US Army Corps of Engineers®

North Pacific Division

2002 DISSOLVED GAS AND WATER TEMPERTURE MONITORING REPORT

COLUMBIA RIVER BASIN

Ice Harbor Tailwater Fix Monitoring Station

Water Management Division
Reservoir Control Center
Water Quality Unit

December 2002

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CORPS OF ENGINEERS
DISSOLVED GAS AND WATER TEMPERTURE MONITORING

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Reservoir Control Center, Water Management Division
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Part 1 Program Description

1.1. Clean Water Act and Endangered Species Act

1.1.1 General

This report describes the Corps' Columbia River Basin Water Quality Monitoring Program for 2002 and was developed to meet the Corps water quality program responsibilities related to the Clean Water Act. The report provides documentation to meet the conditions of the dissolved gas variance issued by the state of Oregon and the rule modification by the state of Washington, to meeting the objectives of the Reasonable and Prudent Alternative RPA 54 of the National Marine Fisheries Service 2000 Biological Opinion and the annual monitoring and reporting as indicated in RPA 131.

The report focuses on the water quality monitoring of total dissolved gas (TDG) and temperature at the US Army Corps of Engineers (Corps) dams in the Columbia River Basin. The monitoring is part of a larger interagency water quality monitoring system operated by the Corps that includes a Corps of Engineers monitoring system, a US Bureau of Reclamation monitoring system, and Washington Public Utility District monitoring systems.

The Corps water quality monitoring program at the ten Federal Columbia River Power System (FCRPS) dams is to: 1) monitor project performance in relation to water quality standards, and 2) provide water quality data for anadromous fish passage at Columbia/Snake mainstem dams. The monitoring program is considered an integral part of the Corps' Reservoir Control Center water management activities.

TDG is one of the primary water quality parameters monitored to meet the recognized or designated beneficial uses of the mainstem Columbia and Snake rivers in the states of Idaho, Oregon and Washington. The designated uses include aquatic life, water supply, recreation, wildlife habitats, and aesthetics. High saturation level TDG can cause physiological damage to fish. Water temperature is also measured because it affects TDG saturation levels, and because it influences the health of fish and other aquatic organisms. Both TDG and water temperature may be influenced by project water management operations (e.g. water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations).

1.1.2 Corps Goals

The general policies of the Corps for are summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, dated 30 July 1999. A principal aspect of the Corps policy is to comply with water quality standards to the extent practicable regarding nationwide operation of water resources projects. "Although water quality legislation does not require permits for discharges from reservoirs,

downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges." (Section 18-3.b, page 18-5)

Definitions

Since various agencies have different definitions for certain terms, it is important to provide the Corps definitions for these terms, which are used throughout this report.

Voluntary spill = spill for juvenile fish passage and flow augmentation.

Involuntary spill = the portion of the total river flow which must pass over a dam's spillway when the dam's powerhouse hydraulic capacity is exceeded.

Intertie line derating = The intertie line is the transmission system that transfers electricity between the Pacific Northwest and California. It is derated when its ability to transfer the electricity is decreased due to stability, thermal or environmental factors.

Unit outage = A unit outage is a period of time when a generating unit cannot be in operation because of maintenance or repairs.

Lack of load = There is a lack of customer need for power resulting in a lack of market for electricity generated.

TDG Exceedance = The definition for TDG exceedance varies with the state standards.

Idaho: A TDG exceedance is any hourly reading that exceeds 110% in the tailwater.

Oregon: A TDG exceedance is a high 12 hour average of TDG during a day that exceeds 115% in the forebay and 120% in the tailwater.

Washington: A TDG exceedance is a high 12 hour average of TDG during a day that exceeds 115% in the forebay and 120% in the tailwater.

1.1.3 Biological Opinion (BiOp)

1.1.3.1 1995 and 1998 BiOps

The data from the Corps Dissolved Gas Monitoring Program before 1984 was used to monitor consistency with water quality standard. In 1984, the Corps Dissolved Gas Monitoring Program was enhanced to serve the dual purposes stated in 1.1.1 General.

With the listing of certain Snake River salmonids in 1991 under the Endangered Species Act (ESA), the Corps implemented a variety of operational and structural measures to improve the survival of listed stocks. The National Marine Fisheries Service (NMFS) 1992 BiOp called for providing summer releases of available water for flow augmentation for migrating juvenile salmon. Spill for fish at the lower Snake River projects was limited to Lower Monumental and Ice Harbor dams. In 1994, the program was further expanded in response to the NMFS request to release water over the spillways at the lower eight Columbia and Snake rivers mainstem dams to a level of 120% TDG where State rule modifications, variances or waivers had been provided. This spill level has become an annual operation for the benefit of listed juvenile fish.

The Corps addressed TDG and water temperature during the ESA consultation in 1994. In a letter from the Corps to the NMFS, dated November 9, 1994, the Corps stated that "Spill for fish passage at Corps projects will be provided in 1995 according to the Fish Passage Plan (FPP) criteria, including any modifications agreed upon in consultation under the [ESA]…Also, any necessary waivers of water quality standards must be obtained beforehand from appropriate State or Federal authorities..."

The Corps' 1995 Record of Decision (ROD) and the 1998 Record of Consultation and Summary Decision (ROCASOD) adopted the recommendations of the NMFS 1995 BiOp, and the 1998 Supplemental BiOp, respectively. Relevant sections of the 1995 and 1998 BiOps regarding operations that impact TDG levels and water temperature include:

<u>TDG</u>

RPA #2 in the 1995 BiOp identified additional voluntary spill at the lower Snake River projects to achieve 80% Fish Passage Efficiency (FPE) and survival of migrating juvenile salmonids (1995 BiOp, pages 104 - 110). At certain projects, voluntary spill up to 110% TDG would not achieve 80% FPE. Therefore, in recommending the spill levels above the State water quality standard of 110%, NMFS considered the risk of the elevated levels of TDG on migrating salmon and decided the risk was acceptable. In the 1998 Action Agency Biological Assessment, it was proposed that voluntary spill be minimized at lower Snake River projects due to concerns of high TDG and to maximize fish transportation by barges.

During consultation with NMFS this proposal was amended and the 1998 Supplemental BiOp increased the voluntary spill levels partially based on observations made after 1995. "NMFS also believes that moving past the per-project FPE goals (stated in the 1995 RPA) to further increase juvenile survival would not violate the intent of the requests to the State water quality agencies for dissolved gas waivers." (98BiOp, page c-4) NMFS

recommended maximum spill up to the higher TDG levels rather than curtailing spill when 80% FPE was achieved, which the Corps agreed to implement. (98ROCASOD)

The NMFS 1998 BiOp also asked the Corps to test increasing voluntary spill at John Day Dam from 12 hours to 24 hours. The Corps initiated those studies during the 1999 spring migration.

Water Temperature

Water management operations to reduce water temperature in the lower Snake River for the benefit of adult Snake River fall Chinook salmon were considered. (95 BiOpIV.A.1.g, pages 44 - 45) The NMFS BiOp concluded that although the priority for cool water releases from Dworshak Dam were for migrating juvenile fall Chinook in July and August, releases to reduce water temperatures in September could be considered on an annual basis through the NMFS Forum's Technical Management Team (TMT). TMT is an interagency adaptive management group that makes recommendations on operations for the Columbia/Snake system for the benefit of listed fish species. TMT consists of representatives from five U.S. federal agencies, the four states of Oregon, Washington, Idaho and Montana, and invitation of membership was extended to Columbia Basin Tribes.

