Before the Federal Energy Regulatory Commission

Amended Final Application for New License for Major Water Power Project – Existing Dam

Turners Falls Hydroelectric Project (FERC Project Number 1889)
Northfield Mountain Project (FERC Number 2485)

FirstLight

VOLUME II OF V (PUBLIC), PART 3 OF 4

- **EXHIBIT E- ENVIRONMENTAL REPORT (PART 1 OF 4)**
- **EXHIBIT E- ENVIRONMENTAL REPORT (PART 2 OF 4)**
- **EXHIBIT E- ENVIRONMENTAL REPORT, APPENDICES (PART 3 OF 4) SECTION 1.0 INTRODUCTION TO 3.3.4 TERRESTRIAL RESOURCES**
- **EXHIBIT E- ENVIRONMENTAL REPORT, APPENDICES (PART 4 OF 4) SECTION 3.3.5 RARE, THREATENED, & ENDANGERED SPECIES TO END**

DECEMBER 2020

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Appendix A: Massachusetts Coastal Zone Management Letter dated June 9, 2015

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THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
OFFICE OF COASTAL ZONE MANAGEMENT
251 Causeway Street, Suite 800, Boston, MA 02114-2136
(617) 626-1200 FAX: (617) 626-1240

June 9, 2015

John S. Howard
Director FERC Compliance, Hydro
FirstLight Power Resources, Inc.
99 Millers Falls Road
Northfield, MA 01360

RE: Federal Consistency Certification: Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485).

Dear Mr. Howard:

The Massachusetts Office of Coastal Zone Management (CZM) has completed its review of the information provided in your April 27, 2015 letter regarding relicensing of the Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485) with the Federal Energy Regulatory Commission. These activities are located in the towns of Greenfield, Montague, Gill, Northfield, and Erving MA.

The activities associated with this project fall outside the geographical boundaries of the Massachusetts Coastal Zone as delineated in *Chapter 5: Massachusetts Coastal Regions and An Atlas of Resources, 1 June 1977* and further described in the Massachusetts Coastal Zone Management Plan. Therefore, these activities are not subject to federal consistency review by this office.

Thank you for submitting the information to CZM. If you have any questions regarding our review process, feel free to call me at (617) 626-1050.

Sincerely,

Robert L. Boeri

Robert L. Boeri
Project Review Coordinator

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Appendix A: FirstLight’s Protection, Mitigation & Enhancement Measure Schedule

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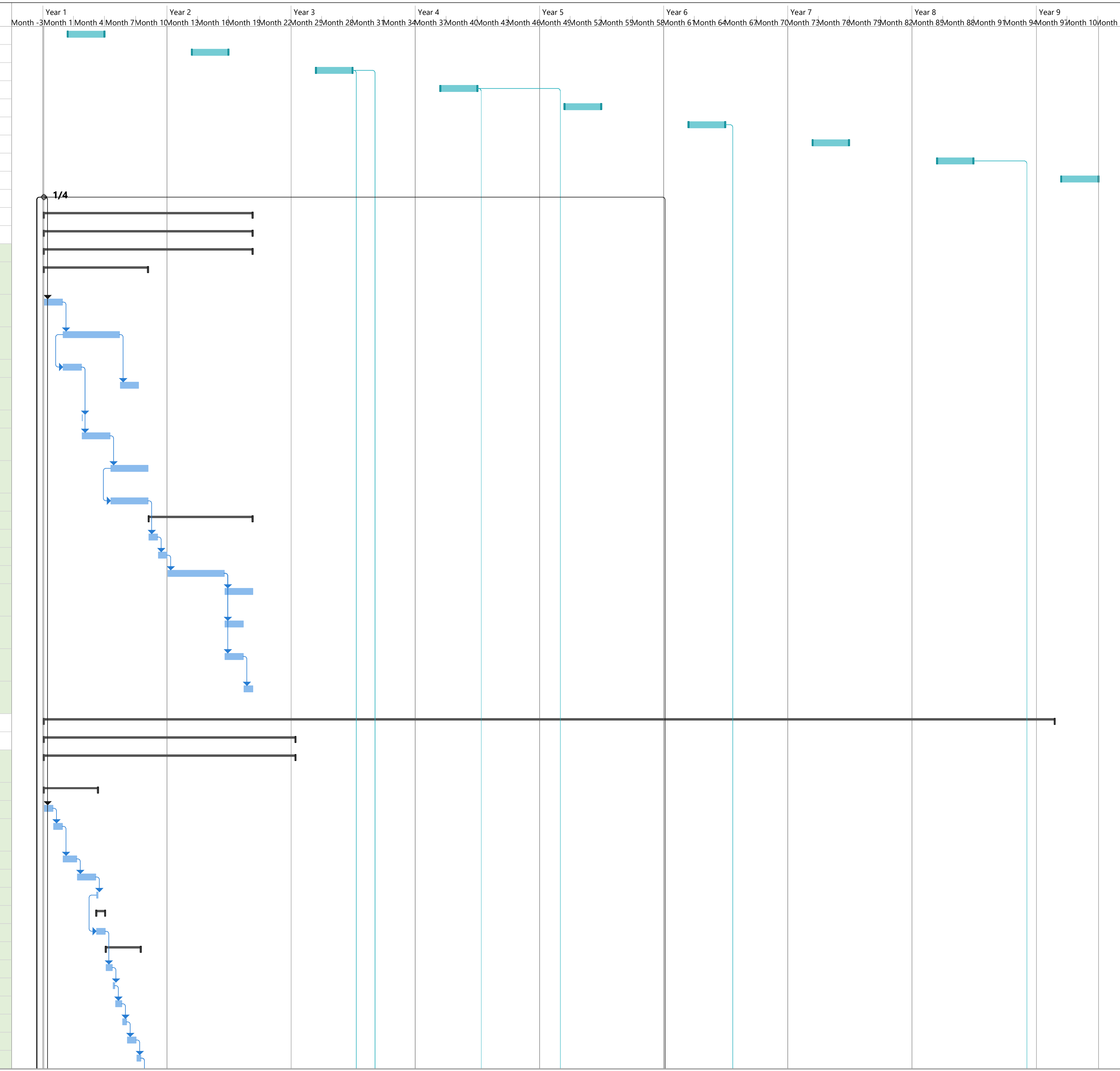
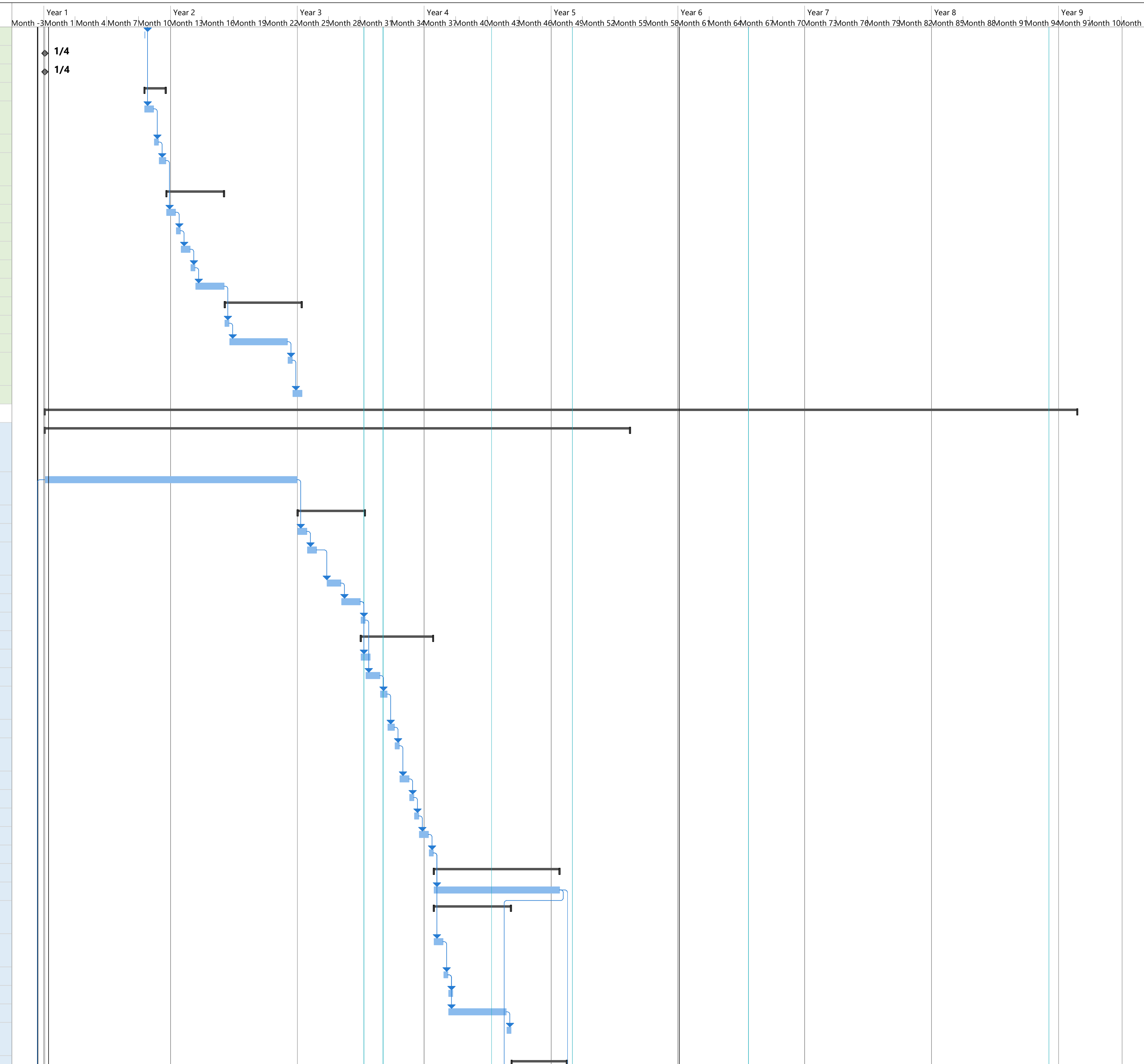
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
1		Fish Passage Season Year 1	78 days		71	178	1
2		Fish Passage Season Year 2	78 days		436	543	2
3		Fish Passage Season Year 3	78 days		801	908	3
4		Fish Passage Season Year 4	77 days		1167	1275	4
5		Fish Passage Season Year 5	77 days		1532	1639	5
6		Fish Passage Season Year 6	78 days		1897	2004	6
7		Fish Passage Season Year 7	77 days		2262	2368	7
8		Fish Passage Season Year 8	77 days		2628	2734	8
9		Fish Passage Season Year 9	78 days		2993	3102	9
10		FERC License Issued (assumed)	0 days		1	0.63	1
11		**Station 1**	**440 days**		**1**	**1**	**1**
12		**Infrastructure Upgrades**	**440 days**		**1**	**1**	**1**
13		**Station 1 Design and Construction**	**440 days**		**0**	**0**	
14		**Field Inspection/Design/Procurement**	**220 days**		**0**	**0**	
15		Condition Assessment, Inspection, Measurement of Equipment	40 days	10	1	54	1
16		Engineering and Design of new overall arrangement	120 days	15	57	222	1
17		Equipment detail drawings/wiring	40 days	16SS	57	110	1
18		Specify equipment, major electrical/mechanical components	40 days	16	225	278	1
19		Notify FERC	1 day	17	113	113	1
20		Develop Electric/Mechanical Equipment Bid Spec	60 days	17	113	194	1
21		Bid/Evaluate/Award/Order long-lead Mech/Elec items	80 days	20	197	306	1
22		Bid/Evaluate/Award Field Work	80 days	21SS	197	306	1
23		**Construction**	**220 days**		**1**	**1**	**1**
24		Lead and Asbestos Abatement	20 days	22	309	334	1
25		Removal of Old Equipment	20 days	24	337	362	1
26		Dis-assembly/Refursbishment/Re-asse	120 days	25	365	530	2
27		Civil works; intake rack/ building/ penstock/ operators	60 days	26	533	614	2
28		Installation of replacement equipment/wiring cabling	40 days	26	533	586	2
29		Refurbishment/reassembly of turbine	40 days	26	533	586	2
30		Start up/ Commissioning/ Punch List	20 days	29	589	614	2
31		**Turners Falls**	**2125 days**		**1**	**1**	**1**
32		**Infrastructure Upgrades**	**530 days**		**1**	**1**	**1**
33		**Heating of Bascule Gates Design and Construction**	**530 days**		**0**	**0**	
34		**Engineering Procurement**	**115 days**		**0**	**0**	
35		Bid Package	20 days	10	1	26	1
36		Bidding (includes Pre-Bid Meeting)	20 days	35	29	54	1
37		Bid Review and Recommendation	30 days	36	57	96	1
38		Contract Finalization	40 days	37	99	152	1
39		Kick-off Meeting	5 days	38	155	159	1
40		**Data Collection**	**20 days**		**0**	**0**	
41		Survey Collection	20 days	39SS	155	180	1
42		**Preliminary Design**	**75 days**		**0**	**0**	
43		Draft Concept Plans	15 days	41	183	201	1
44		Concept Design Review Meeting	5 days	43	204	208	1
45		30% Design Plans	15 days	44	211	229	1
46		30% Design Review Meeting	10 days	45	232	243	1
47		60% Design Plans and OPCC	20 days	46	246	271	1
48		60% Design Review Meeting	10 days	47	274	285	1



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

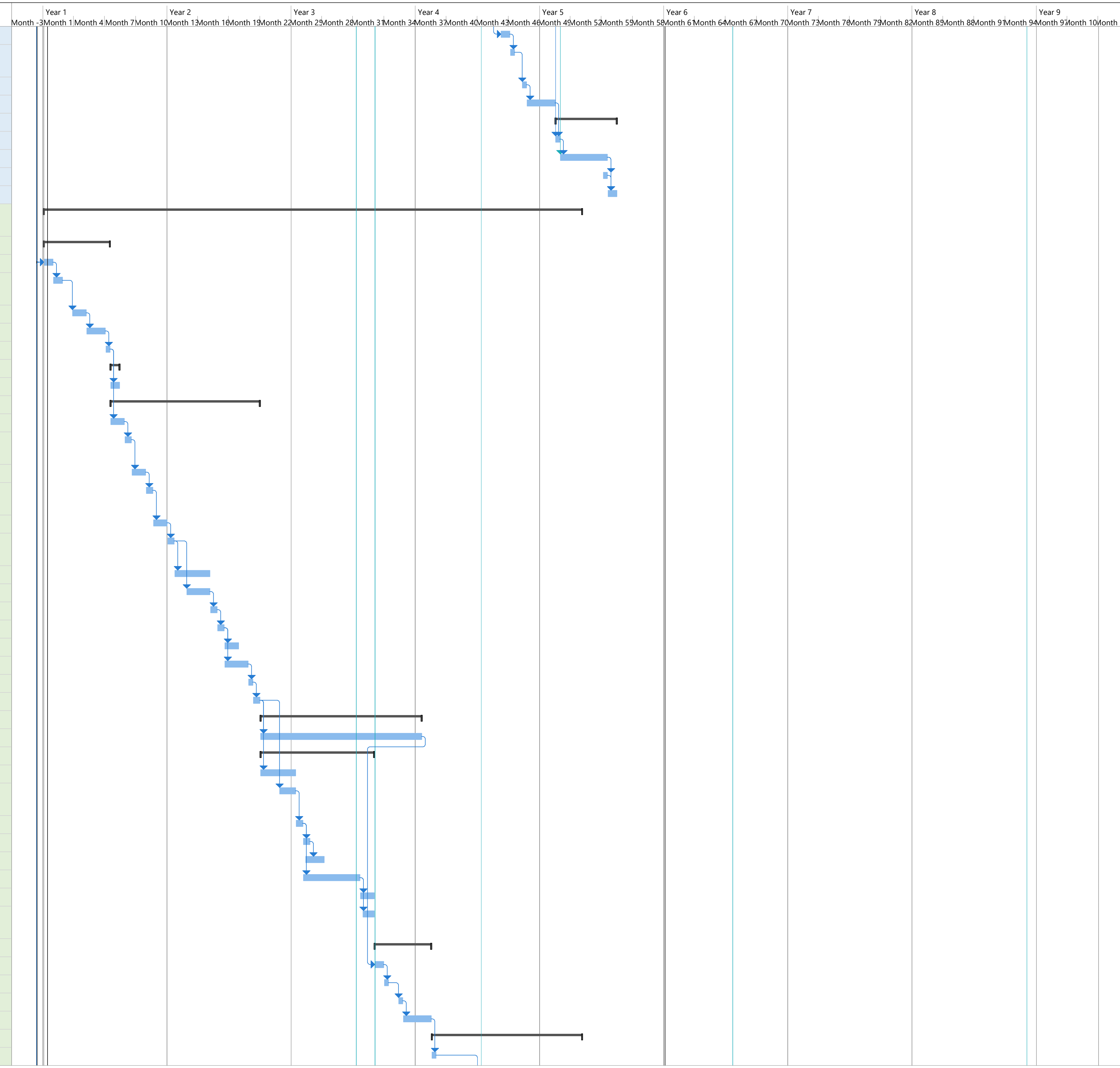
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
49		**Notify FERC**	1 day	48	288	288	1
50		**Permitting**	**0 days**		**0**	**0**	
51		Permitting	0 days		1	0.63	1
52		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
53		90% Design Plans, OPCC, & Technical Specs	20 days	48	288	313	1
54		90% Design Review Meeting	10 days	53	316	327	1
55		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	54	330	348	1
56		**Construction Procurement**	**120 days**		**0**	**0**	
57		Bid Package	20 days	55	351	376	2
58		Pre-Bid Meeting	10 days	57	379	390	2
59		Bidding	20 days	58	393	418	2
60		Bid Review and Recommendation	10 days	59	421	432	2
61		Contract Finalization	60 days	60	435	516	2
62		**Construction**	**160 days**		**0**	**0**	
63		Pre-Construction Meeting	10 days	61	519	530	2
64		Construction	120 days	63	533	698	2
65		Substantial Completion Inspection	10 days	64	701	712	2
66		Record Drawings	20 days	65	715	740	3
67		**Upstream Fish Passage**	**2125 days**		**1**	**1**	**1**
68		**Cabot Tailrace Ultrasound Array Testing, Design, Permitting, and Construction**	**1205 days**		**0**	**0**	
69		Conduct Ultrasound Array Testing in Cabot Tailrace	520 days		1	726	2
70		**Engineering Procurement**	**140 days**		**0**	**0**	
71		Bid Package	20 days	69	729	754	3
72		Bidding (including Pre-Bid Meeting)	20 days	71	757	782	3
73		Bid Review and Recommendation	30 days	72FS+20 days	813	852	3
74		Contract Finalization	40 days	73	855	908	3
75		Kickoff Meeting	10 days	74	911	922	3
76		**Preliminary Design**	**150 days**		**0**	**0**	
77		Survey Collection	20 days	74	911	936	3
78		Develop 1st Draft Concept Plan	30 days	75	925	964	3
79		1st Concept Design Review Meeting	15 days	78	967	985	3
80		Develop Final Concept Plans	15 days	79	988	1006	3
81		Final Concept Design Review Meeting	10 days	80	1009	1020	3
82		30% Design Plans	20 days	81	1023	1048	3
83		30% Agency Design Review	10 days	82	1051	1062	3
84		30% Design Review Meeting	10 days	83	1065	1076	3
85		60% Design Plans and OPCC	20 days	84	1079	1104	4
86		60% Design Review Meeting	10 days	85	1107	1118	4
87		**Permitting**	**260 days**		**0**	**0**	
88		Permitting	260 days	86	1121	1482	5
89		**Final Design, OPCC, Tech Specs for Associated Civil Structures**	**160 days**		**0**	**0**	
90		90% Design Plans, OPCC, & Technical Specs	20 days	86	1121	1146	4
91		90% Agency Design Review	10 days	90	1149	1160	4
92		90% Design Review Meeting	10 days	91	1163	1174	4
93		FERC Plans and Document Review	120 days	91	1163	1328	4
94		Final Design Plans, OPCC, Technical Specs, & Memo	10 days	93	1331	1342	4
95		**Construction Procurement**	**115 days**		**0**	**0**	



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

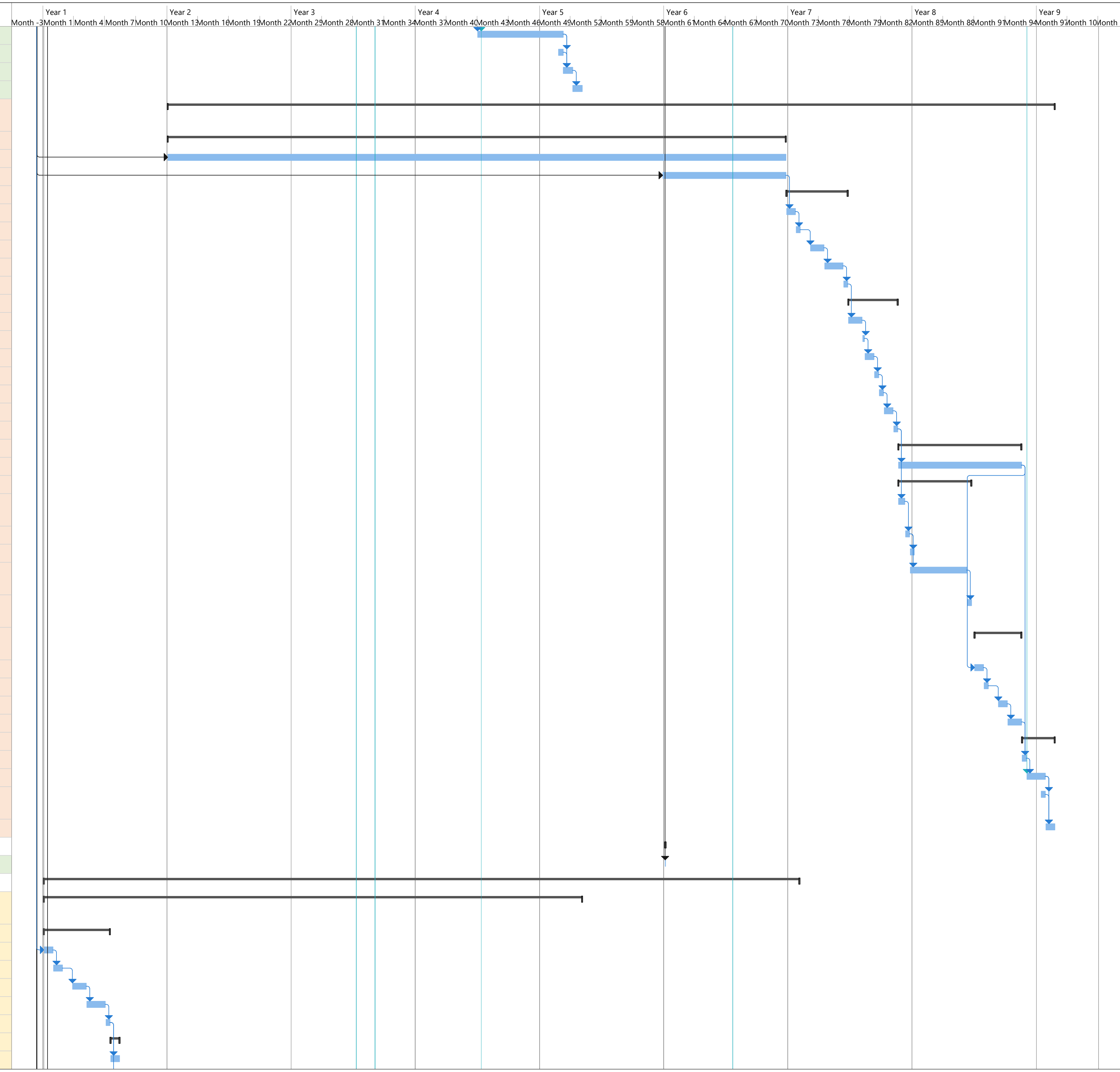
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
96		Bid Package	20 days	88FS-100 days	1345	1370	4
97		Bidding (including Pre-Bid Meeting)	10 days	96	1373	1384	4
98		Bid Review and Recommendation	10 days	97FS+15 days	1408	1419	4
99		Contract Finalization	60 days	98	1422	1503	5
100		**Construction**	**130 days**		**0**	**0**	
101		Pre-Construction Meeting	10 days	88,99	1506	1517	5
102		Construction	100 days	101,4	1520	1657	5
103		Substantial Completion Inspection	10 days	102FS-10 days	1646	1657	5
104		Record Drawings	20 days	102,103	1660	1685	5
105		**Turners Falls Fish Lift Design, Permitting, and Construction**	**1131 days**		**0**	**0**	
106		**Engineering Procurement**	**140 days**		**0**	**0**	
107		Bid Package	20 days	69SS	1	26	1
108		Bidding (includes Pre-Bid Meeting)	20 days	107	29	54	1
109		Bid Review and Recommendation	30 days	108FS+20 days	85	124	1
110		Contract Finalization	40 days	109	127	180	1
111		Kick-off Meeting	10 days	110	183	194	1
112		**Data Collection**	**20 days**		**0**	**0**	
113		Survey Collection	20 days	111	197	222	1
114		**Preliminary Design**	**315 days**		**0**	**0**	
115		Develop 1st Draft Concept Plans	30 days	111	197	236	1
116		1st Concept Design Review Meeting	15 days	115	239	257	1
117		Develop 2nd Draft Concept Plans	30 days	116	260	299	1
118		2nd Concept Design Review Meeting	15 days	117	302	320	1
119		Develop Final Concept Plans	30 days	118	323	362	1
120		Final Concept Design Review Meeting	15 days	119	365	383	2
121		Initial CFD Modeling	75 days	120	386	488	2
122		30% Design Plans	50 days	120FS+25 days	421	488	2
123		30% Agency Design Review	15 days	122	491	509	2
124		30% Design Review Meeting	15 days	123	512	530	2
125		Refine CFD Model (minor)	30 days	124	533	572	2
126		60% Design Plans and OPCC	50 days	124	533	600	2
127		60% Agency Design Review	10 days	126	603	614	2
128		60% Design Review Meeting	15 days	127	617	635	2
129		**Permitting**	**340 days**		**0**	**0**	
130		Permitting	340 days	128	638	1111	4
131		**Final Design, OPCC, Tech Specs**	**240 days**		**0**	**0**	
132		Refine CFD Model (major)	75 days	128	638	740	3
133		90% Design Plans, OPCC, & Technical Specs	35 days	128FS+40 days	694	740	3
134		90% Agency Design Review	15 days	133	743	761	3
135		90% Design Review Meeting	15 days	134	764	782	3
136		Control System Programming	40 days	135FS-10 days	771	824	3
137		FERC Plans and Documents Review	120 days	134	764	929	3
138		Refine CFD Model (minor)	30 days	137	932	971	3
139		Final Design Plans, OPCC, Technical Specs, & Memo	25 days	137FS+5 days	939	971	3
140		**Construction Procurement**	**120 days**		**0**	**0**	
141		Bid Package	20 days	130FS-100 days	974	999	3
142		Pre-Bid Meeting	10 days	141	1002	1013	3
143		Bid Review and Recommendation	10 days	142FS+20 days	1044	1055	3
144		Contract Finalization	60 days	143	1058	1139	4
145		**Construction**	**316 days**		**0**	**0**	
146		Pre-Construction Meeting	10 days	144	1142	1153	4



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

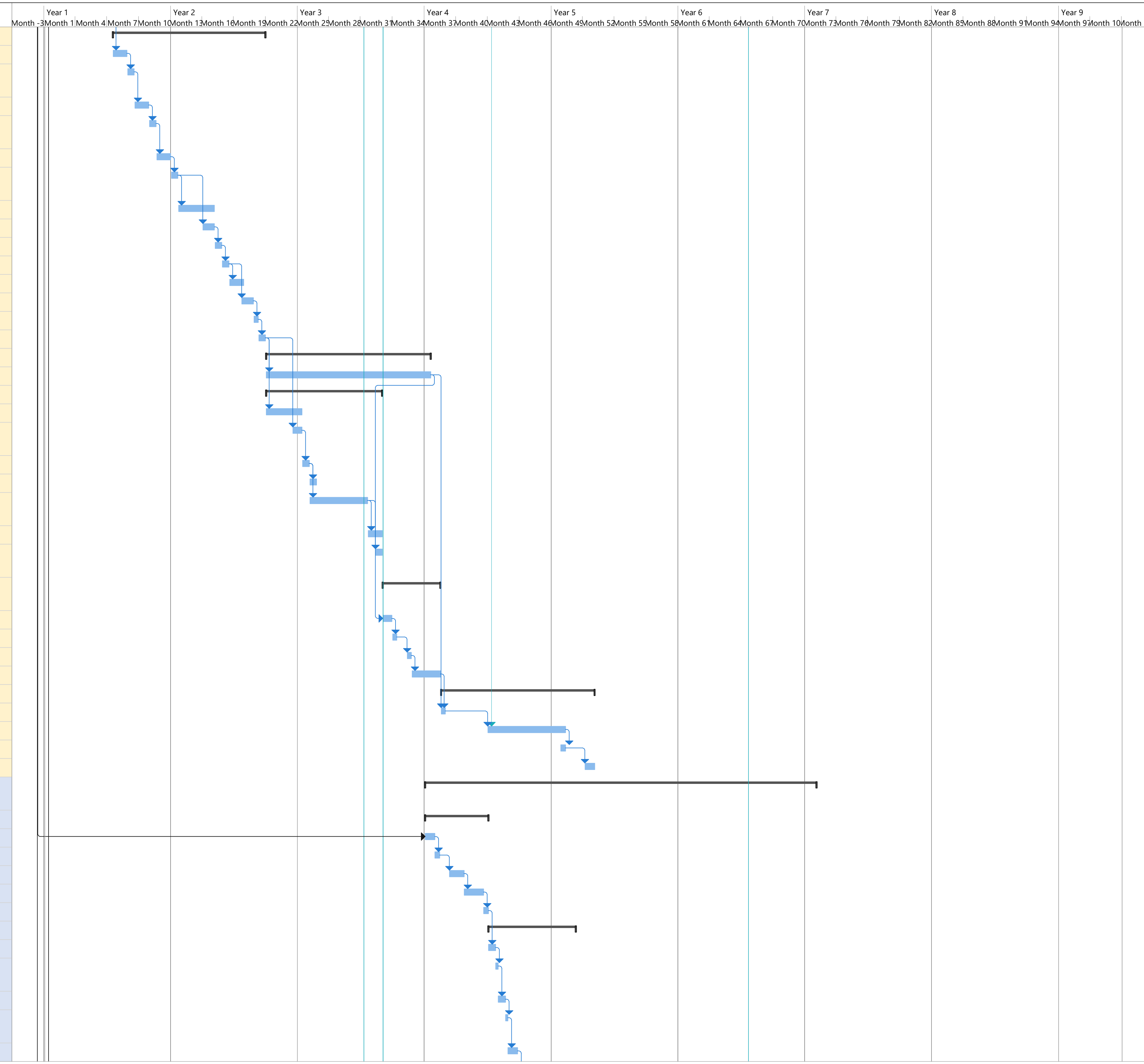
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
147		Construction	180 days	146,4	1276	1527	5
148		Substantial Completion Inspection	10 days	147FS-10 days	1514	1527	5
149		Startup and Commissioning	20 days	147,148	1528	1555	5
150		Record Drawings	20 days	149	1556	1583	5
151		**Turners Falls Eel Ramp Design, Permitting, and Construction**	**1865 days**		**0**	**0**	
152		**Interim Measures and Testing**	**1300 days**		**1**	**1**	**1**
153		Interim Eelway	1300 days	10SS+260 days	365	2182	6
154		Siting Temporary Passage	260 days	10SS+1300 days	1821	2182	6
155		**Engineering Procurement**	**130 days**		**0**	**0**	
156		Bid Package	20 days	154	2185	2210	7
157		Pre-Bid Meeting	10 days	156	2213	2224	7
158		Bid Review and Recommendation	30 days	157FS+20 days	2255	2294	7
159		Contract Finalization	40 days	158	2297	2350	7
160		Kickoff Meeting	10 days	159	2353	2364	7
161		**Preliminary Design**	**105 days**		**0**	**0**	
162		Conceptual Design	30 days	160	2367	2406	7
163		Concept Design Review Meeting	5 days	162	2409	2413	7
164		30% Design Plans	20 days	163	2416	2441	7
165		30% Agency Design Review	10 days	164	2444	2455	7
166		30% Design Review Meeting	10 days	165	2458	2469	7
167		60% Design Plans and OPCC	20 days	166	2472	2497	7
168		60% Design Review Meetings	10 days	167	2500	2511	7
169		**Permitting**	**260 days**		**0**	**0**	
170		Permitting	260 days	168	2514	2875	8
171		**Final Design, OPCC, Tech Specs**	**155 days**		**0**	**0**	
172		90% Design Plans, OPCC, & Technical Specs	15 days	168	2514	2532	7
173		90% Agency Design Review	10 days	172	2535	2546	7
174		90% Design Review Meeting	10 days	173	2549	2560	8
175		FERC Review (may or may not be needed)	120 days	173	2549	2714	8
176		Final Design Plans, OPCC, Technical Specs, & Memo	10 days	175	2717	2728	8
177		**Construction Procurement (assumes 3rd party contractor)**	**100 days**		**0**	**0**	
178		Bid Package	20 days	170FS-100 days	2738	2763	8
179		Pre-Bid Meeting	10 days	178	2766	2777	8
180		Bid Review and Recommendation	20 days	179FS+20 days	2808	2833	8
181		Contract Finalization	30 days	180	2836	2875	8
182		**Construction**	**70 days**		**0**	**0**	
183		Pre-Construction Meeting	10 days	170,181	2878	2889	8
184		Construction	40 days	183,8	2892	2945	9
185		Substantial Completetion Inspection	10 days	184FS-10 days	2934	2945	9
186		Record Drawings	20 days	184,185	2948	2973	9
187		**Retire Cabot Fish Ladder**	**1 day**		**0**	**0**	
188		**Retire Cabot Fish Ladder**	1 day	10FS+1305 days	1828	1828	6
189		**Downstream Fish Passage**	**1588 days**		**1**	**1**	**1**
190		**Turners Falls Plunge Pool Design, Permitting, and Construction**	**1131 days**		**0**	**0**	
191		**Engineering Procurement**	**140 days**		**0**	**0**	
192		Bid Package	20 days	107SS	1	26	1
193		Pre-Bid Meeting	20 days	192	29	54	1
194		Bid Review and Recommendation	30 days	193FS+20 days	85	124	1
195		Contract Finalization	40 days	194	127	180	1
196		Kickoff Meeting	10 days	195	183	194	1
197		**Data Collection**	**20 days**		**0**	**0**	
198		Survey Collection	20 days	196	197	222	1



Project: Combined Schedule
Date: Fri 7/24/20

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
199		**Preliminary Design**	**315 days**		**0**	**0**	
200		Develop 1st Draft Concept Plans	30 days	196	197	236	1
201		1st Concept Design Review Meeting	15 days	200	239	257	1
202		Develop 2nd Draft Concept Plans	30 days	201	260	299	1
203		2nd Concept Design Review Meeting	15 days	202	302	320	1
204		Develop Final Concept Plans	30 days	203	323	362	1
205		Final Concept Design Review Meeting	15 days	204	365	383	2
206		Initial CFD Modeling	75 days	205	386	488	2
207		30% Design Plans	25 days	205FS+50 days	456	488	2
208		30% Agency Design Review	15 days	207	491	509	2
209		30% Design Review Meeting	15 days	208	512	530	2
210		Refine CFD Modeling (minor)	30 days	209	533	572	2
211		60% Design Plans and OPCC	25 days	209FS+25 days	568	600	2
212		60% Agency Design Review	10 days	211	603	614	2
213		60% Design Review Meetings	15 days	212	617	635	2
214		**Permitting**	**340 days**		**0**	**0**	
215		Permitting	340 days	213	638	1111	4
216		**Final Design, OPCC, Tech Specs**	**240 days**		**0**	**0**	
217		Refine CFD Modeling (major)	75 days	213	638	740	3
218		90% Design Plans, OPCC, & Technical Specs	20 days	213FS+55 days	715	740	3
219		90% Agency Design Review	15 days	218	743	761	3
220		90% Design Review Meeting	15 days	219	764	782	3
221		FERC Review (may or may not be needed)	120 days	219	764	929	3
222		Refine CFS Modeling (minor)	30 days	221	932	971	3
223		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	221FS+15 days	953	971	3
224		**Construction Procurement (assumes 3rd party contractor)**	**120 days**		**0**	**0**	
225		Bid Package	20 days	215FS-100 days	974	999	3
226		Pre-Bid Meeting	10 days	225	1002	1013	3
227		Bid Review and Recommendation	10 days	226FS+20 days	1044	1055	3
228		Contract Finalization	60 days	227	1058	1139	4
229		**Construction**	**316 days**		**0**	**0**	
230		Pre-Construction Meeting	10 days	228,215	1142	1153	4
231		Construction	160 days	230,4	1276	1499	5
232		Substantial Completion Inspection	10 days	231FS-10 days	1486	1499	5
233		Record Drawings	20 days	232FS+40 days	1556	1583	5
234		**Station No, 1 Dog Leg Exclusion Design, Permitting, and Construction**	**805 days**		**0**	**0**	
235		**Engineering Procurement**	**130 days**		**0**	**0**	
236		Bid Package	20 days	10SS+783 days	1096	1123	4
237		Pre-Bid Meeting	10 days	236	1124	1137	4
238		Bid Review and Recommentdation	30 days	237FS+20 days	1166	1207	4
239		Contract Finalization	40 days	238	1208	1263	4
240		Kickoff Meeting	10 days	239	1264	1277	4
241		**Preliminary Design**	**180 days**		**0**	**0**	
242		Develop 1st Draft Concept Plans	15 days	240	1278	1298	4
243		1st Concept Design Review Meeting	5 days	242	1299	1305	4
244		Develop 2nd Draft Concept Plans	15 days	243	1306	1326	4
245		2nd Concept Design Review Meeting	5 days	244	1327	1333	4
246		Develop Final Concept Plans	20 days	245	1334	1361	4



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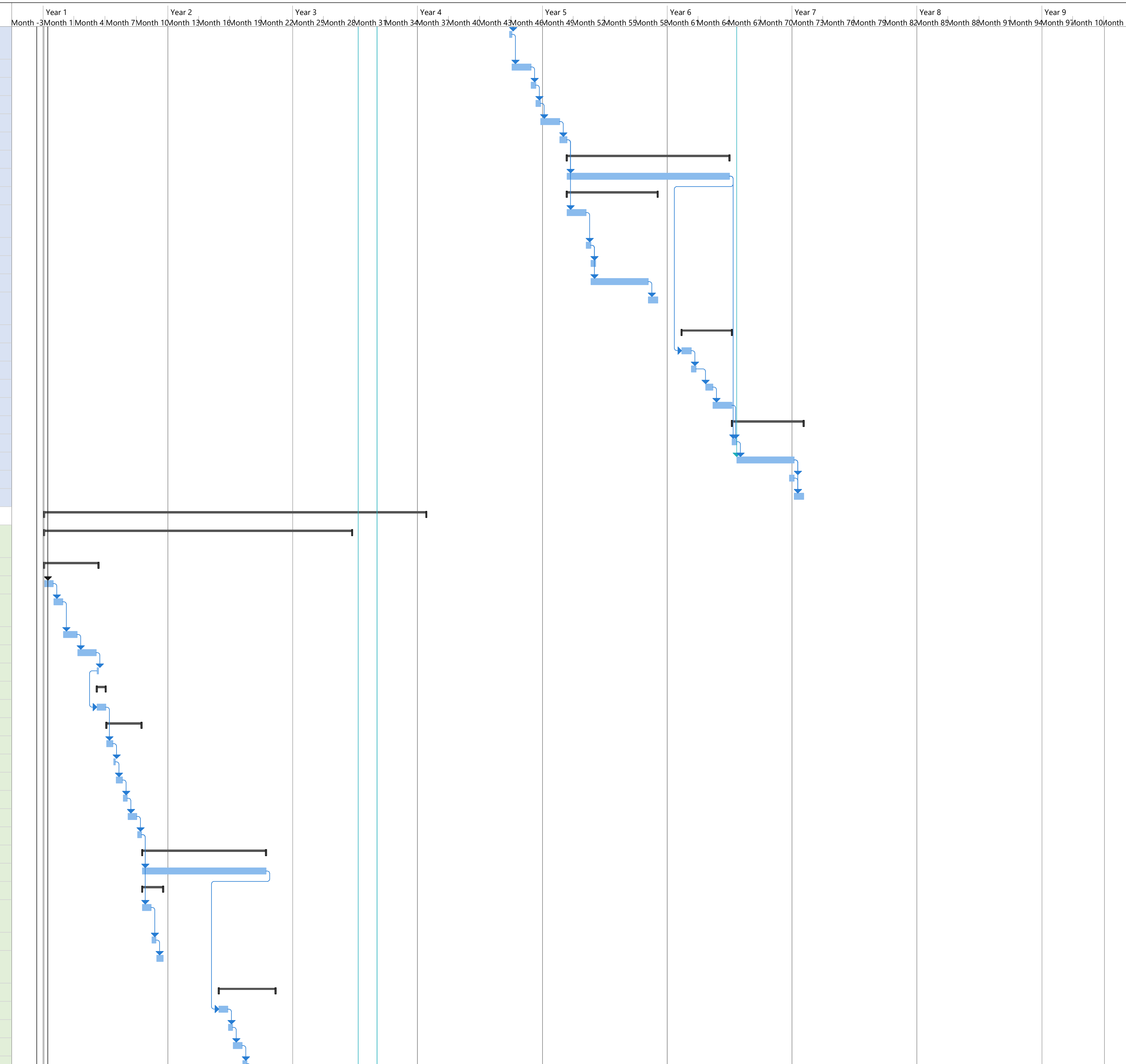
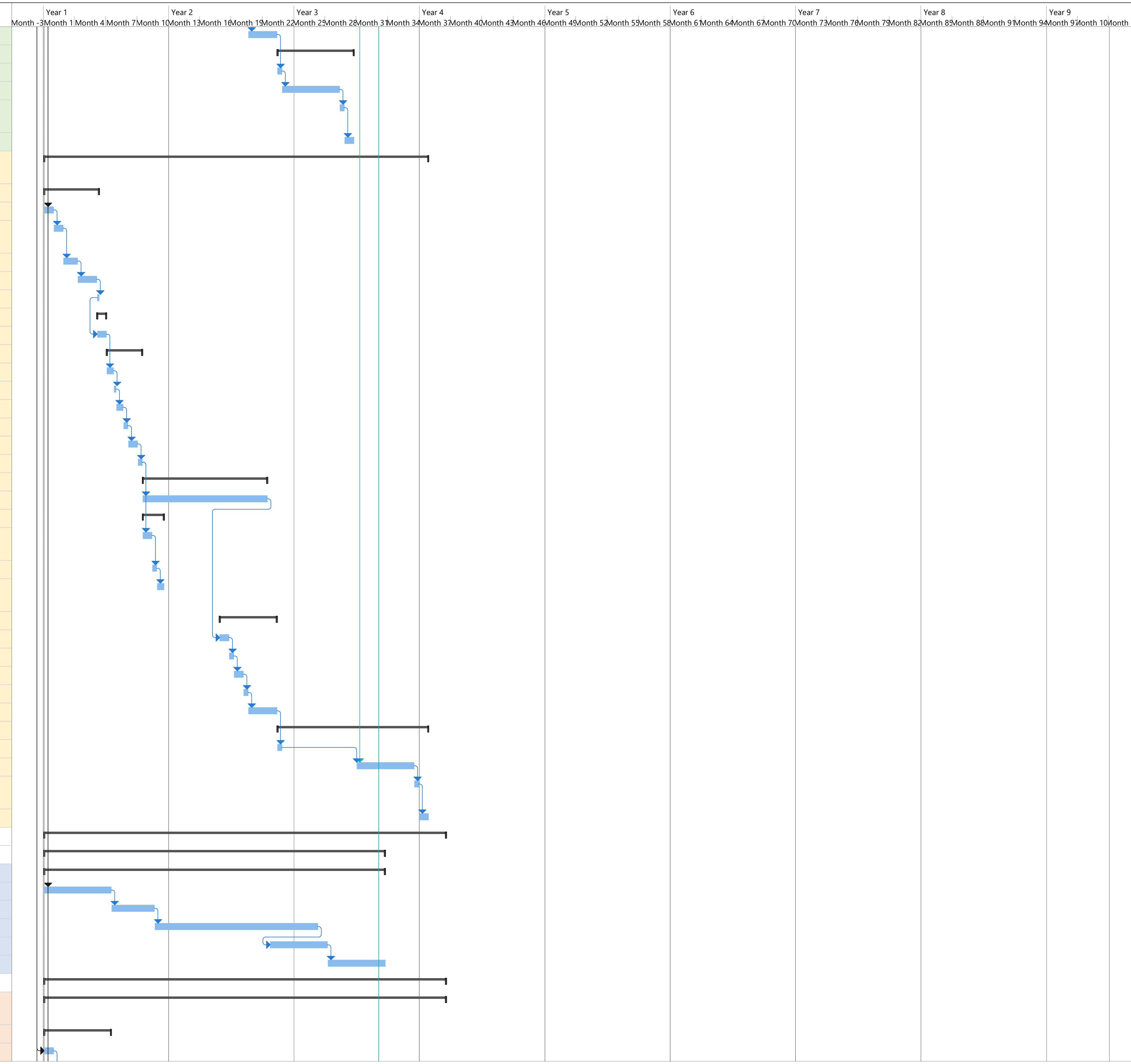
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
247		Final Concept Design Review Meeting	5 days	246	1362	1368	4
248		30% Design Plans	40 days	247	1369	1424	4
249		30% Agency Design Review	10 days	248	1425	1438	4
250		30% Design Review Meeting	10 days	249	1439	1452	4
251		60% Design Plans and OPCC	40 days	250	1453	1508	5
252		60% Design Review Meeting	15 days	251	1509	1529	5
253		**Permitting**	**340 days**		**0**	**0**	
254		Permitting	340 days	252	1530	2005	6
255		**Final Design, OPCC, Tech Specs**	**190 days**		**0**	**0**	
256		90% Design Plans, OPCC, & Technical Specs	40 days	252	1530	1585	5
257		90% Agency Design Review	10 days	256	1586	1599	5
258		90% Design Review Meeting	10 days	257	1600	1613	5
259		FERC Design Review	120 days	257	1600	1767	5
260		Final Design Plans, OPCC, Technical Specs, & Memo	20 days	259	1768	1795	5
261		**Construction Procurement**	**105 days**		**0**	**0**	
262		Bid Package	20 days	254FS-100 days	1866	1893	6
263		Pre-Bid Meeting	10 days	262	1894	1907	6
264		Bid Review and Recommendtation	15 days	263FS+20 days	1936	1956	6
265		Contract Finalization	40 days	264	1957	2012	6
266		**Construction**	**150 days**		**0**	**0**	
267		Pre-Construction Meeting	10 days	254,265	2013	2026	6
268		Construction	120 days	267,6	2027	2194	7
269		Substantial Completion Inspection	10 days	268FS-10 days	2181	2194	7
270		Record Drawings	20 days	268,269	2195	2222	7
271		**Recreation**	**800 days**		**1**	**1**	**1**
272		**Turners Falls - Formal Put-in Trail Design, Permitting, and Construction**	**645 days**		**0**	**0**	
273		**Engineering Procurement**	**115 days**		**0**	**0**	
274		Bid Package	20 days	10	1	26	1
275		Bidding (includes Pre-Bid Meeting)	20 days	274	29	54	1
276		Bid Review and Recommendation	30 days	275	57	96	1
277		Contract Finalization	40 days	276	99	152	1
278		Kick-off Meeting	5 days	277	155	159	1
279		**Data Collection**	**20 days**		**0**	**0**	
280		Survey Collection	20 days	278SS	155	180	1
281		**Preliminary Design**	**75 days**		**0**	**0**	
282		Draft Concept Plans	15 days	280	183	201	1
283		Concept Design Review Meeting	5 days	282	204	208	1
284		30% Design Plans	15 days	283	211	229	1
285		30% Design Review Meeting	10 days	284	232	243	1
286		60% Design Plans and OPCC	20 days	285	246	271	1
287		60% Design Review Meeting	10 days	286	274	285	1
288		**Permitting**	**260 days**		**0**	**0**	
289		Permitting	260 days	287	288	649	2
290		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
291		90% Design Plans, OPCC, & Technical Specs	20 days	287	288	313	1
292		90% Design Review Meeting	10 days	291	316	327	1
293		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	292	330	348	1
294		**Construction Procurement**	**120 days**		**0**	**0**	
295		Bid Package	20 days	289FS-100 days	512	537	2
296		Pre-Bid Meeting	10 days	295	540	551	2
297		Bidding	20 days	296	554	579	2
298		Bid Review and Recommendation	10 days	297	582	593	2



Project: Combined Schedule
Date: Fri 7/24/20

Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Manual Progress	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline			
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress			

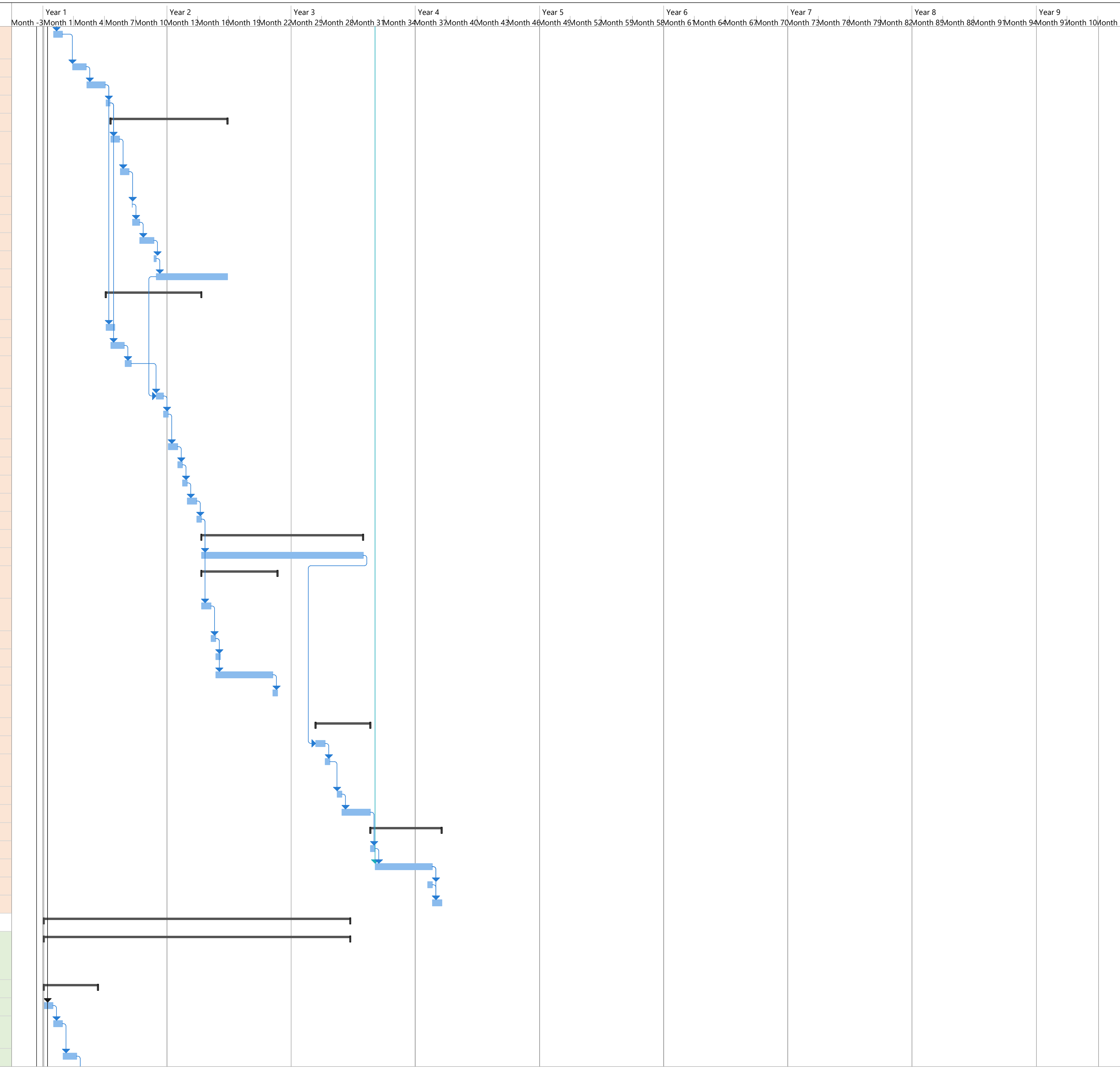
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
299		Contract Finalization	60 days	298	596	677	2
300		**Construction**	**160 days**		**0**	**0**	
301		Pre-Construction Meeting	10 days	299	680	691	2
302		Construction	120 days	301	694	859	3
303		Substantial Completion Inspection	10 days	302	862	873	3
304		Record Drawings	20 days	303	876	901	3
305		**Poplar Street Access Design, Permitting, and Construction**	**800 days**		**0**	**0**	
306		**Engineering Procurement**	**115 days**		**0**	**0**	
307		Bid Package	20 days	10	1	26	1
308		Bidding (includes Pre-Bid Meeting)	20 days	307	29	54	1
309		Bid Review and Recommendation	30 days	308	57	96	1
310		Contract Finalization	40 days	309	99	152	1
311		Kick-off Meeting	5 days	310	155	159	1
312		**Data Collection**	**20 days**		**0**	**0**	
313		Survey Collection	20 days	311SS	155	180	1
314		**Preliminary Design**	**75 days**		**0**	**0**	
315		Draft Concept Plans	15 days	313	183	201	1
316		Concept Design Review Meeting	5 days	315	204	208	1
317		30% Design Plans	15 days	316	211	229	1
318		30% Design Review Meeting	10 days	317	232	243	1
319		60% Design Plans and OPCC	20 days	318	246	271	1
320		60% Design Review Meeting	10 days	319	274	285	1
321		**Permitting**	**260 days**		**0**	**0**	
322		Permitting	260 days	320	288	649	2
323		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
324		90% Design Plans, OPCC, & Technical Specs	20 days	320	288	313	1
325		90% Design Review Meeting	10 days	324	316	327	1
326		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	325	330	348	1
327		**Construction Procurement**	**120 days**		**0**	**0**	
328		Bid Package	20 days	322FS-100 days	512	537	2
329		Pre-Bid Meeting	10 days	328	540	551	2
330		Bidding	20 days	329	554	579	2
331		Bid Review and Recommendation	10 days	330	582	593	2
332		Contract Finalization	60 days	331	596	677	2
333		**Construction**	**315 days**		**0**	**0**	
334		Pre-Construction Meeting	10 days	332	680	691	2
335		Construction	120 days	334,3	911	1076	3
336		Substantial Completion Inspection	10 days	335	1079	1090	3
337		Record Drawings	20 days	336	1093	1118	4
338		**Northfield Mountain**	**836 days**		**1**	**1**	**1**
339		**Infrastructure Upgrades**	**710 days**		**1**	**1**	**1**
340		**Northfield Mountain Intake Dredging**	**710 days**		**1**	**1**	**1**
341		Engineering Procurement	140 days	10	1	194	1
342		Design	90 days	341	197	320	1
343		Permitting	340 days	342	323	796	3
344		Procurement	120 days	343FS-100 days	659	824	3
345		Construction/Dredging	120 days	344	827	992	3
346		**Upstream/Downstream Fish Passage**	**836 days**		**1**	**1**	**1**
347		**NFM Barrier Net Design, Permitting, and Construction**	**836 days**		**0**	**0**	
348		**Engineering Procurement**	**140 days**		**0**	**0**	
349		Bid Package	20 days	10SS	1	26	1



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

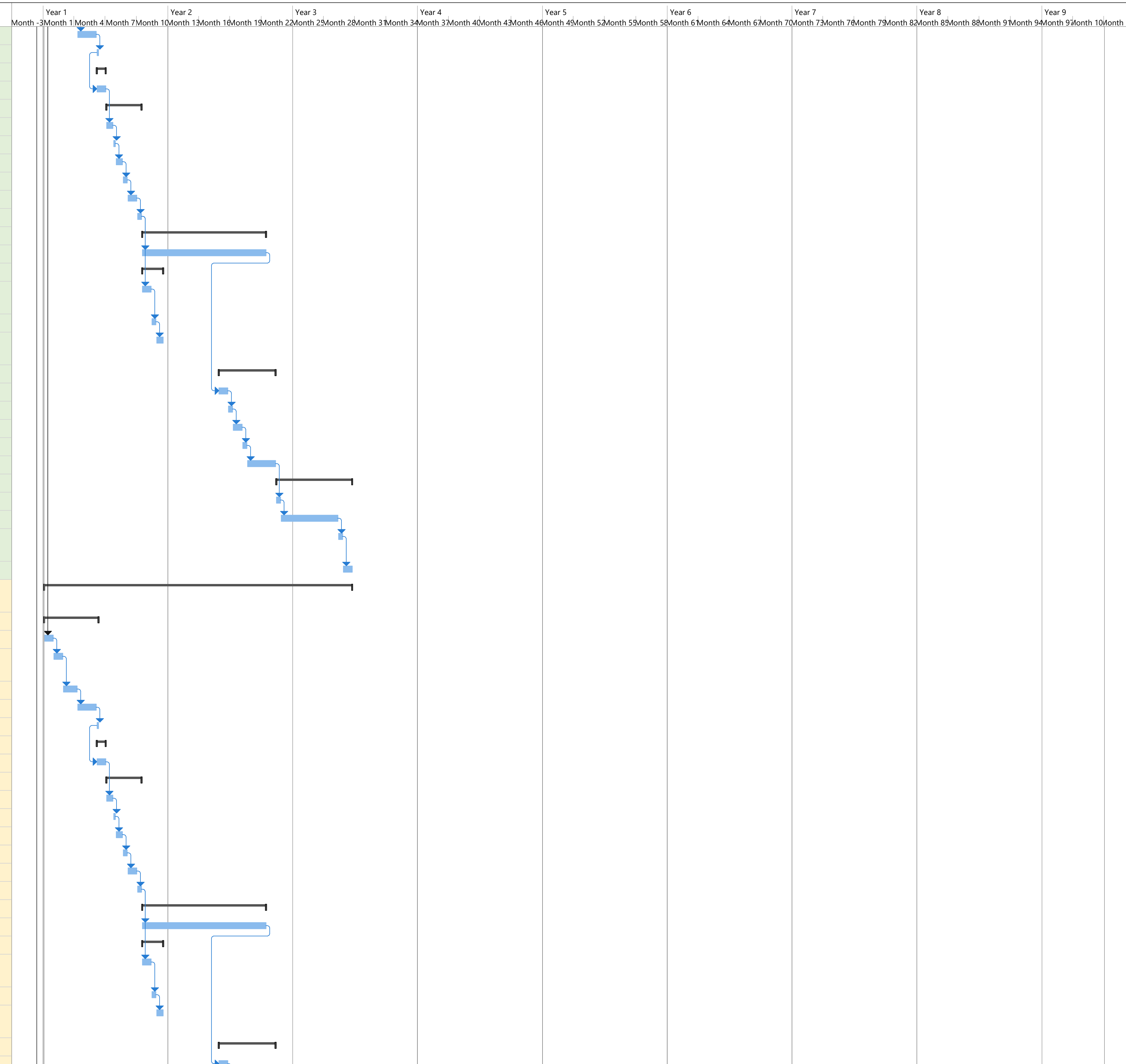
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
350		Bidding (including Pre-Bid Meeting)	20 days	349	29	54	1
351		Bid Review and Recommendation	30 days	350FS+20 days	85	124	1
352		Contract Finalization	40 days	351	127	180	1
353		Kickoff Meeting	10 days	352	183	194	1
354		**Net Design and Procurement**	**246 days**		**0**	**0**	
355		Develop Performance Spec/RFP for Net	20 days	353	197	222	1
356		Agency Review of Performance Spec/RFP	20 days	355	225	250	1
357		Advertise RFP	1 day	356FS+5 days	260	260	1
358		Bidding	15 days	357	261	281	1
359		Contract Finalization	30 days	358	282	323	1
360		NTP for Net Design	5 days	359	324	330	1
361		Net Design and Manufacturing	150 days	360	331	540	2
362		**Preliminary Design for Associated Civil Structures**	**201 days**		**0**	**0**	
363		Survey Collection	20 days	352	183	208	1
364		Develop 1st Draft Concept Plan	30 days	353	197	236	1
365		1st Concept Design Review Meeting	15 days	364	239	257	1
366		Develop Final Concept Plans	15 days	361SS,365	331	351	1
367		Final Concept Design Review Meeting	10 days	366	352	365	2
368		30% Design Plans	20 days	367	366	393	2
369		30% Agency Design Review	10 days	368	394	407	2
370		30% Design Review Meeting	10 days	369	408	421	2
371		60% Design Plans and OPCC	20 days	370	422	449	2
372		60% Design Review Meeting	10 days	371	450	463	2
373		**Permitting**	**340 days**		**0**	**0**	
374		Permitting	340 days	372	464	939	3
375		**Final Design, OPCC, Tech Specs for Associated Civil Structures**	**160 days**		**0**	**0**	
376		90% Design Plans, OPCC, & Technical Specs	20 days	372	464	491	2
377		90% Agency Design Review	10 days	376	492	505	2
378		90% Design Review Meeting	10 days	377	506	519	2
379		FERC Plans and Document Review	120 days	377	506	673	2
380		Final Design Plans, OPCC, Technical Specs, & Memo	10 days	379	674	687	2
381		**Construction Procurement**	**115 days**		**0**	**0**	
382		Bid Package	20 days	374FS-100 days	800	827	3
383		Bidding (including Pre-Bid Meeting)	10 days	382	828	841	3
384		Bid Review and Recommendation	10 days	383FS+15 days	863	876	3
385		Contract Finalization	60 days	384	877	960	3
386		**Construction**	**150 days**		**0**	**0**	
387		Pre-Construction Meeting	10 days	385	961	974	3
388		Construction	120 days	387,3	975	1142	4
389		Substantial Completion Inspection	10 days	388FS-10 days	1129	1142	4
390		Record Drawings	20 days	388,389	1143	1170	4
391		**Recreation**	**645 days**		**1**	**1**	**1**
392		**Riverview - Relocate Existing Boat Tour Dock Design, Permitting, and Construction**	**645 days**		**0**	**0**	
393		**Engineering Procurement**	**115 days**		**0**	**0**	
394		Bid Package	20 days	10	1	26	1
395		Bidding (includes Pre-Bid Meeting)	20 days	394	29	54	1
396		Bid Review and Recommendation	30 days	395	57	96	1



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

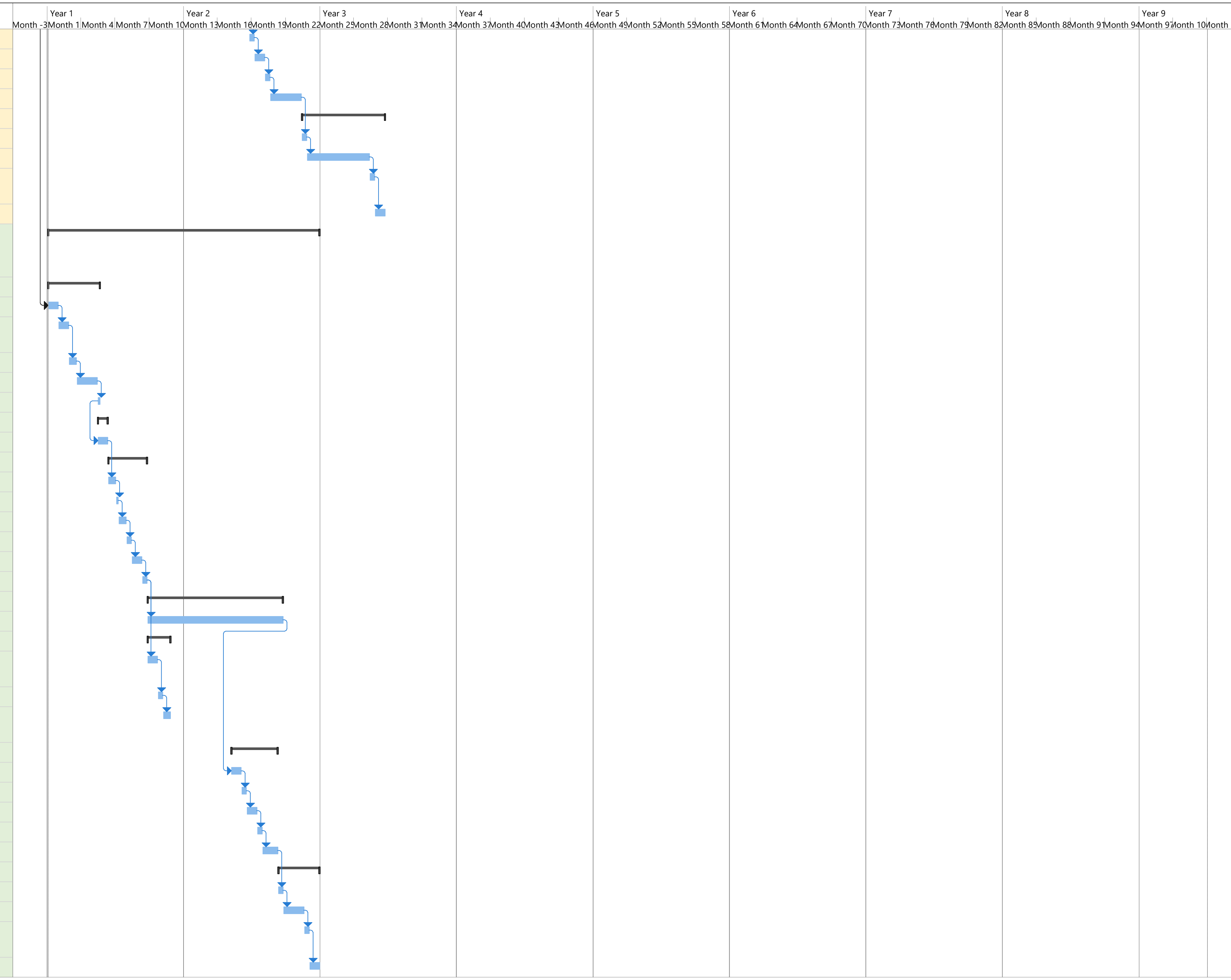
ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
397		Contract Finalization	40 days	396	99	152	1
398		Kick-off Meeting	5 days	397	155	159	1
399		**Data Collection**	**20 days**		**0**	**0**	
400		Survey Collection	20 days	398SS	155	180	1
401		**Preliminary Design**	**75 days**		**0**	**0**	
402		Draft Concept Plans	15 days	400	183	201	1
403		Concept Design Review Meeting	5 days	402	204	208	1
404		30% Design Plans	15 days	403	211	229	1
405		30% Design Review Meeting	10 days	404	232	243	1
406		60% Design Plans and OPCC	20 days	405	246	271	1
407		60% Design Review Meeting	10 days	406	274	285	1
408		**Permitting**	**260 days**		**0**	**0**	
409		Permitting	260 days	407	288	649	2
410		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
411		90% Design Plans, OPCC, & Technical Specs	20 days	407	288	313	1
412		90% Design Review Meeting	10 days	411	316	327	1
413		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	412	330	348	1
414		**Construction Procurement**	**120 days**		**0**	**0**	
415		Bid Package	20 days	409FS-100 days	512	537	2
416		Pre-Bid Meeting	10 days	415	540	551	2
417		Bidding	20 days	416	554	579	2
418		Bid Review and Recommendation	10 days	417	582	593	2
419		Contract Finalization	60 days	418	596	677	2
420		**Construction**	**160 days**		**0**	**0**	
421		Pre-Construction Meeting	10 days	419	680	691	2
422		Construction	120 days	421	694	859	3
423		Substantial Completion Inspection	10 days	422	862	873	3
424		Record Drawings	20 days	423	876	901	3
425		**Riverview - New Access Trail and Put-in, Permitting, and Construction**	**645 days**		**0**	**0**	
426		**Engineering Procurement**	**115 days**		**0**	**0**	
427		Bid Package	20 days	10	1	26	1
428		Bidding (includes Pre-Bid Meeting)	20 days	427	29	54	1
429		Bid Review and Recommendation	30 days	428	57	96	1
430		Contract Finalization	40 days	429	99	152	1
431		Kick-off Meeting	5 days	430	155	159	1
432		**Data Collection**	**20 days**		**0**	**0**	
433		Survey Collection	20 days	431SS	155	180	1
434		**Preliminary Design**	**75 days**		**0**	**0**	
435		Draft Concept Plans	15 days	433	183	201	1
436		Concept Design Review Meeting	5 days	435	204	208	1
437		30% Design Plans	15 days	436	211	229	1
438		30% Design Review Meeting	10 days	437	232	243	1
439		60% Design Plans and OPCC	20 days	438	246	271	1
440		60% Design Review Meeting	10 days	439	274	285	1
441		**Permitting**	**260 days**		**0**	**0**	
442		Permitting	260 days	440	288	649	2
443		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
444		90% Design Plans, OPCC, & Technical Specs	20 days	440	288	313	1
445		90% Design Review Meeting	10 days	444	316	327	1
446		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	445	330	348	1
447		**Construction Procurement**	**120 days**		**0**	**0**	
448		Bid Package	20 days	442FS-100 days	512	537	2



Project: Combined Schedule
Date: Fri 7/24/20

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

ID	Task Mode	Task Name	Duration	Predecessors	Start Day	Finish Day	Years after FERC License Issuance
449		Pre-Bid Meeting	10 days	448	540	551	2
450		Bidding	20 days	449	554	579	2
451		Bid Review and Recommendation	10 days	450	582	593	2
452		Contract Finalization	60 days	451	596	677	2
453		**Construction**	**160 days**		**0**	**0**	
454		Pre-Construction Meeting	10 days	452	680	691	2
455		Construction	120 days	454	694	859	3
456		Substantial Completion Inspection	10 days	455	862	873	3
457		Record Drawings	20 days	456	876	901	3
458		**Cabot Camp - New Access Trail for Put-in Design, Permitting, and Construction**	**520 days**		**0**	**0**	
459		**Engineering Procurement**	**100 days**		**0**	**0**	
460		Bid Package	20 days	10SS	1	26	1
461		Bidding (includes Pre-Bid Meeting)	20 days	460	29	54	1
462		Bid Review and Recommendation	15 days	461	57	75	1
463		Contract Finalization	40 days	462	78	131	1
464		Kick-off Meeting	5 days	463	134	138	1
465		**Data Collection**	**20 days**		**0**	**0**	
466		Survey Collection	20 days	464SS	134	159	1
467		**Preliminary Design**	**75 days**		**0**	**0**	
468		Draft Concept Plans	15 days	466	162	180	1
469		Concept Design Review Meeting	5 days	468	183	187	1
470		30% Design Plans	15 days	469	190	208	1
471		30% Design Review Meeting	10 days	470	211	222	1
472		60% Design Plans and OPCC	20 days	471	225	250	1
473		60% Design Review Meeting	10 days	472	253	264	1
474		**Permitting**	**260 days**		**0**	**0**	
475		Permitting	260 days	473	267	628	2
476		**Final Design, OPCC, Tech Specs**	**45 days**		**0**	**0**	
477		90% Design Plans, OPCC, & Technical Specs	20 days	473	267	292	1
478		90% Design Review Meeting	10 days	477	295	306	1
479		Final Design Plans, OPCC, Technical Specs, & Memo	15 days	478	309	327	1
480		**Construction Procurement**	**90 days**		**0**	**0**	
481		Bid Package	20 days	475FS-100 days	491	516	2
482		Pre-Bid Meeting	10 days	481	519	530	2
483		Bidding	20 days	482	533	558	2
484		Bid Review and Recommendation	10 days	483	561	572	2
485		Contract Finalization	30 days	484	575	614	2
486		**Construction**	**80 days**		**0**	**0**	
487		Pre-Construction Meeting	10 days	485	617	628	2
488		Construction	40 days	487	631	684	2
489		Substantial Completion Inspection	10 days	488	687	698	2
490		Record Drawings	20 days	489	701	726	2



Project: Combined Schedule
Date: Fri 7/24/20

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

Appendix B: Draft License Articles for the Turners Falls Project and Northfield Mountain Project

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Article X. Operational Regime

(a) The Licensee shall operate the Turners Falls Hydroelectric Project in accordance with the following operational flow regime until the third (3rd) anniversary of the effective date of the new license.

Date	Total Bypass Flow[2]	Turners Falls Dam	Station No. 1
01/01-03/31	1,500 cfs or the Naturally Routed Flow (NRF), whichever is less	300 cfs	1,200 cfs[3]
04/01-05-31[1]	6,500 cfs or the NRF, whichever is less	4,290 cfs	2,210 cfs[3]
06/01-06/15[1]	4,500 cfs or the NRF, whichever is less	2,990 cfs	1,510 cfs[3]
06/16-06/30[1]	3,500 cfs or the NRF, whichever is less	2,280 cfs	1,220 cfs[3]
07/01-08/31	1,800 cfs or the NRF, whichever is less	670 cfs	1,130 cfs[3]
09/01-11/30	1,500 cfs or the NRF, whichever is less	500 cfs	1,000 cfs[3]
12/01-12/31	1,500 cfs or the NRF, whichever is less	300 cfs	1,200 cfs[3]

[1]The flow split during these periods is approximately 67% from the Turners Falls Dam and 33% from Station No. 1. If FirstLight conducts further testing, in consultation with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS) and Massachusetts Department of Fish and Wildlife (MADFW), and determines that migratory fish are not delayed by passing a greater percentage of the bypass flow via Station No. 1, it may increase the percentage through Station No. 1 upon written concurrence of those agencies.

[2]If the NRF is less than 6,500 cfs (04/01-05/31), 4,500 cfs (06/01-06/15) or 3,500 cfs (06/16-06/30) the flow split will still be set at approximately 67% of the NRF from the Turners Falls Dam and 33% of the NRF from Station No. 1. If the NRF is less than 1,800 cfs (7/1-8/31), 1,500 cfs (9/1-11/30), or 1,500 cfs (12/1-3/31), the Licensee shall maintain the Turners Falls Dam discharges at 670 cfs, 500, cfs, and 300 cfs, respectively.

[3]The Turners Falls Hydro (TFH) project (FERC No. 2622) and Milton Hilton, LLC project (unlicensed) are located on the power canal and discharge into the bypass reach upstream of Station No. 1. The hydraulic capacity of the TFH project and Milton Hilton, LLC project is 289 and 113 cfs, respectively. If the TFH project is operating, FirstLight will reduce its Station No. 1 discharge by 289 cfs. If the Milton Hilton, LLC project is operating, FirstLight will reduce its Station No. 1 discharge by 113 cfs.

(b) Maintain a continuous minimum flow below Cabot Station of 6,800 cfs from 6/1-6/15 and 5,800 cfs from 6/16-6/30 or the NRF, whichever is less.

The bypass flows and minimum flow below Cabot may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee; and (2) upon mutual agreement among the Licensees for Project Nos. 1889 and 2485 and the USFWS, NMFS, Massachusetts Department of Environmental Protection (MADEP) and MADFW.

(c) The NRF represents the inflow to the Turners Falls Dam. The NRF is defined as the sum of the Vernon Hydroelectric Project (FERC No. 1904) total discharge, Ashuelot River United States Geological Survey (USGS) gage flow and Millers River USGS gage flow.

(d) The Licensee shall operate the Turners Falls Hydroelectric Project in accordance with the conditions in paragraph (a) and (b) and the following operational flow regime beginning on the third (3rd) anniversary of the effective date of the new license.

Date	Total Bypass Flow[2,3]	Maximum Flow below Cabot Station to Protect Puritan Tiger Beetles	Cabot Down-Ramping Rate to Protect Shortnose Sturgeon	Cabot Up-Ramping Rate to Protect Shortnose Sturgeon (4/1-5/31) and Odonates (6/1-8/15)
01/01-03/31	1,500 cfs or the NRF, whichever is less			
[1]04/01-05/31	6,500 cfs or the NRF, whichever is less		Down to 2,300 cfs/hour	Up to 2,300 cfs/hour
[1]06/01-06/15	4,500 cfs or the NRF, whichever is less			Up to 2,300 cfs/hr from 8:00 am to 2:00 pm
[1]06/16-06/30	3,500 cfs or the NRF, whichever is less			Up to 2,300 cfs/hr from 8:00 am to 2:00 pm
07/01-08/15	1,800 cfs or the NRF, whichever is less	Add no more than 4,600 cfs additional flow from Cabot Station from 1 am to 2 pm		Up to 2,300 cfs/hr from 8:00 am to 2:00 pm
08/16-08/31	1,800 cfs or the NRF, whichever is less	Add no more than 4,600 cfs additional flow from Cabot Station from 1 am to 2 pm		
09/01-11/30	1,500 cfs or the NRF, whichever is less			
12/01-12/31	1,500 cfs or the NRF, whichever is less			

[1]The flow split during these periods is approximately 67% from the Turners Falls Dam and 33% from Station No. 1. If FirstLight conducts further testing, in consultation with the NMFS, USFWS, and MADFW, and determines that migratory fish are not delayed by passing a greater percentage of the bypass flow via Station No. 1, it may increase the percentage through Station No. 1 upon written concurrence of those agencies.

[2]If the NRF is less than 6,500 cfs (04/01-05/31), 4,500 cfs (06/01-06/15) or 3,500 cfs (06/16-06/30) the flow split will still be set as approximately 67% of the NRF from the Turners Falls Dam and 33% of the NRF from Station No. 1. If the NRF is less than 1,800 cfs (7/1-8/31), 1,500 cfs (9/1-11/30), or 1,500 cfs (12/1-3/31), the Licensee shall maintain the Turners Falls Dam discharges at 670 cfs, 500, cfs, and 300 cfs, respectively.

[3]The Turners Falls Hydro (TFH) project (FERC No. 2622) and Milton Hilton, LLC project (unlicensed) are located on the power canal and discharge into the bypass reach upstream of Station No. 1. The hydraulic capacity of the TFH project and Milton Hilton, LLC project is 289 and 113 cfs, respectively. If the TFH project is operating, FirstLight will reduce its Station No. 1 discharge by 289 cfs. If the Milton Hilton, LLC project is operating, FirstLight will reduce its Station No. 1 discharge by 113 cfs.

FirstLight has included two timing elements in its Proposed Action to address the new operational paradigm. First, FirstLight is proposing a three (3) year transition period in which it will institute new minimum flows in paragraph (a) and (b), as a license condition, and also put processes in place with Great River Hydro (GRH) and Independent System Operator- New England (ISO-NE) to assure success in meeting its obligations for Cabot Station up and down ramping as well as Cabot Station peak demand flow restrictions. In addition, Station No. 1 upgrades will be completed during this period. In Year 4 of the new *license, FirstLight will be responsible, as a license condition, for the full suite of flow enhancements shown in paragraphs (a), (b) and (d) (i.e. Cabot Station up and down ramping, Cabot Station peak demand flow restrictions).*

In addition, and in an attempt to meet all its obligations for delivering reliable power and capacity, FirstLight is also proposing exceptions where it can deviate from its Cabot Station up- and down-ramping and peak demand flow requirements for a finite period of time as described in (e) below if required to meet either its flood operations (or similar public safety obligation) or ISO-NE obligations, as well as due to unforeseen river conditions from the Vernon Project.

(e) If compliance with the prescribed operating limits (defined as Maximum Flow below Cabot Station, Cabot Up-Ramping Rate and Cabot Down-Ramping Rate which are shown as the last three columns in the table in paragraph (d)) would cause the Licensee to violate or breach any law, any applicable license, permit, approval, consent, exemption or authorization from a federal, state, or local governmental authority, any agreement with a governmental entity, or any tariff, capacity rating requirement, ramping criterion, or other requirement of the ISO-NE or its successors (ISO-NE), Licensee may deviate from the prescribed operating limitations to the least degree necessary in order to avoid such violation or breach. In addition, Licensee may deviate from the operating limits for the following reasons:

- To perform demonstrations of the resources' operating capabilities under ISO-NE rules and procedures. Licensee will use best efforts to be allowed by ISO-NE to perform these demonstrations at times that will not cause it to deviate from the operating limits.
- To manage the Turners Falls Impoundment (TFI) within license limits following unexpected, significant increases or decreases in the NRF.
- To support the needs of ISO-NE grid operations by operating when called upon by the ISO-NE.
- If compliance with the prescribed operating limitations would cause a public safety hazard or prevent timely rescue.

With the exception of public safety, the Licensee agrees that under no conditions shall the four exceptions identified above occur in more than 10% of the hours each year that the limitations apply, without the written concurrence of the USFWS, NMFS, MADFW and MADEP.

The Licensee shall document on an hourly basis for each day any deviations from the Maximum Flow below Cabot Station, Cabot Up-Ramping Rate and Cabot Down-Ramping Rate restrictions. Each day, any deviations would be summed and at the end of each month between April 1 and August 31, the Licensee shall document the total number of deviations and provide the information to USFWS, NMFS, MADFW, and MADEP on a monthly basis.

(f) Cabot Emergency Gate Use. The Licensee shall use the Cabot Emergency Gates under the following conditions: a) in case of a Cabot load rejection, b) in the case of dam safety issues such as potential canal overtopping or partial breach, and c) to discharge approximately 500 cfs between April 1 and June 15 for debris management. The Licensee shall avoid discharging higher flows through the gates from April 1 to June 15 whenever possible; however, if necessary, the Licensee shall coordinate with NMFS to minimize potential impact to Shortnose Sturgeon in the area below Cabot Station.

(g) Flood Flow Operations. The Licensee shall operate the Turners Falls Hydroelectric Project in accordance with its existing agreement with the United States Army Corp of Engineers (USACOE). This agreement, memorialized in the *Reservoir and River Flow Management Procedures* (1976), as it may be amended from time to time, governs how the Turners Falls Project shall operate during flood conditions and coordinate its operations with the Licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485).

Article X. Turners Falls Impoundment Water Level Management

(a) The Licensee shall operate the TFI, as measured at the Turners Falls Dam, between elevation 176.0 feet and 185.0 feet National Geodetic Vertical Datum of 1929 (NGVD29).

(b) The Licensee shall limit the rate of rise of the TFI water level, as measured at the Turners Falls Dam, to be less than 0.9 feet/hour from May 15 to August 15 between the hours of 8:00 am and 2:00 pm for the protection of odonates.

(c) The rate of rise of the TFI may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee; and (2) upon mutual agreement among the Licensees for Projects Nos. 1889 and 2485 and the USFWS, NMFS, and MADFW.

Article X. Whitewater Boating Flows

(a) The Licensee shall provide whitewater boating releases in accordance with the schedule below, or the NRF, whichever is less, from the Turners Falls Dam. The Licensee shall maintain the following whitewater release schedule. FirstLight will provide an annual schedule of releases on its website, for the period July-October by May 31 of each year.

Date	Turners Falls Dam Magnitude of Discharge	Turners Falls Dam Release Duration
1 Saturday in July	2,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in August	2,500 cfs or the NRF, whichever is less	4 hours
3 Saturdays in September	3,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in October	3,500 cfs or the NRF, whichever is less	4 hours
2 Saturdays in October	5,000 cfs or the NRF, whichever is less	4 hours

(b) The whitewater boating flows may be modified temporarily: (1) during and to the extent required by operating emergencies beyond the control of the Licensee; and (2) upon mutual agreement among the Licensees for Projects Nos. 1889 and 2485 and the USFWS, NMFS and MADFW.

Article X. Operating Priorities

In the event of a conflict among the operational requirements of this license, the Licensee shall maintain the priority listing below with 1 being highest priority.

Restriction	Resource Protected	Priority (1- highest, 6- lowest)							
		4/1-4/30	5/1-5/15	5/16-5/31	6/1-6/30	7/1-7/31	8/1-8/15	8/16-8/31	9/1-3/31
Flood Flow Operations	Public safety	1	1	1	1	1	1	1	1
Bypass Flows, or-inflow, 24 hrs/day	Aquatic species	2	2	2	2	2	2	2	2
Up/Down Ramping 2,300 cfs, 24 hrs/day	Shortnose Sturgeon	3	3	3					
Minimum flow below Cabot Station, or-inflow, 24 hrs/day					3				

Restriction	Resource Protected	Priority (1- highest, 6- lowest)							
		4/1-4/30	5/1-5/15	5/16-5/31	6/1-6/30	7/1-7/31	8/1-8/15	8/16-8/31	9/1-3/31
Add no more than 2 additional Cabot Units from 1 am to 2 pm	Puritan Tiger Beetle					3	3	3	
Up Ramping 1 Cabot Unit/hr, 8 am to 2 pm	Odonates			4	4	4	4	4	
TFI elevation rate of rise <0.9 ft/hr as measured at the Turners Falls Dam, 8 am to 2 pm				5	5	5	5	5	
Whitewater Flows, or-inflow, Weekend, 4 hrs/day, flows ranging from 2,500 to 5,000 cfs	Public recreation					6	6	6	6 (Sep, Oct only)

Article X. Fish Passage

(a) The Licensee shall construct the following fish passage facilities, which shall become operational in the years shown below.

