CHIEF JOSEPH DAM GAS ABATEMENT EVALUATION REPORT
PLAN OF STUDY
April 1999

1. **Project:** Chief Joseph Dam, Columbia River, Washington.

2. **Study Authority:** 1998 National Marine Fisheries Service Biological Opinion (BiOp) which states: "The Action Agencies ... shall jointly investigate operational and structural gas abatement measures at Grand Coulee and Chief Joseph Dams as part of the system-wide evaluation of gas abatement measures."

3. **Project Location and Study** Area: Chief Joseph Dam is located in the state of Washington on the Columbia River, 545 miles above the river mouth, .51 miles downstream of Grand Coulee Dam and 30 miles upstream of Wells Dam. The reservoir behind the dam is called Rufus Woods Lake. The dam has 27 power units and a 19-bay gated concrete gravity spillway, which abuts the right bank. The spillway is controlled by 36-foot wide by 58-foot high tainter gates and is designed to pass releases up to 1,200,000 cubic feet per second at a maximum water surface elevation of 958.8 feet. Flows from the Okanogan and Methow Rivers enter the Columbia between Chief Joseph Dam and Wells Dam. The area of study ranges from Grand Coulee Dam downstream past Chief Joseph Dam to the Wells Dam forebay.

4. **Background:** In the past few years, the combination of higher than average flow conditions requiring flood control spills and Endangered Species Act (ESA) efforts requiring s ill for fish passage have magnified the dissolved gas supersaturation problem throughout the Columbia River system. Current state and federal water quality standards for total dissolved gas (TDG) concentrations are 110 percent saturation except when stream flow exceeds a 7-day average, 10-year flood event. The TDG levels downstream of Chief Joseph Dam frequently exceed this standard. In particular, very high levels of TDG supersaturation were observed below Chief Joseph and Grand Coulee Dams in 1996 and 1997. High levels of TDG produced at one dam tend to persist far downstream. Chief Joseph Dam is the upper boundary for the geographic range of the Upper Columbia River Evolutionary Significant Unit (ESU), within which steelhead (August 18, 1997) and spring chinook (March 16, 1999) have been listed as "endangered."

5. **Purpose of Study.** The primary purposes of the Chief Joseph Dam Gas Abatement Evaluation Report are: (1) to evaluate flow deflectors as a short-term gas abatement measure at Chief Joseph Dam; (2) to explore the viability of the side channel canal option as a long-term alternative to achieve 110 percent TDG; (3) to evaluate the gas abatement benefits achieved under a combined Chief Joseph and Grand Coulee Dam gas abatement project; and (4) to continue to examine the range of capabilities provided by Chief Joseph Dam in the context of optimized system operation.

6. **Previous Studies:**

A. Initial Appraisal Report. The total dissolved gas abatement analysis in the Chief Joseph Dam Initial Appraisal Report was conducted by the U.S. Army Corps of Engineers to develop a comprehensive list of appropriate cost-effective, long-term gas abatement measures aimed at reaching a TDG level out of Chief Joseph Dam of 110 percent just below the spillway if feasible from an economic, engineering, and biological standpoint. Eighteen alternatives were identified. Each alternative was evaluated against nine criteria: (1) Project Impact, (2) Cost of Alternative, Water Quality Benefits, (4) Biological Benefits, (5) Engineering/Operational Feasibility, (6) Timeliness, (7) Upstream and Downstream Effects, (8) Acceptable Solution, and (9) Maintenance Effects. Based on results of the Initial Appraisal Report, nine alternatives including one combination of alternatives were recommended for further study and evaluation. These alternatives are:

(1) **Spillway Flow Deflectors** - Consists of modifying the spillway at Chief Joseph Dam with flow deflectors to reduce the plunge depth of spill discharge.

(2) **Spill During Maximum Power Generation/Extend Daily Spill Duration/Market Power at Night** **-** Requires changing, the operation at Grand Coulee and Chief Joseph Dams to spill more consistently even flows during the day and at night, or to time spills in a more effective manner from a TDG perspective. Total river flow (spill and power release) during, the day would be higher than under current operation, while flows at night would be lower.

(3) **Side Channel Canal -** Consists of constructing a side channel that would run parallel to the riverbank. Water would enter the canal upstream and be transported around the dam and discharged back into the river.

(4) **Operate Hydropower Units Outside Peak Efficiency Range** Requires the project to operate power units at a lower output thereby meeting power Generation requirements but doing, it less efficiently.