Incidental Take Statement # 17 of the 1995 BiOp specifically recognizes the potential releases from Dworshak Dam for water temperature control.

Incidental Take Statement # 5 of the 1995 BiOp also recognizes special operating criteria to mitigate adverse warm water conditions that periodically occur at McNary Dam in the summer.

1.1.3.2 2000 BiOp

The Final 2000 NMFS and FWS Biological Opinions states:

"The two agencies intend the recommendations and requirements of these opinions to be mutually consistent. They represent the federal biological resource agencies' recommendations of measures that are most likely to ensure the survival and recovery of all listed species and that are within the current authorities of the Action Agencies."

USFWS BiOp

According to the USFWS 2000 BiOp, operational and structural changes are to be made to reduce uncontrolled spill and the effects of high levels of TDG at lower Columbia River dams if it is determined that bull trout are affected by the Federal Columbia River Power System (FCRPS).

NMFS BiOp

The NMFS 2000 BiOp identified metrics that are indicative of juvenile fish survival to meet system-wide performance objectives consistent with actions likely to avoid jeopardizing the continued existence of 12 listed fish species in the Columbia River Basin. To achieve the objectives of the BiOp, NMFS developed the jeopardy analysis framework.

It was recognized that, in many instances, actions taken for the conservation of ESA-listed species also move toward attainment of State TDG and water temperature standards. There are 14 RPAs (namely, RPAs 130 to 143) identified as part of a water quality strategy in the NMFS 2000 BiOp. Specifically, RPA's 131 and 132 deal with water quality monitoring. RPA 131 indicates that the physical and biological monitoring programs are to be developed in consultation with the NMFS Forum regional Water Quality Team and the Mid-Columbia Public Utility Districts (PUDs). RPA 132 specifies that a plan must be developed to perform a systematic review and evaluation of the TDG fixed monitoring stations (FMSs) in the forebays of all the mainstem Columbia and Snake River dams.

1.1.4 TDG Variance

One of the components of the NMFS 2000 BiOp water quality strategy was for the Corps to take the actions necessary to implement the spill program at the dams called for in RPA 54 BiOp, including obtaining variances from appropriate State water quality agencies. The Corps took the actions necessary for the 2002 spill season. Spill season is from April through August as defined in the NMFS 2000 Biological Opinion.

The Corps obtained total dissolved gas variances with the States and tribes impacted by the program implemented in the Federal Columbia River Power System (FCRPS) for which the Corps has responsibility. As a long-term strategy, the Corps opened discussions about the process of pursuing long-term variances from the entities involved, with the intent of replacing the year-to-year processes.

Long-term variances discussions continue in the development of Total Daily Maximum Loads (TMDLs) for TDG, and water temperature and the development of a regional Water Quality Plan as outlined in Appendix B of the 2000 BiOp.

In the interim, as long-term variances are being worked into the regional planning process, the Corps pursued the following actions to obtain a 2002 variance from the State of Idaho, Oregon, and Washington for juvenile fish passage spill. Juvenile fish passage spill is spill at the four lower Snake River and four lower Columbia River to aid juvenile fish passage and spill at Dworshak to augument flows for juvenile fish passage.

1.1.4.1 State of Idaho

The Corps did not request a variance from the Idaho total dissolved gas standard for 2002. The State of Idaho was approached in 2001 concerning a variance to water quality standards. The State, in conjunction with the tribes, provided a set of conditions that the state requires as part of the variance process. The Corps could not meet these conditions, so after consultation with NMFS, it was decided that projects in Idaho would be operated to the 110% TDG state standards. The Corps operated to the 110% Idaho standard in 2002 and is expected to continue such operation into 2003.

1.1.4.2 State of Oregon

The Corps took appropriate actions for attaining a water quality variance from the State of Oregon for the 2002 spill season. A report of the 2001 TDG monitoring program was provided to the Oregon Department of Environmental Quality on December 28, 2001 that also included a request for a variance during the 2002 spill season. The Oregon Environmental Quality Commission met on March 8, 2002 and approved a variance for the 2002 spill season, subject to specific conditions, as signed by Stephanie Hallock on March 8, 2001. A variance of the TDG standard for the Columbia River was provided from midnight on April 1, 2002 to midnight August 31, 2002. The Commission approved a TDG standard for the Columbia River of a daily (12 highest hours) average of 115% as measured in the forebays of McNary, John Day, The Dalles, and Bonneville dams, and at the Camas/Washougal monitoring stations. They approved a cap on TDG for the Columbia River during the spill program of 120% measured at the McNary, John Day, The Dalles, and Bonneville dams tailwater monitoring stations, based on the average of the 12 highest hourly measurements per calendar day. The Commission also approved a cap on TDG for the Columbia River during the spill program of 125%, based on the highest two hours per calendar day. The Commission also indicated that if 15% of the juvenile fish examined showed signs of gas bubble disease in their non-paired fins, where more than 25% of the surface area of the fin was occluded by gas bubbles, the variance would be terminated.

The following conditions were incorporated into the Commission's variance. The Corps was to provide written notice within 24 hours to the Oregon Department of Environmental Quality on any exceedances of the conditions in the variance as it relates to voluntary spill. The Corps was to provide a written report of the spill program for 2002 by December 31, 2002 and supply information on the levels of TDG, the fish monitoring, and incidence and severity of gas bubble disease. Additionally, any proposal for a modification to the TDG standard in 2003 was to be received by the Oregon Department of Environmental Quality no later than December 31, 2002.

The Corps is currently discussing the possibility of entering into a multiple year agreement for a 2003and beyond variance with the Oregon Department of Environmental Quality. Discussions have revolved around the Corps contribution to a regional water quality plan and the role of the TDG TMDL Implementation Plan to meeting future criteria for a multiple year variance agreement.

1.1.4.3 State of Washington

The State of Washington modified it’s rule on TDG standards for multi-year to accommodate fish passage spill as called for in the NMFS Biological Opinions. The rule is in effect and calls for review of the special conditions by 2003 by the Washington Department of Ecology. Additional actions with the State were not required for the 2002 water year.

The Corps is currently discussing the possibility of entering into long-term agreement similar to the one described for Oregon to meet the conditions for the multiple year rule modification.

1.1.5 Operating Guidelines

The Water Quality Team of the Reservoir Control Center is responsible for monitoring the TDG and water temperature conditions in the forebays and the tailwaters of the lower Columbia River/lower Snake River dams, and selected river sites. The operational water management guidelines in Oregon are to change spill levels and, subsequently, spill patterns at the dams (daily if necessary) so that the forebays are as close to, but do not exceed, daily (12 highest hours) average of 115% TDG, and the tailwater levels are close to, but do not exceed, daily (12 highest hours) average of 120% TDG.

When these decisions are made, the water volume, water elevation (where applicable), project powerhouse and spillway characteristics (where applicable), and short- and long-term weather forecasts were included in the evaluation.

1.2 Monitoring Stations

TDG and temperature are monitored throughout the Columbia River Basin using FMSs (fixed monitoring stations). There are a total of 41 FMSs in the U. S. portion of the Columbia River basin. The Skamania station, downstream of Bonneville dam was not operated in 2002, because another nearby location at Corbett, Oregon was tested as a possible replacement site. The U. S. Bureau of Reclamation, Chelan and Grant County PUDs maintain four stations each. Two stations are maintained by Douglas County PUD. The Corps maintained the remaining stations. Appendix A contains general information about each FMS and a map of their locations.

