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MEMORANDUM

TO: State, Tribal and Federal Fishery Agencies

FROM: Michele DeHart

DATE: November 2, 2016

RE: Historical Spill Summary 1981 to 2016

Attached you will find an updated document that was developed by the Fish Passage Center summarizing spill in the Columbia and Snake River hydrosystem from the completion of the present hydrosystem in1981through the 2016 spill season. The document was developed by the Fish Passage Center for our own use in understanding and interpreting long term trends in fish survival and abundance. Please replace all existing copies with this newest updated version.

There is no one source where the information regarding spill can be derived. In order to develop the document historic documents from several sources were reviewed, summarized and consolidated. We believe that this document may be of some utility to you and, therefore, we have decided to distribute it to the regional fishery agencies.

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The History of Spill and Planned Spill Programs in the Federal Columbia River Power System, 1981 to 2016

I. Introduction

This compendium was developed by the Fish Passage Center and addresses the development and evolution of the planned spill program in the Federal Columbia River Power System (FCRPS). This memo is an update that includes the spill that has occurred over the last five years, since the original memo was developed in 2012.

The present hydrosystem configuration that is in place today was completed in 1981, when the last three units were brought on line at Lower Monumental Dam. The Lower Snake River dams that are part of the FCRPS include: Lower Granite; Little Goose; Lower Monumental; and, Ice Harbor. Those dams that are considered to comprise the Middle Columbia dams of the FCRPS are: McNary; John Day; The Dalles; and, Bonneville.

Spill has been traditionally provided as an alternate route of passage at hydroelectric projects to improve juvenile fish survival by avoiding the mortality associated with turbine passage. The provision of a spill program has evolved from providing spill only when excess energy was present in the hydrosystem, to a planned spill program at each of the FCRPS projects under any conditions. The time period during which spill has been provided has also evolved from a few hours during daily peak juvenile passage at a project, to a set hourly spill amount for the entire twenty-four hour period. Seasonal spill is now provided throughout the spring and summer migration period, whereas, in the early days of the spill program it was limited to peak juvenile passage days.

II. Spill for Fish Passage after completion of current hydrosystem configuration, 1981-1982

This first section addresses spill in the hydrosystem in 1981 and 1982, prior to the first Fish and Wildlife Program under the Northwest Power Act. Spill during this early period was provided only when flows exceeded the energy requirements of the system.

1981 – Planned spill at Lower Monumental, Ice Harbor and John Day dams was to be 10% of daily average flow when monitoring indicated that significant numbers of juveniles were passing the projects. Transportation at Lower Granite and Little Goose dams was expected to decrease the fish numbers at Lower Monumental and Ice Harbor dams, decreasing the need for spill. In addition, the use of the ice trash sluiceway was expected to further decrease spill at Ice Harbor. The vast majority of the volume of spill that occurred in 1981 was involuntary spill that occurred during the latter part of May and early June.

1982 – Planned spring spill was provided for Lower Monumental and John Day dams. The provision of planned spill was dependent on hydroacoustic monitoring showing the presence of fish, with spill occurring at Lower Monumental when sufficient numbers of fish were present, and at John Day Dam, when the daily passage was estimated to be greater than 30,000 fish. The sluiceway had been modified at Ice Harbor Dam and spill would only occur if the sluiceway did not effectively pass juveniles. The 1982 flow year was characterized as having very high runoff. Consequently, spill objectives were generally met, or exceeded, during the spring migration period. Most of the spill provided was involuntary, either as spill in excess of energy needs, or as excess of generation capacity. Involuntary spill extended into the summer period at several projects.

III. Spill for Fish Passage during the Water Budget Years, 1983 – 1992

The following is a summary description of the spill program over the ten years, 1983 -1992. The first Fish and Wildlife Program (Program) was published in November of 1982 as directed by the Northwest Power Act of 1980. The Program recognized the impact of juvenile passage through hydroelectric plants and called for the development of adequate bypass systems at projects and, until those bypass systems were operational, the Program called for the provision of spill to provide safe passage for juveniles. Consequently, spill was provided as mitigation at hydroelectric projects to enhance juvenile project survival. It was deemed the safest and most benign mode of passage for fish past a hydroelectric project. Historically, spill occurred operationally when project capacities, or system generation needs, were exceeded. As the hydrosystem was developed it became more efficient through such actions as the construction of the DC and AC Intertie transmission lines. As a consequence the occurrence of spill declined, accelerating the disagreements between the operators and regulators and the agencies and tribes regarding spill. Up until 1986, the provision of spill was tied to the availability of non-firm energy in the hydrosystem. Subsequent negotiations between the operators and regulators and the state, federal and tribal fishery agencies resulted in a 10 year package for a spill program (Fish Spill Memorandum of Agreement, December 1988) that was to be provided at projects that were not equipped with adequate bypass systems. The development of juvenile fish bypass systems by the operators and regulators was an attempt to provide an alternate route of passage past a hydroelectric project, avoiding spill.

As fish stocks declined and the Endangered Species listings occurred, it became clear that the negotiated contracts were not aggressive enough to recover endangered stocks. The state tribal and federal fishery agencies re-established the goals originally recommended in the Bypass Performance Standards developed in 1986, and continued pursuing those goals. The continued decline of fish stocks under the spill and passage programs in place over the ten years demonstrated the need for more aggressive protection. The following is a summary description of the spill program over the ten years, 1983 -1992.

1983 – Spill was used as a bypass at John Day and Lower Monumental dams. It was also used as a partial bypass at Bonneville, The Dalles, Ice Harbor, Little Goose and Lower Granite dams. At transportation collector projects spill was used to bypass spring Chinook, while transportation was maximized for steelhead by eliminating spill during peak steelhead passage. High flows in the spring and the summer resulted in large amounts of uncontrolled spill.

1984 - High flows and low loads resulted in large amounts of forced spill in the Snake River and at McNary Dam. Spill was requested at all projects, except McNary, during the spring Chinook migration to maximize bypass. Subsequently, spill requests called for spill to be minimized to allow maximum transport for steelhead. However, high flows resulted in forced spill after the steelhead were migrating, and continued through much of the spring migration period at each project. The COE developed the 1984 Spill Plan, which was not endorsed by the fishery agencies and tribes.

1985 - An executive committee process was initiated by the COE since they believed that problems had arisen with spill planning in 1984 due to a lack of policy level involvement. However, the lack of common objectives precluded the possibility of the group having any impact. Flow in 1985 was considerably lower than had occurred in 1984. The COE implemented a spill plan that they developed to meet the Northwest Power Planning Council's 90% survival objective, with the exception of Bonneville Dam where the objective was 85% fish passage efficiency (FPE). Fish passage efficiency (FPE) is a measurement of the proportion of fish that pass a project via a non-turbine route. Based on the assumptions made by the COE in calculating project survival relative to the 90% objective, the COE's plan offered no protection above bypass passage at most projects. Spill was provided at Lower Monumental and Ice Harbor Dam, and was managed on a daily basis using hydroacoustic monitoring of fish abundance.

1986 - High levels of spill occurred during the spring migration due to high river flows from the end of May to June. Requests for spill at the collector projects were denied on the basis of maximizing transportation. Spill at these projects only occurred as excess hydraulic capacity or excess generation spill. Spill was managed in-season based on trigger numbers developed by the COE and coupled with hydroacoustic monitoring. Spill during the summer migration was limited and was only implemented at The Dalles and John Day dams. The agencies and tribes developed bypass performance standards that were based on fish passage efficiencies at a project.

1987 - The agencies and tribes began meeting with the COE in December of 1986 to develop a joint 1987 Juvenile Fish Passage Plan, but the parties could not come to agreement. In February of 1987 the Northwest Power Planning Council amended the Program to require the COE to develop a Fish Passage Plan that incorporated a sliding scale that would provide spill to achieve better than 90% survival, exclusive of transportation, for 80% of the spring and summer migrants at each project in better than critical water years. Efforts were hampered by the inability to agree on the slope of the sliding scale and the flow level used to trigger the start of the slide. Efforts resulted in a separate COE Fish Passage Plan and an agency and tribal Detailed Fishery Operating Plan. Spring spill was only provided at Lower Monumental Dam.

In this extremely low flow year efforts were concentrated on developing a summer spill program for Lower Monumental Dam, which was not equipped with a bypass system. An agreement was reached between the resource agencies and the COE, where the COE would agree to 15 days of spill over a 45 day migration period. In addition, the summer spill agreement was to provide spill at John Day Dam according to a sliding scale whenever BPA was marketing non-firm energy in the system. A similar agreement was established for The Dalles. However, since no non-firm energy was sold during the summer period, no sliding scale spill occurred at either dam. Spill did occur to achieve the NPPC 90% survival, whenever passage indices exceeded 30,000 fish as determined by hydroacoustic monitoring.

1988 – Several processes were initiated prior to the 1988 migration season to facilitate agreement between the hydropower operators and regulators and the agencies and tribes. This included the establishment of the Mainstem Executive Committee, which was to address major policy controversies that precluded agreement on the 1987 Juvenile Fish Passage Plan. Technical and policy staff tried to reach agreement on a 1988, and long term, spill and passage program and Intertie settlement. The agencies and tribes presented a spill proposal based upon the interim 70/50 FPE bypass standards. Discussions continued through the fall and winter on three parallel tracks with policy staff, technical staff and legal staff meeting to address long term spill issues associated with the Intertie expansion development, and settlement of annual spill controversies. Several proposals were exchanged, including a sliding scale proposal by the agencies and tribes, which were based on flow year and the concept of equitable treatment. However, the COE developed their own Fish Passage Plan and spill during 1988 was limited to Lower Monumental Dam during the spring and to Lower Monumental and John Day dams during the summer. The COE again used hydroacoustic monitoring to limit spill to high fish passage days. Spill at Lower Monumental Dam was provided for 39 days during the spring migration, and 5 days during the summer migration. Spill was provided for 57 days at John Day Dam during the summer period.

1989 – The Mainstem Executive Committee, which was established in 1987, conducted negotiations from November of 1987 through the fall of 1988 regarding spill for fish passage at federal Snake and Columbia River hydroelectric projects that were not equipped with, or had inadequate fish bypass facilities. The culmination of these negotiations was a ten year Fish Spill Memorandum of Agreement (MOA) that commenced on December 31, 1988. The Spill MOA was implemented in 1989. More planned spill for fish occurred in the hydrosystem than had occurred in any previous year. The MOA broadened the spill program to include Lower Monumental, Ice Harbor and The Dalles dams during the spring, as well as John Day Dam during the summer. Spill was also provided at Bonneville Dam, but not as part of the MOA.

While the MOA provided more planned spill than ever before, it was a negotiated agreement that did not achieve the interim 70/50 FPE goal of the agencies and tribes.

1990 – The MOA was successfully implemented in 1990. More water was spilled in 1990 than in 1989, and most of that spill came in the form of excess generation spill. The agencies and tribes submitted a recommended operational plan for Bonneville Dam that was based on an interim objective of a 70% FPE during the spring migration and a 50% FPE during the summer migration. The proposal recommended that the second powerhouse not be operated and called for spill equal to 49% of flow for the spring and 44% of average daily flow for the summer. The COE rejected the plan and approximately 24% of average daily flow was spilled during the spill season.

1991 – The MOA was successfully implemented in 1991. In general, spill levels were either at, or above, the levels specified in the MOA due to high flows and excess generation spill. The COE again rejected the agencies and tribes recommended plan for Bonneville Dam and spill averaged 34% of daily average flow over the spill season.

1992 – In 1992 spill was implemented as defined in the NMFS Biological Opinion. Spill amounts were increased at the Snake non-collector projects, while in the Middle Columbia spill was designated a conservation measure and occurred according to the Spill MOA. In addition to increasing spill levels the NMFS Biological Opinion lengthened the spill seasons. Spill levels determined for the Snake projects were based on the interim 70/50 FPE bypass standard. The 70/50 FPE standard was also applied to spill at Bonneville Dam. The agencies and tribes recommendation was for spill to achieve the 80/70 FPE standard. The agencies and tribes maintained that increasing spill in the drought year presented a means of increasing fish survival without increasing flow. The agencies and tribes regarded the NMFS Biological Opinion as establishing minimum spill mitigation for 1992. Requests for increasing spill were denied. Using the same assumptions adopted by NMFS while developing the Biological Opinion, it was estimated that spring spill during 1992 yielded a seasonal 70% FPE at Lower Monumental Dam, a 59% FPE at Ice Harbor Dam, 58% FPE at The Dalles Dam and a 70% FPE at Bonneville Dam. No spring spill was provided at John Day Dam since NMFS assumed a 72% FPE from the bypass system alone. Summer spill in 1992 approximated the 50% FPE objective of the Biological Opinion at Lower Monumental, Ice Harbor, The Dalles and Bonneville dams, but at John Day the FPE was only about 40%. Under direction of NMFS, spill was not required at the collector projects.

IV. Spill for Fish Passage and the Biological Opinion, 1993 - 2004

As fish stocks continued to decline and were listed under the Endangered Species Act, it became clear that the negotiated contracts were not aggressive enough to recover endangered stocks. This lead to the modification of spill programs under the different versions of the Biological Opinion. At the same time that spill was identified as a key element in the recovery of listed stocks, the need to meet the objectives of the Clean Water Act were also identified. Spill causes high levels of total dissolved gas that could increase mortality and eliminate the benefits associated with the implementation of an aggressive spill program. Therefore, subsequent implementation of a spill program has been within the confines of the "risk" associated with increased levels of total dissolved gas. Consequently, spill is limited by the "gas cap" approved by the State water quality agencies as a way of managing risk.

In March of 1995, an ESA Section 7 Biological Opinion on the operation of the Federal Columbia River Power System was issued. The BIOP established a set of reasonable and prudent alternatives with the objective of improving the operation and configuration of the federal power system to meet a no jeopardy requirement of the Endangered Species Act (ESA), and to fulfill the United States commitment to uphold tribal treaty fishing rights. One of the RPAs established the Biological Opinion spill program for fish passage.

