Hydropower Impacts Analysis of Upper Columbia Alternative Flood Control and Fish Operations and Detailed Operating Plan Scenarios including Hydropower Considerations and VARQ On the Columbia River System

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Table of Contents

List of Tables

1.0 <u>Introduction</u>. The Corps of Engineers (Corps) is preparing an Environmental Assessment (EA) for VARQ at Libby and Hungry Horse in response to the U.S. Fish and Wildlife Service and National Marine Fisheries Service (2000 NMFS BiOps) Biological Opinions, which recommended VARQ as a flood control operations strategy for Libby and Hungry Horse. The EA will be used to help determine whether to implement VARQ at Libby on an interim basis beginning in January 2003. An Environmental Impact Statement (EIS) is also being prepared for a long-term decision on implementation of VARQ, and is scheduled for completion in 2004 for implementation of a preferred alternative starting in 2005. Hydropower studies were prepared by the Corps of Engineers, North Pacific Division, Water Management Division, Power Branch. The studies include the regulation of projects in the Columbia River coordinated hydropower system that consist of federal, private, and public utility projects in the Columbia and Snake River Basins.

1.1 Purpose and Scope. The purpose of this study is to assess the hydropower impacts to the Columbia River federal hydropower system due to the implementation of VARQ flood control as compared to standard flood control for the EA, with and without fish operations. Two sets of studies, Flood Control Alternatives, and Detailed Operating Plan Scenarios were prepared and include combinations of CRT63 standard flood control, two VARQ flood control scenarios and other detailed operating criteria. Studies are prepared using the HYSSR model, a hydro system regulation model.

<u>Flood Control Alternatives</u>. The first set of studies includes six alternatives and operates all projects to standard flood control operations or to VARQ flood control, with Libby and Hungry Horse operating for fish in the July and August in four of the alternatives. The purpose of these studies is to determine the hydropower impacts due solely to different flood control operations. The first three scenarios use standard flood control and operate major projects on sturgeon template target elevations. For Alternative 1, the target elevations are standard flood control. For Alternatives 2 and 3, target elevations incorporate a Libby maximum flow of 25 kcfs (thousand cubic feet per second) and 35 kcfs, respectively. Alternatives 4, 5, and 6 are similar to Alternatives 1, 2, and 3, respectively but incorporate VARQ flood control. Details of each alternative are described in Section 3.0 and differences in system generation between alternatives are provided in Section 4.0.

<u>Detailed Operating Plan Scenarios</u>. The second set of studies, include four scenarios that evaluate the effect of specified power operations in addition to the flood control alternatives, and are called Detailed Operating Plan (DOP) Scenarios. The purpose of these studies is to determine the hydropower impacts due to VARQ and standard flood control operations at Libby and Hungry Horse when the system is modeled with planning criteria under the Pacific Northwest Coordination Agreement (PNCA).

The PNCA was ratified in 1964, and the owners of the projects in the coordinated hydropower system have agreed to plan, coordinate, and operate their systems for flood control and to optimize power production taking into consideration non-power uses. Operating criteria for non-federal projects are as submitted by project owners for the operating year 2002-2003, or as otherwise stated in this report. Project operation for federal projects are as described in this report.

For Scenario 7, standard flood control is used and Libby is operated to target flows that incorporate a Libby maximum outflow of 25 kcfs. Scenario 8 also uses standard flood control but incorporates a Libby maximum outflow of 35 kcfs. Scenarios 9 and 10 are similar to Scenarios 7 and 8, respectively, but use VARQ flood control. Details of each scenario are described in Section 3.0. Differences in the federal system generation between scenarios, ability to meet federal firm energy load carrying capability, ability to meet flow objectives at Priest Rapids and McNary, and impacts to Grand Coulee's operation when its flood control curves are adjusted for upstream power drafts, and differences in Grand Coulee elevations between VARQ and standard flood control studies are provided in Section 4.0.

1.2 Prior Studies. Prior to 1995, as part of the Columbia River System Operation Review, studies have been conducted to consider the hydropower impacts of various forms of the VARQ flood control requirements. A study entitled, "Status Report, Work to Date on the Development of the VARQ Flood Control Operation at Libby Dam and Hungry Horse Dam", dated January 1999 and prepared by the Corps of Engineers, Northwestern Division, was the latest published report regarding VARQ.

1.3 General Hydroregulation Assumptions. The Pacific Northwest reservoir system was modeled using the Corps' Hydro System Seasonal Regulation (HYSSR) model. HYSSR is a FORTRAN model with a monthly time step. There are 14 periods, one period for each month except April and August, which are split in half months. Model runs cover a 59-year period covering October, 1928 through September, 1987, except that input data for Alternatives 2, 3, 5, and 6, contain only 9 selected years of sturgeon template target elevation data, therefore output data for these years only are used. The Flood Control Scenarios are "refill" type studies, and start reservoirs full on October 1^{st} in every year. The DOP Scenarios are "continuous" type studies with reservoirs starting full on October 1^{st} in 1928 only. All generation output data provided reflects generation at federal projects only.

2.0 Input Data.

2.1 Flood Control. Standard and VARQ flood control data files were provided by the Corps, Hydrologic Engineering Branch, Northwestern Division. The standard flood control file was used for Alternatives 1, 2 and 3, and Scenarios 7 and 8. The VARQ flood control file was used for Alternatives 4, 5 and 6, and Scenarios 9 and 10. The file names are as follows:

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EISBA1F.txt      CRT63 standard flood control
EISVQ1F.txt      VARQ  flood control
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Details of Standard and VARQ Flood Control development are provided in the report, "Hydrologic Analysis of Upper Columbia Alternative Flood Control and Fish Operations on Columbia River System Including the VARQ Flood Control Plan at Libby and Hungry Horse", October 2002", prepared by the Corps, Northwestern Division.

2.2 Sturgeon Template Target Elevations. The sturgeon template target elevation input data consist of elevations for January through July for Mica, Duncan, Arrow, Libby, Hungry Horse, Grand Coulee, Brownlee, Dworshak, and John Day for selected years. The years that elevations were provided for are 1933, 1948, 1949, 1955, 1968, 1971, 1975, 1981, and 1986. Criteria for selection of these years are detailed in the report, "Local Effects of Alternative Operations at Libby Dam, Hydrologic Study for Upper Columbia EA", prepared by the Corps of Engineers, Seattle District. These files were used for Alternatives 2, 3, 5, and 6.

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EISBIOPBA1F.txt  CRT63 + Upper Columbia fish flows, 25 kcfs Libby Qmax
EISBIOPVQ1F.txt  VARQ  + Upper Columbia fish flows, 25 kcfs Libby Qmax
EISBIOPBA2F.txt  CRT63 + Upper Columbia fish flows, 35 kcfs Libby Qmax
EISBIOPVQ2F.txt  VARQ  + Upper Columbia fish flows, 35 kcfs Libby Qmax
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These target elevations were developed from a daily time step model and incorporate a maximum daily average outflow at Libby of 25 kcfs or 35 kcfs during the sturgeon flow period.

2.3 Sturgeon Template Flows. One set of sturgeon template flows were developed for each of the Scenarios 7, 8, 9 and 10. Sturgeon template flows consist of 59-years of target flows for Libby in January through July. Data for January through April were obtained from Hydrologic Engineering Branch. Sturgeon and bull trout target flows for May through July were computed by Power Branch. The tiered sturgeon volume objectives from Table 11 of the U.S. Fish and Wildlife Service's Biological Opinion were adjusted in March 2002 and were used as a basis for computing minimum flow requirements for sturgeon and bull trout in May through July. Adjustments were made to develop a more continuous relationship between runoff forecast and augmentation volume for use in this study. These adjustments, start dates for each of the 59-years, ramp rates for sturgeon flows, and bull trout minimum flows were provided by Seattle District, Corps of Engineers.

3.0 Description of Alternatives and Scenarios .

Ten alternatives and scenarios were developed. Details of each alternative or scenario are described below. Alternatives 1 through 6 are the Flood Control Alternatives where projects are operated to flood control elevations, and Scenarios 7 through 10 are DOP scenarios, where projects are operated with either VARQ or standard flood control as upper reservoir limits, fish flows, and hydropower operating criteria.

3.1 Alternative 1 Standard Flood Control without Fish Flows. This alternative is a 59-yr run in refill mode, and operates all projects on standard flood control. Flood control was computed based on the 1990-level forecasted volume inflows. Canadian flood control curves are based on a 5.1 Maf and 2.08 Maf flood control space allocation at Arrow and Mica, respectively.

3.2 Alternative 2 Standard Flood Control, 25 Kcfs. Projects are operated to the sturgeon template target elevations for January through July unless otherwise stated (9 selected years of target elevations were provided) reflecting standard flood control and a maximum regulated outflow at Libby of 25 kcfs. In all other periods, projects are operated to their upper rule curves unless otherwise stated below.

Libby. In June through August, if the June ending elevation is above El. 2439, then the reservoir is drafted linearly from the end of June to El. 2439 at the end of August. Libby will further draft in these periods in order to meet the bull trout minimum flow, and may draft below El. 2439 to meet this minimum flow. In some cases, the International Joint Commission's rules for Kootenay Lake will prevent draft from Libby, and this will take precedence. If the June ending elevation is below El. 2439, Libby will run to the bull trout minimum flow until it is above El. 2439. Then, the August end of month elevation is targeted at El. 2439.

Hungry Horse. In July, August 15, and August 31, the project drafts to El. 3550, 3545, and 3540 respectively for McNary flow objectives.

3.3 Alternative 3 Standard Flood Control, 35 Kcfs. Projects are operated to the sturgeon template target elevations reflecting standard flood control and a maximum regulated outflow at Libby of 35 kcfs. In July through August, Hungry Horse and Libby are operated with the same criteria as in Scenario 2.

3.4 Alternative 4 VARQ Flood Control without Fish Flows. Same as Alternative 1 but all projects are operated on VARQ flood control. VARQ flood control incorporates VARQ at Libby and Hungry Horse with associated adjustments made at Grand Coulee.

3.5 Alternative 5 VARQ Flood Control, 25 Kcfs. Same as Alternative 2, except the sturgeon template reflects VARQ flood control and a maximum regulated outflow at Libby of 25 kcfs.

3.6 Alternative 6 VARQ Flood Control, 35 Kcfs. Same as Alternative 3, except the sturgeon template reflects VARQ flood control and a maximum regulated outflow at Libby of 35 kcfs.

3.7 Scenario 7 DOP, Standard Flood Control, 25 Kcfs. This scenario is a 59-year continuous model run with standard flood control as upper limits to reservoir elevations, a fixed Canadian operation, and Libby is operated to sturgeon template flows in January through July that incorporates a Libby maximum flow of 25 kcfs. All other projects use PNCA 03 operating criteria except as described below. Another model run is made that incorporates Grand Coulee flood control curves and Variable Draft Limits adjusted for upstream power drafts. Comparisons are made between model runs without the power draft adjustments and with the power draft adjustments.

Flood Control and Grand Coulee Upper Rule Curve Adjustments. A hydroregulation was made using standard flood control as upper reservoir elevation limits. Reservoir storage contents from this hydroregulation contain a draft for power operation, and the reservoir storage contents for projects upstream of Grand Coulee are then used to compute adjusted upper rule curves for Grand Coulee. This procedure results in the adjusted Grand Coulee flood control curves to be higher than the original flood control curves. The original Grand Coulee curves are replaced by the adjusted curves and a new hydroregulation is run. The process is repeated until there are no changes to upstream power drafts. The purpose of this procedure is to provide modeling results that reflect real operations, and to show the impacts to Grand Coulee's operation resulting from the upper rule curve adjustments.

Load. The load will be the federal firm energy load carrying capability (FELCC) from the PNCA 2002-2003 (OY03) Final Regulation computed by the Northwest Power Pool (NWPP) (the NWPP prepares studies for the PNCA parties). The federal FELCC is the generation capability of the federal system in the low water year of August 1936 through July 1937. The FELCC reflects a regulation with Hungry Horse VARQ, but not Libby VARQ. This FELCC will be the load used for all sixty years. The regulation will include unlimited secondary generation.

Table 1. Federal FELCC (MW-mo)

Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep
617	6244	7551	7538	4824	5346	5958	6284	9260	8006	6924	7308	6276	5084

Critical Rule Curves. Critical Rule Curves are from the PNCA OY03 Final Regulation. The critical rule curves are the project ending elevations for a critical period regulation. For the PNCA 2003 studies, the critical period regulation is from August 1936 through July 1937. The ending elevations reflect the FELCC of the system.

Fish Spill. Fish spill for federal projects are as shown in Table 2 and are based on the Corps of Engineers, PNCA OY03 Data Submittal, which is based on the 2000 NMFS BiOp. The spill caps and percentages are developed based on meeting total dissolved gas standards, and fish passage criteria.

Table 2. Project Period Average Spill Cap (cfs) and Percent Spill of Regulated flow for use in Monthly Modeling

Project	Apr 1-15	Apr 16-30	May 1-31	June 1-30	July 1-31	Aug 1-15	Aug 16-31
L. Granite	16,467	19,000	19,000	12,667			
Little Goose	13,000	15,000	15,000	10,000			
L. Monumental	23,400	27,000	27,000	18,000			
Ice Harbor	62,833	72,500	72,500	72,500	72,500	72,500	72,500
McNary	34,000	85,000	85,000	85,000			
John Day	28,000	70,000	66,801	64,167	64,167	70,000	70,000
John Day %	12%	30%	29%	28%	28%	30%	30%
The Dalles	42,800	107,000	107,000	107,000	107,000	107,000	107,000
The Dalles%	40%	40%	40%	40%	40%	40%	40%
Bonneville (1)	34,750	86,688	85,292	82,500	82,683	84,375	86,875

Note: Spill caps and percentages are prorated for the number of spill days in the period.

Sturgeon Template Target Flows. This template consists of 59-years of January through July target flows for Libby. The template reflects standard flood control, sturgeon and bull trout flow objectives, and a maximum flow from Libby of 25 kcfs.

Canadian Treaty Projects Operation**.** Canadian Treaty projects, Mica, Duncan and Arrow, will be on their 2003 Assured Operating Plan (AOP03) operations including changes agreed to by the U.S. and Canadian Entities as described in the 2003 Detailed Operating Plan (DOP03). The AOP and DOP are developed in accordance with the Columbia River Treaty, an agreement between the United States and Canadian governments to coordinate the operation of the Columbia River. The Canadian Treaty projects are fixed to the operation resulting from the 59-year DOP Treaty Storage Regulation.

Libby. For January through June, Libby operates to the sturgeon template target flows, which incorporates standard flood control and a maximum outflow at Libby of 25 kcfs. In July and August, Libby was drafted to El. 2439 ft for McNary flow objectives. If the June ending elevation is above El. 2439, then the reservoir is drafted linearly from the end of June to El. 2439 at the end of August. Libby will further draft in these periods in order to meet the bull trout minimum flow, and may draft below El. 2439 to meet this minimum flow. In some cases, the International Joint Commission's rules for Kootenay Lake will prevent draft from Libby, and this will take precedence. If the June ending elevation is below El. 2439, Libby will run to the bull trout minimum flow until it is above El. 2439. Then, the August end of month elevation is targeted at El. 2439. The bull trout minimum flows in July and August range from 6 kcfs to 9 kcfs depending upon the April – August forecast volume at Libby. In September through November, Libby drafts for power and meets El. 2411 in December.

Grand Coulee. For Grand Coulee, pumping data was modeled based on the Bureau of Reclamation's PNCA OY03 Data Submittal. In January through March, the project operates for power to the draft limits of the higher of the Variable Draft Limits (VDLs) and the resident fish limits of El. 1260, 1250, and 1240 ft in January, February, and March, respectively. The VDLs were computed by the Bureau of Reclamation for this study and is based on standard flood control. VDLs were adjusted for upstream power drafts after the initial model run and incorporated into the final run. In December through May, Grand Coulee meets the Vernita Bar requirement, and augments for McNary and Priest Rapids flows in April 15, April 30, May, July, August 15, and August 31 to draft limits of El. 1280, 1280, 1280, 1285, 1280, and 1280 feet, respectively. In June, the project targets full or flood control. The project drafts for power in September, October, November and December, with draft limits for FELCC to Els.1283, 1283, 1275, and 1270 feet, respectively.

Hungry Horse. In all periods, minimum flow for Hungry Horse is the higher of the flow needed to meet Hungry Horse minimum local flows and Columbia Falls minimum flows as provided in the PNCA03 data submittal. All draft limits may be violated to meet these minimum flows. In January through March, draft for power to the higher of the Integrated Rule Curves (IRCs) and the VDLs. The IRCs are as submitted in the PNCA OY03 Data Submittal. The VDLs were computed by the Bureau of Reclamation for this study and is based on standard flood control. For the first half of April through June, the project is on minimum flow or flood control. In July, August 15, and August 31, the project drafts to El. 3550, 3545, and 3540 respectively for McNary flows. In September, October, November, and December, the project operates for power to draft limits of Els. 3545, 3545, 3542, and 3533 feet, respectively (minimum flows generally bring Hungry Horse below these power draft limits).

