2040–2049 and 2050–2060; **Figure TA 9-16**) begin to trend towards more similar variability compared to historic conditions, but variability still remains high. The Basic Coordination Alternative and the Maximum Operational Flexibility Alternative are more similar to historic conditions, meeting the minimum level of performance in 26 percent and 50 percent and 22 percent and 52 percent of futures, respectively. Both of these alternatives are more robust than the CCS Comparative Baseline and No Action Alternative, which meet the minimum level of performance in 20 percent and 22 percent, and 20 percent and 24 percent of futures, respectively.

Figure TA 9-16
Lake Mead Woody Riparian Vegetation: Robustness.
Percent of futures in which the maximum 5-year change in Lake Mead elevation is less than 52.24 feet in the number of years specified by each row during any 10-year period



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).

In later decades (2040–2049 and 2050–2060; **Figure TA 9-16**), when variability becomes more similar to historic conditions for the Basic Coordination Alternative and Maximum Operational Flexibility Alternative, woody riparian vegetation may re-establish to a more similar extent as existing conditions compared to other alternatives. Where variability eliminates or prevents the establishment of woody riparian habitat, upland habitat may become the dominant habitat type.

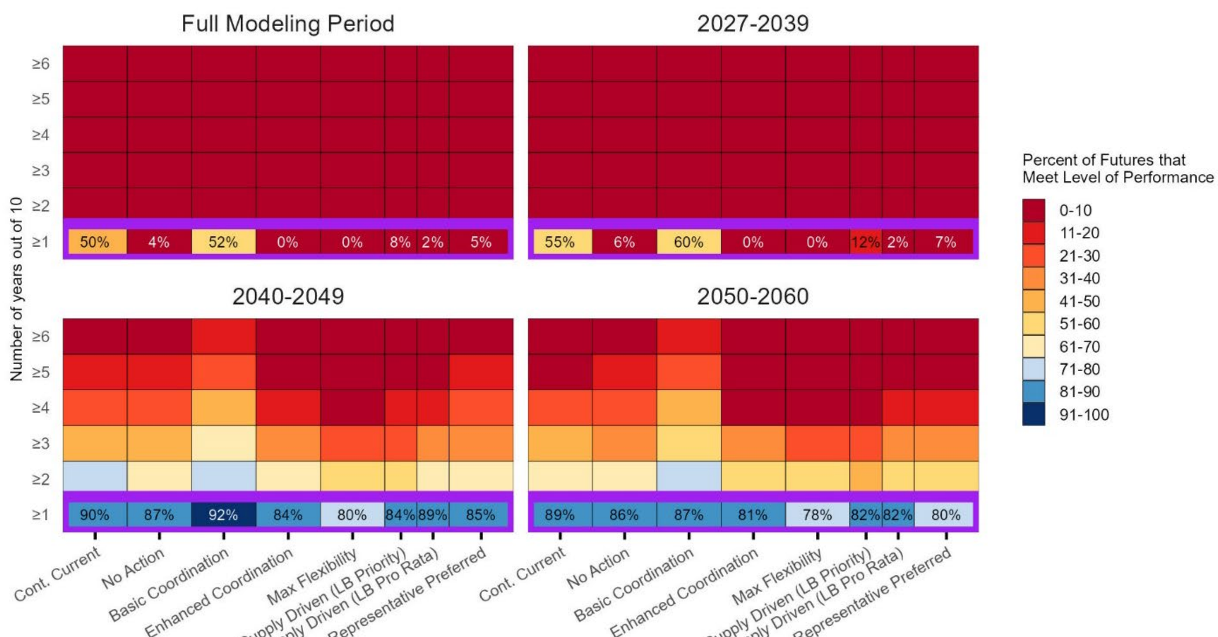
Figure TA 9-15 and **Figure TA 9-16** suggest annual variability in Lake Mead water elevations may be higher, especially in the early decade of the modeling period; however, the variability on a 5-year basis may overall be closer to historic conditions, generally benefiting woody riparian vegetation. As described in **TA 9.1**, historical data indicate that a reduction in variability can create new woody riparian habitat, however, subsequent increases in variability or long term drawdowns can cause vegetation die offs (McKernan and Braden 1998; Reclamation 2004b).

Hoover Dam to SIB

Marsh Vegetation

The median of the maximum annual change in Hoover releases from WY 2008–2025 was 0.256 maf (**Figure TA 9-17**). Over the past 10 years, WY 2016–2025, the maximum annual change was less than 0.256 maf in 1 of 10 years (**Figure TA 9-17**). These data were used to understand the existing variability from Hoover Dam to the SIB, which has led to the current extent of marsh vegetation in the Hoover Dam to the SIB analysis area, and are collectively referred to as historic conditions. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, an alternative must have a change in releases of water of less than 0.256 maf in 1 or more years. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 1 year row is the alternative most similar to historic conditions. **Figure TA 9-17** compares the similarity of each alternative to the historic annual year to year change in Hoover Dam annual release.

Figure TA 9-17
Below Hoover Dam Marsh Riparian Vegetation: Robustness.
Percent of futures in which the year-to-year change in Hoover Dam annual release less than 0.256 maf in the number of years specified by each row during any 10-year period



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).

Similar to Lake Powell and Lake Mead, the first decade of modeling for marsh vegetation is influenced by historical data (**Figure TA 9-17**). In the first decade, the Basic Coordination Alternative is the most robust, meeting the minimum level of performance in 60 percent of futures. The CCS Comparative Baseline Alternative and No Action Alternative meet it in 55 percent and 6 percent of futures, respectively. For all alternatives, the increased variability from historic conditions in the first decade (2027–2039; **Figure TA 9-17**) may result in decreased marsh vegetation cover.

