Transboundary Gas Group

Agenda

Okanogan Public Utility District Office
1331 2nd Ave N, Okanogan, WA

March 22 & 23, 2011

Meeting Agenda
March 22

1:00 PM	Welcome: introductions and updates	Daniel Millar (Chair) Environment Canada
	Fish spill exemptions for TDG in the Oregon Standards	Susan Braley WDoE for Agnes Lut ODEQ
	Fish spill exemptions for TDG in the Washington Standards	Susan Braley WDoE
	Lab experiments on chum larval and juvenile stages	Trevor Oussorren for James Bruce BC Hydro
	Enhancing water quality at Long Lake Dam	Hank Nelson Avista Corp.
	Update on the TDG activities at Boundary Dam per our physical model, CFD, and prediction tool – with a goal to modify one of our spillways in summer 2012	Kim Pate Seattle City Light
	Chief Joseph & Grand Coulee joint operations discussion	Kent Easthouse USACoE
	The Columbia River Treaty	Kelvin Ketchum BC Hydro
	Enloe Dam pre-tour update	Nick Christoph Okanogan PUD
~ 5:00 PM	Adjourn	

Overnight in Okanogan/ Omak

Lodging Options: http://www.yellowpages.com/98841/hotels

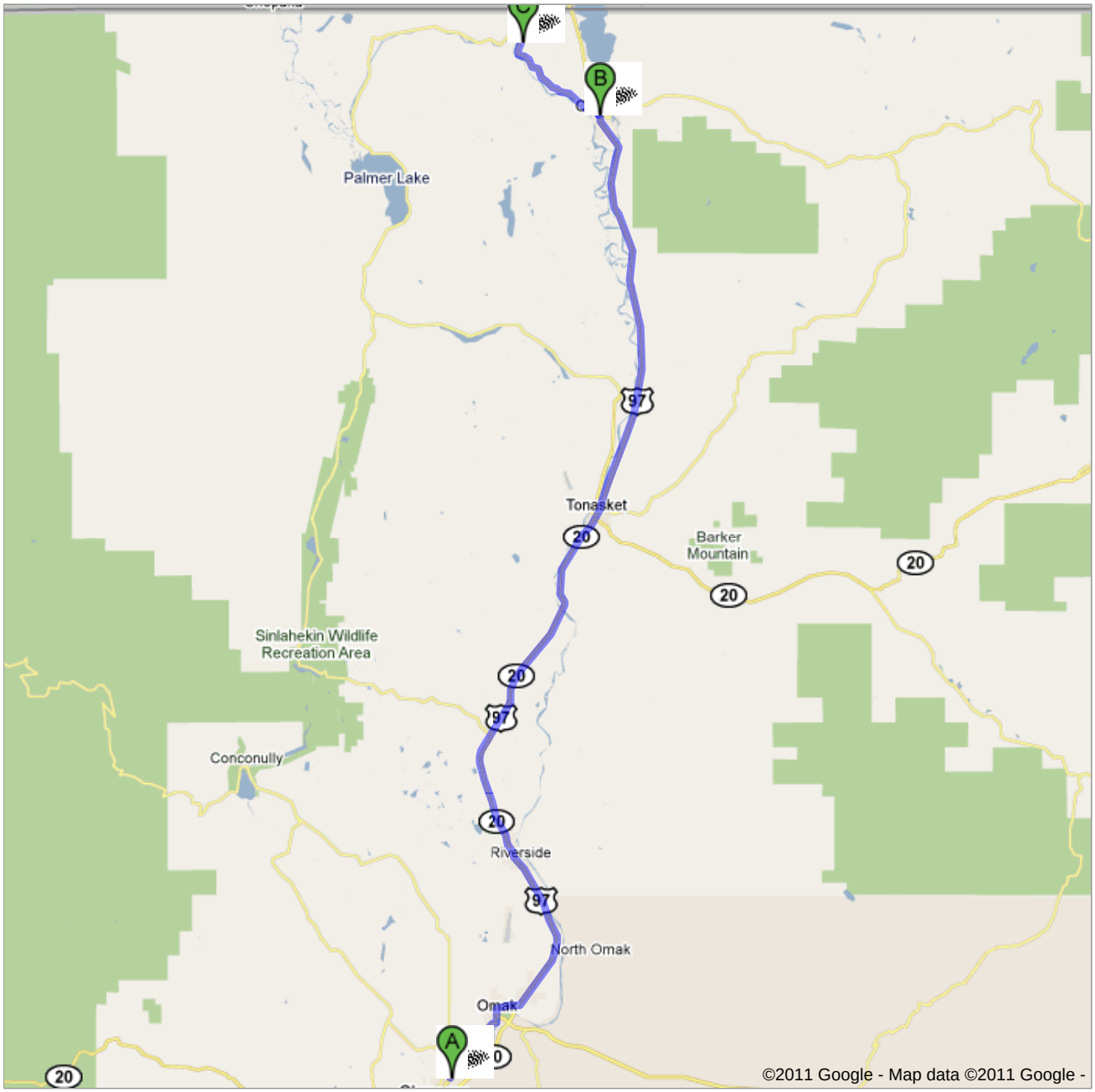
Tour Agenda
March 23, 8:30 AM

Travel to Enloe Dam and Shanker's Bend on the Similkameen River
See attached driving directions.

8:30 AM	Depart Okanogan/ Omak
9:45 AM	Regroup at the Oroville Depot, 1210 Ironwood Street, Oroville
10:00 AM	Depart for Enloe Dam by convoy
10:15 AM	Enloe Dam
11:00	Depart for Shankers Bend
11:05	Shankers Bend
12:00	Depart for home

Google maps Canada

Directions to Loomis-Oroville Rd
49.1 mi – about **1 hour 0 mins**



A 1331 2nd Ave N, Okanogan, WA 98840, USA

	1. Head **northeast** on **2nd Ave N** toward **Greta St** About 2 mins	go 1.4 mi total 1.4 mi
215	2. Continue onto **WA-215 N/Elmway St** Continue to follow WA-215 N About 2 mins	go 1.4 mi total 2.8 mi
	3. Turn right at **4th Ave**	go 0.2 mi total 3.0 mi
	4. Take the 3rd left onto **S Main St** About 2 mins	go 0.6 mi total 3.6 mi
215	5. Continue onto **WA-215 N/Riverside Dr** About 1 min	go 0.9 mi total 4.5 mi
97	6. Turn left at **US-97 N/WA-20 W** Continue to follow US-97 N About 41 mins	go 39.6 mi total 44.1 mi
	7. Turn left at **14th Ave** Destination will be on the left About 1 min	go 361 ft total 44.2 mi

Total: **44.2 mi** – about **51 mins**

B 1210 Ironwood St, Oroville, WA 98844, USA

