III. RESERVOIR REGULATION

The reservoir system in the Northwest is made up of Federal, municipal, public, and privately owned dams. Regardless of ownership major hydroelectric projects are operated in accordance with the Pacific Northwest Coordinating Agreement. This agreement coordinates the seasonal operation of the system member's projects for the best use of their collective reservoir storage, and along with some of the other agreements that affect project operation, is briefly discussed in Chapter VI. In this chapter, however, the regulation of the system as a unit is described followed by the regulation of the operation of individual projects in downstream order and chronologically from the beginning of the operational year.

The members of the coordinated system of reservoirs are listed in the Glossary in Appendix A. Daily project operations are shown on charts in Appendix D. Charts 5-30 show the storage and streamflow hydrographs from July 1, 1997 through September 30, 1998, for major storage projects, Charts 31-56 present the annual hydrographs for flood storage projects, hydrographs of the spring freshet are shown in Charts 57-79, Chart 80 shows The Dalles discharge hydrograph for regulated and unregulated conditions, Charts 81-84 are the Willamette Basin's control point hydrographs, Charts 85-88 are the reservoir hydrographs for other Section 7 projects, and Charts 89-92 are summary hydrographs for the four key stations. Table 17 is the monthly rule curves and observed reservoir elevations for the major storage projects.

A. SYSTEM OPERATION

The operating year began with the coordinated reservoir system officially filling to 99.5% of storage capacity on July 31, 1997. As a result, first year firm energy load carrying capability (FELCC) was adopted for the 1997-98 operating year. Because of persistent high flows, the system generally operated to Operating Rule Curves (ORC) or flood control for the entire year. The system storage energy reached 99.1% of full on July 31, 1998, and the system adopted the first-year FELCC for the 1998-99 PNCA (Pacific Northwest Coordinating Agreement) Final Regulation study.

Daily flood control regulations were required during January at Libby, Grand Coulee, Dworshak and the Snake River projects. This year's observed peak flow at The Dalles was 570.7 kcfs on June 15 with a corresponding unregulated peak of 896.0 kcfs on June 7. The observed winter peak flow at The Dalles was 321.5 kcfs on January 5 with a corresponding unregulated peak of 398.0 kcfs on January 3. Last year's observed peak was 462.2 kcfs. The system reached 47% of its full energy capacity in the Actual Energy Regulation (AER) on July 31, 1997, resulting in first-year FELCC being adopted for the 1997-98 operating year. The observed refill was near 90% of capacity, providing some reservoir operating storage above the proportional draft level going into the new operating year.

B. PROJECT OPERATION

The operation of the individual projects is discussed in downstream order, beginning at the headwaters of the Columbia River. Operation of each project is generally discussed chronologically beginning in the summer or early fall of the preceding water year. Exceptions will be noted by including the calendar year. The locations of these projects are shown on the maps in Chapter I, pages 3 through 6.

1. Mica Project

Kinbasket Lake was formed by the construction of Mica Dam near the Big Bend on the upper Columbia River

in east-central British Columbia. The project was constructed as part of the Columbia River Treaty between the United States and Canada and is owned by BC Hydro and Power Authority (BCH or BC Hydro) and is operated primarily for power and flood control. This year's operation is graphically shown on Chart 5 and Chart 57.

The Mica Reservoir (Kinbasket Lake) level was at 2471.1 ft on July 31, 1997, 3.9 ft below full pool of 2475 ft and the corresponding Treaty Storage was 95% of full, at 3336.9 ksfd (6.7 maf). Treaty Storage continued to fill during August reaching full storage of 3529.2 ksfd (7.0 maf) on August 12. A 200-year rainfall event late in September 1997 produced high inflows that filled the reservoir to its full pool level on October 2 and required a spill of 59 ksfd during October 2-5. The inflows started to recede on October 4 and then the reservoir started to drop as turbine discharges exceeded decreasing inflows. The Mica Treaty underrun of 130 ksfd on August 31 increased in September and October decreasing somewhat in November with the year end underrun of 467 ksfd. The reservoir remained above 2460 ft until late November.

During November and December, the reservoir drafted 29.1 ft to end the year at 2439.8 ft. At that time the BC Hydro Non-Treaty Storage was about 680 ksfd; 60% of full, with Treaty Storage at 2451.6 ksfd (4.9 maf); 69% of full. Inflow decreased throughout the winter and remained low until mid-April when the spring snowmelt began. During March and April, the reservoir was drafted 21 ft, reaching its lowest level for the operating year of 2386.4 ft on April 23, 2.8 ft higher than the lowest level in previous year. Mica Treaty Storage reached a minimum of 15 ksfd (0.03 maf) on April 30 with Mica flex at 513 ksfd.

With the start of the spring freshet in early May, Mica discharges remained low, and the reservoir refilled by 59 ft to 2446 ft. At the end of May, the Mica Treaty underrun had been reduced to 479 ksfd. The Mica Treaty discharge was 10 kcfs for the months of May, June and July, allowing Treaty Storage to refill to 3284 ksfd (6.5 maf; 93% of full) by July 31. Local inflows were the highest in May, June and July averaging about 44, 43, and 49 kcfs, respectively. Actual Mica discharges during July averaged 21 kcfs, resulting in a Mica Treaty underrun of 363 ksfd and a reservoir level of 2463.5 ft by end of July. The corresponding plant generation was about 45% of plant capacity in July. On August 10, the reservoir level reached a maximum for the year, 2466.6 ft, before receding. Very high temperatures in August produced high inflows from glacier melt. Mica Treaty Storage reached full at 3529 ksfd on August 13. The inflows decreased to less than 30 kcfs by August 31.

The peak daily inflow was 63.6 kcfs on May 27, with a corresponding outflow of 3.69 kcfs. Maximum daily outflow was 50.5 kcfs on October 4.

2. Revelstoke Project

The Revelstoke project, located in southeastern British Columbia on the Columbia River between Mica Dam and Arrow Lakes, is owned by BC Hydro and is operated primarily for power generation. This year's operation is graphically shown on Chart 6.

During this operating year the Revelstoke project was basically operated as a run-of-river plant, maintaining the reservoir within 4.8 ft of its normal full pool level of 1880.0 ft. During the snowmelt freshet, June through August, the reservoir level was operated as low as 1874.4 ft to allow control of high local inflows.

3. Keenleyside Project (Arrow Reservoir)

The Arrow Lakes are two tandem natural lakes on the Columbia River in southeastern British Columbia whose surface elevations are controlled by Keenleyside Dam, and is owned and operated by BC Hydro and Power Authority. At normal operating elevations the land area between the lakes is flooded, creating a single lake. This project was constructed as part of the Columbia River Treaty between the United States and Canada for flood control and downstream power generation. It has no on-site hydropower facilities. This year's operation is graphically shown on Chart 7 and Chart 58.

The Arrow Reservoir level reached its 1997 maximum level of 1444.1 ft on July 31 with the Arrow Treaty Storage reaching 100% full a day earlier on 30 July. The maximum Treaty Storage from all the Canadian Projects was recorded on August 8, at 7792 ksfd. The reservoir continued to draft in August and reached 1432.2 ft by the end of September, 3.8 ft higher than the previous year. The Arrow Treaty Storage was 6.4 maf or 90% full at the end of September.

Arrow discharges decreased over the autumn months except during the 200 year high rainfall event in late September that resulted in high inflows. The Arrow Reservoir drafted to 1427.7 ft by December 31 with the Treaty Storage at 3010 ksfd (6.0 maf) or 84% of full.

In late December, BPA agreed, under terms of the Non-Power Uses Agreement, to a BC Hydro request that Arrow outflows be selectively reduced below Treaty requests to keep river levels at acceptable and maintainable levels during the whitefish spawning and emergence period from December 24 to January 21. Subsequently, flow adjustments were made from January through April to meet objectives for rainbow trout spawning. In the transition from whitefish to rainbow trout protection some whitefish eggs were de-watered.

Arrow Reservoir reached its lowest level for the year at 1386.2 ft on April 1 while Arrow Treaty Storage reached its minimum at 547 ksfd (1.1 maf) or 15% of full at the end of March. An innovative 'Siphon Excavation Method' was applied to transfer rainbow trout eggs from redds in danger of being de-watered to temporary hatchery facility at the project. This proved more effective than the previous year's attempt to keep the redds wetted for a limited time using a pump and sprinkler system.

The Arrow fisheries operations were conducted under agreements which enabled the Arrow project flows to be adjusted to reduce impacts to whitefish and trout redds. With the low discharge in April and May, and the start of the spring freshet with high inflows in May, the Arrow Reservoir rose to 1397.2 ft by April 30, 1421.1 ft by May 31, and 1434.4 ft by June 30, remaining below the Treaty flood control curve levels throughout the operating year.

The Arrow discharge was increased substantially in July as Arrow Treaty Storage neared full, and the reservoir reached its highest level, 1438.6 ft, on July 31 while discharge peaked at 72.2 kcfs on August 6, approximately three weeks later than the previous year. The Arrow Treaty Storage content continued to fill and reached full (7.1 maf) on July 29. With the increased Arrow discharges in late July and August, the Arrow Reservoir drafted to 1437.4 ft by the end of August.

To minimize spill at the Kootenay River plants and maintain Lake Koocanusa water levels in Canada for resident fish and recreation, the Canadian and U.S. Entities agreed to a Libby-Arrow water transfer in summer of 1998 as described in the Storage Transfer Agreement section later in this report.

The peak daily inflow was 101.6 kcfs on October 4, with a corresponding outflow of 62.6 kcfs. During the snowmelt season the peak daily inflow was 77.1 kcfs on May 17 and the non-flood maximum daily outflow was 76.8 kcfs on February 19. The unregulated peak inflow was133.3 kcfs on May 26.

4. Libby Project (Lake Koocanusa)

Lake Koocanusa and Libby Dam, on the Kootenai River in northwest Montana, were constructed as part of the Columbia River Treaty with Canada and are operated by the Corps of Engineers for power, flood control, and recreational benefits. The lake extends northward from the dam near the town of Libby, 60 river miles to the international border and another 30 miles (at full pool) into British Columbia. This year's operation is graphically shown on Chart 8 and Chart 59.

Lake Koocanusa started the operating year at 2453.56 ft, 5.44 ft below full pool, and for the first 13 days of August the project released 10.0 kcfs as it continued to fill. By August 12, Lake Koocanusa reached its maximum summer level of 2454.82 ft, 4.18 ft from full. The Libby/Arrow storage agreement was initiated and on August 13 in which Libby outflow was increased to 14.5 kcfs, with an additional 10.0 kcfs released from Arrow Lakes for the remaining days of August, hence the total exchange amount of 190 kcfs. Because of the 190 ksfd exchange, Lake Koocanusa ended August at 2450.12 ft, 8.88 ft from full.

