Bureau of Reclamation
Klamath Basin Area Office
Klamath Project Revised Water Management Procedure
Variable Base Flow Procedure

Introduction

Reclamation has developed the Variable Base Flow (VBF) procedure for the operations of the Klamath Project (Project) in order to comply with the requirements of the 2010 National Marine Fisheries Service (NMFS) biological opinion (BO), reasonable and prudent alternative (RPA), and Incidental Take Statement and associated Terms and Conditions. The VBF procedure was developed based on these objectives: (1) provide more certainty in obtaining minimum Upper Klamath Lake (UKL) elevations, as outline in Table 2-1 of the 2008 U.S. Fish and Wildlife Service (Service) BO (i.e. targeting UKL elevations for the end of September that will be greater than 4138 feet in most years, etc.); and (2) meet the needs of coho salmon through flows outlined in Table 18 of the 2010 NMFS BO and RPA. The following sections describe the elements of the VBF procedure in more detail.

Variable Base Flow Modeling Procedure: March through September Time Period

For the March through September time period, an initial flow will be determined for each month based on the most current 70% exceedence forecast through September. Table 1 relates forecasts from percent of average to flows in cubic-feet-per-second (cfs). These initial base flows for March through September will range between the 95% and 40% exceedence values from Table 18 in the 2010 NMFS RPA with the exception of June. In June the initial base flow will range between the 95% and 30% exceedence flows from Table 18 in the 2010 NMFS RPA.

Table 1: Forecast and VBF Table to Determine Base Flows in Each Time Step

Current Apr - Sept 70% Exceedence Forecast in March	March I	March II	Current 70% Exceedence Forecast	April I	April II	May I	May II	June I	June II	July I	July II	August	September
(% Average)	(cfs)	(cfs)	(% Average)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
0%	1275	1275	0%	1325	1325	1175	1175	1025	1025	805	805	942	1000
31%	1275	1275	28%	1325	1325	1175	1175	1025	1025	805	805	942	1000
38%	1333	1333	37%	1383	1383	1255	1255	1099	1099	838	838	947	1000
42%	1392	1392	41%	1442	1442	1335	1335	1173	1173	872	872	952	1000
51%	1450	1450	46%	1500	1500	1415	1415	1246	1246	905	905	957	1000
60%	1567	1567	61%	1500	1500	1509	1509	1320	1320	925	925	964	1003
64%	1683	1683	63%	1500	1500	1603	1603	1379	1379	945	945	971	1006
68%	1905	1905	66%	1500	1500	1670	1670	1439	1439	973	973	984	1012
71%	2128	2128	71%	1500	1500	1736	1736	1498	1498	1001	1001	997	1018
79%	2350	2350	76%	1500	1500	1803	1803	1522	1522	1029	1029	1010	1024
86%	2510	2510	79%	1745	1745	1865	1865	1546	1546	1034	1034	1013	1029
87%	2670	2670	86%	1989	1989	1928	1928	1570	1570	1040	1040	1017	1034
92%	2830	2830	92%	2234	2234	1990	1990	1594	1594	1045	1045	1021	1038
96%	2990	2990	93%	2478	2478	2053	2053	1616	1616	1051	1051	1024	1043
101%	3150	3150	103%	2723	2723	2115	2115	1638	1638	1056	1056	1028	1048
108%	3164	3164	106%	2877	2877	2379	2379	1660	1660	1063	1063	1032	1054
113%	3177	3177	124%	3030	3030	2642	2642	1682	1682	1070	1070	1035	1060
117%	3346	3346	130%	3182	3182	2748	2748	1702	1702	1074	1074	1037	1064
128%	3516	3516	139%	3333	3333	2854	2854	1723	1723	1078	1078	1039	1067
140%	3685	3685	150%	3485	3485	2960	2960	1743	1743	1082	1082	1041	1071

As hydrological input into UKL occurs each month, additional releases may be made when UKL elevations are above identified Threshold Elevations. The Threshold Elevations for UKL were developed through an iterative process in order to approximate the 2010 NMFS RPA Table 18 flows, while maintaining the 2008 Service BO minimums for UKL more often. The threshold elevations are shown below in Table 2. Above these elevations, flows will be released to mimic the natural inflow pattern into UKL.

Table 2: Threshold Elevations for UKL

Time Period	Threshold Elevations for UKL (in feet)
October	4141.7
November	4141.7
December	4142.0
January	4142.3
February	4142.6
March I	4142.6
March II	4142.9
April I	4143.0
April II	4142.9
May I	4142.6
May II	4142.4
June I	4142.5
June II	4142.5
July I	4141.8
July II	4141.8
August I	4141.0
August II	
September	4141.0

In periods when Threshold Releases are being made during March, April and May, a maximum flow release will be determined. Threshold Releases will not be increased above the maximum unless required for flood control. Therefore, the elevation of UKL will increase above the threshold elevations shown above if the flows at IGD are at the maximum flow. Maximum flows will be determined based on the current percent of average forecast shown in Table 3.

For example, if the May-September 70% exceedance inflow forecast is 124% of average, the maximum flow for May would be 3,480 cfs. If flows in May began to exceed this number while the lake was below the flood control limit of 4143.1 ft, then flows would be limited to 3,480 cfs in order fill UKL. Once flows dropped below the maximum flow, the operations would return to normal as described above. If the forecast falls between two forecasts on Table 3, the maximum

value will be interpolated. For example, if the March forecast was 115% of average, then the maximum would be 4,075 cfs.

Table 3: Forecast and Maximum Flows for March through May

	March	April	May
Current 70% Exceedence Forecast	Max Flow (cfs)	Max Flow (cfs)	Max Flow (cfs)
≥103%	3940	3930	3225
106%	3990	4065	3390
124%	4160	4230	3480
130%	4285	4425	3615
139%	4355	4585	3710
150+%	4460	4790	3845

The June 5% - 25% exceedance flows from Table 18 in the NMFS RPA increase rapidly from the 30% exceedance. Due to the unnatural curve of this increase and the significance of determining when flows above the 30% exceedance should occur, the timing of these higher flows will be determined through further discussions with representatives from Reclamation, the Service, NMFS and other key stakeholders. This team will determine when flows at or above the 25% exceedance would be warranted.

Variable Base Flow Modeling Procedure: October through February Time Period
For the October through February time period, the base flows will be equal to the 95% exceedence flows from Table 18 of the NMFS RPA. This time period includes the use of the 18.6 TAF of available water as required in RPA A.1of the 2010 NMFS BO/Incidental Take Statement for flow variability. The recommended use of this volume will be determined by the flow variability technical team.

Irrigation Demand

Annual irrigation demand and its monthly distribution are based on amount of precipitation experienced in specified months prior to the irrigation season (as shown in Table 4). These precipitation/annual demand relationships are shown below in Table 4. However, irrigation deliveries are determined by the actual available water, and can be lower than the demand.

When determining the amount of water that is expected to be available for the irrigation season, the planning model considers the water necessary to meet the 95% exceedence flows from Table 18 in NMFS' RPA and the end-of-September storage corresponding to the minimum Upper Klamath Lake elevation from the 2008 Service BO.

If the amount of water available to irrigation is less than the expected full irrigation demand, then the deliveries are reduced through the application of a "delivery factor" – a value between 0.0 and 1.0. A target delivery is calculated as the product of the delivery factor and the demand, allowing the target delivery to match the expected available water. The delivery factor calculation is updated each month. For example, in April, the delivery factor is calculated based on the April through September forecast, the 95% exceedence flows for April through September, and the minimum UKL elevation for September. In June, the calculation would change to be based on the expected June through September inflow forecast, the 95% exceedence flows for June through September, and the minimum UKL elevation for September.

If the timing of any time-step's water supply cannot meet the target delivery that is calculated from the seasonal delivery factor and the demand, a shortage to the demand will result. For example, if the inflow forecast was high, but April began with a UKL elevation at or below the BO minimum, the model could calculate a delivery factor of 1.0, or 100%, for April through September but would create a project shortage in April until the UKL elevation was above the minimum elevation.

Table 4: Agriculture and Refuge Demands

Feb-Mar Precipitation (inches)	Apr-Mar Area A1 Demand (TAF)	Apr-Mar Refuge Demand (TAF)	Oct-Jan Precipitation (inches)	Apr-Mar Area A2 Demand (TAF)
0.00 - 1.999	340	30	0.00 - 3.99	105
2.00 - 2.749	310	25	4.00 - 6.99	95
2.75 - 3.299	300	20	7.00 - 9.99	90
> = 3.3	275	15	> = 10.0	80

Conclusion

The VBF procedure attempts to meet the 2010 NMFS RPA exceedence Table 18 values by first calculating a base flow for each month, then releasing additional river flows (up to the maximum flow) based on meeting and/or exceeding UKL Threshold Elevations. The expected available water for irrigation for each month is based on expected inflows, Iron Gate Dam flows, and minimum UKL elevations. The VBF procedure also incorporates operational controls to address flood control realities on UKL. Lastly, any differences, by exceedence, between Table 18 and the modeled flows under the VBF procedure may be further reduced or eliminated through real-time operations that cannot be analyzed in a long-term planning model. Detailed modeling results are included in Appendix A. All modeling used to create these results was completed using the Water Resources Integrated Modeling System (WRIMS) modeling software. This model used the same inflow and project demand assumptions as previous WRIMS models for the Klamath Basin.

Appendix B contains a *"Clarification of Uncommon Terms Used"* in this document.

Appendix A

Iron Gate Flow in Cubic-Feet-Per-Second (cfs)

VBF

61-09 Exceedence

	Oct	Nov	Dec	Jan	Feb	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug	Sep
95%	1000	1300	1410	1280	1300	1338	1296	1325	1325	1175	1187	1077	1077	829	830	945	1000
90%	1000	1300	1410	1280	1300	1386	1366	1325	1343	1264	1264	1121	1121	848	849	948	1000
85%	1000	1300	1410	1280	1300	1665	1452	1403	1443	1374	1336	1178	1178	874	874	952	1000
80%	1000	1300	1410	1280	1300	2172	2035	1467	1500	1506	1507	1247	1247	906	906	957	1000
75%	1000	1300	1410	1280	1300	2321	2199	1500	1500	1630	1652	1322	1322	927	925	965	1003
70%	1000	1300	1410	1280	1300	2839	2327	1500	1734	1711	1823	1378	1378	946	944	971	1007
65%	1000	1300	1410	1280	1679	2986	2480	1705	2073	2144	1930	1442	1442	975	974	985	1012
60%	1000	1300	1410	1285	2029	3061	2562	1829	2454	2266	1991	1515	1515	1020	1019	1006	1022
55%	1000	1300	1410	1505	2501	3217	2773	2353	2640	2309	2100	1533	1533	1032	1032	1012	1026
50%	1000	1300	1410	1804	2658	3469	2957	2695	3150	2636	2379	1548	1548	1034	1036	1014	1029
45%	1000	1300	1410	2129	2792	3575	3074	2991	3496	2982	2522	1579	1572	1041	1042	1017	1034
40%	1000	1300	1410	2364	3296	3637	3157	3335	3764	3225	2901	1608	1593	1044	1045	1020	1039
35%	1000	1300	1902	2801	3567	3896	3555	3550	3930	3225	3225	1660	1621	1054	1052	1026	1045
30%	1000	1300	2196	3008	3802	3940	3850	3899	4219	3225	3225	1692	1651	1066	1058	1029	1051
25%	1000	1300	2605	3056	3936	3977	4926	4289	4761	3349	3349	1726	1672	1077	1063	1031	1057
20%	1000	1358	2922	3235	4290	4160	5658	4636	5259	3495	3494	2524	1690	1086	1070	1035	1061
15%	1000	1593	3032	3643	4886	4401	5921	5385	5385	3753	3754	2751	1714	1428	1073	1036	1065
10%	1000	1900	3069	4822	5646	5034	6595	5850	5943	3913	3913	3512	1735	1932	1077	1038	1067
5%	1000	2920	3917	6379	7364	5750	7311	6399	6599	4261	4261	3778	1917	2167	1082	1041	1071

Upper Klamath Lake (UKL) Elevations in Feet (ft)

VBF

61-09 Exceedence

	Oct	Nov	Dec	Jan	Feb	Mar 1-15	Mar 16-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-15	Jul 16-31	Aug	Sep
95%	4137.95	4138.32	4138.73	4139.57	4140.06	4140.66	4141.34	4141.40	4141.46	4141.60	4141.64	4141.06	4140.53	4140.10	4139.41	4138.42	4137.93
90%	4138.16	4138.45	4139.17	4140.11	4141.08	4141.33	4141.78	4142.17	4142.28	4141.99	4141.80	4141.27	4140.67	4140.10	4139.50	4138.49	4137.94
85%	4138.30	4139.02	4139.56	4140.47	4141.22	4141.78	4142.20	4142.34	4142.44	4142.20	4141.98	4141.47	4140.83	4140.22	4139.56	4138.55	4138.05
80%	4138.40	4139.38	4140.10	4140.77	4141.49	4142.12	4142.42	4142.53	4142.54	4142.32	4142.20	4141.65	4141.15	4140.50	4139.76	4138.66	4138.24
75%	4138.63	4139.43	4140.43	4141.20	4141.93	4142.53	4142.64	4142.66	4142.60	4142.57	4142.27	4141.73	4141.17	4140.57	4139.83	4138.78	4138.30
70%	4138.82	4139.63	4140.60	4141.65	4142.39	4142.60	4142.78	4142.86	4142.81	4142.60	4142.28	4141.80	4141.28	4140.67	4140.03	4138.93	4138.38
65%	4138.89	4139.73	4140.72	4141.78	4142.60	4142.60	4142.85	4142.87	4142.84	4142.60	4142.37	4141.83	4141.38	4140.79	4140.13	4139.04	4138.66
60%	4139.33	4139.83	4141.07	4142.04	4142.60	4142.60	4142.88	4142.92	4142.90	4142.60	4142.40	4141.91	4141.40	4140.86	4140.26	4139.10	4138.76
55%	4139.65	4140.07	4141.27	4142.30	4142.60	4142.60	4142.90	4142.98	4142.90	4142.60	4142.40	4141.92	4141.44	4140.90	4140.28	4139.24	4139.15
50%	4139.67	4140.24	4141.57	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.60	4142.40	4141.94	4141.47	4140.98	4140.41	4139.52	4139.26
45%	4139.84	4140.59	4141.58	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.60	4142.40	4141.98	4141.55	4141.05	4140.44	4139.60	4139.39
40%	4139.92	4140.71	4141.72	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.64	4142.40	4142.03	4141.65	4141.11	4140.46	4139.61	4139.53
35%	4140.01	4140.81	4142.00	4142.30	4142.60	4142.60	4142.90	4143.00	4142.99	4142.68	4142.46	4142.13	4141.77	4141.19	4140.64	4139.95	4139.57
30%	4140.19	4141.04	4142.00	4142.30	4142.60	4142.67	4142.92	4143.00	4143.10	4142.84	4142.66	4142.31	4141.97	4141.44	4140.86	4140.18	4139.61
25%	4140.41	4141.26	4142.00	4142.30	4142.60	4142.77	4143.06	4143.10	4143.10	4142.90	4142.71	4142.46	4142.20	4141.70	4141.17	4140.23	4139.87
20%	4140.77	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.00	4142.91	4142.50	4142.23	4141.80	4141.19	4140.32	4140.14
15%	4141.00	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.39	4141.80	4141.34	4140.59	4140.38
10%	4141.24	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.48	4141.80	4141.42	4140.75	4140.68
5%	4141.65	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.50	4141.80	4141.46	4140.87	4140.88