Brownlee. In January through April, operate to flood control. In May through July, target full at El. 2077 feet. For the first and second half of August, target El. 2068 and 2055 feet, respectively. In September, target 9 kcfs. In December, target El. 2070.0 feet.

Dworshak. In January through June the project operates to minimum flow or flood control. Dworshak drafts to meet Lower Granite target flows in July through August. In September through December, the project operates on minimum flow of 1300 cfs. The NMFS 2000 Biological opinion places priority on June refill over Dworshak meeting spring flow objectives at Lower Granite.

Lower Granite. Lower Granite flow objectives in July and August range from 50 kcfs to 55 kcfs and are based on the April through July volume forecast at Lower Granite. Flow objectives are based on recommendations contained in the 2000 NMFS BiOp.

Lower Snake Projects Minimum Operating Pool. The Lower Snake River projects operate as run-of-river projects, and run to MOP in April-August, except for Lower Granite that runs to MOP in April-October. The projects run to full pool in all other periods.

3.8 Scenario 8 DOP, Standard Flood Control, 35 Kcfs. Same as Scenario 7, but Libby sturgeon template target flows incorporate a maximum flow at Libby of 35 kcfs and standard flood control. A model run was made, Grand Coulee's flood control curves and VDL's were adjusted for upstream power drafts, then a final run was made.

3.9 Scenario 9 DOP, VARQ Flood Control, 25 Kcfs. Same as Scenario 7, but run with VARQ flood control as upper limits to reservoir elevations, run Libby to sturgeon template target flows in January through July that incorporates VARQ and a Libby maximum flow of 25 kcfs. A model run was made, Grand Coulee's flood control curves and VDL's were adjusted for upstream power drafts, then a final run was made.

3.10 Scenario 10 DOP, VARQ Flood Control, 35 Kcfs. Same as Scenario 9, but with VARQ flood control and sturgeon template flows for Libby maximum outflow of 35 kcfs and VARQ. A model run was made, Grand Coulee's flood control curves and VDL's were adjusted for upstream power drafts, then a final run was made.

4.0 Comparison of Alternatives and Scenarios.

Various combinations of comparisons were made for Flood Control Alternatives 1-6 to show differences in hydropower generation based on flood control only. Comparisons between DOP Scenarios 7-10 were also made to show differences in hydropower generation for projects operating for hydropower and fisheries operations. Comparisons were not made between the alternatives and the scenarios.

4.1 Alternative 4 Standard Flood Control without Fish Flows vs. Alternative 1 VARQ Flood Control without Fish Flows. Compare Alternative 4 that operates all projects on VARQ flood control without fish flows vs. Alternative 1 that operates all projects on standard flood control without fish flows. Flood control curves draft from January through April 30th to provide flood control space and then refill in May through July. VARQ flood control curves are generally higher than standard flood control curves during January through June, and both are full in July. In January through April 30, with Libby and Hungry Horse operated with VARQ, more water is held in the pool, thereby reducing generation. In May through July, more generation is produced with VARQ because the flood control elevations in May are higher with VARQ and need to pass more flow than standard flood control to get to the same July elevation. By using VARQ, the 59-year average annual loss in generation is 24 MW-mo and the percent difference is 0.1%. By using VARQ, the largest 59-year average month loss is in January and is 722 MW-mo, which is a 5% loss. The largest gain is in June, and is 700 Mw-mo with a 3.7% gain. Differences in generation for each year and period are shown in Table 3. There were no power generation differences in October through December.

Table 3. System Generation Differences (MW-mo), Alternative 4 Standard Flood Control without Fish Flows minus Alternative 1 VARQ Flood Control without Fish Flows

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1929	-257	-341	-490	-760	-443	920	386	24	35	0	0	-28
1930	-470	-444	-385	-1365	1491	590	252	-200	-111	8	61	-48
1931	25	-428	-454	-744	-459	585	311	-20	0	0	0	-48
1932	-1241	-825	-288	-132	-40	718	1385	48	-21	0	0	-24
1933	-934	17	-378	-106	-209	169	27	870	349	0	0	-17
1934	274	65	-126	-115	99	503	628	-1003	-329	-237	-80	-2
1935	-1186	93	-342	-561	-289	470	1877	-959	313	0	0	-26
1936	-110	-286	289	182	79	125	-250	-127	0	0	0	-19
1937	-64	-328	-962	-274	-1027	1202	989	-247	-440	-133	0	-28
1938	-838	-387	-367	-281	321	566	517	339	157	0	0	-5
1939	-378	-981	-237	-190	269	394	860	76	14	0	0	-18
1940	-814	-428	-11	-335	-759	1283	989	-1174	-92	0	0	-62
1941	-433	-460	-356	-24	-281	207	104	5	108	362	277	-47
1942	-694	-791	-604	-324	-614	1607	531	261	-122	0	0	-18
1943	-1292	-435	-350	173	35	316	599	946	277	0	0	2
1944	-71	-181	22	-969	-1961	766	310	-153	-109	0	0	-68
1945	-147	-465	-550	-484	1	937	497	-512	34	0	0	-38
1946	-1199	-912	-431	-423	258	507	1344	337	61	0	0	-33
1947	-1244	124	-354	295	28	412	1333	-94	-235	0	0	18
1948	-1136	-524	-726	-50	-318	469	-64	175	0	0	0	-165
1949	-1264	-392	-657	-180	175	492	1441	24	425	149	0	-5
1950	-1200	131	-5	74	84	-100	267	662	154	0	0	-7
1951	-511	33	30	-26	-268	280	977	-572	-85	0	0	3
1952	-1226	-441	-140	-151	208	647	1057	-112	65	0	0	-12
1953	-109	-765	-822	-743	-631	751	1030	75	-289	0	0	-55
1954	-853	-120	-4	-202	-489	215	441	216	6	1	0	-37
1955	-902	-345	-617	508	-627	430	623	61	-159	0	0	-74
1956	-50	-74	-361	264	266	55	175	49	-9	0	0	4
1957	-484	-467	-950	-759	-444	718	551	186	36	0	0	-85
1958	-138	-343	-586	-545	-448	546	613	36	0	0	-9	-31
1959	-1563	376	247	372	325	-19	380	676	-423	0	0	19
1960	-303	-952	-182	228	-211	11	1157	306	0	0	0	3
1961	-1335	-316	-141	-673	-327	499	590	349	116	0	0	-66
1962	-1268	-92	-178	-279	17	466	817	312	167	0	0	0
1963	-1349	-493	-193	-490	286	832	651	443	3	0	0	-17
1964	-698	-1004	-369	-837	-439	799	523	609	-109	0	0	-69
1965	-197	113	-52	326	83	-268	-278	919	177	0	0	44
1966	-1268	35	-280	-408	-383	879	857	64	-82	0	0	-12
1967	-1079	156	6	275	84	-71	269	765	-85	0	0	15
1968	2	-581	-7	-963	-590	494	583	51	-114	0	0	-24
1969	-1152	266	-205	-132	-25	384	636	325	165	0	38	24
1970	-132	-269	-142	-466	14	243	318	-50	0	0	0	-21
1971	-871	-191	-60	-208	-89	268	276	255	-17	3	0	-39
1972	-1020	135	-59	-1	-31	83	229	294	-118	-25	0	-35
1973	-791	-848	-510	-480	-693	737	1788	64	19	0	0	-11
1974	-61	44	163	106	-2	-324	288	1175	-276	-54	0	97
1975	-1369	-390	-201	-88	-82	465	730	-157	735	182	0	-45
1976	-1048	-841	-148	113	263	559	905	357	25	4	0	-1
1977	-75	-339	-80	-663	-977	216	127	39	21	22	2	-75
1978	-1271	-759	-29	-188	-320	663	1571	-68	105	0	0	-7
1979	-25	-316	-179	-374	-300	816	450	-732	0	0	0	-26
1980	-320	-771	-152	-699	131	465	787	-171	-17	0	0	-37
1981	-56	-990	-364	-971	-716	572	737	262	-46	-10	0	-59
1982	-394	-874	-105	-691	40	412	893	-70	-54	0	0	-40
1983	-1285	-835	-405	-996	-489	590	2072	554	2	0	0	-4
1984	-1276	-28	-327	-258	-13	412	651	529	0	0	0	-14
1985	-945	-257	-431	-32	-519	400	955	170	236	255	59	-6
1986	-1373	-107	62	-552	-1453	74	1897	380	71	0	0	-2
1987	-1171	-510	-483	-773	655	1142	641	-67	0	0	0	-42
AVE.	-722	-361	-271	-305	-199	484	700	115	9	8	5	-24
% **Diff**	**-5.0**	**-2.5**	**-1.7**	**-2.1**	**-1.3**	**2.6**	**3.7**	**1.1**	**0.1**	**0.1**	**0.1**	**0.1**

4.2 Alternative 5 VARQ Flood Control, 25 Kcfs vs. Alternative 2 Standard Flood Control, 25 Kcfs . For Libby maximum flow of 25 kcfs, Alternative 5 runs projects on sturgeon template target elevations and VARQ, and Alternative 2 runs the projects on sturgeon template target elevations for standard flood control. In general, there were generation losses in January through April 30, and generation gains in May through August. There were no power generation differences in October through December.

Table 4. System Generation Differences (MW-mo), Alternative 5 VARQ Flood Control, 25 Kcfs minus Alternative 2 Standard Flood Control, 25 Kcfs

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1933	-934	57	-412	-106	-209	129	37	-9	617	1340	6	-25
1948	-1136	-524	-689	-129	-318	176	-54	-16	13	196	6	-196
1949	-1219	-9	-577	-665	100	237	673	-437	1215	9	5	-83
1955	-743	-70	-291	129	-816	107	350	-21	787	1	0	-51
1968	2	-581	-7	-963	-590	298	549	-223	1171	0	0	-12
1971	-871	-191	-62	-200	-92	245	159	2	1007	32	0	-28
1975	-1344	-392	-221	-95	-84	437	230	-589	1235	10	5	-111
1981	-56	-939	-198	-876	-755	271	272	-192	1233	46	4	-84
1986	-1373	-72	51	-579	-1365	-222	981	370	2705	958	-3	49

4.3 Alternative 6 VARQ Flood Control, 35 Kcfs vs. Alternative 3 Standard Flood Control, 35 Kcfs. For Libby outflow limited to 35 kcfs, Alternative 6 runs projects on sturgeon template target elevations and VARQ, and Alternative 3 runs projects on sturgeon template target elevations and Standard Flood Control. There were no differences in power generation in October through December.

Table 5. System Generation Differences (MW-mo), Alternative 6 VARQ Flood Control, 35 Kcfs minus Alternative 3 Standard Flood Control, 35 Kcfs

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave.
1933	-934	17	-378	-106	-209	129	85	439	17	6	4	-65
1948	-1136	-524	-689	-129	-318	164	-50	389	0	0	0	-172
1949	-1219	-9	-577	-665	124	253	594	86	24	10	5	-93
1955	-743	-70	-291	129	-816	120	332	161	138	1	0	-63
1968	2	-581	-7	-963	-590	287	621	-300	1199	-2	-1	-13
1971	-871	-191	-62	-200	-92	250	159	263	249	37	0	-37
1975	-1344	-392	-221	-95	-84	437	259	-234	65	11	5	-128
1981	-56	-968	-171	-876	-915	358	113	26	287	251	9	-109
1986	-1373	-72	51	-579	-1365	-262	1007	945	857	694	0	8

4.4 Alternative 2 Standard Flood Control, 25 Kcfs vs. Alternative 1 Standard Flood Control without Fish Flows. For Standard Flood Control, Alternative 2 runs on sturgeon template target elevations with Libby maximum outflow of 25 kcfs, Alternative 1 runs on Standard Flood Control without fish flows. There was an increase in generation in May through August and a loss of generation in September, with an average annual gain in system energy for the 9 years compared.

Table 6. System Generation Differences (MW-mo), Alternative 2 Standard Flood Control, 25 Kcfs minus Alternative 1 Standard Flood Control without Fish Flows

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1933	0	0	0	0	0	64	843	830	-112	1177	-538	144
1948	0	0	0	0	0	290	0	576	1119	2361	-330	189
1949	366	-20	-197	-145	0	279	1418	967	605	1598	-164	306
1955	0	0	0	0	0	297	154	52	673	3011	-300	170
1968	0	0	0	0	0	530	-50	143	1169	2654	-854	140
1971	0	0	3	-6	0	22	143	241	282	2991	-365	139
1975	31	-6	-25	5	1	44	1426	-391	673	1236	-611	118
1981	0	0	0	0	0	276	472	385	92	2279	-403	159
1986	0	0	0	58	-12	442	821	242	-78	1318	-366	148

4.5 Alternative 3 Standard Flood Control, 35 Kcfs vs. Alternative 1 Standard Flood Control without Fish Flows. For Standard Flood Control, Alternative 3 runs on sturgeon template target elevations with Libby capacity of 35 kcfs, Alternative 1 runs on Standard Flood Control. There was an increase in generation in May through August and a loss of generation in September, with an average annual gain in system energy for the 9 years compared. Results are similar to the Alternatives 2 – 1 comparison.

Table 7. System Generation Differences (MW-mo), Alternative 3 Standard Flood Control, 35 Kcfs minus Alternative 1 Standard Flood Control without Fish Flows

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1933	0	0	0	0	0	64	881	843	-177	1177	-538	145
1948	0	0	0	0	0	302	-5	558	1119	2361	-330	188
1949	366	-20	-197	-145	0	373	1388	958	604	1597	-164	310
1955	0	0	0	0	0	297	168	47	654	3010	-300	170
1968	0	0	0	0	0	644	-62	4	1160	2656	-854	136
1971	0	0	3	-6	0	22	163	225	254	2987	-365	138
1975	31	-6	-25	5	1	44	1409	-261	884	1235	-612	136
1981	0	0	0	0	0	374	646	335	-60	2063	-407	162
1986	0	0	0	58	-12	544	816	132	569	1582	-368	185

4.6 Alternative 5 VARQ Flood Control, 25 Kcfs vs. Alternative 4 VARQ Flood Control without Fish Flows. For VARQ Flood Control, Alternative 5 runs on sturgeon template target elevations with Libby maximum outflow of 25 kcfs, Alternative 4 runs on VARQ Flood Control. There were no power generation differences in October through December. The largest difference was a gain in August and was roughly a 25% gain.

Table 8. System Generation Differences (MW-mo), Alternative 5 VARQ Flood Control, 25 Kcfs minus Alternative 4 VARQ Flood Control without Fish Flows.

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1933	0	40	-34	0	0	24	854	-49	157	2517	-532	136
1948	0	0	37	-79	0	-3	9	386	1132	2557	-323	159
1949	411	364	-117	-630	-75	25	650	505	1395	1458	-159	229
1955	159	275	326	-379	-189	-26	-119	-30	1620	3012	-300	193
1968	0	0	0	0	0	334	-84	-131	2454	2655	-854	151
1971	0	0	2	2	-3	-1	26	-12	1305	3020	-365	150
1975	56	-8	-45	-2	-1	16	926	-823	1174	1065	-606	52
1981	0	51	166	95	-39	-25	8	-69	1370	2334	-399	134
1986	0	35	-11	32	76	147	-95	232	2556	2276	-368	200

4.7 Alternative 6 VARQ Flood Control, 35 Kcfs vs. Alternative 4 VARQ Flood Control without Fish Flows. For VARQ Flood Control, Alternative 6 runs on sturgeon template target elevations with Libby maximum outflow of 35 kcfs, Alternative 4 runs on VARQ Flood Control. There were no power generation differences in October through December. Results were similar to the comparison between Alternatives 5 – 4, but there was more generation in July and less in the first half of August.

Table 9. System Generation Differences (MW-mo), Alternative 6 VARQ Flood Control, 35 Kcfs minus Alternative 4 VARQ Flood Control without Fish Flows

	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
1933	0	0	0	0	0	24	940	412	-508	1183	-534	98
1948	0	0	37	-79	0	-3	9	773	1119	2361	-330	182
1949	411	364	-117	-630	-51	135	541	1020	203	1458	-159	223
1955	159	275	326	-379	-189	-13	-123	148	952	3011	-300	180
1968	0	0	0	0	0	437	-25	-347	2473	2654	-854	147
1971	0	0	2	2	-3	4	46	233	520	3021	-365	140
1975	56	-8	-45	-2	-1	16	938	-338	215	1064	-607	54
1981	0	21	194	95	-199	160	23	99	273	2324	-398	112
1986	0	35	-11	32	76	208	-74	696	1355	2276	-368	196

4.8 Scenario 9 DOP, VARQ Flood Control, 25 Kcfs vs. Scenario 7 DOP, Standard Flood Control, 25 Kcfs. For Libby maximum outflow of 25 kcfs, Scenario 9 runs Libby on sturgeon template flows with VARQ Flood Control, and Scenario 7 runs Libby on sturgeon template flows with Standard Flood Control. The rest of the system is operated with criteria as described in Section 3.7. There was an annual average generation increase of 8 MW-mo. with losses in January and February and gains in other months due to VARQ. Percent exceedance curves for Grand Coulee's April 30 Elevation for Scenarios 7 and 9 are shown in Chart 1.

