ALTERNATIVES FOR CONSIDERATION IN THE GLEN CANYON DAM LONG-TERM EXPERIMENTAL AND MANAGEMENT PLAN ENVIRONMENTAL IMPACT STATEMENT

Six alternatives, including the No-Action Alternative, have been developed for consideration in the Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) Environmental Impact Statement (EIS). The alternatives represent different ways Glen Canyon Dam could be operated under the LTEMP over the next 20 years, and will serve as the basis of the National Environmental Policy Act (NEPA) assessment to be presented in the LTEMP EIS. At the February 20, 2014, Adaptive Management Working Group Meeting in Tempe, Arizona, the LTEMP EIS team presented an overview of the alternatives. This presentation can be downloaded at http://www.usbr.gov/uc/rm/amp/amwg/mtgs/14feb19/Attach_11b.pdf. Although these are subject to change as the NEPA process continues, they are being provided now as an update to interested members of the public.

The following information provides a synopsis of the alternatives currently under consideration in the LTEMP EIS.

Alternatives Being Considered

1. No-action
2. Balanced resource alternative
3. Condition-dependent adaptive strategy
4. Resource-targeted condition-dependent alternative
5. Seasonally adjusted steady flows
6. Year-round steady flows

Operational characteristics of base operations of each alternative are summarized in Table 1; condition-dependent and experimental elements are summarized in Table 2. Long-term strategies associated with these alternatives are presented in Table 3. These long-term strategies represent various implementations of the alternatives that are within the flexibility of each alternative. They represent possible ways alternatives could be implemented over the LTEMP period depending on the outcome of experimentation and resolution of critical uncertainties associated with resource response to operational changes.

Elements Potentially Common to All Alternatives

- High flow releases for sediment conservation using the HFE protocol (modified in some alternatives)
- Non-native fish control actions as analyzed and described in the Non-Native Fish Control Environmental Assessment and Finding of No Significant Impact (modified in some alternatives, not included in Seasonally Adjusted Steady Flow alternative)
- Compliance with 2007 record of decision (ROD) on Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead (until 2026)
- NPS management activities (durations as specified in management documents)

- Appraisal study of a temperature control device (TCD) (e.g., an impeller system) as funding allows
- Conservation measures identified in the 2011 Biological Opinion (BO) on operations of Glen Canyon Dam
- Consideration of minor experimental and management actions at specific sites on a case-by-case basis such as non-native plant removal, revegetation with native species, and mitigation at specific and appropriate cultural sites
- Continued adaptive management that includes a resource monitoring program
- Determination of whether to establish a Recovery Implementation Program for endangered fish species below Glen Canyon Dam.

1. No-Action Alternative

- Objective: Maintain existing operations and recent decisions without modification
- Base operations:
  - Modified low fluctuating flows (MLFF) as defined in 1996 ROD
- Modifications to base operations:
  - HFE protocol, non-native fish control actions, and experimentation per EAs (expire in 2020)
  - No spring HFEs until 2015 per EA
- See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the no-action alternative, and Figure 1 for the hydrograph in an 8.23 million acre-ft (maf) year.

2. Balanced Resource Alternative

- Objective: Increase hydropower generation, while limiting impacts to other resources and relying on non-flow actions to the extent possible
- Base operations:
  - Monthly volumes same as no-action alternative
  - Increased fluctuations (approximately 25 to 66% increase in fluctuation level relative to MLFF) in 10 months (all but April and May)
  - Increase down-ramp rates to 4,000 cfs/hr in November through March, and 3,000 cfs/hr in other months
- Modifications to base operations:
  - Follow existing HFE protocol for entire LTEMP period, but HFEs not to exceed one every other year
  - Test "hydropower improvement flows" (i.e., operations with wider fluctuations in high electrical demand months than base operations) in 4 years when annual release volume $\leq$ 8.23 maf years
  - Mechanical removal of trout in the LCR reach
  - Test effectiveness of trout management flows[1]

[1] Trout management flows (TMFs) are highly variable flows that are intended to control the number of young-of-the-year trout in the Glen Canyon reach. A typical TMF would consist of several days at a relatively high sustained flow (e.g., 20,000 cfs) followed by a rapid drop to a low flow (e.g., 5,000 cfs), which is held for a brief period (e.g., 6 hr). This pattern would be repeated for a number of cycles in spring and summer months (May–July). Timing, magnitude, duration, and number of cycles would be tested for efficacy to control trout numbers early in the LTEMP period.

- See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the Balanced Resource alternative, and Figure 2 for the hydrograph in an 8.23 maf year.
- Two long-term strategies will be evaluated (Table 3):
  - BR1: base-operations (as described above) with spring and fall HFEs, mechanical removal of trout, and trout management flows
  - BR2: hydropower improvement flows with increased daily fluctuation levels (approximately 150% increase in fluctuation level relative to MLFF or up to 20,000 cfs daily range in 8.23 maf years) implemented in all ≤ 8.23 maf years, spring and fall HFEs, mechanical removal of trout, and trout management flows.