Fish Passage Feature	No. of Years after License Issuance Fish Passage Feature becomes Operational
Permanent Ultrasound Array at the Outer edge of the Cabot Tailrace	6 years
Spillway Lift	6 years
Plunge Pool below Bascule Gate No. 1	6 years
Station No. 1 Exclusion Structure	8 years
Temporary Upstream Eel Passage	2-9 years
Permanent Upstream Eel Passage	10 years

The Licensee shall continue operating the Cabot fish ladder and gatehouse ladder until the Spillway Lift and the Ultrasound Array are operating. Once operable, the Cabot fish ladder and gatehouse ladder entrances will be retired.

(b) The Licensee shall consult with the USFWS, NMFS and the MADFW in the design of each of the above facilities. The Licensee shall provide a minimum of 60 days for USFWS, NMFS, and the MADFW to comment and make recommendations before filing the designs of each facility with the Commission. If the Licensee does not adopt a design recommendation, the filing must include the Licensee's reasons, based on project-specific information. The Commission reserves the right to require changes to the designs. Construction associated with any of the designs must not begin until the Licensee is notified by the Commission that the design is approved. Upon Commission approval, the Licensee must implement the plan, including any changes required by the Commission

(c) The Licensee shall file with the Commission, within one year from the date of completion of each fish passage facility, "as-built" drawings of the completed facilities.

Article X. Upgrade Station No. 1

(a) Within three (3) years of license issuance, the Licensee shall modify Station No. 1 to automate the facility such that the units can operate over a range of flows instead of single gate settings.

Article X. Modifications to Turners Falls Dam Bascule No. 1 Gate

(a) Within three (3) years of license issuance, the Licensee shall modify Bascule Gate No. 1 and equip it with heaters such that that gate can be safely operated during freezing temperatures to maintain winter bypass flows.

Article X. Recreation Management Plan

The Licensee shall implement the Recreation Management Plan filed with the Commission as part of the AFLA.

Article X. Invasive Plant Species Management Plan

The Licensee shall implement the Invasive Plant Species Management Plan filed with the Commission as part of the AFLA..

Article X. Bald Eagle Protection Plan

The Licensee shall implement the Bald Eagle Protection Plan filed with the Commission as part of the AFLA.

Article X. Northern Long-Eared Bat Protection Measures

The Licensee shall implement the following measures to protect Northern Long-Eared Bat habitat: (1) avoid cutting trees equal to or greater than 3 inches in diameter at breast height within the project boundary from April 1 through October 31, unless they pose an immediate threat to human life or property (hazard trees); and (2) where non-hazard trees need to be removed, only remove non-hazard trees between November 1 and March 31.

Article X. Historic Properties Management Plan

The Licensee shall implement the Historic Properties Management Plan filed with the Commission as part of the AFLA.

Article X. Operational Regime

(a) Flood Flow Operations. The Licensee shall operate the Northfield Mountain Pumped Storage Project in accordance with its existing agreement with the United States Army Corp of Engineers (USACOE). This agreement, memorialized in the *Reservoir and River Flow Management Procedures* (1976), as it may be amended from time to time, governs how the Northfield Mountain Pumped Storage Project shall operate during flood conditions and coordinate its operations with the Licensee of the Turners Falls Hydroelectric Project (FERC No. 1889).

(b) Upper Reservoir Water Level Management: The Licensee shall operate the Northfield Mountain Pumped Storage Project Upper Reservoir between elevation 1004.5 and 920 feet National Geodetic Vertical Datum of 1929 (NGVD29).

Article X. Fish Passage

(a) The Licensee shall construct and operate a barrier net located in the Northfield Mountain Pumped Storage Project tailrace/intake and have it operational within five (5) years of license issuance.

(b) The Licensee shall consult with the USFWS, NMFS and the MADFW in the design of the barrier net located in the Northfield Mountain Project tailrace/intake. The Licensee shall provide a minimum of 60 days for USFWS, NMFS, and the MADFW to comment and make recommendations before filing the designs of each facility with the Commission. If the Licensee does not adopt a design recommendation, the filing must include the Licensee's reasons, based on project-specific information. The Commission reserves the right to require changes to the design. Construction associated with any of the design must not begin until the Licensee is notified by the Commission that the design is approved. Upon Commission approval, the Licensee must implement the plan, including any changes required by the Commission.

(c) The Licensee shall file with the Commission, within one year from the date of installation of the barrier net, "as-built" drawings of the completed facility.

Article X. Upper Reservoir Sediment Management

The Licensee shall implement the Sediment Management Plan entitled *Upper Reservoir Dewatering Protocols* filed with the Commission on June 30, 2017, provided that if FirstLight determines that modifications to the Sediment Management Plan are necessary or desirable and documents that the modifications are not anticipated to reduce the effectiveness of the Plan, the Sediment Management Plan can be amended with the written concurrence of the United States Environmental Protection Agency and MADEP.

Article X. Recreation Management Plan

The Licensee shall implement the Recreation Management Plan filed with the Commission as part of the AFLA.

Article X. Invasive Plant Species Management Plan

The Licensee shall implement the Invasive Plant Species Management Plan filed with the Commission as part of the AFLA.

Article X. Bald Eagle Protection Plan

The Licensee shall implement the Bald Eagle Protection Plan filed with the Commission as part of the AFLA.

Article X. Northern Long-Eared Bat Protection Measures

The Licensee shall implement the following measures to protect Northern Long-Eared Bat habitat: (1) avoid cutting trees equal to or greater than 3 inches in diameter at breast height within the project boundary from April 1 through October 31, unless they pose an immediate threat to human life or property (hazard trees); and (2) where non-hazard trees need to be removed, only remove non-hazard trees between November 1 and March 31.

Article X. Historic Properties Management Plan

The Licensee shall implement the Historic Properties Management Plan filed with the Commission as part of the AFLA.

Appendix A: Geology and Soils- Updated Results

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AFLA Supplemental BSTEM Modeling Report

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)

Prepared for:

Prepared by:

AUGUST 2020

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LIST OF ABBREVIATIONS

AFLA	Amended Final License Application
BL	Baseline conditions
BSTEM	Bank Stability and Toe Erosion Model
Commission	Federal Energy Regulatory Commission
cfs	cubic feet per second
EGL slope	Energy gradeline slope
El.	Elevation
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight MA Hydro LLC and Northfield Mountain LLC, collectively
ft^3/ft/yr.	Cubic feet per feet per year
HEC-RAS	Hydrologic Engineering Center River Analysis System
ILP	Integrated Licensing Process
NFM	Northfield Mountain
NGVD29	National Geodetic Vertical Datum of 1929
Northfield Mountain Project	Northfield Mountain Pumped Storage Project (FERC No. 2485)
NRF	Naturally routed flow
Operations Model	HEC-ResSim Operations Model
Qe_{95}	Flow above which 95% of erosion occurred
SPD	Study Plan Determination
Study No. 3.1.2	Study No. 3.1.2 Northfield Mountain / Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability
TFI	Turners Falls Impoundment
the Projects	Turners Falls Hydroelectric Project and Northfield Mountain Pumped Storage Project, collectively
Turners Falls Project	Turners Falls Hydroelectric Project (FERC No. 1889)
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
Vernon Project	Vernon Hydroelectric Project, FERC No. 1904
WSEL	Water surface elevation

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1 INTRODUCTION

The Turners Falls Hydroelectric Project (Turners Falls Project, FERC No. 1889) and Northfield Mountain Pumped Storage Project (Northfield Mountain Project, FERC No. 2485), collectively "the Projects", are located on the Connecticut River in the Commonwealth of Massachusetts and the States of New Hampshire and Vermont. FirstLight MA Hydro LLC is the owner of the Turners Falls Project. Northfield Mountain LLC is the owner of the Northfield Mountain Project. Throughout this report these entities are collectively referred to as "FirstLight". The current licenses for the Turners Falls and Northfield Mountain Projects were issued on May 5, 1980 and May 14, 1968, respectively. Both licenses expired on April 30, 2018. FirstLight has initiated the process of relicensing the Projects with the Federal Energy Regulatory Commission (FERC or the Commission) utilizing FERC's Integrated Licensing Process (ILP).

As part of relicensing, FirstLight conducted Study No. 3.1.2 *Northfield Mountain / Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability* (Study No. 3.1.2). Study No. 3.1.2 evaluated and identified the causes of erosion, and the forces associated with them, in the Turners Falls Impoundment (TFI) and determined to what extent they are related to existing Project operations. The study was conducted over the course of 2014-2016 in accordance with FERC's September 13, 2013 Study Plan Determination (SPD) and FirstLight's September 15, 2014 addendum to the Revised Study Plan. The final study report (Volumes I-III) was filed with the Commission on April 3, 2017 (FirstLight, 2017a). Study Addendum 1 was also filed with the Commission on that date (FirstLight, 2017b). The addendum evaluated the potential impact that greater use of the Northfield Mountain Upper Reservoir may have on TFI erosion. The results of Study No. 3.1.2 found that existing Project operations is not a dominant cause of erosion anywhere in the TFI.

As detailed in FirstLight (2017a), Study No. 3.1.2 determined bank-erosion rates and the causes of erosion at 25 detailed study sites located throughout the TFI under existing operating conditions via state-of-the-science modeling and supplemental engineering analysis. The detailed study sites spanned the longitudinal extent of the TFI and were representative of the riverbank features, characteristics, and erosion conditions found throughout the study reach. The results of the modeling and analyses conducted at each study site were then extrapolated throughout the TFI such that each riverbank segment identified during the 2013 Full River Reconnaissance (Study No. 3.1.1) (FirstLight, 2014) had a dominant and, in some cases, contributing cause(s) of erosion assigned to it. The complex hydrologic and hydraulic characteristics of the TFI were also evaluated in-depth and accounted for during this process.

Two primary models were used for Study No. 3.1.2 – (1) the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) model, and (2) the Bank Stability and Toe Erosion Model (BSTEM). The HEC-RAS model was used to analyze hydraulics throughout the study reach. Input parameters to the HEC-RAS model were based on historic, empirical water surface elevation (WSEL) and flow data. BSTEM was used to analyze erosion and bank stability at each of the 25 detailed study sites. More specifically, BSTEM was used to execute a series of production runs that examined various operating scenarios (i.e., Northfield Mountain On (baseline-existing conditions), Northfield Mountain Off, and boat wake waves on/off) to determine amounts and causes of erosion at each detailed study site under existing operating conditions. BSTEM required geotechnical, geomorphic, and hydraulic input parameters. Geotechnical and geomorphic parameters were based on field-collected data at each detailed study site. Hydraulic input parameters (i.e., WSEL and energy gradeline slope (EGL slope)) were derived from the HEC-RAS model. Both the HEC-RAS and BSTEM models encompassed the period 2000-2014. The results of these efforts were presented in FirstLight (2017a).

Upon preparing the Amended Final License Application (AFLA), it was determined that modifications to the BSTEM hydraulic input parameters were necessary to allow for a direct comparison between baseline-existing conditions and FirstLight's proposed AFLA operating regime. Such a comparison was necessary to determine the potential impact, if any, of the proposed operating regime on TFI bank erosion. The primary difference between Study No. 3.1.2 and the AFLA supplemental analysis was related to how the HEC-RAS input parameters, and therefore the BSTEM hydraulic input parameters, were determined. As described below, the HEC-RAS input parameters for Study No. 3.1.2 were based on historic data, while the HEC-RAS input parameters for the AFLA analysis were based on modeled data.

For the AFLA supplemental analysis, HEC-RAS input parameters were determined based on the HEC-ResSim Operations Model (Operations Model) for both the baseline-existing condition and AFLA proposed operating regime scenarios. Use of the Operations Model to determine hydraulic input parameters for both scenarios allowed for a direct comparison of both scenarios, which in turn allowed FirstLight to evaluate the impact, if any, of the proposed operating regime on TFI bank erosion. As part of the AFLA analysis, HEC-RAS output parameters (i.e., WSEL and EGL slope) were again used as hydraulic input parameters to BSTEM for both the baseline-existing condition and AFLA proposed operating regime scenarios. A series of BSTEM production runs, utilizing the Operations Model-based hydraulic input data, were then executed to determine bank-erosion rates and the causes of erosion at each detailed study site under both scenarios. The BSTEM production runs utilized the same detailed study sites, geomorphic and geotechnical input parameters, and modeling period (i.e., 2000-2014) as that which was used for Study No. 3.1.2. The BSTEM results for the baseline-existing condition and proposed operating regime scenarios were compared to each other to determine the impact, if any, of the proposed operating regime on TFI bank erosion.

2 OPERATIONS & HYDRAULIC MODELING

As part of the AFLA supplemental analysis, both a HEC-ResSim Operations Model and a HEC-RAS hydraulic model were utilized to determine various model input parameters such as flow, WSEL, and EGL slope. Detailed discussion pertaining to the Operations and HEC-RAS models can be found in FirstLight (FirstLight, 2015), (FirstLight, 2016), and (FirstLight, 2017), respectively. An overview of the operations and hydraulic modeling conducted specifically for this analysis is included in the ensuing sections.

2.1 HEC-ResSim Operations Model

The AFLA supplemental analysis used output parameters from the Operations Model (i.e., flow and WSEL at the Turners Falls Dam) as input parameters for the HEC-RAS model for all model scenarios. Use of the Operations Model to provide hydraulic input data for the HEC-RAS model allowed for a direct comparison between existing and proposed operating conditions. Operations modeling for the AFLA supplemental analysis covered the same period as Study No. 3.1.2 (i.e., 2000-2014) and consisted of three hourly model runs – (1) baseline-existing conditions; (2) baseline-existing conditions, Northfield Mountain 'Off'; and (3) the AFLA proposed operating regime.

The "baseline-existing conditions" model run (Scenario 1) consisted of:

- Historical flows from the Vernon Hydroelectric Project (Vernon Project), Millers River, and Ashuelot Rivers;
- Northfield Mountain 'On'; and
- TFI WSEL at the Turners Falls Dam based on reservoir imbalance scripting in the HEC-ResSim model and the other constraints of the existing license.

The "baseline-existing conditions, Northfield Mountain Off" (Scenario 2) consisted of:

- Historical flows from the Vernon Project, Millers River, and Ashuelot Rivers;
- Northfield Mountain 'Off'; and
- TFI WSEL at the Turners Falls Dam modeled as a function of Vernon Project inflow and the other constraints of the existing license (minus those associated with Northfield Mountain operations).

The "AFLA proposed operating regime" (Scenario 3) consisted of:

- Historical flows from the Millers and Ashuelot Rivers;
- Vernon Project outflow adjusted to provide prorated minimum flows[1] to the TFI while maintaining other current operational characteristics;
- Northfield Mountain 'On' with the full suite of AFLA operational proposals. These included increased Turners Falls Bypass flows, increased flows downstream of Cabot Station, maximum flow

[1] FirstLight's proposal includes seasonally varying minimum flows in the bypass reach on an or-inflow, whichever is less basis. The proposed minimum flows were adjusted by a ratio of drainage area to the Wilder, Bellows Falls and Vernon Projects – also on an or-inflow basis.

restrictions at Cabot Station, ramping restrictions downstream of Cabot Station and in the TFI as well as expanded[2] Upper Reservoir operations;

- TFI WSEL at the Turners Falls Dam modeled using reservoir imbalance scripting in the HEC-ResSim model and the other operating constraints of the proposed operating regime (e.g., flows to the bypass reach and power canal).

A detailed discussion pertaining to the proposed operating regime can be found in AFLA Exhibit E, Section 2 (FirstLight, 2020). A summary of the key proposed operational changes is provided below:

- FirstLight proposes to operate the TFI, as measured at the Turners Falls Dam, between elevation (El.) 176 and 185 National Geodetic Vertical Datum of 1929 (NGVD29)[3], U.S. feet year-round. FirstLight also proposes to limit the rate of rise of the TFI WSEL, as measured at the Turners Falls Dam, to be less than 0.9 feet/hour from May 15 to August 15 between the hours of 8:00 am and 2:00 pm for the protection of odonates.
- FirstLight proposes to operate the Northfield Mountain Project Upper Reservoir between El. 1004.5 and 920, instead of the current range between El. 1000.5 and 938.
- FirstLight proposes seasonally varying bypass flows (considerably higher than baseline conditions) via a combination of Turners Falls Dam spill and Station No. 1 generation. All bypass flows and Cabot Station baseloading flows are on an or-inflow, whichever is less, basis where inflow is the naturally routed flow[4] (NRF);
  - The current license has a minimum flow of 1,433 cubic feet per second (cfs) downstream of the Project.
  - FirstLight proposes minimum bypass flows of 6,500 cfs in April and May; 4,500 cfs June 1-15, 3,500 cfs June 16-30, 1,800 cfs in July and August, and 1,500 cfs for September through the end of March for the protection of aquatic resources.
  - FirstLight proposes up- and down-ramping at Cabot Station of 2,300 cfs/hour in April and May to protect the federally endangered Shortnose Sturgeon, subject to certain exceptions discussed in AFLA Exhibit E Section 2.
  - FirstLight proposes to baseload one Cabot Station unit (~ 2,300 cfs) in June for the protection of the Shortnose Sturgeon.
  - FirstLight proposes upramping at Cabot Station of 2,300 cfs/hour from June 1 to August 15 between 8:00 am and 2:00 pm for the protection of odonates, subject to certain exceptions discussed in AFLA Exhibit E Section 2.
  - FirstLight proposes to add no more than 4,600 cfs of additional flow from Cabot Station from July 1 to August 31 for the protection of the federally endangered Puritan Tiger beetle, subject to certain exceptions discussed in AFLA Exhibit E Section 2.

[2] FirstLight's proposal includes expanding the Upper Reservoir operating range from 938-1000.5 feet to 920-1004.5 feet,
[3] Unless otherwise noted, all elevations referenced throughout this report refer to the National Geodetic Vertical Datum of 1929, U.S. feet.
[4] NRF is defined as Vernon Discharge + Ashuelot River USGS gage flow + Millers River USGS gage flow.

In all three modeling scenarios, the inflow to the TFI from the Ashuelot and Millers Rivers remained the same (Figure 2.1-1). Under Scenario 3 (FirstLight's proposal), inflow from the Vernon Project, which represents the majority of the inflow to the TFI also remains very similar, other than in low flow conditions (generally below 4,000 cfs) when flows are slightly higher in FirstLight's proposal (Figure 2.1-2). During low flow conditions, especially if they occur during the months of April, May, and June, minimum flows from the Vernon Project were higher than historical baseline conditions because minimum flow requirements were prorated from the FirstLight's proposed bypass flows and/or baseloading at Cabot Station. Figure 2.1-3 provides a week long time-series graph of the Vernon Project discharge for both historical baseline conditions and under Scenario 3 when higher minimum flows were provided from the Vernon Project. As shown in Figure 2.1-2 and 2.1-3, modeled changes in the Vernon Project operations to meet FirstLight proposed minimum flows only occur during low flow periods below the hydraulic capacity of the Vernon Project (17,130 cfs).

As described earlier, the HEC-ResSim Model also determined the WSEL at the Turners Falls Dam using reservoir imbalance scripting and the other operating constraints of the existing and proposed operating regimes (e.g., flows to the bypass reach and power canal). Duration curves of the hourly WSELs at the Turners Falls Dam are provided in Figure 2.1.4. In general, the figure shows:

- Historical WSELs and modeled historical (i.e., Scenario 1) are relatively similar.
- In the Northfield Mountain (NFM) "off" scenario (i.e., Scenario 2) modeled WSELs are about 1 foot higher than Scenario 1 or historical.
- In Scenario 3, modeled WSELs are generally slightly higher (about 0.25 feet) than Scenario 1 or historical, but lower than Scenario 2.

Hourly output for each Operations Model scenario were used as boundary conditions in the HEC-RAS model as discussed in Section 2.2.

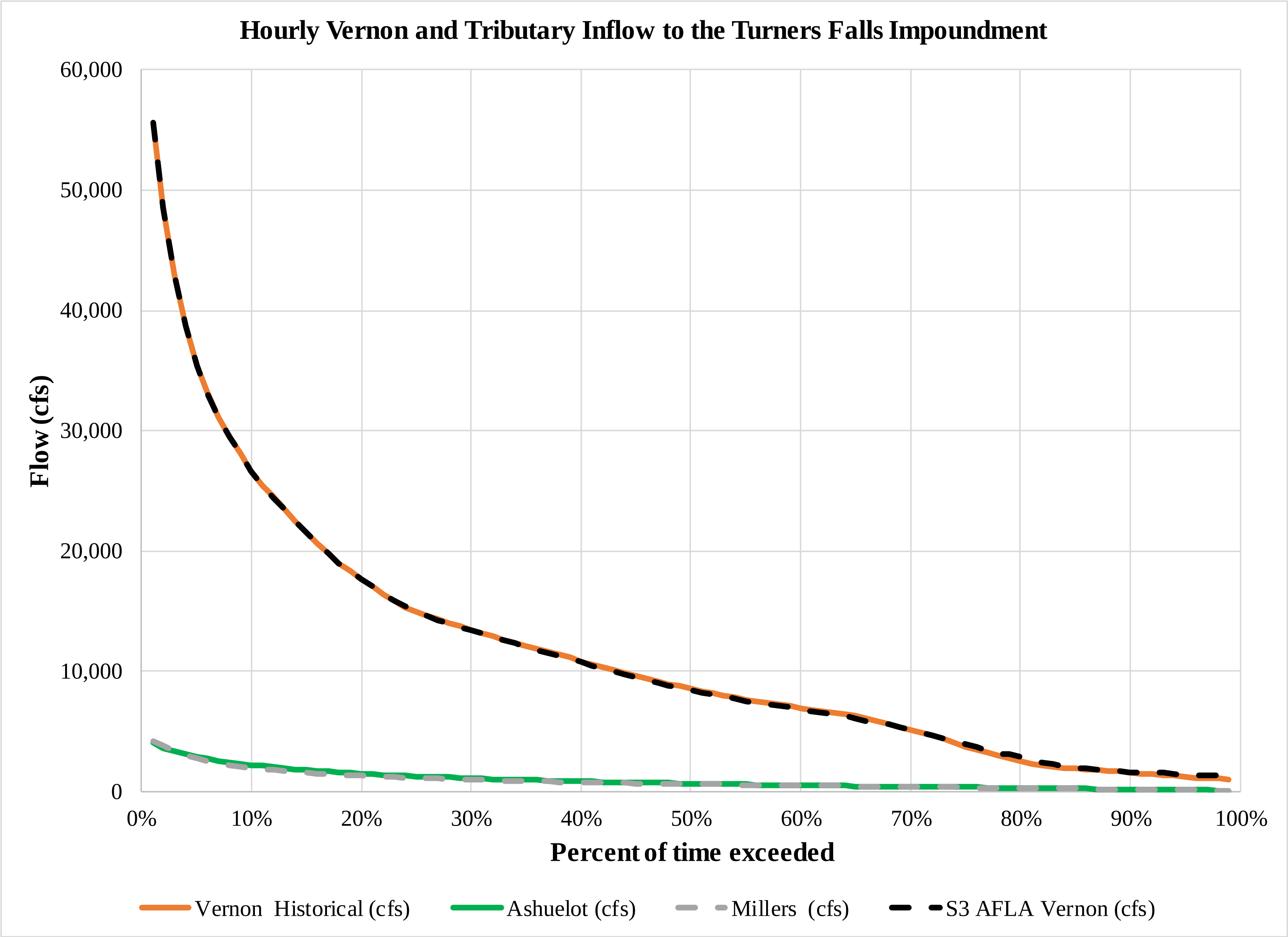

Figure 2.1-1: Annual Duration Curves for Inflow to the Turners Falls Impoundment (Period of Record: 2000-2014)

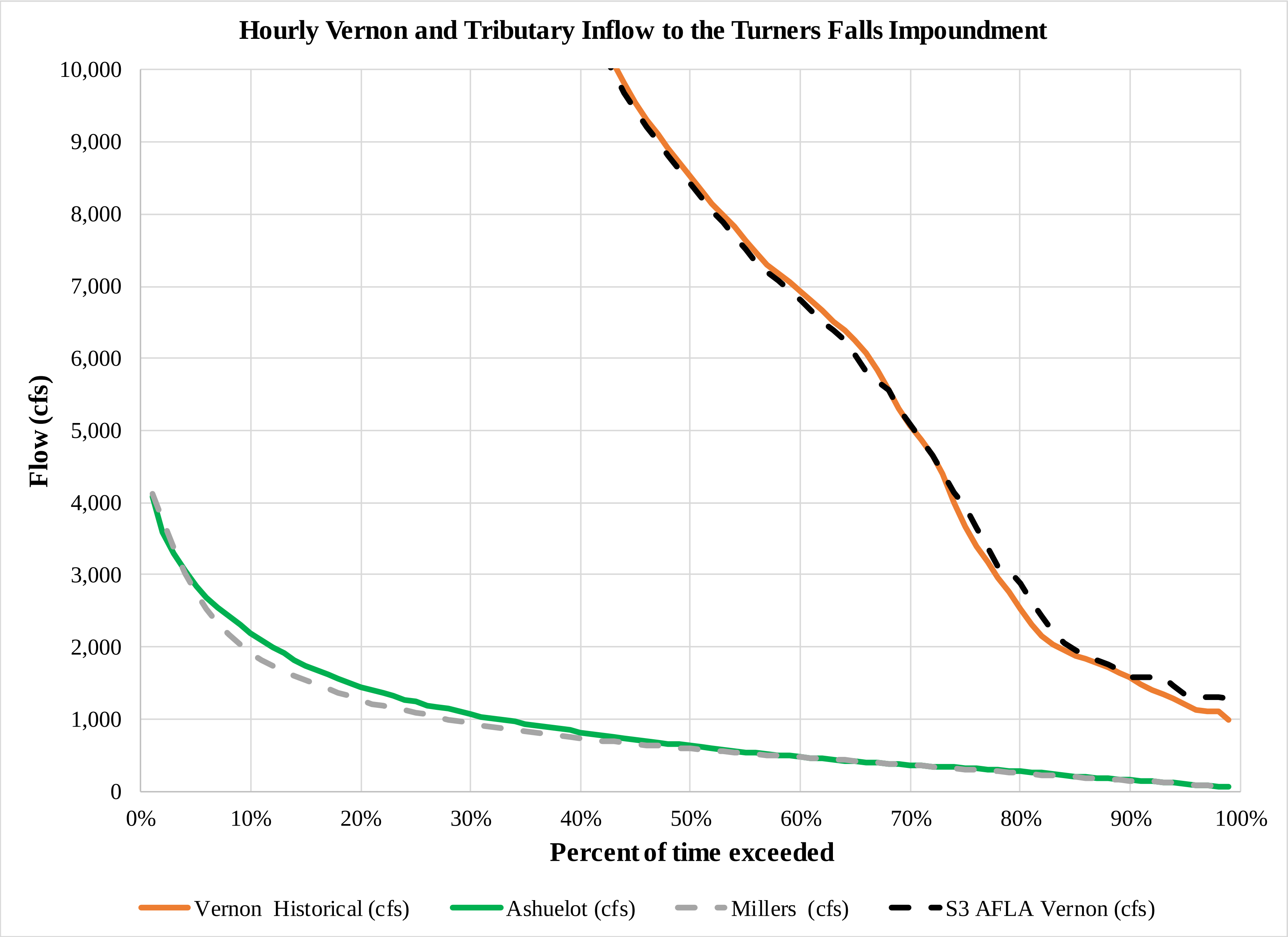

Figure 2.1-2: Annual Duration Curves for Inflow to the Turners Falls Impoundment – Detailed View (Period of Record: 2000-2014)

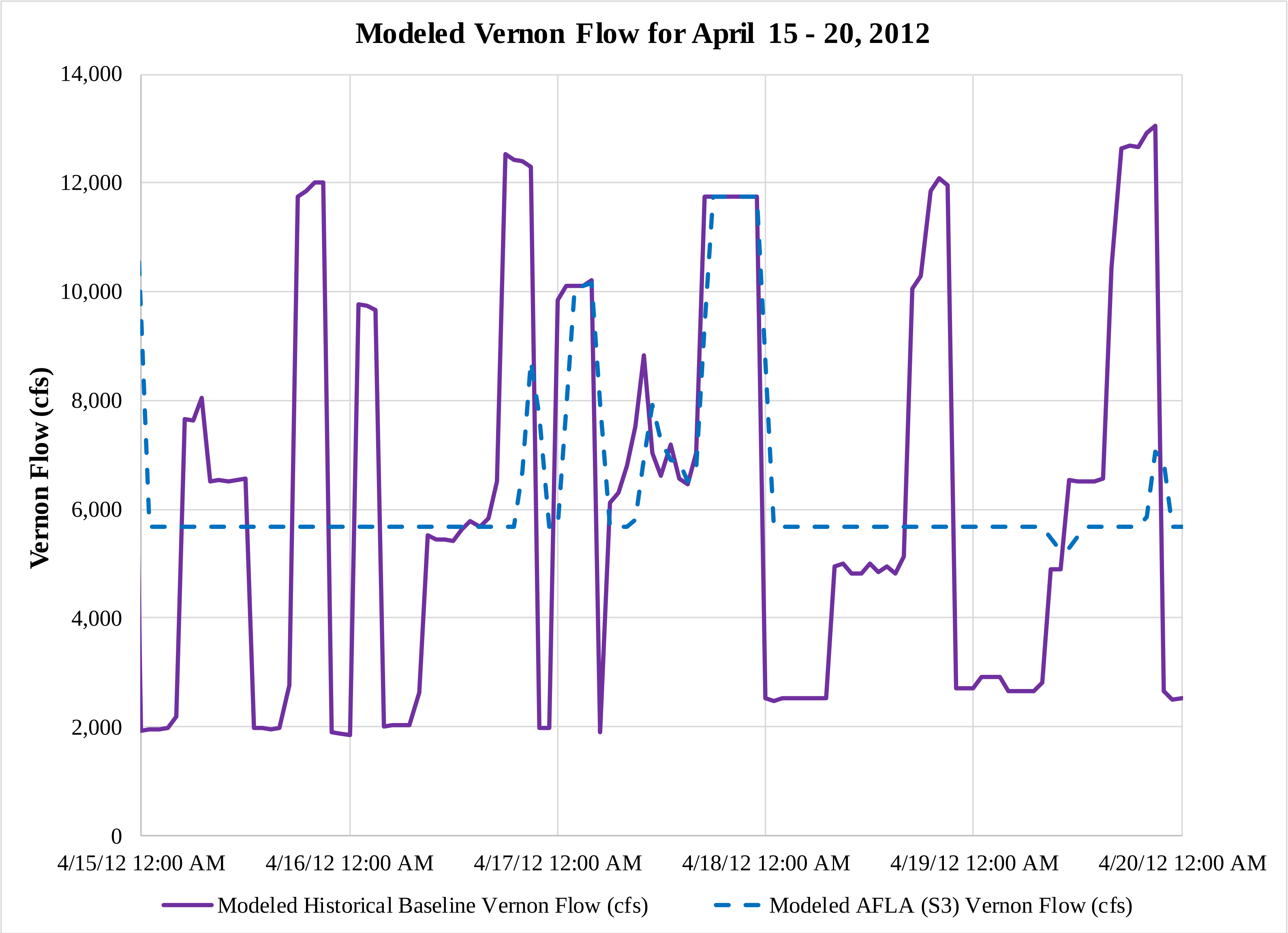

Figure 2.1-3: Time-series Example of Modeled Increased Vernon Project Discharges in Scenario 3

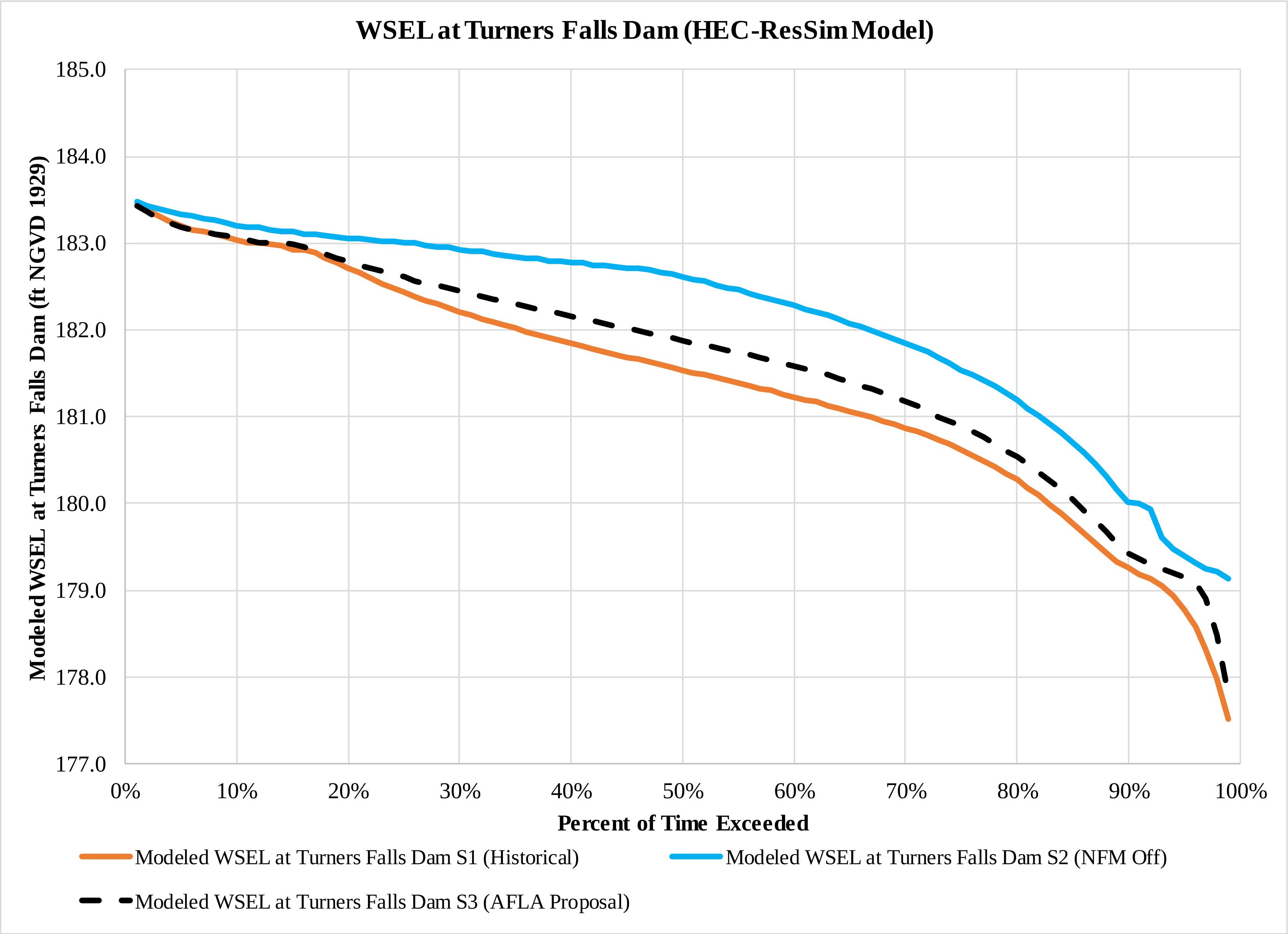

Figure 2.1-4: Annual Duration Curves for WSEL at the Turners Falls Dam

2.2 HEC-RAS Model

The TFI HEC-RAS model was utilized to determine the hourly WSEL and EGL slope at each detailed study site for the same three modeling scenarios discussed in Section 2.1 (i.e., baseline-existing conditions (Scenario 1), existing conditions-Northfield Mountain 'Off' (Scenario 2), and AFLA proposed operating regime (Scenario 3)). The HEC-RAS model is described in detail in Study Report 3.2.2 (FirstLight, 2015) and (FirstLight, 2016), Study No. 3.1.2 (FirstLight, 2017a), and in AFLA Exhibit E, Section 3.3.2 (FirstLight, 2020).

Hourly output for each Operations Model scenario described in Section 2.1 were used as boundary conditions in the HEC-RAS model including:

- Vernon Project Discharge: inflow at the upper end of the HEC-RAS model about 20 miles upstream of Turners Falls Dam.
- Ashuelot River: inflow about 2 miles below the Vernon Project.
- Northfield Mountain: inflow or pumping about 5 miles above Turners Falls Dam.
- Millers River: inflow about 1.2 miles below Northfield Mountain and 3.7 miles above Turners Falls Dam.
- Turners Falls Dam: WSEL boundary condition at the downstream end of the HEC-RAS Model.

Output from the HEC-RAS model (i.e., hourly WSEL and EGL slope) were used as BSTEM hydraulic input parameters at the 25 detailed study sites located throughout the TFI (Figure 2.2-1). Similar to FirstLight (2017a), five representative locations spanning the longitudinal extent of the TFI (about 20 miles long) were identified to illustrate the WSEL and EGL slope relationships in the TFI, including:

- BC-1R - near the entrance to Barton Cove (Station 4,750, about 0.9 miles upstream of Turners Falls Dam).
- 75BL – just downstream of the Northfield Mountain tailrace (Station 27,000, about 5.1 miles upstream of Turners Falls Dam).
- 5CR: just downstream of the Route 10 Bridge (Station 57,250, about 10.8 miles upstream of Turners Falls Dam).
- 4L: downstream of the Pauchaug Boat Launch (Station 74,000, about 14.0 miles upstream of Turners Falls Dam).
- 303BL: between Upper Island and Stebbins Island (Station 94,000, about 17.8 miles upstream of Turners Falls Dam).

Figures 2.2-2 through 2.2-6 depict WSEL and EGL slope comparisons for the three modeling scenarios (S1-baseline, S2-baseline, NFM off and S3-AFLA proposal) described in Section 2.1.

At Site BC-1R (Barton Cove) (Figure 2.2-2), the EGL slopes are similar for all three scenarios. WSELs at this location have slight differences but are very similar to the WSEL at the Turners Falls Dam (shown in Figure 2.1-4). At Sites 75 BL and 5CR (Figures 2.2-3 and 2.2-4), the WSELs show a similar relationship to transect BC-1R at lower WSELs. The EGL slopes are lowest in comparison to the other scenarios during Scenario 2 (NFM off), which also has the highest WSELs. At Site 4L (Figure 2.2-5), higher WSELs are observed under Scenario 2, while the EGL slopes are similar in all three scenarios. At Site 303BL (Figure 2.2-6), the EGL slope begins to be larger and also more independent of the WSELs since this area is more riverine than the lower parts of TFI. Differences in the EGL slopes are observed throughout most of the duration curve.

The WSELs and EGL slopes throughout the TFI are shown in Figures 2.2-7 and 2.2-8. Both of these figures indicate the limited differences between the scenarios in the WSELs and EGL slopes in the majority of the TFI, other than at the upstream more riverine section.

Hourly output for each HEC-RAS scenario were used as hydraulic input parameters in BSTEM as discussed in Section 3.

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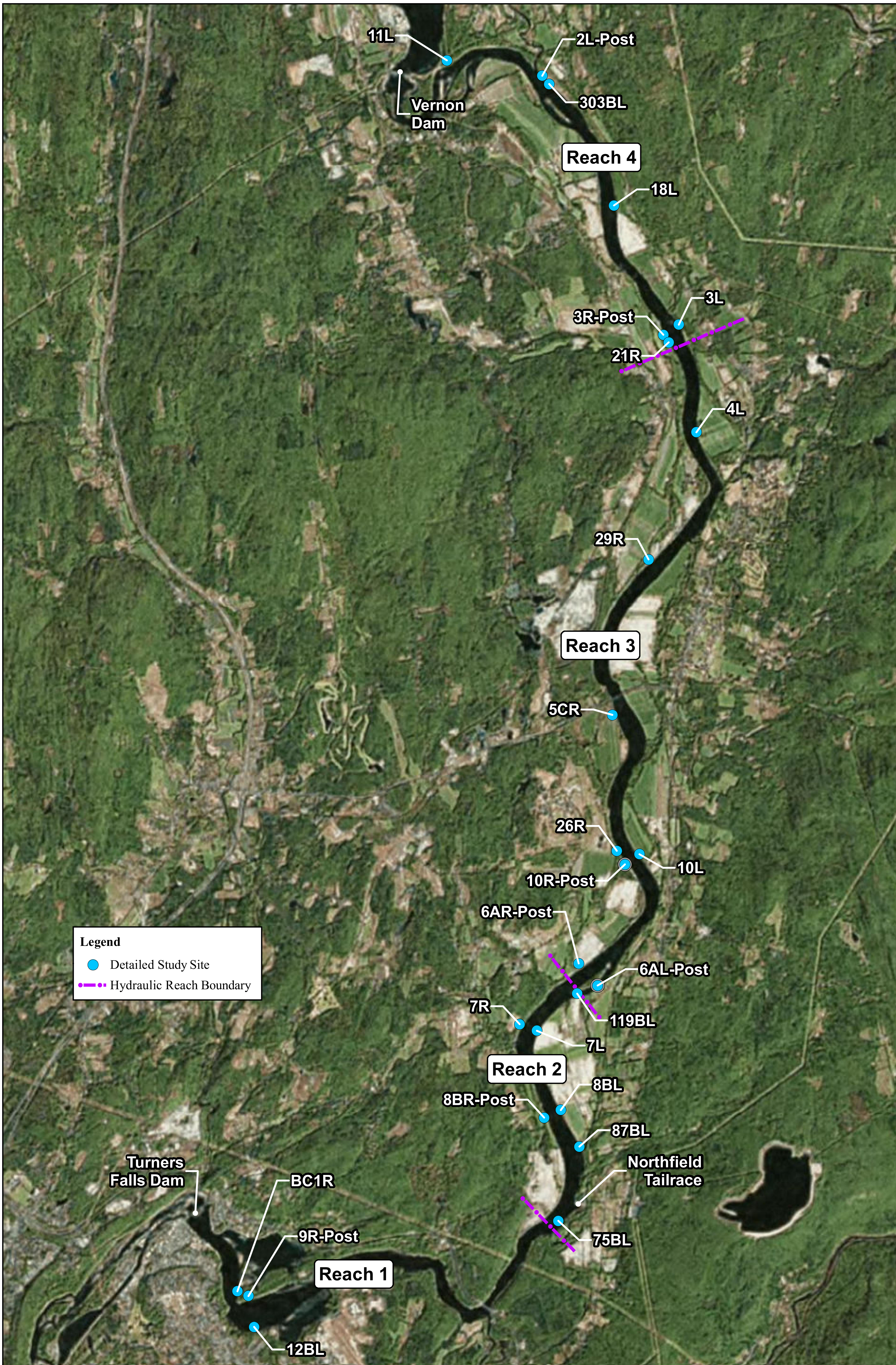

FirstLight

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

AFLA Supplemental BSTEM Modeling

N

0 0.625 1.25 2.5 Miles

Figure 2.2-1:
Turners Falls Impoundment
Detailed Study Sites

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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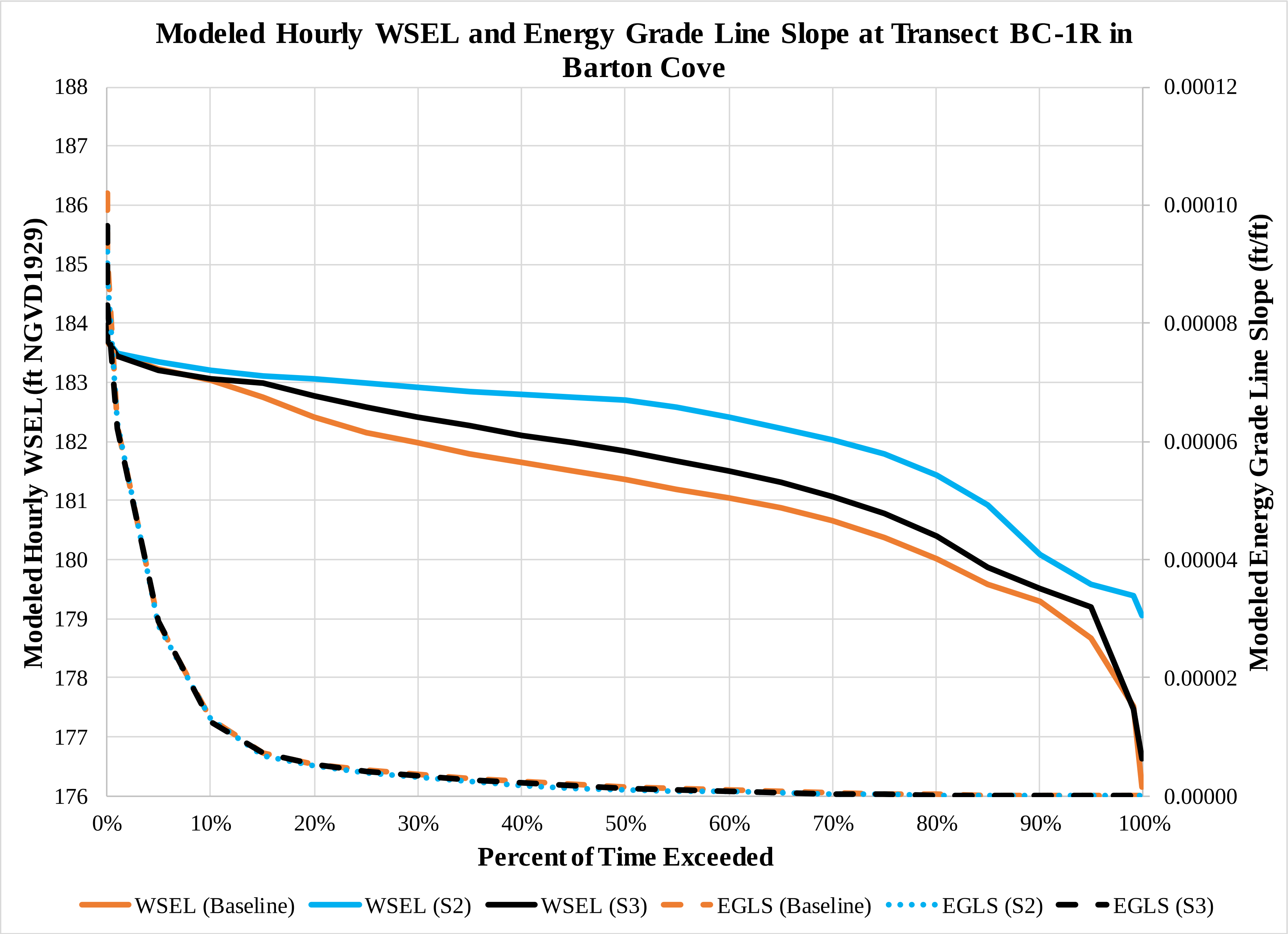

Figure 2.2-2: Modeled WSELs and EGL Slopes at Transect BC-1R

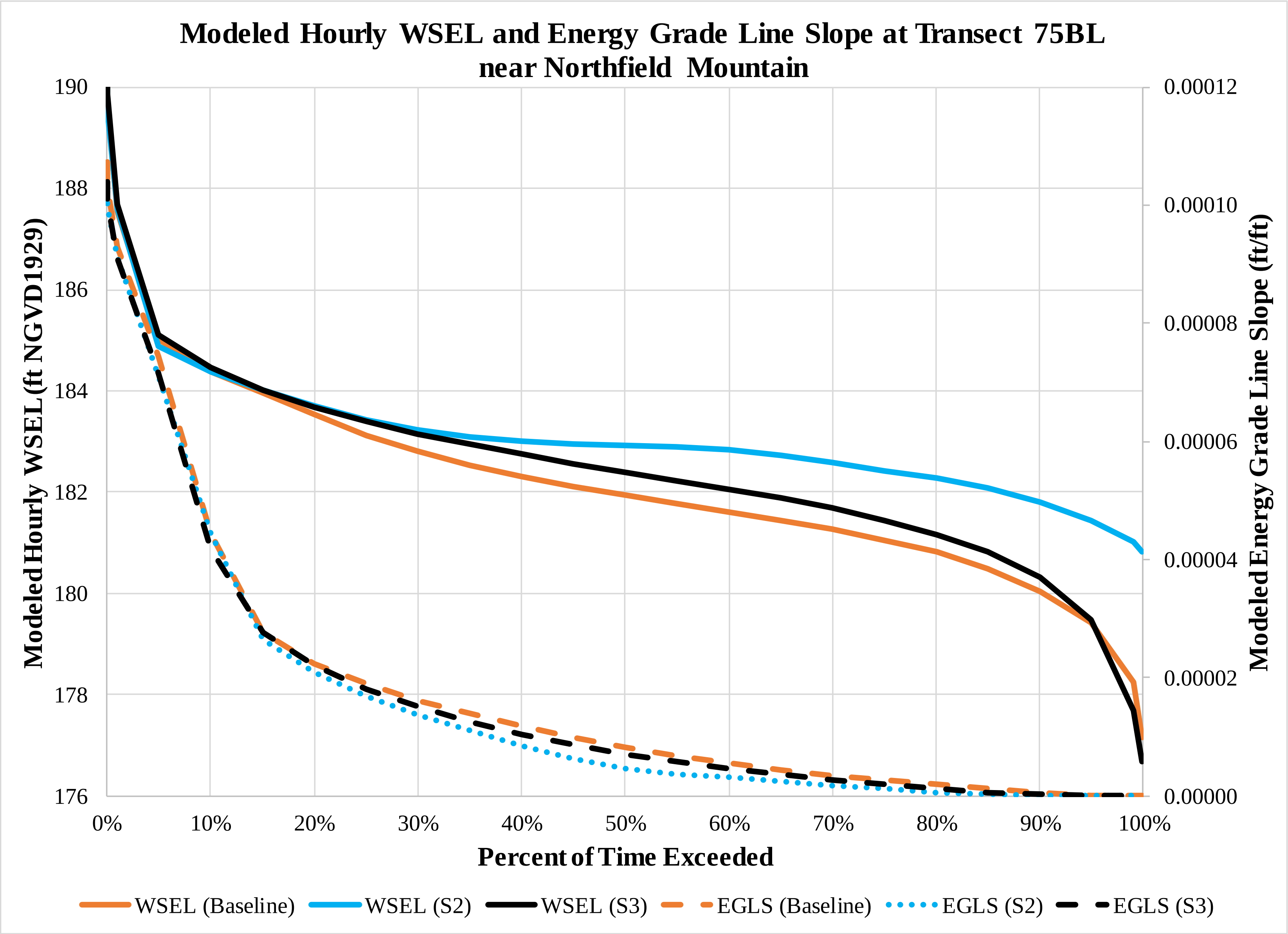

Figure 2.2-3: Modeled WSELs and EGL Slopes at Transect 75BL

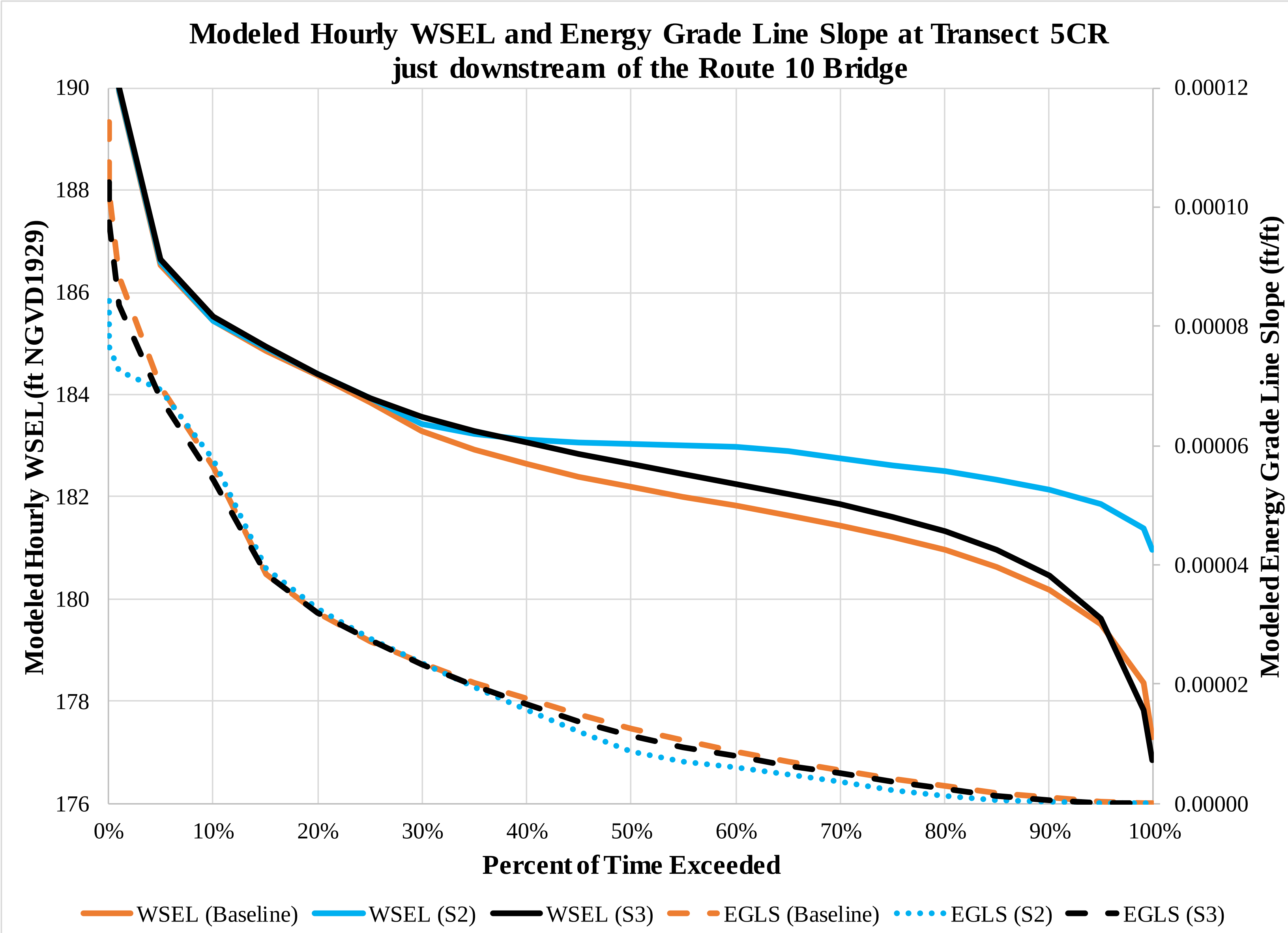

Figure 2.2-4: Modeled WSELs and EGL Slopes at Transect 5CR

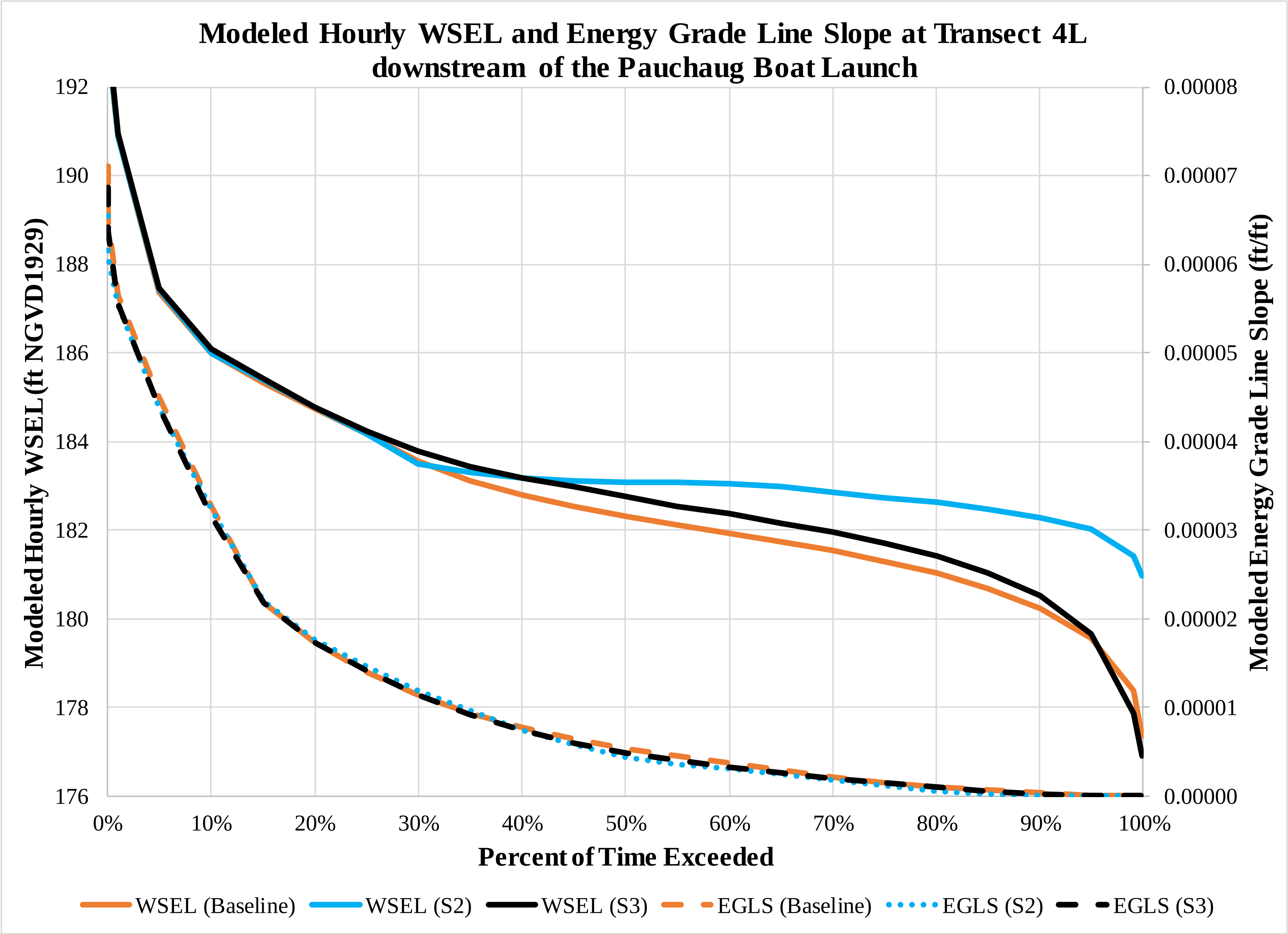

Figure 2.2-5: Modeled WSELs and EGL Slopes at Transect 4L

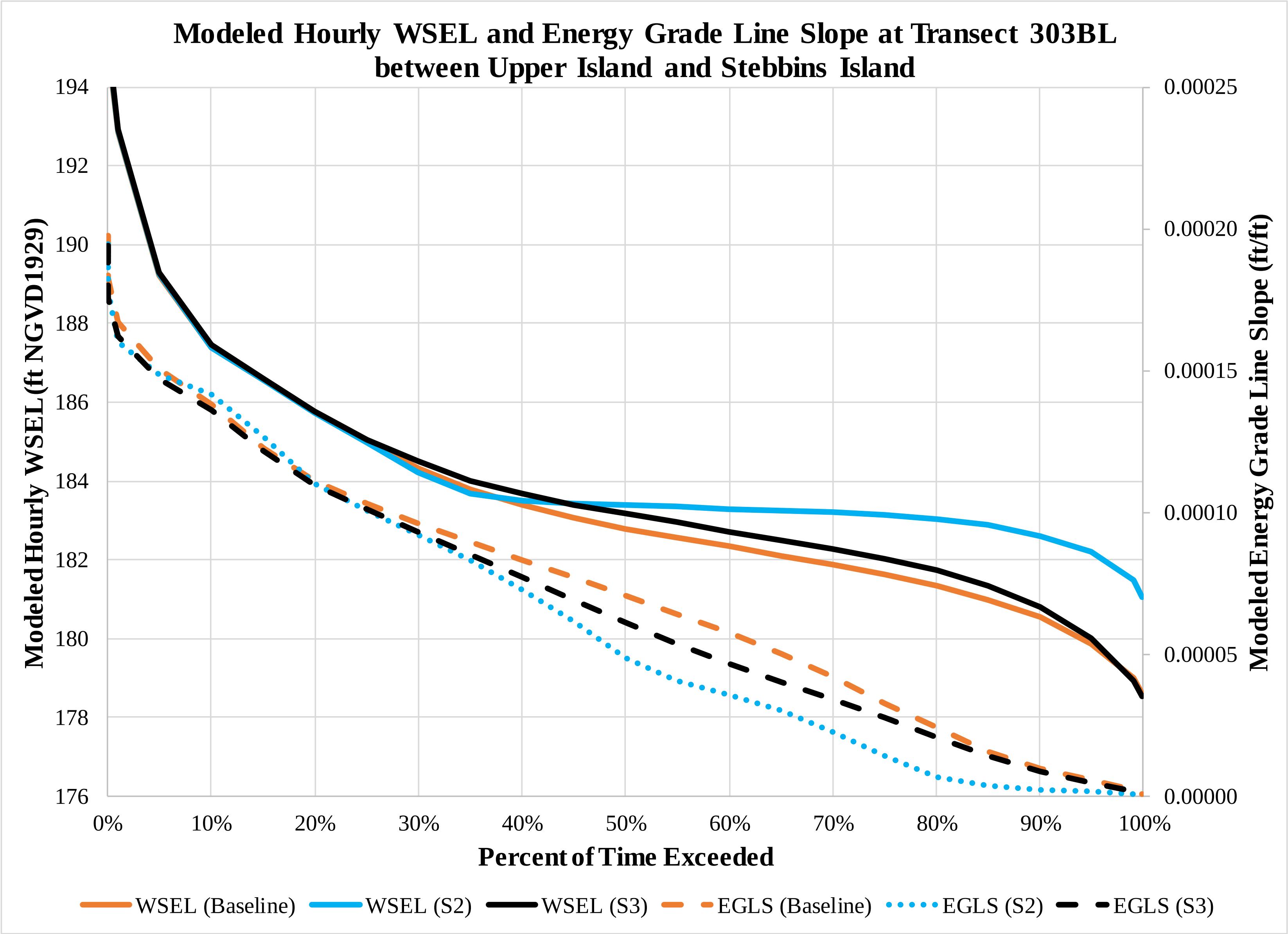

Figure 2.2-6: Modeled WSELs and EGL Slopes at Transect 303BL

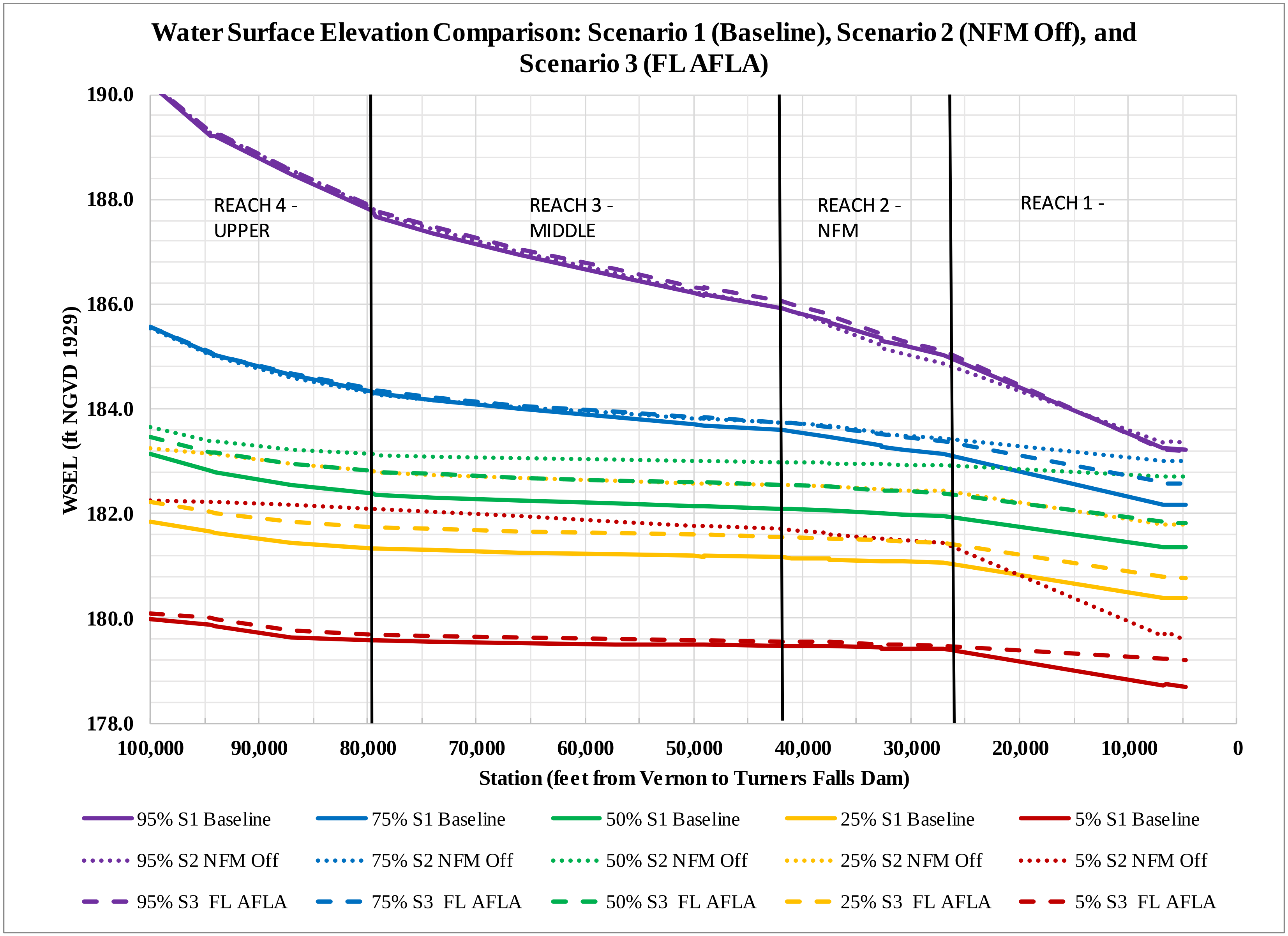

Figure 2.2-7: Modeled WSELs in the Turners Falls Impoundment

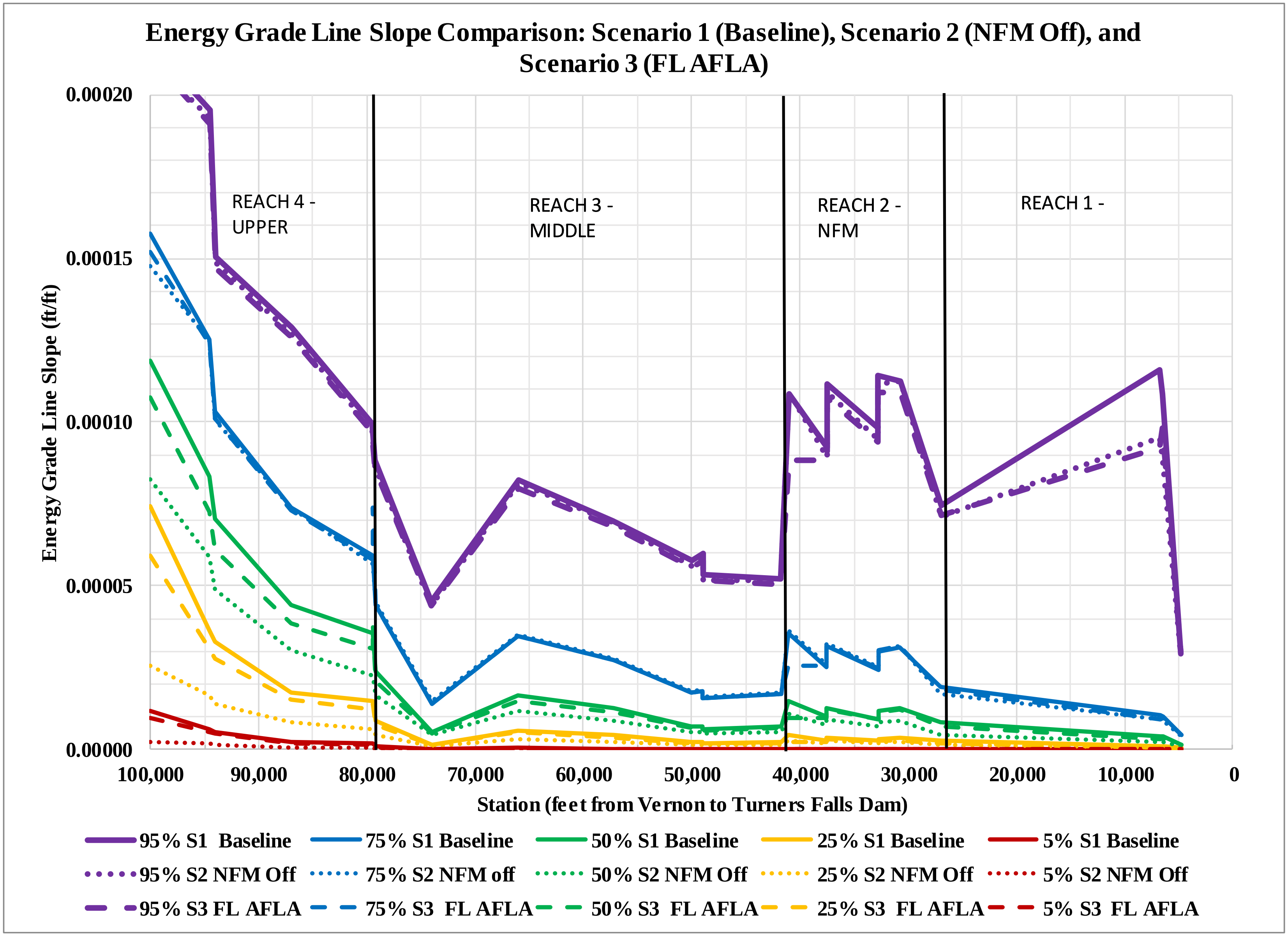

Figure 2.2-8: Modeled EGL Slopes in the Turners Falls Impoundment

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3 BSTEM MODELING

The purpose of the bank-stability modeling conducted for the AFLA was to quantify the difference between bank-erosion rates under the proposed AFLA operational scenario and baseline-existing conditions. For the purpose of this analysis, BSTEM hydraulic input data for both the baseline-existing condition and AFLA proposed operating regime scenarios utilized data from the Operations Model (via the HEC-RAS model) to ensure a direct comparison between both operating scenarios. A series of BSTEM production runs were executed to determine bank-erosion rates and the causes of erosion at each detailed study site under both the baseline-existing condition and AFLA proposed operating regime scenarios. The BSTEM production runs utilized the same version of BSTEM-Dynamic as well as the same detailed study sites, geomorphic and geotechnical input parameters, and modeling period (i.e., 2000-2014) as that which were used for Study No. 3.1.2. Using one-hour time steps, the same initial bank geometry and bank-material properties as those which were used in Study No. 3.1.2 were also applied here. Post-restoration geometry and properties were used at the restoration sites (2L, 3R, 10R, 6AL, 6AR, 8BR, and 9R). The BSTEM results for the baseline-existing condition and proposed operating regime scenarios were compared to each other to determine the impact, if any, of the proposed operating regime on TFI bank erosion.

Bank erosion at all 25 of the detailed study sites was simulated for the hydraulic conditions discussed in Section 2.2. HEC-RAS outputs including hourly WSEL and EGL slopes, were used as inputs to BSTEM-Dynamic for all scenarios. All simulations were conducted initially with the boat-wave sub-model engaged (Waves On). Another set of simulations were then conducted with the sub-model turned off (Waves Off). Differences in those results represented the role of boat waves on bank erosion. In total, four sets of BSTEM-Dynamic simulations were conducted for this analysis:

- Baseline NFM ON, Waves On *(baseline-existing conditions)*
- Baseline NFM ON, Waves Off
- Baseline NFM OFF, Waves On
- AFLA, Waves On *(FirstLight's proposed operating regime as detailed in the AFLA)*

3.1 Role of NFM Operations on Baseline Erosion Rates

Baseline-existing condition BSTEM runs which were executed for Study No. 3.1.2 were re-run for the AFLA supplemental analysis utilizing the previously discussed hydraulic input parameter changes. This was done to establish baseline-existing condition results that would be directly comparable the AFLA proposed operating regime scenario. Table 3.1-1 shows a summary of the total erosion for the baseline-existing scenario, with waves on and waves off, and for the Baseline NFM "off" scenario. Consistent with Study No. 3.1.2, part of determining the role of NFM operations on baseline erosion rates was to assign dominant and contributing causes to erosion. Table 3.1-2 shows a summary of the causes of erosion based on the updated model runs.

To determine the role of NFM operations on bank erosion under baseline-existing conditions, the NFM On, Waves On and NFM Off model runs are compared (columns 2 and 4 of Table 3.1-1). The majority of sites show very little change due NFM operations (<5% difference). The greatest impact of NFM existing operations on bank erosion is at site 8BR (see Figure 2.2-1 for site locations) where there was about 0.08 ft^3/ft/yr. more erosion (~10.8% greater) than without NFM operations. There is also an observed large decrease in erosion (~5 ft^3/ft/yr.) at site 12BL (i.e., more erosion when NFM is off). This was unexpected, but in reviewing the difference in WSELs between the two scenarios, the NFM "off" scenario showed a much smaller range of WSEL variability, thus impacting a smaller area of the bank surface (Figure 3.1-1). Such a smaller range of WSEL variability focuses the erosive forces for a greater duration along this section of the bank, which also coincides with a particularly weak layer of material. Further, in the lower TFI where the dominant cause of erosion is due to wave impact, if the water surface only ranges over a small portion of the bank, the waves impact more heavily on that small area. Together this resulted in greater bank undercutting and subsequent upper-bank failure.

Results of the BSTEM-Dynamic modeling runs were used to analyze and evaluate the primary causes of erosion including: (1) hydraulic shear stress due to flowing water; (2) water-level fluctuations due to hydropower operations; and (3) boat waves. From this analysis, dominant and contributing causes of erosion were identified and bank-erosion rates were calculated at the 25 detailed-study sites. For a cause to be considered dominant, it needs to have been responsible for at least 50% of the erosion at a site. For a cause to be considered contributing, it had to contribute to >5% of the erosion at the site. Based on the BSTEM-Dynamic results and using simulated erosion rates, a matrix of dominant and contributing causes was developed for the detailed-study sites (Table 3.1-2). The term Qe_{95} is the flow above which 95% of the erosion occurred, as determined from the hourly BSTEM-Dynamic results.

The role of high flows on bank-erosion rates was investigated by analyzing the hourly outputs from each time step in BSTEM-Dynamic. Using the same methodology as previously reported (FirstLight, 2017a), flows above which 5%, 50%, and 95% of all erosion occurs were identified for each site. Based on the results of this analysis, the dominant cause of erosion at all of the sites in the TFI with the exception of the three in the lower impoundment (9R, 12BL and BC1R), was found to be natural high flows. As shown in Table 3.1-2, no sites were identified as having Northfield Mountain operations as the dominant cause of erosion, while one site (8BR) was identified as having Northfield Mountain operations as a contributing cause. No sites were identified as having Vernon Project operations as either the dominant or contributing cause of erosion.

Average annual bank-erosion rates (in $ft^3/ft/yr.$) were simulated at each of the 25 locations for all four scenarios. Figure 3.1-2 shows a comparison of the distribution of water-surface elevations between Baseline NFM ON and AFLA for each of the reaches within the TFI. It can been seen that the differences in the distribution of WSELs increase with distance downstream from Vernon Dam. Operations as part of the AFLA scenario do not influence the distribution of WSELs until you reach the NFM reach. There is some impact in the lower reach and that is also compounded by the greater influence of waves. Results for all sites are shown in Table 3.1-3 and Figure 3.1-3.

As seen in Figure 3.1-3 the AFLA scenario results in a very small change from the Baseline scenario. The only significant change under the AFLA scenario is at 12BL (Figure 3.1-4). This increase in erosion is largely attributed to the greater size of multiple mass failures. The importance of the waves in creating undercuts and consequently, mass failures is apparent from the data shown in Table 3.1-3. Thus, waves were the largest contributor to erosion at this site. One thing to note in Figure 3.1-4, the AFLA scenario does not have as small a range of WSELs as the Baseline NFM OFF scenario. This is also observed in the results (Figure 3.1-3 and Table 3.1-3**)** where the total erosion at this site is less under the AFLA than the Baseline NFM OFF scenario.

Table 3.1-1: Results of BSTEM-Dynamic simulations showing average, annual bank-erosion rates expressed per unit length of channel (one foot) under Baseline (BL) conditions

Site	BL NFM ON Waves On	BL NFM ON Waves Off	BL NFM OFF Waves On
	ft^3/ft/yr.		
11L	0.07	0.07	0.07
2L	6.77	6.76	5.76
303BL	0.61	0.61	0.62
18L	1.41	1.37	1.21
3L	6.08	6.04	5.94
3R	0.33	0.32	0.32
21R	2.35	2.24	2.37
4L	0.02	0.01	0.02
29R	1.68	1.67	1.68
5CR	7.35	7.28	7.40
26R	1.13	1.06	1.17
10L	0.15	0.15	0.15
10R	0.00	0.00	0.00
6AL	0.00	0.00	0.00
6AR	0.02	0.00	0.02
119BL	6.02	5.96	5.79
7L	4.17	4.12	4.01
7R	1.95	1.93	1.96
8BL	0.36	0.36	0.38
8BR	0.73	0.73	0.66
87BL	3.58	3.66	3.75
75BL	3.42	3.45	3.62
9R	0.07	0.00	0.07
12BL	3.14	0.16	8.16
BC-1R	0.03	0.00	0.08

Table 3.1-2: Matrix of Dominant and Contributing causes of erosion under existing (Baseline) conditions

Site	Hydraulic Reach	Station	Total Erosion Under Baseline ($ft^3/ft/yr.$)	Dominant Causes				Contributing Causes			
				NFM Project Operations	High Flows	Vernon Operations	Boats	NFM Project Operations	High Flows	Moderate Flows	Boats
11L	4 - Upper	100000	0.07^	-	-	-	-	-	-	-	-
2L*		94500	6.77		X						
303BL		94000	0.61		X						
18L		87000	1.41		X						
3L		79500	6.08		X						
3R*		79500	0.33		X						
21R		79250	2.35		X						
4L	3 - Middle	74000	0.02^	-	-	-	-	-	-	-	-
29R		66000	Failure occurs at first time step, cannot determine primary cause(s)								
5CR		57250	7.35		X						
26R		50000	1.13		X						X
10L		49000	0.15^	-	-	-	-	-	-	-	-
10R*		49000	0.00^	-	-	-	-	-	-	-	-
6AL*		41750	0.00^	-	-	-	-	-	-	-	-
6AR*		41750	0.02^	-	-	-	-	-	-	-	-
119BL	2 - NFM	41000	6.02		X					X	
7L		37500	4.17		X						
7R		37500	1.95		X						
8BL		32750	0.36		X						
8BR*		32750	0.73		X			X			
87BL		30750	3.58		X					X	
75BL		27000	3.42		X					X	
9R*	1-Lower	6750	0.07^	-	-	-	-	-	-	-	-
12BL		6500	3.14				X				
BC-1R		4750	0.03^	-	-	-	-	-	-	-	-

* Indicates restoration site. Erosion amounts shown represent post-restoration condition

^ This amount falls below the 5th percentile of the total erosion (0.161 $ft^3/ft/yr.$) modeled for all sites and is within the minimum survey error used for calibration. Because this amount of total erosion falls below what is considered a measurable amount of erosion, assigning a cause to that erosion would not be appropriate.