(5) **Degas at Brewster Flats** - Some degassing takes place at the Brewster Flats area of the river, where it is wide and about 5 to 20 feet deep. By extending the shallow depth downstream there would be increased opportunity to reduce gas levels before they reach Wells Dam.

(6) **Swap Power for Spill with Downstream Dams** **-** Consists of producing more energy at Chief Joseph and Grand Coulee Dams and less at a dam or dams downstream which have degassing, capability already or fish passage facilities.

(7) **<u>Raise Control Flows at the Dalles</u> Dam -** Raising the control flows at the Dalles Dam could reduce the needed draft from Grand Coulee in the spring. This would help reduce TDG levels caused from “premature spilling" or "spill now to prevent spill later".

(8) **<u>Modify Operation of Grand Coulee</u> Dam -** Consists of reducing, the frequency and volume of pre-emptive spill from Grand Coulee Dam that most of which must be spilled at Chief Joseph Dam.

(9) **<u>Combination of Alternatives</u> -** This particular combination (3, 11, and 14) represented a combination of the most effective measures above.

B. <u>Screening of Alternatives Report</u>: This report titled "Screening, of Alternatives for Plan of Study Phase of the Chief Joseph Dam Dissolved Gas Abatement Study" dated November, 1998 concluded "...from the perspective of engineering, feasibility/known technology, implementation timeliness, and cost effectiveness, flow deflectors have the best potential for reducing, TDG at Chief Joseph Dam. Flow deflectors should be the focus of further evaluation." This report proposed that the evaluation of the Chief Joseph Gas Abatement Study ... proceed with modeling and design of flow deflectors, including an evaluation of installation on fewer than all 19 spillbays. Coincident with this fast-track approach, the Corps would continue to explore the viability of the side channel option as a long-term alternative to achieve 110% TDG". In addition, "a parallel study should be initiated to address how to jointly operate GCL and CHJ to reduce dissolved gas supersaturation at both projects to the greatest extend possible. Also, the range of capabilities provided by CHJ should continue to be examined in the context of optimized system operation."

7. **<u>Chief Joseph Dam Gas Abatement Evaluation Report Description:</u>** The evaluation report will address the: (1) short-term solution to reduce gas supersaturation at Chief Joseph Dam by constructing flow deflectors, (2) long-term solution of constructing a side channel canal that diverts water around the dam instead of over the spillway, and (3) gas abatement measures pertaining to a combined Chief Joseph/Grand Coulee Dam project including a system gas abatement reconnaissance level study of the 13 other hydropower projects located downstream on the Columbia and Snake Rivers to determine the benefits and impacts of a combined project on the downstream dams. Following is additional information pertaining to the content of the evaluation report:

A. <u>Chief Joseph Dam Stand-Alone Analysis</u>. The Initial Appraisal and Screening, of Alternatives Reports were used to identify the problem and alternative solutions at Chief Joseph Dam with a recommendation of further study of two of the alternatives in the evaluation phase. Gas abatement alternatives to be further evaluated include flow deflectors located on the spillway and a side channel canal. Both of these alternatives require studies pertaining to near-field TDG. See Appendix A. These studies are to be focused on describing spatial and temporal dynamics in TDG both near the structure and downstream in the receiving waters. The information gained can be used to better understand the gas exchange processes both near the dam and downstream, an essential step in evaluation of structural modifications for gas abatement. TDG within the stilling, basin and throughout the tailwater channel will be measured with an array of dissolved gas instruments. The array of instruments will provide direct assessment of the vertical, lateral, and longitudinal Gradients in TDG levels. Mixing between powerhouse and spillway releases will also be investigated, singe this interaction may be important to the total flux of TDG introduced into the Columbia River. The influence of the tailwater depth on the exchange of gas during spillway operation will also be investigated by controlling hydropower releases. At selected cross-sections, TDG will be monitored and velocities will be measured with an acoustic Doppler current profiler to allow TDG flux computations. Testing, evaluation, and documentation will take 8 months to complete.

