The Water Report™
Water Rights, Water Quality & Water Solutions in the West

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KLAMATH SETTLEMENT AGREEMENTS

CHARTING A NEW DIRECTION

by Glen Spain – Northwest Regional Director, Pacific Coast Federation of Fishermen's Associations (PCFFA) and the Institute for Fisheries Resources (IFR)

"The great thing in this world is not so much were we stand as in what direction we are moving."
Oliver Wendell Holmes

INTRODUCTION

On September 30, 2009, the Governors of California and Oregon, the US Secretary of Interior and private utility company PacifiCorp — together with many other parties to the Klamath settlement negotiations, including PCFFA & IFR — announced and released a draft Klamath Hydropower Settlement Agreement (KHSA) intended to determine the ultimate fate of PacifiCorp's four Federal Energy Regulatory Commission (FERC) licensed Klamath Hydropower Project dams (J.C. Boyle, Copco 1 & 2, and Iron Gate Dam), including a schedule and process for deciding whether or not to remove them. A process is also outlined whereby a fifth PacifiCorp dam (Keno, which is FERC-licensed but non-generating) is to pass into federal ownership. Removing Keno dam is not currently under consideration and the "four-dam" removal referred to below applies only to the first four dams mentioned.

Together with the previous draft Klamath Basin Restoration Agreement, released January 15, 2008 (see Simmons, *TWR* #49), KHSA acts as a parallel agreement intended to chart a new pathway for the Klamath Basin out of decades of water crisis, political gridlock, and interminable litigation. Your author's analysis, to be presented in two parts, will provide a critical overview of these two agreements — examining both the strengths and uncertainties of this new pathway.

OVERVIEW

DAMS, RIVERS AND FISH IN THE KLAMATH

The Klamath Basin (Basin) is larger than several US states, containing a land-area of about 15,688 square miles (40,623 km^2), or slightly more than 10 million acres (4 million hectares). Roughly two-thirds of the Basin lie in California, including parts of Siskiyou, Modoc, Del Norte, Humboldt and Trinity counties. One-third of the Basin is in Oregon, comprising parts of Jackson, Lake and Klamath counties and including the headwaters of the Klamath River system and several large lakes. Basin rainfall ranges from nearly 100 inches/year in its coastal rainforests to less than 12 inches/year in the arid high-desert Oregon headwaters of the Upper Basin. Political fragmentation is endemic in the basin.

The Basin was historically the third-largest salmon producing river system in America, trailing only the Columbia and Sacramento-San Joaquin river basins. Before European development, the Basin is estimated as having produced between 660,000 and 1.1 million returning adult salmonids every year, with an average of 880,000. Today, however, more than 90% of its salmon carrying capacity has been compromised in the pursuit of development goals and the ensuing massive loss of habitat.

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ESA-Listed Species

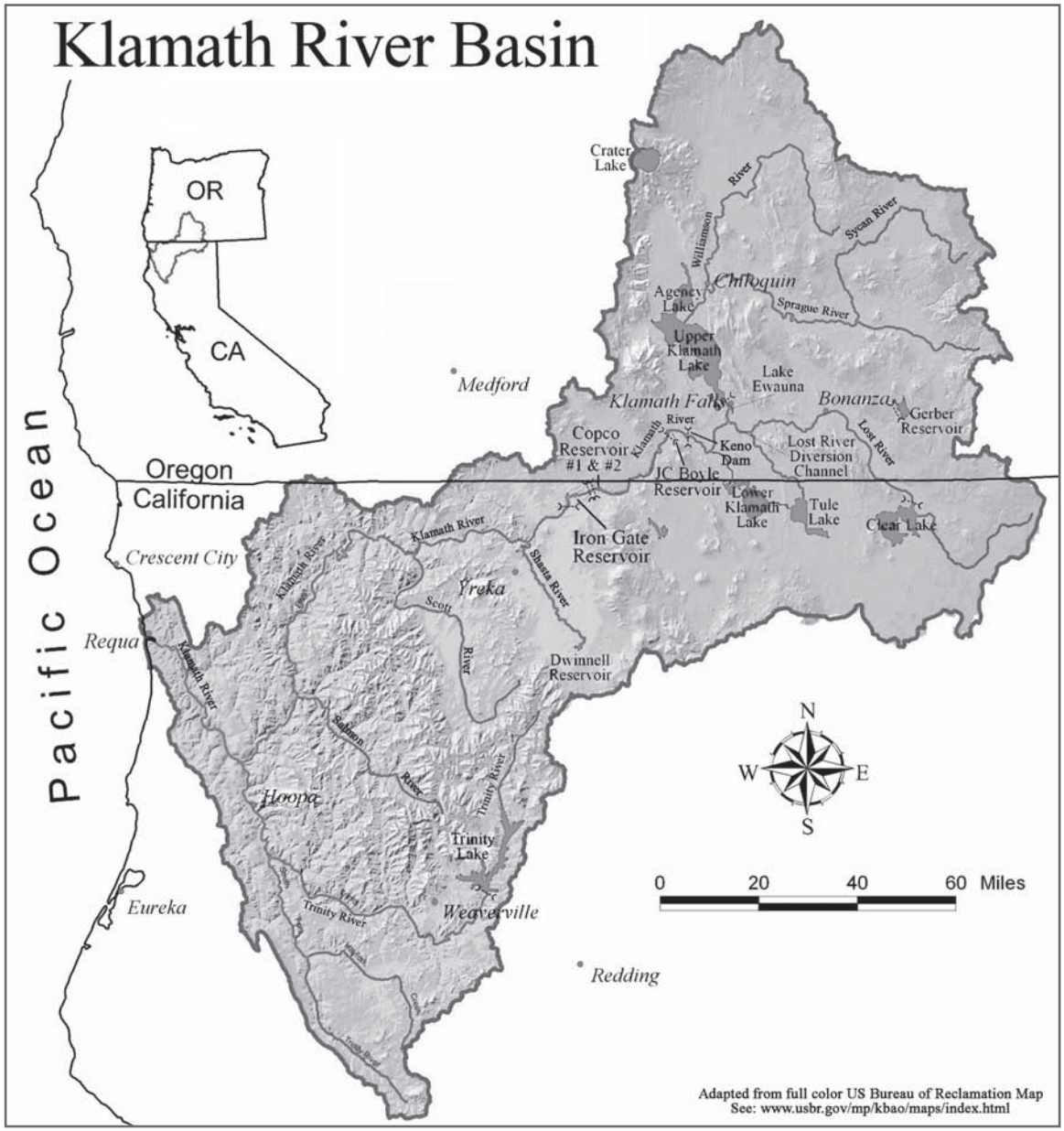
The Water Report
(ISSN 1946-116X)
is published monthly by
Envirotech Publications, Inc.
260 North Polk Street,
Eugene, OR 97402

Editors: David Light
David Moon

Phone: 541/ 343-8504
Cellular: 541/ 517-5608
Fax: 541/ 683-8279
email:
thewaterreport@hotmail.com
website:
www.TheWaterReport.com

Subscription Rates:
$249 per year
Multiple subscription rates available.

Postmaster: Please send address corrections to
The Water Report,
260 North Polk Street,
Eugene, OR 97402



Lost habitat results in declining populations. Some salmon species once common to the Basin, including chum salmon, are now presumed extinct. Other previously thriving fish species or sub-species, such as spring-run chinook and green sturgeon, struggle to survive at seriously depressed population levels. Coho, a particularly important species of anadromous salmon once abundant in the Basin, are now listed as "threatened with extinction" under both the federal Endangered Species Act (62 Fed. Reg. 24588 et seq. (May 6, 1997) as part of the Southern Oregon/Northern California Coho Evolutionarily Significant Unit), as well as under the equivalent California Endangered Species Act. In addition, the Lost River sucker (known to the Klamath Tribes as the "tschum") and the short-nosed sucker ("kuptu") — two other resident fish species dependent on Upper Basin aquatic habitats and culturally important to the Klamath Tribes of Oregon — have been on the federal Endangered Species List (ESA) since 1988 (53 Fed. Reg. 27130 et seq. (July 18, 1988)).

Today the heaviest impact on Klamath salmon production by far comes from a series of power dams built without adequate fish passage along the Klamath River near the California-Oregon border since 1918. In particular, Copco 1 (completed in 1918), Copco 2 (1925), J.C. Boyle (1958), Iron Gate (1962) and Keno Dam (1967) are owned by PacifiCorp (aka Pacific Power), a privately-owned, publicly-regulated, utility providing power to about 560,000 Oregon and 40,000 California customers. Keno Dam is a small mainstem flow regulation dam that produces no power. On average, the other four dams combined have generated only about an average of 88 **m**ega**w**atts (MW) of electrical power over the terms of the last 50-year FERC license, which expired in April 2006. While the relicensing application is pending, FERC has