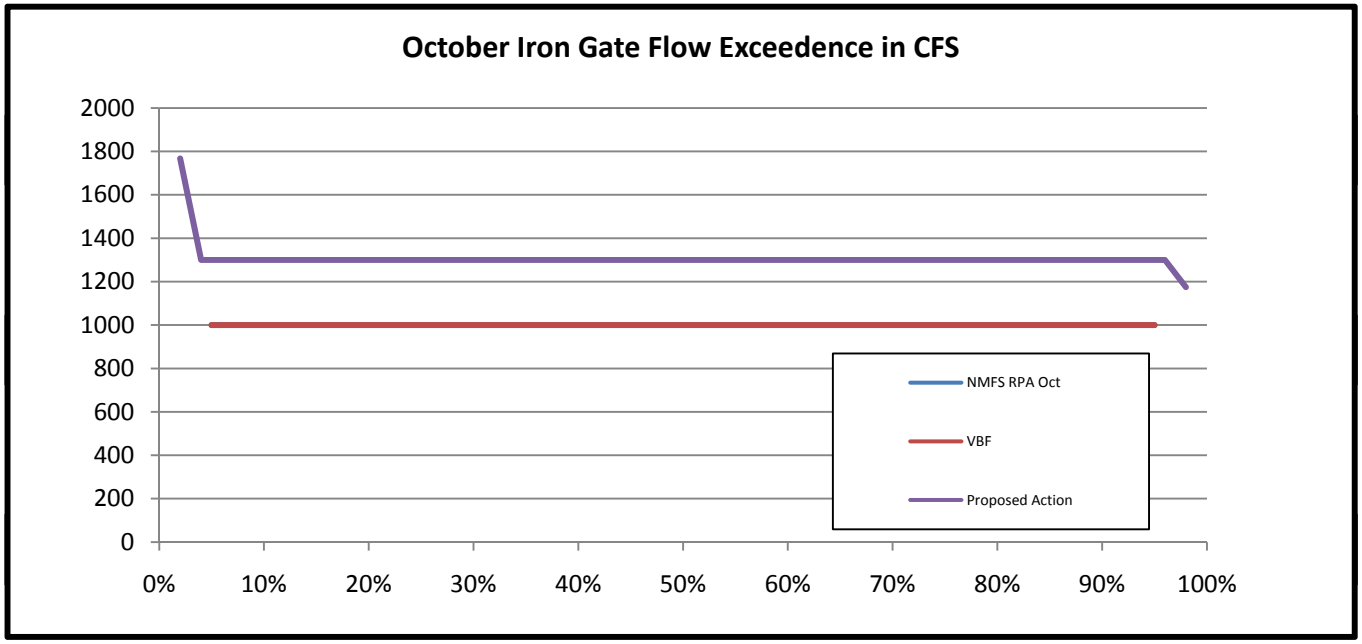
VBF

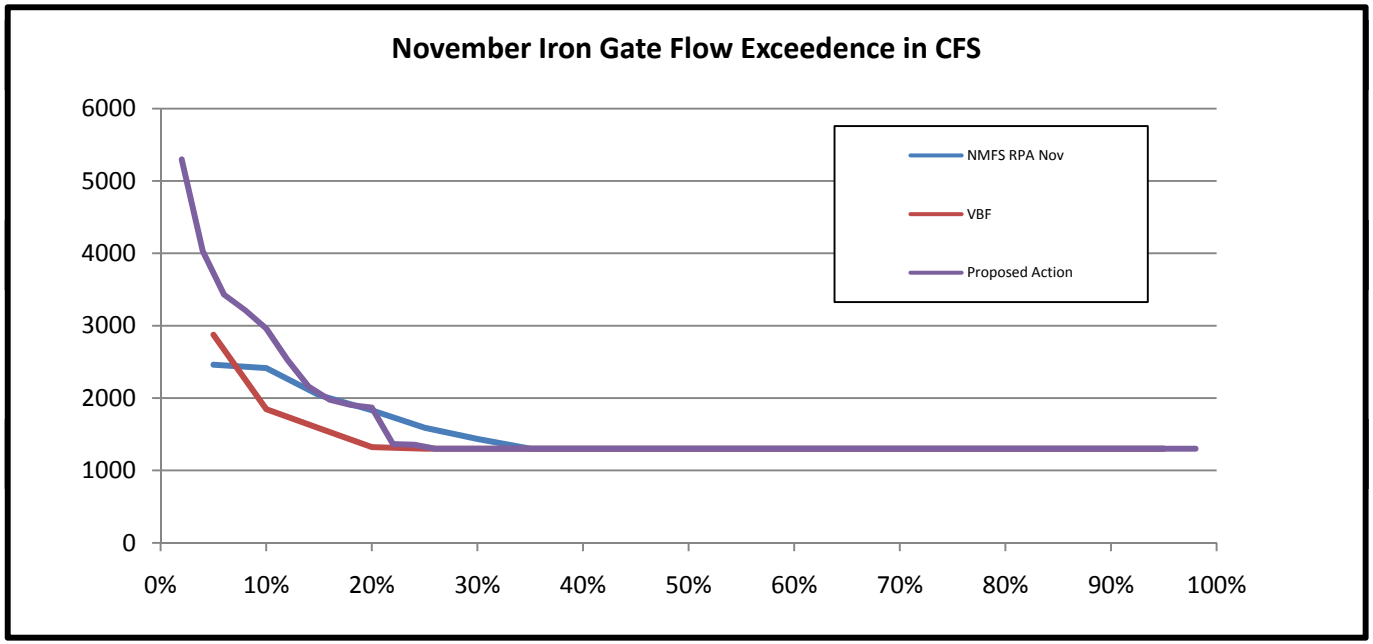
	Iron Gate Flow (cfs) by each Time Step																
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar I**	**Mar II**	**Apr I**	**Apr II**	**May I**	**May II**	**Jun I**	**Jun II**	**Jul I**	**Jul II**	**Aug**	**Sep**
1961	1000	1300	1416	1614	3001	3220	2343	1773	2398	2266	1915	1518	1518	1024	1023	1008	1022
1962	1000	1300	1410	1280	2465	3215	2510	2741	3550	2441	2089	1515	1515	1020	1019	1006	1022
1963	1177	1300	3083	1793	3930	2913	2035	3139	3764	3225	3225	1378	1378	946	944	971	1007
1964	1000	1300	1410	1453	2029	3150	3150	2878	2878	2378	2379	1660	1660	1064	1063	1031	1054
1965	1000	1300	7059	8198	7350	4355	4356	3335	3335	3054	3010	1724	1724	1077	1079	1040	1067
1966	1000	1585	2334	2151	1918	3497	2905	2342	3270	1959	1959	1581	1581	1042	1043	1018	1036
1967	1000	1300	1410	1469	2807	3596	3357	3029	3029	3390	3390	2524	1684	1086	1070	1035	1060
1968	1000	1300	1410	1280	2611	2958	2081	1500	1500	1602	1604	1378	1378	946	944	971	1007
1969	1000	1300	1410	1285	1665	3757	3673	4484	5330	3710	3711	1726	1726	1078	1080	1040	1067
1970	1000	1300	1410	6441	4736	3940	3941	1779	1779	2205	2062	1549	1549	1034	1036	1014	1029
1971	1000	1300	1996	4445	3559	4300	5861	6641	6641	5197	5197	3848	1975	2292	1072	1036	1063
1972	1000	2996	2855	3038	5505	9350	10911	4327	4327	3390	3390	1676	1676	1068	1068	1034	1058
1973	1000	1576	3055	3001	2640	3061	2183	1500	1500	1685	1685	1453	1453	979	979	987	1013
1974	1000	1300	2652	6193	3680	4541	6102	6958	6958	3495	3494	2688	1690	1260	1071	1035	1061
1975	1000	1358	2465	2593	3471	4126	5687	4636	4636	4263	4263	3569	1711	2165	1075	1037	1065
1976	1000	2694	3029	2748	2746	3511	2730	2232	2484	2284	1991	1593	1593	1044	1045	1020	1039
1977	1000	1300	1410	1280	1300	1731	1283	1361	1361	1225	1224	1071	1071	826	827	945	1000
1978	1000	1300	1410	3569	3296	3940	3760	3646	3930	3225	2760	1540	1540	1033	1033	1013	1027
1979	1000	1300	1410	1280	1300	2259	2311	1500	1689	2286	1935	1251	1251	907	907	957	1000
1980	1000	1300	1410	2242	3924	3603	2725	1829	2454	2262	1911	1331	1331	930	928	966	1004
1981	1000	1300	1410	1280	1300	1357	1359	1451	1451	1348	1348	1184	1184	877	876	952	1000
1982	1000	1300	2922	3015	7959	4789	6350	6048	6048	3615	3616	1708	1708	1612	1074	1037	1064
1983	1000	1812	3371	2959	5788	6504	8065	5839	5839	4254	4254	4142	2269	2571	1082	1250	1071
1984	1000	3612	6166	3867	4290	5279	6840	5490	5490	3905	3904	3463	1643	1832	1059	1029	1288
1985	1844	4675	2924	2061	2383	3886	3008	4178	4803	3013	2379	1660	1660	1064	1063	1031	1054
1986	1000	1300	1410	2364	7369	5851	7412	3688	3688	2887	2535	1575	1575	1041	1042	1017	1035
1987	1000	1300	1410	1816	2677	3440	2562	1500	2016	1506	1507	1319	1319	926	924	965	1003
1988	1000	1300	1410	1280	1683	2766	1889	1417	1417	1303	1301	1142	1142	858	858	950	1000
1989	1000	1300	1410	1280	1300	2995	5658	5350	5350	3225	3225	1617	1617	1051	1051	1025	1044
1990	1000	1300	1410	1280	1300	2172	2388	1467	2092	1626	1275	1095	1095	837	838	947	1000
1991	1000	1300	1410	1280	1300	1275	1275	1325	1325	1383	1383	1218	1218	893	892	955	1000
1992	1000	1300	1410	1280	1300	1275	1275	1325	1325	1175	1175	1025	1025	805	805	942	1000
1993	1000	1300	1410	1280	1300	3011	3011	2650	5259	3225	3225	2741	1631	1367	1055	1027	1047
1994	1000	1300	1410	1280	1300	1468	1469	1325	1325	1175	1175	1159	1159	866	865	951	1000
1995	1000	1300	1410	1280	1300	1907	2900	3429	3930	3225	3225	1546	1546	1034	1035	1014	1029
1996	1000	1300	1410	3468	9330	3940	5497	4111	4111	3225	3225	2355	1566	1039	1040	1016	1033
1997	1000	1300	4099	9431	5336	3637	3157	2386	2561	2831	2480	1608	1608	1048	1049	1023	1042
1998	1000	1300	1410	3062	4061	3990	5116	5039	5039	5428	5428	4466	2593	2168	1057	1028	1049
1999	1000	1988	3043	3235	3938	5446	7007	6516	6516	3922	3922	3561	1744	2032	1082	1059	1071
2000	1000	1619	2058	3166	3591	3925	3094	3518	3930	3225	2901	1531	1531	1031	1031	1011	1025
2001	1000	1300	1410	1280	1300	1332	1335	1325	1325	1175	1175	1025	1025	805	805	942	1000
2002	1000	1300	1410	1280	1300	2247	2247	1325	1500	1639	1641	1412	1412	961	960	979	1009
2003	1000	1300	1410	1280	1300	1400	1399	1500	1500	1414	2133	1247	1247	906	906	957	1000
2004	1000	1300	1410	1280	1300	2508	2510	1500	1500	1736	1736	1499	1499	1000	1000	997	1018
2005	1000	1300	1410	1280	1300	1373	1374	1325	1325	1175	1254	1099	1099	839	840	947	1000
2006	1000	1300	1871	5199	4518	4160	3515	5861	6627	3884	3884	2781	1744	1081	1082	1041	1070
2007	1000	1300	1410	1280	2119	3940	3722	2265	2890	2067	1715	1418	1418	964	963	980	1010
2008	1000	1300	1410	1280	1300	2709	2709	2442	2442	2223	2752	1613	1613	1049	1050	1024	1043
2009	1000	1300	1410	1280	1300	1616	1617	1500	1500	1729	1728	1492	1492	997	997	996	1018

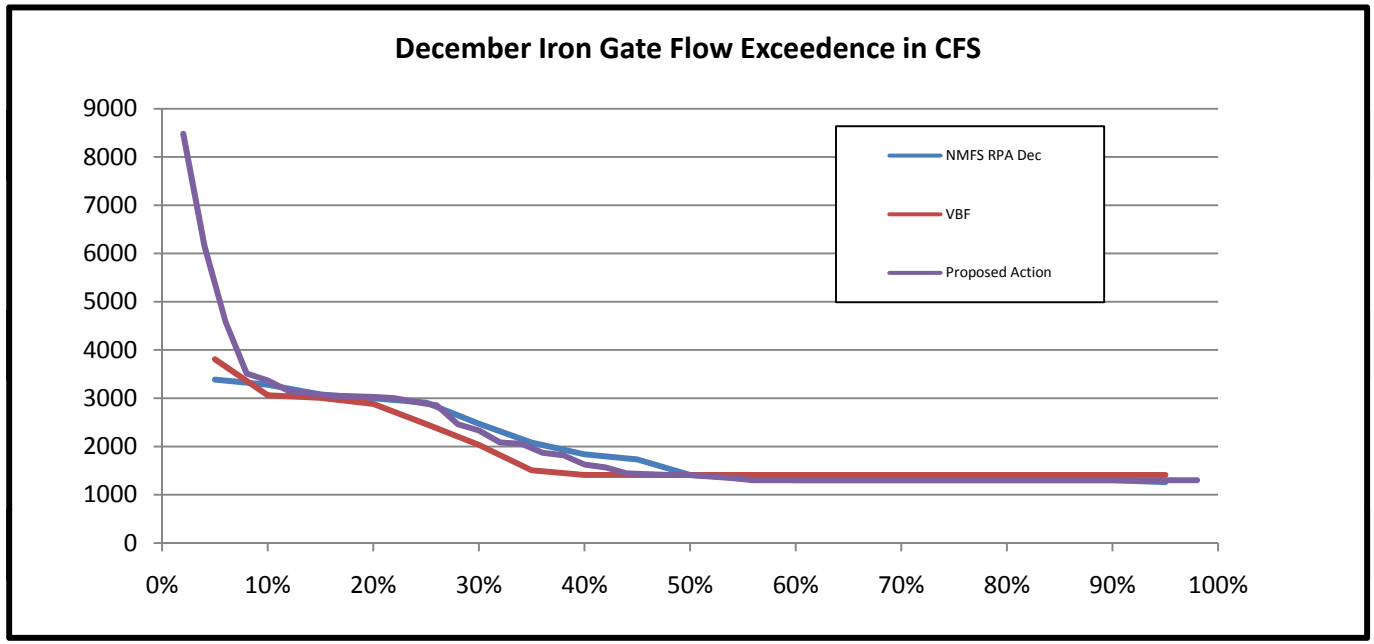
VBF

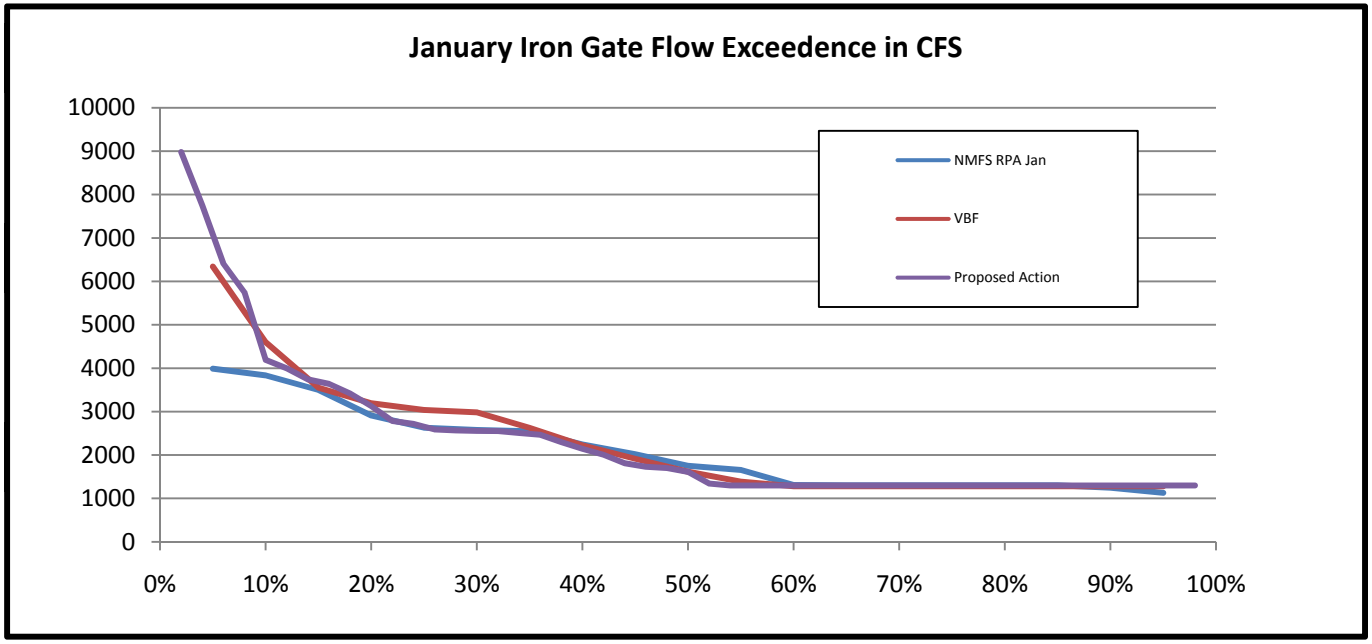
Upper Klamath Lake Elevations by each Time Step