In addition to the TDG studies required for both alternatives, the flow deflector alternative will also require the following model studies:

- **1:40-Scale Section Model:** A 1:40-scale physical section model, built at the Corps Waterway Experiment Station (WES), Vicksburg, MS will be used to refine the spillway flow deflector design. This section model will include one complete spillway bay with adjacent piers and a half of each bay adjacent to the complete bay. This model will be used to evaluate and select the most effective spillway flow deflector design to reduce gas saturation levels. Various designs will be evaluated based on the flow conditions in and downstream of the stilling basin through observing aerated flow patterns, dye movement, and some point velocity measurements. Evaluation of installation of deflectors on fewer than 19 spillbays will also be investigated. The existing design and one deflector design will be selected for detailed evaluation and performance comparisons including installation of pressure cells to document the pressures at selected locations on and in the vicinity of the deflector and the stilling basin baffle blocks. Construction, evaluation and data documentation will take approximately 7 months to complete.

- **1:80-Scale General Model:** A 1:80-scale physical general model, also at WES, will be used to: (1) evaluate the with-deflector condition performance characteristics of the stilling basin, (2) the potential to transport material into the stilling basin, and (3) identify any unacceptable flow conditions due to the three-dimensional characteristics of the spillway and powerhouse flows. The general model will include the spillway, powerhouse (downstream side detailed only), and the channel for about 2,500 feet downstream from the spillway. Recently observed damage to the stilling basin following the spill operations during the 1997 snow melt season supports the need for this model which will be used to document the three-dimensional flow conditions downstream of the spillway for various flow combinations involving the spillway and the powerhouse. The existing spillway design and the deflector design selected from the section model will be installed in this model and flow conditions will be evaluated to determine impacts of the deflectors on stilling basin performance, flow conditions in the channel downstream of the basin, and transport of abrasive material into the stilling, basin under various powerhouse operating plans, spillway bay operating plans and deflector lateral placement schemes. Flow conditions will be documented using dye, surface confetti, and point velocity measurements. The area immediately downstream of the end sill will be constructed with a moveable bed to assist in qualitatively evaluating the movement of bed material. If adverse flow conditions are identified, corrective actions will be identified and might include design modifications and/or optimizing spillway bay operation patterns. A number of spillway bay operation and powerhouse flow combinations will be evaluated. Construction, evaluation and data documentation will take approximately 8 months to complete.

B. <u>Chief Joseph/Grand Coulee Dam Combined Operation Analysis</u>: The Chief Joseph Dam Gas Abatement evaluation report will also address optimization of operational and structural gas abatement alternatives when evaluating a combined Chief Joseph and Grand Coulee project. In an effort to determine the most effective gas abatement measures for combined operations, the Corps, Bureau of Reclamation, and BPA have initiated a system gas abatement reconnaissance level study. As stated in the "System Gas Abatement Reconnaissance Level Study Plan" (Appendix B) the primary purpose of this reconnaissance level evaluation is to determine "what can be done project-by-project concurrent and parallel with other ongoing gas abatement studies and to develop a priority listing ranking, what modifications can be made at each project." As part of this evaluation, a total dissolved gas numerical computer model (SYSTDG) will be used. This model will be used to assess how the system would best benefit from alternative solutions. The SYSTDG model will be used to predict TDG levels in the forebay and tailrace areas of the 15 projects involved once the project releases, spill and gas production relationships are known and entered into the model. The model will accept a range of exchange parameters allowing, sensitivity analyses to be performed. The model will be run under without project conditions to ascertain where the worst TDG areas in the river are likely located and where reductions to the TDG levels should be focused. The system will be represented as a simple linked node network where TDG pressures are estimated from project operations at each node and routed downstream to the next project. Model input will include the total flow entering, and leaving the project, pre-defined spill conditions, powerhouse hydraulic capacity, discharge-to-megawatt conversion factor, and spill-to-TDG production relationships. Typical modeling period will be from April through August. Gas production relationships at individual projects will be based upon information representative of conditions used during the 1996 season and will be updated to reflect the present structural and operational conditions at each project. The results of the model will be used to prioritize where efforts to reduce TDG should be concentrated, based on TDG reduction benefits versus costs. A parallel goal of this study is to develop a computer model that can be incorporated into the Transboundary Gas Group system-wide study efforts.

8. **<u>Views of Federal, State and Regional Agencies.</u>** Numerous federal agencies are involved in efforts to develop system-wide solutions to dissolved gas at Columbia River dams. These agencies include the National Marine Fisheries Service, Bonneville Power Administration, Bureau of Reclamation, and Army Corps of Engineers. This study has their support. Other support for the gas abatement efforts is provided by the Columbia River Intertribal Fisheries Commission, the Colville Tribes of the Colville Reservation and the Washington State Department of Ecology (WDE) and the Oregon Department of Fish and Wildlife (ODFW@.