total 0.0 mi

	8. Head **northeast** on **Ironwood St** toward **Central Ave W**	go 361 ft total 361 ft
	9. Take the 1st left onto **Central Ave W** About 1 min	go 0.4 mi total 0.5 mi
	10. Continue onto **Loomis Oroville Rd** About 8 mins	go 4.5 mi total 4.9 mi

Total: **4.9 mi** – about **9 mins**

C Loomis-Oroville Rd

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Transboundary Gas Group Annual Meeting
and Tour of Grand Coulee Dam

October 27-28, 2009

1. Welcome

Today's meeting was chaired by Daniel Millar of Environment Canada, with representatives of the COE*, USGS, BOR, BPA, Okanogan PUD, Douglas PUD, Teck Metals, BC Hydro, Avista, Grant PUD, WDOE, Seattle City Light, Chelan PUD, the Colville Confederated Tribes and others attending.

2. History and Evolving Purpose of the TGG

Jim Irish (BPA) and Bill Duncan (Teck Metals) gave a presentation focused on the history and purpose of this group. Recently a steering committee member raised the question of whether TGG has fulfilled its mission and should disband. Irish presented a slideshow to frame the discussion.

History. The first TGG meeting was held in 1998 in response to very high flows throughout the Columbia, Snake and Pend Oreille river systems. These had a tremendous impact on Lake Roosevelt, the reservoir behind Grand Coulee Dam. Salmon and resident fish were affected by the high levels of dissolved gas generated by the high flows of 1996-97.

From the very beginning, TGG has served as a technical advisory group, not a regulatory body. This is primarily because dams in the U.S. are regulated by water quality laws, while dams in Canada operate under guidelines that are not considered mandatory, although they are taken very seriously.

Accomplishments. The TGG's first accomplishment was a systematic dissolved gas abatement program, governed by a steering committee and consisting of four technical work groups – biological effects, monitoring, modeling, and operational/structural abatement.

This was followed by a January 1999 review of all available biological literature dealing with the effects of dissolved gas. The result was a number of gas abatement strategies – submerged conduits, spillway gates, extended deflectors and other fixes designed to reduce gas levels.