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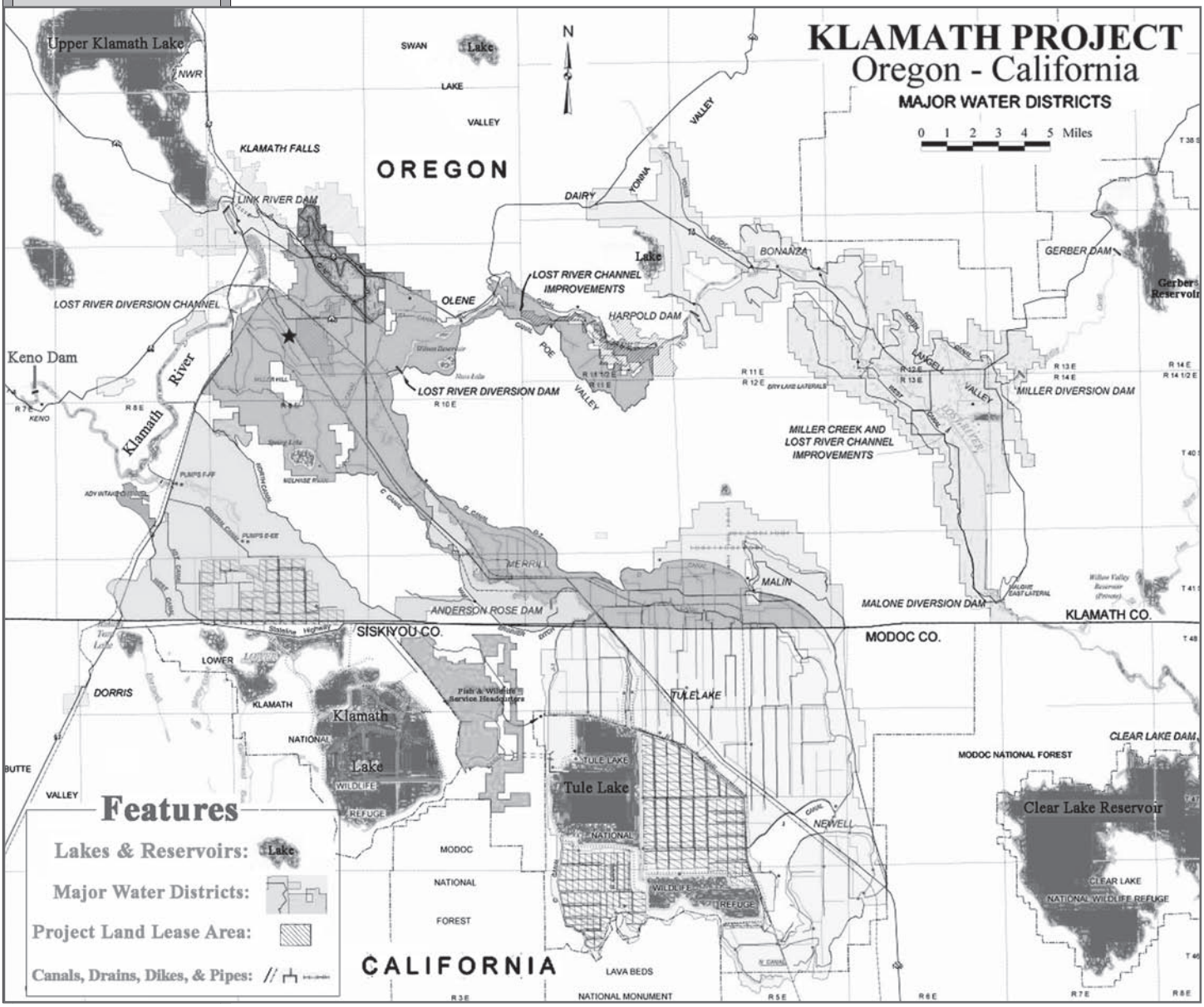
Salmon Habitat

routinely extended PacifiCorp's license to operate the dams on a yearly basis since 2006 on the same terms and conditions as the original 1957 license.

For more than 90 years, the dams have blocked access to more than 600 stream-miles of once fully occupied salmonid habitat above the dams — habitat which fishery biologists estimate could still support as many as 111,000 additional salmon and steelhead (Huntington, C.W., 2006). Reservoirs behind the dams also create or contribute to serious water quality problems, including warming water above tolerance levels for cold-water salmon. The reservoirs also concentrate nutrients, encouraging the explosive growth of toxic blue-green algae and contributing to the growth of fish pathogens downriver (such as Ceratomyxa shasta and Parvicapsula minibicornis).

Reclamation Water Rights

The other major constraint for salmon production is sheer lack of water left in the river. In 1905, the then newly-formed US Bureau of Reclamation (Reclamation) filed Oregon state water right claims to "all the water then available" in Upper Klamath Lake, which feeds the Klamath River, to divert for purposes of irrigation. This allows Reclamation to divert extremely large amounts of water so long as they can use it for irrigation. In the Upper Basin, about 220,000 acres of land are now irrigated as part of Reclamation's Klamath Irrigation Project. Prior to recent federal Endangered Species Act (ESA) constraints, the Project typically diverted up to 435,000 acre-feet of water per year. The highest amounts of diversion occurred during the driest water years — thus exacerbating the impacts of drought on lower river salmon. As noted, much of the Upper Basin headwaters area is perpetually arid and availability of water for fish is always at issue in this area as well.



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There are also at least another 110,000 acres of irrigated land above the federal Project, along the Williamson and Sprague Rivers that feed Upper Klamath Lake. These lands either divert water directly from the flows to Upper Klamath Lake or irrigate using groundwater. The groundwater withdrawals could be reducing nearby stream flows by curtailing inflows from aquifer springs.

ESA Court Decisions

A major source of water conflict in the upper Klamath basin revolves around ESA protections for both resident fish in Upper Klamath Lake and for coho salmon below the dams. The courts have held that various federal water obligations, including those deriving from the ESA and Tribal treaties, are also senior to — and trump all — conflicting Klamath Irrigation Project water contracts. See *Klamath Water Users Assn. vs. Patterson*, 204 F.3d 1206, 1213 (9th Cir. 1996), which held that ESA and Tribal water obligations take precedence over the water rights of irrigators. The federal courts have also ruled that some of the Klamath Indian tribal water rights are senior to all others and date "from time immemorial" (see *U.S. vs. Adair*, 723 F.2d 1394 (9th Cir. 1983)), including the right to sufficient water to protect its Treaty fishery (which includes salmon, although since 1918 salmon could no longer migrate into the Upper Basin). To date, neither of these senior water rights have been given meaningful effect or allocated specific volumes by the relevant Oregon state water agency or through the Klamath Basin Adjudication.

Confrontations

In the case of ESA protections for fish, water over-allocation led to a major confrontation with irrigation water rights during the near-record drought of 2001. Many Klamath Irrigation Project farmers who were dependent upon Project water deliveries found themselves coming up short or losing their anticipated water deliveries (and their crops) altogether that year, causing serious economic losses to these farmers and resulting in a sharp political backlash.

Fish Kill

In 2002, the Bush Administration reacted to this backlash and ordered full irrigation deliveries to the Klamath Project irrigators despite the continuing near-record drought, thus seriously shorting flows needed for salmon protection in the lower river. The result, which was correctly predicted by numerous federal, Tribal and state biologists, was the largest adult fish kill in US history. In 2002, an estimated 70,000 adult spawning salmon died in the lower Klamath River before they could reach their spawning grounds.

These salmon's life-cycle entail a 3-5 year lag time between high mortalities of outgoing chinook juveniles and fewer returning harvestable adults. Consequently, in 2006 the devastating 2002 spawning losses, combined with already serious water quality problems created by the dams, were both major contributing factors in the Klamath fall chinook salmon fishery collapse. This 2006 fishery disaster triggered widespread ocean salmon season closures over more than 700 miles of coastline, with estimated economic losses of at least $100 million. Smaller, but still serious, fishery declines also occurred in 2005 and 2007 from these same causes.

Economic Crises

Thus, back-to-back water, farming, and fisheries crises in 2001, 2002, 2005, 2006 and 2007 resulted in rotating economic disasters throughout the Klamath basin, punctuated by nearly constant litigation and political gridlock. This series of disasters amply demonstrated the desperate need for change in the Basin. The 2006 expiration of PacifiCorp's 50-year FERC license and the looming decision on what to do with its five mainstem dams created both the deadlines and the incentives for negotiating changes.

NEGOTIATED SETTLEMENT

THE BEST AVAILABLE OPTION

FERC Background

Some have argued in favor of simply requiring PacifiCorp to remove its Klamath River dams via the FERC relicensing process. However, FERC has never in its history forced a dam relicensing applicant to remove a dam against its wishes absent a negotiated settlement. Even the one arguable exception — the Edwards Dam in Maine, where FERC appeared about to compel dam removal — ultimately resulted in that dam coming down pursuant to a negotiated settlement.

It follows that the odds are strongly against FERC ordering the Klamath dams removal absent a negotiated settlement of the sort KHSA represents. Indeed, FERC's Final Environmental Impact Statement (FEIS) for the Klamath Hydroelectric Project recommended full relicensing with only a few minor tweaks — even though this pathway is not legally possible (as FERC itself admitted (FERC, 2007)). FERC essentially took the position that deciding whether-or-not to relicense was primarily a PacifiCorp business decision, not one solely for FERC to determine.

Thus, the regular FERC relicensing process is not as secure a route to PacifiCorp dam removal as a negotiated settlement. Therefore, it was essential that PacifiCorp first agree to four-dam removal for it to be obtained with any certainty — which requires a negotiated settlement with the company.

CWA Certifications

PacifiCorp still has an active FERC relicensing application pending. The only remaining legal barrier to PacifiCorp obtaining full FERC relicensing is that PacifiCorp must obtain federal Clean Water Act (CWA) Section 401 Certification from the two CWA-authorized state water agencies (i.e., the Oregon Department of Environmental Quality for J. C. Boyle Dam in Oregon, and the California Water Resources

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Control Board for the three dams in California (Copco 1 & 2 and Iron Gate Dam)). By law, FERC cannot grant a new license unless those two agencies give the project clearances through a CWA Section 401 Certification.

Subject to agreement stipulations, KHSA targets four-dam removal by 2020. Let's compare that to the likely outcome from undergoing the FERC process alone.

Litigation Delays

In order to force PacifiCorp to remove all four power dams via the FERC license denial route, one must first win CWA Section 401 Certification fights in both California and Oregon, with the result that both states firmly deny certification outright or impose pre-conditions PacifiCorp finds prohibitive. One would then have to win all the legal appeals, without exception, all the way through the state court systems in both states, then once again through the federal court system on preemption and related federal issues, and finally go before the US Supreme Court. Seven to eight years of litigation could easily be required. Then, if PacifiCorp loses the appeals in all forums, PacifiCorp could start the whole process over again by withdrawing the original application for CWA Section 401 and resubmitting a new and slightly modified application — administratively giving them one more year to obtain 401 Certification from each state every time they do so — followed perhaps by more years of litigation, and so on. All this could easily delay resolution well past 2020 and maybe past 2030.

"Interim Measures" Requirements

During these potential delays, PacifiCorp would not be required to do any "interim measures" to protect the river or its fish, as it would have to do under KHSA, because it can obtain an automatic annual renewal of its current license from FERC each year, as long as its FERC relicensing application is pending. FERC has always been upheld on these rubber-stamp extensions. Obviously, the river and its fish would not be better off under this purely FERC-track status quo scenario as compared to proceeding under KHSA. Even if KHSA ultimately fails, at least it contains some interim mitigation measures to protect the river.

CWA Certification Issues

Although the California Water Resources Control Board might deny the 401 Certification outright, it is more likely it would simply include conditions. PacifiCorp might be able to meet these conditions (or whittle them down through litigation), again giving them a new 30- to 50-year FERC license. In Oregon, water quality problems generally are much less serious at J.C. Boyle Dam than in the California dams. Thus, PacifiCorp's proposed water quality mitigation measures might be far more effective as well as less expensive at J.C. Boyle Dam. It is therefore not at all certain that the Oregon Department of Environmental Quality will "just say no" to a state CWA Section 401 Certification for relicensing J.C. Boyle Dam, or that a decision to deny Certification would be upheld in court.