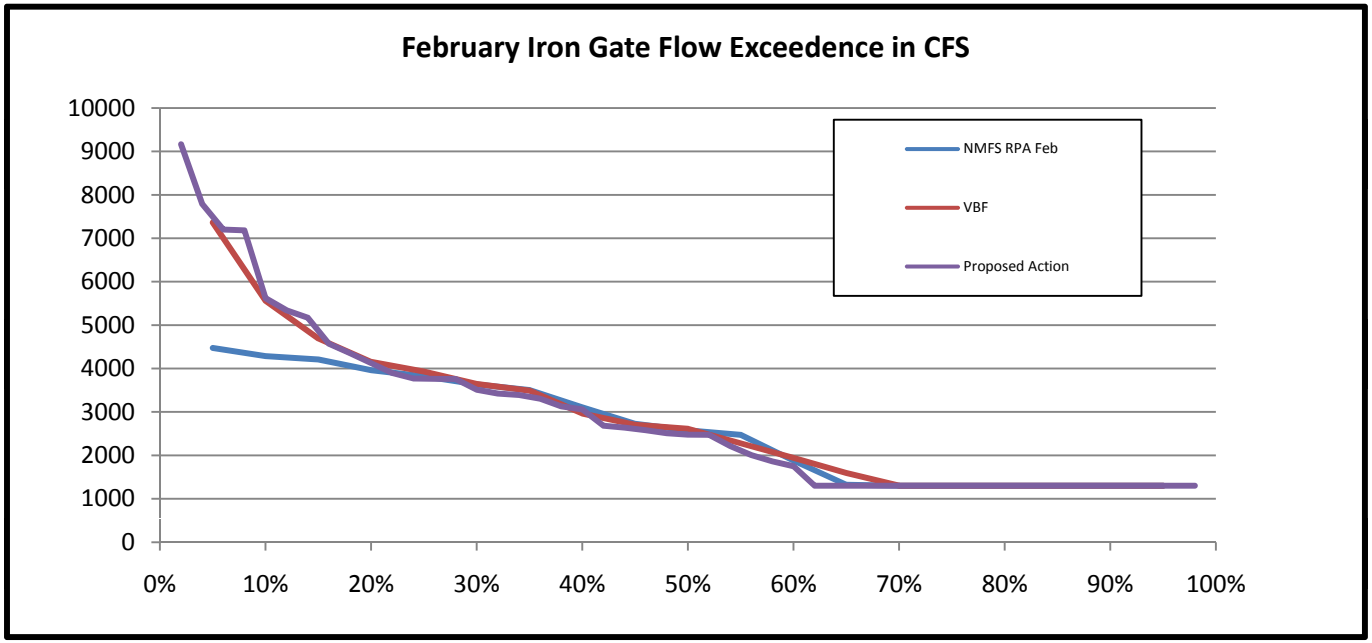
	Oct	Nov	Dec	Jan	Feb	Mar I	Mar II	Apr I	Apr II	May I	May II	Jun I	Jun II	Jul I	Jul II	Aug	Sep
1961	4139.98	4140.92	4142.00	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.60	4142.40	4142.10	4141.79	4141.24	4140.62	4139.89	4139.58
1962	4140.12	4140.79	4141.58	4142.04	4142.60	4142.60	4142.84	4143.00	4142.90	4142.60	4142.40	4141.81	4141.20	4140.52	4139.76	4138.94	4138.42
1963	4140.25	4141.41	4142.00	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.66	4142.41	4141.95	4141.48	4140.99	4140.43	4139.44	4139.14
1964	4139.67	4140.65	4141.32	4142.30	4142.60	4142.51	4142.42	4142.50	4142.59	4142.22	4141.82	4141.50	4141.17	4140.64	4140.07	4139.17	4138.70
1965	4138.91	4139.77	4142.00	4142.30	4142.60	4142.76	4142.93	4142.87	4142.80	4142.60	4142.40	4141.99	4141.57	4141.17	4140.72	4140.28	4140.14
1966	4140.78	4141.70	4142.00	4142.30	4142.60	4142.60	4142.80	4143.00	4142.90	4142.60	4142.28	4141.72	4141.15	4140.59	4139.98	4138.91	4138.67
1967	4138.83	4139.63	4141.07	4142.30	4142.60	4142.60	4142.68	4142.62	4142.57	4142.73	4142.91	4142.50	4142.36	4141.80	4141.19	4140.10	4139.55
1968	4140.01	4140.39	4141.00	4141.80	4142.60	4142.60	4142.90	4142.65	4142.41	4142.06	4141.69	4141.05	4140.50	4140.10	4139.40	4138.66	4138.30
1969	4138.60	4139.38	4140.10	4141.68	4142.60	4142.60	4142.63	4143.00	4143.10	4142.86	4142.61	4142.26	4141.91	4141.33	4140.69	4139.60	4139.14
1970	4139.67	4140.22	4141.72	4142.30	4142.60	4142.77	4142.95	4142.89	4142.83	4142.60	4142.40	4141.92	4141.43	4140.88	4140.26	4138.98	4138.63
1971	4139.13	4140.79	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.50	4141.80	4141.47	4140.72	4140.89
1972	4141.64	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4142.90	4142.69	4142.36	4142.03	4141.54	4141.01	4140.40	4140.32
1973	4140.96	4141.70	4142.00	4142.30	4142.60	4142.60	4142.90	4142.86	4142.83	4142.56	4142.27	4141.58	4140.86	4140.24	4139.57	4138.43	4138.08
1974	4138.73	4140.71	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.22	4141.80	4141.41	4140.77	4140.57
1975	4141.12	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.50	4141.80	4141.43	4140.87	4140.85
1976	4141.65	4141.70	4142.00	4142.30	4142.60	4142.60	4142.87	4142.92	4142.90	4142.60	4142.38	4141.88	4141.37	4140.83	4140.22	4140.23	4140.13
1977	4140.62	4141.28	4141.61	4141.97	4142.47	4142.60	4142.89	4142.67	4142.44	4142.32	4142.20	4141.72	4141.24	4140.56	4139.81	4138.58	4138.24
1978	4138.48	4139.30	4141.56	4142.30	4142.60	4142.72	4142.90	4143.00	4143.01	4142.64	4142.40	4141.94	4141.47	4140.98	4140.44	4139.49	4139.56
1979	4139.78	4140.00	4140.54	4141.50	4142.30	4142.60	4142.90	4142.93	4142.90	4142.60	4142.40	4141.78	4141.15	4140.50	4139.76	4138.76	4138.31
1980	4138.81	4139.69	4140.58	4142.30	4142.60	4142.60	4142.90	4143.00	4142.90	4142.60	4142.40	4141.93	4141.46	4140.90	4140.27	4139.10	4138.76
1981	4138.86	4139.38	4140.15	4140.77	4141.83	4142.12	4142.43	4142.53	4142.63	4142.45	4142.26	4141.65	4141.03	4140.40	4139.73	4138.57	4137.95
1982	4138.31	4139.75	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4142.88	4142.65	4142.46	4142.27	4141.80	4141.48	4140.67	4140.56
1983	4141.16	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.50	4141.80	4141.56	4141.00	4140.99
1984	4141.66	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.48	4141.80	4141.33	4140.84	4141.00
1985	4141.70	4141.70	4142.00	4142.30	4142.60	4142.60	4142.90	4143.10	4143.10	4142.60	4142.28	4141.84	4141.40	4140.78	4140.09	4139.06	4139.34
1986	4140.01	4140.86	4141.57	4142.30	4142.60	4143.10	4143.10	4143.00	4142.90	4142.60	4142.40	4142.02	4141.63	4141.11	4140.54	4139.61	4139.77
1987	4140.44	4141.17	4141.76	4142.30	4142.60	4142.60	4142.90	4142.98	4142.90	4142.60	4142.27	4141.81	4141.33	4140.89	4140.41	4139.60	4139.22
1988	4139.36	4139.63	4140.75	4141.71	4142.60	4142.60	4142.90	4142.87	4142.84	4142.59	4142.33	4142.04	4141.76	4141.07	4140.28	4139.06	4138.34
1989	4138.40	4139.38	4139.87	4140.57	4141.26	4142.60	4143.10	4143.10	4143.10	4142.91	4142.72	4142.24	4141.75	4141.14	4140.45	4139.55	4139.41
1990	4139.85	4140.26	4140.63	4141.61	4142.25	4142.60	4142.90	4143.00	4142.90	4142.60	4142.40	4142.03	4141.65	4141.07	4140.41	4139.58	4139.17
1991	4139.33	4139.59	4139.64	4140.18	4140.62	4141.05	4141.49	4141.66	4141.83	4141.90	4141.79	4141.25	4140.71	4140.14	4139.54	4138.47	4137.94
1992	4137.93	4138.35	4138.62	4138.84	4139.13	4139.27	4139.41	4139.45	4139.48	4139.28	4139.06	4138.72	4138.36	4138.23	4138.09	4137.41	4137.04
1993	4137.12	4137.44	4137.83	4138.45	4139.01	4140.53	4142.01	4142.97	4143.10	4143.00	4142.90	4142.50	4142.46	4141.80	4141.19	4140.22	4139.58
1994	4139.92	4140.03	4140.40	4140.85	4141.12	4141.20	4141.29	4141.31	4141.34	4141.35	4141.35	4141.05	4140.54	4140.10	4139.46	4138.50	4137.92
1995	4137.82	4138.13	4138.30	4139.72	4141.08	4142.14	4142.90	4143.00	4142.94	4142.82	4142.68	4142.46	4142.23	4141.79	4141.30	4140.18	4139.53
1996	4139.64	4139.83	4141.58	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.16	4141.69	4141.18	4140.32	4139.91
1997	4140.33	4141.19	4142.00	4142.30	4142.60	4142.60	4142.76	4142.86	4142.90	4142.60	4142.40	4141.94	4141.47	4140.99	4140.46	4139.63	4139.41
1998	4139.88	4140.68	4141.23	4142.30	4142.60	4143.03	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.50	4141.80	4141.43	4140.57	4140.20
1999	4140.77	4141.70	4142.00	4142.30	4142.60	4143.10	4143.10	4143.10	4143.10	4143.10	4143.10	4142.50	4142.48	4141.80	4141.39	4141.00	4140.78
2000	4141.33	4141.70	4142.00	4142.30	4142.60	4142.60	4142.88	4143.00	4142.98	4142.65	4142.40	4141.91	4141.40	4140.86	4140.27	4139.13	4139.29
2001	4139.67	4140.18	4140.63	4141.10	4141.57	4141.91	4142.27	4142.21	4142.20	4141.92	4141.62	4141.08	4140.53	4140.10	4139.55	4138.52	4137.96
2002	4138.00	4138.50	4139.31	4140.49	4141.30	4141.48	4141.67	4142.12	4142.36	4142.19	4142.00	4141.39	4140.74	4140.10	4139.41	4138.42	4137.94
2003	4138.16	4138.40	4139.05	4140.39	4141.07	4141.47	4141.88	4142.21	4142.54	4142.59	4142.40	4141.91	4141.41	4140.69	4139.89	4138.76	4138.26
2004	4138.36	4138.56	4139.23	4140.04	4141.49	4141.88	4142.29	4142.38	4142.48	4142.21	4141.92	4141.28	4140.64	4140.10	4139.40	4138.38	4137.92
2005	4138.16	4138.31	4139.12	4139.52	4139.87	4140.05	4140.25	4140.42	4140.58	4141.51	4142.11	4141.75	4141.38	4140.79	4140.14	4138.82	4138.13
2006	4138.26	4139.17	4141.26	4142.30	4142.60	4142.62	4142.86	4143.10	4143.10	4143.10	4143.10	4142.50	4142.23	4141.71	4141.12	4140.18	4139.63
2007	4,139.97	4,140.64	4,141.66	4,142.10	4,142.60	4,142.71	4,142.90	4,143.00	4,142.90	4,142.60	4,142.40	4,141.87	4,141.32	4,140.77	4,140.17	4,139.07	4,138.51
2008	4,139.25	4,139.59	4,140.01	4,140.72	4,141.45	4,141.87	4,142.32	4,142.47	4,142.62	4,142.60	4,142.40	4,142.15	4,141.90	4,141.31	4,140.65	4,139.62	4,138.93
2009	4,139.08	4,139.64	4,140.05	4,140.73	4,141.26	4,141.78	4,142.31	4,142.36	4,142.42	4,142.36	4,142.30	4,141.93	4,141.55	4,140.84	4,140.06	4,138.91	4,138.15

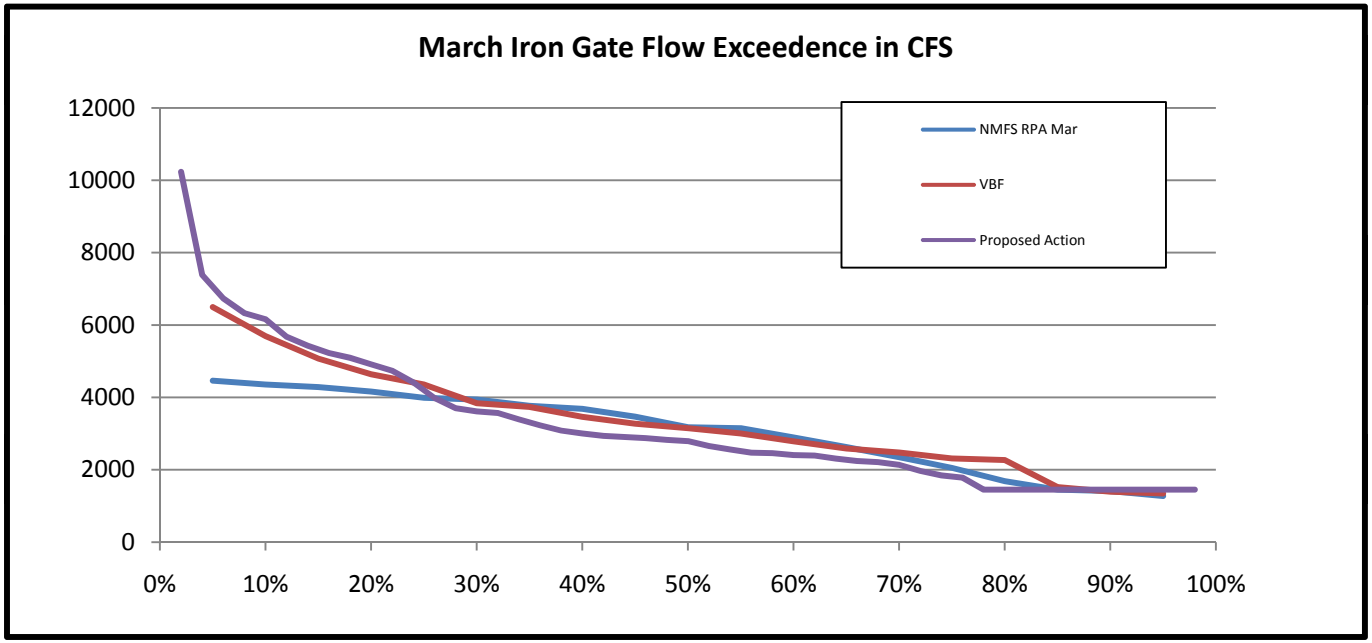

October Iron Gate Flow Exceedence in CFS
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Oct
VBF
Proposed Action