Table 3.1-3: Results of BSTEM-Dynamic simulations showing average, annual bank-erosion rates expressed per unit length of channel (one foot) under Baseline (BL) conditions and for the AFLA Scenario

Site	BL NFM ON Waves On	BL NFM ON Waves Off	BL NFM OFF Waves On	AFLA Waves On
	ft^3/ft/yr.			
11L	0.07	0.07	0.07	0.07
2L	6.77	6.76	5.76	6.48
303BL	0.61	0.61	0.62	0.62
18L	1.41	1.37	1.21	1.15
3L	6.08	6.04	5.94	6.05
3R	0.33	0.32	0.32	0.32
21R	2.35	2.24	2.37	2.33
4L	0.02	0.01	0.02	0.02
29R	1.68	1.67	1.68	1.68
5CR	7.35	7.28	7.40	7.32
26R	1.13	1.06	1.17	1.16
10L	0.15	0.15	0.15	0.16
10R	0.00	0.00	0.00	0.00
6AL	0.00	0.00	0.00	0.00
6AR	0.02	0.00	0.02	0.02
119BL	6.02	5.96	5.79	5.89
7L	4.17	4.12	4.01	4.25
7R	1.95	1.93	1.96	2.00
8BL	0.36	0.36	0.38	0.37
8BR	0.73	0.73	0.66	0.81
87BL	3.58	3.66	3.75	3.64
75BL	3.42	3.45	3.62	3.68
9R	0.07	0.00	0.07	0.07
12BL	3.14	0.16	8.16	7.36
BC-1R	0.03	0.00	0.08	0.02

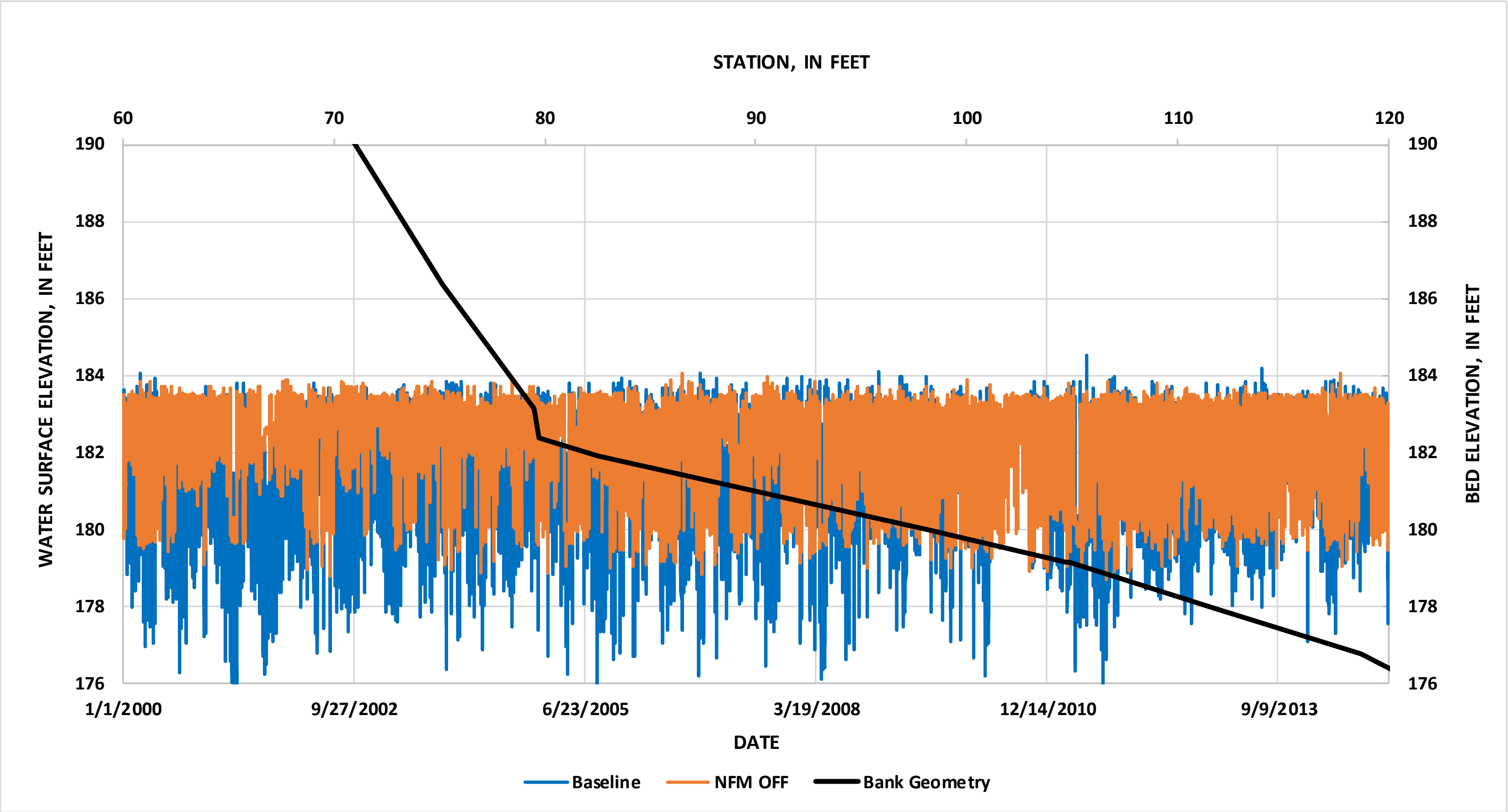

Figure 3.1-1: Comparison of Baseline NFM ON and NFM OFF scenarios at Site 12BL

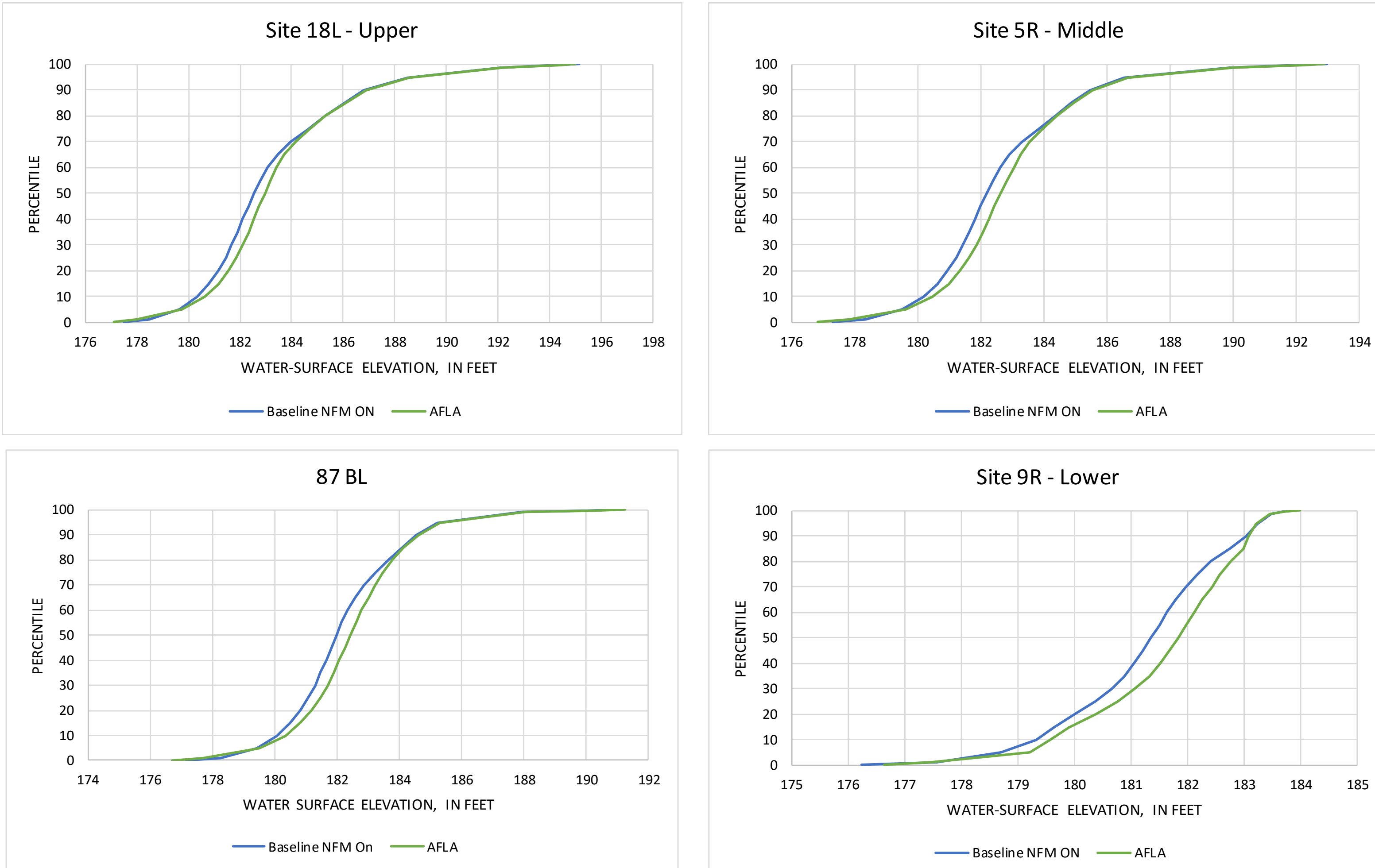

Figure 3.1-2: Comparison of the distribution of water-surface elevation under Baseline conditions and the AFLA Scenario for a representative site in each of the four reaches of the TFI

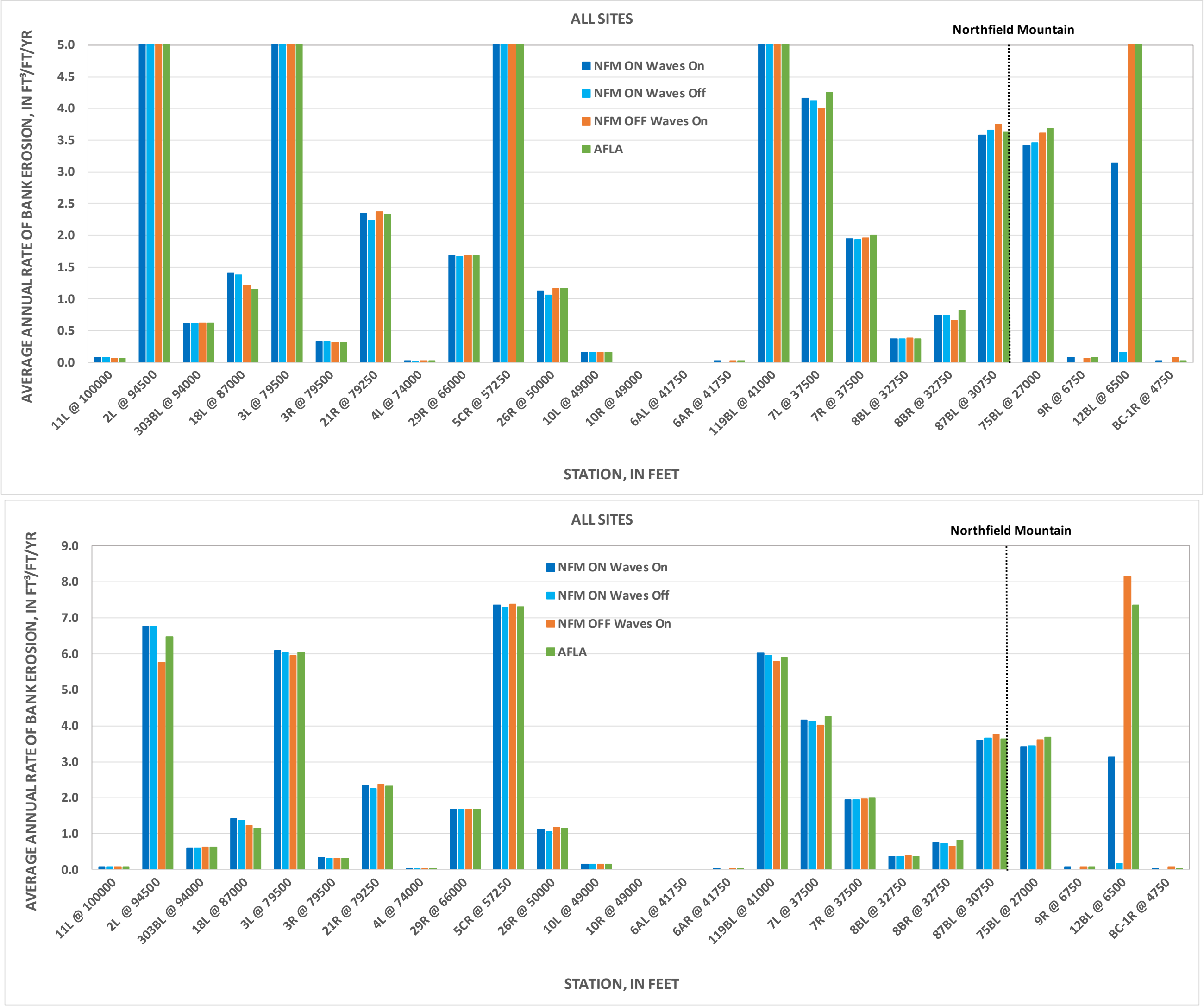

Figure 3.1-3: Average, annual bank-erosion rates per unit length (one foot) of channel length under Baseline conditions and the AFLA Scenario.

Top plot has a reduced y-axis scale to show greater detail. The effect of AFLA operations is the difference between the height of the green and dark blue bars

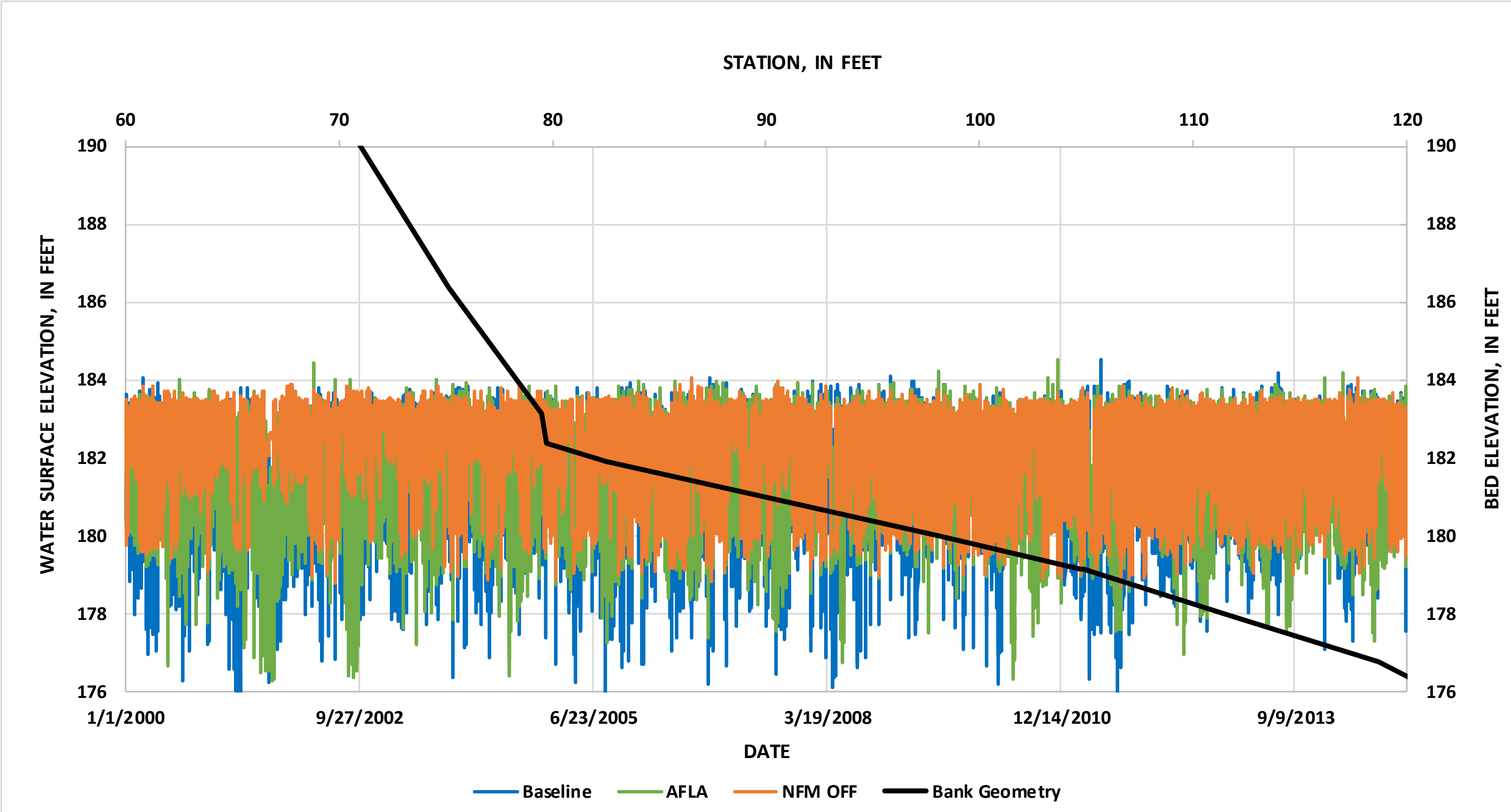

Figure 3.1-4: Comparison of Baseline NFM ON, NFM OFF, and AFLA scenarios at Site 12BL

3.2 Dominant and Contributing Causes of Bank Erosion Under AFLA Conditions

To determine the impact of the AFLA on TFI bank erosion, the difference in bank-erosion rates between the Baseline and AFLA scenarios with waves on were calculated. As shown in Table 3.2-1, the AFLA scenario had no measurable increase on bank-erosion rates in the upper and middle impoundment. There is some impact in the Northfield Mountain reach, with an increase in erosion rate at sites 7L, 7R, 8 BL, 8BR, 87 BL, and 75 BL. While most of the sites in the NFM reach show an increase in erosion rate under AFLA, only the increase in erosion rates at sites 8 BR and 75 BL were large enough to be classified as a contributing cause of erosion (>5%) (Table 3.2-2). The remaining sites showed less than a 5% increase.

Site 12BL in the lower TFI also showed an increase in erosion rate under the AFLA. The majority of this erosion is again due to failures induced by waves. Comparing only the erosion with waves off the difference is an increase of 0.08 ft^3/ft/yr. (2.4%).

Table 3.2-1: Differences in unit bank-erosion rates as a result of AFLA

Transects	Hydraulic Reach	AFLA-BL
		$ft^3/ft/yr.$
11L	4 - Upper	-0.01
2L		-0.29
303BL		0.01
18L		-0.26
3L		-0.03
3R		-0.01
21R		-0.02
4L	3 - Middle	0.00
29R		0.00
5CR		-0.03
26R		0.03
10L		0.01
10R		0.00
6AL		0.00
6AR		0.00
119BL	2 - NFM	-0.12
7L		0.09
7R		0.05
8BL		0.00
8BR		0.08
87BL		0.05
75BL		0.26
9R	1 - Lower	0.00
12BL*		0.08
BC-1R		-0.01

*Comparison with waves off

Table 3.2-2: Matrix of Dominant and Contributing Causes of Erosion under the AFLA

Site	Hydraulic Reach	Station	Total Erosion Under Baseline ($ft^3/ft/yr.$)	Dominant Causes				Contributing Causes			
				Cumulative Proposed Ops Changes	High Flows	Vernon Operations	Boats	Cumulative Proposed Ops Changes	High Flows	Moderate Flows	Boats
11L	4 - Upper	100000	0.07^	-	-	-	-	-	-	-	-
2L*		94500	6.48		X						
303BL		94000	0.62		X						
18L		87000	1.15		X						
3L		79500	6.05		X						
3R*		79500	0.32		X						
21R		79250	2.33		X						
4L	3 - Middle	74000	0.02^	-	-	-	-	-	-	-	-
29R		66000	Failure occurs at first time step, cannot determine primary cause(s)								
5CR		57250	7.32		X						
26R		50000	1.16		X						X
10L		49000	0.16^	-	-	-	-	-	-	-	-
10R*		49000	0.00^	-	-	-	-	-	-	-	-
6AL*		41750	0.00^	-	-	-	-	-	-	-	-
6AR*		41750	0.02^	-	-	-	-	-	-	-	-
119BL	2 - NFM	41000	5.89		X					X	
7L		37500	4.25		X						
7R		37500	2.00		X						
8BL		32750	0.37		X						
8BR*		32750	0.81		X			X			
87BL		30750	3.64		X					X	X
75BL		27000	3.68		X			X			
9R*	1 - Lower	6750	0.07^	-	-	-	-	-	-	-	-
12BL		6500	7.36				X				
BC-1R		4750	0.02^	-	-	-	-	-	-	-	-

4 SUMMARY

The purpose of this evaluation was to quantify the change in bank-erosion rates under the AFLA Scenario when compared to Baseline conditions. The difference in bank-erosion rates between the two scenarios (as determined by BSTEM) would indicate what impact, if any, the AFLA would have on streambank erosion in the TFI. In addition to BSTEM, HEC-ResSim and HEC-RAS models were utilized to satisfy the goals of this evaluation.

The results of the BSTEM modeling found that the AFLA Scenario had minimal impact on bank-erosion rates when compared to Baseline conditions. As expected, although minor, sites within the NFM reach show the greatest increase in erosion due to the AFLA. One site in the lower impoundment (i.e., 12BL) also shows an increase in erosion due to boat wakes under the AFLA. Increases in erosion rates at such sites are limited and are vastly smaller than the erosion resulting from high flows beyond the control of Project operations. The only sites that show enough of an increase in erosion to be classified as a contributing cause (>5%) under the AFLA cumulative operational changes was site 8BR and 75BL (erosion at site 12BL was the result of boat wakes, not Project operations).

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FirstLight. (2017a). Relicensing Study 3.1.2 Northfield Mountain / Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability Study Report. Prepared for FirstLight Power Resources. Northfield, MA: Author.

FirstLight. (2017b). Relicensing Study 3.1.2 Northfield Mountain / Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability Evaluating the Impact of Increasing the Useable Storage Volume of the Upper Reservoir on Streambank Erosion in the Turners Falls Impoundment. Prepared for FirstLight Power Resources. Northfield, MA: Author.

FirstLight. (2020). Amended Final Application for New License for Major Water Power Project – Existing Dam Turners Falls Hydroelectric Project (FERC Project Number 1889) and Northfield Mountain Pumped Storage Project (FERC Project Number 2485) Exhibit E – Environmental Report. Prepared for FirstLight MA Hydro LLC and Northfield Mountain LLC. Northfield, MA: Author.

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Appendix A- Water Resources- Duration Curves

- Monthly and annual duration curves of TFI WSEL at the Turners Falls Dam under Historic (Observed 2000-2016) and Modeled Baseline (1962-2003) Conditions;
- Monthly and annual duration curves of inflow to the TFI under Historic (Observed Calculated 1941-2016) and Modeled Baseline (1962-2003) Conditions; and
- Monthly and annual duration curves of flow at the Montague USGS Gage under Historic (Observed 1941-2016) and Modeled Baseline (1962-2003).

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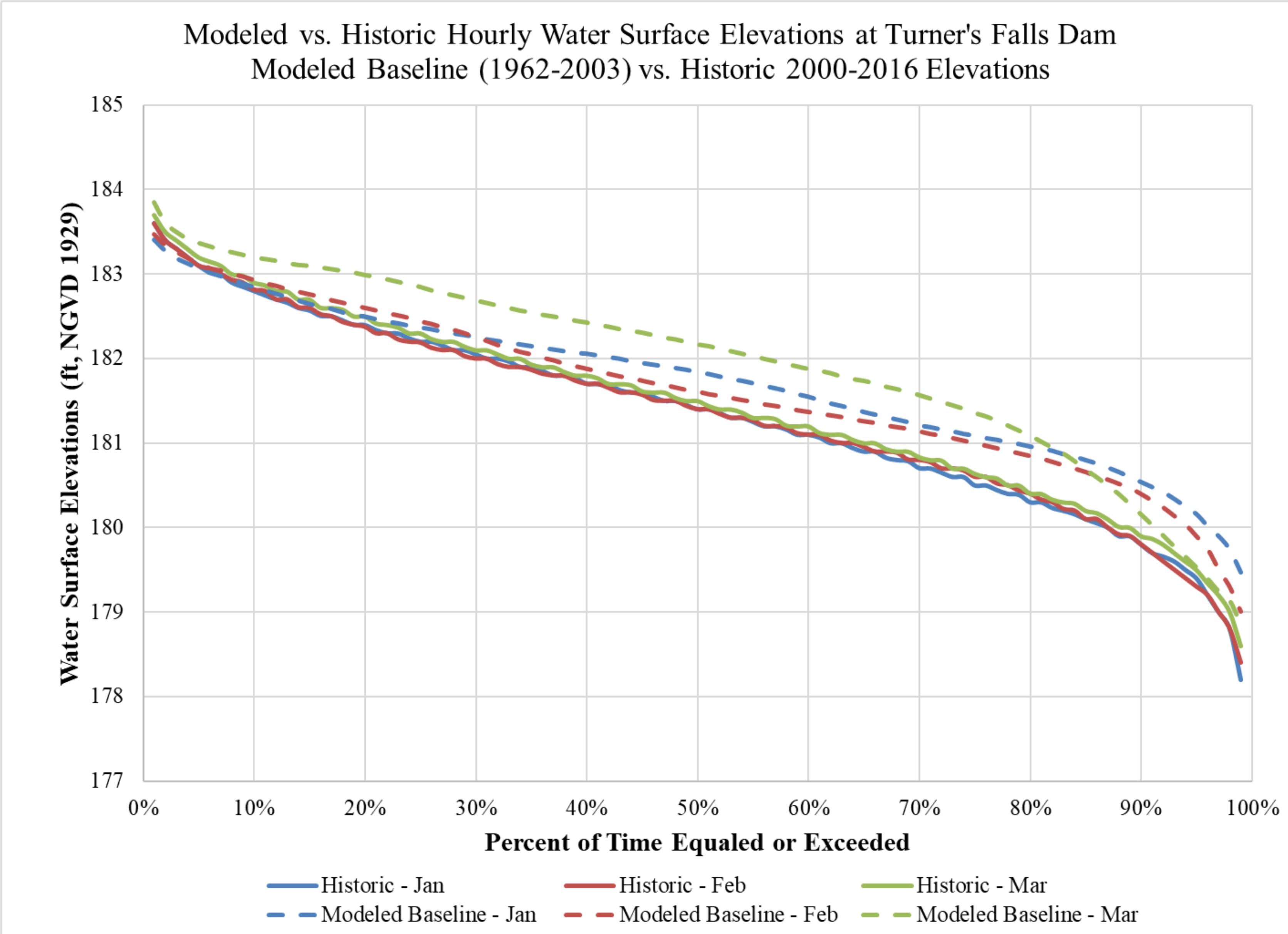
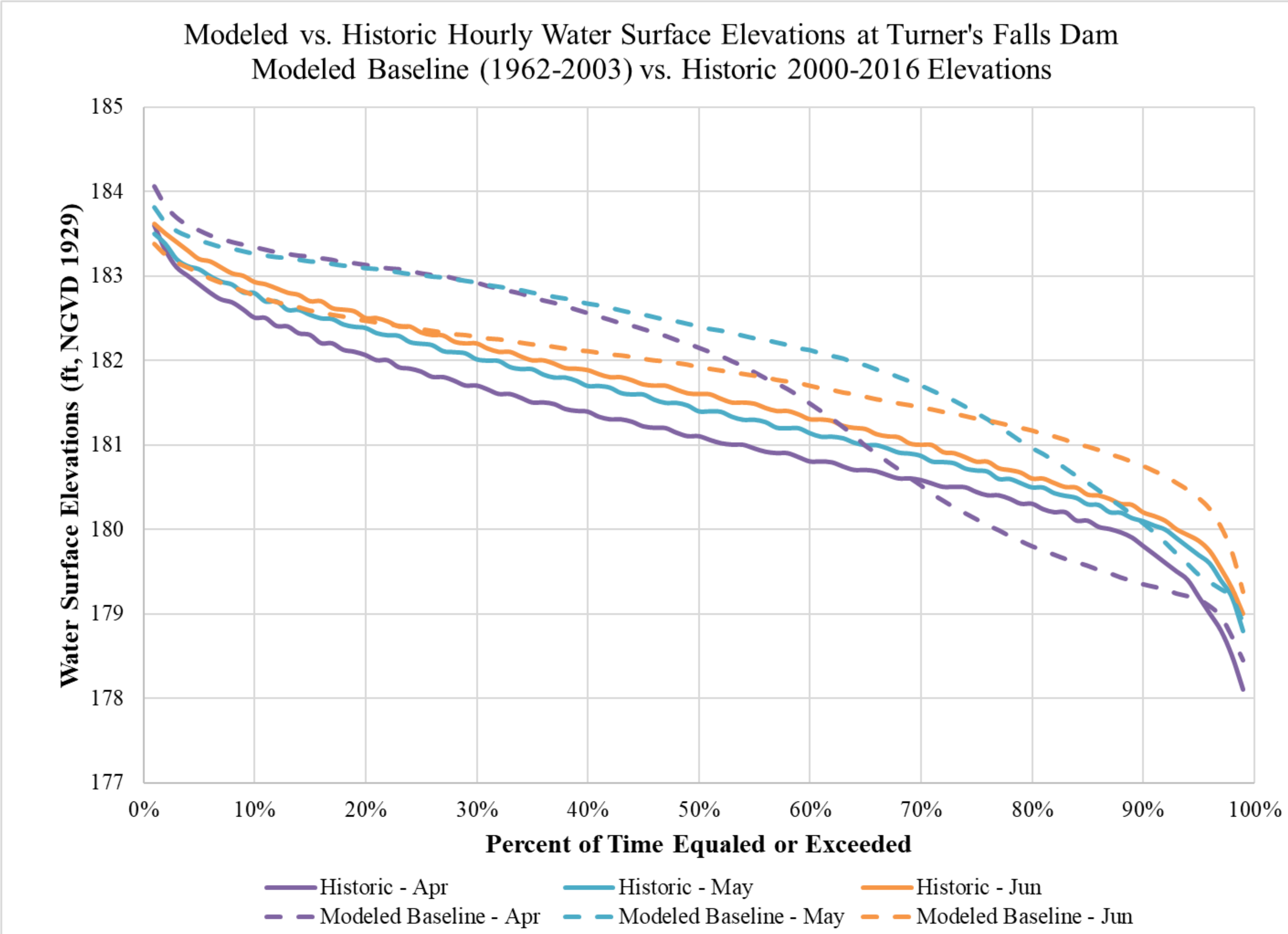
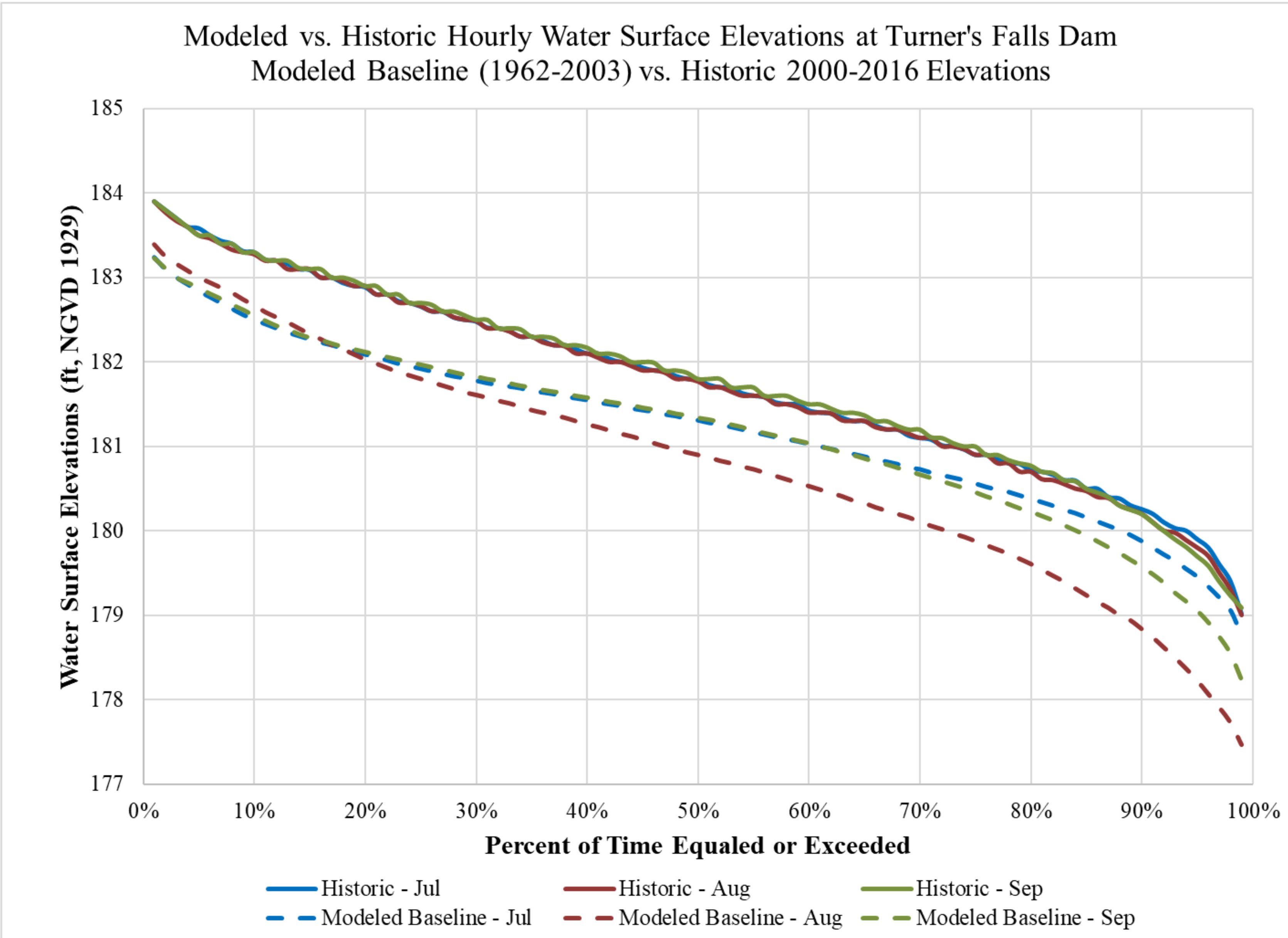
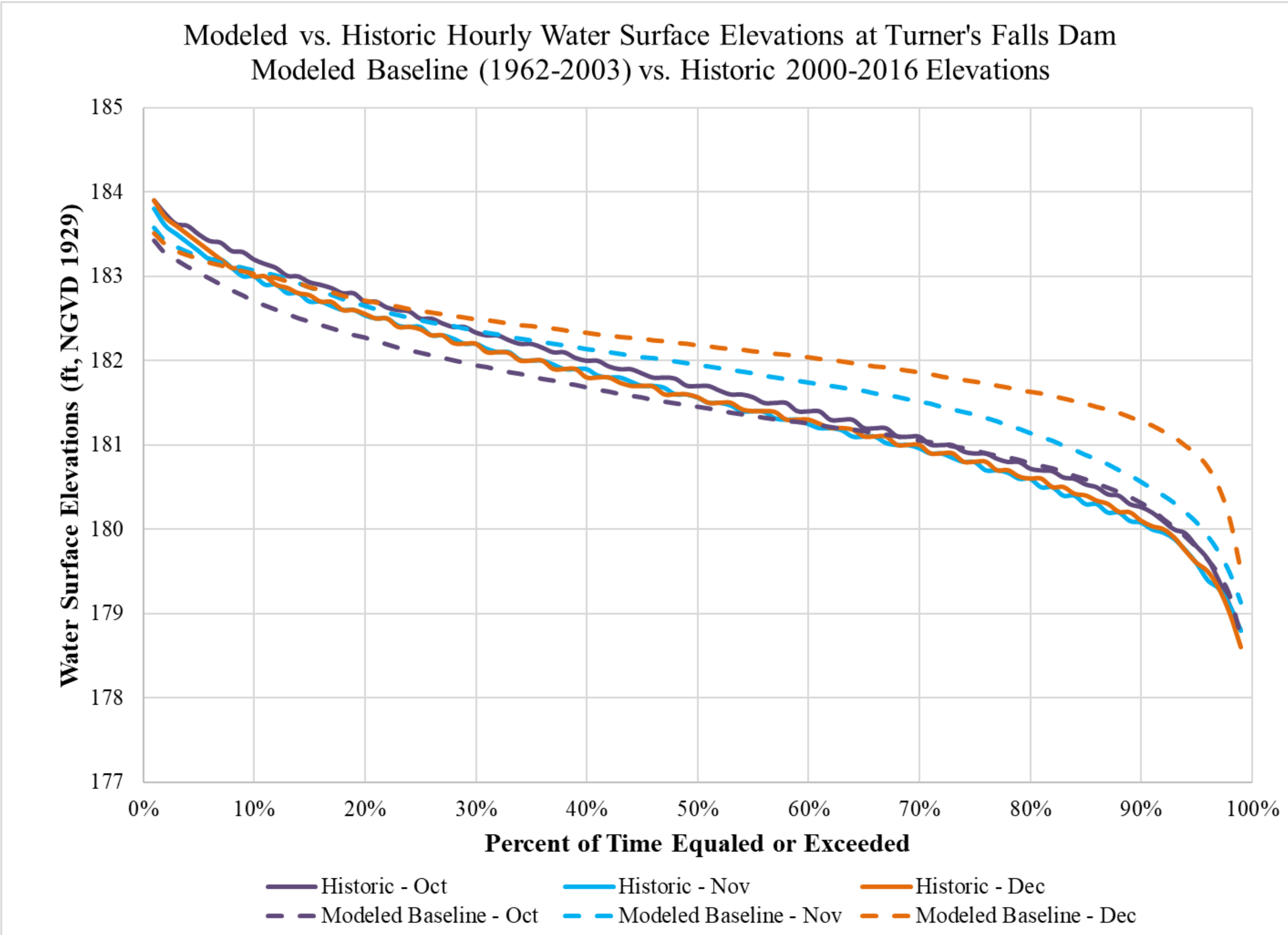

Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
185
184
183
182
181
180
179
178
177
Water Surface Elevations (ft, NGVD 1929)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline - Jan
Modeled Baseline - Feb
Modeled Baseline - Mar

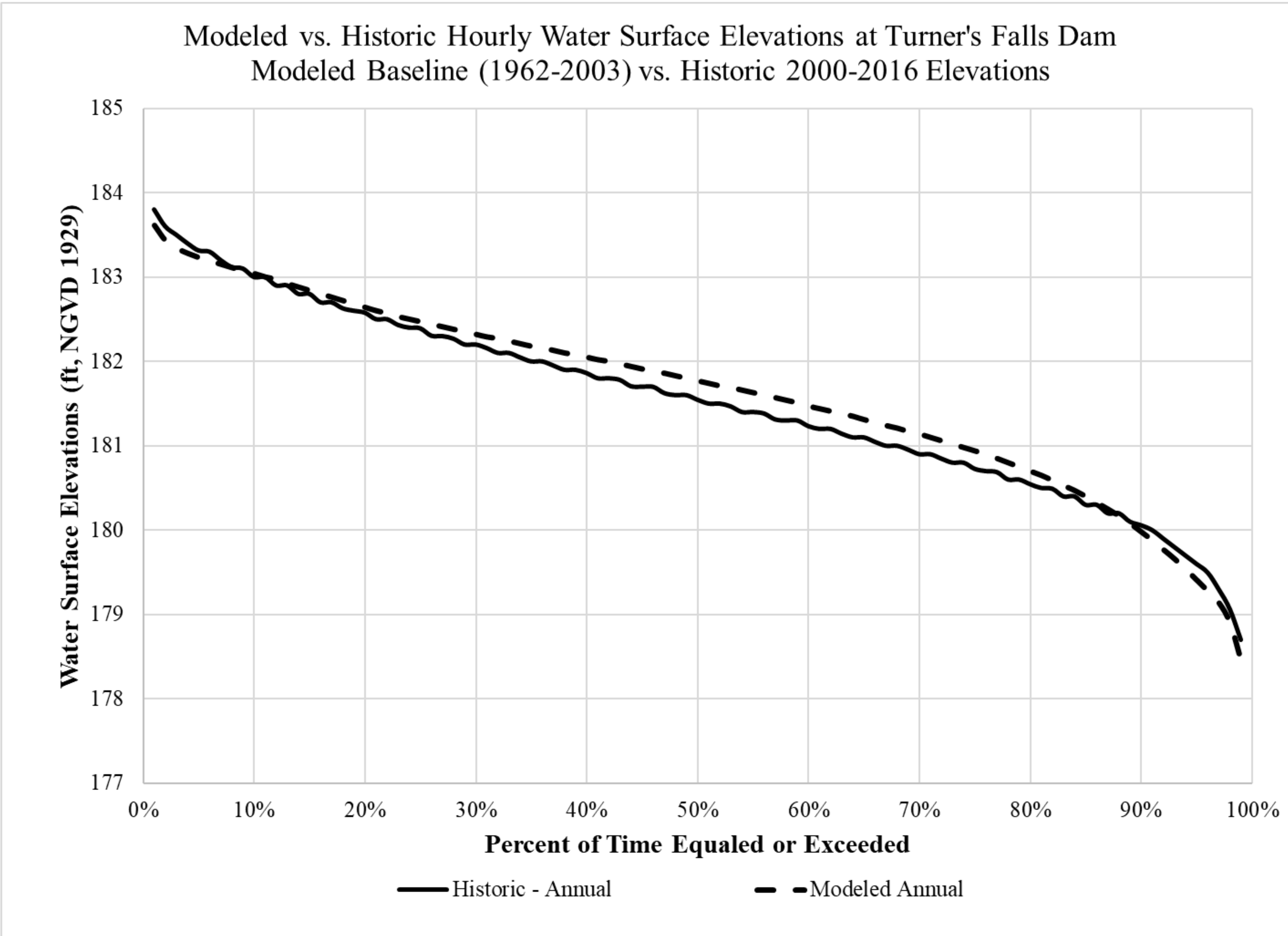


Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Historic - May
Historic - Jun
Modeled Baseline - Apr
Modeled Baseline - May
Modeled Baseline - Jun

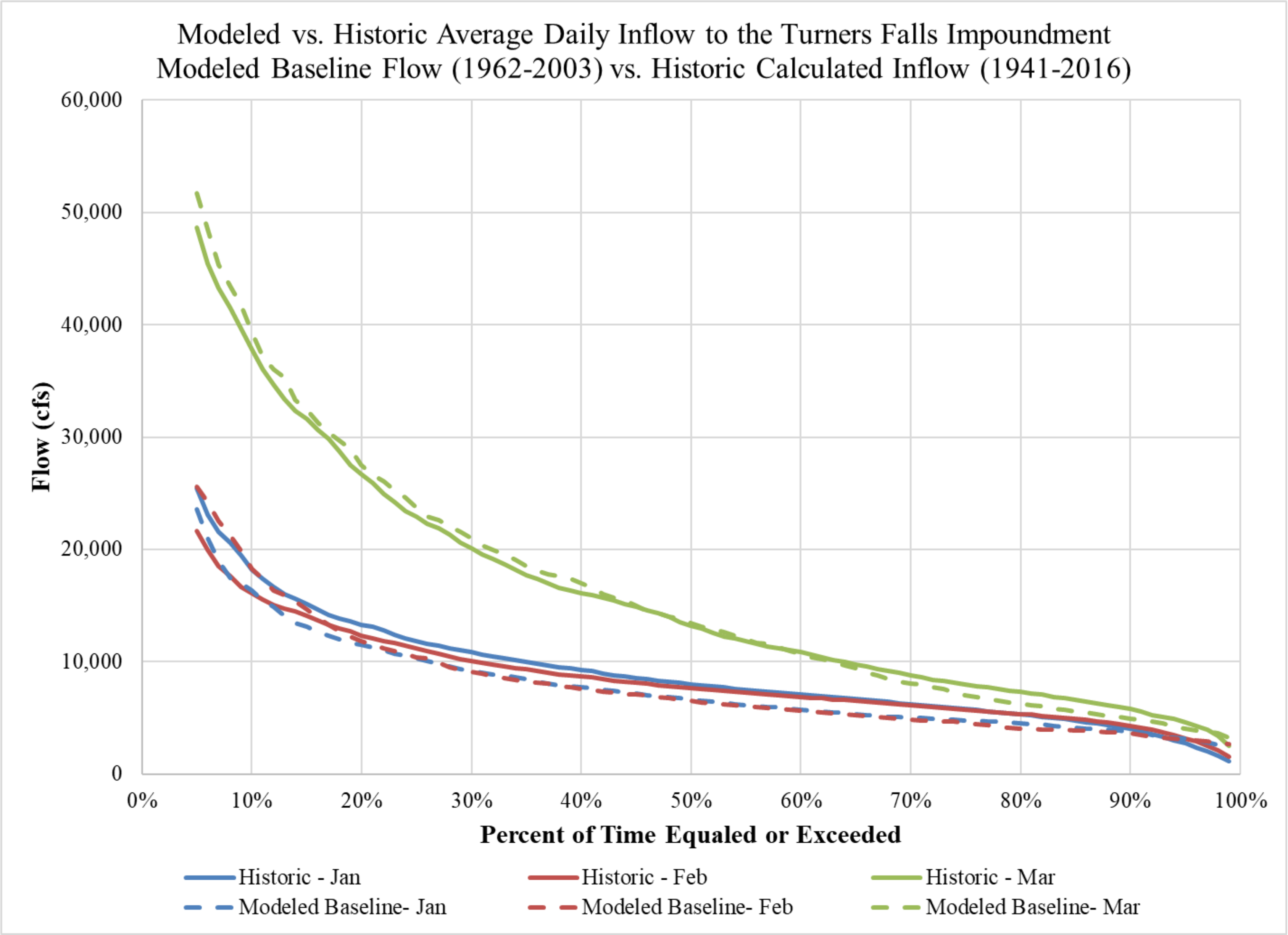


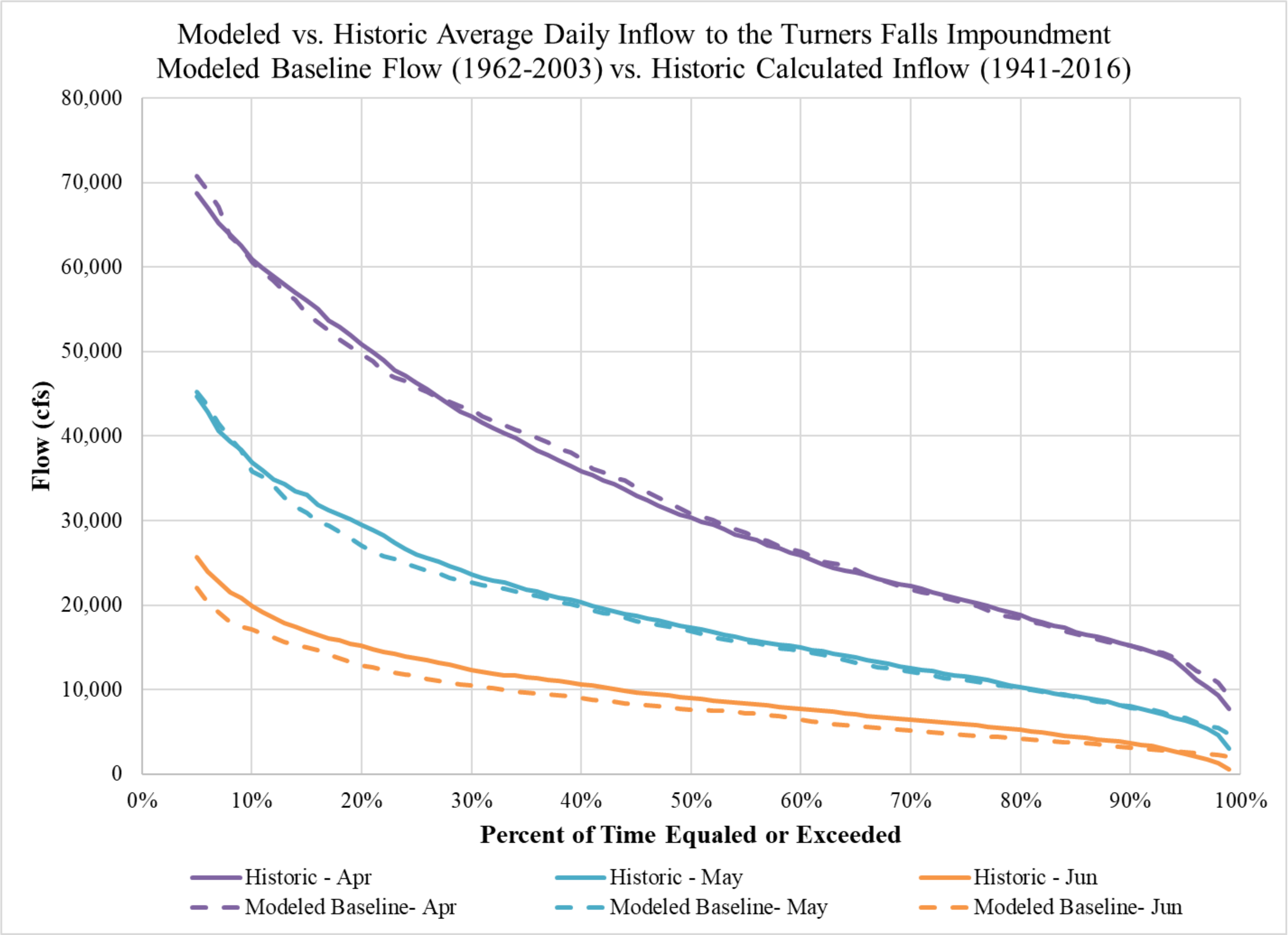
Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline - Jul
Modeled Baseline - Aug
Modeled Baseline - Sep

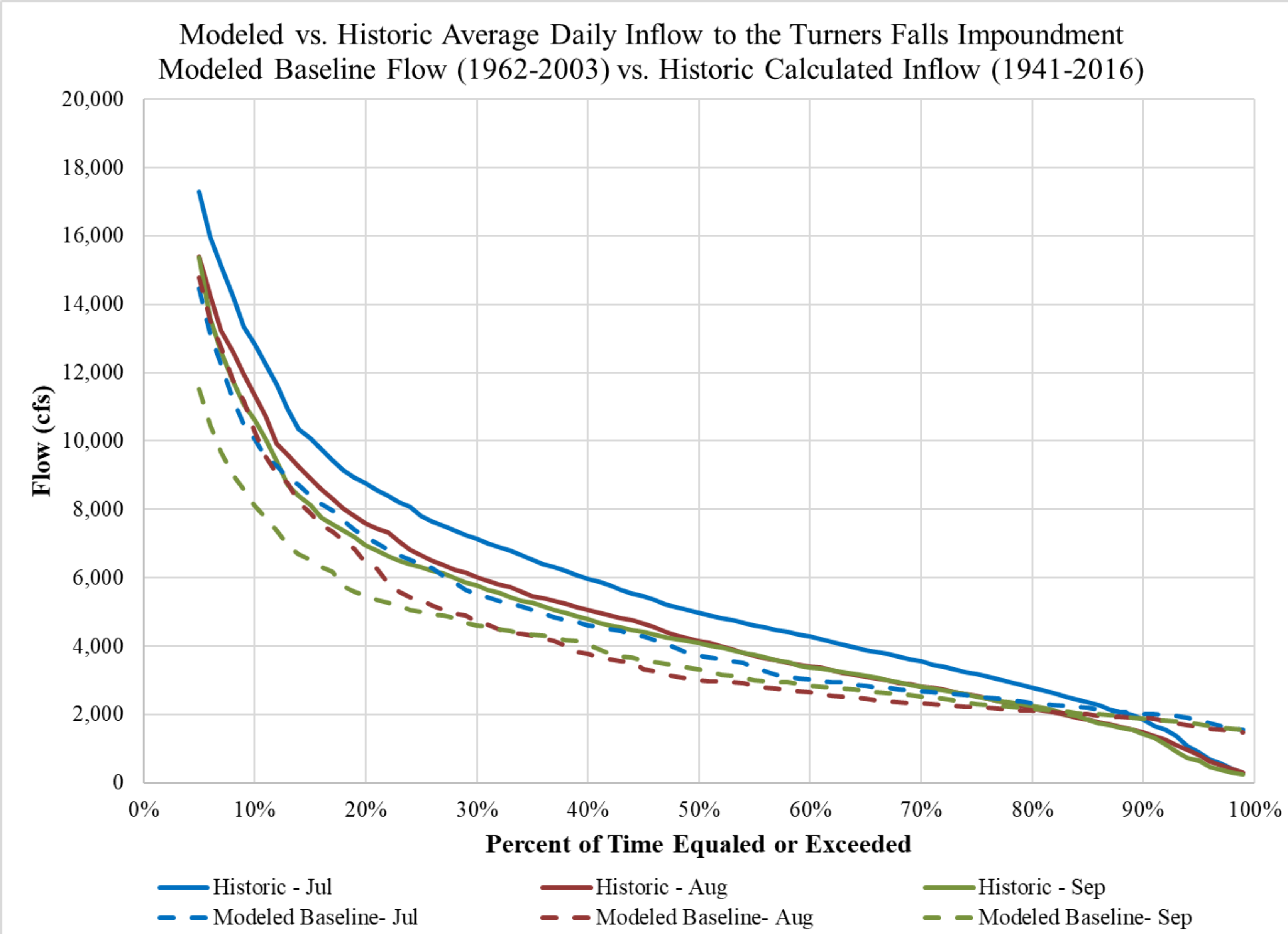

Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline - Oct
Modeled Baseline - Nov
Modeled Baseline - Dec



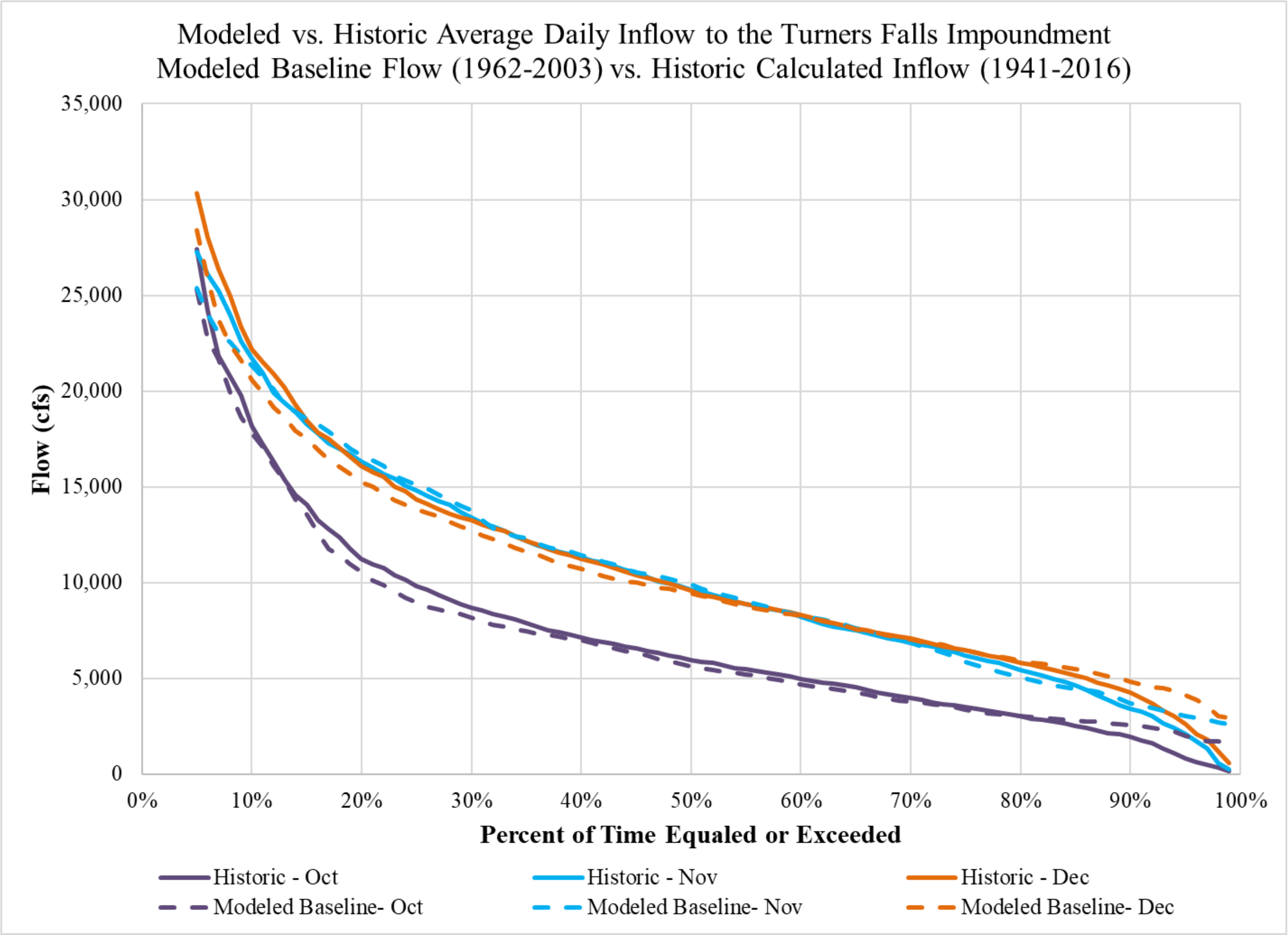
Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Annual

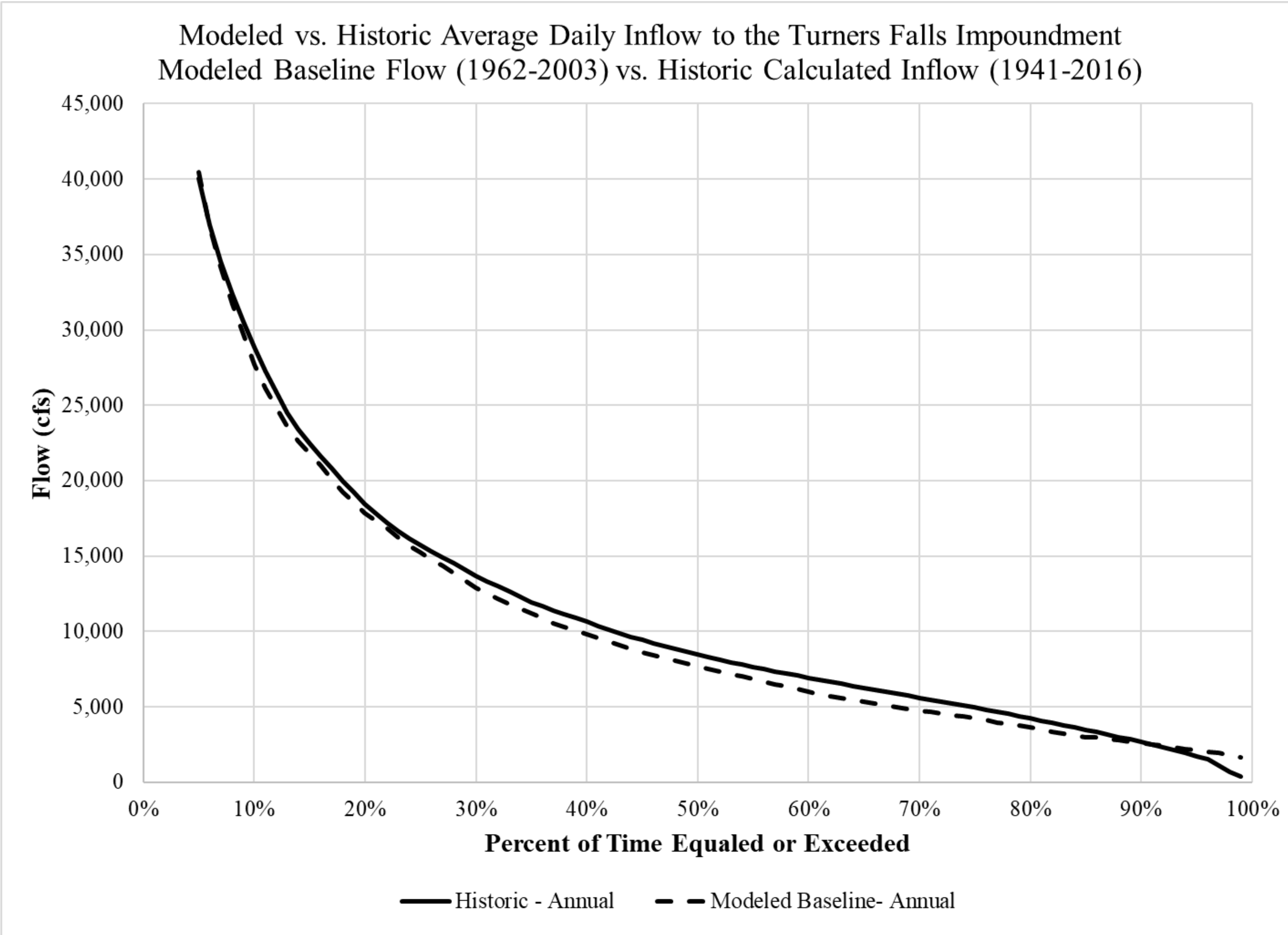

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
Flow (cfs)
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline- Jan
Modeled Baseline- Feb
Modeled Baseline- Mar

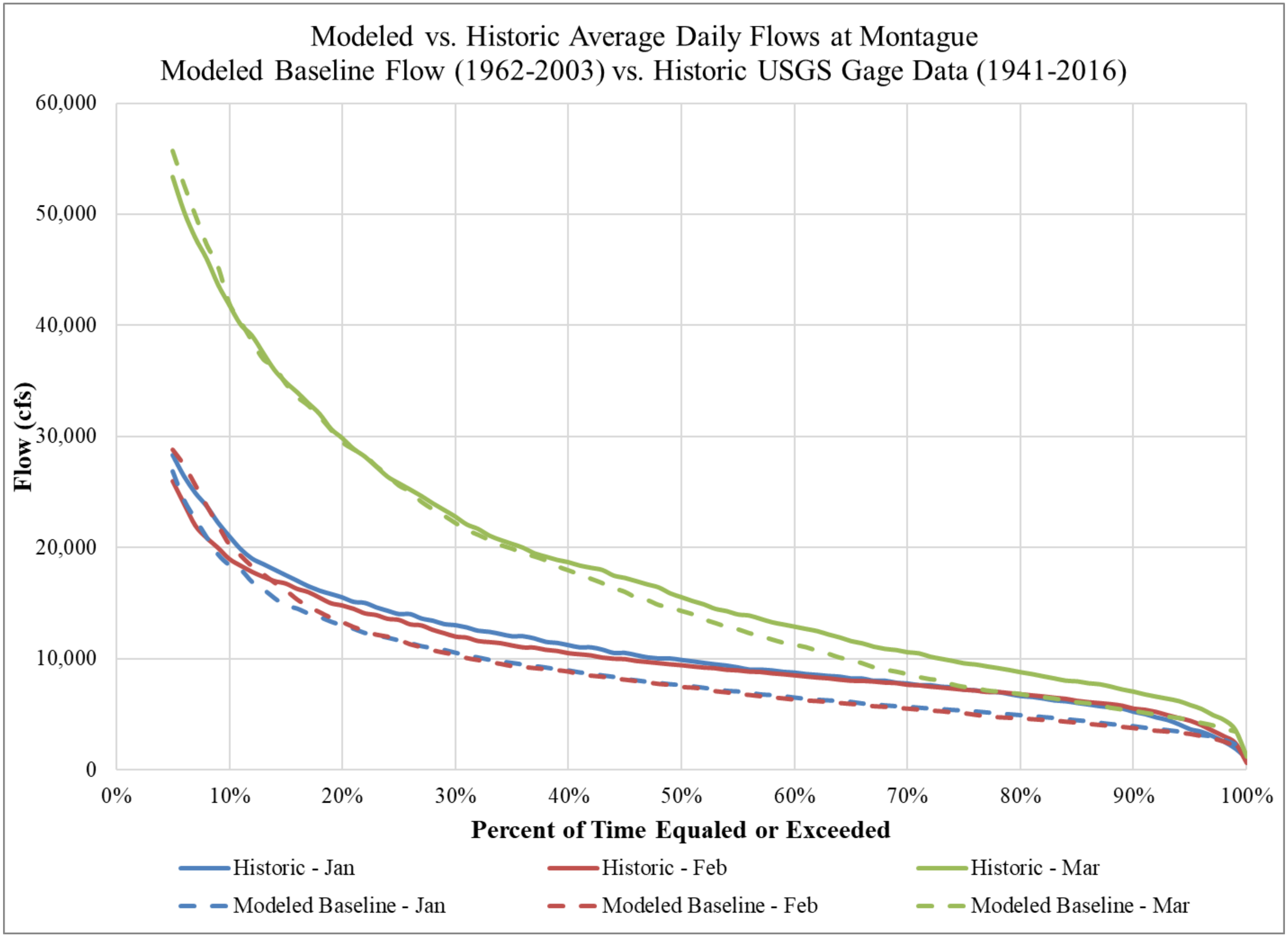

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
Flow (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Modeled Baseline- Apr
Historic - May
Modeled Baseline- May
Historic - Jun
Modeled Baseline- Jun

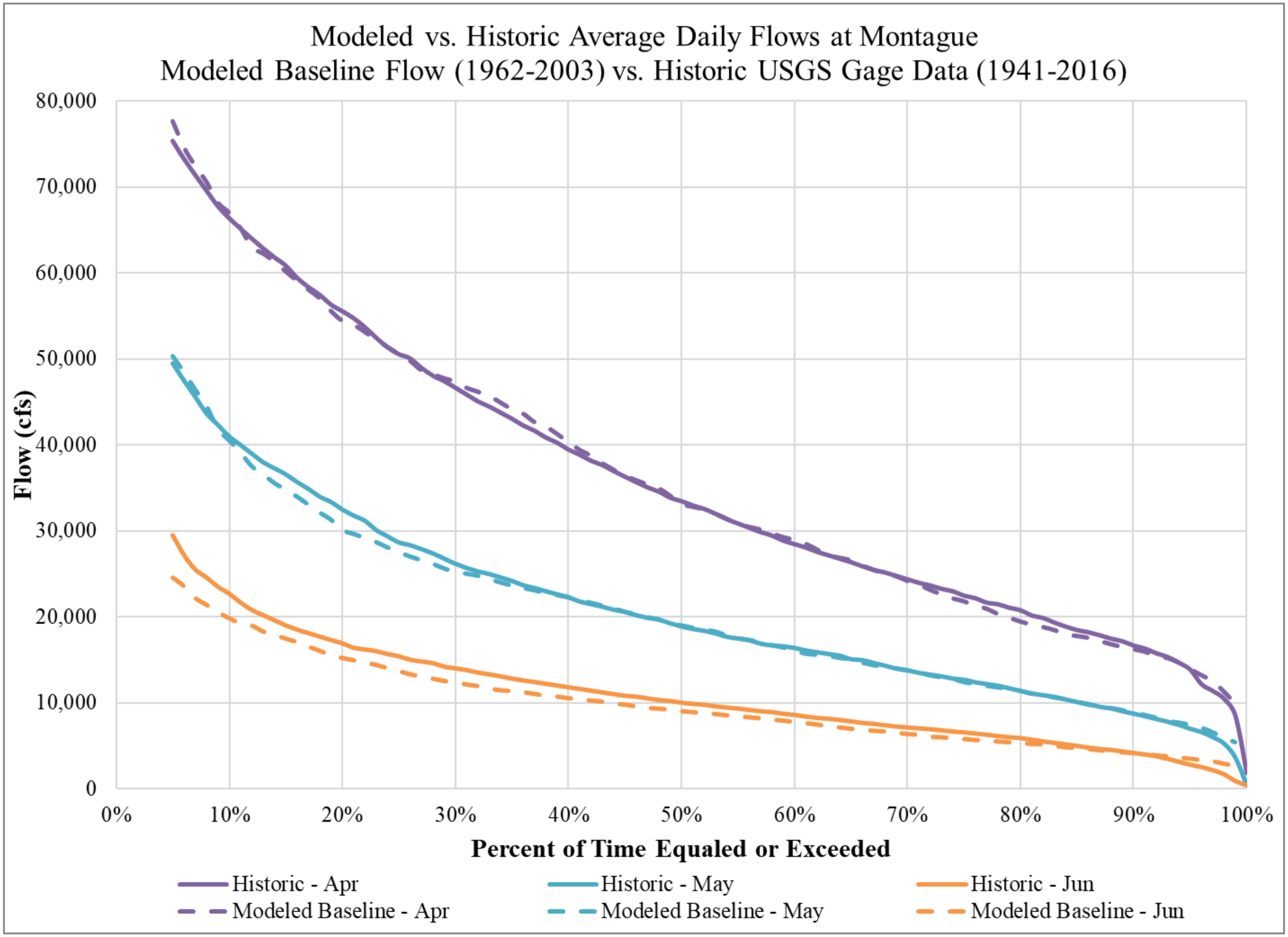


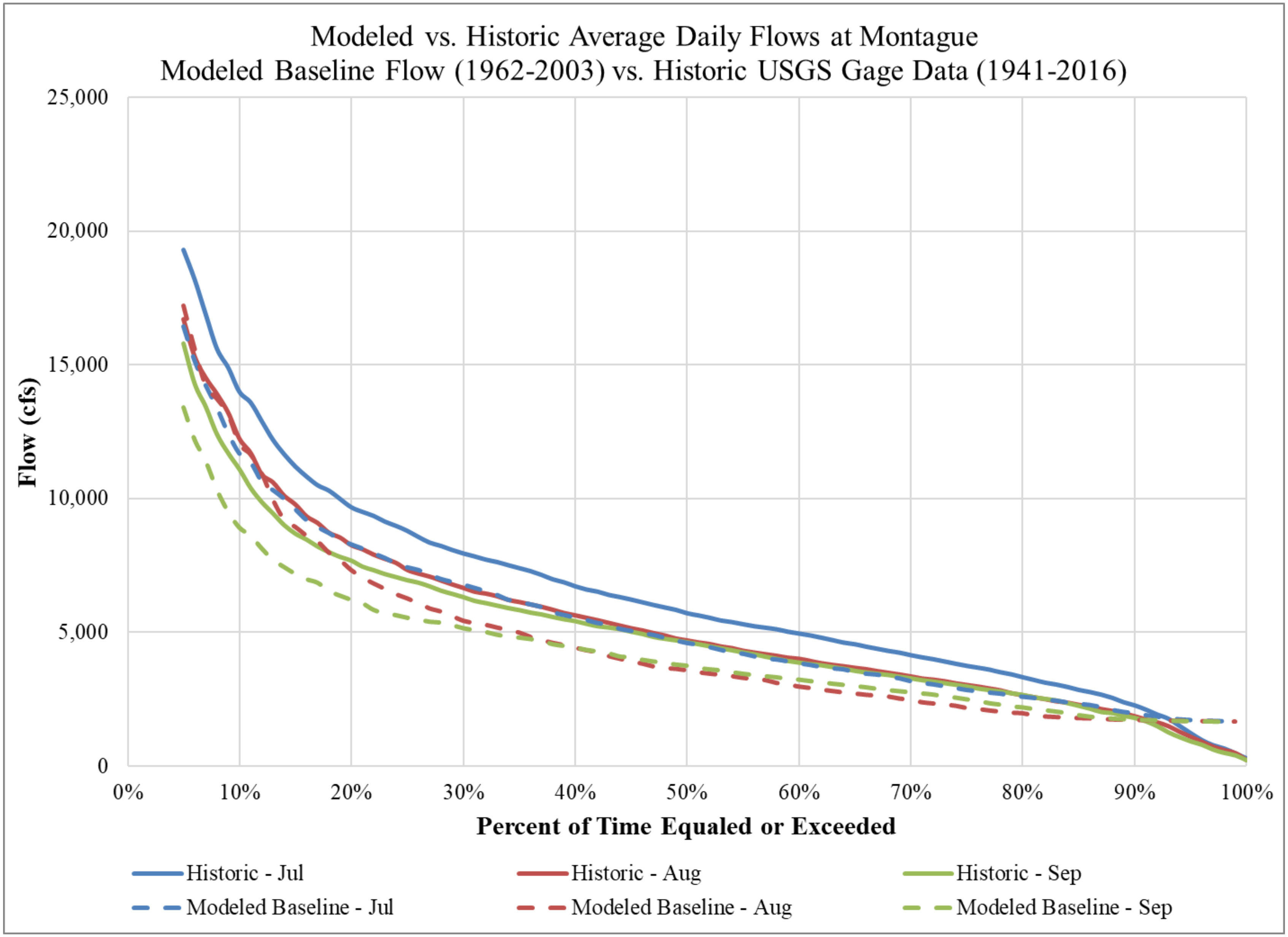
Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline- Jul
Modeled Baseline- Aug
Modeled Baseline- Sep

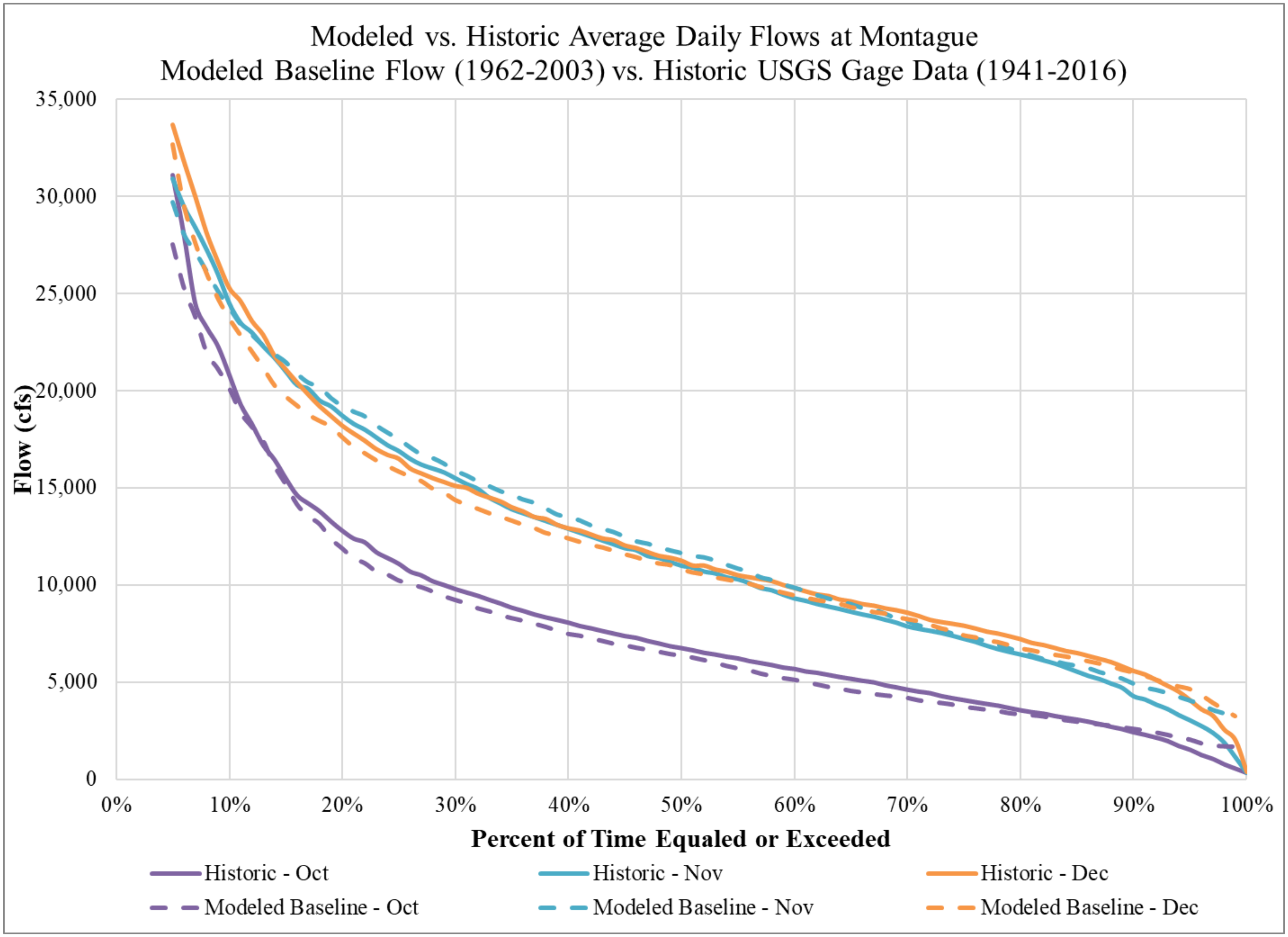

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline- Oct
Modeled Baseline- Nov
Modeled Baseline- Dec

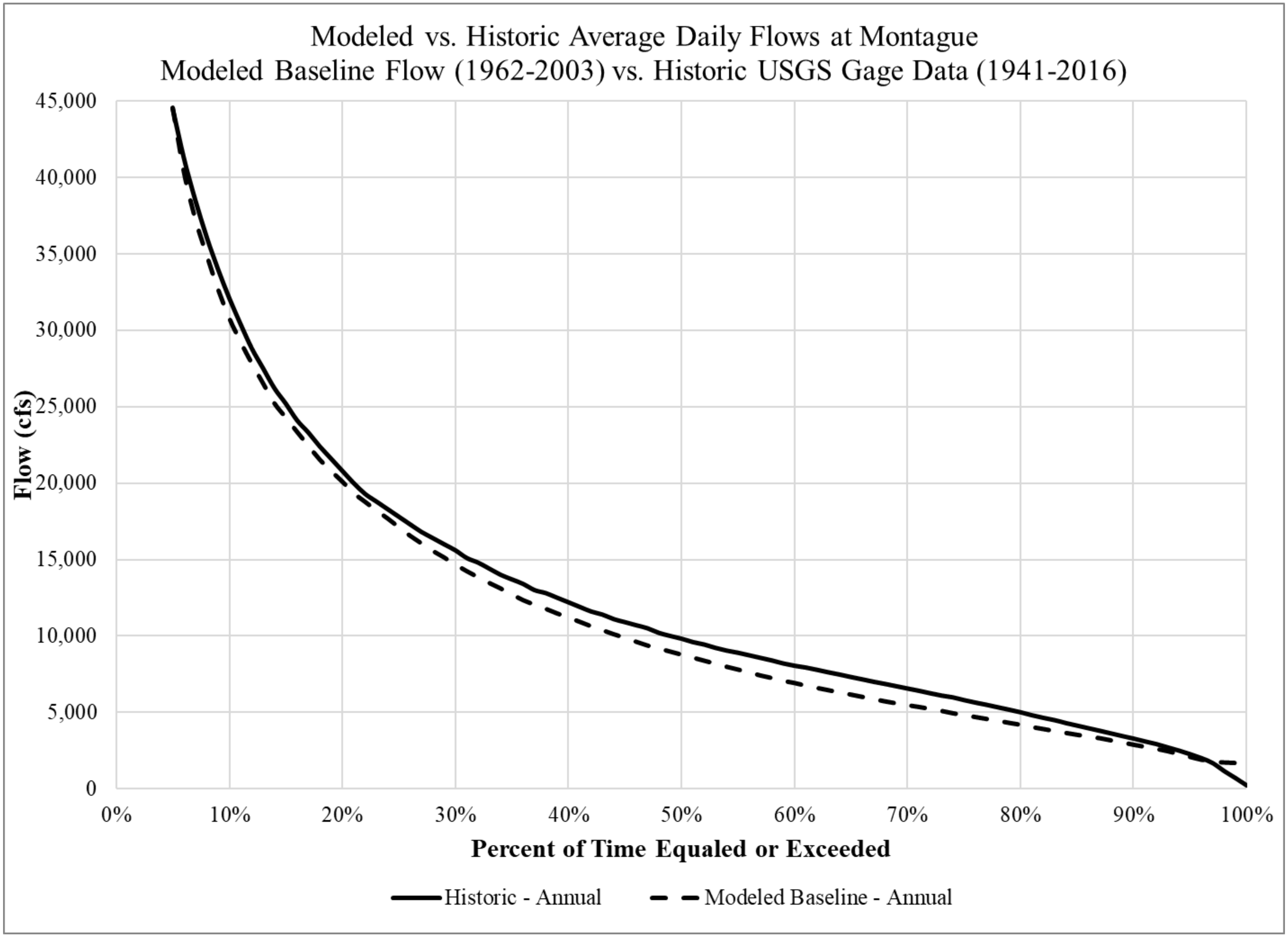

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Baseline- Annual


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline - Jan
Modeled Baseline - Feb
Modeled Baseline - Mar


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Historic - May
Historic - Jun
Modeled Baseline - Apr
Modeled Baseline - May
Modeled Baseline - Jun


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline - Jul
Modeled Baseline - Aug
Modeled Baseline - Sep


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline - Oct
Modeled Baseline - Nov
Modeled Baseline - Dec



Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Baseline - Annual

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Appendix B- Water Resources- TFI Rating Curves

Rating Curves at the following transects in the Turners Falls Impoundment

- Near Vernon Dam about 19.9 miles above Turners Falls Dam (above French King Gorge)
- Upstream of Stebbins Island about 19.1 miles above Turners Falls Dam (above French King Gorge)
- Pauchaug Boat Launch about 13.4 miles above Turners Falls Dam (above French King Gorge)
- Munn’s Ferry about 8.4 miles above Turners Falls Dam (above French King Gorge)
- Northfield Mountain Tailrace about 5.1 miles above Turners Falls Dam (above French King Gorge)
- Cabot Camp about 3.7 miles above Turners Falls Dam (below French King Gorge)