A Supplemental Biological Opinion was signed on March 2, 1995 in part to address the needs of the newly listed as threatened Snake River steelhead and the Middle Columbia River steelhead, as well as the endangered Upper Columbia River steelhead. The Supplemental Biological Opinion called for additional spill to the gas caps on a system-wide basis and modified the planning dates for the initiation and duration of the spill program. To the extent that the fish passage efficiency (FPE) at some projects exceeded 80%, the additional spill supplemented the 1995 BIOP RPA Measure 2 for an interim period pending decisions regarding biologically based performance standards for project passage.

NOAA Fisheries (then National Marine Fisheries Service) again modified spill in the 2000 Biological Opinion (BIOP) issued in December of 2000. In the 2000 BIOP spill at Lower Monumental Dam was increased from a 12-hour period to a 24-hour period. At The Dalles Dam the instantaneous spill level was decreased from 64% of instantaneous flow to 40% of instantaneous flow. Spill at John Day and Bonneville dams remained unchanged from the 1998 Supplemental Opinion, but called for the initiation of daytime spill test at John Day Dam and a test of increasing daytime spill volume at Bonneville Dam.

In June 2003, Judge James A Redden remanded the 2000 BIOP to NOAA Fisheries to resolve several deficiencies including: reliance on federal mitigation actions that have not undergone section 7 consultation under the ESA; and reliance on range-wide off-site non-federal mitigation actions that are not reasonably certain to occur. In a subsequent "minute order," the Judge denied plaintiffs' motion to vacate the Biological Opinion and the BIOP remains in place as deficiencies were addressed. Consequently, the system in 2004 was operated as called for by the 2000 BIOP.

The following is a yearly account of the program in place and the spill that occurred in the federal hydrosystem.

1993 - The NMFS Biological Opinion was issued on May 26, 1993. Prior to that date spill was in accordance with the COE Annual Fish Passage Plan, which prohibited spill at the collector projects and only called for spill at the non-collector projects to achieve a 70/50 fish passage efficiency. The Fish Passage Plan criteria applied to Ice Harbor and Bonneville dams. Spill according to the 1989 Fish Spill MOA was implemented at The Dalles and John Day dams. The 1993 Opinion superseded the earlier implementation scheme and prohibited planned spill at the collector projects, limited spill at Ice Harbor Dam, called for the removal of fish screens at Ice Harbor and Bonneville dams during the summer migration and implemented spill according to the 1989 MOA at John Day and The Dalles dams. The 1989 Spill MOA called for spill at John Day during the spring for 10 hours a day at a level equal to 20% of instantaneous flow, and spill at The Dalles Dam at a level equal to 10% of the daily average flow during the spring and 5% of daily average flow during the summer.

No planned spill occurred at the Snake River collector projects, but some excess generation spill did occur during the spring season. The spill MOA was implemented at John Day and The Dalles dams. During the period of peak runoff spill exceeded the levels of the MOA, but whenever possible they were managed down to those levels.

1994 - Spill was initially provided according to the 1994 –1998 BIOP, which required 70% spring and 50% summer FPE at non-collector projects. Operations changes on May 11 and implementation was requested to the 80% FPE. Spill was adjusted and varied up to the TDG waivers until May 27, when NMFS requested a one-third reduction in spill levels. Summer spill was limited at John Day and The Dalles Dams.

1995 - Spill was provided according to the 1995 Biological Opinion. This included spring spill at the Snake and Lower River projects and summer spill at Ice Harbor, John Day, The Dalles and Bonneville dams. Spill was up to the 80% FPE objective, or as limited by the gas cap. Ice Harbor Dam's hydraulic capacity was limited to 66 Kcfs; consequently, significant excess hydraulic capacity spill occurred at this project. John Day Dam did not have spillway deflectors installed and spill was limited

1996 - Spill was provided according to the 1995 Biological Opinion. Extremely high natural runoff conditions resulted in spill levels in excess of those that would have occurred under a spill program managed for total dissolved gas levels.

1997 - Spill was provided according to the 1995 Biological Opinion. Extremely high natural runoff conditions again this year resulted in spill levels in excess of those that would have occurred under a spill program managed for total dissolved gas levels. Full use of the John Day Dam spillway was delayed until after May 5 because of delays in spillway deflector installation due to contested contracts. The Ice Harbor project operated with spillway deflectors. The addition of spillway deflectors at both Ice Harbor and John Day resulted in lower levels of total dissolved gas compared to the previous high flow year values.

1998 – The 1998 Supplemental BIOP called for additional spill to the gas caps on a system-wide basis, even if the project met the 80% FPE at lower spill amounts. The Supplemental BIOP also modified the planning dates for spill allowing earlier initiation of the program and keying the duration to fish passage movement.

1999 – Spill was provided according to the 1998 Supplemental BIOP and was primarily involuntary, resulting from flows in excess of hydraulic capacity and power needs. Spill at most projects met or exceeded the 80% fish passage efficiency objective. The notable exception was The Dalles Dam, where spill alternated between 64% of average daily flow and 30% of average daily flow as part of a spill test. The spill levels for this test resulted in less spill than called for in the BIOP.

2000 – In April of 2000 NMFS released a Spill Plan agreement that modified the 1998 Supplemental BIOP spill levels, and was to be the basis for the 2000 BIOP spill program. Spill at Lower Monumental Dam was increased from a 12 hour to a 24-hour period. At The Dalles Dam, spill was reduced from the 64% of daily average flow, to 40% of daily average flow. In addition, while spill remained the same at John Day and Bonneville dams, spill tests were called for at both the projects. In general, the BIOP was implemented up to the spill gas caps.

2001 – The low flows and the declaration of a power system emergency resulted in no spill occurring in the Snake River during either the spring or the summer migration. A limited spill program equal to 600 MW months of energy was implemented after mid-May at Bonneville and The Dalles dams, and on May 25th at McNary and John Day dams that extended to June 15th. A limited summer spill program was implemented beginning in mid-July at The Dalles and Bonneville dams.

2002 - Spring and summer spill were provided according to the NMFS 2000 BIOP, as constrained by the total dissolved gas caps. The only exception occurred at Lower Monumental Dam where spill was not implemented because of repair work that was being conducted in the stilling basin.

2003 - Spring and summer spill were provided according to the NMFS 2000 BIOP, with modifications and, as constrained by the total dissolved gas caps. The BIOP was remanded in June, but left in place as deficiencies were addressed. The runoff volume was close to the BIOP cut-off for maximizing transportation in the Snake River, but the decision was made to continue spill through the spring migration. Spill was variable at Lower Granite Dam due to RSW testing. Spill at Lower Monumental Dam was 50% of flow to address tailrace egress issues, based on physical modeling, resulting in about a 10 Kcfs daily reduction from BIOP levels. At Ice Harbor Dam research studies were conducted and NOAA made in-season management decisions to curtail spill based on very preliminary findings suggesting survival through the spillway was lower than survival through the turbine units. The final results did not substantiate the earlier findings, but modification was not made to return the spill program to BIOP levels. Gas cap spill levels increased at McNary Dam due to new spillway deflectors. Spring spill tests were conducted at John Day and Bonneville dams, and a summer spill test was conducted at John Day Dam.

2004 - Spill was provided in accordance with the NMFS 2000 BIOP. Several issues with the implementation of the BIOP spill program were addressed this year. The Action Agencies proposed to terminate spill for Spring Creek National Fish Hatchery (NFH) fish and only operate the untested corner collector. The Bonneville Dam corner collector was tested against spill for Spring Creek NFH release prior to the BIOP spill season. It was a low flow year and, according to the 2000 BIOP, spill would be terminated and maximum transportation implemented. However, the salmon manager's wanted to invoke the adaptive management provisions in the BIOP since research was showing that early season transportation was not beneficial for spring Chinook (however, among the salmon managers there was not an agreement as to when to transition to transport operation. NMFS recommended an April 23 start date, while the others recommended a May 1 start date). The regional process was not able to reach a decision regarding implementation, and the decision regarding spill in 2004 stating, "Based on the discussions at IT (Implementation Team), the COE has decided to provide spill at Lower Granite and Little Goose until 23 April to provide in-river passage for yearling Chinook prior to the steelhead juvenile migration". Also this year, the Bonneville Power Administration implemented a requirement for revenue neutral decisions regarding the provision of spill at Lower Granite Dam to reduce the number of fish collected and offsetting this spill by a reduction of spill at Bonneville Dam. The Implementation Team considered the issue and recommended that in the future, revenue-neutrality should not be a constraint. The Action Agencies proposed a modified summer spill program that was less than included in the BIOP. On July 28, Judge Redden in the District Court of Oregon ruled in favor of plaintiffs' motion for a preliminary injunction to stop implementation of a modified summer spill proposal. The Department of Justice on August 4 filed a request with the Ninth Circuit Court to stay the district court's preliminary injunction on or before August 9, 2004, pending appeal of the decision. The request was denied and spill was implemented as described in the 2000 Biological Opinion until August 31, 2004. An incorrect calibration at Bonneville Lock and Dam caused less water to be released than reported. Because of this calibration error the daytime spill quantity reported at Bonneville Dam was increased to approximately 85 Kcfs, while the actual spill quantity was about 75 Kcfs. The discrepancy in flow between Bonneville and The Dalles was first noted in December 2003 and appears related to the new spill pattern and flow deflectors that came online at Bonneville in 2002. Historically there have been two types of gates at Bonneville: 50-foot-high gates and 60-foot-high gates. The last time the Bonneville rating curves were recalibrated was 1967. This discrepancy may have been occurring since 1972, when the gates were modified at Bonneville, although the most serious discrepancies have most likely occurred since 2002, when the flow deflectors were installed and the flow pattern was modified. In essence, much more limited fish protection has occurred historically at Bonneville Dam than previously estimated.

V. Spill for Fish Passage under Court Ordered Operations, 2005 – present.

Spill during this period has been guided by the Court Ordered Operations after the 2004 Biological Opinion and the 2008 Biological Opinions were remanded to the courts. In December of 2004 the Biological Opinion was released and in a May 2005 court opinion, it was found that the 2004 BIOP violated the ESA and it was remanded. The provisions contained in the 2004 BIOP remained in place for the 2005 migration, with the exception of the requirements for additional summer spill. Judge Redden's June 10, 2005 opinion in NWF v. NMFS granted the spill portion of the National Wildlife Federation's requested injunctive relief. For the first time, a planned summer spill program at Lower Granite, Little Goose, Lower Monumental (since 1993) and McNary dams to the gas cap limits was implemented in the hydrosystem.

In May of 2008 a new Biological Opinion was issued. On February 19, 2010 the Federal Court granted a limited, voluntary remand to the defendants of the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BIOP). The remand was granted for a three month period and was granted for the purpose of integrating the Adaptive Management Implementation Plan into the 2008 BIOP.

2005 - In December of 2004 a new Biological Opinion was released. In a May 2005 decision it was found that the 2004 BIOP violated the ESA, and it was remanded. The provisions contained in the 2004 BIOP remained in place for the 2005 migration, with the exception of the requirements for additional summer spill. Fish from Spring Creek NFH were passed with the operation of the Bonneville corner collector and no spill. Spring spill operations were terminated at the transport collector projects due to projected flows below 85 Kcfs. Spill at The Dalles Dam was restricted in 2005 due to the inability to operate spill gates at all but two spillbays because of gate hoist problems and the project only had the ability to pass a fixed volume of spill. At times, this resulted in spill less than the 40% called for in the BIOP. Although a volume trade-off was requested throughout the period for spill at John Day to be increased to mitigate the loss, the Action Agencies only implemented it for 7 days. Judge Redden's June 10, 2005 opinion in NWF v. NMFS granted the summer spill portion of the National Wildlife Federation's requested injunctive relief to provide spill at Lower Granite, Little Goose, Lower Monumental and McNary dams to gas cap limits.

2006 - Although the 2004 BIOP was remanded in October of 2005, the provisions remained in place for 2006. On December 29, 2005 the court granted the plaintiffs a preliminary injunction which provided for spill operations in 2006 that were, in part, different than the 2004 BIOP. The changes to the spring spill program from the 2004 Biological Opinion provided 24-hour spill at 30% of river flow at Little Goose Dam and a flat spill of 100 Kcfs at Bonneville Dam. In addition, spill was to be provided at all projects during the summer period at the same levels that occurred in 2005. This year (2006) was the last year of the USFWS agreement with the Action Agencies and spill was not provided for the March release from Spring Creek NFH. Spill that occurred in the spring of 2006 offered less mitigation to migrating salmonids than what could have occurred if spill only met the 120% TDG tailrace objective, after excess hydraulic capacity and excess market spill were removed from the equation. The bias towards a higher TDG reading at the forebay monitors results in an unnecessary limitation of protection measures for fish passage. John Day Dam's T-1 bank of transformers suffered a fault to ground that damaged bushings. The result of this mishap was that turbine units 1 through 4 were out of service throughout the spring and summer juvenile and adult fish migration season, reducing the hydraulic capacity of John Day and affecting fish passage conditions and spill at the project. Spill for fish passage provided at The Dalles Dam was less than the BIOP established level of 40% throughout most of April and early May due to either the limited operational bays at The Dalles Dam due to spillway cable repairs or the 115% forebay dissolved gas limitations at the Bonneville forebay.

2007 - Spill occurred according to the 2007 FCRPS Operations Agreement. The 2007 migration year was unique in that spill occurred throughout the spring period in a low flow year. The 2007 FCRPS Operations Agreement states that in water years when the projected seasonal average flow is greater than 70 Kcfs, transportation is initiated between April 20 and May1 at Lower Granite Dam, and at staggered dates at the downstream transport collector projects. In years where projected flows are less than 70 Kcfs, transport is initiated on April 20. The early projections were for spring flows to exceed 70 Kcfs and therefore transport operations were not initiated until May 1 at Lower Granite Dam. The 2007 FCRPS Operations Agreement specifies spill levels that exceed those contained in the 2004 Biological Opinion. Spring spill at Lower Granite Dam was expanded from 12 to 24 hours daily to accommodate the continuous operation of the removable spillway weir. Spill hours at Little Goose and McNary Dams increased from twelve to twenty-four hours daily.

