

**Gas Supersaturation Monitoring Report  
During Spill and Corner Collector Operation  
at Bonneville Dam in March, 2008**



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# Gas Supersaturation Monitoring Report During Spill and Corner Collector Operation at Bonneville Dam in March, 2008

## Introduction

To improve the passage survival of juvenile salmonids listed under the Endangered Species Act, the U.S. Army Corps of Engineers (Corps) submitted a request in November 2006 for a five year total dissolved gas (TDG) waiver from the Oregon Department of Environmental Quality (ODEQ) and an adjusted dissolved gas standard from the Washington Department of Ecology (WDOE) for spill at the Corps hydro-power projects on the lower Snake and Columbia rivers beginning with the 2008 out-migration year. These requests were made to allow for TDG saturation up to 120% in the project tailrace and 115% as measured at the next downstream project forebay. The Oregon Environmental Quality Commission approved a modified version of the request at its June 21, 2007 meeting. The TDG modification requested was approved, but only for a ten day period in March and from April 1 through August 31 for two years (2008 and 2009). This waiver applies to the four Corps dams on the lower Columbia River (Bonneville, The Dalles, John Day, and McNary).

The WDOE issued the adjusted TDG standard on February 8, 2008. The WDOE adjusted TDG standard extends through February 2010. This exemption applies to the four Corps dams on the lower Snake (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) and the four Corps dams on the lower Columbia River.

To aid the downstream survival of about 7.5 million tule fall Chinook (*Oncorhynchus tshawytscha*) juveniles scheduled for release from the Spring Creek National Fish Hatchery (SCNFH) in early March 2008, and to continue the passage study begun in 2004, the U.S. Fish and Wildlife Service (Service) requested a Bonneville Dam (river mile-RM 146.1) Power House 2 Corner Collector (B2CC) operation that included 96 hours of spillway flow. A modified agreement with the Action Agencies (Bonneville Power Administration-BPA, Bureau of Reclamation-BR, and the Corps) was reached that provided 78 hours of spill.



(B2 Corner Collector, photo by Corps)



(Bonneville Dam spill, photo by BPA)

Sufficient depth for compensation from gas supersaturation was requested as measured by total dissolved gas (TDG) over listed chum salmon (*O. keta*) redds below the Bonneville Dam project. Service biologists anticipated the level of flow with spill and B2CC operation would produce a maximum TDG level not exceeding 120% in the tailrace of Bonneville Dam, and a maximum TDG level not exceeding 105% when compensated by water depth at the chum and fall Chinook salmon redds located below Bonneville Dam at the Ives Island complex (RM 142.5). This includes across the river along the Oregon shore, principally at the Multnomah Falls (RM 136.5) area (Figures 1 and 2).

This report summarizes the results of the physical monitoring of TDG and biological monitoring of fish at and below Bonneville Dam during the spill and B2CC operation in March 2008.

## **Operations**

The first release of 2007 brood of tule fall Chinook smolts, estimated at 3.72 million fish, was on Wednesday March 5, 2008. The Bonneville Powerhouse 2 Corner Collector (B2CC) also began operation on March 5, and was scheduled to remain in operation for the entire month to accommodate a Corps evaluation of steelhead (*O. mykiss*) kelt passage through the B2CC. A second group of about 3.69 million hatchery smolts was released on Thursday March 6. Spill at Bonneville Dam began at 12:01 AM on March 7. The Service goal was to pass 95% of the SCNFH tule smolts during a four day period after the smolts begin passing Bonneville Dam. Spill ended at 6:00 AM on March 10.

The Service monitored TDG levels from the mainstem Columbia River dissolved gas monitoring network gauges below Bonneville Dam (the tailrace gauge at Warrendale (RM 140.3) and the downstream surrogate forebay gauge, the Camas/Washougal monitoring station (RM 121.7). Tailwater depth was monitored from the Bonneville Dam project tailwater gauge at Tanner Creek (RM 144.5). To establish the critical tailwater elevations and TDG levels at the chum salmon redd locations, water depth (feet) and TDG levels (using a calibrated Hydro-Lab Datasonde4 probe ) were measured over the redds at the Ives Island complex and Multnomah falls spawning areas during periods of the spill operation.

## **Results**

### Monitoring of Physical Conditions:

The Service monitored tailwater depth and TDG data from the forebay of Bonneville Dam, the tailrace monitor, and TDG data from the downstream monitor before, during, and after the three-plus days of spill. These data are collected and transmitted automatically for display of the most recent five days on a Corps website: <http://www.nwd-wc.usace.army.mil/report/total.html> Older data is stored in a Corps database of historical data:

<http://www.nwd-wc.usace.army.mil/tmt/wcd/tdg/months.html>

Table 1 is a summary of Bonneville Dam spill, total flow, tailwater elevation, and percent TDG at three monitoring sites for the month of March, divided into three periods: pre-spill (March 1-6), spill (March 7-10), and post-spill (March 11-31). During the spill period the TDG levels ranged from 102.3-104.4% in the Bonneville forebay. Recorded TDG levels at the Warrendale