One of the most effective strategies in the U.S. has been the power trade agreement between Grand Coulee and Chief Joseph dams, with Grand Coulee generating the power and Chief Joseph abating the gas downstream.

Most TDG abatement work in Canada has consisted of expanding existing facilities – an ALGS generating system that generates power instead of spilling,

* See Acronyms on final page.

an expansion at Brilliant Dam; an upgrade at Waneta Dam that allows more water to pass through the bottom of the dam; added generation capacity at other dams. The added generation capacity strips gas out of the water. In the U.S., integrated monitoring of the Columbia River for total dissolved gas is underway.

By 2000, there were 26 entities participating in the TGG, working together to develop Phase 1 of the TDG abatement plan. These included BPA, NOAA, BOR, COE, WDOE, ODEQ, IDEQ, NPCC, two tribes and several public utility districts.

Phase 1 objectives in the U.S. included an inventory of facilities, a database, and simulation models to evaluate gas conditions and potential gas abatement structures. The COE developed SYSTDG, a model that provides likely scenarios for areas throughout the Columbia. SYSTDG and Canadian databases are integrated for transboundary dissolved gas management thanks to TGG. The group also worked on the limitations of operational measures. All of this was useful in developing a system of spill priorities from Grand Coulee down the river. Phase 1 projects in the U.S. have upgraded facilities on the Columbia, Snake and Pend Oreille river systems. Phase 1 in the U.S. concluded with recommendations for structural modifications for a Phase 2 study.

Phase 1 in Canada included a report on gas bubble disease, monitoring for preferential use of spillways, and numerous facility upgrades, mentioned above. These steps have reduced but not eliminated TDG concerns during high flow years. Among the Canadian accomplishments are short-term operational analysis and live modeling, culminating in a 2009 assessment of Ruskin Dam (in the Fraser River basin).

Objectives. Information exchange remains one of the TGG's primary ongoing objectives. Has the group accomplished this goal? Should it expand to address other water quality issues beyond total dissolved gas?

A review of the number of scientific and technical experts who would need to be involved in order to address broader water quality issues such as toxic TMDLs led the steering committee to conclude that the TGG could provide better service by staying focused on its original objective – to reduce system-wide gas to levels that are safe for all aquatic life in the most cost-effective manner possible.

Since the gas abatement work began, TGG has focused on 4 objectives:

1. Characterize existing gas conditions in U.S. and Canada;
2. Identify data and information needs for screening models;
3. Identify structural alternatives for better transboundary gas planning;
4. Establish best gas management practices.

Discussion. Members considered whether the group should continue and whether their organizations would support ongoing attendance. One benefit is the annual opportunity to see other dams and how they have addressed TDG, Bill Duncan (Teck Metals) said. Laura Hamilton (COE) asked how the TGG fits into 2008 BiOp requirements. Phase 1 abatement work addressed several provisions of the BiOp, Irish recalled. The TGG is mentioned in the 2008 BiOp, which also encourages the Corps to discuss and share SYSTDG modeling results at TGG meetings.

The information-sharing alone makes it worthwhile to continue having TGG meetings, someone said. There was a suggestion to combine the annual TGG meeting with the COE's annual TDG monitoring review. Both of these are typically half-day meetings. But the two meetings have different purposes and different audiences, so it would not be easy to blend them.

If information sharing between British Columbia and states in the U.S. is the reason for continuing to meet annually, then let's make that the group's official purpose, Susan Braley (WDOE) commented.

Dan Millar (Environment Canada) asked for volunteers to work with Braley on a subcommittee tasked with developing a charter for TGG. Canada, WDOE, BPA and the COE said they would provide representation on the subcommittee.

3. Inventory of TDG Abatement Work to Date

FOR ACTION: Irish requested any agencies that have made operational or physical changes in order to reduce total dissolved gas levels document the work. Email him this information at jtirish@bpa.gov.

4. Effect of States' TDG Monitoring on Hydro System Operations

Laura Hamilton (COE) gave a presentation describing how modifications to TDG monitoring and tracking affect water quality in the Columbia and Snake Rivers. She covered four topics:

1. The adaptive management team process and results, which affect how the COE manages TDG monitoring on the lower Snake and Columbia rivers;
2. Two recent modifications to TDG monitoring and tracking;
3. Effects of the BiOp court case on how the COE implements TDG requirements;
4. The effect of the hydrosystem and TDG monitoring.