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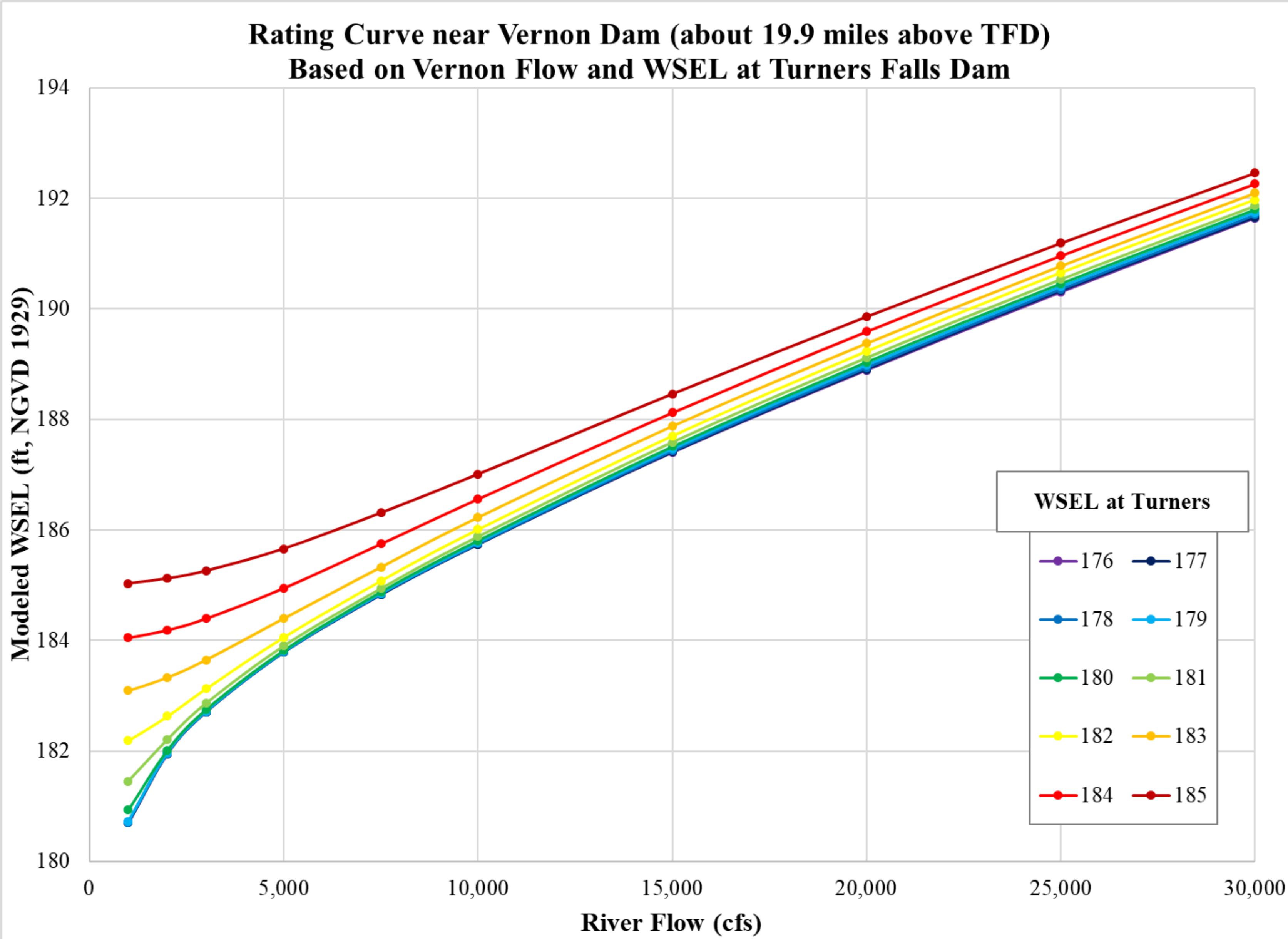
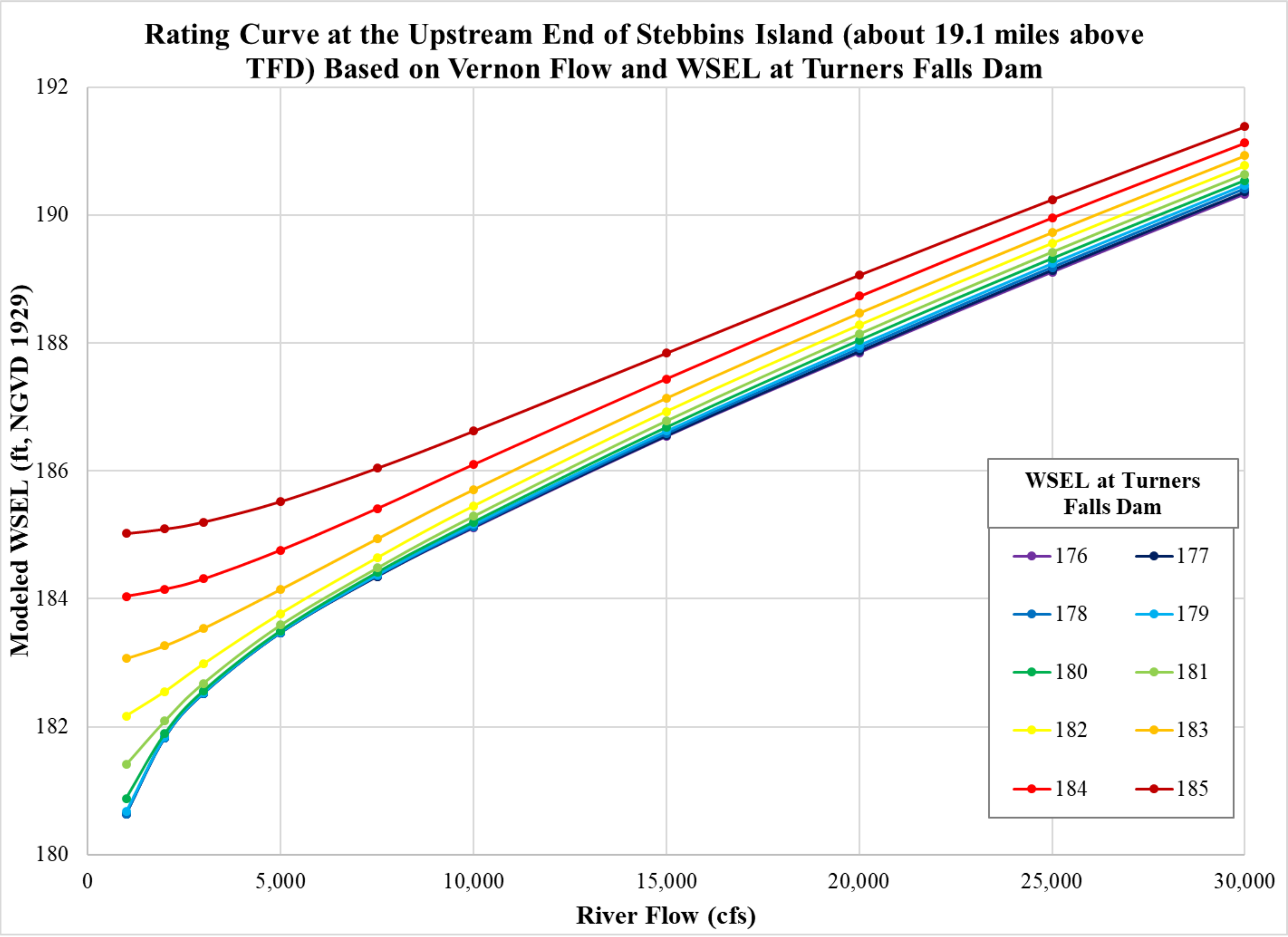
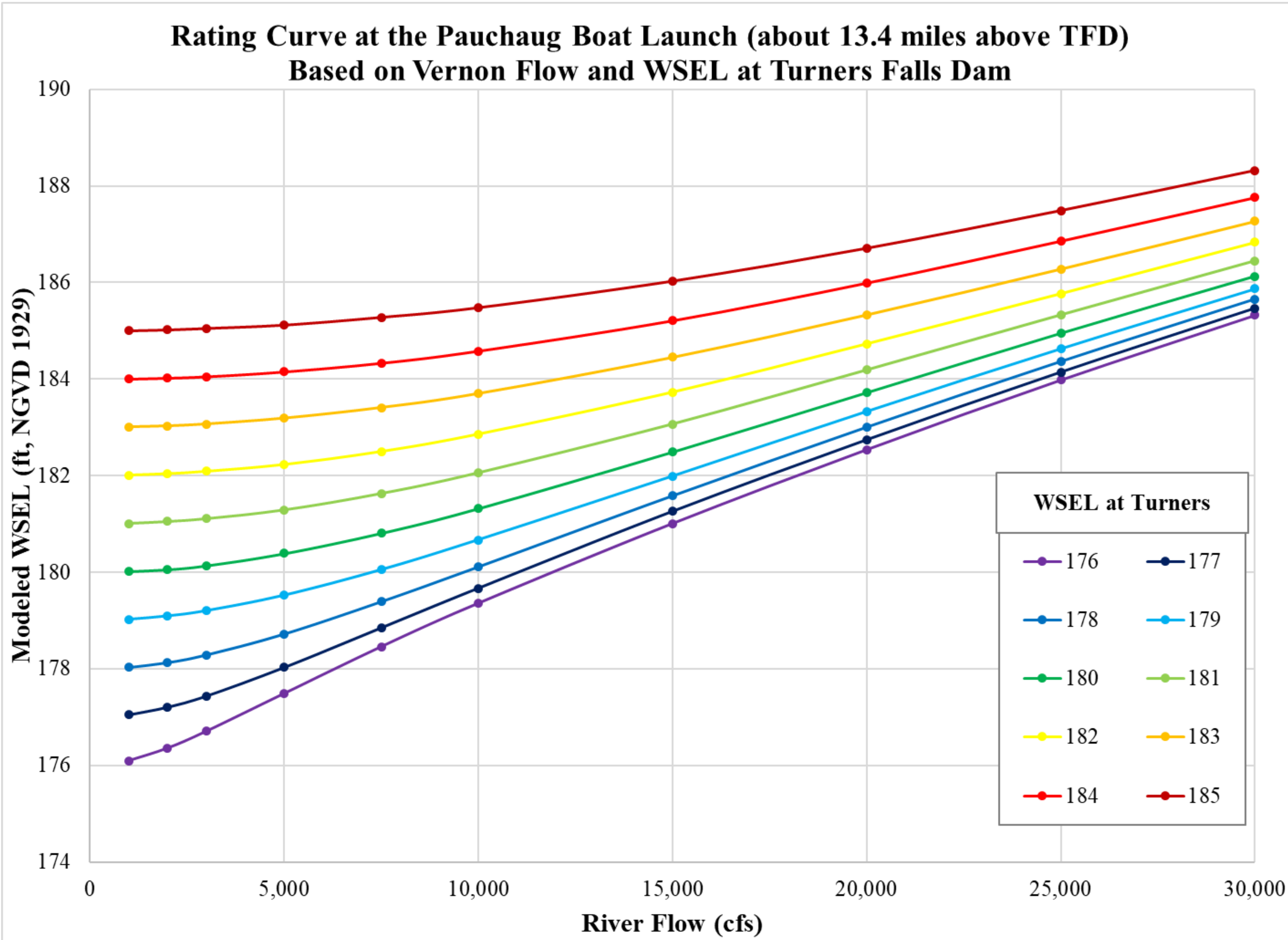
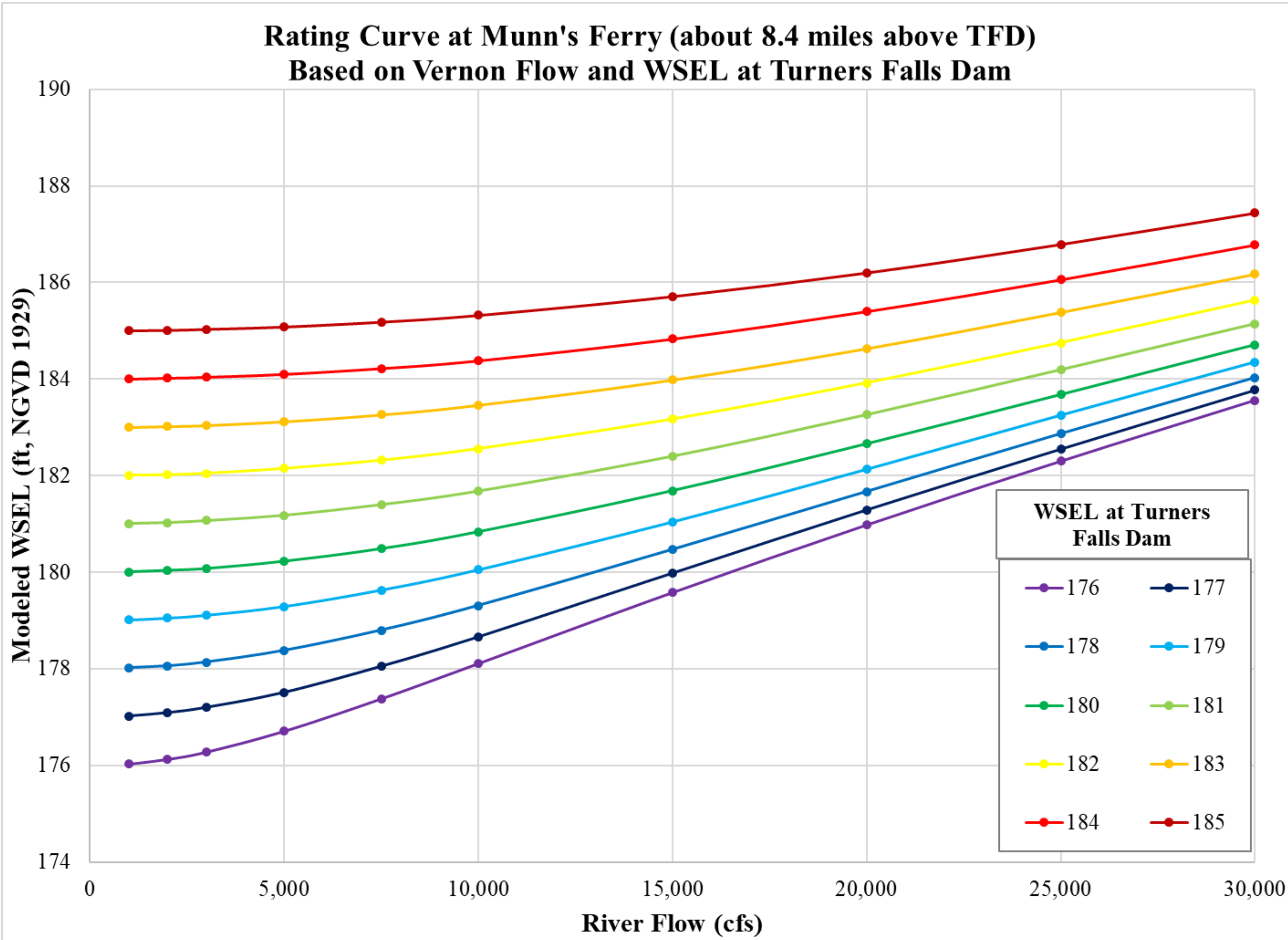
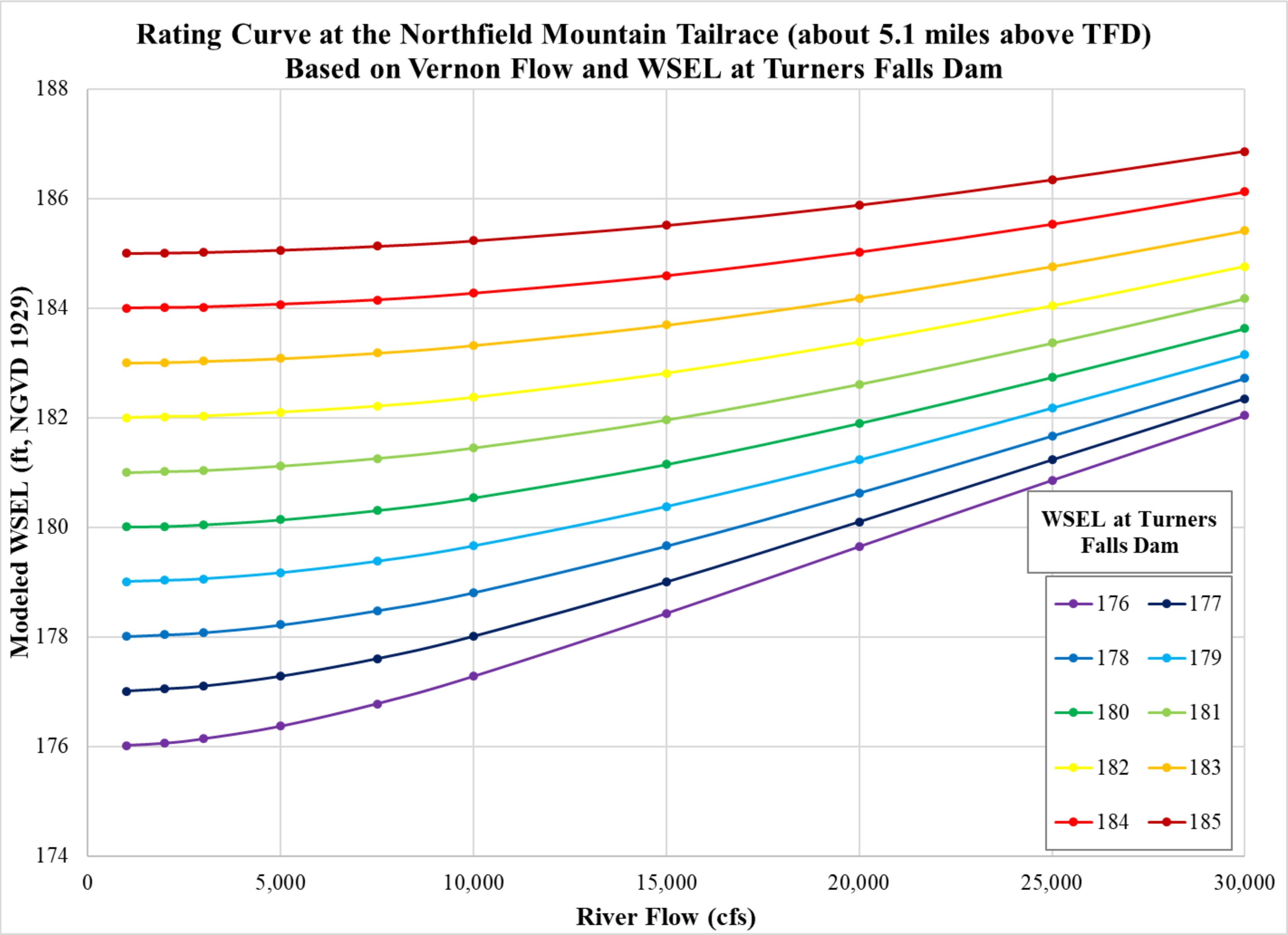


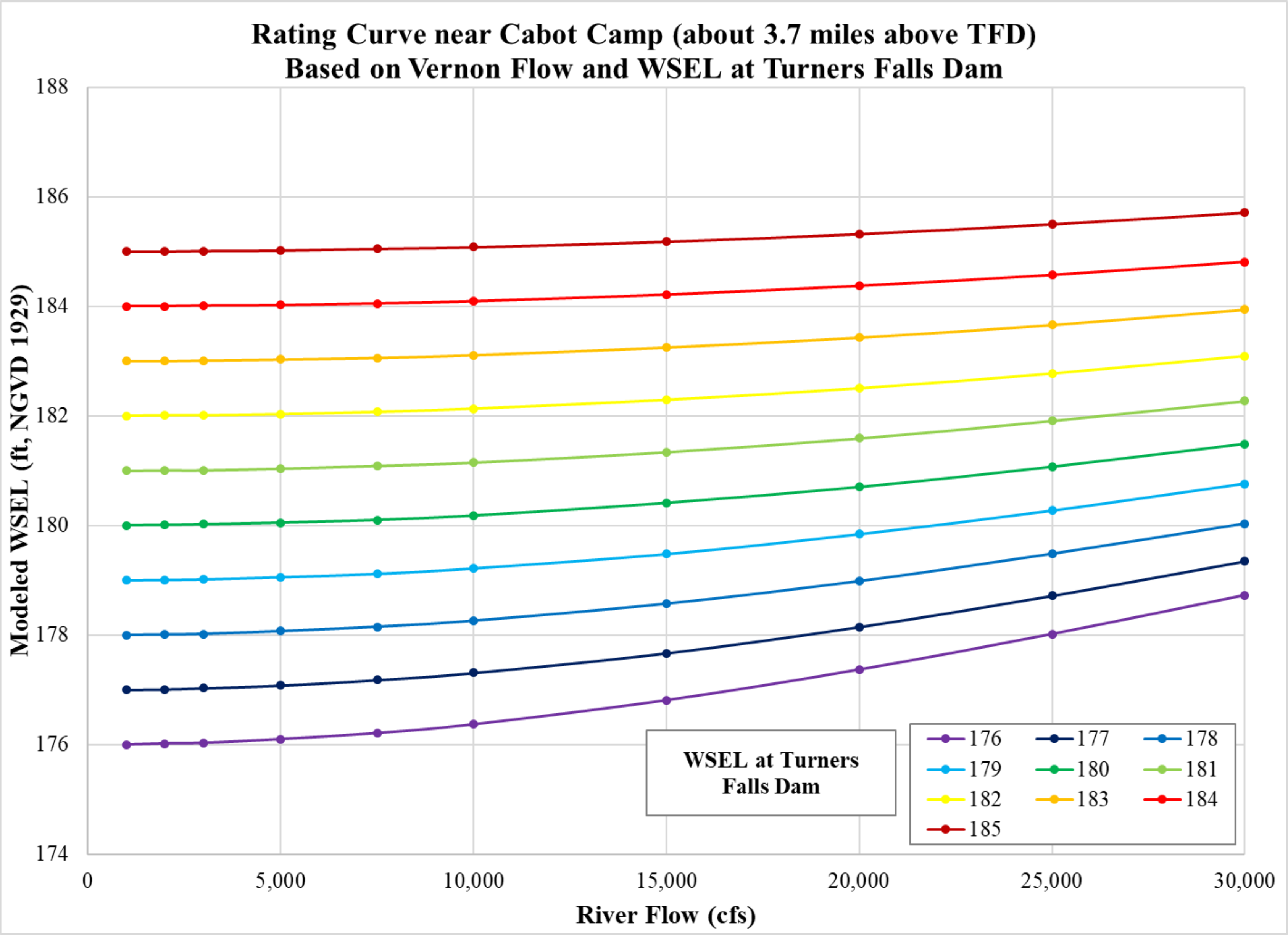
Rating Curve near Vernon Dam (about 19.9 miles above TFD)
Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
194
192
190
188
186
184
182
180
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Turners
176
177
178
179
180
181
182
183
184
185


Rating Curve at the Upstream End of Stebbins Island (about 19.1 miles above TFD) Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
River Flow (cfs)
192
190
188
186
184
182
180
0
5,000
10,000
15,000
20,000
25,000
30,000
WSEL at Turners Falls Dam
176
177
178
179
180
181
182
183
184
185


Rating Curve at the Pauchaug Boat Launch (about 13.4 miles above TFD)
Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
190
188
186
184
182
180
178
176
174
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Turners
176
177
178
179
180
181
182
183
184
185


Rating Curve at Munn's Ferry (about 8.4 miles above TFD)
Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
River Flow (cfs)
190
188
186
184
182
180
178
176
174
0
5,000
10,000
15,000
20,000
25,000
30,000
WSEL at Turners Falls Dam
176
177
178
179
180
181
182
183
184
185


Rating Curve at the Northfield Mountain Tailrace (about 5.1 miles above TFD)
Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
188
186
184
182
180
178
176
174
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Turners Falls Dam
176
177
178
179
180
181
182
183
184
185



Rating Curve near Cabot Camp (about 3.7 miles above TFD)
Based on Vernon Flow and WSEL at Turners Falls Dam
Modeled WSEL (ft, NGVD 1929)
188
186
184
182
180
178
176
174
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Turners Falls Dam
176
177
178
179
180
181
182
183
184
185

Appendix C- Water Resources- Downstream Rating Curves

Rating Curves at the following transects in the Turners Falls Impoundment are provided under two conditions- Holyoke Dam water surface at 100.67 and at 99.47 feet. In upstream to downstream order:

- Near Montague at the Upper end of Reach 4, River Mile 118.5
- Reach 4 at River Mile 115.07
- Reach 4 at River Mile 112.36
- Lower end of Reach 4 at River Mile 109.52
- Reach 5 at River Mile 100.24
- Reach 5 at River Mile 94.298
- Reach 5 at River Mile 92.69

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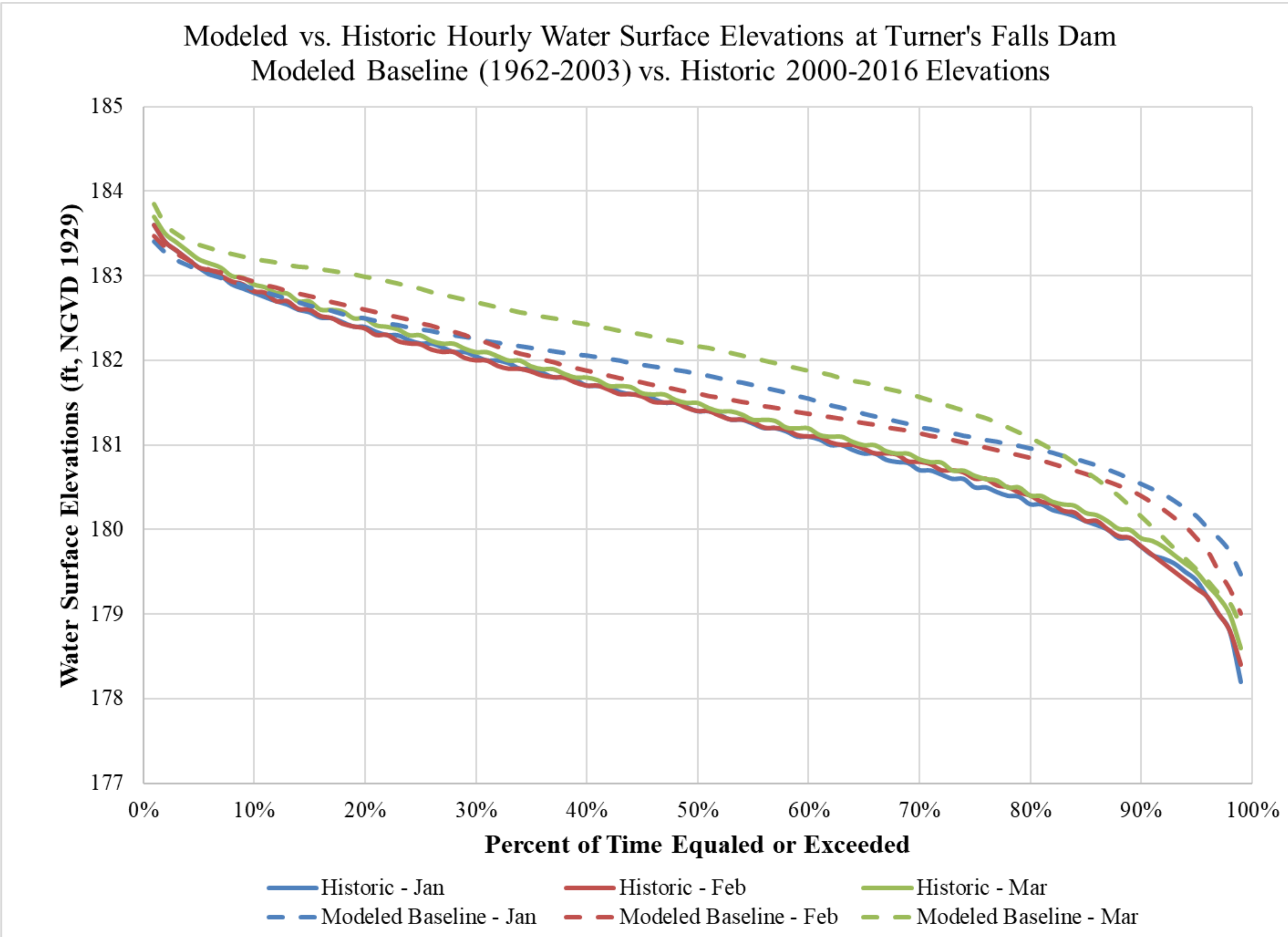
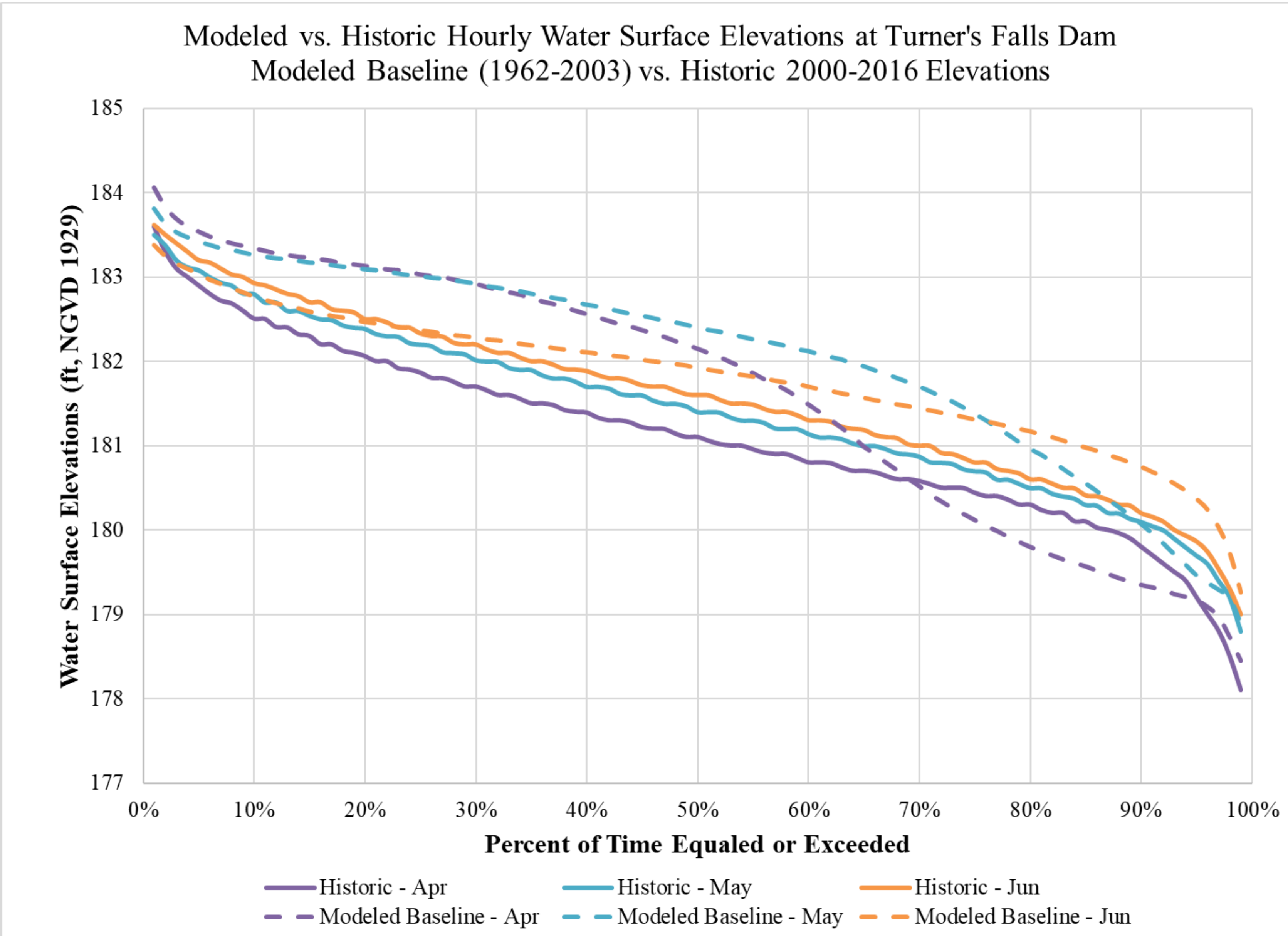
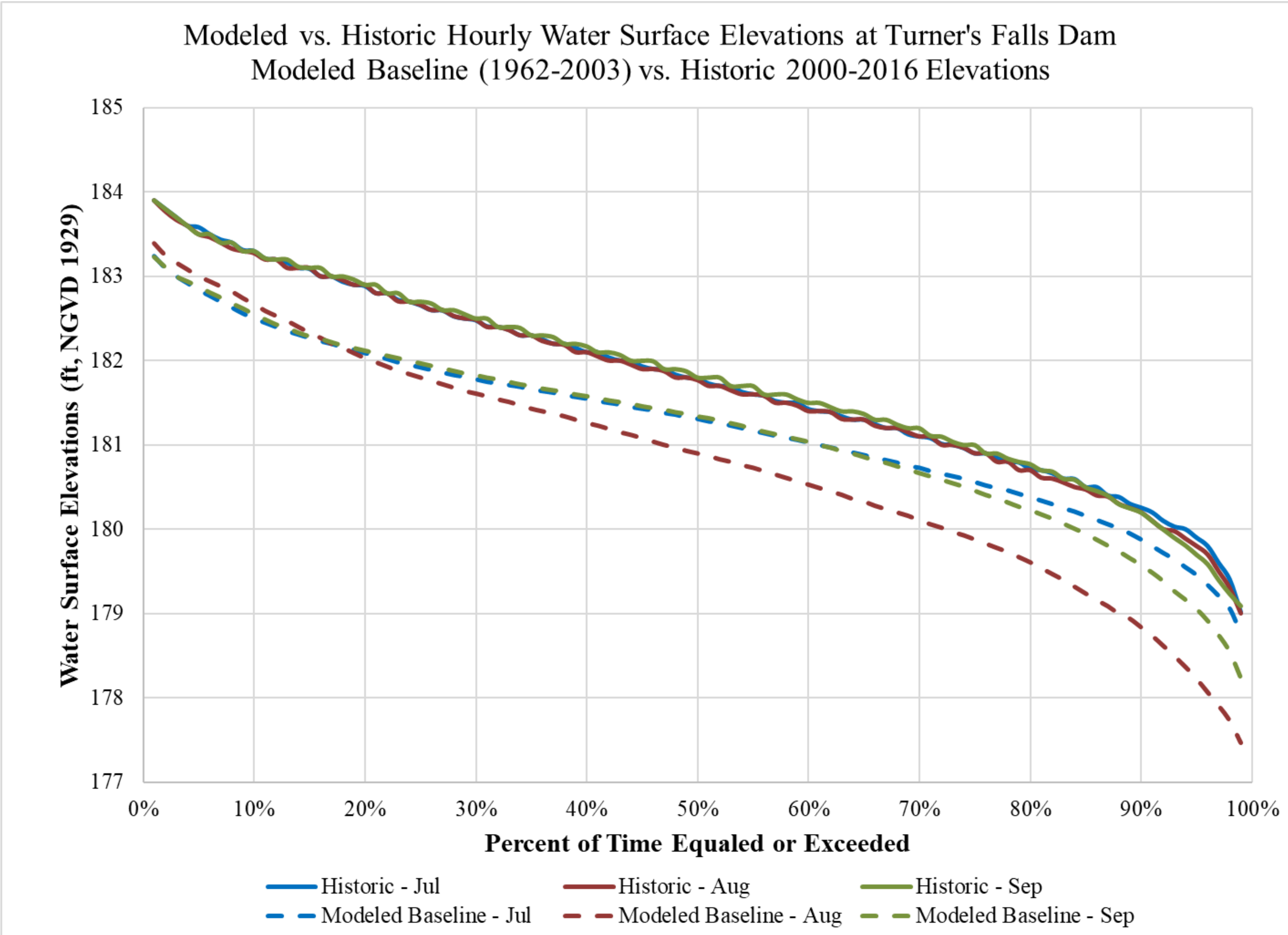
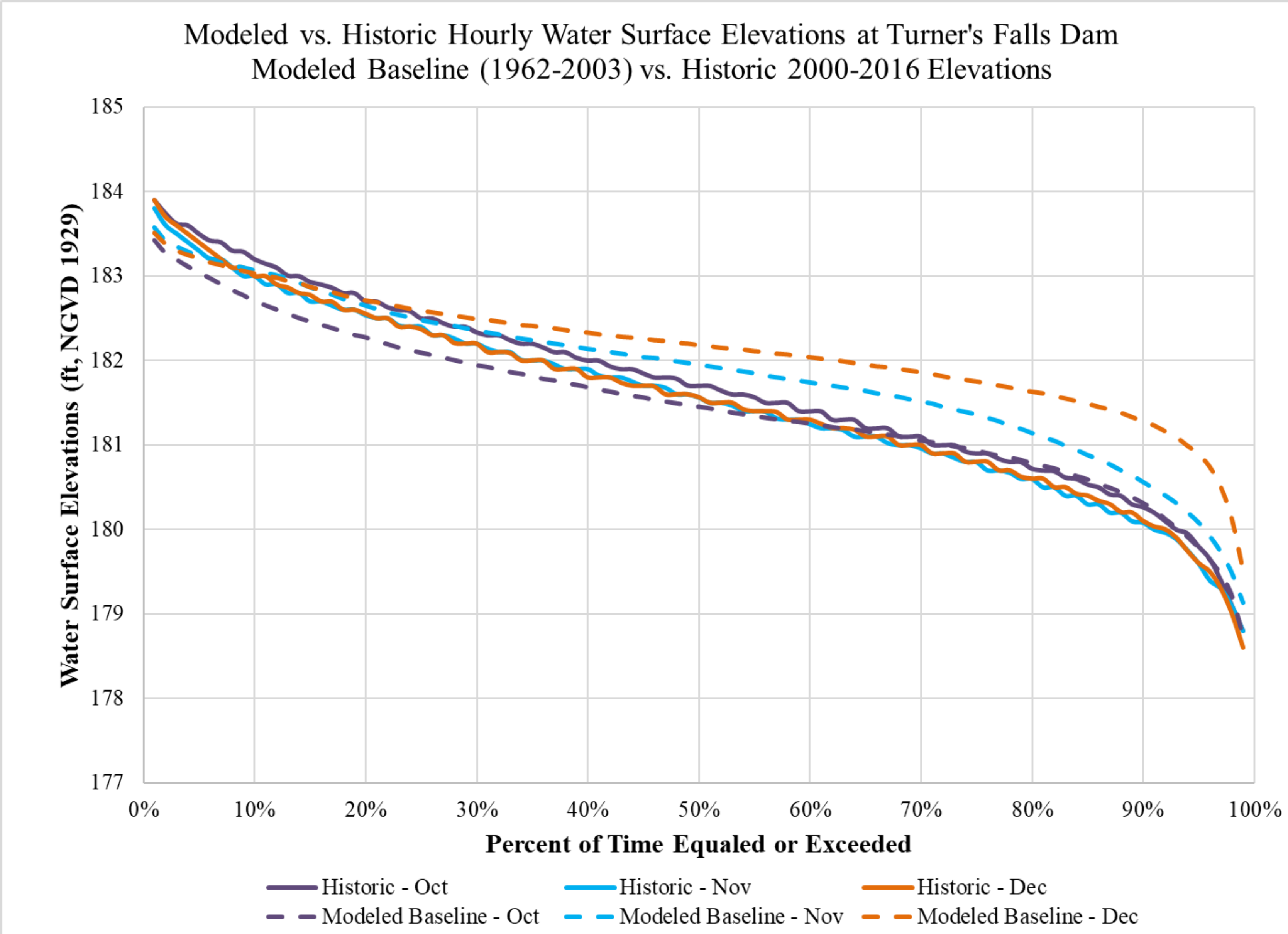


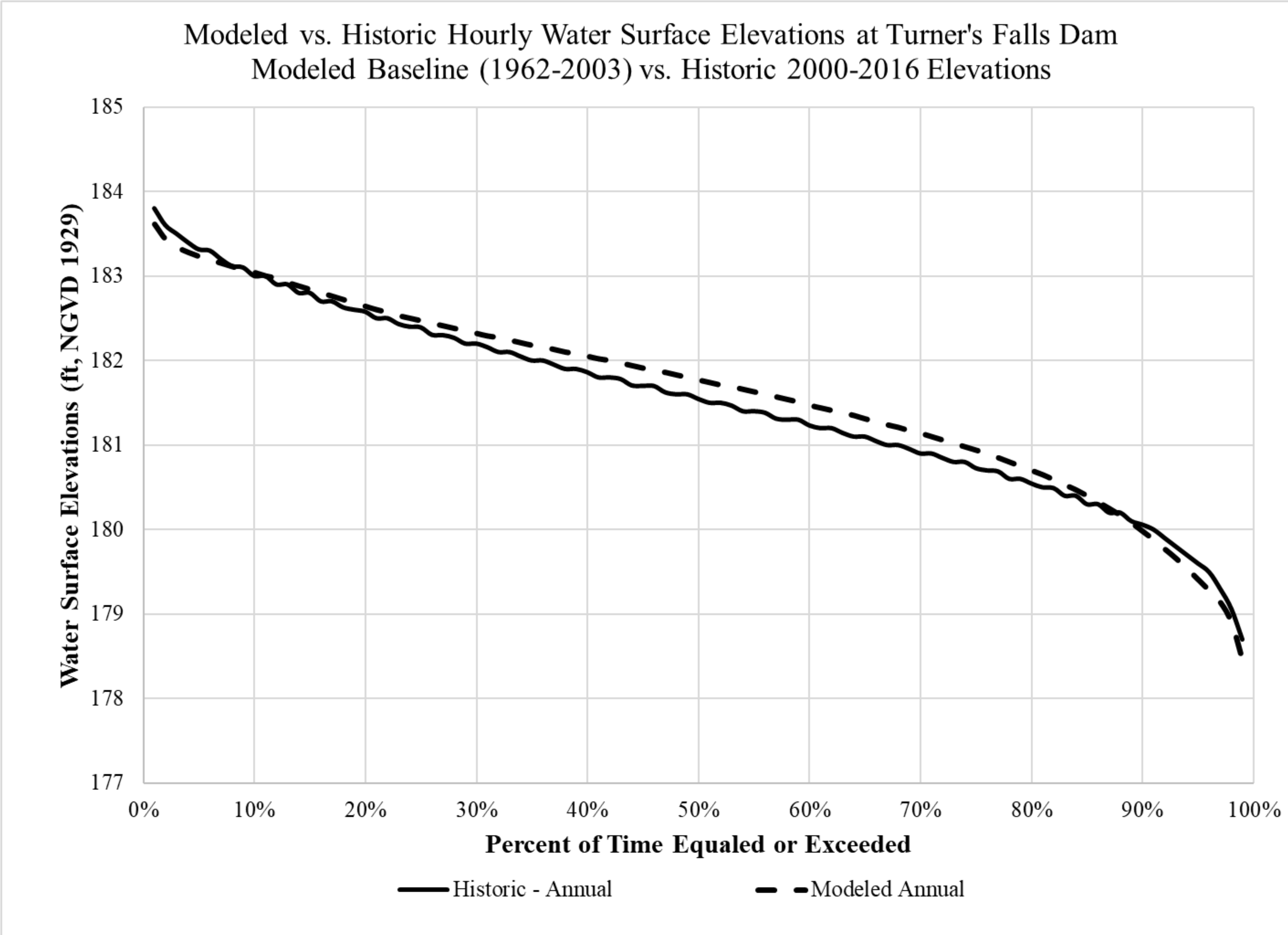
Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline - Jan
Modeled Baseline - Feb
Modeled Baseline - Mar


Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Historic - May
Historic - Jun
Modeled Baseline - Apr
Modeled Baseline - May
Modeled Baseline - Jun

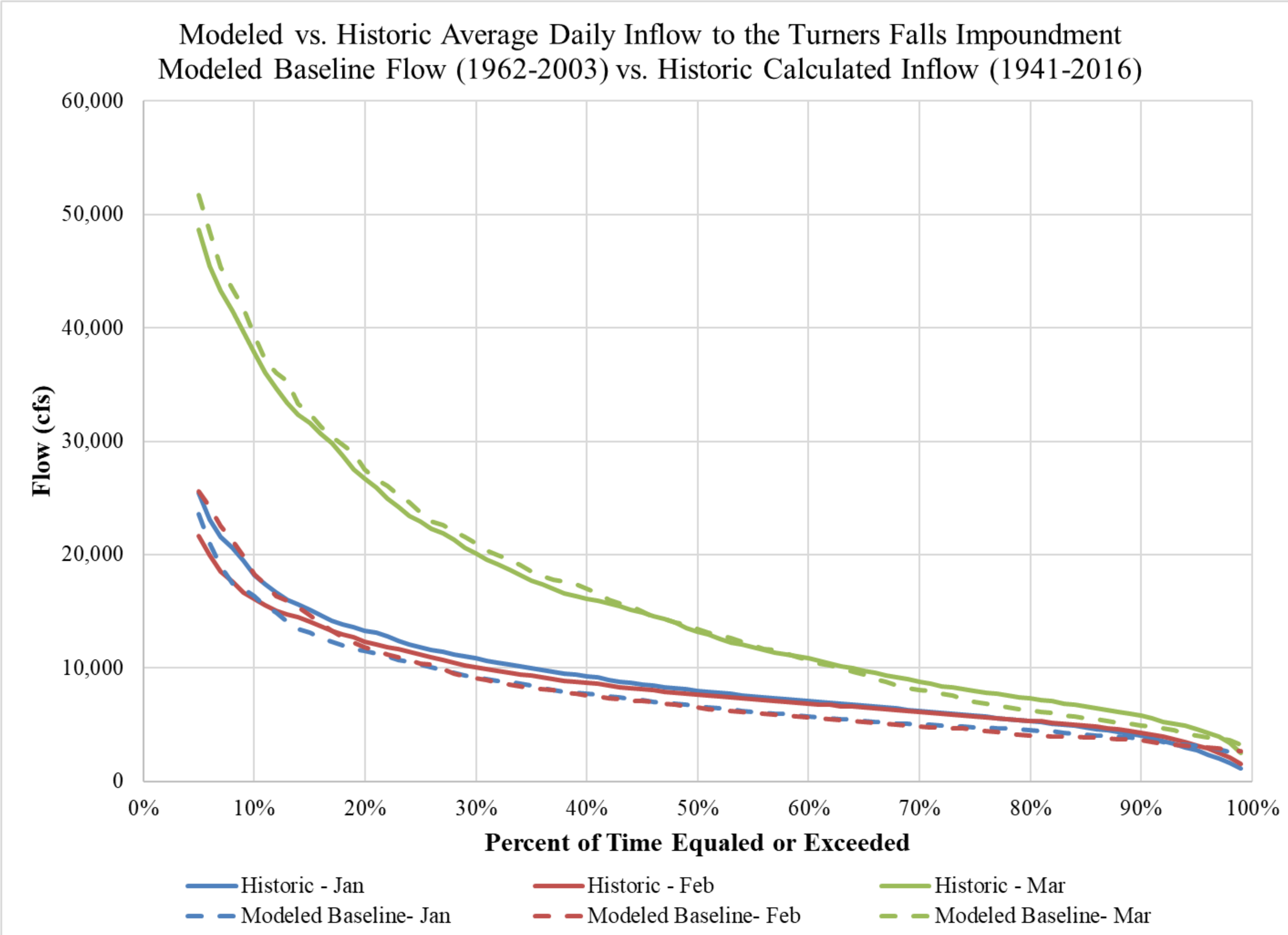

Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline - Jul
Modeled Baseline - Aug
Modeled Baseline - Sep

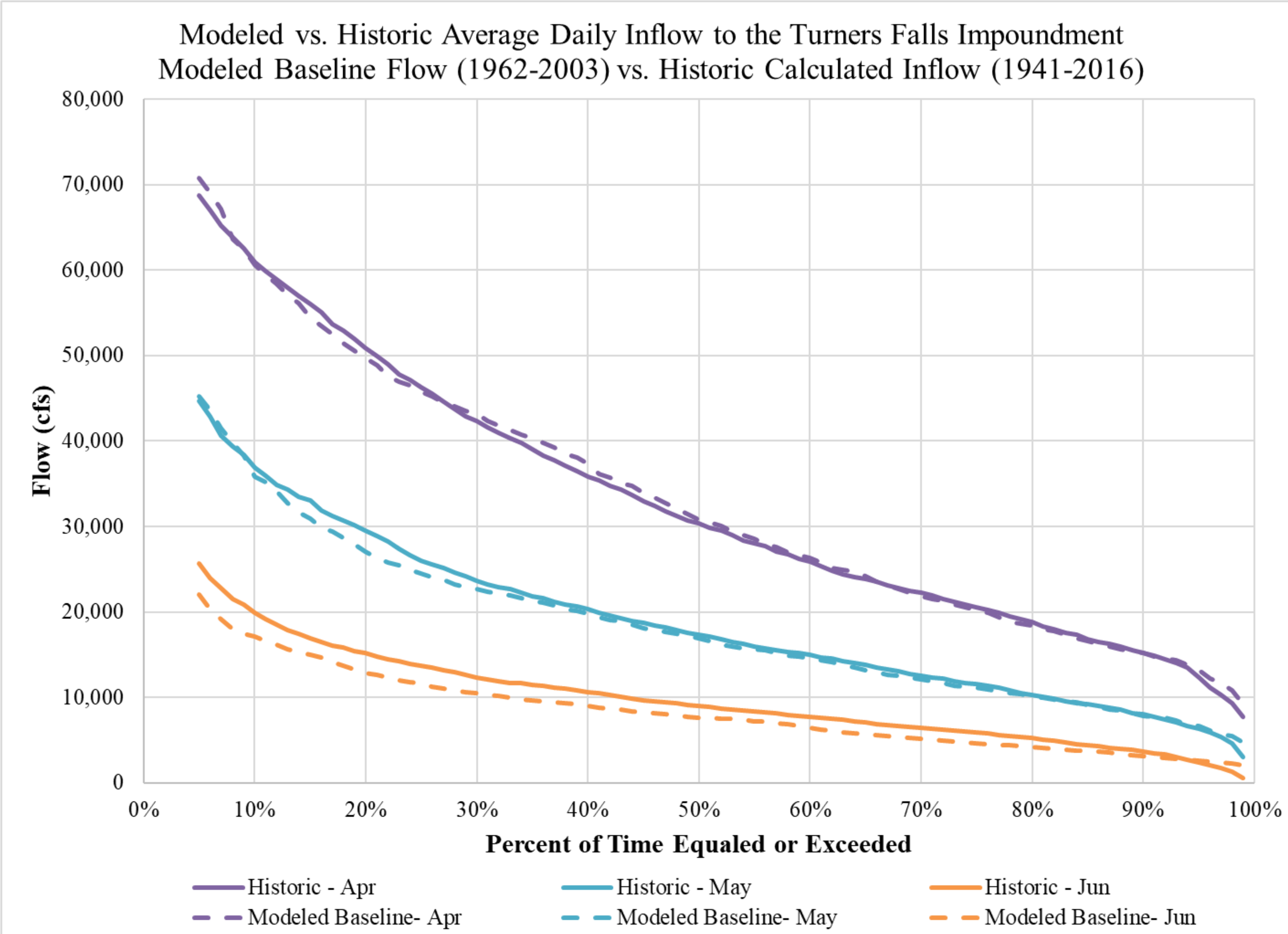


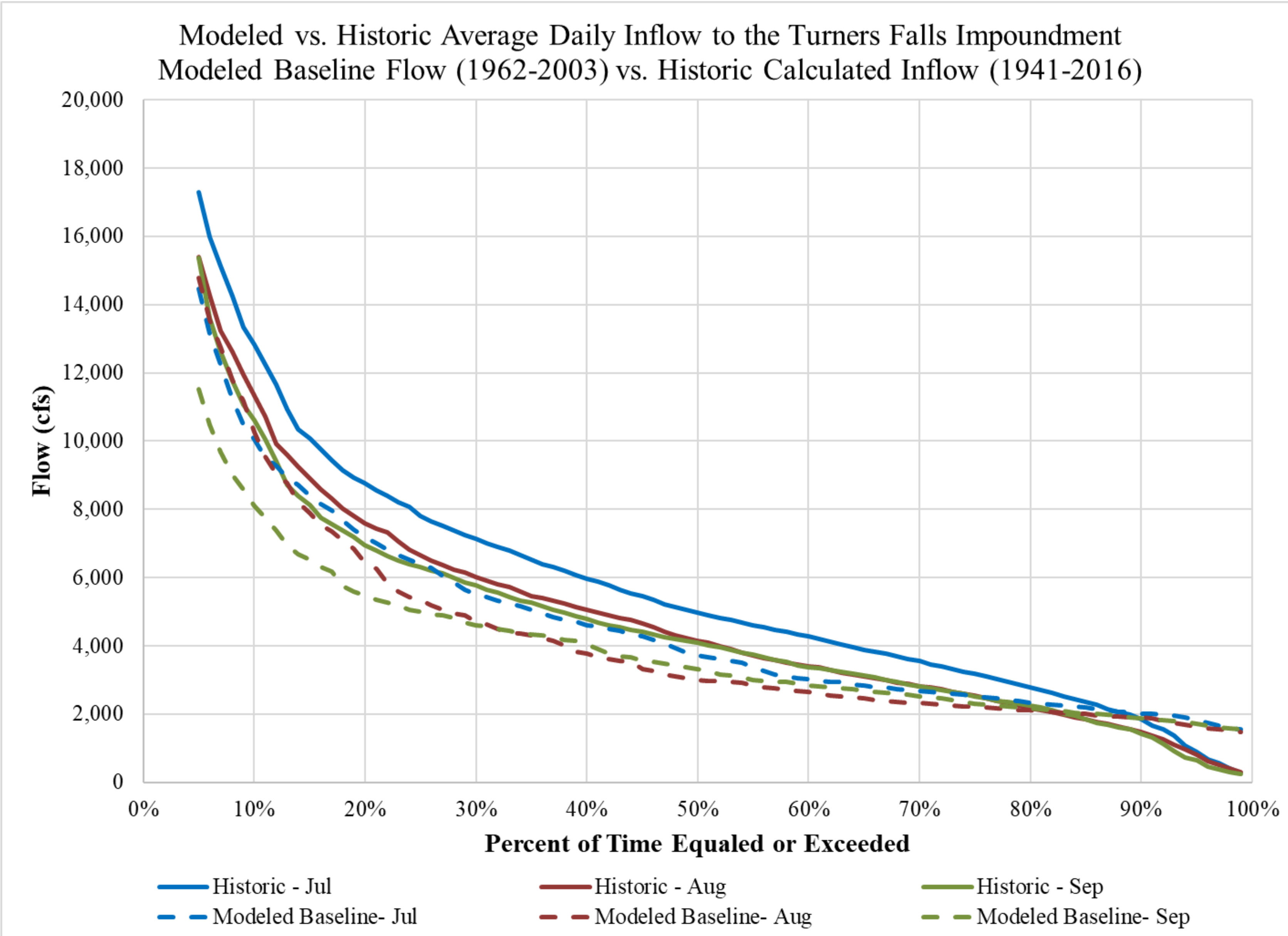
Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline - Oct
Modeled Baseline - Nov
Modeled Baseline - Dec

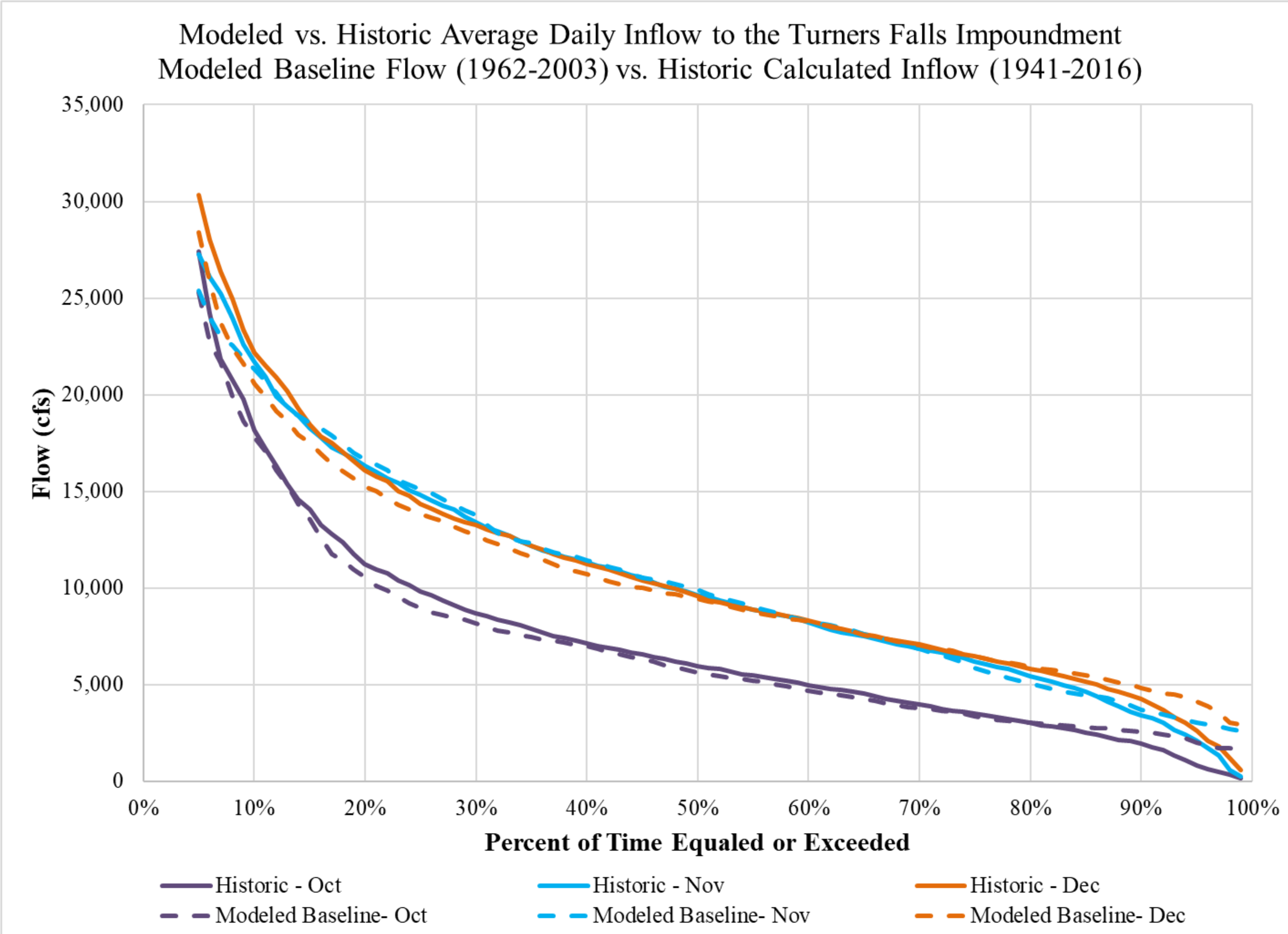


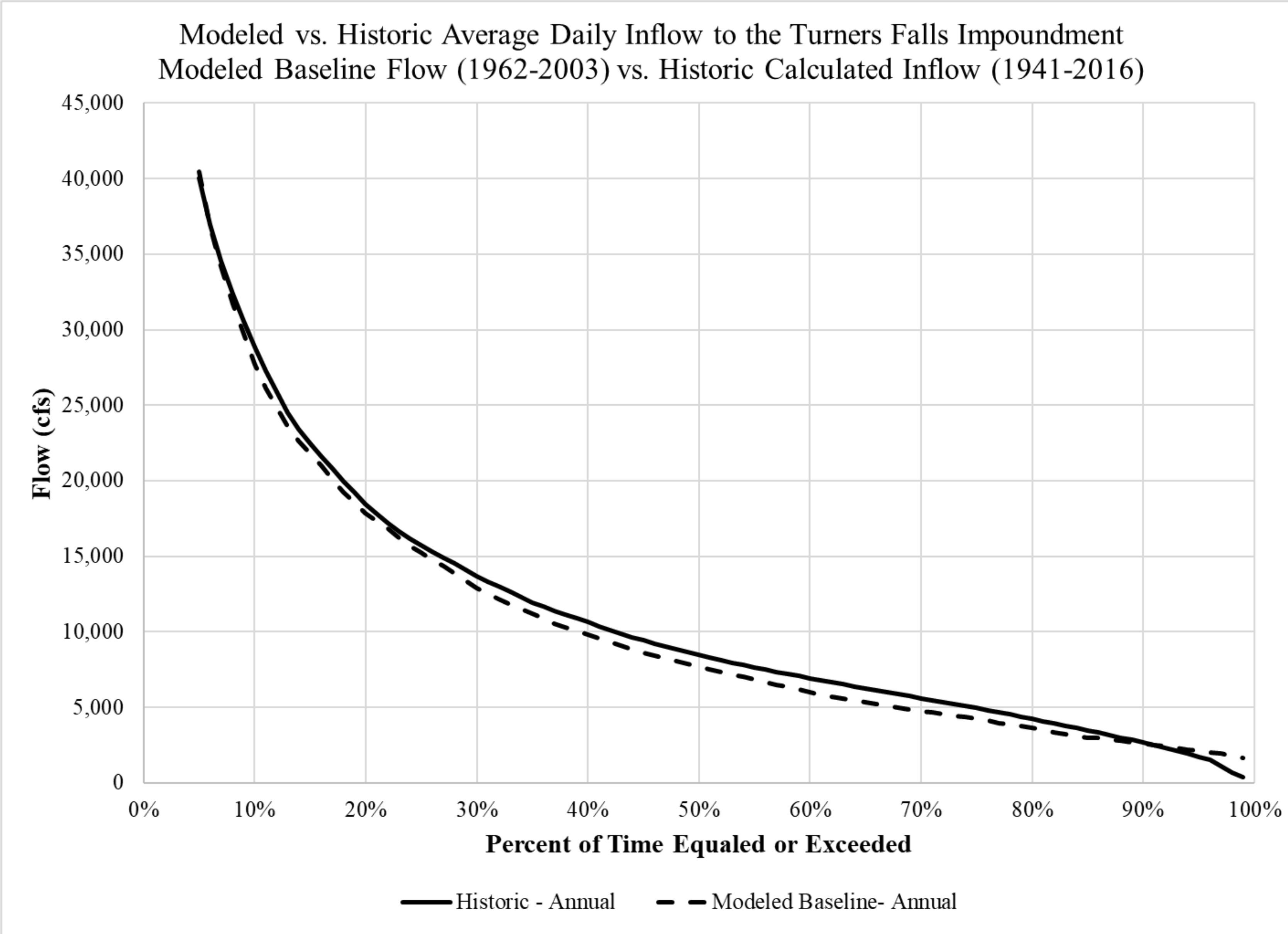
Modeled vs. Historic Hourly Water Surface Elevations at Turner's Falls Dam
Modeled Baseline (1962-2003) vs. Historic 2000-2016 Elevations
Water Surface Elevations (ft, NGVD 1929)
185
184
183
182
181
180
179
178
177
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Annual

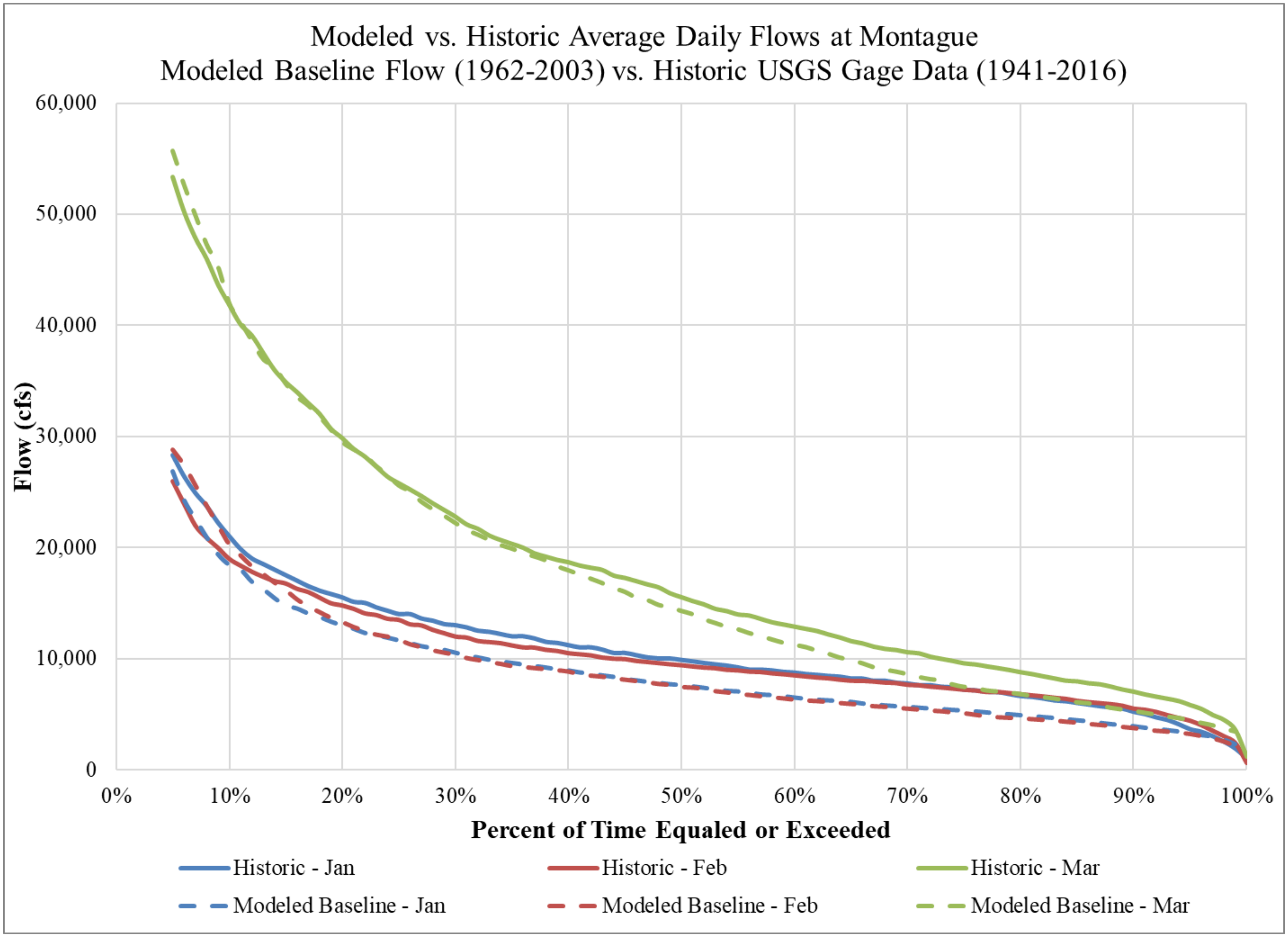

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
60,000
50,000
40,000
30,000
20,000
10,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline- Jan
Modeled Baseline- Feb
Modeled Baseline- Mar


Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
Flow (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Modeled Baseline- Apr
Historic - May
Modeled Baseline- May
Historic - Jun
Modeled Baseline- Jun

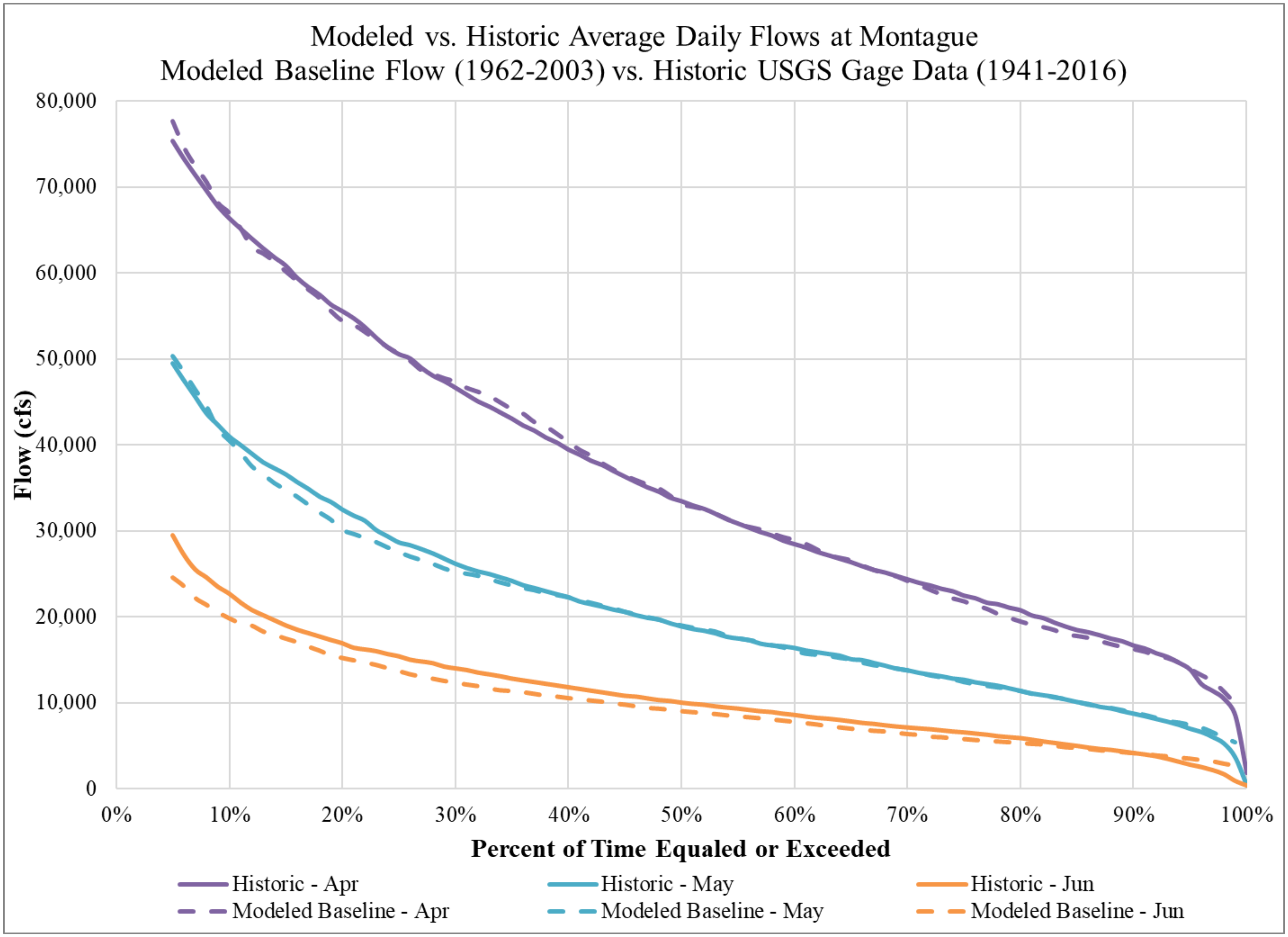

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline- Jul
Modeled Baseline- Aug
Modeled Baseline- Sep


Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline- Oct
Modeled Baseline- Nov
Modeled Baseline- Dec

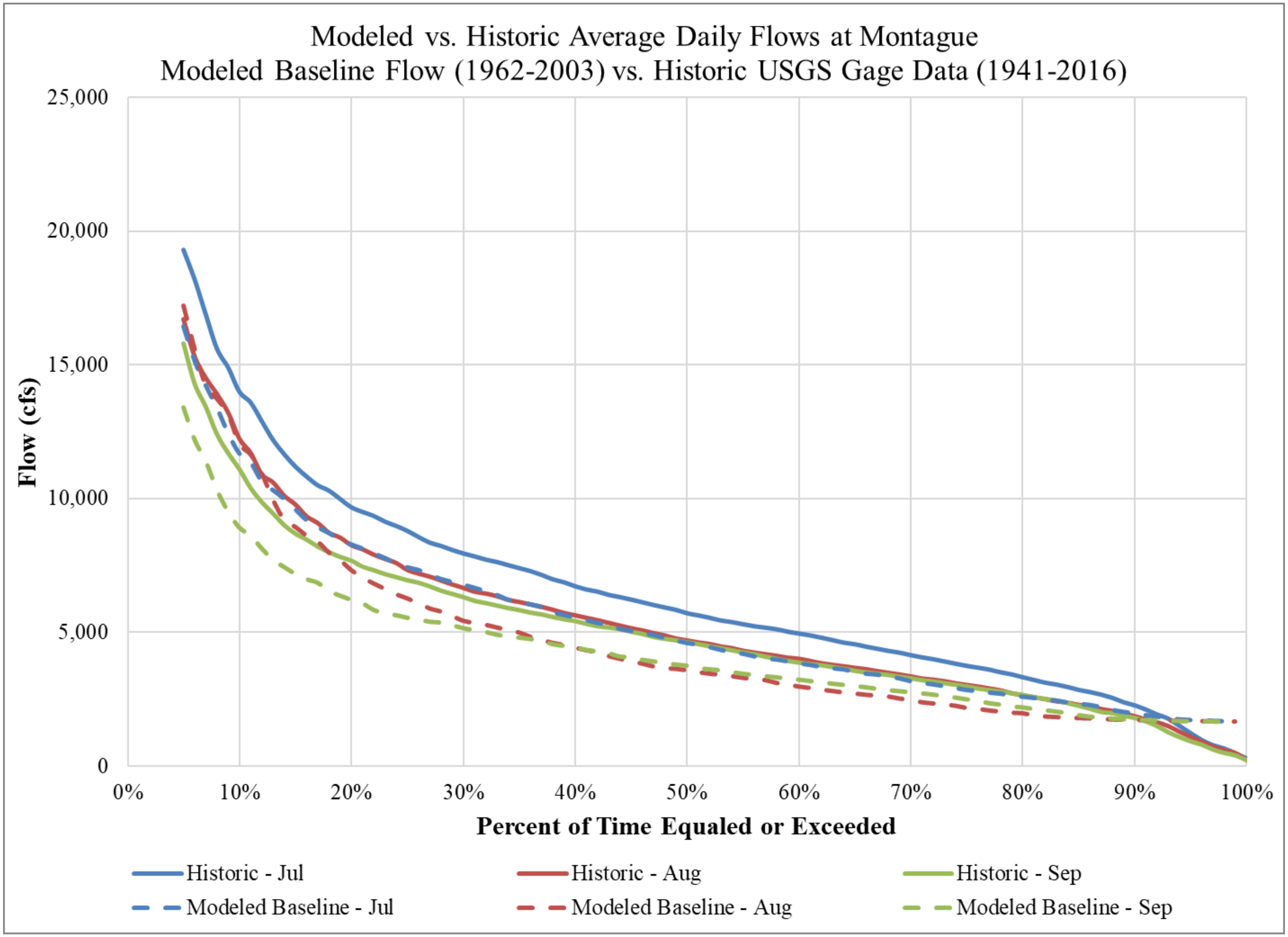

Modeled vs. Historic Average Daily Inflow to the Turners Falls Impoundment
Modeled Baseline Flow (1962-2003) vs. Historic Calculated Inflow (1941-2016)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Baseline- Annual



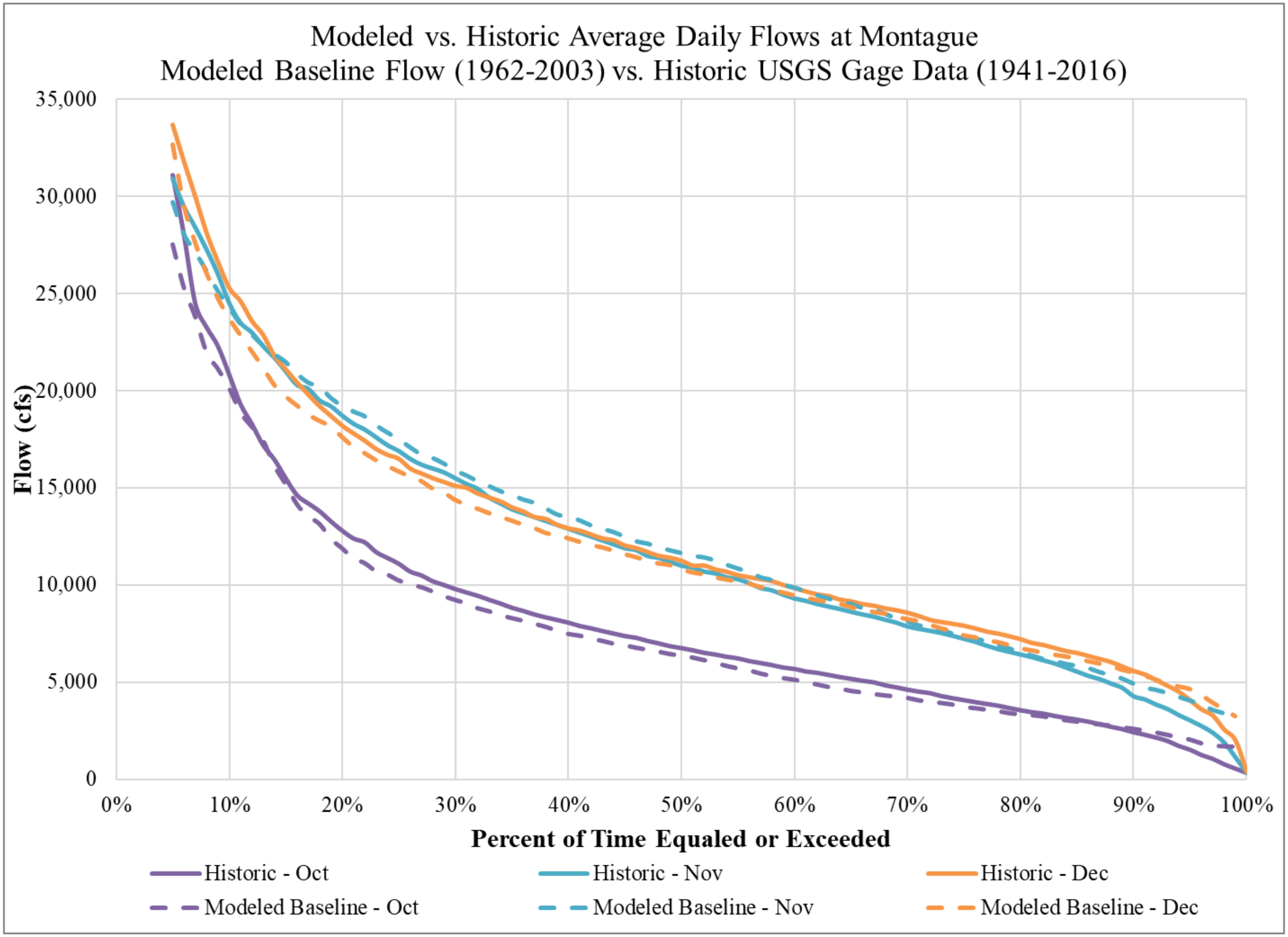
Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
60,000
50,000
40,000
30,000
20,000
10,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jan
Historic - Feb
Historic - Mar
Modeled Baseline - Jan
Modeled Baseline - Feb
Modeled Baseline - Mar

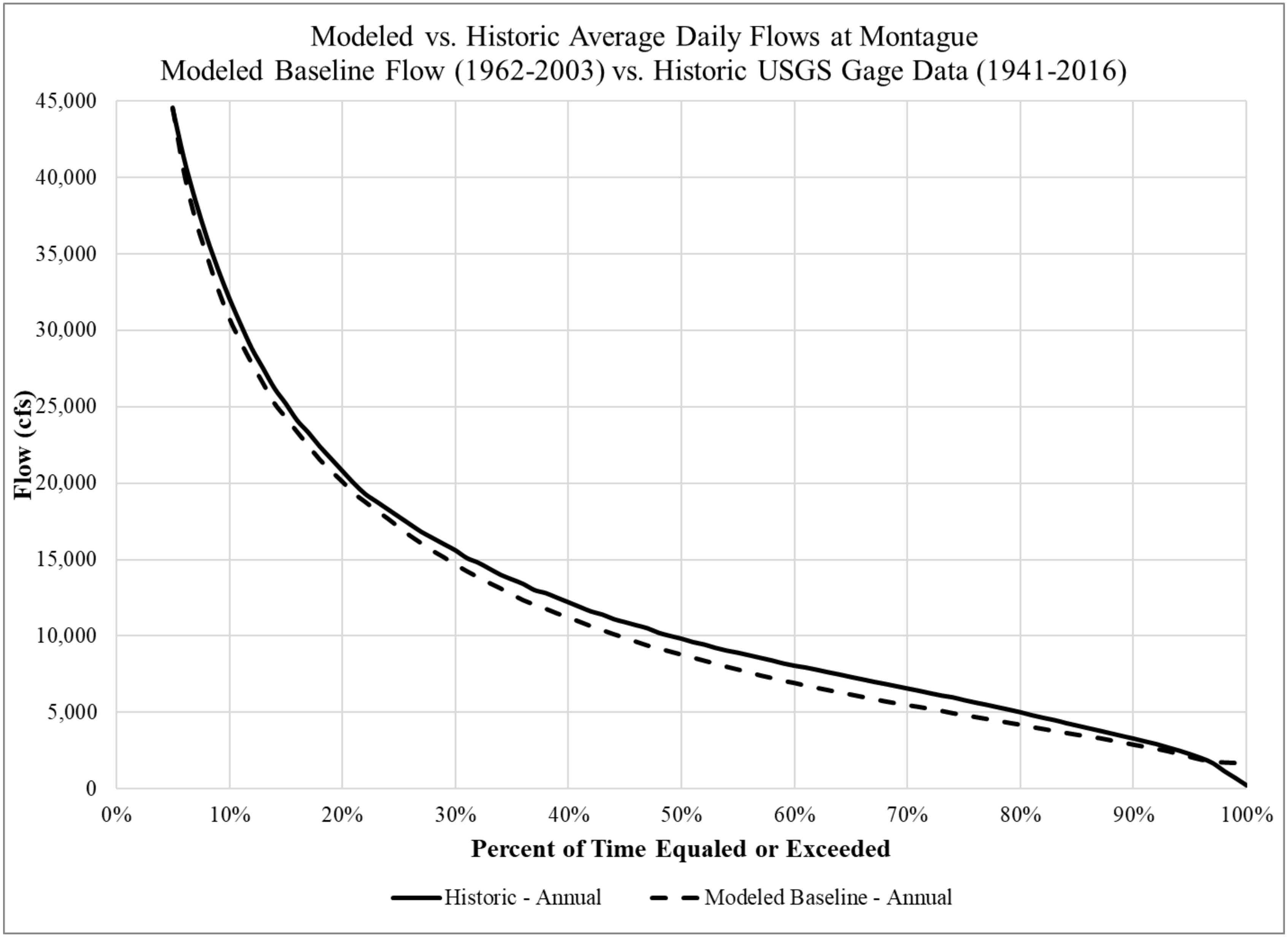


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Apr
Modeled Baseline - Apr
Historic - May
Modeled Baseline - May
Historic - Jun
Modeled Baseline - Jun

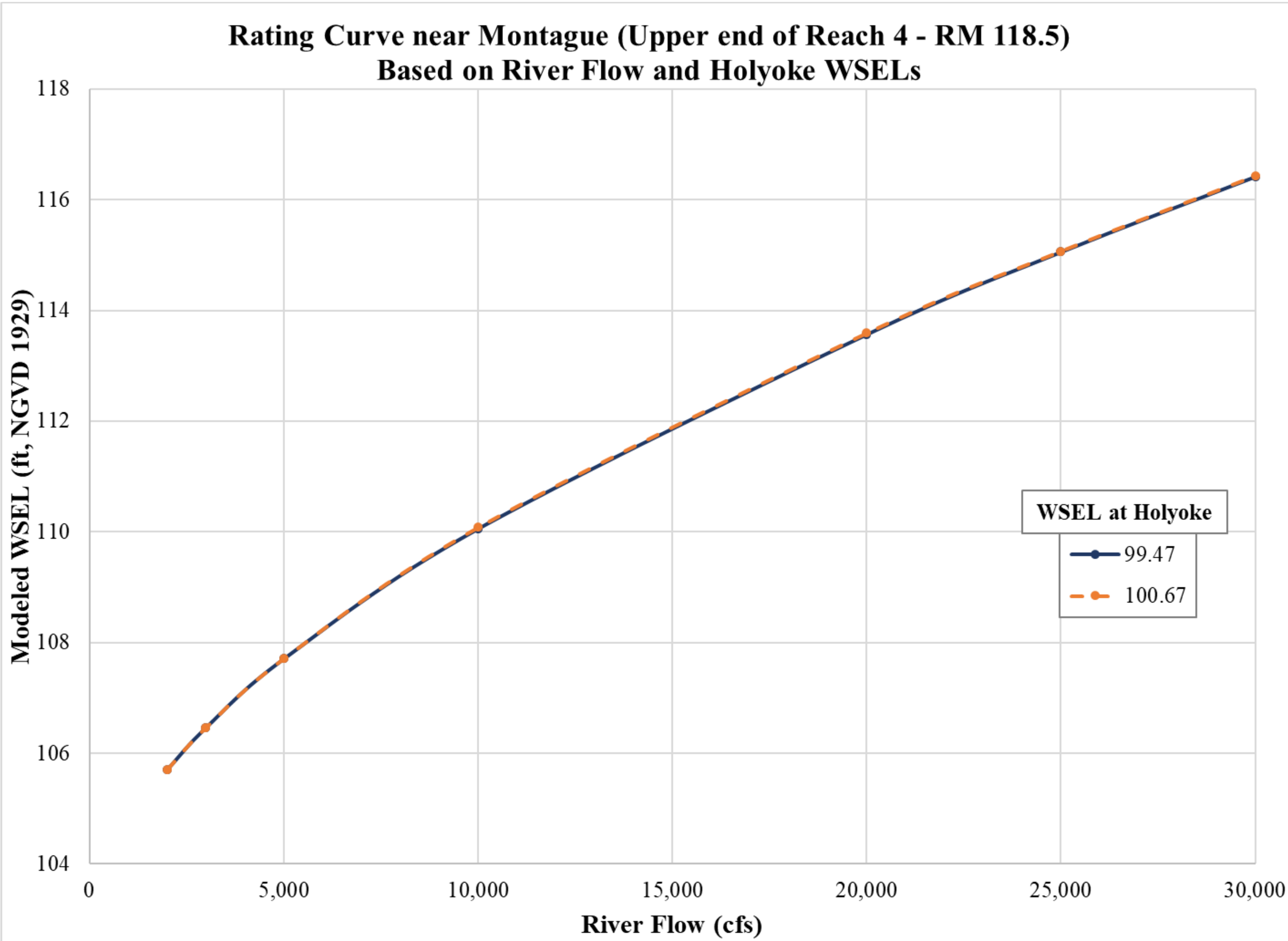


Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Jul
Historic - Aug
Historic - Sep
Modeled Baseline - Jul
Modeled Baseline - Aug
Modeled Baseline - Sep

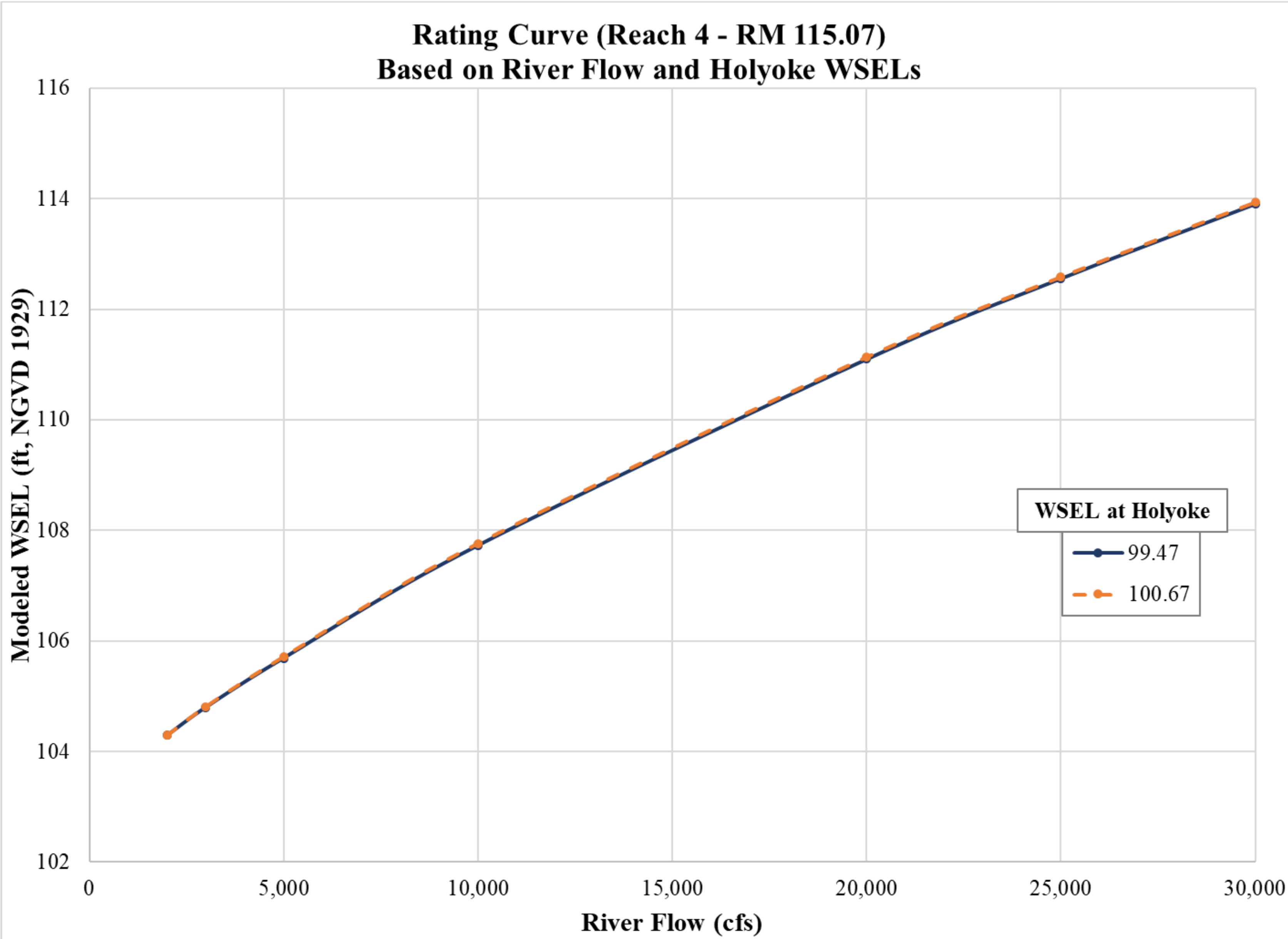

Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow (cfs)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Oct
Historic - Nov
Historic - Dec
Modeled Baseline - Oct
Modeled Baseline - Nov
Modeled Baseline - Dec