The 2007 FCRPS Operations Agreement also incorporated a summer spill program at the Snake River Transport collector projects (Lower Granite, Little Goose and Lower Monumental Dams) as well as at McNary Dam. In general spill during 2007 met the objectives of the 2007 FCRPS Operations Agreement, with the caveats that a) no spill was provided for the March Spring Creek NFH release and high mortality was observed for this release, b) there was a failure to meet 2007 FCRPS Operations Agreement spill levels at the beginning of the season that resulted in the changing of the 2007 FCRPS Operations Agreement into a Court Order; and, c) spill volumes were again constrained by forebay total dissolved gas readings.

2008 – The Court ordered operations from 2007 were continued into 2008. Spill according to the 2008 Operations Agreement was to occur under all flow years. The 2008 runoff volume was above average and, consequently, spill in excess of the Court Order occurred in the system as excess hydraulic capacity or generation throughout most of the spring and into the beginning of the summer. Spill during 2008 generally met the objectives of the 2008 Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project. A little more than 3 days of spill at 35 Kcfs was provided for the March Spring Creek NFH release and turbine units were operated at the low end of the 1%

efficiency range to minimize fish mortality. A negotiated total of 14 days of nighttime gas cap spill at Little Goose Dam were provided in early May.

2009 - A new NOAA FCRPS Biological Opinion was released in May of 2008. Court-ordered spill operations for spring and summer 2009 were implemented, subject to modifications necessary to accommodate new structures and perform essential research. The 2009 Fish Operations Plan was signed on April 10, 2009 as an order directing 2009 FCRPS hydro operations for spring migrating fish and on June 2, 2009 for summer migrating fish. The Fish Operations Plans continued the 2008 operations into 2009, subject to modifications necessary to accommodate new structures and research at specific dams. The 14 days of gas cap spill at Little Goose, which had been provided in 2008, was eliminated from the "roll over" operations in 2009 to accommodate the testing of the newly installed temporary spillway weir (TSW).

On October 23, 2008 an agreement was signed by the U. S. Fish and Wildlife Service, U. S. Army Corps of Engineers, NOAA Fisheries and the Bonneville Power Administration to reprogram fish production at Spring Creek National Fish Hatchery in Washington. The agreement moved a portion of Spring Creek's production to other facilities so the hatchery could raise the remaining juvenile salmon until they were larger. These larger fish were released later and passed Bonneville Dam during the Biological Opinion spring spill period, thus eliminating the March hatchery release and the need for spill at Bonneville Dam outside of the spring spill period.

2010 - On February 19, 2010 the Federal Court granted a limited, voluntary remand to the defendants of the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BIOP). The remand was granted for a three month period and was granted for the purpose of integrating the Adaptive Management Implementation Plan into the 2008 BIOP. On March 31, 2010 a Spring Fishery Implementation Plan was introduced to the Court that included a strategy for the upcoming low water year that terminated spring spill and maximized transportation for Snake River migrants. According to NOAA the maximum transport plan for expected flows less than or equal to a season average regulated flow of 65 Kcfs was based on new scientific information, and "*the Corps and NOAA, in coordination with the regional sovereigns, will consider the best available science, including the ISAB input"*, to make a determination on the transportation operations. The transportation operations were submitted to the Independent Scientific Advisory Board for an independent scientific review. After reviewing the information, the ISAB concluded that "a mixed strategy of spill and transport during the critical spring migration period allows learning from spill conditions and supports potential advances in knowledge to improve decision-making in the future." The ISAB's conclusions looked at broader ecosystem considerations than the NOAA proposal's focus on the protection of ESA-listed Snake River Chinook salmon and steelhead stocks during a low-flow year.

While NOAA stated that they had "reservations about leaving juvenile fish in-river during these low flow conditions, implementation of a mixed strategy of spill and transport for 2010 will allow us to gather additional information." The 2009 spring and summer operations were continued into 2010, subject to modifications necessary to accommodate new structures and research at specific dams.

2011 – The runoff volume this year was significantly above average (the January to July runoff volume was 133% of average above The Dalles Dam and 139% of average above Lower Granite Dam). Spill prior to the onset of the Court ordered spill program occurred due to high flows early in the season as projects drafted to flood control elevations. In general, the 2010 Court Ordered spill operations were extended to 2011, subject to modifications necessary to accommodate new structures and perform essential research. Spill during the spring season met or exceeded the court ordered amounts due to high flows in excess of hydraulic capacity, or due to limited market availability. During the early part of the summer season, flow was still high and court ordered operations were often exceeded. In addition, several of the FCRPS projects (particularly Lower Granite, McNary and Bonneville dams) were operating with limited hydraulic capacity. At Little Goose Dam there was a complete powerhouse outage between May 24 and June 1, during which time the entire river flow (less 5 Kcfs for station power service) was passed in spill.

2012 - Runoff (January-July) in 2012 was 100% of average (1971-2000) above Lower Granite and 121% of average above The Dalles Dam. There were turbine units out of service limiting the hydraulic capacities of the projects at several hydro projects in the FCRPS. River flows were extremely high during March, April, May, June, and into July. Above average precipitation in late spring, snowmelt, and the drafting of storage reservoirs for flood control resulted in the high flow and consequently, high spill and total dissolved gas levels. Uncontrolled spill (spill in excess of hydraulic capacity or power needs) occurred regularly during this period. Spill during 2012 generally exceeded the objectives of the 2012 Fish Operations Plan due to the uncontrolled spill. However, whenever possible, spill was managed within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and meeting the requirements for minimum turbine operations at each project.

2013 - The runoff (January–July) volume for the 2013 water year was near average in the Middle Columbia River but below average in the Lower Snake River. Runoff (January–July) was 96% of average (1981–2010) at The Dalles Dam and 69% of average at Lower Granite Dam. In the Snake River, this resulted in mostly lower than average flows throughout the spring and summer seasons, with peak flows in May. In the Middle Columbia, the 2013 runoff resulted in near average flows in both the spring and summer 2013. The peak flow conditions in the Snake River and Middle Columbia rivers in mid-May resulted in some uncontrolled spill for a few days at the Snake and Columbia River sites. Spill during 2013 generally met the objectives of the 2013 Fish Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and meeting the requirements for minimum turbine operations at each project.

2014 - The runoff (January–July) volume for the 2014 water year was above average in the Middle Columbia River and near average in the Lower Snake River. Runoff (January–July) was 107% of average (1981–2010) at The Dalles Dam and 98% of average at Lower Granite Dam. In the Snake River, this resulted in near average flows throughout the spring and summer seasons, with peak flows in May. In the Middle Columbia, the 2014 runoff resulted in above average flows in both the spring and summer periods. The peak flow conditions in the Snake River and Middle Columbia rivers in mid-May resulted in uncontrolled spill for periods of time at the Snake and Columbia River sites. The spill in excess of the planned amount generally occurred at McNary Dam, which has a more limited hydraulic capacity that the other Middle Columbia River projects. Outside of the peak flow period, spill during 2014 generally met the objectives of the 2014 FOP, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project.

2015 - The runoff volume (January–July) for the 2015 water year was considerably below average in both the Middle Columbia and Lower Snake rivers. Runoff (January–July) was 83% of average (1981–2010) at The Dalles Dam and 69% of average at Lower Granite Dam. To put the low runoff volumes into perspective, the 2015 January–July runoff volumes at The Dalles and Lower Granite were ranked 68th and 74th, respectively, over the 87 year record (1929–2015). In the Snake River, this resulted in below average flows throughout the spring and summer seasons, with peak flows of only about 71 Kcfs in mid-May. In the Middle Columbia, the 2015 runoff resulted in below average flows in both the spring and summer periods. Flows in the Snake and Middle Columbia rivers were sufficiently low throughout the entire spring and summer seasons that uncontrolled spill events were extremely rare. Summer flow operation at Bonneville Dam continued the "test operations" of alternating every two days between 85 Kcfs/121 Kcfs and 95 Kcfs instantaneously, rather than reverting to the 75 Kcfs/gas cap spill operations on July 21.

2016 - The runoff (January–July) volume for the 2016 water year was near average for both the Middle Columbia River and the Lower Snake River. Runoff (January–July) was 96% of average (1981–2010) at The Dalles Dam and 88% of average at Lower Granite Dam. In the Snake River, this resulted in near average flows throughout the spring and summer seasons. To put the 2016 runoff volumes into perspective, the 2016 January–July runoff volumes at The Dalles and Lower Granite were ranked 54th and 52nd, respectively, over the 88 year record (1929–2016). Almost no uncontrolled spill occurred in 2016. Spill was provided according to the Fish Operations Plan, within the constraints of research study requirements, managing to the dissolved gas criteria of 120% TDG in the tailraces of the dams and 115% in the forebays of the dams, and the requirements for minimum turbine operations at each project.

VI. Planned Spill Operations

Each year throughout the history of the spill program, there has been a planned operation for spill at each of the federal hydroelectric projects. Actual spill levels may have been greater than the planned spill levels as a result of high river flows that exceeded powerhouse capacity, or river flow levels that exceeded the energy needs. Tables 1-7 (below) are based on the pre-season plans for each year and capture the essence of the planned operation of each project by the spring and summer season. Seasons have been of different lengths among years, and are defined for each year in Appendix A.

Table 1. Planned spill operations at FCRPS projects, 1983-1987.

Season/Project	1983	1984	1985	1986	1987
SPRING					
Lower Granite	No spill (unless surplus spill available and spring Chinook dominate)	No spill (unless surplus spill available and spring Chinook dominate)	No spill	No spill	No spill
Little Goose	Same as Lower Granite	Same as Lower Granite	No spill	No spill	No spill
Lower Monumental	Up to 50% of flow, for up to 5 hours When fish # > 15K	Up to 50% of flow, for up to 5 hours When fish # > 15K	50% of flow 2000 to 0600	50% of flow 2000 to 0600	55% of flow for 3 hours (or more if needed) beginning at 2000, when fish # > 15K
Ice Harbor	40% of flow, for up to 4 hours if sluiceway less effective than screened bypass at LGR & LGO	No spill	30% of flow 2000 to 0600	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	50% of river flow exceeding the capacity of screened units 2000 to 0600	No spill	No spill
The Dalles	No spill	No spill	24% of river flow 1000-2000 (if warranted and if non-firm energy)	5% of daily average flow	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17 & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	50% of flow 2000 to 0600 to July 15	50% of flow 1800 to 0600	100% for 8 hours, 15 days out of 45 day period
Ice Harbor	No spill	No spill	No spill	No spill	No spill
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	Spill 50% of flow 1 hr before sunset for several hours when fish # >30K/d	36% of river flow 1800 to 0600	36% of river flow 1800 to 0600	Spill 18% of flow for 3 hours (or more if necessary) when fish # >30K/d
The Dalles	No spill	No spill	5% of daily average flow	No spill	No spill
Bonneville	No spill	Spill above capacity of PH1 and units 11,12,17 & 18	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

Table 2. Planned spill operations at FCRPS projects, 1988-1992.

Season/ Project	1988	1989	1990	1991	1992
SPRING					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	40% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	60% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	No spill	No spill	No spill	No spill	No spill
The Dalles	No spill	10% of daily average flow	10% of daily average flow	10% of daily average flow	10% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental		70% of flow 1800 to 0600	70% of flow 1800 to 0600	70% of flow 1800 to 0600	43% of flow 1800 to 0600
Ice Harbor	No spill	25% of flow 1800 to 0600	25% of flow 1800 to 0600	25% of flow 1800 to 0600	30% of flow 1800 to 0600
McNary	No spill	No spill	No spill	No spill	No spill
John Day	5% of daily average flow	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600	20% of flow 2000 to 0600
The Dalles	No spill	5% of daily average flow	5% of daily average flow	5% of daily average flow	5% of daily average flow
Bonneville	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)	Spill above capacity of PH1 except to reduce daytime spill to 75 Kcfs (0700-2000)

Table 3. Planned spill operations at FCRPS projects, 1993-1997.

Season/ Project	1993 (1993 BIOP)	1994 (1994-1998 BIOP)	1995 (1995 BIOP)	1996 (1995 BIOP)	1997 (1995 BIOP)
SPRING					
Lower Granite	No spill	No spill	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<100Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Little Goose	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)	Flow<85 Kcfs, No spill; otherwise 80% of instantaneous flow (1800-0600) (gas cap approx 35 Kcfs)
Lower Monumental	No spill	No spill	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)	Flow<85 Kcfs, No spill; otherwise 81% of instantaneous flow (1800-0600) (gas cap approx 40 Kcfs)
Ice Harbor	60% up to a max of 25 Kcfs (1800-0600)	60% up to max of 25 Kcfs (1800-0600)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)	27% of instantaneous flow day/night (gas cap approx 25 Kcfs)
McNary	No spill	No spill	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)	50% of instantaneous flow (1800-0600) (gas cap approx 120 Kcfs)
John Day	No spill	No spill	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)	33% of instantaneous flow (1800-0600) (gas cap approx 50 Kcfs)
The Dalles	10% day/night	10% (2000-0400)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)	64% of instantaneous flow day/night (gas cap approx 230 Kcfs)
Bonneville	70 % FPE - 75 Kcfs day/gas cap (110%) night	70 % FPE - 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)	75 Kcfs day/100% night(gas cap approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	60% up to a max of 25 Kcfs (1800-0600)	30% up to max of 25 Kcfs (1800-0600)	70% of instantaneous flow day/night	70% of instantaneous flow day/night	70% of instantaneous flow day/night
McNary	No spill	No spill	No spill	No spill	No spill
John Day	20% (2000-0600)	20% (2000-0600)	86% (2000-0600)	86% (2000-0600)	86% (2000-0600)
The Dalles	5% day/night	5% (2000-0400)	64% of instantaneous flow day/night	64% of instantaneous flow day/night	64% of instantaneous flow day/night
Bonneville	50% FPE - 75 Kcfs Day/gas cap (110%) night	50% FPE - 75 Kcfs day/gas cap (110%) night	75 Kcfs day/100% night	75 Kcfs day/100% night	75 Kcfs day/100% night

Table 4. Planned spill operations at FCRPS projects, 1998-2002.

Season/ Project	1998 (1998 Supplemental BIOP)	1999 (1998 Supplemental BIOP)	2000 (Spill Plan Agreement)	2001 (2000 BIOP)	2002 (2000 BIOP)
SPRING					
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)
Little Goose	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)
SUMMER					
Lower Granite	No spill	No spill	No spill	No spill	No spill
Little Goose	No spill	No spill	No spill	No spill	No spill
Lower Monumental	No spill	No spill	No spill	No spill	No spill
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)
McNary	No spill	No spill	No spill	No spill	No spill
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise
The Dalles	64% day/night	64% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)

Table 5. Planned spill operations at FCRPS projects, 2003-2007.