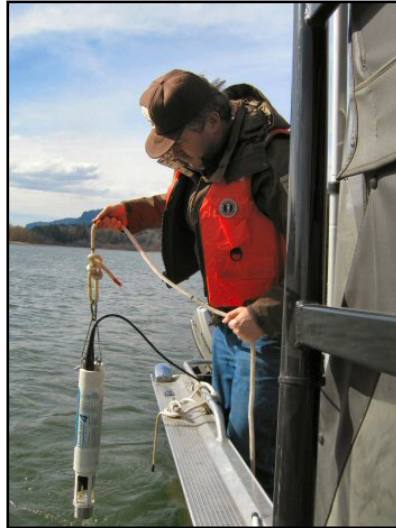
monitoring station varied from 104.9-110.2% during this time period. The TDG levels recorded at the Camas/Washougal monitoring station varied from 104.5-108.9%. Figures 3 and 4 represent the data for the first half of March.

The Bonneville Dam discharge, spill, and official project tailwater height can be retrieved from the Corps data query website: <http://www.nwd-wc.usace.army.mil/perl/dataquery.pl>

Table 2 lists the measured TDG readings and water depths taken by the Service at the chum redd sites during spill and passage. There is approximately a 3% TDG compensation for every foot of water above the redds. The November-December 2006 tailwater elevation for spawning chum salmon was targeted to the 11.5 foot tailwater elevation (11.3-11.7) 24 hours per day. If flows exceeded the ability to maintain that criteria the excess water was moved during the nighttime hours, if possible. Chum spawning occurred from November 9 through December 23, 2007. The average daytime tailwater elevation was 11.8 feet (11.3-17.6). Most of the daytime tailwater elevations above 11.7 feet occurred in the later half of December when very few chum were spawning. Redd surveys by Washington Department of Fish and Wildlife indicated no redds located at high elevations. During this spill period the highest TDG readings remained below the 105% limit for chum redds at the Ives Island complex and at the Multnomah Falls site, when factored for depth compensation, except for three hours, as calculated by the Corps (Figure 5). The exceedences ranged from 105.1-105.4%.



(Ives Island area, photo by USFWS)



(TDG sampling, photo by USFWS)

Biological Monitoring:

Passage timing of the tule smolts past Bonneville Dam was tracked with combined sub-yearling smolt data collected by the Smolt Monitoring Program at the Bonneville Dam Juvenile Fish Facility. Passage data from 2004-2008 is listed Table 3 and shown in Figure 6. In-season estimates of passage indicated that 93.8% of the tule fall Chinook salmon smolts for the entire March release from SCNFH passed Bonneville Dam by March 10. A post-season evaluation, correcting for non-tule Chinook sub-yearling passage, estimated that 94.6% of the March release from SCNFH passed Bonneville Dam by March 10. This was four days after the first fish began passing the dam.

The biological TDG monitoring included the collection of at least 100 live fish (juvenile salmonids and resident fish) during the period of spill and B2CC operations for examination of signs of (gas bubble trauma) GBT. Sampling was conducted on March 7 and 8. Personnel from the USFWS who examined fish for signs of GBT had been trained on examination techniques by staff from the U.S. Geological Survey and the Fish Passage Center, the administrator of the mainstem Columbia River GBT monitoring program for the Corps of Engineers.

Washington Department of Fish and Wildlife (WDFW) and Service personnel, using a 100-foot-long beach seine, sampled near shore areas of the Columbia River and Ives Island side channels. Figure 7 displays the locations of sites where fish were collected. Service biologists used dissection microscopes to examine captured fish for signs of GBT. A minimum of 10x magnification was used for viewing fins. Protocol for GBT exams in 2008 followed the protocol used in 2007 (Fish Passage Center 2007). The estimated percent of the structure occluded determines the ranking. Rank 1 equals 0% to 5% occlusion; Rank 2 equals 6% to 25% occlusion; Rank 3 equals 26% to 50% occlusion; and Rank 4 is >50% occlusion of the structure. This has been shown to be best non-invasive indicator of prevalence of gas bubble disease (GBD) at all TDG levels tested, with fins showing the progressive change in severity of GBD.



(Chinook salmon smolts, photo by USFWS)



(Fish examinations for GBT, photo by USFWS)

A total of 154 fish were examined for signs of GBT (Table 4). Only one fish showed any signs of GBT, and this was a single bubble in the anal fin putting it into Rank 1. The one fish equates to 0.65% of the total sample, and 2.1% of the daily sample, well below the limit of 15% or more of the juvenile fish examined showing signs of GBD in their non-paired fins where more than 25% of the surface area of the fin (Rank 3) is occluded by gas bubbles.

## **Summary**

The Service collected and monitored water quality data (TDG) from the mainstem Columbia River gauges below Bonneville Dam (Warrendale and Camas/Washougal) and at the critical chum salmon redd locations during the March 7- 10 spill period.

Total dissolved gas levels recorded at the tailrace monitoring station (Warrendale) did not exceed the 120% waiver limit (108.3% actual). The TDG levels recorded at the Camas/Washougal monitoring station did not exceed the 115% waiver limit (107.1% actual). The TDG levels measured by the Service for shallow redds at the Ives Island and Multnomah Falls sites did not exceed the 105% TDG limit, when factored for depth compensation.