3. Condition-Dependent Adaptive Strategy (CDAS)

- Objective: Adaptively operate Glen Canyon Dam to achieve a balance of resource objectives with priorities placed on humpback chub, sediment, trout, and hydropower
- Base operations:
  - Highest release volumes in high electric demand months of December, January, and July; February through June volumes proportional to power contract rate of delivery; lower volumes from August through November to conserve sediment inputs during monsoon period
  - Maximum daily flow range is proportional to monthly volume, and equal to 7 × monthly volume (in kaf) in all months (e.g., for a 700,000 ac-ft month, the allowable daily flow range in cfs would equal 7 × 700, i.e., 4,900 cfs)
  - Increase down ramp rates from 1,500 cfs/hr to 2,500 cfs/hr
- Modifications to base operations:
  - Follow existing HFE protocol for entire LTEMP period with the following adjustments:
    - Reduce fluctuations to ± 1,000 cfs in February and March until the spring HFE or August, September, and October until the fall HFE if significant input of Paria River sediment occurred during the HFE-protocol accounting periods (December–March and July-October)
    - Reduce fluctuations to ± 1,000 cfs after HFEs until May 1 for spring HFEs and December 1 for fall HFEs
    - Allow flexibility in the duration of HFEs while holding the maximum HFE peak volume to that of a 96-hr, 45,000 cfs flow (i.e., 357,000 ac-ft)
    - Test proactive spring HFE in high volume years (≥ 10 maf) prior to equalization. Proactive spring HFEs would occur in April, May, or June, and would consist of a 24-hr release up to 45,000 cfs.
  - Low summer flows (8,000 cfs from July 1 through September 30) in years when adult humpback chub numbers are below 7,000 and release temperatures would allow reaching target temperatures of at least 13°C at the Little Colorado River confluence
  - Mechanical removal of trout in the LCR reach
  - Test effectiveness of trout management flows
- See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the CDAS alternative, and Figure 3 for the hydrograph in an 8.23 maf year.
- Four long-term strategies will be evaluated (Table 3):

- CDAS 1: includes spring and fall HFEs and trout management flows, but no mechanical removal of trout or low summer flows
- CDAS 2: includes spring and fall HFEs and triggered low summer flows, but no mechanical removal of trout or trout management flows
- CDAS 3: includes mechanical removal of trout, but no spring or fall HFEs, triggered low summer flows, or trout management flows
- CDAS 4: includes fall HFEs and mechanical removal of trout, but no spring HFEs, triggered low summer flows, or trout management flows.

4. Resource Targeted Condition-Dependent Alternative (RTCD)

- Objective: Provide for recovery of the humpback chub while protecting other important resources including sediment, the rainbow trout fishery at Lees Ferry, aquatic food base, and hydropower resources
- Base operations:
  - Target lower monthly water volumes in August, September, and October to conserve sediment
  - Volume of water released in October, November, and December = 2.0 maf in $\geq$ 8.23 maf years
  - Maximum daily range in flows proportional to monthly volume (12 × monthly volume [kaf] in June, July, and August, and 10 × monthly volume [kaf] in other months). For example, if monthly volume in June, July, and August is 700,000 ac-ft, the allowable daily flow range in cfs would equal 12 × 700 (8,400 cfs); in other months, it would equal 10 × 700 (7,000 cfs)
  - Increase hourly down-ramp rates from 1,500 cfs/hr to 2,500 cfs/hr
- Modifications to base operations:
  - Follow existing HFE protocol for entire LTEMP period with the following adjustments:
    - Reduce fluctuations to $\pm$ 1,000 cfs in August, September, and October until the fall HFE if significant input of Paria River sediment occurred during the HFE-protocol accounting period (July-October)
    - No spring HFEs in first 10 years
    - Test rapid response HFE every 4th HFE
  - Mechanical removal of trout in the LCR reach
  - Test effectiveness of trout management flows
  - Test low summer flows in second 10 years if flows have been cold (< 12 ^{o}C) and the humpback chub population is less than 7,000 adults.
- See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the RTCD alternative, and Figure 4 for the hydrograph in an 8.23 maf year.
- Six long-term strategies will be evaluated (Table 3):
  - RTCD 1: includes spring (years 11-20 only) and fall HFEs and trout management flows, but no mechanical removal of trout or low summer flows
  - RTCD 2: includes spring (years 11-20 only) and fall HFEs and triggered low summer flows, but no mechanical removal of trout or trout management flows
  - RTCD 3: includes mechanical removal of trout, but no spring or fall HFEs, triggered low summer flows, or trout management flows

  - RTCD 4: includes fall HFEs and mechanical removal of trout, but no spring HFEs, triggered low summer flows, or trout management flows
  - RTCD 5: includes triggered low summer flows, but no spring or fall HFEs, mechanical removal of trout, or trout management flows
  - RTCD 6: includes trout management flows, but no spring or fall HFEs, triggered low summer flows, or mechanical removal of trout.