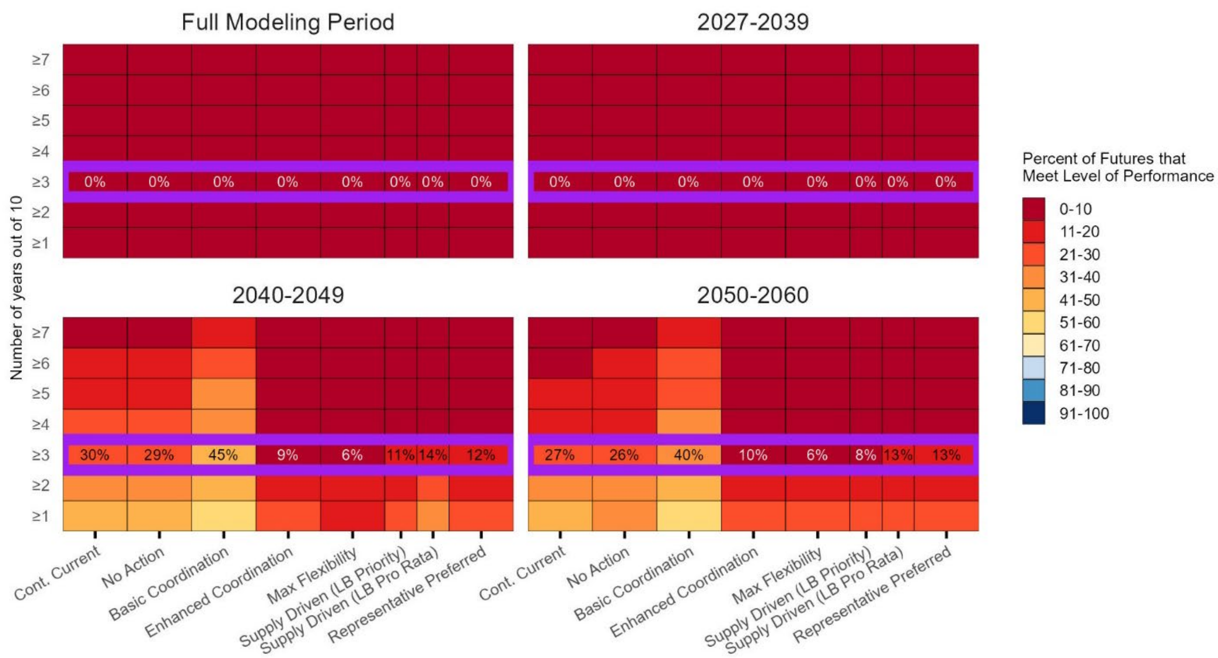
In later decades (2040–2049 and 2050–2060; **Figure TA 9-17**), all alternatives trend towards more similar variability compared to historic conditions. All alternatives meet the minimum level of performance in 78 percent or more of futures. As variability becomes closer to historic conditions, marsh vegetation may re-establish to a similar extent. Where variability eliminates or prevents the establishment of marsh habitat, woody riparian or upland habitat may become the dominant habitat type.

During the 2007 Interim Guidelines period, the annual volume of the Colorado River below Hoover averaged 9.185 maf (see **Section TA 3.1**, Affected Environment, in **TA 3**, Hydrologic Resources). For all alternatives under Average and Dry Flow Categories, the interquartile ranges of the modeled annual volume are below 9.185 maf (**Table TA 3-21** and **Figure TA 3-27**, in **TA 3**, Hydrologic Resources). This suggests that the annual flow volume below Hoover Dam may decrease under all alternatives in Average and Dry Flow Categories. The 2007 Interim Guidelines reduced average annual releases from Hoover Dam by approximately 1.014 maf from prior operating guidelines (see **Section TA 3.1**, Affected Environment, in **TA 3**, Hydrologic Resources). As described in **TA 9.1**, recent change analysis indicates marsh vegetation has generally decreased from 2000 to 2024 (RiverRestoration.Org 2025). If water releases decrease with higher levels of variability compared to historic conditions (**Figure TA 9-17**), marsh vegetation is expected to continue to decrease over time under Average and Dry Flow Categories. If water releases decrease with similar levels of variability to historic conditions (**Figure TA 9-17**), marsh vegetation is expected to decline at a rate similar to existing conditions under Dry and Critically Dry Flow Categories.

Woody Riparian

The median of the maximum 5-year change in Hoover releases from WY 2008–2025 was 0.338 maf (**Figure TA 9-18**). Over the past 10 years (WY 2016–2025), maximum annual change was less than 0.338 maf feet in 3 of 10 years (**Figure TA 9-18**). These data were used to understand the existing variability in flows from Hoover Dam to the SIB that has led to the current extent of marsh vegetation in the Hoover Dam to the SIB analysis area and are collectively referred to as historic conditions. The minimum level of performance was established based on these historic conditions. Therefore, to meet the minimum level of performance, an alternative must have a change in the 5-year average release of water of less than 0.338 maf in 3 or more years. The more times an alternative meets that criterion, the higher the percentage in each respective box. The alternative with the highest percentage within the greater than or equal to 3 years row is the alternative most similar to historic conditions. **Figure TA 9-18** compares the similarity of each alternative to the historic 5-year average year to year change in Hoover Dam annual release.

Figure TA 9-18
Below Hoover Dam Woody Riparian Vegetation: Robustness.
Percent of futures in which the 5-year average year-to-year change in Hoover Dam annual release is less than 0.338 maf in the number of years specified by each row during any 10-year period



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).

Similar to Lake Powell and Lake Mead, the first decade of modeling for woody riparian vegetation is influenced by historical data (**Figure TA 9-18**). In the first decade, all alternatives are equally non-robust, meeting the minimum level of performance in 0 percent of futures. Increased variability from historic conditions in the first decade (2027–2039; **Figure TA 9-18**) may result in decreased woody riparian vegetation cover due to inconsistent water availability.

In later decades (2040–2049 and 2050–2060; **Figure TA 9-18**) all alternatives trend towards variability more similar to historic conditions, but variability still remains high. The Basic Coordination Alternative is the most robust, meeting the minimum level of performance in 45 percent and 40 percent of futures, respectively. The CCS Comparative Baseline and No Action Alternative meet it in 30 percent and 27 percent, and 29 percent and 26 percent of futures, respectively. This increased variability may result in decreased riparian vegetation cover for all alternatives, but to a lesser extent under the Basic Coordination Alternative and No Action Alternative. Where variability eliminates or prevents woody riparian habitat establishment, upland habitat may become the dominant habitat type.

Previous planning efforts, including the LCR MSCP HCP, 2007 Final EIS, 2024 LTEMP SEIS, and their associated Biological Assessments (Reclamation 2004a, 2004c, 2016, 2022, 2023, 2024) assessed and predicted the quantities of habitat impacts from ongoing and future reductions in flow from Hoover Dam, which are here incorporated by reference. The best available information at this time indicates that these analyses are still valid based on predicted operations of Hoover Dam and the dams and diversions between Hoover Dam and SIB. A summary of FWS consultation for this planning effort is included in **Chapter 4**, Consultation and Coordination.

Federal, state, and tribal managed areas, such as Cibola National Wildlife Refuge, depend on water from the Colorado River to ensure woody riparian and marsh habitat. If water in the river drops below the level at which water is able to properly flow through diversion structures or pumps are able to function, there may be impacts on these habitats unless another method is used to transport water to the managed habitat areas. If a prolonged period of dryness occurs, woody riparian and marsh vegetation may begin to desiccate; however, the extent to which this would occur is unknown.

TA 9.2.3 Summary Comparison of Alternatives

Marsh vegetation requires consistent inundation, so when variability increases from historic conditions on an annual scale, marsh vegetation extent is expected to decrease. Woody riparian vegetation is more resilient to water fluctuations, but when variability increases from historic conditions on a 5-year scale, woody riparian vegetation extent is expected to decrease. Similarly, if variability decreases on an annual or 5-year scale, marsh, woody riparian, or upland vegetation may increase in extent.