In fact, PacifiCorp might well want to hang on to J.C. Boyle Dam. FERC has suggested doing so and this dam is by far the most valuable of the four dams in terms of power production. It is also the one with the least water quality impact (i.e., a very small reservoir). It is quite possible that FERC would approve J.C. Boyle Dam for a new license, conditioned on adding minor fish passage improvements and water quality mitigations, if push came to shove. Therefore, even if the problematic FERC-only track described above eventually results in the removal of the three lower California dams, the J.C. Boyle Dam could remain.

FERC Option Drawbacks

Compared to the Klamath Basin Restoration Agreement (KBRA), the FERC-only track lacks: beneficial interim measures; needed water reforms; additional water left in the river institutionalized in any permanent manner; and a parallel long-term basin fisheries restoration program. Pursuing a FERC-only track, salmon restoration advocates and Tribes would be utterly reliant on the ESA to give them, at best, only the minimum flows sufficient to prevent "jeopardy" — as opposed to achieving true salmon recovery, which is a much higher bar.

KHSA has its own uncertainties and contingencies. If it can be made to work, however, this negotiated settlement gives everyone in the Basin far more certainty of obtaining four-dam removal by 2020.

DECOMMISSIONING VERSUS REMOVAL

No dam, and no FERC license to operate dams, lasts forever. Dams are designed to provide benefits for limited periods of time, after which they can become obsolete and may even become safety hazards as they eventually silt in or crack. This is why FERC generally does not grant licenses to operate power dams for more than 50 years — so each dam project can be reviewed periodically to see if it still efficiently serves its original purposes.

PacificCorp Options

The four Klamath dams are old, dating back to 1918, and do not meet modern dam environmental standards. Copco 1 and 2, and Iron Gate were built without fish passage of any sort, which is illegal under current law, and fish passage at the others is inadequate for salmon. This means that the company that owns the dams, PacifiCorp, is faced with only two legal options: (1) relicense the dams by retrofitting them to modern environmental standards, including installing expensive fish passage or; (2) decommission and remove them, and replace them with more efficient and less costly power sources elsewhere.

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Costs Allocation

Publicly regulated utilities essentially "pass-through" their costs. Utility customers who benefit from power production nearly always pay the total costs of their utility company's power plant construction, deconstruction, and operating costs. Customer payment plans are generally subject to approval by state Public Utilities Commissions (PUCs) which aim to insure that the costs are prudently incurred and are fairly divided. This is how public utilities always operate. This means that if the Klamath dams were relicensed by FERC, PacifiCorp's customers would almost certainly have to pay all of these relicensing costs (including the costs of expensive fish passage construction that current law now requires).

Since neither option will be cheap, PacifiCorp customers will have to pay slightly higher rates to cover these costs regardless of which option is chosen. The real question is: which option will be cheapest for PacifiCorp's customers? The state PUCs will not allow PacifiCorp to recover its costs for either option unless they are convinced the option chosen is the most prudently incurred (i.e. "cheapest") for the company's customers.

Retrofit Option

Though more studies will be done, several studies to date (including a study by the California Energy Commission and another by FERC itself) indicate that dam decommissioning and removal is by far the least expensive option for PacifiCorp's customers (California Energy Commission (Oct. 2007) study available at their website: www.energy.ca.gov >> A to Z listing >> Klamath). Happily, it is also the most effective at protecting and restoring damaged salmon fisheries. FERC, in its Final Environmental Impact Statement (FEIS), for instance, calculated that if all four dams are relicensed with the required fish passage and other mandatory conditions installed, they would operate at a $20 million/year financial loss under the new FERC license (FERC, 2007, pg. 4-2, Table 4-3). Obviously it would not make much sense for PacifiCorp or its customers to subsidize a net loss of revenues by keeping dams that are functionally and financially obsolete.

HYDROPOWER AGREEMENT: KEY ELEMENTS

The basic framework of the current agreement was thrashed out (with some input by other Parties) between the Governors of Oregon and California, the US Secretary of Interior, and PacifiCorp and released as a non-binding "Agreement in Principle" in November 2008. It was contemplated that a binding "Full Agreement" would be developed after that point by multiple parties to the negotiations. With a number of notable improvements, this framework became KHSA. Key elements of KHSA are now discussed.

Dam Removal Decision Process

Removal Decision

Under KHSA, the final decision whether or not to remove the dams is federalized. The US Secretary of Interior will make that decision by March 31, 2012, based on a thorough National Environmental Policy Act (NEPA) analysis and additional studies.

KHSA set forth the standard for determination as follows:

> "Sec. 3.3.1. Standard. Based upon the record, environmental compliance and other actions described in Section 3.2, and in cooperation with the Secretary of Commerce and other Federal agencies as appropriate, the Secretary shall determine whether, in his judgment, the conditions of Section 3.3.4 have been satisfied, and whether, in his judgment, Facilities Removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes."

KHSA Sec. 3.2 outlines the National Environmental Policy Act (NEPA) process for this effort. This process will include conducting additional studies as well as coordination of efforts with the "Parties to the Agreements" and the states, and input from the general public.

KHSA also has preconditions to the Secretarial Determination mentioned above.

Required Preconditions

KHSA Sec. 3.3.4 determination preconditions include:

- enactment of appropriate federal authorizing legislation, essentially allowing the Secretary of Interior to take over some of FERC's traditional authority to make a "go or no go" decision on dam removal in this specific case
- an acceptable agreement for the transfer of Keno Dam from PacifiCorp to the federal government (presumably the Bureau of Reclamation)
- that both Oregon and California have passed appropriate funding mechanisms (Oregon's was recently enacted as Senate Bill 76 in its last Legislative Session)
- a plan to deal with excess costs above a $450 million set-aside to pay for removal, if after analysis the additional money is needed

"DRE"

- the Secretary of Interior's designation of an acceptable entity to actually perform dam removal operations (called the "Dam Removal Entity" or "DRE").

Klamath Agreements

States' Concurrence

Some of these preconditions are more problematic than others. The States of California and Oregon have reserved their respective rights to sign off on the Secretarial Determination, and both must concur with that Determination within 60 days. Though this state "right of concurrence" has been criticized by some as an unnecessary off-ramp, as a matter of law neither state can devote its resources nor issue state permits for such a project without formal state approval. California must also do its own parallel environmental analysis under the California Environmental Quality Act (CEQA) (KHSA Sec. 3.2.5(B)). Oregon would base its concurrent decision on a somewhat similar analysis (KHSA Sec. 3.2.5(C)). To prevent unnecessary duplication, however, both states may tier their analyses off of NEPA documents in the federal process (KHSA Sec. 3.2.3). If the Secretary appoints a federal Dam Removal Entity (the presumptive pathway under the KHSA), there is no concurrence by the states necessary to this appointment; a second concurrence is only necessary if the DRE is a non-federal entity (KHSA Sec. 3.3.5(A)(ii)-(iii)).

Payment for Removal: Who and How Much?

Cost Cap

Until more engineering studies have been completed, no one can closely estimate how much removal of the four mainstem Klamath power dams (and transfer of the Keno flow regulation dam) will actually cost. This is why, in November 2008, the initial four-party "Agreement in Principle" (AIP) set aside a contingency "State Cost Cap" fund of up to $450 million for dam removal purposes. However, as a precautionary measure, the State Cap Cost is much larger than the likely costs of removal by a factor of perhaps two-to-three times.

Removal Cost Estimates

There is comfort in knowing that FERC itself estimated four-dam removal costs at only $79.9 million, and that other studies cited by FERC Staff in the FEIS came in between $37.5 million and $102.4 million (FERC, 2007, pg. 4-6, Table 4-4; all in 2006 dollars). All these engineering estimates were, however, preliminary. The estimates also assumed no significant problems with toxic contamination in reservoir sediment. Any toxic disposal problems could greatly escalate costs. Fortunately, there does not appear to be any significant toxic contamination in the reservoirs indicated in any of the preliminary studies, but this must be confirmed.

State Contributions

In the AIP it was decided that roughly equal contributions toward dam removal should come from each of the two states in which the dams sit. However, only 45,000 of PacifiCorp's customers reside in California, so PacifiCorp's contribution would come primarily from its approximately 560,000 Oregon customers. Nevertheless, three of the four dams are located in California — and most of the economic benefits of restored salmon fisheries would also accrue to California — so it was decided that a roughly comparable amount should come from California through the only funding means then available, i.e., as part of a conservation bond package. These two funds make up the "State Cost Cap" of up to $450 million, which is the maximum funding responsibility the two states were willing to bear. Dam removal costs will be paid for through this fund, not through Congressional appropriations.

California Water Bond Act

The "State Cost Cap" will, therefore, be composed of two funds: (1) a PacifiCorp contribution of up to a cap of $200 million as the initial funding, accumulated between now and 2020 through a small ratepayer Klamath surcharge capped at about $1.50/customer-month in a typical utility bill (i.e., capped at 2% of current rates). Collection of these PUC-supervised Klamath Trust Funds is already provided for under Oregon Senate Bill (SB) 76; (2) passage of a California Water Bond Act providing up to an additional $250 million from California, if needed. That Klamath bond funding is part of the current proposed California Water Bond Act ("The Safe, Clean and Reliable Drinking Water Supply Act of 2010") that will go before California voters in November, 2010.

Removal Study

There is federal contribution to this process. Through already appropriated funds, additional engineering studies will be conducted through at least the summer of 2011 by the federal government to firm up dam removal cost estimates in what is referred to in the Agreement as a "Detailed Plan." This will be the basis of the Secretarial Determination, in which costs will matter. Nevertheless, given the precautionary approach used to develop that number, it is highly likely that total costs of four-dam removal will be considerably under the $450 million "State Cost Cap."

Cost Cap Protection

It should be emphasized that under the current negotiated Settlement Agreement, if PacifiCorp removes the dams, its Oregon customers are protected under the SB 76 "cap" from paying more than a total of about $200 million. If, however, the Settlement did not exist (or breaks down and is terminated) and PacifiCorp went back to FERC for a new license, its customers would have to pay the entire costs of expensive fish passage and other retrofitting that would be required, plus potentially expensive additional water quality mitigation measures, without any rate increase "cap" to protect them. This is another reason the negotiated Klamath Hydropower Settlement Agreement is a good deal for PacifiCorp's customers.

Klamath Agreements

Federal Shift

Dam Removal Entity

The most important single change between the original November 2008 four-party "Agreement in Principle (AIP)" and KHSA is that under KHSA a *federal* Dam Removal Entity (DRE) is highly likely. The Bush Administration refused to consider a federal DRE at all. Since there are no likely non-federal DRE candidates, this became a major problem for the feasibility of the project as a whole. The Obama Administration has now corrected this problem. For various reasons, a federal DRE is likely to be cheaper, more efficient, and far more likely to accomplish the project on time and within budget than an unknown private corporation. Under the enabling legislation, the US Secretary of Interior would have the authority to designate any agency within the Department of Interior for that purpose.