5. Seasonally Adjusted Steady Flows (SASF)

- Objective: Provide flows that follow a more natural pattern while limiting sediment transport and providing for warming in summer months
- Base operations:
  - Monthly volumes follow a more natural pattern with peak flows provided in May and June, and base flows from July through January
  - Peak flow period would include a 24-hr, 45,000 cfs on May 1 (if no triggered spring HFE in same year) and a 168-hr (7-day) 25,000 cfs flow at the end of June
  - Daily range of 0 cfs in all months
- Modifications to base operations:
  - Follows existing HFE protocol for the entire LTEMP period
  - No trout management flows or mechanical removal of trout
  - See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the SASF alternative, and Figure 5 for the hydrograph in an 8.23 maf year.
- One long-term strategy will be evaluated (Table 3):
  - SASF: base operations (as described above), including spring and fall HFEs, but no mechanical removal of trout or trout management flows.

6. Year-Round Steady Flows (YRSF)

- Objective: Maximize conservation of sediment
- Base operations:
  - Daily range of 0 cfs in all months with no variation in monthly volumes other than in response to changes in forecast and other operating requirements such as equalization
- Modifications to base operations:
  - Follows existing HFE protocol for the entire LTEMP period with the following exception:
    - Extend duration of HFE for up to 336 hours (2 weeks) if sand supply will support
    - Test proactive spring HFEs in high volume years ($\geq$ 10 maf) prior to equalization
  - Mechanical removal of trout in the LCR reach
  - Test effectiveness of trout management flows
- See Table 1 and 2 for summary of operational characteristics and condition-dependent and experimental elements of the YRSF alternative, and Figure 6 for the hydrograph in an 8.23 maf year.
- One long-term strategy will be evaluated (Table 3):
  - YRSF: base operations (as described above), including spring and fall HFEs, mechanical removal of trout, and trout management flows.

TABLE 1 Operational Characteristics of LTEMP Alternatives

Elements of Base Operations	No Action	Balanced Resource	Condition-Dependent Adaptive Strategy	Resource-Targeted Condition-Dependent	Seasonally Adjusted Steady Flows	Year-Round Steady Flows
Monthly Pattern in Release Volume	Higher release volumes in high electric demand months of Dec, Jan, Jul, and Aug	Same as no-action	Highest volume in high electric demand months of Dec, Jan, and Jul; Feb–Jun volumes proportional to contract rate of delivery; lower volumes from Aug–Nov	Monthly volumes proportional to the contract rate of delivery, but with a targeted reduction in Aug–Oct volumes; volume released in Oct, Nov, and Dec = 2.0 maf in > 8.23 maf years	Relative to no-action, higher release volumes in April through June; lower volumes in remaining months	Equal monthly volumes, adjusted with changes in runoff forecast
Minimum Flows (cfs)	8,000 between 7 a.m. and 7 p.m. 5,000 between 7 p.m. and 7 a.m.t	Same as no-action	Same as no-action	Same as no-action	5,000	5,000
Maximum Flows (cfs)[1]	25,000	Same as no-action	Same as no-action	Same as no-action	Same as no-action	Same as no-action
Daily range (cfs/24 hr)[2]	5,000 for monthly volumes < 600 kaf[1] 6,000 for monthly volumes between 600–800 kaf 8,000 for monthly volumes > 800 kaf	Dec and Jan: 12,000 Feb, Jul, and Aug: 10,000 Oct, Nov, Mar, Jun, and Sep: 8,000 Apr and May: 6,000	Equal to 7 × monthly volume in kaf in all months 2,000 cfs following significant sediment input in summer or fall	Equal to 12 × monthly volume in kaf in Jun–Aug, and 10 × monthly volume in kaf in other months 2,000 cfs following significant sediment input in summer or fall	0 cfs	0 cfs
Ramp rates (cfs/hr)	4,000 up 1,500 down	4,000 up 4,000 down in Nov through Mar 3,000 down in other months	4,000 up 2,500 down	4,000 up 2,500 down	None	None

[1] Maximum flows presented are for normal operations, and would be exceeded as necessary for HFEs, emergency operations, and equalization purposes.

[2] Values presented are the daily range in mean hourly flow. Some variation in instantaneous flows within hours is allowed in all alternatives to accommodate regulation and spinning reserve requirements.