For Lake Powell marsh and woody riparian vegetation, the Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative would result in vegetation most similar to historic conditions (**Table TA 9-4**). The Maximum Operational Flexibility Alternative would also result in vegetation most similar to historic conditions for Lake Mead marsh and woody riparian vegetation. However, for Hoover Dam to the SIB reach, the Maximum Operational Flexibility Alternative and Enhanced Coordination Alternative would result in vegetation least similar to historic conditions, which would result in larger changes in vegetation compared to historic conditions for that reach. Similarly, the Basic Coordination Alternative would result in conditions least similar to historic conditions for Lake Powell woody riparian vegetation, but would be closest to historic conditions for Lake Mead and Hoover Dam to the SIB. This suggests that no single alternative would result in vegetation similar to historic conditions across all reaches. For all reaches, multiple alternatives provide variability more similar to historic conditions than the CCS Comparative Baseline, except for the Hoover Dam to SIB reach, where all alternatives are similarly robust for marsh vegetation. This suggests that a change in management from the current strategies would benefit a large portion of the analysis area.

Table TA 9-4
The Alternatives that Result in the Most Similar or Least Similar Conditions compared to Historic Conditions for All Reaches and Vegetation Types

Reach and Vegetation Type	Most Similar to Historic Conditions	Least Similar to Historic Conditions
Lake Powell Marsh	Enhanced Coordination Alternative, Maximum Operational Flexibility Alternative	Supply Driven Alternative (both LB Priority and LB Pro Rata approaches)
Lake Powell Woody Riparian	Enhanced Coordination Alternative, Maximum Operational Flexibility Alternative	Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), Representative Preferred Alternative, Basic Coordination Alternative
Glen Canyon Dam to Lake Mead Marsh	Variable based on hydrology	Variable based on hydrology
Glen Canyon Dam to Lake Mead Woody Riparian	Variable based on hydrology	Variable based on hydrology
Lake Mead Marsh	Maximum Operational Flexibility Alternative, Basic Coordination Alternative	No Action Alternative, CCS Comparative Baseline
Lake Mead Woody Riparian	Basic Coordination Alternative, Maximum Operational Flexibility Alternative	No Action Alternative, CCS Comparative Baseline, Enhanced Coordination Alternative, Representative Preferred Alternative
Hoover Dam to SIB Marsh	All Alternatives Similarly Robust	All Alternatives Similarly Robust
Hoover Dam to SIB Woody Riparian	Basic Coordination Alternative	Maximum Operational Flexibility Alternative, Enhanced Coordination Alternative, Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), Representative Preferred Alternative

For the Glen Canyon Dam to Lake Mead reach, the alternative that would result in vegetation patterns most similar to historic conditions depends strongly on the flow categories. Under the Dry and Critically Dry Flow Categories, some differences among the alternatives emerge, presumably because there are greater differences in the lowest flows, the median flows, and peak flows under those conditions. However, across all alternatives, all sub-reaches, and all evaluated criteria (suitable habitat area, arrowweed, native species richness, proportion native species cover, and annual total vegetation cover), the interquartile ranges often overlap. When the interquartile ranges overlap, it is difficult to determine whether one alternative is truly different from another. Therefore, no single alternative emerged as the best or worst for retaining vegetation similar to historic conditions. The Enhanced Coordination Alternative and Maximum Operational Flexibility Alternative prioritize protecting elevations in Lake Powell and are therefore most likely to result in HFEs in this reach.

For all alternatives in Lake Powell, Lake Mead, and Hoover Dam to the SIB, the first decade would experience more variability, which would result in a reduction in marsh, woody riparian, and upland habitat compared to historic conditions. All alternatives see conditions return closer to historic conditions in the second and third decades, which may result in vegetation reestablishing to a similar extent. Where variability eliminates or prevents the establishment of marsh, woody riparian, or upland habitat, there may be a shift to one of the other habitat types.

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TA 9 Attachment 1

Special Status Plant Species Table

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TA 9 Attachment 1. Special Status Plant Species

Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Alkali mariposa lily *(Calochortus striatus)*	BLM NV	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025a).
Amargosa buckwheat *(Eriogonum contiguum)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025a).
Amargosa niterwort *(Nitrophila mohavensis)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (CDFW 2013).
Antelope Canyon goldenbush *(Ericameria cervina)*	BLM NV	Upland	—	—	—	—	No, this species has been observed upland areas which would not be affected by any alternatives (NatureServe 2025b).
Aravaipa sage *(Salvia amissa)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Botanical Realm 2024).
Aravaipa woodfern *(Thelypteris puberula var. sonorensis)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025c).
Arizona chalk dudleya *(Dudleya pulverulenta ssp. arizonica)*	BLM NV	Upland	—	X	—	—	Yes, this species has been observed in the analysis area and could be affected by inundation (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025, FNA 2020).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Arizona claret cup (*Echinocereus canyonensis*)	N/A	Upland	—	X	—	—	Yes, this species has been observed in the analysis area and could be affected by inundation (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Arizona eryngo *(Eryngium sparganophyllum)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (FWS 2025a).
Arizona Sonora rosewood *(Vauquelinia californica ssp. sonorensis)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Arizona Rare Plant Committee n.d.).
Arizona centaury (*Zeltnera arizonica*)	N/A	Marsh	—	X	—	—	Yes, the species has been documented in the analysis area (Palmquist et al. 2023).
Ash Meadows blazingstar *(Mentzelia leucophylla)*	BLM NV	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of this species (FWS 2025b).
Ash Meadows gumplant *(Grindelia fraxinipratensis)*	BLM NV	Marsh, Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025d).
Ash Meadows ladies tresses *(Spiranthes diluvialis)*	BLM NV	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025e).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Ash Meadows milkvetch *(Astragalus phoenix)*	BLM NV, Threatened	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025f).
Ash Meadows mousetails *(Ivesia kingii* var. *eremica)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (FWS 2025c).
Ash Meadows sunray *(Enceliopsis nudicaulis* var. *corrugata)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025g).
Bartram stonecrop *(Graptopetalum bartramii)*	BLM AZ	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of this species (FWS 2025d).
Bearded screwmoss *(Pseudocrossidium crinitum)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025h).
Beatley's milkvetch *(Astragalus beatleyae)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NNSS 2024a).
Beatley's scorpionflower *(Phacelia beatleyae)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NNSS 2024b).
Beaver dam breadroot *(Pediomelum castoreum)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025i).
Black woollypod *(Astragalus funereus)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025j).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Blue diamond cholla *(Cylindropuntia multigeniculata)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (Baker 2005).
Blue sand lily *(Triteleiopsis palmeri)*	BLM AZ	Upland	—	—	—	X (7)	No, this species grows on sand dunes, which would not be affected by any alternative (NatureServe 2025k).
Bullfrog Hills sweetpea *(Lathyrus hitchcockianus)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025l).
Calico Basin sunflower *(Helianthus devernii)*	BLM NV	Upland	—	—	—	—	No, this species is only found at Red Rock Canyon National Conservation Area (NatureServe 2025m).
California flannelbush *(Fremontodendron californicum)*	BLM AZ	Upland	—	—	—	—	No, the analysis area is outside the range of this species (Abrahamson 2021).
California screw moss *(Tortula californica)*	BLM CA	Upland	—	—	—	—	No, the analysis area is outside the range of this species (Calflora 2025a).
California sawgrass (*Cladium californicum*)	N/A	Marsh	—	X	—	—	Yes, the species has been documented in the analysis area (Palmquist et al. 2023).
Cane Spring suncup *(Chylismia megalantha)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (FNA 2022).
Chaparral sand-verbena *(Abronia villosa var. aurita)*	BLM CA	Upland	—	—	—	—	No, the analysis area is outside the range of this species (UC Berkeley 2025a).