1.3 Monitoring Plan of Action

The Corps prepares a dissolved gas Plan of Action each year. It is a supporting document for the NMFS Forum Technical Management Team (TMT) an interagency group responsible for making recommendation on dam and reservoir operations.

The 1995 BiOp called for the establishment of a Technical Management Team to optimize passage conditions at dams for juvenile and adult anadromous salmonids. A web site description of the TMT can be found at:

http://www.nwd-wc.usace.army.mil/TMT/

The 2002 Plan of Action can be found listed under the TDG category of the Reservoir Control Center Water Quality Team page on the following web site:

http://www.nwd-wc.usace.army.mil/TMT/wqwebpage/mainpage.htm

The Monitoring Plan of Action for 2002 is also attached as Appendix B. The Plan summarizes the roles and responsibilities of the Corps as they relate to dissolved gas monitoring. The Plan stipulates what to measure, how, where, and when to take the

measurements and how to analyze and interpret the resulting data. The Plan also provides for periodic review and alteration or redirection of efforts when monitoring results and/or new information from other sources justifies a change. The Plan identifies channels of communications with other cooperating agencies and interested parties.

Part 2 Program Operating Conditions

2.1. Water Year Runoff Conditions

2.1.1 Weather

The precipitation during water year 2002 in the upper Columbia River Basin was 93 percent of normal (1971-2000) above Grand Coulee Dam, 82 percent of normal in the Snake River upstream of Ice Harbor Dam, and 89 percent of normal in the Columbia River above The Dallas, Oregon (Western Region Climate Center). The following month-by-month discussion of the weather provides more detailed information.

October 2001, at the beginning of the water year, was the last month of calendar year 2001 with near average temperatures. Apart from a few weak fronts in early October, high pressure aloft held over the Pacific Northwest, sufficiently weakening to allow the jet stream to bring storms in mid to late October, resulting in higher than normal precipitation. The Columbia above Grand Coulee had 128 percent of normal precipitation; the Snake River above Ice Harbor had 132 percent of normal precipitation, and the Columbia above The Dalles had 145 percent of normal precipitation. Temperatures were near normal in October 2001.

In early November 2001, the high-pressure ridge temporarily recovered. This placed eastern sections of the region in a drier mode, even though the storms returned some precipitation late in the month, which still resulted in below average precipitation. The Columbia above Grand Coulee had 67 percent of normal precipitation; the Snake River above Ice Harbor had 96 percent of normal precipitation, and the Columbia above The Dalles had 86 percent of normal precipitation. In November 2001, temperatures were above normal. High temperature records outnumbered low temperature records, most occurring early in the month. The majority of the new high temperature records were set in western Montana.

Frequent storms continued into the first part of December. December 2001 was a wet mild period, concentrated mainly across the northern U.S. basins and through Canada. While the jet stream targeted these areas, high pressure aloft kept southern basins drier than normal, by weakening incoming fronts. This pattern resulted in near to above average precipitation. The Columbia above Grand Coulee had 90 percent of normal precipitation; the Snake River above Ice Harbor had 111 percent of normal precipitation, and the

Columbia above The Dalles had 98 percent of normal precipitation. The regional temperatures averaged near normal.

The December weather conditions continued into January 2002, which resulted in below average to above average precipitation. Columbia above Grand Coulee had 101 percent of normal precipitation; the Snake River above Ice Harbor had 91 percent of normal precipitation, and the Columbia above The Dalles had 94 percent of normal precipitation. January's regional temperatures were above normal.

The January 2002 weather conditions continued into February, which resulted in below average to above average precipitation. The Columbia above Grand Coulee had 114 percent of normal precipitation; the Snake River above Ice Harbor had 49 percent of normal precipitation, and the Columbia above The Dalles had 82 percent of normal precipitation. February 2002 had slightly below normal regional temperatures. There were several high temperature records in February, ironically when regional temperatures averaged cooler than normal.

March was a wet period existed mainly through Canada and across the northwest U.S. tier. An upper level low-pressure trough kept a cool northwest flow into the region, the strongest impact of which was felt. As a result, precipitation was near average to above average. Columbia above Grand Coulee had 115 percent of normal precipitation; the Snake River above Ice Harbor had 95 percent of normal precipitation, and the Columbia above The Dalles had 108 percent of normal precipitation. Regional temperatures were below normal in March 2002, with record low temperatures dropping below -17.8 °C (zero °F) in southeast Idaho and western Montana. They included: -1.1 °C (-2.0 °F) in Pocatello, ID and –11.6 °C (-21.0 °F) at Havre, MT. March also had some record high temperatures, coming early in the month before the northwest flow began: Portland, OR at 20.6 °C (69.0 °F) and 22.2 °C (72.0 °F) at Salem, OR.

The wet period that began in March continued into April 2002 mainly in Canada and across the northwest U.S. tier. A secondary wet area was over the southeastern basins. Higher pressure aloft ridged up early in April, but did not last through the month. Columbia above Grand Coulee had 93 percent of normal precipitation; the Snake River above Ice Harbor had 100 percent of normal precipitation, and the Columbia above The Dalles had 95 percent of normal precipitation. April temperatures were closer to normal, region wide, although many record temperatures were broken. Some of the new record lows included: Pendleton, OR, -3.3 °C (26.0 °F) on 3 April; -5.0 °C (23.0 °F) at Grand Coulee Dam and Yakima, WA on 24 April, and –6.1 °C (21.0 °F) at Spokane, WA also on 24 April.

The wet period that began in March continued into May 2002 through Canada and across the northwest U.S. tier. Like in March, an upper level low-pressure trough kept a cool northwest flow into the region, the strongest impact of which was felt in May. Higher pressure aloft was suppressed south in early May, it bulged back north about mid month. This resulted in below average to above average precipitation. Columbia above Grand Coulee had 129 percent of normal precipitation; the Snake River above Ice Harbor had

55 percent of normal precipitation, and the Columbia above The Dalles had 94 percent of normal precipitation. This caused the storm track to mainly cut across southern B.C. and northwest Montana in mid to late May. Temperatures averaged slightly below normal, even though new low temperature records again strongly outnumbered new high temperature records.

In June 2002, drier weather became more widespread across most southern basins, including Oregon and central through southern Idaho. The storm track, therefore, pointed across British Columbia, Washington, northern Idaho and northwest Montana. As a result, precipitation was below average. Columbia above Grand Coulee had 97 percent of normal precipitation; the Snake River above Ice Harbor had 80 percent of normal precipitation, and the Columbia above The Dalles had 89 percent of normal precipitation. June was warmer than normal, even through a few low temperature records were tied or broken. Just as in March through May, the new record high temperatures outnumbered the cool ones. For June 2002, these high temperature records included: 27.8 °C (82 °F) at Astoria, OR, 30 °C (86 °F) at Olympia, WA, 31.7 °C (89 °F) at Eugene, OR, and 33.9 °C (93 °F) at Portland, OR, all on 12 June. On 13 June, another record fell at Portland, OR: 36.1 °C (97 °F) and the temperature reached 34.4 °C (94 °F) at Sea/Tac Airport in Seattle, WA.