The states of Washington and Oregon and other entities, via the Adaptive Management Team or AMT, have been examining whether the 115% TDG criterion at forebay gages is necessary. What would be the effects on spill, TDG levels and fish survival if the forebay gages were removed?

To answer that question, Oregon and Washington scientists worked together to review all available data. Federal agencies have developed a number of models to use in the AMT collaborative process, including:

- SYSTDG, an hourly model developed by the COE to predict TDG levels and set spill volumes.
- HYDSIM, developed by BPA to generate actual daily flow and spill volumes (based on 70 water years) for use in the COMPASS model. (HYDSIM correlates all water quality regulations, not just those for total dissolved gas.)
- COMPASS, developed by NOAA to quantify survival rates of chinook and steelhead from April-June in the lower Columbia and Snake rivers.

According to COE modeling of spill levels, if the 115% forebay standard were removed, an additional 2.3-5.9 maf of spill would occur per year, mostly from Lower Monumental and Bonneville dams. That results in a 1.1% drop in survival rates for steelhead, attributed to decreased transportation because of the additional spill through the spillway. If TDG were managed to 120%, the additional spill would go to Lower Monumental and Bonneville dams.

All 3 models (SYSTDG, HYDSIM, and COMPASS) were involved in reaching this conclusion. The COE found that the 3 models correlated closely with regard to spill levels, which is considered successful in terms of predictive accuracy. Hamilton showed TGG graphs depicting the -1.1% survival impacts to Snake River steelhead, as well as small positive effects that removing the 115% TDG standard and increasing spill would have on other listed species. The models generate data based on low, medium and high water years.

Based on these findings, the states made two regulatory changes:

1. Oregon eliminated the 115% TDG forebay standard, meaning forebay gages are no longer required by Oregon to assess TDG levels on the Columbia. However, Washington decided to maintain the 115% forebay standard, so forebay gages are still needed for spill management according to Washington standards.
2. Washington revised how TDG exceedances are calculated. While Oregon uses a 24-hour average of the 12 highest hourly tailwater gage readings, Washington uses the 12 highest consecutive hourly readings within a 24-hour period.

Since the border between the two states bisects the Columbia, the COE will operate to the more restrictive standard, which on most days is Washington's. There are occasional days when the Oregon standard is more restrictive at some locations.

A point of controversy has been the use of Camas Washougal gage, located in the upper estuary just below Bonneville Dam. Because it limits spill, both Oregon and Washington have removed the gage from their water quality standards. Nonetheless, the COE still uses Camas Washougal gage as part of the BiOp rollover operation that was court-ordered through 2009.

Neither of the states' regulatory changes has fully taken effect. It's unknown what shape the COE's TDG monitoring plan will take in 2010 as the litigation proceeds. No forebay gages will be physically removed. The COE will use both the Oregon and Washington methods for calculating the high 12-hour average in future, once the BiOp litigation is resolved. Future use of the Camas Washougal gage in spill management is undetermined at this point.

Based on tracking TDG levels in 2008-09, the Washington method of calculation resulted in more TDG exceedances, predominately in the forebay. Susan Braley (WDOE) said she'd heard the COE isn't doing consecutive TDG calculations, just the Oregon calculations. While the COE didn't use consecutive readings for spill management in 2009, these readings were documented in annual TDG and temperature reports, Hamilton replied.

Patti Bailey (Colville Tribe) commented that this strategy doesn't address resident fish. The mid-Columbia PUDs and Avista have published a literature review of all fish species and gas bubble trauma since 1980, recently updated, someone announced.

Discussion turned to the disparate methodologies used by Oregon and Washington to calculate TDG exceedances, particularly the way in which the Washington method can result in double-counting a single incident on two separate days. Since the Washington method tends to result in more exceedances, it could mean less spill when the COE begins applying it when the BiOp litigation is resolved.

As for the BiOp litigation, it likely will be resolved by April 2010 when spill season starts, Hamilton said. Now that the 2008 BiOp has received support from the Obama administration, it's unlikely that it will be completely thrown out by the court, Irish added. So the actual date that the BiOp litigation will be resolved is unknown. Judge Redden will also address the issue of resident fish and their importance to tribes of the Northwest.