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Common Name (Scientific Name)	**Listing Status**	**Habitat**	**Lake Powell**	**Glen Canyon Dam to Lake Mead**	**Lake Mead**	**Hoover Dam to SIB**	**Potential Impact**
Charleston grounddaisy *(Townsendia jonesii var. tumulosa)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (GBIF 2023).
Charleston Mountain angelica *(Angelica scabrida)*	BLM NV	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025n).
Charleston violet *(Viola charlestonensis)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025o).
Clarke phacelia *(Phacelia filiae)*	BLM NV	Upland	—	—	—	—	No, this species is endemic to a small area in southern Nevada, outside the analysis area (NNSS 2024c).
Clark Mountain agave *(Agave utahensis var. nevadensis)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025p).
Clark Mountain green gentian *(Frasera albomarginata var. induta)*	BLM NV	Upland	—	X	—	—	No, this species is limited to Clark Mountains in Nevada (FNA 2025a).
Clokey buckwheat *(Eriogonum heermannii var. clokeyi)*	BLM NV	Upland	—	—	—	—	No, the analysis area is outside the range of this species (NatureServe 2025q).
Clokey Mountain sage *(Salvia dorrii var. clokeyi)*	BLM NV		—	—	—	—	No, this species is found in the Spring Mountains west of Las Vegas and the analysis area is not within its range (NatureServe 2025r).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Cochise sedge *(Carex ultra)*	BLM AZ	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025s).
Coulter's goldfields *(Lasthenia glabrata ssp. coulteri)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025t).
Dainty moonwort *(Botrychium crenulatum)*	BLM NV	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025u).
Deane's milkvetch *(Astragalus deanei)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (UC Berkeley 2025b).
Death Valley beardtongue *(Penstemon fruticiformis ssp. amargosae)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (iNaturalist 2025a).
Death Valley sage *(Salvia funerea)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside the areas affected by any alternatives (CNPS 2025b).
Decumbent goldenbush *(Isocoma menziesii var. decumbens)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025v).
Delicate clarkia *(Clarkia delicata)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025w).
Desert mountain thistle *(Cirsium arizonicum)*	BLM NV	Upland	—	X	—	—	Yes, this species has been observed in the analysis area and could be affected by inundation (iNaturalist 2025b).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Dune spurge *(Euphorbia platysperma)*	BLM CA	Upland	—	—	—	X (7)	No, this species occurs in upland desert dune and scrub habitats which would not be affected by any alternative (Arizona Rare Plant Committee n.d.).
Dune sunflower *(Helianthus deserticola)*	BLM NV	Upland	X	—	X	—	Yes, this species has been observed in the analysis area and could be affected by inundation (iNaturalist 2025c).
Dunn's mariposa lily *(Calochortus dunnii)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025c).
Eastern joshua tree *(Yucca jaegeriana)*	BLM NV	Upland	—	—	X	X (2)	Yes, species has been documented within analysis area (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Entire leaved thelypody (*Thelypodium integrifolium*)	N/A	Upland	—	X	—	—	Yes, species has been documented within analysis area (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Fish Creek fleabane *(Erigeron piscaticus)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025x).
Felt-leaved monardella *(Monardella hypoleuca ssp. lanata)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025d).
Gander's pitcher sage *(Lepechinia ganderi)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025e).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Gander's ragwort *(Packera ganderi)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025y).
Garret's California fuchsia *(Epilobium canum ssp. garrettii)*	BLM NV	Woody Riparian	—	—	—	—	No, this species has not been observed in the analysis area (iNaturalist 2025d).
Gilman's milkvetch *(Astragalus gilmanii)*	BLM NV	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025z).
Gold butte moss *(Didymodon nevadensis)*	BLM NV	Woody Riparian	—	?	X	—	Yes, this species is found in Gold Butte north of Lake Mead, Arizona and Utah. This species may be present in other locations with gypsum soils (Zander et al. 1995).
Golden crispleaf buckwheat *(Eriogonum corymbosum var. aureum)*	BLM NV	Upland	—	X	—	—	No, this species is present in creosote bush and blackbrush communities which are above analysis area (SEINet 2025a).
Goodding's willow (*Salix gooddingii*)	N/A	Woody Riparian	X	X	X	X	Yes, the species has been documented in the analysis area (Palmquist et al. 2023).
Grand Canyon rose *(Rosa stellata var. abyssa)*	BLM AZ	Upland	—	X	—	—	No, this species grows in upland habitat which would not be affected by any alternative (NatureServe 2025aa).
Gypsum Cave evening primrose *(Oenothera cavernae)*	BLM NV	Woody Riparian	—	X	—	—	Yes, this species is common in Grand Canyon National Park and in canyon washes (NatureServe 2025bb).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Half-ring milkvetch *(Astragalus mohavensis var hemigyrus)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025f).
Harrison's barberry *(Berberis harrisoniana)*	BLM AZ	Upland	—	X	—	—	No, this species grows on talus slopes on and along canyon sides, which would not be affected by any alternative (NatureServe 2025cc).
Harwood's eriastrum *(Eriastrum harwoodii)*	BLM CA	Upland	—	—	—	X (6)	No, this species grows in upland habitat near the Rosevelt Mine, which would not be affected by any alternative (CNPS 2025g).
Newberry's mock yucca (*Hesperoyucca newberryi*)	N/A	Upland	—	X	—	—	No, this species grows on rocky granite slopes in upland habitats, which would not be affected by any alternative (SEINet 2025b).
Hohokam agave *(Agave murpheyi)*	BLM AZ	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025dd).
Horn's milk- vetch *(Astragalus hornii var. hornii)*	BLM CA	Marsh	—	—	—	—	No. This species' range is outside of areas affected by any alternatives. (CNPS 2025h)
Huachuca golden aster *(Heterotheca rutteri)*	BLM AZ	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ee).
Hualapai blazingstar (*Mentzelia hualapaiensis*)	N/A	Woody Riparian	—	X	X	—	Yes, species can occur in upland and woody riparian habitats (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Ivory-spined agave *(Agave utahensis var. eborispina)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (iNaturalist 2025e).
Jaeger beardtongue *(Penstemon thompsoniae ssp. jaegeri)*	BLM NV	Upland	—	—	—	—	No, this species has not been observed in the analysis area (iNaturalist 2025f).
Jaeger's ivesia *(Ivesia jaegeri)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ff).
Johnson's Fishhook Cactus *(Echinomastus johnsonii)*	NPL	Upland			X	X (2)	Yes, this species could be affected by inundation (NatureServe 2025gg).
Kaibab agave (*Agave utahensis ssp. kaibabensis*)	N/A	Upland	—	X	—	—	No, this species grows on rocky outcrops in upland habitats, which would not be affected by any alternative (SEINet 2025c).
Lace-leaved rockdaisy *(Perityle ambrosiifolia)*	BLM AZ	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025hh).
Lakeside ceanothus *(Ceanothus cyaneus)*	BLM CA	Upland	—	—	—	—	No, this species grows in upland habitats, which would not be affected by any alternative (NatureServe 2025ii).
Las Vegas bearpoppy *(Arctomecon californica)*	BLM NV	Marsh	—	—	X	—	Yes, this species is found around Lake Mead in gypsum soils (NatureServe 2025jj).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Las Vegas buckwheat *(Eriogonum corymbosum var. nilesii)*	BLM NV	Upland	—	—	—	—	No, this species grows in upland gypsum soils, which would not be affected by any alternative (NatureServe 2025kk).
Las Vegas catseye *(Oreocarya insolita)*	BLM NV	Upland	—	—	—	—	No, it is suggested this species is currently extinct (NPS 2010).
Latimer's woodland-gilia *(Saltugilia latimeri)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025d).
Limestone monkeyflower *(Erythranthe calcicola)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025e).
Lincoln rockcress *(Boechera lincolnensis)*	BLM CA	Upland	—	—	—	—	No, this species grows in upland habitat, which would not be affected by any alternative (SEINet 2025f).
Littlefield milkvetch *(Astragalus preussii var. laxiflorus)*	BLM NV	Upland	—	—	X	—	Yes, this species has been observed near Lake Mead (SEINet 2025g).
Little San Bernardino Mtns. linanthus *(Linanthus maculatus ssp. maculatus)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025i).
Long-spined spineflower *(Chorizanthe polygonoides var. longispina)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025h).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Longstem evening primrose (*Oenothera longissima ssp. typica*)	N/A	Woody Riparian	—	X	—	—	Yes, species has been documented along Colorado River in Grand Canyon (SEINet 2025i).
Maguire's lewisia *(Lewisia maguirei)*	BLM NV	Upland	—	—	—	—	No, this species is associated with pinyon-juniper woodlands which would not be affected by any alternatives (NatureServe 2025ll).
Marble Canyon milkvetch *(Astragalus cremnophylax var. hevronii)*	BLM AZ	Upland	—	X	—	—	No, this species grows along canyon edges, which would not be affected by any alternative (Arizona Rare Plant Committee n.d.).
Meadow Valley sandwort *(Eremogone stenomeres)*	BLM NV	Upland	—	—	—	—	No, there are no known populations of this species within the areas affected by any alternatives (SEINet 2025j).
Mecca-aster *(Xylorhiza cognata)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025mm).
McDougall's flaveria (*Flaveria mcdougallii*)	N/A	Marsh	—	X	—	—	Yes, this species is found in Grand Canyon and occurs in alkaline seeps and springs (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Mojave fishhook cactus *(Sclerocactus polyancistrus)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025nn).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Mojave indigo bush *(Psorothamnus arborescens var. pubescens)*	BLM AZ	Upland	—	X	—	—	Yes, this species is found in Grand Canyon and can occur in washes (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Mojave monarrdella *(Monardella mojavensis)*	BLM NV	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025j).
Mojave tarplant *(Deinandra mohavensis)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025k).
Mojave thistle *(Cirsium mohavense)*	BLM NV	Woody Riparian	—	X	—	—	Yes, this species is found in Grand Canyon and occurs in hanging gardens and wet soil in canyons (NatureServe 2025oo). *C. mohavense* populations in Grand Canyon may be a *Cirsium* species new to science (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Mokiak milkvetch *(Astragalus mokiacensis)*	BLM NV	Upland	—	—	X	—	Yes, this species has been observed within the full pool line of Lake Mead and could be affected by inundation (SEINet 2025l).
Mount Trumbull beardtongue *(Penstemon distans)*	BLM AZ	Upland	—	X	—	—	No, this species grows in upland forest and woodland habitat, which would not be affected by any alternative (NatureServe 2025pp).