The actual study design for Chief Joseph near-field studies is partially a result of coordination with NMFS and WDE.

9. On-Going Studies:

A. System-Wide Evaluation: In March 1998, the System Configuration Team and the Dissolved Gas Team, two coordination groups of the U.S. National Marine Fisheries Service (NMFS) Regional Forum, were given the task to begin developing a system-wide approach to dissolved gas management and abatement for the entire Columbia Basin. Previous and ongoing, efforts have concentrated on reducing dissolved gas levels at individual dams or through particular river reaches, such as the lower Snake and lower Columbia Rivers. This new effort, on the other hand, would characterize the locations and extent of dissolved gas levels produced by dams on the main river channels and major tributaries of the Columbia and Snake Rivers. The geographic scope of this cooperative effort will include river basins in British Columbia, Canada, and the states of Oregon, Washington, Idaho and Montana. The Transboundary Gas Group is working on this comprehensive system-wide evaluation which will include all significant U.S. and Canadian projects. Results of the Chief Joseph Dam Gas Abatement Study will be included in this larger system-wide evaluation.

10. Chief Joseph Dam Gas Abatement Project

Milestones:

Complete Initial Appraisal Report	May 1998
Complete Alternatives Screening Document	November 1998
Complete System Evaluation Plan of Study	March 1999
Initiate Physical Model Development	April 1999
Initiate Numerical Model Development	April 1999
Complete Plan of Study	April 1999
Conduct Near-Field Testing	June 1999
Complete System Evaluation	September 1999
Complete Model Studies	January 2000
Draft Report Complete	January 2000
Draft Report to NWD & HQ for IRC Review	January 2000
Issue Resolution Conference	29 February 2000
Report Reach Washington Review Level CECW-P	27 March 2000
HQ to ASA (CW)	26 June 2000
Report @ ASA (CW)	3 July 2000
ASA (CW) Approval	1 August 2000
Complete P&S	September 2000
Award Construction Contract	January 2002
Complete Construction	March 2003

Financial Data:

	Total	FY98	FY99	FYOO	FYO1	FY02	FY03
Initial Appraisal	20	20					
Model Studies	720		555	165			
Near Field Testing	135	10	125				
System Evaluation	30		30				
Plan of Study	20	10	10				
Evaluation Report	240		80	160			
P&S	275			275			
Construction	40,000					20,000	20,000
Total	41,440	40	800	600		20,000	20,000

11. **Appendices:**

A. Draft Plan of Study for 1999 TDG Field Investigations, Chief Joseph Dam

B. System Gas Abatement Reconnaissance Level Study Plan, dated 23 March 1999

Draft Plan of Study for
1999 TDG Field Investigations
Chief Joseph Dam

1. **Introduction.** Total dissolved gas (TDG) generated by the dams on the Middle Columbia River contributes to system wide TDG and reduces the ability to provide fish protective spill at downstream dams. The Seattle District Corps of Engineers has given short-term priority to conducting intensive TDG studies at Chief Joseph Dam (CJD). These studies are to be directed at describing spatial and temporal dynamics in TDG both near the structure and downstream in the receiving waters. The information gained can be used in better understanding the gas exchange processes, particularly dissolved gas production from spill and gas dissipation downstream from the project. Results from these studies will enable the determination of benefits associated with gas abatement measures evaluated for CJD such as spillway deflector installation. The planned time for the field-testing is the weeks of May 16 and 23, requiring a total of 14 days to complete.

2. The degree of mixing between powerhouse and spillway releases will be investigated since this is important to the total flux of TDG introduced into the Columbia River. In addition, the study is to characterize transport, mixing, and degassing of dissolved gas that may occur in Lake Pateros, the forebay of the next downstream dam, Wells Dam, located 25 miles below CJD. It is believed that significant degassing may occur in the area know as "Brewster Flats," about halfway between CJD and Wells Dam, where the river is shallow and wide. This portion of the study will aid in evaluating one of the alternatives identified in "Initial Appraisal Report (IAR) of Dissolved Gas Abatement at Chief Joseph Dam." This alternative consists of a structural modification to the river bottom that would enhance dissolved gas dissipation by forcing the river to flow over a shallow, wide sill.