Season/ Project	2003 (2000 BIOP)	2004 (2000 BIOP)	2005 (2004 BIOP)	2006 (Court Order)	2007 (Court Order)
SPRING					
Lower Granite	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<85 Kcfs, No spill; Gas cap 1800-0600 (approx 45 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 45 Kcfs)	20 Kcfs day/night	20 Kcfs day/night
Little Goose	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<85 Kcfs, No spill ; Gas cap 1800-0600 (approx 60 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; Gas cap 1800-0600 (approx 60 Kcfs)	30% day/night	30% day/night
Lower Monumental	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<85 Kcfs, No spill; Gas cap day/night (approx 40 Kcfs)	Flow<70 Kcfs, No spill; 70-85 Kcfs, Spill through April 20; Flow > 85 Kcfs; 45-50% of outflow	40 Kcfs day/night	Gas Cap day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	Gas cap 1800-0600 (approx 150 Kcfs)	40% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise)	60% of outflow until June 20 (1800-0600;1900-0600): Starting June 21; 30% of outflow	60% night (1800-0600 to May 15;1900-0600 after May 15)	0 day / 60% night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	100 Kcfs day/night	100 Kcfs day/night
SUMMER (Court Order)					
Lower Granite	No spill	No spill	Spill in excess of the flow necessary for station service	18 Kcfs day/night	18 Kcfs day/night
Little Goose	No spill	No spill	Spill in excess of the flow necessary for station service	30% day/night	30% day/night
Lower Monumental	No spill	No spill	Spill in excess of the flow necessary for station service	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	45 Kcfs day/gas cap night (approx 75 Kcfs)	45 Kcfs day/gas cap night (approx 75 Kcfs)	Spill in excess of the flow necessary for station service	45 Kcfs (0500 to 1800)/gas cap night (approx 75 Kcfs)	30% day/night vs. 45 Kcfs day/gas cap night
McNary	No spill	No spill	Spill in excess of 50 Kcfs flow	Alternate between 40% day/night and 60% day/night	40% day/night vs. 60% day/night
John Day	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	180 Kcfs/ not to exceed 60% of instantaneous flow (1 hour before sunset to 1 hour after sunrise	30% of outflow for 24 hrs	30% of outflow for 24 hrs	30% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day/gas cap night (approx 120 Kcfs)	75 Kcfs day / gas cap night (approx 120 Kcfs)

Table 6. Planned spill operations at FCRPS projects, 2008-2011.

Season/ Project	2008 (Court Order)	2009 (Court Order)	2010 (Court Order)	2011 (Court Order)
SPRING				
Lower Granite	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night
Little Goose	30% day/night 14 nights of gas cap spill	30% day/night (To accommodate new spillway weir testing, 14 nights of gas cap spill used in 2008 will not occur)	30 % day/night	30 % day/night
Lower Monumental	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night
Ice Harbor	30% day/night vs. 45 Kcfs day/gas cap night	45 Kcfs / gas cap on non-test days; 30% day/night vs. 45 Kcfs day/gas cap night	April 3-April 28: 45 Kcfs/Gas Cap April 28-June 20: 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 27: 45 Kcfs/Gas Cap April 28- mid July 30%/30% vs. 45 Kcfs/Gas Cap
McNary	40% day/night	40% day/night	40% day/night	40% day/night
John Day	0 day / 60% night	30% day/night on pre-test days; 30% day/night vs.40 day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night
SUMMER				
Lower Granite	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night
Little Goose	30% day/night	30% day/night	30% day/night	30% day/night
Lower Monumental	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	30% day/night vs. 45 Kcfs day/gas cap night	45 Kcfs/gas cap on non-test days; 30% day/night vs. 45 Kcfs day/gas cap night	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 12: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap
McNary	40% day/night vs. 60% day/night	40% day/night vs. 60% day/night	50% day/night	50% day/night
John Day	30% day/night	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days	30% day/night on non-test days; 30% day/night or 40% day/night on test days
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	75 Kcfs day / gas cap night	85 or 75 Kcfs day/gas cap night (85 Kcfs day through July 20, then 75 Kcfs day through August 31)	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap

Table 7. Planned spill operations at FCRPS projects, 2012-2016.

Season/ Project	2012 (Court Order)	2013 (Court Order)	2014 (Court Order)	2015 (Court Order)	2016 (Court Order)
SPRING					
Lower Granite	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night	20 Kcfs day/night
Little Goose	30% day/night	30% day/night	30 % day/night	30 % day/night	30 % day/night
Lower Monumental	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night	Gas Cap day/night
Ice Harbor	April 3-April 28: 45 Kcfs/Gas Cap April 28- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 28- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap	April 3-April 28: 45 Kcfs/Gas Cap April 29- June 20 30%/30% vs. 45 Kcfs/Gas Cap
McNary	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
John Day	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; 30% day/night vs.40 day/night	30% day/night on pre-test days; Testing 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing (Apr 28-June 15) 30% day/night vs.40% day/night	30% day/night on pre-test days; Testing (Apr 28-June 15) 30% day/night vs.40% day/night
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night	100 Kcfs day/night
SUMMER					
Lower Granite	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night	18 Kcfs day/night
Little Goose	30% day/night	30% day/night	30% day/night	30% day/night	30% day/night
Lower Monumental	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night	17 Kcfs day/night
Ice Harbor	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap	June 21-July 13: 30%/30% vs. 45 Kcfs/Gas Cap July 13-August 31: 45 Kcfs/Gas Cap
McNary	50% day/night	50% day/night	50% day/night	50% day/night	50% day/night
John Day	Testing (July 1-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (July 1-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (June 16-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	Testing (June 16-July 20): 30% of instantaneous flow vs. 40% of instantaneous flow Post-Test (July 21-August 31): 30% of instantaneous flow	30% day/night on non-test days; 30% day/night or 40% day/night on test days
The Dalles	40% day/night	40% day/night	40% day/night	40% day/night	40% day/night
Bonneville	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	Testing (June 16-July 20): 85 Kcfs/121 Kcfs vs. 95 Kcfs/95 Kcfs Post-Testing (July 21-August 31): 75 Kcfs/Gas Cap	85 Kcfs/121 Kcfs and 95 Kcfs/95 Kcfs (alternating every two days)	85 Kcfs/121 Kcfs and 95 Kcfs/95 Kcfs (alternating every two days)

VII. Actual Spill Volumes Among Years

While spill has mostly been provided in accordance with the prevailing spill program in any specific year, there has been a considerable variation in spill among years for a variety of reasons (excess generation spill, excess hydraulic capacity spill, maintenance issues, and test schedules). To capture this variation, Tables 8 and 9 summarize the amount of spill that actually occurred in two different ways. The daily average spill (in Kcfs-days) that occurred is summed over the spring and summer period to give an estimate of the magnitude of water spilled (ΣKcfs-days). For comparison sake, all periods were standardized, that is to say, the spring period extends from April 3 to June 20 in the Snake River and April 10 to June 30 in the Middle Columbia River, while the summer period extends from June 21 to August 31 in the Snake and July 1 through August 31 in the Middle Columbia.

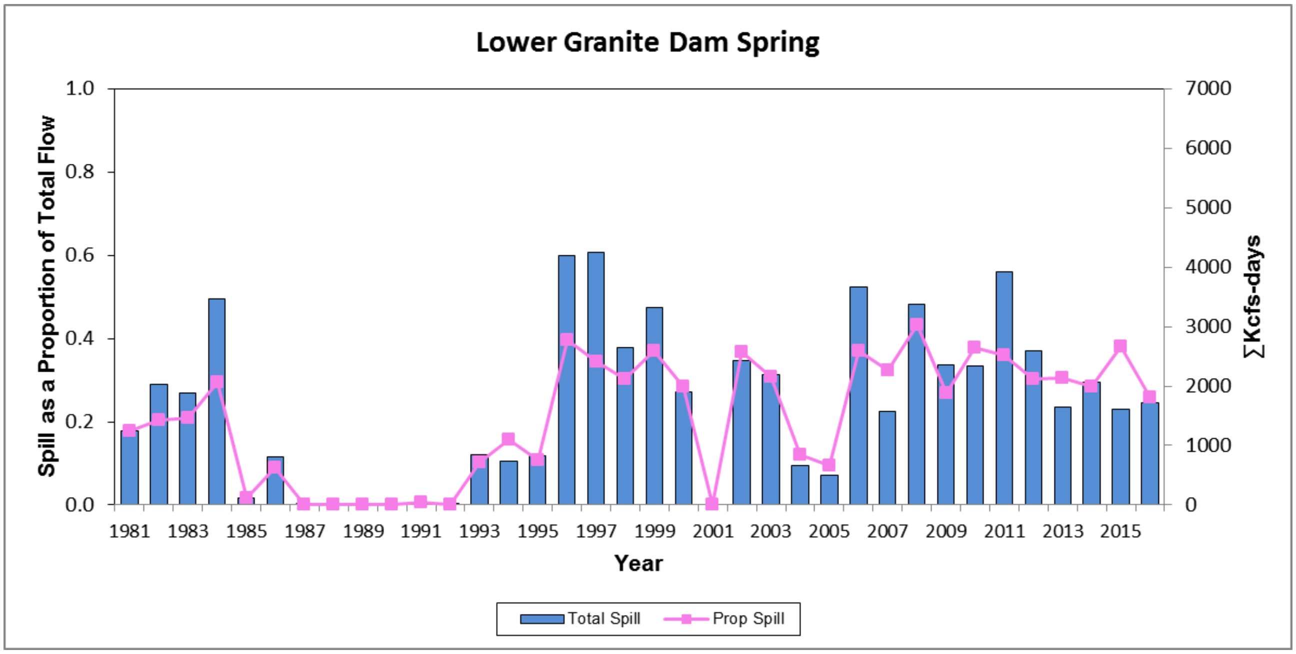
The second summary statistic on the graphs (Figures 1-8) averages the daily proportion of water spilled (relative to total flow) over the same time periods. Spill over the period has ranged from the lows observed during the power emergency in 2001 to the highs observed during the high flow years of 1996 and 1997. Tables 8 and 9 and Figures 1-8 depict this information in a standard format and provide the annual runoff volume as a way of illustrating the magnitude of the individual flow year.

Table 8. Total sum of Kcfs-days spill at each Lower Snake River dam by season for each year, as well as the runoff volume (MAF) provided as a relative measure of flow volume among years.

YEAR	Runoff Vol	Lower Granite				Little Goose				Lower Monumental				Ice Harbor			
	Snake	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	above LGR	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill
	(Jan -July)	∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days	
1981	**25.4**	1249	0.18	57	0.02	520	0.08	9	0.00	2906	0.41	809	0.32	2778	0.40	658	0.26
1982	**42.8**	2025	0.20	973	0.18	1965	0.20	895	0.17	5248	0.53	2318	0.44	4185	0.43	1596	0.31
1983	**37.8**	1886	0.21	0	0.00	2018	0.22	494	0.13	4288	0.48	469	0.12	3969	0.44	685	0.18
1984	**44.5**	3475	0.30	718	0.15	3187	0.27	655	0.14	4343	0.37	1099	0.23	4352	0.37	1178	0.25
1985	**25.6**	116	0.02	0	0.00	0	0.00	0	0.00	1246	0.17	0	0.00	680	0.10	0	0.00
1986	**38.0**	807	0.09	0	0.00	829	0.09	0	0.00	3637	0.40	143	0.06	3350	0.37	1	0.00
1987	**17.1**	0	0.00	0	0.00	0	0.00	0	0.00	403	0.10	63	0.04	33	0.01	0	0.00
1988	**17.3**	0	0.00	0	0.00	0	0.00	0	0.00	367	0.08	0	0.00	0	0.00	0	0.00
1989	**25.0**	0	0.00	0	0.00	0	0.00	0	0.00	1635	0.24	297	0.13	650	0.10	146	0.07
1990	**20.2**	0	0.00	0	0.00	112	0.02	2	0.00	1689	0.30	414	0.20	843	0.15	163	0.08
1991	**18.9**	39	0.01	7	0.00	24	0.00	0	0.00	1770	0.33	616	0.27	757	0.14	225	0.10
1992	**14.1**	0	0.00	0	0.00	0	0.00	0	0.00	719	0.19	341	0.25	1028	0.28	198	0.15
1993	**26.7**	848	0.10	0	0.00	1748	0.21	0	0.00	1382	0.17	0	0.00	2548	0.31	906	0.27
1994	**15.9**	736	0.16	13	0.01	1069	0.23	0	0.00	424	0.09	14	0.01	1611	0.34	342	0.18
1995	**29.4**	824	0.11	33	0.01	1491	0.20	96	0.02	1176	0.15	87	0.02	2768	0.36	1817	0.44
1996	**42.4**	4203	0.40	332	0.09	4015	0.39	407	0.11	3892	0.37	465	0.12	4506	0.44	1825	0.47
1997	**49.5**	4245	0.34	327	0.07	4386	0.37	254	0.05	4653	0.36	278	0.06	6854	0.56	2925	0.56
1998	**31.3**	2647	0.30	106	0.03	2813	0.33	14	0.00	2501	0.28	8	0.00	5151	0.57	2998	0.71
1999	**36.1**	3328	0.37	359	0.09	2136	0.25	84	0.02	1848	0.21	88	0.02	5567	0.60	3178	0.73
2000	**24.7**	1895	0.29	0	0.00	1654	0.26	19	0.01	2353	0.36	0	0.00	4907	0.70	2167	0.80
2001	**14.4**	0	0.00	15	0.01	0	0.00	1	0.00	0	0.00	9	0.00	10	0.00	0	0.00
2002	**24**	2432	0.37	383	0.13	2142	0.34	271	0.09	70	0.01	0	0.00	4463	0.66	2397	0.76
2003	**23.8**	2193	0.31	17	0.01	1770	0.26	0	0.00	2360	0.34	0	0.00	4106	0.57	1038	0.44
2004	**20.7**	663	0.12	0	0.00	356	0.06	0	0.00	559	0.10	41	0.02	3672	0.62	1873	0.75
2005	**18.1**	496	0.09	1367	0.57	141	0.03	1097	0.45	337	0.06	1213	0.52	3124	0.58	1467	0.62
2006	**32.2**	3675	0.37	1226	0.45	2820	0.29	837	0.31	2621	0.26	1091	0.41	4939	0.49	1602	0.59
2007	**18.9**	1571	0.32	1084	0.52	1430	0.30	664	0.32	1752	0.37	1000	0.49	2831	0.58	1178	0.58
2008	**27.5**	3384	0.43	1595	0.39	2752	0.36	1214	0.31	2581	0.34	1293	0.33	4656	0.58	2508	0.61
2009	**28.9**	2352	0.27	1339	0.39	2361	0.29	1021	0.30	2411	0.28	1219	0.37	4671	0.53	2126	0.63
2010	**22.5**	2330	0.38	1311	0.39	1897	0.32	1018	0.30	2374	0.39	1178	0.36	3452	0.56	2016	0.61
2011	**41.6**	3914	0.36	2228	0.38	5036	0.49	1820	0.32	3536	0.33	1883	0.33	6234	0.56	3671	0.61
2012	**29.9**	2584	0.30	1373	0.45	2753	0.34	1102	0.36	2588	0.30	1191	0.39	5194	0.60	2052	0.65
2013	**19**	1643	0.31	1058	0.49	1612	0.31	697	0.32	2115	0.39	1001	0.45	3307	0.60	1260	0.56
2014	**26.9**	2058	0.28	1225	0.42	2109	0.30	903	0.31	2284	0.32	1135	0.39	4288	0.58	1866	0.62
2015	**18.5**	1603	0.38	822	0.44	1219	0.30	596	0.33	1953	0.47	860	0.48	2628	0.62	976	0.54
2016	**24.1**	1711	0.26	1115	0.50	1903	0.30	699	0.33	2430	0.39	985	0.48	3914	0.59	1234	0.56
AVG 1981-2016	**27.0**	**1693**	**0.21**	**530**	**0.17**	**1619**	**0.21**	**413**	**0.13**	**2124**	**0.28**	**600**	**0.20**	**3278**	**0.43**	**1341**	**0.41**