The Service sampled 154 juvenile fish below Bonneville Dam during the spill period. Only one fish showed any signs of GBT, and this was in Rank 1, the lowest category of incidence.

## **Reference**

Fish Passage Center. 2007. 2007 GBT Monitoring Program Protocol for Juvenile Salmonids.  
Revised 11/21/2006. 6 p. <ftp://ftp.fpc.org/gbtprogram/>

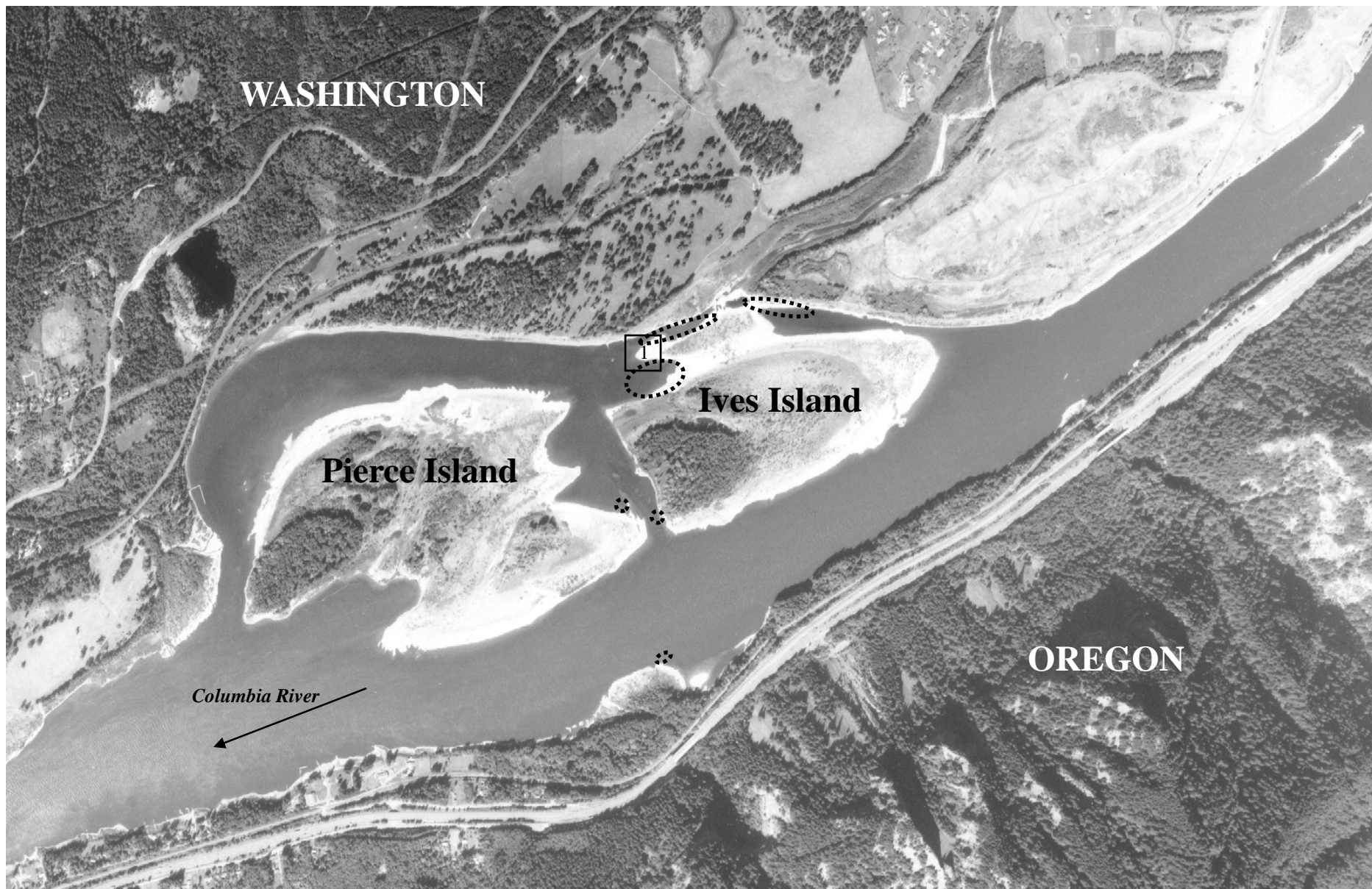


Figure 1. Location of TDG sample sites in March 2008 at the Pierce/Ives area below Bonneville Dam. Chum salmon redd sites are from the 2007 spawning season.

⋯⋯⋯ chum spawning site

# TDG sample site



Figure 2. Location of and TDG sample sites in March 2008 from Ives Island, to Warrendale, to Multnomah Falls. Chum salmon redd sites are from the 2007 spawning season.