As July 2002 progressed, the drier weather that became more widespread across most southern basins, including Oregon and central through southern Idaho expanded north. The storm track lifted into the Canadian Upper Columbia region. As a result, precipitation continued to be below average. Columbia above Grand Coulee had 70 percent of normal precipitation; the Snake River above Ice Harbor had 65 percent of normal precipitation, and the Columbia above The Dalles had 71 percent of normal precipitation. July was also warmer than normal, even through a few low temperature records were tied or broken. Just as in March through May, the new record high temperatures outnumbered the cool ones. For July, record high temperatures crumbled at Astoria, OR, Olympia, WA, Portland, OR, Boise, ID, Pendleton, OR, and Missoula, MT to name a few. Many of these values broke the 100 °F mark, ranging from 38.3 °C (101 °F) at Pocatello, ID to 43.3 °C (101 °F) at Boise, ID.

In August 2002, several weak low-pressure systems moved across the Pacific Northwest. However, there was little opportunity for these systems to tap any significant moisture. The result was drier and cooler than normal conditions across much of the region. Columbia above Grand Coulee had 66 percent of normal precipitation; the Snake River above Ice Harbor had 49 percent of normal precipitation, and the Columbia above The Dalles had 56 percent of normal precipitation. August temperatures were slightly cooler than normal. Several record high and low temperatures were either tied or broken.

In September 2002, a few weak cold fronts brought showers to northern tier basins early in the period and an area of low pressure brought light precipitation to southern tier basins during the middle of the month. Late in the month, a ridge of high pressure dominated and brought warmer and drier than normal conditions to most of the Pacific Northwest. The result was drier and warmer than normal conditions across much of the region. Columbia above Grand Coulee had 48 percent of normal precipitation; the Snake River above Ice Harbor

had 54 percent of normal precipitation, and the Columbia above The Dalles had 49 percent of normal precipitation. August temperatures were slightly cooler than normal. Several record high and low temperatures were either tied or broken. The temperatures for the region were warmer than normal with many records tied or broken and a vast majority of them occurred across Western Montana. In fact, September 2002 was the hottest September on record in Helena, where the average monthly temperature was 9.2 degrees above normal.

2.1.2 Streamflow

The 1 April 2002 forecast of January through July runoff for the Columbia River upstream of The Dalles was 96.4 Maf or 90 % of the 1971-2000 average. The actual observed runoff for the Columbia River was 103.8 Maf or 97 % of the 1971-2000 average. The average January-July runoff for the 1971-2000 period was 107.3 Maf. In general, precipitation was slightly above normal for March, and then gradually declined, reaching low levels in July and very low levels in August and September. The water supply gradually declined over the period, finally leveling off in August and September. The unregulated runoff from April through August was 93.8 Maf at the Dalles, 101% of the 1971 to 2000 average. The timing of the runoff in 2002 was slightly later than normal, with the peak-unregulated flows at the Dalles occurring in June. The observed unregulated flow at the Dalles was 606,800 on June 7, 2002.

The Columbia River was operated to meet chum salmon needs below Bonneville Dam and meet power demands from November 2001 through May 8, 2002. The lower Columbia River flow was regulated for juvenile fish between April 3 and August 31 based on recommendations of the TMT. The reservoirs were operated to target the April 10 flood control elevation per the NMFS 2000 BiOp for juvenile fish needs. The storage projects refilled by July 31, 2002. Projects were then drafted to the NMFS 2000 BiOp draft limits for August 31, except for Dworshak Dam, which reached it draft limit in September.

Composite operating year unregulated (natural) streamflows in the basin above The Dalles were slightly below average, but well above the previous year's drought-like streamflows. These flows have been corrected to exclude the effects of regulation provided by storage reservoirs. June was the highest month during the spring runoff, at 120 percent of average. The August 2001 through July 2002 runoff for The Dalles was 125.03 Maf, 90 percent of the 1971-2000 average. The peak unregulated discharge for the Columbia River at The Dalles was 606,800 cfs on June 7, 2002. The 2001-02 monthly-unregulated (natural) streamflows and their percentage of the 1971-2000 average monthly flows are shown in Table 1 for the Columbia River at Grand Coulee and The Dalles. These flows have been corrected to exclude the effects of regulation provided by storage reservoirs.

TABLE 1

2002 Stream flow Data

	Columbia River at Grand Coulee in (cfs)		Columbia River at The Dalles in (cfs)	
Time Period	Natural Flow	Percent of Average	Natural Flow	Percent of Average
Aug-01	74,660	71	90,668	66
Sep-01	40,448	63	58,195	61
Oct-01	28,459	63	55,654	67
Nov-01	42,500	87	77,504	82
Dec-01	33,244	77	68,404	69
Jan-02	44,023	105	87,365	85
Feb-02	40,262	85	83,871	69
Mar-02	42,641	68	100,685	65
Apr-02	123,821	101	229,508	96
May-02	245,979	92	375,679	87
Jun-02	407,159	132	562,793	120
Jul-02	223,423	116	281,124	109
Operating Period Average	108,035	92	172,700	90

2.1.3 Reservoir Operation

2.1.3.1 General

The 2001-2002 operating year followed the second lowest January through July runoff at The Dalles since 1928 and reservoirs elevations were low. Precipitation across the basin began to return to normal by the fall of 2001. The official January 2002 Water Supply Forecast prepared by the National Weather Service was 93 percent of average (100.0 Maf for the January through July period) for the period 1971-2000. The April 2002 water supply forecast was 90 percent of average (96.4 Maf for the January through July period).

Project releases were being used to maintain a minimum flow at Bonneville Dam from November through April for listed chum salmon downstream of Bonneville Dam. Projects were drafted from January through April for flood control. Flood control drafts in January through April contributed to maintaining a flow of 125,000 cfs at Bonneville Dam to keep the chum spawning area downstream of Bonneville Dam wet. Once the chum move into the area and spawn during November and December, this flow should be maintained through early May when the newly developing fish emerge.

Spill for juvenile fish passage was executed for spring and summer 2002 at all lower Snake and lower Columbia projects, except Lower Monumental Dam, and the Lower Snake

projects were operated at, or near, their minimum operating pools for the fish passage season. Storage projects were again required to reach their 10 April refill target and the system was operated to meet flow objectives at McNary and Lower Granite Dams, if possible.

Flows in the basin were generally below average until April and the peak of the runoff for 2002 occurred in June. There was a double peak, as measured at The Dalles, in June. The second peak produced higher than expected runoff and involuntary spill occurred throughout the Columbia Basin for approximately two weeks with TDG levels exceeding 120%. The observed January through July unregulated runoff at The Dalles was 97 percent of average (103.8 Maf). All U.S. storage projects filled to within 0.5 feet from full in 2002.

2.1.3.2 Flood Control

With the 2002 water supply forecasts averaging near normal across the Columbia River Basin, the reservoir system, including the Columbia River Treaty projects were required to draft for flood control in preparation for the spring freshet. Inflow forecasts and reservoir regulation modeling were done weekly throughout the winter and spring. Projects were operated according to the 1999 Flood Control Operating Plan. With above normal precipitation in May and warm temperatures in June, actual runoff volumes were higher than forecasted at the Columbia River Treaty projects. Libby Dam had to spill for the first time in 21 years, which happened to occur during a spill test as requested in the US Fish and Wildlife 2000 Biological Opinion. The spill test and the TDG levels at Libby are discussed in Appendix L. The unregulated peak flows at The Dalles, OR is estimated at 606,800 cfs on June 7 and a regulated peak flow of 374,400 cfs occurred on June 6. The unregulated peak stage at Vancouver, WA was calculated to be 20.8 feet on June 8 and the highest-observed stage was 13.1 feet on April 18.