Table 10. System Generation Differences (MW-mo), Scenario 9 DOP, VARQ, 25 Kcfs minus Scenario 7 DOP, Standard Flood Control, 25 Kcfs

	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
28-29	0	0	0	0	-94	1	1	-26	-62	149	29	-11	0	0	0
29-30	0	0	0	-391	0	2	2	-327	207	110	181	99	-1	0	0
30-31	-1	0	0	16	0	0	0	-125	-36	0	54	0	5	0	-2
31-32	-1	0	37	-337	-254	-14	-2786	133	588	429	291	330	279	0	-23
32-33	1	-1	0	-892	263	11	181	-202	75	21	831	4	311	-79	31
33-34	-43	0	0	-4	-38	27	33	-161	542	427	-42	-184	-12	-1	58
34-35	1	0	-1	-1702	-393	73	282	-392	281	1772	-1648	75	7	0	-135
35-36	-1	0	0	675	-2	-1	-2	-403	203	143	-95	-136	1	-1	54
36-37	-1	0	0	-70	0	-244	-14	1	-16	139	13	-1	0	0	-15
37-38	0	0	0	-652	-309	196	213	-297	451	-63	374	4	0	1	-3
38-39	-1	-1	-1	0	-407	-34	5	-332	252	-74	368	520	-1	1	16
39-40	0	0	0	-273	-176	76	1	-397	296	447	-889	-4	-1	0	-59
40-41	0	-1	-1	507	14	12	18	2	11	-133	120	271	28	0	58
41-42	1	78	269	-493	-335	15	11	-281	167	302	-14	141	1419	1	53
42-43	0	0	0	-1353	-465	127	415	317	126	382	901	-37	218	0	14
43-44	0	0	0	-85	0	-1	-7	9	43	-76	-3	52	39	0	-6
44-45	0	0	0	0	0	0	0	0	103	45	-114	0	0	0	2
45-46	0	0	0	-1319	-769	-19	57	304	618	324	545	590	274	0	0
46-47	-1	1	16	-686	-270	86	-219	-95	153	237	215	989	0	-1	7
47-48	328	0	0	-1066	-470	6	-87	-262	181	137	285	0	3	0	-64
48-49	0	0	0	-908	-3	-197	18	-690	221	456	8	-3	-245	1	-73
49-50	0	0	161	-653	220	456	20	68	-80	172	740	12	335	0	102
50-51	73	0	0	-496	39	98	-52	-11	235	692	-272	19	4	0	29
51-52	0	0	0	-882	-390	-59	-9	46	253	210	482	534	0	-1	-8
52-53	0	0	-1	239	-736	-224	211	-302	100	424	78	163	749	0	24
53-54	0	2	32	-717	-54	-7	48	-313	-66	151	284	49	28	923	37
54-55	0	0	0	-548	4	-7	5	-135	90	353	68	18	10	0	-7
55-56	179	0	0	-179	-184	-37	-104	158	47	18	107	592	187	-1	30
56-57	27	0	16	-681	-855	-125	-128	-99	451	744	326	259	0	0	-6
57-58	-1	-1	0	-5	-316	-49	7	-457	229	489	-2	25	0	0	10
58-59	-1	4	7	-713	126	-81	34	413	164	115	278	226	76	19	24
59-60	0	0	0	-845	-234	-72	410	-83	144	545	479	4	-2	0	15
60-61	1	0	1	-947	-260	-6	-208	-304	348	541	339	304	221	0	1
61-62	0	0	0	-1055	-298	55	3	22	166	528	519	284	115	0	10
62-63	0	0	0	-1508	-119	-13	-45	-117	657	219	371	752	287	-1	3
63-64	0	0	0	-436	-1048	-18	289	-456	364	140	222	172	1616	70	8
64-65	0	0	0	-170	28	187	-259	71	-188	-121	-49	266	-4	270	0
65-66	354	0	0	-926	160	-163	326	-306	474	443	1	3	-1	0	29
66-67	0	0	-1	-642	108	104	-124	147	17	32	127	1036	32	169	38
67-68	0	0	0	-314	-417	47	-62	-146	315	278	200	-21	-54	0	-2
68-69	0	0	0	-737	64	85	-220	-35	347	209	88	268	-1	0	5
69-70	0	-1	0	-91	-178	-8	8	32	-60	148	181	117	-1	0	5
70-71	1	0	-1	-896	-173	-157	-25	18	267	274	101	23	604	346	6
71-72	86	0	0	-1014	-144	157	112	98	129	322	194	352	-12	-72	-5
72-73	0	0	0	-589	-308	12	-30	-379	89	267	64	94	257	1	-41
73-74	-1	0	390	-195	26	190	72	171	-344	-12	551	-113	934	245	115
74-75	1	0	0	-1054	-246	115	4	-105	371	525	-210	-333	11	0	-59
75-76	548	418	0	-722	-710	28	192	202	386	338	215	460	385	127	103
76-77	0	0	0	0	0	0	2	0	24	-201	29	2	-1	0	-12
77-78	0	-1	0	-899	-659	108	287	-516	146	-196	1494	-209	1	188	-3
78-79	1	0	0	406	-14	-87	214	58	-78	27	1	0	-1	0	32
79-80	0	0	0	-67	-259	-2	-57	-197	-86	593	72	8	0	1	10
80-81	1	0	2	-401	-1056	-17	-72	-374	521	592	-10	108	1115	1	1
81-82	0	0	103	-340	-770	-129	-153	40	424	98	654	92	573	0	26
82-83	0	0	0	-954	-649	160	-115	-544	196	346	999	460	534	-1	22
83-84	-1	29	64	-1263	134	-72	301	-147	243	37	602	571	110	0	15
84-85	0	62	120	-905	-34	181	-346	-456	197	533	-848	-6	-436	0	-109
85-86	-1	377	-1	-350	-312	180	-198	-668	-159	546	1446	698	1	0	136
86-87	1	0	-1	-767	75	-19	-175	-581	571	236	35	27	792	-1	13
AVE.	**26**	**16**	**20**	**-531**	**-222**	**15**	**-29**	**-142**	**191**	**268**	**192**	**169**	**182**	**37**	**8**
%Diff	**0.4**	**0.2**	**0.2**	**-4.9**	**-2.4**	**0.2**	**-.31**	**-1.4**	**1.6**	**2.1**	**2.0**	**1.9**	**2.6**	**0.7**	**0**

The difference in Grand Coulee's elevation between Scenario 9 minus Scenario 7 is shown in Table 11. A negative sign in Table 11 indicates that Grand Coulee's elevation is lower in the VARQ scenario than Standard Flood Control scenario.

Table 11. Grand Coulee Elevation Difference- Scenario 9 DOP, VARQ, 25 Kcfs minus Scenario 7 DOP, Standard Flood Control, 25 Kcfs

	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
28-29	0	0	0	-0.7	0	0	0	0	0	0	0	0	0	0	0
29-30	-1.9	-0.2	-0.1	0	0	-0.1	-0.1	0	0	0	0	0	0	0.1	-0.2
30-31	0	0	0.2	0	0	0.1	0.1	-0.3	0	0	0	0	0	0	0
31-32	0	0.3	0	-11.4	-20.4	-20.6	0	0	1.7	1	1.3	0	0	0	-4
32-33	0.1	0.3	0.8	0	-2.4	-2.6	-2.7	-1.6	-1.8	1.6	0	2.3	0	0	-0.5
33-34	0	0	0	0	0.1	-0.3	-1.1	0	-0.6	0	0	0	0	-0.1	-0.1
34-35	-1.9	-6.2	-5.9	0	0	-2.5	-2.6	-1.7	-1.7	-16.3	0	0	0	0.1	-3
35-36	1.7	3.2	3.6	-0.7	-0.9	-0.6	-0.6	0	0	0	0	0	0	0	0.5
36-37	0	-0.1	-0.4	0	0	-3.1	-4.5	-4	0	0	0	0	0	0	-0.7
37-38	0.2	0.3	0.7	0	0	-1.1	-2.6	0	0.2	5.5	0	0	0	0	0.3
38-39	0.4	0.7	2.7	0.8	-3.4	-2.9	-4.3	-3.8	-3.7	-1.3	0	0	0	0	-0.9
39-40	0.2	0.3	1.1	0	1.1	0	0	-0.5	-2.3	0	0	0	0	0.2	0
40-41	2.2	4.9	4.6	0	0	0	0	0	0	0	0	0	0	0	0.9
41-42	0.4	0.6	0	0	1.4	0	0	0	0	0	-0.6	1.5	0	0	0.2
42-43	0.1	0.1	0.3	0	0	0	0	0	-0.3	-0.5	0	1.7	0	0	0.1
43-44	-0.1	-0.1	-0.6	-0.1	-0.1	-0.1	0	0	0	0	0	0	0	0	-0.1
44-45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45-46	0	-0.1	-0.3	0	0	-0.4	0	0	0.7	5.8	0	0	0	0	0.4
46-47	0	0.1	0	0	0	-4	-3.6	-2.5	1.2	0.8	2.8	0	0	0	-0.2
47-48	0	0	0	0	2.7	-4.4	-3.3	-2.9	0.9	0	0	0	0	0	-0.4
48-49	0	0	0	0	0	-2.6	-4.4	-3.7	-1.2	0	0	0	0	0.2	-0.6
49-50	0.5	0.8	1.9	0	0	-0.1	0	0	0	-0.2	0	2.5	0	0	0.4
50-51	0	0	0	0	0	0	0	0	2.4	-3.4	0	0	0	0	0
51-52	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0.1	0
52-53	1.5	2.8	2.3	0	0	-2.2	-3.9	-4.2	-3.5	0.5	0	3.9	0	0	0
53-54	0	0.1	0	0	0	0	0	0	1.4	2.8	0	0	0	0	0.3
54-55	0	0	0	-0.1	-0.1	0	0	0	0	0.2	0	0	0	0	0
55-56	0	0	0	0	0	-0.9	-1	0	-0.3	0	0	0	0	0	-0.1
56-57	0	1.6	0	0	7.8	0.8	0	0	0	0	0	0	0	0.1	0.8
57-58	0.2	0.3	0.4	0	2.2	-2.1	-2.5	-2.8	0.2	0	0	0	0	0	-0.1
58-59	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	0.4
59-60	0	0	0	11.7	0	-0.6	-4	-3	2.5	0	0	0	0	0	0.8
60-61	0.2	0.3	1	0	-2.9	-4.4	-4.7	-3.9	-1.3	0	0	0	0	0	-0.9
61-62	0	0	0	0	0.6	0	0	0	0.9	2.9	0	0	0	0	0.3
62-63	0	0	0	4.5	1.1	0	0	0	-0.7	0	0	0	0	0.1	0.5
63-64	0	0.2	0.5	0	0	0.1	-2.7	-3.1	-2.9	0.8	0	3.3	0	0	-0.2
64-65	0	0	0	0	0	-0.9	0	0	0	2.1	0	0	0	0.1	0
65-66	0	0	0	0	0	0	-3.3	-3.6	-2	0	0	0	0	0	-0.5
66-67	0.2	0.3	0.9	0	0	-2.2	-1	0	0.5	0.6	0	0	0	0	-0.1
67-68	0	0	0	0	-0.7	-2	-2.6	-2.8	-1.8	0	0	0	0	0	-0.6
68-69	0	0	0	0	0.8	-1.9	0	0	-0.4	0	0	0	0	0	-0.1
69-70	0.1	0.3	0.7	0	-0.3	-0.3	-1.5	-1.7	-1.2	0	0	0	0	0	-0.2
70-71	0	-2.1	-2	0	0	0.1	0	0	0.4	1.6	0	0	0	0.1	-0.2
71-72	0	0	0	0	0	0	0	0	4.3	0	0	0	0.5	0	0.3
72-73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73-74	2.4	4.2	0	0	0	-0.1	0	0	0	4.1	0	0	0	0.1	0.9
74-75	0.2	0.4	1	0	0	0	0	0	0	-3.8	0	0	0	0.1	-0.2
75-76	0	0	0	0	1.3	0	0	0	0.8	0	0	0	0	0	0.2
76-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77-78	0.1	0.2	0.9	0	0	0	-3.9	-3.5	-3.5	6	0	0	0	0	0
78-79	0.5	0.9	3	-3.1	-3.5	-2.1	-4.6	-7.6	-2.6	0	0	0	0	0	-1.1
79-80	0	0	0	1.6	-0.7	-0.7	-1.6	-1.9	2.2	0	0	0	0	0	0.1
80-81	0	0	0	0	2.1	0	0	0	-0.8	0	0	0.6	0	0.1	0.1
81-82	0.1	0.2	0	0	0	0	0	0	1.9	8	0	2.3	0	0	0.9
82-83	0	0	0	0	0	-3.8	-3.4	-0.9	0.2	7.2	5	3.8	0	0	0.7
83-84	0.1	0	0	0	-2.6	-1.2	-4	-4.2	-1.6	0.7	0	0	0	0	-0.7
84-85	0.2	0	0	0	0	-2.9	-1.1	-0.8	-1.1	0	0	0	0	0.2	-0.4
85-86	1.9	1.8	3.5	-3.4	0	-7.5	-9	-9.6	-5.5	0	0	0	0	0.1	-1.5
86-87	0.4	0.8	2.2	2.1	0	0	0	0	0	0	0	0	0	0	0.5
AVE.	0.2	0.3	0.4	0	-0.2	-1.4	-1.5	-1.3	-0.3	0.5	0.1	0.3	0.1	0	-0.1

4.9 Scenario 10 DOP, VARQ Flood Control, 35 Kcfs vs. Scenario 8 DOP, Standard Flood Control, 35 Kcfs. For Libby maximum outflow of 35 kcfs, Scenario 10 runs Libby to sturgeon template flows with VARQ Flood Control, and Scenario 8 runs Libby to sturgeon template flows with Standard Flood Control. The rest of the system is operated with criteria as described in Section 3.7. There was an annual average generation increase of 9 MW-mo. with losses in January and February and gains in other months due to VARQ. Percent exceedance curves for Grand Coulee's April 30 Elevation for Scenarios 8 and 10 are shown in Chart 2.

Table 12. System Generation Differences (MW-mo), Scenario 10 DOP, VARQ Flood Control, 35 Kcfs minus Scenario 8 DOP, VARQ Flood Control, 35 Kcfs

	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
28-29	0	0	0	0	-94	1	1	-26	-62	149	29	-17	-1	0	0
29-30	0	1	0	-377	0	2	2	-324	200	91	173	149	0	-1	0
30-31	1	-1	0	13	0	0	0	-115	-28	0	75	-4	4	0	0
31-32	0	0	36	-337	-254	-14	-2788	133	588	552	218	334	198	0	-22
32-33	0	0	-1	-847	263	11	170	-201	75	36	854	0	247	-3	41
33-34	-120	0	0	-12	-38	27	33	-161	542	356	-139	-74	-12	0	42
34-35	0	0	0	-1550	-417	75	262	-408	268	1776	-1643	15	7	-1	-129
35-36	-1	0	0	681	-2	-2	-2	-408	180	180	-98	-187	0	1	53
36-37	-1	0	0	-80	0	-136	-21	-6	-145	150	9	0	0	-1	-18
37-38	0	0	0	-653	-311	196	214	-297	449	-62	373	4	0	0	-3
38-39	-2	0	1	0	-438	-27	-5	-328	251	-53	346	543	0	0	15
39-40	0	0	0	-272	-176	76	1	-397	279	611	-1082	-5	0	1	-63
40-41	-1	-1	1	468	15	12	19	-1	9	-66	139	268	162	0	66
41-42	0	77	269	-493	-335	15	11	-281	149	263	40	187	1331	0	50
42-43	0	0	0	-1322	-465	127	417	317	126	384	878	-39	186	0	14
43-44	0	0	1	-62	1	0	33	8	72	-74	-3	52	61	0	1
44-45	0	-5	0	1	1	2	2	2	77	89	-90	0	0	-1	6
45-46	1	0	0	-1316	-791	-20	57	304	618	319	554	541	228	0	-5
46-47	-2	0	49	-686	-270	77	-70	33	237	318	70	697	-1	0	10
47-48	342	0	0	-1066	-470	6	-87	-262	431	133	79	0	21	0	-59
48-49	0	0	0	-908	-3	-197	18	-690	288	481	-14	-6	-387	1	-73
49-50	0	0	180	-721	256	439	86	60	-99	228	695	3	294	0	99
50-51	80	0	0	-496	39	98	-52	-11	234	725	-249	17	-28	0	32
51-52	-48	0	0	-882	-390	-59	-9	67	384	241	293	444	0	0	-17
52-53	1	0	0	227	-743	-225	207	-287	131	416	60	119	706	0	19
53-54	-1	1	55	-717	-54	-7	48	-313	-66	180	265	-26	25	1012	44
54-55	0	0	0	-548	4	-7	5	-135	-70	371	146	-18	475	0	4
55-56	0	0	0	-179	-184	-37	123	215	33	5	44	524	156	0	15
56-57	44	0	8	-679	-856	-125	-128	-99	453	701	326	310	0	0	-7
57-58	0	-1	0	-18	-242	-75	-8	-459	234	476	-5	-31	-1	1	10
58-59	0	-6	-11	-713	126	-81	183	476	115	140	281	171	7	41	25
59-60	0	0	0	-845	-234	-72	409	-83	144	544	5	9	-1	0	-24
60-61	1	0	0	-607	-193	60	-207	-307	349	507	326	355	273	0	41
61-62	0	0	0	-1055	-298	55	3	22	146	490	534	344	147	0	10
62-63	0	0	0	-1508	-119	-13	-45	-117	663	206	204	734	861	0	12
63-64	-1	-1	0	-429	-1045	-18	290	-456	379	130	207	173	1541	93	7
64-65	0	0	0	-156	28	173	76	62	-279	-132	306	207	-8	199	25
65-66	63	0	0	-926	160	-163	326	-306	473	443	0	4	0	0	5
66-67	0	0	0	-641	108	103	215	-12	-53	35	184	852	-13	220	39
67-68	0	0	0	-314	-417	47	-62	-146	409	352	147	-11	-114	-147	-7
68-69	0	0	0	-737	64	85	-146	-40	335	245	-59	709	0	0	16
69-70	1	2	0	-100	-179	-7	11	3	-56	147	195	125	0	0	6
70-71	0	0	0	-594	-192	-156	14	-2	315	148	34	22	4	378	-4
71-72	84	0	0	-1014	-144	157	232	84	110	343	21	12	22	565	24
72-73	0	0	0	-589	-308	12	-30	-305	77	236	32	3	286	0	-46
73-74	-1	0	423	-194	26	187	343	168	-408	19	594	-5	910	0	112
74-75	1	0	-1	-1028	-245	115	-4	-75	371	618	-344	-333	-4	1	-59
75-76	448	445	72	-722	-710	28	192	202	395	359	217	450	317	122	102
76-77	0	0	0	0	0	0	0	7	39	-206	20	1	0	-1	-12
77-78	1	0	0	-842	-659	111	287	-516	152	-133	1364	-242	-1	187	-4
78-79	0	0	0	506	-14	-87	226	55	-82	34	1	-2	-1	0	41
79-80	0	0	0	-61	-264	-3	-59	-197	-99	621	0	-17	1	-1	4
80-81	1	-1	-4	-402	-1056	-17	-53	-378	415	553	159	159	1070	0	3
81-82	0	0	119	-340	-767	-129	-153	40	424	228	498	98	609	0	27
82-83	0	0	0	-954	-649	160	-116	-544	196	349	952	454	494	0	16
83-84	-1	53	118	-1264	131	-70	298	-146	234	-1	617	504	97	0	16
84-85	-1	74	142	-905	-34	181	-344	-458	180	515	-799	-6	-435	0	-105
85-86	1	371	0	-359	-312	179	-199	-670	-129	373	1254	837	1	0	113
86-87	-1	0	0	-573	178	-5	-194	-517	540	248	35	40	770	0	39
AVE.	**15**	**17**	**24**	**-511**	**-219**	**18**	**0**	**-139**	**189**	**277**	**158**	**160**	**178**	**45**	**9**
% Diff	**0.3**	**0.3**	**0.3**	**-4.7**	**-2.3**	**.2**	**0**	**-1.4**	**1.5**	**2.2**	**1.7**	**1.8**	**2.5**	**0.9**	**0.1**