During September through December Libby was used for weekly load shaping, with the monthly average outflow increasing slightly each month. Two periods of minimum outflow were supplied to complete a study of burbot movement downstream of Libby. Those two study periods were November 28 - 30, and December 25 - 28, when the Libby outflow was held at 4.0 kcfs. Lake Koocanusa ended December at 2411.71 ft, within one foot of the normal December 31 flood control point of 2411 ft.

Since the May final water supply forecast was less than 80% of normal, the US fish and Wildlife Service agreed to request only one sturgeon pulsing operation. The outflow from Libby remained at minimum of 4000 cfs through May 11. By May 19, the outflow was 21.6 kcfs at Libby. This pulse delivered when the water

temperature at Bonners Ferry reached 10°C. After the pulse operation, outflow was ramped down slowly. During the May 28 through June 1 period a rain event in the Kootenai Basin caused Libby outflow to be reduced to as low as 8500 cfs for downstream flood control. During May, Lake Koocanusa refilled to 2440.15 ft.

May rainfall was 201% of normal and although this raised the water supply forecast most of the water also ran off during May. The June operational objective was to gradually fill Lake Koocanusa without causing flooding downstream, or threatening to fill and force spill later in the year. This was working on schedule for the first 25 days of June as outflow from the Libby were held steady to maintain a level wetted perimeter after sturgeon spawning, as requested by the US fish and Wildlife Service. During July the objective was to maintain a level outflow from Libby that could be maintained through July and August that would draft Libby to 2439.0 ft by August 31. This objective was to maintain downstream fishery habitat and supply summer salmon flow. While this outflow of 15-18 kcfs was underway, the Libby/Arrow storage exchange agreement, to change the end of August target elevation and the level outflow required, was being negotiated. On July 14, following close coordinated with the fisheries agencies, Libby outflow was reduced to 4000 cfs for two days to assist a local sheriff's office in search and recovery of two drowning victims near Kootenai Falls. Because of this unplanned reduced outflow Lake Koocanusa filled to 2458.33 ft on July 16, its highest elevation in 1998, only 0.67 ft from full. After the search operation, the project outflow was set at 14.0 kfs again to continue the level flow operation through August; however the Libby/Arrow storage exchange was appearing more likely. Outflow from Libby was reduced to 12.0 kcfs by July 23 to prepare for an exchange of as much as 200 ksfd.

By August 4 the hydrologic conditions in Canada had deteriorated and the amount of storage exchange from Libby to Arrow could not be as high as 200 ksfd. Since Arrow was drafting too deeply it could not draft much more Libby exchange storage. By August 23 the US and Canada agreed to exchange 106 ksfd of storage in Libby so that the end of August target elevation would be near 2444 ft. In response to a US salmon managers request the outflow from Libby was ramped down slowly over a six day period from 22.0 kcfs to 9.9 kcfs on August 28, allowing the water to pass McNary before August 31.

In September, Libby outflow was set to meet power demands for five days and then adjusted to begin the fall draft. Lake Koocanusa was at 2437.9 ft on September 30, 21.28 ft from full pool.

The peak daily inflow was 64.4 kcfs on May 28, with a corresponding outflow of 10.8 kcfs. Maximum daily outflow was 21.6 kcfs in May 19.

5. Kootenai River at Bonners Ferry

The Kootenai River at Bonners Ferry, Idaho, a major control point for the flood control operation of Libby Dam, is located 82 miles downstream of Libby Dam. Its stages are affected by both river flow and by backwater from Kootenay Lake. This year's operation is graphically shown on Chart 60.

The peak regulated stage was 60.5 ft on May 28. Libby was releasing 10.8 kcfs at the time of this peak. The unregulated peak stage would have been 72.5ft, well above the 66.5 ft bankfull stage.

6. Duncan Project

Duncan Dam and Lake on the Duncan River, a tributary to Kootenay Lake in southeastern British Columbia, was constructed as part of the Columbia River Treaty between the United States and Canada. The project is owned and operated by BC Hydro and, although it has no on-site power-generating facilities, it is operated for downstream power generation and for flood control. This year's operation is graphically shown on Chart 9 and Chart 61.

Duncan Lake level began the operating year at 1892.1 ft, slightly above full pool and exceeded it slightly on several days in August and September. The reservoir remained within one-foot of the full pool (1892.0 ft). By September 30, Duncan had been drafted to 1889.8 ft.

Duncan monthly discharged averaged between 4.2 and 6.0 kcfs from September through mid-December. Higher discharges between mid-December and February were necessary to again support Kootenay Lake levels and flows. The Duncan Reservoir level was at 1859.4 ft (58% of full) on December 31. During January, the discharge was increased to about 8.2 kcfs which drafted the reservoir throughout February to mid-March, reaching its lowest level for the year at 1795.9 ft (1.7 ft above empty) on March 24.

The project discharge was reduced to minimum, 100 cfs, during most of May through July 5, to begin refilling the reservoir which reached 1844.3 ft by May 31 and 1872.2 ft by June 30. After July 5, discharge was gradually increased to slow the rate of reservoir refill. The reservoir reached full pool, 1892.0 ft, on August 12 and essentially passed inflow for the remainder of August to maintain the reservoir near full pool. On September 1, the project discharge was increased to start drafting the reservoir and fill Kootenay Lake to the IJC limit.

The peak daily inflow was 15.7 kcfs on May 27 with a corresponding outflow of 90 cfs. Maximum daily outflow was 10.2 kcfs on January 15.

7. Kootenay Lake

Kootenay Lake is a large natural lake on the Kootenay River in southeastern British Columbia which has most of its inflow regulated by Libby and Duncan dams. The seasonal regulation of the lake level is governed by rules established by the International Joint Commission (IJC) as agreed upon by the United States and Canada. Outflow from the lake is discharged through a series of instream powerhouses and/or diverted to the offstream Kootenay Canal Plant before it joins the Columbia River below Brilliant Dam near Castlegar, British Columbia. Although Corra Linn Dam, the project immediately downstream from the lake, controls the lake level, a constriction in the river channel at Grohman Narrows, between the lake and the dam, limits the maximum project outflow both during periods of high flows and when the lake approaches its minimum level. This year's project operation is graphically shown on Chart 10 and Chart 62.

The level of Kootenay Lake at Queens Bay was at 1745.5 ft on July 31 and then was gradually drafted during August to meet the summer IJC maximum of 1743.32 ft (Nelson gage level) and on August 27, was at 1743.1 ft. Discharges were adjusted to pass inflow until month end.

During September, the Lake discharge was adjusted to keep the downstream Brilliant plant at full load without spill at approximately 19 kcfs. This raised the lake level, as allowed in the IJC Order, to approximately 1745 ft by the end of October. By passing inflow, this level was maintained until December 31, when the pool was at 1744.6 ft. The lake did not reach the maximum IJC level of 1745.32 ft but remained within 0.5 ft of it.

Beginning in January, Kootenay Lake was drafted as required by the IJC order. The lake discharge was kept slightly above the inflows during January to mid-March to stay below the IJC limits. The lake reached a minimum level of 1738.6 ft on April 21, then rising quickly with the commencement of the spring freshet. The inflow peaked on May 27 at 79.8 kcfs. The Kootenay Lake discharge was then increased, and the Duncan outflow was reduced to minimum, to reduce the Kootenay Lake level rise. The Kootenay Lake discharges peaked on June 6 at 60 kcfs.

Kootenay Lake reached its peak level for the year at 1749.1 ft on June 2. The lake level gradually started to lower due to receding runoff in June and July, and reduced Libby discharges in July. Kootenay Lake drafted in these months with the lowest summer lake level of 1743.0 ft occurring on August 31. High energy demand into mid-August also required greater Kootenay Lake discharge and contributed to the lowest month-end level with the Nelson gage level dropping below the IJC summer level of 1743.32 ft on July 27. Except for on August 2, when the elevation reached 1743.38 ft due to unexpected high inflows, lake discharges were adjusted to keep the Nelson gage level below 1743.32 ft until the end of August. During September, increased outflows from Libby and Duncan, combined with only a moderate energy market demand, the lake started a slow refill. The lake level was controlled in September to retain operating space to accommodate unit outages at Kootenay projects in the fall as well as potentially high inflows forecast for this winter. The lake is projected to remain near 1744.0 ft from September into mid-October.

8. Columbia River at Birchbank

The Columbia River at Birchbank, British Columbia, includes the effects of regulation of all the Columbia River Treaty Projects. Its flow is regulated by the use of storage in Kinbasket, Arrow, Koocanusa, Duncan, and Kootenay Lakes. This is the portion of the Grand Coulee inflow contributed by the Columbia and Kootenay rivers. The Flathead/Pend Oreille River enters the Columbia River downstream of the Birchbank gage. This year's operation is graphically shown on Chart 63.

The observed daily peak discharge at Birchbank was 84.9 kcfs on June 1 and the unregulated peak flow was

207.9 kcfs on June 3. Bankfull and flood discharge is 225 kcfs.

9. Hungry Horse Project

Hungry Horse, a Section 7 Project on the South Fork Flathead River near Kalispell, Montana, is owned and operated by the Bureau of Reclamation for flood control, power, recreation, and fisheries. This year's operation is graphically shown on Chart 11 and Chart 64.

On October 1, the reservoir surface was 3537.2 ft after filling to 3559.8 ft on July 21. The reservoir began drafting in October with a goal to reach 3521.0 ft by January 1. The reservoir continued to draft during the remainder of winter to meet the minimum flow requirement of 3,500 cfs at Columbia Falls, reaching its lowest level on March 22 at 3505.1 ft, 55 ft from full. During the refill period releases were not provided through the outlet works so the total dissolved gas standard would not be exceeded. Due to the low potential for flooding the spillway flashboards were added to increase storage space. The reservoir reached its maximum elevation of 3560.85 ft on June 30. Releases were provided for Endangered Species Act (ESA) operations from mid-July through August, following the official Technical Management Team (TMT) weekly forecasts. The reservoir was drafted 20 ft to 3540 ft by August 31 and by September 30 it was at 3535.95 ft. A kokanee spawning flow of at least 3500 cfs was provided at Columbia Falls for the entire year.

The peak inflow of 18.7 kcfs occurred on May 27 and the maximum outflow was 7.19 kcfs on August 10.