In the 2002 spill season, there were two-peak runoff periods characterized by greater than 300 kcfs total river flow, which prompted spilling for flood control. The peaks occurred on May 29 through June 11 and June 27 through July 4. The BiOp spill graphs in Appendix M illustrate the effects the two peak runoff periods had on voluntary and involuntary spill at the various projects. During the two peak runoff periods, all the projects had involuntary spill since the river flow exceeded generation capacity.

2.2 Water Releases

2.2.1 Spill

Spring Spill

The spring spill program started on April 4 for Lower Granite, April 5 for Little Goose, and April 10 for Ice Harbor. The spring spill program ended on July 16. Total river flow on the Snake was high (between 120 and 80 kcfs) from early April to approximately early

June, when flow began to taper off. There was voluntary spill for juvenile fish passage at most of the Snake River projects, except for Lower Monumental, which was undergoing repairs. Managing spill at the Lower Granite and Little Goose projects was constrained by the TDG levels in the Lower Monumental forebay. Of the Columbia and Snake River projects, Lower Monumental forebay had the second most exceedances with a total of 49 for the 2002 spill season.

The rationale for determining which Columbia River projects to spill at and in what order are outlined in the NMFS regional forum TMT documents contained on the following web site: http://www.nwd-wc.usace.army.mil/TMT/

The spring spill program started April 10 for McNary, John Day, The Dalles and Bonneville dams. The spring spill program ended on June 20. The 2000 NMFS BiOp calls for spilling forty (40) percent of the river at The Dalles, but at no time is the project to spill more than the 120% gas cap voluntarily.

Summer Spill
The Summer Spill Program was characterized by high river flows, which resulted in spill continuing at McNary until August 1. Spill also continued at Ice Harbor, John Day, The Dalles and Bonneville until August 31. There was no summer spill at Lower Granite and Little Goose.

2.2.1.1 Special Spill Operations
There were four special spill operations in 2002: Lower Granite Dam removable spillway weir test juvenile fish passage tests at Bonneville and John Day dams and no spill conditions at Lower Monumental Dam.

Lower Granite Dam Removable Spillway Weir Test
There were special spill operations at Lower Granite for the removal spillway weir test. The primary purpose of this test was to determine the fish passage effectiveness of the RSW. The special spill operations at Lower Granite caused wide fluctuations in the TDG levels. Spill for the Lower Granite removable spillway weir (RSW) test varied from RSW + 8 or 16 kcfs to the gas cap of 120% from April 15 to June 8. Spilling RSW + 8 kcfs resulted in a 16 kcfs spill with 108 to 109% TDG. Spilling RSW + 16 resulted in a 24 kcfs spill with 111 to 112% TDG at the Lower Granite tailwaters. Spilling to the gas cap resulted in approximately 42 kcfs spill with TDG levels between 116 to 120 %. The test was designed using a randomized block design. Researchers have reported that the removable spillway weir was found to pass comparable percentage of fish as the current BiOp spill to the gas cap for fish passage, using a median of 42.5 kcfs during 2002. The RSW may significantly reduce the time for fish to pass and decrease the frequency of upriver movement, especially during low flows. Moreover, the RSW passed the highest percentage of fish using substantially less water than spilling to the gas cap. To date, the RSW has been the most effective and efficient surface bypass structure retrofitted to the face of Lower Granite Dam, and may prove to be a beneficial management tool for the future. (Anadromous Fish Evaluation Program 2002 Annual Review)

Bonneville and John Day Dam Fish Passage Spill Tests
The fish passage spill tests at Bonneville and John Day began on April 14 and April 10, respectively. Both tests ended on August 31. The primary purpose of these tests was to determine the effects of higher daytime spill amounts on adult and juvenile fish passage. These tests were designed using a randomized block design. The special spill operations at Bonneville resulted in wide fluctuations in the TDG levels. The daytime spill for the Bonneville test varied from 75 kcfs to the 120/115% TDG gas cap. The lower spill days of 75 kcfs resulted in TDG levels between 111 and 114% at downstream Warrendale location. The high spill days with 118% to 120% TDG in the Warrendale were associated with spills between 120 and 180 kcfs. Results of the 2002 research have shown that more fallback occurred on high spill days (gas cap). However, there was no significant difference in fallback for fish that passed the project with high spill verses a low spill day (75 kcfs). There was no significant difference in project passage time between high and low spill days, but fewer fish passed the project on high spill days.

The spill for the John Day test varied between 0 and 30 % daytime spill and between 30 and 60% nighttime spill. Since the spill level for the John Day special spill operations was established as a percentage of the total river flow, the TDG levels were at approximately 119 to 120% as long as the total river flows were high. TDG levels began to drop in the middle of July due to lower flows and spill levels. The John Day test had mixed biological results.

Lower Monumental Dam – No Spill Operation
There was no spill during the 2002 spill season at Lower Monumental due to dam safety concerns. Portions of the tailrace were eroding and required repairs, which occurred during 2002 to prevent further erosion of the tailrace.

2.2.1.2 Voluntary and Involuntary Spill
In previous water quality monitoring reports, the Corps included calculations and graphs of voluntary and involuntary spill. This year, this information is not displayed pending discussions with regional parties on the definitions of voluntary and involuntary spill.

In order to address stakeholders' interest in the amount of spill associated with the Biological Opinion, BiOp spill graphs are included in Appendix M. The BiOp Spill graphics were developed by the Corps Reservoir Control Center staff for daily operational monitoring of BiOp spill compliance and have been used since 1998. The BiOp spill can be compared to the TDG levels by using Appendix C, which contains graphs of spill, flow, and TDG for the Snake and lower Columbia River projects.

As the BiOp spill graphs show, Lower Granite McNary and Bonneville projects had significant amount of spill above the BiOp spill levels. This involuntary spill was associated mainly due to unscheduled unit outages and occasionally with a lack of load. The Spill Priority List influences involuntary spill, especially during high river flows.

Lower Granite was first on the Spill Priority list from April 11-16. McNary was first on the Spill Priority list from April 17 to May 1, 2002. Bonneville was first on the Spill Priority list from June 7 to August 31.

Involuntary spill occurred on the Snake and Columbia River projects from June 3 through June 8. On June 3, a fire occurred near the DC intertie line in California, which resulted in the line being derated, then taken out of service, which effected the Columbia and Snake river projects' generation and the AC intertie line. The AC intertie line was further derated because of the Bridger and Boardmen power plants (coal fired) were not running, since the price for hydroelectric power generation was so inexpensive that power entities could buy energy for less than they could generate it. The damage to the DC intertie line occurred during peak freshet river flow of 404 kcfs on June 5 and 6, which together created a situation of involuntary spill and TDG levels exceeding the 115/120% gas caps at 13 of the possible 17 fixed monitoring stations (FMS) from June 3 through 8. Intertie line repairs were completed on June 8, which assisted in reducing the amount of involuntary spill. On June 5, Little Goose and Bonneville tailwaters 12 hours average TDG exceeded the 125% gas cap. The high river flows and the derating of the DC and AC intertie lines continued through June 14, resulting in 10 or more FMS exceeding the 115/120% gas cap.

On June 28 through July 3, there was involuntary spill at the Columbia River projects due high total river flows and continued intertie line problems. The involuntary spill resulted in TDG levels above the 120% but below the 125% TDG limit at all the Columbia River projects except for Bonneville, which was first on the priority list. Warrendale had TDG levels above 125% for five hours on July 2, 2002 and for two hours on July 3.