The difference in Grand Coulee's elevation between Scenario 10 minus Scenario 8 is shown in Table 13. A negative sign in Table 13 indicates that Grand Coulee's elevation is lower in the VARQ scenario than Standard Flood Control scenario.

Table 13 Grand Coulee Elevation Difference, Scenario 10 DOP, VARQ Flood Control, 35 Kcfs minus Scenario 8 DOP, VARQ Flood Control, 35 Kcfs

	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep	Ave
28-29	0	0	0	-0.7	0	0	0	0	0	0	0	0	0	0	0
29-30	0	0	0	0	0	-0.1	-0.1	0	0	0	0	0	0	0	0
30-31	0	0.1	0.1	0	0	0.1	0.1	-0.3	0	0	0	0	0	0	0
31-32	0	0.3	0	-11.4	-20.4	-20.6	0	0	1.7	1	1.3	0	0	0	-4
32-33	0.2	0.4	1	0	-2.4	-2.6	-2.7	-1.6	-1.8	1.6	0	1.9	0	0	-0.4
33-34	0	0	0	0	0.1	-0.3	-1.1	0	-0.6	0	0	0	0	-0.1	-0.1
34-35	-1.7	-3.2	-5.2	0	0	-2.5	-2.6	-1.7	-1.7	-16.3	0	0	0	0.1	-2.7
35-36	1.7	3.2	3.7	-0.8	-0.9	-0.7	-0.6	0	0	0	0	0	0	0	0.5
36-37	-0.1	-0.1	-0.4	0	0	-5	-6.4	-5.8	0	0	0	0	0	0	-1
37-38	0.1	0.3	0.7	0	0	-1.1	-2.6	0	0.2	5.5	0	0	0	0	0.4
38-39	0.3	0.7	2.6	1.3	-3.2	-2.9	-4.3	-3.8	-3.7	-1.3	0	0	0	0	-0.9
39-40	0.2	0.3	1.1	0	1.1	0	0	-0.5	-2.3	0	0	0	0	0.2	0
40-41	2.3	5.1	4.5	0	0	0	0	0	0	0	0	0	0	0	1
41-42	0.3	0.6	0	0	1.4	0	0	0	0	0	-0.7	1.6	0	0	0.2
42-43	0.1	3.1	0.5	0	0	0	0	0	-0.3	-0.5	0	1.5	0	0	0.3
43-44	0	-0.1	-0.3	0.3	0.3	0.3	0	0	0	0	0	0	0	0	0
44-45	3.3	1.5	0.3	0.5	0.5	0.6	0.5	0.5	0.8	0	0	0	0	0	0.7
45-46	-0.1	-0.1	-0.4	0	0	-0.4	0	0	0.7	5.8	0	0	0	0	0.5
46-47	0	0.1	0	0	0	-3.8	-3.2	-2.4	1.2	0.8	1.3	0	0	0	-0.2
47-48	0	0	0	0	2.7	-4.4	-3.3	-2.9	0.9	0	0	0	0	0	-0.4
48-49	0	0	0	0	0	-2.6	-4.4	-3.7	-1.2	0	0	0	0	0.2	-0.6
49-50	0.4	0.9	1.2	0	0	-0.1	0	0	0	-0.2	0	2.2	0	0	0.3
50-51	0	0	0	0	0	0	0	0	2.4	-3.4	0	0	0	0	0
51-52	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0.1	0
52-53	1.5	2.8	2.1	0	0	-2.2	-3.9	-4.2	-3.5	0.5	0	4	0	0	0
53-54	0.1	0.1	0	0	0	0	0	0	1.4	2.8	0	0	0	0	0.3
54-55	0	0	0	-0.1	-0.1	0	0	0	0	0.2	0	0	0	0	0
55-56	0	0	0	0	0	-0.9	-1	0	-0.3	0	0	0	0	0	-0.1
56-57	0	0	0	0	7.8	0.8	0	0	0	0	0	0	0	0.1	0.7
57-58	0.1	1.6	0.5	0	2.2	-2.1	-2.5	-2.8	0.2	0	0	0	0	0	0
58-59	0	0	0	0	0	0	0	0	0	4.1	0.4	0	0	0	0.4
59-60	0	0	0	11.7	0	-0.6	-4	-3	2.5	0	0	0	0	0.1	0.8
60-61	0.6	1.3	3.7	0	-2.9	-4.4	-4.7	-3.9	-1.3	0	0	0	0	0	-0.6
61-62	0	0	0	0	0.6	0	0	0	0.9	2.9	0	0	0	0	0.3
62-63	0	0	0	4.5	1.1	0	0	0	-0.7	0	0	0	0	0.1	0.5
63-64	0.1	0.2	0.5	0	0	0.1	-2.7	-3.1	-2.9	0.8	0	3.7	0	0	-0.1
64-65	0	0	0	0	0	-0.1	0	0	0	2.1	0	0	0	0.1	0.1
65-66	0	0	0	0	0	0	-3.3	-3.6	-2	0	0	0	0	0	-0.5
66-67	0.1	0.3	0.9	0	0	-2.2	-1	0	0.5	0.6	0	0	0	0	0
67-68	0	0	0	0	-0.7	-2	-2.6	-2.8	-1.8	0	0	0	0	0	-0.6
68-69	0	0	0	0	0.8	-1.9	0	0	-0.4	0	0	0	0	0	-0.1
69-70	0.2	0.2	0.6	0	-0.3	-0.3	-1.5	-1.7	-1.2	0	0	0	0	0	-0.2
70-71	1.1	2.1	0.3	0	0	0.1	0	0	0.4	1.6	0	0	0	0.1	0.5
71-72	0	0	0	0	0	0	0	0	4.3	0	0	0	0	0	0.3
72-73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73-74	2.4	4.4	0	0	0	0	0.1	0	0	4.1	0	0	0	0.1	0.9
74-75	0.2	0.5	1.3	0	0	0	0	0	0	-3.8	0	0	0	0.1	-0.1
75-76	0	0	0	0	1.3	0	0	0	0.8	0	0	0	0	0	0.2
76-77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77-78	0.1	0.2	1.1	0	0	0	-3.9	-3.5	-3.5	6	0	0	0	0	0.1
78-79	0.6	1.1	3.6	-3.1	-3.5	-2.1	-4.7	-7.7	-2.6	0	0	0	0	0	-1
79-80	0	0	0	1.6	-0.7	-0.7	-1.6	-1.9	2.2	0	0	0	0	0	0.1
80-81	0	0	0	0	2.1	0	0	0	-0.8	0	0	1.7	0	0	0.2
81-82	0.1	0.2	0	0	0	0	0	0	1.9	8	0	2.6	0	0	1
82-83	0	0	0	0	0	-3.8	-3.4	-0.9	0.2	7.2	5	3.5	0	0	0.7
83-84	0.1	0	0	0	-2.6	-1.2	-3.9	-4.2	-1.5	0.7	0	0	0	0	-0.7
84-85	0.2	0	0	0	0	-2.9	-1.1	-0.8	-1.1	0	0	0	0	0.2	-0.4
85-86	1.9	1.8	3.5	-3.4	0	-7.5	-9	-9.6	-5.5	0	0	0	0	0.1	-1.5
86-87	0.7	2.5	3.9	2	0	0	0	0	0	0	0	0	0	0	0.8
AVE.	0.2	0.6	0.5	0	-0.3	-1.4	-1.5	-1.3	-0.3	0.5	0.1	0.4	0	0	-0.1

4.10 Effect of Grand Coulee Upper Rule Curve Adjustment on Grand Coulee Operation. When Canadian Treaty projects and federal projects upstream of Grand Coulee draft for power, the space below their flood control curves becomes additional space available for flood control. Grand Coulee's flood control curve is then raised so that the system is not over conservative on flood control space. In addition, VDLs for Grand Coulee are adjusted to reflect this change in the flood control and upstream power drafts. VDLs are draft limits such that there is an 85% confidence level that the April 10^{th} flood control elevation is achieved. The Bureau of Reclamation provided the adjusted VDLs for January through March for these studies.

The procedure to adjust Grand Coulee's flood control and VDLs is used in real operations. The difference in Grand Coulee's reservoir operations for Scenarios 7 through 10 due to adjusting Grand Coulee flood control and VDLs for upstream power drafts is shown in the Tables 14 through 17. In general, Grand Coulee's elevations were up to about 6.5 feet higher in March through April with the upper rule curve and VDL adjustments. There were few or no differences in the July through December periods.

Table 14. Difference in Grand Coulee Reservoir Elevation (feet)- With minus Without Flood Control Adjusted for Power Drafts, Scenario 7.

1929	0	0.5	0.5	0.5	0	0	0
1930	0	0	0	-0.3	0.3	0	0
1931	0	0	0	0	0	0	0
1932	6.7	6.2	6.7	4.8	4.5	2.4	0.1
1933	0	17.7	14.5	10.9	9.6	9.4	0.4
1934	0	2.3	13.7	10.9	1	2.8	0
1935	0	0	15.8	11.7	8.4	8.4	1.2
1936	8.7	9.7	9.7	9.4	0	0	0
1937	0	0	-2	-2.2	-2.1	0	0
1938	0	0	12.3	9.8	17.8	12.3	4.8
1939	-12.1	0.9	12.7	15.8	15.1	4.3	0.1
1940	0	-7.2	4.2	5.1	18.5	11.3	0
1941	0	0	2	0	0	0	0
1942	0	11.2	-0.2	0	0	0	0
1943	0	0	-0.6	-2.1	4.4	10.3	2.1
1944	6.2	-1	-1	0	0	0	0
1945	-0.4	-0.7	-2.5	-2.9	-3	2	0
1946	0	0	-1	-0.1	8.7	6.1	2.4
1947	0	0	4.2	12.6	14.4	6.1	0.1
1948	0	5.9	23.6	15.1	10.8	2.1	0
1949	0	0	1.4	10.1	-2.8	-0.3	0
1950	0	0	-1.7	-0.1	0.1	0.1	0
1951	0	0	2.4	3.3	6.3	3.3	0.4
1952	0	0	-0.2	-0.1	10.6	4.1	0
1953	0	0	15	12.1	11.7	11.5	0.9
1954	0	0	6.4	-0.1	0.1	0.1	0
1955	5.3	-1.4	-0.2	0.5	16.9	16.9	1
1956	0	0	4.5	5	2.8	1.6	0
1957	0	10.4	6.2	7	6.3	0	0
1958	0	15	11.9	12.3	10.5	1.2	0
1959	0	0	-0.5	-0.1	1.9	1.9	1
1960	0.9	0	11.9	2.5	1.1	1	0
1961	0	19.3	19.9	13.3	11.7	4.8	0
1962	-8.1	-8.8	2.7	2.5	-4.6	-3.8	-0.3
1963	4.3	-10.2	-0.2	0	8.5	8	0
1964	0	38.3	40.3	27.9	8	7.9	0.2
1965	0	0	11.8	0.1	9.4	14.4	1.9
1966	0	14.2	1.6	15.9	16.1	7	0
1967	0	0	6.8	1.5	0.1	0.1	0
1968	0	24	12.3	15.6	15.9	14.9	0
1969	0	19.2	12.9	0.1	20	8.5	0
1970	-2.1	12.5	11.6	12.2	13.3	9.9	0
1971	0	0	0.1	0.7	0.6	0.5	0.1
1972	0	0	0	-5.8	-3	-2.7	0
1973	0	14.2	6.9	0	0	0	0
1974	0	0	4.4	0.7	1.1	1.1	0.2
1975	0	0	2.7	-0.1	0.1	0.1	0
1976	0	11.9	-0.2	0	3	1.1	0
1977	-0.6	-0.1	0	-0.2	0	0	0
1978	0	0	-0.2	10.4	13.9	13.9	4
1979	-4.1	-0.5	17	12.3	16	2.3	0
1980	3.2	-0.6	12.2	13.6	3	1.5	0
1981	0	12	1.8	2.7	14.9	8.3	0
1982	0	0	2.3	3.3	6.3	4.9	0.7
1983	0	0	-4.8	1.9	1	0.4	0.1
1984	0	-16.3	7.9	14.4	7.8	7.4	0.9
1985	0	0	12.6	10.8	8.3	5	0
1986	6.7	8	14.1	18.7	19.3	12.3	0
1987	-4.9	2	-0.2	-0.2	0	0	0
AVE.	0.2	3.5	6.2	5.5	6.2	4.2	0.4

Table 15. Difference in Grand Coulee Reservoir Elevation (feet)- With minus Without Flood Control Adjusted for Power Drafts, Scenario 8

