2000
Annual Report
To the
Oregon Department of
Environmental Quality
December, 2000

Introduction

The purpose of the spill program is to improve the downstream passage of ESA listed stocks by providing a route with less associated mortality than turbine passage. It is recognized that spilling water generates atmospheric gas supersaturation of the river that can have detrimental effects on fish. In providing spill as an alternate passage route the associated mortality due to dissolved gas, supersaturation must be balanced against mortality of turbine passage.

In 2000, as in previous years, the NMFS requested that the Oregon Department of Environmental Quality (DEQ) consider a temporary waiver of the Oregon water quality standard for total dissolved gas supersaturation (TDGS). Because of the risk associated with dissolved gas supersaturation, the requested waiver was for a twelve-hour average of 115 and 120 percent TDGS in the forebay and tailrace of a project, respectively. The waiver was granted for the 2000 spill season and specified several stipulations including the provision of an annual report.

Significant interagency cooperation and coordination is necessary to conduct dissolved gas research and monitoring. We would like to recognize the efforts of the agency staff that participated in the development of this report. This includes the following: Fish Passage Center; National Marine Fisheries Service; Bonneville Power Administration and the U.S. Army Corps of Engineers.

2000 Water Conditions

The 2000 water year was characterized at the April 1 forecast to be 90% of average (1961-1990) runoff volume above Lower Granite Dam, and 99% of average above The Dalles Dam for the January to July time period. This below average runoff volume trend continued through the spring with the final July runoff volume forecast calling for 92% of average runoff volume above The Dalles and 84% of average above Lower Granite. The flows during the 2000 migration season were considerably less than those observed during recent past years, and the dissolved gas levels observed in 2000 reflect these lower flows. The average monthly flows that occurred at Lower Granite and McNary Dams are contained in Table 1.

Table 1. Average monthly flows at Lower Granite and McNary dams in 2000.

	Average Monthly Flow (kcfs)	
Month	Lower Granite	McNary
April	90.2	254.9
May	84.1	255.4
June	68.4	206.4
July	37.8	166.7
August	25.9	140.4

The flows that occurred during 2000 rarely exceeded the hydraulic capacity of the projects during the spring migration period. The hydraulic capacity of a project is defined as the amount of water that can be passed through a powerhouse of a project. Any water above the hydraulic capacity must pass over the spillway of a project. Most of the excess hydraulic capacity occurred at McNary Dam.

1. Physical Monitoring of Total Dissolved Gas

In general, because of the substantially lower runoff volume that occurred in the spring/summer of 2000, spill was managed to meet the TDGS waivers with few exceptions. The following graphs contain the final TDGS data provided by the COE for the federal projects in the State of Oregon. The hourly data provided by the COE were summarized as the average of the 12 highest hourly measurements in the 24-hour period. Also presented on the graph are the high and low values obtained in the 24-hour period.

McNary Dam - The TDGS levels in the McNary Forebay reflect the levels of spill at the upriver projects (Ice Harbor on the Snake and Priest Rapids on the Mid Columbia) (Fig.1). The 115% forebay criterion at McNary Dam was exceeded by a few percent in late April/early May. Spill at upstream projects (Ice Harbor and Lower Monumental) was constrained to address the forebay TDGS at McNary Dam. With a few exceptions in late April the tailrace TDGS criterion of 120% was met.

John Day Dam – The forebay monitors measured TDGS of 115% or less throughout the season (Fig. 2). Tailrace gas levels in 2000 were managed to less than the 120% TDGS waiver throughout most of the season. Spill testing was conducted at this project during the 2000 migration. Daytime spill varied between 0 and 30% of instantaneous flow in three-day blocks of time.

The Dalles Dam – The TDGS in The Dalles Dam forebay reflected the conditions in the John Day tailrace. The forebay TDGS levels rarely exceeded the waiver (Fig. 3). Spill at The Dalles was a consistent 40% of instantaneous flow. The downstream TDGS levels exceeded the waiver on only a few days.

Bonneville Dam - Like all the other lower river projects, the TDGS in the forebay and tailrace of the project only exceeded the State waivers for a few days (Fig.4). Figure 5 shows TDGS levels at a further distance from the federal hydroelectric system. Spill levels at Bonneville Dam were constrained throughout most of the season in an effort to meet the 115% TDGS level at the Camas/Washougal monitor. This monitor is supposed to be analogous to the "next downstream forebay". However, the siting of this monitor is problematic and it likely does not sample well-mixed water (Fig 6). The adequacy of the location of this monitor continues to be investigated

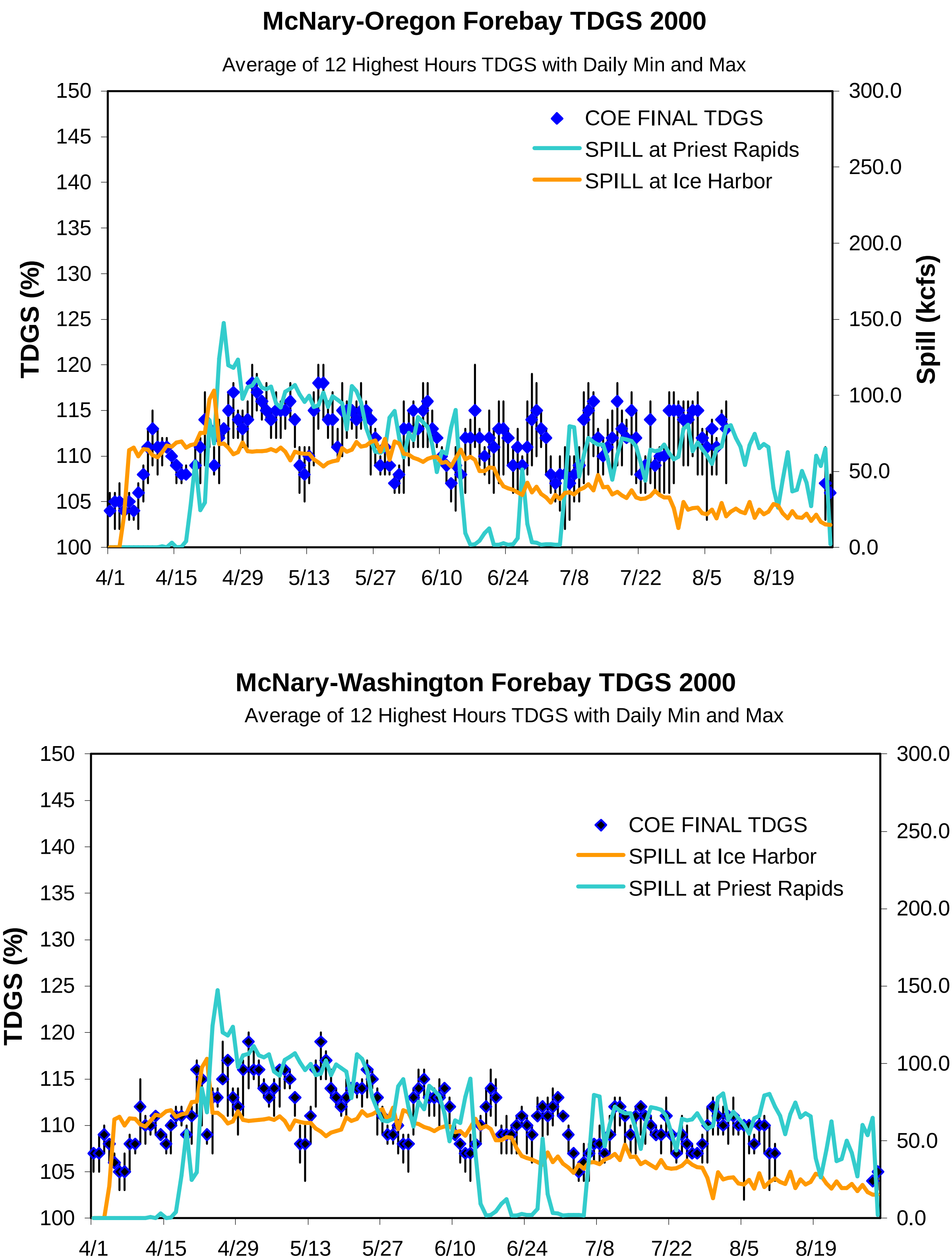


Figure 1. McNary Dam forebay and tailrace measurements of TDGS and associated upriver spill levels.