Nevertheless, the Secretary of Interior cannot make a DRE decision until due diligence NEPA analysis and appropriate engineering studies to create a Detailed Plan for dam removal have been completed. Thus the Secretary must reserve that final DRE decision as part of the Secretarial Determination to be made by March 31, 2012 (KHSA Sec. 3.3.5(A)(i)).

2020 Target Date

Dam Removal Timelines

Another major improvement between the previous AIP and KHSA is that the target date for physical dam removal will now be 2020. Under the original AIP it could have been delayed until 2025 or later.

As a practical matter, it will probably take about ten years from execution of KHSA to jump through all the NEPA, CEQA, permit and probable litigation hoops necessary to get to physical removal by 2020. Similar dam removal projects have taken as long or longer. However, during the interim the Klamath Trust Fund rate surcharge account will continue to accrue funds to pay for dam removal, with the full $200 million projected to be reached in 2020 in conjunction with obtaining the required permits.

Facilities Transfer

The physical facilities of the dams, including underlying lands, are to be transferred by PacifiCorp once both those events occur — removal funding is available and all required permits obtained — upon request by the DRE. The necessary preparation for dam removal, of course, has already started — and indeed, could be said to have started several years ago as part of making the FERC record. The accumulating Klamath Trust Fund can be used to pay for preparatory steps toward final physical removal as 2020 approaches.

Liability

PacifiCorp is only entitled to liability protection under KHSA and its authorizing legislation from actual dam removal activities after title to the Project facilities and underlying lands are transferred from PacifiCorp ownership and control. The liability protection does not encompass any of PacifiCorps' actions before that time (KHSA Sec. 2.1.1(E)(i)).

Interim Protection

Interim River Protection

Under KHSA there are a number of "Interim Measures" that PacifiCorp will pay for and implement that will help to keep water quality and other conditions in the Klamath River from deteriorating any further during the interim period between now and the 2020 removal target date. These are expected to cost PacifiCorp several million dollars a year to perform (see KHSA Appendices C & D).

TMDL

PacifiCorp will also be responsible for meeting its later mainstem Klamath **t**otal **m**aximum **d**aily **l**oad (TMDL) requirements that are scheduled to be adopted by December. 31, 2010. A later TMDL Implementation Plan will be worked out between PacifiCorp and the relevant water quality agencies of each state (KHSA Sec. 6.3.2). PacifiCorp will also have to implement TMDL load allocations for Keno dam up until the time of its transfer to the federal government (KHSA Sec. 6.3.3).

Hydropower 88MW

Replacement Power Options

While the Klamath dams do provide hydropower that is carbon dioxide (CO_2) neutral, they do not actually provide very much power — only about 88 MW of power on average, representing less than 2% of PacifiCorp's total power generation. Moreover, the dams also cause enormous damages to the Klamath River's once-abundant salmon fisheries and create serious water quality problems. A power source that kills salmon in large numbers is not in any environmental sense true "green power."

The 88 MW of hydropower that the Klamath Dams create can be easily replaced by true "green power" elsewhere. PacifiCorp is already committed to bringing 1,400 MW of such renewable power online (mostly wind power) by 2016 as part of the deal it made with the state PUCs when the company was purchased by MidAmerican Energy Company in 2006. Thus, completely replacing the small amount of carbon-free power the Klamath Dams generate with an equivalent amount of true "green power" is feasible to do over the next few years. Under KHSA, Replacement costs are completely absorbed by PacifiCorp.

Klamath Agreements

Legislative Requirements

Implementing Legislation

Giving the Secretary of Interior decisional power over Klamath dam removal preempts traditional FERC jurisdiction and this will require special Congressional authorization. Additionally, the federal government accepting transfer of Keno Dam (assuming mutually acceptable terms can be negotiated) also requires Congressional authorization, as does authorizing acceptance of the dams by a federal DRE. Congressional authorizing legislation is necessary to implement KBRA, even though its implementation is not dependent upon specific Congressional appropriations. Instead, dam removal is self-funding through State Cost Cap funds.

Parallel Agreements

Connection to the KBRA

KHSA connects to the KBRA in only two ways: (1) the two documents must be executed together by most negotiating Parties (except PacifiCorp, which will not be a Party to the KBRA, and the Federal Parties, which can only sign after Congressional authorization); and (2) the KHSA Congressional authorizing bill will be the same bill containing the KBRA, though with a separate title. Thus, the two agreements remain connected and parallel, but KHSA is not dependent upon the full funding or implementation of any particular provisions of KBRA. No event in the KBRA can "crash" the KHSA if it fails, and dam removal is thus not directly dependent upon the KBRA.

KHSA WEAK POINTS

There are two primary weak points in implementing the KHSA that cannot be ignored.

Bond Measure Tie-In

Problematical California "Water Bond Act" Funding

The $250 million bond funding mechanism for California's contribution to the "State Cost Cap" is unfortunately entangled in California's thorny water politics. The Safe, Clean, and Reliable Drinking Water Supply Act approved this November by the California Legislature as SBX7-2 contains the Klamath bond money but only as a small part of a massive $11.14 billion dollar water bond measure (Water Bond Act) that contains many highly controversial provisions that have nothing to do with the Klamath.

Delta Issues

Many people believe the Water Bond Act is a stealth mechanism for jamming through construction of the contentious "Peripheral Canal" which would ship even more northern California river water away from the damaged San Francisco Bay Delta than occurs today. Not only do many see this as a southern California water grab, but the Peripheral Canal would have devastating impacts on key Central Valley salmon runs that depend on the ecological health of the Delta for their survival. (See Nomellini, *TWR* #53).

For these and other reasons, the Water Bond Act may simply not pass in November, 2010. The next opportunity to put California's share of Klamath money before California voters would not come until well after the Secretarial Determination is to be made by March 31, 2012. Since passage is a prerequisite for this Determination, failure to pass could create quite a bind for implementing KHSA.

"Safety Valve"

Fortunately, there is now a "safety valve" provision in KHSA Sec. 3.3.4 that allows the Secretary to still make that Affirmative Determination if the money that will be available turns out to be sufficient to meet the needs, or if not, that the Secretary has received "satisfactory assurances" from California that the additional money necessary from California will be available by the 2020 target date for removal. If the Water Bond Act does not pass, there are alternative ways of funding this effort that will have to be explored.

Keno Dam Transfer

Terms for the Disposition of Keno Dam (Sec. 7.5)

A new pre-condition to the Secretarial Determination is that a transfer agreement must be negotiated between PacifiCorp and the federal government for the transfer of PacifiCorp's Keno Dam, presumably to Reclamation (KHSA Sec. 3.3.4(B)). Keno Dam is part of PacifiCorp's current FERC license and remains under FERC jurisdiction until that transfer.

Unknown Costs

Those negotiations will need to address the unknown costs of upgrading Keno Dam to meet more stringent federal dam safety standards, and costs of upgrading fish passage at that small dam to meet the needs of salmon and steelhead that will be swimming upriver once the lower dams are removed. There are also many potential CWA compliance problems associated with Keno Reservoir. While nothing in these negotiations seems insurmountable, this additional contingency does add to an already complicated deal.

Klamath Agreements

DIRECT FEDERAL DAM TAKEOVER: PROBLEMS

Some critics of KHSA's negotiated settlement route (or of its parallel KBRA) have proposed a direct and immediate "federal takeover" of the dams as a faster and "cleaner" alternative that does not tie dam removal to the KBRA. Is this really a viable alternative?

Federal Takeover Funding Problems

Condemnation Option

A never before used provision of the Federal Power Act (FPA) (16 U.S.C. § 807(a)) does theoretically allow for federal condemnation takeover of abandoned (but unlicensable) dams after the termination or surrender of its FERC license by the owner. Congress may also provide for federal takeover through separate special legislation, though in practice this has been very rare.

In fact, KHSA does set up a de facto federalized dam removal process. As discussed above, under the agreement the designating of a federal "**d**am **r**emoval **e**ntity" (or "DRE") is one likely outcome of the March 31, 2012 Secretarial Determination. The KHSA process has an important difference from federalization per se, however, in that dam removal costs will be paid almost entirely by PacifiCorp and other non-federal funds.

Federal Costs

Without KHSA, any immediate federal takeover would be very expensive for the federal Treasury — a politically problematic path even in good economic times. Under an immediate federal condemnation, Congress would have to first appropriate and pay directly to PacifiCorp the company's total "net investment" in the Klamath Hydropower Project (estimated $60 million), plus potentially pay other PacifiCorp reimbursement claims incurred in the condemnation process, plus thereafter pay for all the costs of dam removal. Under KHSA, the federal government pays none of these costs.

Political Considerations

In addition to having its $60 million net investment costs in hand, under a federal takeover PacifiCorp would also walk free of $200 million in dam removal funding obligations. For Congress to bail a private power company out of financial obligations for power plants from which it has earned profit and to assume costs generally required as part of their FERC license, would not be politically popular with Congress or the American public at large.

Putting Klamath dam removal at the mercy of the annual Congressional appropriations process also means making dam removal a political football for unrelated Congressional issues, as well as forcing dam removal to compete against every other federal interest in a seriously deficit federal budget.

Elwha Dam Example

A good example of a federal takeover of this sort would be the Elwha Dam in the Puget Sound area of Washington State. After years of struggle, this FERC licensed dam — which was privately owned but built illegally on federal lands — was specially authorized by Congress for federal takeover and removal by the Elwha River Ecosystem and Fisheries Restoration Act of 1992. Funding for all the necessary studies, however, was held up year after year by former Senator Slade Gorton and others, because of completely unrelated political issues. Only now, more than 17 years later, is Elwha Dam removal likely to move forward next year — that is, if funding is not blocked again in Congress in the meantime.

Under KHSA, since no Congressional money would be required to fund dam removal itself, the project is largely immune to annual appropriations battles and deficit budget politics in Washington, DC.

Federal Takeover Dam Removal Adverse Time Impacts

Probable Delays

Some people have suggested that under a federal takeover the dams could come down starting in 2013. This is highly unlikely. Any federal takeover would still need all the engineering studies to develop a solid removal plan, as well as an extensive NEPA process to assess the environmental impacts of such federal action, including a similar Secretarial Determination (though with no clear deadline as under KHSA). A parallel California CEQA process would also still be required to obtain various state permits. Similar legislative changes as required by KHSA would have to be passed in the California and Oregon Legislatures in order to actually remove the dams. Similar delays would be expected to obtain local permits, resolve disputes and conclude likely litigation. All this could easily push the actual demolition date to 2020, resulting in no net gain in timing.