10. Flathead R at Columbia Falls

Discharges on the Flathead River at Columbia Falls gage record the combined flows of the North, Middle and South forks of the Flathead River. The flows on the North and Middle forks are uncontrolled and those of the South Fork are regulated by Hungry Horse Dam. This year's operation is graphically shown on Chart 65.

This year's peak stage of 10.27 ft, or 27.5 kcfs, on May 28 at the time Hungry Horse outflow was 180 cfs. The unregulated peak was 43.1 kcfs on May 27.

11. Kerr Project (Flathead Lake)

Flathead Lake is a natural lake, the level of which is controlled by Kerr Dam which is owned by Montana Power Company and is licensed to be operated for power, flood control, and recreation. Spring refill of Flathead Lake is coordinated with the Corps of Engineers' Reservoir Control Center to control flooding of the agricultural lowlands between Kalispell and Flathead Lake. This area is prone to flooding if the lake reaches its full level, 2893.0 ft, coincident with the river flow being above 45 kcfs. This year's operation is shown on Chart 12 and Chart 66.

Flathead Lake was maintained in its top foot, 2892.0-2893.0 ft, into November then was gradually drafted throughout the autumn and winter months for power and flood control, reaching its minimum level for the year, 2883.08 ft on March 16. In late May, after heavy rainfall, Flathead Lake filled above 2891.0 ft which was the desired flood control level on May 31. The Corps requested the project increase releases over the Memorial Day weekend, May 22–26. Montana Power did not increase Kerr discharges which resulted in the lake reaching 2891.9 ft on May 25. Then, to reduce the lake level, Montana Power increased discharges from 13 kcfs on May 26 to 24 kcfs and 33 kcfs on May 27-28. This caused Lake Pend Oreille, downstream, to exceed it's normal maximum level of 2062.5 ft for four days.

The peak seasonal inflow was 35.3 kcfs on June 2 and the maximum discharge was 32.5 kcfs on May 28. Average monthly discharges were 24.8, 21.5, and 15.5 kcfs for May, June, and July respectively. On June 1 the lake had filled to 2892.0 ft and was operated in the top foot of its operating range through September 14. The unregulated peak inflow would have been 51.2 kcfs on May 28.

12. Albeni Falls Project (Lake Pend Oreille)

Lake Pend Oreille is a natural lake, whose outflow and lake level are controlled by constrictions in the outlet channel and by Albeni Falls Dam, a Corps project that is operated for flood control, power, and recreation. The dam is located 29 miles downstream of Lake Pend Oreille on the Pend Oreille River. Although the dam controls

the lake level, the river channel between the lake and the dam limits the project outflow during both high flow periods and when the lake is near its minimum level. Inflow to Albeni Falls Dam is affected by the regulation of upstream impoundments, namely Hungry Horse and Flathead Lake (Kerr Dam) on a seasonal basis, and by two Washington Water Power projects, Noxon Rapids and Cabinet Gorge, on a daily basis. This year's operation is graphically shown on Chart 13 and Chart 67.

The annual autumn drawdown of Pend Oreille Lake began immediately after Labor Day and reaching 2060.0 ft on October 1. The lake continued drafting in October and November, with the discharge averaging 21 kcfs and 20.8 kcfs, respectively, with corresponding lake levels of 2055.85 ft and 2055.15 ft, respectively. This was the second year of a three year fish habitat study, a Fish and Wildlife measure adopted by the Northwest Power Planning Council and conducted by the Idaho Department of Fish and Game, to test the effects of higher winter lake levels on kokanee salmon spawning and overall population recruitment in Lake Pend Oreille. The theory is that there are cleaner gravels at higher lake levels which are more conducive to spawning and population recruitment. Normally, 2051.0 ft is the minimum winter elevation but during this test, the minimum was raised to 2055.0 ft. The minimum of 2055.0 ft was established for the January through March period. The maximum flood control rule curve elevations for January, February and March were 2060 ft, 2060 ft and 2056 ft, respectively. The project stayed at or below these levels through March. Pend Oreille Lake exceeded it's normal maximum pool elevation of 2062.5 ft between May 29 and June 1 due to high discharges from Kerr. A peak observed inflow of 74.8 kcfs was reached on May 29.

Unregulated peak inflows peaked at 85.0 kcfs on May 29. Project discharges averaged 35.7 and 50.4 kcfs in May and June, respectively. Peak discharges were 66.8 kcfs on May 31. The project did not have to go to free flow (all spill, no generation) this year. The lake reached a maximum of 2062.63 ft on May 31 and maintained the lake in its summer operating range, 2062.0-2062.5 ft, from June 2 through September 7.

13. Grand Coulee Project

Grand Coulee Dam and Franklin D. Roosevelt (FDR) Lake are owned by the Bureau of Reclamation and operated for flood control (under Section 7 of the 1944 Flood Control Act), power, irrigation, recreation, fisheries, and navigation. The project includes Banks Lake, an irrigation/pumped storage reservoir. This year's operation is graphically shown on Chart 14 and Chart 68.

On October 1, FDR Lake was at 1284.1 ft and was operated above 1270 ft through early January. It was necessary to draft the reservoir to approximately 1255 ft by mid-February in order to perform critical security related maintenance on the drumgates. The drumgate work required the reservoir to be held near 1255 ft for about six weeks. The work schedule was accelerated in March to around the clock in order to complete all repairs by the end of the month. The project was successfully completed and the reservoir began to refill on April 1. The reservoir reached its lowest level the year, 1252.3 ft, on March 4, and refilled to 1289.7 ft by June 22. FDR continued operations of flow augmentation and ESA requirements until the end of August. The maximum daily outflow for the year was 205 kcfs on June 2.

The seasonal *spring* flow objective (228 kcfs April 20 - June 30) at McNary was met on a seasonal basis, and was met on a weekly basis for all but the first two weeks. The *summer* seasonal flow objective (200 kcfs July - August) at McNary was not able to be met, with July - August seasonal flow averaging 173 kcfs. This objective was met, however, on a weekly basis until July 19. Releases were provided to the extent possible for ESA operations for the remainder of July and August following the official weekly forecasts and flow recommendations established through the TMT process. Additional water was provided for flow augmentation in August by foregoing pumping to Banks Lake. This resulted in a draft of Banks Lake of approximately 5 ft, and provided about 100 kaf of additional water to the river. The lowest elevation reached at FDR reservoir for ESA operations was 1278.8 ft on September 2. The reservoir refilled to elevation 1281.7 ft by September 30, rather than the normal 1285 ft, in order to help meet downstream flow objectives in September (outside the BiOp period) at the request of the Salmon Managers.

The peak inflow of 202.5 kcfs occurred on June 1 and the maximum outflow was 205.0 kcfs on June 2. The unregulated peak flow was320.8 kcfs on June 2.

14. Mid-Columbia PUD Projects

Five run-of-river projects located on the mid-Columbia River in central Washington are operated by three separate Public Utility Districts (PUD's) primarily for power, flood control, fishery, and recreation. The five projects, in downstream order, are Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids and the three Public Utility Districts are those of Douglas, Chelan, and Grant counties. Although the projects are operated by these PUD's, 14 utilities, in addition to the three PUD's, split ownership of the generation output of these plants. Article 34 of the Federal Energy Regulatory Commission licenses for these projects states that some flood control space be provided, as instructed by the Corps, to replace lost valley storage under certain flood potential conditions but was not required this year. The operation of these projects is summarized in the flow of the Columbia River at Priest Rapids, Washington as shown on Chart 89.

Numerous special operations occurred at these projects to assist in the downstream passage of juvenile anadromous fish during the 1998 outmigration, including FERC-required spill. These include: during autumn, a coordinated effort was carried out to operate Priest Rapids to encourage fish to spawn at lower levels in the Vernita Bar area; from mid-October to late November (the primary spawning period), daytime flows were held as low as possible in an attempt to reduce the subsequent minimum flow necessary to protect redds until emergence of fry in early spring. The protection level was established at 65.0 kcfs.

The unregulated peak flow at Priest Rapids was 368.6 kcfs on June 2, and the observed peak was 256.1 kcfs on June 2.

15. Yakima Project

The five storage reservoirs in the Yakima Basin in eastern Washington were operated by Reclamation for irrigation, fish and wildlife enhancement, flood control, power generation, recreation, and dam safety concerns. This year's operation is graphically shown on Chart 31 and Chart 32.

The Yakima reservoirs were operated to enhance both fish spawning conditions during September to mid-October 1997 and incubation/rearing levels mid-October through December. The bypassing of reservoir inflows to maintain flood space requirements or power rights supported incubation/rearing level flows for the rest of the season. Incubation/rearing releases from reservoirs included 6.9 kaf from Keechelus, 5.4 kaf from Cle Elum, and 0.6 kaf from Rimrock. These below normal incubation/rearing releases were due to the above-normal carryover from last summer which required early bypassing of storage inflow to maintain flood control space.

The Yakima reservoir system reached maximum storage for the year on June 1 at 1,069,694 af, and was placed on storage control on June 26. From mid-July the runoff in the Yakima River Basin dropped to below normal until the end of irrigation season, due in-part to minimal effective precipitation during July through September. All entitlement water users received a full water supply during the irrigation season (March 15 to October 20). The project storage on September 30 was 279,150 af, 76% of normal.

With the projection for Total Water Supply Available, the Yakima River Basin was managed to provide target flows of 400 cfs for Yakima River at Parker, and 400 cfs for Yakima River at Prosser (Note: Power subordination agreement increases this flow to 450 cfs). These flows are provided for by law in "TITLE XII -- YAKIMA RIVER BASIN WATER ENHANCEMENT PROJECT", Section 1205.

Both fish spawning enhancements,"Mini-Flip-Flop" and "Flip-Flop" operations, were executed. The "Mini-Flip-Flop" operation requires increasing outflows from Kachess Reservoir and decreasing outflows from Keechelus Reservoir to supply the demands in the Easton reach of the upper Yakima River. This provides for low spawning flows in the Yakima River above Lake Easton. The incubation/rearing level flows required during the winter are then supported by releases from Keechelus Reservoir. The "Mini-Flip-Flop" operation began during the week of August 24-30.