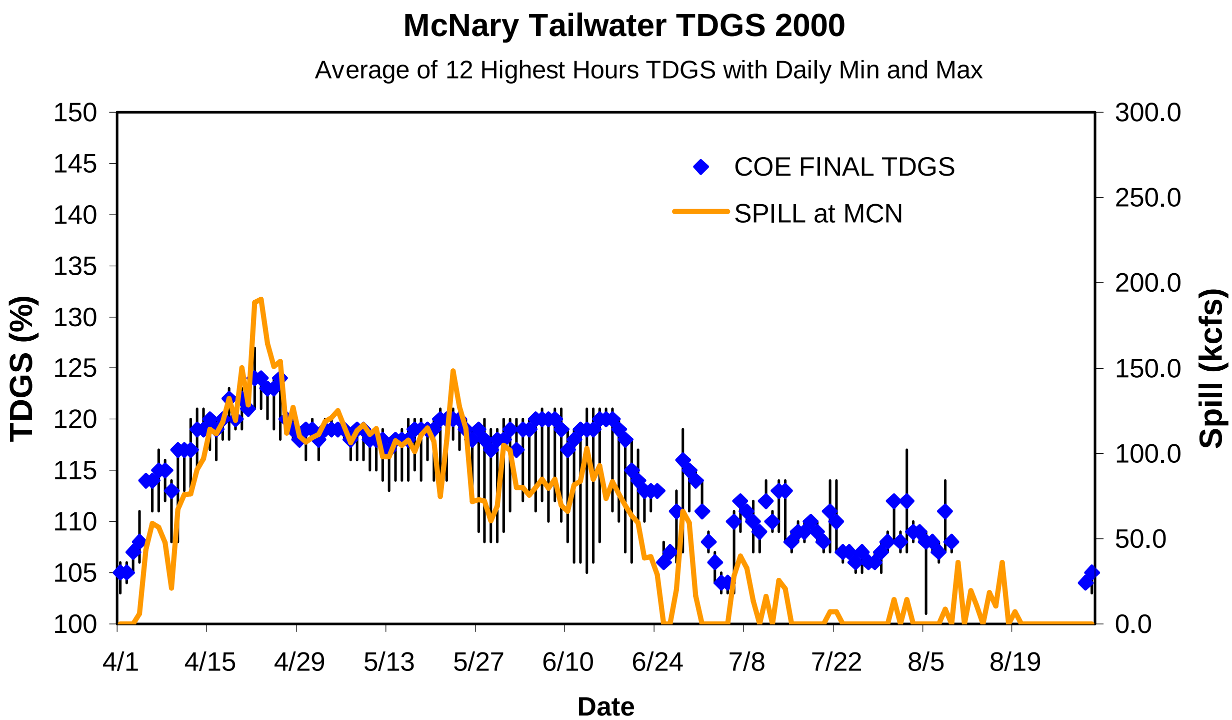
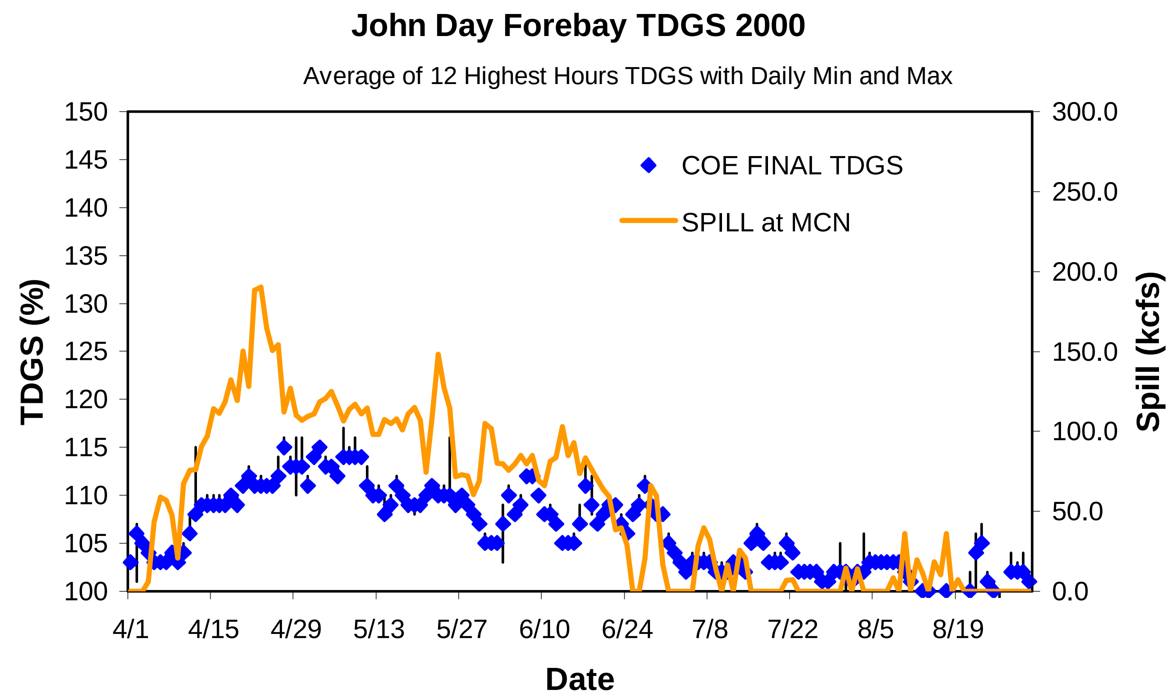


Figure 1. Continued.



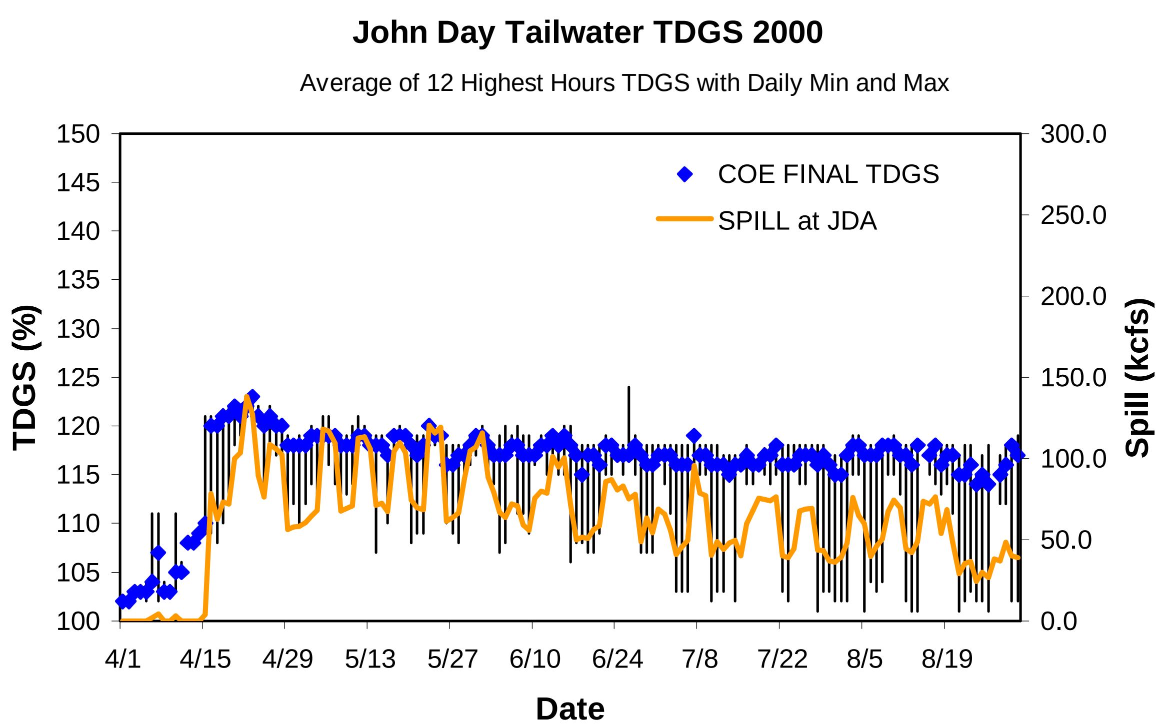
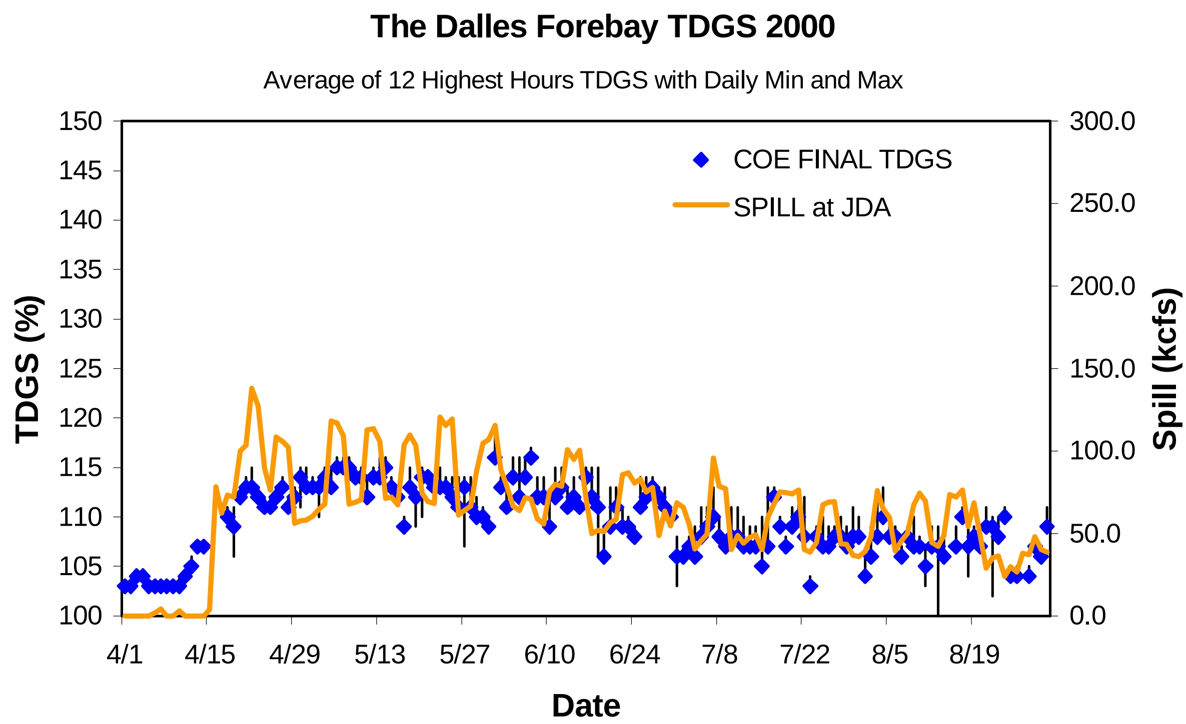


Figure 2. John Day Dam forebay and tailrace measurements of TDGS and associated upriver spill levels.



