AQ 1 – HYDROLOGY TECHNICAL MEMORANDUM

KERN RIVER NO. 1 HYDROELECTRIC PROJECT
FERC PROJECT NO. 1930

PREPARED FOR:

SOUTHERN CALIFORNIA EDISON®
Energy for What's Ahead℠

May 2026

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LIST OF ACRONYMS

ac-ft	acre-feet
AQ 1 TM	AQ 1 – Hydrology Technical Memorandum
AQ 1 TSP	AQ 1 – Hydrology Technical Study Plan
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
KR1	Kern River No. 1
POR	Period of Record
Project	Kern River No. 1 Hydroelectric Project
SCE	Southern California Edison

SPD	Study Plan Determination
TWG	Technical Working Group
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WY	water year

1.0 INTRODUCTION

This AQ 1 – Hydrology Technical Memorandum (AQ 1 TM) provides the methods and findings of the AQ 1 – Hydrology Technical Study Plan (AQ 1 TSP) in support of the Southern California Edison's (SCE) Kern River No. 1 (KR1) Hydroelectric Project (Project) relicensing, Federal Energy Regulatory Commission (FERC) Project No. 1930. The AQ 1 TSP was included in SCE's Revised Study Plan filed on February 13, 2024 (SCE 2024). In its March 14, 2024 Study Plan Determination (SPD), FERC approved the AQ 1 TSP without modifications (FERC 2024).

This AQ 1 TM presents a hydrological operations model of the Project, including inflow hydrology, powerhouse flows, and releases to the Kern River bypass reach using an hourly timestep over the hydrological period of record (POR) covering water years 1999 through 2023. This AQ 1 TM also includes a hydrologic alteration analysis of flows in the bypass reach.

2.0 STUDY OBJECTIVES

The objectives of the study, as outlined in AQ 1 TSP (SCE 2024), include the following:

- Develop a model of the Project operations with and without the Project diversion and refine (as needed) the analysis of hydrology presented in the Pre-Application Document Section 3.3, Water Use and Hydrology.
- Perform a hydrologic alteration analysis of flows related to Project diversions.

3.0 STUDY AREA

The Study Area includes the bypass reach on the Kern River from Democrat Dam to the KR1 Powerhouse Tailrace (Map 3-1).

4.0 METHODS

The methods below were used to develop the Project Operations Model and provide a hydrologic alterations analysis of the bypass reach on the Kern River from Democrat Dam to the KR1 Powerhouse Tailrace. Study implementation followed the methods described in the AQ 1 TSP (SCE 2024).

4.1 STUDY PLAN VARIANCES

There was one minor study plan variance. The AQ 1 TSP specified that a POR of 1998–2021 would be used for the hydrology modeling. Based on data availability (historical gage data), a POR of 1999–2023 water year (WY) was used for the modeling and hydrologic alteration analysis.

4.2 HYDROLOGY MODEL DEVELOPMENT

- Four stakeholder hydrological modeling Technical Working Group (TWG) meetings were conducted in 2023 and 2024 (July 7, July 31, and August 24, 2023, and August 8, 2024) to review and help guide the hydrological modeling approach.

- The 1999–2023 POR was used for hydrological modeling based on data availability. This is a slightly different POR (longer and different start year) than the AQ 1 TSP identified (i.e., 1998–2021) due to availability of data.

- A spreadsheet-based operations model was developed to characterize the Project average hourly flow hydrology for the POR. The model includes inflow to Democrat Dam, releases to the bypass reach below the dam, and powerhouse outflows. The model includes minimum instream flow requirements and other constraints Project (e.g., flow line capacity).

- Climate change modeling for Lake Isabella releases (inflow to the Kern No. 1 Project), which are controlled by United States Army Corps of Engineers (USACE) operations and the Kern River Water Master scheduled releases, was not available over the 1999–2023 POR; therefore, climate change modeling of the inflow hydrology was not included in the t operations model.

- We coordinated with other study plans / analyses (e.g., recreation, riparian) to ensure the model addressed their needs.

4.3 HYDROLOGIC ALTERATION ANALYSIS

- A hydrologic alteration analysis was developed comparing with Project and without Project flows in the bypass reach using the following data and approaches (e.g., Richter et. al. 1996):

  – Timeseries plots for the POR.

  – Monthly flow exceedance plots / tables for the POR.

  – January to December (annual) plots / tables showing mean daily and 95%, 90%, 75%, 50% (median), 25%, 10%, and 5% exceedance flows.

  – Tables and summary analysis showing differences in the following:

    - Monthly timing and magnitude of mean and median flow conditions.

    - Magnitude, duration, and timing of annual high flow conditions and low flow conditions (1-day, 3-day, 7-day, monthly), including the presence of pulse flow events.

- Rate, timing, and frequency of hydrograph changes (e.g., rate and timing of the declining limb of the spring high flow hydrograph) were developed to characterize flow changes on a sub-daily basis.

5.0 RESULTS SUMMARY

5.1 HYDROLOGY DEVELOPMENT

5.1.1 Flow Data

Hourly flow data was developed for the 1999–2023 POR using the flow gages listed in Table 5-1. Hourly flows were only available from SCE beginning in 2004 or 2005. The United States Geological Survey (USGS) gage daily average flow was used for each hour of the day before that hourly flows were available. Some discrepancies were found between the USGS (USGS 2022a,b,c) daily flow record and the SCE hourly flow record in WY 2007–2009 at SCE Gage No. 409. The USGS record was used when discrepancies occurred. The periods where the USGS record was used to replace the SCE hourly gage data records are shown in Table 5-2. An example of the hourly and daily flow discrepancies is shown in Figure 5-1 with the discrepancy periods highlighted in orange. The revised / combined hydrology data set is also shown in Figure 5-1.

5.1.2 Hourly Flow Dataset

The resulting hydrology set provides an hourly timestep dataset for use in the hydrologic model and the hydrologic alteration analysis. Annual flow volumes in acre-feet (ac-ft) for the hydrology dataset are shown in Table 5-3. The monthly average flows for the diversion into the Kern River No. 1 Conduit and release to the bypass reach are shown in Figure 5-2.

5.2 HYDROLOGIC ALTERATION ANALYSIS

The hydrologic alteration analysis compares observed flows in the bypass reach resulting from the operation of the Project (release to bypass reach) to flows that would be present in the bypass reach without the Project (Project inflow).

5.2.1 Time Series Plots for the POR

Time series plots for the POR are shown on an hourly time step in Figure 5-3 and Figure 5-4.

5.2.2 Flow Exceedance Plots for the POR

Hourly time step flow exceedance plots for the POR are shown for each month in Figure 5-5 and Figure 5-6.

5.2.3 Annual Plots Showing Mean Daily and 95%, 90%, 75%, 50%, 25%, 10%, and 5% Exceedance Flows.

Annual plots showing mean daily and 95%, 90%, 75%, 50%, 25%, 10%, and 5% exceedance flows are shown in Figure 5-7.

A table of annual exceedances for Project inflow is shown in Table 5-4 and for release to the bypass reach in Table 5-5.

5.2.4 Monthly Timing and Magnitude of Mean and Median Flow Conditions

Monthly mean and median Project inflow and release to the bypass reach are shown in Table 5-6, along with the change in the mean and median flow. Monthly mean flows are shown graphically in Figure 5-8.

5.2.5 Magnitude, Duration, and Timing of Annual High-Flow and Low-Flow Conditions

Average magnitude of the annual high and annual low 1-day, 3-day, 7-day, 30-day, and 90-day flow events are shown in Table 5-7. The timing of the maximum flow events is shown in Figure 5-9.

The count of average annual high-flow pulses (flow events that exceed the 25% exceedance level) and annual low-flows pulses (flows events below the 25% exceedance level) and the average duration of these pulses are shown in Table 5-8.

5.2.6 Rate, Timing, and Frequency of Hydrograph Changes

The count of hourly flow increases and decreases, and the mean hourly flow increase and decrease is shown in Table 5-9. The declining limb of the hydrograph is shown in Figure 5-10, with an average of dry, median, and wet years (below 25% exceedance, between 25% and 75% exceedance, and above 75% exceedance) highlighted.

5.3 OPERATIONS MODEL

5.3.1 Model Development

A spreadsheet-based operations model was developed to characterize existing Project operations on an hourly time step. The model operates the Project with the following priorities:

1. Make minimum instream flow requirement releases to the Project bypass reach, plus a buffer flow to ensure compliance.

2. Divert water to the powerhouse conduit up to the available capacity of the conduit.

3. Remaining inflow is released (spilled) to the Project bypass reach.

Minimum instream flow requirements and buffer flows (releases above the minimum flow requirement to ensure the minimum flow requirement is always met) are shown in Table 5-10.

In the model, the powerhouse conduit capacity is limited to 385 cfs to provide sufficient freeboard on the canal sections. Unit outages are modeled as they occurred historically as a representation of potential outage timing and frequency and limit the powerhouse capacity.

5.3.2 Model Validation

Plots showing model results compared to gaged flow for the diversion to Kern No. 1 Powerhouse conduit are shown in Figure 5-11 and Figure 5-12. Plots showing model results compared to gaged flow for the release to the project bypass reach are shown in Figure 5-13 and Figure 5-14.

Modeled annual flow compared to gaged annual flow is shown in Table 5-11. Annual flows are shown graphically for the release to the Project bypass reach in Figure 5-15 and for the diversion to the powerhouse conduit in Figure 5-16.

6.0 STUDY SPECIFIC CONSULTATION

This study included four hydrological modeling consultation meetings with the hydrology TWG (see Section 4.2) that included stakeholders with expertise in hydrology modeling.

7.0 OUTSTANDING STUDY PLAN ELEMENTS

There are no outstanding study plan elements. The AQ 1 – Hydrology Study is complete.

8.0 REFERENCES

FERC (Federal Energy Regulatory Commission). 2024. Study Plan Determination for the Kern River No. 1 Hydroelectric Project. March 14.

Richter, B.D., Baumgartner, J.V., Powell, J., and Braun, D.P. 1996. A Method for Assessing Hydrologic Alteration within Ecosystems.

SCE (Southern California Edison). 2024. Kern River No. 1 Hydroelectric Project (FERC Project No. 1930) Revised Study Plan. February 13.

USGS (United States Geological Survey). 2022a. USGS 11192000 Kern River No 1 Conduit near Democrat Springs. Available at: https://waterdata.usgs.gov/nwis/dv/?site_no=11192000. Accessed August 22, 2022.

_____. 2022b. USGS 11192500 Kern River near Democrat Springs (River only). Available at: https://waterdata.usgs.gov/nwis/dv/?site_no=11192500. Accessed August 22, 2022.

_____. 2022c. USGS 11192501 Kern River near Democrat Springs Total Flow. Available at: https://waterdata.usgs.gov/nwis/dv/?site_no=11192501. Accessed August 22, 2022.