3. **Objectives.** The purpose of the field study is to more clearly define and quantify processes that contribute to dissolved gas transfer during spillway releases at Chief Joseph Dam. In general, the transfer of dissolved gas is thought to be a function of the unit spillway discharge, spill pattern, spillway geometry, stilling basin and tailwater depth and flow conditions, forebay TDG concentration, project head differential, and water temperature. This study will focus on resolving questions regarding accurate source and sink descriptions of mass conservation of dissolved gases from below the dam to an area adjacent to the downstream water quality fixed monitor. TDG time history information as related to specific project operation is of particular interest. The data will be analyzed to provide estimates of the gas transfer throughout the tailwater area that should provide guidance on the relative importance of gas exchange processes within the stilling basin and in the downstream tailrace. The specific objectives of the field investigations are as follows:

- describe dissolved gas exchange processes in the tailwater for various spillway/powerhouse operational scenarios

- describe transport, mixing, and exchange characteristics of the tailrace/tailwater/Lake Pateros area for selected spillway/powerhouse operational scenarios
- characterize and evaluate the functional operation of the present fixed monitoring systems in both the tailwater and forebay of Chief Joseph Dam
- provide recommendations for future WQ monitoring as needed for gas abatement
- provide recommendations for minimizing TDG resulting from Chief Joseph project operations

The conclusions drawn from this effort will aid in the identification of operational and structural measures that reduce dissolved gas supersaturation.

4. **Approach.** A single TDG monitoring study will be conducted to address all of the objectives stated above. The work will include near field sampling (immediate tailrace/tailwater often within aerated flow) and far field sampling downstream of the tailwater and out of the aerated flow). This field study will employ an array of approximately 32 automated remote logging instruments, which are capable of describing the complete water quality time histories. The instruments shall be deployed in a spatial pattern adequate to quantify the water quality and hydrologic processes characteristic of the river/reservoir system. In addition, the instruments will be programmed to measure and log data on a routine time interval of 15 minutes. The variables include total dissolved gas (TDG), dissolved oxygen (DO), temperature (T), and depth (Z). Manual sampling, will be used where and when necessary to supplement the automated approaches.

5. The intent of the instrument array is to quantify the TDG flux at various locations in the Columbia River near and downstream of the CJD. The TDG instruments will be deployed on multiple transects, including one above the dam plus several immediately below the dam, and downstream to Wells Dam. This deployment array will provide direct assessment of the lateral and longitudinal Gradients and dynamics in TDG concentrations throughout study area. This will then provide descriptions of the gas exchange characteristics of the existing CJD spillway, stilling basin, and tailrace.

6. Near field sampling instruments deployed downstream of the spillway from the stilling, basin end sill to the fixed monitoring station (FMS) will be placed along three to six longitudinal profiles forming two to three lateral transects. The first of these near field transects will be located about 400 ft downstream of the spillway but upstream of the powerhouse. A second transect of instruments will be located at the Highway 17 bridge at Bridgeport near the existing tailwater fixed water quality monitor. Auxiliary instruments will be located in the forebay, in the tailwater off the powerhouse deck, and at two additional transects across the Columbia River between Chief Joseph and Wells Dam (far field).

7. The additional downstream transects in Lake Pateros will allow the characterization of TDG dissipation down to the Wells Dam forebay, located 25 miles below CJD. The first

downstream transect will be positioned at the highway 173 bridge downstream of Brewster. The farthest one will be in the Wells Dam forebay.

8. Velocity data describing flow distributions at selected TDG transects will be taken to allow the estimation of TDG flux down the river as well as hydrodynamic interactions between generation and spill water. This will support the rating, of operational scenarios in TDG production. It will also provide support in describing transport processes throughout the receiving waters.

9. **Operating Conditions.** Spillway discharge and hydropower discharge will be systematically varied during the field study to achieve a total project discharge of 180 kcfs (or average daily for the week of testing). A second tailwater elevation will be examined during the testing. This will be accomplished by operating at a second total river flow of 80 kcfs for two treatments during the study. The spillway will be operated in a uniform pattern across bays 2-19 for a range of 18.0 to 97.2 kcfs. This will result in individual spillbay releases of 1, 2, 3.1, 4.2 and 5.4 kcfs. Spillway discharges will then be concentrated on the south side of the structure to achieve higher per spillbay discharges of 7.8 and 10.1 kcfs but remain under a total spill of 90.9 kcfs for the project.

