200~~0~~1 Total Dissolved Gas Management Plan

(07/02/01~~04/11/00~~)

1. Introduction

High total dissolved gas (TDG) saturation levels are observed in various parts of the Columbia and Snake Rivers system where spill occurs, sometimes creating conditions that may adversely affect fish survival. Therefore, a plan to control TDG is developed annually along with a water management plan, based on the runoff and the resulting spill for that year. This document outlines the TDG management plan adopted by the Technical Management Team (TMT) for ~~1999~~2001. It includes a review of voluntary and involuntary spill, applicable management options, expected flow and spill conditions, and a detailed TDG management plan, with spill priority list and spill caps. This plan reflects relevant provisions of the 2000~~1998~~ ~~Supplemental~~ U.S. Fish and Wildlife Service and the National Marine Fisheries Service Biological Opinions ~~(1998 Supplemental BiOp)~~.

2. Voluntary and Involuntary Spill

2.1 Voluntary Spill

Voluntary spill, as the terms imply, is not a physical constraint in that project operators have the means and capability to turn it off if needed. Spill for-fish-passage is a voluntary spill that will be adjusted by the action agencies so that the resulting TDG levels do not exceed the state standards waivers. The planning dates for voluntary spill for spring/summer chinook migration as called for in the ~~1998 Supplemental BiOp (Page III-5)~~ 2000 NMFS BiOp are April 3 - June 20 in the Snake River and April 1~~2~~0 - June 30 in the Columbia River. For fall chinook migration, the planning dates for spill are June 21 - August 31 in the Snake River and July 1 - August 31 in the Columbia River (Page ~~III-11~~ 9-56). The ~~1998 Supplemental~~ 2000 NMFS BiOp (Pages ~~III-11 through III-17~~ 9.6.1.7.1, Water Quality Strategy, page 9-119) calls for spilling up to the 120% TDG spill caps at the lower Columbia and lower Snake Rivers Corps projects. A summary of the general guidance on spill requirements and other considerations is listed in Table 1, and shown on page 9-89 of the 2000 NMFS BiOp.

Table 1. Summary of 2000 NMFS BiOp Spill Requirements and Other Considerations

Project [1]	**Estimated Spill Level** [2]	**Hours**	**Limiting Factor**
Lower Granite	60 kcfs	6 p.m. - 6 a.m.	gas cap
Little Goose	42 kcfs	6 p.m. - 6 a.m.	gas cap
Lower Monumental	27 kcfs	24 hours	gas cap
Ice Harbor	105 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	170 kcfs	6 p.m. - 6 a.m.	gas cap
John Day	140 kcfs/60% [3] (night)	6 p.m. - 6 a.m. [4]	gas cap/percentage
The Dalles	40% of instant flow	24 hours	tailrace flow pattern and survival concerns (ongoing

			studies)
Bonneville	105 kcfs (night) 75 kcfs (day)	24 hours	

Notes

1 Summer spill is curtailed beginning on or about June 20 at the four transport projects (Lower Granite, Little Goose, Lower Monumental, and McNary dams) due to concerns about low inriver survival rates.
2 Estimated spill levels shown in the table will increase for some projects as spillway deflector optimization measures are implemented.
3 The TDG cap at John Day Dam is estimated at 85 to 160 kcfs, and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be at the gas cap (up to the hydraulic limit of the powerhouse).
4 Spill at John Day Dam will be 7:00 p.m. to 6:00 a.m. (night) and 6:00 a.m. to 7:00 p.m. (day) between May 15 and July 31.

Project	Flow trigger	Spill Duration	Recommended Min/Max Powerhouse Capacity (1)	Spill Cap for 120% TDG (2) at the start of the spring season	Other Considerations (per 1998 Suppl. BiOp Appendix C) to prevent eddy formation, improve fish passage, etc.
	Kcfs	Hours	Kcfs	kcfs	% of flow or kcfs
LWG	85	12 (4)	11.5/123	45	
LGS	85	12 (4)	11.5/123	60	35% max(3), page C-11
LMN	85	12 (4)	11.5/123	40	50% max (3) page C-11
IHR		24	7.5/94	75	
MCN		12 (4)	50/175	120-160	
JDA		12(5)	50/301	150-180	60% max (for flows up to 250-300) or TDG cap (whichever is less) 25% min (due to eddy) See page C-13
TDA (6)		24	50/	230 (5)	(6)64% max 30% min (test). See page C-14
BON		24	30 min. (BPA); see page C-14. 60 min. (FPP)	120	50 kcfs min. spill (tailrace hydraulics); 75 kcfs max. daylight hours (adult fallback) See page C-14