The Yakima River to Naches River "Flip-Flop" operation was executed for the 18th consecutive year. It involved drawing storage from Keechelus, Kachess, and Cle Elum reservoirs to meet all Yakima River diversions in June, July, August and the first few days of September. During these months Rimrock and Bumping reservoirs were used only to meet the Naches and Tieton river diversions. In September, when low stages of river flows were required in the Yakima River from Easton to the mouth of the Teanaway, the Yakima River reservoirs were set to

meet only the spawning flow levels. Also, up to 400 cfs was routed around that reach via the Kittitas Canal at Wasteway 1146. The Yakima system requirements below the confluence of the Naches River, as well as the Naches and Tieton diversions, were met with releases from Tieton and Bumping reservoirs for the rest of the irrigation season. These flows were provided for spring Chinook salmon under a 1980 court order. The onset of the "flip-flop" operation was implemented during September 1-10, providing a longer, more environmentally friendly ramping down of flow levels in the upper Yakima River.

Spawning flows were set at 60 cfs at Yakima River near Crystal Springs, 200 cfs in Yakima River below Easton Dam, and 200 cfs in the Cle Elum River below the reservoir. Due to the late fisheries spawning cycle throughout the Yakima River Basin, incubation/rearing flow levels were not established for water year 1999 until the second week of November 1998, providing for 150 cfs at Yakima River below Easton Dam, and 145 cfs in the Cle Elum River below the reservoir.

The October through September natural flow for the Yakima River at Parker was 3.35 maf, about 99% of normal. The peak daily observed flow of 13.9 kcfs occurred on May 6 and the peak daily unregulated flow of 23.3 kcfs occurred on May 3.

16. Jackson - Palisades Project

Active storage in the Snake River Basin above Heise, Idaho, includes 847 kaf in Jackson Lake and 1,200 kaf in Palisades Reservoir (a Section 7 project) for a combined total of 2,047 kaf. The system is operated as a multipurpose unit for flood control, irrigation, recreation, fish and wildlife, and power production. Discharge measurements from Jackson Lake are gaged at the Snake River at Moran, Wyoming, and from Palisades Reservoir at the Snake River near Irwin, Idaho. Flood regulation curves are designed to maintain flows at Heise at or below 20.0 kcfs. This years operation is shown graphically on Chart 33, Chart 34, Chart 69, and Chart 70.

Jackson Lake and Palisades reservoirs combined contents were 1,741 kaf on October 1. Storage increased slightly through the first half of the winter until flood control rule curves dictated that flood control space be evacuated. Once at the desired level was reached in early May flood control releases from Jackson Lake were periodically adjusted to maintain existing space. Releases were gradually increased in mid-May from 1100 cfs to 6100 cfs on June 7. This release was decreased to 3000 cfs during June, then increased rapidly to 5000 cfs in early July due to a sudden increase in inflows as the reservoir approached full. Jackson Lake filled on July 2 and 0.13 ft of surcharge was used for a maximum content of 850,325 af on July 4. Starting July 8 releases were gradually decreased to match inflow, reaching 2300 cfs by July 23.

Flood control releases to make space in Palisades Reservoir began February 9 and increased to 7500 cfs in mid-March. As the runoff season proceeded, the release was increased to 18.0 kcfs by early June then decreased to 13.0 kcfs by mid-June due to slow runoff. Releases were increased starting July 2 due to increased inflows caused by warm weather and reached the peak release for the year of 19.0 kcfs on July 4 through July 7. Palisades filled on July 7, and on July 8 releases were gradually reduced to match inflow, reaching 8500 cfs by August 5.

September 30 content was 1,523 kaf, 301 kaf above normal contents on September 30. The unregulated peak flow at the Heise Gage was 27.1 kcfs on June 14, and the peak regulated flow was 19.2 kcfs on June 7.

17. Ririe Project

Ririe Reservoir is a Section 7 project on Willow Creek in eastern Idaho that is owned and operated by the Bureau of Reclamation for the joint uses of irrigation, flood control, recreation, and fish and wildlife. Its active capacity of 90.5 kaf includes exclusive flood control space of 10.0 kaf. This year's operation is graphically shown on Chart 35.

The peak daily inflow was 1170 cfs on May 3 and the maximum release was 752 cfs on May 15 The maximum active reservoir content was 80.94 kaf on May 18. Storage at the end of the water year was 62.5 kaf, 69% of capacity.

18. American Falls Project

American Falls Dam is a Section 7 project on the Snake River near Pocatello, Idaho, that has an active

capacity of 1673 kaf and is operated primarily for irrigation, power, and flood control. During the irrigation season American Falls Reservoir is operated to meet irrigation needs in the Snake Basin downstream from American Falls Dam. The streamgage on the Snake River near Shelley, approximately 73 miles upstream from the dam, is the control point for flood regulation in American Falls Reservoir and for irrigation releases from upstream reservoirs. Milner Dam, located 74.0 river miles below American Falls, serves as a headworks for irrigation diversion in the middle Snake River plain. In normal years only minimum flows pass Milner with the remainder of the flow diverted for irrigation. This year's operation is graphically shown on Chart 36, Chart 37, Chart 38, and Chart 71.

Fall releases gradually decreased throughout October reaching 6200 cfs by early November and then remained between 6000 cfs and 7000 cfs until February. Starting February 10 they were gradually increased to 8000 cfs by early March. On March 3 releases were reduced from 8000 cfs to 4600 cfs, to accommodate USGS spring flow measurements below Milner Dam, on March 13 increased to 9500 cfs and then gradually increased to 12.0 kcfs by March 25. The reservoir filled May 11 at a release of 11.5 kcfs. Starting May 12 releases were increased to 22.0 kcfs by May 25 due to large inflows caused by heavy rain and a near depletion of irrigation demands. When the rain stopped and irrigation demands resumed releases dropped fairly quickly from 22.0 kcfs on June 1 to 13.0 kcfs by early July then gradually dropped as irrigation demands diminished to 7,500 cfs by September 30.

Maximum storage during the year was 1,689,434 af on June 29. Reservoir contents on September 30 was 848,082 af, 325,000 af above the 30 year normal.

19. Little Wood Project

Little Wood Dam and Reservoir was originally constructed by Little Wood Irrigation District for exclusive irrigation use, and has been designated as a Section 7 project since its enlargement, by the Bureau of Reclamation, to an active capacity of 30.0 kaf and is now operated also for flood control. The Little Wood River at Carey, Idaho, streamgage, approximately 3 miles downstream from the dam, is the control point for reservoir operations. This year's operation is graphically shown on Chart 39.

Flood control space was evacuated and maintained starting in mid February and continued through the end of April with periodic discharges of 300 to 400 cfs. The reservoir started filling the last week in March, filling on May 8 and remaining full until July 12.

Maximum reservoir content was 30,412 af on May 10. The storage at the end of September was 8,293 af, 1,193 af above normal. Maximum mean daily springtime inflow was 893 cfs on May 11 and peak mean daily discharge at the Carey gage was 917 cfs on May 15.

20. Owyhee Project

Owyhee Reservoir has an active capacity of 715 kaf and, although it was constructed by Reclamation as a single-purpose irrigation reservoir, it can provide significant incidental flood protection along the lower Owyhee River and along the Snake River from Nyssa, Oregon, to Weiser, Idaho. Most of the largest floods from this basin result from winter rains on snowpack over frozen ground. This year's operation is graphically shown on Chart 40.

The runoff this year was above normal with the December-June runoff volume 873 kaf, 120% of normal. The peak mean daily inflow was 13.25 kcfs on May 14 and the peak daily outflow was 10.2 kcfs on May 16. The reservoir reached a maximum content of 729 kaf on May 28. The Owyhee net inflow for the period of June through September was 143% of normal.

21. Boise Project

The Boise Project, Arrowrock Division, is a three-reservoir system composed of Anderson Ranch, Arrowrock, and Lucky Peak reservoirs with a combined total active storage capacity of 974 kaf. Anderson Ranch and Arrowrock, Section 7 projects, are operated by Reclamation while Lucky Peak is a Corps project that is regulated in close cooperation with the two upstream projects. A powerhouse was retrofitted to Lucky Peak by Seattle City Light. This system is operated as a multipurpose unit for flood control, fish and wildlife, power production, recreation, and irrigation. The Boise River at Glenwood Bridge streamgage is the control point for the flood

control operation of the system. This year's operation is graphically shown on Chart 41 and Chart 72.

The release from Anderson Ranch Reservoir was maintained at the minimum release of 300 cfs from the end of the 1997 irrigation season until early February, 1988. Through most of February and March the release was maintained at powerplant capacity of 1700 cfs. In late May releases from Anderson Ranch Reservoir reached a seasonal maximum release of about 4300 cfs with flows in excess of powerplant capacity released over the spillway.

The release from Lucky Peak Reservoir was reduced to 240 cfs at the end of the irrigation season in mid-October and further reduced to 150 cfs in early November where it remained throughout November. In December the release was increased again to 240 cfs and maintained at that rate until flood control releases were initiated in early February and then maintained at about 2000 cfs through most of March. Heavy rains in May resulted in rapid filling of the reservoir system and required system releases in excess of flood control goals. Salmon flow augmentation totaling 40 kaf was released from Boise River reservoirs between early July and late August.

The maximum release from Lucky Peak was 10.56 kcfs on June 8. The peak flow of the Boise River at the Glenwood Bridge gaging station was 8260 cfs on May 31. Flood stage at the Glenwood station is 7000 cfs. Flood damage associated with these high releases was minimal.

22. Malheur Project

Beulah (Agency Valley Dam) and Warm Springs Reservoirs were originally constructed and operated as single-purpose irrigation reservoirs. Since the construction of Bully Creek Reservoir in 1962, all three of these Section 7 reservoirs are operated for multipurpose benefits and have a combined active capacity of 281 kaf. The Malheur River is similar to the Owyhee River in that the major floods are usually caused by rain on frozen and snow-covered ground. The Malheur River at the Vale, Oregon, streamgage is the control point for flood control operation of the reservoirs, with the primary goal of limiting flows to 8000 cfs. This year's operation is graphically shown on Chart 43, Chart 44, and Chart 45.

This was a normal water supply year in the Malheur Basin. December through June runoff at Warm Springs Reservoir was 98% of normal and inflow on the North Fork at Beulah Reservoir was 114%. Warm Springs Reservoir reached a maximum storage volume of 191 kaf on June 11 and the end of year content was 94 kaf.

Beulah Reservoir filled and reached a maximum storage content of 60 kaf on May 25. End of year carryover storage in Beulah Reservoir was 25 kaf.

Bully Creek Reservoir reached a maximum storage volume of 31 kaf on May 26 and the end of year carryover storage volume was 16 kaf.