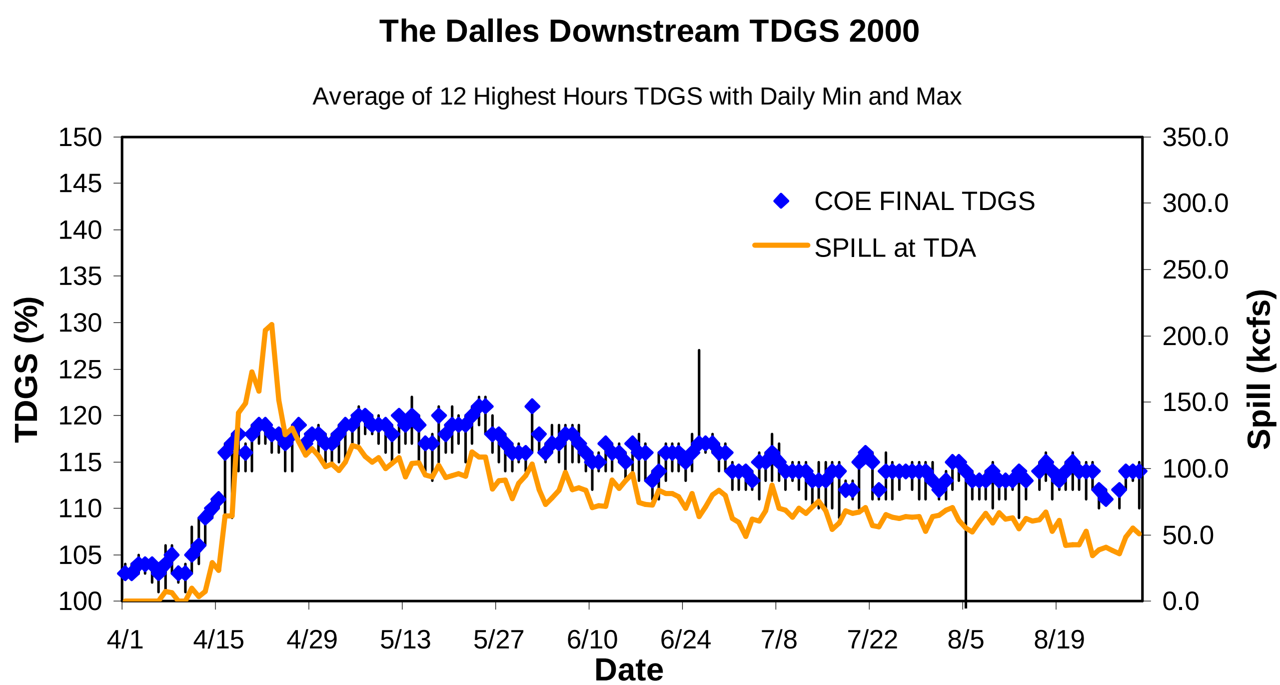
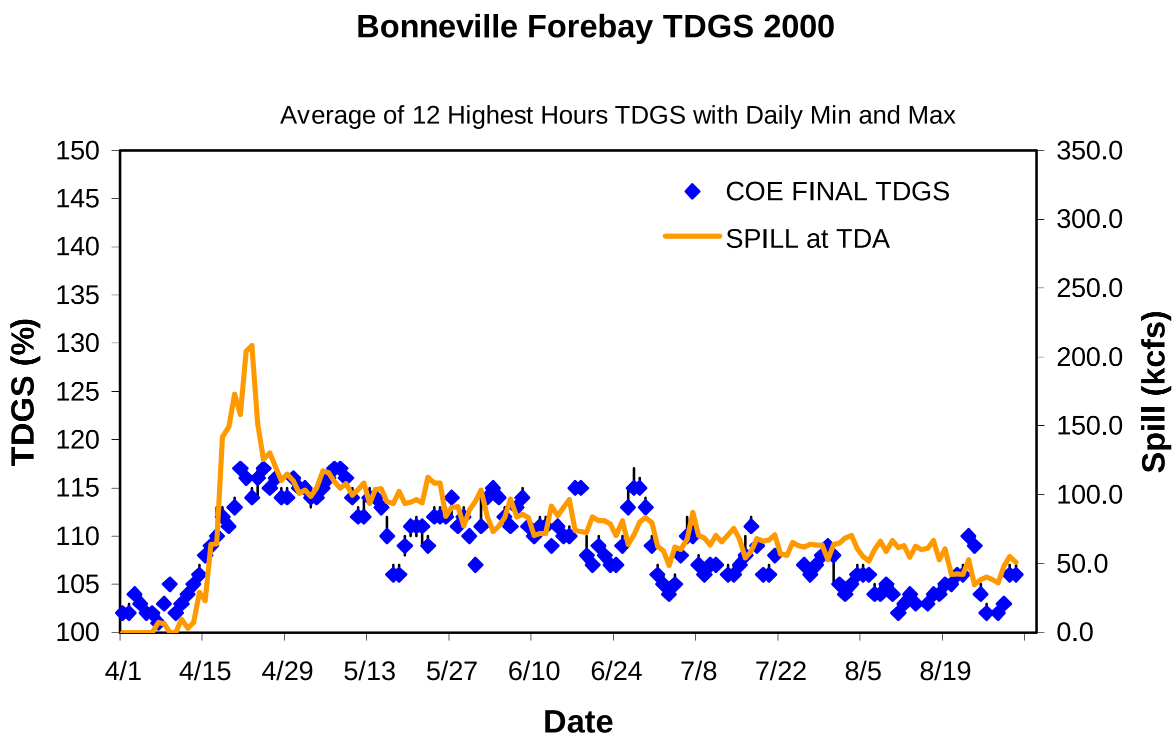


Figure 3. The Dalles Dam forebay and tailrace measurements of TDGS and associated upriver spill levels.