1.Max. value is for powerhouse with units operating within 1% peak efficiency
2.Starting value subject to in-season adjustments based on real-time information
3.Levels provided in the 1998 BiOp to prevent eddy formation and maintain good adult passage conditions. May be adjusted in-season by TMT
4.Normally between 1800-0600 hours
5.From 1900 to 0600 from May 15 to July 31 and from 1800-0600 in August at John Day.
6.Spill at TDA is limited to the 1995 BiOp level of 64% (rather than spilling to the TDG cap). Limit to 30% spill for approximately 50% of the 1998 fish passage season (based on additional tests). See below for 2000 changes.

A discussion of April final volume forecasts that are less than 16 MAF at Lower Granite Dam and 80 MAF at McNary dam is found on pages 9-57 and 9-58 in the 2000 NMFS BiOp.

2.2 Involuntary Spill

Involuntary spill, on the other hand, is caused by project and/or system physical limitations. In general, there are two basic causes for involuntary spill:

1. When an above average water supply results in flows which exceed the hydraulic capacity of power generation facilities, and
2. When potential power generation from above average water supplies exceeds the available market, especially during light market hours at night and on weekends. Others causes are subsets of the first basic case.

For example, the water supply forecast may underestimate the seasonal streamflows and causes the project operators to leave too little space in the reservoirs to catch the water. In other instances, unusually high winter precipitation may force the operators to store water in the reservoirs above the flood control elevations, causing involuntary spill to occur later as the water is evacuated to get to the reservoir flood control elevations.

Isolated instances of involuntary spill are likely to occur in 200~~1~~0, prompted by scheduled or unscheduled turbine unit outages of various durations.

The (~~Aprill~~June Final) January-July runoff volume forecasts indicate that 2001~~0~~ will be a ~~an~~ significantl;y below average
~~average~~ runoff year (~~99~~ 52 percent of normal at The Dalles) and a significantly below average year (~~90~~ 50 percent of normal) at Lower Granite. As a result, it is anticipated that spill, both voluntary and involuntary, will prevail throughout the system.

2.3 Distinction Between Voluntary and Involuntary Spill

In some cases, the distinction between voluntary and involuntary spill may not be as straightforward as described above. A voluntary spill could become involuntary when the nature and extent of the circumstances causing the spill to occur in the first place change. For example, spill caused by service and maintenance schedules is normally voluntary when those schedules could have been postponed. The spill can become involuntary when turbine conditions demand that the service and maintenance work be done immediately, for public safety or other compelling reasons. Such an occurrence in any given year is theoretically always a possibility, but can never be accurately

3. Management Options

As defined above, voluntary spill for-fish-passage needs no further control other than making spill adjustments to keep the TDG within the allowable standards. In the ~~1998~~ 2000 NMFS ~~Supplemental~~ BiOp, John Day will spill up to the 120% TDG cap or up to 60% of the flow, whichever is lower; and The Dalles will spill up to 120% TDG cap or up to ~~64~~ 40% of the flow ~~(30% of the flow on alternate days)~~, whichever is lower. However, For 2000, an average runoff forecast year, final spill amounts have not been finalized yet. At Bonneville, there ~~an in-season test~~ will be 24-hour spill, 75 kcfs in the daytime and 105 kcfs at night. made comparing spilling during daytime hours to the gas cap as opposed to spilling at the 75 kcfs adult fallback cap. The Dalles will spill at the level between 30 and 50% based on the research that showed better juvenile survival at 30% than at the BiOp specified level. . A study at John Day will evaluate daytime spill at a 20% level on the days when Bonneville is spilling during the daytime at the gas cap (?)%. At Bonneville, a test will be made determining the effects of spilling during the daytime at the gas cap as opposed to spilling during the day to the 75 kcfs adult fallback cap. At Ice Harbor a similar test to the one at Bonneville is proposed alternating daytime spill between 45 kcfs and 105 kcfs at night.the gas cap and the 45 kcfs adult fallback cap. Because of the continuing testing of the surface bypass collector at Lower Granite spill will be set at a level of 20% of flow for 24 hours a day. Lower Granite Dam will spill 60 kcfs from 6 p.m to 6 a.m. Little Goose Dam will spill 42 kcfs from 6 p.m. to 6 a.m anf Lower Monumental Dam will a have 24-hour spill of 27 kcfs. As in previous years, summer spill will only occur at non-collector projects (John Day, The Dalles and Bonneville). Summer spill levels will be the same as spring spill levels, except for possible minor adjustments needed for test purposes.