10. Powerhouse discharges are expected to range from 42 to about 162 kcfs to allow a total river discharge of approximately 1 80 kcfs throughout most of the test. Total river discharge and tailwater elevation should remain constant throughout the test treatment time periods. Two powerhouse-operating scenarios based on the location of turbines will be tested. One in which all generation is forced to the west or downstream end of the powerhouse and the second using turbines on the east or upstream end of the powerhouse.

11. The testing will require 4 days to complete all requested treatments. For the first 2 days, each spill/powerhouse combination discharge or test treatment will last for 2 hours. A 2-hour spill outage will be required during the middle of the day to allow river conditions to return to ambient before running the afternoon treatments. Treatments required to examine the second powerhouse condition will be run for 2 hours each on the second day of testing.

12. The third and fourth days will start with 5-hour treatments of 2 and 4.2 kcfs respectively. These long duration treatments will be followed by 4-hour spill outages to allow the river to return to ambient conditions for TDG pressures. This will be followed up with short 2-hour treatments of fairly high bay specific spills of 10.1 and 7.8 kcfs on days three and four. The last treatment on each of these days (2 kcfs for day 3 and 4.2 kcfs for day 4) is to be conducted at a total river flow of approximately 100 kcfs lower than the normal flow treatments. This will give an approximate 5-foot drop in tailwater elevation.

13. **Real Time Monitoring.** Real time TDG monitoring will be conducted throughout the testing at the existing fixed water quality monitoring stations located in the Chief Joseph forebay and tailwater sites and at the Wells Dam forebay site. In addition, a manual sampling boat will be operated at the Highway 173 Bridge in Brewster. This information will be used to provide real time guidance regarding TDG concentrations moving down the river and potential water quality compliance violations, which may result. The data may be used in modifying test conditions to prevent biological impact in the downstream reaches.

14. Stage and velocity information collect in these studies will be use to calibrate and verify the general physical model of Chief Joseph Dam.

15. <u>Test Schedule and Project Operations.</u>

Date	Hour	SpillBay	KCFS/Bay	QS(KCFS)	QG(KCFS)
May 17	1000-1200	Coordination/Safety Meeting at Chief Joseph Dam			
May 18	1300-1700	4 hours of No Spill for Instrument Deployment			
May 24*	0800-1000	2-19(2hr)	1	1.8	162
	1000-1200	2-19(2hr)	3.1	55.8	124.2
	1200-1400	(2hr no spill)			
	1400-1600	2-19(2hr)	5.4	97.2	82.8
	1600-1800	11-19(2hr)	5.4	48.6	131.4
May 25**	0800-1000	2-19(2hr)	1	18	162
	1000-1200	2-19(2hr)	3.1	55.8	124.2
	1200-1400	(2hr no spill)			
	1400-1600	2-19(2hr)	5.4	97.2	82.8
	1600-1800	11-19(2hr)	3.1	27.9	152.1
May 26*	0500-1000	2-19(5hr)	2	36	144
	1000-1400	(4hr no spill)			
	1400-1600	11- 1 9(2hr)	10.1	90.9	89.1
	1600-2000	(4hr no spill)			
	2000-2200	2-19(2hr)	2	6	44
May 27*	0500-1000	2-19(5hr)	4.2	75.6	104.4
	1000-1400	(4hr no spill)			
	1400-1600	11-19(2hr)	7.8	70.2	109.8
	1600-2000	(4hr no spill)			
	2000-2200	2-19(2hr)	4.2	75.6	4.4
May 28	(No special test conditions required)				
May 29	0800-1200	4 hours of No Spill for Near Field Instrument Retrieval			

***** Generation flows from upstream end of powerhouse
****** Generation flows from downstream end of powerhouse

16. <u>Water Quality Instrument Maintenance and Calibration (see Appendix A)</u>

17. Velocity Methods and Instrumentation (see Appendix B)

18. Field Operations Safety Plan (see Appendix C)

19. Points of Contact. The WES primary points of contact for this work are Joe H. Carroll 541.298.6656 and Mike Schneider 601.634.3424.

23 March 1999
North Western Division
Seattle District

SYSTEM GAS ABATEMENT RECONNAISSANCE LEVEL STUDY PLAN

1. Project: Columbia River System Gas Abatement Study, Columbia River, Washington and Oregon.

2. Study Authority: 1998 National Marine Fisheries Service Biological Opinion (BiOp) which states "The Action Agencies ... shall jointly investigate operational and structural gas abatement measures at Grand Coulee and Chief Joseph Dams as part of the system-wide evaluation of gas abatement measures."