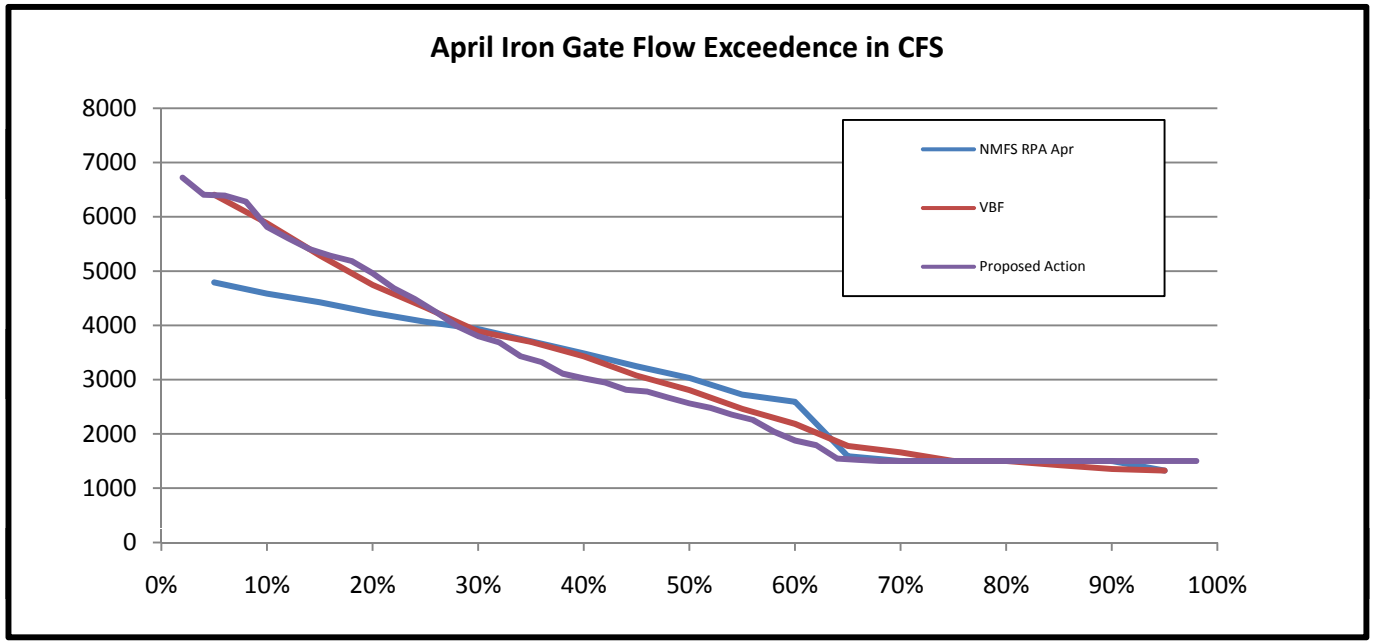

November Iron Gate Flow Exceedence in CFS
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Nov
VBF
Proposed Action

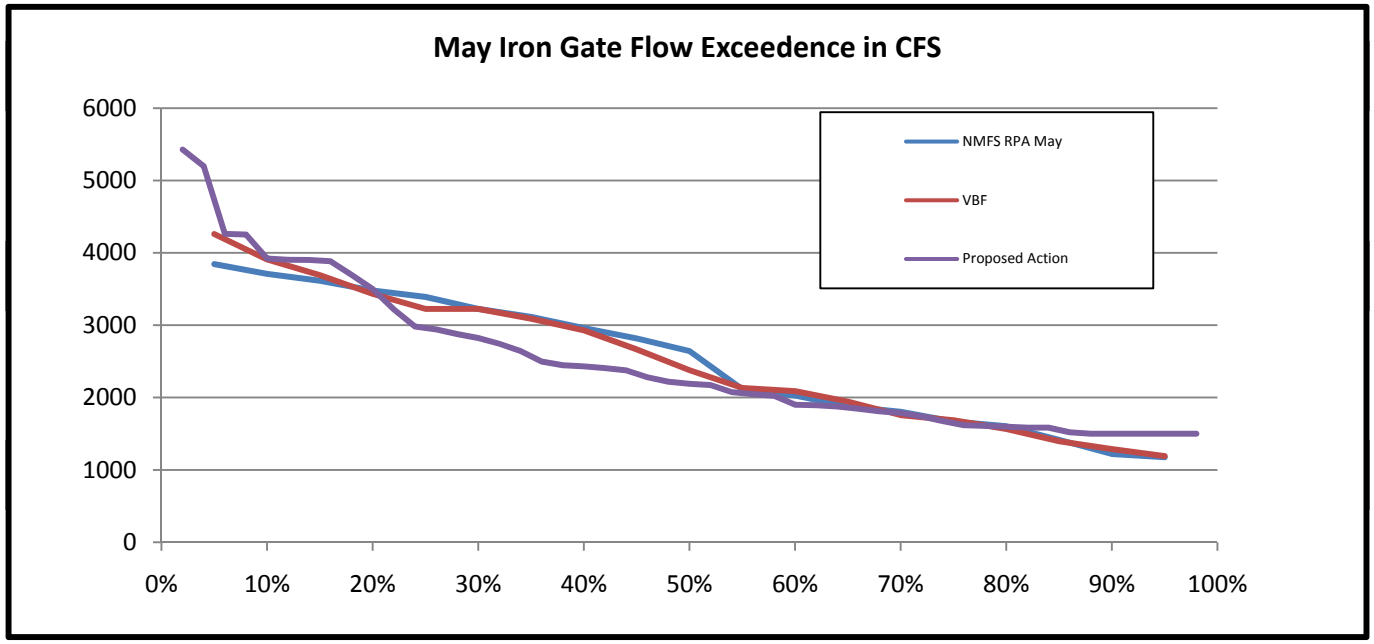

December Iron Gate Flow Exceedence in CFS
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Dec
VBF
Proposed Action

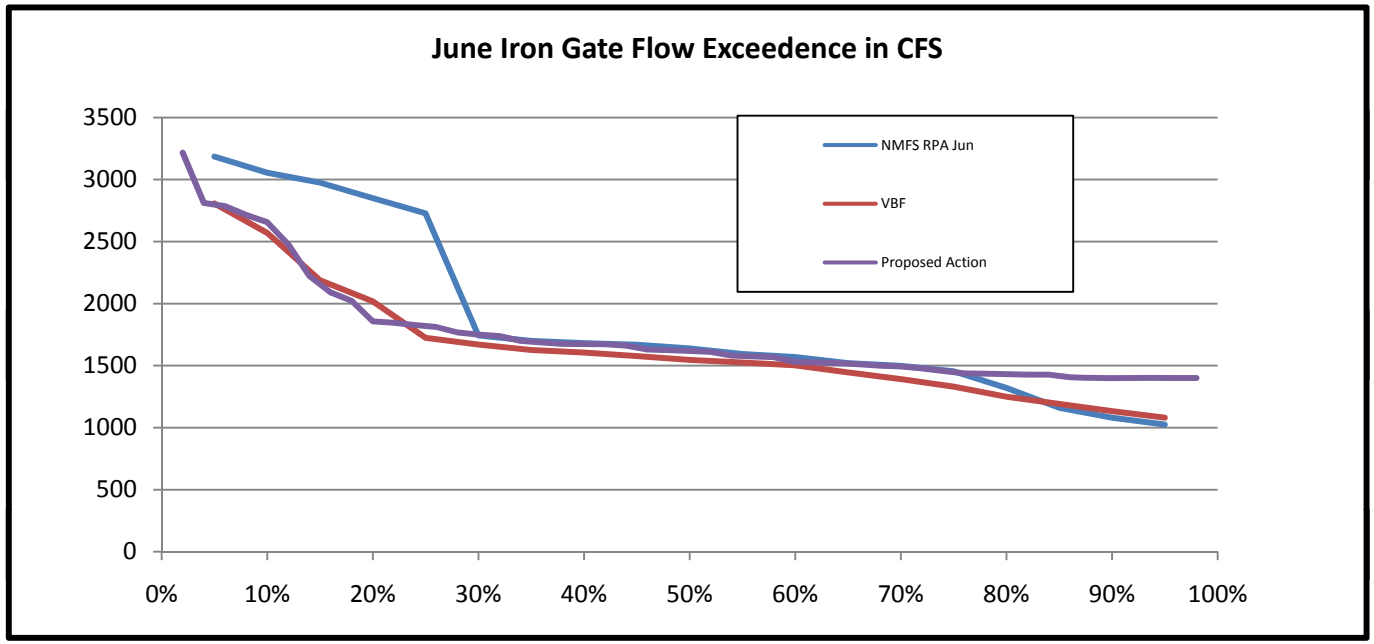

January Iron Gate Flow Exceedence in CFS
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Jan
VBF
Proposed Action

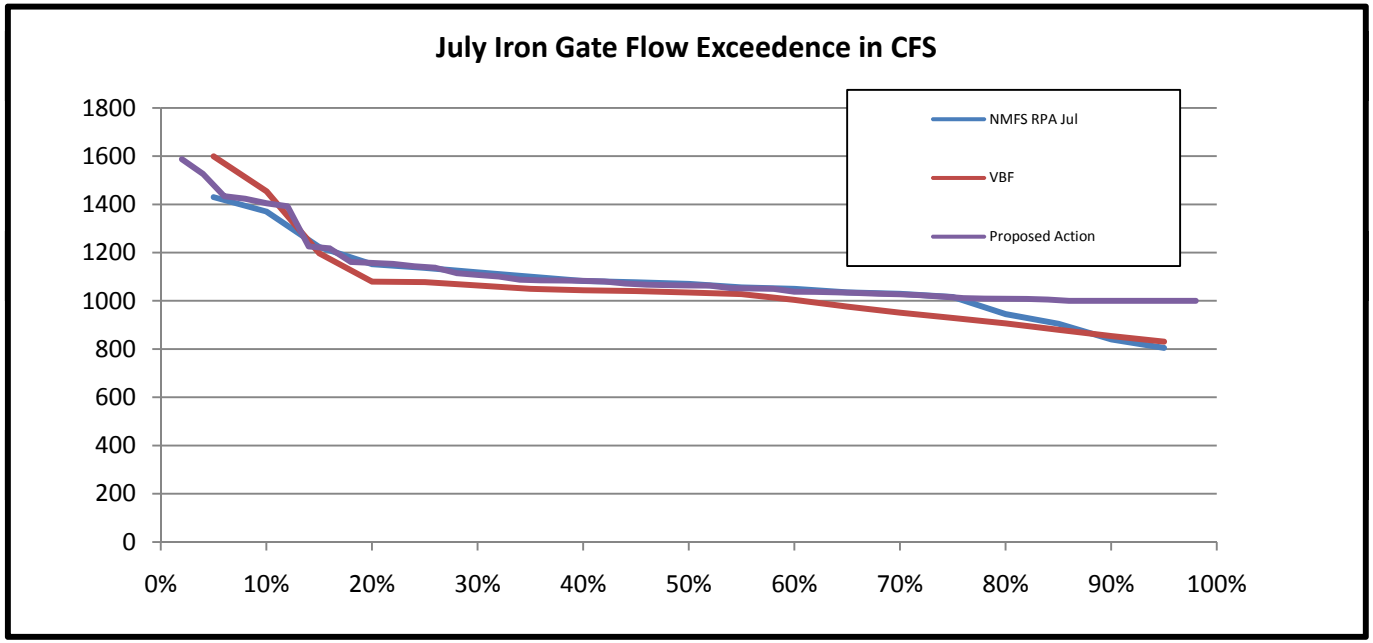

February Iron Gate Flow Exceedence in CFS
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Feb
VBF
Proposed Action

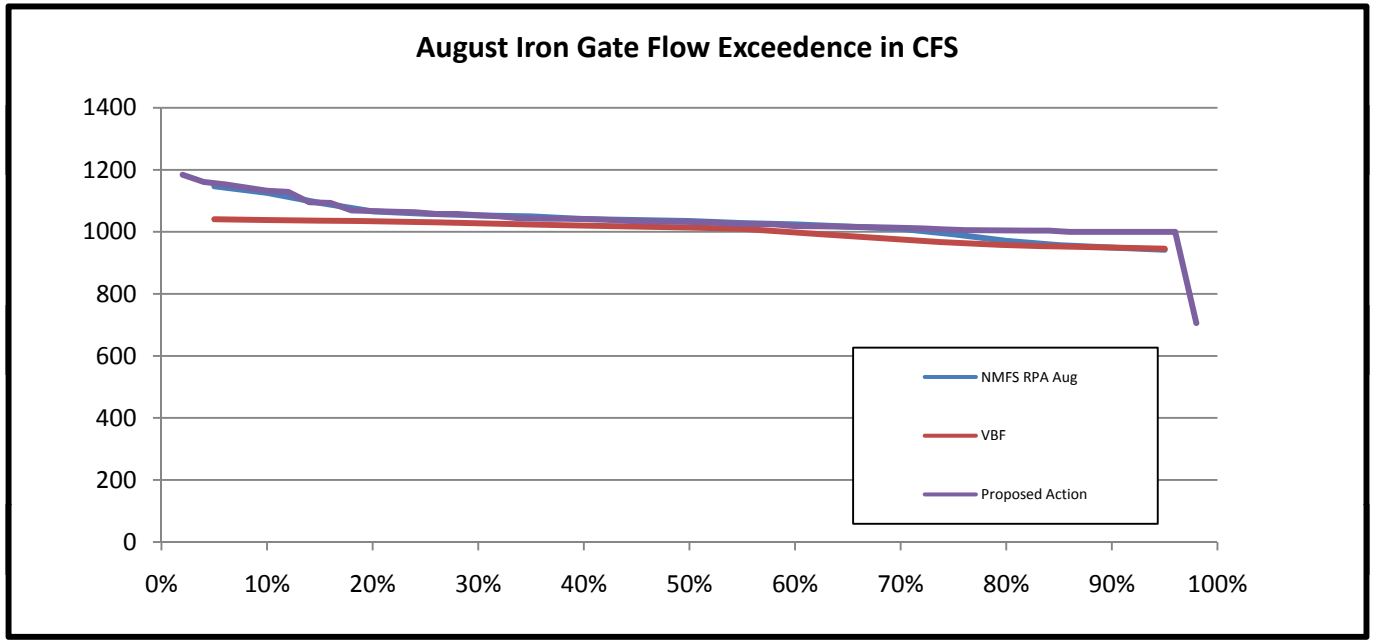

March Iron Gate Flow Exceedence in CFS
12000
10000
8000
6000
4000
2000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Mar
VBF
Proposed Action

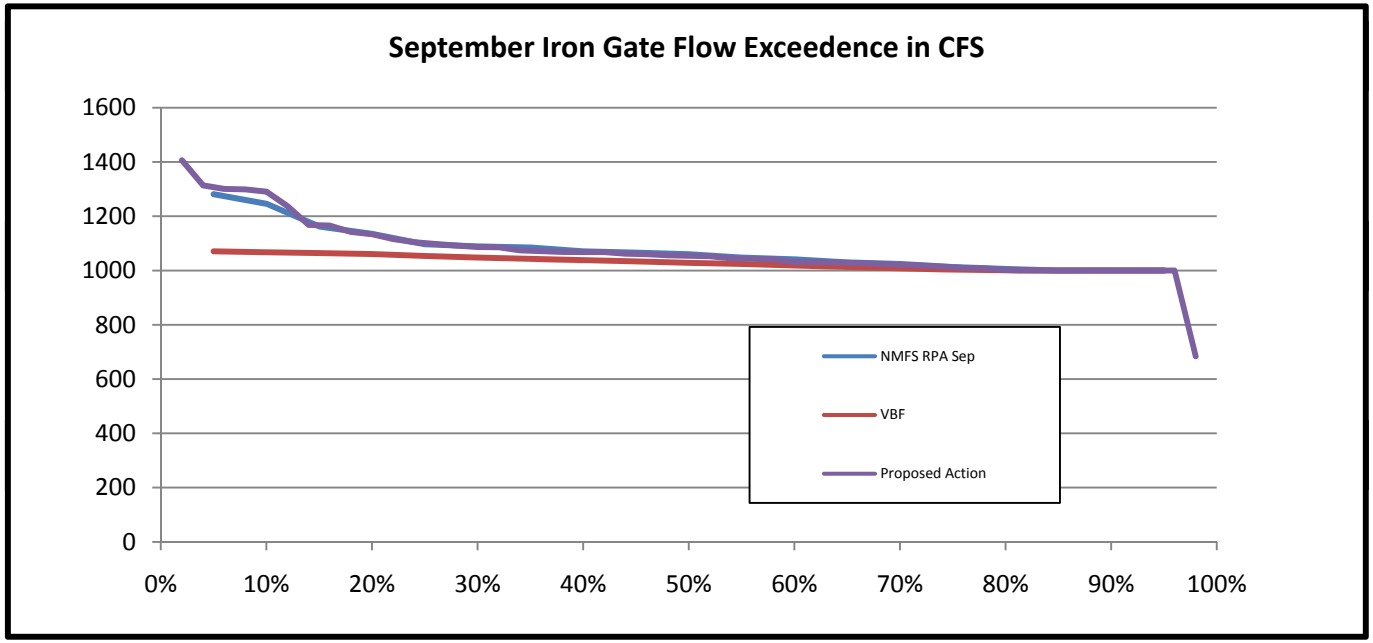

April Iron Gate Flow Exceedence in CFS
8000
7000
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Apr
VBF
Proposed Action