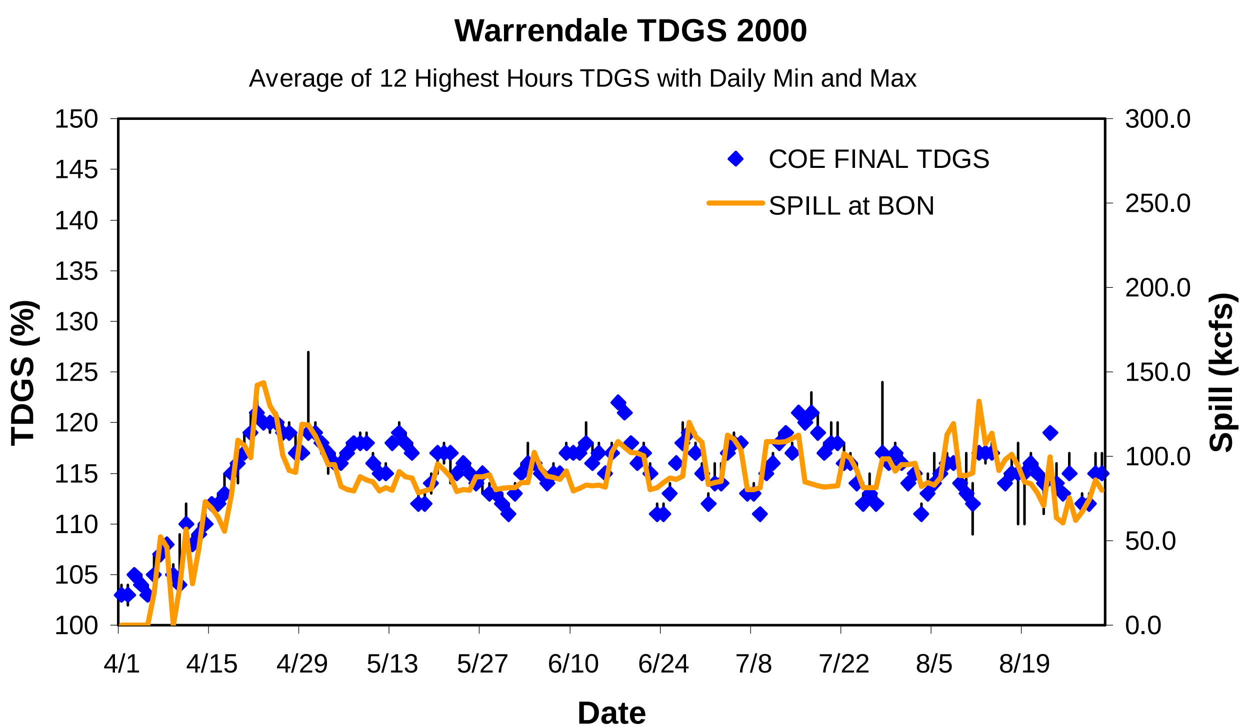
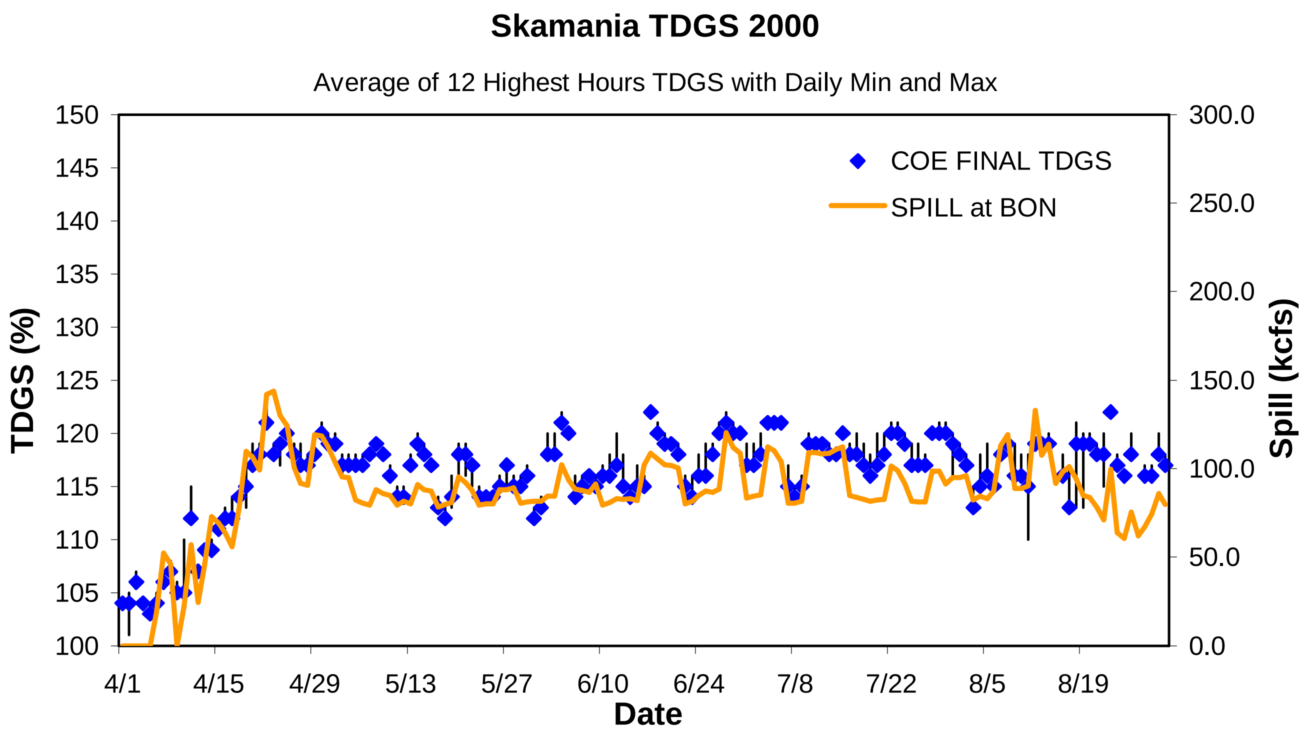


Figure 4. Bonneville Dam forebay and tailrace measurements of TDGS and associated upriver spill levels.



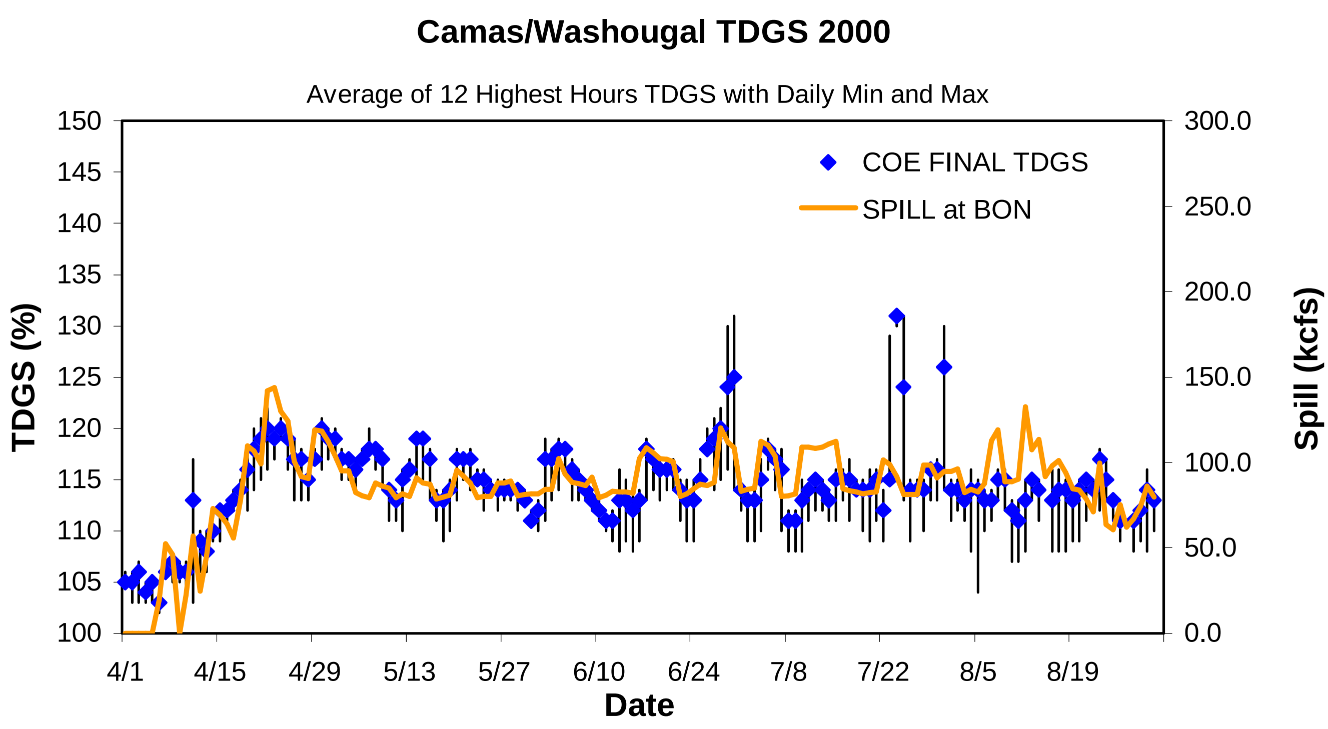


Figure 5. TDGS measurements at stations below Bonneville Dam.

2. The Factors Causing Spill

Spill for fish passage, as described in the NMFS Biological Opinion, is an example of voluntary spill when flows are controllable. Voluntary spill can be managed so as not to exceed the total dissolved gas caps, or may be managed to varying amounts based on the data obtained from a biological monitoring program. Conversely**,** involuntary spill is a physical constraint because it is caused by a project or system physical limitation. There are two primary causes of involuntary spill: flow levels exceeding the hydraulic capacity of a hydroelectric project (excess hydraulic capacity spill), or spill from a water supply that exceeds the available power markets (lack of market spill).

In 2000, data were collected by the BPA and the COE to allow for the distinction of voluntary and involuntary spill. This allowed the following analysis that addresses the impact of the presence of the hydrosystem on the total dissolved gas levels during 2000. The results of the analysis are presented in Figures 6 through 9.