Spill caps will be assigned to each project, and will be adjusted in-season based on actual TDG readings. In this case, there is no spill priority list to follow except for minor adjustments to take best advantage of the 120% TDG limits (115% TDG limit measured at Camas-Washougal is applied to the spill for-fish-passage at Bonneville). For example, to account for cumulative impacts, some spill reduction may be needed at upstream projects so that some meaningful spill can still occur in the lower river within the stated 120% TDG limits. The decision on where to cut or increase spill is highly fish-dependent, and will be based on salmon managers' recommendations.

Management options are limited to the following:

- More water can be stored in the reservoirs behind the dams;
- The quantity of spill can be shifted to various periods within the day;
- More water can be put through the turbines;
- Spill can be shifted within the system to avoid excessive local concentrations;
- Spill can be transferred outside the system; and
- Spill bays can be used more effectively.

Changing the spill from a crown to an uniform pattern, avoiding the use of spillway bays without deflectors, and allowing turbine units to operate outside their 1% peak efficiency flow range are additional management options. Proper scheduling of service and maintenance time tables, identifying additional energy loads to serve, and displacing available thermal projects that are serving the same loads also help relieve the need for spill. Some of these mitigation measures have potential impacts on the environment, fish survival and other reservoir regulation requirements. Further, they must be implemented early enough in the season to be fully effective.

To maintain uniformly low TDG conditions or to avoid spill in river reaches where the greatest number of fish are actively migrating, spill may be distributed to various other projects in a pre-planned sequence. This requires starting with projects with the least propensity for developing high TDG level or those located outside the fish migration corridor. A spill priority list will establish the order in which projects will start spilling and the maximum amount of water these projects are allowed to spill.

In general spill will first occur at projects with assigned spill for-fish-passage levels; any other spill will be distributed to other projects in the system as conceptually illustrated in Figures 1 and 2. The two periods shown are April 3-April 20 (voluntary spill at lower Snake projects only) and April 20-

August 31 (voluntary spill at both lower Snake and lower Columbia River projects). The TMT will recommend adjustments to the spill priority based on real-time TDG and fish migration conditions and/or other relevant considerations.

4. Projected High Spill/High TDG Periods

Pertinent water supply forecasts issued by the River Forecast Center are summarized in Table 2 for key locations on the Columbia and Snake Rivers. The (~~April~~ June Final) January - July forecast for the Columbia River at The Dalles is ~~105.0~~ 55.5 million acre-feet (maf), ~~99~~ 52% of normal. Runoff forecasts for Reclamation reservoirs above Brownlee are in the ~~79~~33 to 78 percent of normal range.

Table 2. 2001~~0~~ Runoff Volume Forecasts

Location	Jun~~April~~ Final '00	% of Normal April Fin. '00
	Maf	%
~~Libby (Jan-Jul) *~~	~~7.07~~	~~111~~
~~Libby (Apr-Aug) *~~	~~6.87~~	~~108~~
Libby (Apr-Sep) *	3.75~~7.29~~	55~~108~~
~~Hungry Horse (Jan-Jul)~~	~~2.14~~	~~94~~
Hungry Horse (Apr-Sep)	1.35~~2.09~~	62~~96~~
Grand Coulee (Apr-Sep)~~Jan-Jul)~~	37.9~~65.8~~	58~~104~~
Dworshak (Apr-Jul~~Jul~~) *	1.55~~2.66~~	57~~99~~
~~Lower Granite (Jan-Jul)~~	~~26.7~~	~~90~~
Lower Granite (Apr-Jul)	10.8~~19.2~~	50~~89~~
~~Lower Granite (Apr-Aug)~~	~~20.5~~	~~89~~
~~Lower Granite (Apr-Sep)~~		
~~The Dalles (Jan-Jul)~~	~~105.0~~	~~99~~
The Dalles (Apr-Sep)	52.0~~98.2~~	53~~99~~
~~The Dalles (Apr-Aug)~~	~~92.5~~	~~99~~
~~Brownlee (Jan-Jul)~~	~~7.73~~	~~79~~
Hells Canyon~~Brownlee~~ (Apr-Jul)	2.15~~3.93~~	35~~68~~
~~Brownlee (Apr-Aug)~~		
~~Brownlee (Apr-Sep)~~		