23. Payette Project

The Payette River reservoir storage system includes Cascade and Deadwood reservoirs which have a combined total active storage capacity of 815 kaf. These reservoirs were originally constructed by Reclamation for irrigation and power purposes, but now are also operated informally for incidental flood control. The control point for flood control operation of these projects is the Payette River near Horseshoe Bend streamgage at river mile 60.8. A second key streamgage is the Payette River near Emmett at river mile 38.4. Approximately 65% of the drainage basin above Horseshoe Bend is unregulated. This year's operation is shown on Chart 42 and Chart 73.

Runoff in the Payette Basin was near normal. Peak daily inflow into Cascade Reservoir was 7979 cfs on May 11 and the peak inflow into Deadwood Reservoir was 1292 cfs on May 9.

The peak flow of the Payette River near Emmett was 17,000 cfs on May 27. Flood flow is 16.0 kcfs at Emmett. However, there was no report of flood damage associated with the 17.0 kcfs flow.

Cascade Reservoir filled on June 19 and was maintained at full pool through July 8. Releases gradually decreased after Labor Day and decreased to 700 cfs by the end of the water year.

Deadwood Reservoir filled on May 31 and remained full until July 17.

A total of 145 kaf was obligated for release for salmon flow augmentation. About 85 kaf was released from Cascade and Deadwood reservoirs between mid-July and the end of August. The remaining 60 kaf was to be released between late mid-December and mid-January of WY-99. Some of the water released from Cascade

Reservoir for this purpose was water conveyed downstream from Payette Lake.

24. Snake R at Weiser

Snake River at Weiser flows are highly regulated by upstream irrigation diversions and reservoir storage operations previously discussed in this chapter. These operations normally results in a fairly smooth hydrograph at Weiser. This year's operation is graphically shown on Chart 46 and Chart 74.

A major rain on snow event in late December and early January established the peak flow for the year. The computed unregulated peak flow at Weiser was 154.6 kcfs on January 2 and the observed peak was 81.8 kcfs on January 3, which is just shy of the record flow of 83.8 kcfs established in 1952, and third highest since record keeping began in 1910. (Peak flow in 1921 was also slightly higher). Operation of the Boise, Payette, and Owyhee projects were responsible for an approximate 50% flow reduction at the Weiser gage during this flood. The spring freshet observed peak was 60.5 kcfs of June 17 and the unregulated peak was 122 kcfs on May 19.

25. Powder Project

Phillips Lake is formed by Mason Dam on the Powder River in eastern Oregon that is owned by Reclamation and is operated by the Baker Valley Irrigation District as a multipurpose project with 17 kaf for exclusive flood control, 21 kaf for joint use, and 52.5 kaf for active conservation use, for a total active capacity of 90.5 kaf. The control point for flood control regulation is the Powder River at Baker streamgage, which should be controlled to 500 cfs, if possible. This year's operation is graphically shown on Chart 88.

The Powder River basin had an above normal runoff year. Phillips Reservoir nearly filled and reached a maximum storage volume of 83,944 af on June 10.

The peak flow of the Powder River at Baker City was 545 cfs on May 26. Storage of high inflows in Phillips Reservoir substantially reduced downstream flooding as the peak mean daily inflow on May 26 was 1060 cfs.

26. Brownlee Project

The Brownlee, Oxbow, and Hells Canyon dam complex is owned and operated by Idaho Power Company (IPC). These tandem projects on the Snake River on the border between Oregon and Idaho are operated in accordance with a single license issued by the Federal Energy Regulatory Commission (FERC) which requires operation for flood control and navigation, in addition to power. Specifically, this license requires that Brownlee, the only one of the three projects with significant storage, provide a minimum of 500 kaf of flood control space by March 1 in years of normal or greater forecast water supply at Brownlee and The Dalles. The license does, however, have a provision for a partial waiver of this requirement in dry years or for increased space in wet years. The license also requires adequate navigation depths be maintained below Hells Canyon Dam. Spring refill of Brownlee is coordinated with the Corps of Engineers Reservoir Control Center for flood control. This year's operation is graphically shown on Chart 15 and Chart 75.

Brownlee began the water year at 2044.5 ft and was drafted to 2031.4 ft by October 19 to create space in the reservoir so a portion of the inflow could be stored while discharge from Hells Canyon could be maintained between 9.5 and 12 kcfs to encourage fall chinook salmon to spawn at a low elevation in the downstream channel from late October through December 9. The goal, to fill the lake near the end of the spawning operation, was met by December 16 when the pool filled to 2076.4 ft (2077 ft is full). The Hells Canyon Dam discharges were then maintained above 12.5 kcfs until salmon fry emergence in the spring.

The February water supply forecast for Brownlee for the April-July period was 88% of normal. Based on this forecast and the forecast at The Dalles the Corps notified IPC that kaf of flood control space (2044.5 ft) be available at Brownlee by February 28 and 500 kaf of flood control storage space be available (2034.6 ft) by April 30. Because of the low volume forecast in the Columbia basin, the Corps also notified IPC that until April 30, Brownlee's entire flood control requirement could be shifted to Grand Coulee. Grand Coulee was currently drafted for drum gate maintenance work anyway, so the Corps agreed to allow Brownlee to be within 50 kaf of its end of February flood control draft. However, in late February the in-season TMT requested the draft of Brownlee be suspended while an operation to shift system flood control to Grand Coulee was considered by the Salmon

Managers. This operation was agreed to by IPC, and subsequently Brownlee was drafted to 2050.2 ft which was within 62.0 kaf of the end of February flood control draft. The April final volume forecast had a flood storage requirement of only 50.0 kaf (2073.5 ft) by April 30 and by that date the reservoir was drafted to 2073.23 ft. The project continued to draft for flood control to a low of 2073.19 ft on May 1. Increasing project inflows from the beginning of the spring runoff refilled Brownlee reservoir to 2077.0 ft on June 26.

The State of Idaho developed a plan (which was approved by the TMT) to start drafting Brownlee the week of July 6 to meet the 237 kaf augmentation volume required per the BiOp and shape the 137 kaf contribution from the Payette River. The objective was to draft not more than 1-foot per day at Brownlee and release not more than 25 kcfs at Hells Canyon (maximum turbine capacity at Hells Canyon Dam). Brownlee was drafted to 2052.3 ft by July 31, then to 2042.4 ft by August 31 and 2020.0 ft by September 30.

The regulated peak inflow was 90.6 cfs on May 28 and the unregulated peak inflow was123.2 kcfs on May 28. Maximum daily outflow was 89.6 cfs on May 29.

27. Dworshak Project

Dworshak Lake and Dam are located on the North Fork Clearwater River near Orofino in west central Idaho. This headwater project was constructed and is operated by the Corps of Engineers for power, flood control, fishery, navigation and recreation. This year's operation is graphically shown on Chart 16 and Chart 76.

Dworshak Lake level was at 1500.33 ft on October 1 where it remained, through December 1, to facilitate contract grouting to slow down seepage through the dam. The grouting work was completed December 15. The project filled to 1505.1 ft by the end of December, which was far below the Upper Rule Curve level of 1558.0 ft. Because of the low volume forecast little flood control storage was required and the project remained on minimum flow (1.3 kcfs) from December 1 through April 19, at which time the TMT called for flow augmentation for Lower Granite. The TMT called for water off and on again from Dworshak in April and May and the project filled (1600.0 ft) on June 4. The TMT again called for water from Dworshak at the July 1 meeting but the State of Idaho and Salmon Managers disagreed on the timing of the augmentation. The Salmon Managers wanted to start drafting Dworshak on July 6, even though the Lower Granite summer target flows (55 kcfs) were being met without help from Dworshak. The State of Idaho wanted to delay the draft until Lower Granite needed help from Dworshak to meet their target flows. The two groups reached an agreement at the Implementation call on July 2. Idaho granted a 110% dissolved gas waiver to allow Dworshak outflows to exceed 10 kcfs so all the augmentation water can be delivered before the end of August. The actual agreed upon operation involved gradually increasing Dworshak outflows starting on July 11. The full amount of BiOp water was delivered by the end of August, at which time the pool drafted to 1520.3 ft.

The peak daily inflow was 20 kcfs on May 4-8, while outflow was 1300 cfs. The peak daily outflow was 20 kcfs which was maintained July 10–31.

28. Clearwater River at Spalding

The streamgage on the Clearwater River at Spalding in west-central Idaho measures the portion of the inflow to Lower Granite Dam that originates in the Clearwater River Basin. It is also used as a flood control point in the operation of Dworshak Dam. This year's operation is graphically shown on Chart 77.

The observed peak flow at Spalding this year was 12.8 kcfs on May 27 when Dworshak was releasing 1.0 kcfs. The unregulated peak flow during the flood season was 59.8 kcfs on May 8, well above the flow at flood flow of 111.6 kcfs.

29. Lower Snake Projects

Lower Granite, Little Goose, Lower Monumental, and Ice Harbor are run-of-river projects on the lower portion of the Snake River in southeastern Washington. Lower Granite and Little Goose have 5-foot forebay operating ranges, and Lower Monumental and Ice Harbor have 3-foot ranges. All four projects are operated by the Corps of Engineers for navigation, hydropower, fishery, and recreation. This year's operation is graphically shown on Chart 78 and Chart 90.

Lower Monumental and Little Goose projects operated in their top foot operating ranges October 1 through December 31 to enhance adult fish ladder access. Ice Harbor operated slightly below its top foot through December 31 to provide as good fish ladder conditions as possible (for upstream adult fish migration) and also provide reservoir space to protect workers who are installing flip lips in the tailrace. Lower Granite operated between 734.0–735.0 ft from October 1 through November 15 which was as low as possible for juvenile fish migration yet high enough for navigation restrictions. On November 15, Lower Granite operation was opened up to 734.0-738.0 ft and was operated to maintain the Lewiston elevation below 738.0 ft, if flows were low and below 737.0 ft if flows were above 50.0 kcfs for flood control. Starting on April 6, all projects were drafted to MOP (Minimum Operating Pool level) or MOP + 1 ft for juvenile fish migration, as required by the BiOp. Required night time spill was initiated at Lower Granite, Little Goose, and Lower Monumental on that same day and continued through June 20. Required around the clock spill was initiated at Ice Harbor on April 6 and terminated August 31 (lasted longer than the other Lower Snake projects because Ice Harbor does not have fish collection system). Between April 6 and 9, Ice Harbor spill was limited to 110% because the State of Oregon's 120% dissolved gas waiver was not effective until April 10. Spill at Lower Granite, Little Goose and Lower Monumental was 120% beginning April 6 at night. Voluntary spill at the Lower Snake projects was terminated at midnight on June 20. Navigation companies had problems navigating barges at Ice Harbor because of the newly installed flip lips. Spill adjustments were made for navigation traffic when requested by towboat personnel to aid in safe navigation. The Ice Harbor forebay was operated at a level to provide the contractor 3 hours to evacuate the tailwater work area in the event of an emergency. Lower Monumental and Little Goose refilled in September to enhance adult fish ladder access.