TABLES

Table 5-1. Project Flow Gages

Station	USGS Gage No. (daily average flow, cfs)	SCE Gage No. (hourly average flow, cfs)	POR
Kern River No 1 Conduit near Democrat Springs	11192000	410	USGS: 1999–2003 and 2005–2023 SCE: 2004–2023
Kern River near Democrat Springs (River Only)	11192500	409	USGS: 1999–2023 SCE: 2005–2023
Kern River near Democrat Springs Total Flow	11192501	N/A	USGS: 1999–2023

Key: POR = period of record
SCE = Southern California Edison
USGS = United States Geological Survey

Table 5-2. Time Periods That Daily Average USGS Gage Data Were Used to Estimate Hourly Hydrology

Time Period
March 12, 2007, to July 16, 2007
October 3, 2007, to December 1, 2007
March 22, 2008, to May 6, 2008
September 3, 2008 to November 17, 2008
June 12, 2009, to July 20, 2009

Table 5-3. Annual Flow Volumes for the Hydrology Dataset

Water Year	Kern River near Democrat Springs (River Only) (ac-ft)	Kern River No 1 Conduit near Democrat Springs (ac-ft)	Total Project Inflow (ac-ft)
1999	339,126	269,454	608,580
2000	230,172	232,290	462,461
2001	196,044	185,575	381,619
2002	120,234	220,920	341,154
2003	285,398	169,272	454,670
2004	274,816	165,446	440,262
2005	685,244	168,368	853,611
2006	1,017,034	81,910	1,098,945
2007	178,527	186,211	364,738
2008	392,651	74,970	467,621
2009	279,215	171,928	451,144
2010	642,122	81,230	723,353
2011	1,086,910	251,831	1,338,740
2012	239,940	244,564	484,503
2013	117,081	114,136	231,217
2014	61,580	106,909	168,490
2015	30,712	105,262	135,974
2016	64,754	189,169	253,923
2017	1,558,647	179,263	1,737,909
2018	286,359	233,530	519,889
2019	880,313	202,479	1,082,792
2020	217,605	226,271	443,876
2021	30,811	156,655	187,466
2022	47,237	159,640	206,877
2023	1,725,595	178,189	1,903,783
Average	**439,525**	**174,219**	**613,744**

Key: ac-ft = acre-feet

Table 5-4. Annual Exceedance Flows, Project Inflow

Year	Mean (cfs)	95% Exd (cfs)	90% Exd (cfs)	75% Exd (cfs)	50% Exd (cfs)	25% Exd (cfs)	10% Exd (cfs)	5% Exd (cfs)
1999	618	187	221	391	540	775	1,227	1,328
2000	638	178	200	324	466	954	1,280	1,368
2001	527	190	207	277	416	679	1,031	1,365
2002	482	212	236	330	409	567	868	1,017
2003	634	226	237	371	466	953	1,305	1,372
2004	585	213	237	273	460	858	1,092	1,212
2005	1,293	363	462	583	865	1,824	3,033	3,219
2006	1,428	298	325	375	626	1,948	4,663	4,705
2007	466	150	163	265	392	598	903	989
2008	658	123	231	296	517	991	1,387	1,559
2009	650	152	191	335	549	874	1,293	1,428
2010	1,037	180	220	330	841	1,829	2,152	2,380
2011	1,922	386	436	1,085	1,531	2,787	3,982	4,134
2012	522	160	186	255	459	631	1,070	1,171
2013	294	37	113	175	289	381	507	594
2014	243	106	118	139	213	350	405	431
2015	184	67	70	129	168	239	310	325
2016	358	136	153	197	331	396	665	728
2017	2,513	346	387	896	1,554	4,405	5,063	5,334
2018	618	164	180	257	411	1,065	1,353	1,468
2019	1,580	112	309	406	1,031	2,744	3,669	4,439
2020	514	138	159	196	377	818	1,072	1,157
2021	259	99	111	151	239	364	423	481
2022	276	99	109	154	250	395	458	492
2023	3,472	319	393	1,073	3,325	5,424	6,646	7,083

Key: cfs = cubic feet per second
Exd = exceedance

Table 5-5. Annual Exceedance Flows, Release to Bypass Reach

Year	Mean (cfs)	95% Exd (cfs)	90% Exd (cfs)	75% Exd (cfs)	50% Exd (cfs)	25% Exd (cfs)	10% Exd (cfs)	5% Exd (cfs)
1999	280	21	22	26	166	415	847	958
2000	377	19	28	90	288	599	885	981
2001	215	20	21	25	58	288	633	987
2002	180	18	19	22	56	274	489	672
2003	395	32	37	76	244	641	1,016	1,080
2004	363	29	29	61	321	612	815	892
2005	1,113	240	275	345	767	1,720	2,721	2,899
2006	1,243	34	38	223	570	1,617	4,326	4,648
2007	281	54	65	149	227	373	581	664
2008	500	28	29	65	396	877	1,091	1,241
2009	467	40	53	154	371	789	981	1,110
2010	856	28	33	180	615	1,463	2,021	2,238
2011	1,549	29	56	694	1,169	2,399	3,587	3,735
2012	232	28	29	36	113	354	680	776
2013	183	35	37	64	161	292	341	398
2014	61	21	21	23	46	66	156	192
2015	42	16	18	20	25	61	65	106
2016	90	20	20	23	30	81	277	345
2017	2,215	22	26	612	1,442	4,139	4,708	4,980
2018	337	24	27	29	109	702	992	1,103
2019	1,275	35	65	120	709	2,375	3,299	4,067
2020	236	16	16	27	102	423	680	765
2021	45	17	17	18	23	58	69	130
2022	65	20	21	23	48	75	160	178
2023	3,178	20	30	1,073	3,087	5,143	6,279	6,725

Key: cfs = cubic feet per second
Exd = exceedance

Table 5-6. Monthly Mean and Median Flows

Month	Mean Flow (cfs)			Median Flow (cfs)		
	Project Inflow	Release to Bypass Reach	Change	Project Inflow	Release to Bypass Reach	Change
January	398	224	-174	330	113	-216
February	452	288	-163	333	147	-186
March	678	447	-231	409	123	-286
April	1,032	743	-289	509	186	-323
May	1,530	1,212	-318	763	423	-340
June	1,875	1,530	-345	1,227	858	-369
July	1,510	1,182	-328	1,226	892	-334
August	1,013	721	-292	860	555	-305
September	625	413	-212	435	194	-241
October	441	257	-185	271	35	-236
November	302	133	-169	213	30	-183
December	289	115	-174	264	32	-232

Key: cfs = cubic feet per second

Table 5-7. Average Magnitude of Annual Extremes

Duration	Minimum Flow (cfs)			Maximum Flow (cfs)		
	Project Inflow	Release to Bypass Reach	Change	Project Inflow	Release to Bypass Reach	Change
1-day	134	31	-103	2,289	1,990	-300
3-day	141	33	-108	2,243	1,943	-301
7-day	150	35	-115	2,176	1,872	-304
30-day	180	41	-139	2,015	1,697	-317
90-day	233	67	-166	1,745	1,430	-316

Key: cfs = cubic feet per second

Table 5-8. Average Annual Pulse Flow Events

Indicator	Project Inflow	Release to Bypass Reach	Change
Average count of annual high-flow pulses	3.7	4.3	0.6
Average count of annual low-flow pulses	4.7	5.5	0.8
Average duration of high-flow pulses, days	22.8	19.6	-3.2
Average duration of low-flow pulses, days	19.4	16.7	-2.7

Table 5-9. Average Annual Hydrograph Changes

Indicator	Project Inflow	Release to Bypass reach	Change
Average count of increases in flow per year	1,063	671	-392
Average count of increases in flow per year	1,100	730	-370
Mean flow increase, cfs per hour	1.7	1.5	-0.2
Mean flow decrease, cfs per hour	-1.7	-1.5	0.2

Key: cfs = cubic feet per second

Table 5-10. Minimum Instream Flow Requirements and Buffer Flows

Season	Minimum Instream Flow	Buffer Flow
October 1 through May 31	15 cfs	5 cfs
June 1 through September 30	50 cfs	10 cfs

Key: cfs = cubic feet per second

Table 5-11. Annual Flow Volumes, Modeled and Gaged

Water Year	Inflow (ac-ft)	Release to Project Bypass Reach (ac-ft)		Diversion to Powerhouse Conduit (ac-ft)	
		Gaged	Modeled	Gaged	Modeled
1999	608,580	339,126	330,537	269,454	278,043
2000	462,461	230,172	225,129	232,290	237,333
2001	381,619	196,044	198,500	185,575	183,119
2002	341,154	120,234	108,264	220,920	232,891
2003	454,670	285,398	278,247	169,272	176,423
2004	440,262	274,816	268,909	165,446	171,353
2005	853,611	685,244	679,924	168,368	173,687
2006	1,098,945	1,017,034	1,006,921	81,910	92,024
2007	364,738	178,527	155,929	186,211	208,810
2008	467,621	392,651	381,592	74,970	86,028
2009	451,144	279,215	250,252	171,928	200,892
2010	723,353	642,122	642,089	81,230	81,264
2011	1,338,740	1,086,910	1,087,686	251,831	251,054
2012	484,503	239,940	237,777	244,564	246,727
2013	231,217	117,081	115,558	114,136	115,659
2014	168,490	61,580	58,300	106,909	110,190
2015	135,974	30,712	29,409	105,262	106,565
2016	253,923	64,754	61,566	189,169	192,357
2017	1,737,909	1,558,647	1,547,226	179,263	190,683
2018	519,889	286,359	275,165	233,530	244,725
2019	1,082,792	880,313	867,105	202,479	215,687
2020	443,876	217,605	213,996	226,271	229,880
2021	187,466	30,811	31,322	156,655	156,144
2022	206,877	47,237	45,571	159,640	161,306
2023	1,903,783	1,725,595	1,712,624	178,189	191,160
Average	**613,744**	**439,525**	**432,384**	**174,219**	**181,360**