Additional involuntary spill occurred from June 20 through July 1 at Dworshak Dam. During early June, a combination of late season rains and warm temperatures produced an unexpectedly high runoff, which resulted in spilling 14 days for flood control operations. By June 20, the reservoir almost reached its maximum pool elevation of 1600 ft. Releases were increased and as shown on the Dworshak TDG hourly data graph in Appendix C, the TDG levels were between 115% and 118%. The circumstances that prompted spilling for flood control operations at Dworshak also prompted similar operations at Chief Joseph Dam and Libby Dam. Chief Joseph and Libby flood control operations are described in Appendix L.

It may be helpful to consider the TDG exceedances from a general overall annual perspective. As Table 2 shows, the hours and percent of time of exceedances for 2002 at Dworshak were higher than 2001, which is to be expected since 2001 was a drought year. For the number of hours that spill occurred in 2002 and 2000, the number of exceedances is similar. The amounts of precipitation for 2000 and 2002 water years were similar too. In 2000, the Snake River upstream of Ice Harbor Dam, was 85 percent of normal (1961-1990) and in 2002 it was 82 percent of normal (1971-2000). Even though the amount of precipitation was similar, the shape of the runoff was different, which resulted in more spill at Dworshak in 2002 than 2000.

TABLE 2

SUMMARY OF ANNUAL TDG EXCEEDANCES
At Dworshak Dam

Year	No. of Hours Exceedances	Possible No. of Hours Exceedances	Hours spill occurred	Percent of Hours in Exceedance	Percent of Hours Consistent w/Standards
Before 2000	Not calculated	Unknown	Unknown	Unknown	Unknown
2000	146	3,312	1776	8.2	91.8
2001	2	3,312	0	0.06	99.94
2002	262	3,312	2,684	8	92

There were several repair and maintenance efforts that resulted in involuntary spill at Lower Granite. On June 10, repair of damage caused by the total load rejection at Lower Granite on April 30, 2002 was being completed. On June 17 through 21, there was involuntary spill at Lower Granite during the RSW deployment.

2.2.2 Dworshak Releases

During the mid to late summer, water releases from Dworshak Dam were adjusted and used to cool the lower Snake River. The cool water operational period end date was extended from the end of August through September. Flow augmentation from Dworshak Dam began on July 25, 2002 and continued until October 17. TMT requested 45^{o} F water to be released for two weeks, beginning July 25, 2002 and continued until August 7. Calculations of how long 45^{o} F or 48^{o} F water could be maintained were prepared and can be found in Appendix D. Based on the calculations, there was enough water in the Dworshak reservoir to maintain 45^{o} F temperature for approximately four weeks. Instead of continuing the 45^{o} F releases, TMT choose to raise the temperature of the Dworshak release to 48^{o} F and maintain it through September. Based on the calculations in Appendix D, this operation would be possible.

Appendix H contains graphs showing water temperatures at the Lower Granite Dam forebay, and Lower Granite tailwater FMSs. The benefit of the cold-water releases can be clearly seen in the Lower Granite forebay and to a lesser degree in tailwater temperature monitoring. The Lower Granite forebay daily average water temperature exceeded 68^{o} F for approximately 21days beginning on July 12. The Lower Granite forebay daily average water temperature peaked at 77^{o} F on June 24. The daily average water temperature dropped significantly within three days of July 25, when flow augmentation from Dworshak Dam began. A three-day time span to see the effects of flow augmentation harmonizes with the travel time for the river mass to travel from Dworshak to Lower Granite. With flow augmentation from Dworshak, temperatures were maintained near 68^{o} F for most of the rest of spill season.

The Lower Granite tailwater daily average water temperature peaked at 68.5^{o} F on July 22 as shown on the Appendix H Lower Granite tailwater graph. The daily average water temperature gradually decreased as flow augmentation continued. The daily average water temperature did not exceed 68^{o} F.

Part 3 Program Results

3.1. Water Quality Review

3.1.1 Total Dissolved Gas

Operation of the Federal Columbia River Power System (FCRPS) to meet multiple purposes may necessitate spill operations that may result in exceedances of state water quality standards for TDG. The Corps, in accordance with the NMFS Biological Opinion, voluntarily spills for fish passage. In addition, spill at Corps projects occurs when power house capacity is exceeded, resulting in water passing the dams through the spillway.

The NMFS 1995, 1998, and 2000 BiOp voluntary spill for fish program was implemented consistent with the State water quality standards variances. During the spill season the TDG level in the project forebays and tailwaters was monitored. Adjustments, when necessary, were made to the upstream project spill levels to maintain the average of the 12 highest values in 24 hours in project forebays at less than 115% TDG and the average of the 12 highest values in 24 hours in project tailwaters at less than 120%.

Appendix E contains a listing of the maximum and minimum TDG values measured at each FMS for each month of the spill season as well as the number of hours and days the TDG standards were exceeded each month.

There are instances of voluntary and involuntary spill at Dworshak. Idaho state standards were exceeded for 11.3 days at Dworshak from June 20 to July 1, 2002 when spill for flood control were necessary. The releases through the Dworshak Dam powerhouse were monitored and maintained at levels that would not generate TDG above the State standard.

Washington and Oregon state standards during the 2002 spill season were exceeded 491 days at the projects on the Lower Columbia and Snake rivers out of a possible 3,312 days (number of projects x days in spill season). Table 3 provides a summary of the occurrence of exceedances, defined as when the 12 hour average exceeds 115% TDG in the forebay or 120% in the tailwater.

As in previous years, the Camas/Washougal simulated forebay site was the most problematic location of the system monitoring stations with 65 exceedances. The Water Quality Team subcommittee continued in 2002 to provide technical assistance in evaluating potential actions to reduce the number of exceedances. The exceedances of the

TDG variance standards at other sites are ascribed to a combination of factors. A small number of exceedance can be attributed to operating so close to the voluntary spill caps that meteorological conditions sometimes caused level to exceed the spill for fish passage. Other factors related to involuntary spill include exceeding powerhouse capacity, intertie line derating; unit outages; lack of load and spilling for flood control operations caused by a combination of late season rains and warm temperatures. Refer to Appendix L for the Seattle District TDG Report discussion on Chief Joseph and Libby. Refer to Appendix I for the U. S. Geological Survey (USGS) discussion of the John Day, The Dallas, Bonneville, Warrendale and Camas/Washougal site. Refer to Appendix K for the Walla Walla District TDG Report discussion of all other sites. (It is a CD)

TABLE 3

2002 Spill Season
Number of TDG Exceedances
From Voluntary and Involuntary Spill

Project Name FMS location	No. Of Exceedances During 2002 Spill Season
Chief Joseph Forebay	53
Chief Joseph Tailwater	11
Lower Granite Forebay	0
Lower Granite Tailwater	17
Little Goose Forebay	17
Little GooseTailwater	6
Lower Monumental Forebay	49
Lower Monumental Tailwater	6
Ice Harbor Forebay	24
Ice Harbor Tailwater	6
McNary - Washington Forebay	43
McNary - Oregon Forebay	45
McNary Tailwater	31
John Day Forebay	11
John Day Tailwater	29
The Dalles Forebay	18
The Dalles Tailwater	11
Bonneville Forebay	30
Warrendale	19
Camas/Washougal	65
Total No. of Exceedances	**491**

There is interest in knowing the number of exceedances associated with the various factors, especially due to spill amounts for fish passage. In order to address this interest, the definitions of intertie line derating; unit outages; lack of load; too high of spill for fish passage and spilling for flood control operations must be established. Once these definitions are established, then the Corps can track which exceedances are associated with what factor.