The regulated peak flow into Lower Granite was 213.3 kcfs on May 27 and the unregulated peak was 245.0 kcfs on May 28.

30. Mill Creek Project

Mill Creek Dam and Bennington Lake is a Corps of project in the Mill Creek basin, east of Walla Walla, Washington. This off-stream project receives high flows that were diverted from Mill Creek for flood control. The reservoir's active storage capacity of 8,200 af was used for flood control and recreation. This year's operation is graphically shown on Chart 47.

From October 1 through December 31 Bennington Lake's level ranged between 1195.0 ft and 1194.5 ft. During January two major flood control operations were required, each followed quickly by drafting the pool to prepare for possible subsequent flood control operations. The first, on January 1, was caused by storms in late December that filled Bennington Lake to a peak of 1211.7 ft. The second flood operation on January 31, was caused by storms in late January that filled the pool from 1207.8 ft to a peak of 1212.1 ft on February 1. Seepage and evaporation losses caused drawdown of Bennington Lake to conservation pool level of 1205.0 ft by April 14 and to 1193.8 ft by September 30; streamflows were not sufficient to maintain the pool at 1205.0 ft.

31. Willow Creek Project

Willow Creek Dam at river mile 52.4, together with the City of Heppner Flood Warning System, constitutes the Corps of Engineers flood protection provided for the urban reach of Willow Creek through the city and immediately north of Heppner in north-central Oregon. The dam is a 154 ft high roller-compacted concrete structure with an ungated spillway. The 14,091 af of storage space below the ungated spillway crest, 2113.5 ft, is allocated to flood control, irrigation, and minimum flow maintenance. The lake is held at 2063.0 ft in the winter and 2076.5 ft in the summer to provide for flood control. This year's operation is graphically shown on Chart 48.

There were small two flood control regulation events this water year, both occurred in January and had inflows in the 400 cfs range and each followed quickly by drafting the pool to prepare for possible subsequent flood control operations. The early January storm filled the pool to 2075.5 ft and the late January event filled the pool to 2073.0 ft. Maximum summer operation pool of 2076.5 ft occurred in early June. The water year, and also the water conservation season ended with a pool level consistent with the scheduled water control regulation curves. Pool drawdown does not occur until the next water year, starting after Columbus Day each October.

32. John Day Project

Lake Umatilla, the reservoir behind John Day Dam on the Columbia River that straddles the Oregon-Washington border, is operated by the Corps primarily for power, flood control, and navigation. The lake has approximately 500 kaf of active storage in its full operating range, 257-268 ft. Historically, the Corps generally operated the lake in the range of 260.0-265.0 ft from November through the spring runoff. Following the spring runoff, and continuing until mid-October, the pool is normally operated in its top three feet, 265.0-268.0 ft. However, in recent years the lake has been operated at lower levels in an attempt to improve juvenile fish passage through the reservoir with lower surface levels and faster water velocities. In addition, the lake may be drafted to as low as 257.0 ft for flood control and power. This year's operation is graphically shown on Chart 17.

While there were no flood control operations at John Day this year, there were special operations. From October through March the John Day forebay was operated in such a way to provide extra storage space to protect the workers from spill as they installed flip lips in the tailrace. The forebay was as low as 260 ft on December 1-4. There were also special goose operations, for hunting (mid October through early January) and for nesting (March 10 – June 1). The 'hunting' request was to operate in the top foot of the operating range on Mondays, Wednesdays, weekends, and holidays and the 'nesting' request was to operate the pool in the top foot of the range at least once every four days. Between April 20 and September 30 the forebay was operated in a 1.5 foot operating range per the BiOp. The range started out 262.5-264.0 ft and subsequently was raised to 263.5- 265.0 ft for the irrigators.

33. Upper Deschutes Project

This multiple-reservoir system is composed of six reservoirs: Prineville and Ochoco reservoirs (both Section 7 projects) on the Crooked River (a mid Deschutes Basin tributary) and Crane Prairie, Wickiup, Crescent Lake, and Haystack reservoirs on the upper Deschutes River. Including Haystack, which is an offstream re-regulating reservoir, the combined total active storage capacity is 559 kaf. This year's operation is graphically shown on Chart 49 and Chart 50.

Crescent Lake storage at the beginning of the water year was 71.5 kaf, the second highest carryover amount since record keeping began in 1922. Outflows typically ranged between 40 and 60 cfs from November through April to maintain some reservoir space for informal flood control objectives. Storage peaked for the season at 82.2 kaf on May 12 and carryover storage at the end of the year was 60.7 kaf. The maximum combined Wickiup and Crane Prairie storage of 255 kaf was reached on April 3 and at the end of the year it was 169.5 kaf.

Prineville Reservoir entered the water year with a carryover of 89.6 kaf (93% of normal). Winter flood control space was maintained by releasing a 'stream resource maintenance' flow of approximately 70 cfs from mid-November until late January, when higher flood control releases became necessary. Project outflows ranged between 200 cfs and 2000 cfs during February through April. The reservoir filled to full by late April and passed inflow during May. A record rain event occurred in late May, causing the maximum inflow for the year of 5730 cfs on May 30. Flood control operations were critical in reducing flooding on the Crooked River through Prineville. Outflows were reduced at the onset of the flood and were not increased until local runoff below the project diminished and the river receded back within its banks. The emergency flood surcharge space in the reservoir was used to store over 20 kaf of flood runoff, surcharging the reservoir by 6.5 ft. The maximum release for the year of 2243 cfs occurred on June 9 during evacuation of this space. Peak storage of 173.2 kaf, 113% of active capacity, was reached on June 1 and then decreasing to 103.1 kaf (108% of average) at the end of September.

Ochoco Reservoir began the water year with a carryover of 25.3 kaf. The outlets were closed following irrigation season and all inflow was stored until late March, when flood control releases were necessary in accordance with the rule curves. Discharges from late March through April ranged from about 50 cfs to 200 cfs to keep the reservoir at or near its rule curve requirements, which allowed the reservoir to fill by early May. All snowpack in the basin was essentially melted out by mid-May and inflows had receded, although persistent rains during the month kept inflows from dropping to base levels and held irrigation demands to a minimum. The reservoir passed inflow during May at a rate of about 150 cfs. A major flood event occurred in the basin beginning on May 29. This flood was caused by an intense, basin wide rain event lasting approximately 28 hours. Rainfall amounts were very uniform over the basin and typically ranged from 2 to 3 inches. This is approximately 25% of

the annual rainfall at Prineville. It also appears from initial investigation that this will set a new record for one-day precipitation. The largest rain events in the basin have typically occurred in the winter months; a rain event of near this magnitude is unprecedented for late May. Inflow to the reservoir peaked at an estimated 2550 cfs (peak instantaneous). Attenuation of the flood through the full reservoir resulted in a peak discharge estimated at 2050 cfs (instantaneous flow) over the spillway, with higher flows through Prineville due to local inflows below the dam. The spillway had recently undergone safety of dam modifications and performed as designed during the event. Flood damage was extensive in the suburbs and city of Prineville and to the irrigation structures of the Ochoco Irrigation District, resulting in a federal disaster declaration and flood relief actions.

Peak mean daily inflow was 2092 cfs on May 30, and peak mean daily discharge was 1843 cfs on the same day. (Peak instantaneous values cited in previous paragraph are perhaps more meaningful during a short duration flood.) The reservoir reached a maximum capacity of 46.4 kaf (1.3 ft into surcharge) on May 30. Irrigation demand drafted the reservoir during the summer to 24.7 kaf by the end of September.

34. Chief Joseph, McNary, The Dalles, and Bonneville Projects

These run-of-river projects are operated by the Corps for hydropower, navigation, irrigation, recreation, and fisheries. Chief Joseph is located on the mid-Columbia River in central Washington while McNary, The Dalles, and Bonneville are on the lower Columbia River, straddling the Oregon-Washington border. Several special operations occur each year at these projects to meet special operational requirements. This year's operation is graphically shown on Chart 80 and Chart 91.

McNary Dam had Biological Opinion flow requirements that varied throughout the spring summer (see Chapter IV, Section G, Fishery Operations). Also continuing at McNary this year was the unloading of ten decommissioned de-fueled submarine reactor compartments at the Hanford Reservation, one during March and the other nine in September and October 1998, necessitating special operation of the water level behind McNary Dam and the Priest Rapids discharges to allow barge docking at the Port of Benton slip. Also, special operations at McNary for national level competitive boat races, shoreline weed control, boat ramp construction, habitat island maintenance, waterfowl nesting, and waterfowl hunting occurred throughout the year. At times, these requests conflicted with each other, requiring special coordination.

Spill for juvenile fish passage occurred at McNary, John Day, The Dalles, and Bonneville during the spring and summer. Spill levels were set in accordance with the Corps' Fish Passage Plan for 1998. (See Section g, Fishery Operations for additional information.)

The peak winter flood regulated flow at The Dalles was 321.5 kcfs on January 5 and the peak unregulated flow was 398.0 kcfs on January 3. The unregulated peak snowmelt flow at The Dalles was 896.0 kcfs on June 7 and was controlled to a peak of 570.7 kcfs on June 15.

35. Columbia River at Vancouver

The Columbia River Basin reservoir system was operated for flood control once during the winter of 1997-98. Most of the flood contribution came from the Willamette River and lower Columbia River tributaries. Treaty projects' outflows were not reduced to alleviate flooding conditions in the Portland-Vancouver harbor during this high water event because there was sufficient storage available in Grand Coulee to achieve flood control objectives. This year's operation is graphically shown on Chart 79.

The observed peak stage at Vancouver, which was the result of an unusual winter rain/snowmelt flood, was 22.1 ft, 6.1 ft over flood stage, on January 2 and the unregulated peak stage for this event was 23.9 ft on January 4. As a comparison, in 1964, the flood crest was 27.7 ft and in February 1996, 27.2 ft was reached. The all time record is 31 ft in 1948. Bankfull at Vancouver is 16 ft and a major flood is at a stage of 26 ft.

The flood stage at Vancouver, Washington, was not exceeded during the spring runoff in WY-98. The observed peak stage was 14.9 ft on June 2, 1.1 ft below flood stage.