TABLE 2 Condition-Dependent and Experimental Elements of LTEMP Alternatives(1)

Condition-Dependent Elements	Trigger and Primary Objective	No Action	Balanced Resource	Condition-Dependent Adaptive Strategy	Resource-Targeted Condition-Dependent	Seasonally Adjusted Steady Flows	Year-Round Steady Flows
High Flow Experiments							
Spring HFE (existing protocol, Mar or Apr)	Trigger: Paria River sediment input in spring Objective: Rebuild sandbars	Follows existing protocol through 2020; no spring HFEs until 2015	Follows existing protocol for entire LTEMP period, but not to exceed one spring or fall HFE every other year	Follows existing protocol for entire LTEMP period	Follows existing protocol for entire LTEMP period, but no spring HFEs in first 10 years;	Follows existing protocol for entire LTEMP period	Follows existing protocol for entire LTEMP period
Proactive spring HFE in Apr, May, or Jun, with maximum possible 24-hr release up to 45,000 cfs	Trigger: High equalization year (≥ 10 maf) Objective: Protect sand supply from high equalization releases	No	No	Yes, if no other spring HFE in same water year	No	No	Yes, if no other spring HFE in same water year
Fall HFE (existing protocol, Oct or Nov)	Trigger: Paria River sediment input in fall Objective: Rebuild sandbars	Follows existing protocol through 2020	Follows existing protocol for entire LTEMP period, but not to exceed one spring or fall HFE every other year	Follows existing protocol for entire LTEMP period	Follows existing protocol for entire LTEMP period	Follows existing protocol for entire LTEMP period	Follows existing protocol for entire LTEMP period
More rapid response HFE	Trigger: Paria River flood Objective: Improve sediment retention	Test; nearly simultaneous with Paria flood	Test; nearly simultaneous with Paria flood	No	Every fourth HFE; nearly simultaneous with Paria flood	No	No

Table 2 (Cont.)

Condition-Dependent Elements	Trigger and Primary Objective	No Action	Balanced Resource	Condition-Dependent Adaptive Strategy	Resource-Targeted Condition-Dependent	Seasonally Adjusted Steady Flows	Year-Round Steady Flows
Adjustments to Base Operations							
HFEs longer than 96 hr duration	Trigger: Paria River flood Objective: Improve sediment retention	No	No	Yes, but HFE volume limited to that of a 45,000 cfs, 96 hr flow (357,000 ac-ft)	No	No	Yes, magnitude (up to 45,000 cfs) and duration (up to 336 hr) dependent on sediment supply
Steady flows or reduced fluctuations before HFEs	Trigger: Significant sediment input from Paria River in Dec–Mar or Jul–Oct Objective: Conserve sediment input for spring or fall HFE	No	No	Reduced fluctuations (± 1,000 cfs) in Feb and Mar (spring HFE) or Aug, Sep, and Oct (fall HFE)	Reduced fluctuations (± 1,000 cfs) in Aug, Sep, and Oct (fall HFE)	No change in operations, which already feature low fluctuations throughout the year	No change in operations, which already feature steady flows throughout the year
Steady flows or reduced fluctuations after HFEs	Trigger: HFE Objective: Reduce erosion of newly built sandbars	No	No	Reduced fluctuations (± 1,000 cfs) until Dec 1 after fall HFEs, or May 1 after spring HFEs whichever is shorter	No	No change in operations, which already feature low fluctuations throughout the year	No change in operations, which already feature steady flows throughout the year

Table 2 (Cont.)

Condition-Dependent Elements	Trigger and Primary Objective	No Action	Balanced Resource	Condition-Dependent Adaptive Strategy	Resource-Targeted Condition-Dependent	Seasonally Adjusted Steady Flows	Year-Round Steady Flows
Low summer flows (Jul, Aug, Sep)	Trigger: number of adult HBC, temperature at LCR confluence, and release temperature Objective: Improve recruitment of HBC in mainstem	No	No	Test if number of adult HBC < 7,000, <12ºC at LCR confluence, and release temperature is sufficiently warm to achieve 13ºC only if low flows are provided; daily range 2,000 cfs	Test in second 10 years if releases have been cold, number of adult HBC ≥ 7,000, and temperature of 16ºC can be reached	No change in operations, which already feature low flows during summer	No
Hydropower improvement flows (increased fluctuation levels)	Trigger: annual volume ≤ 8.23 maf Objective: Test effect on sediment, HBC, and trout	No	Maximum daily flow (held for as long as possible): 25,000 cfs (Dec–Feb, Jun–Aug) 20,000 cfs (Sep–Nov) 15,000 cfs (Mar–May) Minimum daily flow all months: 5,000 cfs Ramp rate up and down: 5,000 cfs/hr. Test in 4 years	No	No	No	No

Table 2 (Cont.)