1929	0	0.5	0.5	0.5	0	0	0
1930	0	0	0	-0.3	0.3	0	0
1931	0	0	0	0	0	0	0
1932	6.7	6.2	6.7	4.8	4.5	2.4	0.1
1933	0	17.7	14.5	10.9	9.6	9.4	0.4
1934	0	2.3	13.7	10.9	1	2.8	0
1935	0	0	16	11.7	8.4	8.4	1.2
1936	9.6	10.8	10.8	10.5	0	0	0
1937	0	0	0	-0.3	-0.3	0	0
1938	0	0	12.3	9.8	17.8	12.3	4.8
1939	-12.4	0.9	12.7	15.8	15.1	4.3	0.1
1940	0	-7.2	4.2	5.1	18.5	11.3	0
1941	0	0	2	0	0	0	0
1942	0	11.2	-0.2	0	0	0	0
1943	0	0	-0.6	-2.1	4.4	10.3	2.1
1944	6.2	-1.1	-0.2	0	0	0	0
1945	-0.4	-0.7	-2.5	-2.9	-3	2	0
1946	0	0	-1	-0.1	8.7	6.1	2.4
1947	0	0	4	12.2	14.3	6.1	0.1
1948	0	5.9	23.6	15.1	10.8	2.1	0
1949	0	0	1.4	10.1	-2.8	-0.3	0
1950	0	0	-1.7	-0.1	0.1	0.1	0
1951	0	0	2.4	3.3	6.3	3.3	0.4
1952	0	0	-0.2	-0.1	10.6	4.1	0
1953	0	0	15	12.1	11.7	11.5	0.9
1954	0	0	6.4	-0.1	0.1	0.1	0
1955	5.3	-1.4	-0.2	0.5	16.9	16.9	1
1956	0	0	4.5	5	2.8	1.6	0
1957	0	10.4	6.2	7	6.3	0	0
1958	0	15.1	11.9	12.3	10.5	1.2	0
1959	0	0	-0.5	-0.1	1.9	1.9	1
1960	0.9	0	11.9	2.5	1.1	1	0
1961	0	19.3	19.9	13.3	11.7	4.8	0
1962	-8.1	-8.8	2.7	2.5	-4.6	-3.8	-0.3
1963	4.3	-10.2	-0.2	0	8.5	8	0
1964	0	38.3	40.3	27.9	8	7.9	0.2
1965	0	0	11	0.1	9.4	14.4	1.9
1966	0	14.2	1.6	15.9	16.1	7	0
1967	0	0	6.8	1.5	0.1	0.1	0
1968	0	24	12.3	15.6	15.9	14.9	0
1969	0	19.2	12.9	0.1	20	8.5	0
1970	-2.1	12.5	11.6	12.2	13.3	9.9	0
1971	0	0	0.1	0.7	0.6	0.5	0.1
1972	0	0	0	-5.8	-3	-2.7	0
1973	0	14.2	6.9	0	0	0	0
1974	0	0	4.3	0.6	1.1	1.1	0.2
1975	0	0	2.7	-0.1	0.1	0.1	0
1976	0	11.9	-0.2	0	3	1.1	0
1977	-0.6	-0.1	0	-0.2	0	0	0
1978	0	0	-0.2	10.4	13.9	13.9	4
1979	-4.1	-0.5	17	12.3	16	2.3	0
1980	3.3	-0.6	12.2	13.6	3	1.5	0
1981	0	12	1.8	2.7	14.9	8.3	0
1982	0	0	2.3	3.3	6.3	4.9	0.7
1983	0	0	-4.8	1.9	1	0.4	0.1
1984	0	-16.4	7.9	14.3	7.8	7.3	0.9
1985	0	0	12.6	10.8	8.3	5	0
1986	6.7	8	14.1	18.7	19.3	12.3	0
1987	-4.9	2	-0.2	-0.2	0	0	0
AVE.	0.2	3.6	6.3	5.5	6.2	4.2	0.4

Table 16. Difference in Grand Coulee Reservoir Elevation (feet)-With Minus Without Flood Control Adjusted for Power Drafts, Scenario 9

1929	0	0.5	0.5	0.5	0	0	0
1930	0	0	0	0	4	1.4	0
1931	0	0	0	0	0	0	0
1932	0	0	0	5.9	5.2	2.6	0
1933	0	15.3	12	8.2	8	7.9	0.2
1934	0	2.4	13.4	9.8	2.8	3	0
1935	0	0	15.2	12.6	10.3	10.3	-8.3
1936	8.9	9.6	5.4	5.4	0	0	0
1937	0	0	0	0	0	0	0
1938	0	0	11.3	7.2	17.8	12.1	10.3
1939	-8.2	0.7	12.3	15.2	16.8	6.3	0.8
1940	0	-4.8	7.1	9.6	22.7	16.1	0
1941	0	0	2	0	0	0	0
1942	0	12.6	-0.2	0	0	0	0
1943	0	0	-0.5	-2.2	2.1	10.3	2.3
1944	6.2	6.2	6.2	2.7	0	0	0
1945	0	0	0	0	0	4.3	0
1946	0	0	-1.3	-0.1	8.7	5.6	8.2
1947	0	0	0.2	9	11.9	4.6	0
1948	0	12.1	23.3	15.7	9.8	1.7	0
1949	0	0	-1.2	7.7	0.1	0	0
1950	0	0	-1.8	-0.1	0.1	0.1	0
1951	0	0	2.4	3.3	6.3	3.7	0.6
1952	0	0	-0.2	0	11.5	4.8	0.8
1953	0	0	17.1	12.9	12.2	11.6	0.6
1954	0	0	6.4	-0.1	0.1	0.1	0
1955	5.2	1.5	2.8	5.1	21.7	21.7	1
1956	0	0	3.7	4.1	2.3	1.6	0
1957	0	21.3	10	9.9	8	0	0
1958	0	20.1	13.1	12.6	9.8	1.1	0
1959	0	0	-0.5	-0.1	1.9	1.9	0.6
1960	12.6	0.3	14.6	3.8	3.4	2.2	0
1961	0	18.8	17.7	11.3	9.9	3.9	0
1962	-6.7	-6.8	4	3.5	-3.5	-2.6	0
1963	10.6	-8.8	0.1	0	15.3	11.4	0
1964	0	40	43.1	29.1	10.1	10	0.1
1965	0	0	10.6	0.1	9.6	14.7	1.6
1966	0	18	6.1	16.1	15.9	7.2	0
1967	0	0	4.6	0.5	0.1	0.1	0
1968	0	24.3	12.5	15.6	15.5	13.8	0
1969	0	19.7	12	-0.9	20	8.6	0
1970	-0.5	12.2	12.9	11.8	12.8	9.5	0
1971	0	0	4.1	3.8	3.7	2.7	0.3
1972	0	0	0	-3.8	-1	-0.8	0
1973	0	14.2	6.9	1.4	0	0	0
1974	0	0	4.3	0.7	1.1	1.1	0.1
1975	0	0	2.7	-0.1	0.1	0.1	0
1976	0	13.2	-0.2	0	3	1	0
1977	-0.6	-0.1	0	-0.2	0	0	0
1978	0	0	-0.2	7	11	11	10
1979	-6	-2.6	16.2	8.9	9.7	1.8	0
1980	4.8	0.6	13.3	13.5	2.8	1.3	0
1981	0	20.5	7.6	9.3	22.9	11.9	0
1982	0	0	2.3	3.3	6.3	4.8	8.7
1983	0	0	-8	-0.8	0.1	0	7.3
1984	0	-15.9	10	14.5	10.2	9.4	1.6
1985	0	0	9.8	12.6	10	6.1	0
1986	3.3	12.9	11.1	15.6	15.1	8.6	0
1987	-2.8	2	-0.2	-0.2	0	0	0
AVE.	0.5	4.4	6.4	5.6	6.7	4.6	0.8

Table 17. Difference in Grand Coulee Reservoir Elevation (feet)-With Minus Without Flood Control Adjusted for Power Drafts, Scenario 10

1929	0	0.5	0.5	0.5	0	0	0
1930	0	0	0	0	4	1.4	0
1931	0	0	0	0	0	0	0
1932	0	0	0	5.9	5.2	2.6	0
1933	0	15.3	12	8.2	8	7.9	0.2
1934	0	2.4	13.4	9.8	2.8	3	0
1935	0	0	15.3	12.6	10.3	10.3	-8.3
1936	9.7	10.6	7.7	7.7	0	0	0
1937	0	0	0	0	0	0	0
1938	0	0	11.3	7.2	17.8	12.1	10.3
1939	-8	0.9	12.3	15.2	16.8	6.3	0.8
1940	0	-4.8	7.1	9.6	22.7	16.1	0
1941	0	0	2	0	0	0	0
1942	0	12.6	-0.2	0	0	0	0
1943	0	0	-0.5	-2.2	2.1	10.3	2.3
1944	6.5	6.5	6.5	2.7	0	0	0
1945	0	0	0	0	0	5.1	0
1946	0	0	-1.4	-0.1	8.7	5.6	8.2
1947	0	0	0.2	9	11.9	4.6	0
1948	0	12.1	23.3	15.7	9.8	1.7	0
1949	0	0	-1.2	7.7	0.1	0	0
1950	0	0	-1.8	-0.1	0.1	0.1	0
1951	0	0	2.4	3.3	6.3	3.7	0.6
1952	0	0	-0.2	0	11.5	4.8	0.8
1953	0	0	17.1	12.9	12.2	11.6	0.6
1954	0	0	6.4	-0.1	0.1	0.1	0
1955	5.2	1.5	2.8	5.1	21.7	21.7	1
1956	0	0	3.7	4.1	2.3	1.6	0
1957	0	21.3	10	9.9	8	0	0
1958	0	20.1	13.1	12.6	9.8	1.1	0
1959	0	0	-0.5	-0.1	1.9	1.9	0.6
1960	12.6	0.3	14.6	3.8	3.4	2.2	0
1961	0	18.8	17.7	11.3	9.9	3.9	0
1962	-6.7	-6.8	4	3.5	-3.5	-2.6	0
1963	10.6	-8.8	0.1	0	15.3	11.4	0
1964	0	40	43.1	29.1	10.1	10	0.1
1965	0	0	10.6	0.1	9.6	14.7	1.6
1966	0	18	6.1	16.1	15.9	7.2	0
1967	0	0	4.6	0.5	0.1	0.1	0
1968	0	24.3	12.5	15.6	15.5	13.8	0
1969	0	19.7	12	-0.9	20	8.6	0
1970	-0.5	12.2	12.9	11.8	12.8	9.5	0
1971	0	0	4.1	3.8	3.7	2.7	0.3
1972	0	0	0	-3.8	-1	-0.8	0
1973	0	14.2	6.9	1.4	0	0	0
1974	0	0	4.3	0.7	1.1	1.1	0.1
1975	0	0	2.7	-0.1	0.1	0.1	0
1976	0	13.2	-0.2	0	3	1	0
1977	-0.6	-0.1	0	-0.2	0	0	0
1978	0	0	-0.2	7	11	11	10
1979	-6	-2.6	16.2	8.8	9.6	1.8	0
1980	4.9	0.7	13.3	13.5	2.8	1.3	0
1981	0	20.5	7.6	9.3	22.9	11.9	0
1982	0	0	2.3	3.3	6.3	4.8	8.7
1983	0	0	-8	-0.8	0.1	0	7.3
1984	0	-15.9	10	14.5	10.2	9.4	1.6
1985	0	0	9.8	12.6	10	6.1	0
1986	3.3	12.9	11.1	15.6	15.1	8.6	0
1987	-2.8	2	-0.2	-0.2	0	0	0
AVE.	0.5	4.4	6.4	5.7	6.7	4.6	0.8

4.11 Ability to meet FELCC. Table 18 shows the number of years federal projects were unable to meet federal FELCC for Scenarios 7 - 10. The federal FELCC was developed based on the final regulation by the Northwest Power Pool (coordinating group for PNCA activities) that included Hungry Horse VARQ, but not Libby VARQ. The final regulation does not include adjustments at Grand Coulee for upstream power drafts. If the FELCC were developed based on the scenarios in this study, the number of years that FELCC would not be met would be less than as shown in Table 18. Of the years that FELCC was not met, the average amount that FELCC was not met is shown in Table 19. The FELCC is also shown in the Table 18. A graph of the 59-year month average generation for Scenarios 7-10 is shown on Chart 3, along with the maximum and minimum generation out of 59-years for each month for Scenarios 7 and 9. The maximum and minimum generation for Scenarios 8 and 10 are similar to Scenarios 7 and 9 respectively, and therefore was not shown.

Table 18. Number of Years out of 59 FELCC is Not Met

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug	Sep
7	0	0	3	9	1	5	8	8	8	4	6	2	9	0
8	0	0	3	9	1	5	8	8	8	4	7	3	9	0
9	0	0	2	9	1	6	8	8	8	4	5	1	6	0
10	0	0	2	9	1	6	8	8	8	4	6	3	6	0

Table 19. Average Amount FELCC was Not Met (MW-mo)

Scenario	Dec	Jan	Feb	Mar	Ap1	Apr	May	Jun	Jul	Ag1	Aug
7	402	1376	136	218	712	1255	1200	691	521	42	272
8	418	1413	136	218	712	1253	1130	707	484	40	293
9	505	1371	136	204	725	1376	1167	606	910	203	335
10	520	1409	135	204	721	1367	1110	618	809	90	364
FELCC	**7551**	**7538**	**4824**	**5346**	**5958**	**6284**	**9260**	**8006**	**6924**	**7308**	**6276**

4.12 Priest Rapids Flow Objectives. The Priest Rapids flow objective is 135 kcfs April 10^{th} through the month of June. For monthly modeling purposes for the first half of April, the flow objective was assumed to be 90 kcfs (60 kcfs to meet Vernita Bar Requirement April 1-9 and 135 kcfs to meet Priest Rapids flow objectives April 10-15). In the first half of April through May, when Priest Rapids' flow objectives were not met, Grand Coulee was at its draft limit of El. 1280. In June, Grand Coulee did not draft for Priest Rapids because it was targeting full pool or flood control. The number of years that Priest Rapids flow objectives were not met are shown in Table 20. The average amount that Priest Rapids flow objectives were missed is shown in Table 21. Charts of Percent Exceedence of Regulated Flow at Priest Rapids for each of the first and second half of April, May and June, is provided in Charts 4-7.

For modeling, the Vernita Bar Requirement is measured at Priest Rapids. The Vernita Bar minimum flow requirement covers the period December through May, and is equal to 68% of the higher of Wanapum's October and November regulated flow rounded to the nearest 5 kcfs, but no lower than 50 kcfs, and no higher than 70 kcfs. Grand Coulee will draft as needed to El. 1208 to meet the Vernita Bar Requirement. In this study the Vernita Bar Requirement was always met.

Table 20. Number of Years out of 59-years Priest Rapids Flow Objectives were Missed for Power Scenarios

Scenario	Ap1	Apr	May	Jun
7	16	27	11	12
8	16	27	11	12
9	16	27	11	11
10	16	27	9	11

Table 21. Average Amount Priest Rapids Flow Objectives were Missed (kcfs) for Power Scenarios

Scenario	Ap1	Apr	May	Jun
7	15.9	33.6	12.2	16.9
8	16.1	33.1	10.9	16.8
9	15.8	34.9	11.6	16.7
10	15.8	34.8	13.5	16.3

4.13 McNary Flow Objectives. The flow objective for McNary for the period April 10 through June 30 varies between 220 kcfs and 260 kcfs. For the monthly model, the flow objective for the first half of April was prorated for the number of days in that period. If the January-July runoff volume forecast at The Dalles is less than 85 MAF, the flow objective is 220 kcfs. If the forecasted volume is greater than 105 MAF, the flow objective is 260 kcfs. If the forecasted volume lies between 85 MAF and 105 MAF, the flow objective will be linearly interpolated between 220 kcfs and 260 kcfs. The flow objective for the period July 1 through August 31 is 200 kcfs. Grand Coulee does not draft below El. 1280 from the first half of April through May, and July through August to meet McNary flow objectives, resulting in McNary not meeting its flow objectives in some years. For this study, Grand Coulee did not draft for McNary in June because it was targeting full pool or flood control. The number of years that McNary flow objectives were not met is shown in Table 22. The average amount that McNary missed its flow objectives is shown in Table 23. Charts of Percent Exceedence of Regulated Flow at McNary for each of the first and second half of April, May, June, July, and the first and second half of August is provided in Charts 8-14.

Table 22. Number of Years out of 59-years that McNary Flow Objectives were Missed

Scenario	Ap1	Apr	May	Jun	Jul	Ag1	Aug
7	7	34	13	19	39	45	58
8	7	33	14	20	40	45	57
9	7	34	12	17	36	45	58
10	7	34	12	17	37	46	57

Table 23. Average Amount McNary Flow Objectives were Missed (kcfs)

Scenario	Ap1	Apr	May	Jun	Jul	Ag1	Aug
7	10.1	59.5	29.4	38.7	43.7	40.7	61.6
8	10.4	60.5	27.5	37.3	43.3	40.9	63.0
9	10.3	60.9	30.5	39.6	45.9	37.8	59.2
10	10.2	60.8	29.7	39.3	45.6	37.3	60.6

5.0 **<u>Conclusions</u>.**

In comparing a regulation that assumes projects operate solely on standard flood control and no fish flows Alternative 1, versus VARQ flood control Alternative 4, there was a 59-year average annual federal system generation of 0.1%. Less generation was produced in January through April, and more generation in May through August. The largest 59-year month average generation loss occurs in January, and is 722 Mw-mo for a difference of 5.0%. The largest 59-year month average generation increase occurs in May, and is 700 Mw-mo, for a difference of 3.7%.

In comparing a regulation that assumes projects operate on standard flood control and no fish flows Alternative 1, against regulations with sturgeon template target elevations and standard flood control Alternatives 2 and 3, for the 9 years compared, generation increases occurred in May through August, with a generation decrease in September with VARQ. This occurs because there is more flow from Libby and Hungry Horse in May through August for sturgeon, bull trout, and McNary flow objectives in the Alternatives 2 and 3. There were little or no differences in October through April. Results for Alternatives 2 and 3 were similar.

In comparing a regulation that assumes projects operate on VARQ flood control Alternative 4, versus regulations with the sturgeon template target elevations and VARQ flood control Alternatives 5 and 6, for the 9 years compared, there was no definite pattern of generation differences in January through April. In general there was an increase in May and June, and a 1000-3000 Mw-mo increase in July and August, with about an average of 500 Mw-mo decrease in September for Alternatives 5 and 6. The 25 kcfs Alternative 5 showed less generation in May through July and more generation in the first and second half of August.

For the DOP scenarios, comparing standard flood control scenarios Scenarios 7 and 8 versus VARQ Scenarios 9 and 10, there was less generation in January through April, and an increase in generation in May through September with the VARQ scenarios. The average annual generation difference was 8 to 9 MW-mo, for a difference of 0.0%. The largest month average generation loss occurs in January of 531 Mw-Mo, for a difference of about 5%, and the largest month average generation gain occurs in the June and is 277 Mw-mo for about a 2% gain.