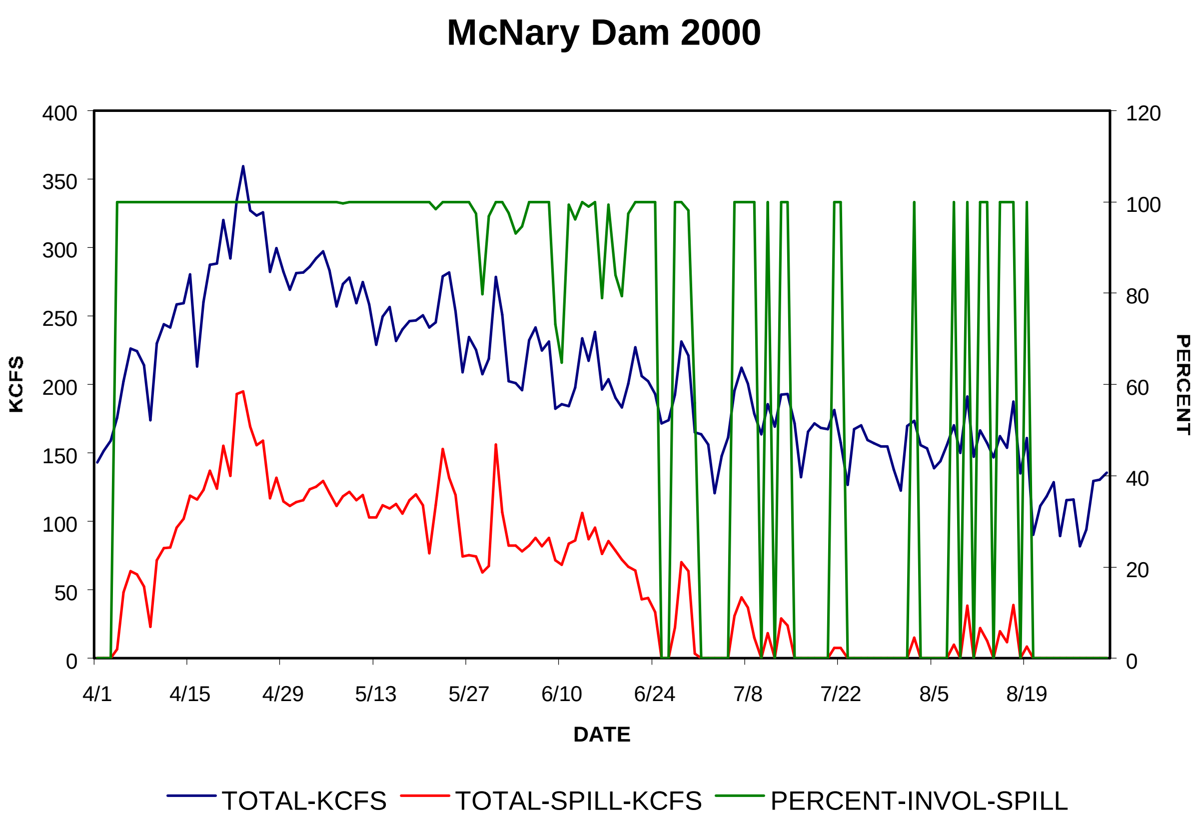


Figure 6. Total flow, spill and the percent of spill that was considered involuntary at McNary Dam from April through August.

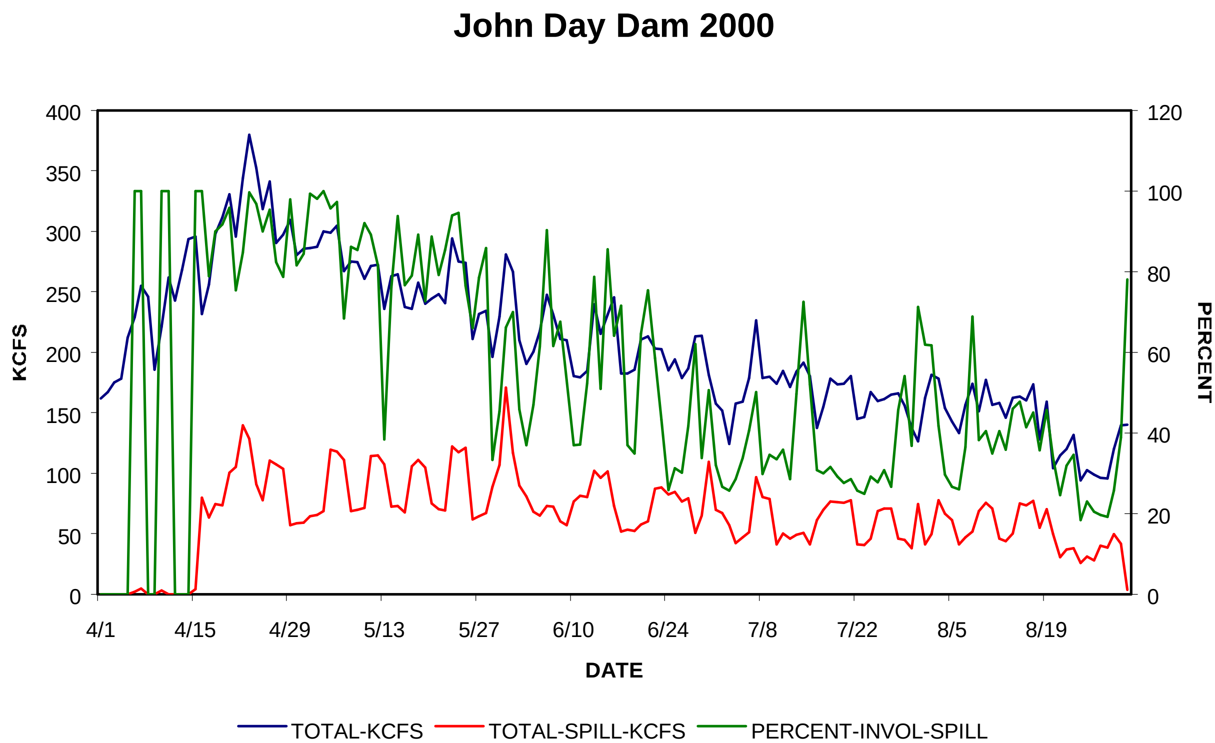


Figure 7. Total flow, spill and the percent of spill that was considered involuntary at John Day Dam from April through August.

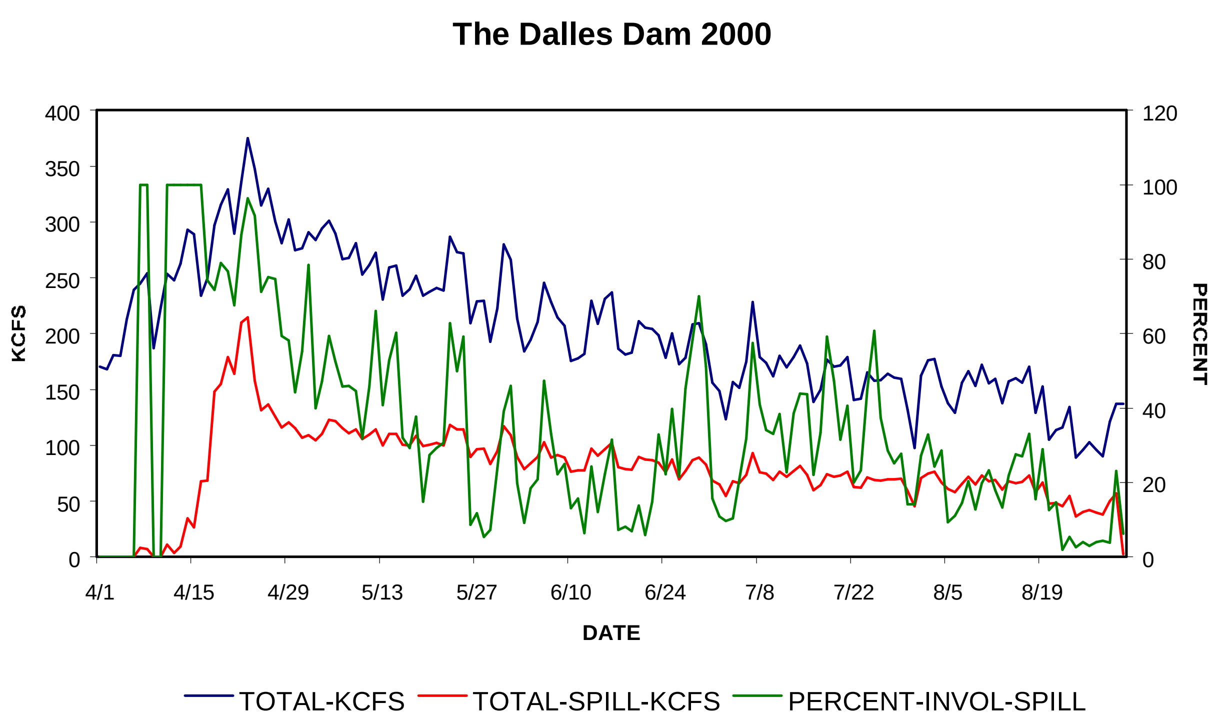


Figure 8. Total flow, spill and the percent of spill that was considered involuntary at The Dalles Dam from April through August.