36. Willamette Basin Projects

There are 25 dams in the Willamette Valley of western Oregon. The Corps operates 11 storage and two re-regulating reservoirs, Reclamation operates, Scoggins Dam, a Section 7 project, and the remaining 11 are single-purpose, hydroelectric plants operated by public and private utilities. The Federal projects are:

Hydroelectric		**Non-power**
Storage	**Re-regul'n**	**Storage only**
Hills Creek	Big Cliff	Fall Creek
Lookout Point	Dexter	Cottage Grove
Cougar		Dorena
Green Peter		Blue River
Foster		Fern Ridge
Detroit		Scoggins

These projects are operated for flood control, hydropower (where applicable), irrigation, fishery habitat, and recreation. Since these federal projects are operated as a system to control the flow of the Willamette River, their operation will be discussed as a unit. This year's operation is graphically shown on Charts 18-28, Charts 81-84, and Chart 92.

a. CORPS PROJECTS The Willamette reservoirs operated by the Corps were in the middle of their normal fall draft at the beginning of October 1997. All projects were on or below their rule curve except for Detroit Dam, which was slightly above. In late October, a localized storm hit Detroit Reservoir with 3.7 inches of rain in a 48-hour period. The Detroit pool rose 6.2 ft during the storm (from a starting 5.1 ft below the rule curve) and ended 12 ft above the flood control rule curve. After the storm, it took 14 days for Detroit releases and spilling to evacuate the excess water. A January storm hit the Willamette Valley with more than an inch per day for several days. Reservoirs were used to keep downstream control points at, or below, bankfull conditions. Peak stream levels at control points, in feet, are shown below.

Overall, Willamette reservoirs were 3.6% full prior to the storm and peaked at 20.4% full on January 18. During the storm Lookout Point pool rose 27.5 ft, Green Peter rose 25.9 ft, and Detroit rose 33.0 ft. Reservoir levels were drawn back down by the end of January and spring refill began on February 1.

Location	**Obs stage**	**Bankfull stage**	**Flood stage**	**Major flood**
Jasper		9.4	10.0	15.0
Goshen		9.3	13.0	16.0
Eugene		16.8	23.0	29.0
Vida	6.1	6.0	11.0	14.0
Harrisburg	10.4	10.3	14.0	17.0
Monroe		7.8	9.0	9.0
Waterloo	8.6	9.9	12.0	18.0
Mehama		7.6	11.0	13.5
Jefferson	12.7	12.8	15.0	20.0
Salem	21.3	21.4	28.0	33.0

From February through April, some projects fell behind their refill schedule, with Lookout Point, the farthest behind, was 25 ft below the fill schedule and Cougar was 19 ft behind. The other projects were within 5% of the rule curve. Strong rains in May, filled all projects while some were spilling to get rid of the water and keep projects at their maximum conservation pools.

During July through October streamflows were near normal so augmentation of the mainstem flows was accomplished by the normal releases from the projects as outlined in the summer augmentation plan. Additional

augmentation of the main stem was not required. The following minimum flows, in cfs, for the mainstem Willamette were adopted:

Location	June	July	August	September
Albany	4,500	4,500	5,000	5,000
Salem	6,000	6,000	6,500	7,000

The outflows from Lookout Point were increased in July to 2500 cfs and in August Cougar releases were increased to full powerhouse capacity. Fall Creek stilling basin repair contract required all flows to pass through the fish horns during the construction period, August 1 – September 30. Since the hydraulic capacity of the fish horns was only 220 cfs, the project had to be drawn down 17 ft by August 1 in order to avoid going above the rule curve in September. The 17 ft draft was coordinated with the Corps' Park Manager and the drawdown was postponed until July 20 to maximize recreation days at Fall Creek Reservoir. Outflow was increased at Fall Creek in early October and the normal drawdown schedule was resumed.

b. RECLAMATION PROJECT. Henry Hagg Lake was formed by Scoggins Dam on Scoggins Creek, tributary to the Tualatin River near Forest Grove, Oregon. The reservoir has an active capacity of 53.64 kaf and is operated for flood control, irrigation, municipal supply, fish and wildlife, recreation, and water quality. The inflow occurs mostly from winter rain storms. The year's operation was generally according to flood control regulations and is graphically shown on Chart 85.

Henry Hagg Lake storage at the beginning of the water year was 24.2 kaf, 45% of capacity and 93% of normal. The reservoir reached its lowest storage for the year of 23.9 kaf on October 3. Storage began to accumulate when the discharge was reduced to the project minimums beginning in mid October. Storage accumulation reached the flood control rule curve on November 23. High water events in late November and again in mid December forced storage above the rule curve and subsequent evacuation of water following the events. An extended period of high water during most of January forced the reservoir to store to within 2 kaf of full pool. The lake reached a maximum level of 301.5 ft on January 26, 2 ft below the maximum authorized pool level of 303.5 ft. The maximum outflow during this event was 910 cfs. Reservoir releases were not started until the downstream flows had peaked and began receding. The reservoir was able to draft back down to the rule curve by the second week of February, and followed the rule curve until filling in late April. The gage height at the Tualatin River near Dilley flood control point peaked for the year at about 17.6 ft on January 15 (Scoggins outflow was at minimum release.) The year's highest peak mean daily inflow to the reservoir occurred on January 14 at 1,240 cfs, and peak discharge of 1,013 cfs was measured on February 3. The reservoir began its summer draft in late June. Storage at the end of the water year was 22 kaf, 41% of capacity and 84% of normal. Inflow during water year 1998 was 111.8 kaf, 122 % of normal.

37. Western Washington Projects

a. HOWARD A. HANSON DAM. Howard A. Hanson Dam, at river mile 64.5 on the Green River, is a flood control and conservation storage project. The project provides winter flood protection primarily for the lower Green-Duwamish River valley between the cities of Auburn and Seattle. In the spring, over 24 kaf is stored to augment low flows for fisheries in late summer and fall. The City of Tacoma (Tacoma) operates a major M&I water supply diversion dam and pipeline 3.5 miles downstream from Hanson Dam. The year's operation is graphically shown on Chart 51.

The project began the water year with the pool at 1129.5 ft, 7.5 ft above the 98% rule curve and on November 15 reached the normal minimum flood control level of 1070.0 ft. This pool level provides a few feet for water quality control, yet the reservoir is essentially empty. The annual basin precipitation was the second driest on record due to the influence of the century's strongest El Niño episode. As a result the project was not operated for flood control during the year. The pool reached a winter peak of 1088.8 ft on December 17, and a minimum level of 1063.4 ft on January 23. The peak streamflow was 4,115 cfs on December 29 at the Green River near Auburn streamgage, well below the authorized 12.0 kcfs limit. The greatest release from the project was 3,578 cfs.

Beginning in February the Corps, Tacoma, Muckleshoot Indians, Federal and State resource agencies, and recreation interests coordinated the project's annual spring refill operation, continuing a policy initiated in 1988. Due to an unusually small snowpack and weather forecasts associated with El Niño refill of the reservoir was begun on March 1, much earlier than normal, with the pool at 1080.6 ft, by storing a constant 250 cfs (500 af/day). The early start allowed an artificial freshet test to be conducted for multiple agencies on April 18. Flows at the Green River near Auburn were increased to 2000 cfs for a 24-hour period in order to move fish. This event was coordinated with boaters who took advantage of the higher flows to perform the annual Green River Cleanup.

The conservation pool level of 1141.0 ft was reached on April 26. Refill continued to a maximum elevation of 1148.7 ft on May 2 to facilitate debris removal and to improve juvenile rearing conditions by augmenting summer and early fall instream flows. The pool was held above 1141.0 ft until July 15 or a total of 81 days. There was no significant habitat impact from holding the pool above the conservation level for such an extended period of time. Conservation storage was gradually evacuated through the end of the water year.

b. MUD MOUNTAIN DAM Mud Mountain Dam, on the White River at river mile 29.6, is a single-purpose, flood control project which is normally empty except during flood control operation, project maintenance, and occasional regulation for downstream needs. The year's operation was generally according to flood control regulations and is graphically shown on Chart 52.

Due to the influence of the strongest El Niño episode of the century, precipitation for the year was the third driest on record. As a result the project was not operated for flood control during the year. Due to 2 inches of rain on December 16-17, inflows reached a peak of 3800 cfs. The rain caused the pool to rise to only 983.4 ft, well below the spillway crest of 1215 ft.

On three occurrences, special regulation caused incidental short-term reservoir storage and streamflow fluctuations. The first special regulation was on November 12-13 when the discharge was reduced to allow Puget Sound Energy (PSE) to reconstruct their diversion structure below the project. The second was during March and April when about 10 kaf of water was stored for a PSE fish passage test in early April. Discharge was increased to about 2000 cfs on April 1-2 for the test. Third, from early June until mid-September contractor work in the mixing chamber and in the 9 ft tunnel required careful monitoring of the pool level.

c. WYNOOCHEE DAM Wynoochee Dam, on the Wynoochee River at river mile 51.8, provides flood control for the lower Wynoochee Valley, water supply for the city of Aberdeen's diversion at river mile 8.1, fishery enhancement, recreation, and irrigation benefits. On July 26, 1995 the project ownership was transferred from the city of Aberdeen to the city of Tacoma. However, the Corps' role in the flood control operation of the project remains unchanged while Tacoma is responsible for all non-flood reservoir regulation duties. The year's operation was generally according to flood control regulations and is graphically shown on Chart 53.

The reservoir began the year with the pool at 774.45 ft, slightly below the flood control pool level of 776.1 ft. There were five freshets large enough to cause the Corps to assume flood control operation of the project, however, none were large events. The observed peak flow for the Wynoochee River near Black Creek, the control point, was 10,018 cfs on January 25. The zero damage flow at Black Creek is approximately 18.0 kcfs.

Refill of the summer conservation pool to 800 ft began March 25 with the pool at 776.7 ft. However, due to low streamflows caused by the strong El Niño episode, the pool reached a maximum of only 787.19 ft on June 2.

c. LAKE WASHINGTON SHIP CANAL & HIRAM M. CHITTENDEN LOCKS PROJECT The Chittenden Locks project controls the level of both Lake Union and Lake Washington, and provides a navigation channel between these lakes and Puget Sound. Project facilities include a large and small lock, spillway gates, fish ladder, smolt slide, saltwater drain, and a special saltwater barrier at the upstream end of the large lock. The saltwater drain and barrier are designed to reduce and control saltwater intrusion into the fresh water lakes.