3. Study Area: The area of study encompasses the US Columbia and Snake Rivers from Grand Coulee Dam on the upper Columbia River and Lower Granite Dam on the Snake River downstream to the mouth of the Columbia River.

4. Problem and Purpose of Study: This system study is in response to concerns of significant impacts to salmon and steelhead from increased levels of total dissolved gas (TDG) in the Columbia River system ranging from downstream of Grand Coulee/Chief Joseph Dams to the mouth of the river which exceed state and federal water quality standards. TDG levels have increased throughout the river in recent years due to higher than average flow conditions resulting from Endangered Species Act (ESA) actions as well as increased flood control actions both of which require increased spill at many of the Columbia River Dams. Chief Joseph Dam is the upper boundary for the geographic range of the Upper Columbia River Evolutionary Significant Unit (ESU) within which steelhead have been listed as "endangered" under the ESA on August 18, 1997. Chinook salmon within this ESU have been proposed for listing as endangered. The primary purpose of this broad level system evaluation is to develop a plan of action that will result in system benefit reductions of TDG. The plan of action will include: (1) a determination of what can be done project by project concurrent and parallel with other ongoing gas abatement studies and (2) a priority listing ranking what modifications can be made at each project. Modification recommendations would be both structural and operational.

5. On-Going Studies: Dissolved gas abatement study efforts are underway at individual projects in the Columbia River Basin. In addition, and as called for in the BiOp, the Corps of Engineers and Bureau of Reclamation, with assistance from Bonneville Power Administration, have initiated discussions relative to a joint study to determine the optimal abatement measures for Chief Joseph and Grand Coulee Dams in combination. The Transboundary Gas Group (TGG) is working on a comprehensive system-wide evaluation, which will eventually include all significant U.S. and Canadian projects.

6. System Evaluation Methodology: A reconnaissance level evaluation of the TDG problem in the Columbia River from a system perspective will be accomplished using a (TDG) computer model (SYSTDG). This model will be used to assess how the system would best benefit from alternative solutions. The SYSTDG model will be used to predict TDG levels in the forebay and tailrace areas of the 15 projects involved once the project releases, spill and gas production functions are known and entered into the model. The model will be run under without project conditions to ascertain where the worst TDG areas in the river are likely located and where reductions to the TDG levels should be focused. The results of the model will be used to prioritize where efforts to reduce TDG should be concentrated, based on TDG reduction benefits versus cost. This reconnaissance- study should save some related CHJ and GCL study costs by eliminating some measures from consideration that were identified for intensive investigation in independent project-by-project studies. A parallel goal of this study is to develop a model that can be incorporated into the TGG study efforts.

7. Views of Federal, State and Regional Agencies: Numerous federal, state, and regional agencies are participating in Columbia River gas abatement related activities which are required by the BiOp. The Corps of Engineers and Bureau of Reclamation are working within the SCT/DGT framework to coordinate actions with water resource and fisheries agencies and tribes within the region. There is strong support within the region for a system evaluation of gas abatement measures.

8. Study Issues: This study provides a unique opportunity for the Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration to jointly work to solve a long time "hot spot" within the Columbia system. This reconnaissance level system study is viewed by the three agencies as a subset of the Transboundary Gas Group's comprehensive system-wide evaluation.

9. Estimated Study Costs and Schedule: The estimated cost to perform a reconnaissance level system evaluation study of the TDG problem in the Columbia River using a computer model is $150,000 ($50,000 for model development, $100,000 for analysis). Each agency's contribution is identified below in the cost breakdown. The dollar values reflect in-kind labor with the exception of the model development by WES funded by BPA. It will take approximately 5 months to complete the study. See paragraph 12 for study milestones.

Cost Breakdown:

BPA:	$50K to the Corps for model development by WES
BPA:	$20K for providing load input, participating in study
Corps:	$30K for NWS labor to run scenarios and do sensitivity analysis $5K for NWD Reservoir Control Center participation $5K for NWD Hydropower Branch participation
BOR:	$40K for participation in study

10. Ongoing Chief Joseph Dam Tasks:

Feasibility Study: This next level of evaluation will proceed with modeling, and design of flow deflectors, including an evaluation of installation on fewer than all 19 spillbays. Coincident with this study, the Corps will continue to explore the viability of the side channel option as a long-term alternative. The Feasibility Study will be completed by the end of 2000.