Table 9. Total sum of Kcfs-days spill at each Middle Columbia River dam by season for each year, as well as the runoff volume (MAF) provided as a relative measure of flow volume among years.

YEAR	Runoff Vol	McNary				John Day				The Dalles				Bonneville			
	Columbia	Spring		Summer		Spring		Summer		Spring		Summer		Spring		Summer	
	above TDA	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill	Total Spill	Prop Spill
	(Jan -July)	∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days		∑Kcfs days	
1981	**104.5**	6230	0.30	266	0.02	4914	0.22	1022	0.08	4638	0.21	178	0.01	9187	0.42	2236	0.18
1982	**134.9**	11010	0.41	3096	0.23	9434	0.33	3001	0.22	8749	0.32	2703	0.20	11063	0.39	2207	0.16
1983	**123.4**	8700	0.37	48	0.00	8980	0.37	2558	0.22	4689	0.20	1338	0.12	6800	0.28	2374	0.20
1984	**123.7**	10762	0.42	1234	0.12	7978	0.29	2300	0.22	5012	0.19	578	0.06	10792	0.40	842	0.08
1985	**90.5**	575	0.03	0	0.00	970	0.05	0	0.00	1312	0.08	126	0.02	5271	0.29	82	0.01
1986	**112.9**	3759	0.18	0	0.00	5017	0.23	571	0.07	5040	0.24	189	0.02	8880	0.41	147	0.02
1987	**79.2**	1060	0.07	0	0.00	7	0.00	102	0.02	29	0.00	0	0.00	2797	0.19	0	0.00
1988	**76.0**	0	0.00	0	0.00	126	0.01	141	0.02	0	0.00	0	0.00	2080	0.15	1	0.00
1989	**93.2**	679	0.04	0	0.00	297	0.02	354	0.06	1087	0.06	292	0.05	5534	0.30	122	0.02
1990	**99.7**	2740	0.14	71	0.01	2785	0.14	602	0.06	2433	0.12	425	0.04	6832	0.33	996	0.10
1991	**107.1**	5303	0.25	847	0.08	2872	0.13	910	0.08	3176	0.15	818	0.07	7769	0.35	2610	0.23
1992	**70.4**	307	0.02	0	0.00	350	0.02	453	0.07	983	0.07	292	0.04	7300	0.48	2546	0.34
1993	**88.1**	4574	0.25	0	0.00	2645	0.14	609	0.07	4450	0.24	408	0.05	8289	0.43	3783	0.42
1994	**75**	1494	0.10	159	0.02	558	0.04	419	0.06	3341	0.22	397	0.05	6410	0.41	2780	0.36
1995	**104**	7611	0.38	423	0.04	693	0.03	319	0.03	10189	0.51	6138	0.60	6888	0.33	5403	0.50
1996	**139.3**	16650	0.57	4094	0.31	6758	0.22	2231	0.17	16859	0.58	7253	0.56	14296	0.48	5482	0.40
1997	**159**	21698	0.62	4829	0.33	11630	0.31	2839	0.19	21923	0.61	9102	0.64	18751	0.52	6220	0.42
1998	**104.5**	9389	0.43	1186	0.11	7116	0.31	2939	0.27	10342	0.46	4856	0.46	8373	0.36	5456	0.49
1999	**124.1**	10960	0.46	4867	0.34	6403	0.26	3938	0.28	10599	0.43	7871	0.56	8274	0.33	5350	0.37
2000	**98**	7760	0.39	365	0.04	6274	0.31	3311	0.35	7627	0.38	3688	0.39	7306	0.34	5653	0.57
2001	**58.2**	163.09	0.02	0	0.00	400	0.04	0	0.00	1263	0.12	1163	0.21	1482	0.13	1281	0.21
2002	**103.8**	9560	0.43	2015	0.17	6952	0.31	3426	0.29	8107	0.37	4507	0.39	9919	0.44	6724	0.55
2003	**87.7**	6188	0.33	1	0.00	4661	0.25	2016	0.24	6942	0.37	3159	0.38	9319	0.45	5617	0.57
2004	**83**	5548	0.33	20	0.00	4560	0.28	2464	0.30	6410	0.38	3227	0.39	7039	0.37	5139	0.52
2005	**81.4**	5801	0.36	6829	0.67	4465	0.28	2820	0.30	5363	0.34	3598	0.39	6507	0.40	5335	0.55
2006	**114.7**	13156	0.49	5122	0.50	10361	0.39	2878	0.30	10054	0.39	3713	0.40	9775	0.36	5335	0.53
2007	**95.7**	8047	0.41	5069	0.50	4880	0.26	2802	0.30	7422	0.40	3675	0.40	7942	0.40	5666	0.57
2008	**99.2**	11645	0.50	5345	0.50	8088	0.34	3140	0.32	9332	0.41	3944	0.40	11166	0.46	5415	0.50
2009	**90.2**	9698	0.44	4343	0.49	6794	0.31	2626	0.32	8034	0.38	3174	0.40	9054	0.40	5012	0.58
2010	**84.7**	8300	0.45	4781	0.50	6406	0.34	2992	0.33	6977	0.39	3484	0.40	8766	0.46	5259	0.55
2011	**142.6**	18658	0.60	9153	0.56	12763	0.40	5029	0.32	13695	0.44	5943	0.39	16103	0.50	7345	0.46
2012	**129.4**	15293	0.54	9042	0.55	10781	0.38	5385	0.33	10835	0.40	6035	0.40	11205	0.39	6783	0.42
2013	**97.7**	10056	0.47	5820	0.51	7550	0.35	3524	0.32	7852	0.39	4015	0.40	8327	0.38	5621	0.51
2014	**108.1**	11930	0.51	5896	0.50	8435	0.36	3623	0.32	8627	0.39	4198	0.40	9166	0.39	5945	0.52
2015	**83.7**	5908	0.42	4431	0.50	4656	0.34	2682	0.32	5082	0.40	3026	0.40	7985	0.57	5494	0.65
2016	**97.6**	8890	0.44	4625	0.50	6735	0.34	2786	0.32	5082	0.40	3026	0.40	8716	0.43	5506	0.62
AVG 1981-2016	**101.8**	**7781**	**0.34**	**2610**	**0.23**	**5397**	**0.23**	**2134**	**0.20**	**6765**	**0.31**	**2959**	**0.28**	**8482**	**0.38**	**3938**	**0.37**



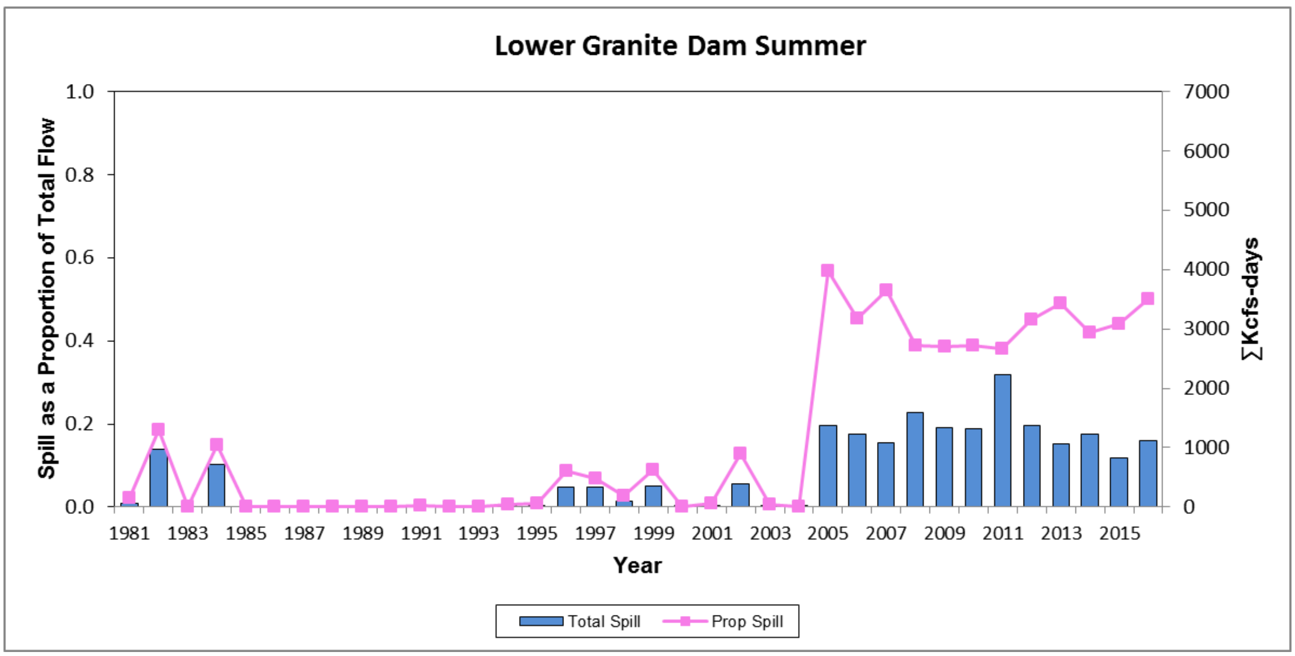
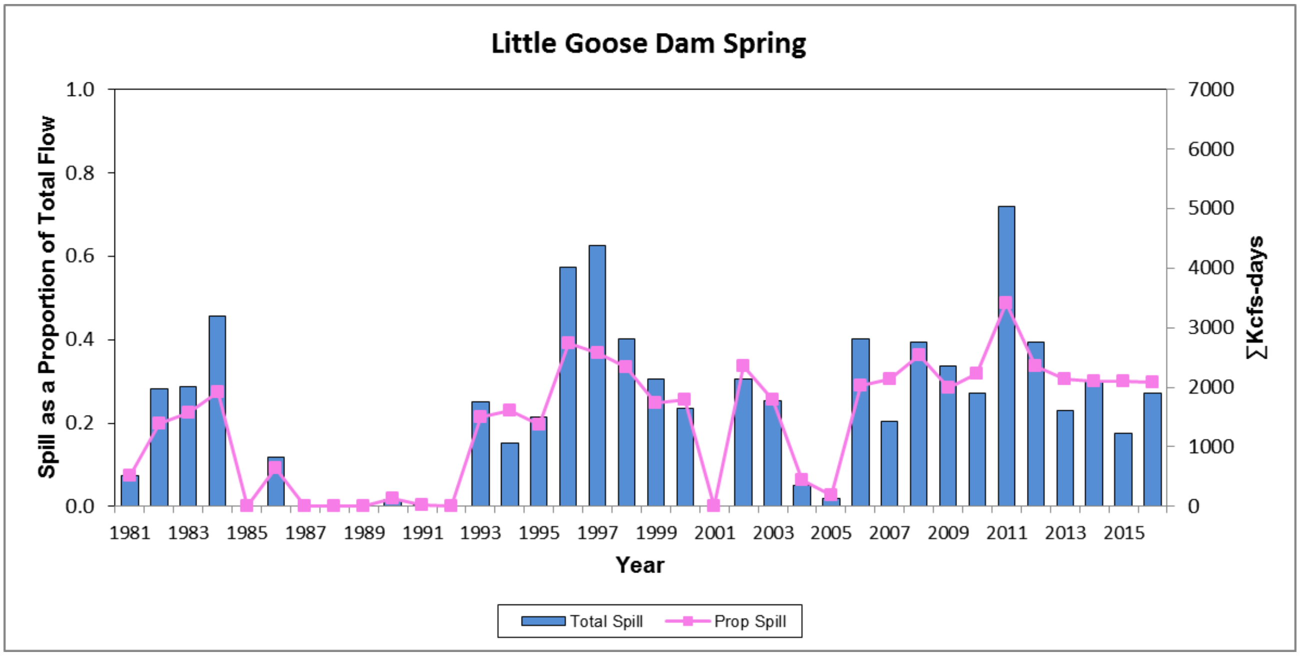


Figure 1. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Granite Dam, and spill as a proportion of total flow for the same time period.