5. Discussion of Exceedance Measurements in Various Jurisdictions

Susan Braley (WDOE) discussed monitoring of TDG levels for compliance with the new Washington water quality standards. The standards were revised in 2003, with special conditions for amorphous spill on the Snake and Columbia rivers to help get more fish over dams despite the fact that it will cause higher

gas levels. The WDOE continually grapples with the tradeoff between conditions that benefit migrants and those that benefit resident fish.

By Washington standards, TDG levels may not exceed an average of 115% as measured in the forebay of the next downstream dam, and may not exceed an average of 120% in the tailrace of each dam. These averages are measured as an average of the 12 highest consecutive hourly readings in a day. The 2003 ruling received EPA approval and went into effect in 2008, adding "consecutive" to what was previously the same rule as Oregon's.

Since the rule became effective in February 2008, WDOE has gotten numerous questions from PUDs, the COE and others regarding how the "12 highest hourly readings" should be applied. In April 2008, WDOE responded with a letter defining it as a rolling average of hourly TDG values, with a day defined as from 1 am to 12 am. Each hourly TDG measurement should be averaged with the previous 11 hours. The highest average in a calendar day is what determines whether TDG levels exceeded the standard that day.

Not long after the April 2008 memo was distributed, Grant and Douglas PUDs noted a problem in applying the change – at times, double-counting occurred, with the same incident creating two exceedances. This is because spills often occur in the late evening and early morning hours that transcend the definition of a day. WDOE is working on resolving this issue and will respond to the PUD inquiry soon.

A meeting of PUDs and the COE in June 2008 came up with the following TDG monitoring goals:

- Monitoring should be done from a biological perspective. This supports keeping "consecutive" in the definition of a TDG exceedance because it measures duration of exposure.
- WDOE needs to clarify how data will be used to assess compliance.
- Definition of an "episode" is needed, as distinguished from hourly exceedances.
- The term "day" must be defined so that the "12 highest consecutive readings in any one day" can be uniformly applied to all data.

Until these issues are resolved, Braley recommended that operators continue to report water quality data as they have in the past, noting when double-counting occurs. WDOE will continue its discussions with PUDs on revisions to this methodology. The goal is to have a consistent reporting mechanism in place for 2010 spill season.

For further information on Washington's water quality standards, contact:

- Susan Braley at 360-407-6414, susanbraley@ecy.wa.gov
- Chad Brown at 360-407-6000, chadbrown@ecy.wa.gov.

Commenters responded to Braley's presentation with these observations:

- There are 3 different possible ways to interpret the ruling regarding the 12 highest consecutive readings. This aspect needs definition.
- The most relevant metric is quantifying continuous exposure that results in biological impacts.
- The methodology for calculating radiation exposure at Hanford could serve as an example for how to interpret Washington's TDG ruling.

Canadian dams operate to a guideline of 110% TDG levels in all locations. Compliance is calculated in terms of the number of days TDG levels were in exceedance, based on a daily average. Most spill at Canadian dams is involuntary, and spill arrives at some forebays with TDG readings in the range of 120%. While the TDG guidelines are considered voluntary, dam operators are held to regulatory accountability if they kill fish.

6. April 2009 Spill Test of Deflectors at Chief Joseph Dam

Kent Easthouse (COE) gave an overview of results from the spill tests at Chief Joseph in April and May 2009.

The new deflectors on all 19 spill bays have greatly reduced TDG levels at the dam when compared to 1999 test results without deflectors. The new deflectors are designed for a maximum spillway discharge of 175 kcfs, with a skimming flow, plunging flow or jet action, based on the depth of the deflector.

Spill patterns were found to make a big difference in the amount of gas generated. A uniform spill pattern across all 19 bays created significantly less gas than bulk spill. Higher tailwater elevations produced higher gas levels.

The four-day study had multiple objectives, among them learning the amount of gas produced with different spillway patterns and looking at how powerhouse flows might be entrained with spillway flows as a result of the deflectors. The study looked at what types of spill would produce TDG levels of 110%, 115% and 120% and how the gas moves down the Columbia River. Another chief aspect was optimal joint operation of Chief Joseph and Grand Coulee dams for TGD abatement. Finally, the study looked at impacts of water velocities on hatcheries.

To conduct the study, the COE placed 24 instruments along 5 transects for 12 different spill tests, each lasting 3 hours. Total river flows ranged from 77 to 226 kcfs. Deflector submergence varied by 10 feet depending on powerhouse flows. An overview of deflector performance showed that the maximum TDG level produced was around 120% compared to 135% in 1999 without deflectors.