6.0 <u>Future Studies.</u> Future studies will be undertaken for input to the Environmental Impact Statement for the Upper Columbia alternative flood control and fish operations. These studies are scheduled to begin January 2003. Hydropower studies will be prepared with updated project operating criteria. An evaluation will be prepared to assess the VARQ affects on generating capacity and economic impacts.

APPENDIX
CHARTS FOR SCENARIOS 7-10

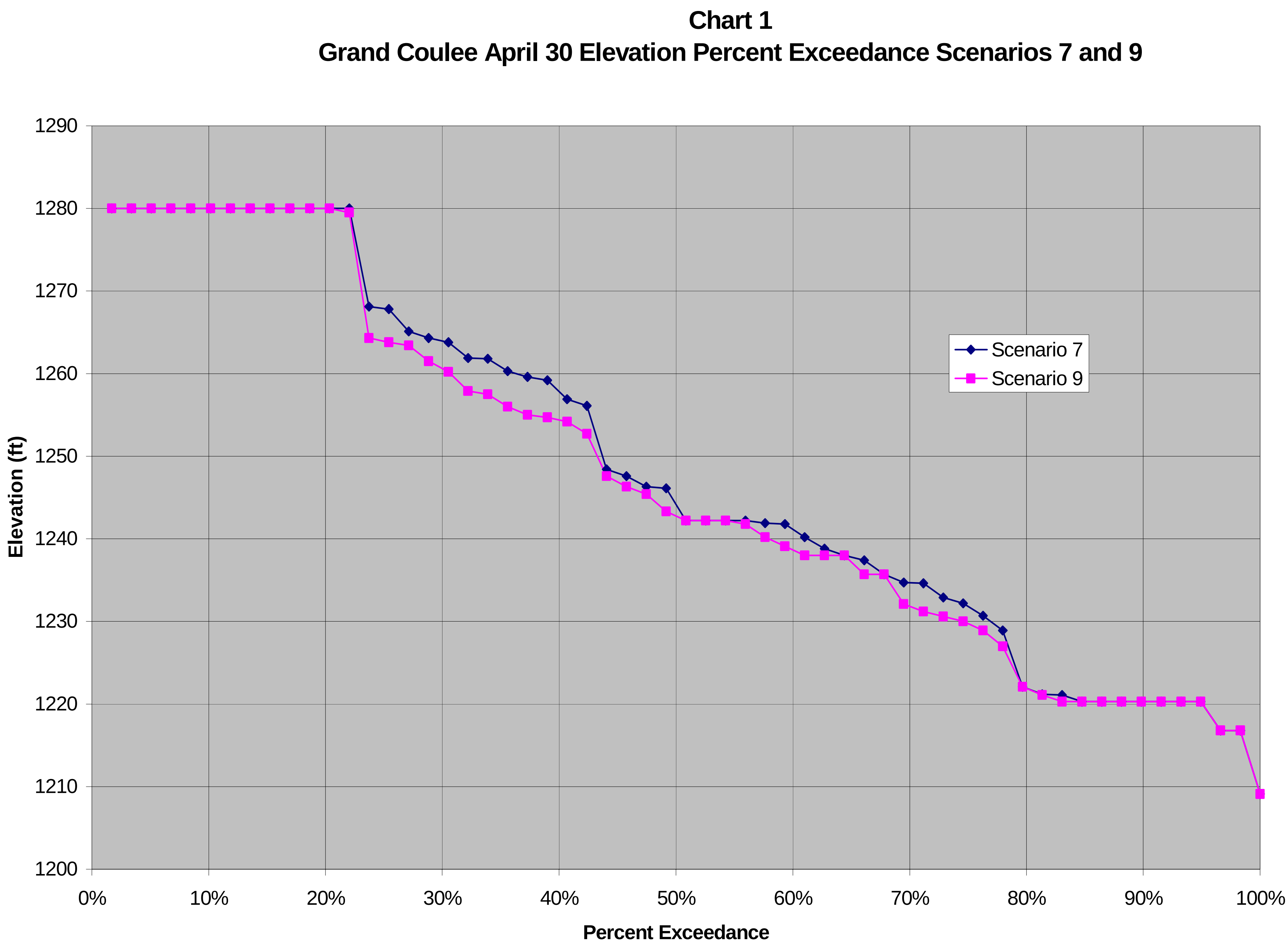


Chart 1
Grand Coulee April 30 Elevation Percent Exceedance Scenarios 7 and 9
Elevation (ft)
Percent Exceedance
Scenario 7
Scenario 9
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Chart 2
Grand Coulee April 30 Elevations Percent Exceedance Scenarios 8 and 10