Condemnation Dispute

Such a federal takeover might even cause additional delays beyond 2020 given additional litigation over disputed condemnation claims on "net investment" payments due to PacifiCorp. The only way such litigation could be avoided would be through a settlement agreement with PacifiCorp in advance — which then begins to look very much like the present KHSA.

The year 2020 is only ten years away. Ten years to do all the preliminary work to take down four dams in the largest dam removal project to date is hardly unreasonable. The only practical way to shorten the required statutory compliance timeframes through a federal takeover would be to obtain Congressional waivers of NEPA, ESA, CWA requirements and legislated preemptions of CEQA and various state and

Klamath Agreements

Interim Mitigation Loss

Water Reallocation Considerations

local laws. This would be extremely unpopular with many members of Congress, making passage of such a bill extremely unlikely.

Adverse Fish Impacts

In a federal takeover without KHSA, there would be no provisions for any "Interim Measures" to protect water quality and fisheries between now and actual removal of the dams. Under KHSA, PacifiCorp plans to spend several million dollars each year, over the next ten years, on targeted Interim Measures to prevent further harm to the river and its fisheries while planning for dam removal proceeds. Those numerous Interim Measures are set forth in KHSA Appendices C & D.

Under KHSA, costs of the Interim Measures are chargeable to PacifiCorp's ratepayers as a cost of doing business. Under an immediate federal takeover, even if some mitigation measures were specified they would then be "federal programs" requiring NEPA as well as ongoing annual Congressional appropriations.

Most of the proponents of an immediate federal takeover are ultimately seeking to disconnect dam removal completely from the Klamath Basin Restoration Agreement (KBRA) and to scrap KBRA entirely. However, eliminating KBRA also eliminates all the benefits to the lower river from KBRA provisions that would provide additional water, which would clearly benefit salmon in the lower river. Dam removal alone cannot recover the lower river's damaged salmon runs without major reallocation of water back into the river from reduced Upper Basin irrigation diversions. The KBRA does this. A federal takeover of the dams by itself cannot.

CONCLUSION

The KHSA offers a faster, cheaper and more certain route for removal of the four dams on the Klamath River than any conceivable immediate federal takeover — and with better results for both the river and its salmon. In Part 2 of this article in next month's *TWR*, the Klamath Basin Restoration Agreement (KBRA) will be similarly analyzed, including a close look at the common criticisms of that agreement, its strengths and its weaknesses, and the viability of its critics' proposed alternatives.

For Additional Information:

Glen Spain, PCFFA & IFR, 541/ 689-2000 or email fish1ifr@aol.com

Agreements Website: Copies of the January 15, 2008 draft of the KBRA and the September 30, 2009 draft of the KHSA, plus neutral summaries, are available at www.edsheets.com
PCFFA website: www.pcffa.org
IFR website: www.ifrfish.org

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Glen Spain, JD, is the Northwest Regional Director of the Pacific Coast Federation of Fishermen's Association (PCFFA), the West Coast's largest association of commercial fishing families, as well as Program Director of PCFFA's affiliate organization, the Institute for Fisheries Resources.

ENDOCRINE DISRUPTORS IN WASTEWATER

IMPACTS IN AN EFFLUENT DOMINATED STREAM

by Clint Rogers , Carollo Engineers and Michael Luers , Snyderville Basin Water Reclamation District

Endocrine Disruptors

Wastewater Effluent

Detection Levels

"EDCs"

Effluent Dominated Streams

Treatment Facility

INTRODUCTION

"You might think that Park City residents have high cholesterol, are depressed, and rub bug spray on themselves before engaging in sexual activities based on what we find in our wastewater effluent," said Michael Luers, General Manager of the Snyderville Basin Water Reclamation District (SBWRD) in Park City, Utah. "However, the presence of trace level pharmaceuticals, birth control drugs, cosmetics, and other household and industrial chemicals in wastewater effluent is not unique to Park City."

These chemicals are introduced to wastewater from the everyday practices of personal hygiene, excreting ingested medications (found mostly in urine), and flushing of unused prescriptions. Common terms used to describe these compounds include: **p**harmaceuticals and **p**ersonal **c**are **p**roducts (PPCPs); **c**ompounds of **e**merging **c**oncern (CECs); and microconstituents. Treated effluent from wastewater facilities is considered to the primary source of microconstituents to the natural environment since current wastewater treatment processes are not designed to remove these chemicals.

The microconstituents can be detected in extremely low concentrations — levels as low as a **p**art **p**er **t**rillion (PPT) or **n**ano**g**ram per **l**iter (ng/L) — in discharges of treated effluent to oceans, lakes, and streams. By way of perspective a ppt is the equivalent of a drop of water diluted into 20 Olympic-sized swimming pools. They have been found in surface waters, groundwater, and even drinking water. Recent advancements in analytical chemistry have made it possible to detect these trace level contaminants. Researchers are also trying to understand the potential impacts to both human health and the environmental from exposure.

Perhaps the microconstituents of greatest concern in the aquatic environment are those that mimic or interfere with natural hormones that are part of the endocrine system, which regulate the processes of development and reproduction in humans and other organisms. The trace level compounds that have the potential to disrupt the endocrine system of aquatic organisms are called **e**ndocrine **d**isrupting **c**ompounds (EDCs).

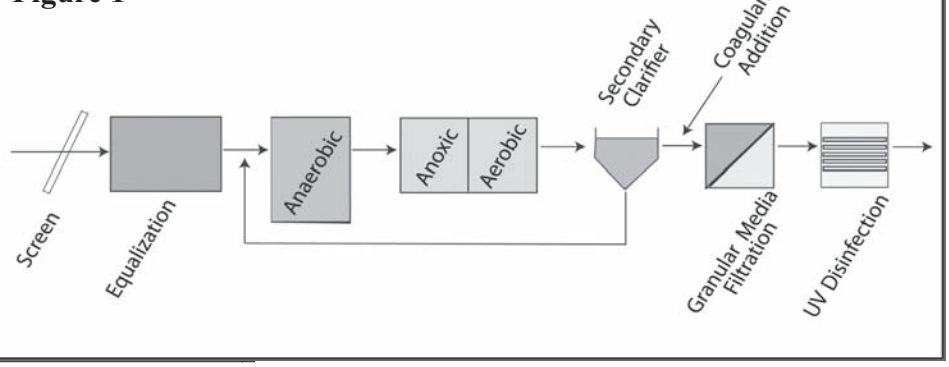
Oftentimes the negative effects of EDCs have been found in fish populations that reside in effluent dominated streams where the volume of discharged wastewater is greater than the baseflow of natural runoff. Streams near urban centers often become effluent dominated, and this condition can exist year round or be seasonal.

Municipal wastewater has been identified as a primary source of these EDCs to the environment. Snyderville Basin Water Reclamation District (SBWRD) in Park City, Utah, became concerned about the potential estrogenic effects of their sewage effluent on brown trout (Salmo trutta) and Bonneville cutthroat (Oncorhynchus clarki) in the receiving stream, especially during late summer months each year when low flows upstream of the wastewater discharge point cause the lower reaches of the stream to become effluent dominated.

PROJECT BACKGROUND

SBWRD had already made significant investments to its wastewater treatment facility, the East Canyon Water Reclamation Facility (ECWRF), in an effort to improve downstream water quality and be good stewards of the water resource. In preparation for the 2002 Winter Olympics, ECWRF was expanded to a maximum treatment capacity of 4 **m**illion **g**allons per **d**ay (mgd) and upgraded with a treatment process that made it one of the most advanced facilities in the state of Utah (see Figure 1). In addition to the normal treatment operations of removing inorganic (primary treatment) and organic waste products (secondary treatment), ECWRF was designed to go one step further (tertiary treatment) and

Figure 1



Endocrine Disruptors

remove phosphorus, a nutrient which causes excess aquatic plant growth. ECWRF uses both biological and chemical processes to remove phosphorus down to concentrations consistently below 0.1 **p**art **p**er **m**illion (ppm) or **m**illi**g**rams per **l**iter (mg/L). However, despite this advanced level of treatment, water samples collected by SBWRD staff in June 2007 of raw influent wastewater and treated effluent from the ECWRF were found to contain trace levels of a variety of common pharmaceuticals and EDCs.

No Current Regulations

In the face of growing industry and public concern regarding pharmaceuticals and EDCs in water, SBWRD felt it was important to take a proactive approach to addressing this issue. SBWRD wanted to incorporate EDC treatment alternatives into facility planning documents and be able to intelligently address this issue with their customers, even though there are no specific regulations yet in place that require treatment of EDCs. SBWRD contracted with Carollo Engineers (Carollo) to conduct an investigation of treatment technologies that could be used to remove trace level concentrations of EDCs from their effluent. Carollo was asked to: test the effectiveness of three advanced treatment processes on ECWRF effluent; develop costs of full-scale treatment for each; and then provide a recommendation as to which technology should be implemented at ECWRF. SBWRD also asked Carollo to identify any possible methods of treating EDCs using existing infrastructure.

EDC Treatment Costs

The cost of the improvements recommended for EDC treatment was significant. In the absence of regulation SBWRD felt like these improvements could only be justified if there was evidence that EDCs were negatively impacting downstream fish populations. Thus, Carollo was asked to conduct a second study focused on identifying the estrogenic impacts of the ECWRF effluent. Carollo and SBWRD teamed with biologists at Utah Department of Natural Resources Fish Experiment Station (FES) to develop a work plan for a study that looked at impacts to fish held directly in the effluent (Sentinel Study) and an investigation of ratio of females to males in the downstream reaches of East Canyon creek (Field Study).

Stream Flows

SBWRD's four mgd treatment facility (ECWRF) discharges to East Canyon Creek. The creek provides habitat for two sensitive trout species: the brown trout (Salmo trutta) and the native Bonneville cutthroat (Oncorhynchus clarki). The concern about the potential estrogenic effects of their sewage effluent is heightened by the fact the that low flows upstream of the treatment facility occur each year in the fall, causing the downstream reaches of East Canyon Creek to become effluent dominated. The flows in East Canyon Creek (2008 monthly average) range from 12.07 **c**ubic **f**eet per **s**econd (cfs) in August to 114.13 cfs in May, with the low flow period running from August through October. Effluent flows, meanwhile, range from a low of 3.28 cfs in October to a high of 6.28 cfs in April. In addition, ECWRF's discharge point is located at the top of the watershed and water from the creek is used by downstream users as a source of both irrigation and drinking water.