The COE is using data from this study to develop a regression model of gas saturation based on unit spillway discharge. This effort is complicated by the fact that tailwater depth affects gas production, as well as the type of spill pattern used. The COE is working to improve the model's accuracy in predicting gas levels based on spillway discharge.

Data from the fixed monitoring station was found to be unreliable, so only data from the loggers is being used for the regression model. At the highest spill levels of 98 kcfs and 142 kcfs, gas peaked in the center of the river, not on the banks. Higher flows and deeper tailwaters tended to produce higher gas levels in the center of the spillway. Mobile sampling was used to measure dissolved oxygen as a surrogate for dissolved gas, which takes too long to equilibrate.

The new deflectors appear to be highly effective at reducing dissolved gas. TDG levels were lower than expected with the deflectors in place. In general there was about a 16% improvement with each amount of spill. Previously, gas levels at Chief Joseph shot up fast and didn't level off until they hit 135%.

A primary purpose of the deflectors was to enhance the power trading agreement between Chief Joseph and Grand Coulee. The concept of operating the two dams as one has worked out well from a TDG standpoint.

7. Spokane River FERC Licensing Process at Long Lake Dam

Hank Nelson (AvistaCorp) gave a presentation on TDG abatement work at Long Lake Dam, the main producer of gas on the Spokane river system. This work was part of the Spokane River FERC project to relicense Post Falls, Upper Falls, Monroe Street, Nine Mile and Long Lake dams.

One of the key requirements of relicensing the dams is their ability to maintain a maximum summertime elevation of 2,128 feet at Lake Coeur d'Alene. Nelson showed a photo of the recreational parking lot inundated at 2,136 feet elevation. The difficulty of preventing such flooding is exacerbated by a geological feature that restricts outflow from the lake.

Flow management in the north channel of the river near downtown Spokane was key to the FERC relicensing process. The 26 megawatt Nine Mile Falls Dam outside Spokane tends to strip gas out of the river system. But the next dam, Long Lake, is the culprit when it comes to gas production.

Built in 1915, Long Lake Dam was at one time the world's tallest dam at 217 feet. Numerous entities and tribes helped shape a global settlement agreement that was key to relicensing. Five work groups were involved – water resources, land use, aesthetics, fish issues and cultural resources.

The year 2008 was one of heavy spill on the Spokane River, with 7Q10 flows of 32 kcfs. Stakeholders have been considering a number of alternatives to bring TDG levels under control. The next step will be hiring a contractor to conduct a phase 2 feasibility study of the selected alternatives.

8. TDG Study of New Fish Bypass at Wanapum Dam

Ross Hendrick (Grant PUD) discussed a 2008 study of the new fish bypass at Wanapum Dam, where the current12 spill gates tended to produce high levels of total dissolved gas. The goals of the new bypass system were to pass fish more efficiently, reduce gas levels, and reduce spill at the project. These goals are in accordance with a BiOp requirement of 95% juvenile salmon survival.

At normal flow operations, the bypass flow volume is about 20 kcfs. Vertical inclined gates allow for lesser flow rates and create a skimming flow that helps to dissipate gas.

Objectives of the TDG study were to quantify the impacts of gas in the river; correlate readings in the tailwater 17,000 feet downstream of the dam with those at the transect 2,000 feet downstream; and most importantly to determine whether operating the fish bypass will allow the project to meet both state water quality standards and BiOp survival standards.

The 29-day test found an average of 19-20 kcfs moving through the bypass. It correlated forebay and tailwater elevations to gas levels. Throughout the test period there was only one exceedance of 120% in the tailrace, caused by involuntary spill. In most cases, gas levels stayed below 115% while the bypass was operating. Gas levels entering the forebay were generally low, but as levels in the forebay rose, the daily delta between forebay and tailwater readings got smaller. This data suggests that with increasing Wanapum forebay TDG levels, the delta between the Wanapum forebay and Wanapum tailrace TDG levels decreases, suggesting that maximum TDG levels are likely to remain below WDOE water quality standards within the Wanapum Dam tailrace during operation of the Wanapum fish bypass.

Throughout the test period in July-August 2009, TDG levels stayed well below the 115% and 120% state standards for forebay and tailrace, a promising finding. The normal operation of 140 kcfs through the powerhouse and 18-20 kcfs through the bypass produced gas levels of around 111-116% in the tailrace. Maximum TDG readings for the spill season were below 118% at the tailrace.