Lake Washington was operated within the normal 20.0 to 22.0 ft operating range the entire water year. The project began the water year with the lake at 20.9 ft and gradually drafted to 20.0 ft by December 1 to provide shoreline protection against wind and wave action.

Special regulation occurred on several occasions. Early in the morning of October 7, a 24-ft tugboat sank in the large lock. The diesel oil spill was quickly contained with booms, heavy equipment was immediately brought in to raise the tug and the large lock was back in operation late in the day. Beginning on December 31, a constant

source of spill was created near the fish ladder to attract steelhead away from the locks to the ladder. The spring refill of Lake Washington began February 15 but was interrupted on May 1 to prepare for of a series of smolt passage tests. The test objective was to quantify passage of juvenile salmon through the locks when no discharge was occurring over the spillways. This necessitated a series of fill and spill operations that continued until June 11. During these operations the lake varied from a low of 21.75 ft on several occasions to a high of 22.0 ft on May 28.

Lake Washington reached the normal conservation pool of 21.85 ft on June 5, and continued to fill to 21.90 ft on June 14 and drafting began on June 28. Beginning in July, and continuing the rest of the year, operation of the saltwater drain and smolt slide were reduced to slow the lowering of the lake. As is normal, the lake continued to draft and was at 20.44 ft on September 30.

e. ROSS PROJECT Ross Dam, located on the Skagit River at mile 105.2, is owned and operated by the City of Seattle, Department of Lighting (Seattle City Light). The FERC license for the Dam states that evacuation of flood control storage must begin by October 1 and be completed by December 1 to provide storage of 120.0 kaf above the pool elevation of 1,592.1 ft and must remain available until at least March 15 of the following year. The FERC license also gives the Corps limited authority to specify project regulation during a flood emergency. During a flood event, when the unregulated or natural flow in the Skagit River near the town of Concrete is forecast to exceed the major damage level of 90.0 kcfs, the Corps can specify operation of the project. Under this flood control operation, Seattle City Light is permitted to release full powerhouse capacity from Ross provided the flow is reregulated by the two downstream projects, Diablo and Gorge, to a maximum outflow of 5,000 cfs. The year's operation was generally according to flood control regulations and is graphically shown on Chart 54.

The pool began the water year at 1601.9 ft and by the end of the drawdown period on December 1 it was at 1588.1 ft, well below the flood control rule curve of 1592.1 ft. It remained well below the curve the rest of the water year as none of the storms that moved through the Skagit River basin raised flood concerns. At no time during the year did the Corps specify project regulation.

f. UPPER BAKER PROJECT Upper Baker Dam is located near Concrete, Washington at river mile 9.3 on the Baker River, a tributary of the Skagit River. The two dam hydroelectric project is owned and operated by Puget Sound Energy (PSE) formally Puget Sound Power & Light Company. The FERC license for Upper Baker Dam requires 16 kaf of flood control storage space to be provided by November 1 for replacement of natural valley storage eliminated by the project. An additional 58.0 kaf of flood control storage is provided by November 15 in accordance with congressional legislation and an agreement between PSE and the Federal government for reimbursement of power losses due to operation of the additional storage for flood control. When necessary, flood control storage is managed by the Corps from November 1 through March 1 each year. As with Ross Dam, the Corps can specify operation of Upper Baker Dam when the unregulated or natural flow in the Skagit River near the town of Concrete is forecast to exceed 90.0 kcfs. Under flood control operation, PSE is required to maintain a release of 5,000 cfs from Upper Baker Dam. The year's operation was generally according to flood control regulations and is graphically shown on Chart 55.

At the beginning of the water year the pool was at 723.3 ft and by the end of the drawdown period on November 15, it reached the flood control rule curve of 707.8 ft. The pool continued to drop and remained well below the curve for the remainder of the water year as winter storms did not raise flood concerns. As at Ross Dam, the Corps did not specify operation of the project at any time during the year.

g. MOSSYROCK & MAYFIELD DAMS Mossyrock and Mayfield dams are tandem projects on the Cowlitz River that are owned and operated by Tacoma City Light for hydroelectric power generation and flood control. Their FERC license gives the Corps limited authority to specify project regulation during a flood emergency. The flood control plan for Mossyrock is to provide a maximum of 360 kaf of flood control storage between 778.5-745.5 ft during December and January, with a gradual drawdown from full pool beginning October 1 and gradual refilling to full pool between February 1 and June 1. Storage space of 21 kaf assigned to Mayfield may be substituted at any time for an equal amount in Mossyrock. The year's operation was generally according to flood control regulations and is graphically shown on Chart 56.

The project was operated according to the authorized flood control rule curves during the flood season. The pool level was held between 10 ft and 25 ft below the rule curves between November and May. The most

significant flood control operation occurred during November 1-5 when the inflow peaked at 45,000 cfs and the pool rose to 765.5 ft on November 5. The pool was then drafted back to below its flood control rule curve where it remained until spring refill began.

h. SEDIMENT RETENTION STRUCTURE The Sediment Retention Structure (SRS) is a Corps project on the North Fork Toutle River in southwestern Washington designed to trap Mount St. Helens volcanic sediment by slowing the river flow. The dam was designed with six rows of outlet pipes which allow the water to pass through the SRS and into the outlet channel. The rows of outlets are successively blocked and closed as the sediment deposited in the pool continues to increase.

The uppermost and final tier of outlet conduits, designed to pass inflow as the "pool" filled with sediment, were closed on April 21. In its nine years of operation nearly 70 million cubic yards (mcy) of volcanic sediment accumulated behind the Structure. The Toutle River now flows over the spillway as sediment continues to accumulate, to a maximum of 284 mcy, behind the 184-ft high structure. Other conduit-tiers were closed in 1991, 1993, 1994, 1995, and 1997.

38. Oregon Coastal Projects

Out of the 11 dams in the Rogue River Basin of southwestern Oregon, two are operated by the Corps, seven by Reclamation, and two by a private utility. Only the Corps projects, one of the Reclamation projects, and a county owned project are operated for flood control. The Corps reservoirs, Lost Creek and Applegate, with a combined active storage of 390 kaf, are operated for flood control, irrigation, fish and wildlife enhancement, municipal and industrial water supply, water quality, recreation and power (at Lost Creek only). Elk Creek Dam is a partially completed Corps project on Elk Creek, a tributary to the Rogue, five miles below Lost Creek. Reclamation's Emigrant Lake has 39 kaf of storage and is operated for flood control, irrigation, and recreation. Galesville Dam is owned by the Douglas County. The latter two projects are operated under Corps direction, when needed, for flood control.

a. LOST CREEK DAM. This was a wet water year, but without any major runoff events to cause flooding as seen in Chart 29. Project outflow during October was held steady at 1100 cfs to accommodate downstream anadromous fish spawning. Consequently, the flood control pool level was 5% encroached into the flood during the major portion of the downstream spawning period. The pool level was lowered to its minimum flood control level by mid-November. Pool filling began on January 1 and was followed in mid-January by a moderate runoff event with inflow near 6000 cfs. Another event occurred in late March with a peak inflow near 6000 cfs. Then, during April and May inflow were generally between 2000 cfs and 3000 cfs with the project filling on schedule by 1 May. Releases in May, June, and July were higher than the same period last water year, ranging between 2000 cfs and 3400 cfs, followed by August releases of about 2100 cfs. The Lost Creek pool level was drafted after Labor Day. September water releases were incrementally reduced from 2100 cfs at the beginning of September to 1100 cfs by the end of the water year.

Water temperature of the release during October, November, and December were above the target temperatures which were based on pre-project, free flowing natural conditions. Water releases generally climb from near 45°F in October to near 50°F in December as most of the cool water from the lake bottom is released to keep downstream anadromous fish spawning redds cool. Winter meteorological conditions cause lake cooling through December and the lake was near 42°F by the end of February. Because of the cooler, wetter than normal spring, lake water was not warmed by solar radiation and water release temperatures were general 3°F to 5°F cooler than target temperatures. The water temperature releases from June through September were generally within 3°F of the target temperatures. September water release temperatures were at or near target temperatures.

b. APPLEGATE DAM. The lake was drafted to the minimum flood control pool level on schedule during October and early November while inflow stayed below 1000 cfs from October to January 8 as seen in Chart 30. A mid-January storm produced a relatively low storm inflow of about 4000 cfs. Pool filling began on schedule starting February 1. In March, a larger storm produced inflows of about 9500 cfs, causing the pool to temporarily increase to 15 ft above the filling schedule. The project filled on schedule on 1 May. During June, outflows were reduced from about 1000 cfs at the beginning of the month to above 500 cfs by the end of the month. These late

spring – early summer releases were higher than normal but were compelled by wet weather. The pool remained full until the Fourth of July when increased outflows were required to augment summer flows even though they were higher than normal. The summer pool levels were generally higher than previous years. Water releases during September remained high, near 200 cfs, to draft the pool on schedule toward the minimum flood control pool level.

Water temperature releases during October, November and December, like at Lost Creek Lake, were above the target temperatures which were based on pre-project, free-flowing natural conditions. October water release temperatures were near 55°F. The coldest water temperatures, near 38°F, in the lake occurred in late December and early January. Because of the cooler and wetter spring, the water release temperatures were up to 5°F cooler than the target temperatures. The temperature of the project outflow from June through mid-September were generally with 3°F of the target temperature of 57°F. There were two notable exceptions. In mid-August and at the end of September, water release temperatures varied from the target temperatures by greater than 5°F. This condition occurs as the pool level passes the withdrawal range of the selective withdrawal elevation ports in the lake. When the range from which water can be released from the reservoir is passed, water must be with drawn from the next lower port located deeper in the lake. The water temperature at that location is generally greater than the 5°F from the target temperature.

c. ELK CREEK DAM. The storage area behind the partially-completed Elk Creek Dam is dry except for involuntary storage during high water periods.

d. GALESVILLE DAM. The lake was operated according to its rule curve and its operations were in compliance with flood control regulations. The lake filled to the flood control curve in April. The year's operation is graphically shown on Chart 86.

The lake was operated according to the authorized water control diagram by filling between February 1 and May 1, in accordance with its flood control curves. No major storms occurred during the water year.

e. EMIGRANT DAM. The lake was operated by Reclamation in accordance with the authorized rule curve as graphically shown on Chart 87.

The lake was filled between January 1 and May 1, in accordance with the project rule curve. The maximum lake level for the year occurred on May 21 and was 2241.4 ft (maximum conservation pool level is 2241.0 ft and full pool is 2251.3 ft). Maximum outflow for the year was 690 cfs.