(*) COE official Forecast

Consequently, there are no projected high spill/high TDG periods for the spring or summer of 2001.

The COE Power Branch made a 59-year (1929-1987) monthly flow computer simulation based on the March Final 2001~~0~~ runoff forecasts at Lower Granite and The Dalles. The model simulation provides an estimate of the expected flows at Lower Granite and McNary for any of the 59 years having the January--July runoff volume as the water supply volume forecasted for 2000.~~ When more reliable information becomes available,~~ T~~t~~he results of the 59-year monthly study is~~will be~~ superceded by weekly spreadsheet flow projections made more specifically for 2001~~1999~~.

The Power Branch's analysis produced a wide range of flow and spill conditions as a result of meeting relevant 2001~~0~~ system requirements for flood control, power, Libby sturgeon operation, and the BiOp seasonal flow objectives. Using the monthly simulation output from this power model run, a more detailed analysis was performed to provide expected ranges of TDG levels. Three years with different timing for peak runoff were selected and used in a more detailed simulation of the spill operation on an hourly basis. The first two water years (1934 and 1957) had their peak runoff in April and in May respectively. Runoff in the third water year (1951) was more normally distributed. Shown in Table 3 are the projected spill and TDG levels for the three years at Lower Granite, Ice Harbor and McNary.

Table 3. Projected Flow, Spill and Max. TDG at Lower Granite, Ice Harbor and McNary

Projects/ Characteristics	1934 (Early Runoff)	1951 (Normal Runoff)	1957 (Late Runoff)
ICE HARBOR Peak Runoff Period High Flow, kcfs High Spill, kcfs Max Hourly TDG, %	 April 11–30 145-180 90-100 122	 April 11 – May 26 106-133 90-95 122	 May 1 – 26 123-146 82-95 122
McNARY Peak Runoff Period High Flow, kcfs High Spill, kcfs Max Hourly TDG, %	 April 14-30 423-462 250-292 137	 April 25-30 367-440 200-270 132	 May 2-31 388-459 240-270 135
JOHN DAY Peak Runoff Period High Flow, kcfs High Spill, kcfs Max Hourly TDG, %	 April 14-30 489-530 188-230 133	 April 17-June 3 321-406 143-150 127	 May 18 – May 26 422-468 136-167 129

The regression equations used to predict TDG are based only on the spill level. The spill caps shown are also equation-predicted spill values that yield 120% TDG.

Table 4 summarizes periods with TDG in excess of the 120% saturation levels, assuming a 2001~~0~~ runoff distribution similar to that of the three years analyzed.

Table 4. Projected Spill Periods with TDG > 120% TDG

Projects/ Characteristics	High TDG Periods in 1934 (Early Runoff)	High TDG Periods in 1951 (Normal Runoff)	High TDG Periods in 1957 (Late High Runoff)
ICE HARBOR Pwh Cap=94 Night Cap = 95 kcfs Day Cap = 45 kcfs Days > 120% Max Daily TDG, %	 0 120	 0 117	 0 117
McNARY Pwh. Cap.=175 kcfs	April 2 - May 27	April 25 - May 3	May 1-June 2

Spill Cap = 150 kcfs Days > 120% Max Daily TDG, %	 36 133	 9 125	 33 131
JOHN DAY Pwh. Cap.=301 kcfs Spill Cap = 150 kcfs Days > 120% Max Daily TDG, %	April 18-May19 16 132	April 28-May 1 3 122	May 1 - June 5 31 128

Based on these projections, TDG below McNary would exceed the 120% saturation level for extended periods (one to two months). Daily TDG below Ice Harbor stayed at a level of 120% or less.