Key: ac-ft = acre-feet

FIGURES

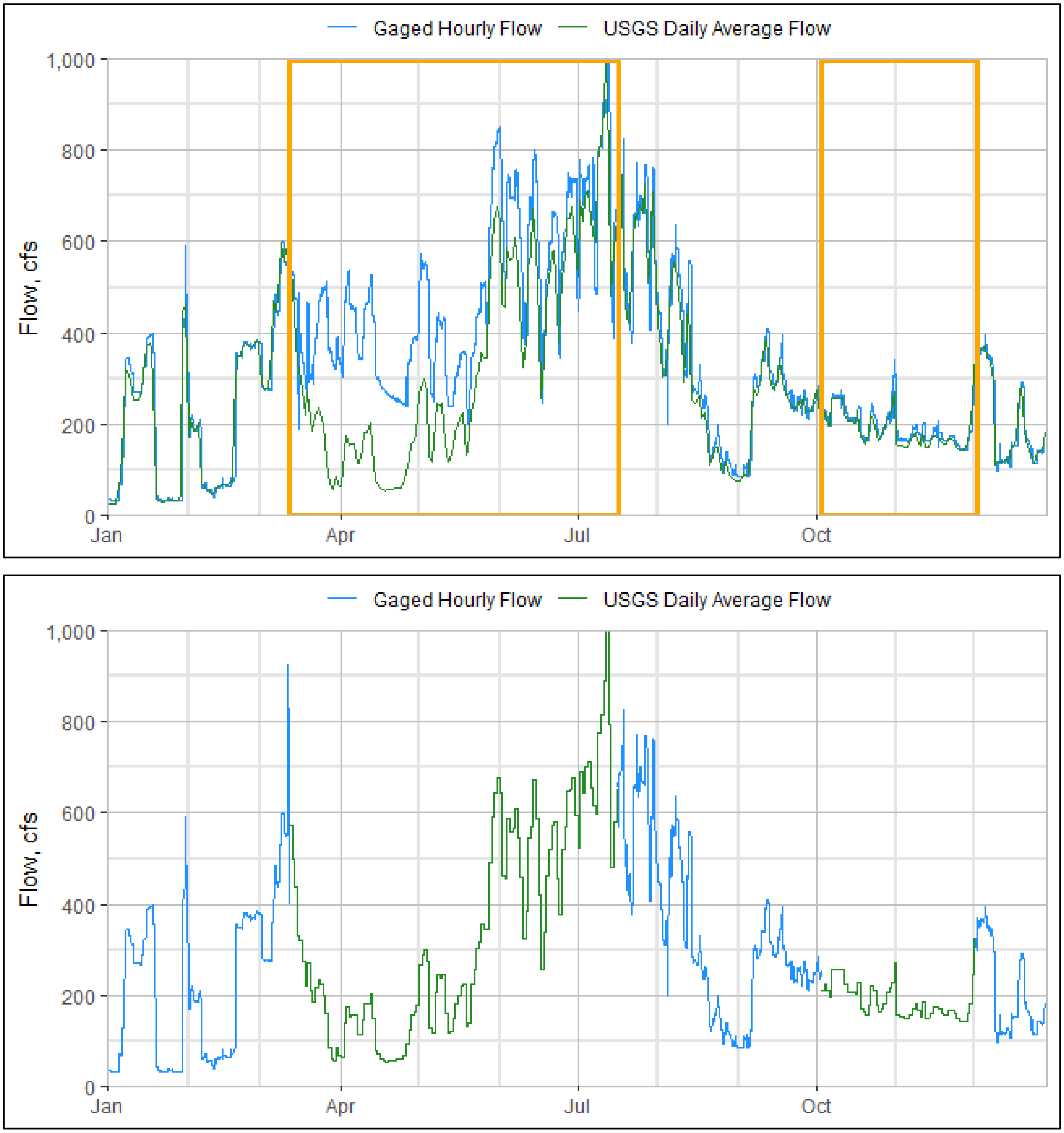


Figure 5-1. Year 2007 USGS Gage No. 11192500 daily average flow and SCE Gage No. 409 hourly average flow showing an example of hourly flow discrepancies highlighted in yellow (top) and a revised combined hourly flow dataset using the USGS daily average flows to replace the SCE Gage No. 409 hourly flow discrepancies (bottom).

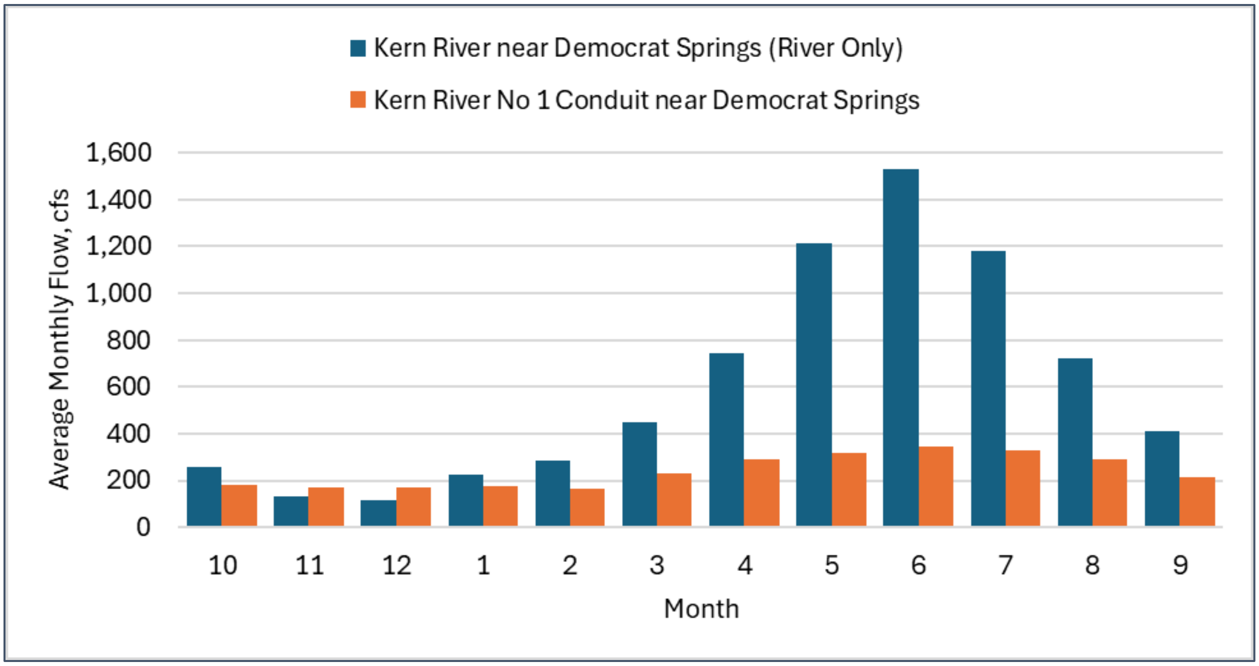


Figure 5-2. Average Monthly Flow, Water Years 1999–2023

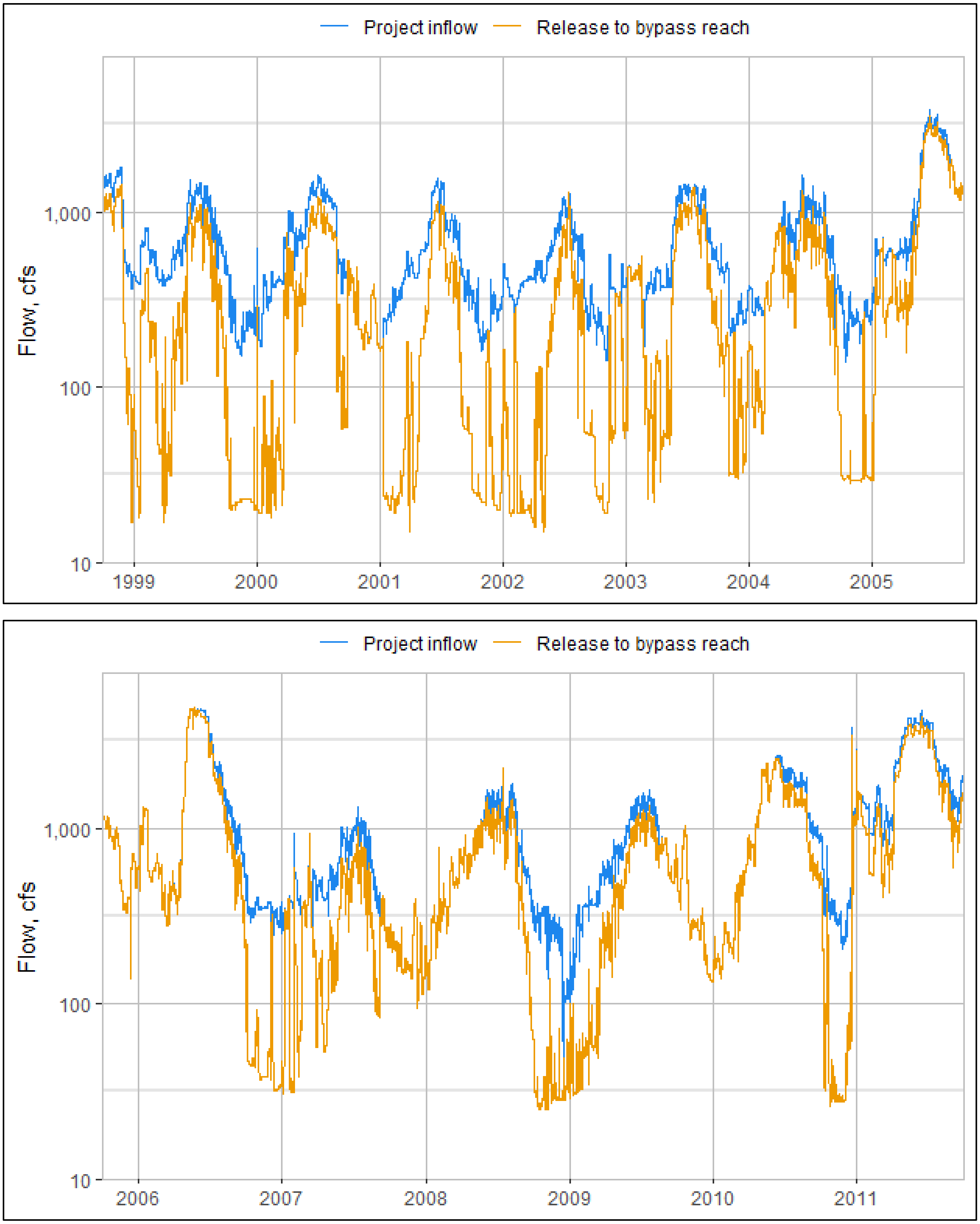


Figure 5-3. Project Inflow and Release to Bypass Reach, Water Years 1999 through 2011