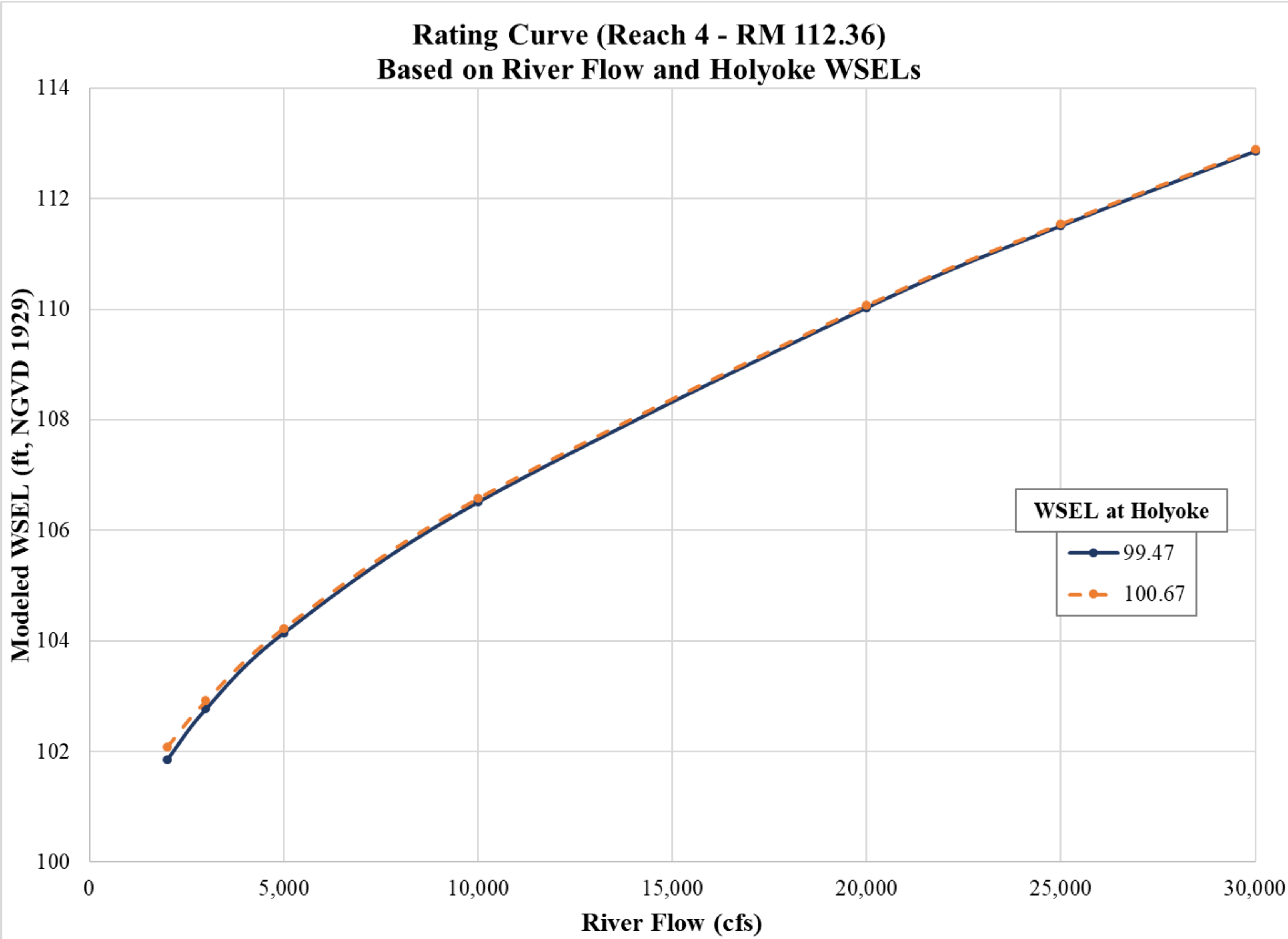
Modeled vs. Historic Average Daily Flows at Montague
Modeled Baseline Flow (1962-2003) vs. Historic USGS Gage Data (1941-2016)
Flow (cfs)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Equaled or Exceeded
Historic - Annual
Modeled Baseline - Annual

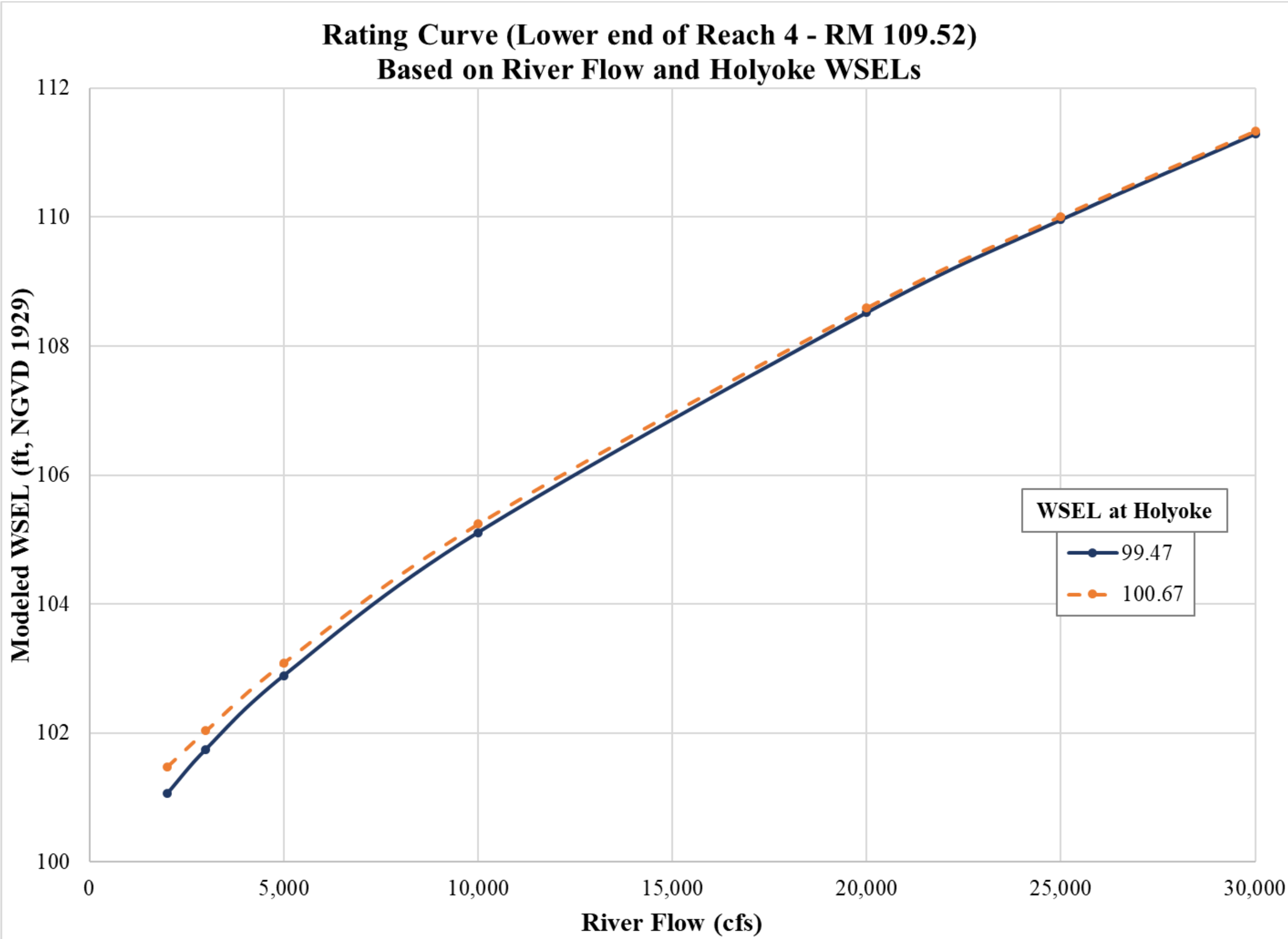


Rating Curve near Montague (Upper end of Reach 4 - RM 118.5)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
118
116
114
112
110
108
106
104
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Holyoke
99.47
100.67

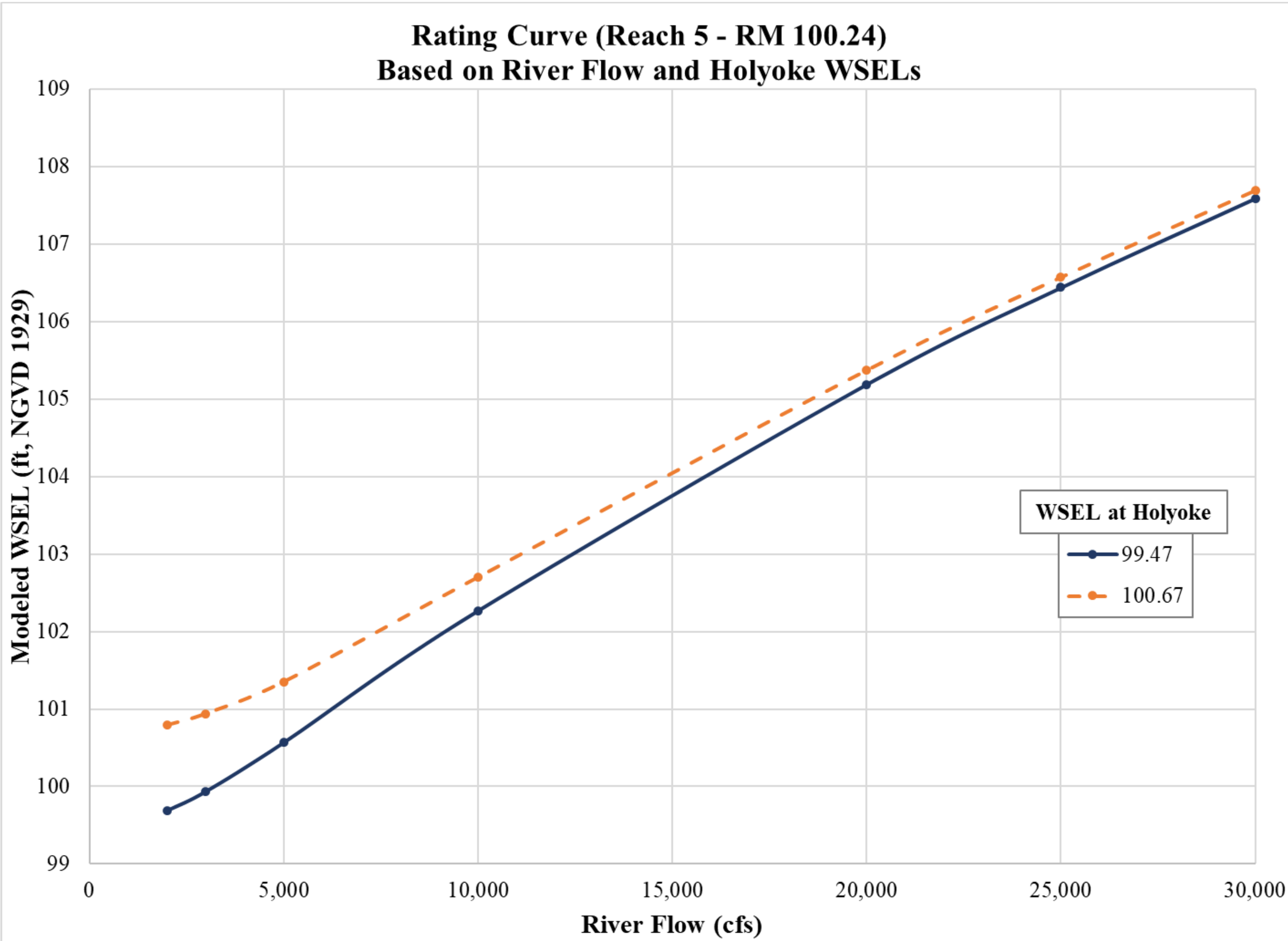


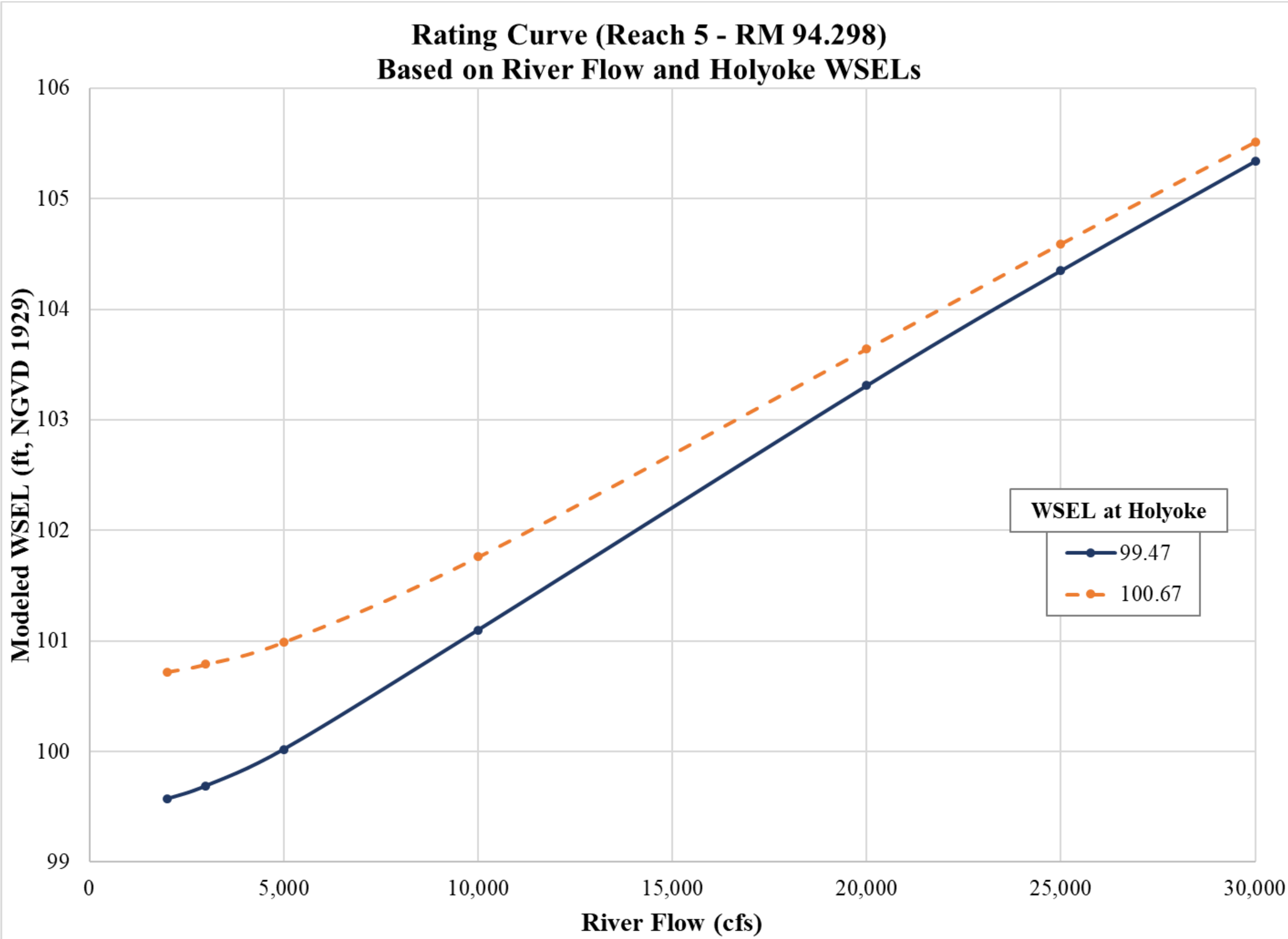
Rating Curve (Reach 4 - RM 115.07)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
116
114
112
110
108
106
104
102
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Holyoke
99.47
100.67


Rating Curve (Reach 4 - RM 112.36)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
114
112
110
108
106
104
102
100
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Holyoke
99.47
100.67

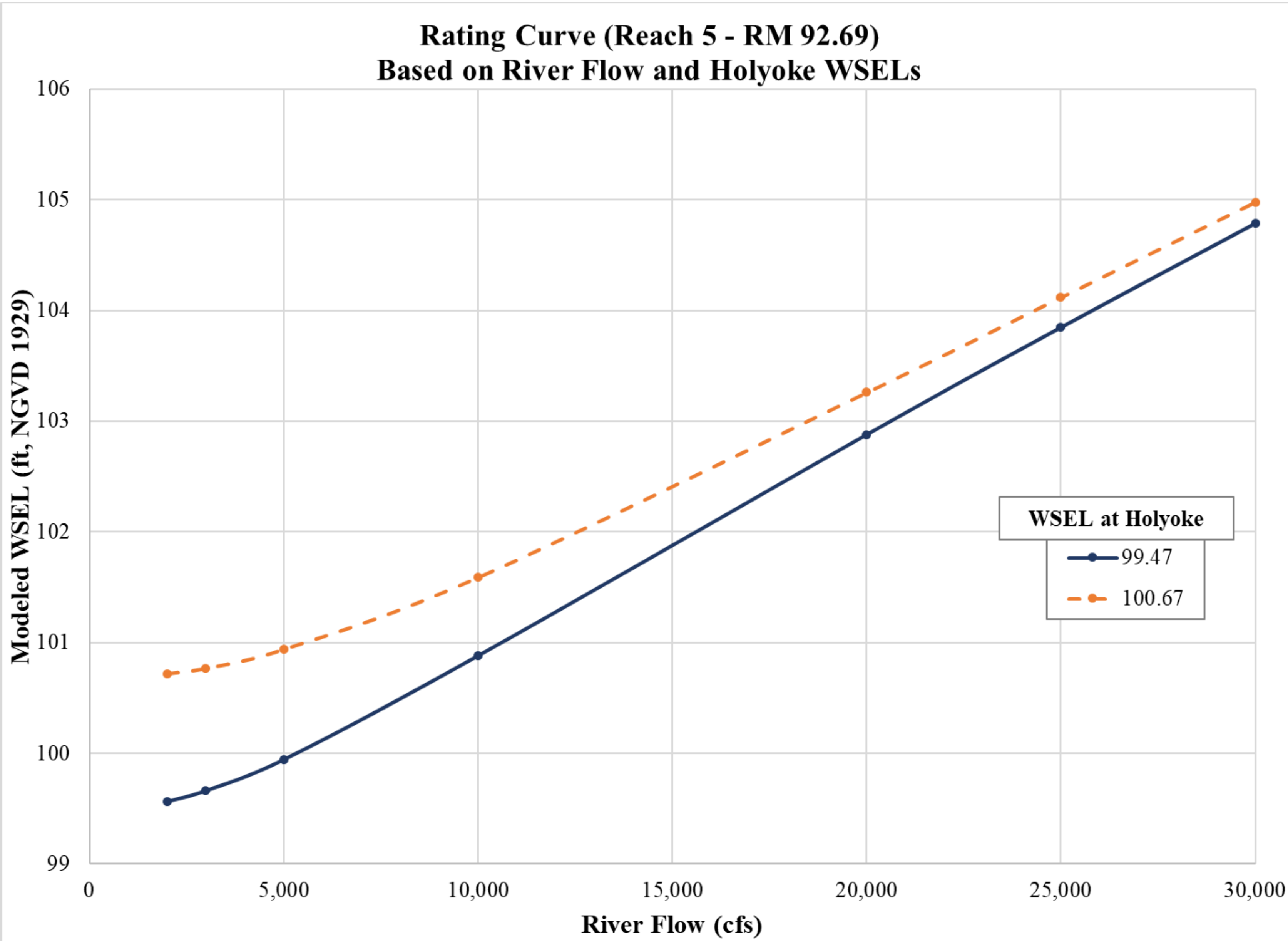


Rating Curve (Lower end of Reach 4 - RM 109.52)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
River Flow (cfs)
112
110
108
106
104
102
100
0
5,000
10,000
15,000
20,000
25,000
30,000
WSEL at Holyoke
99.47
100.67


Rating Curve (Reach 5 - RM 100.24)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
River Flow (cfs)
WSEL at Holyoke
99.47
100.67
109
108
107
106
105
104
103
102
101
100
99
0
5,000
10,000
15,000
20,000
25,000
30,000



Rating Curve (Reach 5 - RM 94.298)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
106
105
104
103
102
101
100
99
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Holyoke
99.47
100.67



Rating Curve (Reach 5 - RM 92.69)
Based on River Flow and Holyoke WSELs
Modeled WSEL (ft, NGVD 1929)
106
105
104
103
102
101
100
99
0
5,000
10,000
15,000
20,000
25,000
30,000
River Flow (cfs)
WSEL at Holyoke
99.47
100.67

Appendix D- Water Resources- Downstream Hydrographs

Time series figures for June 13 to July 13, 2017 containing:

WSEL on the left vertical axis:

- Holyoke: observed data from a FirstLight water level logger upstream of Holyoke Dam near river mile 86.
- T2 (Transect 2 from the Mussel IFIM field work): observed data from a FirstLight water level logger at river mile 92.257.
- Rainbow Beach: Modeled from the FirstLight Downstream HEC-RAS Model at River Mile 94.298.
- T5 (Transect 5 from the Mussel IFIM field work): observed data from a FirstLight water level logger at river mile 99.14.
- T7 (Transect 5 from the Mussel IFIM field work): observed data from a FirstLight water level logger at river mile 101.08.

Flows on the right vertical axis:

- Montague USGS gage flows at river mile 118.5
- Holyoke USGS gage flows: about a half mile downstream of Holyoke Dam near river mile 85.

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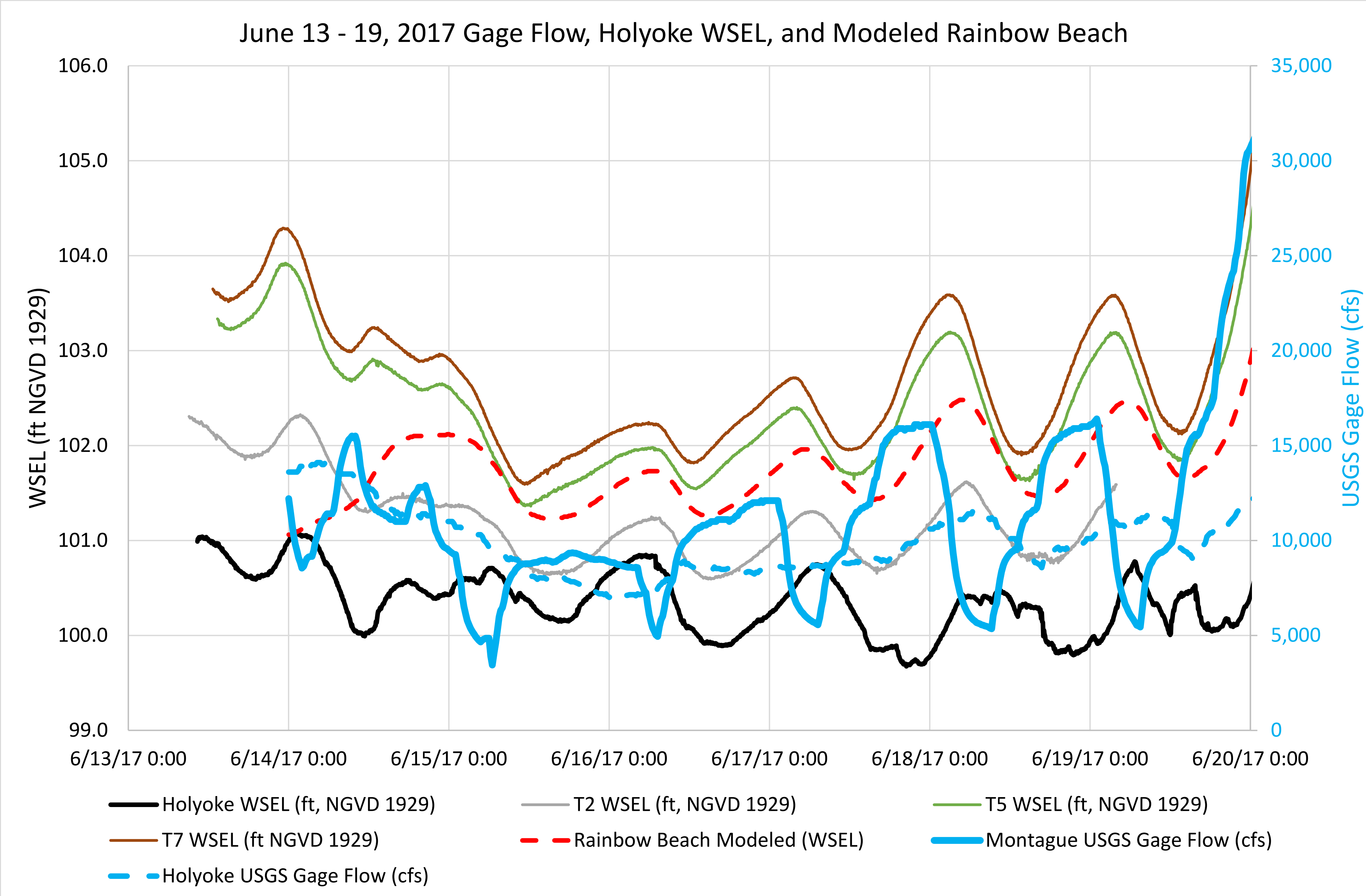
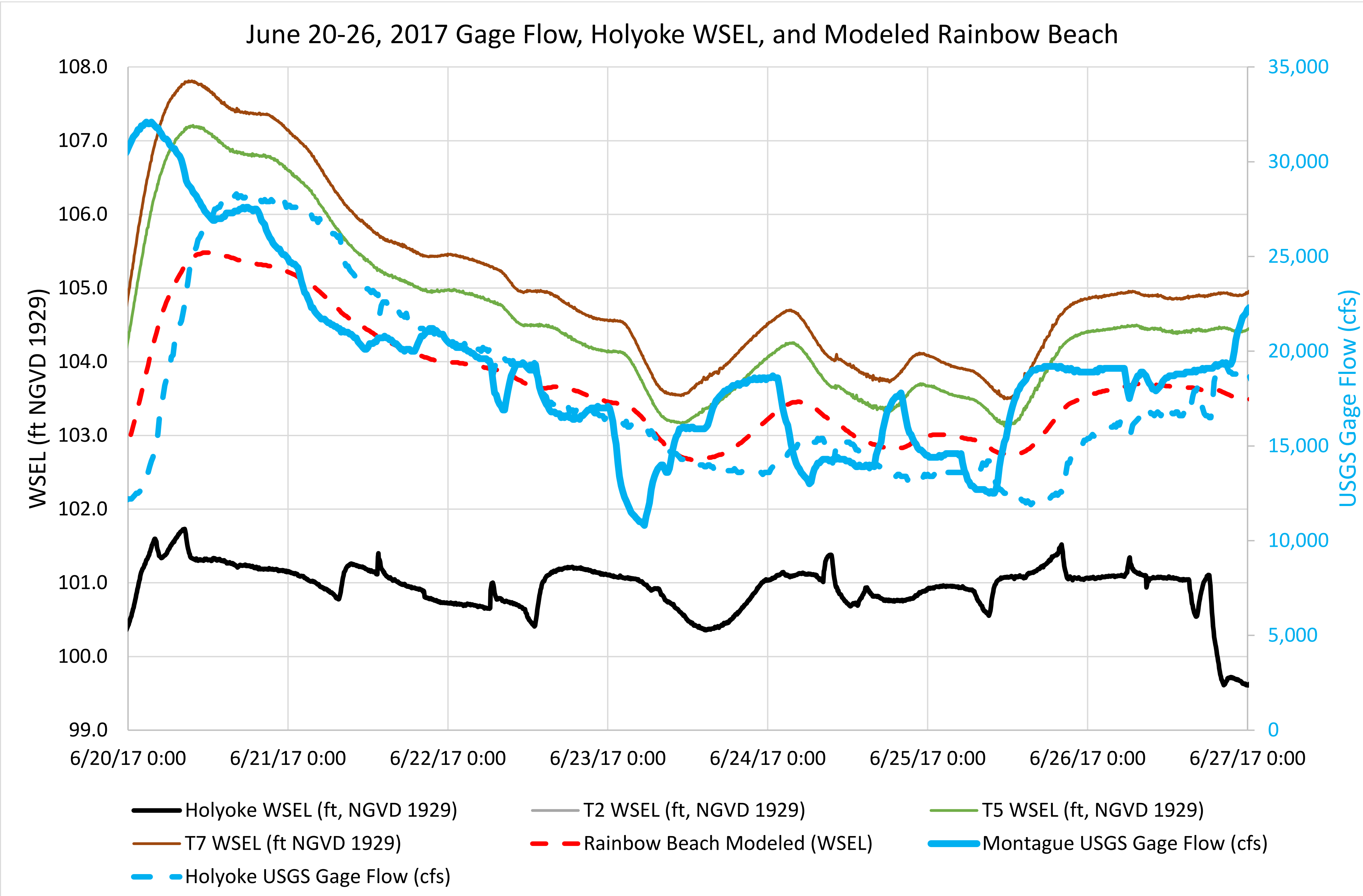
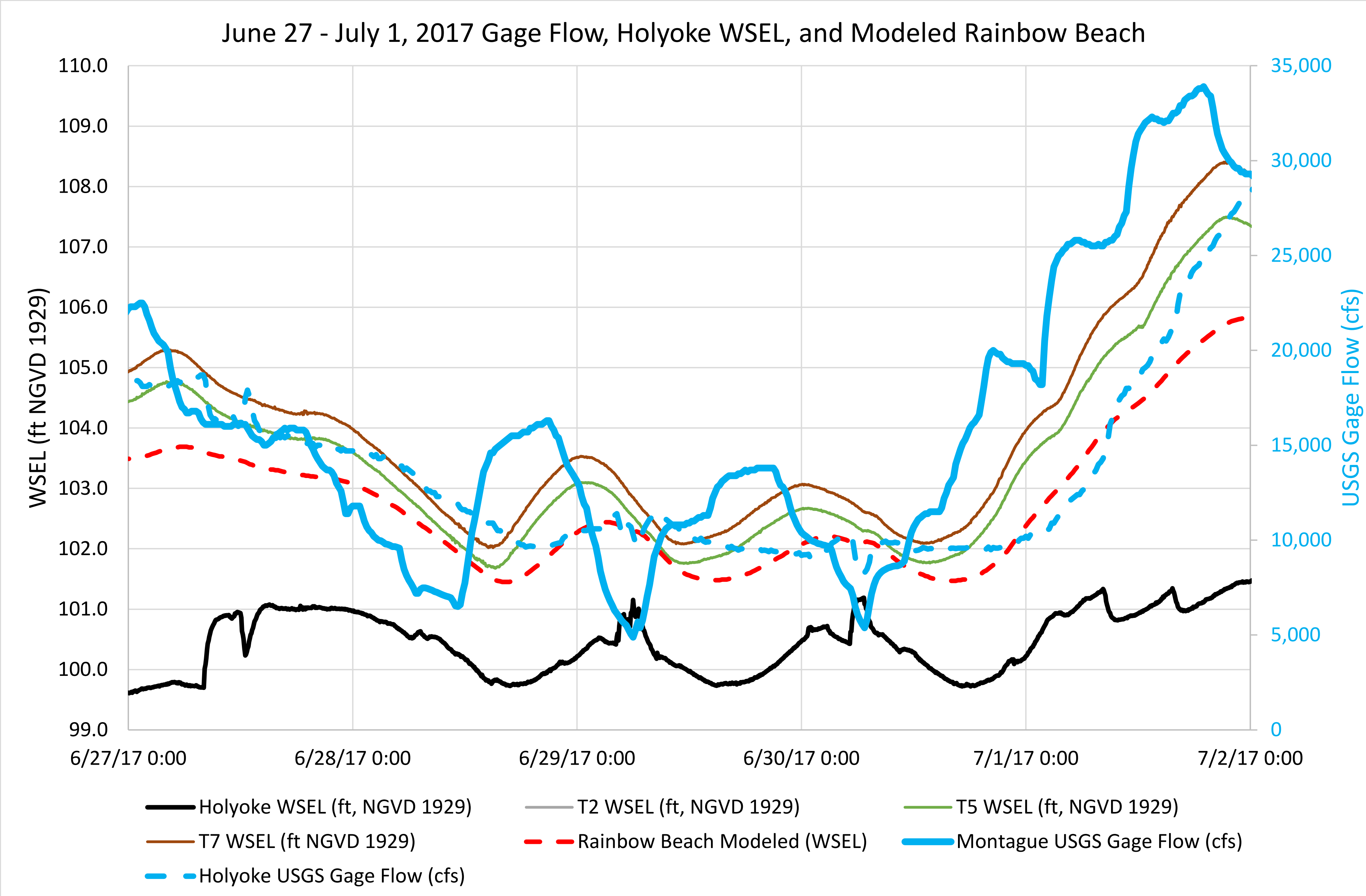
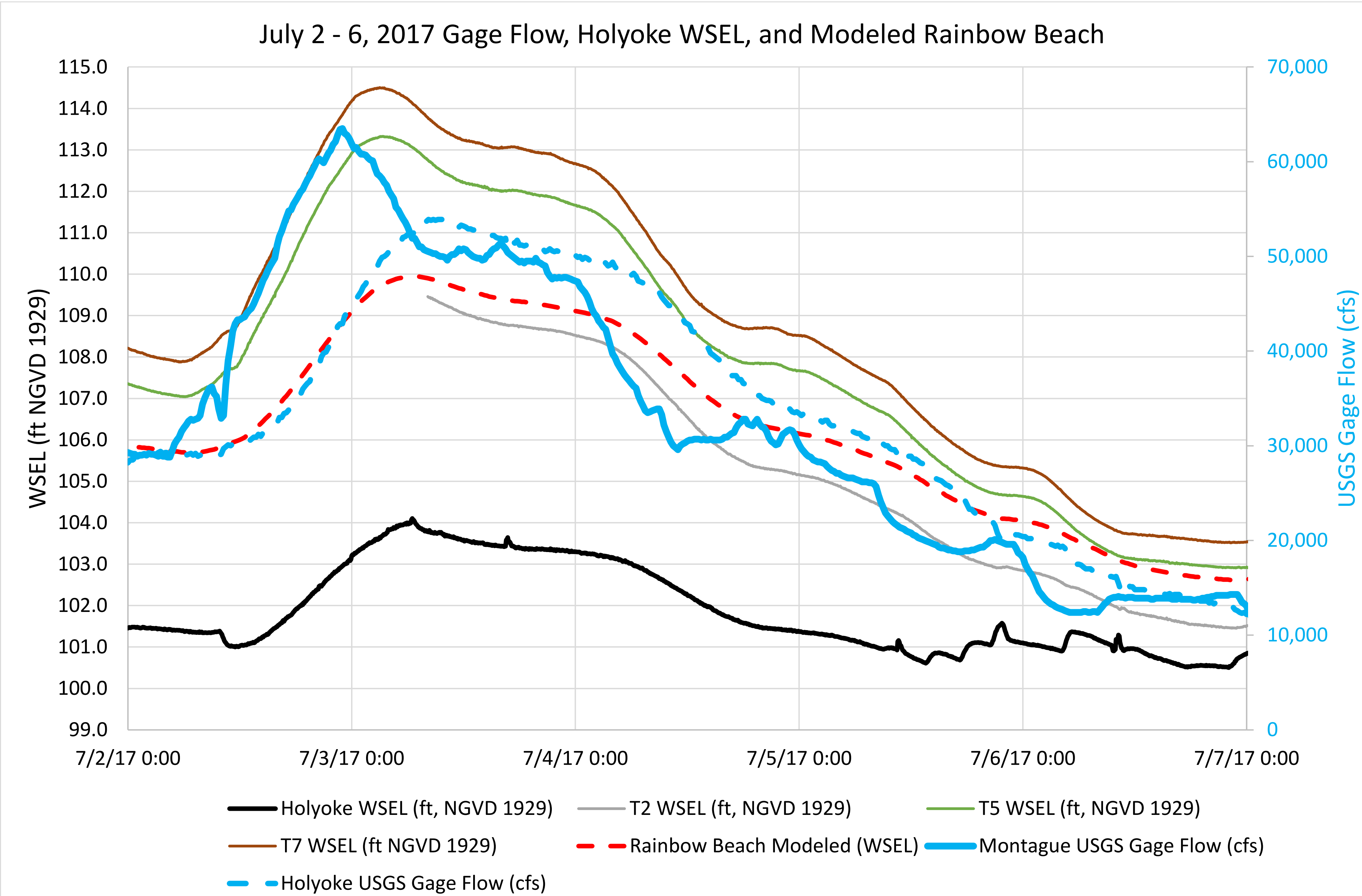
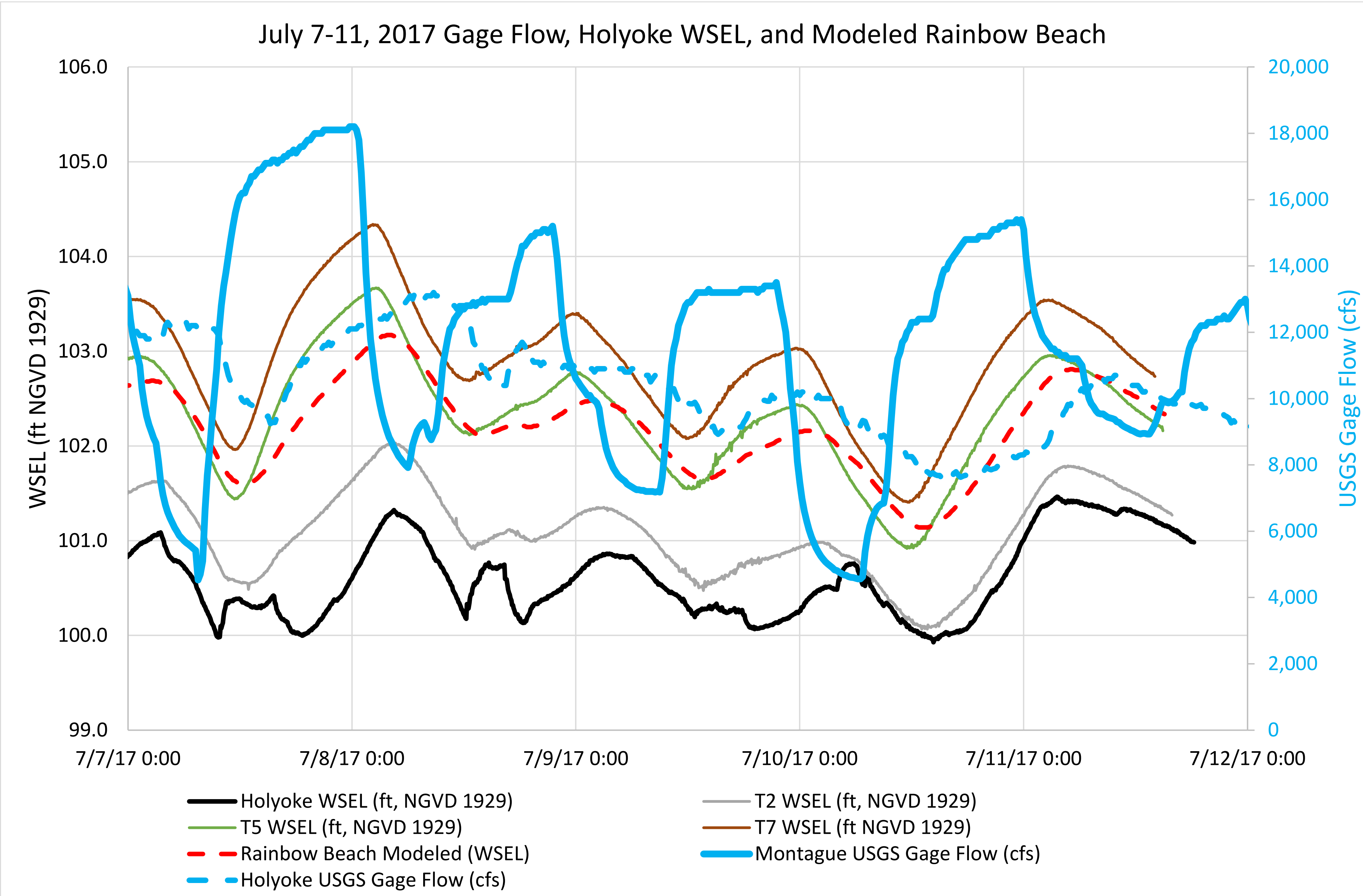

June 13 - 19, 2017 Gage Flow, Holyoke WSEL, and Modeled Rainbow Beach
WSEL (ft NGVD 1929)
USGS Gage Flow (cfs)
106.0
105.0
104.0
103.0
102.0
101.0
100.0
99.0
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
6/13/17 0:00
6/14/17 0:00
6/15/17 0:00
6/16/17 0:00
6/17/17 0:00
6/18/17 0:00
6/19/17 0:00
6/20/17 0:00
Holyoke WSEL (ft, NGVD 1929)
T2 WSEL (ft, NGVD 1929)
T5 WSEL (ft, NGVD 1929)
T7 WSEL (ft NGVD 1929)
Rainbow Beach Modeled (WSEL)
Montague USGS Gage Flow (cfs)
Holyoke USGS Gage Flow (cfs)



June 20-26, 2017 Gage Flow, Holyoke WSEL, and Modeled Rainbow Beach
WSEL (ft NGVD 1929)
USGS Gage Flow (cfs)
108.0
107.0
106.0
105.0
104.0
103.0
102.0
101.0
100.0
99.0
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
6/20/17 0:00
6/21/17 0:00
6/22/17 0:00
6/23/17 0:00
6/24/17 0:00
6/25/17 0:00
6/26/17 0:00
6/27/17 0:00
Holyoke WSEL (ft, NGVD 1929)
T2 WSEL (ft, NGVD 1929)
T5 WSEL (ft, NGVD 1929)
T7 WSEL (ft NGVD 1929)
Rainbow Beach Modeled (WSEL)
Montague USGS Gage Flow (cfs)
Holyoke USGS Gage Flow (cfs)


June 27 - July 1, 2017 Gage Flow, Holyoke WSEL, and Modeled Rainbow Beach
WSEL (ft NGVD 1929)
USGS Gage Flow (cfs)
110.0
109.0
108.0
107.0
106.0
105.0
104.0
103.0
102.0
101.0
100.0
99.0
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
6/27/17 0:00
6/28/17 0:00
6/29/17 0:00
6/30/17 0:00
7/1/17 0:00
7/2/17 0:00
Holyoke WSEL (ft, NGVD 1929)
T2 WSEL (ft, NGVD 1929)
T5 WSEL (ft, NGVD 1929)
T7 WSEL (ft NGVD 1929)
Rainbow Beach Modeled (WSEL)
Montague USGS Gage Flow (cfs)
Holyoke USGS Gage Flow (cfs)


July 2 - 6, 2017 Gage Flow, Holyoke WSEL, and Modeled Rainbow Beach
WSEL (ft NGVD 1929)
USGS Gage Flow (cfs)
115.0
114.0
113.0
112.0
111.0
110.0
109.0
108.0
107.0
106.0
105.0
104.0
103.0
102.0
101.0
100.0
99.0
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
7/2/17 0:00
7/3/17 0:00
7/4/17 0:00
7/5/17 0:00
7/6/17 0:00
7/7/17 0:00
Holyoke WSEL (ft, NGVD 1929)
T2 WSEL (ft, NGVD 1929)
T5 WSEL (ft, NGVD 1929)
T7 WSEL (ft NGVD 1929)
Rainbow Beach Modeled (WSEL)
Montague USGS Gage Flow (cfs)
Holyoke USGS Gage Flow (cfs)


July 7-11, 2017 Gage Flow, Holyoke WSEL, and Modeled Rainbow Beach
WSEL (ft NGVD 1929)
USGS Gage Flow (cfs)
106.0
105.0
104.0
103.0
102.0
101.0
100.0
99.0
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
7/7/17 0:00
7/8/17 0:00
7/9/17 0:00
7/10/17 0:00
7/11/17 0:00
7/12/17 0:00
Holyoke WSEL (ft, NGVD 1929)
T2 WSEL (ft, NGVD 1929)
T5 WSEL (ft, NGVD 1929)
T7 WSEL (ft NGVD 1929)
Rainbow Beach Modeled (WSEL)
Montague USGS Gage Flow (cfs)
Holyoke USGS Gage Flow (cfs)

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Appendix E- Water Resources- Model Duration Curves

Flow duration Curves comparing Baseline and Proposed Actions flows at the following locations:

- Downstream of Turners Falls Dam,
- Station No. 1,
- Total bypass,
- Cabot Station, and
- Montague.

For the following time periods:

- April 1 – May 31,
- June 1 – June 15,
- June 16 – June 30,
- July 1 – August 31,
- September 1 – November 30, and
- December 1 – March 31.

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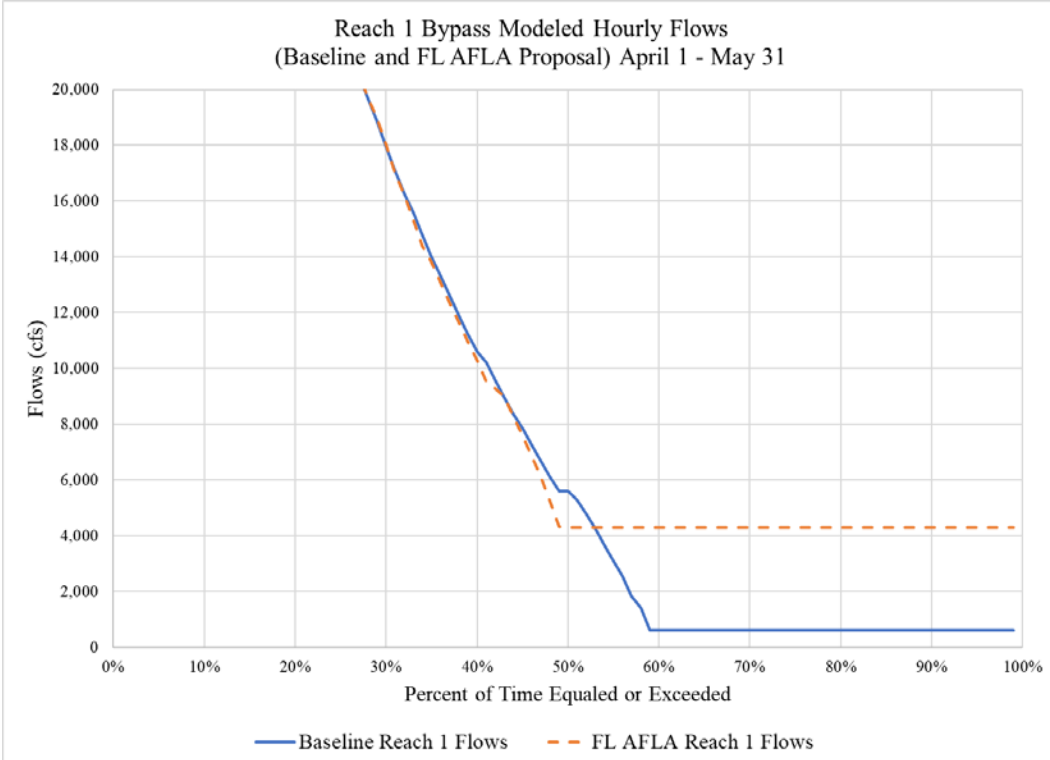
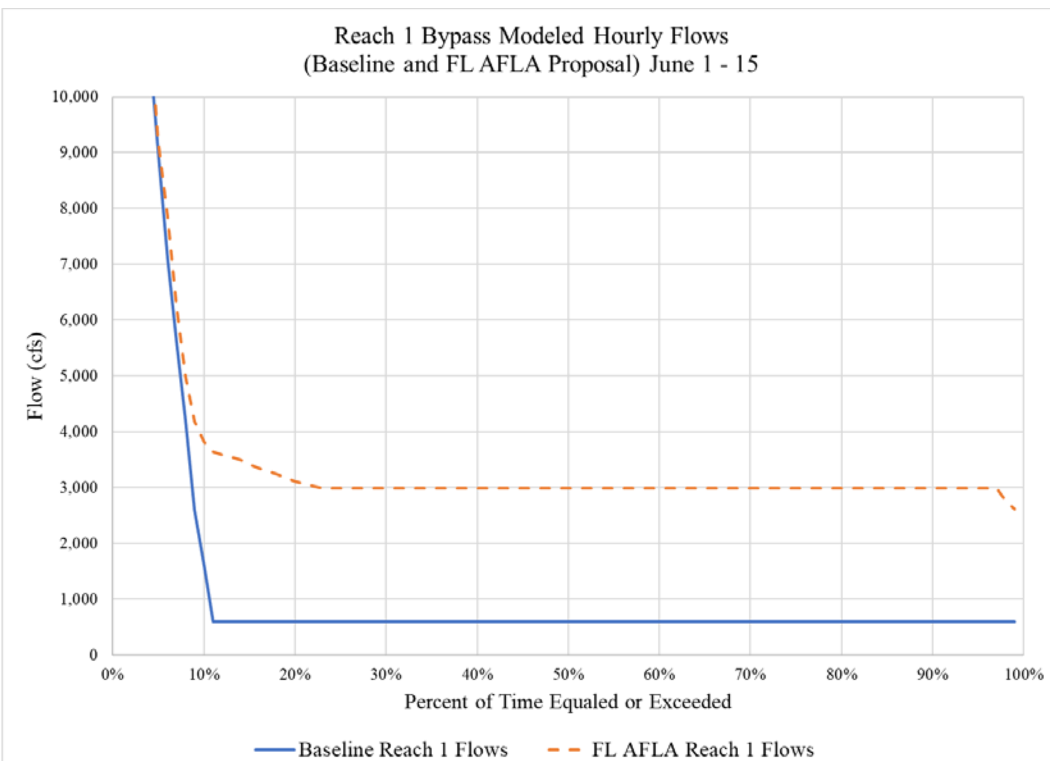
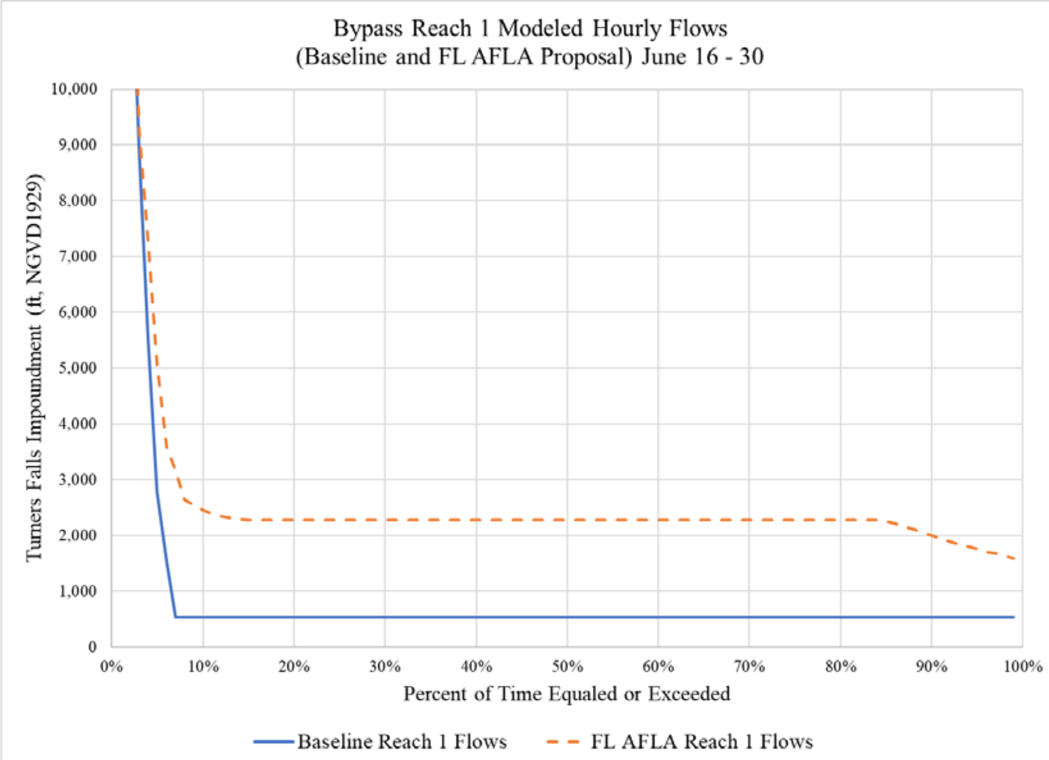


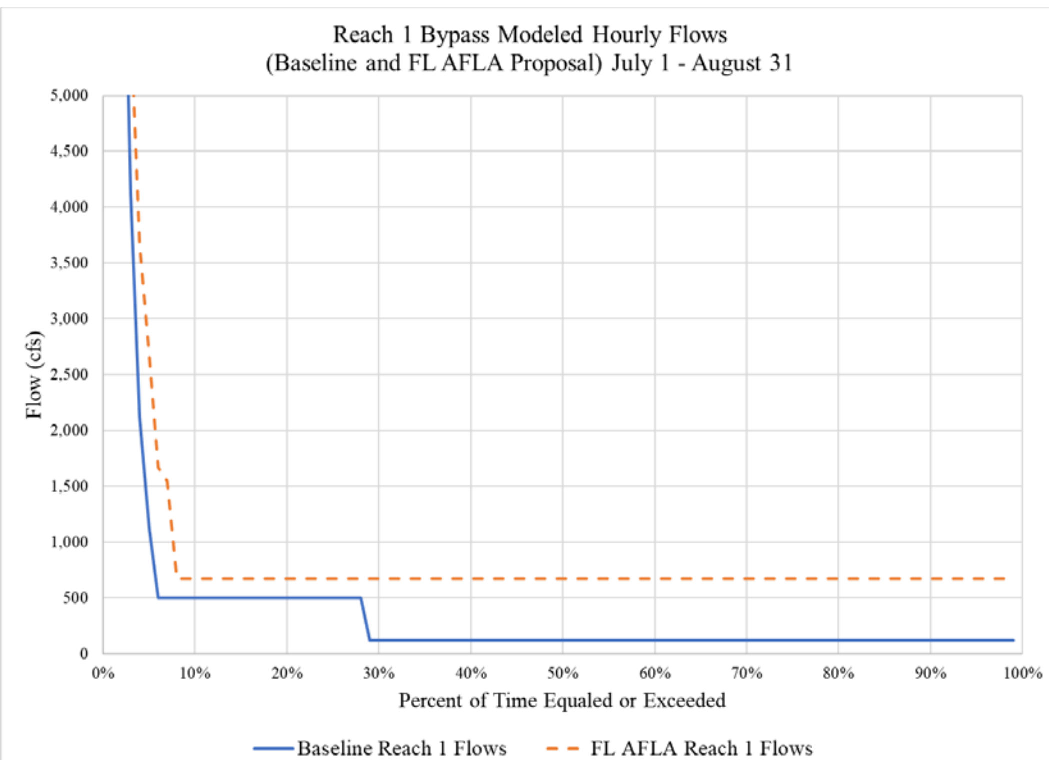
April 1 – May 31 Duration Curves for Reach 1



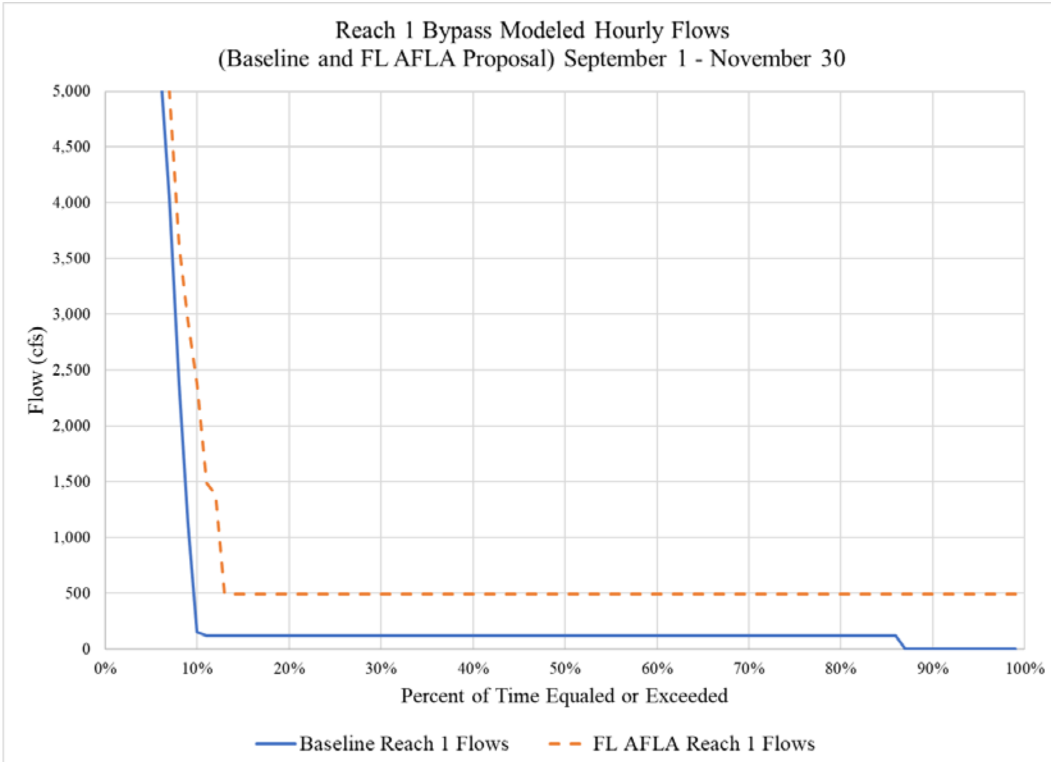
June 1 – 15 Duration Curves for Reach 1



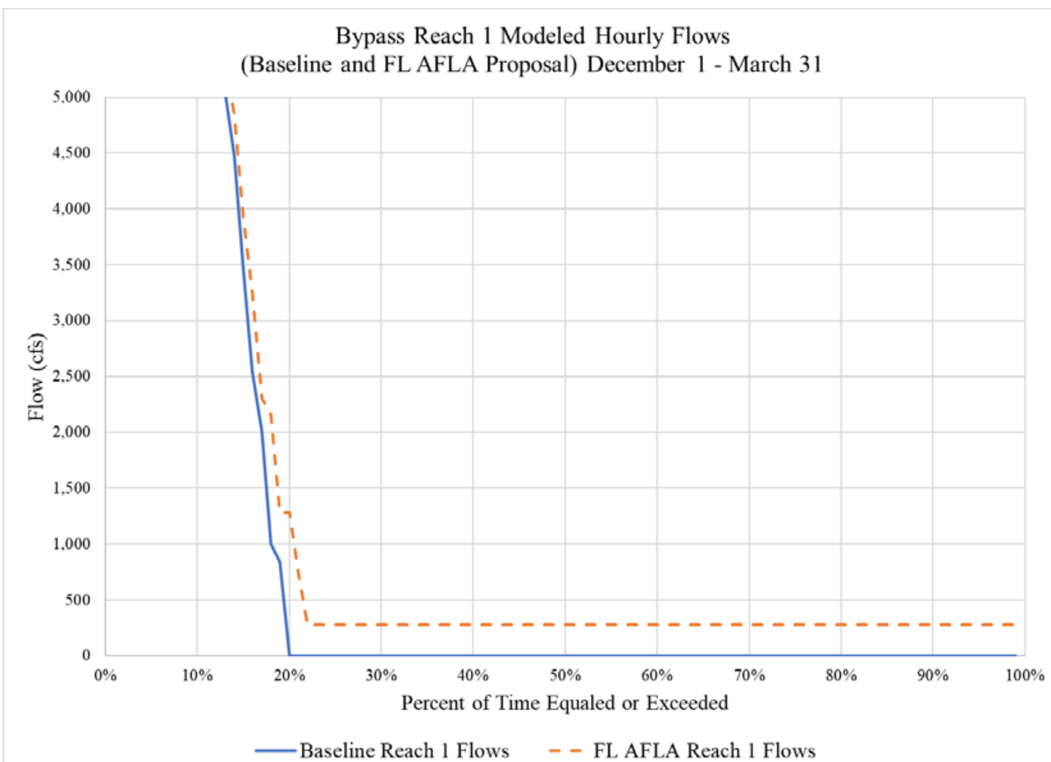
June 16 – 30 Duration Curves for Reach 1



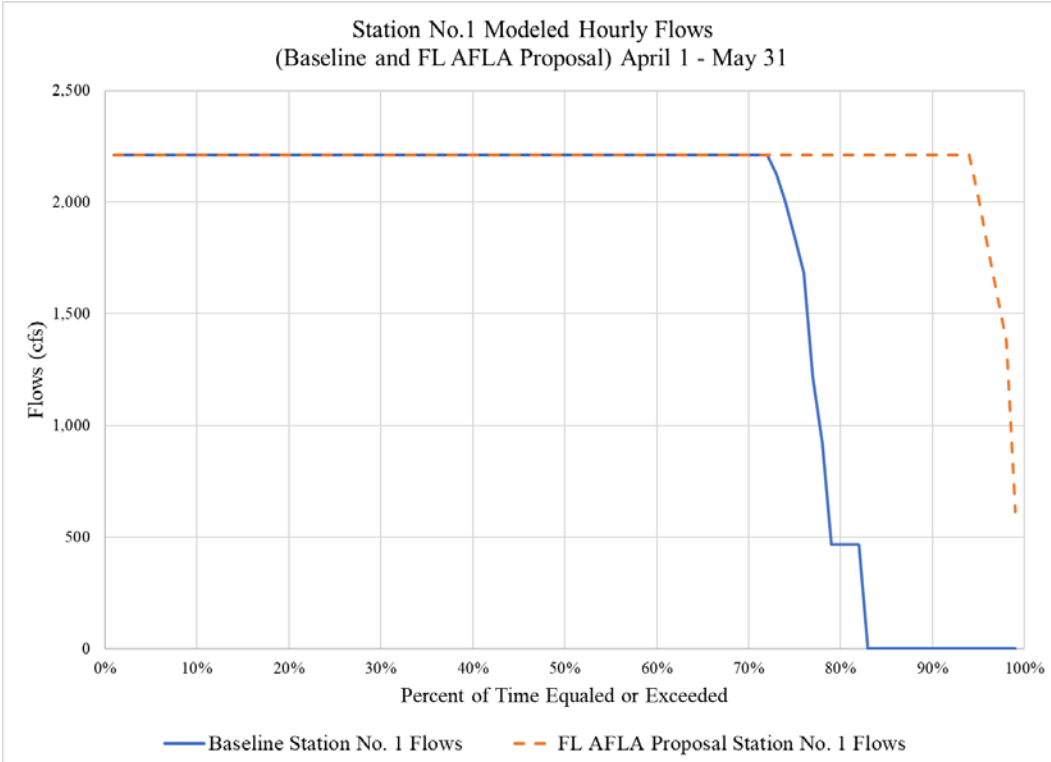
July 1 – August 31 Duration Curves for Reach 1



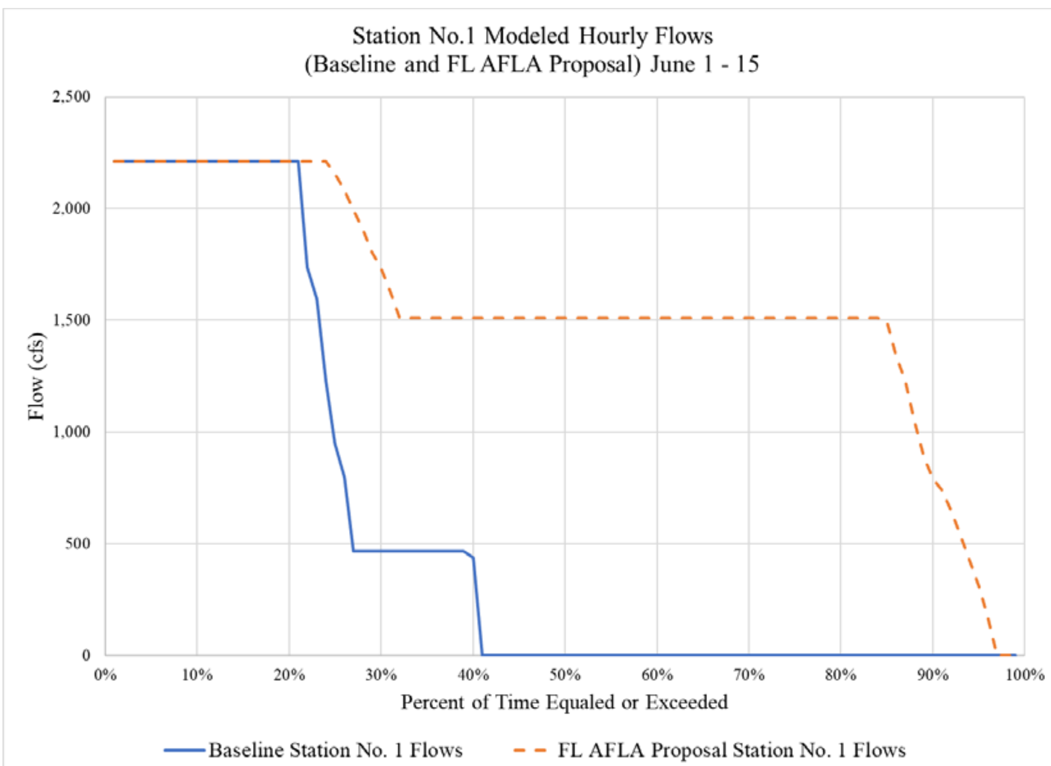
September 1 – November 30 Duration Curves for Reach 1



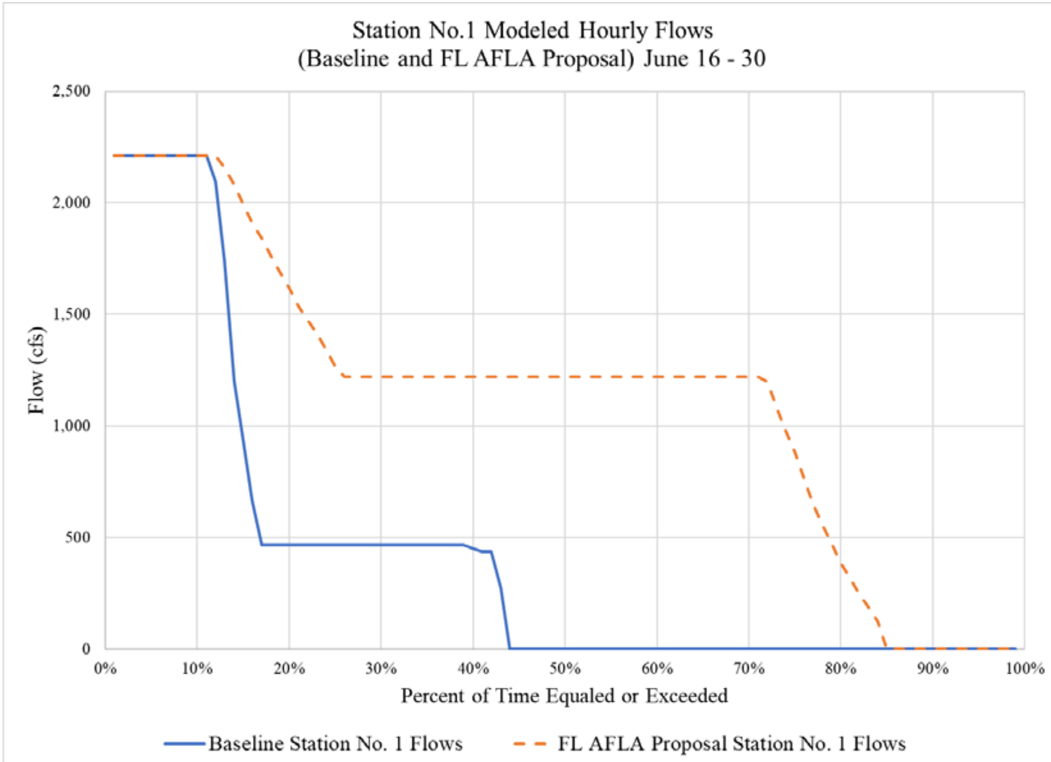
December 1 – March 31 Duration Curves for Reach 1



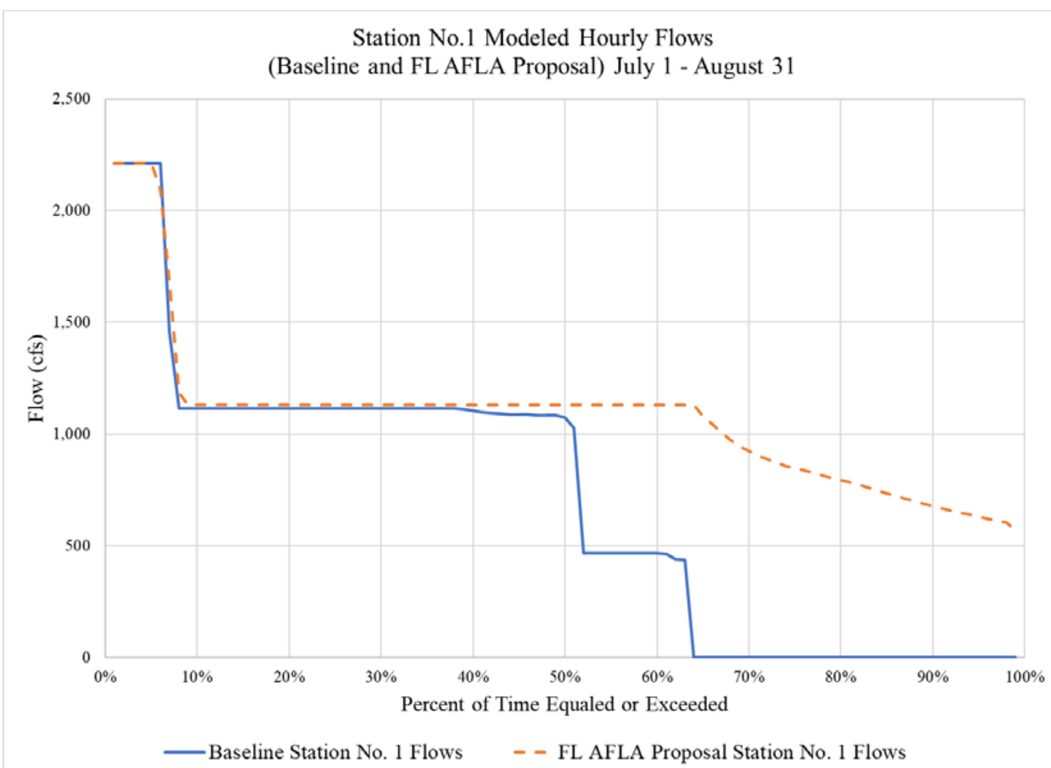
April 1 – May 31 Duration Curves for Station No. 1



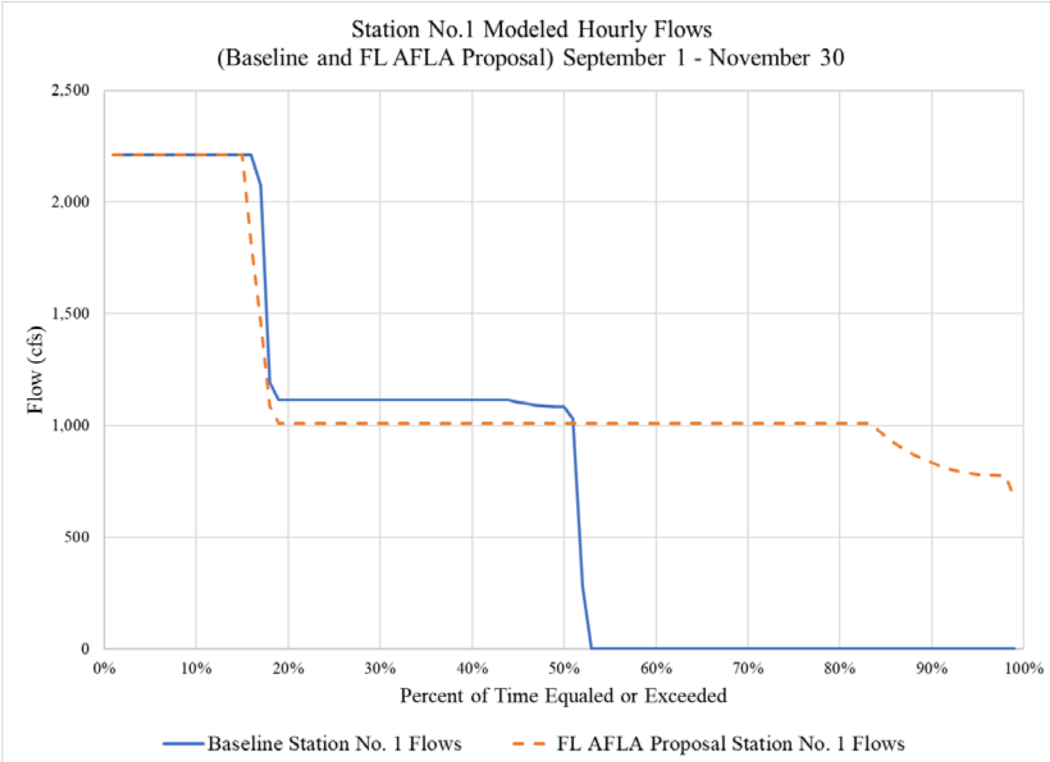
June 1 – 15 Duration Curves for Station No. 1



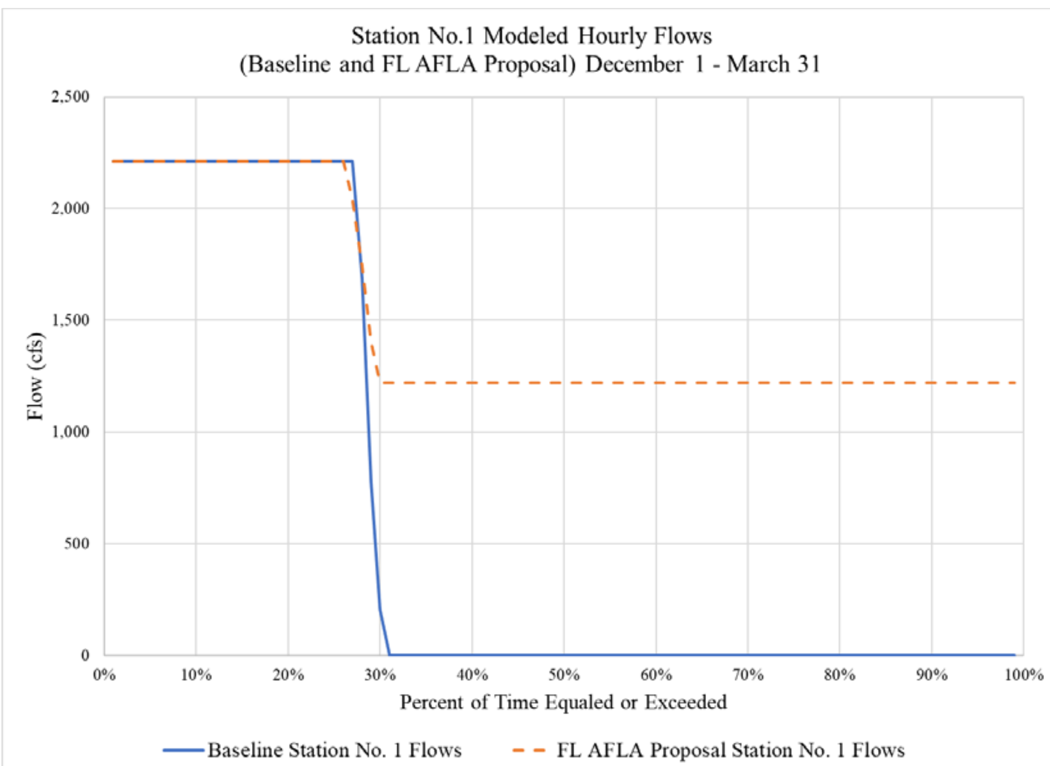
June 16 – 30 Duration Curves for Station No. 1



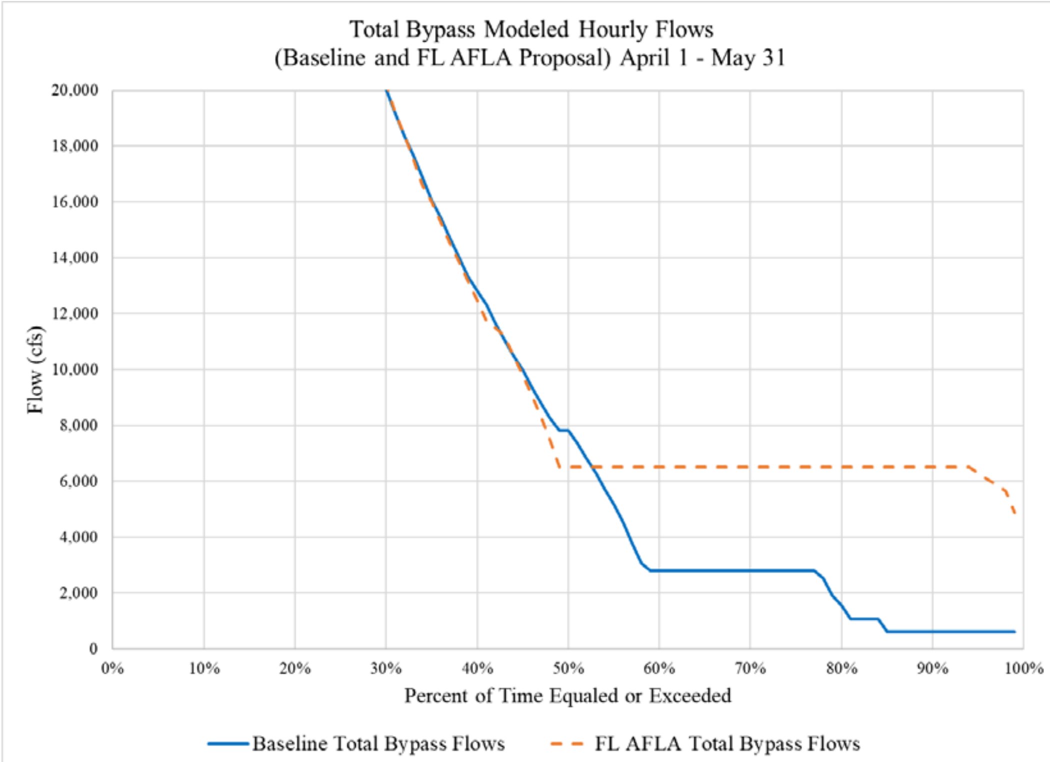
July 1 – August 31 Duration Curves for Station No. 1



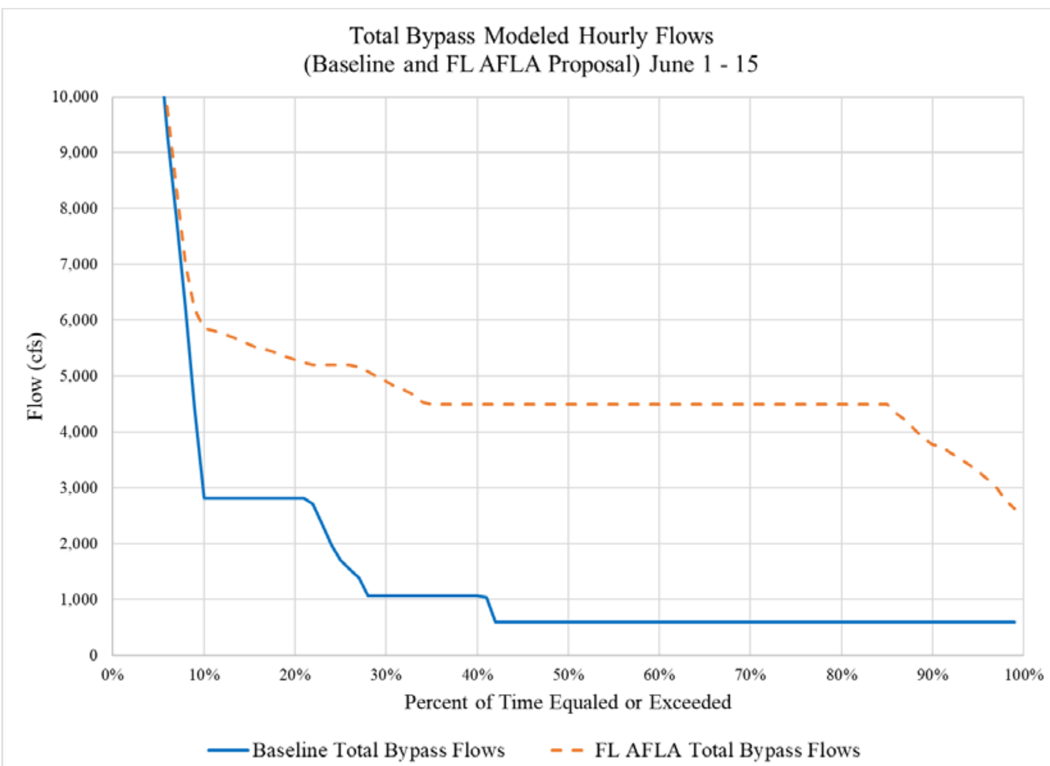
September 1 – November 30 Duration Curves for Station No. 1



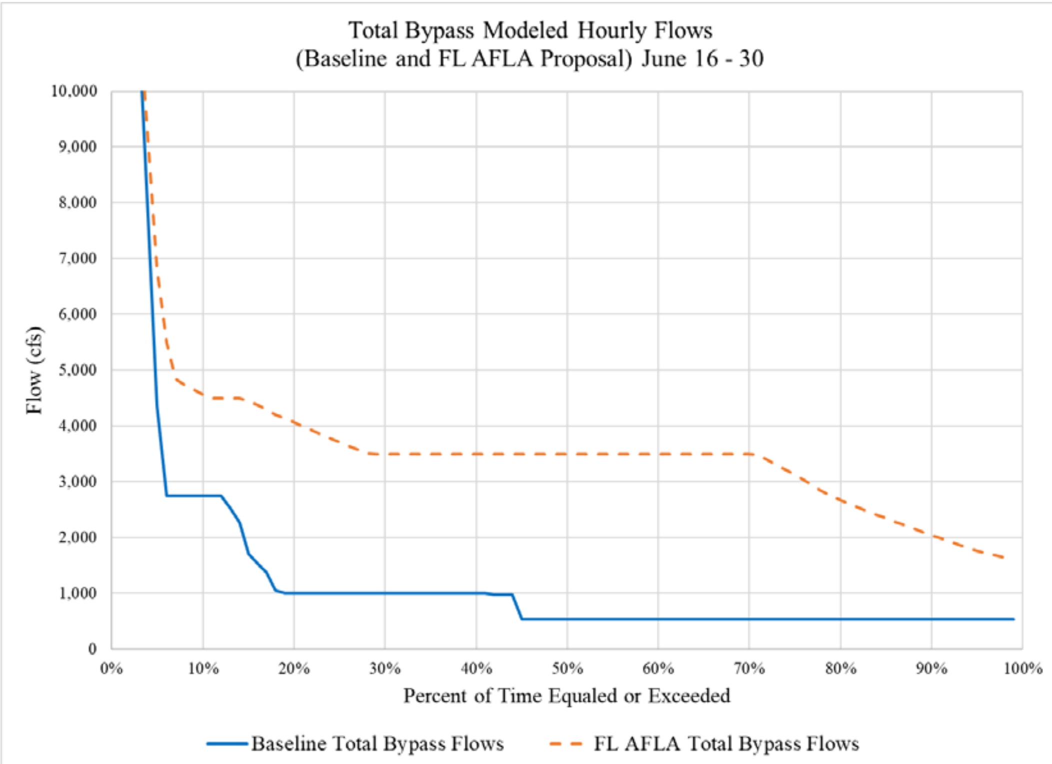
December 1 – March 31 Duration Curves for Station No. 1



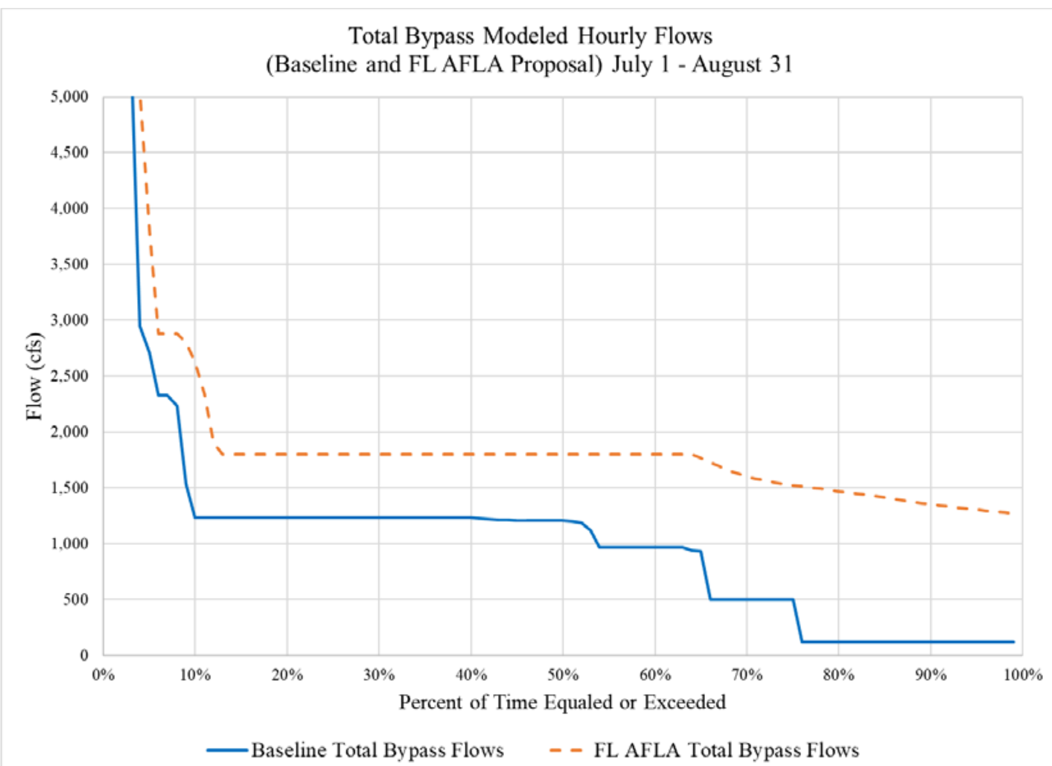
April 1 – May 31 Duration Curves for Total Bypass Flow