Mourning buckwheat *(Eriogonum concinnum)*	BLM NV	Woody Riparian	—	—	—	—	No, the analysis area is outside the range of the species (SEINet 2025m).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Nakestem sunray (*Enceliopsis nudicaulis*)	N/A	Woody Riparian	—	X	X	—	Yes, this species has been documented within full pool of Lake Mead (SEINet 2025n)
Nevada willowherb *(Epilobium nevadense)*	BLM NV	Woody Riparian	—	X	—	—	Yes, this species is found in Grand Canyon and grows on gravelly slopes, canyon walls, and sandy soils (NatureServe 2025qq).
Nuttall's scrub oak *(Quercus dumosa)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Caliscape 2025).
Nye milkvetch *(Astragalus nyensis)*	BLM NV	Woody Riparian	—	—	X	—	Yes, Lake Mead is within the range of this species (Nature Serve 2025rr).
Oil neststraw *(Stylocline citroleum)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025k).
Orcutt's brodiaea *(Brodiaea orcuttii)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025o).
Orocopia Mountains spurge *(Euphorbia jaegeri)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ss).
Otay manzanita *(Arctostaphylos otayensis)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025tt).
Otay Mountain ceanothus *(Ceanothus otayensis)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025p).
Pahrump silverscale *(Atriplex argentea var. longitrichoma)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025uu).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Pahrump Valley buckwheat *(Eriogonum bifurcatum)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025vv).
Pahute Mesa beardtongue *(Penstemon pahutensis)*	BLM NM	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ww).
Panamint Spring beauty *(Claytonia panamintensis)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (CNPS 2025l).
Parish's meadowfern *(Limnanthes alba ssp. parishii)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025xx).
Parish Onion *(Allium parishii)*	BLM AZ	Upland	—	—	—	X (3 [full pool Lake Havasu])	Yes, this species has been observed in the analysis area (SEINet 2025q).
Parish's phacelia *(Phacelia parryi)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025r).
Parry's spineflower *(Chorizanthe parryi var. parryi)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025yy).
Parry's tetracoccus *(Tetracoccus dioicus)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025zz).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Peach Springs cholla (*Cylindropuntia abyssi*)	N/A	Upland	—	X	X	—	Yes, species has been documented within analysis area (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Peirson's milk-vetch *(Astragalus magdalenae var. peirsonii)*	BLM CA, Threatened	Upland	—	—	—	—	No, this species occurs in aeolian dunes between the Salton Sea and Colorado River, outside of areas affected by any alternatives (FWS 2022).
Pima Indian mallow *(Abutilon parishii)*	BLM AZ	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Arizona Rare Plant Committee n.d.).
Pintwater rabbitbrush *(Chrysothamnus eremobius)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025aaa).
Planoconvex cordmoss *(Entosthodon planoconvexus)*	BLM NV	Woody Riparian	—	—	—	—	Yes, this species prefers desert washes and canyons which occur in the analysis area (NatureServe 2025bbb).
Polished blazing star *(Mentzelia polita)*	BLM NV	Upland	—	—	—	—	No, this species is restricted to gypsum or mixed gypsum and clay soils in Mohave County at elevations between 1350-1500m (SEINet 2025s).
Rainbow manzanita *(Arctostaphylos rainbowensis)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Calflora 2025b).
Ramona horkelia *(Horkelia truncata)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025t).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Red Rock Canyon false golden aster *(Ionactis caelestis)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (Nesom and Leary 1992).
Reese River phacelia *(Phacelia glaberrima)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ccc).
Reveal's buckwheat *(Eriogonum contiguum)*	BLM CA	Woody Riparian	—	—	—	X (2 and 3)	Yes, this species is associated with lower bajadas in California and southern Clark County Nevada (NatureServe 2025ddd).
Robinson's monardella *(Monardella robinsonii)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025eee).
Rock purpusia *(Ivesia arizonica var. saxosa)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025fff).
Rosy twotone beardtongue *(Penstemon bicolor ssp. roseus)*	BLM NV, BLM AZ	Woody Riparian	—	—	X	X (2)	Yes, this species may be found within full pool of Lake Mead (NPS 2004)
Rough dwarf greasebush *(Glossopetalon pungens var. pungens)*	BLM NV	Upland	—	—	—	—	No, there are no known occurrences of this species in the analysis area (iNaturalist 2025g).
Rough fringemoss *(Crossidium seriatum)*	BLM NV	Woody Riparian	—	—	X	—	Yes, this species has been observed in the analysis area (COSEWIC 2014).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Rush lemonweed (*Psoralidium junceum*)	N/A	Woody Riparian	—	X	—	—	Yes, this species is found in Grand Canyon and can occur in washes (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
St. George blue-eyed grass *(Sisyrinchium radicatum)*	BLM NV	Woody Riparian	—	—	X	—	Yes, this species can occupy riparian areas and has been observed in the analysis area (NatureServe 2025ggg).
Salt marsh bird's-beak *(Chloropyron maritimum ssp. maritimum)*	BLM CA	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025hhh).
San Bernadino milk-vetch *(Astragalus bernardinus)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025u).
San Diego goldenstar *(Bloomeria clevelandii)*	BLM CA	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025iii).
San Diego gumplant *(Grindelia hallii)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025v).
San Diego milk- vetch *(Astragalus oocarpus)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025jjj).
Sandfood *(Pholisma sonorae)*	BLM AZ	Upland	—	—	—	X (7)	No, this species is endemic to sand dunes and would not likely be found in washes (SEINet 2025w).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Sanicle biscuitroot *(Cymopterus ripleyi var. saniculoides)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025kkk).
San Jacinto mariposa-lily *(Calochortus palmeri var. munzii)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025x).
San Luis Obispo sedge *(Carex obispoensis)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025lll).
San Miguel savory *(Clinopodium chandleri)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025mmm).
Sanford's arrowhead *(Sagittaria sanfordii)*	BLM CA	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025nnn).
Santa Lucia dwarf rush *(Juncus luciensis)*	BLM CA	Marsh	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025ooo).
Satin-tail (*Imperata brevifolia*)	N/A	Marsh	—	X	—	—	Yes, the species has been documented in the analysis area (Palmquist et al. 2023).
Scaly sandplant *(Pholisma arenarium)*	BLM AZ	Upland	—	X	X	X (4)	No, this species grows in upland sand and dune habitats, which would not be affected by any alternative (NatureServe 2025ppp).
Screwbean mesquite *(Prosopis pubescens)*	BLM NV	Woody Riparian	—	—	X	X (2, 3, 4, 5, 6, 7)	Yes, this species is present in riparian areas with honey mesquite and cottonwood-willow and has been observed near the Little Colorado River (Meyer 2005).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Scrub lotus *(Lotus argyraeus var. multicaulis)*	BLM NV	Upland	—	—	—	—	No, this species is endemic to desert mountains which would not be affected by any alternatives (NatureServe 2025qqq).
Sheep fleabane *(Erigeron ovinus)*	BLM NV	Upland	—	—	—	—	No, this species is endemic to the Sheep and Groom ranges and on Mt. Irish in Nevada (NatureServe 2025rrr).
Sheep Range milkvetch *(Astragalus amphioxys var. musimonum)*	BLM NV	Upland	—	—	—	—	No, this species variety has not been observed in the analysis area (SEINet 2025y).
Shevock's copper moss *(Mielichhoferia shevockii)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025sss).
Siler fishhook cactus *(Sclerocactus sileri)*	BLM AZ	Upland	—	X	—	—	No, this species grows in upland desert habitats which would not be affected by any alternatives (NatureServe 2025ttt).
Silverleaf sunray *(Enceliopsis argophylla)*	BLM AZ, BLM NV	Upland	—		X	X (2)	Yes, this species can occupy riparian areas and has been observed near the analysis area (SEINet 2025z).
Small wirelettuce *(Stephanomeria exigua ssp. exigua)*	BLM AZ	Upland	—	—	—	—	No, this species has not been documented in areas affected by alternatives (SEINet 2025aa).
Smooth dwarf greasebush *(Glossopetalon pungens var. glabrum)*	BLM NV	Upland	—	—	—	—	No, this species prefers mountain ranges which would not be affected by any alternatives (FNA 2025b).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Snake cholla *(Cylindropuntia californica var. californica)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025bb).
Southwestern ringstem *(Anulocaulis leisolenus var. leisolenus)*	BLM NV	Woody Riparian	—	X	—	—	Yes, species has been collected near Colorado River (personal communication, Wendy Hodgson, Desert Botanical Garden, to Lonnie Pilkington, NPS, October 28, 2025).
Spring-loving century plant *(Zeltnera namophila)*	BLM NV	Marsh	—	—	—	—	No, this species is endemic to Nye County Nevada in Ash Meadows (SEINet 2025cc).
Spring Mountains milkvetch *(Astragalus remotus)*	BLM NV	Upland	—	—	—	—	No, this species grows in upland talus and rocky slopes which would not be affected by any alternative (NatureServe 2025uuu).
Sticky buckwheat *(Eriogonum viscidulum)*	BLM AZ, BLM NV, LCR MSCP	Upland	—	—	X	—	Yes, this species can occupy riparian areas and has been observed near the analysis area (SEINet 2025dd).
Sticky dudleya *(Dudleya viscida)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (SEINet 2025ee).
Sticky ringstem *(Anulocaulis leiosolenus)*	BLM NV	Upland	—	—	X	—	No, this species grows in upland habitats which would not be affected by any alternative (Rees 2007).
Straw milkvetch *(Astragalus lentiginosus var. stramineus)*	BLM NV	Upland	—	—	X	—	Yes, this species has been observed within the analysis area (iNaturalist 2025h).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Summer holly *(Comarostaphylis diversifolia ssp. Diversifolia)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025vvv).
Sweet moustache moss *(Trichostomum sweetii)*	BLM NV	Upland	—	—	X	—	No, this species occurs in upland habitats outside of areas affected by any alternatives (GBIF 2004).
Tecate cypress *(Hesperocyparis forbesii)*	BLM CA	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (UC Berkeley 2025c).
Tecate tarplant *(Deinandra floribunda)*	BLM CA	Upland	—	—	—	—	No, this species grows in upland habitats which would not be affected by any alternative (NatureServe 2025www).
Tecopa salty bird's beak *(Chloropyron tecopense)*	BLM NV	Upland	—	—	—	—	No, this species' range is outside of the analysis area (CNPS 2025m).
Threecorner milkvetch *(Astragalus geyeri var. triquetrus)*	BLM NV, LCR MSCP	Marsh	—	—	X	—	Yes, this species is found along the shores of Lake Mead (D'Ambrosi 2023).
Tumamoc globeberry *(Tumamoca macdougalii)*	BLM AZ	Upland	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025xxx).
Variegated dudleya *(Dudleya variegata)*	BLM CA	Woody Riparian	—	—	—	—	No, this species' range is outside of areas affected by any alternatives (NatureServe 2025yyy).