..... chum spawning site

# TDG sample site



Table 1. Summary at and below Bonneville Dam of average spill, total flow, tailwater elevation (TW), and percent TDG in March 2008 for: a) the six day period before spill began; b) the four day period with spill; and c) the 21 day period (March 11-31) after spill ended, as measured at the official gages.

a) <b>March 1 - 6, 2008 B2CC only</b>				TDG % Saturation		
	SPILL (KCFS)	TOTAL FLOW (KCFS)	Project TW (ft)	Bonneville Forebay (BON)	Warrendale (WRNO)	Camas (CWMW)
	-----	-----	-----	-----	-----	-----
Average	1.3	147.2	13.1	102.6	103.9	103.8
Minimum	0.0	122.8	11.5	101.7	102.2	101.8
Maximum	2.5	188.7	15.9	104.6	106.3	106.8

b) <b>March 7 - 10, 2008 Spill and B2CC</b>				TDG % Saturation		
	SPILL (KCFS)	TOTAL FLOW (KCFS)	Project TW (ft)	Bonneville Forebay (BON)	Warrendale (WRNO)	Camas (CWMW)
	-----	-----	-----	-----	-----	-----
Average	30.2	142.9	13.1	103.3	108.3	107.1
Minimum	0.0	108.5	11.5	102.3	104.9	104.5
Maximum	38.2	181.4	14.9	104.1	110.2	108.9

c) <b>March 11 - 31, 2008 B2CC only</b>				TDG % Saturation		
	SPILL (KCFS)	TOTAL FLOW (KCFS)	Project TW (ft)	Bonneville Forebay (BON)	Warrendale (WRNO)	Camas (CWMW)
	-----	-----	-----	-----	-----	-----
Average	1.3	152.0	13.9	102.9	105.0	104.8
Minimum	0.0	104.7	11.5	101.0	102.3	100.9
Maximum	2.5	221.4	17.9	104.5	107.8	108.4

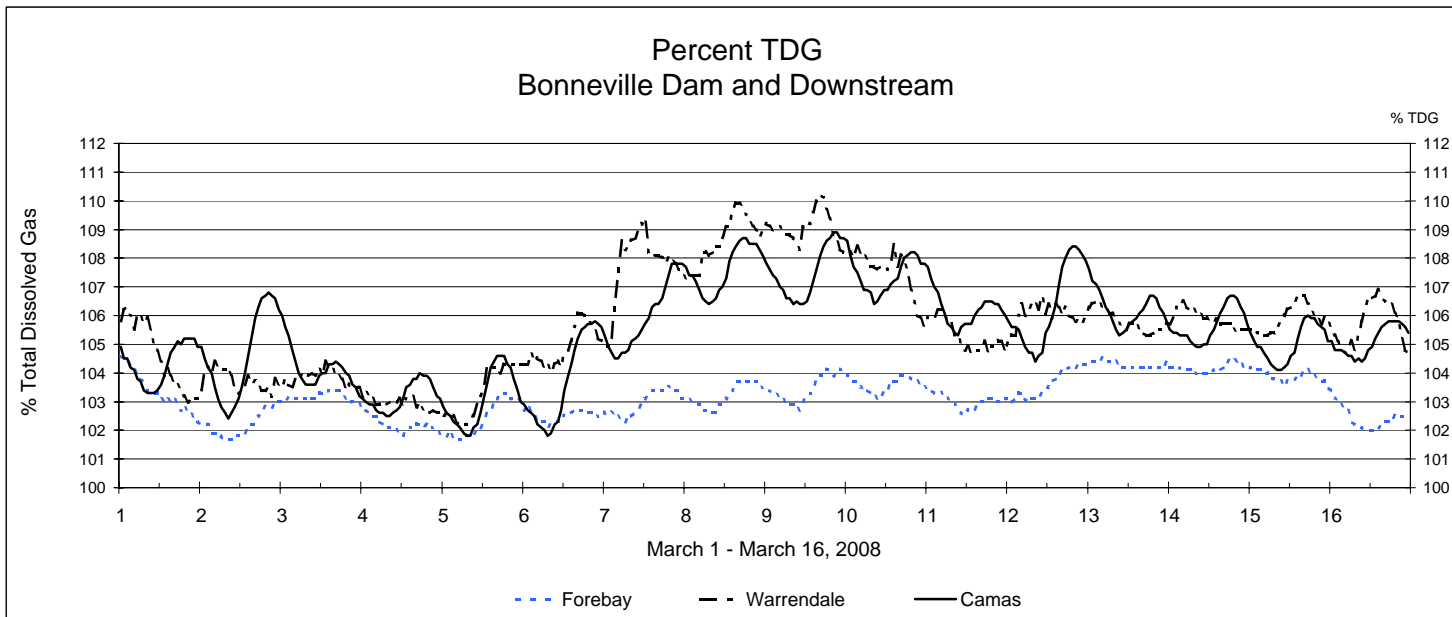


Figure 3. Percent saturation of Total Dissolved Gas at Bonneville Dam forebay and downstream gauges, March 1 through March 16, 2008.