There were no problems with sedimentation of the probes during the test. All survival results during the test were well above the BiOp standard of 95%. It became clear that operation of the bypass allows Grant PUD to cut back on spill

for fish passage, while still meeting the BiOp passage requirements. Grant PUD will seek agency approval to operate the bypass during 2010 spill season.

Another mitigating measure at Wanapum Dam was installation of a wire array that appears to have seriously curtailed bird predation. Juvenile survival rates through the bypass showed substantial improvement over pre-bypass survival rates. Attraction flows are being used to guide fish into the bypass. With the bypass system in operation, the only spill through the Wanapum tainter gates is involuntary.

9. BC Hydro's Experiments on Bottom Fish Effects

This presentation was cancelled.

10. Boundary Dam TDG Study Update

Kim Pate (Seattle City Light) and Keith Moen (Hatch Acres) gave a presentation on the process of relicensing Boundary Dam, which is located near the Canadian border upstream of Lake Roosevelt on the Pend Oreille River.

Seattle City Light has been tracking TDG issues at Boundary Dam since 1999. The 340-foot dam has two 50-foot spill gates and operates to a 110% TDG standard. The hydraulic capacity of the powerhouse is 55 kcfs, and the 7Q10 flow is approximately 108 kcfs (53 kcfs of spill flow). Such high flows make controlling gas levels a challenge.

In general there are two ways to pass water through the Boundary Project: the spill gates and sluice gates. It's possible to pass up to 20 kcfs through this existing configuration without increasing TDG levels.

The two most recently installed of the six units in the powerhouse were found to raise gas production significantly because of the way air was drawn into the units. The operation has since been changed to resolve that issue.

As far as mitigating overall gas levels, it's very difficult to reduce entrainment of flows from the two spill gates at Boundary. Researchers have therefore focused on reducing the energy of flows and penetration of the jets. Seven potential alternatives were whittled down to three:

1. Throttle sluice gates that were originally intended for emergency conditions;
2. Roughen the sluice ways so deflectors spread the flow;
3. Modify the existing spillway (dentated flip bucket) to dissipate flow.

The main issue for Alternative 1 is making sure it can be done safely. Throttled flow from the sluice gates hits the water at a steeper angle than if the

gates are left wide open. A computational fluid dynamics model is being used to ensure that throttling the sluice gates doesn't have unintended consequences.

Alternative 2 involves installing deflectors designed to interrupt the angled flow created by the sluice gates.

Alternative 3 involves changes in spill patterns, including roughness elements to change flow dynamics and placing a dentated flow bucket in spillways to spread flows out as much as possible.

A need to spread flows was one of the main conclusions reached in a design workshop held recently. Adding roughness elements to the spillway tends to increase turbulence and break up the jet to reduce the depth of plunge below the spillway. A related concept involves widening the spillway to spread the flow over a greater area and thereby reduce the depth of plunge. However, the presence of post tensioned tendons supporting a large rock mass on the left side of the spillway could make that difficult.

Modeling will continue to assess the three alternatives using two methods: a physical model and a computational fluid dynamics (CFD) numeric model. The CFD model serves to cross-check the physical model and vice versa. Because the physical model is built to a 1:25 scale, it would be impractical to model the entire dam from forebay to tailrace. CFD modeling is used for areas outside the physical model's scope.

Because there isn't much information available on fish populations at Boundary Dam, it could take up to 20 years for sufficient data to be gathered for refining the delicate balance between passing fish and controlling TDG levels at Boundary. The history of how seven alternatives were narrowed to three is described in the study report Seattle City Light filed with FERC in February 2009.

A question about bull trout highlighted system-wide recovery efforts being made collaboratively by U.S. agencies and regional parties. Options for TDG mitigation at Boundary Dam could be used in combination and probably will be – the solution won't be simple, given such high 7Q10 flows. Modifying the deflectors would help, but probably won't be enough. A large part of bull trout recovery will consist of habitat protection at reservoirs.

11. Next Steps and Next Meeting

FOR ACTION: The issue of the TGG's future purpose and direction will receive further scrutiny by members of the subcommittee headed by Susan Braley (WDOE) with Jim Irish, Laura Hamilton, Dan Millar, Bill Duncan, Pat Irle, and Ross Hendrick.

The COE Northwest Division will post TGG's presentations and minutes on its water quality website: http://www.nwd-wc.usace.army.mil/tmt/wqnew/.

The 2010 TGG annual meeting will be October 26-27 in Trail, BC.