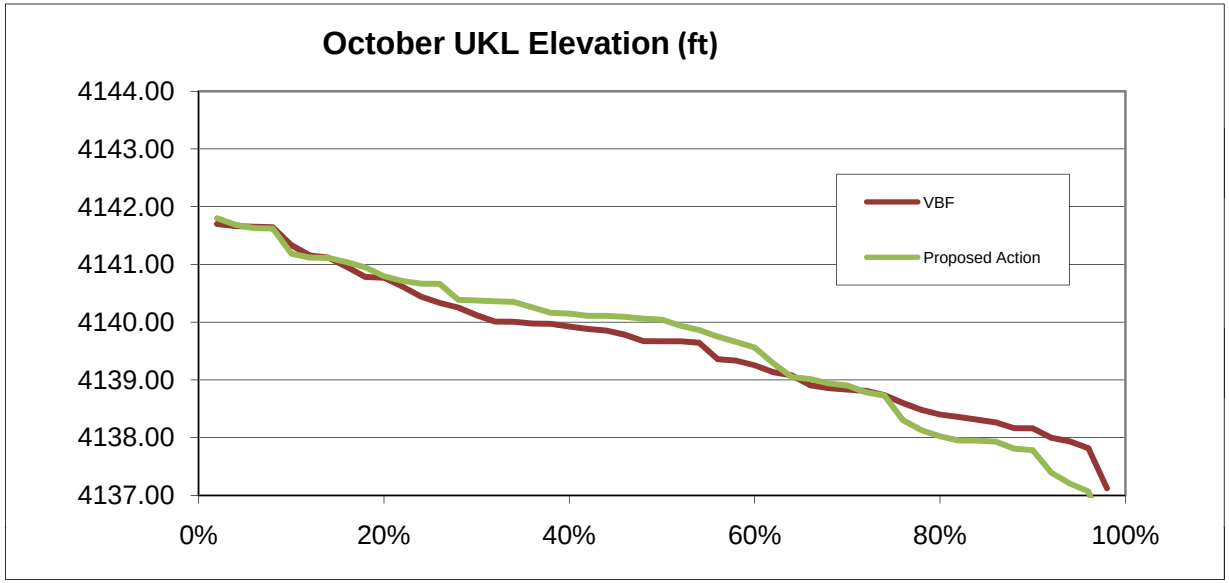

May Iron Gate Flow Exceedence in CFS
6000
5000
4000
3000
2000
1000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA May
VBF
Proposed Action

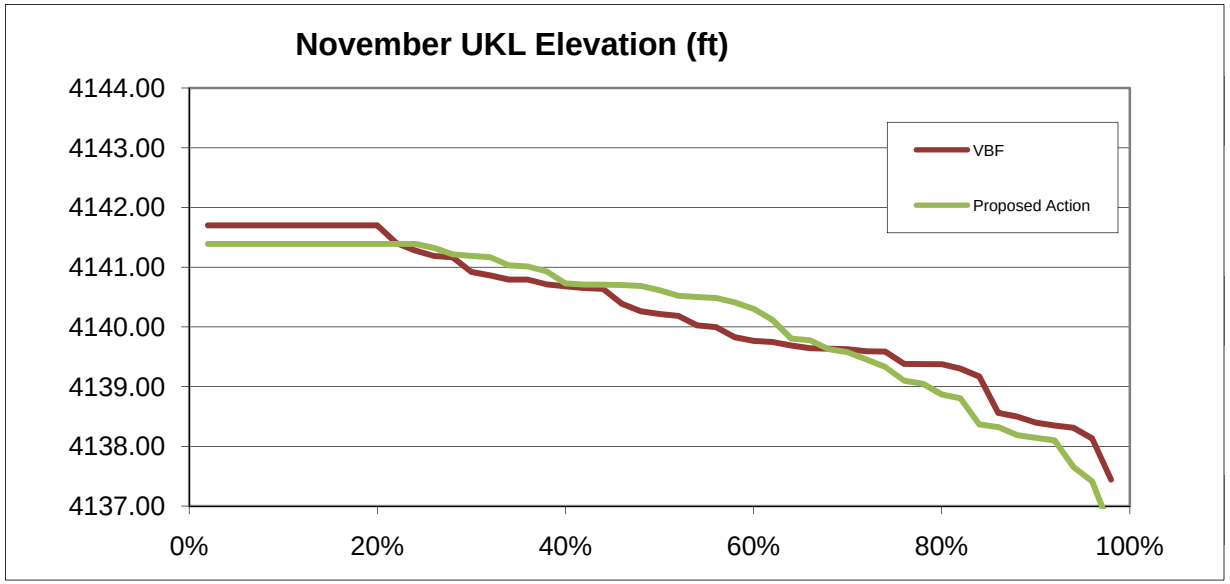

June Iron Gate Flow Exceedence in CFS
3500
3000
2500
2000
1500
1000
500
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Jun
VBF
Proposed Action

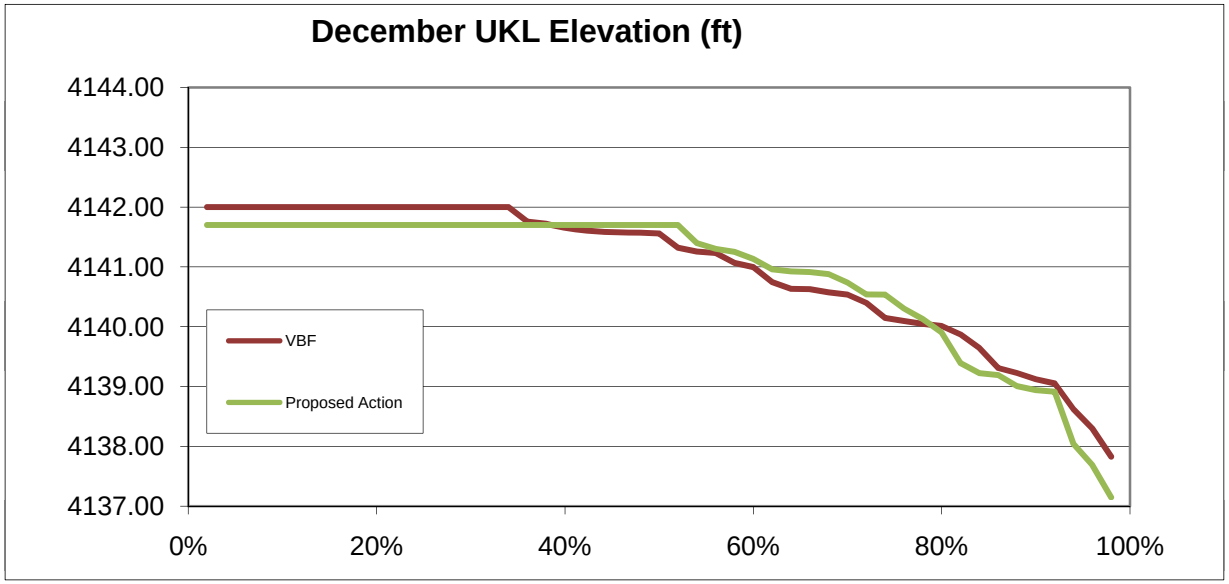

July Iron Gate Flow Exceedence in CFS
1800
1600
1400
1200
1000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Jul
VBF
Proposed Action


August Iron Gate Flow Exceedence in CFS
1400
1200
1000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Aug
VBF
Proposed Action


September Iron Gate Flow Exceedence in CFS
1600
1400
1200
1000
800
600
400
200
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
NMFS RPA Sep
VBF
Proposed Action


October UKL Elevation (ft)
4144.00
4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
100%
VBF
Proposed Action


November UKL Elevation (ft)
4144.00
4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
100%
VBF
Proposed Action


December UKL Elevation (ft)
4144.00
4143.00
4142.00
4141.00
4140.00
4139.00
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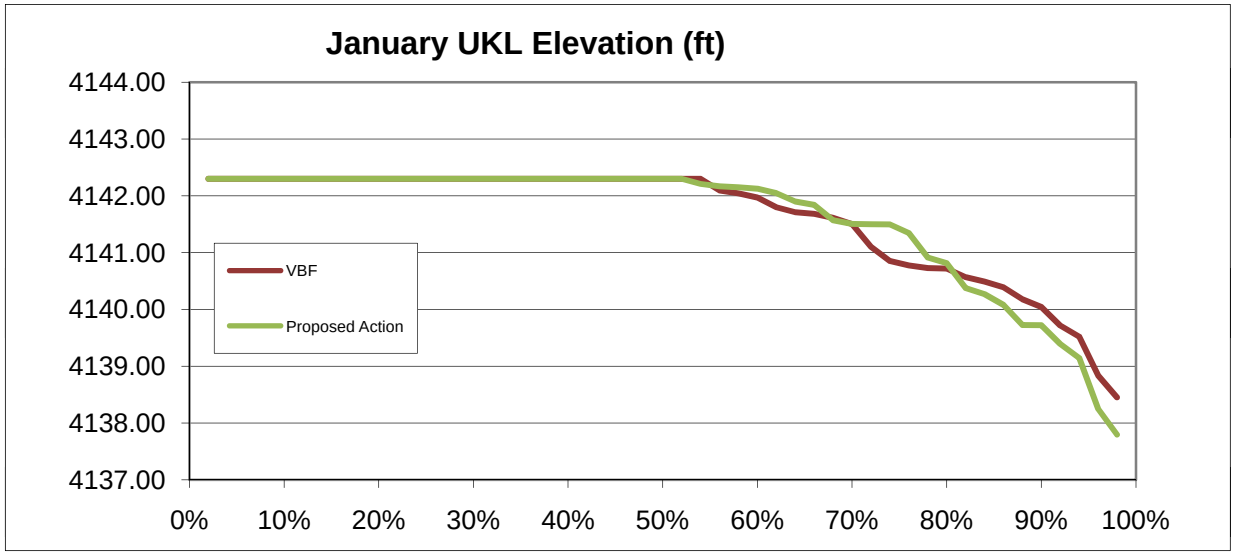
0%
20%
40%
60%
80%
100%
VBF
Proposed Action


January UKL Elevation (ft)
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4139.00
4138.00
4137.00
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20%
30%
40%
50%
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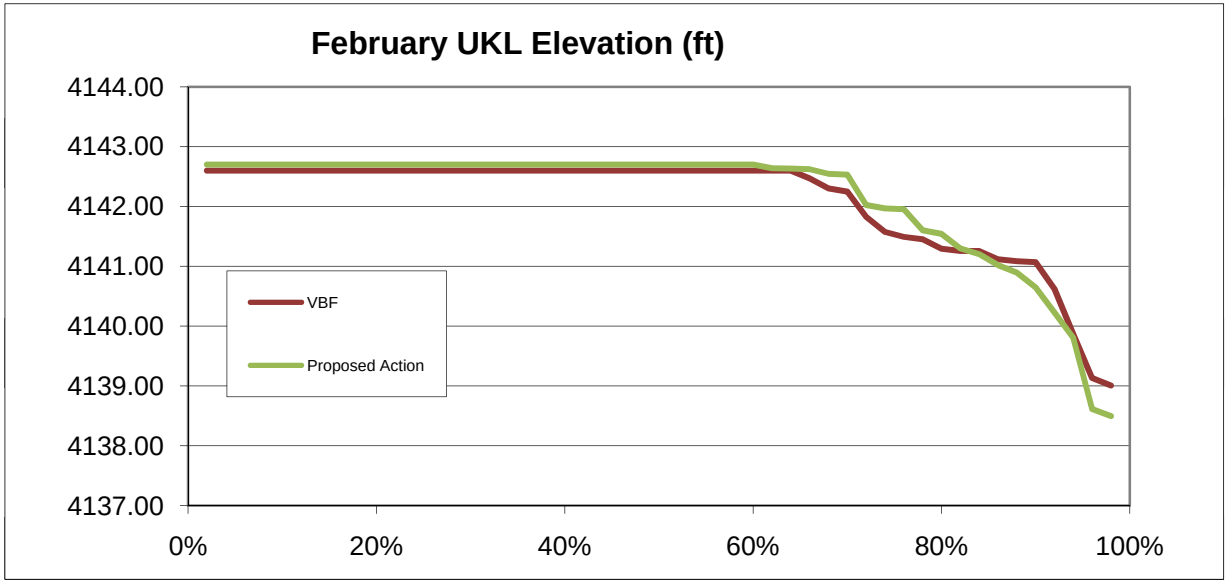
80%
90%
100%
VBF
Proposed Action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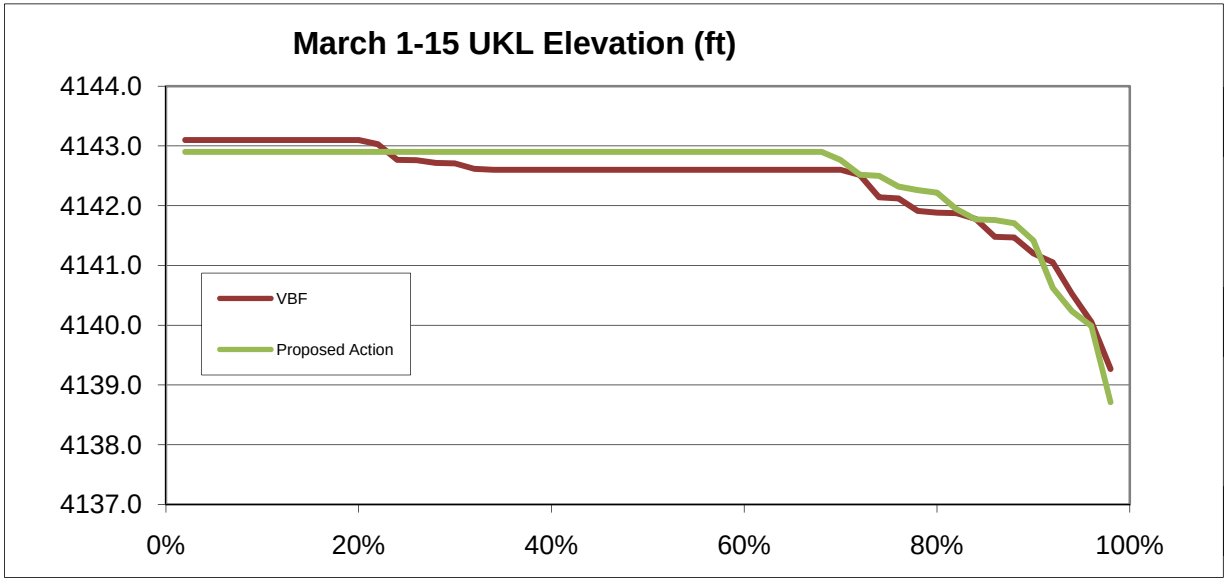
VBF
Proposed Action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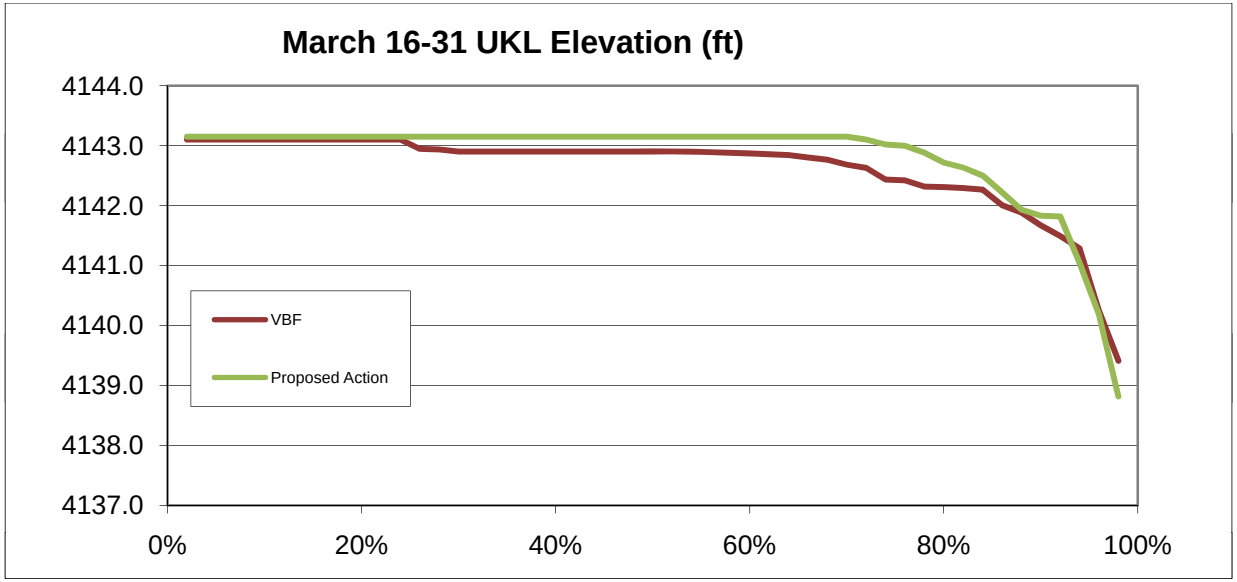
VBF
Proposed Action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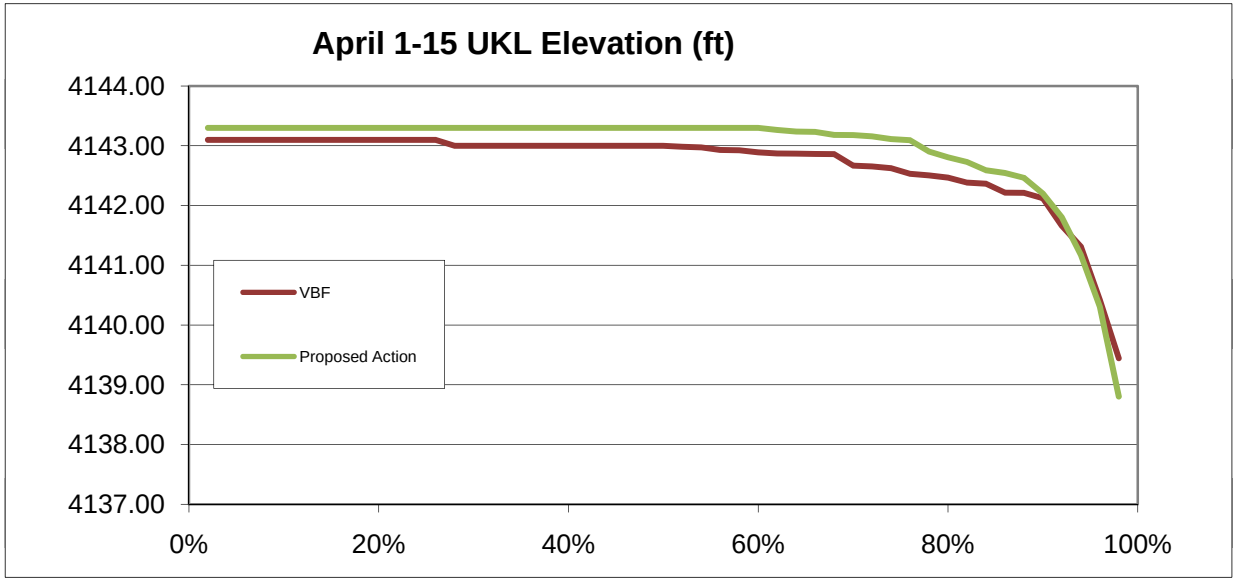
60%
80%
100%
VBF
Proposed Action