1:40-scale Section Model: A 1:40-scale section model would be used to select a spillway deflector design. This section model would include one complete spillway bay with adjacent piers and a half of each bay adjacent to the complete bay. This model would be used to evaluate and select the most effective spillway flow deflector design to reduce -as saturation levels. Various designs would be evaluated based on the flow conditions in and downstream of the stilling basin through observing aerated flow patterns, dye movement, and some point velocity measurements. The existing design and one deflector design would be selected for detailed evaluation and performance comparisons including installation of pressure cells to document the pressures at selected locations on and in the vicinity of the deflector and the stilling basin baffle blocks. Construction, evaluation and data documentation will take approximately 8 months to complete

1:80-scale General Model: A 1:80-scale general model would be used to evaluate the with-deflector condition performance characteristics of the stilling basin, the potential to transport material into the stilling basin and identify any unacceptable flow conditions due to the three-dimensional characteristics of the spillway and powerhouse flows. The proposed general model would include the spillway, powerhouse (downstream side detailed only), and the channel for about 2,500 feet downstream from the spillway. Recently observed damage to the stilling basin following the spill operations during the 1997 snow melt season supports the need for this model which would be used to document the three-dimensional flow conditions downstream of the spillway for various flow combinations involving the spillway and the powerhouse. The existing design and the deflector design selected from the section model would be installed in this model and flow conditions would be evaluated to determine impacts of the deflectors on stilling basin performance, flow conditions in the channel downstream of the basin, and transport of abrasive material into the stilling basin under various powerhouse operating plans, spillway bay operating plans and deflector lateral placement schemes. Flow conditions would be documented using dye, surface confetti, and point velocities. The area immediately downstream of the end sill would be constructed with a moveable bed to assist in qualitatively evaluating the movement of bed material. If adverse flow conditions were identified, corrective activities would be identified and might include design modifications and /or optimizing spillway bay operation patterns. A number of spillway bay operation and powerhouse flow combinations would be evaluated. Construction, evaluation, and data documentation will take approximately 9 months to complete.

Near Field TDG Studies: These studies are to be directed at describing spatial and temporal dynamics in TDG both near the structure and downstream in the receiving waters. The information gained can be used to better understand the gas exchange processes both near the dam and downstream, an essential step in evaluation of structural modifications for gas abatement. TDG within the stilling basin and throughout the tailwater channel will be measured with an array of dissolved gas instruments. The array of instruments will provide direct assessment of the vertical, lateral, and longitudinal Gradients in TDG levels. Mixing between powerhouse and spillway releases will also be investigated, since this interaction may be important to the total flux of TDG introduced into the Columbia River. The influence of the tailwater depth on the exchange of gas during spillway operation will also be investigated by controlling hydropower releases. At selected cross-sections, TDG will be monitored and velocities will be measured with an acoustic Doppler current profiler to allow TDG flux computations. Testing, evaluation, and. documentation will take 8 months to complete.

11. Ongoing Grand Coulee Dam Tasks:

Feasibility Study: This study is investigating the feasibility for gas abatement of structural alternatives at Grand Coulee Dam. The Feasibility Study will be completed by the end of 2000.

Gas Bubble Disease in Resident Fish Below Grand Coulee Dam: The Bureau of Reclamation and USGS are funding a three-year research effort in cooperation with the Colville Confederated Tribes to investigate whether gas-supersaturated water from Grand Coulee Dam may cause gas bubble disease (GBD) in resident fish in Rufus Woods Lake. Resident fish populations have not been examined systematically and may be protected from GBD by behavioral depth compensation. This research will (1) determine the species composition and distribution in the lake so that we can determine where and when to collect fish, (2) determine the prevalence and severity of GBD in fish collected, (3) determine the significance of observed signs of GBD, and (4) determine if fish are protected from the adverse effects of GBD by depth compensation.

12. Study Milestones:

Milestone	Date
Initial Technical Meeting	1/6/99
Complete Study Plan	3/19/99
3 Agency Approval	4/2/99
Brief SCT	4/22/99
Start SYSTDG Model Development	4/9/99
Complete Model Development	6/9/99
Collect Input Data	4/30/99
Run Scenarios	7/16/99
Analyze Output	8/6/99
Develop Prioritized Project List	8/27/99