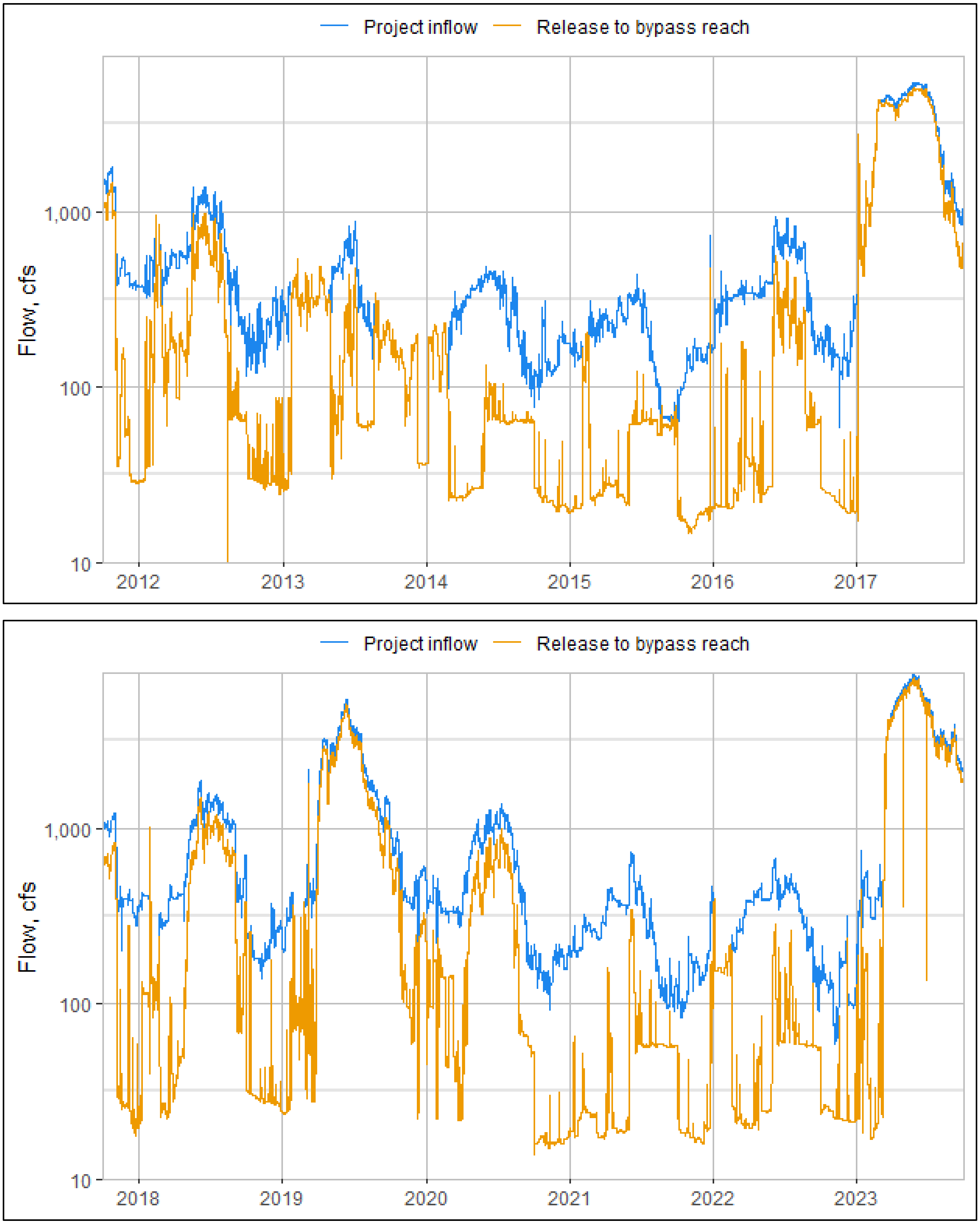


Figure 5-4. Project Inflow and Release to Bypass Reach, Water Years 2012 through 2023