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Common Name (Scientific Name)	Listing Status	Habitat	Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to SIB	Potential Impact
Virgin River thistle *(Cirsium virginense)*	BLM NV	Woody Riparian	—	X	—	—	No, although this species occurs in hanging gardens, its range is along the Virgin River (Arizona Rare Plant Committee n.d.).
White bearpoppy *(Arctomecon merriamii)*	BLM NV	Upland	—	—	—	—	No, this species grows in upland habitat which would not be affected by any alternative (NatureServe 2025zzz).
Whitemargined beardtongue *(Penstemon albomarginatus)*	BLM NV	Upland	—	—	—	—	No, this species grows in upland sand and dune habitats which would not be affected by any alternative (NatureServe 2025aaaa).
White-bracted spineflower *(Chorizanthe xanti var. leucotheca)*	BLM CA	Upland	—	—	—	—	No, this species grows in upland habitat which would not be affected by any alternative (NatureServe 2025bbbb).
Wiggins' croton *(Croton wigginsii)*	BLM CA	Woody Riparian	—	—	—	X (7)	Yes, this species grows in sandy arroyos and has been observed within 200m of the Colorado River (NatureServe 2025cccc).
Yellow twotone beardtongue *(Penstemon bicolor ssp. bicolor)*	BLM NV	Upland	—	—	X	X (2)	Yes, this species may be found within full pool of Lake Mead (NatureServe 2025dddd).
Yucaipa onion *(Allium marvinii)*	BLM CA	Upland	—	—	—	—	No, this species grows in upland habitat which would not be affected by any alternative (SEINet 2025ff).