12. Tour of Grand Coulee Dam

On Oct. 28, Lynn Brougher (BOR public affairs officer) led several TGG members on a tour of Grand Coulee Dam's right powerhouse and third powerhouse. With three powerhouses and a total generating capacity of 6,809 MW, Grand Coulee is the largest hydropower-producing dam in the U.S. and one of the largest dams in the world. Grand Coulee was built by the WPA for irrigation. World War II shifted its purpose to power production.

The 600 MW and 805 MW turbines in Grand Coulee's third powerhouse, built in the 1970s during the Johnson administration, are so huge they had to be assembled on site. Tour members saw the 805-MW G19 generator disassembled for repairs. It measures 71 feet across and is one of the largest generating units in existence. Lifting the rotor out of G19 requires a 2,000 ton gantry crane, the world's heaviest lifter. The 125 MW turbines in the right powerhouse were built in the 1950s during the Eisenhower administration.

Power production at Grand Coulee tends to peak in the morning and at dinnertime. There are times when Grand Coulee produces no power because demand has fallen off. The temporarily idled generators can be brought on line again in two minutes as demand rises.

Grand Coulee has two reservoirs, one for irrigation and one for power production. It takes six pumps to move water for irrigation into Banks Lake, upstream of Lake Roosevelt. Grand Coulee (which means "dry canyon") has a natural reservoir that was formed by a diversion of the Columbia River during the Missoula floods. The reservoir behind the dam, known as Lake Roosevelt, stores 9.5 maf and extends to the Canadian border. It is considered full at 1,290 feet. The elevation fluctuates by up to 82 feet in a good water year.

Because there's no fish passage at Grand Coulee itself, the dam rarely spills. Spill is usually involuntary, occurring in spring. The reservoir may spill for the sake of later storage capacity. Reservoir elevation must be at least 1,260 feet to spill over the spillway. Spill from a lower elevation passes through the outlet tubes and gasses up the river.

Fish pass downstream of the turbines; there's no passage at either Grand Coulee or at Chief Joseph Dam further downstream. One negative outcome of this has been impacts on the tribal fishery. The federally funded Leavenworth Hatchery supplies chinook, steelhead, and five other species to Columbia River runs. Smolts are released into Icicle Creek and return to the hatchery as adults.

This meeting summary prepared by consultant and writer Pat Vivian.

Attendees

Name:	***Affiliation:***
Patti Bailey	Colville Tribes
Dan Boettger	Okanogan PUD
Susan Braley	WDOE
Chad Brown	WDOE
Nick Christoph	Okanogan PUD
Adam Croxall	BC Hydro
Bob Drzymkowski	USGS Spokane
Bill Duncan	Teck Metals Ltd
Kent Easthouse	COE Seattle
Joe Gilbert	USGS
Laura Hamilton	COE
Waikele Hampton	Chelan PUD
Ross Hendrick	Grant PUD
Wendy Horan	Columbia Power Corp.
Jim Irish	BPA
Pat Irle	WDOE
Clyde Lay	BOR
Daniel Millar	Environment Canada
Keith Moen	Hatch Acres
Josh Murauskas	Douglas PUD
Hank Nelson	Avista Spokane
Joe Orlins	AECOM
Gary Passmore	Colville Tribes
Kimberly Pate	SCL Seattle
Sheri Sears	Colville Tribes
Pat Vivian	writer

Acronyms

ALGS ..... Arrow Lakes Generating Station
AMT ..... Adaptive Management Team
BiOp..... Biological Opinion on Federal Columbia River Power System
BOR..... U.S. Bureau of Reclamation
BPA..... Bonneville Power Administration
CFD ..... computational fluid dynamics
COE..... U.S. Army Corps of Engineers
FERC..... Federal Energy Regulatory Commission
IDEQ..... Idaho Department of Environmental Quality
kcfs ..... cubic feet per second (times 1,000)
NOAA..... National Oceanic and Atmospheric Administration (Fisheries)
NPCC..... Northwest Power and Conservation Council
ODEQ ..... State of Oregon: Department of Environmental Quality
PUD ..... Public Utility District
SCL..... Seattle City Light
TDG ..... total dissolved gas
TGG..... Transboundary Gas Group
USGS..... U.S. Geological Survey
WDOE..... Washington State Department of Ecology
WPA..... Work Projects Administration
7Q10..... The streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval period, or a 1 in 10 chance of occurring in any one year.