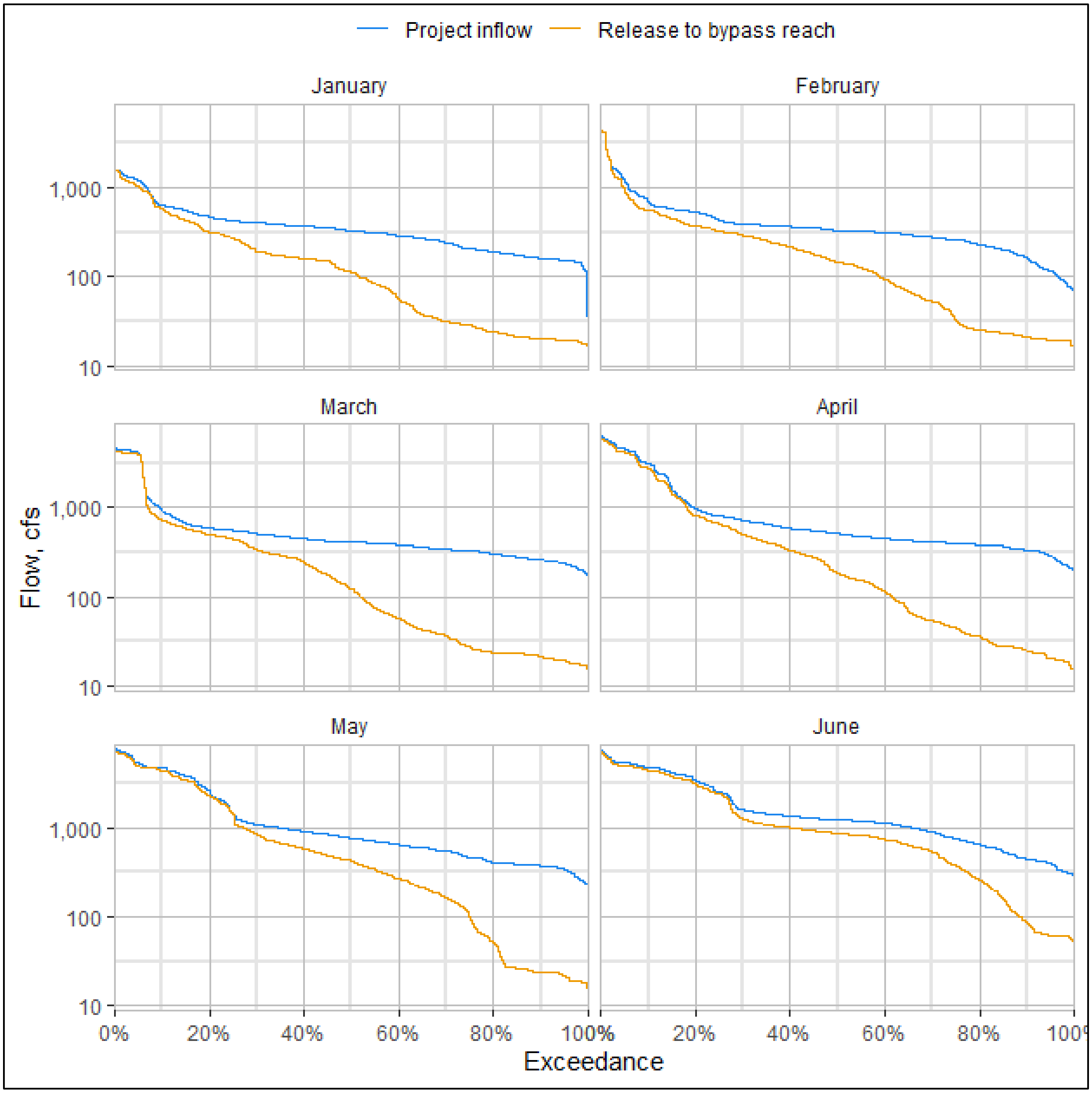


Figure 5-5. Hourly Flow Exceedance Plots, January through June

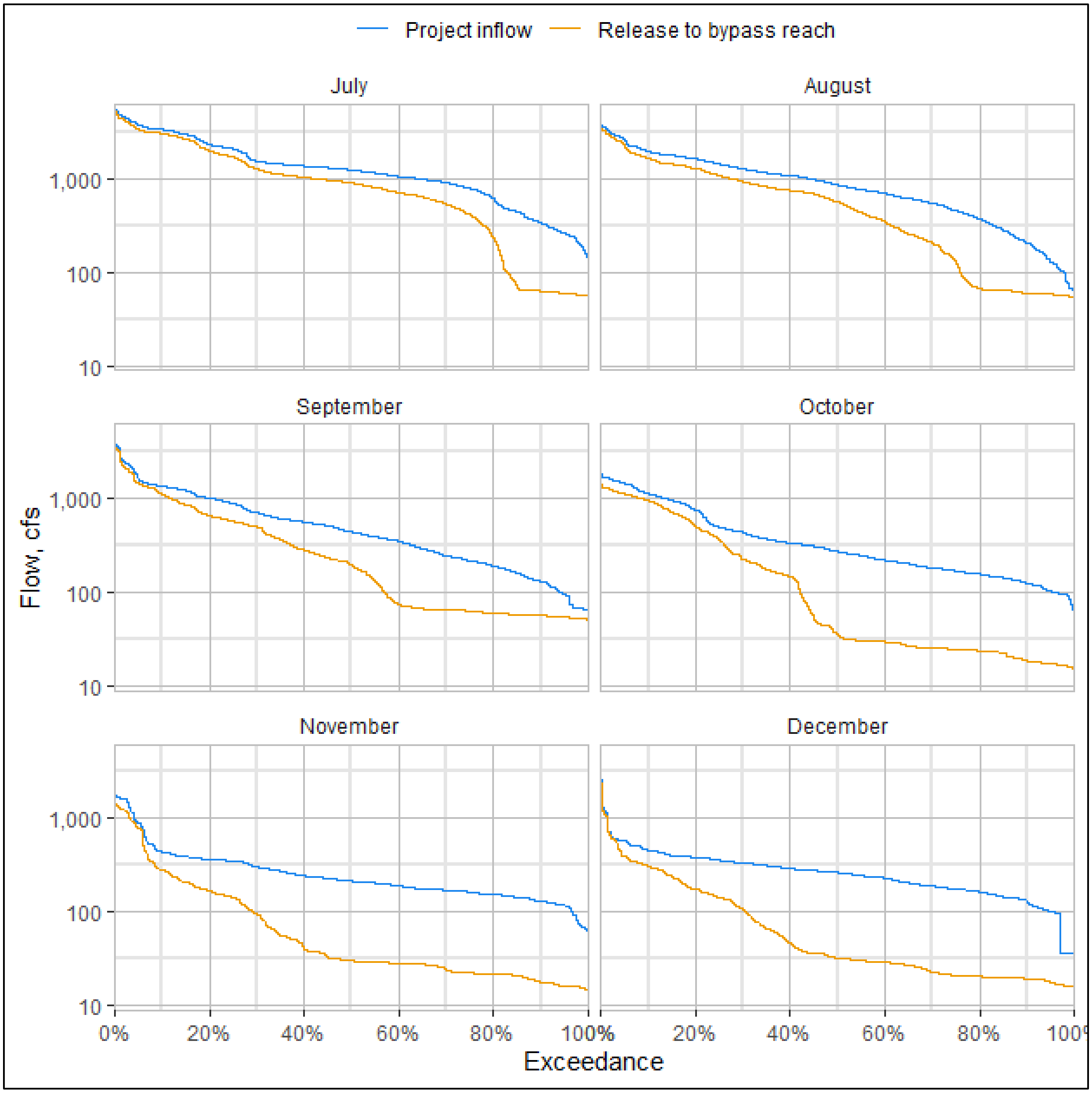


Figure 5-6. Hourly Flow Exceedance Plots, July through December

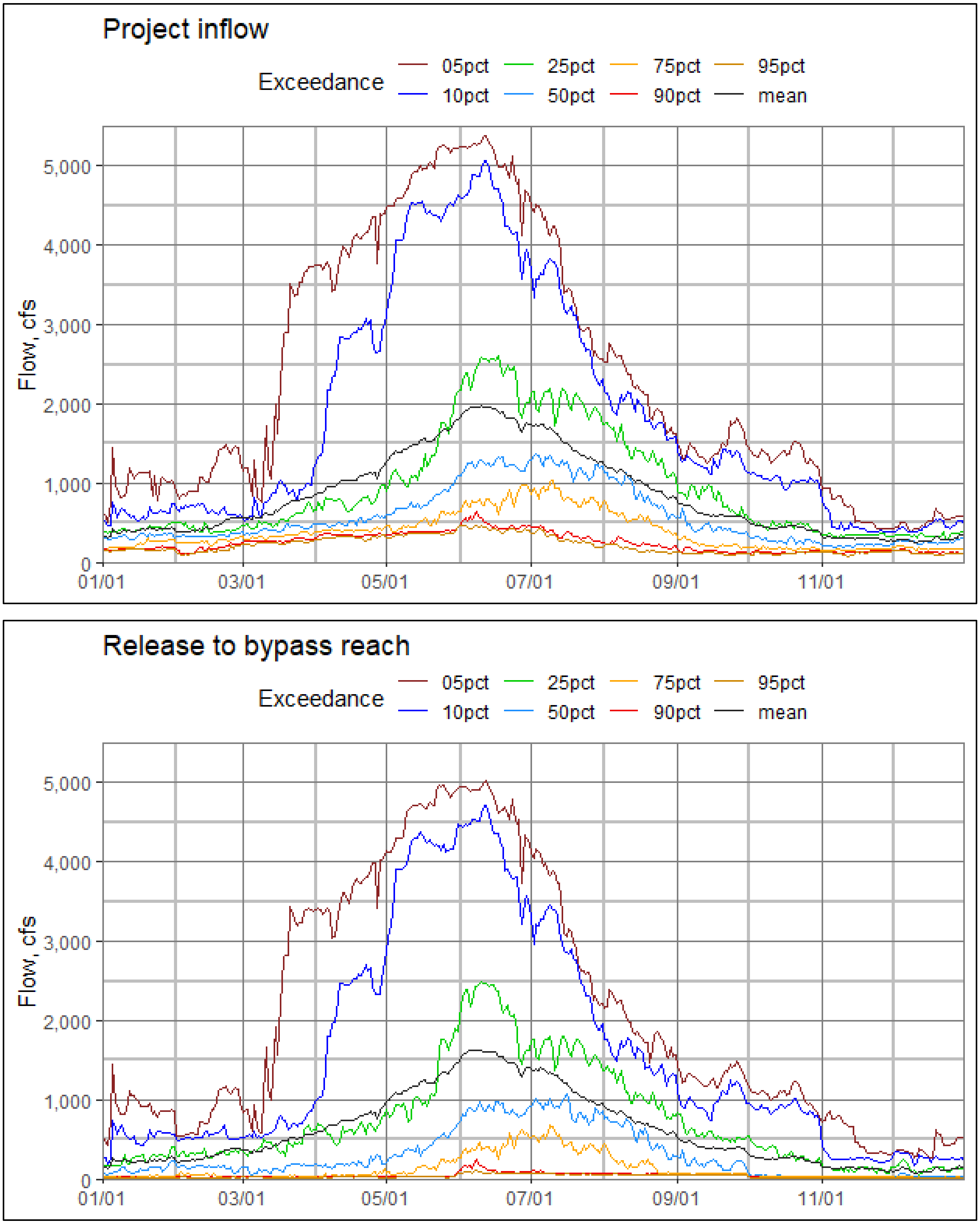


Figure 5-7. Yearly Exceedance Plots for the 1999–2023 Period-of-Record for Project Inflow (top) and Release to Bypass Reach (bottom)