Comparison of Annual Exceedances
It is be helpful to put the number of 2002 exceedances in an annual overall perspective. Table 4 provides the number of annual voluntary and involuntary spill related exceedances for 2000 through 2002. As shown on Table 4, the percent of 2002 spill season days in exceedance is higher and the exceedances are more numerous than the previous two years. This is to be expected for 2001 since it was a drought year with little to no spill.

2000 actually had a slightly higher percent of precipitation than 2002. In 2000, the upper Columbia River Basin was 100 percent of normal (1961-1990) above Grand Coulee Dam, 85 percent of normal in the Snake River upstream of Ice Harbor Dam, and 93 percent of normal in the Columbia River above The Dallas, Oregon. The 2002 precipitation was 93 percent of normal (1971-2000) above Grand Coulee Dam, 82 percent of normal in the Snake River upstream of Ice Harbor Dam, and 89 percent of normal in the Columbia River above The Dallas, Oregon. The shape of the runoff was unusual in 2002, which attributes to the higher number of TDG exceedances.

TABLE 4

SUMMARY OF ANNUAL EXCEEDANCES
On COE Columbia and Snake River Projects
From Voluntary and Involuntary Spill

Year	No. Of Days Exceedances	Possible No. Of Days Exceedances	Percent of Days in Exceedance	Percent of Days Meeting Variance
Before 2000	Not calculated	Unknown	Unknown	Unknown
2000	269	2760	9.7	90.3
2001	13	2760	0.5	99.5
2002	490	2760	17.7	82.3

3.1.2 Water Temperature
The water temperature standards for the states of Idaho, Oregon, and Washington are shown below in Table 5.

TABLE 5

State Water Quality Standards

	Washington Standard	Oregon Standard	Idaho Standard
Chief Joseph Dam, Columbia River, RM 545.1	"Temperature shall not exceed 18° C (64.4 F) due to human activities. When natural conditions exceed 18° C (64.4 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F). Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/T+7). Incremental increase resulting from nonpoint source activities shall not exceed 2.8° C (5.4 F)." WAC 173-210A-130(21) and WAC 173-201A-030(2)	None	
Lower Granite Dam, Snake River, RM 107.5 Little Goose Dam, Snake River, RM 70.3 Lower Monumental Dam, Snake River, RM 41.6 Ice Harbor Dam, Snake River, RM 9.7	"Temperature shall not exceed 20° C (68 F) due to human activities. When natural conditions exceed 20° C (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F) nor shall such temperature increases, at any time exceed t=34/(T+9)." WAC 173-210A-130(98)(a)	None	Lower Snake – Asotin (Idaho/Oregon border) to Lower Granite Dam pool, Hydrologic Unit Code (HUC) 17060103, Rule Section 130.02. Aquatic Life: COLD (Cold Water Communities) "Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C."

	Washington Standard	Oregon Standard
McNary Dam. Columbia River, RM 292.0 John Day Dam, Columbia River, RM 215.6 The Dalles Dam, Columbia River, RM 191.5 Bonneville Dam, Columbia River, RM 146.1	"Temperature shall not exceed 20° C (68 F) due to human activities. When natural conditions exceed 20° C (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F) nor shall such temperature increases, at any time exceed 0.3 C (0.5 F) due to a single source or 1.1° C (2.0 F) due to all such activities combined." WAC 173-210A-130(20)	From June 1 to September 30, "To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable (defined as 0.25° F) surface water temperature increase resulting from anthropogenic activities is allowed:… (ii)when surface water temperatures exceed 68° F (20.0° C)." (OAR 340-041-0205(2)(b)(A). From October 1 to May 31, , "To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable (defined as 0.25° F) surface water temperature increase resulting from anthropogenic activities is allowed:… (iii) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55° F(12.8° C)…" (OAR 340-041-205(2)(b)(A). (v) In water determined by the Department to support or to be necessary to maintain the viability of the native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
	T=the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge. t=the maximum permissible temperature increase measured at a mixing zone boundary	

Hourly water temperatures in the forebays and the tailwaters of the Corps projects are shown in Appendix H.

The NMFS 1995, 1998, and 2000 BiOps call for cold-water releases from Dworshak reservoir. These releases are to reduce and/or maintain cooler water temperatures in the Snake River in the July and August timeframe when ambient conditions would typically cause the temperature to rise above 68°F.

3.1.3 Recurring TDG Exceedance Problems

There were five locations that were difficult to avoid TDG exceedances from voluntary and involuntary spill, leading to recurring exceedance problems in 2002. As show on Table 3, there were recurring exceedance problems at McNary forebays, both Washington and Oregon sides; Camas/Washougal; Chief Joseph forebay; Lower Monumental forebay.

3.1.3.1 McNary

As shown on Table 3, the McNary forebay – Oregon side had 45 days of exceeding the 12 hour average for TDG and the Washington side had 43 days. The McNary forebay is at the confluence of the Snake and Columbia Rivers and receives waters that have not been fully mixed. Consequently, the water coming from the mainstem Columbia on the Washington side of the river often contains different TDG levels and water temperatures from the water entering from the Snake River on the Oregon side. The only control that the Corps has in changing forebay conditions at McNary are by operating Ice Harbor Dam releases on the Snake River. For example, operational decisions on reducing spill at Ice Harbor Dam on the lower Snake River occurred when TDG levels coming down the main stem Columbia River were high or above the 115 percent forebay limit. Occasionally, the TDG level in the Ice Harbor tailwater needed to be significantly reduced below the 120 percent objective to help reduce the McNary forebay levels that was above 115 percent. This resulted in spill levels at Ice Harbor that were less than the 120 percent called for in the Biological Opinion.

3.1.3.2 Camas/Washougal

As shown on Table 3, the Camas/Washougal site had 65 days of exceeding the 12 hour average for TDG. The Camas FMS represents a theoretical forebay in the lowest reach of the Columbia River, a site that is influenced by tidal interactions. Tidal interaction probably influenced the travel time of parcels of water spilled over Bonneville Dam. Typically the travel time was 12 to 15 hours.

This site was also significantly affected by environmental conditions such as changes in gorge winds, barometric pressures and changes in daily solar radiation and resulting water temperatures. The aquatic plants' production of oxygen may also be involved in causing diurnal variations in TDG. Consequentially, these factors contributed to the difficulty in decision making on how much to spill at Bonneville and still remain at or below the 115 percent TDG limit at Camas/Washougal.

3.1.3.3 Lower Monumental

As shown on Table 3, the Lower Monumental forebay site had 49 days of exceeding the 12 hour average for TDG. In order to understand the TDG fluctuation at Lower Monumental forebay, it is necessary to also look at the TDG fluctuations at Little Goose and Lower Granite tailwaters. As shown on the TDG graphs in Appendix G, the TDG fluctuations at Lower Monumental forebay correlates closely with the fluctuations at Little Goose tailwater, if you take into consideration the river mass travel time between Little Goose to Lower Monumental. Depending on the total river flow, travel time can range from 1.1 to 4.5 days. At the beginning of the spill season, Little Goose began to spill on April 5, 2002 19:00 with a total river flow between 50 and 70 kcfs. The TDG impacts of spill operations at Little Goose arrived at Lower Monumental forebay on April 7, 2002 24:00. In this instance, the travel time for the high TDG water was 53 hours or 2.2 days. This fact is important when analyzing the data, graphs and amount of spill. For instance, on June 1, 2002 24:00 the percent TDG at Little Goose soared to 122%. The impact of this high TDG water did not appear at Lower Monumental forebay until June 3, 2002 6:00, 31 hours (1.3 day) later. The shorter travel time is associated with the higher river flows of 120 to 150 kcfs. Using the travel time information to establish a chronological offset, the correlations of TDG levels between Lower Monumental forebay, Little Goose and Lower Granite tailwaters become apparent. The close relationship in TDG levels between Lower Granite tailwater, Little Goose tailwater and Lower Monumental forebay can also be seen in the average of the spill season high 12 hour average TDG for each project. At Lower Granite, the average was 110.8%. At Little goose, the average was 111.0%. At Lower Monumental, the average was 111.1%.