April 1-15 UKL Elevation (ft)
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4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
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20%
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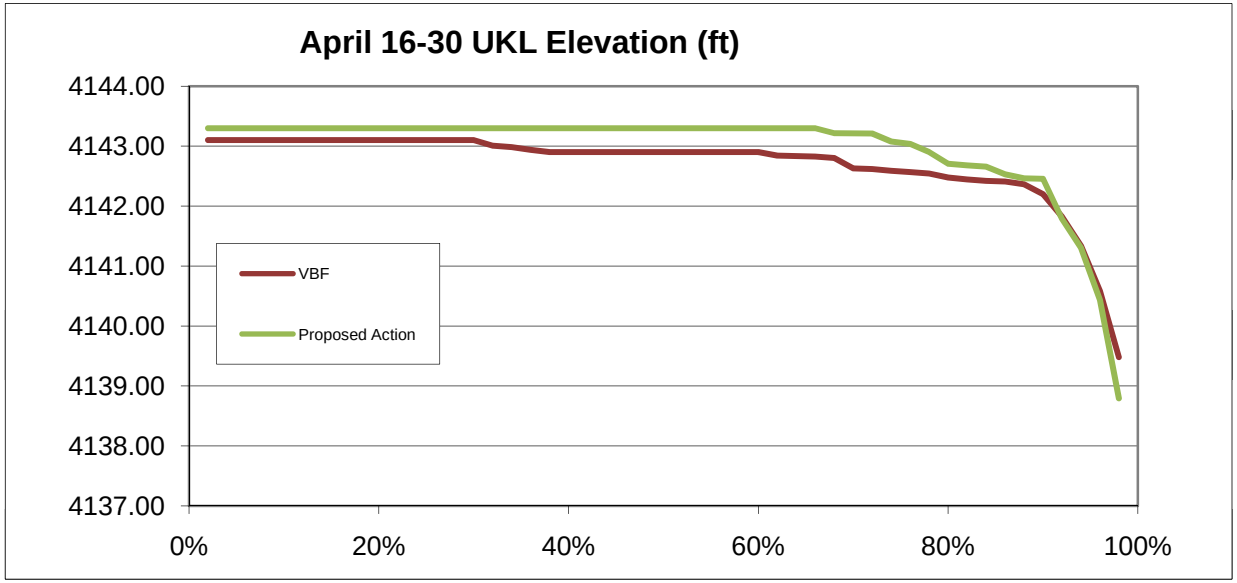
VBF
Proposed Action


April 16-30 UKL Elevation (ft)
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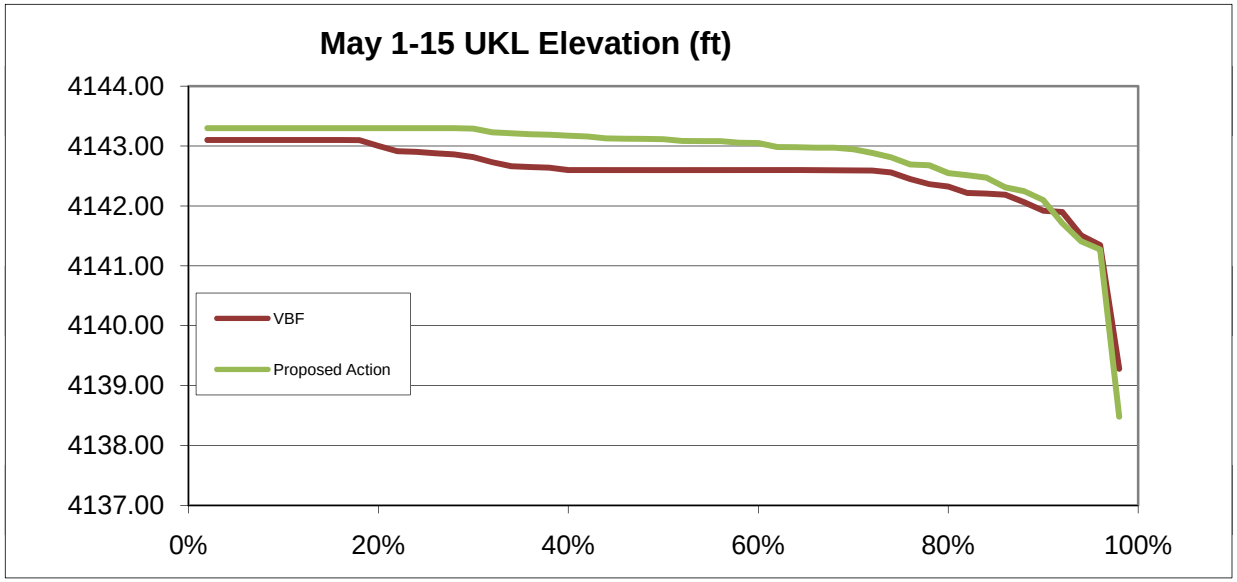
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
100%
VBF
Proposed Action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4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
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20%
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60%
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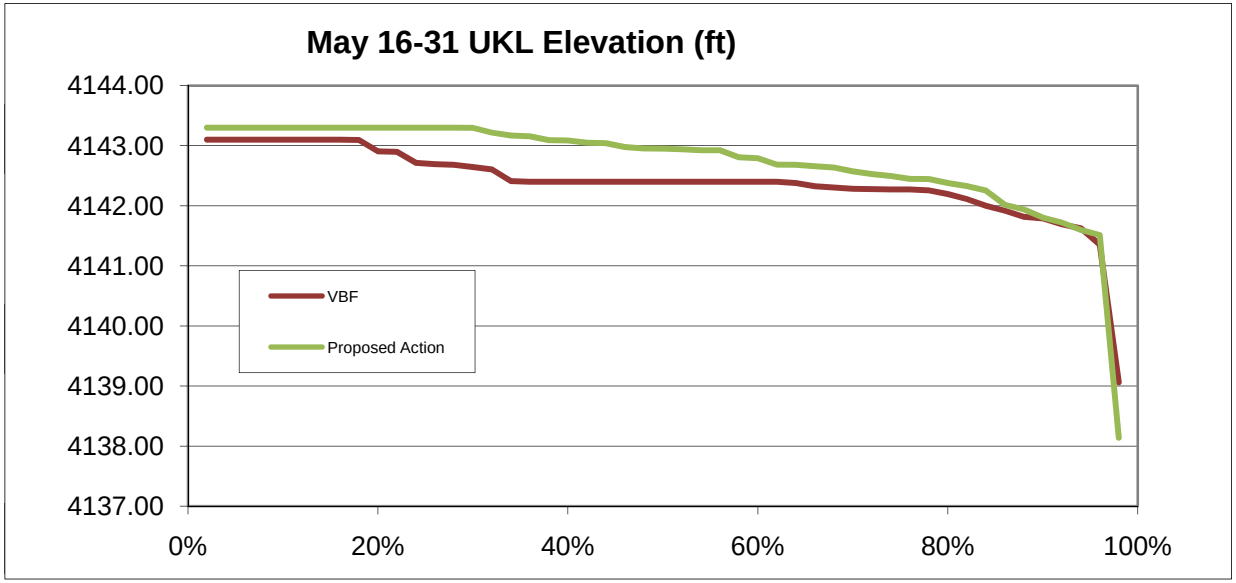
100%
VBF
Proposed Action


May 16-31 UKL Elevation (ft)
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4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
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20%
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60%
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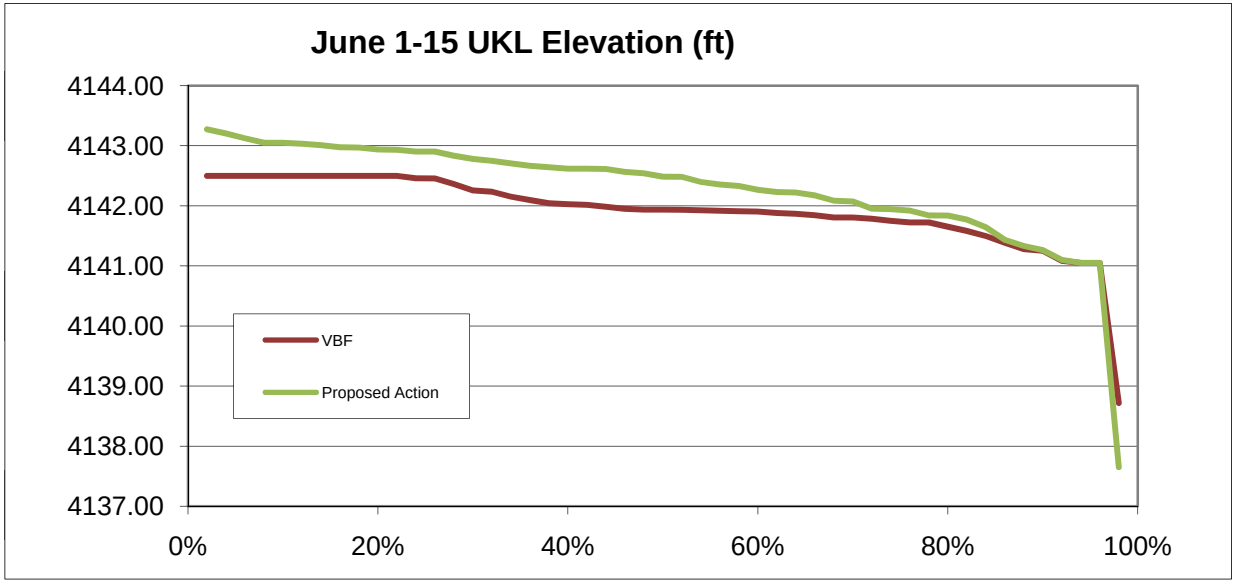
VBF
Proposed Action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4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
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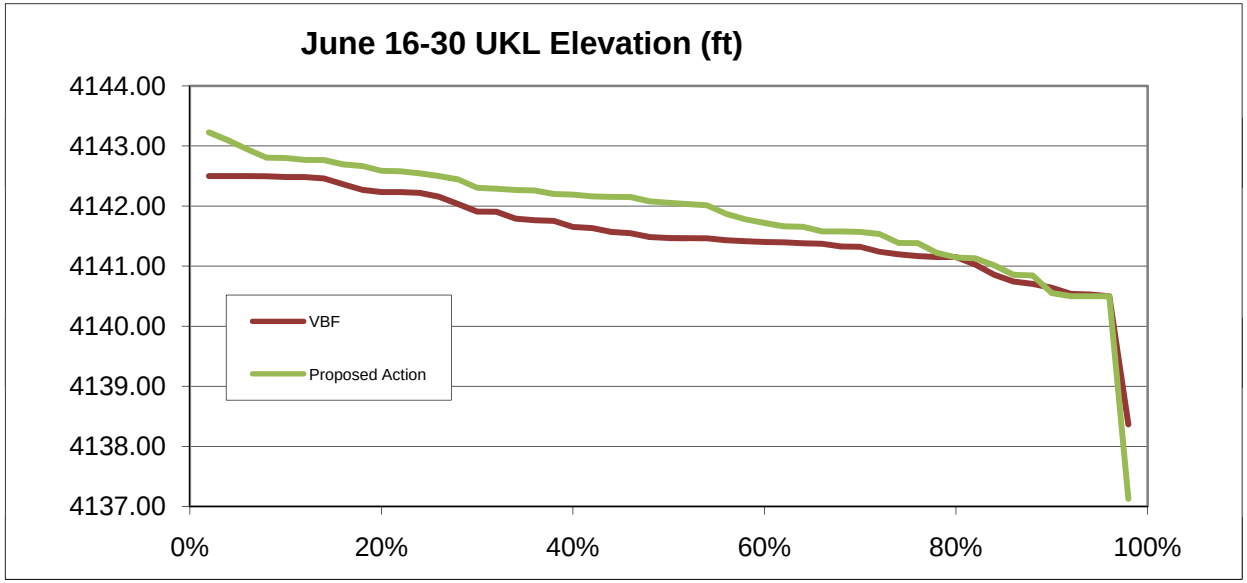
VBF
Proposed Action


June 16-30 UKL Elevation (ft)
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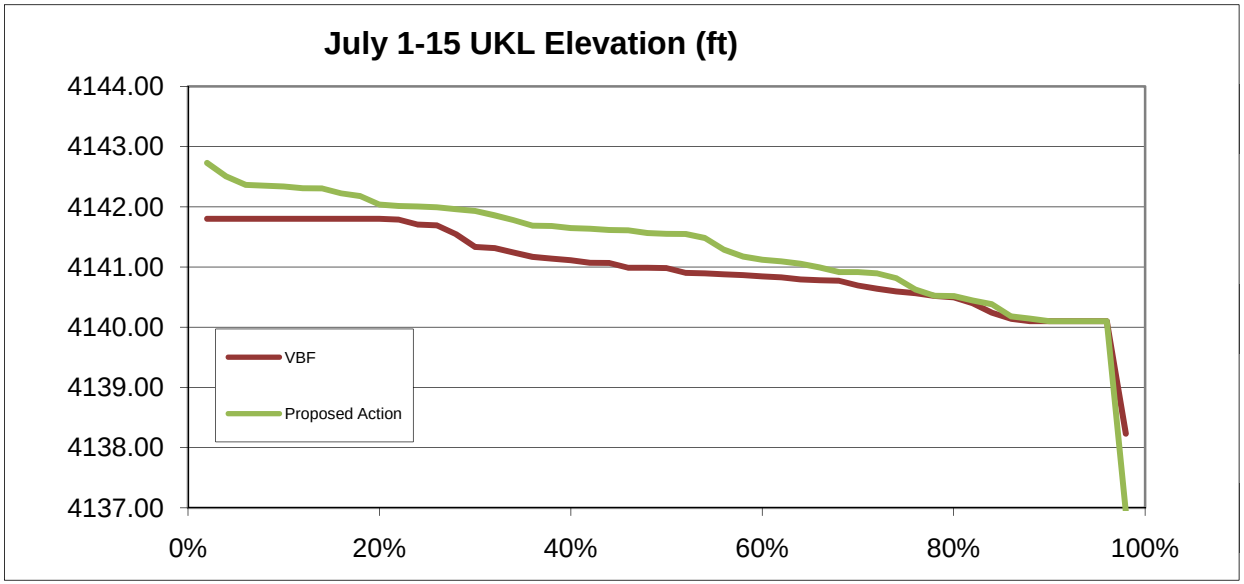
4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
100%
VBF
Proposed Action