The results shown above are for planning purposes and are not indicative of the limited extent and much smaller magnitude of the spill conditions that may be expected for 20010. More reliable flow projections will be made starting in late March, using the results of the SSARR run adjusted as needed to meet the seasonal flow objectives at Lower Granite, Priest Rapids and McNary. The projected seasonal average flows derived from the weekly flow projection spreadsheet will be shown in the following format:

Lower Granite: 4/03 - 6/20: X1 kcfs; 6/21 - 7/31: X2 kcfs
Priest Rapids: 4/10 - 6/30: Y1 kcfs
McNary: 4/20 - 6/30: Z1 kcfs 7/01 - 7/31: Z2 kcfs

5. 2001~~1999~~ TDG Management Plan

The 20010 TDG Management Plan is not similar ~~in many respects~~ to previous years' plans. Storage reservoirs will be operated to flood control rule curves and ~~are projected to provide some cushion that will minimize incidences of~~ little or no involuntary spill is expected. No pre-emptive reservoir drafting below flood control elevation is expected~~will be attempted~~, as the Salmon Managers are also concerned about reservoir refill. Flows will be regulated to maximize potential for voluntary spill. When project voluntary spill occurs, the projects will be operated to try to keep TDG at or below 120% as long as possible without jeopardizing flood control objectives. ~~When~~ During the unlikely event that TDG cannot be managed to 120%, the river will be managed in the best interest of listed and proposed salmon stocks. It is recognized that measures designed to physically reduce TDG could have significant impact on migrating salmon. Therefore, input from state and tribal salmon managers and DGT will be sought when attempting to use those TDG control measures.

The essence of the 20010 TDG Management Plan (see Figures 1 and 2), which may be modified in-season by the TMT if necessary, is as follows:

- Implement spill for-fish-passage at all mainstem Federal dams as specified in the 2000~~1998~~ NMFS ~~Supplemental~~ BiOp up to the spill caps for 120% TDG given in Attachment. Adjust spill as needed, based on real-time TDG data, and fish movement and biological conditions in that order.
- Operate unit operation within 1% of peak efficiency,
- Limit daytime spill at Bonneville to avoid adult fallback ~~will be tested.]~~
- Accommodate special spill requirements/restrictions for research, adult passage, etc. that have the full endorsement of all concerned parties. Also, continue to implement fish

transportation program as agreed to and using calculation method endorsed by NMFS (or an equivalent method agreed to at TMT),

- If systemwide TDG exceed 120%, update and implement the spill priority outlined in Attachment 1, with incremental system TDG control objectives. Unless and until a different reach priority is recommended by the TMT, spill will start from the lower river and work its way upstream,
- Discontinue or postpone field research and non-critical unit service and maintenance schedules that create (or have potential for creating) high localized TDG levels, especially when and where high numbers of listed fish are present,
- Operate turbines outside their respective 1% peak efficiency flow range at projects where measurable reduction in TDG (at least 3%, given the accuracy range of the instrumentation) and no intolerable adverse fish impacts can be expected,
- Store water at lower Snake reservoirs above MOP, if this would result in a measurable (3% or more, based on instrumentation accuracy) reduction in TDG levels,
- Experiment with promising, new spill patterns,
- Implement other operations or measures recommended by the TMT or the IT. This may include appropriate changes in transportation targets when TDG exceeds levels that are universally recognized as lethal (130% more for one week or longer, per NMFS) or when obvious in-river lethal conditions exist.