Condition-Dependent Elements	Trigger and Primary Objective	No Action	Balanced Resource	Condition-Dependent Adaptive Strategy	Resource-Targeted Condition-Dependent	Seasonally Adjusted Steady Flows	Year-Round Steady Flows
Trout Management Actions[2]							
Remove trout in LCR reach	Trigger: High trout numbers in LCR reach, low HBC numbers Objective: Reduce predation on HBC	Yes	Yes	Yes	Yes	No	Yes
Trout management flows	Trigger: High trout numbers in Glen Canyon reach Objective: Improve fishery, reduce emigration to LCR reach, and predation on HBC	Test	Test and implement if successful	Test and implement if successful	2 × 2 factorial design testing with/without HFE and warm/cold water effects	No	Test and implement if successful

[1] HFE = high flow experiment, HBC = humpback chub, LCR = Little Colorado River, maf = million ac-ft.

[2] Trout removal in the Paria River-Badger Rapids reach was proposed in the Non-Native Fish Protocol EA, but has since been determined to be an impractical approach to controlling trout emigrating to the Little Colorado Reach. It is not considered viable for any alternatives.

TABLE 3. Elements of Long-Term Strategies Being Evaluated in LTEMP EIS

	Triggered Actions						
Long-Term Strategy	Spring HFEs	Proactive Spring HFEs	Fall HFEs	Low Summer Flows	Mechanical Removal of Trout	Trout Management Flows	Hydropower Improvement Flows
NA	Through 2020	No	Through 2020	No	Through 2020	No	No
BR 1	Entire LTEMP period	No	Entire LTEMP period	No	Yes	Yes	No
BR 2	Entire LTEMP period	No	Entire LTEMP period	No	Yes	Yes	Yes
CDAS 1	Entire LTEMP period	Yes	Entire LTEMP period	No	No	Yes	No
CDAS 2	Entire LTEMP period	Yes	Entire LTEMP period	Yes	No	No	No
CDAS 3	No	No	No	No	Yes	No	No
CDAS 4	No	No	Entire LTEMP period	No	Yes	No	No
RTCD 1	Second 10 years of LTEMP period	No	Entire LTEMP period	No	No	Yes	No
RTCD 2	Second 10 years of LTEMP period	No	Entire LTEMP period	Yes	No	No	No
RTCD 3	No	No	No	No	Yes	No	No
RTCD 4	No	No	Entire LTEMP period	No	Yes	No	No
RTCD 5	No	No	No	Yes	No	No	No
RTCD 6	No	No	No	No	No	Yes	No
SASF	Entire LTEMP period	No	Entire LTEMP period	Not triggered, occurs every year	No	No	No
YRSF	Entire LTEMP period	Yes	Entire LTEMP period	No	Yes	Yes	No

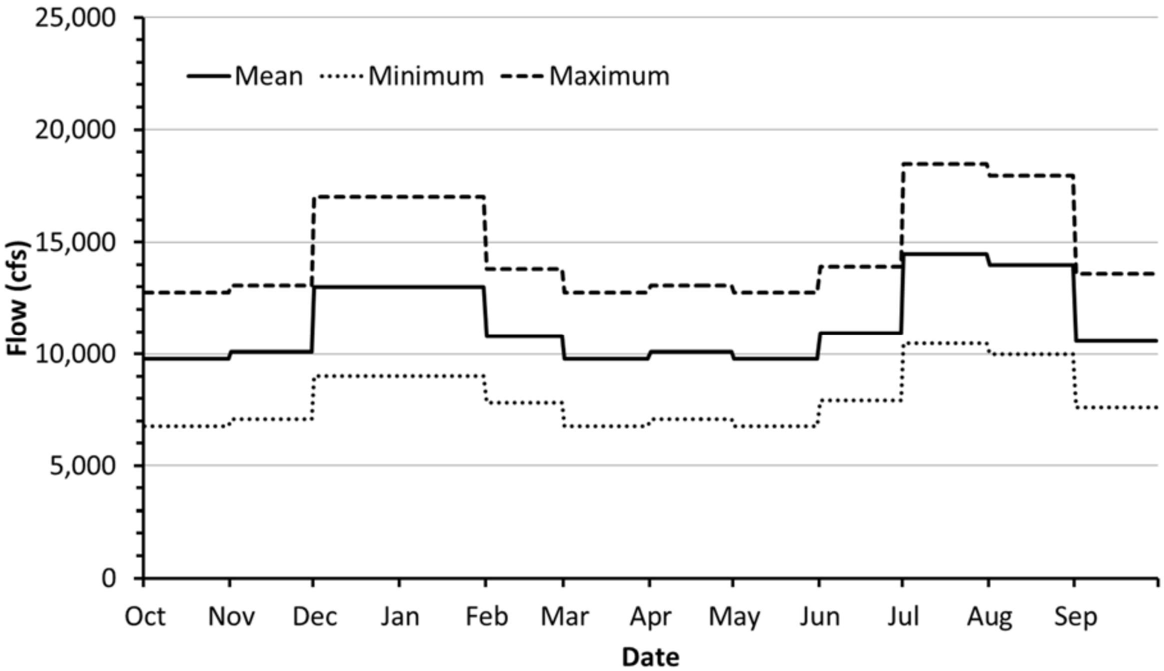

FIGURE 1 Mean, Minimum, and Maximum Daily Flows Under the No-Action Alternative in an 8.23 maf Year