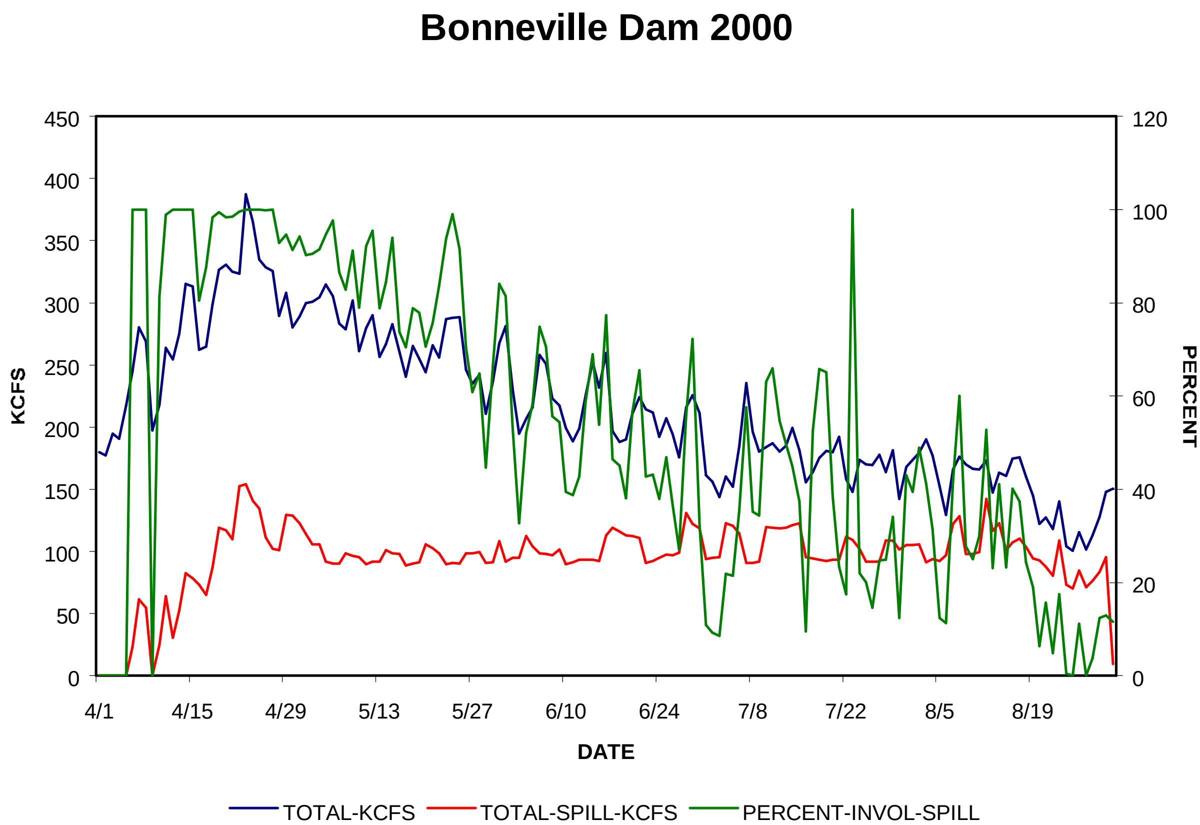


Figure 9. Total flow, spill and the percent of spill that was considered involuntary at Bonneville Dam from April through August.

As can be seen from the graphs spill during 2000 was in part involuntary. In other words, spill in excess of hydraulic capacity or market needs comprised a portion of the spill in the spring. In the lower Columbia spill at McNary dam was involuntary due to the river flows and the limited hydraulic capacity of this project. Some excess generation spill occurred at the other projects.

Figure 10 summarizes the total amount of spill at each project from April through August. The graph illustrates that significantly less excess generation spill occurred in 2000 than in past years'. This is primarily due to the reduced runoff volume for this year. While this spill was at times involuntary it did not exceed the amount of spill that would have occurred for the Biological Opinion Spill Program. This simply translates into a lower cost for the spill that did occur; since this volume of water was not marketable it would have occurred even without a Biological Opinion Spill Program in place.

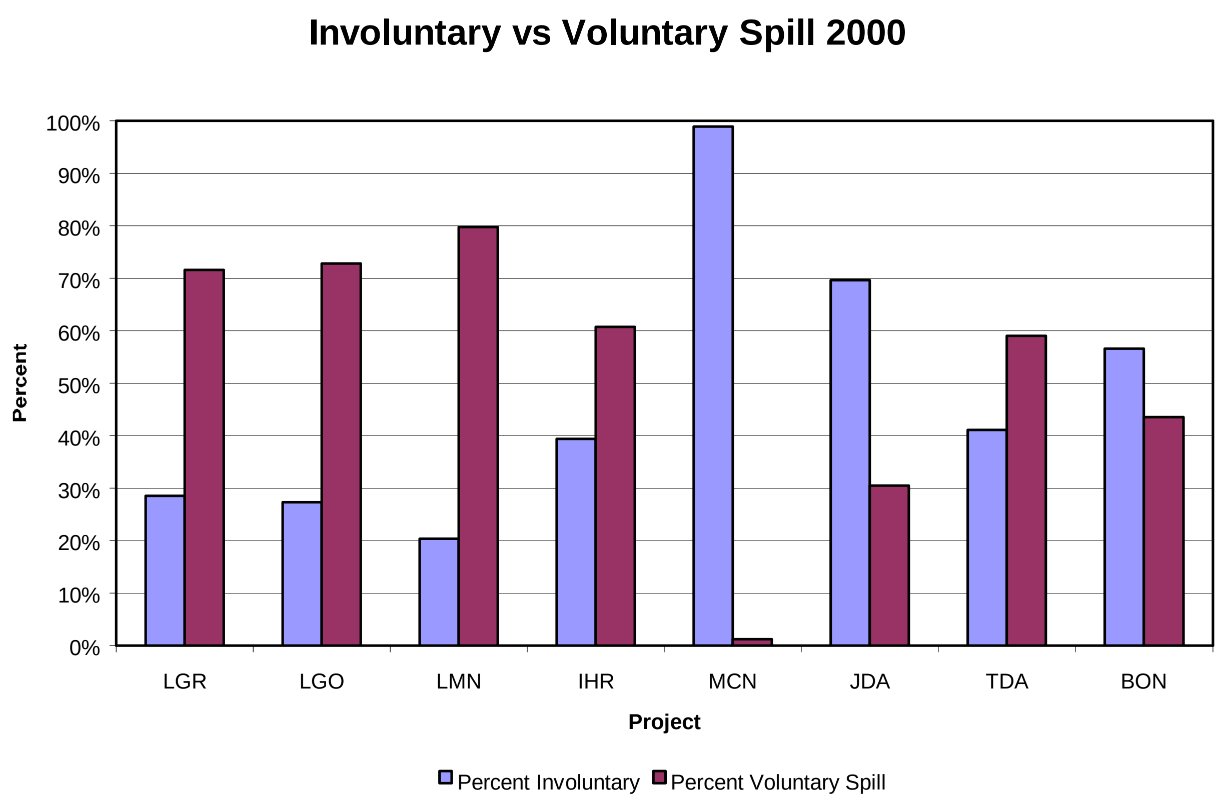


Figure 10. Involuntary versus voluntary spill at the eight mainstem Corps of Engineers projects. Data courtesy of Bonneville Power Administration.

3. Biological Monitoring for Real-Time Spill Management

Monitoring of juvenile salmonids was conducted at Bonneville and McNary dams in the Lower Columbia River; Rock Island Dam in the Mid-Columbia River; and at Ice Harbor, Lower Monumental, Little Goose and Lower Granite dams on the Lower Snake River. Fish were examined by Smolt Monitoring Program (SMP) personnel at each site. Sampling of fish began the first week of April at all sites and continued through the end of June at Snake River sites, when the numbers of steelhead and yearling chinook were too few to sample effectively. Subyearling chinook were not sampled in the Lower Snake River due to their endangered status and because the Biological Opinion does not call for the implementation of summer spill at the Snake River collector projects. Sampling continued to the end of August at other sites where subyearling chinook continued to be examined.

Sampling occurred two days per week at projects in the Lower Columbia and one day per week at the Lower Snake River sites. The goal was to sample 100 fish of each species during each day of sampling (100 each of the two most prevalent species) at each site when fish were available. Examination of fish was done using variable magnification (6x to 40x) dissecting scope at all locations. The lateral line and unpaired fins were examined for the presence of bubbles. The bubbles present in the fins were quantified using a ranking system based on the percent area of the fins covered with bubbles. A rank of 0 was recorded when no bubbles were present; rank 1 was recorded when up to 5% of a fin area was covered with bubbles; rank 2 was for 6% to 25%; rank 3 indicated 26% to 50% fin area was bubbled; and rank 4 indicated greater than 50% of a fin was covered with bubbles. The left-side lateral line was examined for the presence of bubbles. A similar ranking system to that used for the fins was used to assign a rank to the percent lateral line occluded. Based on the average number of lateral line scales in chinook and steelhead, the length spanned by seven lateral line scales was equivalent to approximately 5% of the total length of the lateral line. The scale approximation was used as a guide to estimate percent occlusion. Then a rank was assigned based upon this approximation. It was assumed that few fish would have greater than 5% lateral line occlusion. The eyes of the fish were also examined and the eye with the highest amount of bubbles in it was ranked using the same criteria as was used for the fins. Additional information was recorded for each fish including, species, age, race, rearing disposition, fork length, fin clips, and tags.

A total of 21,391 juvenile salmon were examined for signs of gas bubble trauma between April and August. A total of 96 or 0.44% showed some signs of GBT in fins, eyes or lateral lines. Of these fish 91 or 0.42% showed signs of GBT in their fins. The fin signs observed were broken down by rank: 75, or 0.4% were rank 1 (1-5% of a fin covered with bubbles); 15, or 0.1% were rank 2 (5-25%); and 1 or 0.005% were rank 3 or greater (> 25%). This breakdown and predominance of rank 1 signs and few of greater severity was anticipated based on the dissolved gas levels observed.

The prevalence of signs at Rock Island Dam (68 of the 96 fish with signs) may obscure the trends observed at other sites. Only three fish with signs were observed at the lower Columbia sites throughout the spring and summer spill season. These signs were the lowest observed since monitoring began in 1995. The biological criterion that was established by NMFS for the termination of the spill program was never violated.

Table 2. Exceedences of NMFS criteria for signs of GBT.

Summary of GBT Monitoring Program Exceedences by Site*						
Site	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Bonneville	0	1	5	0	0	0
John Day	0	2	0	0	**	**
McNary	0	0	1	0	0	0
Ice Harbor	0	0	1	0	0	0
Lower Monumental	0	8	6	0	0	0
Little Goose	0	1	0	0	0	0
Lower Granite	0	0	0	0	0	0
Rock Island	0	11	12	0	0	0
Total	**0**	**23**	**25**	**0**	**0**	**0**

*Sample size greater than or equal to 100 fish.
**No sampling at John Day Dam.

Figures 11-17 depict the observations of signs by sample at each site. The prevalence of signs varied over the season and was related to flow and spill volume.