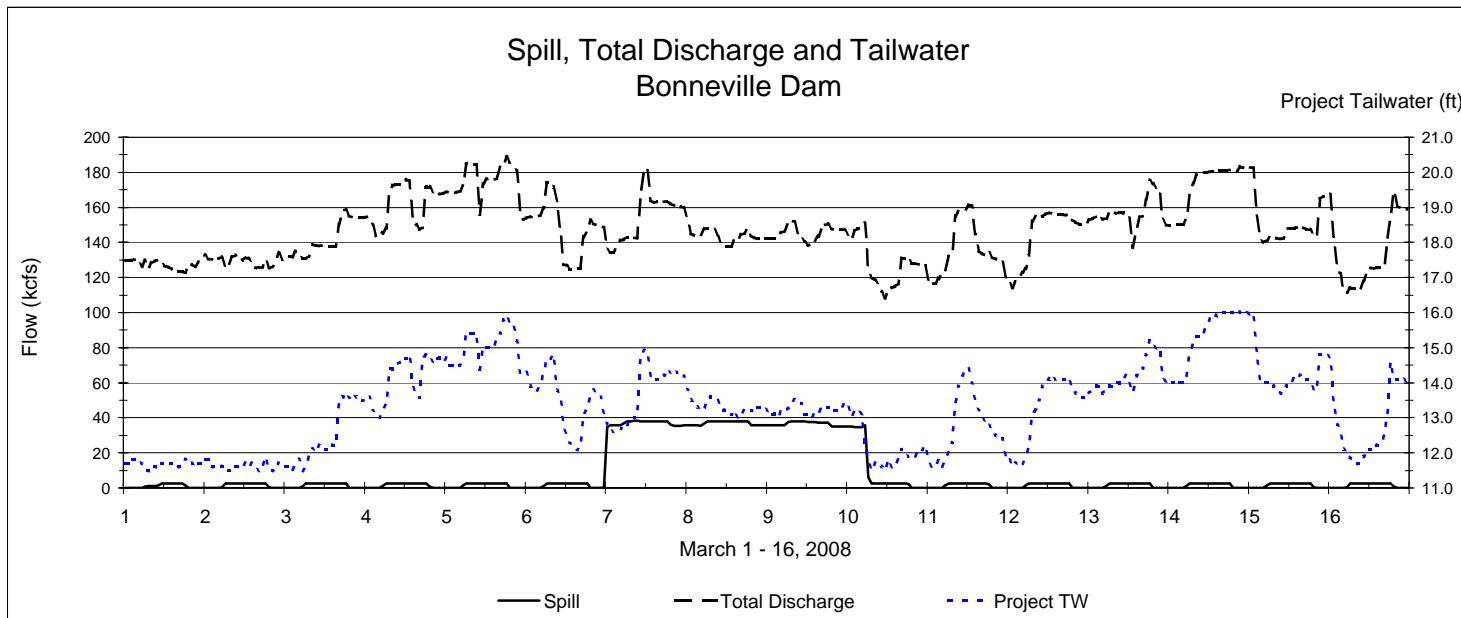


Figure 4. Spill, flow, and tailwater elevation at Bonneville Dam, March 1 - 16, 2008.

Table 2. USFWS TDG field measurements below Bonneville Dam during the 2008 Spring Creek release.

Sample Site	Date	Time Probe1 into Water	Time of Sample	Total Depth (feet)	Probe1 Depth (feet)	Probe1 Temp (°C)	Probe1 TDG Pressure (mmHG)	Baro Pres Warrendale (mmHG)	%TDG	Depth Compensated %TDG	%TDG Warrendale (WRNO)	Time of Sample
Ives Island <sup>2*</sup>	7-Mar	9:30 AM	10:02 AM	1.5	1.4	6.1	798	769	103.8%	99.3%	108.7%	10:00 AM
Warrendale Gauge Dock <sup>2</sup>	7-Mar	10:40 AM	11:00 AM	7.0	6.0	5.4	836	769	108.7%	87.7%	109.0%	11:00 AM
Warrendale Gauge Dock <sup>2</sup>	7-Mar	10:40 AM	11:11 AM	7.0	6.0	5.4	836	769	108.7%	87.7%	109.0%	11:00 AM
Multnomah Falls <sup>2</sup>	7-Mar	11:30 AM	11:53 AM	2.0	1.5	6.3	828	769	107.7%	101.7%	109.2%	12:00 PM
Multnomah Falls <sup>2</sup>	7-Mar	11:30 AM	11:59 AM	2.0	1.5	6.6	828	769	107.7%	101.7%	109.2%	12:00 PM
Multnomah Falls <sup>2</sup>	8-Mar	8:40 AM	9:00 AM	2.0	1.7	6.0	818	771	106.1%	100.1%	108.2%	9:00 AM
Warrendale Gauge Dock <sup>2</sup>	8-Mar	9:20 AM	9:45 AM	8.5	6.0	5.4	830	771	107.7%	82.2%	108.4%	10:00 AM
Ives Island <sup>2*</sup>	8-Mar	10:12 AM	10:32 AM	2.4	1.9	6.1	820	771	106.4%	99.2%	108.4%	11:00 AM
Multnomah Falls <sup>2</sup>	8-Mar	12:15 PM	12:40 PM	1.7	1.3	7.0	834	771	108.2%	103.1%	109.1%	1:00 PM

1 Hydro-Lab Datasonde4 probe was used. Pre-season calibration.

2 Probe stabilized for at least 20 minutes.

\* Downstream from the mouth of Hamilton Creek.