Effluent Flows

As part of Carollo's first task regarding wastewater treatment, SBWRD funded bench- and pilot-scale studies of three EDC removal technologies: **g**ranular **a**ctivated **c**arbon (GAC) filtration, and the advanced oxidation processes of ozone/peroxide and Ultraviolet/peroxide (UV/peroxide). Cost of full-scale treatment for each of these alternatives was developed, and a recommendation was made as to the treatment technology of choice. Carollo also identified a unique alternative for SBWRD that would allow for treatment of EDCs using existing infrastructure.

Estrogenic Effects

Carollo's work plan for the research study designed to investigate the potential for effluent to cause estrogenic effects on downstream trout included the following objectives:

- Determine if microconstituent concentrations in the effluent were high enough to induce vitellogenin synthesis in male trout during a Sentinel Study
- Evaluate the ratio of male to female brown trout downstream of the effluent discharge; a skewed sex ratio might be due to endocrine disruptor exposure
- Determine if microconstituents were accumulating in fish tissues

EDCs & ANALYTICAL ADVANCEMENTS

Effluent Source

Recent advancements in analytical methods have led to the detection of trace level concentrations of common pharmaceuticals, endocrine disrupting compounds, and household and industrial chemicals in the aquatic environment. Subsequently, effluent from domestic wastewater treatment facilities has been identified as the primary source of these microconstituents (Fent et al. 2006). Although the potential health impacts of microconstituents are yet to be understood, especially for humans, research has shown that the estrogenic properties of effluent can cause measurable effects in fish and other aquatic organisms.

Estrogen

The most potent of the EDCs may be the natural and synthetic forms of estrogen, estradiol and ethinyl estradiol respectively, that have been shown to induce measurable effects in fish at environmentally relevant concentrations (1-4 ng/L). However, other chemicals — both natural and synthetic — have been found to have estrogen like properties.

Endocrine Disruptors

EDC Effects

Biomarker

Target EDCs

Reported EDC effects include:

- Vitellogenin synthesis in males: males producing the egg yolk protein vitellogenin, normally only seen in female fish (Purdom et al. 1994)
- Intersex characteristics at the cellular level in gonad tissues: the presence of both male and female gonad tissues, known as intersex fish (Jobling et al. 1998; Woodling et al. 2006)
- Reduced fertility (Nash et al. 2004)
- Population level effects such as skewed sex ratios or collapse — greater numbers of female fish (Kidd et al. 2007; Nelson et al. 2007)

Thus, the presence of vitellogenin in male fish is commonly used as a biomarker of environmental estrogen exposure (Sumpter and Jobling 1995). Estradiol and ethinyl estradiol, natural and synthetic sex hormones, are potent estrogens that can induce vitellogenesis at environmentally relevant concentrations (as low as 1 ng/L) (Purdom et al. 1994). However, there are numerous compounds and mixtures of compounds that may also contribute to the overall estrogenic activity of an effluent (Sumpter 1998).

Biological tools like an in vitro bioassay can be used to determine the overall estrogenic activity of an effluent (Nelson et al. 2007). The limitation of the bioassay is that it does not identify the specific source or sources of the estrogenic activity. Less is known about how estrogenic impacts progress from vitellogenesis to the more severe reproductive effects (Cheek et al. 2001), and this is an area that requires more research.

METHODOLOGY

Testing of Advanced Treatment Technologies

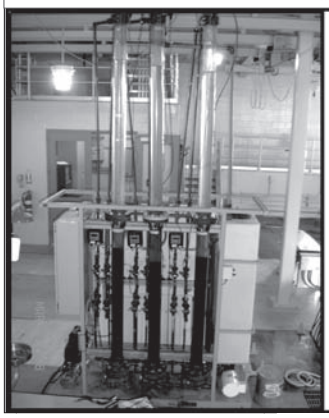
For each removal technique, sampling was designed to quantify and compare EDC concentrations, estrogenic activity (E-screen bioassay), and water quality parameters in treated water against untreated plant effluent. The water quality parameters included: Biological Oxygen Demand (BOD); Total Suspended Solids (TSS); Total Organic Carbon (TOC); Ultraviolet Transmittance; and/or coliform counts. In an attempt to reduce the cost of analyses and focus on some of the EDCs that may contribute most to the potential estrogenicity of fish, only the first phase of an analytical quantification method (US Geological Survey (USGS) Method 2, LC/MS APCI positive-ion mode only) was used. This narrowed the spectrum of possible EDCs to the six compounds shown in Table 1: carbamazepine, estrone, estradiol, ethinyl estradiol-17 alpha, progesterone, and testosterone.

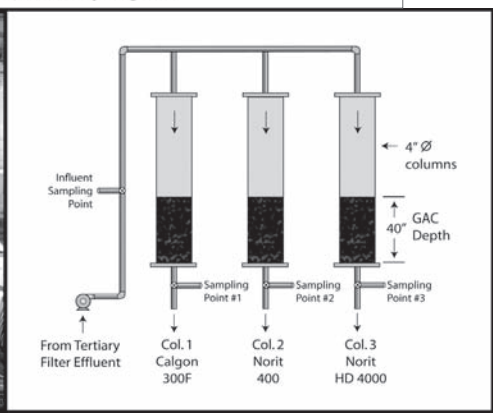
Table 1. Target microconstituents analyzed during testing of treatment technologies

Microconstituent	MRL[1] (ng/L)	Type/Purpose
Carbamazepine	5.0	Anti-Epileptic
Estrone	1.0	Natural Hormone
Estradiol	1.0	Natural Hormone
Ethinyl Estradiol - 17a	1.0	Synthetic Hormone
Progesterone	1.0	Natural Hormone
Testosterone	1.0	Natural Hormone
Estradiol Equivalents	0.030	E-Screen Bioassay

1) Method Reporting Limit

Water samples for microconstituent analysis were collected in one liter (1 L) amber glass bottles with an ascorbic acid and sodium azide preservative. The samples were placed on ice and shipped via overnight delivery to an analytical lab (MWH Labs, Monrovia, CA). The lab performed the extractions and then analyzed the samples using liquid chromatography tandem mass spectrometry. Similarly, water samples for E-Screen bioassay analysis were collected in 2 L amber glass bottles, preserved with ascorbic acid and sodium azide, and sent on ice via overnight delivery to another analytical lab (Wisconsin State Laboratory of Hygiene, Madison, WI). Extracted samples are diluted and cultured with a line of human breast cancer cells. Increased cell growth in the culture is correlated to a positive control and reported as ng/L of estradiol equivalents.





Pilot scale testing of GAC contactors was conducted at ECWRF using tertiary effluent from the existing granular media filters (Figure 2). Three GAC columns were dosed at an overflow rate scaled to match that of the full-scale filters (143 liters per minute per square meter (Lpm/m^2) or 3.5 gallons per minute per square feet (gpm/ft^2) and sampled once a week over a six-week study period. Vendors provided three different GAC products for the study: Column 1 contained Calgon 300F, Column 2 was Norit 400, and Column 3 was Norit Hydrodarco 4000.

Endocrine Disruptors

Treatment Tests

Additionally, larger sample volumes (19-38 liters or 5-10 gallons) of ECWRF effluent were placed on ice and sent via overnight delivery to laboratories for bench-scale testing of advanced oxidation processes: ozone/peroxide and UV/peroxide. Applied Process Technology, Inc. (Pleasant Hill, CA) performed the ozone/peroxide testing using a bench-scale sized reactor of their proprietary product known as the HiPOx system. Effluent was treated with three different ozone doses (5, 10, 15 ppm) and two ozone/peroxide doses (peroxide:ozone molar ratios of 0.35 and 0.70 at an ozone dose of 5 ppm).

UV and UV/peroxide bench-scale testing was performed under the direction of Karl Linden's research group at Duke University (Durham, NC) (Dr. Linden has since joined the University of Colorado at Boulder). Plant effluent was treated at a UV fluence of 80, 200, and 400 mJ/cm^2 and for each fluence three different doses of peroxide (2, 5, 10 ppm) were added. A "UV fluence" is a term for UV dose or the intensity of UV light energy that is applied to the wastewater for disinfection. Adding hydrogen peroxide in conjunction with UV, a process known as advanced oxidation, creates a strong oxidant capable of destroying EDCs.

ESTROGENIC IMPACTS OF ECWRF EFFLUENT

Effluent Study

This portion of the project consisted of two major components: a Sentinel Study of trout held in the effluent in a pen to observe whether vitellogenesis occurred in male fish, and a field survey of females to males in the brown trout population downstream of the treatment facility to observe whether there was a skewed sex ratio towards a greater number of female fish.

Sentinel Study

Negative Control

For the Sentinel Study 100 rainbow trout (Oncorhynchus mykiss) were individually tagged, measured for length and weight, and blood plasma samples (0.5 mL (milli-Liters)) were collected before and after a three-week exposure period. Fifty fish were placed in a pen in the final effluent, and the other 50 fish were held as a negative control at a hatchery. Blood plasma was treated with an anticoagulant and a protease inhibitor and then assayed for vitellogenin using an **e**nzyme-**l**inked **i**mmuno**s**orbent **a**ssay (ELIZA) kit. The assay is used to detect the presence of proteins. Although commonly used in immunology to detect the presence of diseases or food allergens, there are also commercial kits available to test for the egg-yolk protein vitellogenin in fish serum. At the end of the exposure period, fish were anesthetized and subsequently measured for total weight, length, gonad weight, and examined by necropsy to determine gender. Results for vitellogenin, gonadosomatic indices, and general health were compared for the two test groups of sentinel fish.

Sentinel Study Details

The Utah Division of Wildlife Resources' Fisheries Experiment Station (FES), Logan, Utah, provided a total of 100 rainbow trout fingerlings for the Sentinel Study. Brown trout or Bonneville cutthroat were not available at the hatchery. However, literature suggests that trout species respond similarly to environmental estrogen exposure (Bjerregaard et al. 2008). The fingerling trout had been raised in hatchery well water and at approximately one year old were not yet sexually mature. At the onset of the experiment the fish were temporarily anesthetized with MS-222 (tricane methane sulfonate) and then individually tagged with alphanumeric tags (Northwest Marine Technologies, Shaw Island, WA) injected into the clear periorbital region of the left eye (Figure 3). Each fish was then weighed and measured for length, and a blood sample (0.5 mL) was collected to determine plasma vitellogenin concentrations. A heparinized syringe was used to draw blood from the caudal vein. The syringe tip was then removed to prevent hemolysis prior to expressing the sample into a microcentrifuge tube. Tubes were pretreated with 12 µg/L aprotinin (a protease inhibitor, 2 TIU/mL; Rodgers-Gray et al. 2000) and centrifuged for three minutes to achieve plasma separation. [Editor's Note: "TIU" is trypsin inhibitor unit and µg/L is microgram per Liter, equivalent to parts per billion]. Plasma was transferred to a clean set of microcentrifuge tubes, labeled according to the alphanumeric tracking system, and frozen until assayed for vitellogenin. During this collection process all samples were kept in an ice water bath.