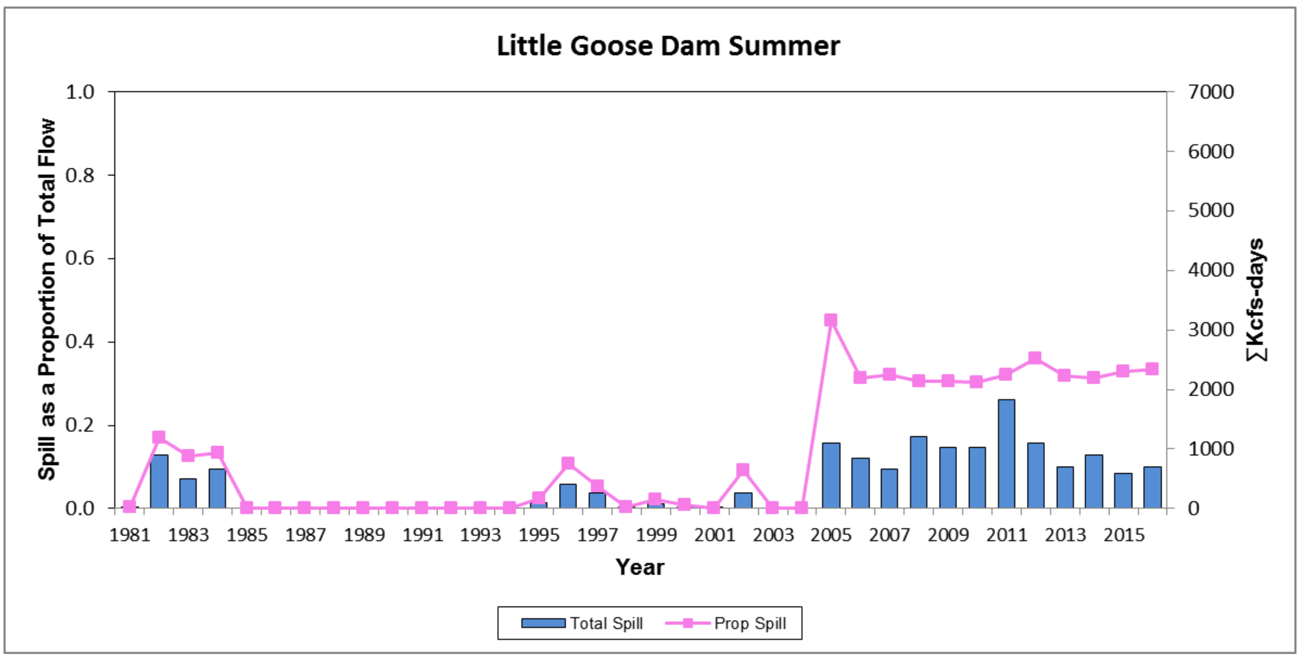
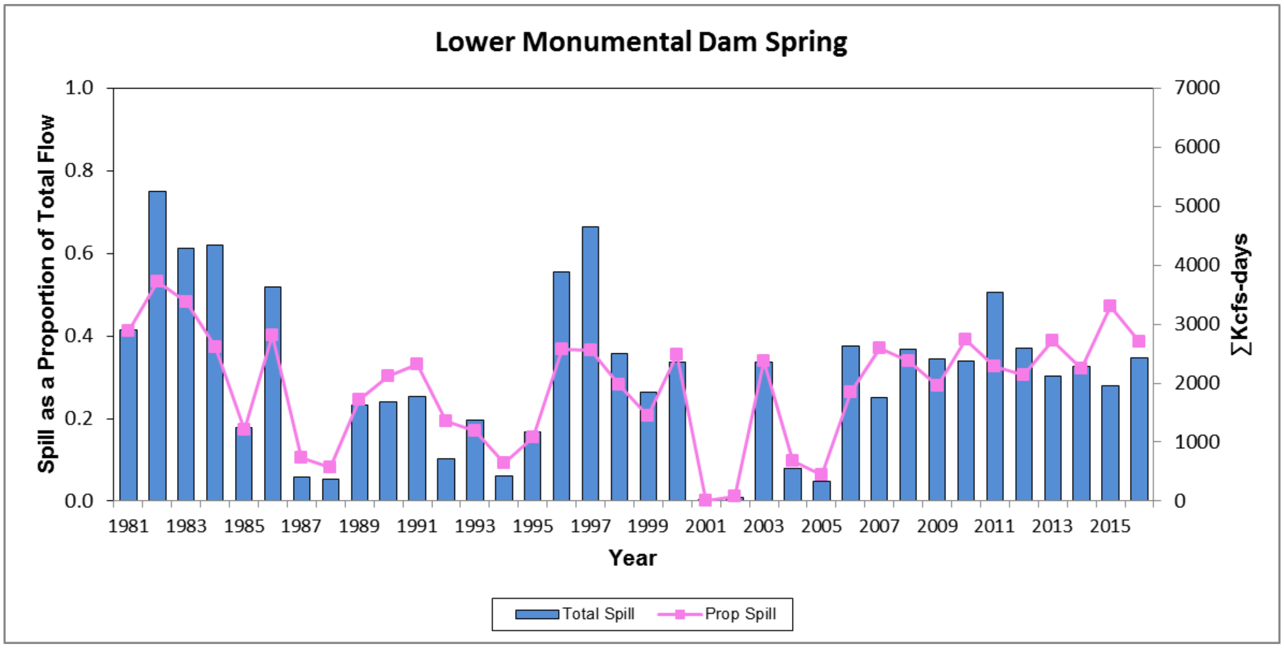


Figure 2. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Little Goose Dam, and spill as a proportion of total flow for the same time period.



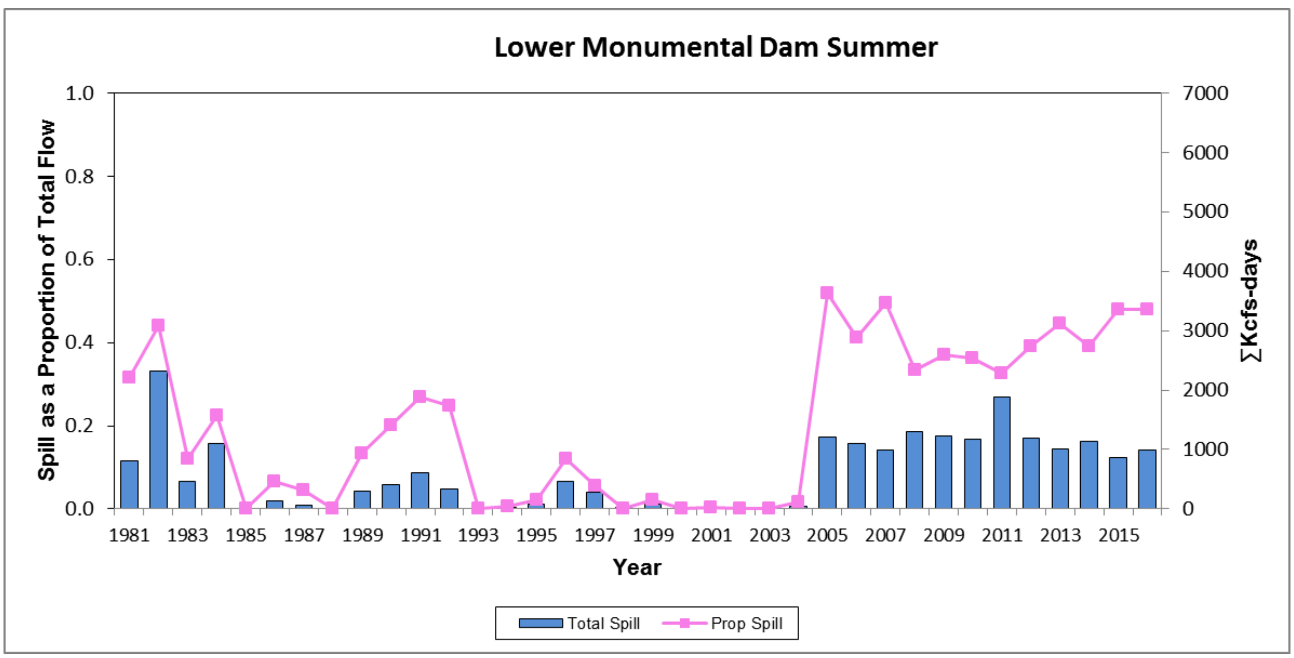
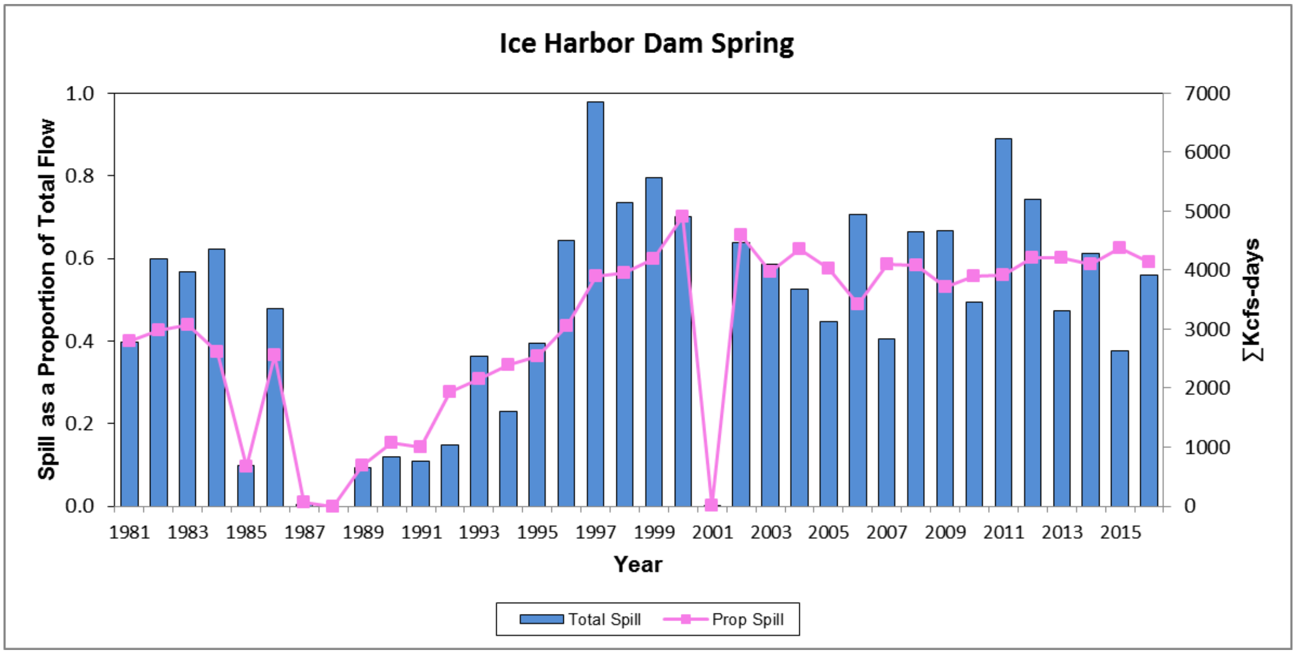


Figure 3. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Lower Monumental Dam, and spill as a proportion of total flow for the same time period.



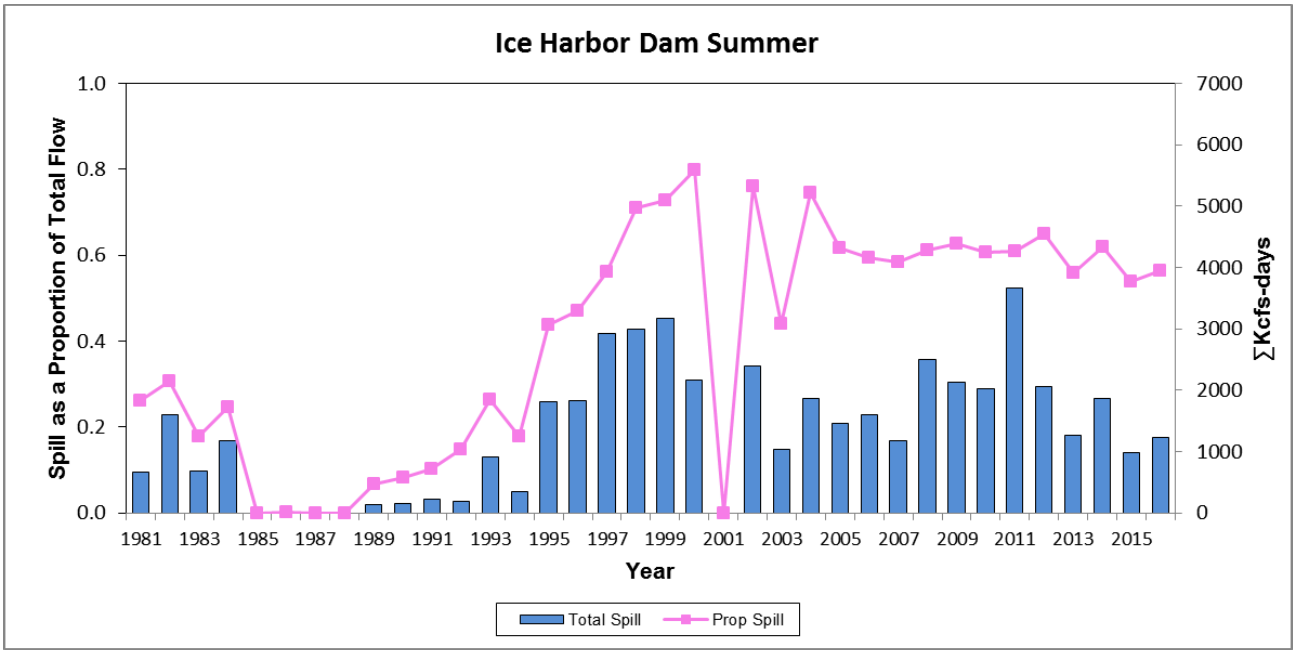
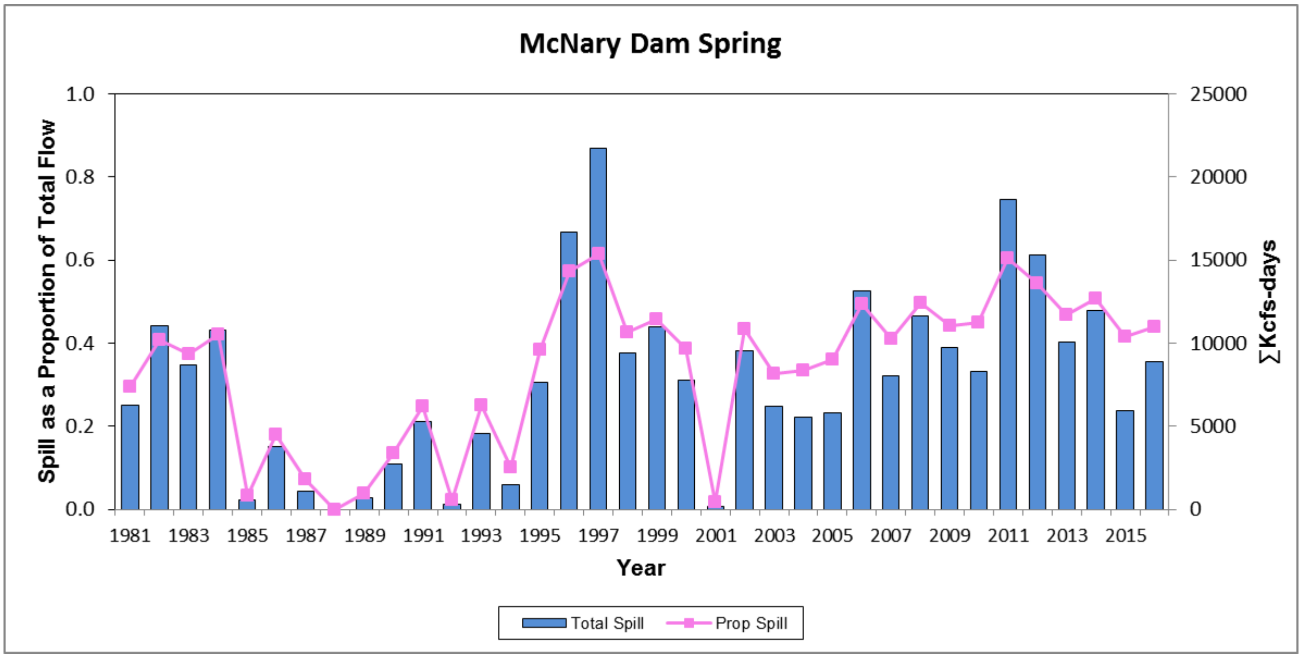