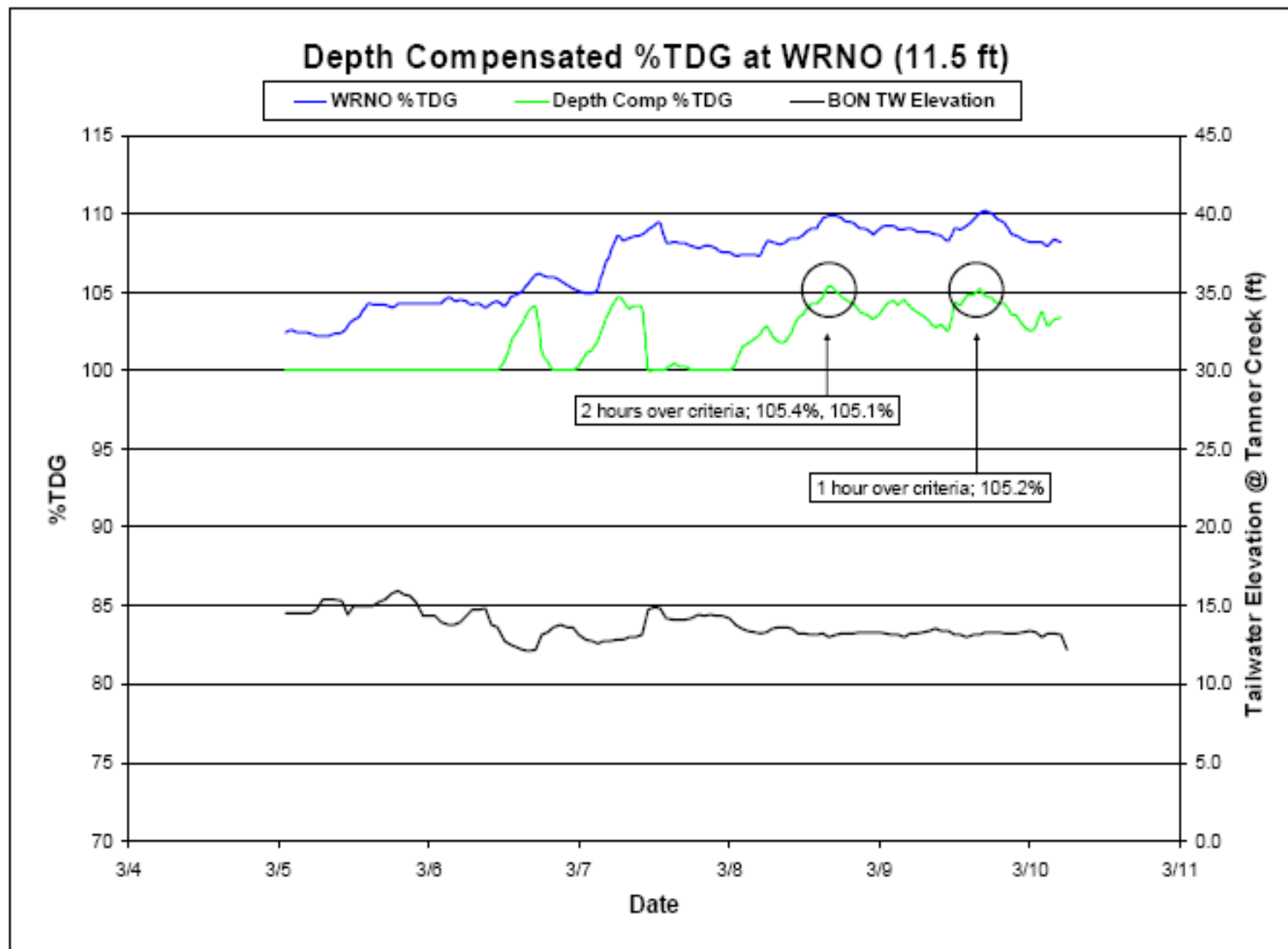


Figure 5. Depth compensated TDG for a Bonneville tailwater of 11.5 feet, as measured at the Warrendale gauge. Courtesy of Corps of engineers.

Table 3. Sub-yearling Chinook passage index counts at Bonneville Dam Power House 2 during the March release from Spring Creek NFH (2004-2008)