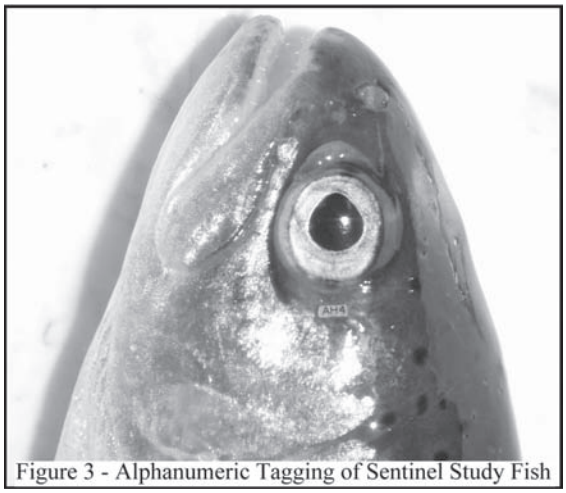


Figure 3 - Alphanumeric Tagging of Sentinel Study Fish

Once the baseline measurements were collected, the fish were separated into two 50 fish groups, a test

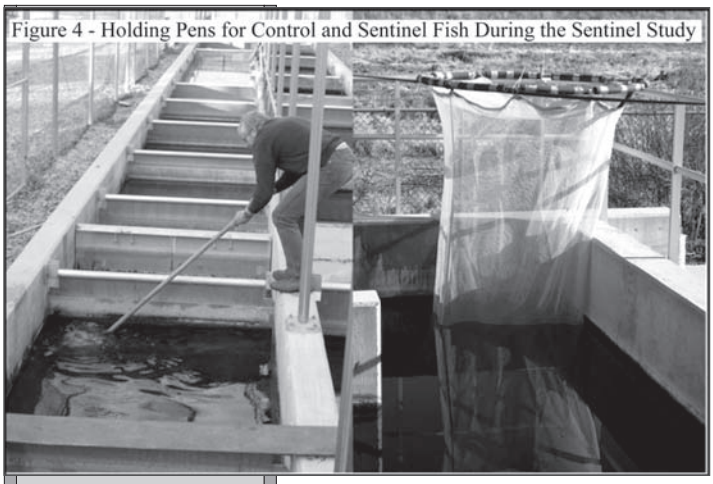


Figure 4 - Holding Pens for Control and Sentinel Fish During the Sentinel Study

group and a negative control. The test group was placed in a fish hauling truck and transported to ECWRF in Park City.

There, the fish were transferred into a limnocorral (a stretch-mesh (1 centimeter) cage, 3 meters deep by 1 meter in diameter) that was placed in the final effluent aeration structure as shown in Figure 4. Efforts were made to keep the cage walls straight and the bottom was weighted with large rocks. The other 50 fish were held at the FES as a negative control (hatchery group), crowded into the head end of a raceway. The water temperature at both sites was similar at 12-13 degrees Celsius over the course of the experiment. FES and SBWRD staff fed the fish a ration of 1.5 percent of body weight per day of commercial trout chow (Silvercup, Murray Elevator, Murray, UT). The mechanical aerator in the aeration basin was turned off to avoid causing undue stress to the sentinel fish, but dissolved oxygen levels remained above the discharge limit of 6.0 mg/L. Fish were held in each test condition for three weeks.

Endocrine Disruptors

Effluent Analysis

Plant Effluent Testing

Each week during the Sentinel Study a grab sample of plant effluent was collected and analyzed for microconstituents and estrogenic activity as measured by an estrogen screen or E-screen bioassay. Similar grab samples were collected from the FES control at the beginning and end of the study for comparison purposes. Table 2 shows the microconstituents of interest for this study, which included natural and synthetic hormones (possible endocrine disruptors), common pharmaceuticals, and a household antimicrobial (triclosan). Samples were collected in 1 L amber glass bottles with an ascorbic acid and sodium azide preservative. The samples were placed on ice and shipped via overnight delivery to an analytical lab (MWH Labs, Monrovia, CA). The lab performed the extractions and then analyzed the samples using liquid chromatography tandem mass spectrometry. Similarly, water samples for E-Screen bioassay analysis were collected in 2 L amber glass bottles, preserved with ascorbic acid and sodium azide, and sent on ice via overnight delivery to an analytical lab (Wisconsin State Laboratory of Hygiene, Madison, WI). Extracted samples are diluted and cultured with a line of human breast cancer cells. Increased cell growth in the culture is correlated to a positive control and reported as ng/L of estradiol equivalents.

Table 2
Target Microconstituents
& E-Screen Bioassay for Water Sample Analysis

Microconstituent	MRL[1] (ng/L)	Type/Purpose
Acetaminophen	1.0	Pain Relief
Caffeine	3.0	Stimulant
Carbamazepine	5.0	Anti-Epileptic
Cotinine	1.0	Stimulant
Diazepam	1.0	Anti-anxiety
Estrone	1.0	Natural Hormone
Estradiol	1.0	Natural Hormone
Ethinyl Estradiol - 17	1.0	Synthetic Hormone
Fluoxetine	1.0	Anti-Depressant
Progesterone	1.0	Natural Hormone
Sulfamethoxazole	1.0	Antibiotic
Testosterone	1.0	Natural Hormone
Trimethoprim	1.0	Antibiotic
Triclosan	5.0	Anti-Microbial
Estradiol Equivalents	0.0	E-Screen Bioassay

1) Method Reporting Limit

At the end of the exposure period, survivors from both test locations were anesthetized with a lethal dose of MS-222. A blood plasma sample was collected using the previously described procedures, and fish were measured for total weight and total length. FES staff examined the fish by necropsy to determine gender, and then carefully excised and weighed gonad tissue. A **g**onado**s**omatic **i**ndex (GSI) was calculated by the following formula: GSI = (Gonad Weight/Total Fish Weight)*100

Vitellogenin concentration in the rainbow trout plasma samples from the sentinel fish and negative control groups for both pre- and post-exposure sampling events was determined using a commercial enzyme-linked immunosorbant assay (ELISA) kit (Biosense Laboratories, Bergen, Norway; Product #V0100442; sold by Caymen Chemical, Ann Arbor, MI). All reagents were provided in the kit and the ELISA instructions were followed without deviation. Vitellogenin standard values were used to create a standard curve from which unknowns were determined. In instances in which vitellogenin concentration was too high (i.e. beyond the range of the standard curve) samples were re-analyzed at greater dilutions (up to 10,000 fold in some cases).

Endocrine Disruptors

In Stream Fish Study

Tissue samples were also collected from expired fish at both locations. A total of five whole fish were taken from each site as well as fillets and some liver tissue from 20 other fish. These samples were wrapped in aluminum foil and kept on ice until they were frozen. Tissue was sent to an analytical lab for analysis of the same suite of microconstituents listed in Table 1 (Utah Water Research Lab, Utah State University, Logan, UT). Also, a sample of the trout chow fed to both test groups was included with the tissues to determine if it was a potential source of microconstituents.

Field Study & Sex Ratio Investigation

For the Field Study, 70 brown trout were collected by electrofishing and gender was determined by partial stripping of gametes or necropsy.

A field expedition was planned to determine whether the brown trout population downstream of ECWRF's discharge was skewed toward a greater number of female fish. Using chi-square analysis, values of likelihood ratio probability were calculated to determine the sample size needed to identify a skewed sex ratio based on a presumed female to male sex ratio of 50:50 (Table 3, SPSS version 13.0, SPSS Inc., 1993). Chi square analysis is a statistical analysis technique used to identify differences of observed frequencies from expected frequencies. In this case the expected was a 50:50 ratio of males to females in the stream. If the results of the field survey showed a ratio different than 50:50, the chi square test would be used to assess how confident we could be that the observed difference was real and that there had been a shift in the population away from the expected ratio. It was determined that if 60-70 brown trout could be collected from the stream this improved the chance of observing a statically significant difference in the sex ratio of the population.

Table 3
Likelihood Ratio Probability for Differences
from 50% Frequency at Different Sample Sizes

Sample Size	Percent Female	Likelihood Ratio	Likelihood Ratio Probability
55	55%	0.551	0.458
	60%	2.215	0.137
	65%	5.027	0.025
60	55%	0.601	0.438
	60%	2.416	0.120
	65%	5.484	0.019
65	55%	0.651	0.420
	60%	2.618	0.106
	65%	5.941	0.015
70	55%	0.701	0.402
	60%	2.819	0.093
	65%	6.398	0.011

Initially fish were to be collected only in the reaches below the discharge point. If females represented less than 60 percent of the sampled population, the conclusion would be made that there was no significant difference from the presumed female to male sex ratio of 50:50, and no additional upstream fish sampling would be conducted. If females represented more than 60 percent of fish taken in the downstream reaches, fish sampling would be continued in the reach upstream. There is a dam that isolates the upper and lower reaches of the stream. The sex ratio for the sample set of upstream fish, which are less likely to have been exposed to effluent, would then be compared to that observed for the downstream fish.

Downstream Electrofishing

Brown trout were collected by electrofishing within East Canyon Creek below the point of ECWRF effluent discharge (Figure 5). The sampling team began approximately a mile downstream and advanced against the current back towards the discharge point. One team member ran the electrofishing apparatus and the other team members netted the stunned trout that became visible. Trout were placed in partially filled buckets and transferred to an oxygenated holding tank to await inspection.

Gender Examination

The trout collected were measured for total length, total weight, and examined for gender. Ripe or mature fish readily exuded gametes by palpitation because the fish were preparing to spawn. [Editor's Note: When the field work was about to start the fish were beginning to spawn. At such a time, reproductive matter (eggs or sperm) leaks out of the end of the fish. The field study could identify the sex of the fish without killing them simply by squeezing the fish. Immature fish would not have any eggs or sperm appear; such fish must be dissected to determine the sex.] Where gender was indeterminate the fish were sacrificed and gender was determined by necropsy. For fish that were sacrificed, tissues (whole fish, liver, and fillets) were preserved for microconstituent analysis and gonadosomatic indices were calculated. Blood samples were collected from male, female, and indeterminate fish for analysis of plasma vitellogenin. A commercially available ELISA kit has not been developed for brown trout, therefore these samples were not sent to the same lab as the Sentinel Study plasma. Rather they were sent to an analytical lab (University of Florida Center for Environmental and Human Toxicology, Gainesville, FL) that has developed a modified ELISA specific to brown trout. Plasma samples from three ripe females were identified, but the rest were sent as blind samples. Vitellogenin from the three ripe females was purified and used to develop the species specific ELISA for sample analysis.