July 1-15 UKL Elevation (ft)
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4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
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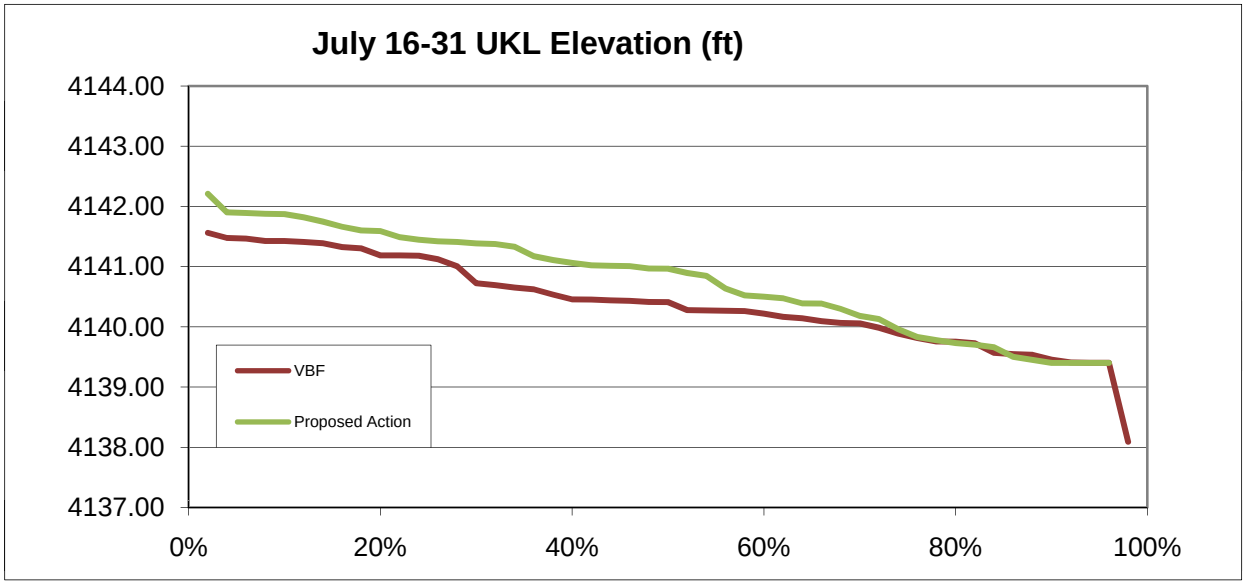
VBF
Proposed Action


July 16-31 UKL Elevation (ft)
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4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
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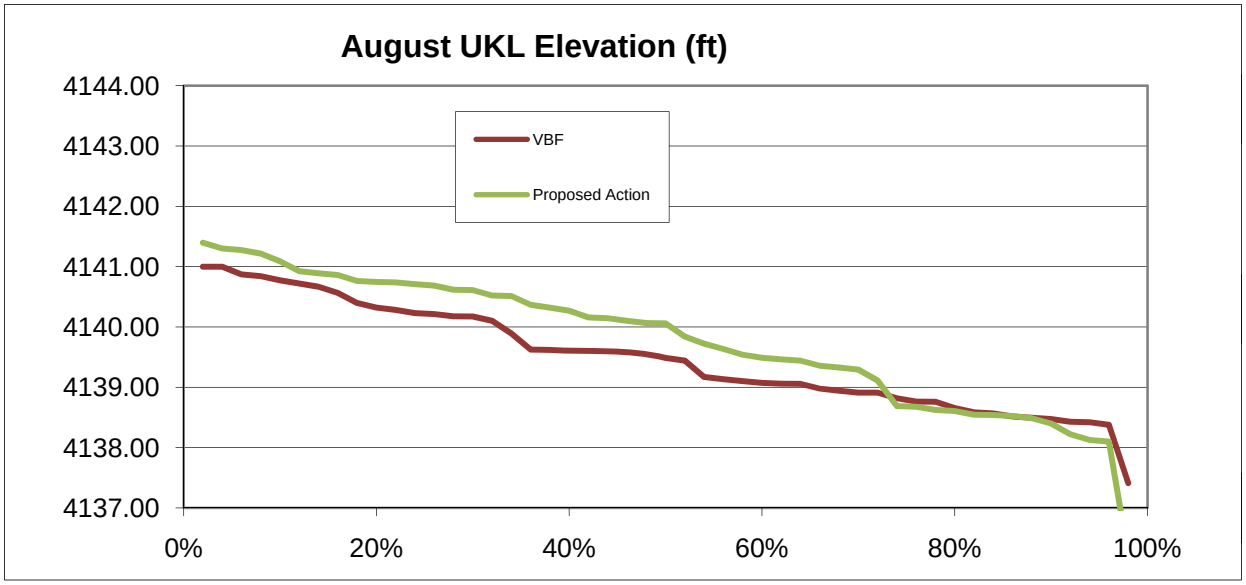
80%
100%
VBF
Proposed Action


August UKL Elevation (ft)
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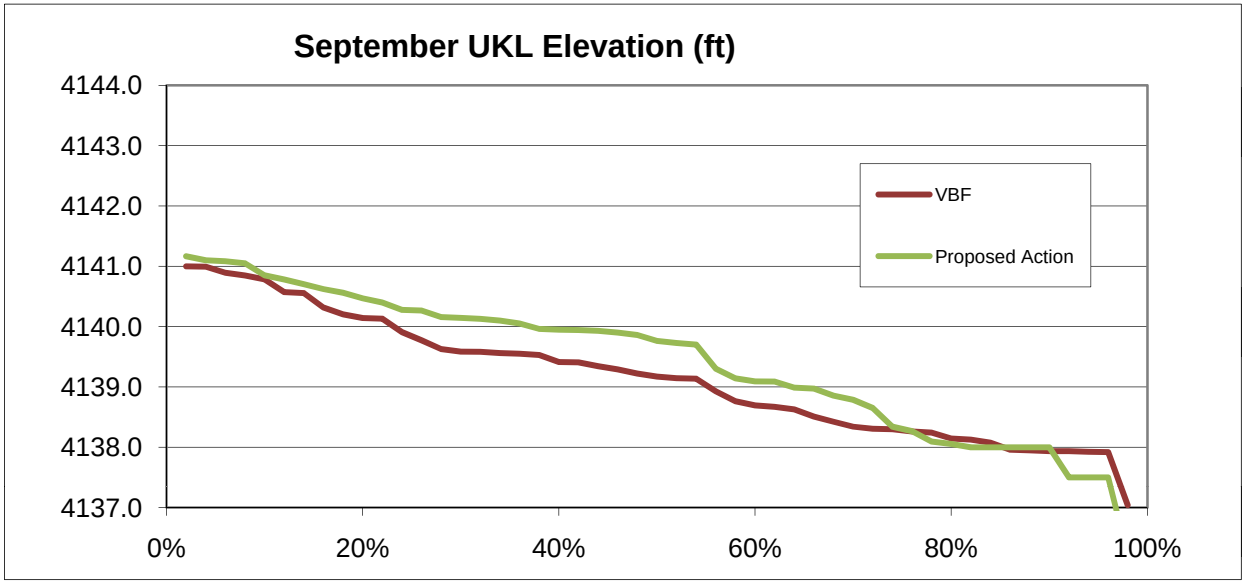
4143.00
4142.00
4141.00
4140.00
4139.00
4138.00
4137.00
0%
20%
40%
60%
80%
100%
VBF
Proposed Action


September UKL Elevation (ft)
4144.0
4143.0
4142.0
4141.0
4140.0
4139.0
4138.0
4137.0
0%
20%
40%
60%
80%
100%
VBF
Proposed Action

Appendix B

Clarification of Uncommon Terms Used in the Klamath Project Revised Water Management Procedure Variable Base Flow (VBF) Procedure

1. Exceedance Tables

A probability distribution function, commonly called an exceedance function, indicates the probability, or likelihood, that a variable will be greater than or less than a particular value. Regulatory agencies have requested to have Klamath basin modeling studies display model results for flows at Iron Gate Dam and water surface elevations in Upper Klamath Lake (UKL) this way, using separate exceedance functions for each individual time step through the year. This is intended to help regulatory agencies and stakeholders to visualize the range of results for a particular scenario and how often, over time, a flow or lake level target exceeds threshold values in time-steps of concern for various life stages of fish species.

The historical period of record for Net Inflow to UKL for water years 1985-2009 will be used as an example. The time series of inflow volumes can be organized in a column of values and a time series plot. See Figure B1.

The exceedance table, shown in Table B2, was created by sorting the values in each column, ranking the values from high to low. In the presentation of hydrology analyses, it cannot be stated that a value will never be exceeded or always be exceeded in the future, so the probabilities are assigned to range between 1/(n+1) and n/(n+1) where n is the number of items in the sample being sorted. In the example, we have 25 years of data, so the exceedance probabilities range from 1/26 to 25/26. The data can be visualized by plotting as in Figure B2, which shows exceedance plots for selected time steps from TableB2.

An example interpretation of the data is as follows. For the time period that is the first half of March ("Mar I"), the highest value in our 25-year period is 161.9, which happened in 1986. It cannot be said that this value will never be exceeded, but it is not exceeded in our period of record, so it is assigned a low exceedance percentile of 1/26, or 3.8%. The lowest value in our 25-year period is 36.1, which happened in 1992. Again, we cannot say that there will never be a value lower than this, but there is no lower value in our period of record. The exceedance is determined as 25/26, or 96.2%.

An awareness of the following will help in using exceedance information in an appropriate manner.

- One cannot "read across a row" of an exceedance table as if it were a sequence. In other words, the values in the exceedance table for, say, the 50% row did not all happen in the same year. (It is important to note that the exceedance value is not an exceedance for a particular year, but rather for that particular time-step. In this case, the time-step is monthly or bi-monthly.) The March values are from 1997, April from 2007, May from 2009, June from 2005, July from 1993, August from 2007, and September from 1993, as highlighted in yellow in Table A1. This is especially the case for hydrology elements which are influenced by probabilistic weather events.

- When the period of record being analyzed is changed – more years or fewer years are considered, the exceedances associated with a particular value will necessarily change as well. For example, Table A2 has a 50% March I value of 79.0 TAF for the period of record of 1989-2009, but when considering the longer 1961-2009 period for UKL Inflows typically used in Klamath Basin modeling, the same March I value of 79.0 TAF has an exceedance of 52% instead. This can be an important type of distinction, depending on how the information is being used.

		Net UKL Inflow (taf)
1985	Oct	126.2
	Nov	201.9
	Dec	152.8
	Jan	127.2
	Feb	119.6
	Mar 1-15	80.7
	Mar 16-31	86.0
	Apr 1-15	124.3
	Apr 16-30	124.3
	May 1-15	57.9
	May 16-31	61.7
	Jun 1-15	38.7
	Jun 16-30	38.7
	Jul 1-15	17.4
	Jul 16-31	18.6
	Aug	22.2
	Sep	91.3
1986	Oct	95.6
	Nov	119.0
	Dec	115.4
	Jan	165.3
	Feb	303.1
	Mar 1-15	161.9
	Mar 16-31	172.7
	Apr 1-15	87.4
	Apr 16-30	87.4
	May 1-15	64.8
	May 16-31	69.1
	Jun 1-15	35.9
	Jun 16-30	35.9
	Jul 1-15	15.8
	Jul 16-31	16.9
	Aug	37.2

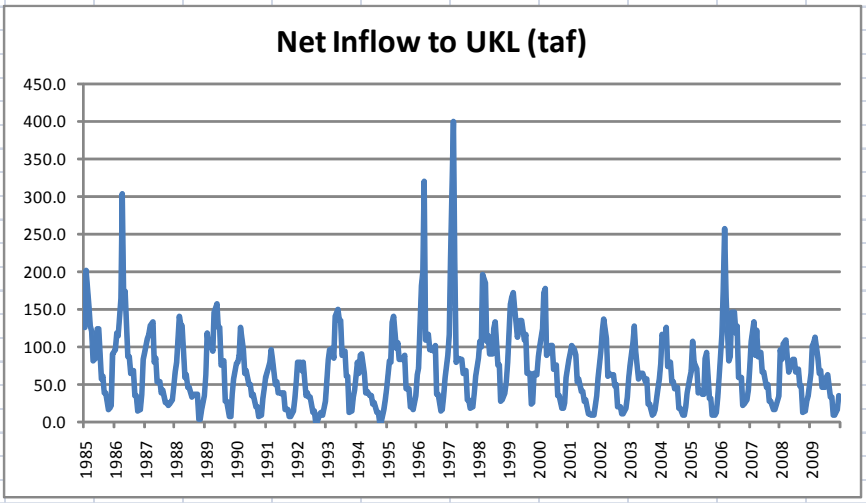


Figure B1: A column of values can be plotted as a time series, showing the sequence of values over time. Only a portion of the time series is shown in column form, while the entire series is shown in the same time plot. Values are often presented in a table with annual rows and monthly columns, as shown for March through September in **Table B1**. This allows for easy annual and monthly computations.

Table B1 – Net Inflows to UKL in thousand-acre-feet (TAF) for March through September *(Highlighted values represent a 50% exceedance.)*

WY	Mar I	Mar II	Apr I	Apr II	May I	May II	Jun I	Jun II	Jul I	Jul II	Aug	Sep
1985	80.7	86.0	124.3	124.3	57.9	61.7	38.7	38.7	17.4	18.6	22.2	91.3
1986	161.9	172.7	87.4	87.4	64.8	69.1	35.9	35.9	15.8	16.9	37.2	82.8
1987	80.5	85.9	54.4	54.4	39.2	41.9	26.4	26.4	22.4	23.9	30.0	48.7
1988	59.7	63.6	46.7	46.7	32.8	34.9	37.6	37.6	3.8	4.0	16.5	34.8
1989	146.4	156.1	125.1	125.1	76.3	81.4	28.0	28.0	7.9	8.4	37.6	58.4
1990	64.5	68.8	50.5	50.5	35.3	37.6	21.5	21.5	8.6	9.2	32.1	45.3
1991	50.5	53.9	39.1	39.1	36.4	38.9	16.1	16.1	8.1	8.6	14.7	30.9
1992	36.1	38.5	33.7	33.7	13.6	14.5	1.0	1.0	12.1	12.9	9.2	27.7
1993	139.9	149.3	134.0	134.0	89.3	95.3	61.6	61.6	13.3	14.2	33.0	42.1
1994	39.0	41.6	34.8	34.8	23.9	25.5	13.2	13.2	0.4	0.4	17.5	29.2
1995	98.7	105.3	84.1	84.1	82.6	88.1	44.5	44.5	20.4	21.8	16.6	35.9
1996	110.0	117.3	95.9	95.9	94.7	101.0	37.0	37.0	15.2	16.2	34.6	59.5
1997	79.0	84.2	84.1	84.1	64.2	68.5	30.1	30.1	18.7	20.0	38.9	60.6
1998	106.9	114.0	91.5	91.5	124.0	132.3	76.8	76.8	27.5	29.3	39.3	54.1
1999	113.5	121.1	134.1	134.1	109.7	117.0	65.8	65.8	24.9	26.5	64.5	63.2
2000	88.9	94.8	101.2	101.2	71.0	75.7	36.0	36.0	18.1	19.3	25.7	59.8
2001	54.4	58.0	41.4	41.4	28.6	30.5	11.5	11.5	9.7	10.3	21.8	34.9
2002	60.6	64.7	63.1	63.1	47.8	51.0	20.9	20.9	10.5	11.2	18.3	34.5
2003	57.0	60.8	64.4	64.4	54.7	58.3	23.8	23.8	10.2	10.9	17.3	45.4
2004	74.4	79.4	53.3	53.3	44.4	47.3	17.9	17.9	9.4	10.1	21.4	38.6
2005	39.9	42.5	37.7	37.7	85.9	91.6	31.0	31.0	9.2	9.8	13.0	34.3
2006	81.2	86.6	145.5	145.5	118.8	126.7	60.0	60.0	22.2	23.7	30.6	42.6
2007	86.8	92.6	66.2	66.2	46.4	49.5	28.7	28.7	16.7	17.8	22.7	35.5
2008	67.3	71.7	83.6	83.6	65.9	70.3	47.8	47.8	13.6	14.5	28.1	35.5
2009	64.8	69.2	47.1	47.1	59.2	63.1	33.4	33.4	9.5	10.1	17.3	34.9

Table B2 – Exceedance table based on the columns in Table A1.