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TA 9 Attachment 2

Parker and Davis Dams DMDU Figures

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TA 9 Attachment 2. Parker and Davis Dams DMDU Figures

Figure TA 9 Attachment 2-1
Robustness Heat Map showing Davis Dam Max Annual Change in Release Variability in any 10-year Period

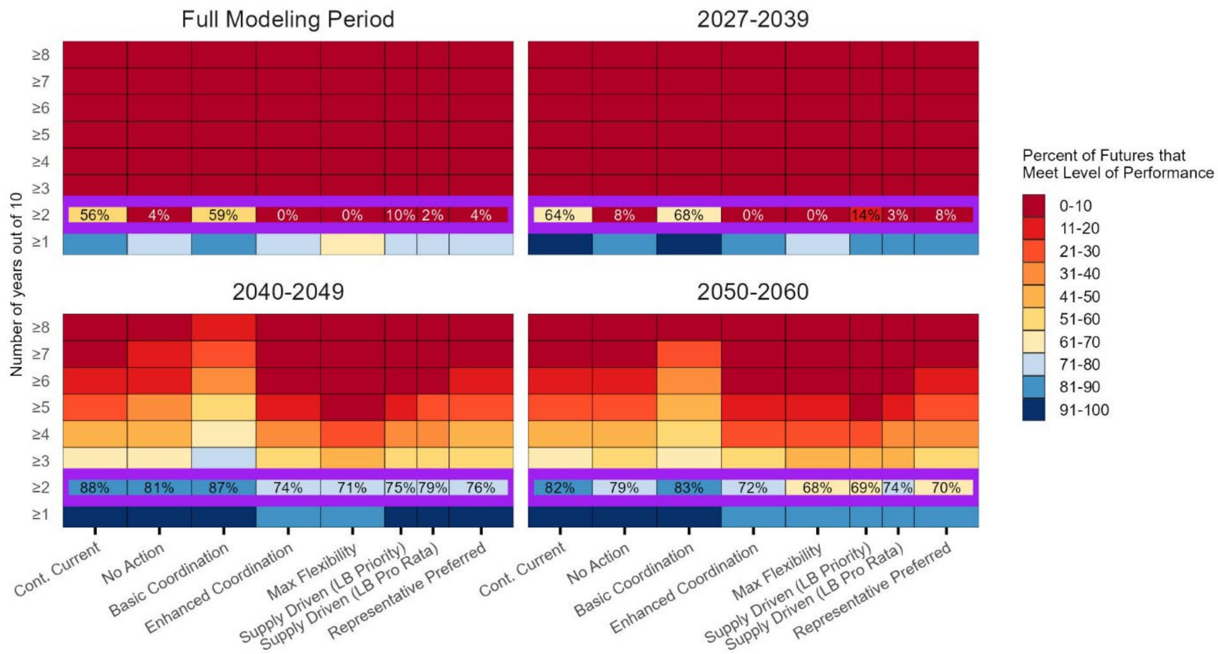


Figure TA 9 Attachment 2-2
Robustness Heat Map showing Davis Dam Max 5-year Change in Surface Elevation Variability in any 10-year Period