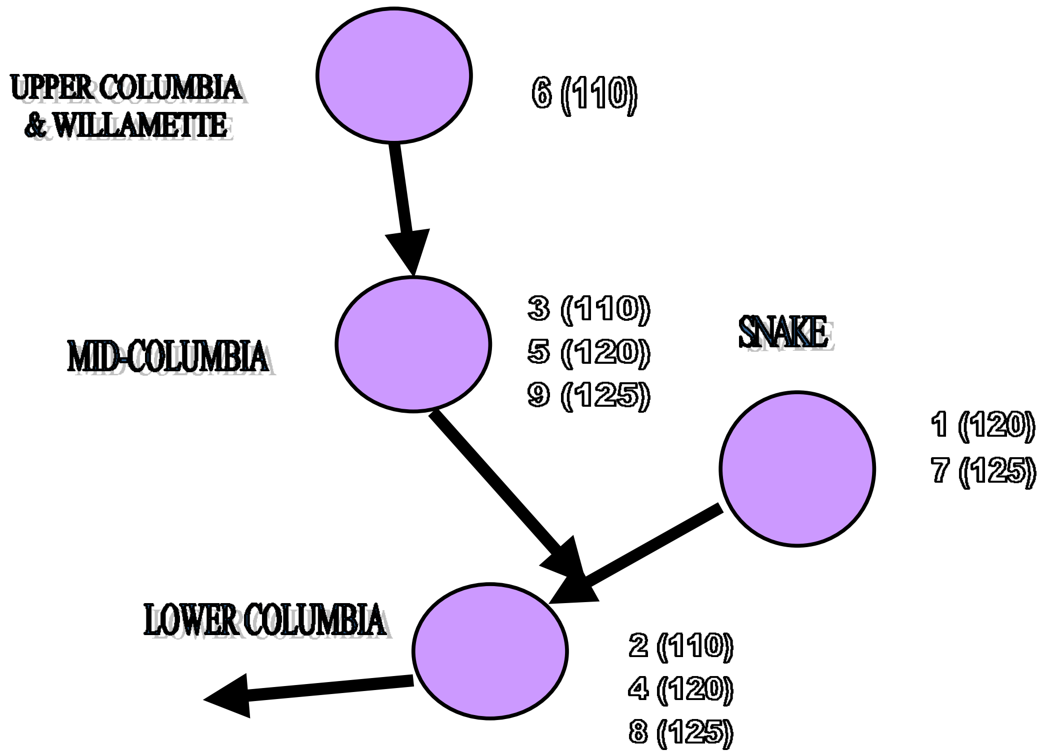

FIGURE 3
SPILL PRIORITY FOR APRIL 3 - APRIL 20
Priority (% TDG)

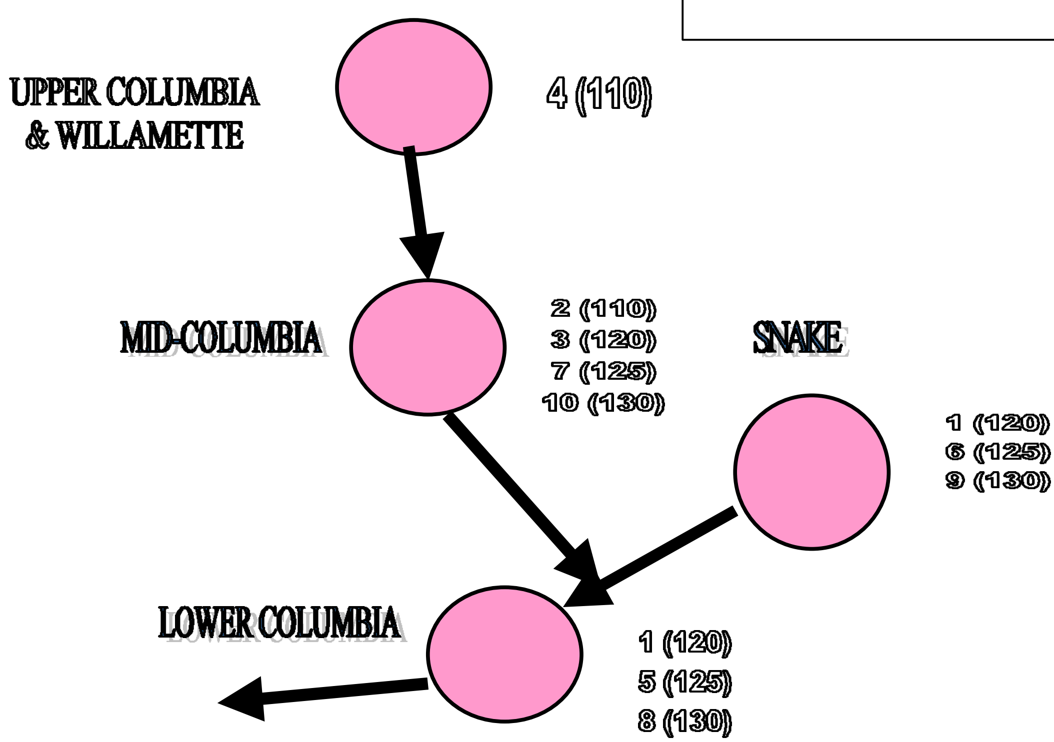

FIGURE 4. SPILL PRIORITY FOR APRIL 14-AUGUST 31
Priority (% TDG)