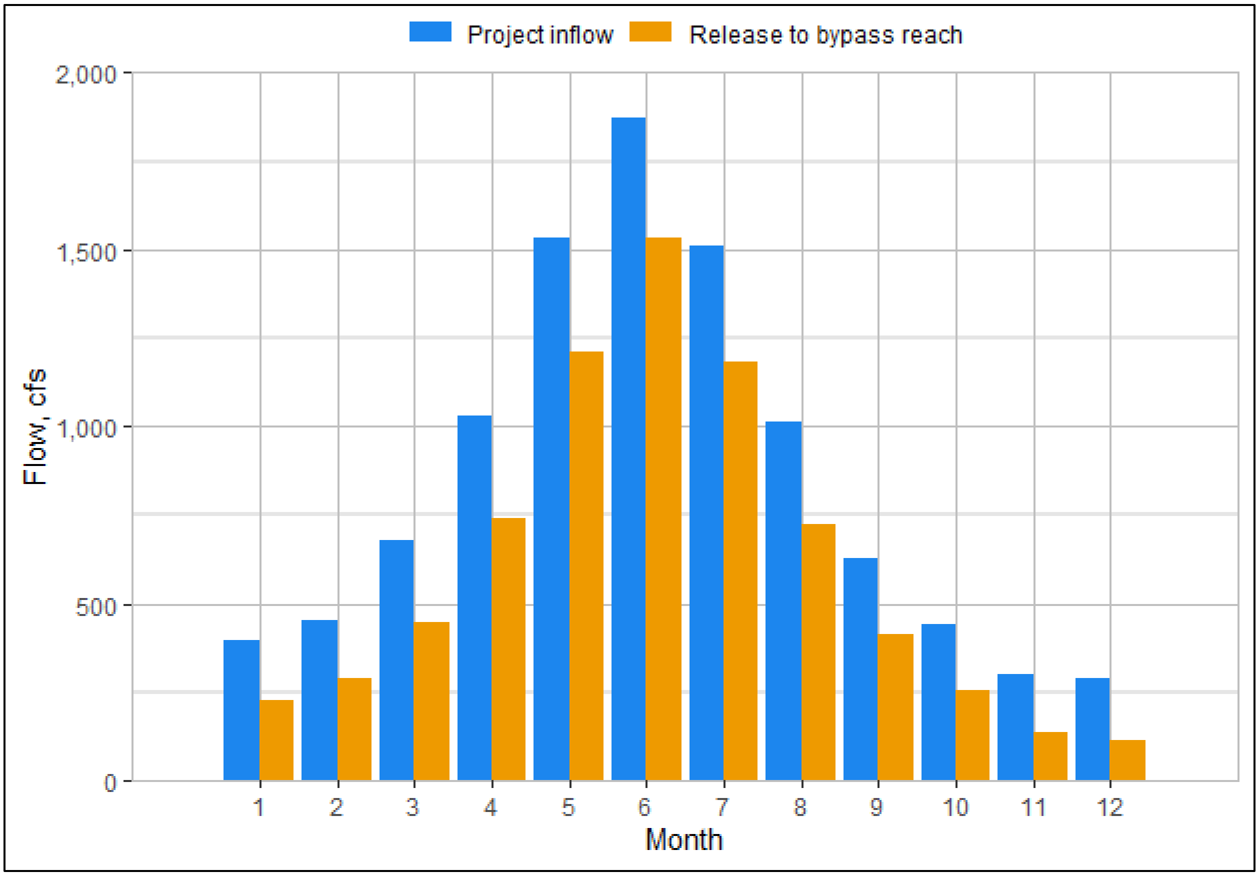


Figure 5-8. Monthly Mean Flows

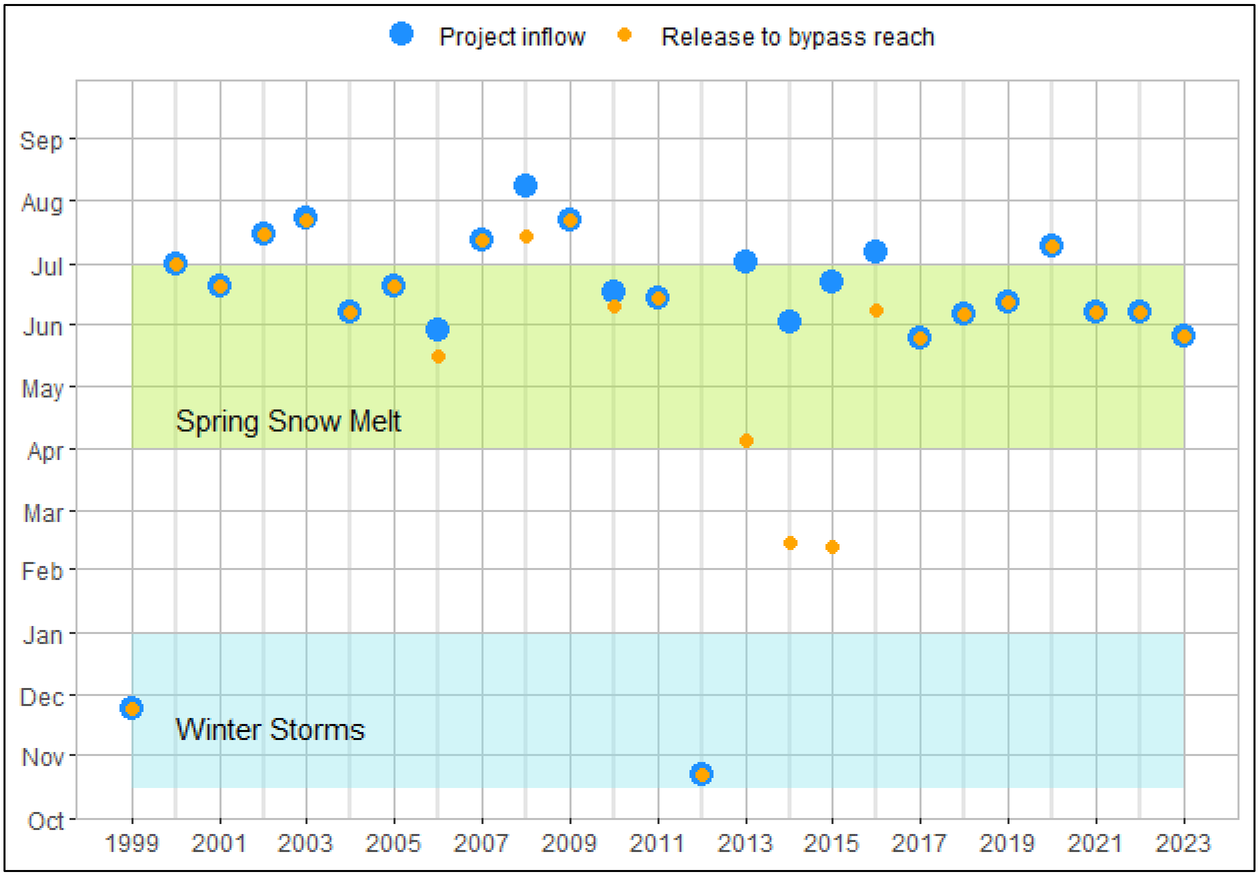


Figure 5-9. Timing of Annual Peak Flow

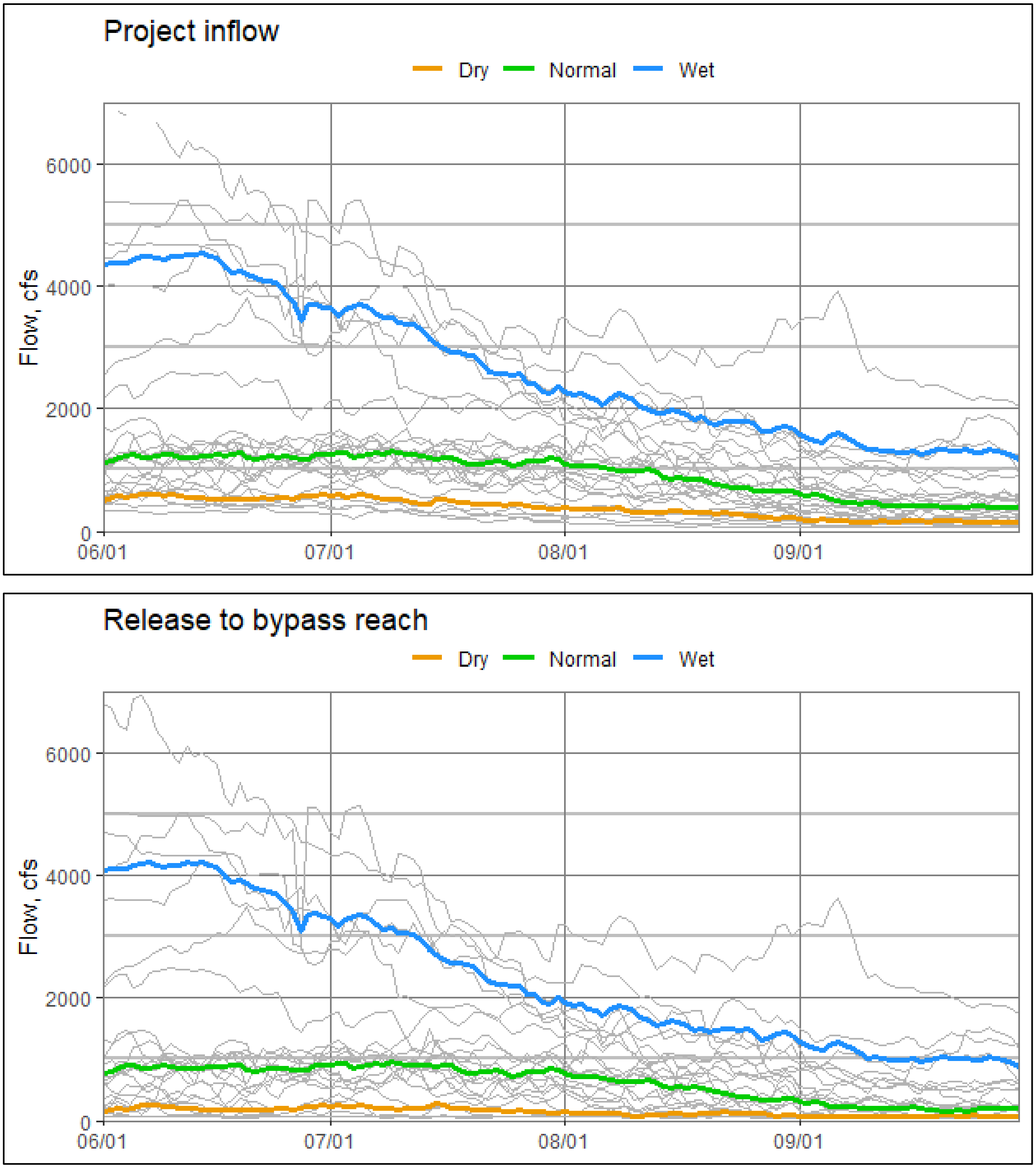
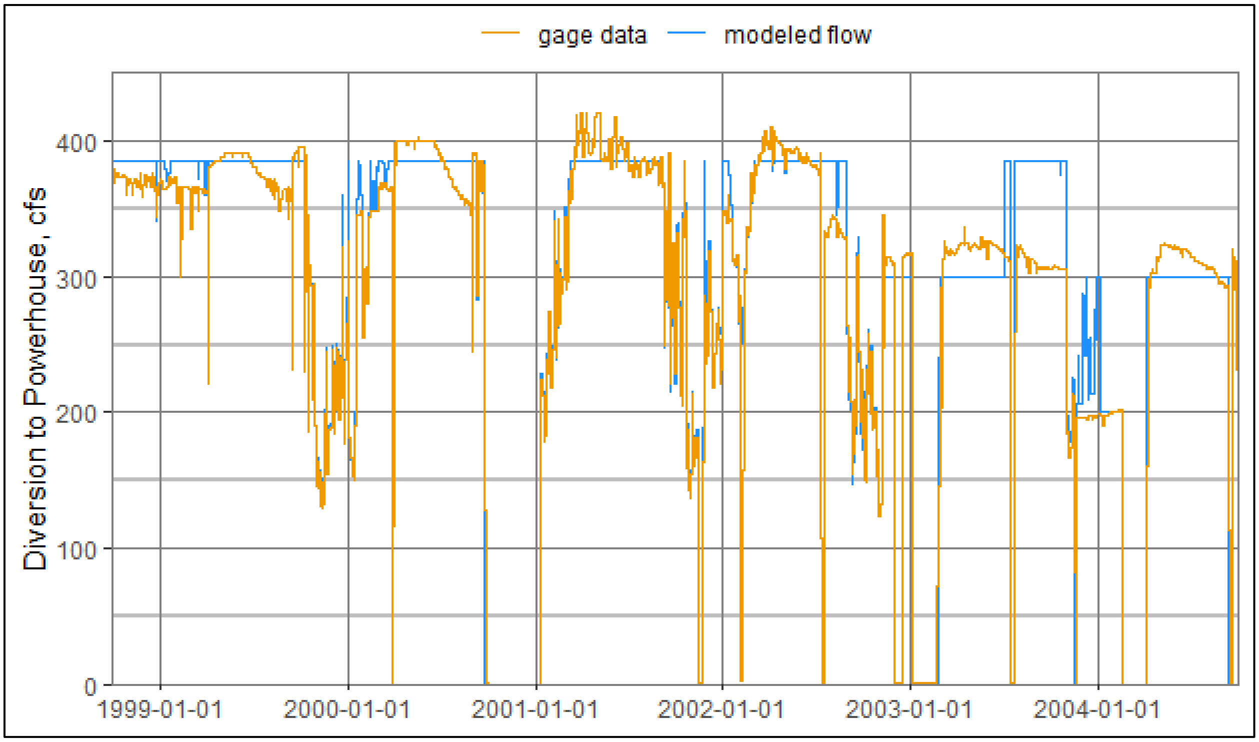


Figure 5-10. Declining Limb Hydrograph for the 1999–2023 Period-of-Record for Project Inflow (top) and Release to Bypass Reach (bottom)



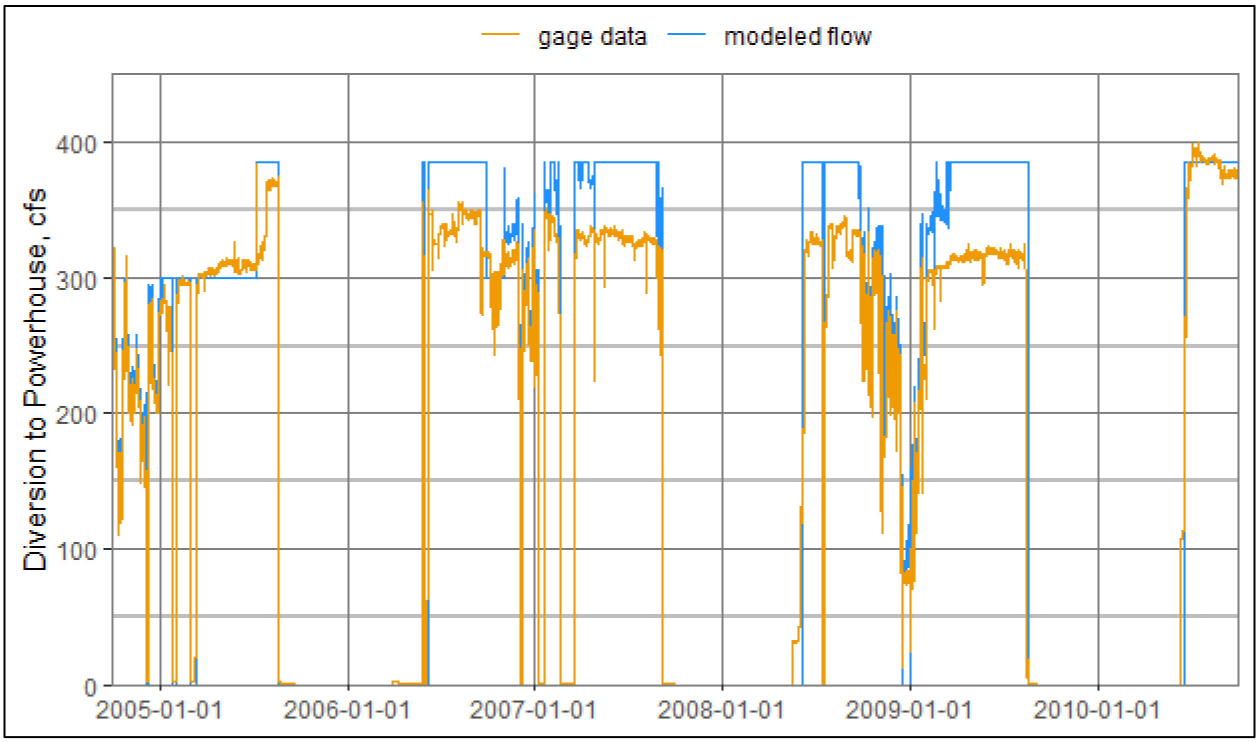


Figure 5-11. Modeled Diversion to KR1 Powerhouse Conduit, Water Years 1999 through 2010