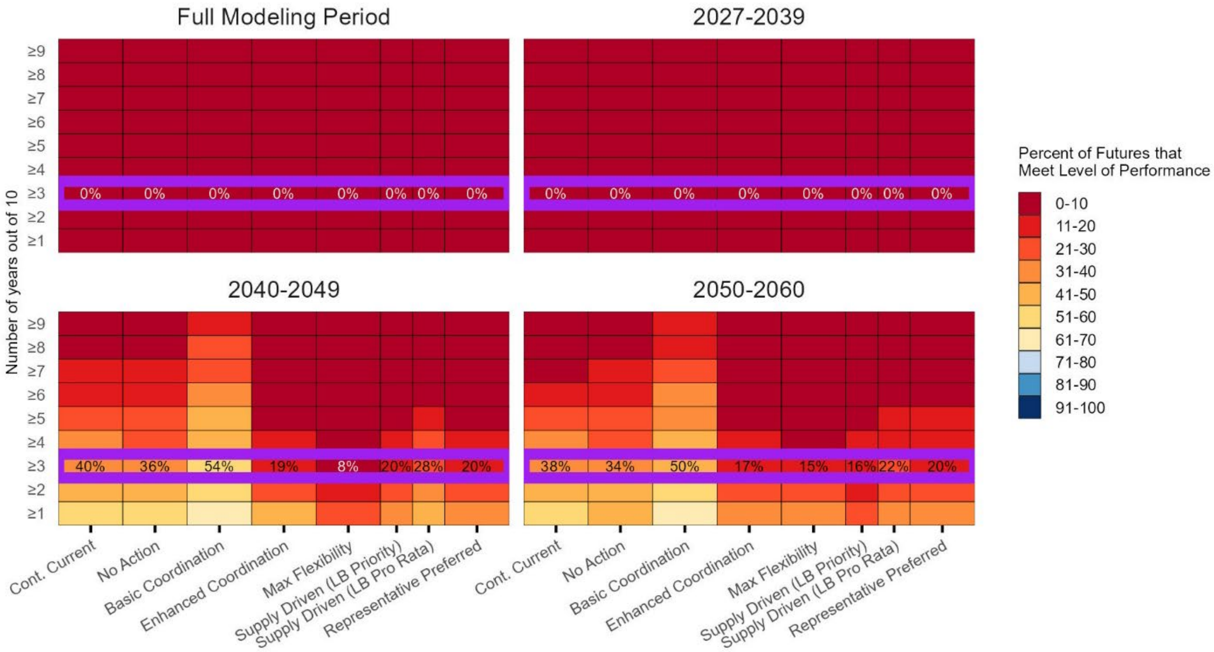


Figure TA 9 Attachment 2-3
Robustness Heat Map showing Parker Dam Max Annual Change in Release Variability in any 10-year Period

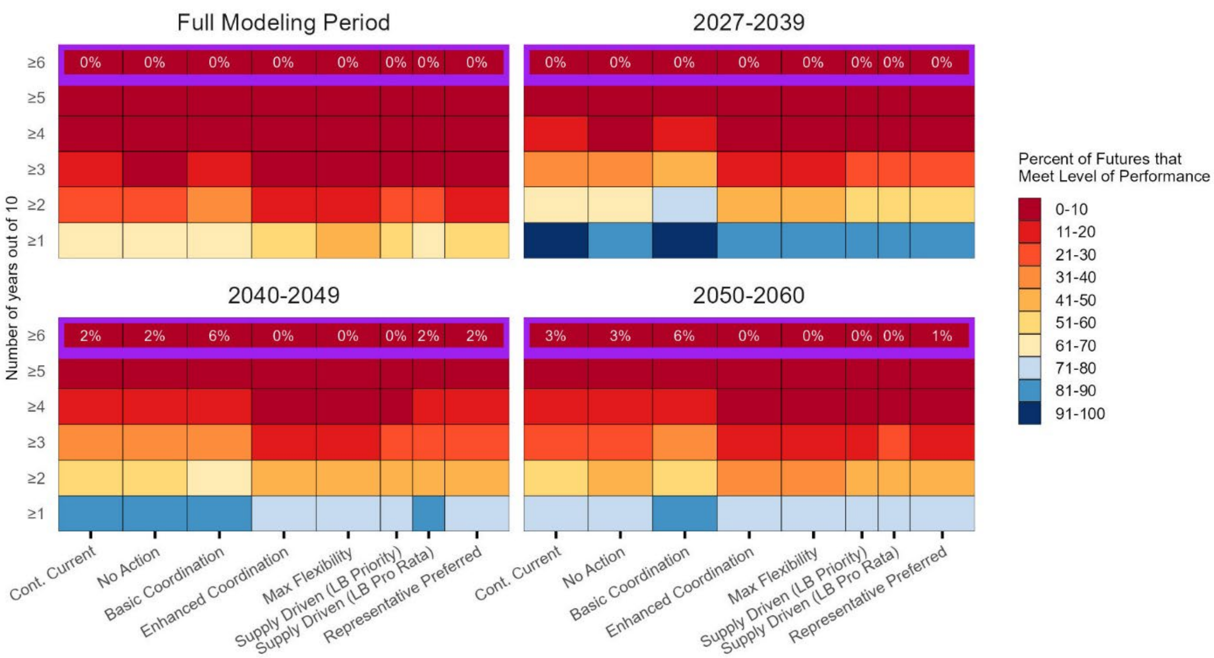
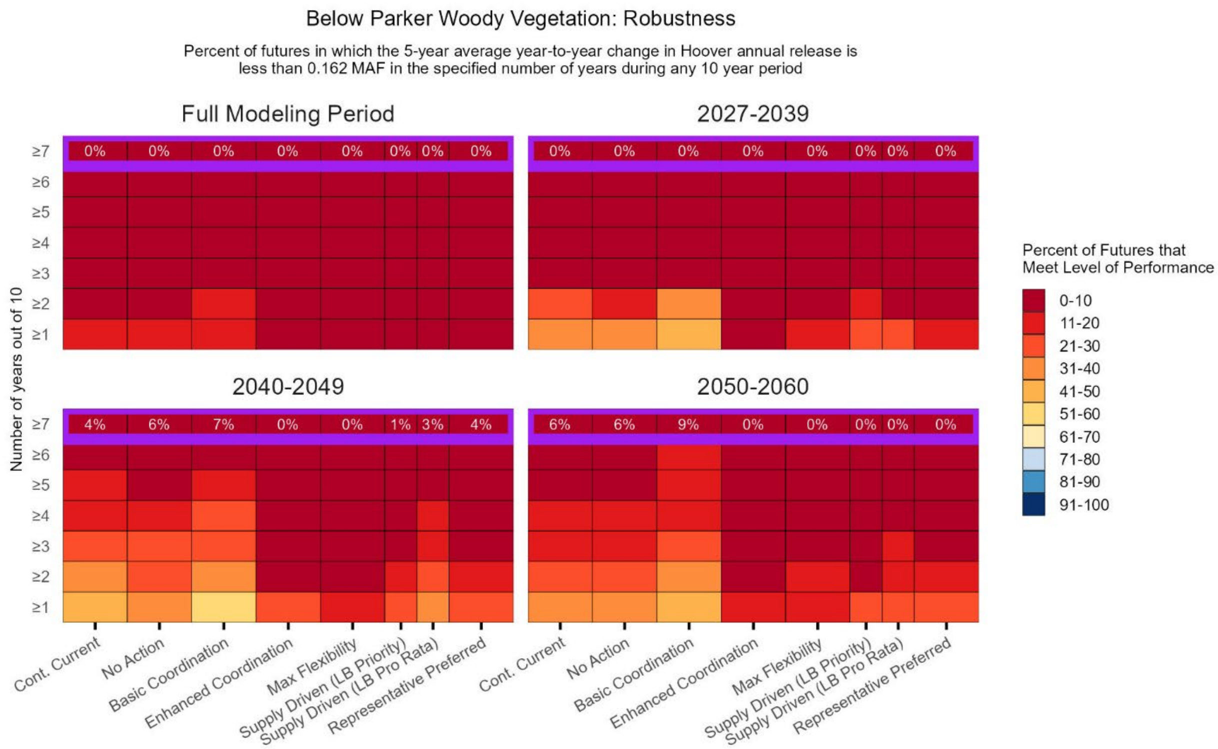


Figure TA 9 Attachment 2-4
Robustness Heat Map showing Parker Dam Max 5-year Change in Surface Elevation Variability in any 10-year Period



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