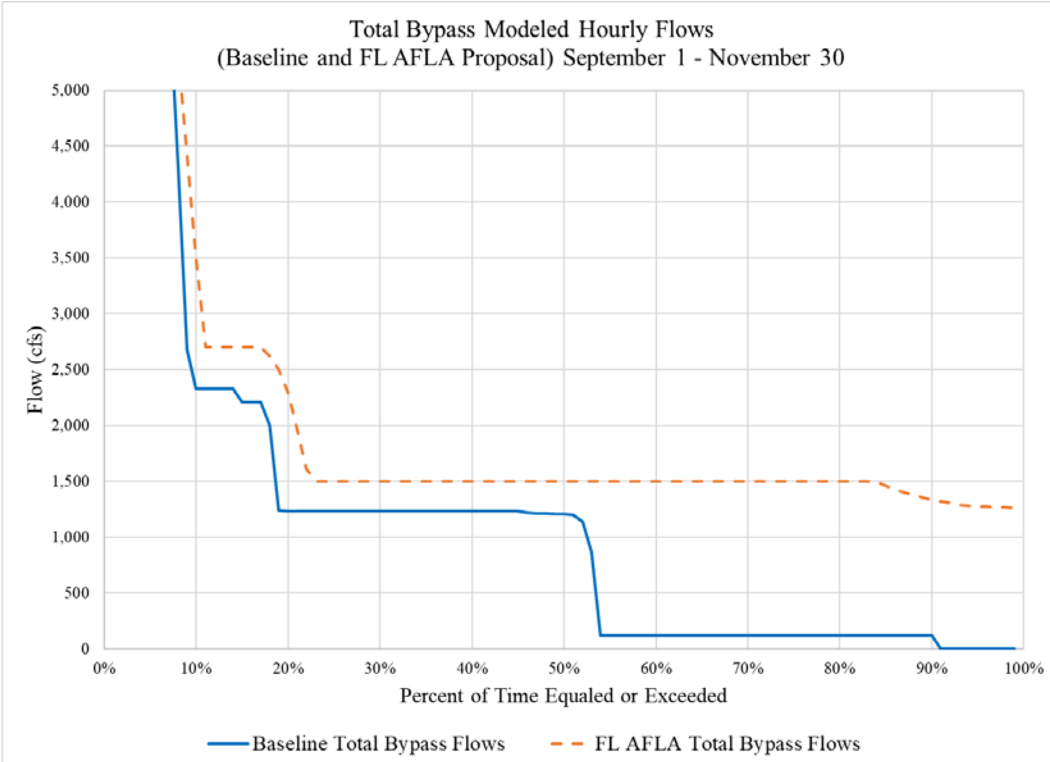
June 1 – 15 Duration Curves for Total Bypass Flow



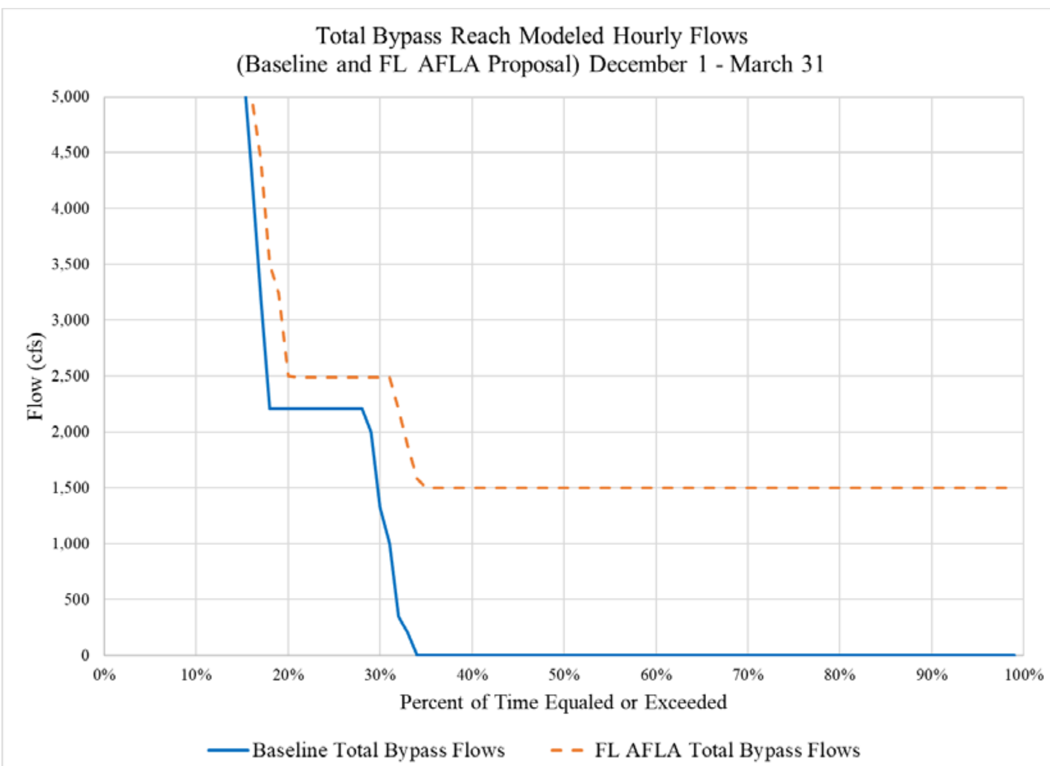
June 16 – 30 Duration Curves for Total Bypass Flow



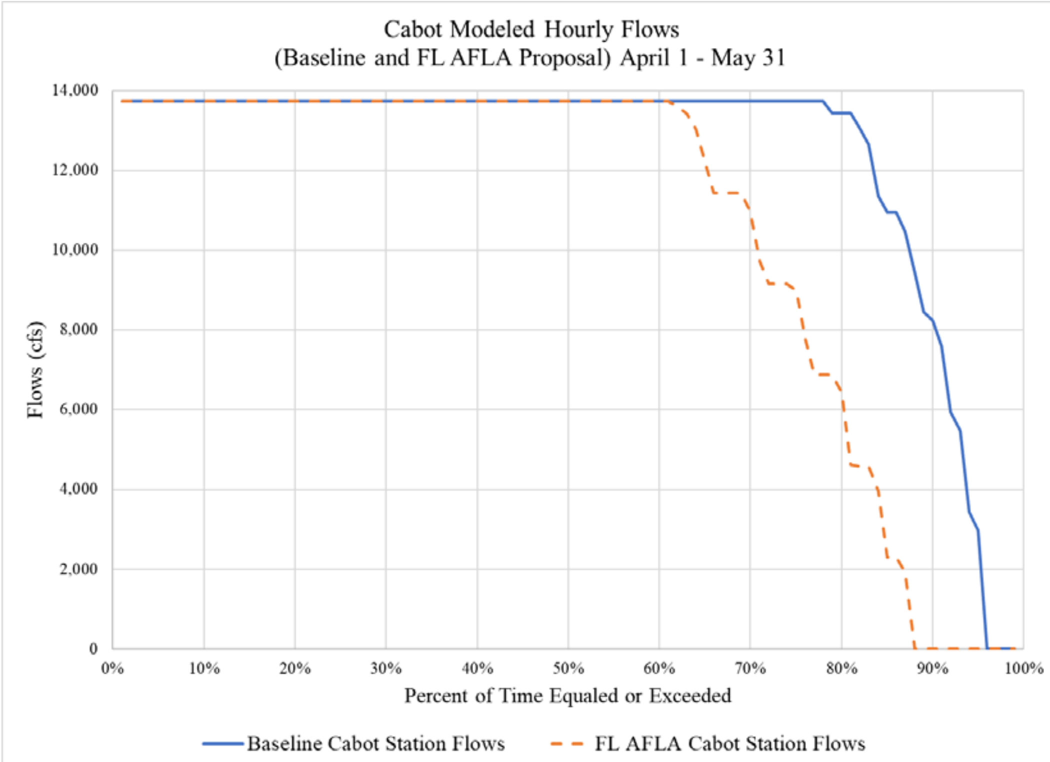
July 1 – August 31 Duration Curves for Total Bypass Flow



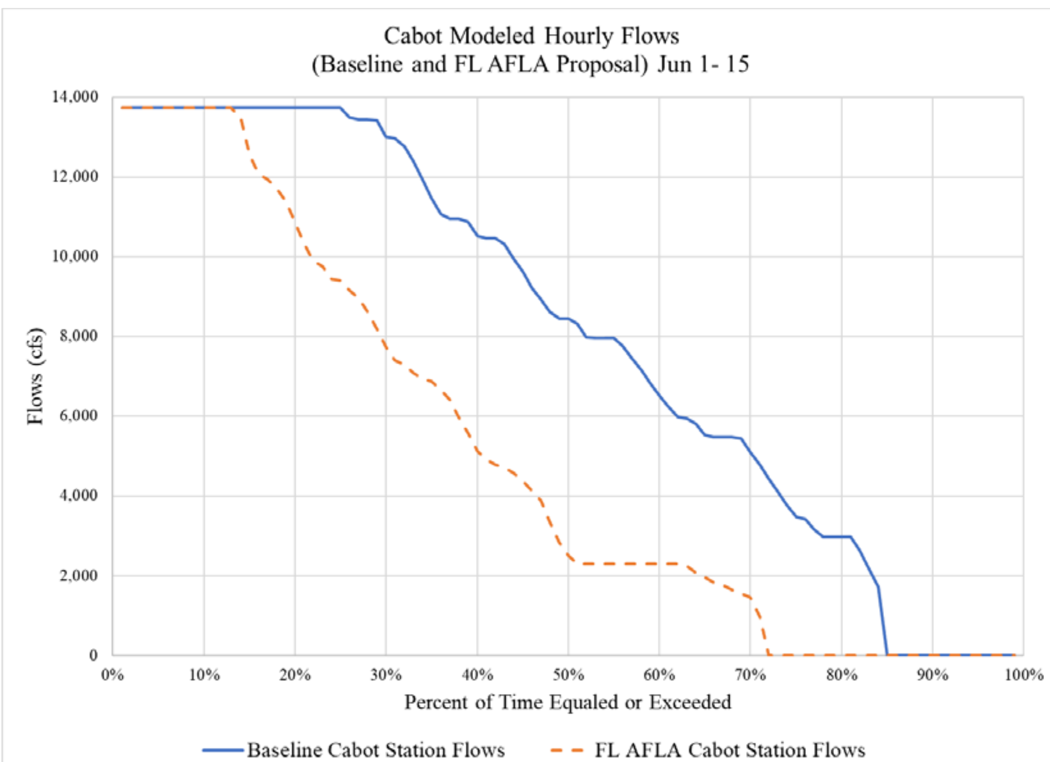
September 1 – November 30 Duration Curves for Total Bypass Flow



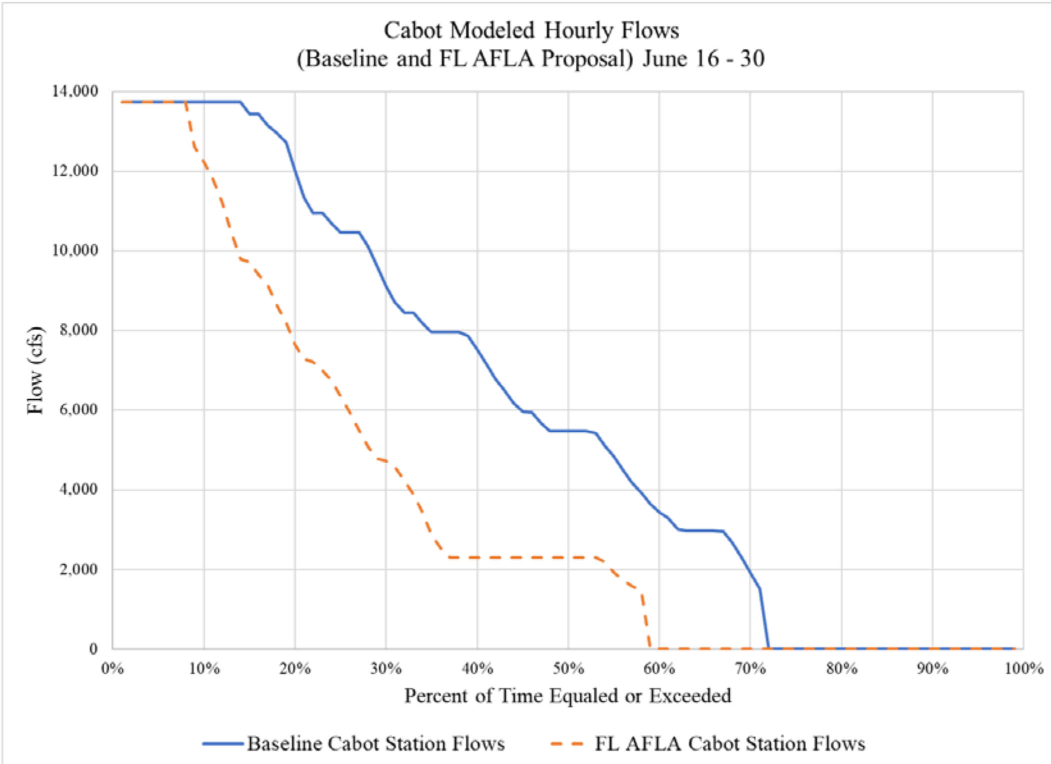
December 1 – March 31 Duration Curves for Total Bypass Flow



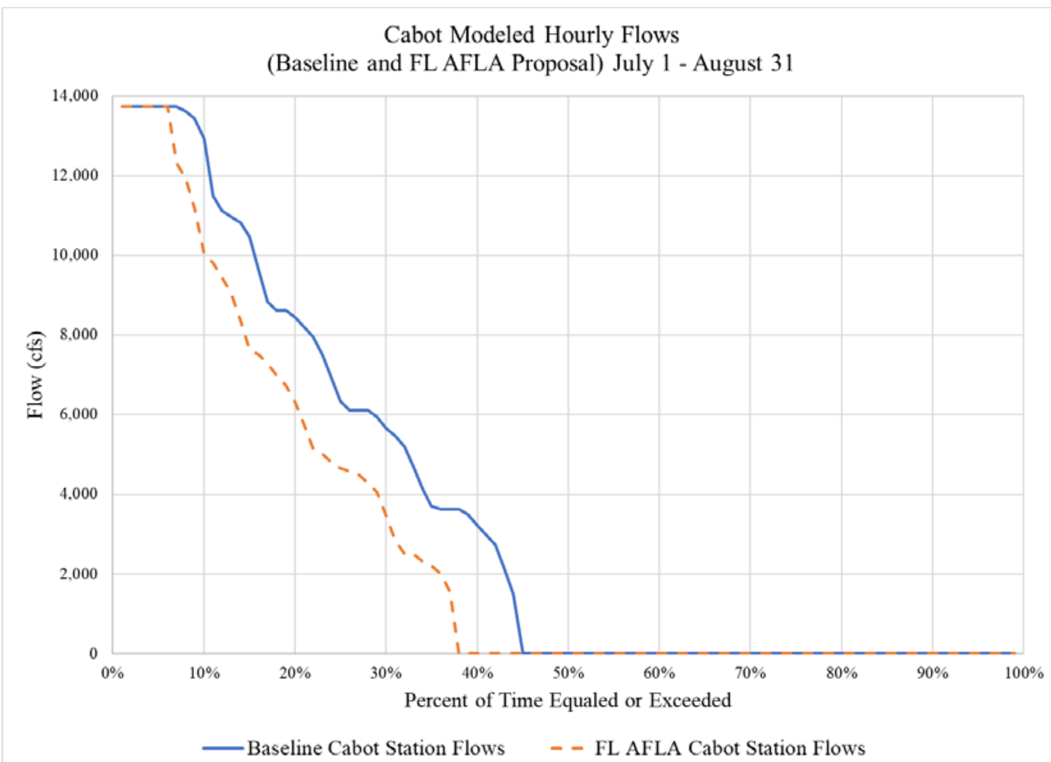
April 1 – May 31 Duration Curves for Cabot Flows



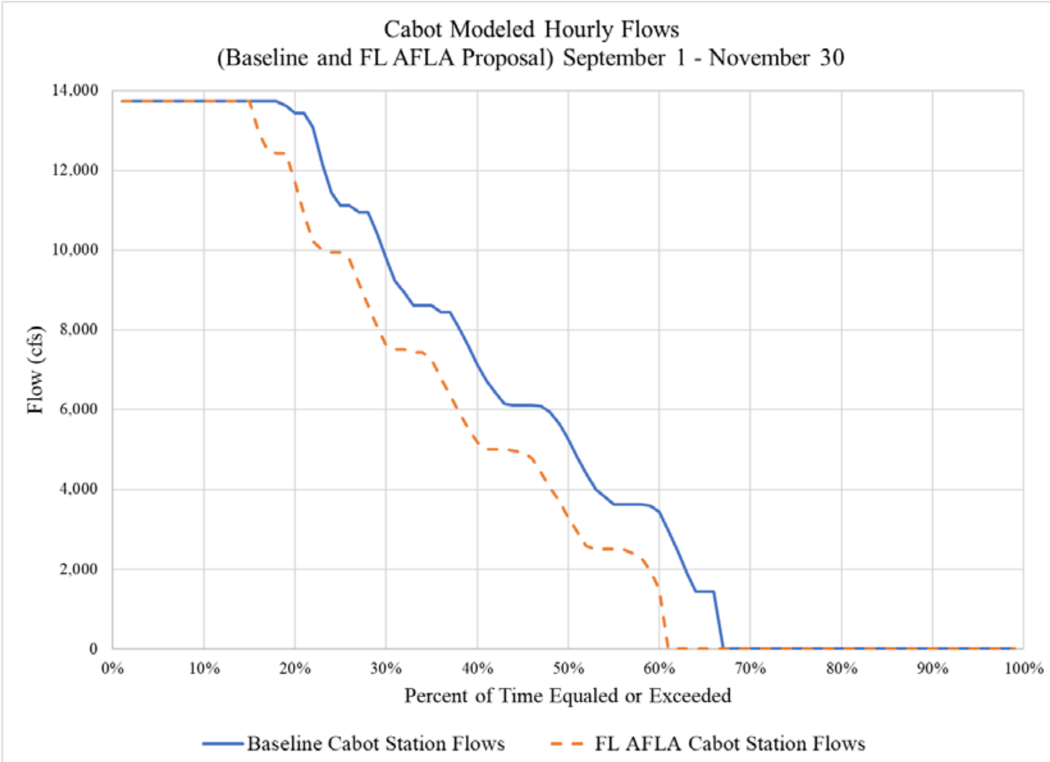
June 1 - 15 Duration Curves for Cabot Flows



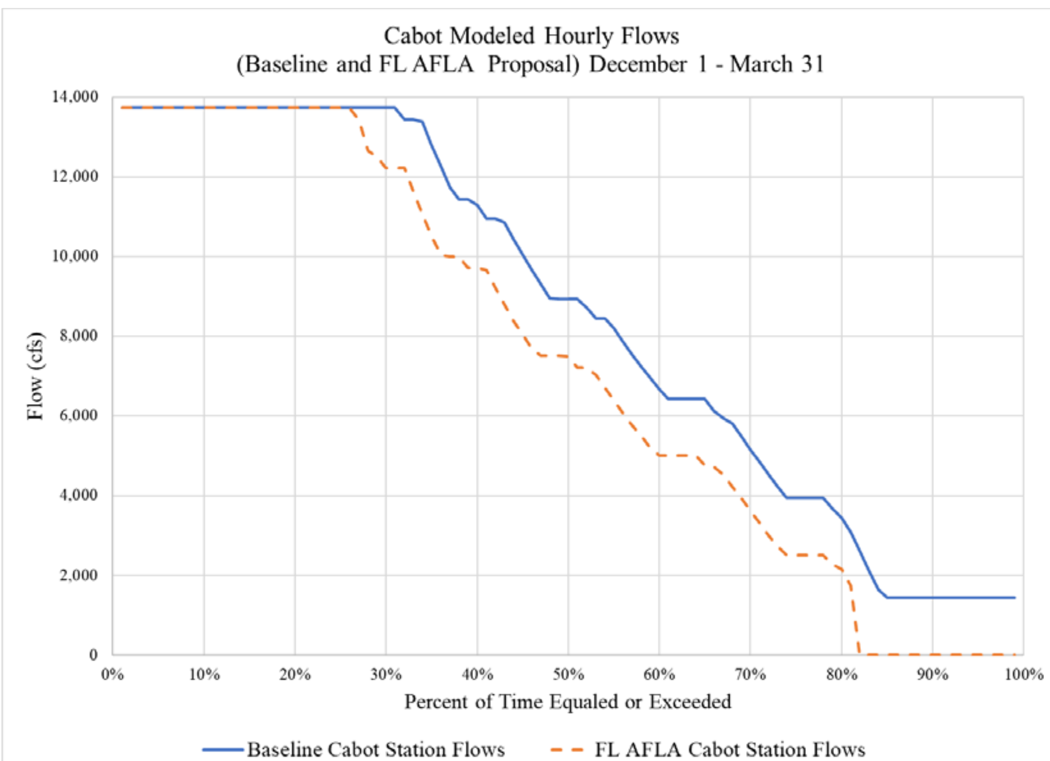
June 16 - 30 Duration Curves for Cabot Flows



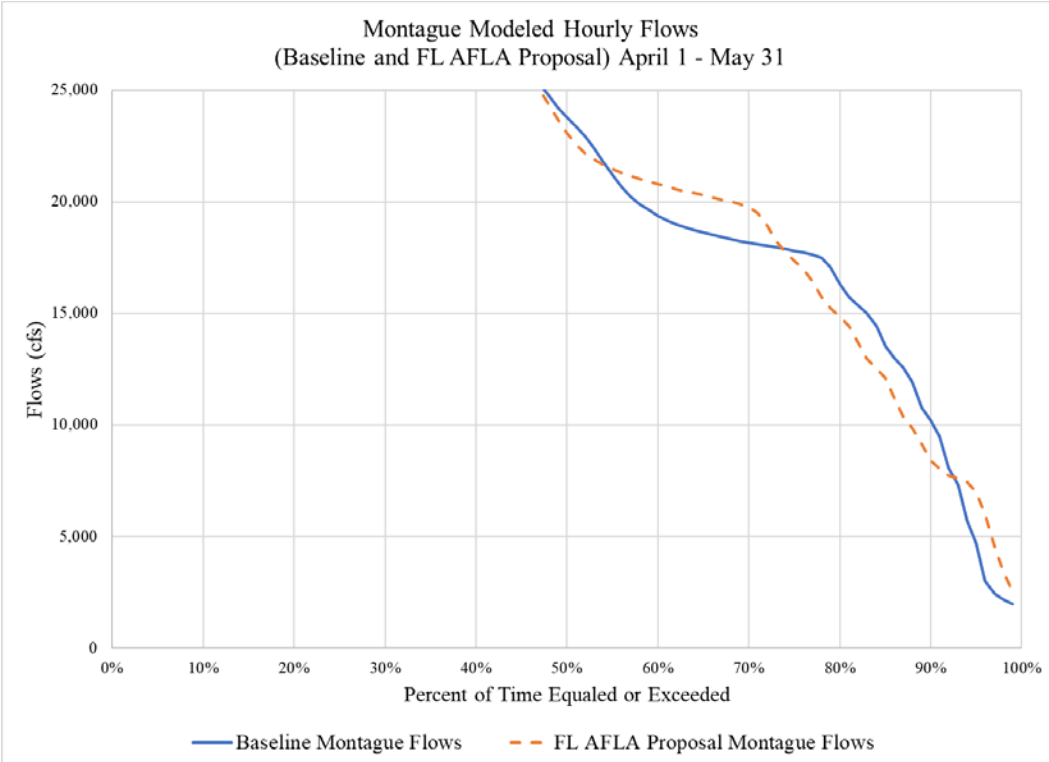
July 1 – August 31 Duration Curves for Cabot Flows



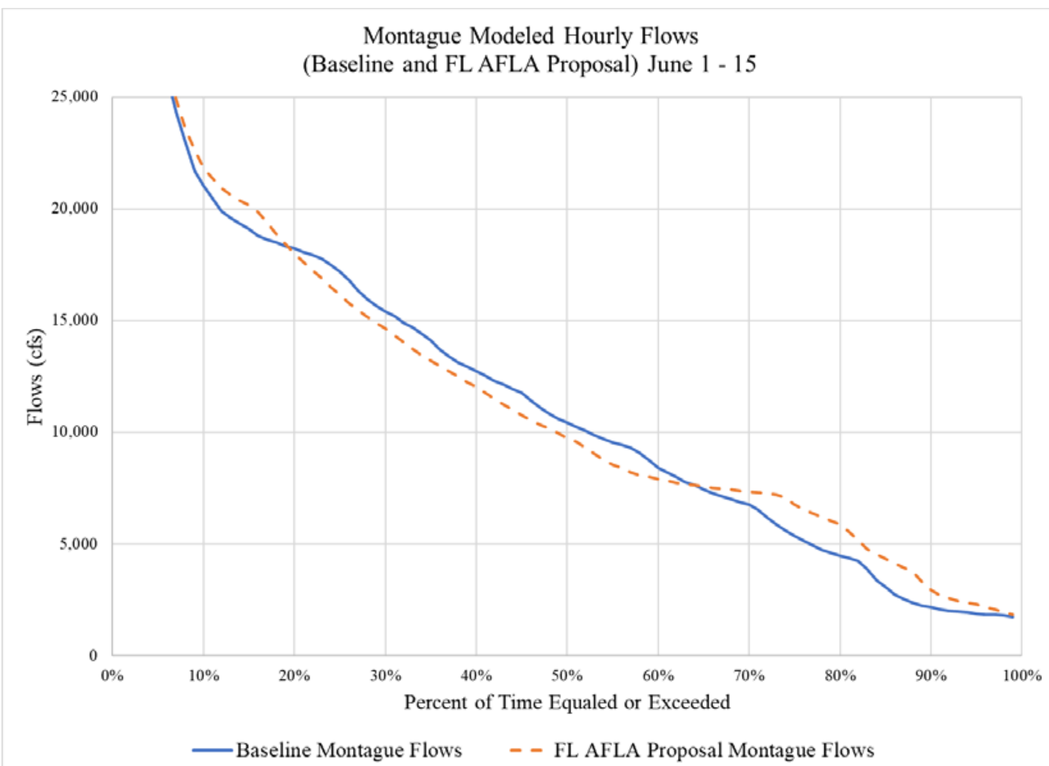
September 1 – November 30 Duration Curves for Cabot Flows



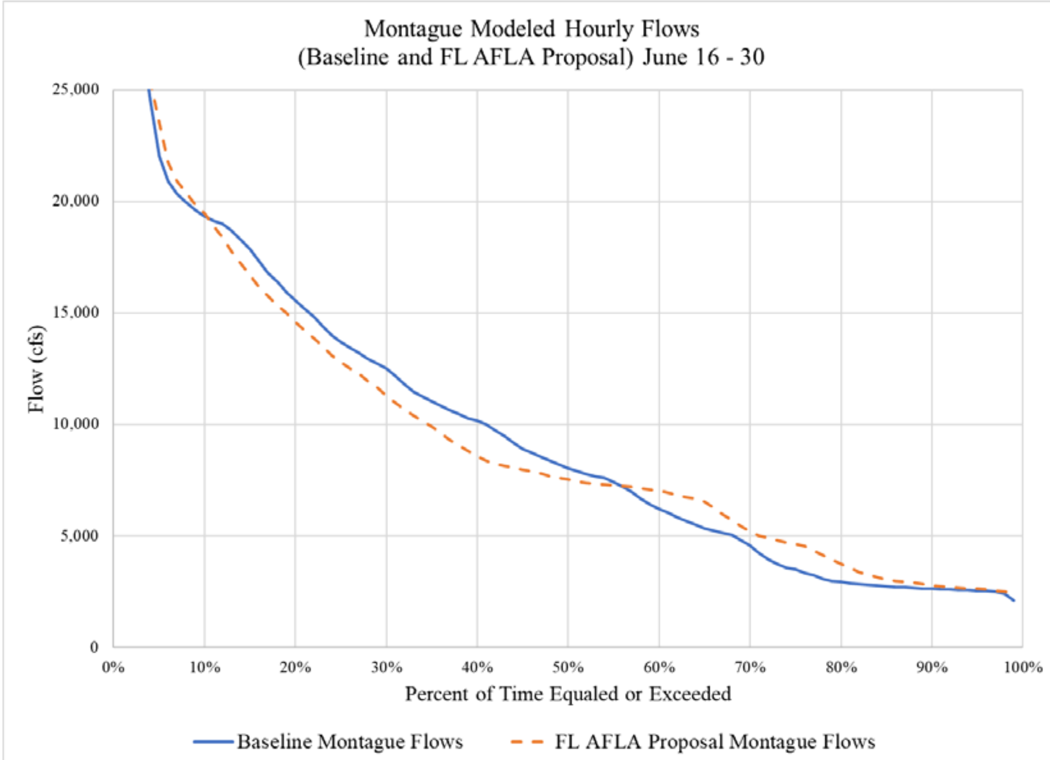
December 1 – March 31 Duration Curves for Cabot Flows



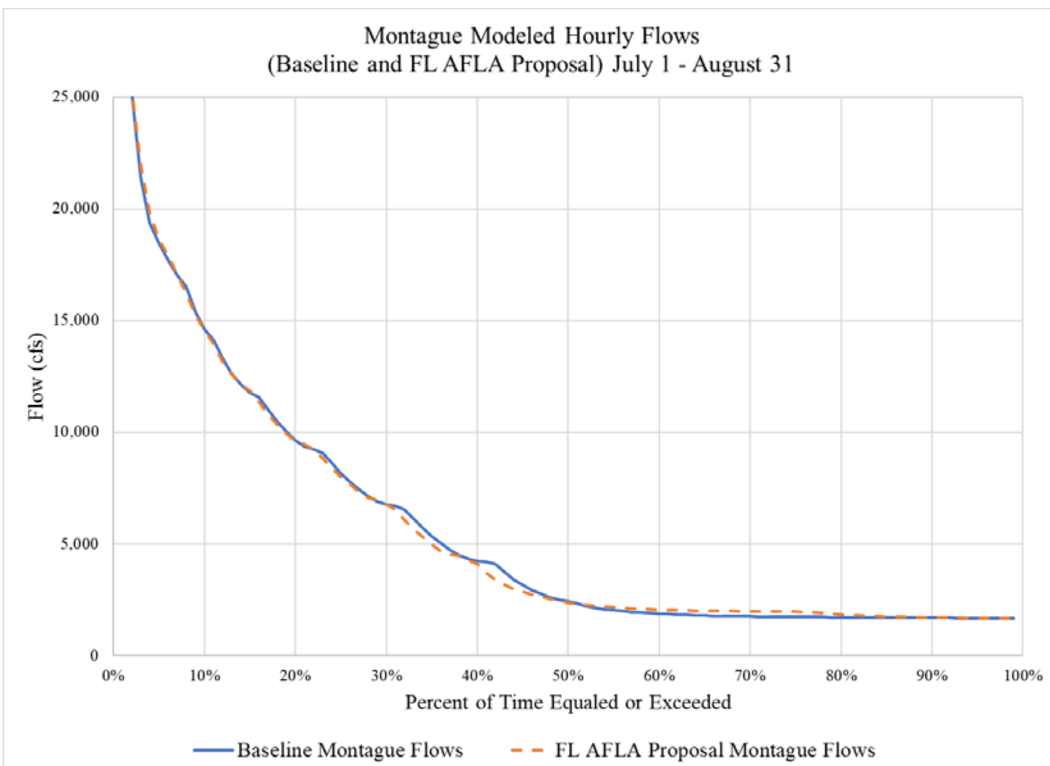
April 1 – May 31 Duration Curves for Montague Flows



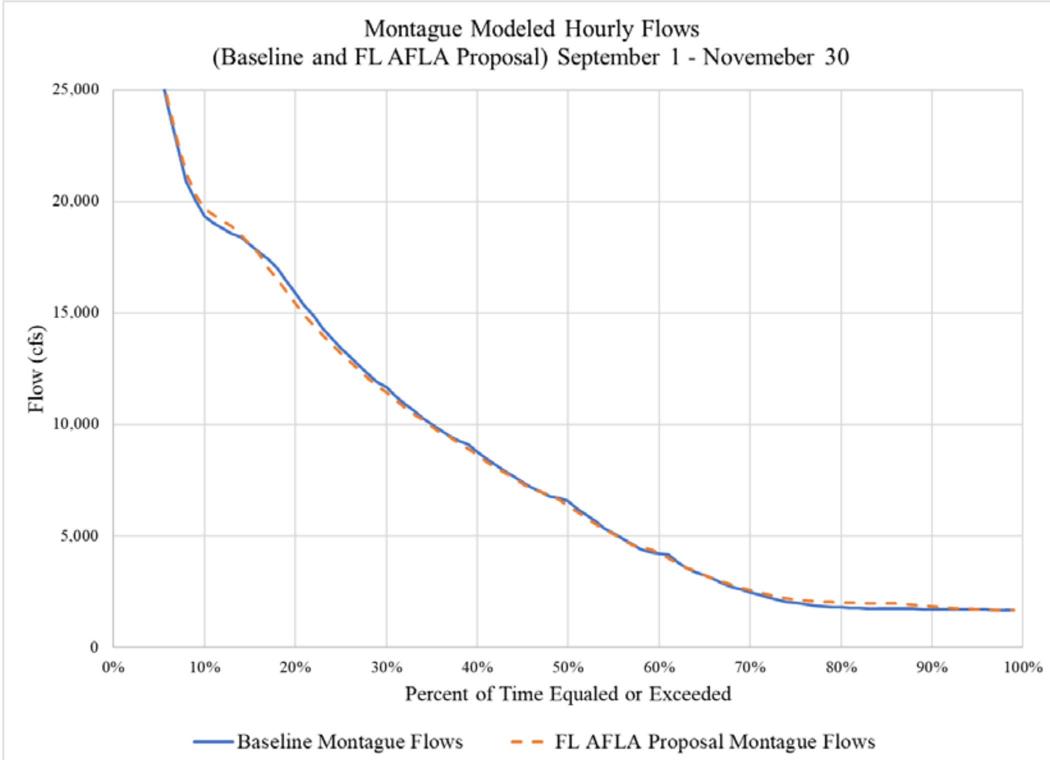
June 1 - 15 Duration Curves for Montague Flows



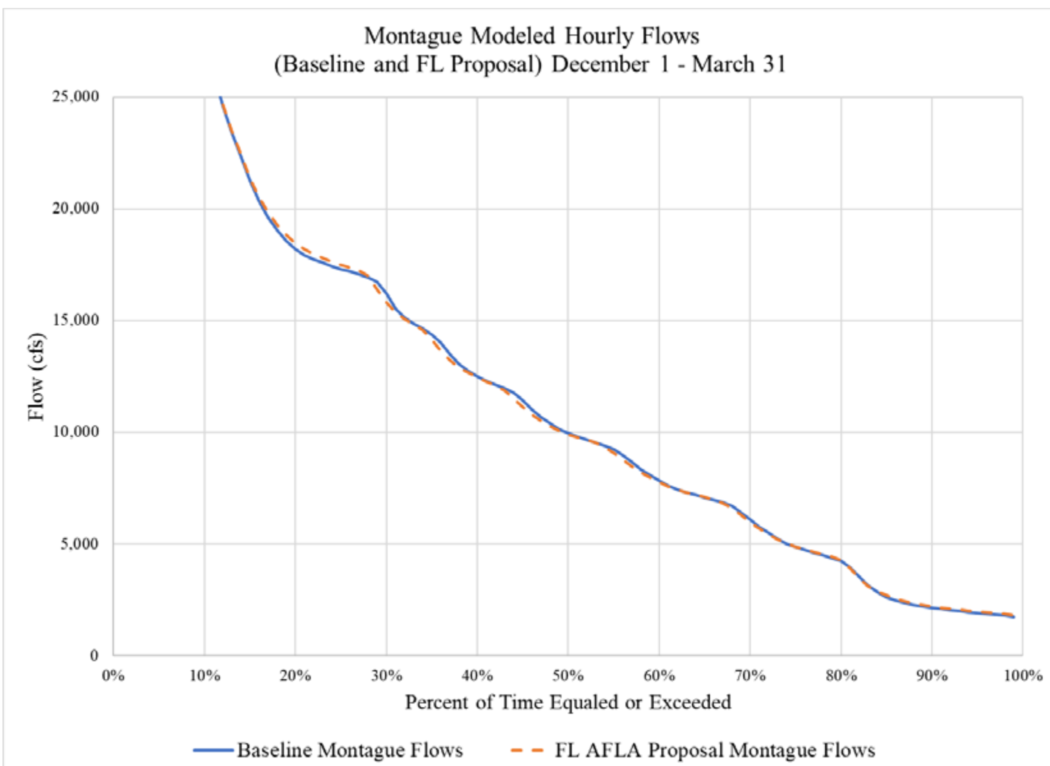
June 16 - 30 Duration Curves for Montague Flows



July 1 – August 31 Duration Curves for Montague Flows



September 1 – November 30 Duration Curves for Montague Flows



December 1 – March 31 Duration Curves for Montague Flows

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Appendix F- Water Resources- Downstream Histograms

Reach 4 and 5 Histograms of the modeled maximum daily change in water levels in Baseline and FirstLight Proposed Action conditions when the daily average flow at the Montague USGS gage is less than 18,000 cfs.

River mile: 118.508 (near the Montague USGS gage):

- Annual and monthly comparison between Baseline and the FirstLight Proposed action under low Holyoke WSEL downstream boundary conditions for annual and monthly
- Annual comparison between Baseline and the FirstLight Proposed action under low and high Holyoke WSEL downstream boundary conditions for annual and monthly

River miles: 115.07, 112.36, 109.52 (Route 116 Bridge), and 94.298 (Rainbow Beach):

- Annual and monthly comparison between Baseline and the FirstLight Proposed action under low Holyoke WSEL downstream boundary conditions for annual and monthly
- Annual and June comparison between Baseline and the FirstLight Proposed action under low and high Holyoke WSEL downstream boundary conditions for annual and monthly

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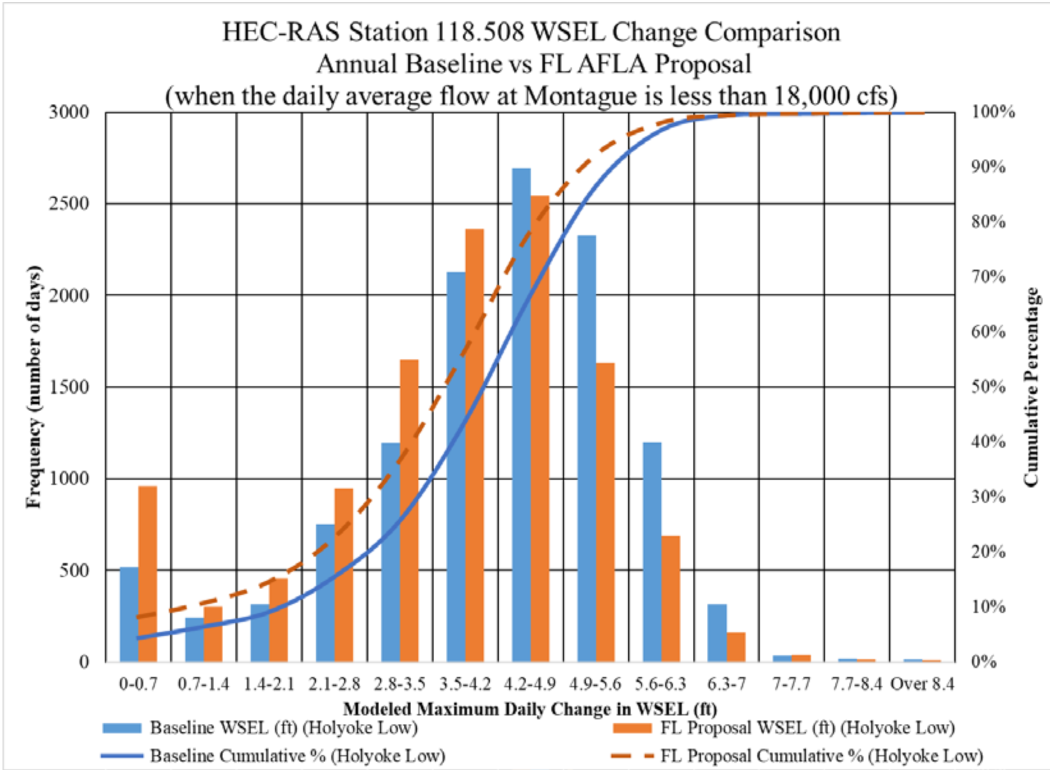
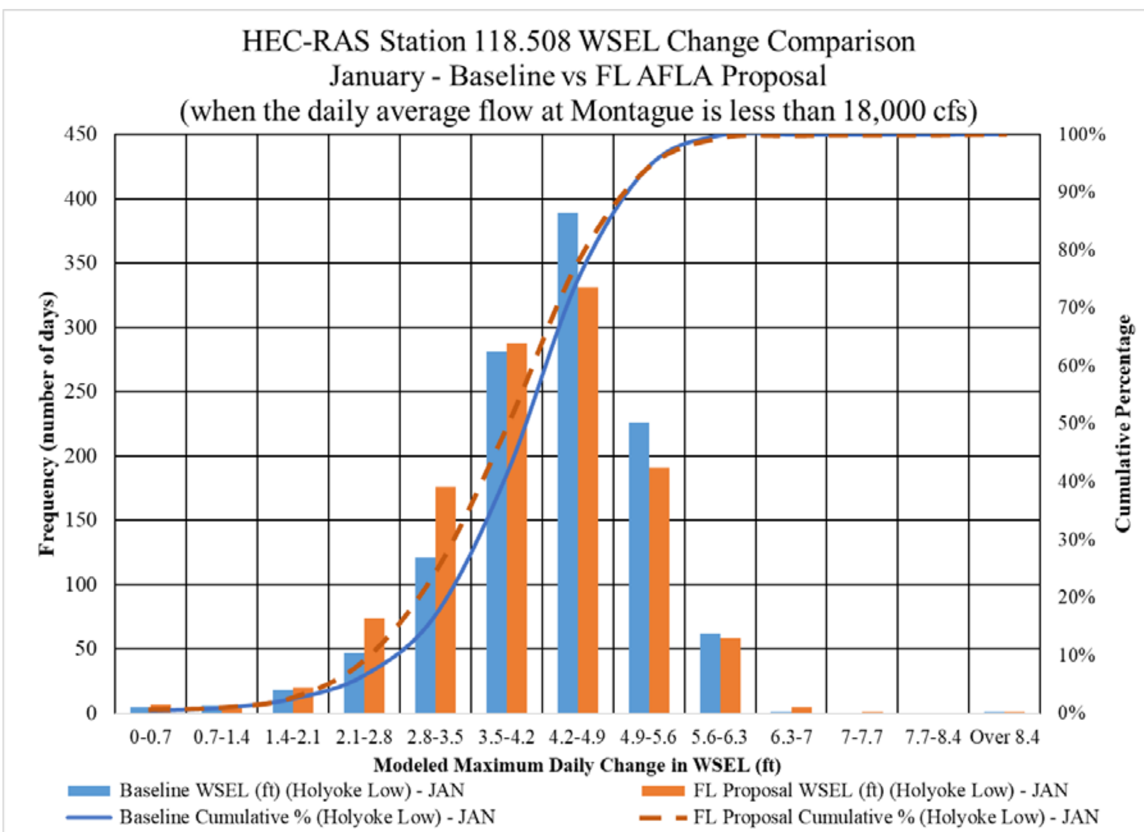
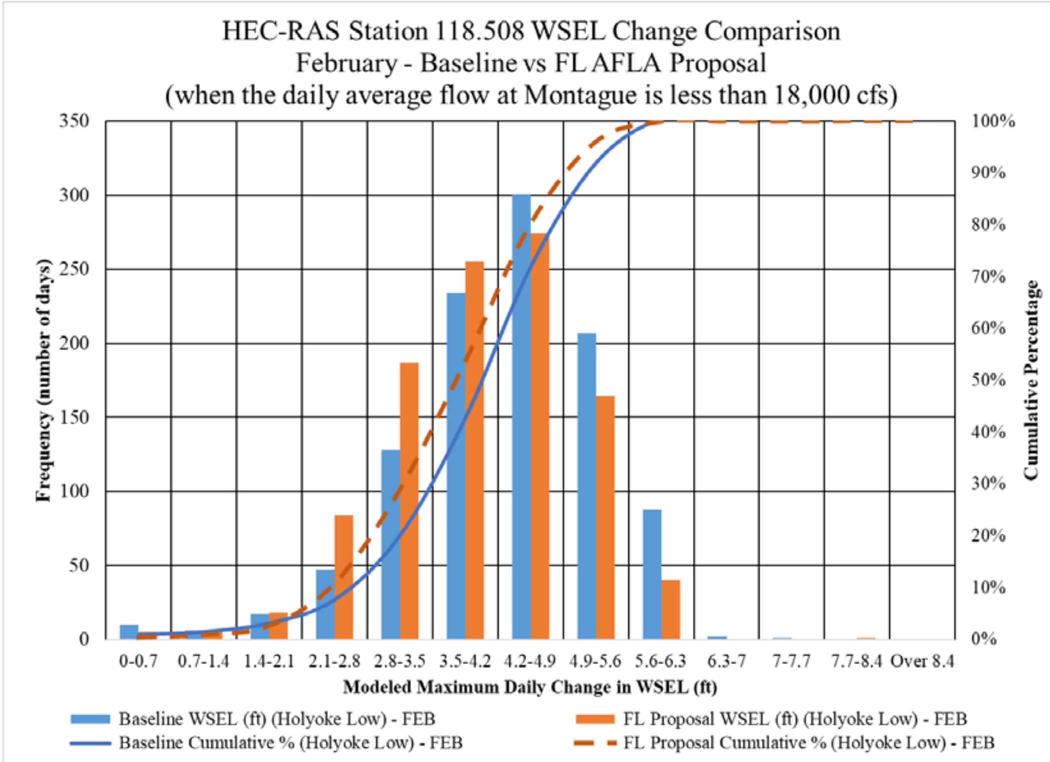


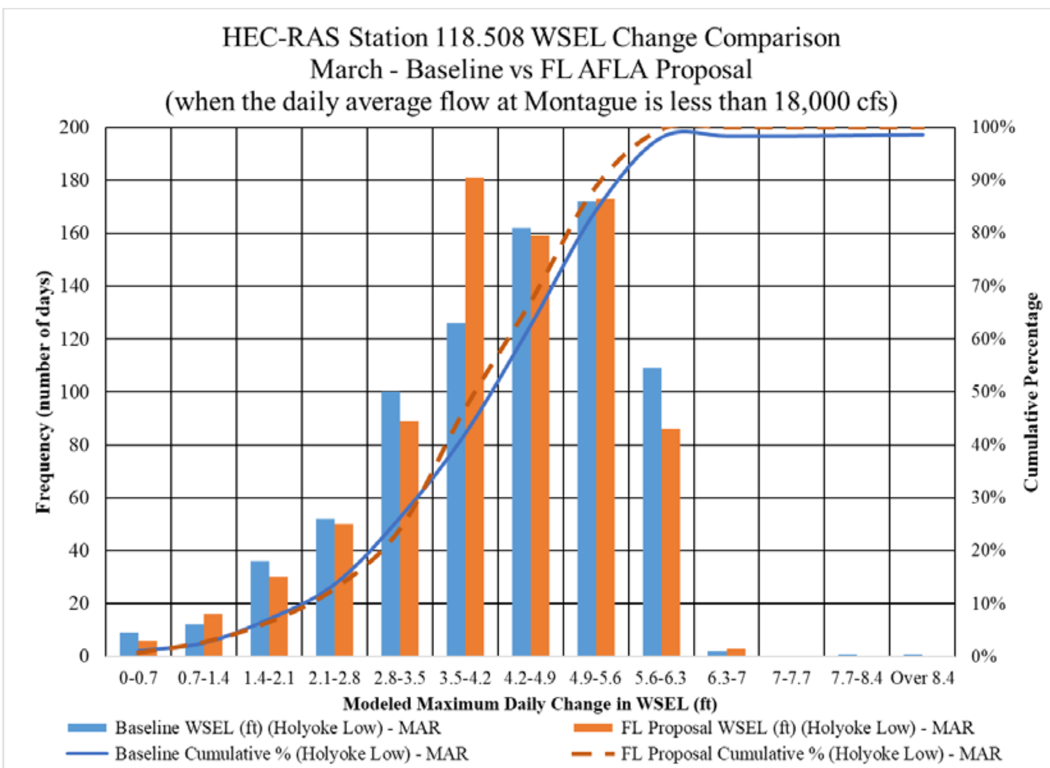
RM 118.508 Annual Comparison



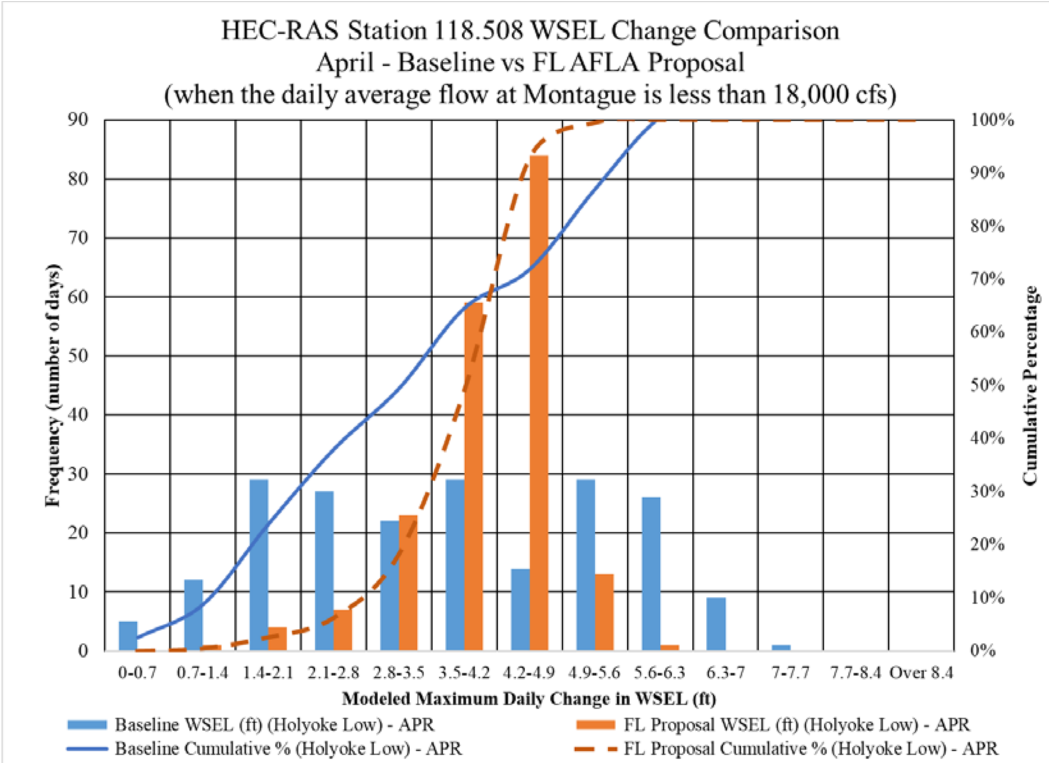
RM 118.508 January Comparison



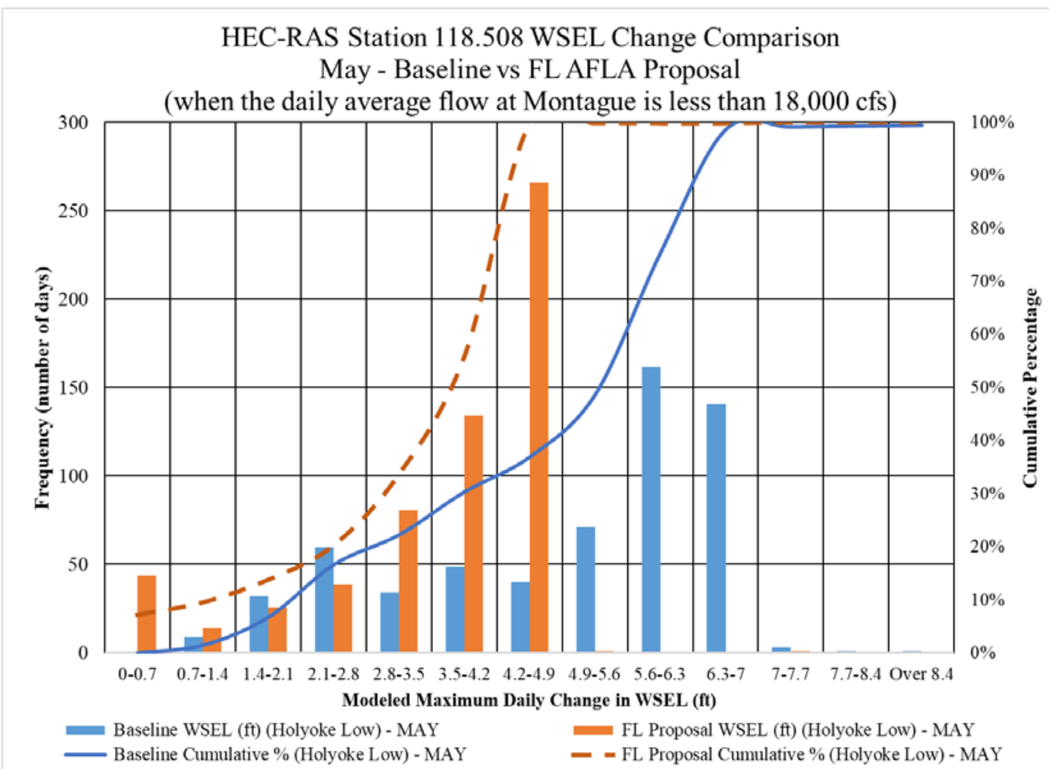
RM 118.508 February Comparison



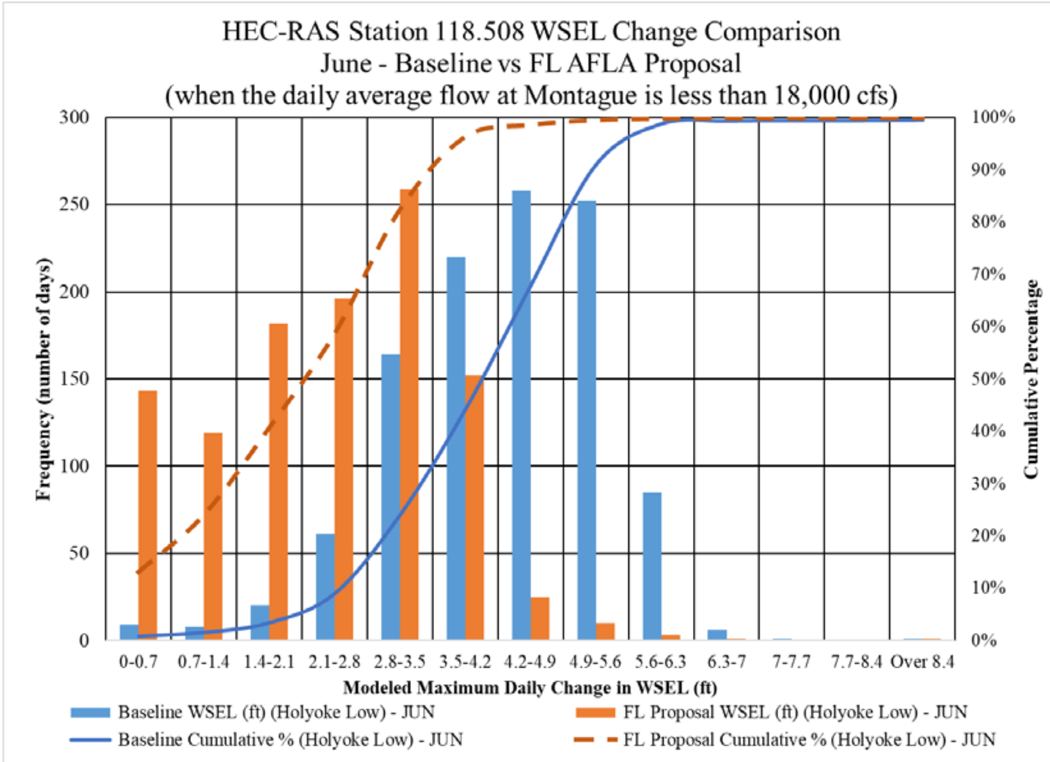
RM 118.508 March Comparison



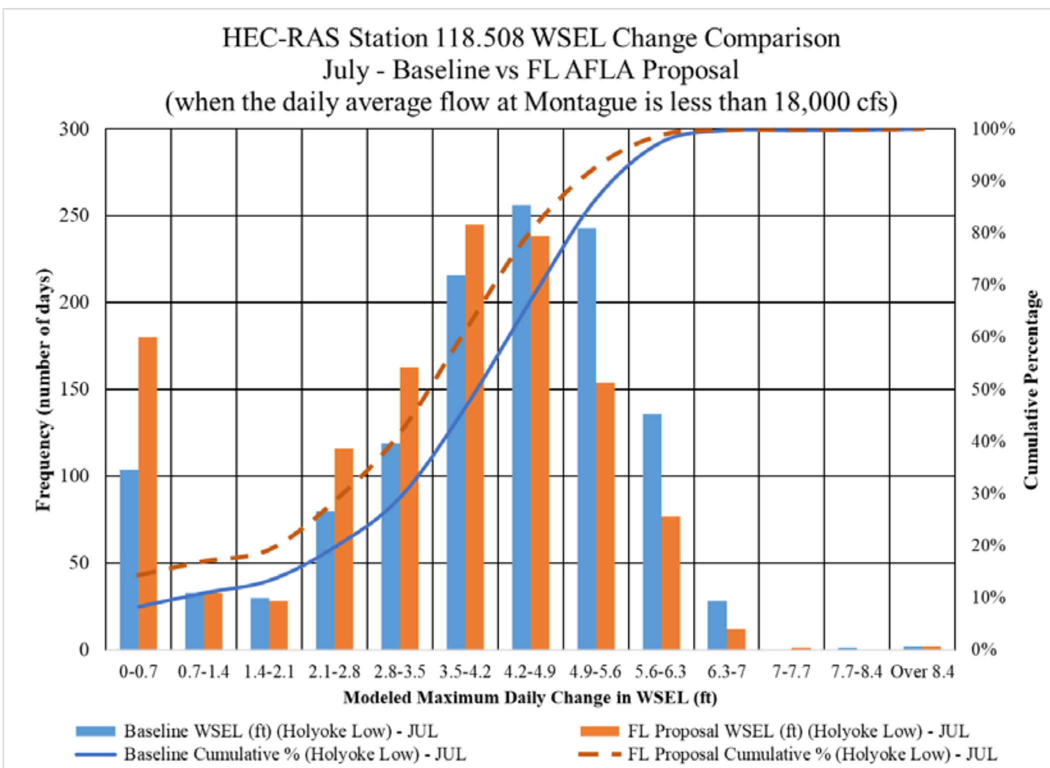
RM 118.508 April Comparison



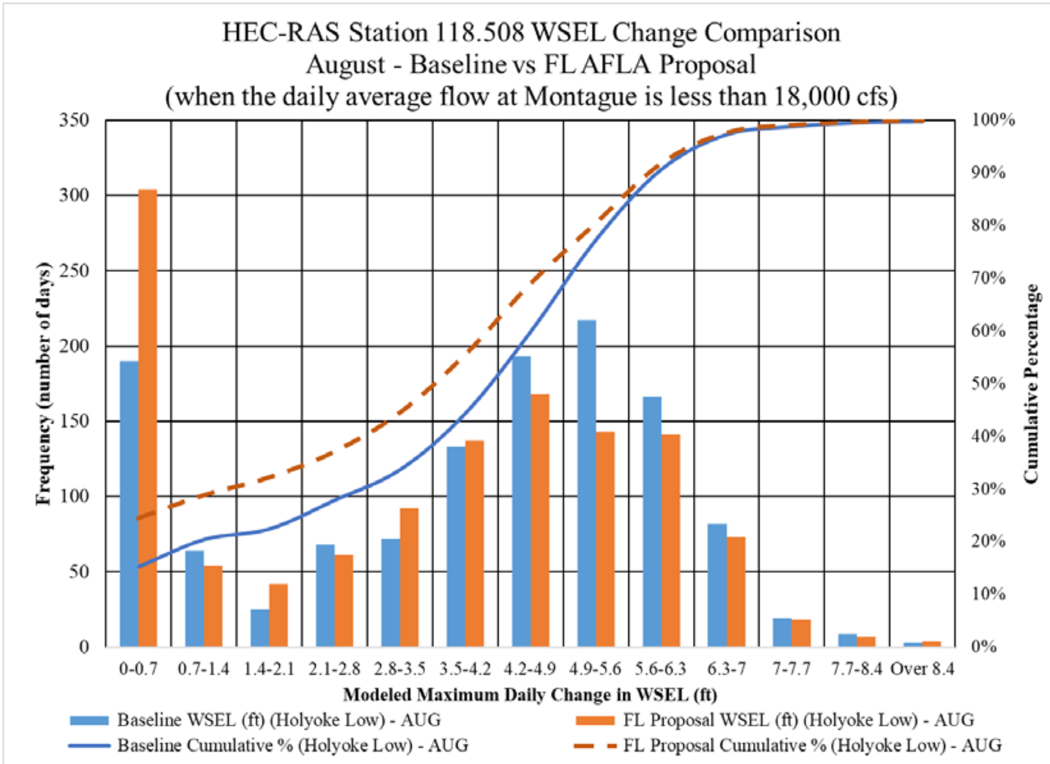
RM 118.508 May Comparison



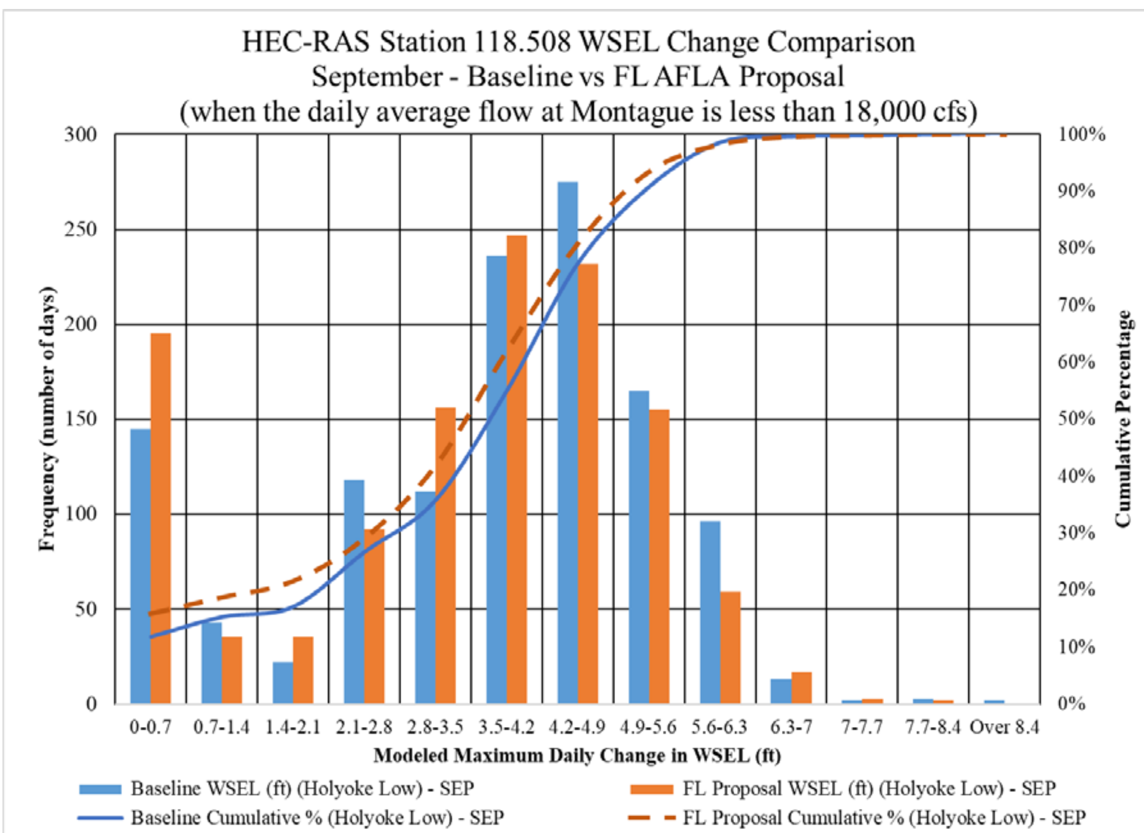
RM 118.508 June Comparison



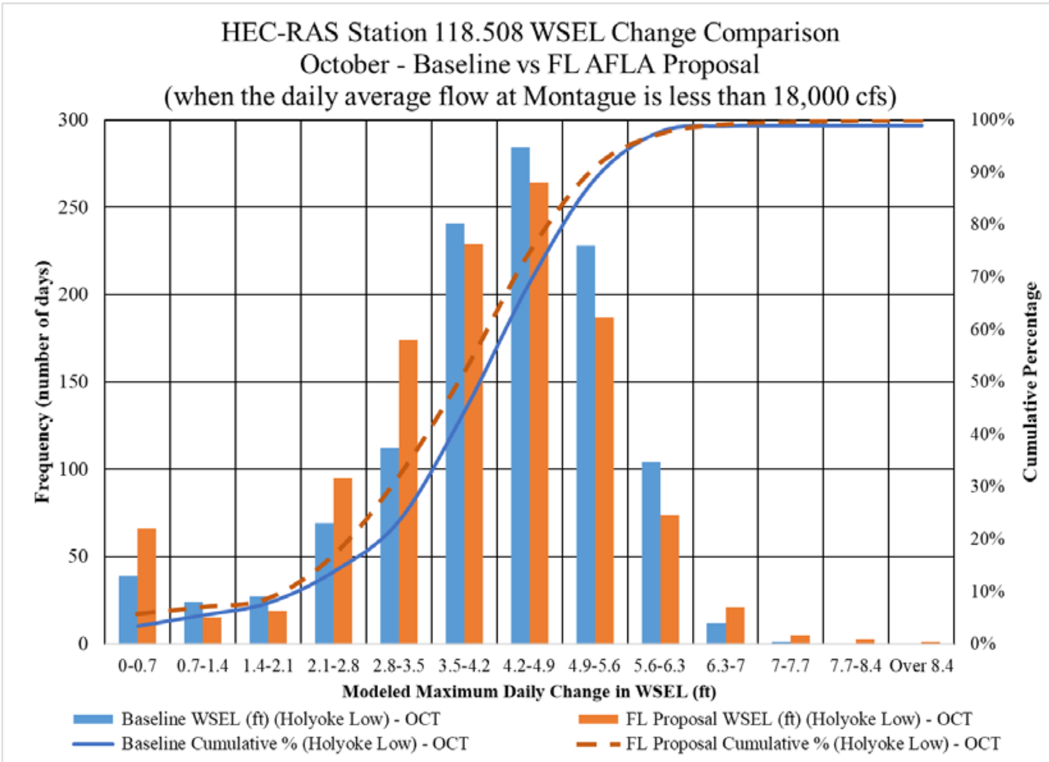
RM 118.508 July Comparison



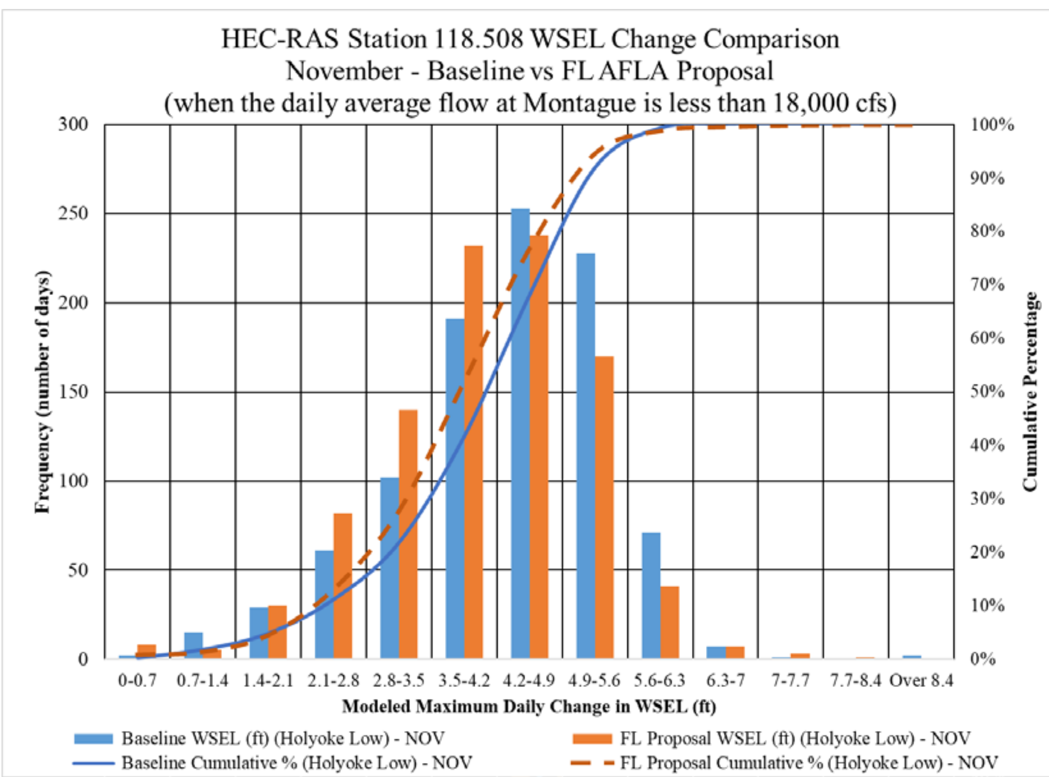
RM 118.508 August Comparison



RM 118.508 September Comparison



RM 118.508 October Comparison



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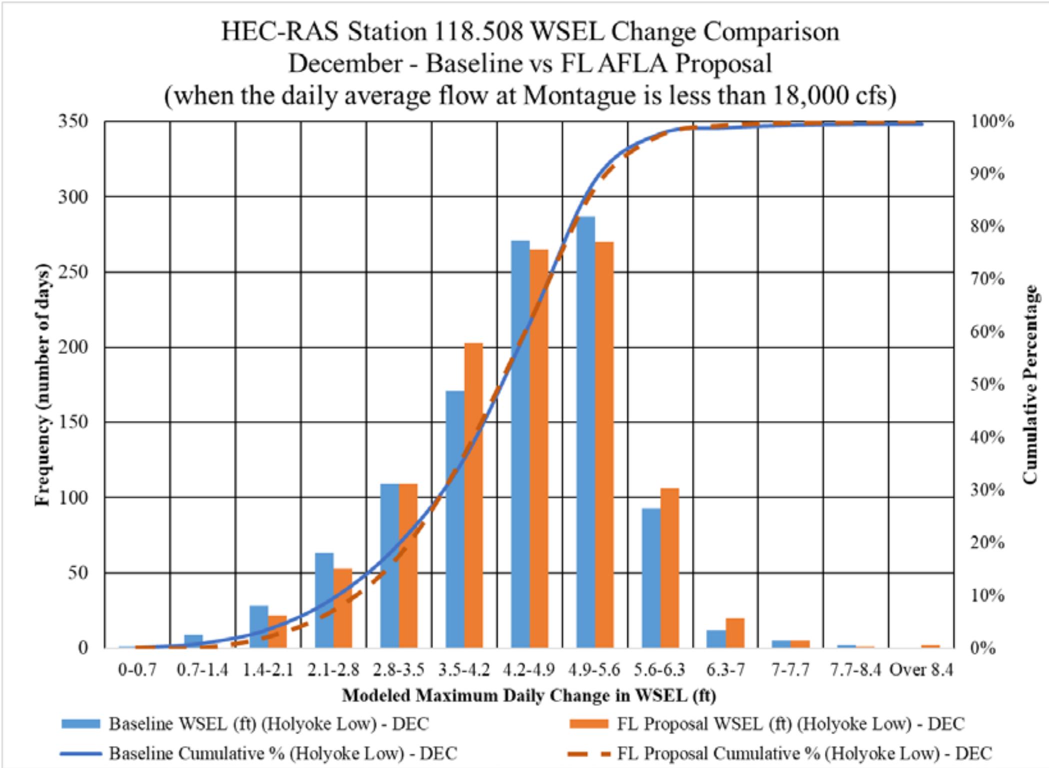
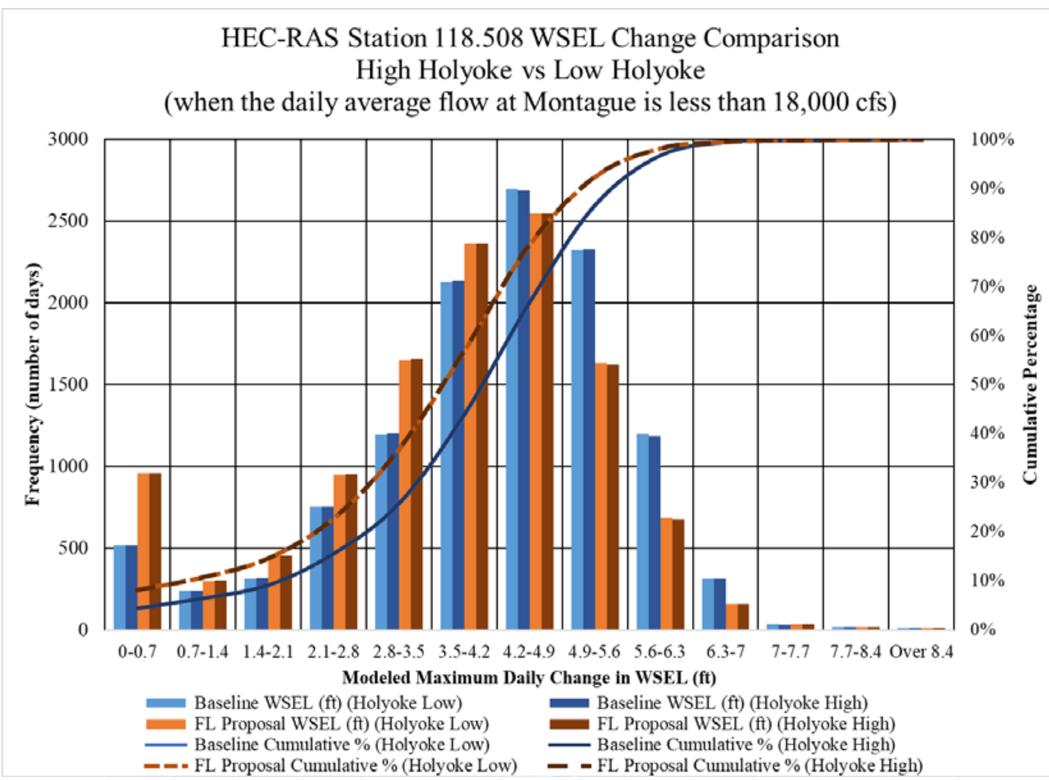
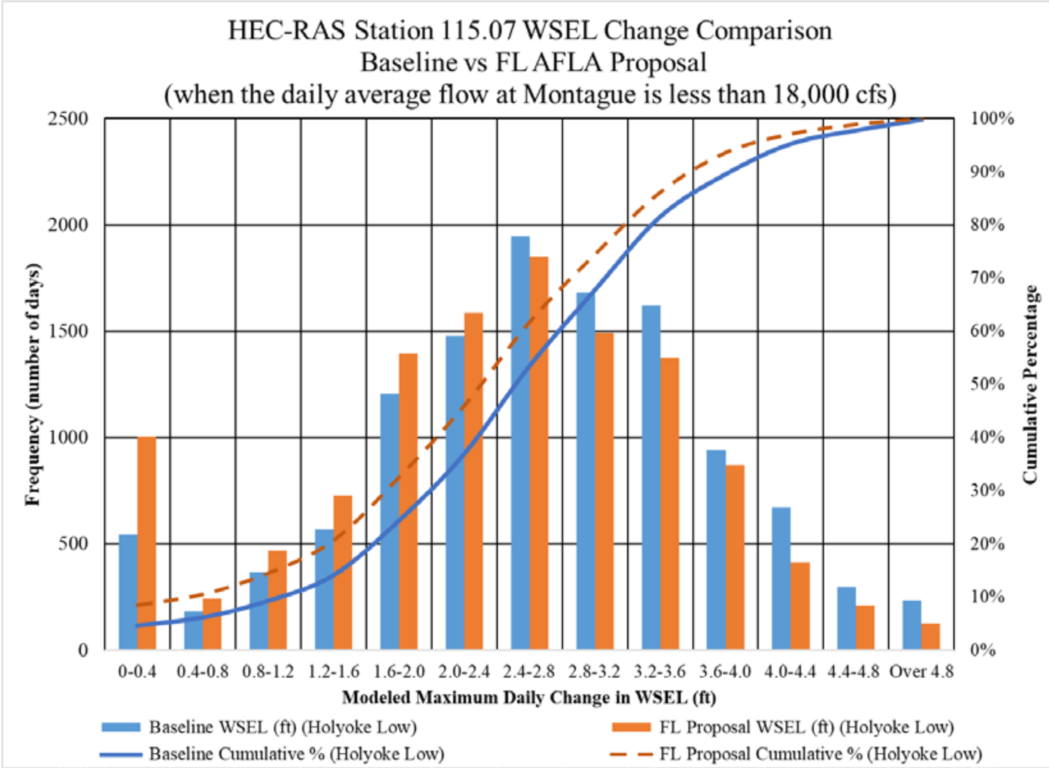


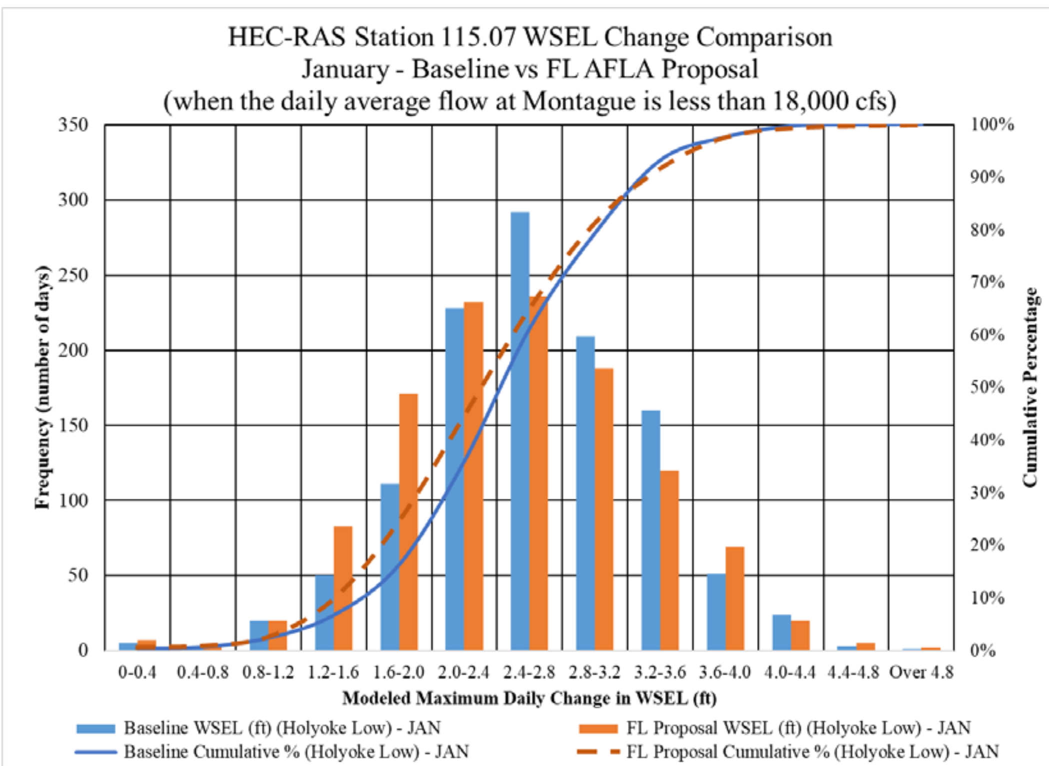
RM 118.508 December Comparison



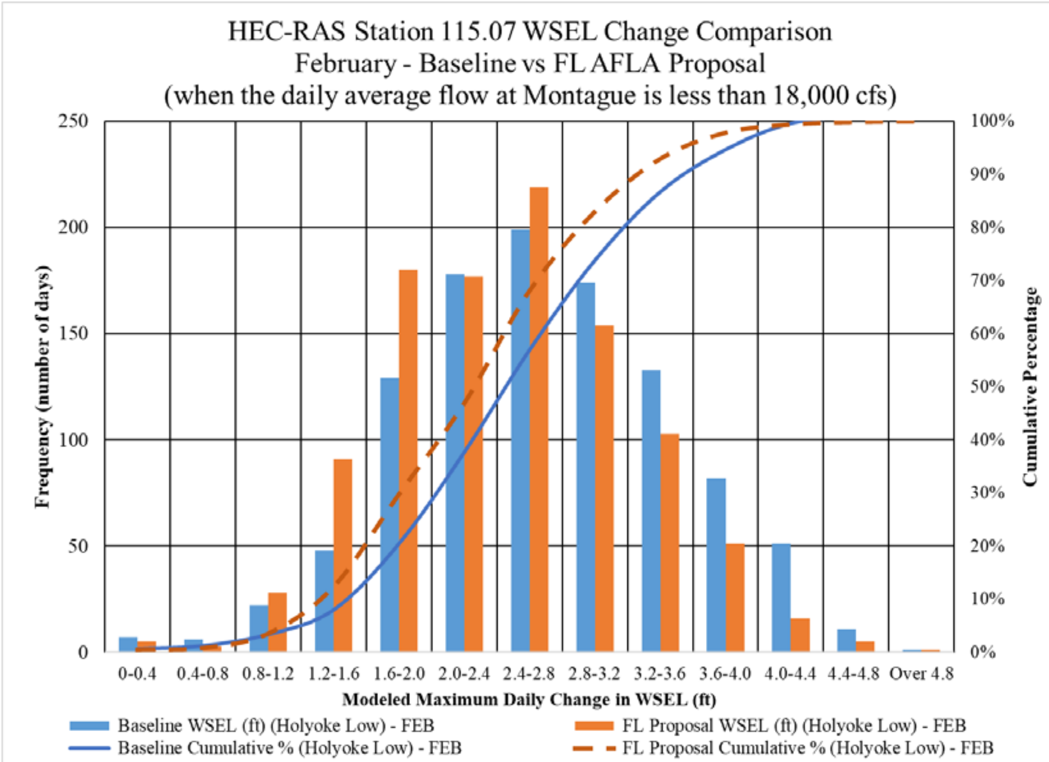
RM 118.508 Annual Comparison High vs Low Holyoke



RM 115.07 Annual Comparison



RM 115.07 January Comparison



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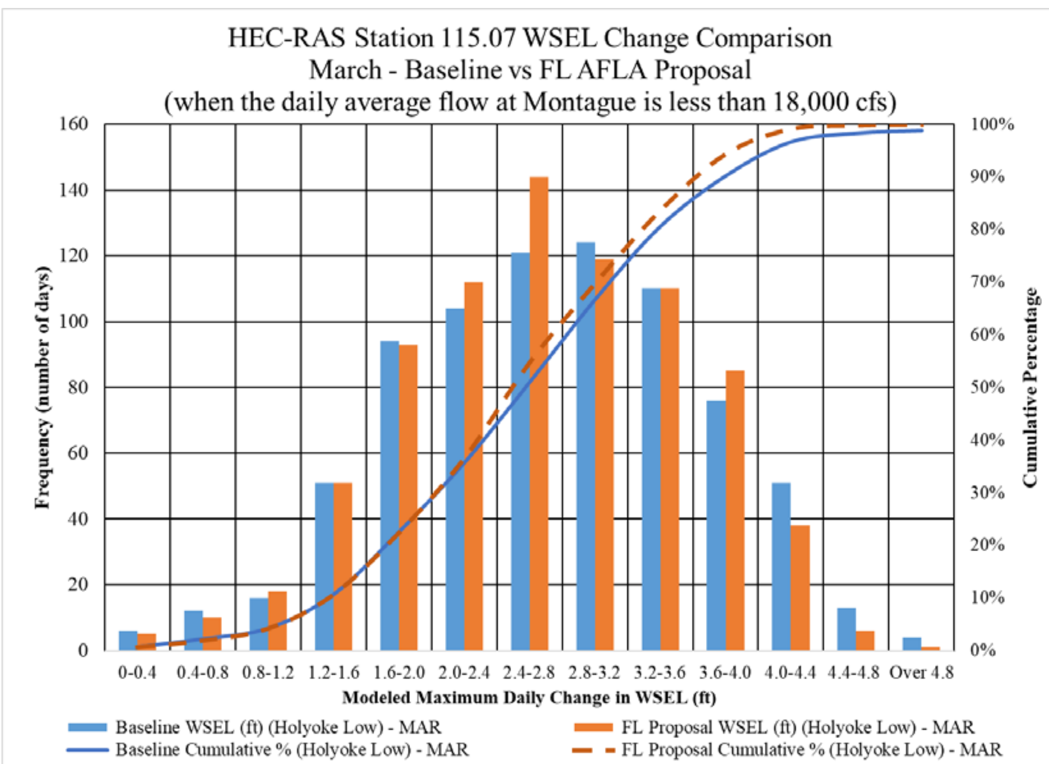