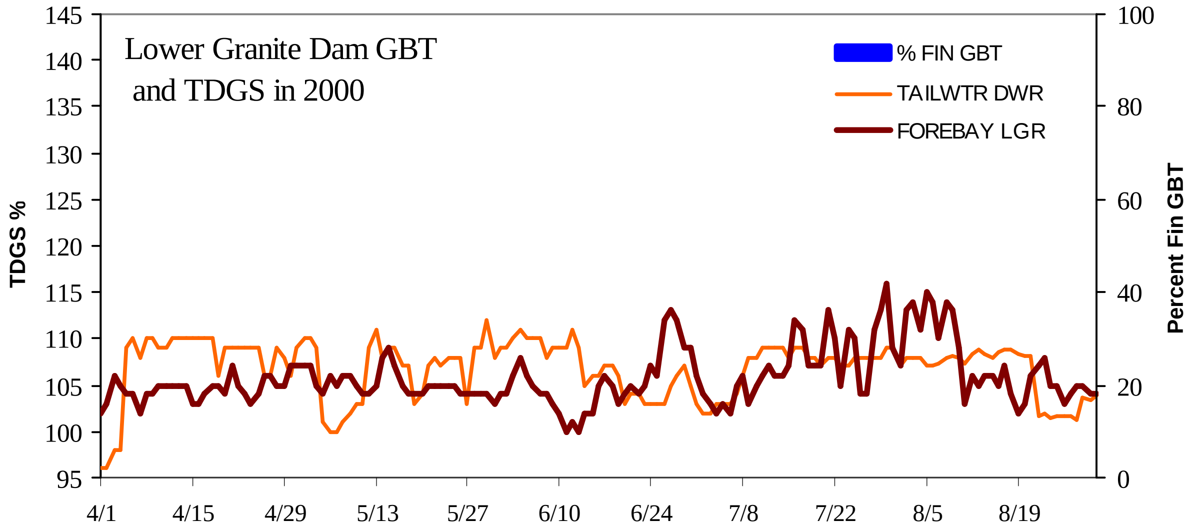


Figure 11. Data collected at Lower Granite Dam for the smolt monitoring program.

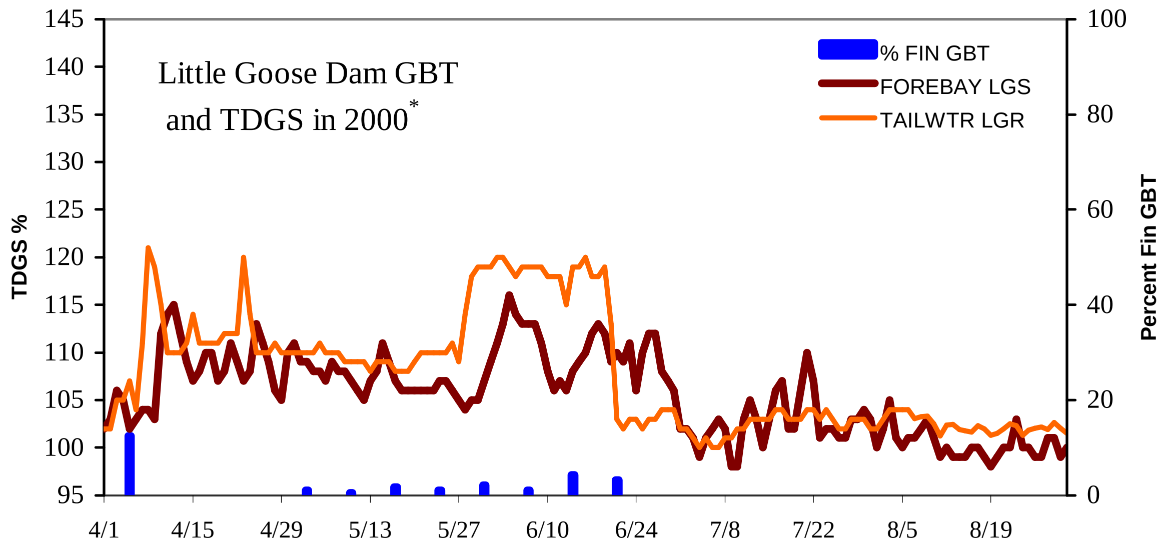


Figure 12. Data collected at Little Goose Dam for the smolt monitoring program.
* note on 4/5 there were eight fish in the sample.

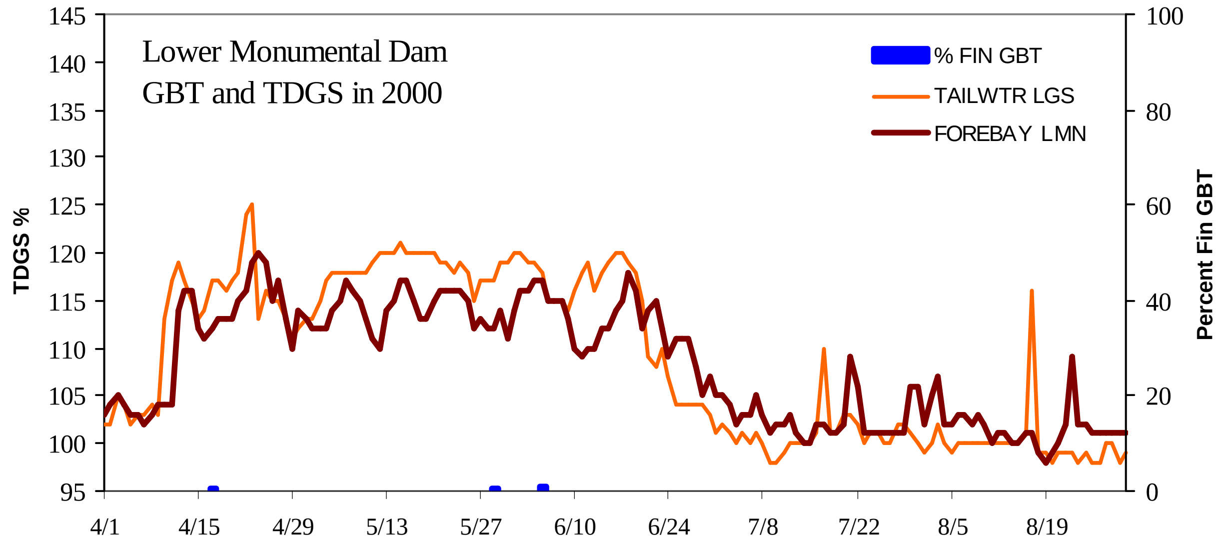


Figure 13. Data collected at Lower Monumental Dam for the smolt monitoring program.

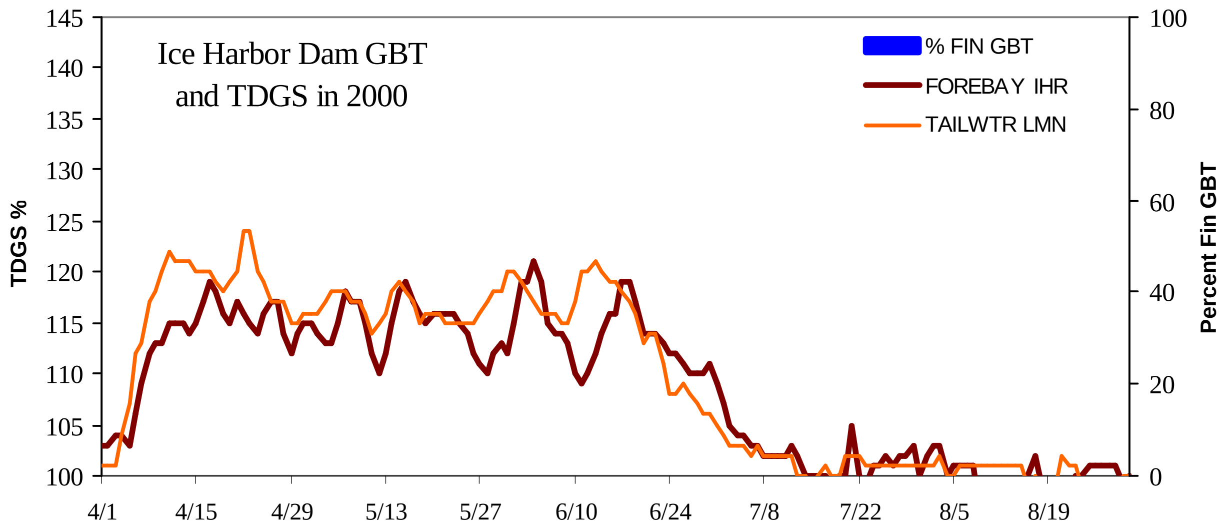


Figure 14. Data collected at Ice Harbor Dam for the smolt monitoring program.