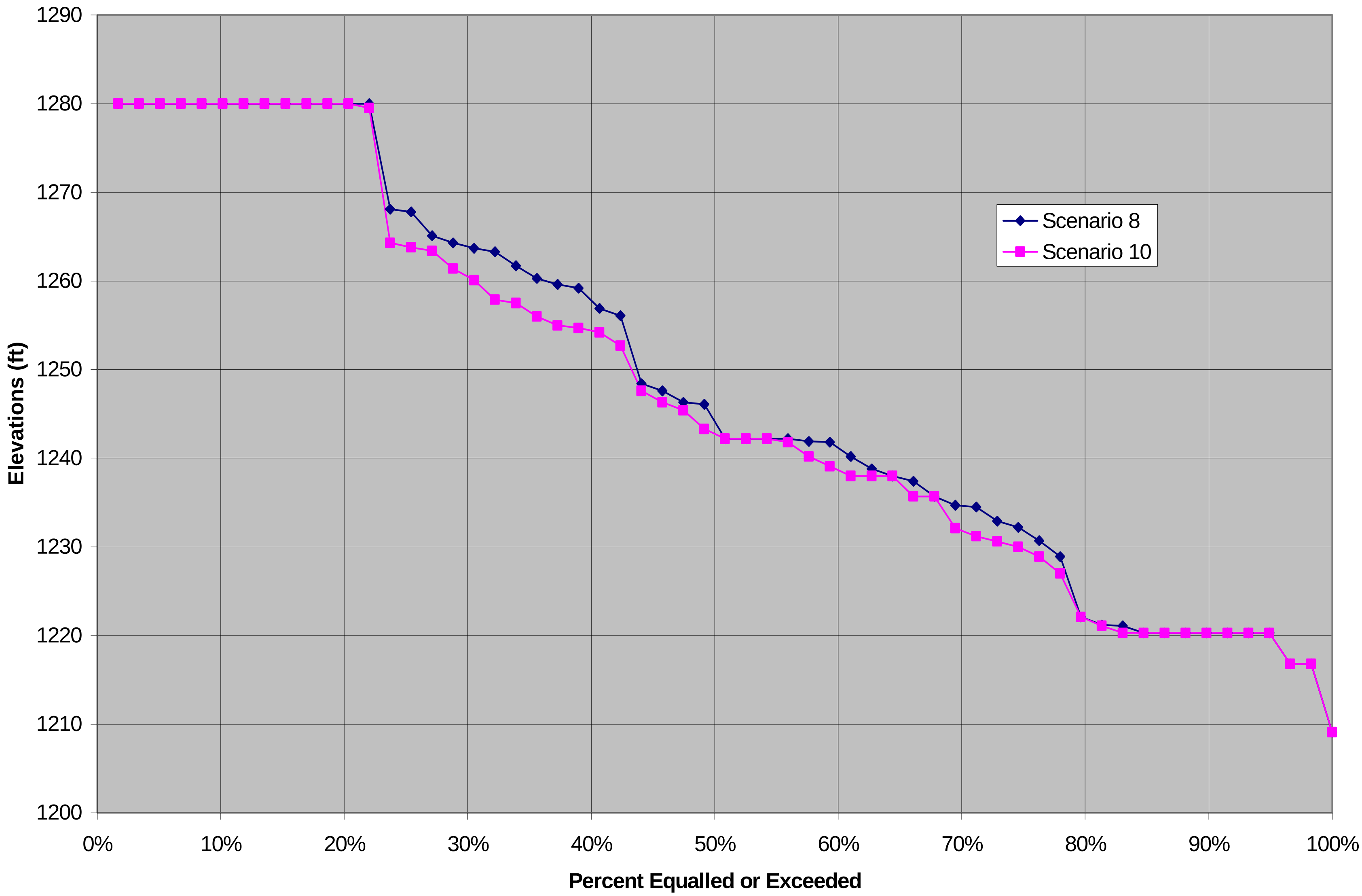


Chart 3
59-Year Month Average, Maximum and Minimum Federal System Generation

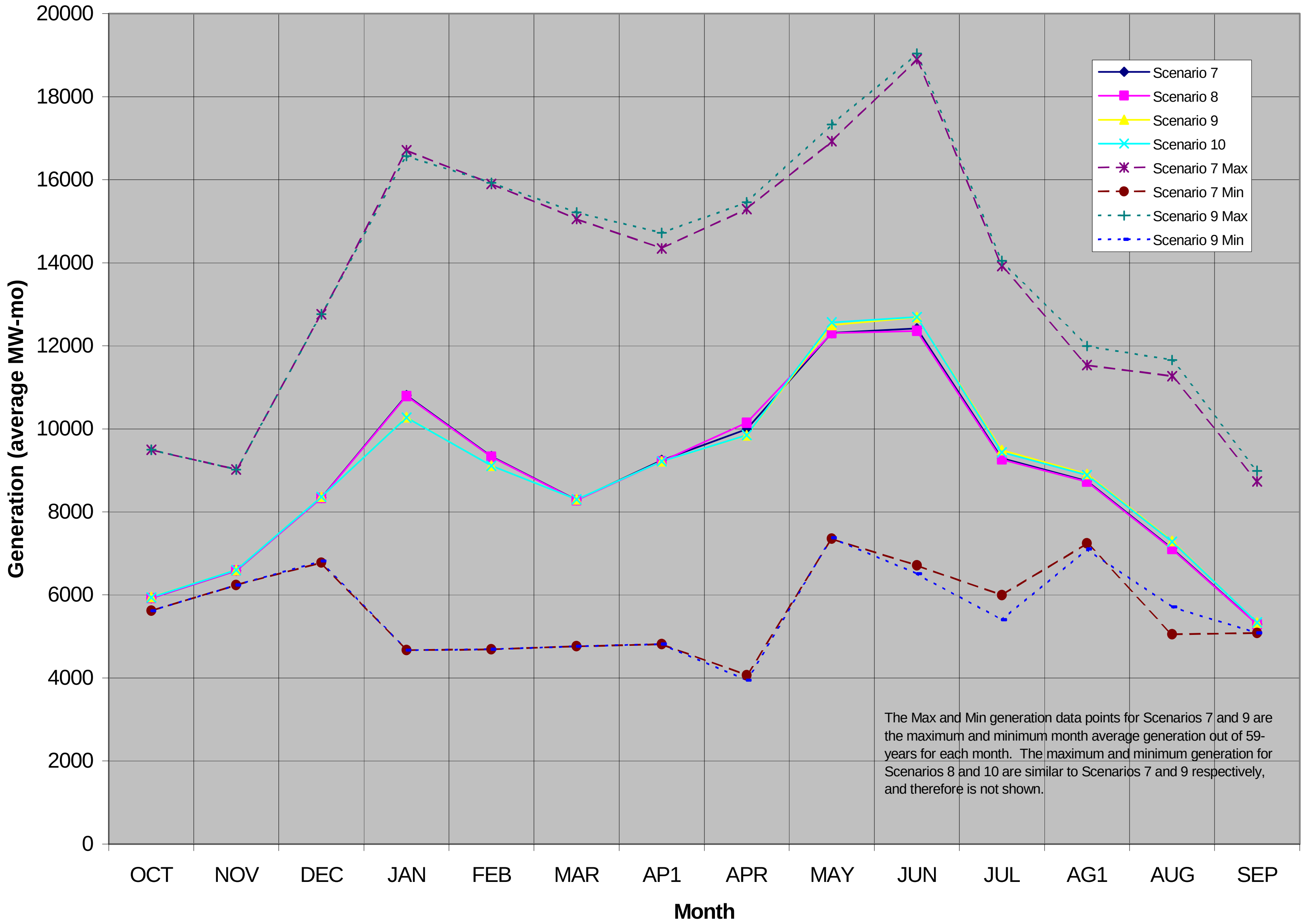


Chart 4
Priest Rapids Regulated Flow Apr 1-15 Percent Exceedance

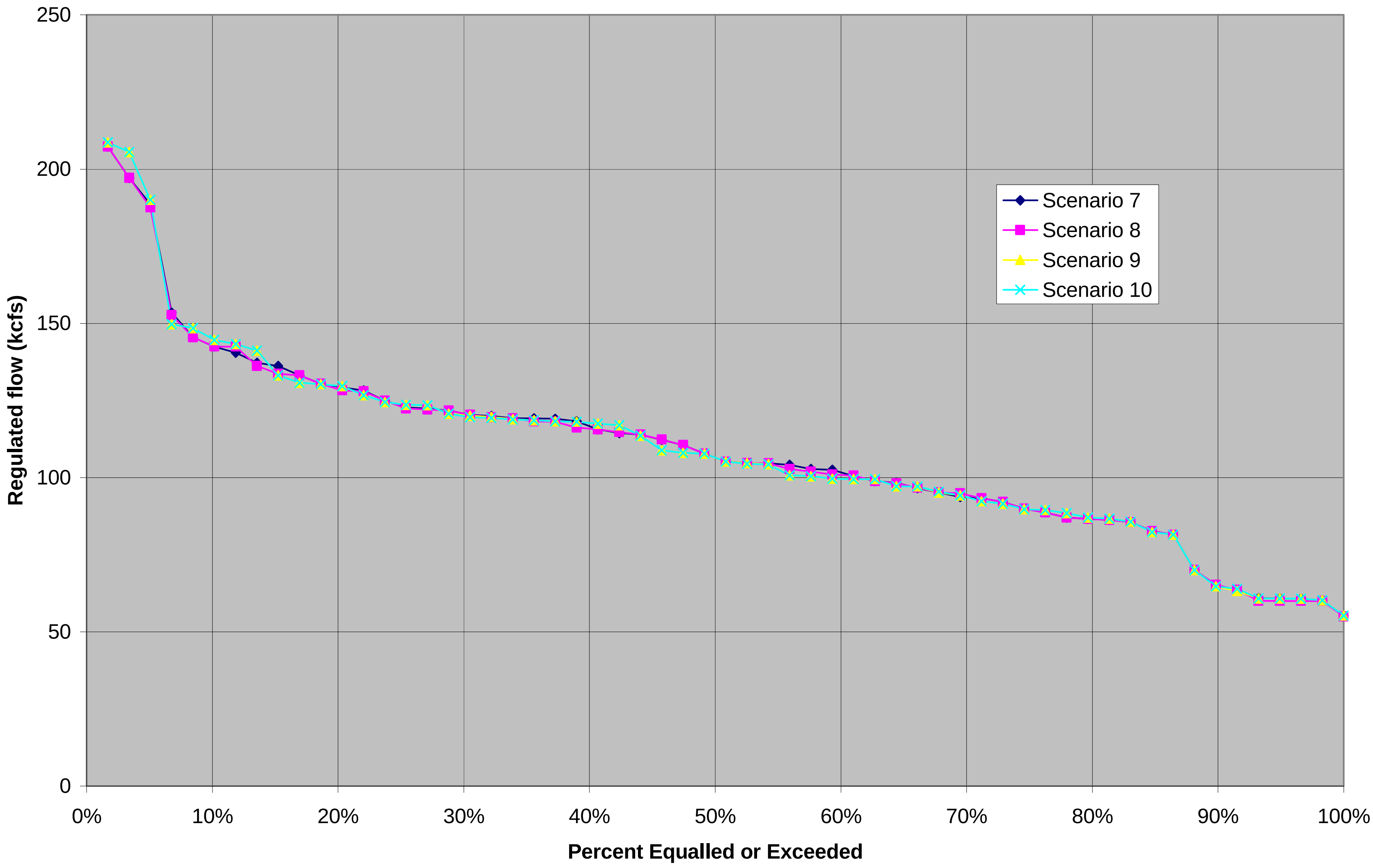


Chart 5
Priest Rapids Regulated Flow April 16-30 Percent Exceedance

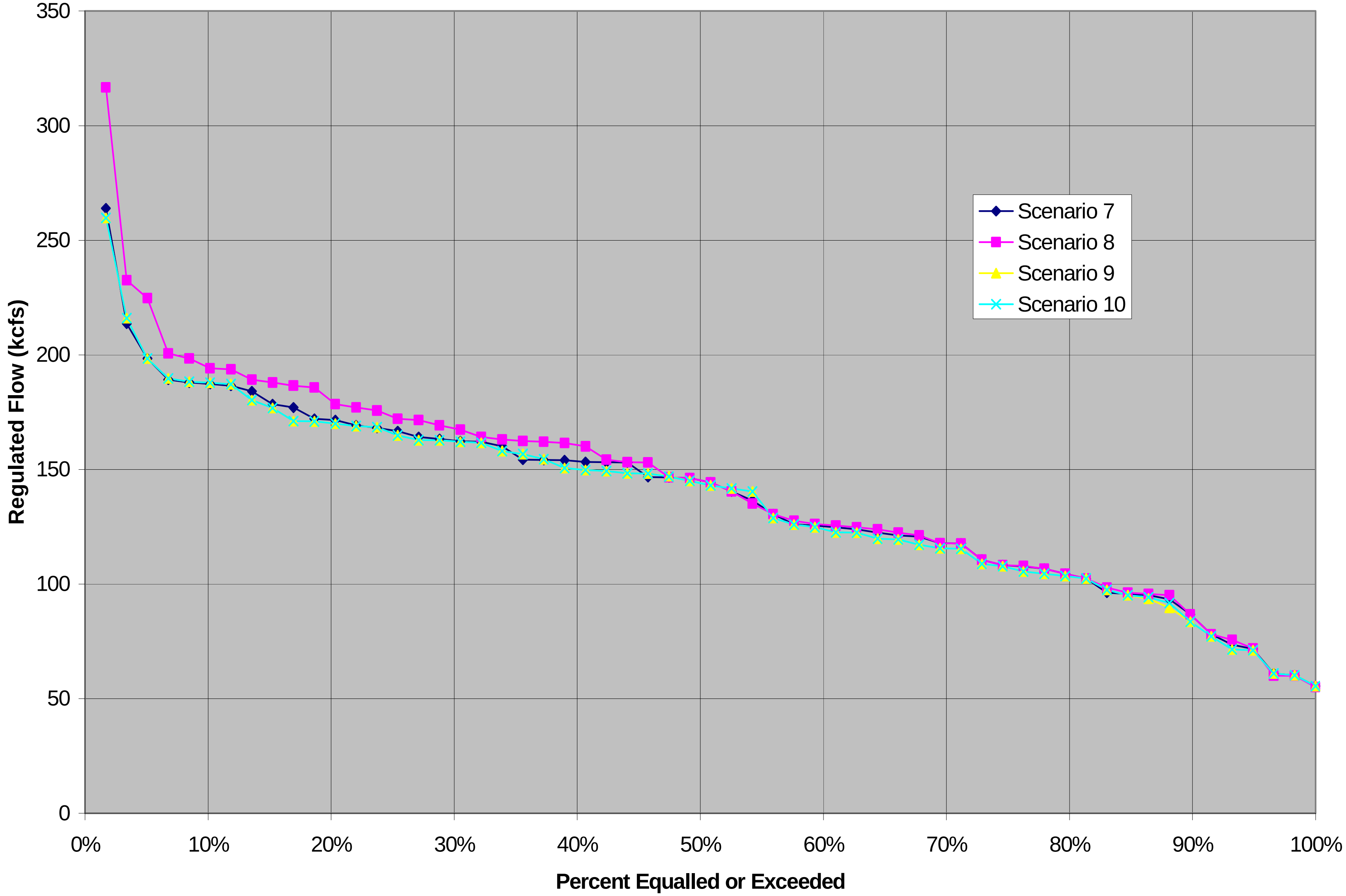


Chart 6
Priest Rapids May Regulated Flow Percent Exceedance

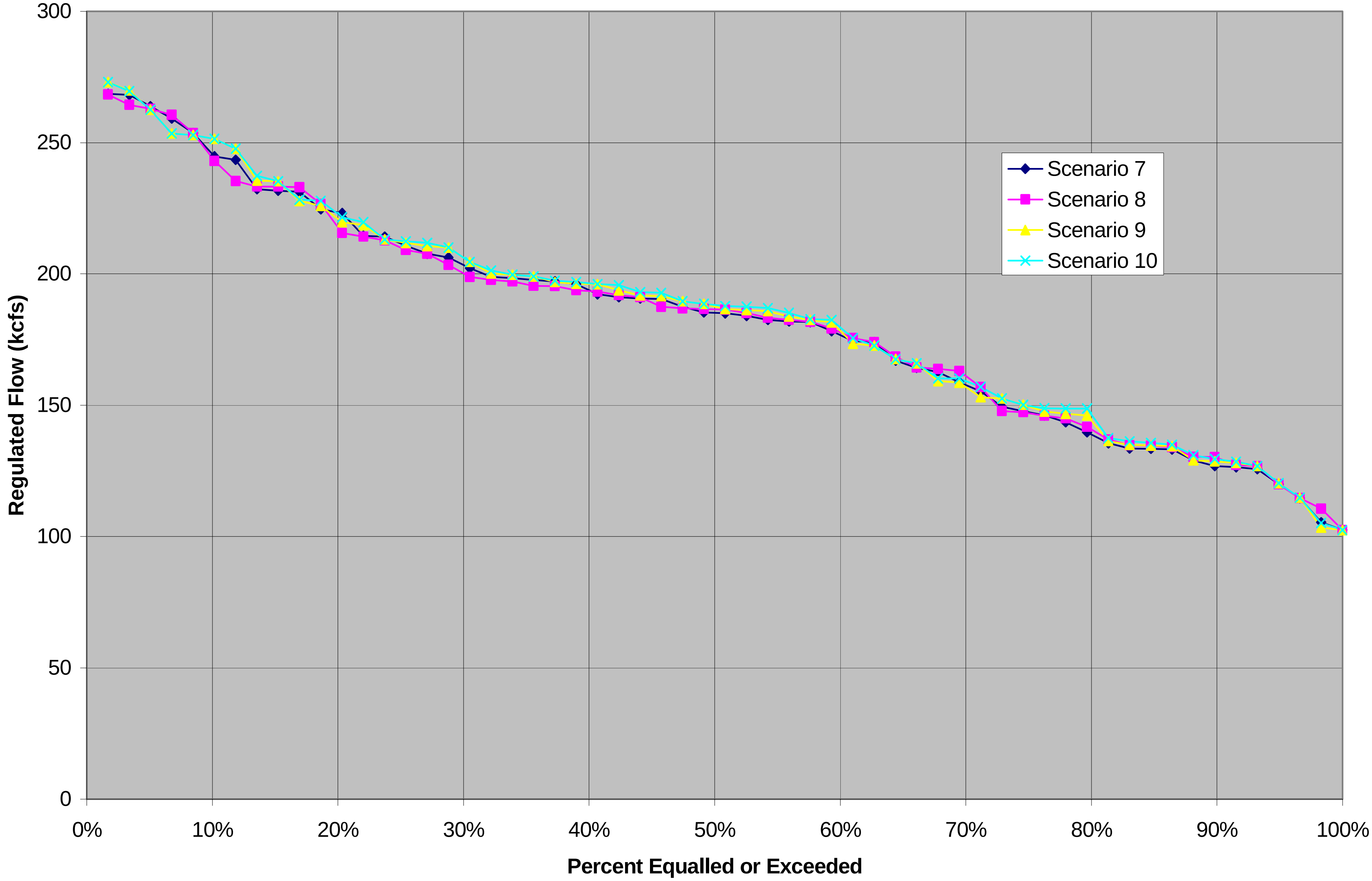


Chart 7
Priest Rapids June Regulated Flow Percent Exceedance

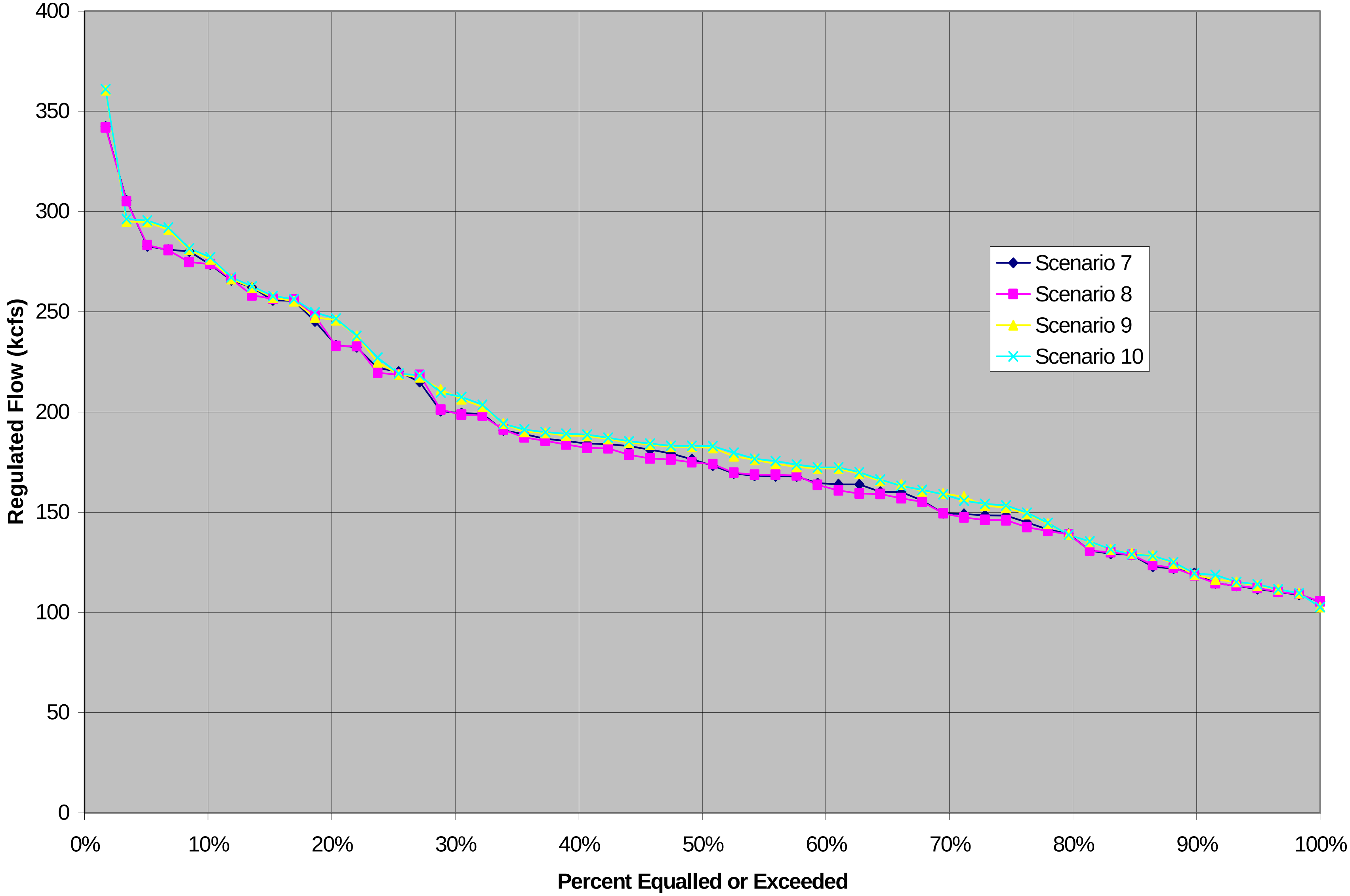


Chart 8
McNary Apr 1-15 Regulated Flow Percent Exceedance

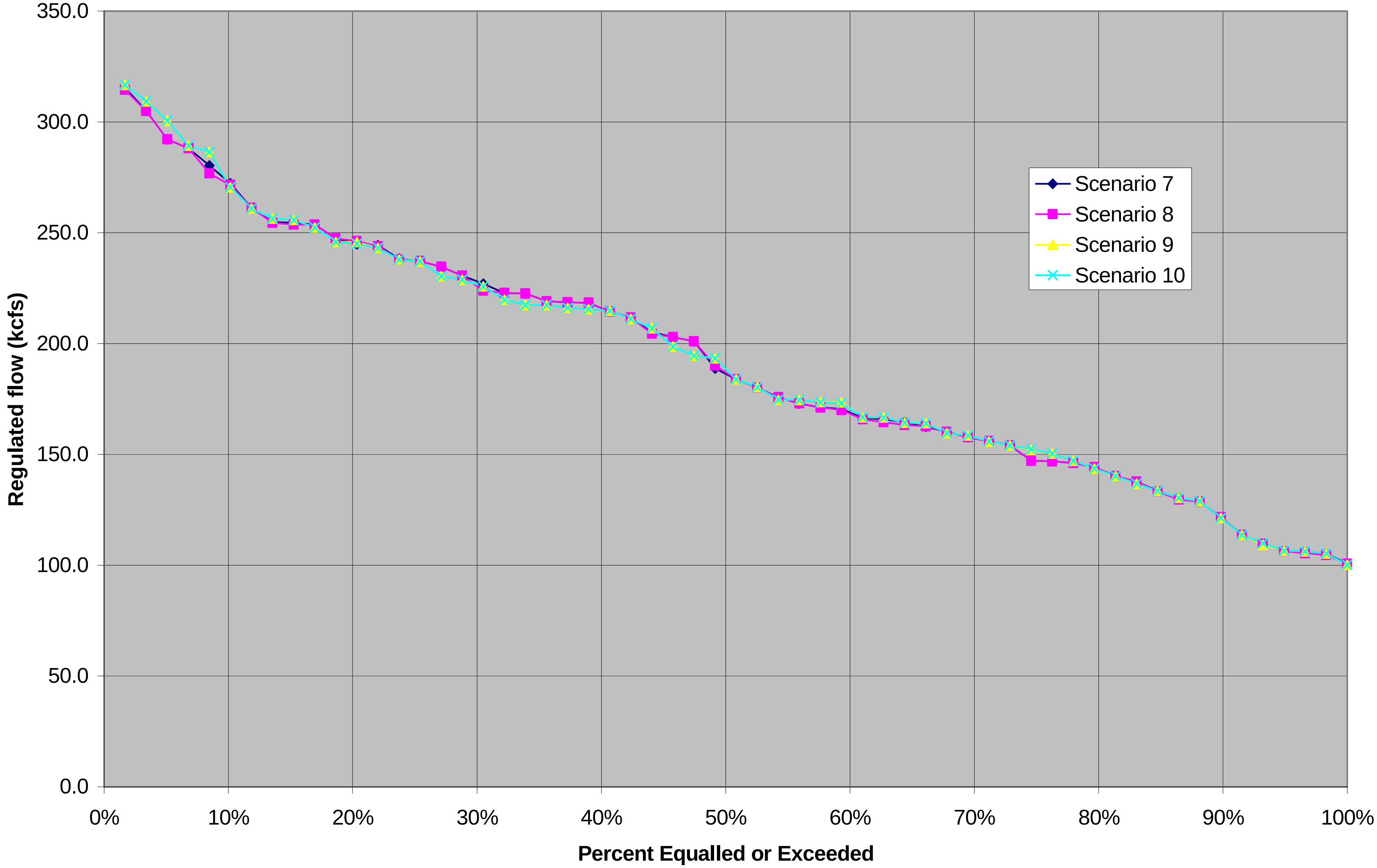


Chart 9