Figure 4. Total spill (ΣKcfs-days) for spring (April 3 to June 20) and summer (June 21-August 31) at Ice Harbor Dam, and spill as a proportion of total flow for the same time period.



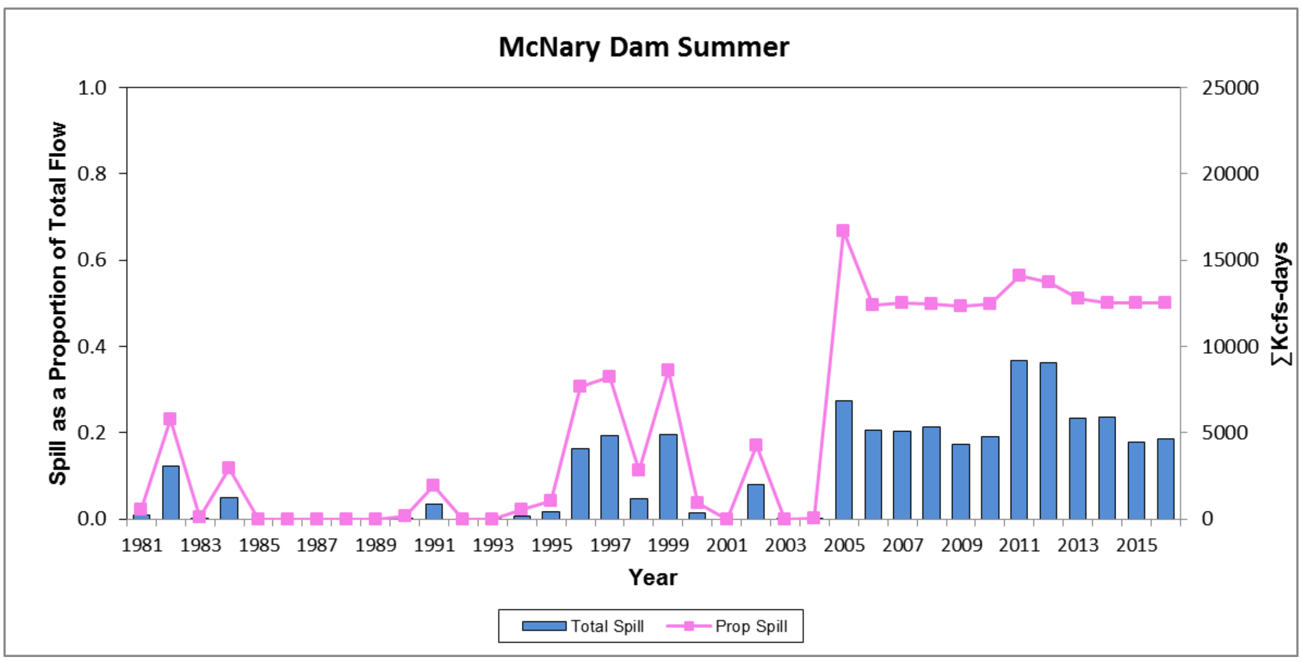
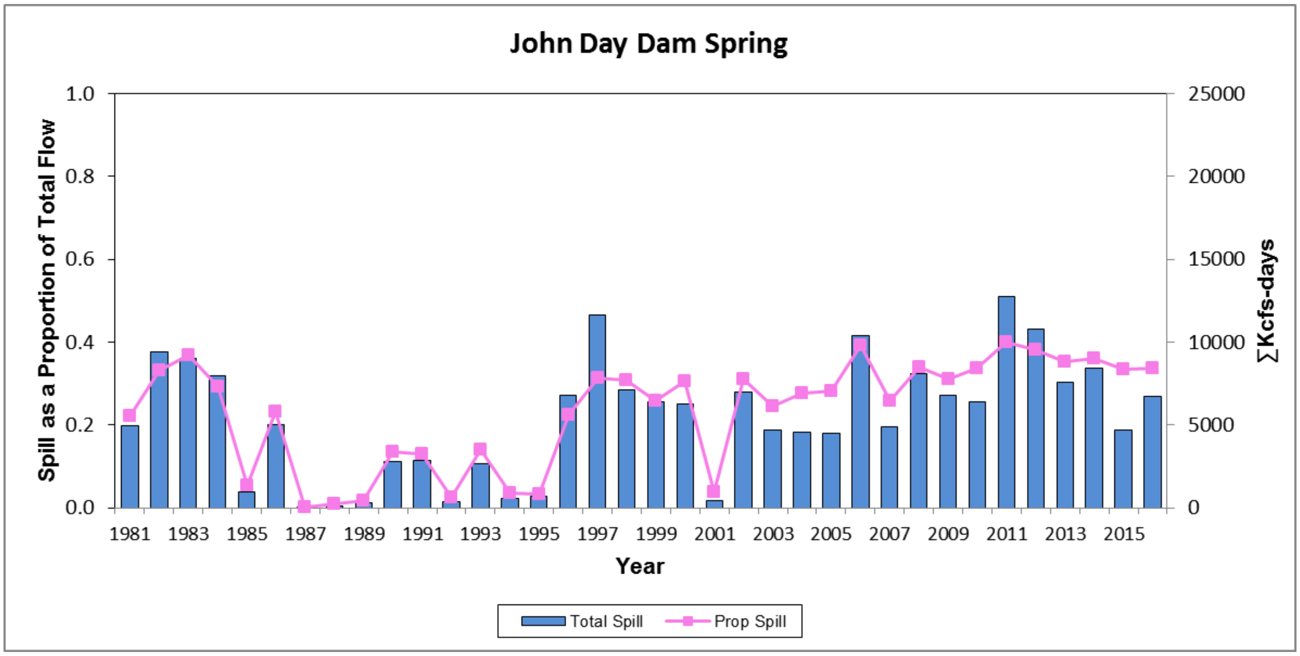


Figure 5. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at McNary Dam, and spill as a proportion of total flow for the same time period.



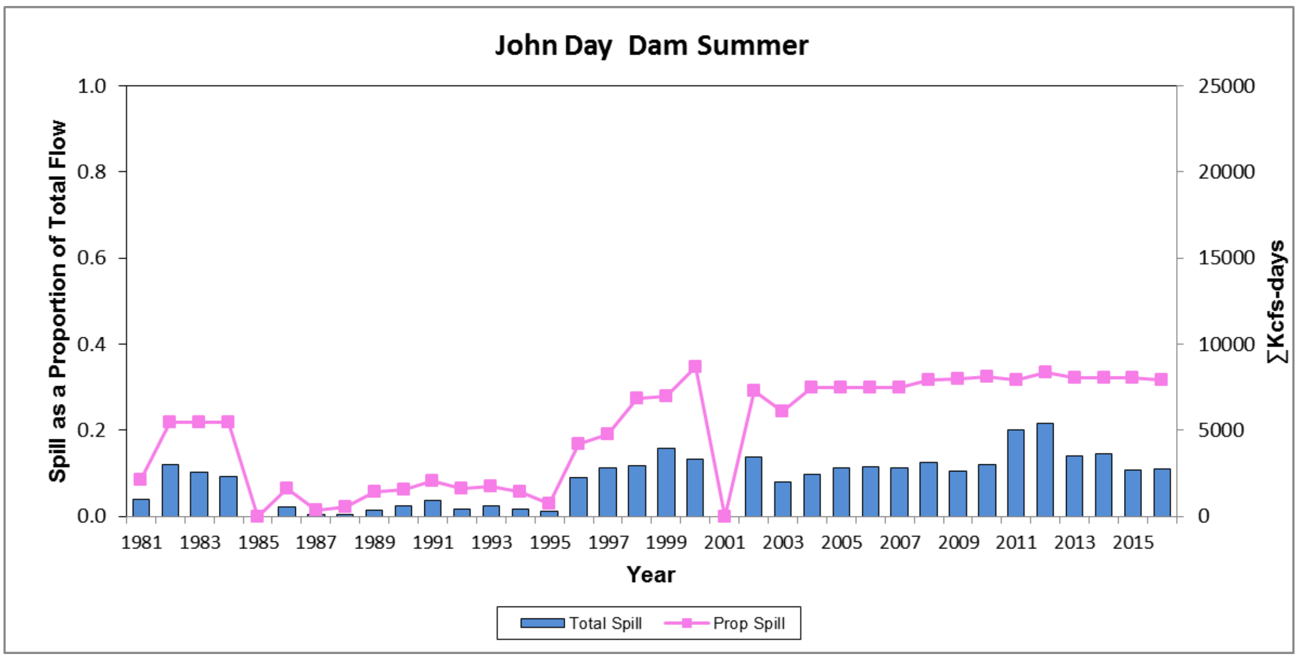
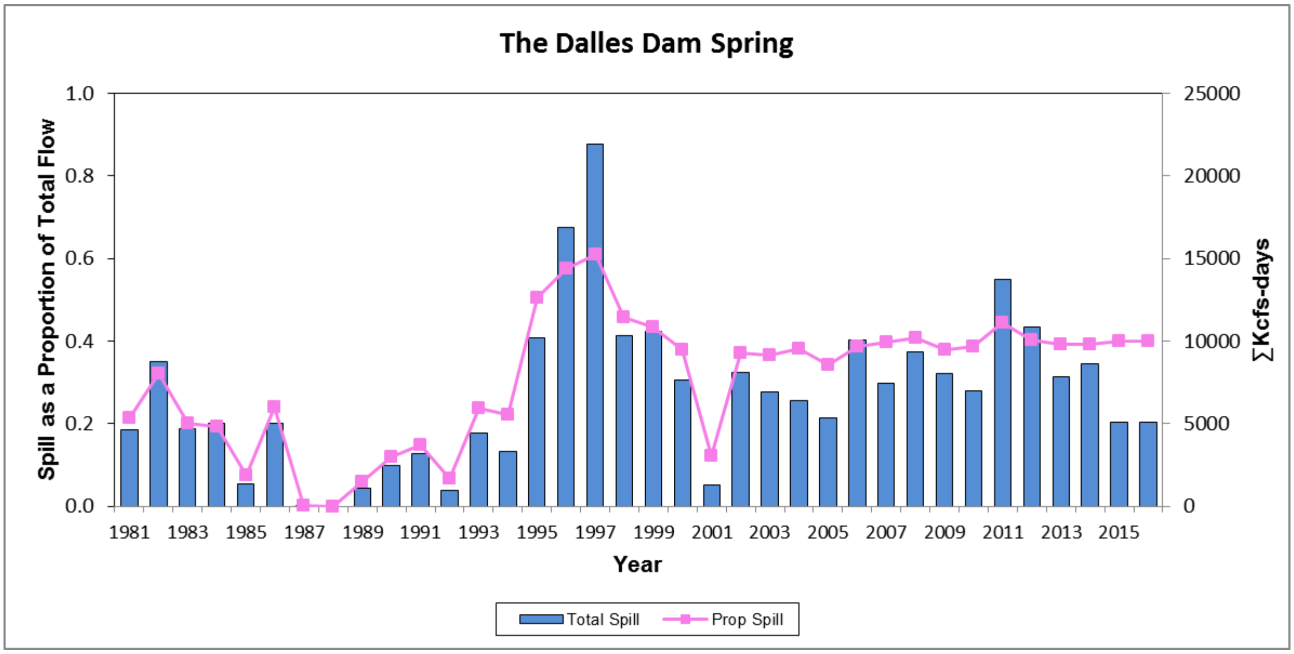


Figure 6. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at John Day Dam, and spill as a proportion of total flow for the same time period.