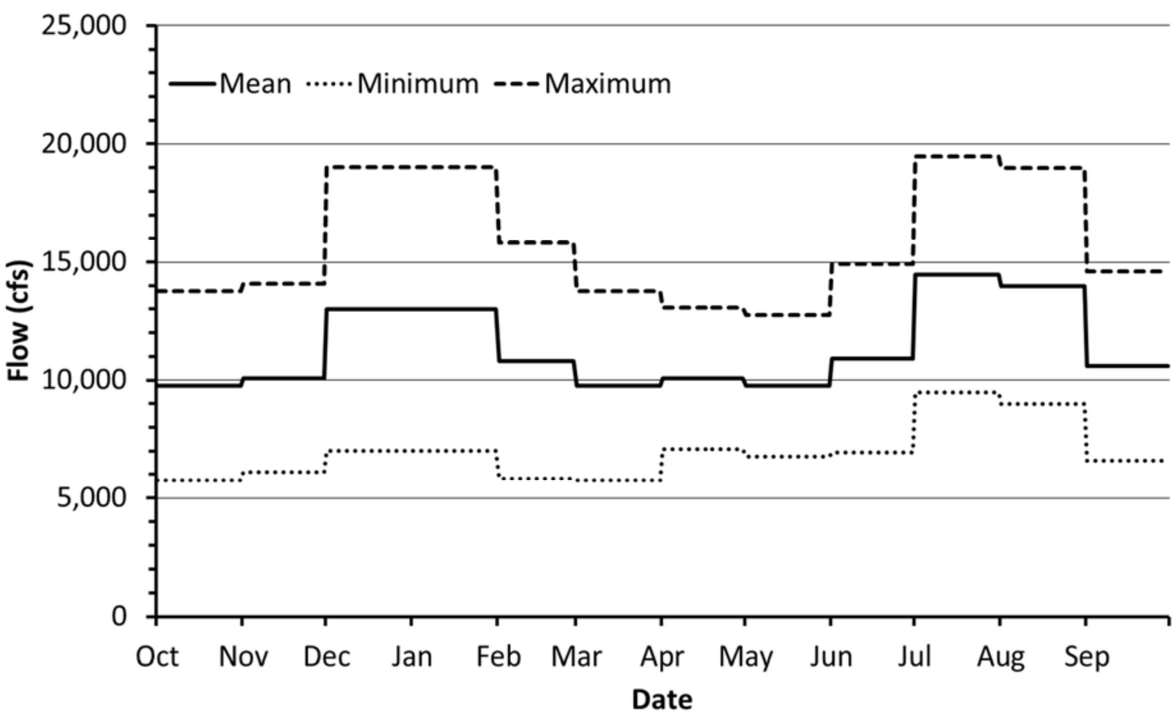

FIGURE 2 Mean, Minimum, and Maximum Daily Flows Under the Balanced Resource Alternative in an 8.23 maf Year