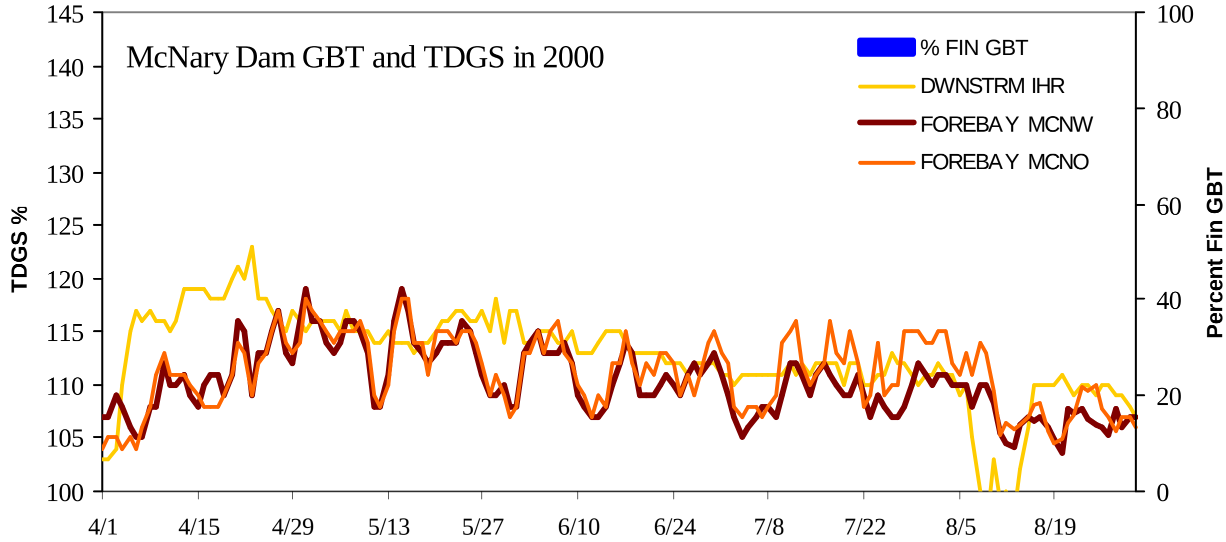


Figure 15. Data collected at McNary Dam for the smolt monitoring program.

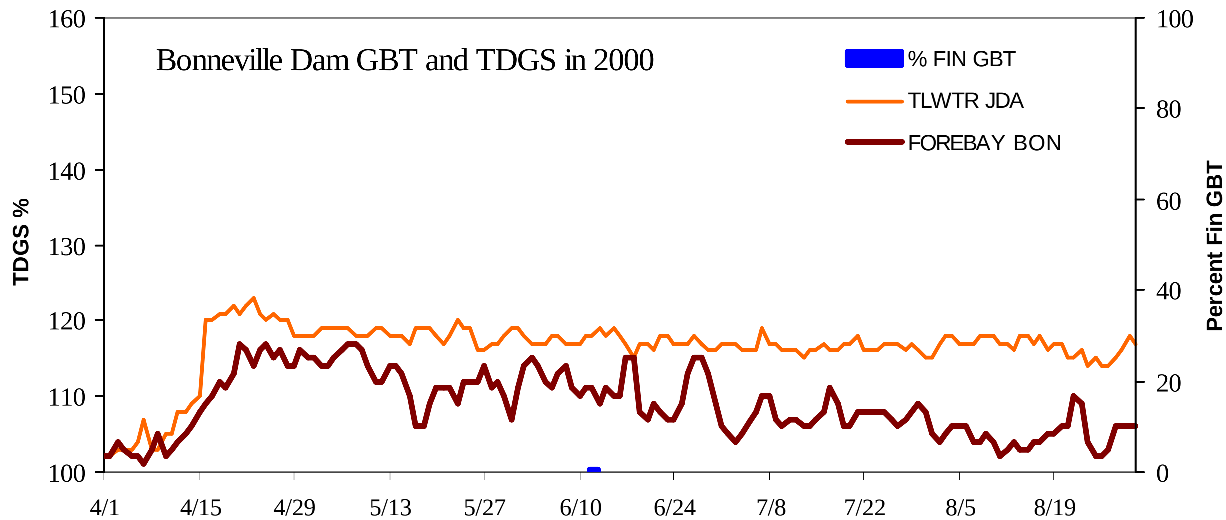


Figure 16. Data collected at Bonneville Dam for the smolt monitoring program.

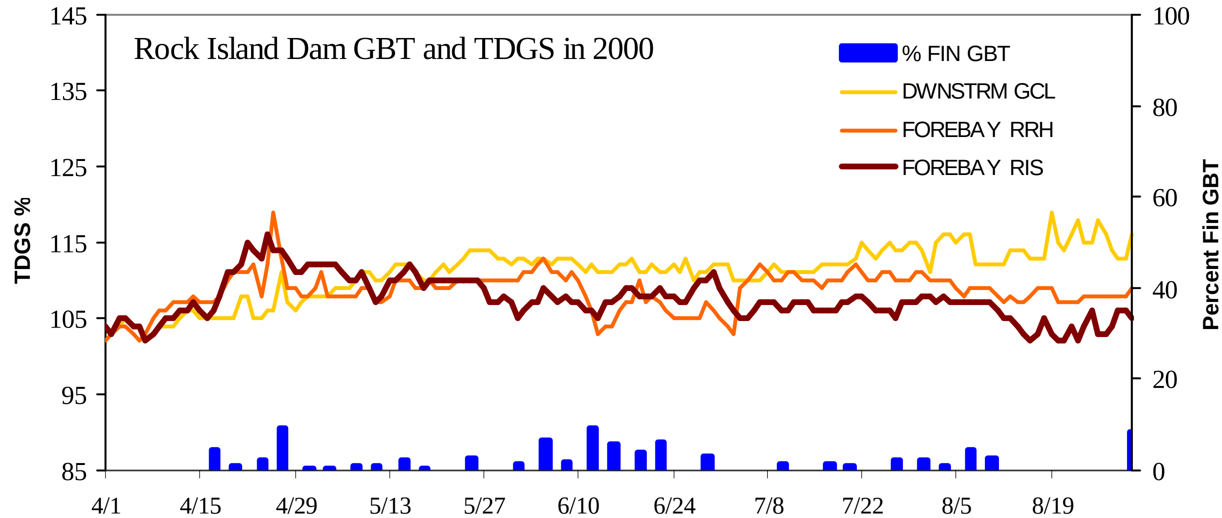


Figure 17. Data collected at Rock Island Dam for the smolt monitoring program.

Severity of GBT

In addition to the prevalence of signs of GBT in the migrating population, the SMP also records the incidence of severe signs of GBT. Laboratory research indicated that not only the prevalence, but also the severity of signs increases with the length of time exposed to high levels of TDGS. Only one fish was observed with severe signs (defined as Rank 3 or Rank 4) during the 2000 sampling season. The table below summarizes the severe signs observed during GBT monitoring at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day and Bonneville dams.

Table 3. Summary of Fish with severe GBT at Lower Snake and Lower Columbia River sites.

	Juvenile salmonids		
Year	**# Fish Examined**	**# Severe GBT**	**Percent**
1995 (4X)	55,219	0	0.000
1995 (DS)	16,021	0	0.000
1996	38,925	47	0.121
1997	42,751	117	0.273
1998	46,498	0	0.000
1999	25,184	0	0.000
2000	21,391	1	0.005

4X refers to the power of the magnifying lens used to examine fish in 1995
DS refers to fish examined with dissecting scope in 1995.

The number of days of TDGS greater than 120% and greater than 130% for the years 1995 through 2000 are summarized below. Five representative tailwater monitoring stations were used to calculate an index of the total number of days TDGS levels were greater than 120% from April 1 to

August 31 and also number of days greater 130%. The COE monitoring sites used to calculate the index of high TDGS were Lower Granite Tailwater, Little Goose Tailwater, Ice Harbor Tailwater, McNary Tailwater, and John Day Tailwater. These sites are representative of the conditions in the Lower Snake River and the Lower Columbia River during the period when GBT monitoring occurred.

Table 4. The number of days when tailwater TDGS exceeded 120% and 130% at Lower Snake River and Lower Columbia River sites.[1]

COE TDGS Monitor	2000		1999		1998		1997		1996		1995	
	>120	**>130**	**>120**	**>130**	**>120**	**>130**	**>120**	**>130**	**>120**	**>130**	**>120**	**>130**
John Day Tailwater	8	0	47	0	37	0	73	69	52	21	29	0
McNary Tailwater	8	0	54	0	22	0	77	33	91	12	4	0
Ice Harbor Tailwater[2]	2	0	16	0	19	1	80	22	105	66	20	16
Little Goose Tailwater	3	0	4	0	26	0	68	23	57	7	4	0
Lower Granite Tailwater	1	0	14	0	12	0	52	15	52	7	0	0
All Index Sites	**22**	**0**	**135**	**0**	**116**	**1**	**350**	**162**	**357**	**113**	**57**	**16**

[1]Approximate number of days based on graphs of COE TDGS data.
[2]Values for 1995 at Ice Harbor may underestimate total.

Data collected for 2000 showed the lowest level of exceedences of the TDGS criteria since the beginning of the Biological Opinion spill program in 1994. The exceedences usually represented small excursions of total dissolved gas above the waivers, which was then corrected by reducing spill levels at projects above the monitors. This lower total dissolved gas levels observed this year was because this was a less than average flow year and spill levels were controllable. However, while this was the lowest TDGS year, it was also the lowest fish mitigation spill levels observed in recent years.

In summary, few signs of GBT were observed with the levels of spill provided in 2000. With few exceptions total dissolved gas levels remained below the waiver limits. Uncontrolled spill during 2000 was much less than observed in higher runoff volume years'.

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