	Mar I	Mar II	Apr I	Apr II	May I	May II	Jun I	Jun II	Jul I	Jul II	Aug	Sep
3.8%	161.9	172.7	145.5	145.5	124.0	132.3	76.8	76.8	27.5	29.3	64.5	91.3
7.7%	146.4	156.1	134.1	134.1	118.8	126.7	65.8	65.8	24.9	26.5	39.3	82.8
11.5%	139.9	149.3	134.0	134.0	109.7	117.0	61.6	61.6	22.4	23.9	38.9	63.2
15.4%	113.5	121.1	125.1	125.1	94.7	101.0	60.0	60.0	22.2	23.7	37.6	60.6
19.2%	110.0	117.3	124.3	124.3	89.3	95.3	47.8	47.8	20.4	21.8	37.2	59.8
23.1%	106.9	114.0	101.2	101.2	85.9	91.6	44.5	44.5	18.7	20.0	34.6	59.5
26.9%	98.7	105.3	95.9	95.9	82.6	88.1	38.7	38.7	18.1	19.3	33.0	58.4
30.8%	88.9	94.8	91.5	91.5	76.3	81.4	37.6	37.6	17.4	18.6	32.1	54.1
34.6%	86.8	92.6	87.4	87.4	71.0	75.7	37.0	37.0	16.7	17.8	30.6	48.7
38.5%	81.2	86.6	84.1	84.1	65.9	70.3	36.0	36.0	15.8	16.9	30.0	45.4
42.3%	80.7	86.0	84.1	84.1	64.8	69.1	35.9	35.9	15.2	16.2	28.1	45.3
46.2%	80.5	85.9	83.6	83.6	64.2	68.5	33.4	33.4	13.6	14.5	25.7	42.6
50.0%	79.0	84.2	66.2	66.2	59.2	63.1	31.0	31.0	13.3	14.2	22.7	42.1
53.8%	74.4	79.4	64.4	64.4	57.9	61.7	30.1	30.1	12.1	12.9	22.2	38.6
57.7%	67.3	71.7	63.1	63.1	54.7	58.3	28.7	28.7	10.5	11.2	21.8	35.9
61.5%	64.8	69.2	54.4	54.4	47.8	51.0	28.0	28.0	10.2	10.9	21.4	35.5
65.4%	64.5	68.8	53.3	53.3	46.4	49.5	26.4	26.4	9.7	10.3	18.3	35.5
69.2%	60.6	64.7	50.5	50.5	44.4	47.3	23.8	23.8	9.5	10.1	17.5	34.9
73.1%	59.7	63.6	47.1	47.1	39.2	41.9	21.5	21.5	9.4	10.1	17.3	34.9
76.9%	57.0	60.8	46.7	46.7	36.4	38.9	20.9	20.9	9.2	9.8	17.3	34.8
80.8%	54.4	58.0	41.4	41.4	35.3	37.6	17.9	17.9	8.6	9.2	16.6	34.5
84.6%	50.5	53.9	39.1	39.1	32.8	34.9	16.1	16.1	8.1	8.6	16.5	34.3
88.5%	39.9	42.5	37.7	37.7	28.6	30.5	13.2	13.2	7.9	8.4	14.7	30.9
92.3%	39.0	41.6	34.8	34.8	23.9	25.5	11.5	11.5	3.8	4.0	13.0	29.2
96.2%	36.1	38.5	33.7	33.7	13.6	14.5	1.0	1.0	0.4	0.4	9.2	27.7

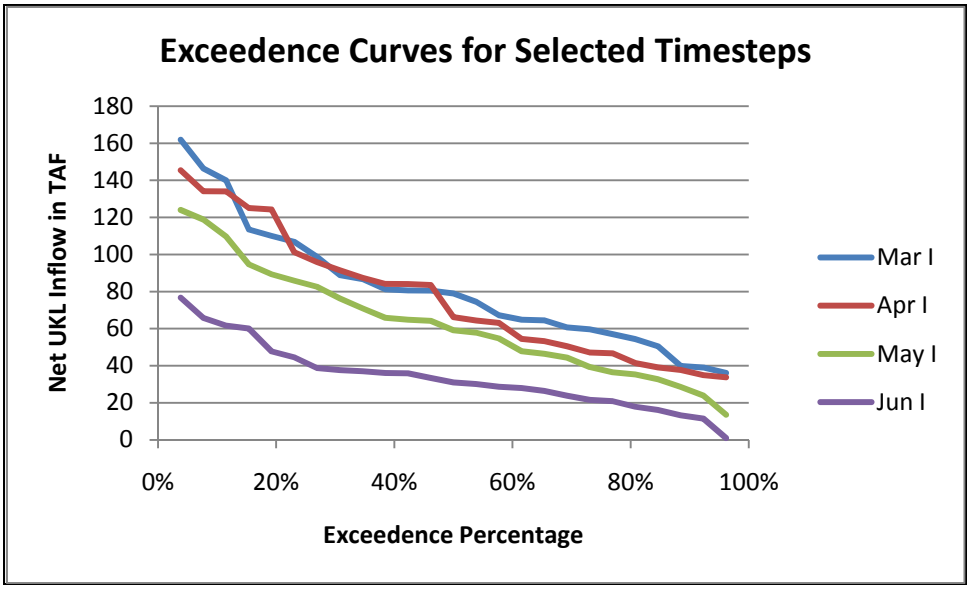


Figure B2: Exceedance Plots

2. Table 18

In this report, the term "Table 18" is often referenced. Table 18 refers to a table located within the 2010 National Marine Fisheries Service (NMFS) biological opinion (BO) and reasonable and prudent alternative (RPA) on page 177. Table 18 is a table of flows below Iron Gate Dam in the Klamath River in an exceedance format. This table was developed by altering the original exceedance table of flows in the proposed action (Table 6 in the 2010 NMFS BO on page 18) to increase flows in wetter time steps and decrease flows during drier time steps during the spring months. The Table 18 values were based solely on estimated biological needs of coho salmon, not a water balancing calculation considering the needs of ESA listed suckers in UKL, and irrigation and Wildlife Refuge responsibilities. This table was altered to show a desired flow result, not an operational procedure or an exceedance table resulting from an operational procedure. The NMFS RPA did not provide an operational procedure to achieve the RPA elements (including Table 18 flows). The current VBF procedure was designed to meet the intent of the NMFS RPA while accommodating the needs of listed suckers.

3. Baseline Flows

The VBF methodology uses a "baseline" flow to define the Iron Gate flow. The total Iron Gate flow = baseline flow + threshold releases. Therefore, the Iron Gate flow should never average below the baseline flow as this is the minimum flow for that time period. The baseline flow is chosen from a range of flows (Table 1 of the Klamath Project Revised Water Management Procedure; VBF Procedure document) depending on the current NRCS forecast ("water year types" are not utilized to define Iron Gate flows as in the past). The flows in Table 1 are the 95-40% exceedance flows (except June when it's 95-30%) from the NMFS RPA Table 18. The reason for developing a range of flows rather than just the absolute minimum flows (95% exceedance flow) is to ensure that absolute minimum flows are not experienced in non-drought years where the UKL elevation is low. For example, if a drought year occurs, followed by a wet spring, the March UKL elevation may still be low as UKL is still filling, but under this

method, the base Iron Gate releases would still be above the minimum since the forecasted inflow to UKL would be higher. The threshold UKL elevations for March through May were designed so that in most years Iron Gate flow is above the baseline due to additional releases from UKL that occur when UKL elevation is above the threshold elevation. Use of a 40% exceedance , rather than another exceedance, was derived by an iterative process along with the threshold elevations to achieve total Iron Gate flows (base+threshold) that meet the NMFS RPA while also meeting UKL needs for suckers (2008 U.S. Fish and Wildlife Service (FWS) BO), and the Project.

In October through February, the baseline flow does equal the 95% exceedance flow from the NMFS RPA Table 18. October and November have different patterns in Table 18 than December through February. October and November flows in Table 18 are fairly consistent through every exceedance. October's 95% exceedance flow is the same as the 5% exceedance flow. In November, the 95% through 35% exceedance flows are also the same. The threshold elevations for UKL in these months were set to mimic the Table 18 values for total flow. Therefore, the threshold elevation in October was set high enough that so that it was never exceeded in the period of record modeled. Therefore, the October flows would be 1000 cfs in all exceedances, as shown in Table 18. In November, the UKL threshold elevation was designed to only be exceeded in wet years as is shown in Table 18. In December through February, the threshold elevations were derived through an iterative process to allow total flows (base + threshold releases) to be above the 95% exceedance flow in most years in the period of record. This allows for monthly Iron Gate flows to be above the 95% exceedance level while UKL is filling during the winter months. In addition, using the 95% exceedance level as the baseline flows provides additional water to meet another element of the NMFS RPA that requires fall and winter flow variability between the months of October and February.

Table 1 in the Klamath Project Revised Water Management Procedure; VBF Procedure document, which lists the baseline flows, uses the actual flows in the NMFS RPA Table 18 and then interpolates between them. For example, in April, the baseline flows range from the 40-95% exceedance flows in Table 18. Therefore, the minimum flow in the April column equals the 95% flow of 1325 cfs and the maximum flow in the April column equals the 40% exceedance flow of 3485 cfs. The values in between are linearly interpolated. The forecast values in Table 1 are the actual NRCS forecasts that occurred during the period of record shown in an exceedance table format. For example, a forecast of 31% of average for March through September was exceeded 95% of the time in the period of record (1961-2009) and 140% of average was exceeded 5%.

4. Maximum Flows

The term "maximum flows" refers to flows which can be managed when UKL is below its flood control restrictions. This is not the same as flood releases which can be higher and occur when there is no additional storage in UKL. Maximum flows were developed based on the 15-5% exceedance flows in Table 18 of the NMFS RPA. Rather than just using the 5% flow as the maximum flow, the maximum flow is chosen based on the current forecast (% of average). This prevents pulling UKL down to threshold levels in very wet years during months when very high downstream flows are not biologically warranted, and meets the 2008 FWS BO requirements. The modeling results show that maximum flows are only used in one or two time periods (half months) in 30% of the years in the period of record. They are not used more frequently because when the Iron Gate flows are very high, UKL is often at a high enough elevation that additional storage is not permitted due to flooding risk.

The managed Iron Gate flow will always be between the VBF and the maximum flow which are both determined based on the forecast. The maximum flows are only identified between March and May since those are the only times significantly larger flows are expected to occur. Flows above the maximum flow could still occur if UKL's elevation rises to a level that requires releases for flood protection. Once average inflows start to decrease in June, high flows will likely only occur from a large singular event rather than a seasonal warming trend or other longer-term climate factor. At these times, there is no maximum flow.

5. NMFS BO Term and Condition 1B

"Reclamation shall, in coordination with the NMFS and USFWS, codify written operational procedures for coordinating and implementing the Klamath Project Operations as it applies to Upper Klamath Lake levels and Klamath River flows. Through this term and condition, Reclamation shall, in coordination with NMFS and USFWS, develop and implement a protocol for coordinating their Operations (including those elements of the IM process that still apply to the RPA) with the Services and other key agencies, tribes and stakeholders. Reclamation shall complete the document by July 15, 2010."

The Klamath Project Revised Water Management Procedure; VBF Procedure document provides the updated operational procedures for implementing Klamath Project Operations to meet the requirements of the NMFS and FWS BOs.

6. Irrigation/Agricultural Demand and/or Shortage

Project irrigation demands are currently predicted from the fall/winter precipitation levels. Using historical precipitation and historical irrigation use (prior to 2001), a mathematical relationship was developed between the two. This relationship is used in the model to predict the demand in each time step although the actual deliveries depend on the water availability.

The Project water availability is determined in 2 different ways: short term and long term. The long term (April through September) availability calculates the water availability by total inflow (through September) predicted by the forecast plus the current water stored in UKL minus the end-of-September minimum elevation of UKL minus the minimum (95% exceedance) Iron Gate flows. If minimum Iron Gate flows, UKL elevations, and irrigation demands cannot be met, then a season-wide reduction in available irrigation water will be applied. This reduction is also called the delivery factor. Although minimum flows and elevations are not the goal for UKL and the River, these values are used to identify a definitive shortage for the project. A condition where even minimums cannot be met would require early detection, planning, and action. The early decisions made in a situation like this can have long-term impacts on agricultural production and may not be able to be reversed once the season begins, even if the forecast under estimated the inflow. Such decisions may include actions such as crop changes, land idling, and early groundwater pumping.

This delivery factor is not necessarily the shortage that will occur in each time step but rather an indicator of potential upcoming shortages in all remaining months of the season. The actual potential shortage will be calculated based on the short term availability. The short term availability is for the current time step only and calculates the water availability by the predicted inflow for the current time step plus the current water stored in UKL minus the current month's minimum elevation of UKL minus the baseline Iron Gate flows.

7. Hydrologic Model

An exceedance table of flows below Iron Gate Dam resulting from the VBF procedure is included in Table 1 of the Klamath Project Revised Water Management Procedure; VBF Procedure document. This table was developed from an existing hydrologic planning model which is programmed in the WRIMS modeling software. This model takes historical input data (UKL inflow, Klamath River inflow below Link River Dam, precipitation, and related parameters), and applies certain operational rules to produce UKL elevations, Iron Gate flows, and agriculture deliveries.

For example, in August of 1981 the model calculated the following:

- The most recent forecast was 41% of average inflows,
- The August inflow was 16.65 TAF,
- The Iron Gate 95% exceedance (and therefore minimum) flow was 942 cfs,
- The minimum Iron Gate base flow requirement was 952 cfs,
- The end of July UKL elevation was 4139.73 feet,
- The minimum end of August UKL elevation was 4138.1 feet,
- The predicted agricultural demand was 61.9 TAF, and
- The agricultural delivery factor was 0.91, meaning that the adjusted demand was 61.9 TAF*.91= 56.3 TAF.

Using a system of weights/preferences for each of these items, the model divided the total available water between Iron Gate flows, UKL, and agricultural deliveries in the following order:

1. Ensure UKL has water above the dam gate openings (so water can be released our of UKL)
2. Meet 95% exceedance of Iron Gate flow (942 cfs)
3. Meet UKL minimum elevations (as specified in the FWS BO) of 4138.1 feet
4. Meet Iron Gate base flow (952 cfs)
5. Meet adjusted agricultural demand of 53.6 TAF
6. Meet threshold elevation in UKL of 4141.0 feet
7. Meet full agricultural demand of 61.9 TAF
8. Deliver water above UKL threshold elevation downstream for Iron Gate flows

By using this order, the model calculated that there was enough water to satisfy items 1 through 5, but there was not enough water to bring the UKL elevation to the threshold of 4141.0 feet. As a result, UKL ended at 4138.57 feet, full agricultural deliveries were not met, and releases for Iron Gate flows above the UKL threshold were not calculated.

This calculation is done for the period of record (1961-2009) and calculates on a monthly time step. In the critical months of March through July, the model divides the month and calculates every 2 weeks.

8. Real Time Management

Any operational methodology requires real time management to some degree to maximize the intended purposes of water management while protecting the listed species, preventing flood hazards, and meeting agricultural demands (including Refuge needs). For example, the model may indicate that the April Iron Gate flow should be 4,160 cfs, however, a heavy snowpack and an expected rain-on-snow event may require a significant release of water from UKL that would take it below the threshold

elevation in order to prepare for a large, fast inflow. Real time management simply describes the day-to-day decisions that are made in order to adapt to current situations.

In some cases, real time management will be used to meet the intent of the BOs where the model shows a difference between VBF and Table 18, such as the wetter years in June. The sharp increase between the 25% and 30% exceedance levels for June in Table 18 does not fit a natural release pattern. Due to the unnatural curve of this increase and the significance of determining when flows above the 30% exceedance should occur, the timing of these higher flows will be determined through further discussions with representatives from Reclamation, the Service, NMFS and other key stakeholders. This team will determine when flows at or above the 25% exceedance would be warranted.