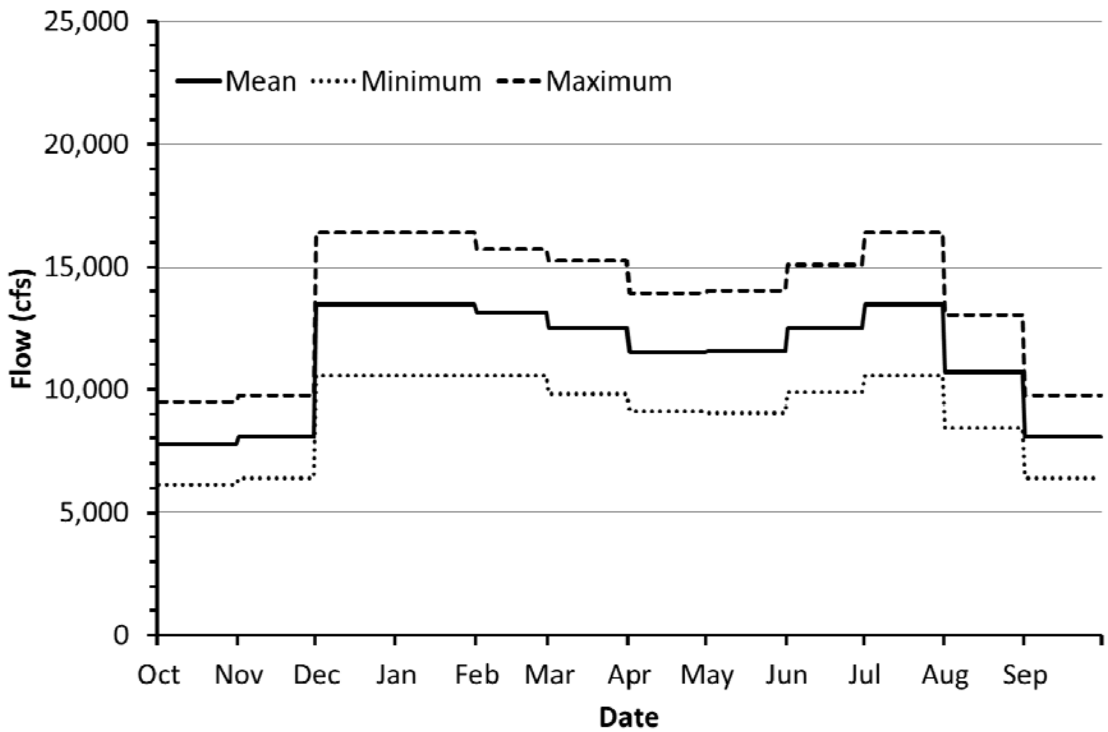

FIGURE 3 Mean, Minimum, and Maximum Daily Flows Under Base Operations of the Condition-Dependent Adaptive Strategy Alternative in an 8.23 maf Year

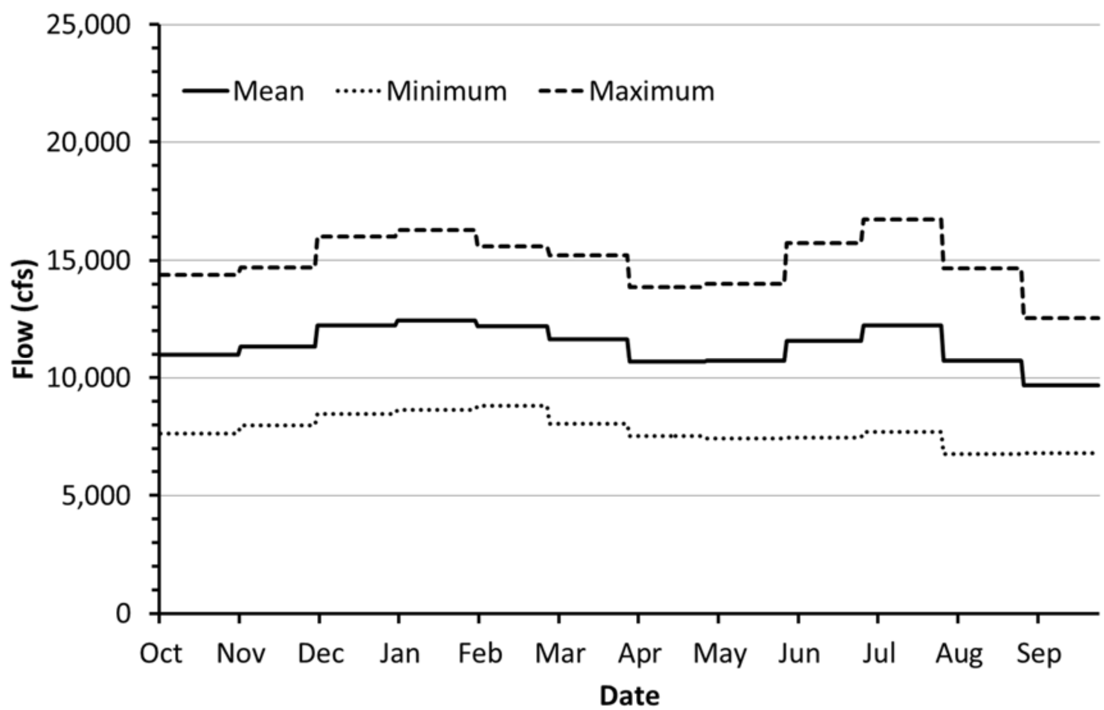

FIGURE 4 Mean, Minimum, and Maximum Daily Flows Under the Resource Targeted Condition-Dependent Alternative in an 8.23 maf Year