Number of days from spill start	Spring Creek Release <sup>1</sup>		Spring Creek Release <sup>2</sup>		Spring Creek Release		Spring Creek Release		Spring Creek Release "B"		Spring Creek Release "A"	
	03/5&6/08 Index Count *	Spill & B2CC <sup>3</sup> Date	03/5&9/07 Index Count *	B2CC <sup>3</sup> Date	3/2/2006 Index Count *	B2CC Date	3/2/2005 Index Count *	B2CC Date	3/10/2004 Index Count *	B2CC Date	3/1/2004 Index Count *	Spill Date
-1	107	3/6/08	8	3/5/07	57	3/2/06	35	3/2/05	***	3/10/04	-----	3/1/04
0	343	<b>3/7/08</b>	0	3/6/07	55	<b>3/3/06</b>	33	<b>3/3/05</b>	***	<b>3/11/04</b>	-----	<b>3/2/04</b>
1	52931	3/8/08	106,076	3/7/07	51,611	3/4/06	8,924	3/4/05	50,260	3/12/04	20,825	3/3/04
2	304738	3/9/08	429,248	3/8/07	387,150	3/5/06	387,479	<b>3/5/05</b>	242,411	3/13/04	173,388	3/4/04
3	345234	<b>3/10/08</b>	298,932	3/9/07	219,703	3/6/06	264,004	3/6/05	52,319	3/14/04	123,449	3/5/04
4	117906	3/11/08	37,238	3/10/07	54,658	<b>3/7/06</b>	89,485	3/7/05	18,647	<b>3/15/04</b>	26,718	<b>3/6/04</b>
5	20159	3/12/08	80,973	3/11/07	24,241	3/8/06	29,584	3/8/05	7,230	3/16/04	4,464	3/7/04
6	8659	3/13/08	71,001	3/12/07	6,284	3/9/06	13,558	3/9/05	7,322	3/17/04	6,740	3/8/04
7	4675	3/14/08	32,204	3/13/07	2,314	3/10/06	6,037	3/10/05	4,644	3/18/04	3,678	3/9/04
8	3957	3/15/08	7,633	3/14/07	1,548	3/11/06	6,785	3/11/05	3,829	3/19/04	2,331	3/10/04
9	1545	3/16/08	1,855	3/15/07	1,095	3/12/06	2,846	3/12/05	6,186	3/20/04	2,310	3/11/04
10	1191	3/17/08	2,041	3/16/07	1,006	3/13/06	2,898	3/13/05	5,976	3/21/04	***	3/12/04
12 Day Total	861,445		1,067,209		749,722		811,668		398,824		363,903	
5 Day Passage	840,968		952,467		737,363		779,476		363,637		344,380	
5 Day %	97.6%		89.2%		98.4%		96.0%		91.2%		94.6%	

----- no counts taken, \*\*\* not used

**Bolded dates are first and last days of Sill or Corner Collector operations**

\* Index counts are based on a 24 hour Smolt Monitoring Program sample collection counted about 8 AM on the listed date.

<sup>1</sup> Split release March 5 and March 6.

<sup>2</sup> Split release March 5 and March 9.

<sup>3</sup> B2CC opened March 1 and closed in August.