Attachment

SPILL PRIORITY LIST and SPILL CAPS (April 20 - August 31)

1. This attachment provides project priority for spill and allowable spill levels to be used in an attempt to control total dissolved gas (TDG) to 120%, 125%, 130% and 135%. Projects are listed in a sequential order, placing first priority on spilling at mainstem Columbia projects before spilling at projects outside the fish migration corridor (HGH, Willamette, etc). See also Figure 1.

2. When system-wide TDG is at or below 120%, provide the spill for-fish-passage up to the 120% TDG spill caps in the following order:

- Spill up to the 120% TDG spill caps at McNary (MCN), John Day (JDA(,), The Dalles (TDA), Bonneville (BON),,), , Lower Monumental (LMN), Little Goose (LGS), and Lower Granite (LWG);
- Spill up to the 110% TDG spill caps at projects outside the lower river fish migration corridor: Priest Rapids (PRD), Rocky Reach (RRH), Wells (WEL), Rock Island (RIS), Wanapum (WAN), Chief Joseph (CHJ), Grand Coulee (GCL), Dworshak (DWR) in that order. The priority order for the mid-Columbia projects is as recommended for the period beyond 15 April by the Mid-Columbia Coordinating Committee
- Spill up to the 120% TDG spill caps at projects where State standards waivers have been granted: PRD, RRH, WEL, RIS, and WAN in that order;
- Spill up to the 120% TDG spill caps at DWR if release from DWR is for use in maintaining 100 kcfs flow at LWG;
- Spill up to the 110% TDG spill caps at Hungry Horse (HGH) and Willamette Projects.

3. When systemwide TDG exceeds 120% TDG, then try to control systemwide TDG to 125%, then to 130% and so on by spilling up to the spill caps indicated for those TDG levels, at lower Columbia, Snake, mid-Columbia, HGH, and Willamette Projects in that order. To accommodate the 64/30 tests, the spill priority for The Dalles will be such that spill at this project can follow the 64/30 alternating percent requirement as much as possible. The spill level at John Day may also be dictated by the test at The Dalles.

4. Spill caps for various applicable TDG levels are provided below. They will be updated, as needed based on real-time TDG information.

Table A-1. Spill caps (in kcfs) corresponding to 110-120 % TDG Levels

PROJECT	TDG%	TDG%	TDG%	TDG%	TDG%	TDG%	REMARKS
	110	115	120				
MCN)	20	60	120				(NEW DATA)
JDA	20	50	110				(NEW DATA)
TDA	50	100	200				(NEW DATA)
BON(1)	SEE	REMARKS	BELOW				(NEW DATA)
IHR	30	45	100				(NEW DATA)

LMN	35	40	45				(NEW DATA)
LGS	30	35	40				(NEW DATA)
CHJ	5	10	15				(NEW DATA)
LWG	20	30	55				
DWR	04	7	7	7	7	7	
WAN	10	15	20	50	100	200	
PRD	25	30	40	100	210	350	
RIS	05	10	20	30	150(2)	300	(LIMITED DATA)
RRH	05	10	20	30	150(2)	300	(LIMITED DATA)
WEL	10	15	25	45	130(2)	250	(LIMITED DATA)
	05	10	15	25	45	65	(LIMITED DATA)
GCL(3)	0 20	5 25	10 30	20 75	35 120	55 170	
HGH	03	3	3	3	3	3	
HCR	04	4	6	6	6	6	
LOP/DEX	05	5	5	5	5	5	
GPR	02	2	2	2	2	2	
DET/BCL	07	7	7	7	7	7	
TDG %	110	115	120	125	130	130	

1. BON: For flows less than 200 kcfs, spill 50 kcfs. For flows between 200 and 260 kcfs, spill between 50 and 95 kcfs. For flows over 260 kcfs, spill between 50 and 145 kcfs.
2. Limit daytime spill to 100 kcfs
3. Assume forebay TDG at 120% (1st row=outlet El<1260'), 2nd row=spillway (El>1260')
4. HGH spill to 3 kcfs (110% TDG) until further notice