3.1.3.4 Chief Joseph

As shown on Table 3, the Chief Joseph forebay site had 53 days of exceeding the 12 hour average for TDG. As the Chief Joseph forebay graph in Appendix G shows, the TDG levels were above the state standard of 115% from June 14, 2002 to August 5, 2002. In order to understand Chief Joseph forebay recurring exceedances, Grand Coulee tailwater TDG readings must also be considered. The dates of high TDG levels at Grand Coulee and Chief Joseph correlate well. Grand Coulee tailwater TDG reading began to have TDG reading above 115% on June 14, 2002 7:00 as a result of high TDG levels coming from their inflowing waters from the U.S. and Canada, which was 10 hours before Chief Joseph forebay began to exceed its 115% TDG limit. Chief Joseph forebay TDG dropped below 115% on August 5, 2002 22:00, which was 24 hours after Grand Coulee tailwater TDG dropped below 115%. As this correlation shows, the cause of Chief Joseph's recurring exceedances included upstream conditions from the U.S and Canada and Grand Coulee operations, which included spilling for flood control from June 18, 2002 to July 15, 2002. Like Dworshak and Libby Dams, Grand Coulee also experienced a combination of late season rains and warm temperatures during early June, which produced an unexpectedly high runoff.

3.1.3.5 Compensation Depth

The Lower Granite tailwater was the only FMS that could be characterized as being shallow for a portion of the spring/summer monitoring season. Appendix F contains a graph of the gage depth at Lower Granite with the calculated compensation depth. As the graph shows, the FMS gage depth was below the calculated compensation depth from 4/1/02 6:00 to 4/5/02 11:00, which is not the typical situation and is recognized as a problem. When the TDG is measured in the water column above the calculated compensation depth the TDG measured may be biased low, the actual TDG might be higher than the reading measured due to degassing. The shallow gage depth existed for 102 hours during the spill season. The shallow gage depth was corrected on 4/5/02 18:00 when Walla Walla District put the gage in a cage and lowered it into the navigational channel of the river at a depth of approximately 15 feet. The Lower Granite gage depth graph for April shows clearly the increase of gage depth and that it was maintained between 14.5 and 18.8 ft for the rest of spill season. As the Lower Granite gage depth graph shows, gage depth was measured at the Lower Granite site throughout the entire spill season and the remedy of moving the gage effectively resolved the problem of a shallow gage depth.

The Lower Granite removable weir fish test proscribed fluctuations in river flow, which prompted wide fluctuations in the gage depth during most of the spill season. Gage depth for April was graphed separately to illustrate the wide swings associated with the flows and its resultant TDG levels.

3.2 TDG Monitoring Results

3.2.1 TDG – Average of the High 12 values in 24 hours

Consistency with state water quality standards for TDG in Oregon and Washington is based on the calculation of the average of the 12 highest values in a 24-hour period. Consistency with state water quality standards for TDG in Idaho is based on the instantaneous TDG level not exceeding 110%.

Appendix G contains charts of the calculated TDG values for each monitoring station for the 2001 spill season. The charts also include representation of the applicable standard (110% for Idaho stations, and Oregon and Washington forebays at 115% or tailwaters at 120%).

As shown on Table 2, there were a combined total of 491 exceedances of the average of the high 12 values in 24 hour measured at the FMS on all Columbia and Snake Rivers projects. Lower Granite forebay was the only FMS that did not exceed state standards for TDG during the 2002 spill season. All others projects exceeded between 6 and 65 days during the spill season.

3.2.2 TDG – Hourly flow, spill and TDG

Supersaturated water is a result of voluntary and involuntary spill at the projects. The charts contained in Appendix C represent the hourly flow, spill, and TDG data for each monitoring station. These charts show the relationship between elevated TDG levels and spill.

The Ice Harbor graph is a good representation of the relationship between spill and TDG. During the entire spill season, operations at the project were varying between 0 kcfs spill and 140 kcfs spill. The TDG fluctuations directly track the changes in spill.

Part 4 Fish Passage Summary

4.1 Biological Monitoring

The Action Agencies (Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation) are responsible for managing the FCRPS under the Endangered Species Act Biological Opinions.

Near-term TDG improvements such as spill deflectors may have little effect on reducing tailwater TDG levels since the benefits they provide will be expressed in terms of additional spill amounts to attain higher project passage juvenile survival levels and therefore, progress in species survival. As new fish passage facilities are completed and evaluated, their contribution to the attainment of hydrosystem performance standards will allow spill levels, and TDG levels, to be reduced.

The spill cap levels recognized in the 2000 Biological Opinion, and consistent with state and tribal water quality variances, are: a daily average (based on the12 highest hours) of 115 percent in the project forebays, a daily average (based on the 12 highest hours) of 120 percent in the project tailwaters, and a maximum high 2-hour average of 125 percent anywhere in the river. The criteria replace the 80 percent fish passage efficiency criteria of the 1995 Biological Opinion.

“Gas Bubble Trauma Monitoring and Data Reporting for 2002” by the Fish Passage Center is shown in Appendix J. Sampling of juvenile salmonids for gas bubble disease was conducted at Bonneville and McNary dams on the lower Columbia River, and at Rock Island Dam on the mid-Columbia River. The monitoring sites on the lower Snake River included Lower Monumental, Little Goose and Lower Granite dams. Sampling occurred two days per week at the lower Columbia River sites and once per week at the lower Snake River sites.

A total of 13,477 juvenile salmonids were examined between April and August 2002. A total of 155 or 1.2% showed some signs of gas bubble trauma in fins or eyes. Fin signs were found in 150 or 1.1% of the fish sampled at all sites. These were composed of 140

fish with rank 1 (up to 5% of the fin area), eight fish had rank 2 (6 to 25% of the fin area) signs, while another two fish had a rank of 3 (26 to 50% of the fin area).

At the lower Columbia and lower Snake dams operated by the Corps, a total of 9,986 juvenile fish were examined, with 74 or 0.7% exhibiting signs of gas bubble disease. One fish was found with severe fin gas bubble trauma. In the 2001 low flow spill season, the figure was 0.1%. In the near-average flow 2000 spill season, the figure was 0.2%. In the 1998 high flow spill season, 1% of the juvenile fish sampled had fin signs. In 2002, one fish was found with severe fin gas bubble trauma. This was similar to 2001 and 2000, when no severe fin gas bubble trauma was found.

Lower Monumental Dam was the only location in the lower Columbia and lower Snake where gas bubble trauma exceeded the National Marine Fisheries Service action criteria on June 17 and June 24, 2002. The action criteria for the biological monitoring program is set at 15% prevalence of sampled fish having fin signs or 5% with severe signs (rank 3 or greater) in the fins. The Lower Monumental forebay is also the location with the greatest number of days when TDG exceeded 120%.