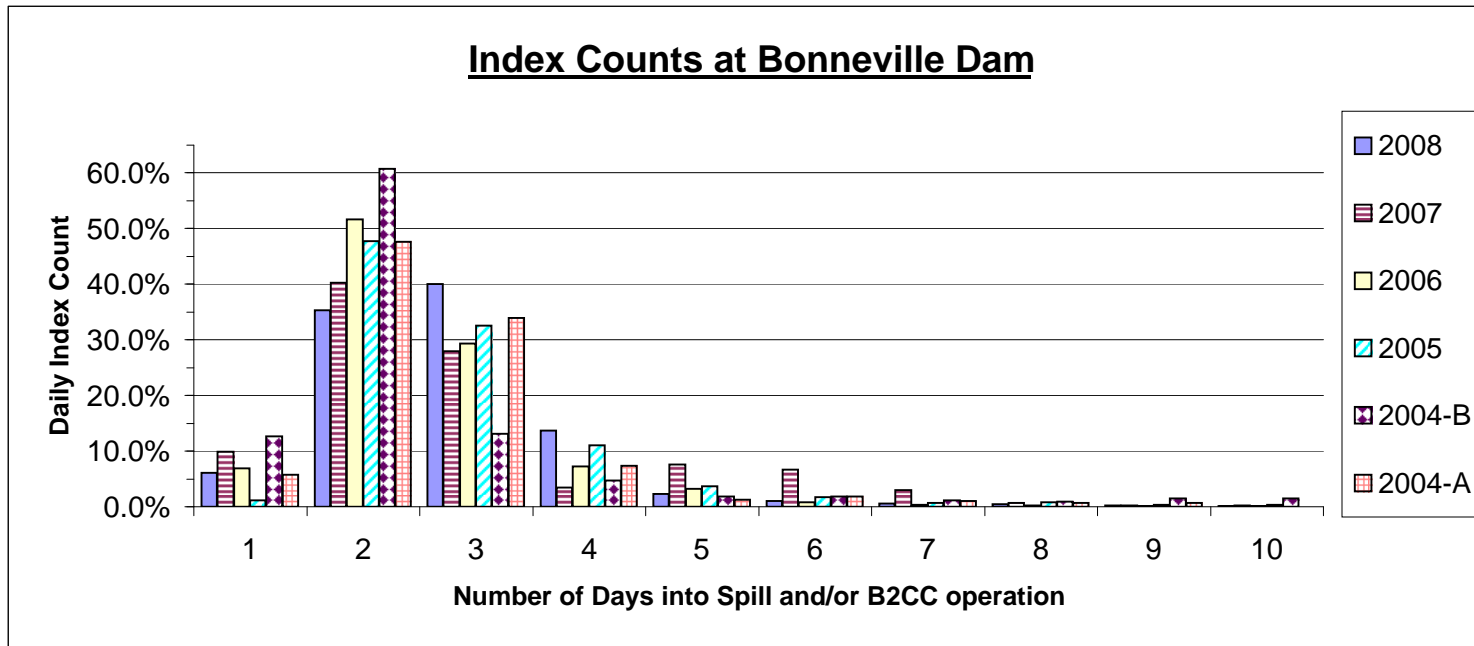


Figure 6. Sub-yearling Chinook passage index counts at Bonneville Dam expressed as a daily percentage of the total in a 10 day period during the March release from Spring Creek NFH, from 2004-2008.

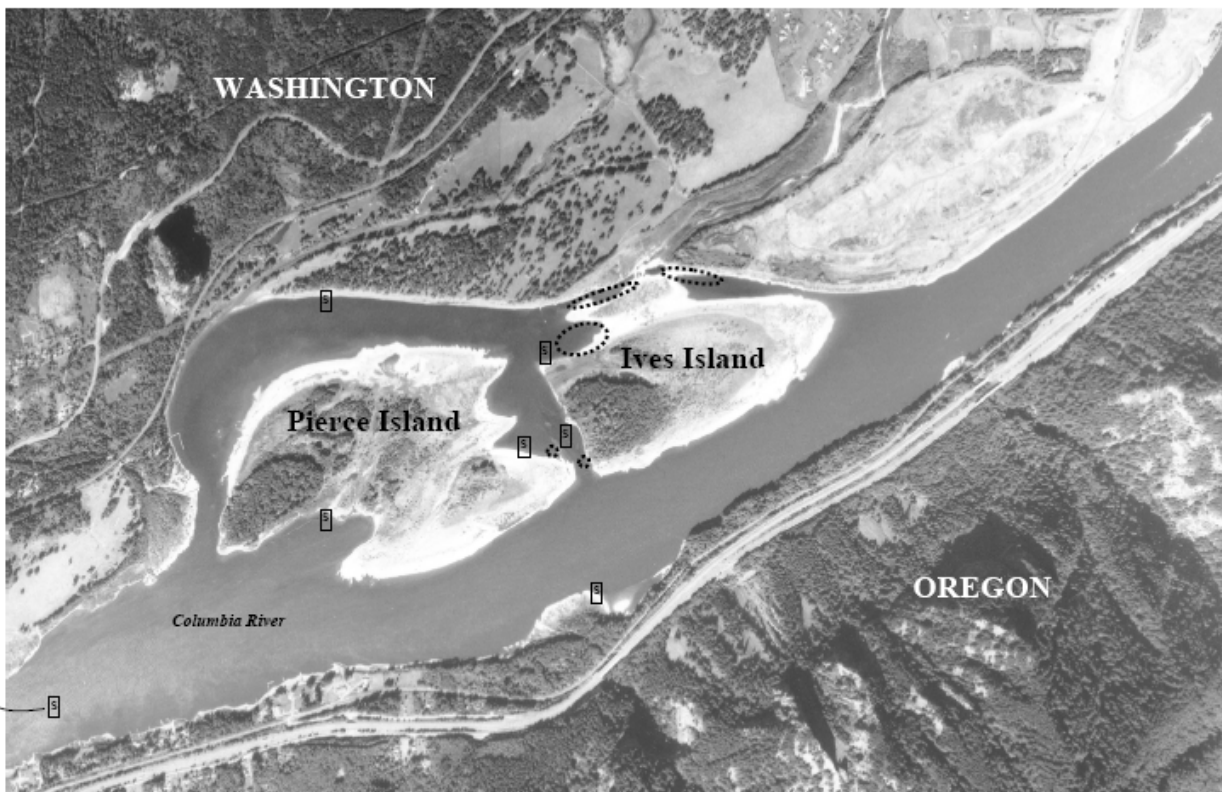


Figure 7. Location of fish sample sites for gas bubble trauma (GBT) monitoring in March 2008.

..... chum spawning site      □ S fish sample site

Table 4. Summary of fish sampled for signs of gas bubble trauma (GBT) below Bonneville Dam - March 2008. One hundred fifty-four fish were examined. There was one fish with one bubble detected. This is only a 0.65% incidence rate.

Species	# of fish examined for signs of GBT	Mean Fork Length (mm)	Range (mm)	GBT Rank <sup>1</sup>			
				DF*	AF*	CA*	EY*
Chinook	128	67.7	56-80	0	1	0	0
chum	17	42.5	36-47	0	0	0	0
coho	3	39.7	37-44	0	0	0	0
pikeminnow	1	54.0	54.0	0	0	0	0
stickleback	5	49.6	37-58	0	0	0	0
Totals	154			0	1	0	0

<sup>1</sup> GBT Rank = % of structure occluded: 0 to 5% = 1; 6% to 25% = 2; 26% to 50% = 3; >50% = 4  
 \* DF = dorsal fin, AF = anal fin, CA = caudal fin, EY = eye