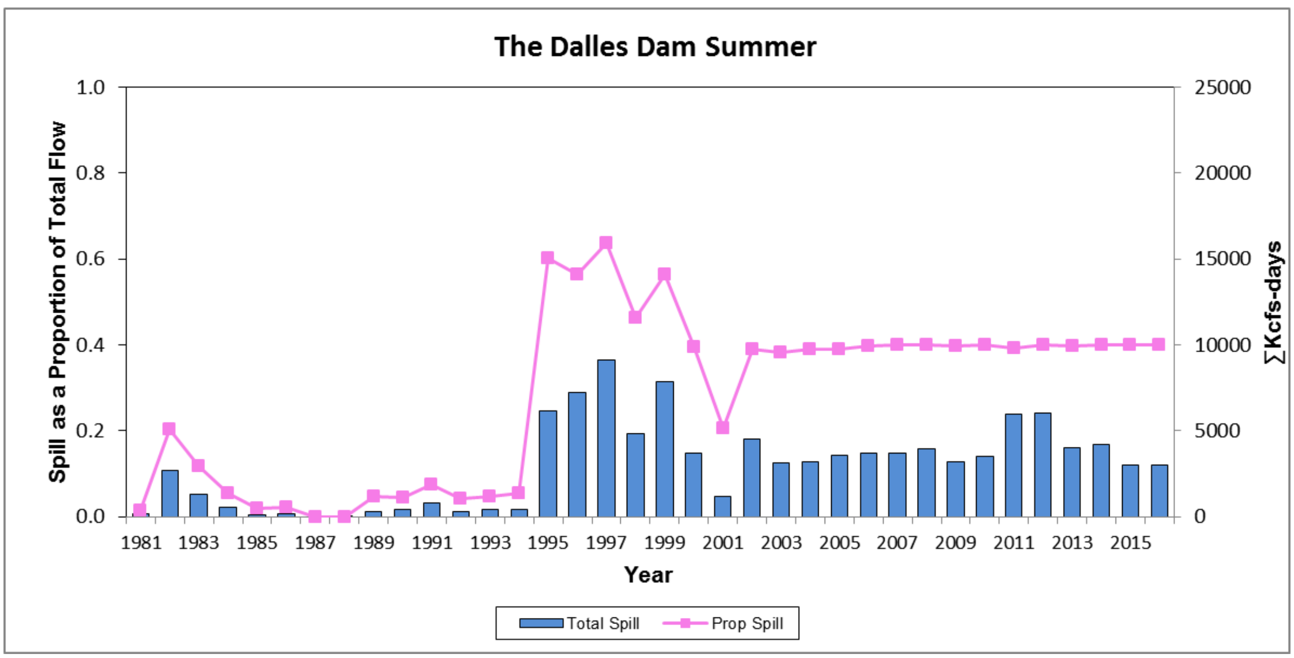
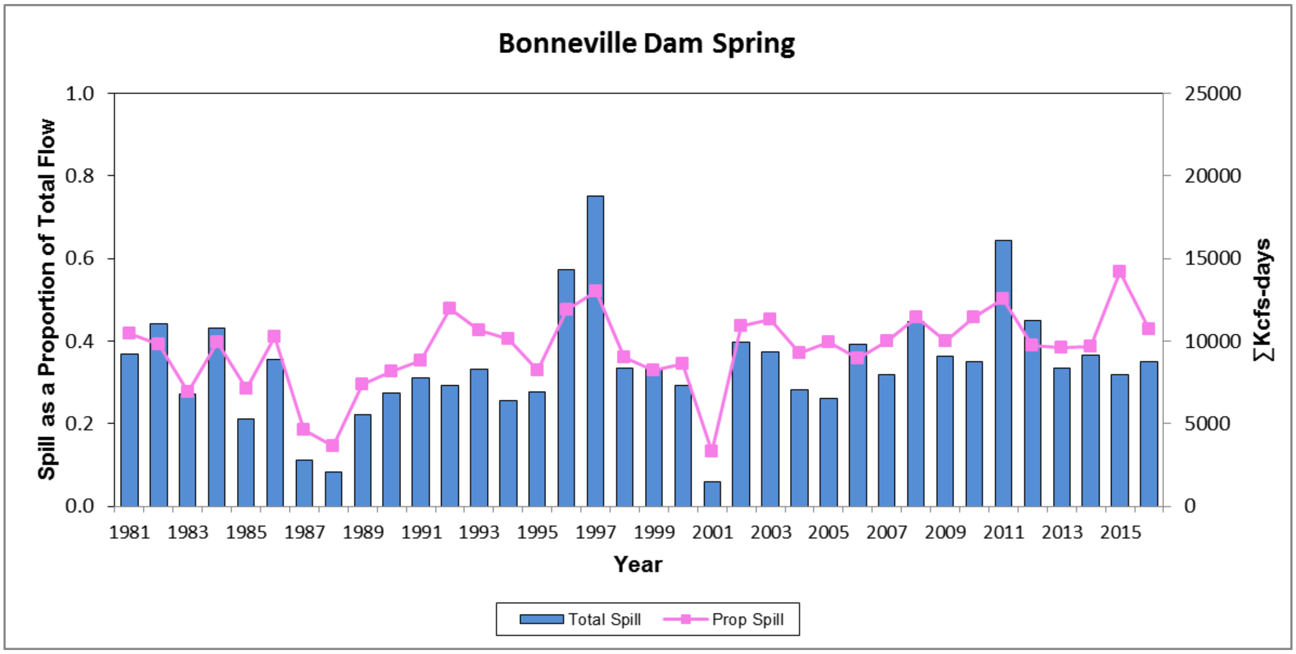


Figure 7. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at The Dalles Dam, and spill as a proportion of total flow for the same time period.



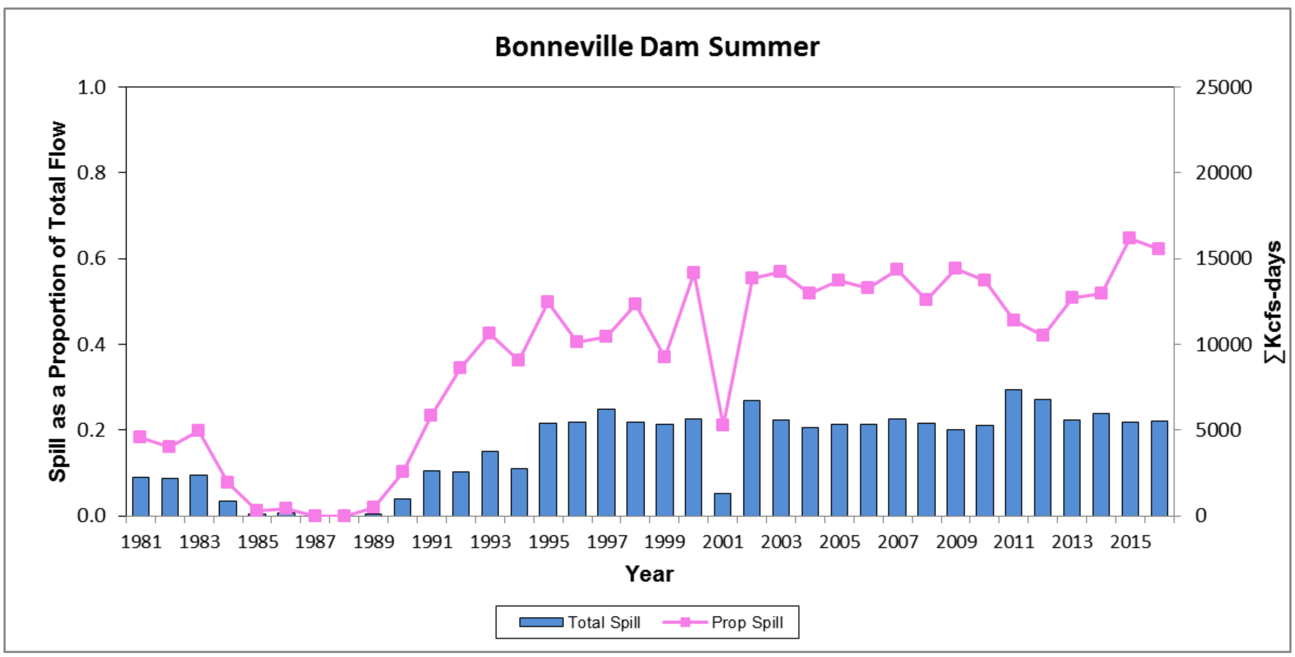


Figure 8. Total spill (ΣKcfs-days) for spring (April 10 to June 30) and summer (July 1 - August 31) at Bonneville Dam, and spill as a proportion of total flow for the same time period.

VIII. Summary

From the historic record it is evident that spill has become a more important tool in the recovery of listed stocks. Major modifications to spill over the time period addressed in this compendium include expanding spill to all hydroprojects in the FCRPS; implementing a "spread the risk" transportation policy at transport collector dams by providing spill simultaneously with transport operations; providing spill in low runoff volume years, and the provision of spill during the summer months.

The benefits of spill are outlined in several publications, including: Haeseker et al., 2012; Tuomikoski et al., 2009, 2010, 2011, 2012, 2013; McCann et al., 2014, 2015, 2016; Petrosky and Schaller, 2010; and, Schaller et al., 2014. Some of the recently recognized benefits of spill passage include the following:

- Increasing proportion of spill provided for fish passage at hydroelectric projects has resulted in higher juvenile spring/summer Chinook, fall Chinook, sockeye and steelhead survival and faster juvenile fish travel time through the FCRPS. The addition of the most recent data to the historic CSS time series continues to show the importance of spill and flow for in-river juvenile survival and SARs.

- Increasing spill proportion provides mitigation for low flows through the hydrosystem. In observations of years with similar flow and water travel time, juvenile fish survival and fish travel time are improved in years with higher average spill.

- Spill proportion and water travel time (i.e. flow) are correlated with smolt-to-adult return rate. Increasing spill proportion and faster water travel time (i.e. higher flow) result in higher smolt-to-adult return rate.

- Fresh water passage conditions affect early ocean survival. Spill proportion and water travel time affect ocean survival of Chinook and steelhead.

- Increasing spill proportion allows a higher proportion of downstream migrants to avoid power house passage. Powerhouse passage through juvenile bypass systems decreases smolt-to-adult return rates. The Comparative Survival Study (CSS) has conducted analyses comparing the survival of fish that pass a hydroelectric project undetected at a transportation collection site (C_0) in the Snake River versus fish that have passed through a bypass (C_1) at a collection site. The smolt-to-adult return rates (SARs) indicate that bypassed juvenile Chinook and steelhead appear to have a lower SAR than undetected in-river migrants that did not pass through the powerhouse juvenile bypass system, with the magnitude of those differences varying across years.

- Direct estimates of project survival do not capture the delayed mortality effect of project passage and therefore underestimate project impact on juvenile survival and adult return.

- Model simulations indicate that juvenile survival could be significantly increased and juvenile fish travel time could be decreased by increasing spill proportion in low flow periods.

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Appendix A. Spring and summer migration period spill seasons.

Year	Project	Spring	Summer
1981	LMN	Apr 20 – June 2	na
	IHR	Apr 22 - June 2	na
	JDA	Apr 21 – June 8	na
1982	LMN	Apr 19 – June 4	na
	IHR	Apr 12 - July 18	na
	JDA	May 1 – June 1	na
1983	LMN	Apr 15 – June 15	na
	IHR	Apr 15 – June 15	na
	JDA	May 1 – June 30	July 1 – Sept 1
1984	LMN	Apr 15 – June 15	na
	JDA	May 1 – June 30	July 1 – Aug 29
	BVL	May 1 – June 30	July 1 – July 11
1985	LMN	Apr 10 – June 12	na
	IHR	Apr 17 – June 12	na
	JDA	May 1 – June 14	na
	BVL	May 1 – June 29	July 2 – July 4
1986	LMN	Apr 15 – June 15	June 15 – July 7
	JDA	Apr 15 – June 15	na
	TDA	Apr 15 – June 11	June 15 – Aug 21
	BVL	Apr 15 – June 11	June 15 – Aug 21
1987	LMN	Apr 15 –May 26	June 22-July 7
	JDA	na	July 8 – Aug 14
	BVL	Apr 29 – June 11	na
1988	LMN	Apr 15 – May 29	June 5 – Jun 9
	JDA	na	June 8 – Aug 15
1989	LMN	Apr 15 – May 31	June 11 – July 23
	IHR	Apr 19 – May 31	June 13 – July 23
	JDA	na	June 13 – Aug 22
	TDA	May 9 – June 11	June 13 – Aug 23
	BVL	Apr 7 – Apr 24	June 5-June 22
1990	LMN	Apr 19 – May 31	June 1 – July 23
	IHR	Apr 22 – May 31	June 1 – July 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	Apr 23 – June 6	June 7 – Aug 23
1991	LMN	Apr 20 – May 31	June 1 – July 23
	IHR	Apr 23 – May 31	June 1 – July 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	Apr 15 – June 6	June 7 – Aug 20
1992	LMN	Apr 15 – May 31	June 1 – Aug 15
	IHR	Apr 15 – May 31	June 1 – Aug 22
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23

	BVL	May 1 – June 6	June 7 – Aug 23
1993	IHR	Apr 15 – May 31	June 1 – Aug 31
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	May 1 – June 6	June 7 – Aug 23
1994	IHR	Apr 15 – May 31	June 1 – Aug 23
	JDA	na	June 7 – Aug 23
	TDA	May 1 – June 6	June 7 – Aug 23
	BVL	May 1 – June 6	June 7 – Aug 23
1995	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1996	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1997	Snake	Apr 10 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1998	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
1999	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 20 – June 30	July 1 – Aug 31
2000 to 2007	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30	July 1 – Aug 31
2008	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) Bonneville April 10 - June 20	July 1 – Aug 31 (except) Bonneville June 21 - Aug 31
2009	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) Bonneville April 10 - June 20	July 1 – Aug 31 (except) Bonneville June 21 - Aug 31
2010	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 10 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 21 - Aug 31
2011	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 10 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 21 - Aug 31
2012	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 15 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 16 - Aug 31
2013	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 30 (except) McNary Apr 10 - June 19 Bonneville April 15 - June 20	July 1 – Aug 31 (except) McNary June 20 - Aug31 Bonneville June 16 - Aug 31
2014 to present	Snake	Apr 3 – June 20	June 21 – Aug 31
	Middle Columbia	Apr 10 – June 15	June 15 – Aug 31