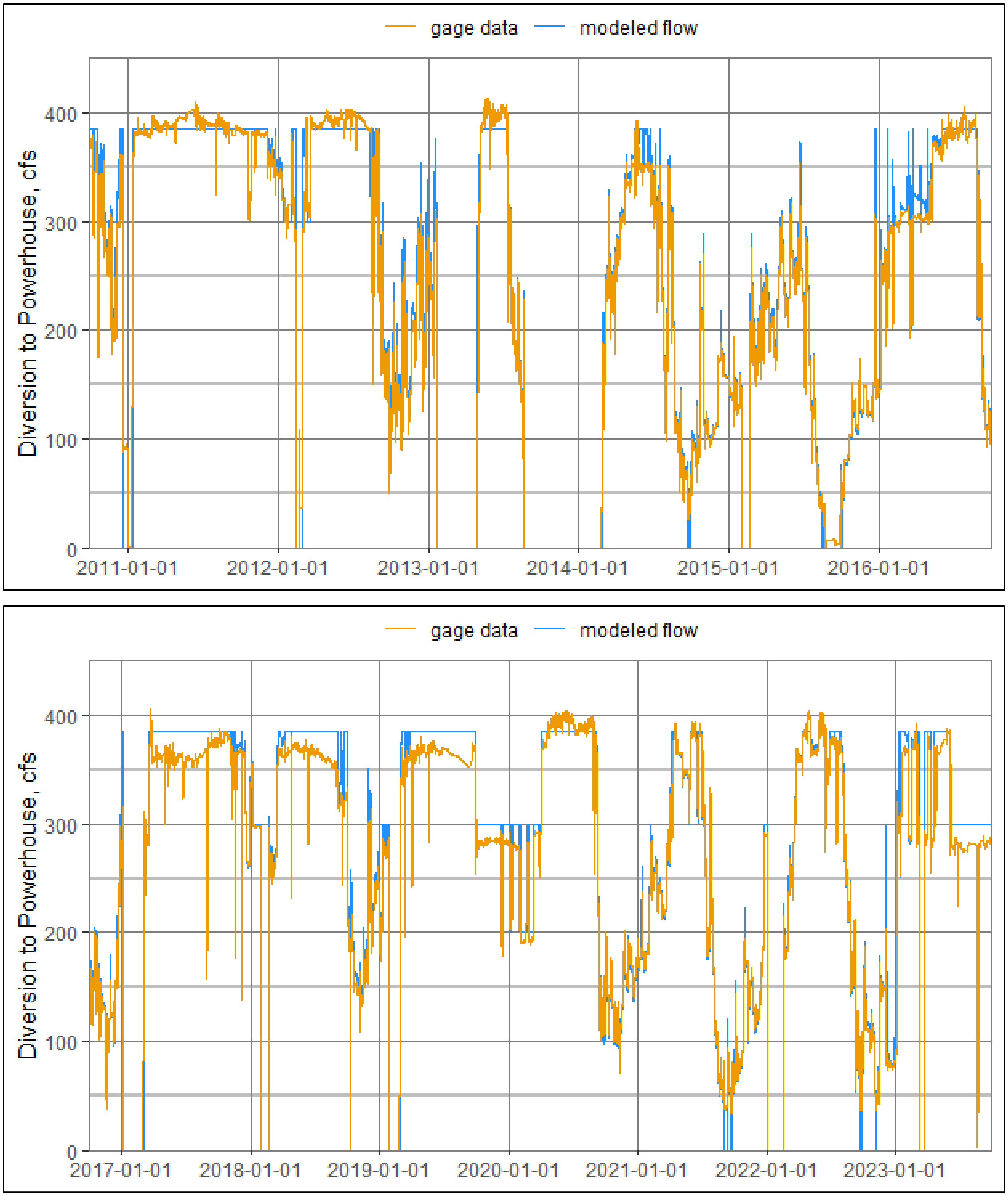


Figure 5-12. Modeled Diversion to KR1 Powerhouse Conduit, Water Years 2011 through 2023

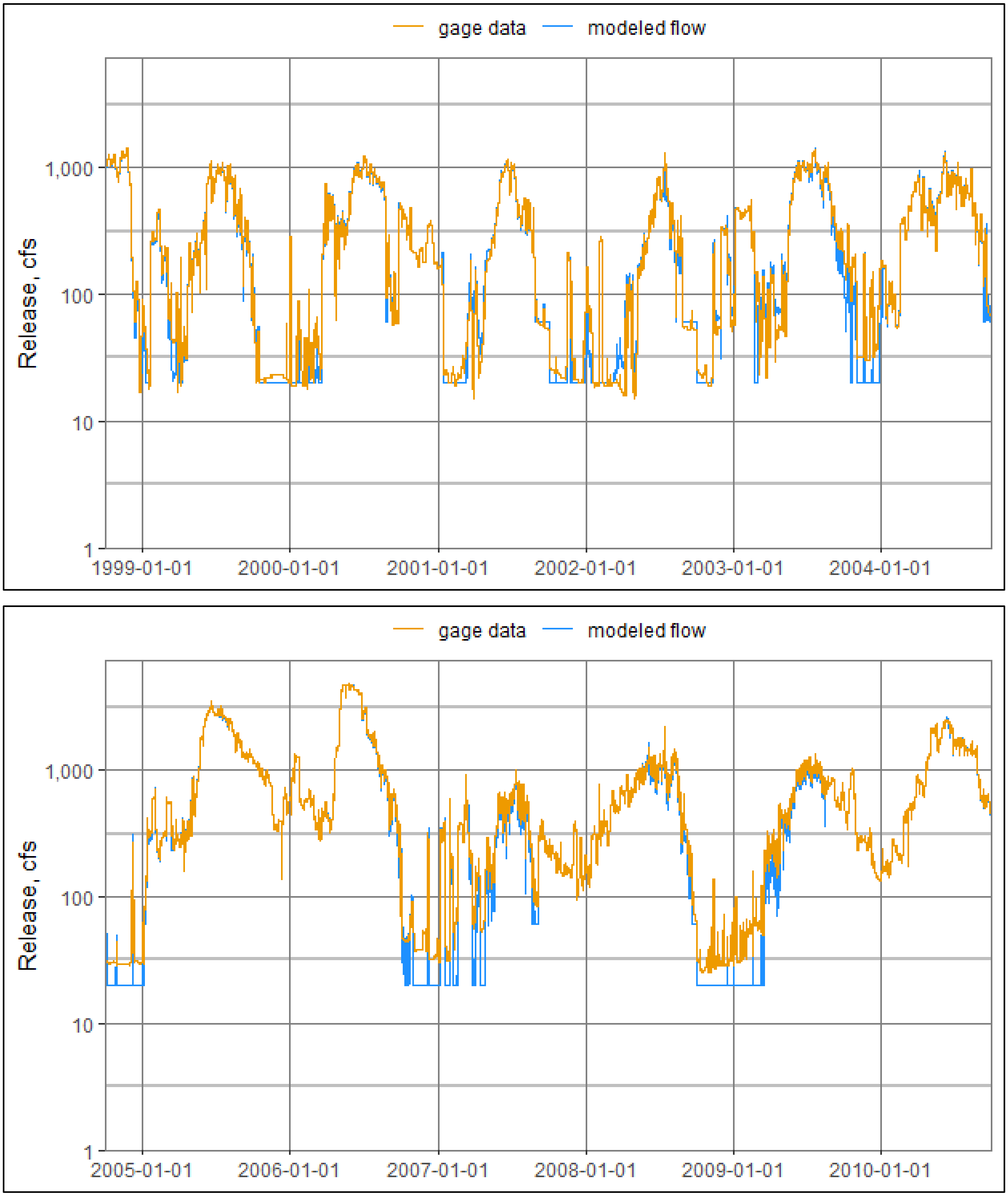


Figure 5-13. Modeled Release to Project Bypass Reach, Water Years 1999 through 2010

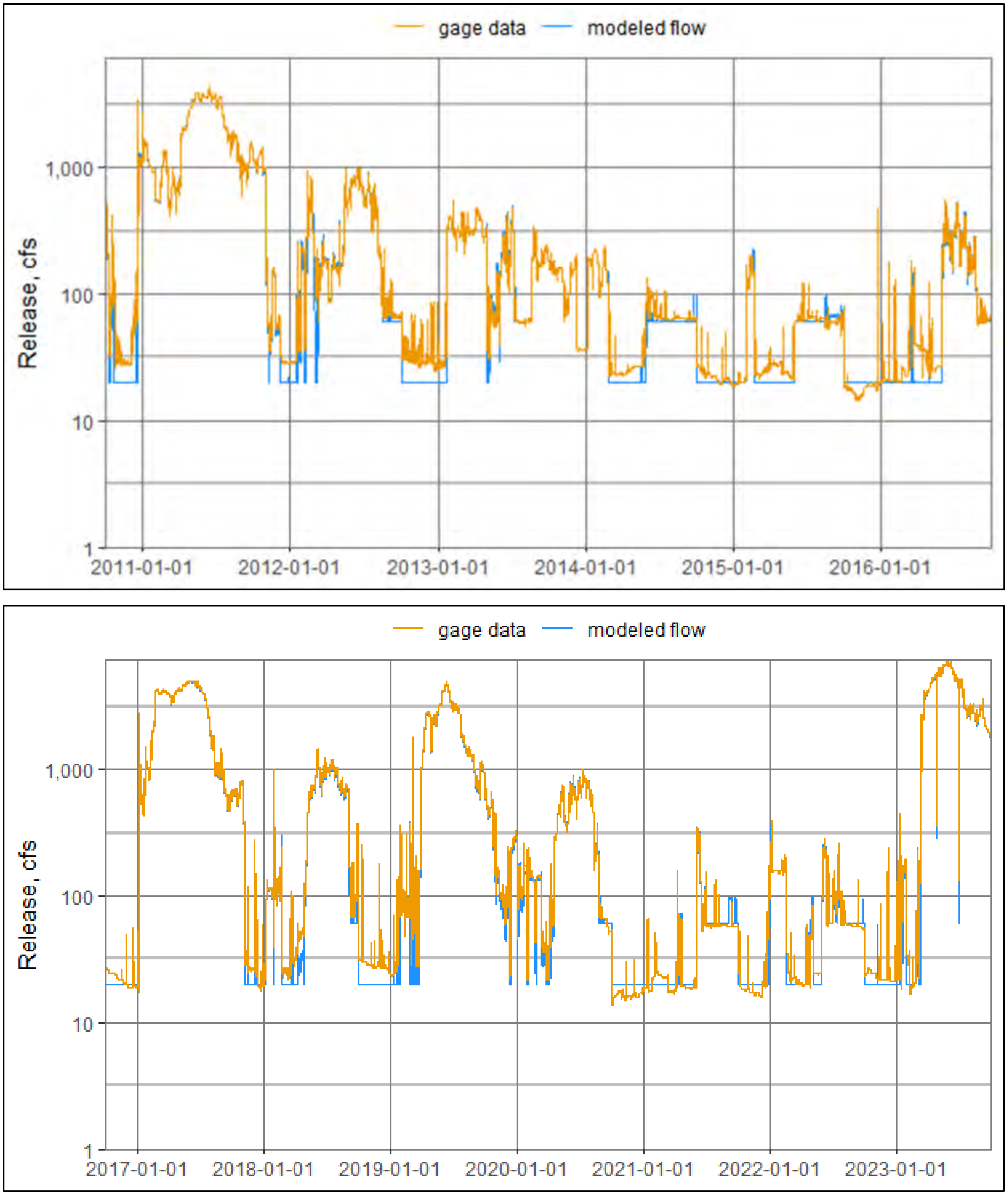


Figure 5-14. Modeled Release to Project Bypass Reach, Water Years 2011 through 2023