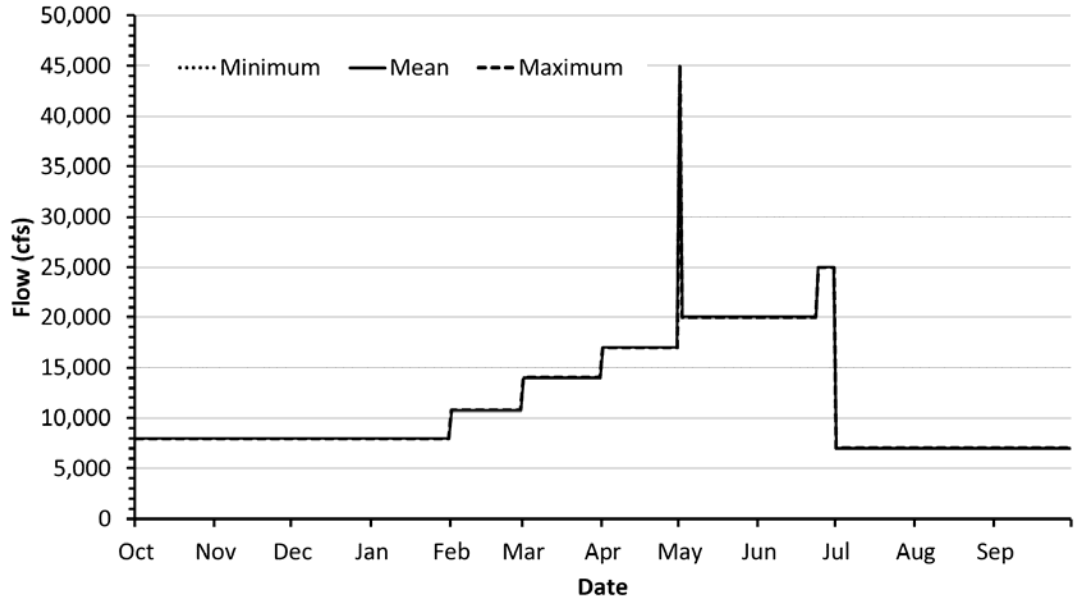

FIGURE 5 Mean, Minimum, and Maximum Daily Flows Under the Seasonally Adjusted Steady Flow Alternative in an 8.23 maf Year

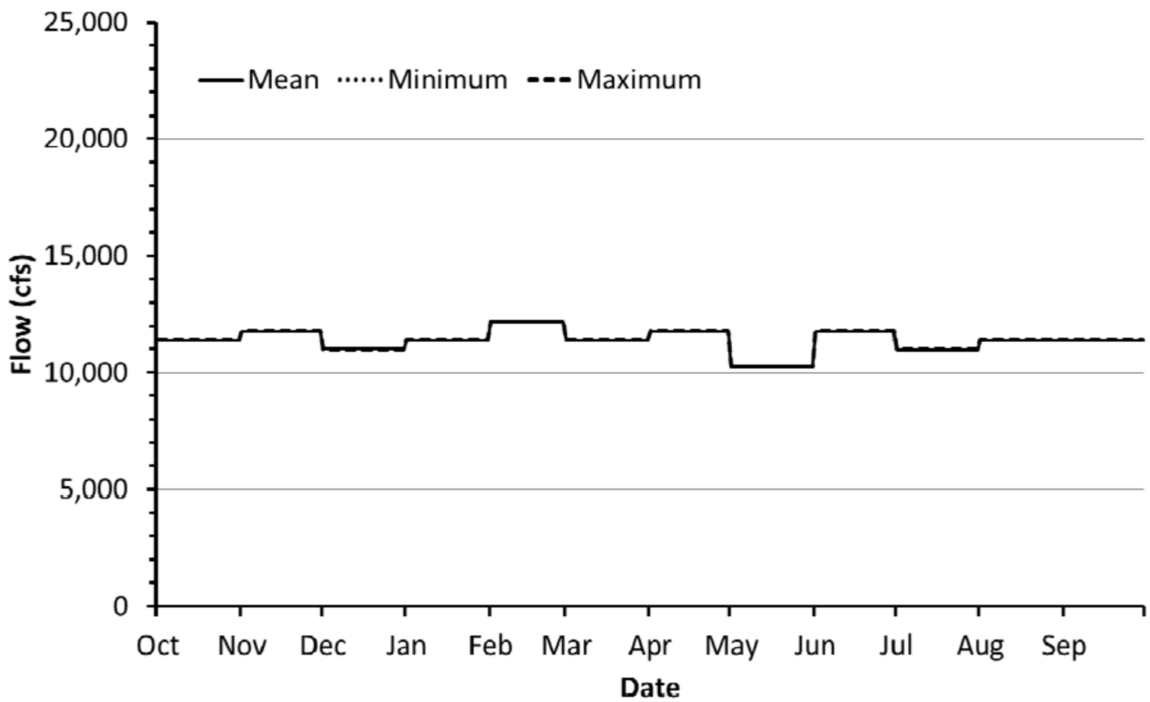

FIGURE 6 Mean, Minimum, and Maximum Daily Flows Under the Year-Round Steady Flow Alternative in an 8.23 maf Year