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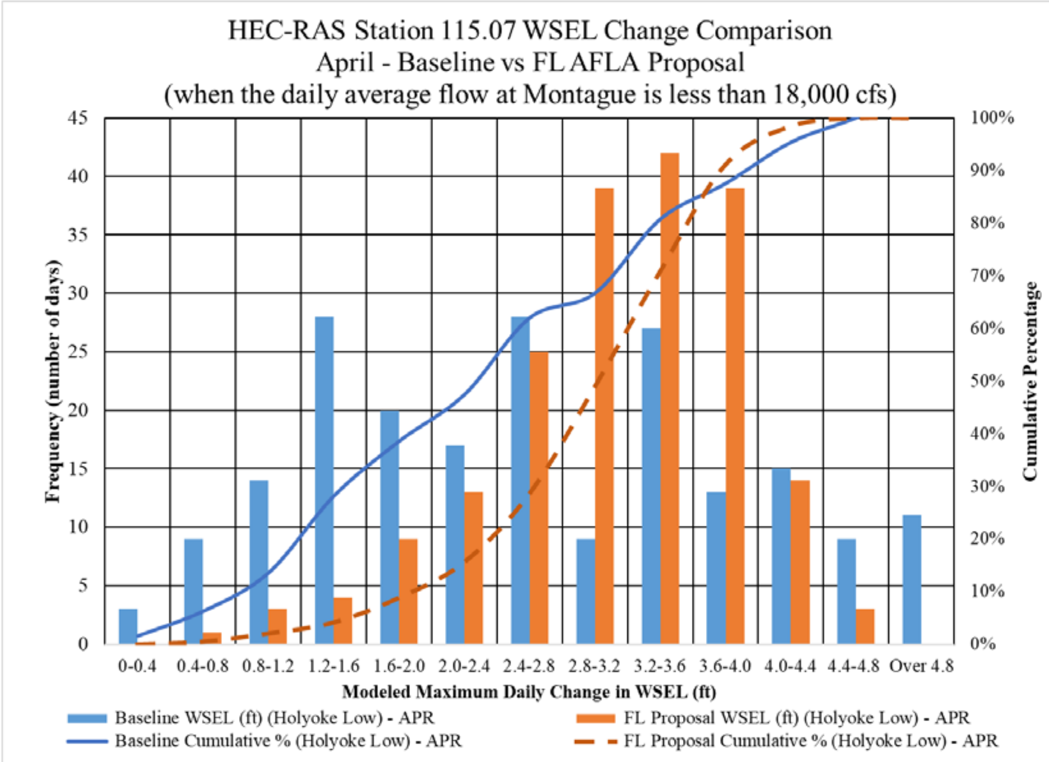

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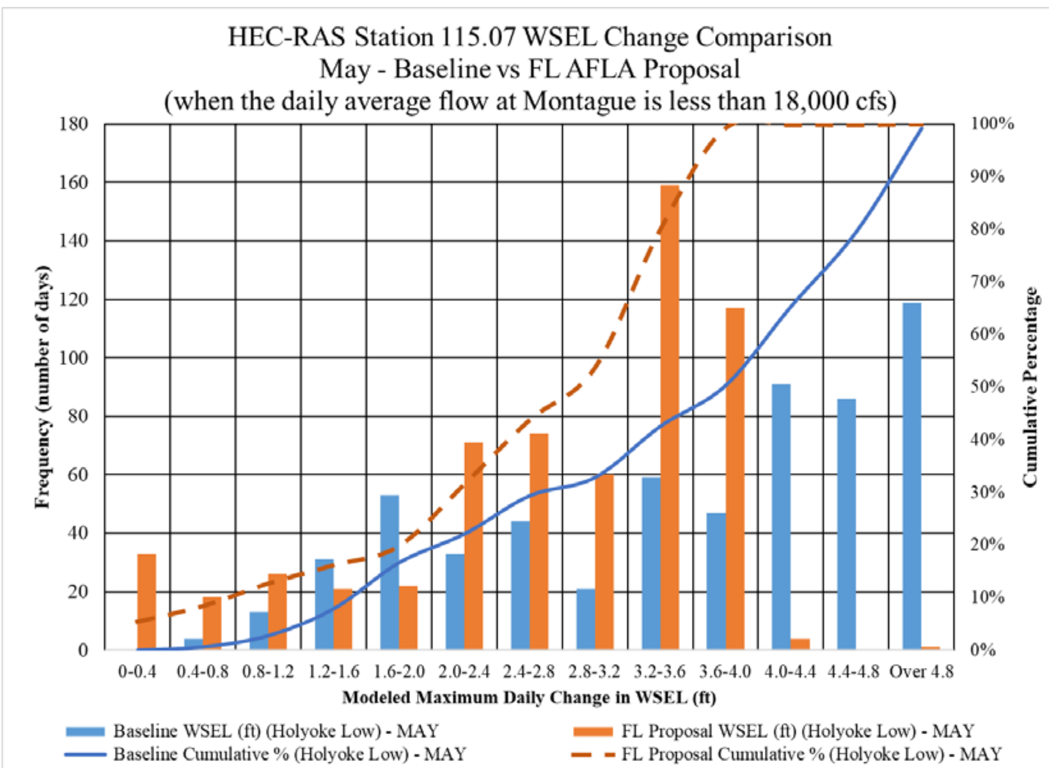

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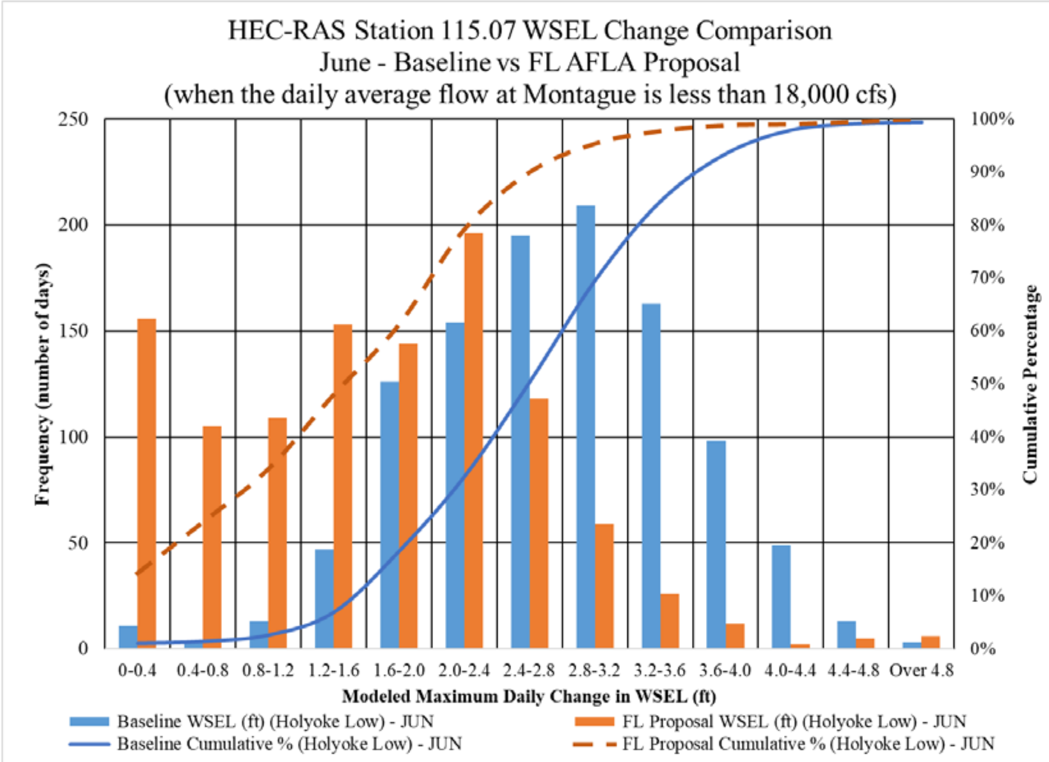

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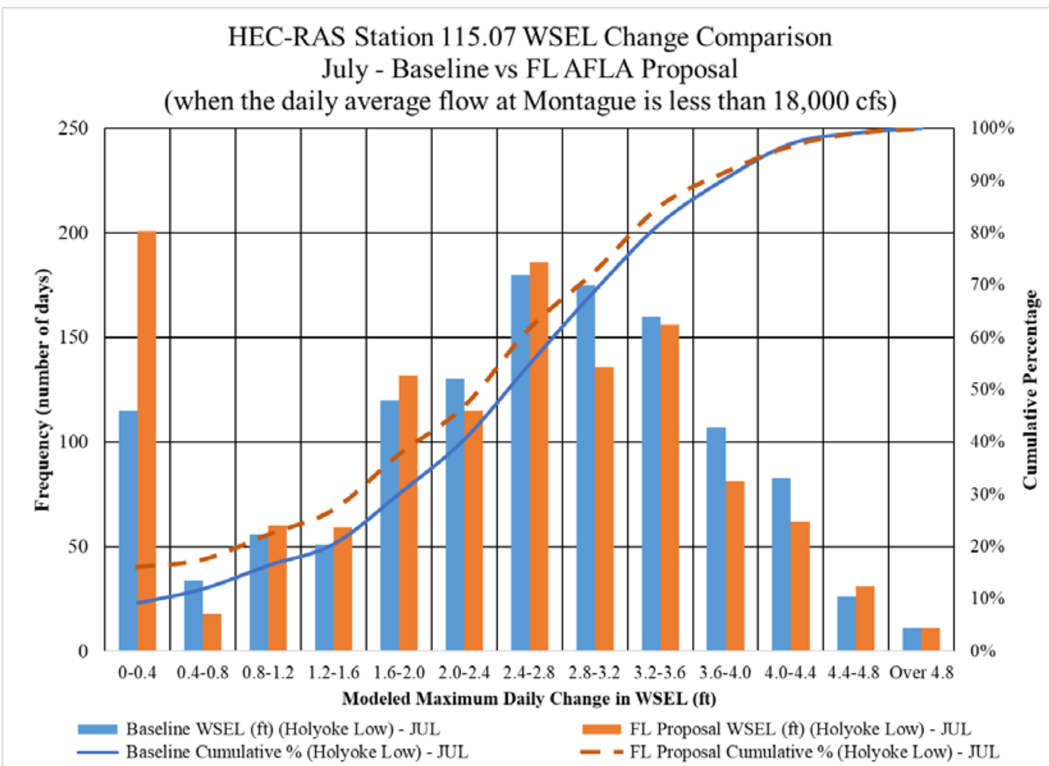
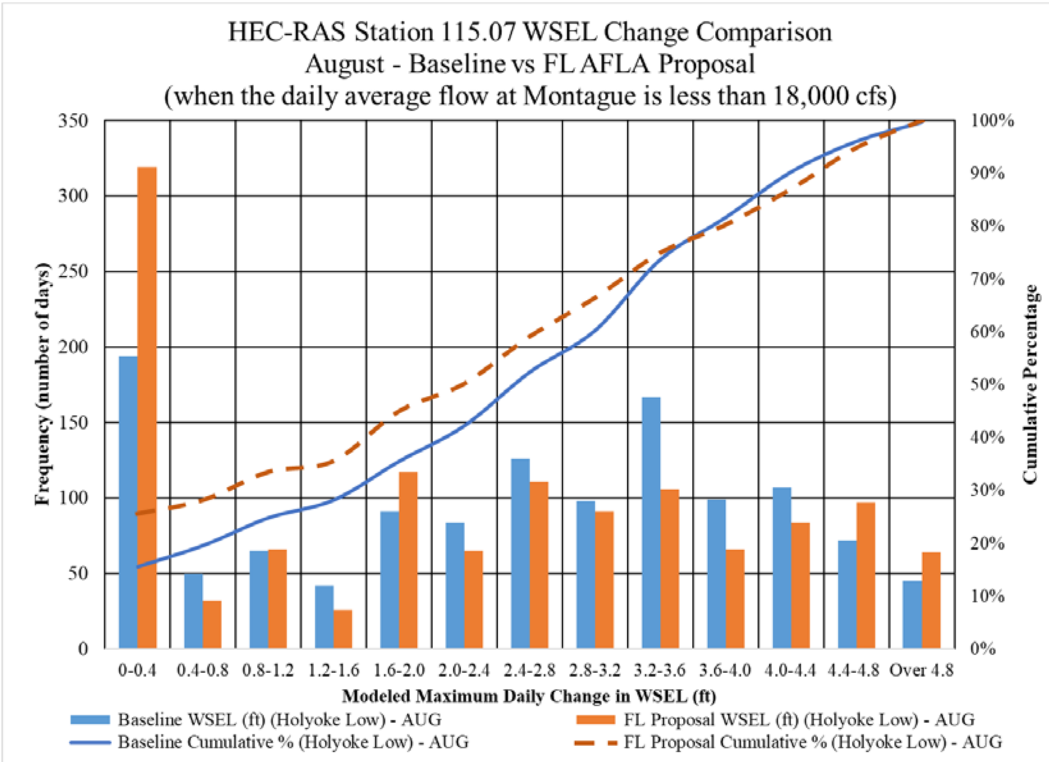


RM 115.07 July Comparison



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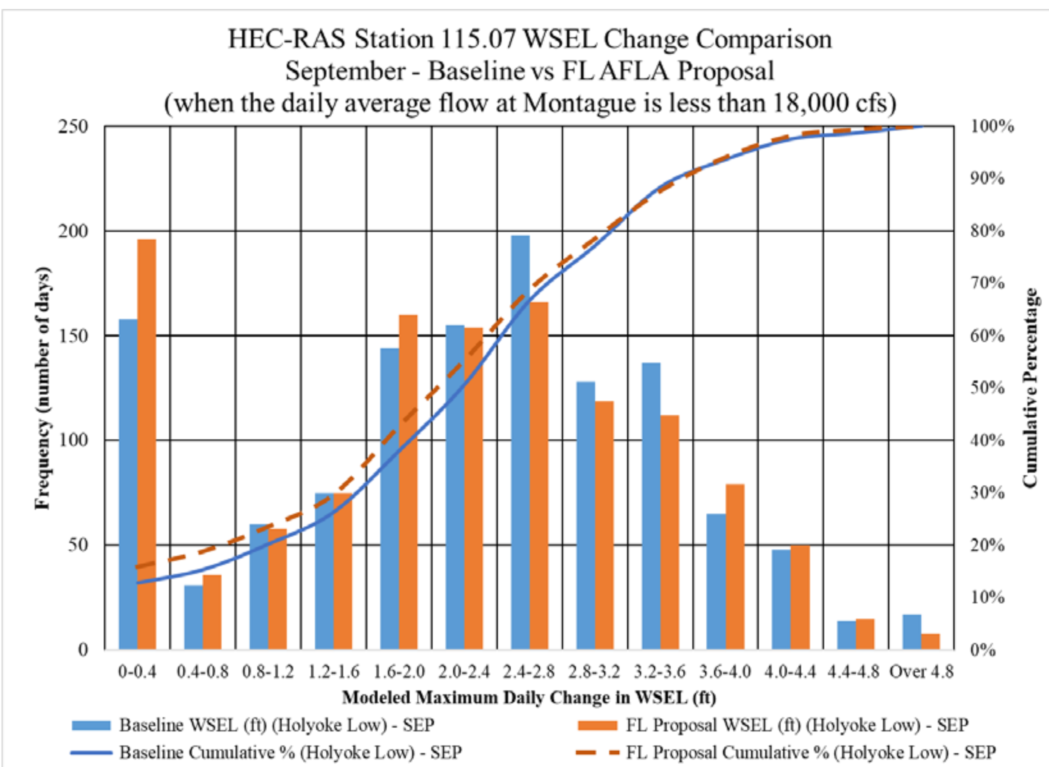

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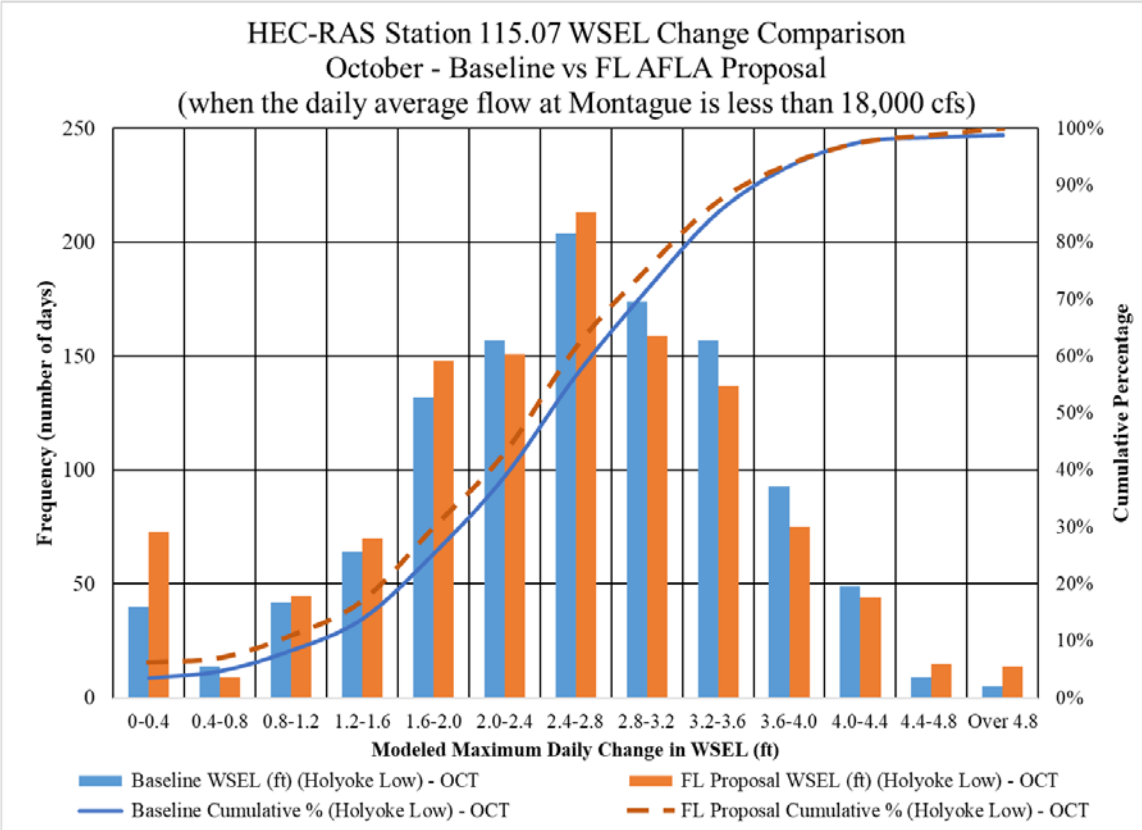

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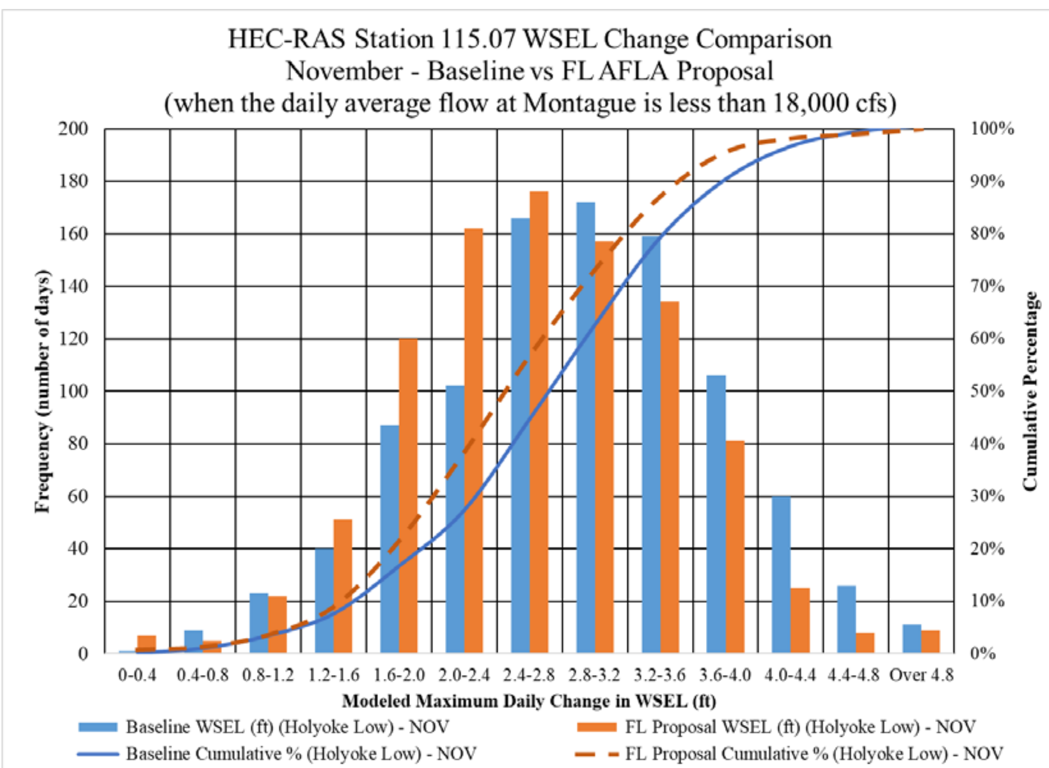
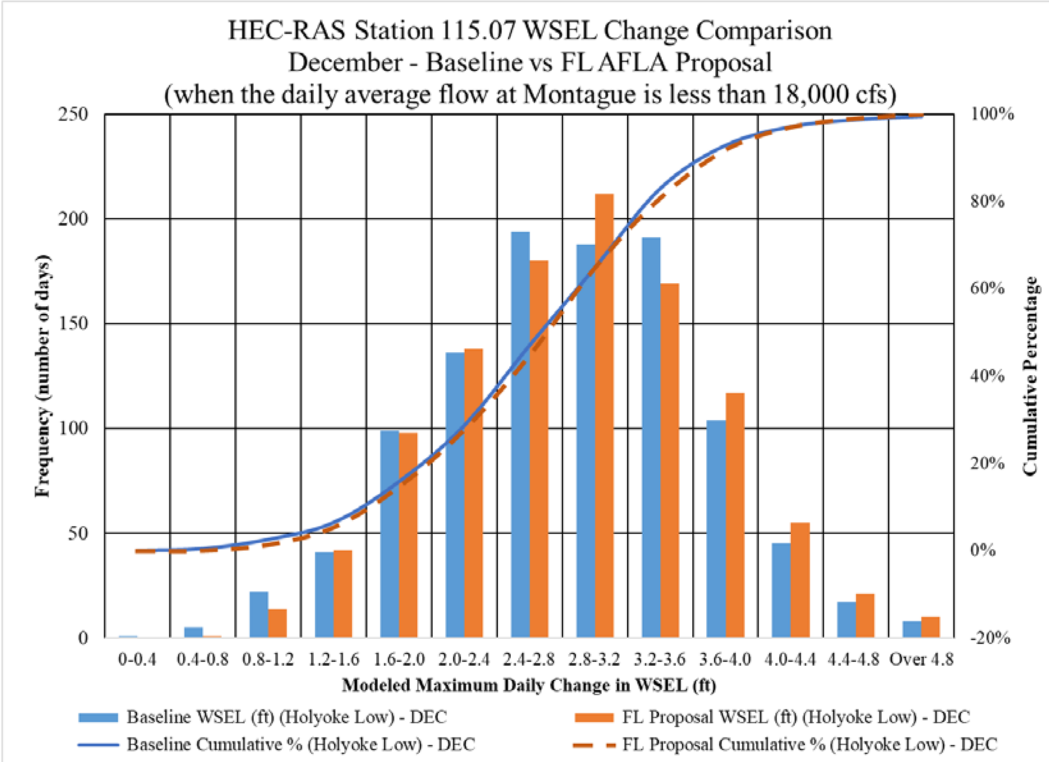


RM 115.07 November Comparison



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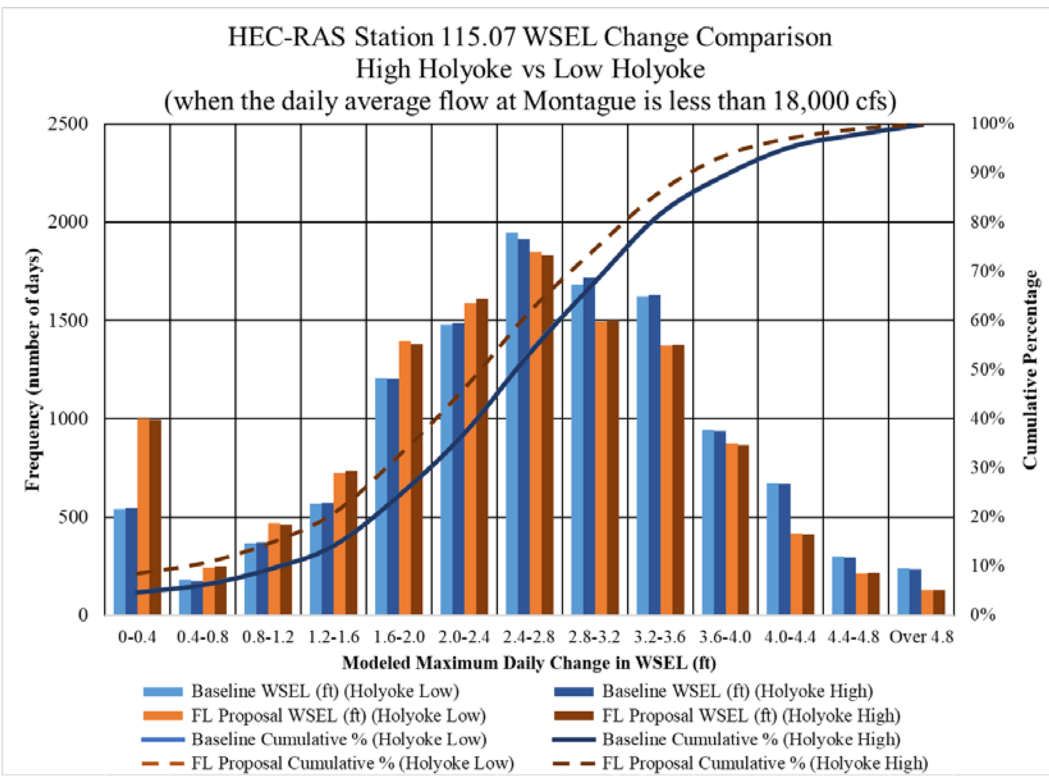
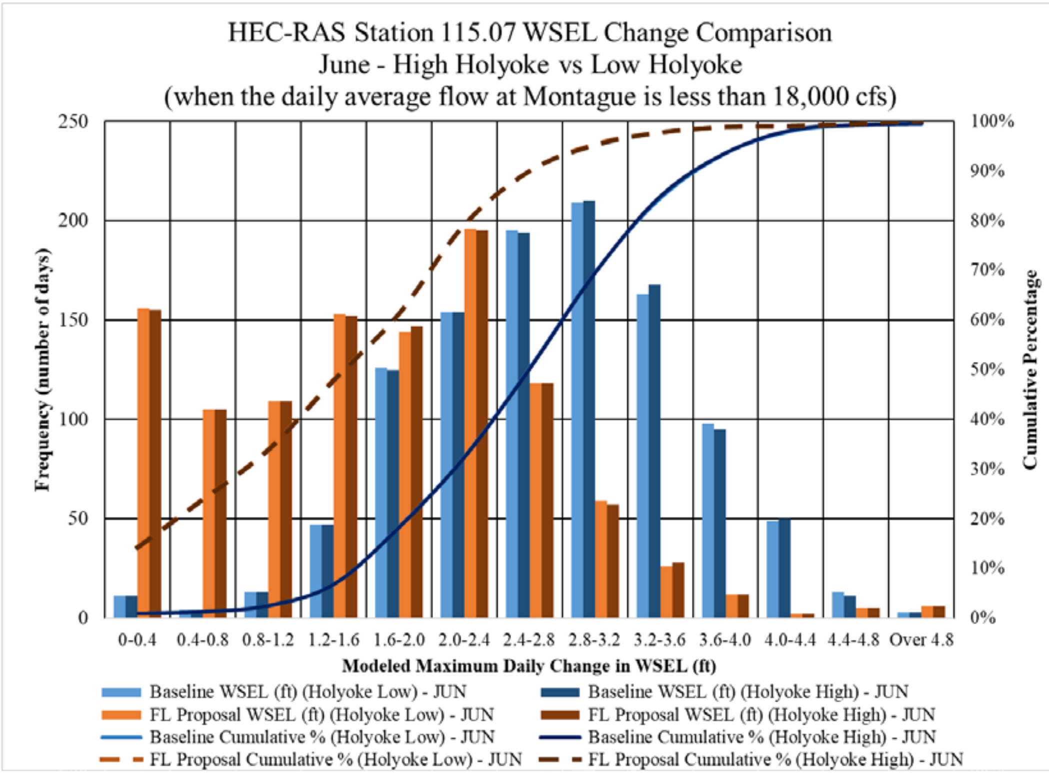
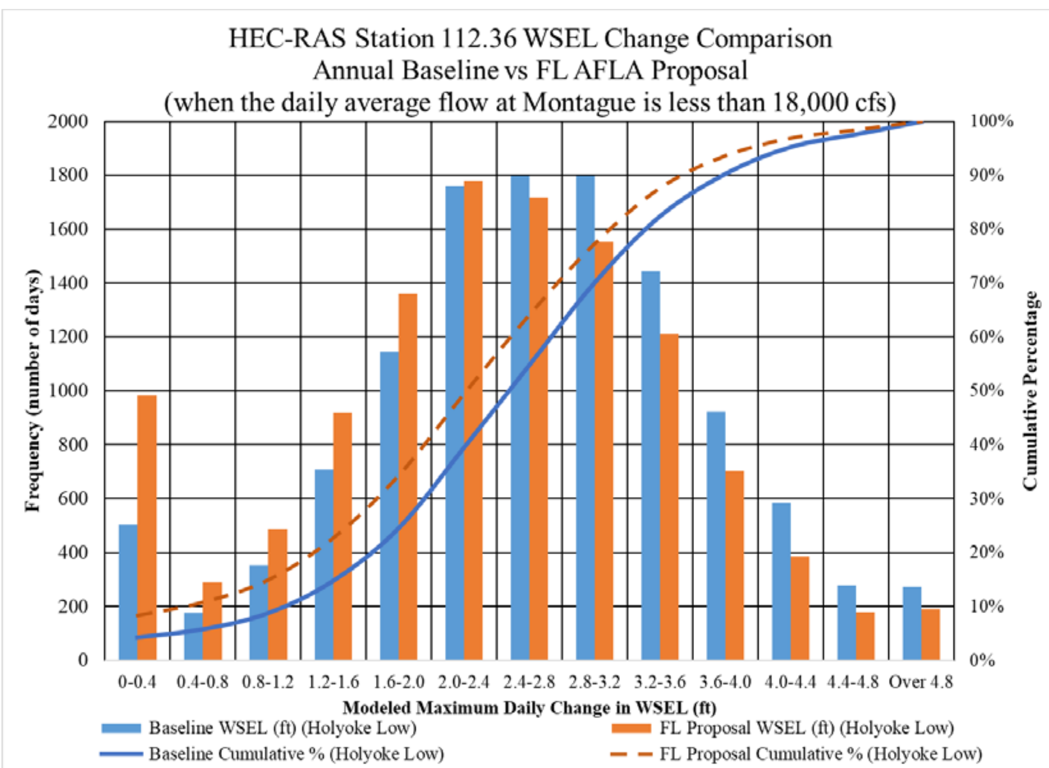


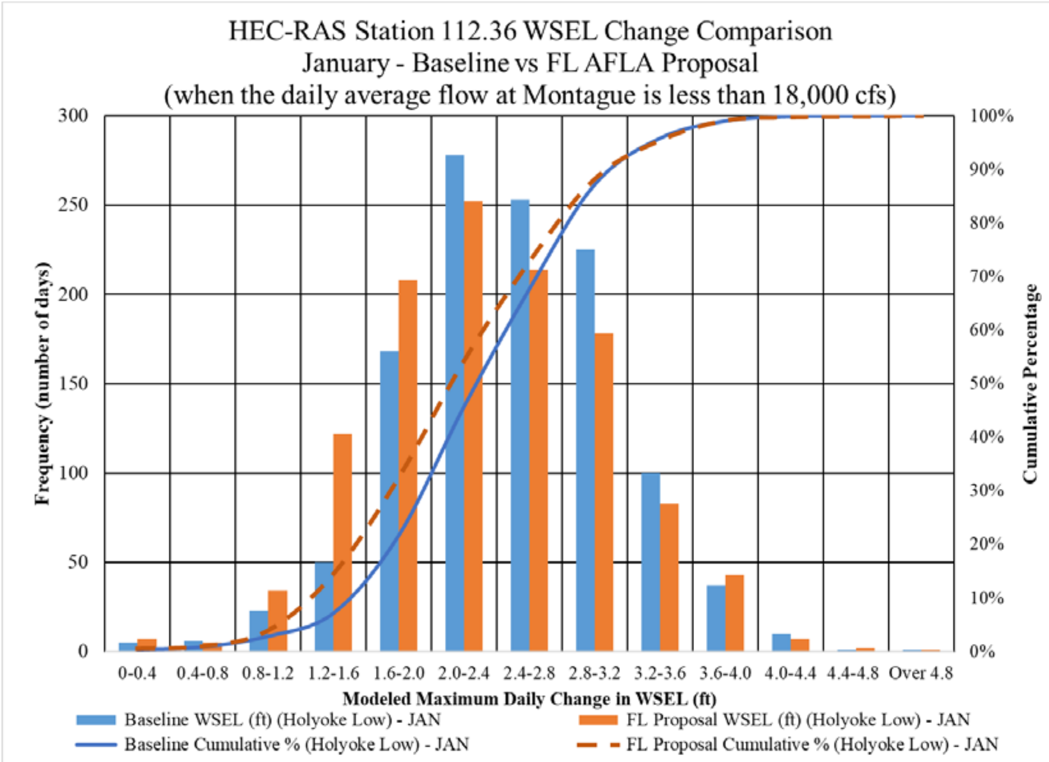
RM 115.07 Annual High vs. Low Holyoke Comparison



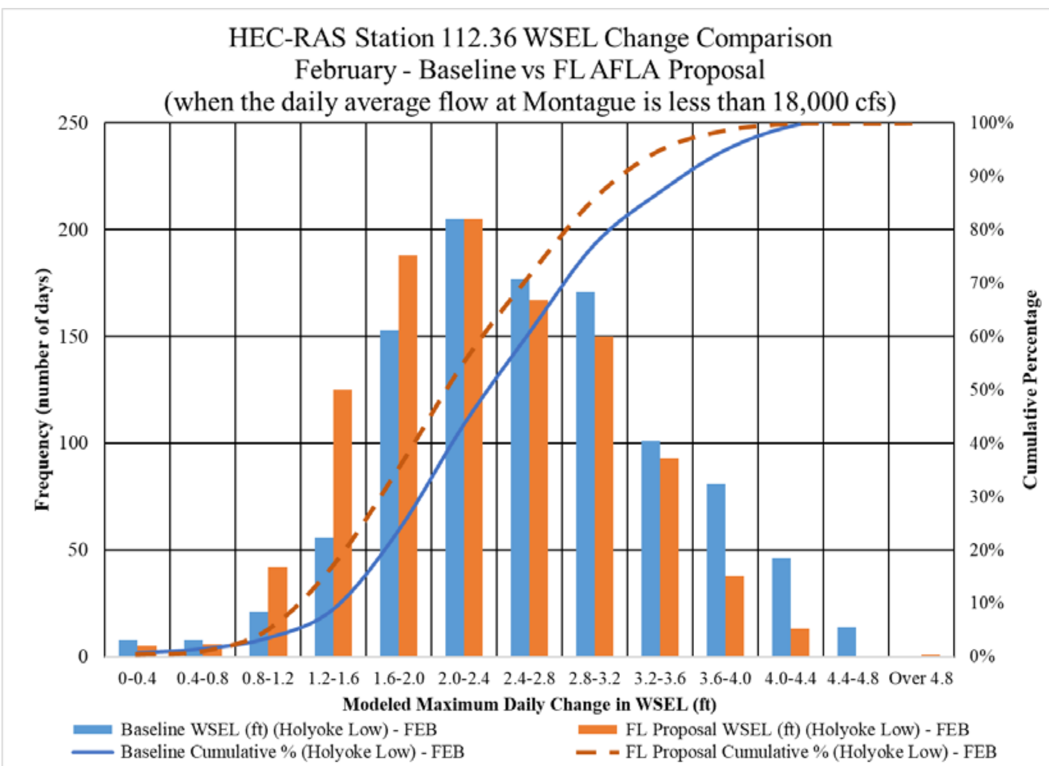
RM 115.07 Low vs High Holyoke June Comparison



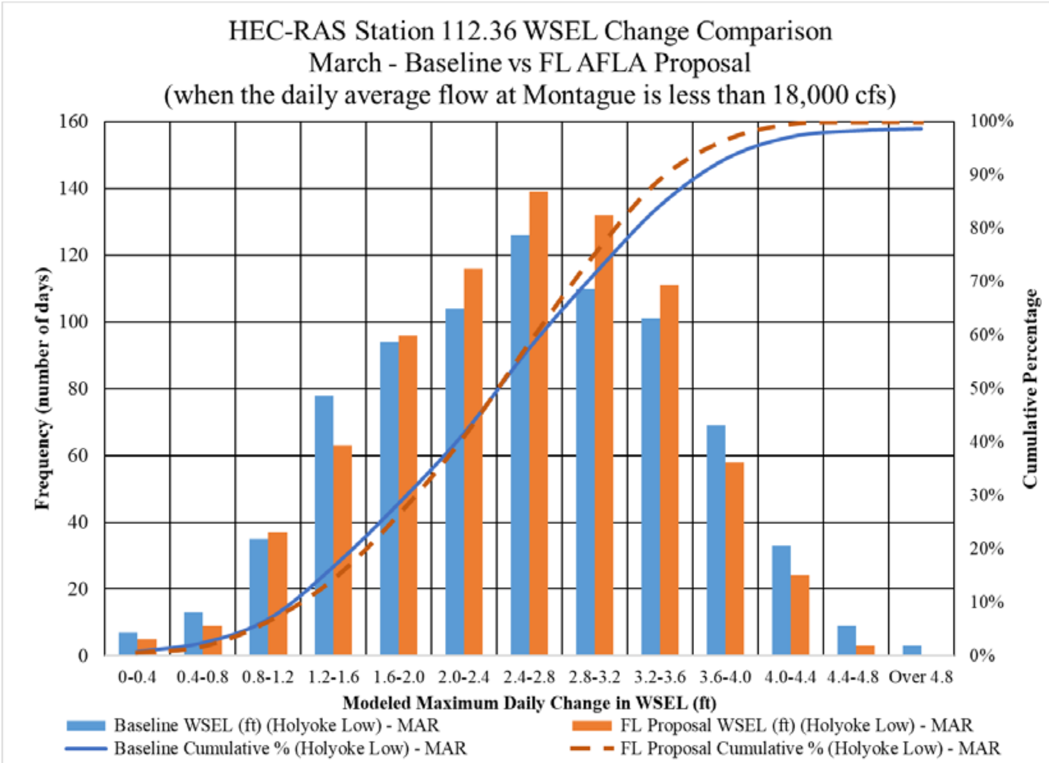
RM 112.36 Annual Comparison



RM 112.36 January Comparison



RM 112.36 February Comparison



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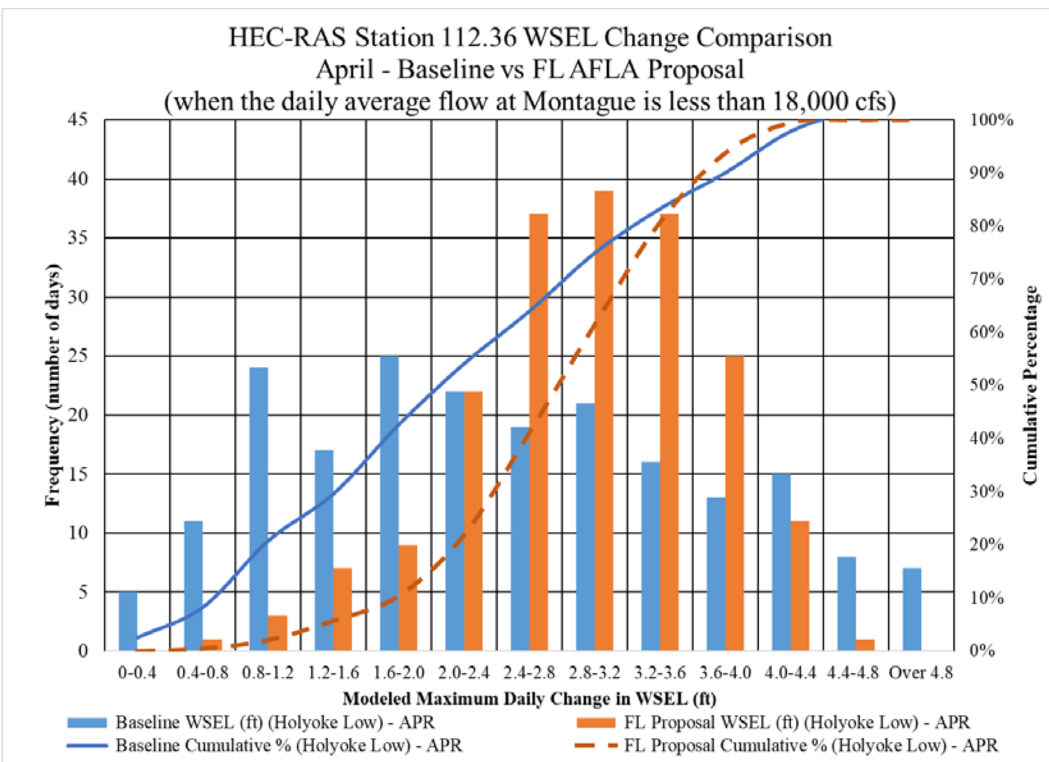

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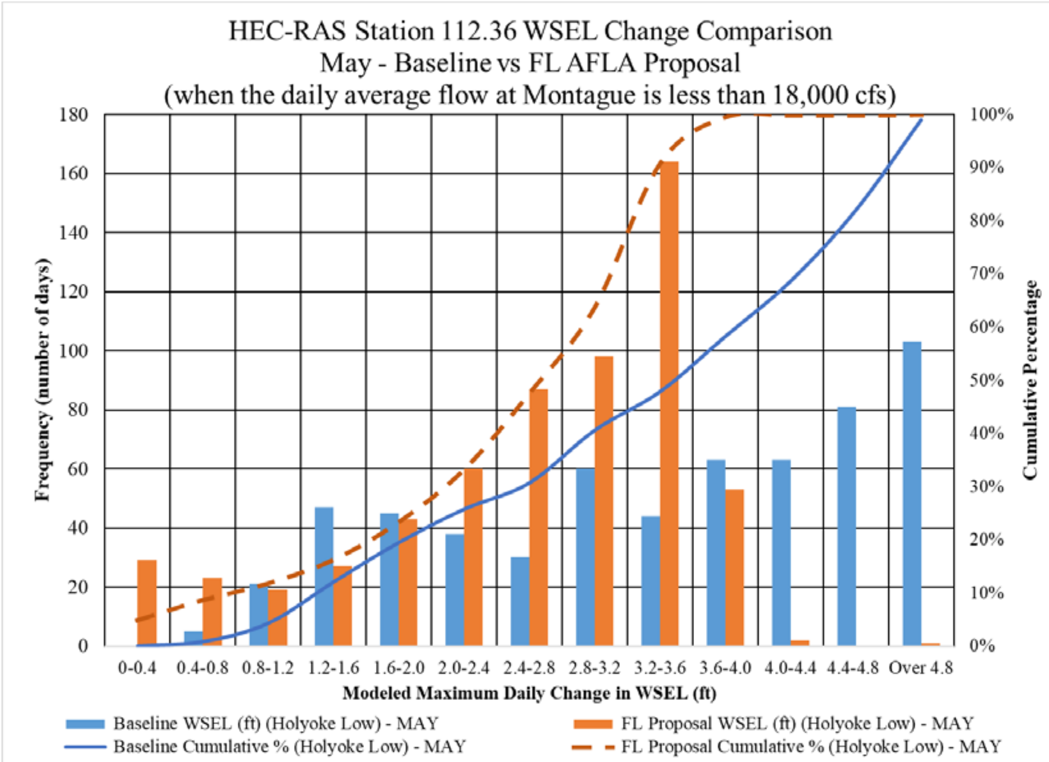

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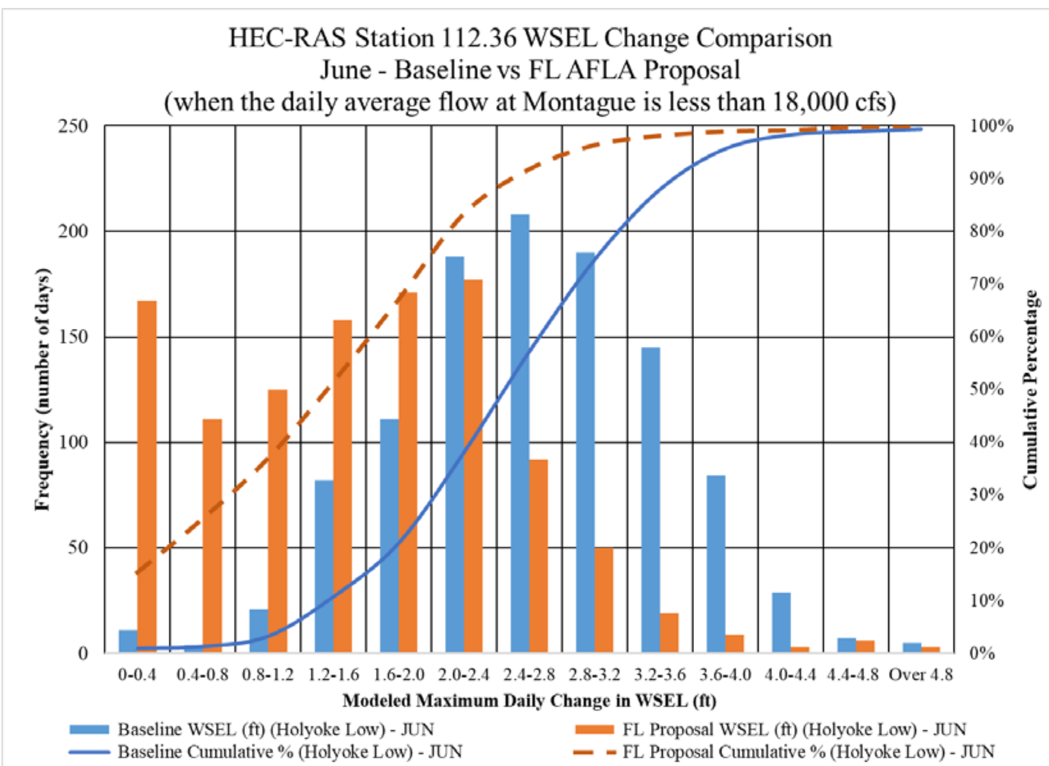

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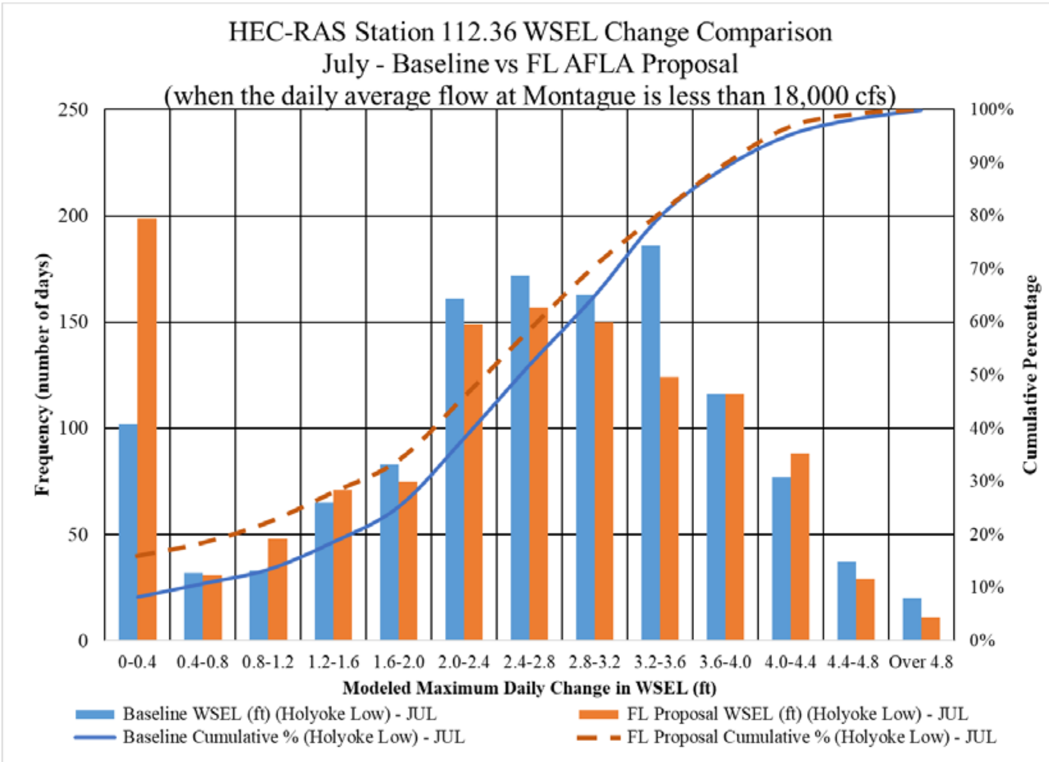

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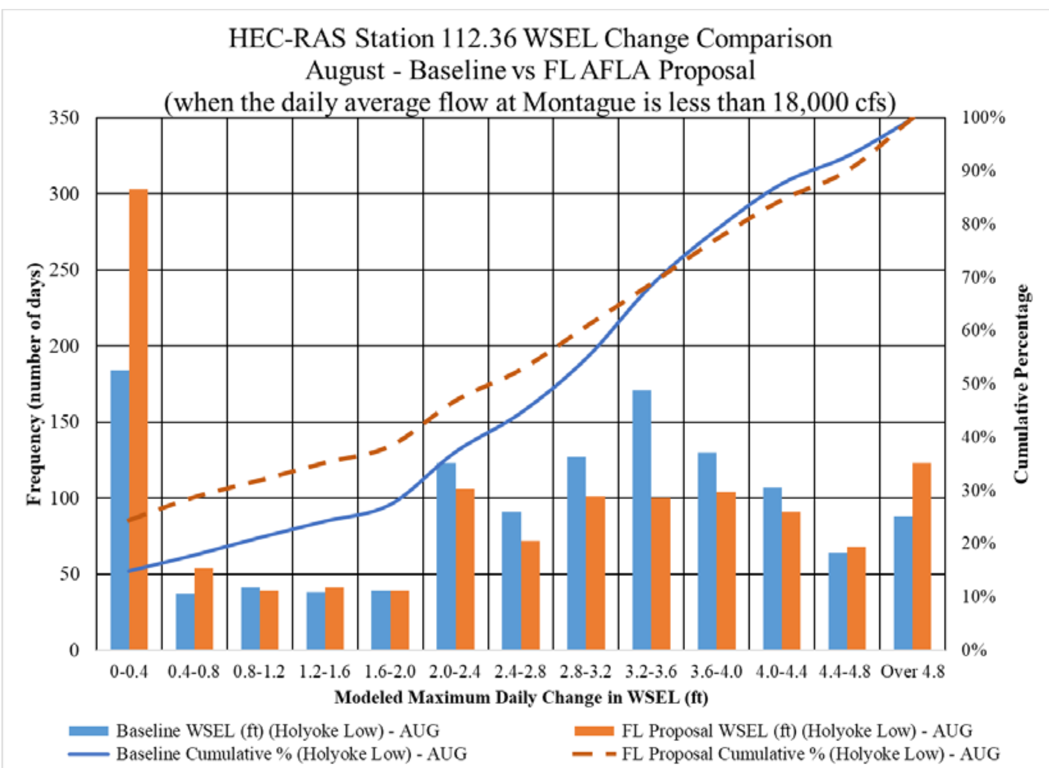

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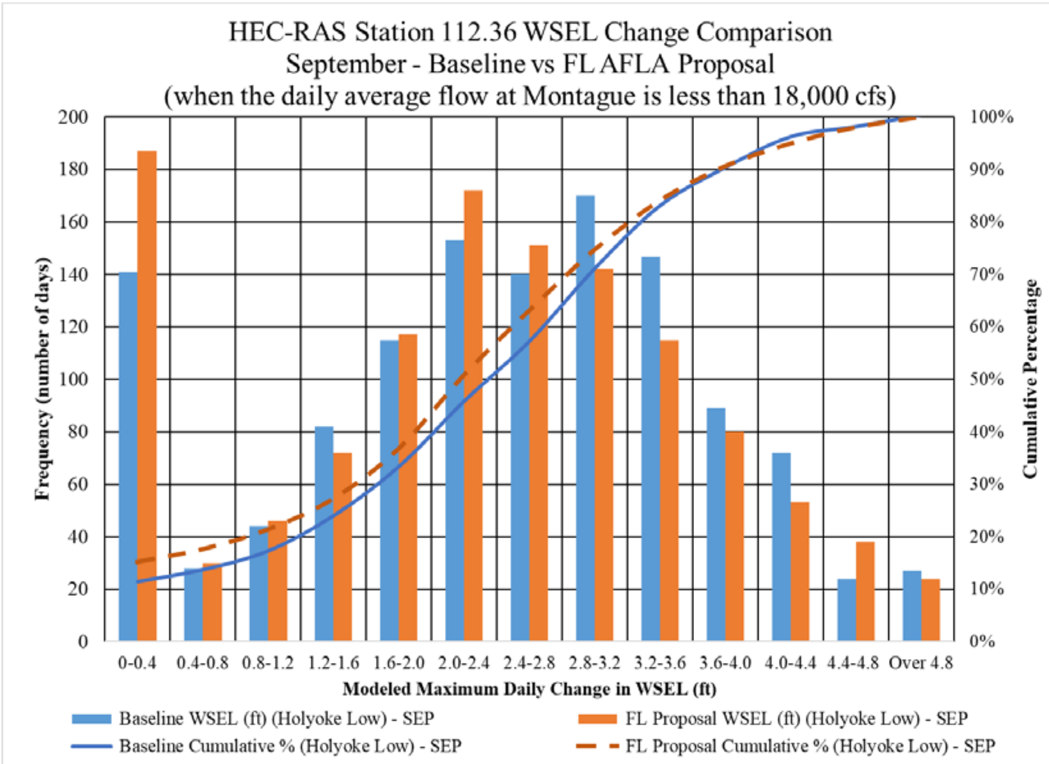

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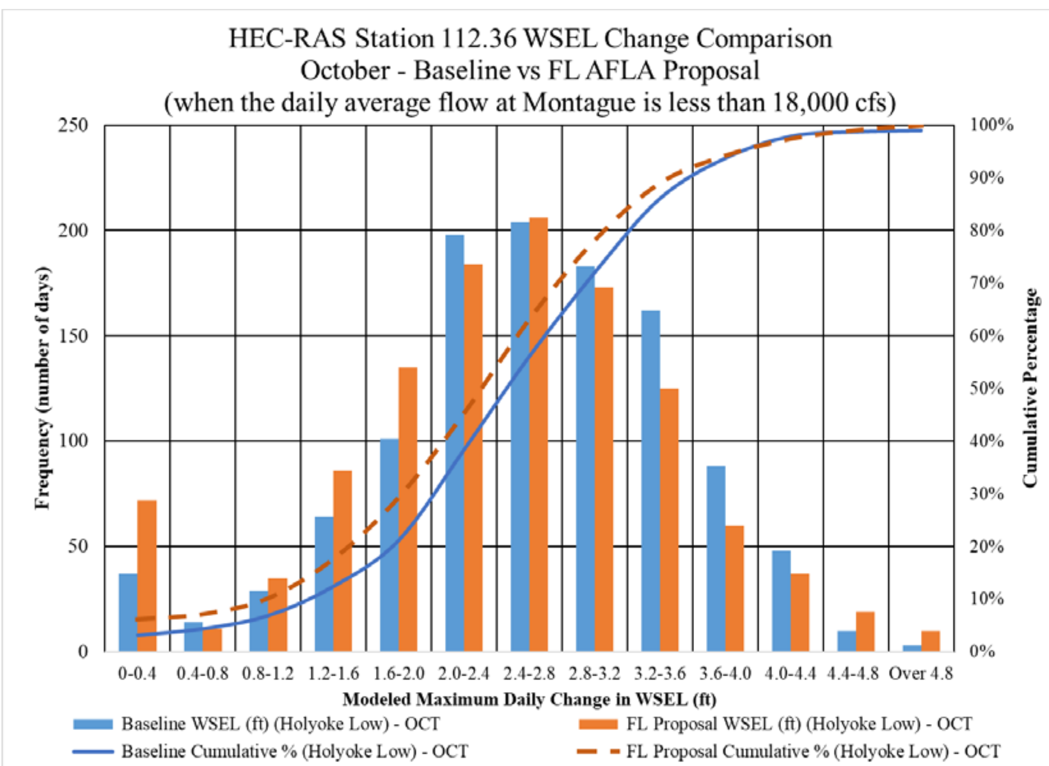
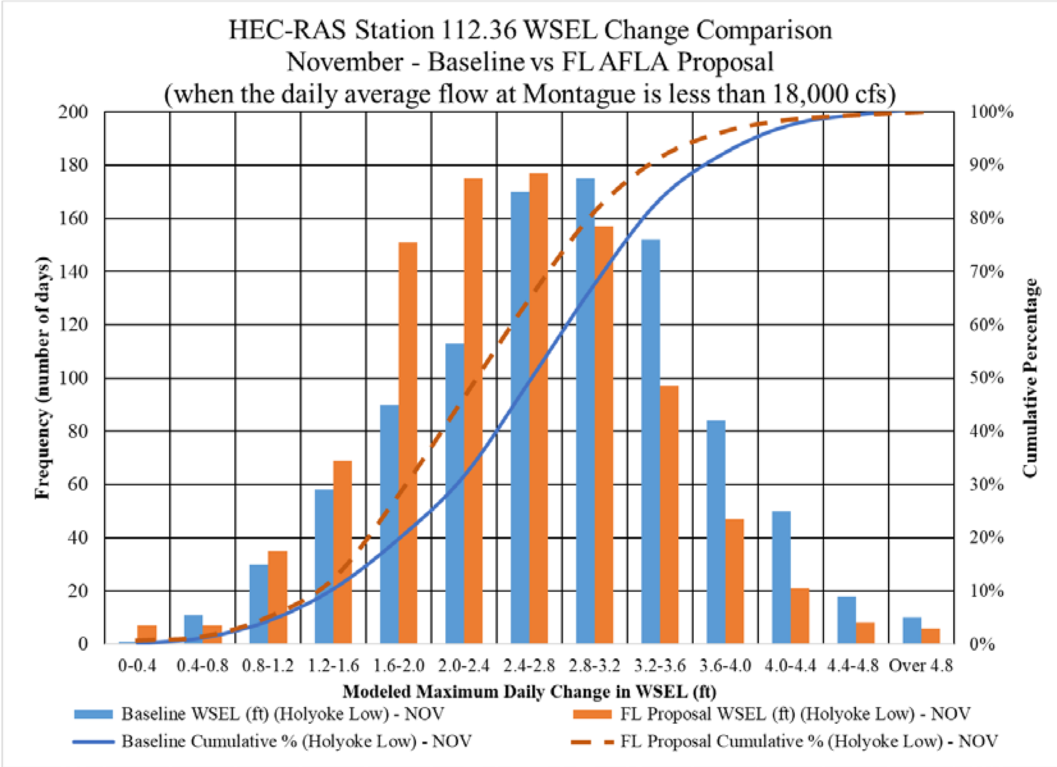
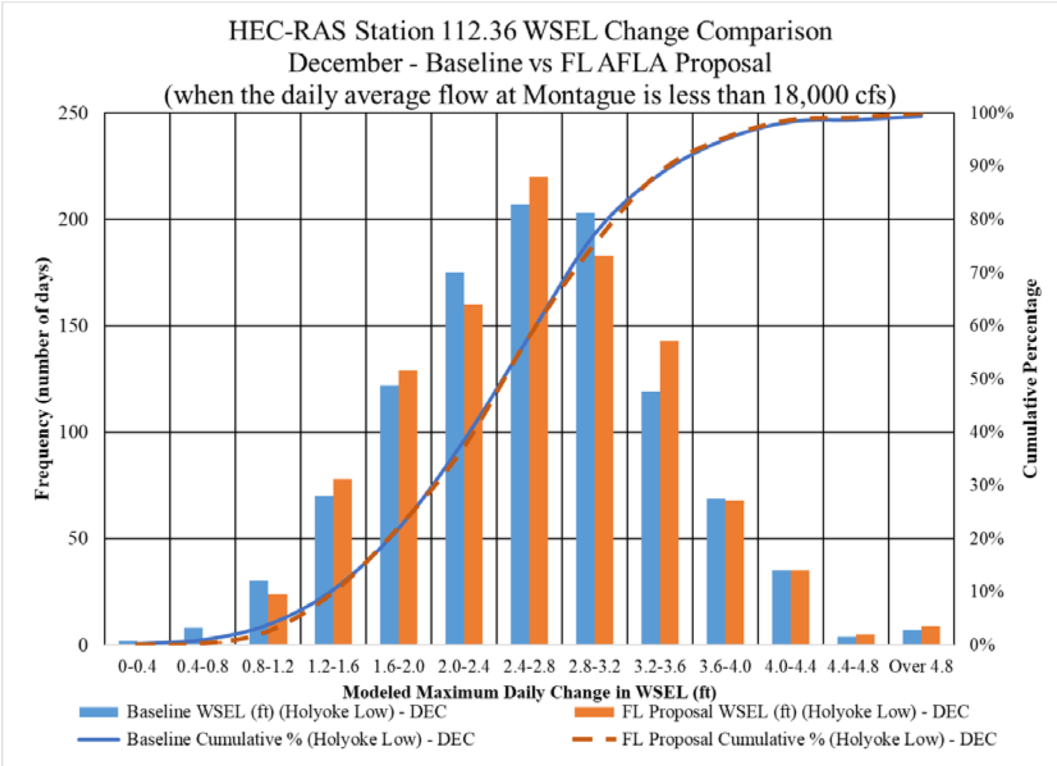


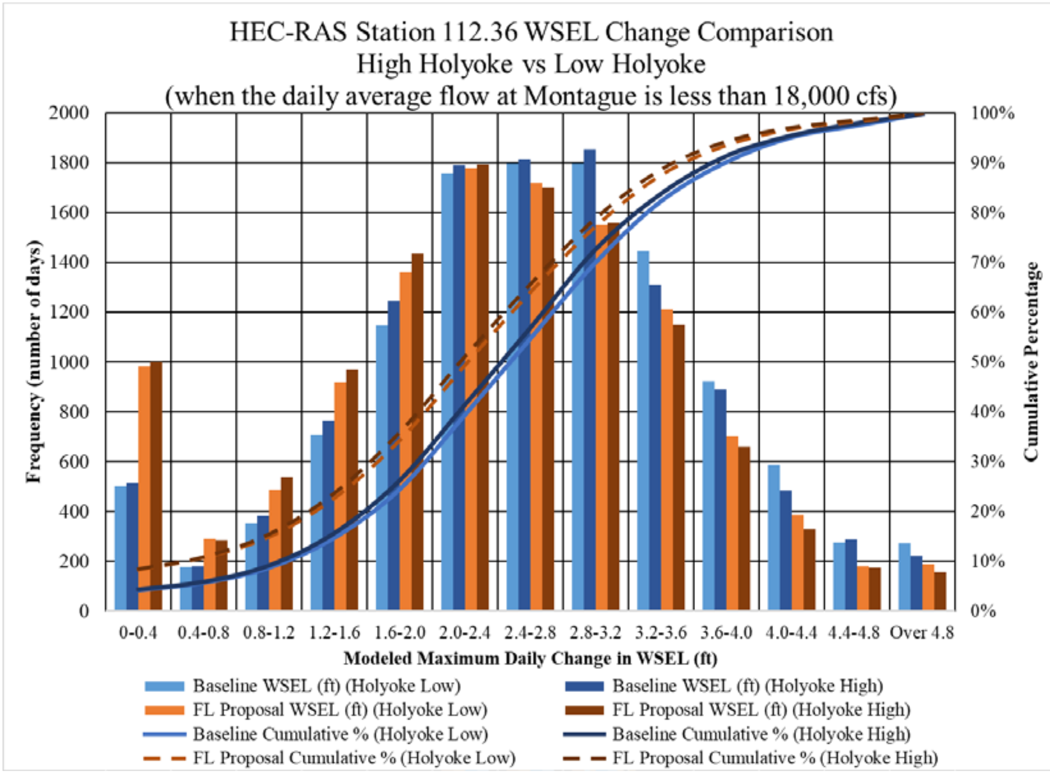
RM 112.36 October Comparison



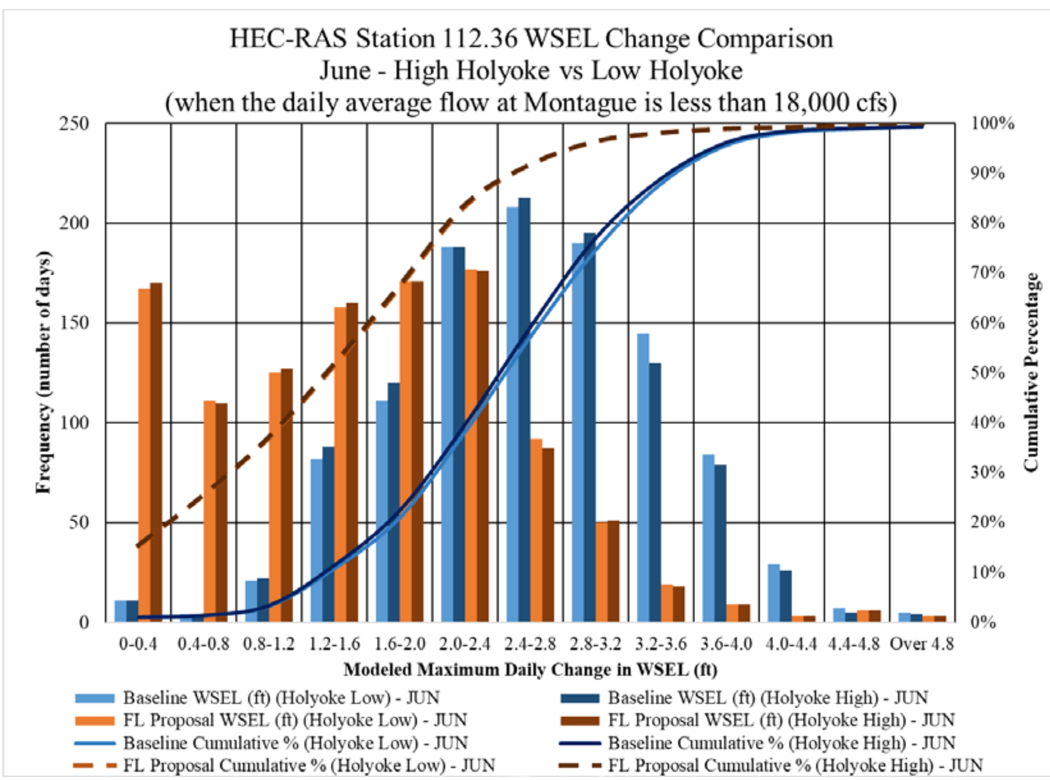
RM 112.36 November Comparison



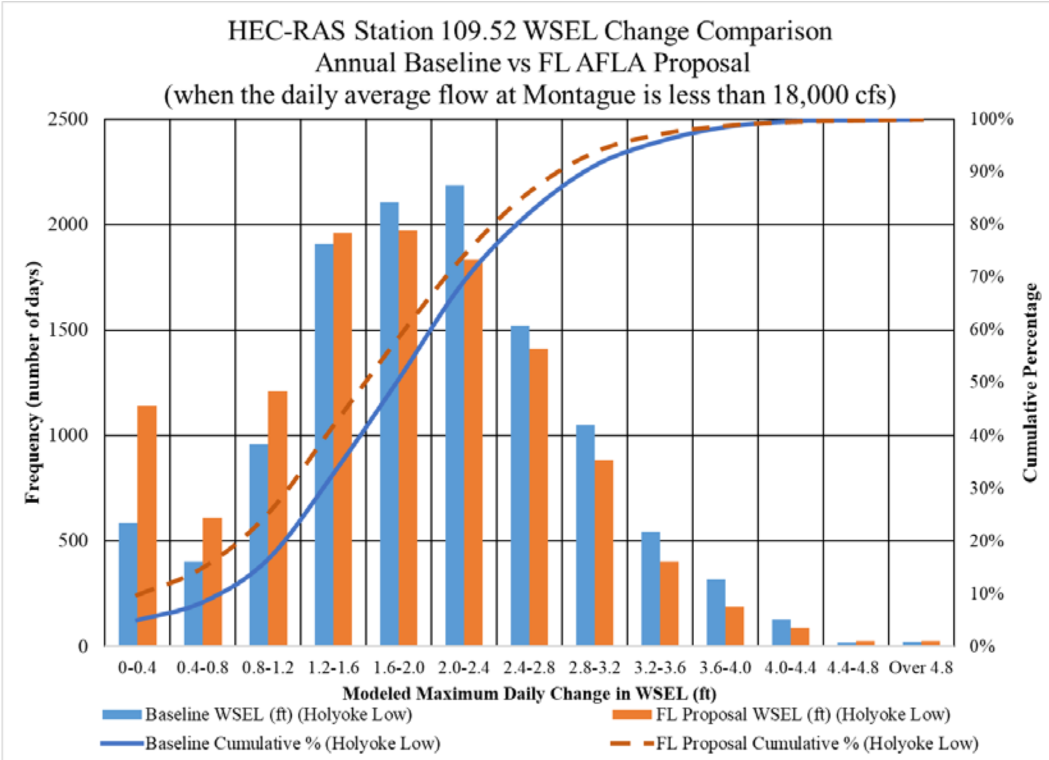
RM 112.36 December Comparison



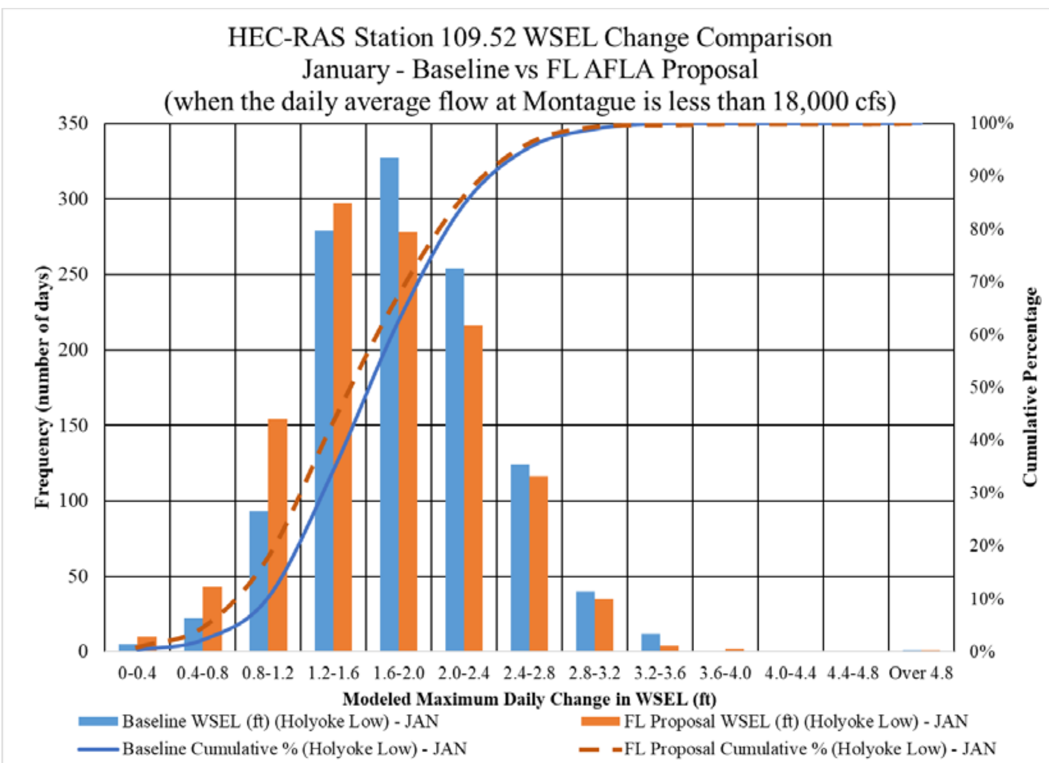
RM 112.36 Low vs High Holyoke Annual Comparison



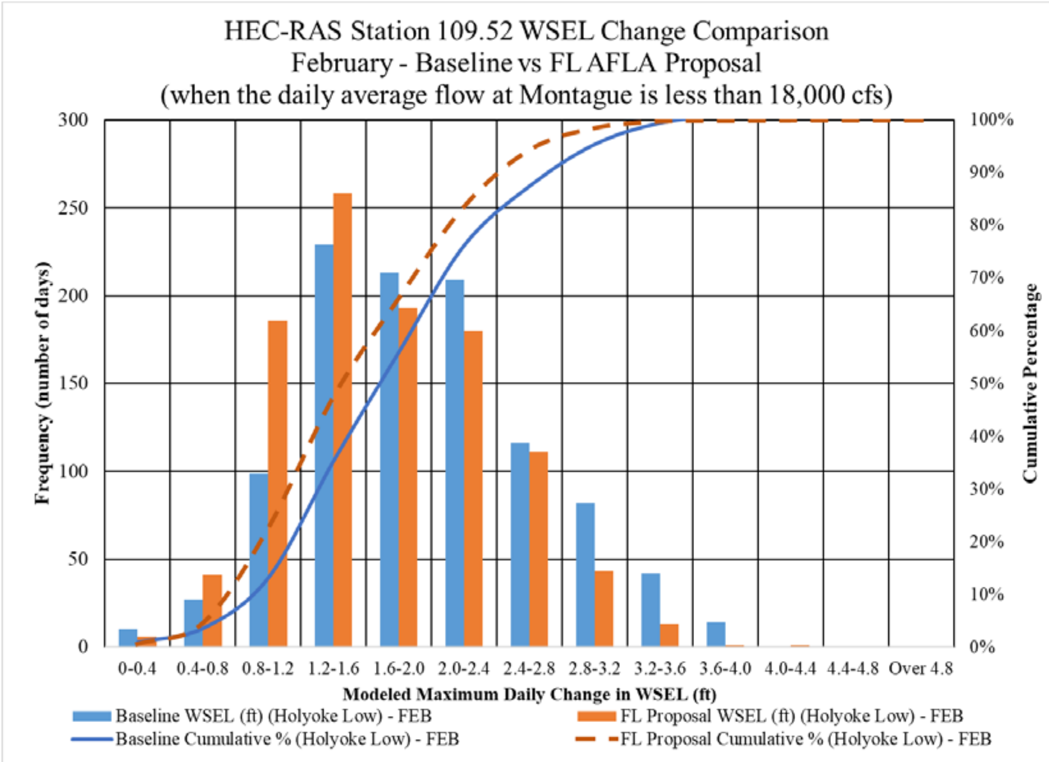
RM 112.36 Low vs High Holyoke June Comparison



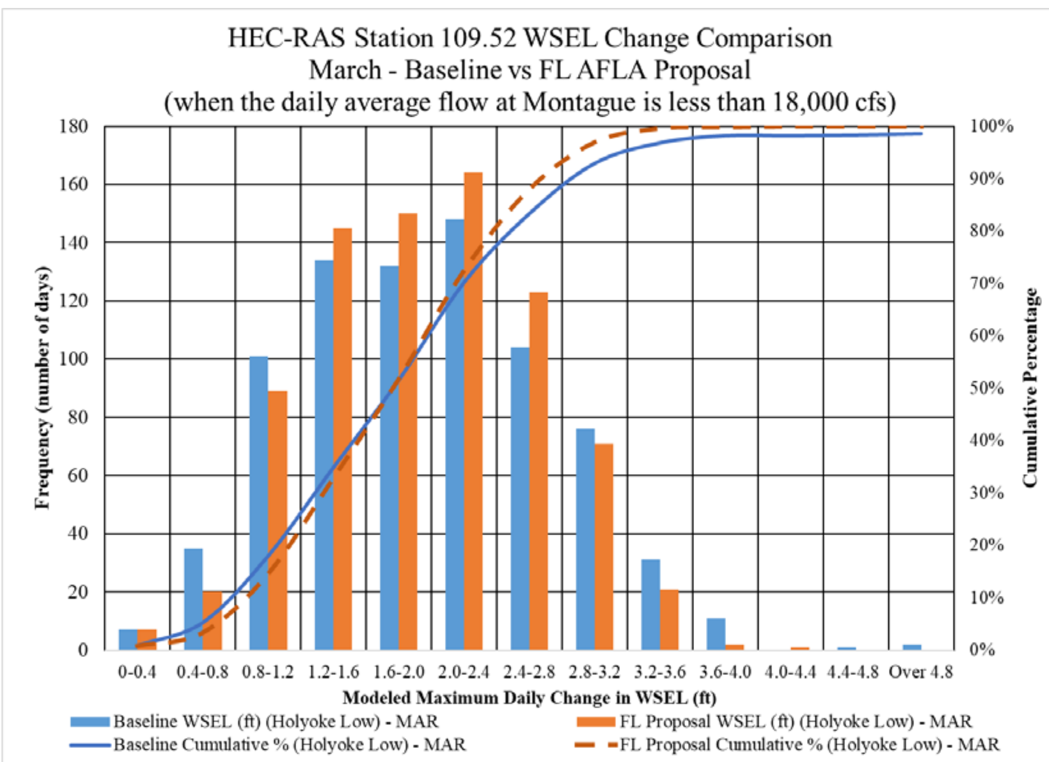
RM 109.52 Annual Comparison



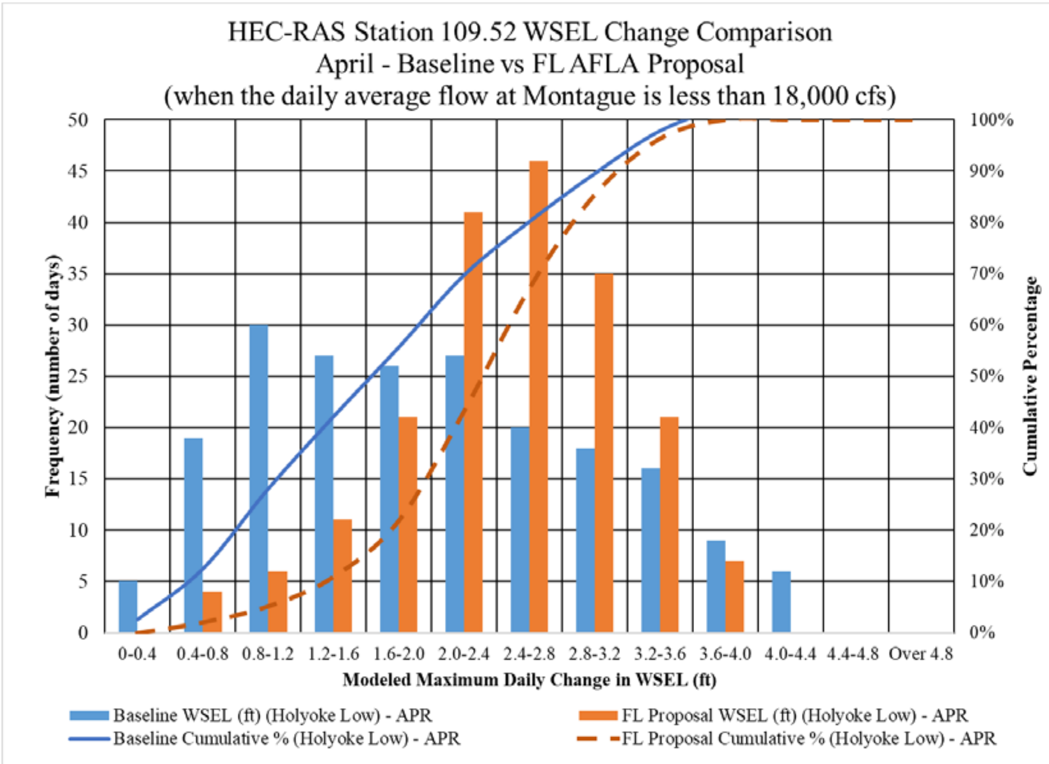
RM 109.52 January Comparison



RM 109.52 February Comparison



RM 109.52 March Comparison



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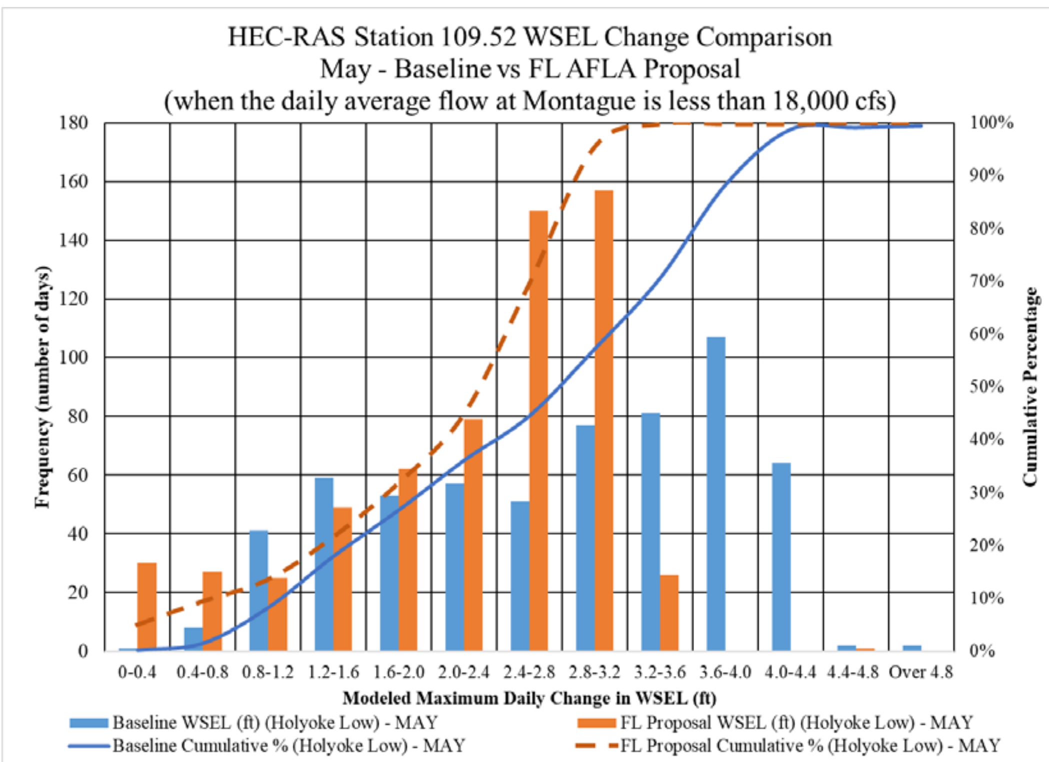