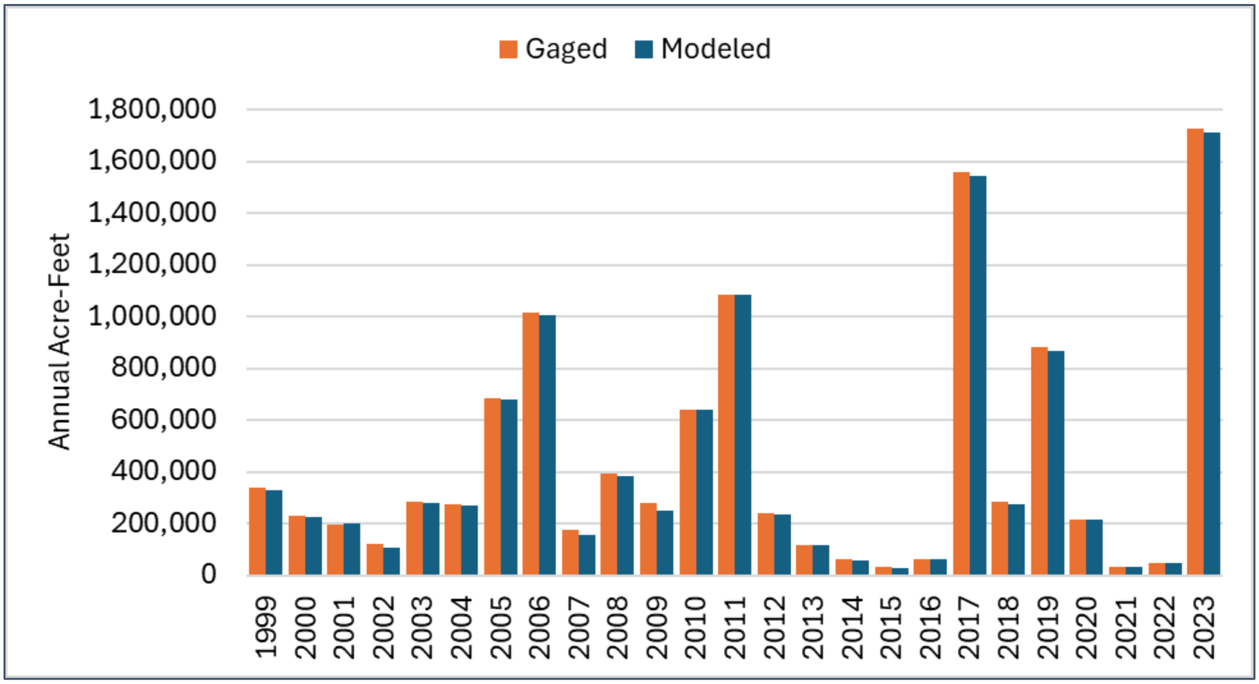


Figure 5-15. Annual Release to Project Bypass Reach, Modeled and Observed

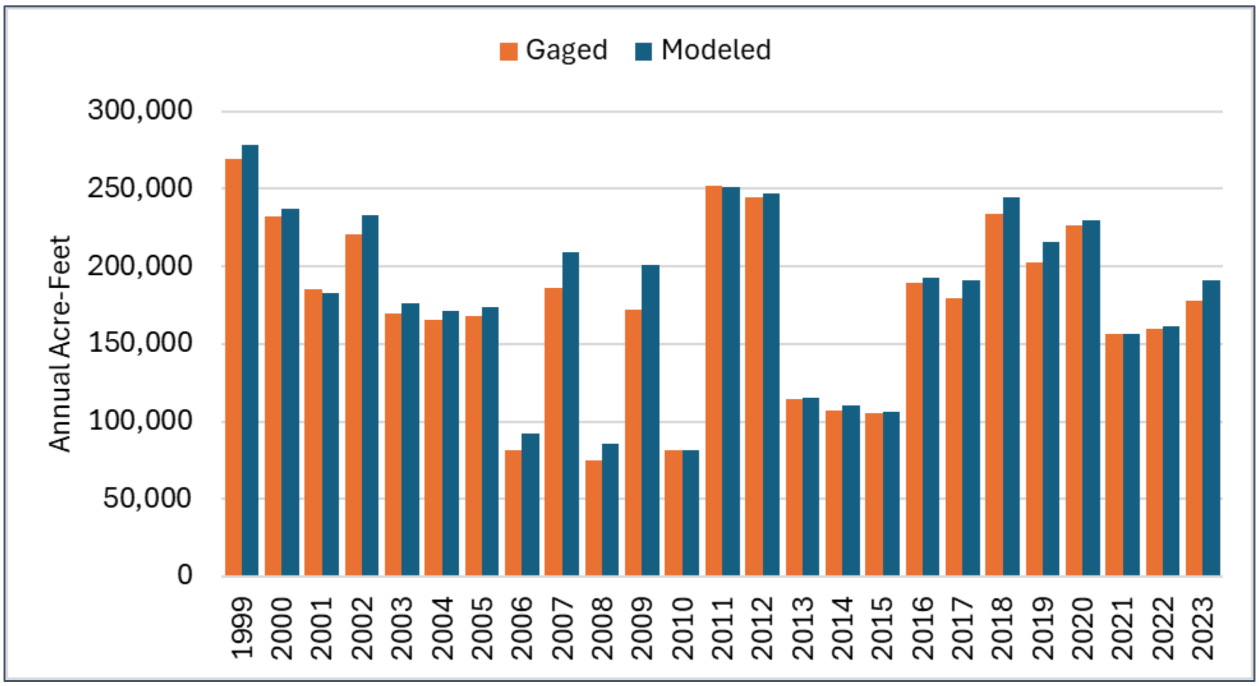
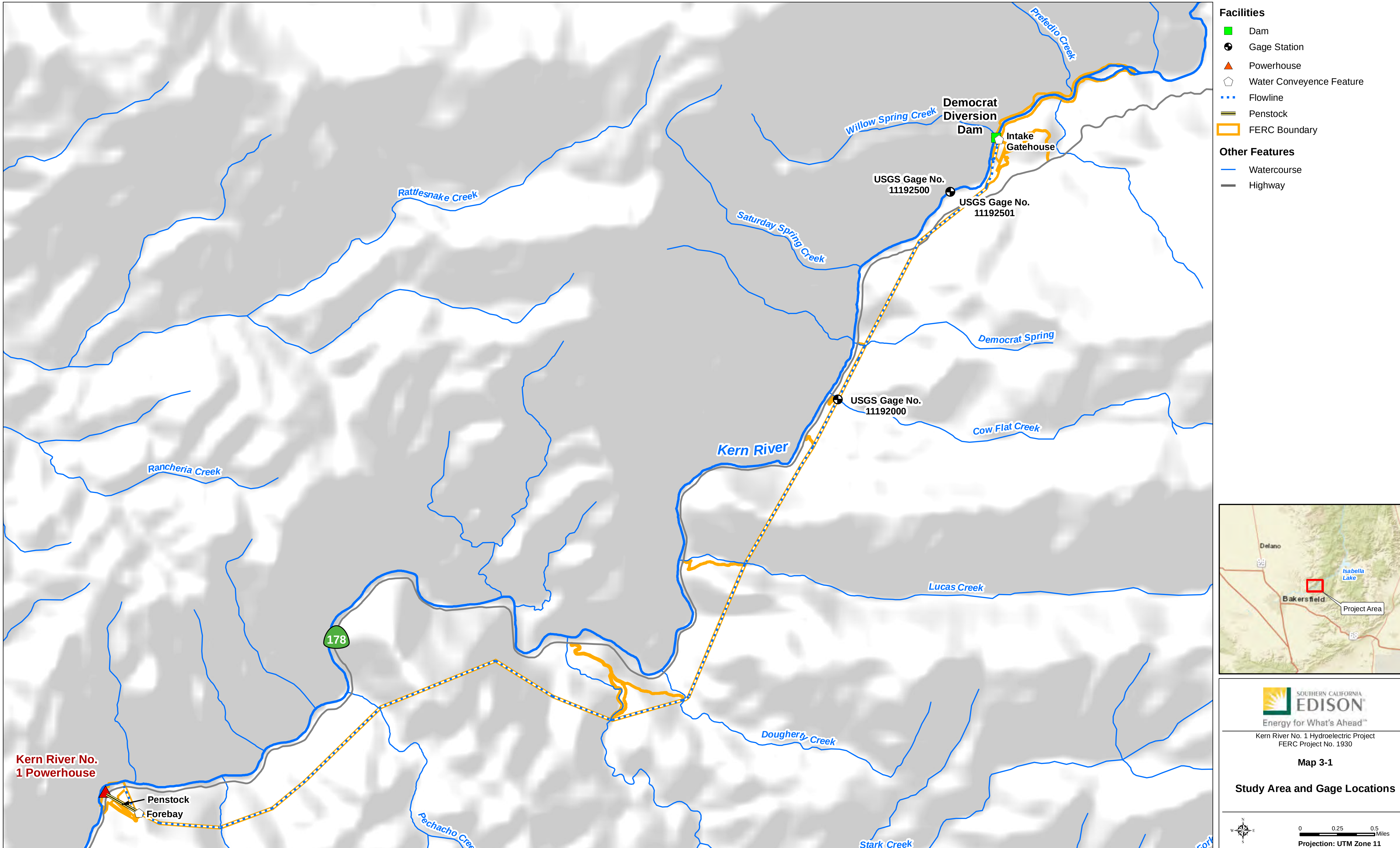


Figure 5-16. Annual Diversion to KR1 Powerhouse Conduit, Modeled and Observed

MAPS



SOUTHERN CALIFORNIA EDISON
Energy for What's Ahead

Kern River No. 1 Hydroelectric Project
FERC Project No. 1930

Map 3-1

Study Area and Gage Locations

Projection: UTM Zone 11
Datum: NAD 83

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