McNary Apr 16-30 Regulated Flow Percent Exceedance

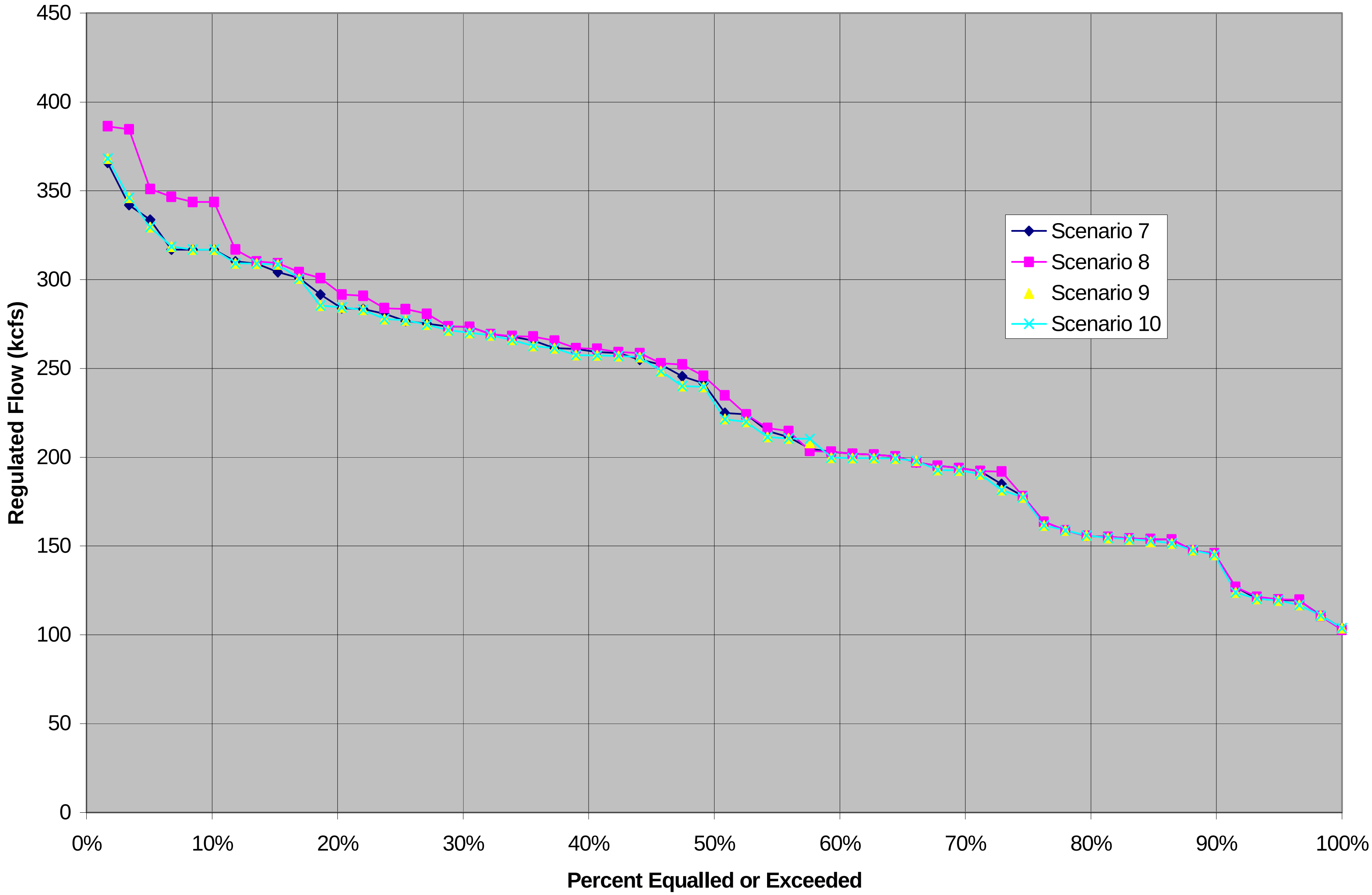
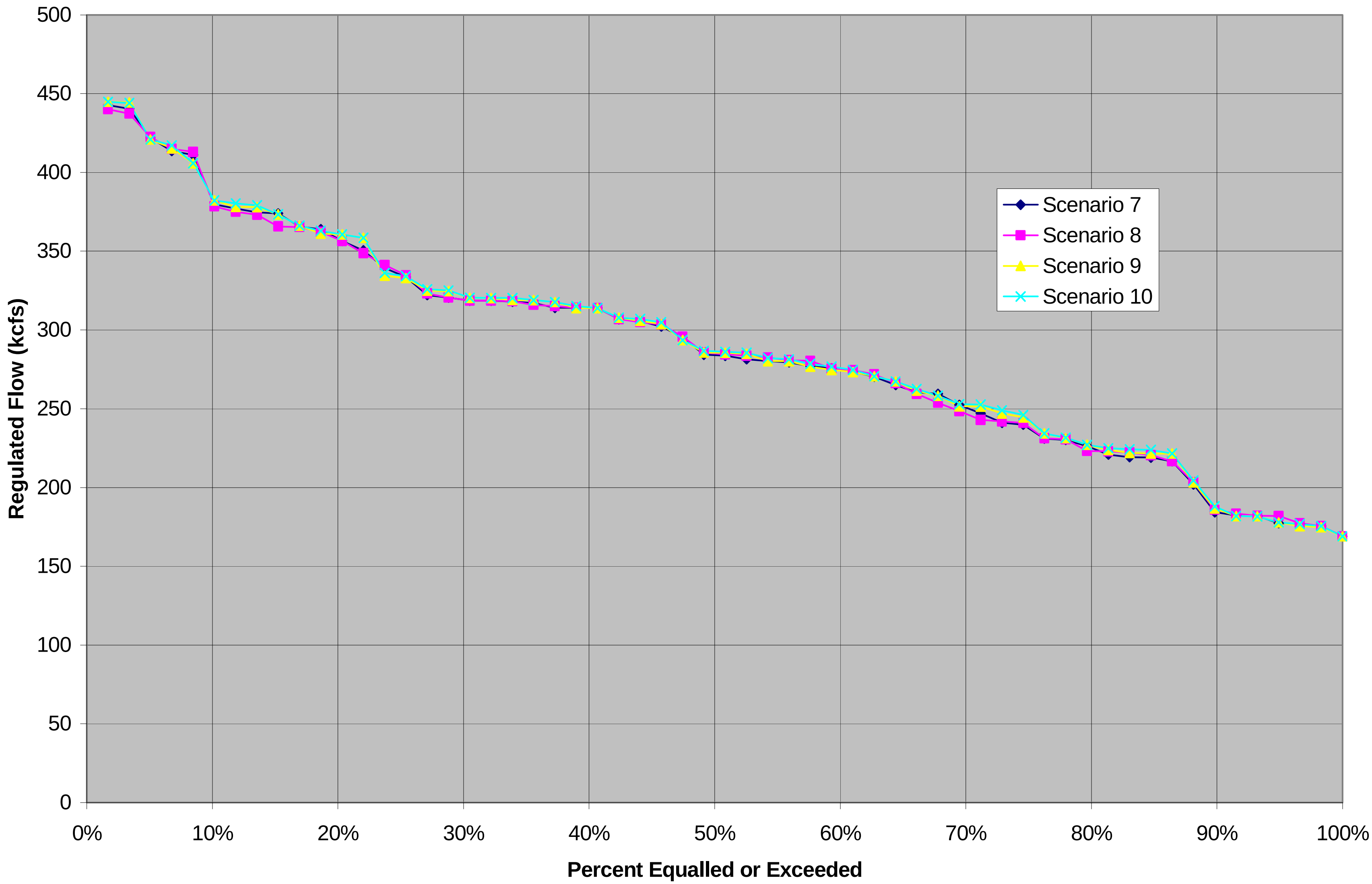


Chart 10
McNary May Regulated Flow Percent Exceedance



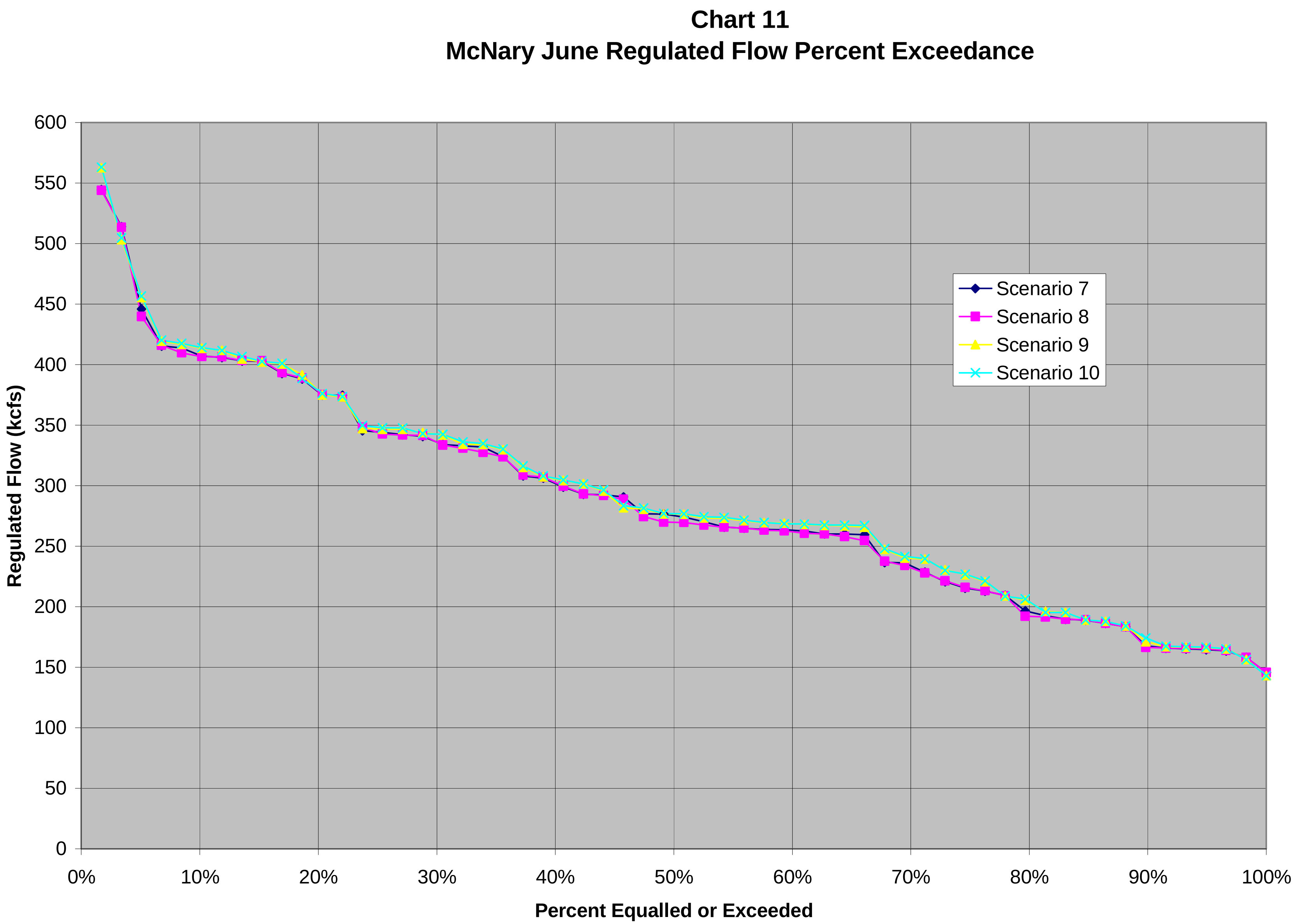


Chart 11
McNary June Regulated Flow Percent Exceedance
600
550
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Regulated Flow (kcfs)
Percent Equalled or Exceeded
Scenario 7
Scenario 8
Scenario 9
Scenario 10

Chart 12
McNary July Regulated Flow Percent Exceedance

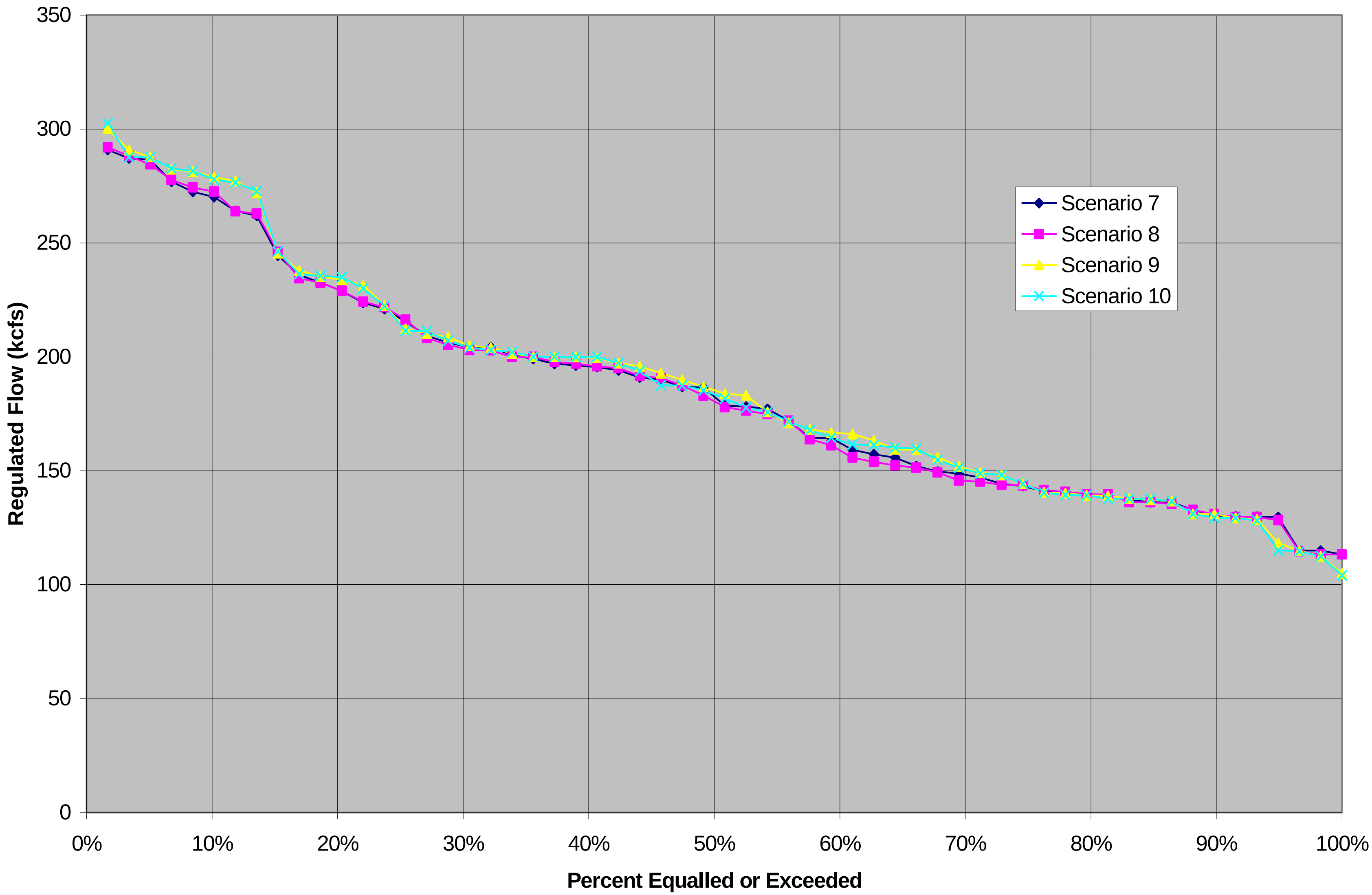


Chart 13
McNary Aug 1-15 Regulated Flow Percent Exceedance

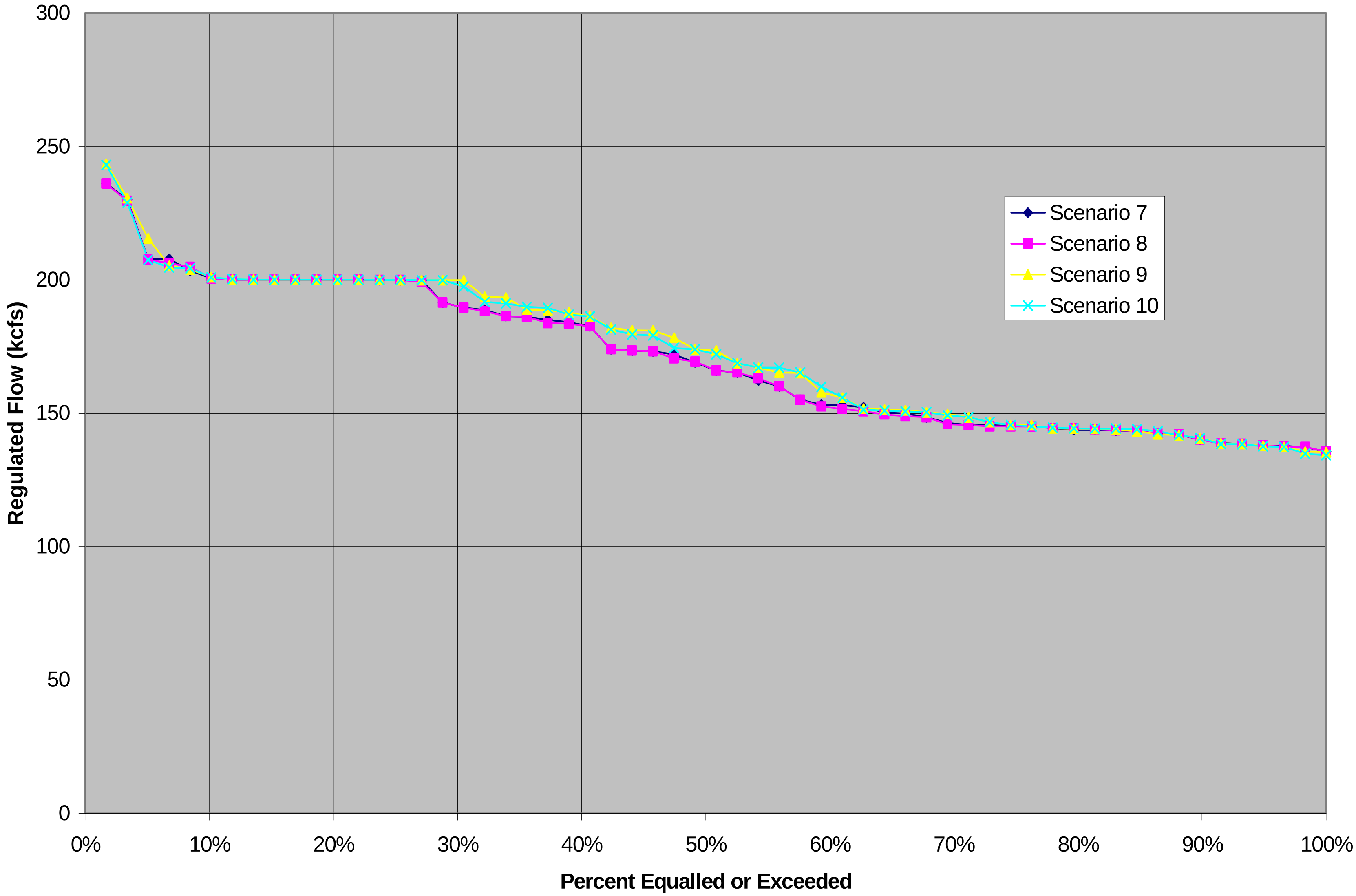


Chart 14
McNary Aug 16-31 Regulated Flow Percent Exceedance