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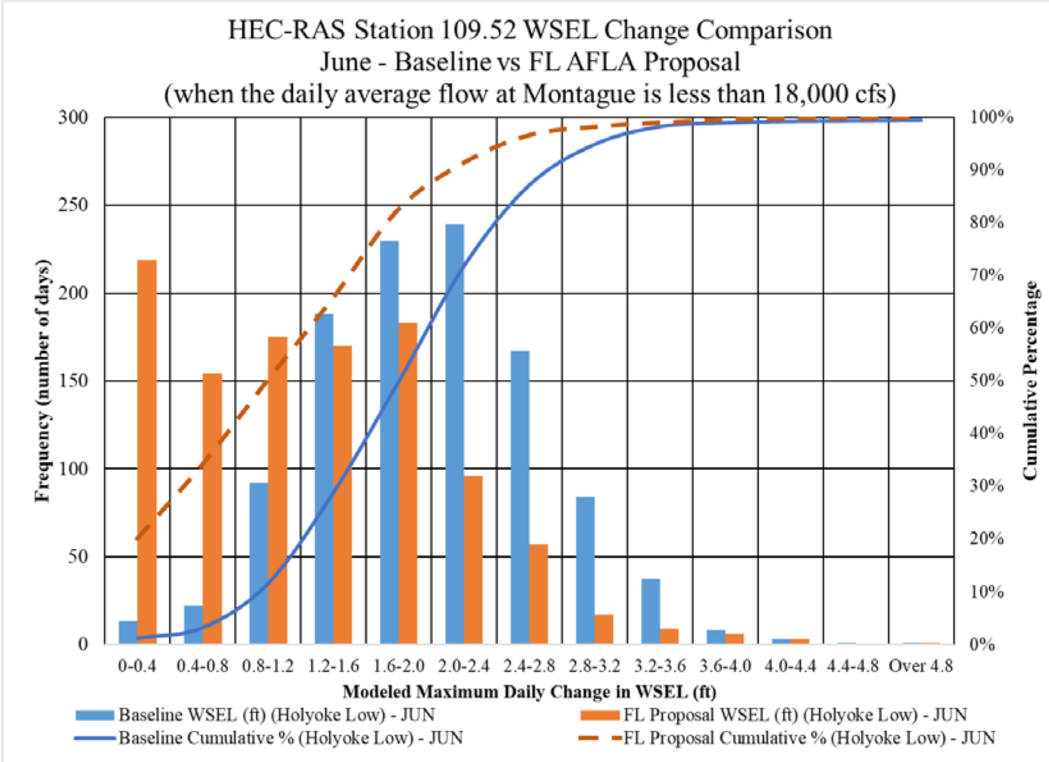

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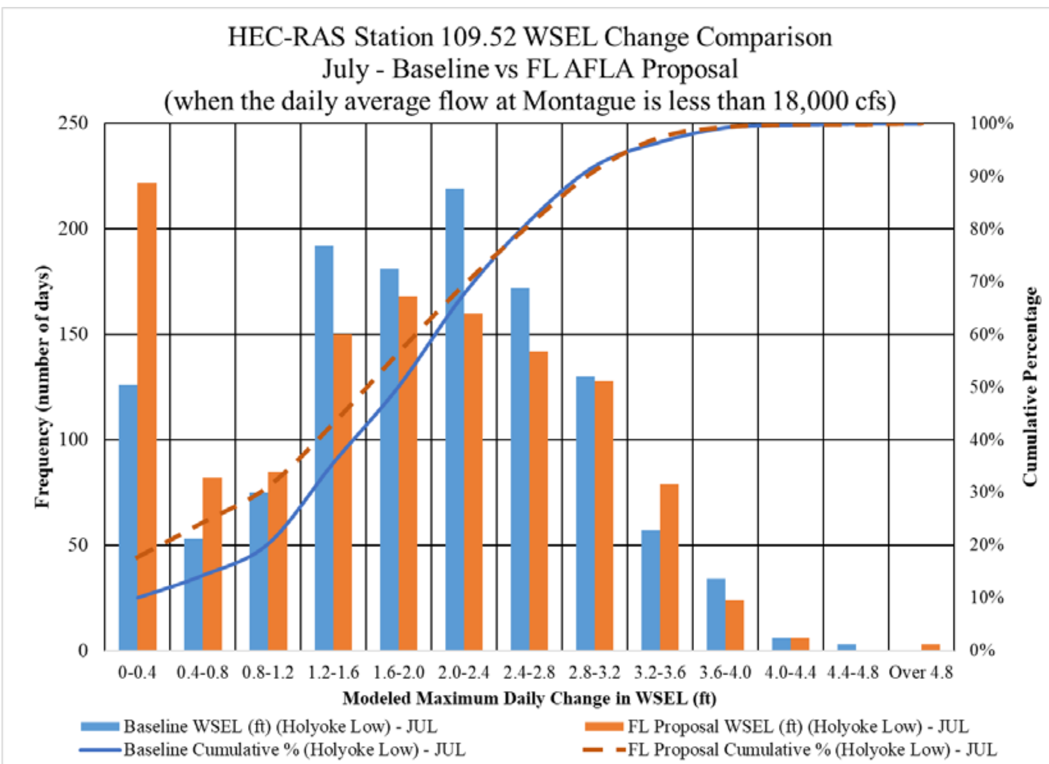
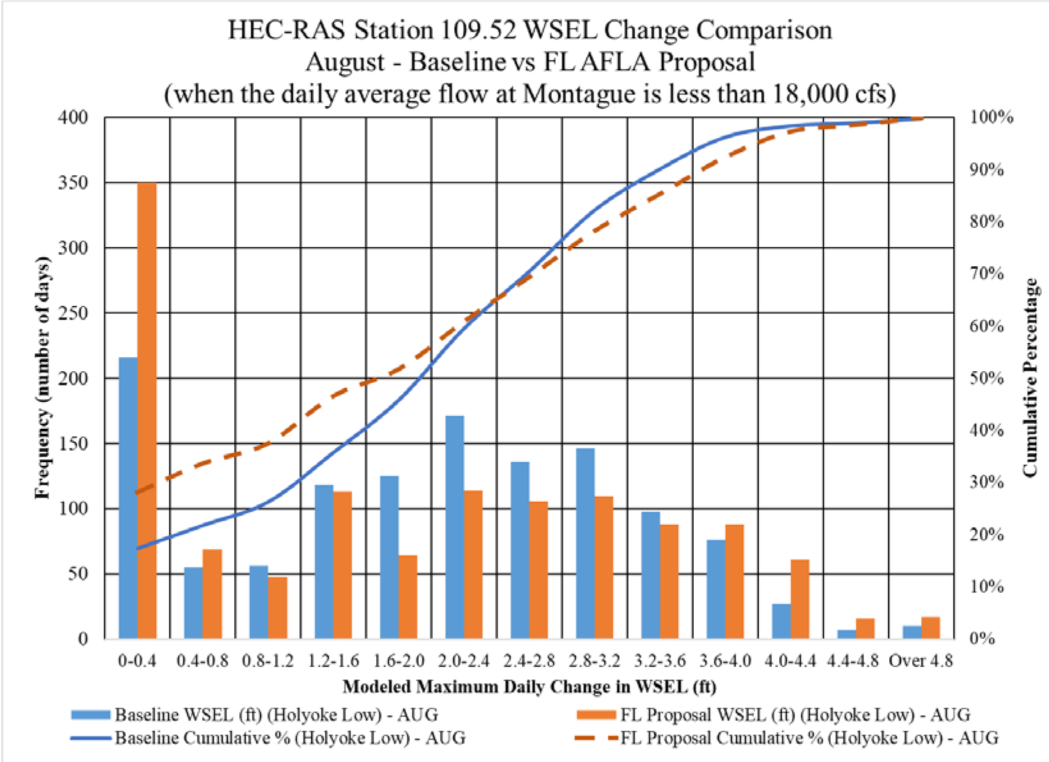


RM 109.52 July Comparison



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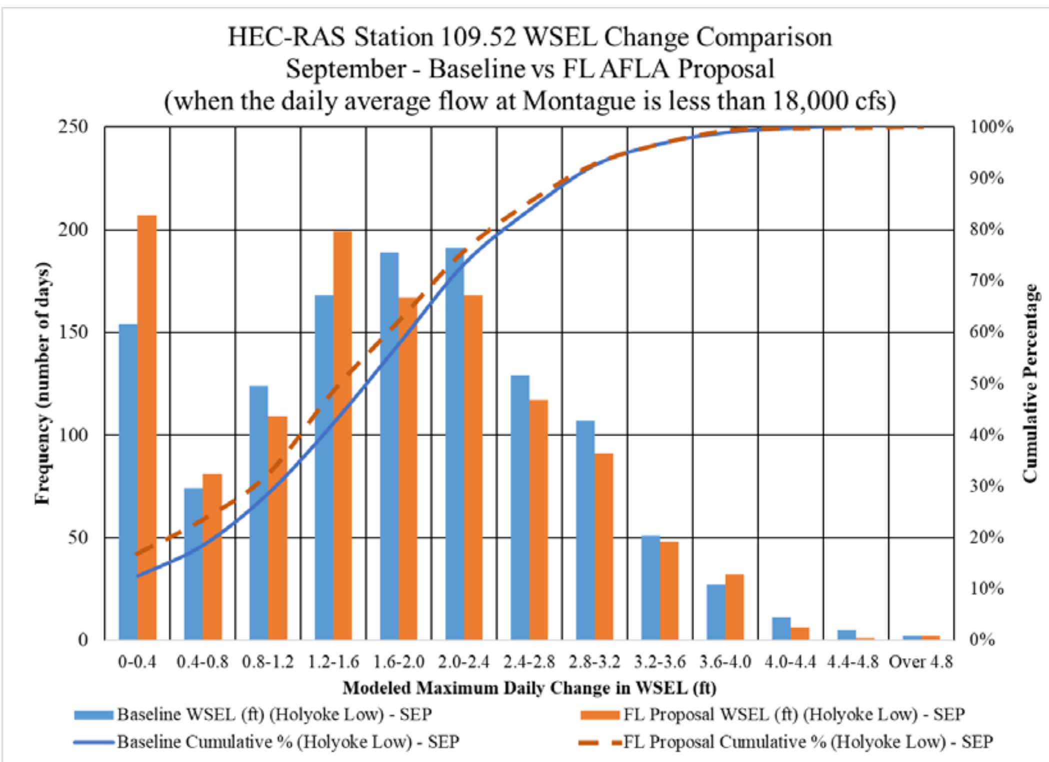

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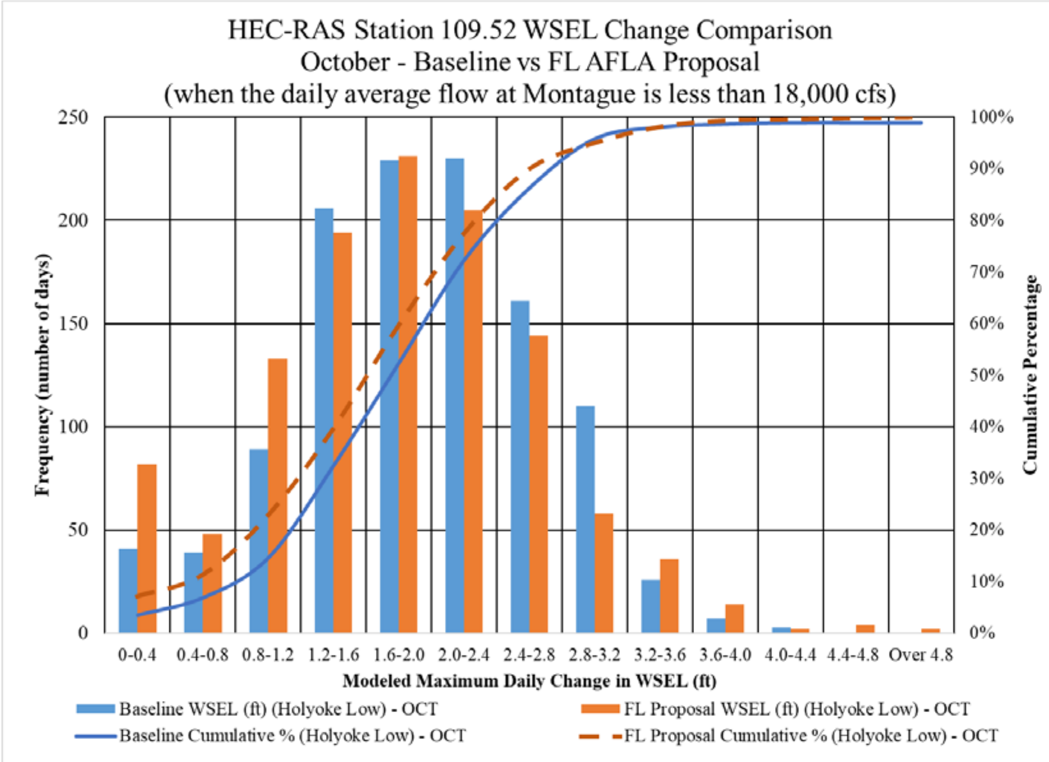

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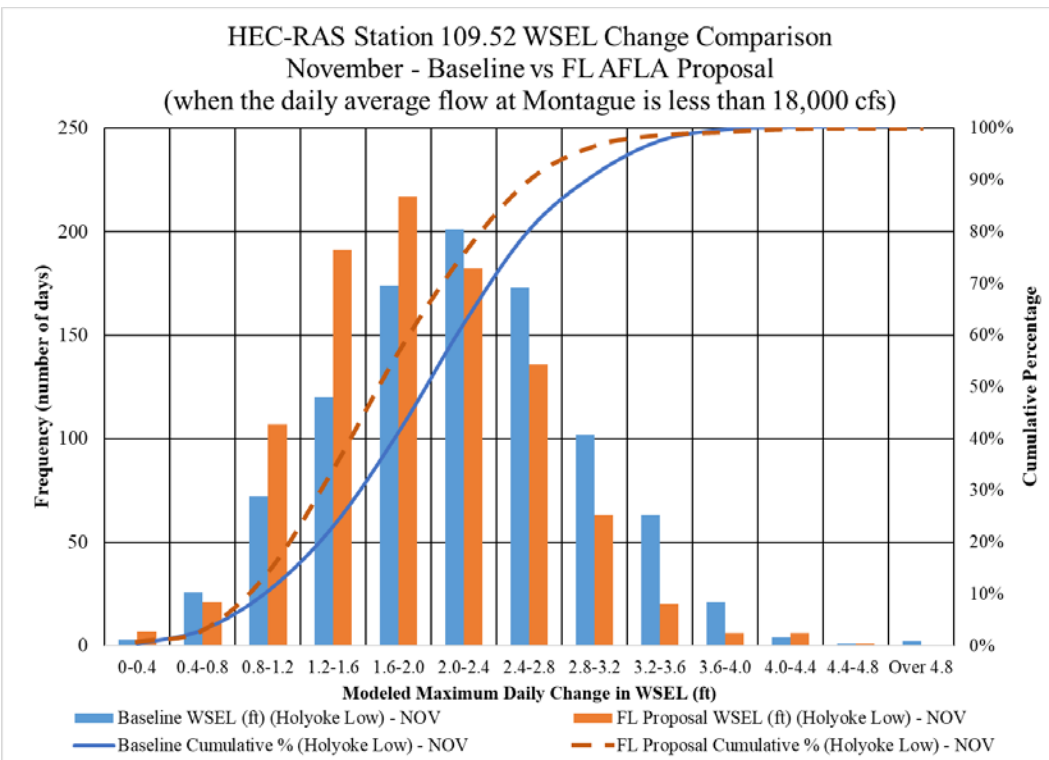

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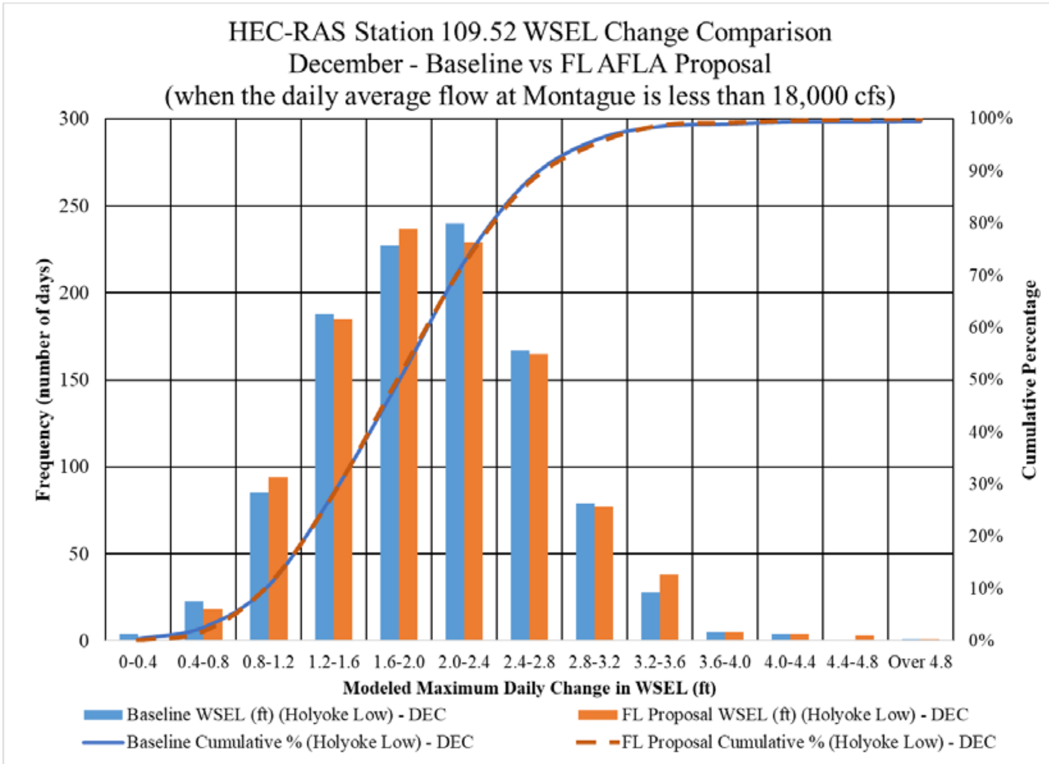

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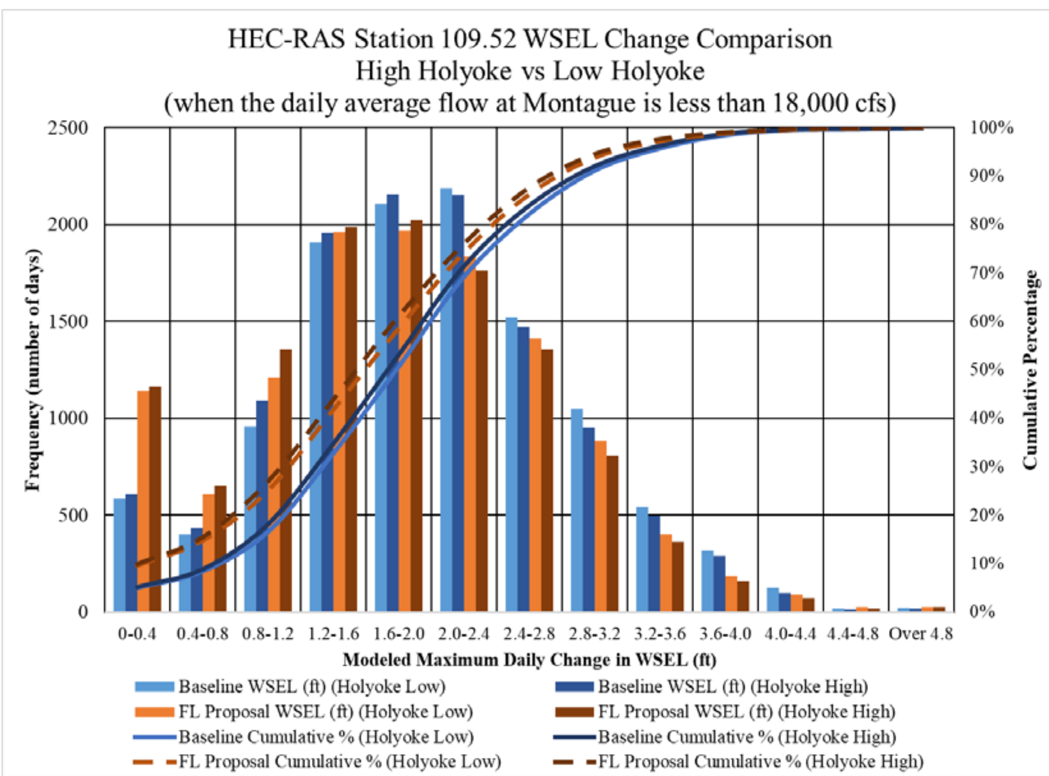
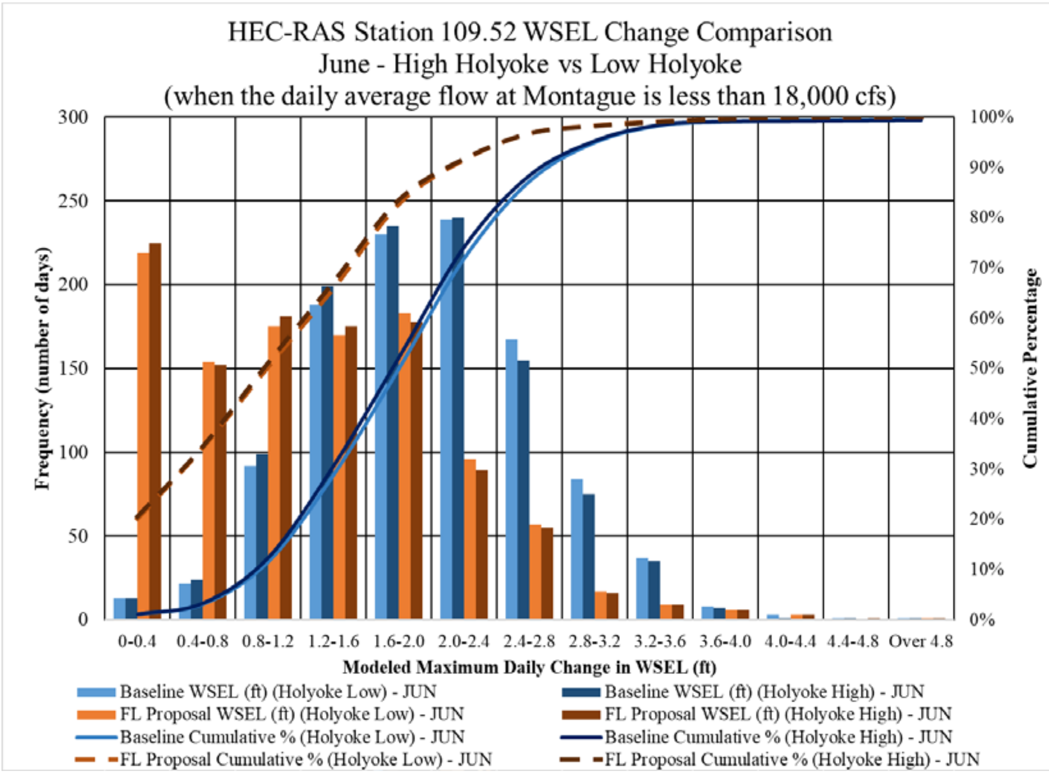


RM 109.52 Low vs High Holyoke Annual Comparison



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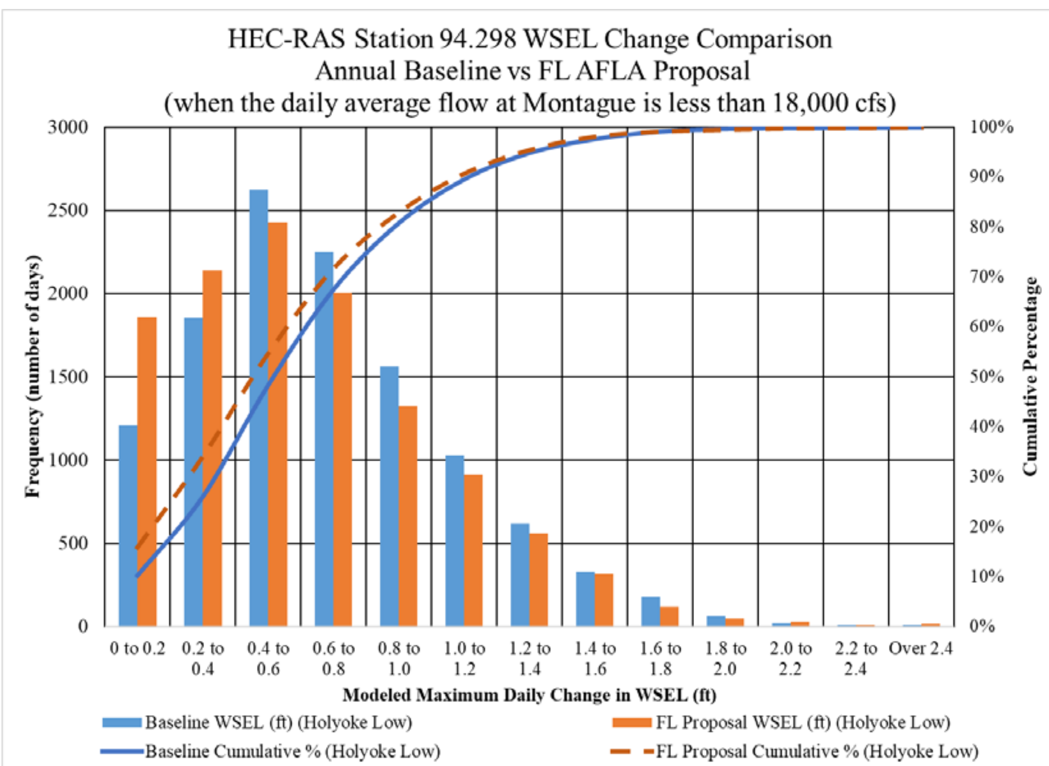
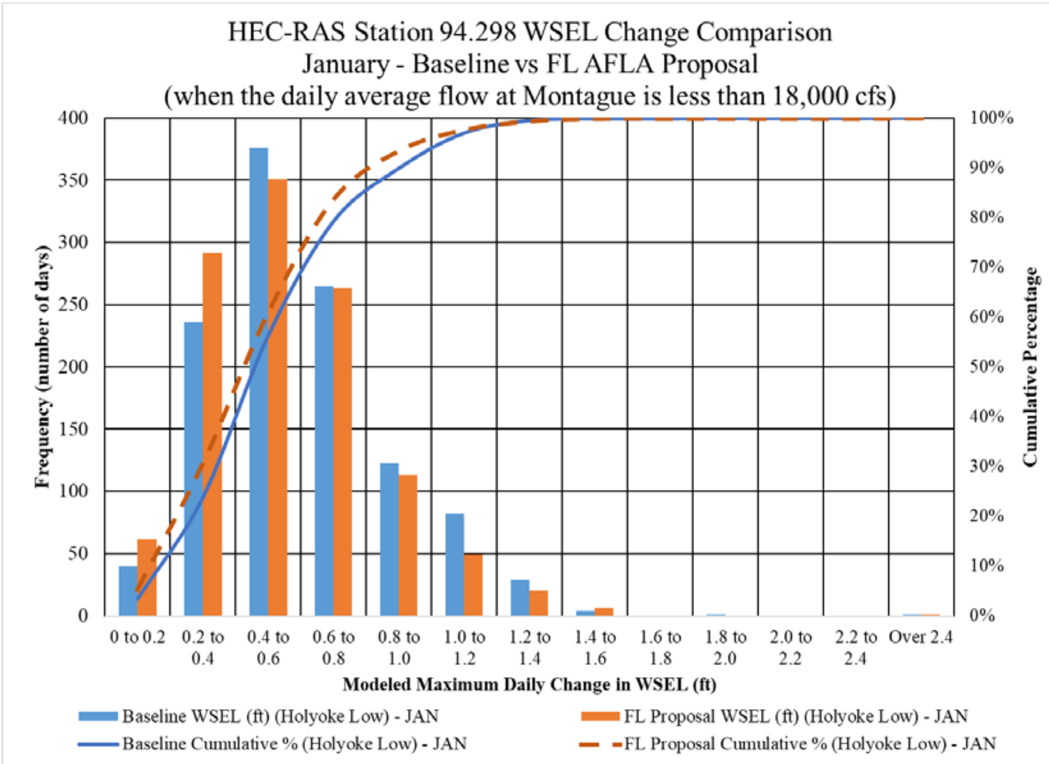


RM 94.298 Annual Comparison (Rainbow Beach)



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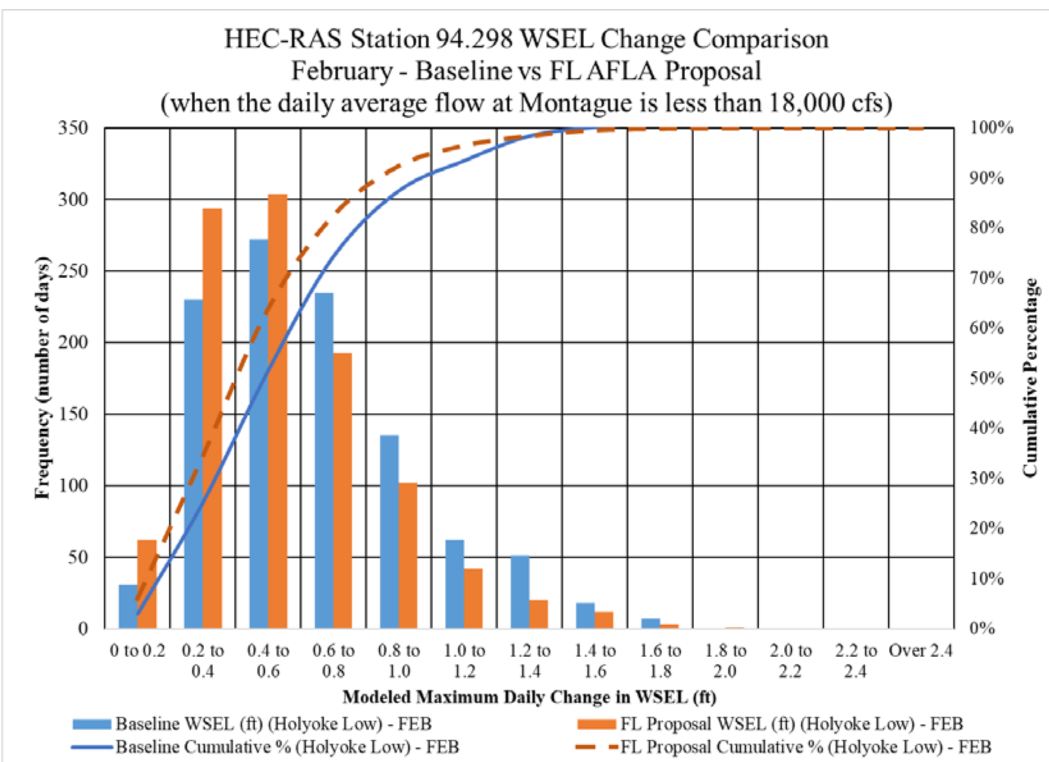

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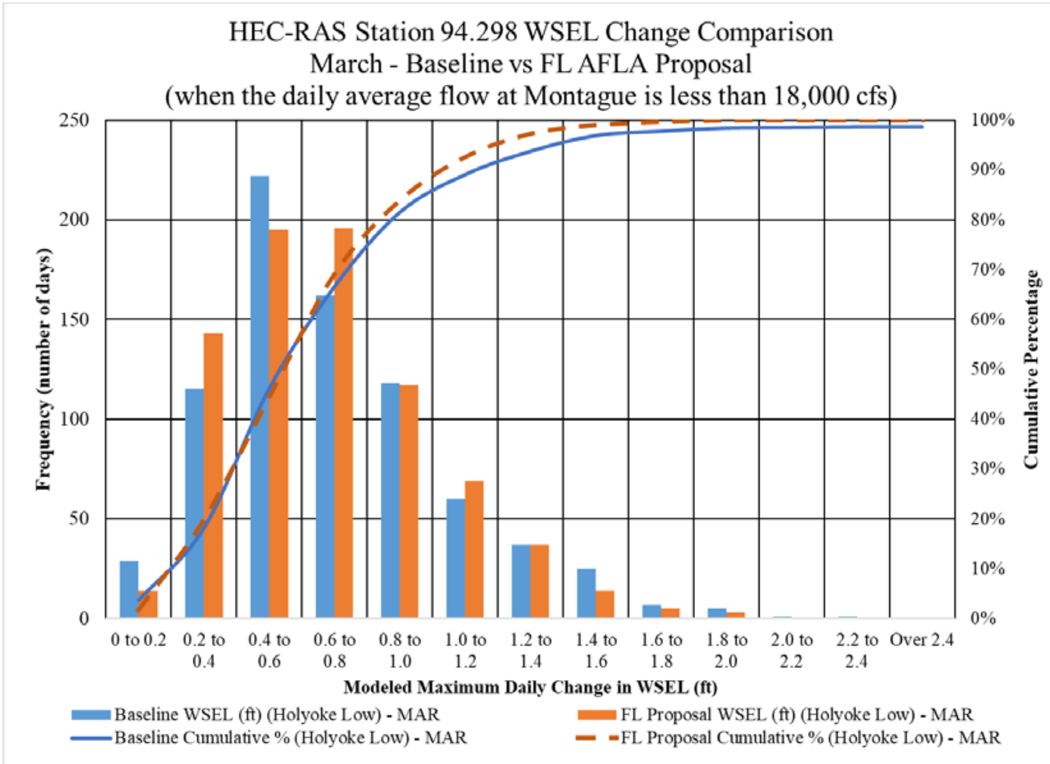

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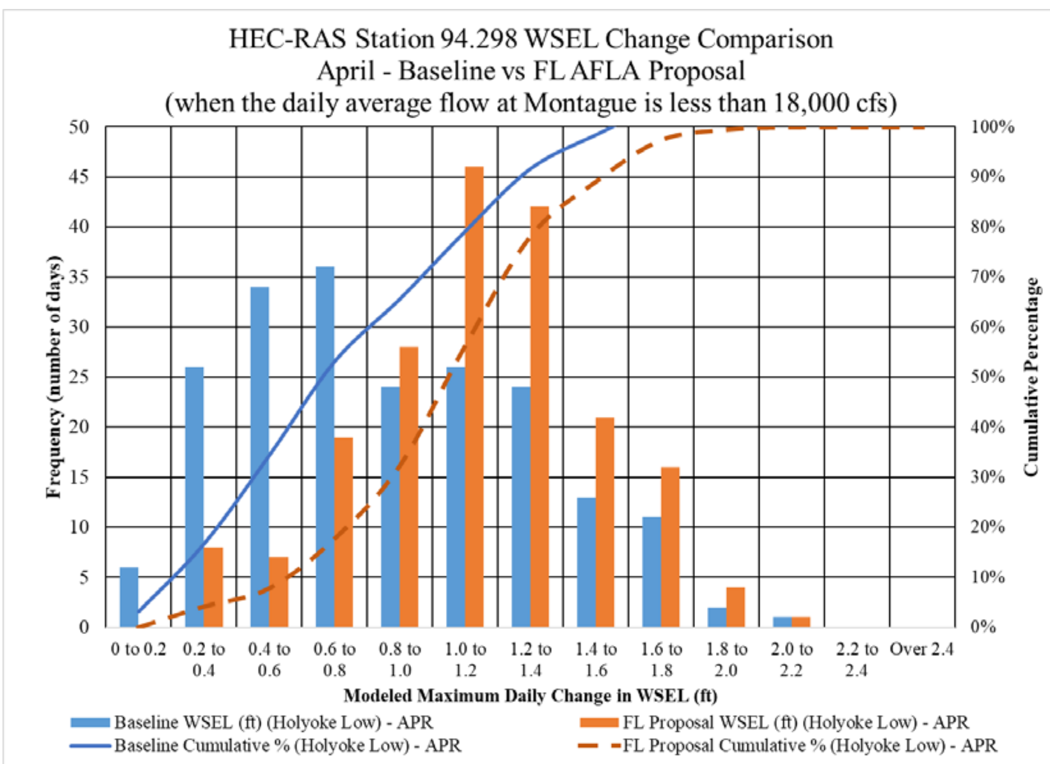

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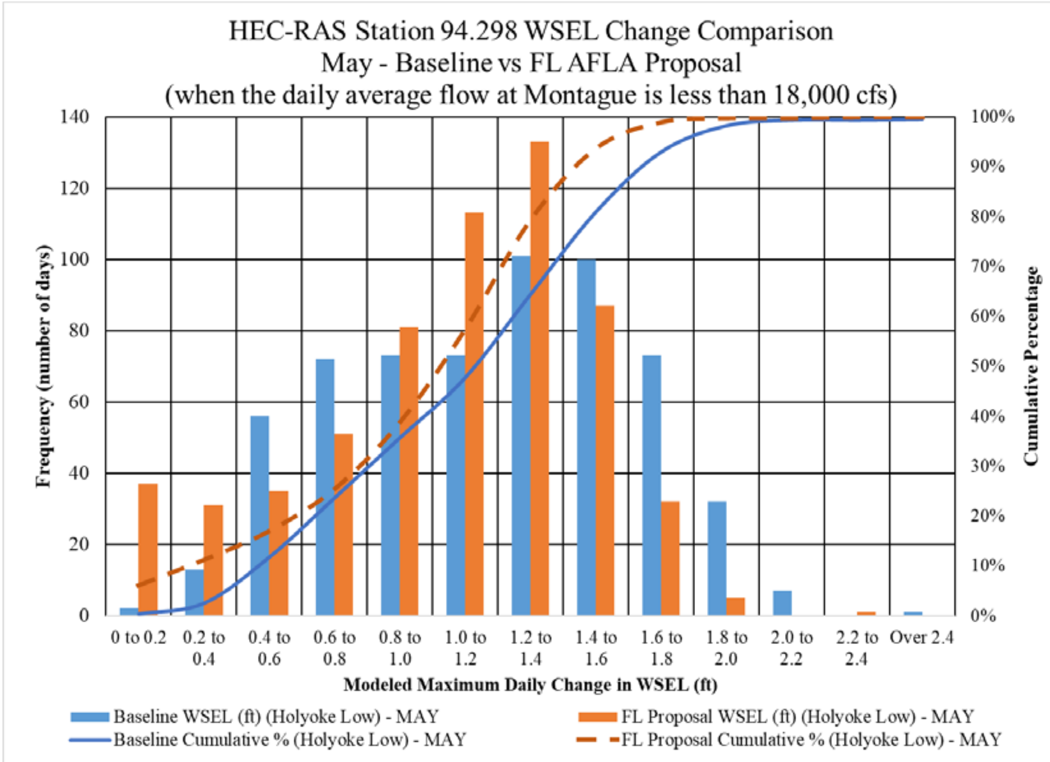

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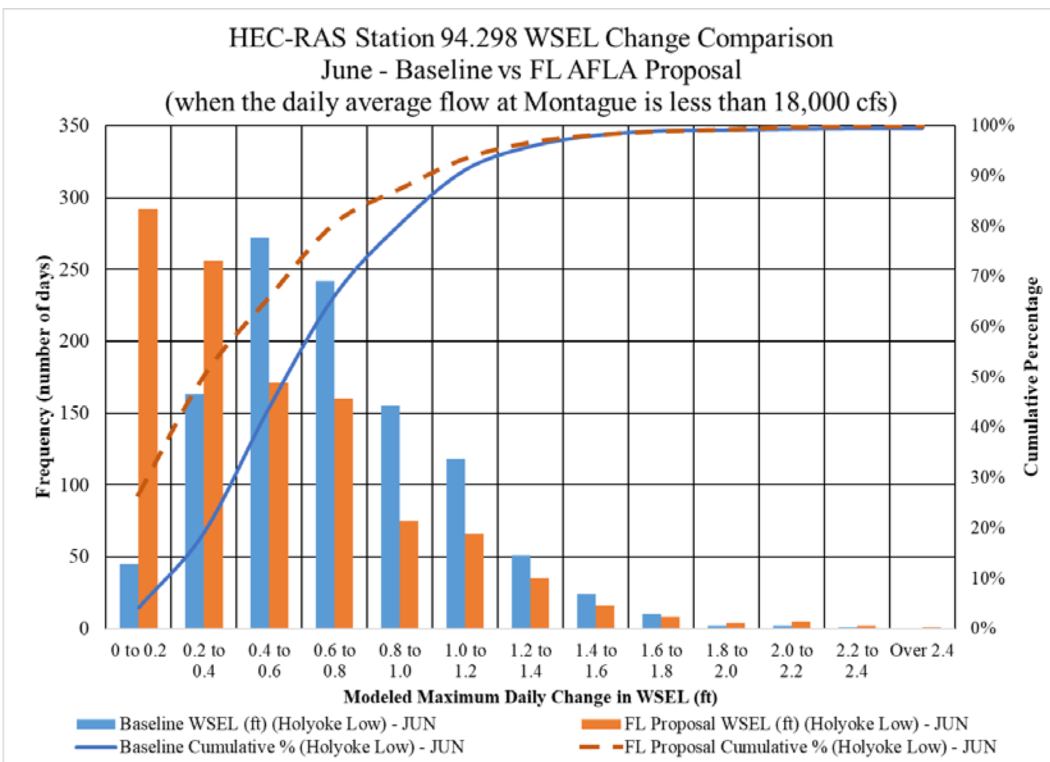

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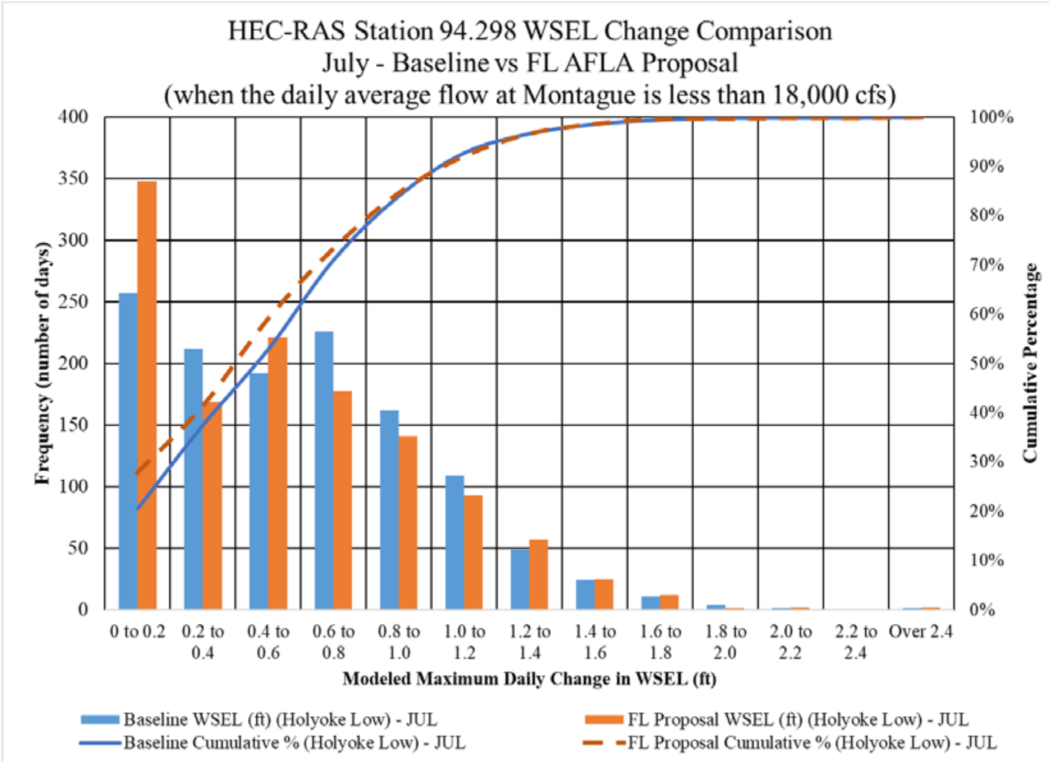

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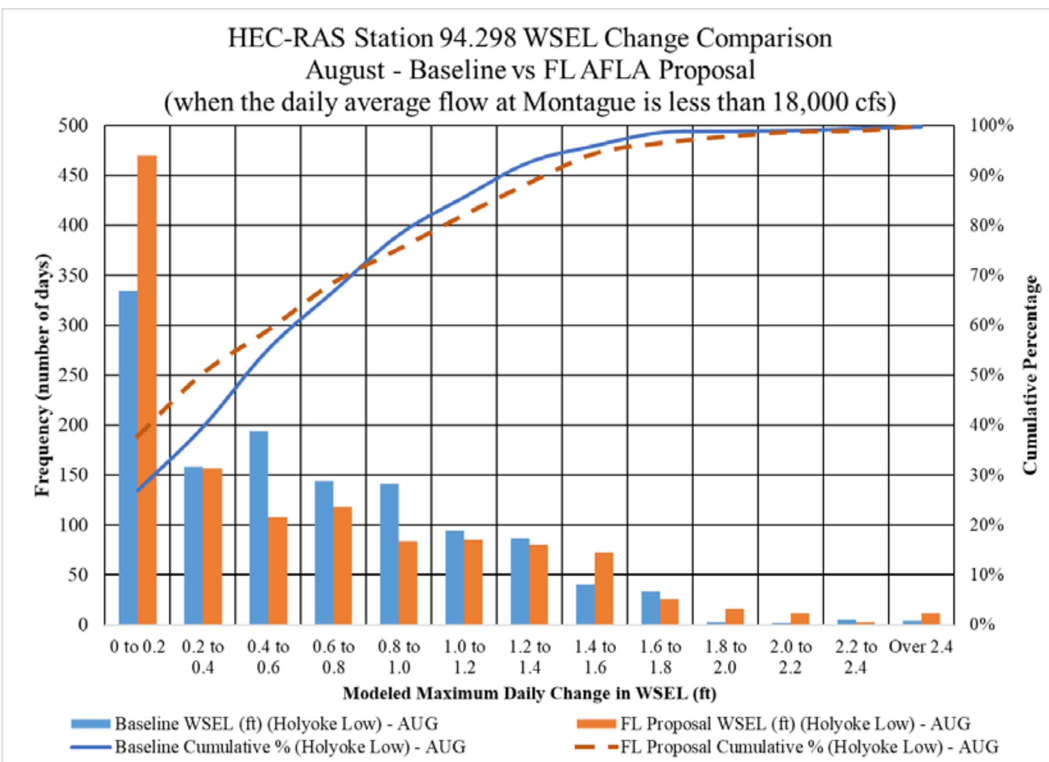

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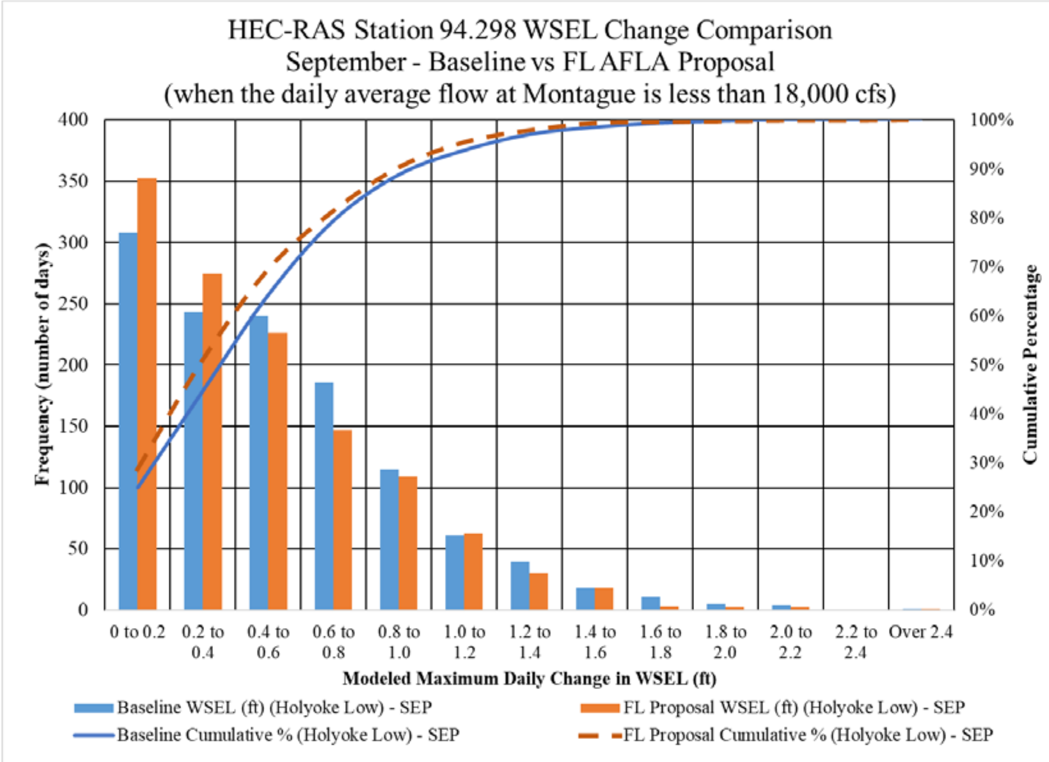

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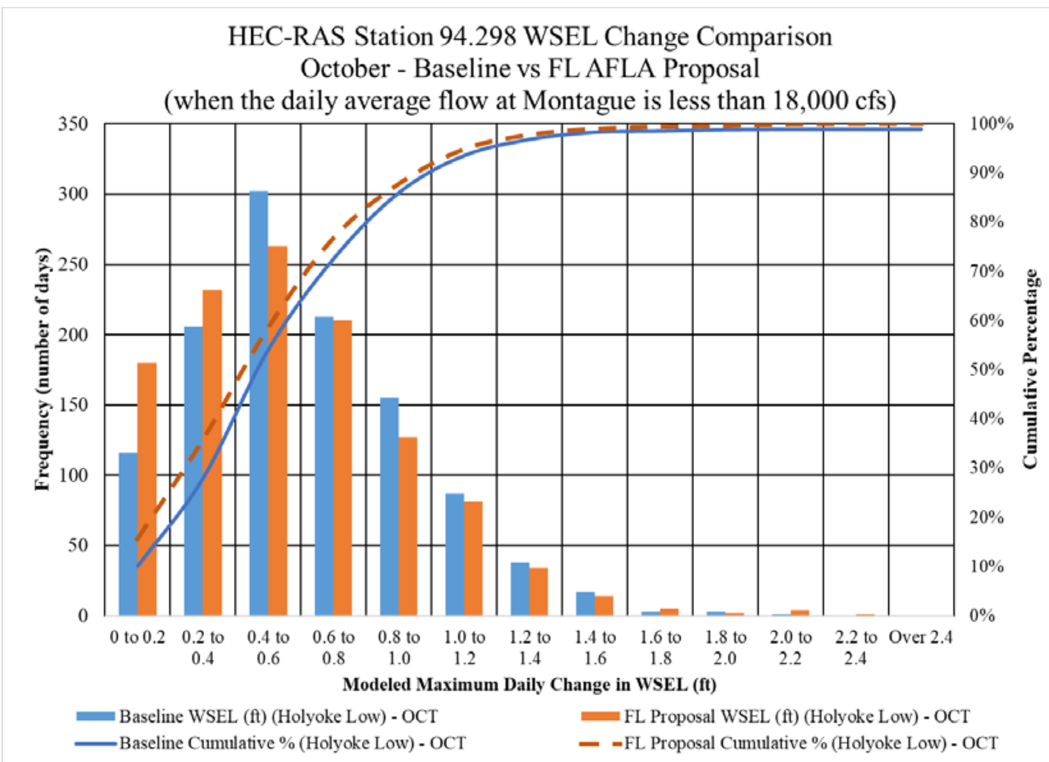

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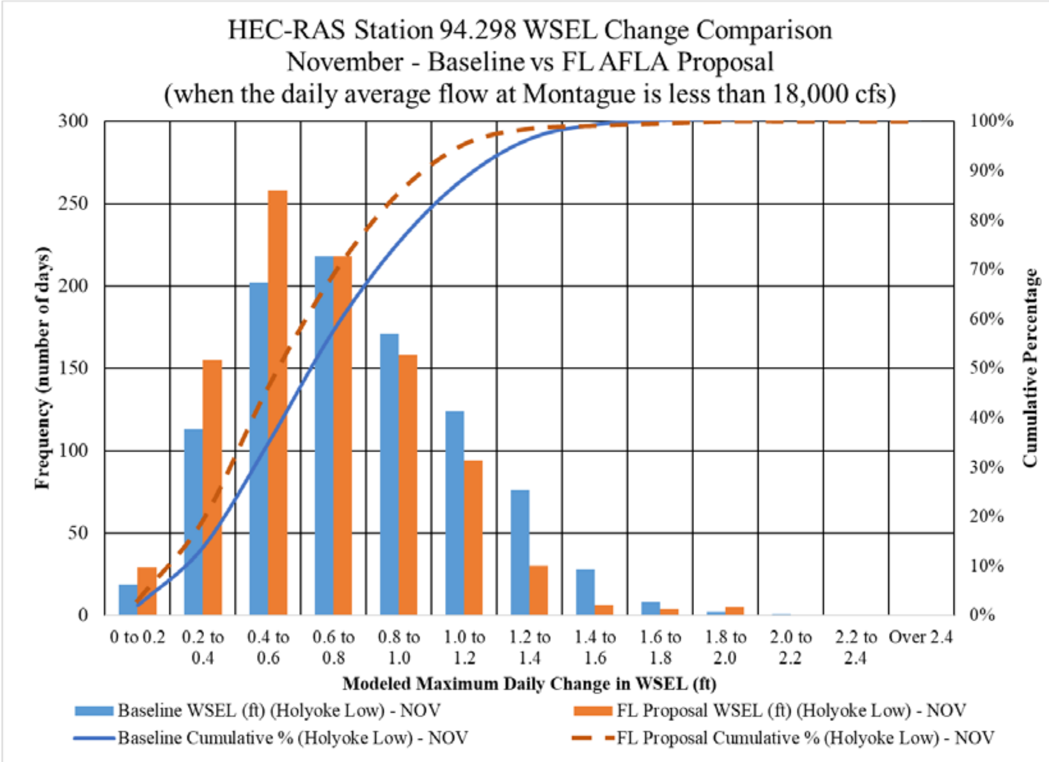

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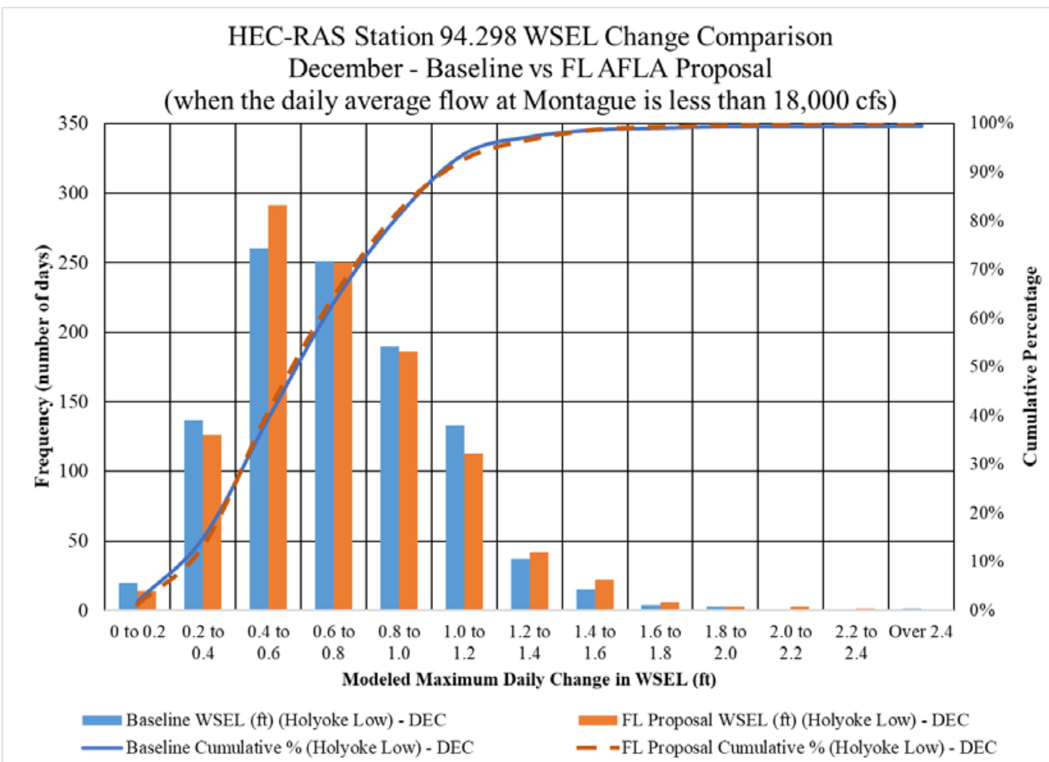

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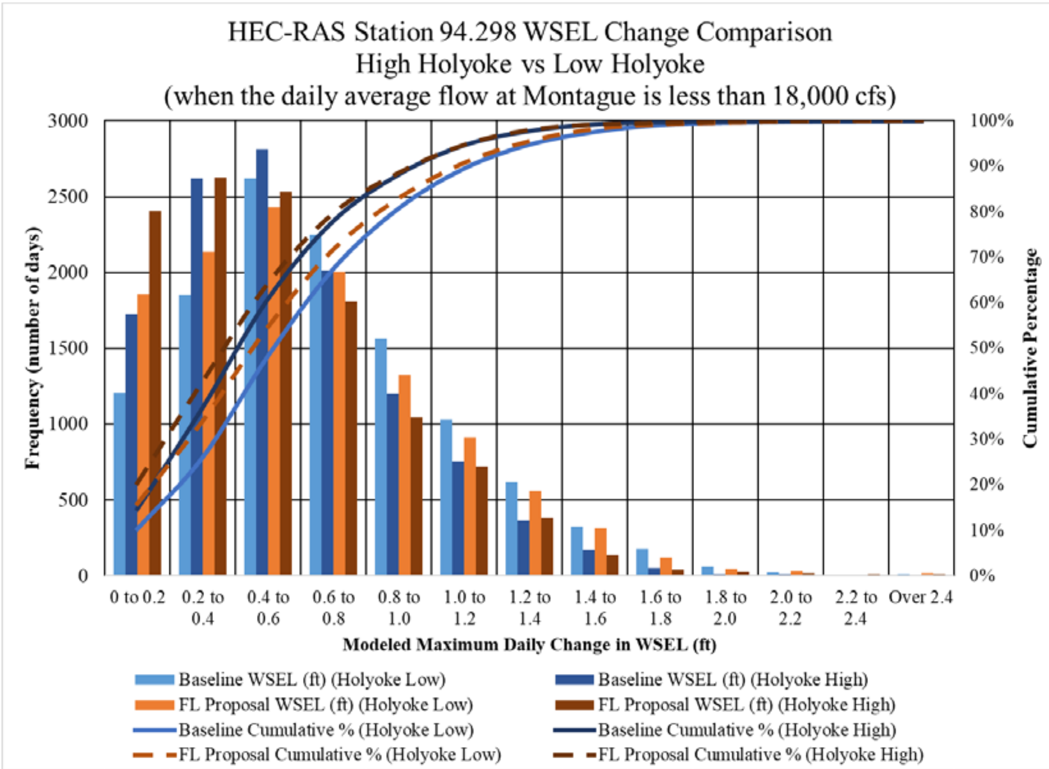
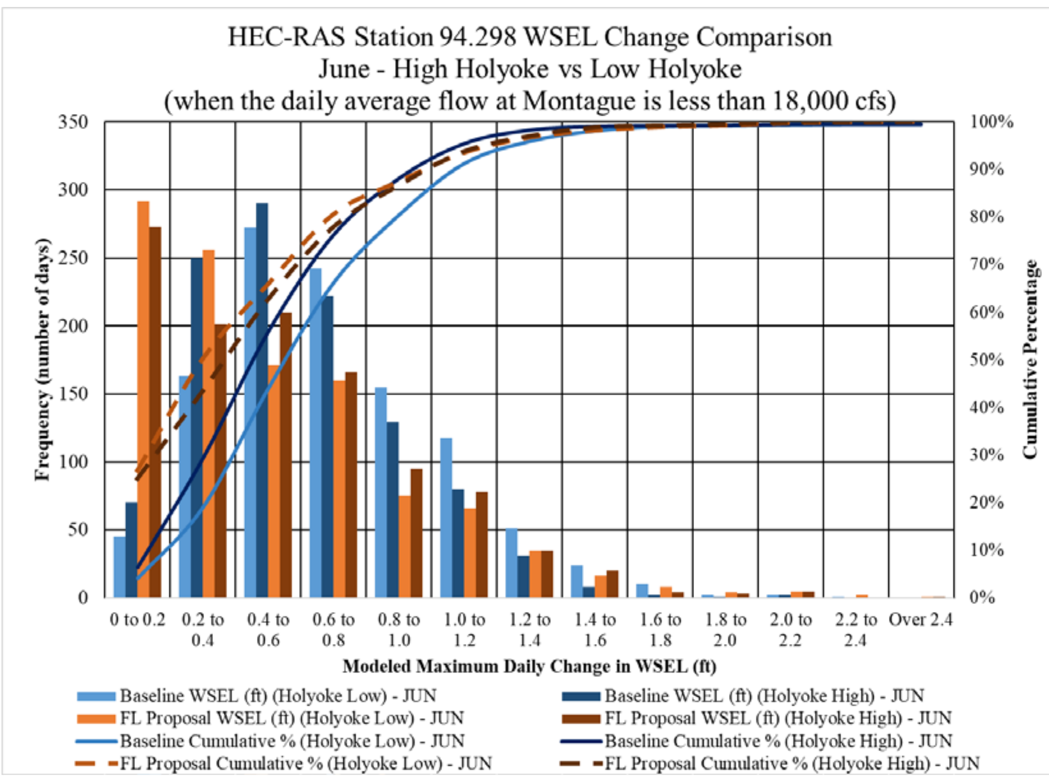


RM 94.298 Low and High Holyoke Annual Comparison (Rainbow Beach)



RM 94.298 Low and High Holyoke June Comparison (Rainbow Beach)

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Appendix A- Terrestrial- Turners Falls- Invasive Plant Species Management Plan

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Amended Final Application for New License for Major Water Power Project – Existing Dam

Turners Falls Hydroelectric Project (FERC Project Number 1889)

Invasive Plant Species Management Plan

FirstLight

DECEMBER 2020

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1 PURPOSE

The purpose of this Management Plan is to prevent the introduction and/or spread of invasive species within the Turners Falls Project (Project) boundary through the implementation of best management practices and through supporting the education of individuals performing construction, maintenance, and/or operational activities within the Project boundary. This plan does not require the Licensee to police or oversee any activities performed by the public associated with the management of invasive species within the Project boundary.

Invasive plant species are defined by the Massachusetts Invasive Plant Advisory Group (MIPAG) as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems."

In 2013, an Act Protecting Lakes and Ponds from Aquatic Nuisances became effective in Massachusetts, which made the introduction of nonnative aquatic species illegal, and included provisions that boats, trailers and recreational equipment must be examined and cleaned for nonnative aquatic species before and after use.

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2 EXISITING INFORMATION

During relicensing studies conducted in support of obtaining the Project's new FERC license, a series of observations for invasive species were performed in conjunction with other study activities throughout the 2014 field season.

2.1 Aquatic Plant Species

During the summer of 2014, the Turners Falls Impoundment (TFI) was surveyed for submergent aquatic vegetation (SAV). The intent was to describe dominant species as well as estimate the coverage within mapped patches of SAV. In most cases, very dense stands were dominated by exotic species, primarily variable leaf and Eurasian milfoil (*Myriophyllum heterophyllum* and *Myriophyllum spicatum*).

Several exotic and invasive aquatic species are currently found within the study area including variable leaf milfoil, Eurasian milfoil, curly-leaf pondweed (*Potamogeton crispus*), fanwort (*Cabomba caroliniana*), and water chestnut (*Trapa natans*). In total, 41 of the mapped 107 SAV beds had some level of infestation by exotic species, which accounted for 38% of the SAV beds. The majority of the exotic species occur immediately upstream of the Turners Falls Dam with fewer occurrences upstream of the French King Bridge. In general, exotic species upstream of the French King Bridge are not as widespread and occur at lower densities. No exotic SAV was identified in mapped SAV beds below the bypass reach.

2.2 Terrestrial Plant Species

During the 2014 relicensing studies, biologists identified 25 invasive plants in the Northfield Mountain and Turners Falls study area as shown in Table 2.2-1. Locations of invasive species within the study area observed during 2014 field reconnaissance surveys are shown in the license application. The following five (5) exotic and invasive plant species were found to be common within the study area during the 2014 field surveys:

1. Oriental Bittersweet - found throughout the study area, particularly ubiquitous along the edge of the river where there is abundant sunlight. Highest concentrations were noted in the TFI north of Pauchaug Brook where the TFI transitions to a more dynamic riverine environment. In the upper reaches of the TFI, Oriental bittersweet can be found covering at least 50% of the trees and shrubs along the shoreline.
2. Japanese Knotweed - typically confined to discrete patches along the immediate shoreline and, in some instances, in small stands along the edge habitat of previously disturbed areas.
3. Multiflora Rose - scattered throughout the study area, particularly along edges of field habitat and along shoreline/transition areas abutting agricultural lands.
4. Japanese Barberry - throughout the study area, a common forest understory shrub that forms monoculture thickets. Particularly found in low lying lands and on upland islands within the river.
5. Black Swallowwort – found throughout study area, particularly on the banks of the river and the TFI.

Botanical resources within the Project area may be impacted by vegetation management and maintenance of development lands around the TFI, power canal and the maintenance of development-related access ways. Specifically, there is some potential for ground disturbing activities (i.e., land clearing construction activities) which may result in the spread or propagation of invasive species as well as degradation of existing habitat. In addition, recreational facilities (i.e., boat launches) may allow for the movement or introduction of invasive vegetation (both terrestrial and aquatic). However, such effects would be minimized through vegetation management planning.

Operation and maintenance of the Project may, to a limited degree, have a cumulative effect on the spread of invasive species. Commercial, residential and agricultural development within and adjacent to the Project boundary potentially introduce invasive species to terrestrial habitat within the Project boundary. Other potential vectors for invasive species include recreational activities (e.g. boating) within the TFI that could disturb the shoreline or bring in aquatic invasive plants from other locations.

Table 2.2-1: Invasive Plant Species Identified During 2014 Relicensing Study Surveys

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
autumn olive	*Elaeagnus umbellata*	Shrub	X	X	Grows in full sun, berries spread by birds, aggressive in open areas
black locust	*Robinia pseudoacacia*	Tree		X	Occurs in uplands, grows in full sun to full shade, aggressive in areas with sandy soils
black swallow-wort	*Cynanchum louiseae*	Perennial vine		X	Grows in full sun to partial shade, forms dense stands, deadly to Monarch butterfly larvae
burning bush	*Euonymus alatus*	Shrub	X	X	Capable of germinating in full sun to full shade. Escapes from cultivation and can form dense thickets and dominate the understory
coltsfoot	*Tussilago farfara**	Perennial herb	X		Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands
common buckthorn	*Rhamnus cathartica*	Shrub-tree		X	Occurs in uplands and wetlands, grows in full sun to full shade.
common reed	*Phragmities australis*	Perennial grass	X	X	Grows in uplands and wetlands, full sun to full shade, forms dense stands, flourishes in disturbed areas
creeping jenny	*Lysimachia nummularia*	Perennial herb		X	Occurs in uplands and wetlands, grows in full sun to full shade, forms dense mats
European alder	*Alnus glutinosa***	Shrub	X		Rapidly growing shrub that establishes nonspecific stands displacing natives
garlic mustard	*Alliaria petiolatea*	Biennial Herb		X	Widespread, grows in full sun to full shade, spreads by seed, especially in wooded areas
glossy buckthorn	*Frangula alnus*	Shrub-tree	X		Occurs in uplands and wetlands, grows in full sun to full shade, forms thickets
Japanese barberry	*Berberis thunbergii*	Shrub	X	X	Wooded uplands and wetlands, grows in full sun to full shade, spread by birds, forms dense stands
Japanese honeysuckle	*Lonicera japonica*	Perennial vine	X	X	Widespread, grows full sun to full shade, climbs vegetation, seeds dispersed by birds
Japanese knotweed	*Fallopia japonica*	Perennial Herb-subshrub	X	X	Widespread, grows in full sun to full shade, spreads vegetatively and by seed, forms dense thickets
leafy spurge	*Euphorbia esula*	Perennial herb		X	Aggressive, grows in full sun, occurs in grasslands
lesser celandine	*Ranunculus ficaria*	Perennial herb		X	Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
multiflora rose	*Rosa multiflora*	Shrub	X	X	Widespread, grows in full sun to full shade, forms thorny thickets, dispersed by birds.
Morrow's honeysuckle	*Lonicera morrowii*	Shrub		X	Widespread, grows full sun to full shade, dispersed by birds, can hybridize with other honeysuckle species
Norway maple	*Acer platanoides*	Tree		X	Common in woodlands with colluvial soils, grows full sun to full shade dispersed by water, wind and vehicles
Oriental bittersweet	*Celastrus orbiculatus*	Perennial vine	X	X	Grows in full sun to partial shade, berries spread by birds and humans
purple loosestrife	*Lythrum salicaria*	Perennial herb	X	X	Occurs in uplands and wetlands, grows in full sun to partial shade, high seed production, overtakes wetlands
reed canary grass	*Phalaris arundinacea*	Perennial grass		X	Occurs in uplands and wetlands, grows full sun to partial shade, can form large colonies, common in agricultural settings
spotted knapweed	*Centaurea maculosa**	Perennial herb	X	X	Occurs in full sun, spreads rapidly in artificial corridors, agricultural fields, and margins.
yellow iris	*Iris pseudacorus*	Perennial herb	X		Occurs in wetland habitat, grows in full sun to partial shade, out-competes native plant communities.

NFM=Northfield Mountain, TF=Turners Falls (Includes the shoreline of Turners Falls Impoundment, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland)
** Denotes Likely Invasive according to MIPAG*
*** Not on MIPAG list, but noted for consistency with other studies*

3 PROTECTION MEASURES

The following activities will be performed by the Licensee in order to assist in preventing the establishment, and/or spreading, of terrestrial and aquatic invasive plant species.

3.1 Activities Associated with Daily Operations and Routine Maintenance

1. The Licensee will continue to maintain Project grounds in a manner that helps prevent the introduction and spread of invasive plant species within the Project boundary, as provided below.
2. The Licensee will not actively plant any terrestrial plants listed under the noxious weeds in the United States Department of Agriculture (USDA) Natural Resources Conservation Service Plants Database, which incorporates plants listed by the MIPAG.
3. The Licensee will monitor areas of disturbance caused by routine operation or maintenance activities within the Project area to ensure that invasive plant species do not out-compete desirable vegetation during the reestablishment phase.
4. The Licensee will instruct its work personnel to visually inspect all of Licensee's exposed boating equipment for attached invasive plant species.
5. The Licensee will clean and dry its boats and trailers that come in contact with the water following removal from the water. The Licensee will remove any visible plants or animals before entering the water or leaving the site. Plants and animals are to be discarded in an upland area.
6. At recreation areas such as boat launches, the Licensee will post signage explaining the threats of nonnative aquatic species and steps to prevent the spread will be posted.

3.2 Activities Associated with Construction or Major Maintenance

Prior to major construction or major maintenance activities, the Licensee will consult with the Massachusetts Department of Fish and Wildlife (MADFW) regarding the best management practices (BMP) to be employed to help prevent the introduction and/or spread of invasive plant species within the area associated with the activity to be performed. In addition to activity specific BMPs that may be developed through consultation, the Licensee will employ the following BMPs during construction and major maintenance activities.

1. Clean, drain and dry boats and trailers that come in contact with the water following removal from the water.
2. Remove visible plants or animals before entering the water or leaving the site. Plants and animals are to be discarded in an upland area.

3.2.1 During Construction

1. Workers will be trained to identify invasive plants and informed of the importance of infestation prevention.
2. Obvious vegetative material will be removed from construction equipment before allowing the equipment to enter an invasive-free area.
3. Invasive plants that could potentially be spread by construction equipment or workers will be removed. Along access roads, invasive plants will be identified and controlled to avoid introducing them into invasive-free areas.
4. Where practical, gravel and fill will come from invasive-free sources to avoid introducing invasive vegetation to the construction site.

5. Where practical, certified invasive-free straw, mulch, fiber rolls, and sediment logs will be used for erosion and sediment control.

3.2.2 During Seeding and Planting

1. Where practical, soil amendments (if any) and mulches will be obtained from invasive-free sources.
2. The Licensee will make a reasonable effort to use only native seed mixes for reseeding disturbed areas.
3. Seeding and planting operations and maintenance will be conducted in a manner to promote vigorous growth of desirable vegetation and discourage invasive species.
4. Bare ground will be seeded as quickly as possible following disturbance.
5. Seeded sites will be monitored for infestation by invasive plant species.
6. Identified invasive plant species at monitored sites will be treated in the first full growing season.
7. Where practical, mulch will be used to limit the amount of unwanted seed sources reaching bare soil.
8. The Licensee will ensure that all construction contractors are aware of, and comply with, the terms listed above.

3.2.3 Post Construction

1. The Licensee will monitor any areas of disturbance caused by construction activities on lands owned by the Licensee within the Project boundary as needed to ensure that invasive species have not out-competed desirable vegetation during the reestablishment.

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Appendix B- Terrestrial- Northfield Mountain- Invasive Plant Species Management Plan

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Amended Final Application for New License for Major Water Power Project – Existing Dam

Northfield Mountain Pumped Storage Project (FERC Project Number 2485)

Invasive Plant Species Management Plan

FirstLight

DECEMBER 2020

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1 PURPOSE

The purpose of this Management Plan is to prevent the introduction and/or spread of invasive species within the Northfield Mountain Pumped Storage Project (Project) boundary through the implementation of best management practices and through supporting the education of individuals performing construction, maintenance, and/or operational activities within the Project boundary. This plan does not require the Licensee to police or oversee any activities performed by the public associated with the management of invasive species within the Project boundary.

Invasive plant species are defined by the Massachusetts Invasive Plant Advisory Group (MIPAG) as “non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems.”

In 2013, an Act Protecting Lakes and Ponds from Aquatic Nuisances became effective in Massachusetts, which made the introduction of nonnative aquatic species illegal, and included provisions that boats, trailers and recreational equipment must be examined and cleaned for nonnative aquatic species before and after use.

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2 EXISITING INFORMATION

During relicensing studies conducted in support of obtaining the Project's new FERC license, a series of observations for invasive species were performed in conjunction with other study activities throughout the 2014 field season.

2.1 Aquatic Plant Species

During the summer of 2014, the Turners Falls Impoundment (TFI) was surveyed for submergent aquatic vegetation (SAV). The intent was to describe dominant species as well as estimate the coverage within mapped patches of SAV. In most cases, very dense stands were dominated by exotic species, primarily variable leaf and Eurasian milfoil (*Myriophyllum heterophyllum* and *Myriophyllum spicatum*).

Several exotic and invasive aquatic species are currently found within the study area including variable leaf milfoil, Eurasian milfoil, curly-leaf pondweed (*Potamogeton crispus*), fanwort (*Cabomba caroliniana*), and water chestnut (*Trapa natans*). In total, 41 of the mapped 107 SAV beds had some level of infestation by exotic species, which accounted for 38% of the SAV beds. The majority of the exotic species occur immediately upstream of the Turners Falls Dam with fewer occurrences upstream of the French King Bridge. In general, exotic species upstream of the French King Bridge are not as widespread and occur at lower densities.

2.2 Terrestrial Plant Species

During the 2014 relicensing studies, biologists identified 25 invasive plants in the Northfield Mountain and Turners Falls study area as shown in Table 2.2-1. Locations of invasive species within the study area observed during 2014 field reconnaissance surveys are shown in the license application. The following five (5) exotic and invasive plant species were found to be common within the study area during the 2014 field surveys:

1. Oriental Bittersweet - found throughout the study area, particularly ubiquitous along the edge of the river where there is abundant sunlight. Highest concentrations were noted in the TFI north of Pauchaug Brook where the TFI transitions to a more dynamic riverine environment. In the upper reaches of the TFI, Oriental bittersweet can be found covering at least 50% of the trees and shrubs along the shoreline.
2. Japanese Knotweed - typically confined to discrete patches along the immediate shoreline and, in some instances, in small stands along the edge habitat of previously disturbed areas.
3. Multiflora Rose - scattered throughout the study area, particularly along edges of field habitat and along shoreline/transition areas abutting agricultural lands.
4. Japanese Barberry - throughout the study area, a common forest understory shrub that forms monoculture thickets. Particularly found in low lying lands and on upland islands within the river.
5. Black Swallowwort – found throughout study area, particularly on the banks of the river and the TFI.

Botanical resources within the Project area may be impacted by vegetation management and maintenance of development lands around the TFI, the Northfield Mountain Upper Reservoir, and the maintenance of development-related access ways. Specifically, there is some potential for ground disturbing activities (i.e., land clearing construction activities) which may result in the spread or propagation of invasive species as well as degradation of existing habitat. In addition, recreational facilities (i.e., boat launches) may allow for the movement or introduction of invasive vegetation (both terrestrial and aquatic). However, such effects would be minimized through vegetation management planning.

Operation and maintenance of the Project may, to a limited degree, have a cumulative effect on the spread of invasive species. Commercial, residential and agricultural development within and adjacent to the Project boundary potentially introduce invasive species to terrestrial habitat within the Project boundary. Other potential vectors for invasive species include a transmission line right-of-way maintained by Eversource in the western portion of the Northfield Mountain Project study area, the Northfield Mountain trail system, which includes over 25 miles of trail, and recreational activities (e.g. boating) within the TFI that could disturb the shoreline or bring in aquatic invasive plants from other locations.

Table 2.2-1: Invasive Plant Species Identified During 2014 Relicensing Study Surveys

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
autumn olive	*Elaeagnus umbellata*	Shrub	X	X	Grows in full sun, berries spread by birds, aggressive in open areas
black locust	*Robinia pseudoacacia*	Tree		X	Occurs in uplands, grows in full sun to full shade, aggressive in areas with sandy soils
black swallow-wort	*Cynanchum louiseae*	Perennial vine		X	Grows in full sun to partial shade, forms dense stands, deadly to Monarch butterfly larvae
burning bush	*Euonymus alatus*	Shrub	X	X	Capable of germinating in full sun to full shade. Escapes from cultivation and can form dense thickets and dominate the understory
coltsfoot	*Tussilago farfara**	Perennial herb	X		Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands
common buckthorn	*Rhamnus cathartica*	Shrub-tree		X	Occurs in uplands and wetlands, grows in full sun to full shade.
common reed	*Phragmities australis*	Perennial grass	X	X	Grows in uplands and wetlands, full sun to full shade, forms dense stands, flourishes in disturbed areas
creeping jenny	*Lysimachia nummularia*	Perennial herb		X	Occurs in uplands and wetlands, grows in full sun to full shade, forms dense mats
European alder	*Alnus glutinosa***	Shrub	X		Rapidly growing shrub that establishes nonspecific stands displacing natives
garlic mustard	*Alliaria petiolatea*	Biennial Herb		X	Widespread, grows in full sun to full shade, spreads by seed, especially in wooded areas
glossy buckthorn	*Frangula alnus*	Shrub-tree	X		Occurs in uplands and wetlands, grows in full sun to full shade, forms thickets
Japanese barberry	*Berberis thunbergii*	Shrub	X	X	Wooded uplands and wetlands, grows in full sun to full shade, spread by birds, forms dense stands
Japanese honeysuckle	*Lonicera japonica*	Perennial vine	X	X	Widespread, grows full sun to full shade, climbs vegetation, seeds dispersed by birds
Japanese knotweed	*Fallopia japonica*	Perennial Herb-subshrub	X	X	Widespread, grows in full sun to full shade, spreads vegetatively and by seed, forms dense thickets
leafy spurge	*Euphorbia esula*	Perennial herb		X	Aggressive, grows in full sun, occurs in grasslands

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
lesser celandine	*Ranunculus ficaria*	Perennial herb		X	Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands
multiflora rose	*Rosa multiflora*	Shrub	X	X	Widespread, grows in full sun to full shade, forms thorny thickets, dispersed by birds.
Morrow's honeysuckle	*Lonicera morrowii*	Shrub		X	Widespread, grows full sun to full shade, dispersed by birds, can hybridize with other honeysuckle species
Norway maple	*Acer platanoides*	Tree		X	Common in woodlands with colluvial soils, grows full sun to full shade dispersed by water, wind and vehicles
Oriental bittersweet	*Celastrus orbiculatus*	Perennial vine	X	X	Grows in full sun to partial shade, berries spread by birds and humans
purple loosestrife	*Lythrum salicaria*	Perennial herb	X	X	Occurs in uplands and wetlands, grows in full sun to partial shade, high seed production, overtakes wetlands
reed canary grass	*Phalaris arundinacea*	Perennial grass		X	Occurs in uplands and wetlands, grows full sun to partial shade, can form large colonies, common in agricultural settings
spotted knapweed	*Centaurea maculosa**	Perennial herb	X	X	Occurs in full sun, spreads rapidly in artificial corridors, agricultural fields, and margins.
yellow iris	*Iris pseudacorus*	Perennial herb	X		Occurs in wetland habitat, grows in full sun to partial shade, out-competes native plant communities.

NFM=Northfield Mountain, TF=Turners Falls (Includes the shoreline of Turners Falls Impoundment, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland)
** Denotes Likely Invasive according to MIPAG*
*** Not on MIPAG list, but noted for consistency with other studies*

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3 PROTECTION MEASURES

The following activities will be performed by the Licensee in order to assist in preventing the establishment, and/or spreading, of terrestrial and aquatic invasive plant species.

3.1 Activities Associated with Daily Operations and Routine Maintenance

1. The Licensee will continue to maintain Project grounds in a manner that helps prevent the introduction and spread of invasive plant species within the Project boundary, as provided below.
2. The Licensee will not actively plant any terrestrial plants listed under the noxious weeds in the United States Department of Agriculture (USDA) Natural Resources Conservation Service Plants Database, which incorporates plants listed by the MIPAG.
3. The Licensee will monitor areas of disturbance caused by routine operation or maintenance activities within the Project area to ensure that invasive plant species do not out-compete desirable vegetation during the reestablishment phase.
4. The Licensee will instruct its work personnel to visually inspect all of Licensee's exposed boating equipment for attached invasive plant species.
5. The Licensee will clean and dry its boats and trailers that come in contact with the water following removal from the water. The Licensee will remove any visible plants or animals before entering the water or leaving the site. Plants and animals are to be discarded in an upland area.
6. At recreation areas such as boat launches, the Licensee will post signage explaining the threats of nonnative aquatic species and steps to prevent the spread will be posted.

3.2 Activities Associated with Construction or Major Maintenance

Prior to major construction or major maintenance activities, the Licensee will consult with the Massachusetts Department of Fish and Wildlife (MADFW) regarding the best management practices (BMP) to be employed to help prevent the introduction and/or spread of invasive plant species within the area associated with the activity to be performed. In addition to activity specific BMPs that may be developed through consultation, the Licensee will employ the following BMPs during construction and major maintenance activities.

1. Clean, drain and dry boats and trailers that come in contact with the water following removal from the water.
2. Remove visible plants or animals before entering the water or leaving the site. Plants and animals are to be discarded in an upland area.

3.2.1 During Construction

1. Workers will be trained to identify invasive plants and informed of the importance of infestation prevention.
2. Obvious vegetative material will be removed from construction equipment before allowing the equipment to enter an invasive-free area.
3. Invasive plants that could potentially be spread by construction equipment or workers will be removed. Along access roads, invasive plants will be identified and controlled to avoid introducing them into invasive-free areas.
4. Where practical, gravel and fill will come from invasive-free sources to avoid introducing invasive vegetation to the construction site.

5. Where practical, certified invasive-free straw, mulch, fiber rolls, and sediment logs will be used for erosion and sediment control.

3.2.2 During Seeding and Planting

1. Where practical, soil amendments (if any) and mulches will be obtained from invasive-free sources.
2. The Licensee will make a reasonable effort to use only native seed mixes for reseeding disturbed areas.
3. Seeding and planting operations and maintenance will be conducted in a manner to promote vigorous growth of desirable vegetation and discourage invasive species.
4. Bare ground will be seeded as quickly as possible following disturbance.
5. Seeded sites will be monitored for infestation by invasive plant species.
6. Identified invasive plant species at monitored sites will be treated in the first full growing season.
7. Where practical, mulch will be used to limit the amount of unwanted seed sources reaching bare soil.
8. The Licensee will ensure that all construction contractors are aware of, and comply with, the terms listed above.

3.2.3 Post Construction

1. The Licensee will monitor any areas of disturbance caused by construction activities on lands owned by the Licensee within the Project boundary as needed to ensure that invasive species have not out-competed desirable vegetation during the reestablishment.