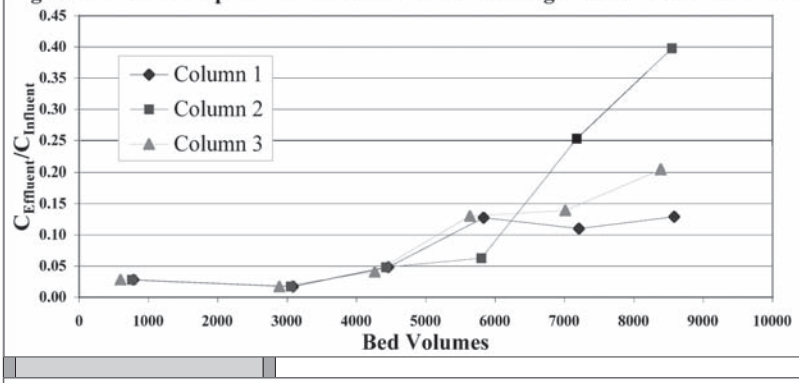
Figure 5 - Electrofishing of Brown Trout During the Sex Ratio Investigation

Table 4. Microconstituent Sample Results for GAC Pilot Scale Test

Description	Number of Detections	Minimum Concentration (ng/L)	Maximum Concentration (ng/L)	Average Concentration (ng/L)
Carbamazepine				
Effluent	6	40	146	95
Column 1	4	5.1	12	7.9
Column 2	3	20	37	27
Column 3	4	5.0	19	10
Estradiol				
Effluent	4	4	4	4
Ethinyl Estradiol - 17α				
Effluent	1	13	13	13
Column 1	1	2.6	2.6	7.9
Column 2	1	4.5	4.5	27
Column 3	1	3.0	3.0	3.0
E-Screen Bioassay				
Effluent	1[1]	0.77	0.77	0.77

[1]Only one E-Screen bioassay sample collected during GAC pilot test.

Figure 6. Carbamazepine used as a tracer for estimating useful bed life of the GAC



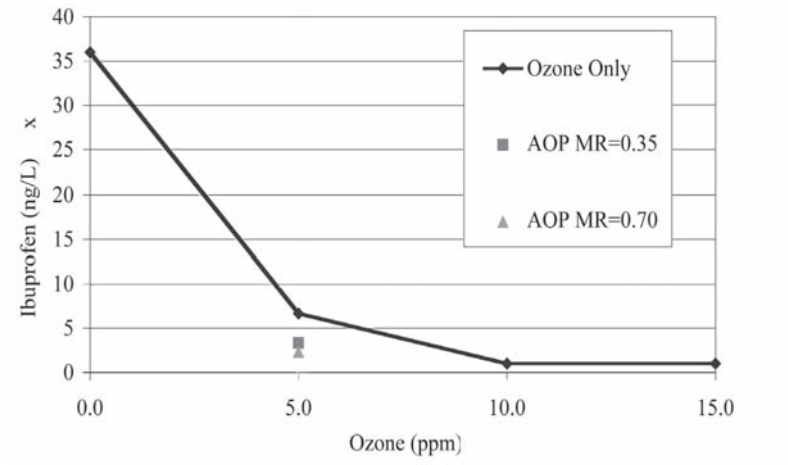


Figure 7. Effect of Ozone and Ozone/Peroxide Treatment on Ibuprofen Concentration in ECWRF Effluent

RESULTS

Testing of Advanced Treatment Technologies

Sampling results for the GAC pilot testing on ECWRF effluent are shown in Table 4. Only three of the six EDCs of interest were detected during the study. One E-Screen bioassay sample was collected during the pilot and results showed that there was measurable activity in the untreated effluent of nearly 1 ng/L of estradiol equivalents. However, bioassay results for GAC treated effluent collected at the same time showed no measurable activity. Because carbamazepine was detected in every sampling event it was used to predict the useful bed life of the GAC for EDC removal. Figure 6 plots the ratio of carbamazepine in the effluent to the concentration in the influent versus bed volumes.

Results for ECWRF effluent treated with ozone are shown in Table 5. None of the compounds of interest were detected (from Table 1) for the ozone testing, however results are reported for a broader range of pharmaceuticals that were analyzed. The table shows that after the effluent was treated with an ozone dose of 5 ppm, with no peroxide addition, only ibuprofen was detected. All other measured compounds had been oxidized below the detection limits, including the estrogen activity as measured by bioassay. Additional oxidation of ibuprofen occurred as the water sample was treated with additional doses of ozone and ozone/peroxide advanced oxidation (Figure 7).

A summary of the results for just the E-Screen bioassay samples is shown for the UV/peroxide treatment of the effluent (Figure 8, page 20). There were some inconstancies with these results and possible sample contamination as illustrated by the increase in estradiol equivalent concentration over the different UV and UV/peroxide treatments. However there is an observed trend of reduction in estrogen activity at the higher UV fluence of 400 mJ/cm^2 with peroxide addition (mJ is a milliJoule or light energy per unit of area).

Carollo also came up with a unique alternative for treatment of EDCs using part of the existing SBWRD facility. A sand filter has been utilized to rid the effluent of phosphorus. It would be possible to change the function of the filter by changing out the sand with carbon. The filter could then be used as a GAC contacter, i.e., a carbon adsorption process. This potential gives SBWRD a planning option for the future.

Sentinel Study Results

The initial sample populations were 50 trout each for both the hatchery control and the effluent sentinels. Over the course of the three-week study (Nov-Dec 2008) there were events such as mortalities and lost tags on individual fish that caused a reduction in the number of pre and post exposure samples. There were also several fish in each test group for which gender could not be determined. Results from these fish were excluded from the data set.

Table 5. Sampling Results - ECWRF Effluent Treated with Ozone

Microconstituent	Untreated Effluent Concentration (ng/L)	After 5 ppm Ozone (ng/L)
Gemfibrozil	116	<1.0
Ibuprofen	36	6.7
Triclosan	13	<5.0
Caffeine	45	<3.0
Fluoxetine	20	<1.0
Sulfamethoxazole	524	<1.0
Trimethoprim	76	<1.0
Estradiol Equivalents	0.92	<0.10

Table 6 - Sample Populations Before and After the Sentinel Study

Description	Hatchery Control	Effluent Sentinel
Initial Sample Population	50	50
Mortalities	7	10
Lost Tags	4	9
Indeterminate Gender	4	3
Actual Sample Population	35	28

Table 7 - Fish Sampling Results for the Sentinel Study

Result	Control		Sentinel	
	Baseline	Sentinel	Baseline	Sentinel
Vitellogenin (mg/L)	0.343 ± 0.09	0.110 ± 0.03	0.136 ± 0.05	26.049 ± 9.0
Total Length (mm)	255.2 ± 3.6	265.6 ± 3.9	250.0 ± 4.9	263.9 ± 5.3
Total Weight (g)	188.3 ± 8.0	207.9 ± 9.8	181.4 ± 9.6	216.6 ± 11.8
Gonadosomatic Index(GSI)		0.21 ± 0.07		0.19 ± 0.06

Table 6 presents a summary of how the initial sample populations were reduced in number and shows the number of fish remaining in each test group at the end of the study. In total there were pre- and post- exposure data for 35 hatchery control fish and 28 effluent sentinel fish.

Using the alphanumeric tag numbers for each individual fish, results were compiled for plasma vitellogenin concentration, total length, total weight, and GSI for both the baseline and post three-week sampling events. The mean values for each category along with standard error are reported in Table 7 by test group and sample type.

A more detailed comparison of vitellogenin between the test groups is shown in Figure 9 (next page). The mean vitellogenin concentrations with standard error are shown for male fish only and female fish only at both baseline and three-week exposure. There is a break in the scale of Figure 9 in order to accommodate the higher concentrations found in the sentinel fish. Hatchery and effluent water samples collected during the study were analyzed for the target microconstituents shown in Table 1. Table 8 displays microconstituent results only for the compounds detected in concentrations greater than the method reporting limits. The last line of Table 8 shows the results for the E-Screen bioassays.

Results for tissue analysis are still pending for both the Sentinel Study and field investigation and are not presented in this article. Fish tissues were collected and will be analyzed for common pharmaceuticals and EDCs in order to evaluate if these substances accumulate in tissues. Researchers don't think that pharmaceuticals and EDCs accumulate in tissues because they tend to stay dissolved in water versus pollutants like Mercury or PCBs which accumulate in the fat tissues or animals. Note, though, that there isn't much data to support this conclusion and only a few labs that can do the work. Fisherman have asked SBWRD if it is okay to eat fish caught in East Canyon, so SBWRD wanted data to respond to this question.

Table 8. Microconstituent and Estradiol Equivalent Concentrations for Hatchery and Effluent Waters During the Sentinel Study

Microconstituent	MRL[1] (ng/L)	Initial		Week 1	Week 2	Week 3	
		Hatchery	Effluent	Effluent	Effluent	Hatchery	Effluent
Estrone	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Estradiol	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ethinyl Estradiol -17a	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Progesterone	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Testosterone	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Iopromide	5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Acetaminophen	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Caffeine	3.0	<3.0	<3.0	9.1	8.5	<3.0	25.0
Carbamazepine	5.0	<5.0	48.0	62.0	66.0	<5.0	280
Cotinine	1.0	<1.0	28.0	30.0	30.0	<1.0	32.0
Diazepam	1.0	<1.0	<1.0	1.5	1.2	<1.0	300
Fluoxetine	1.0	<1.0	28.0	18.0	2.8	<1.0	<1.0
Gemfibrozil	1.0	<1.0	57.0	71.0	52.0	<1.0	78.0
Ibuprofen	1.0	1.4	25.0	37.0	20.0	3.3	57.0
Sulfamethoxazole	0.5	<0.5	1400	900	820	<0.5	860
Triclosan	5.0	<5.0	31.0	43.0	39.0	<5.0	35.0
Trimethoprim	1.0	<1.0	11.0	13.0	12.0	<1.0	22.0
Estradiol Equivalents	0.027	0.36	0.55	0.50	0.36	0.30	1.00

1) Method Reporting Limit

Endocrine Disruptors

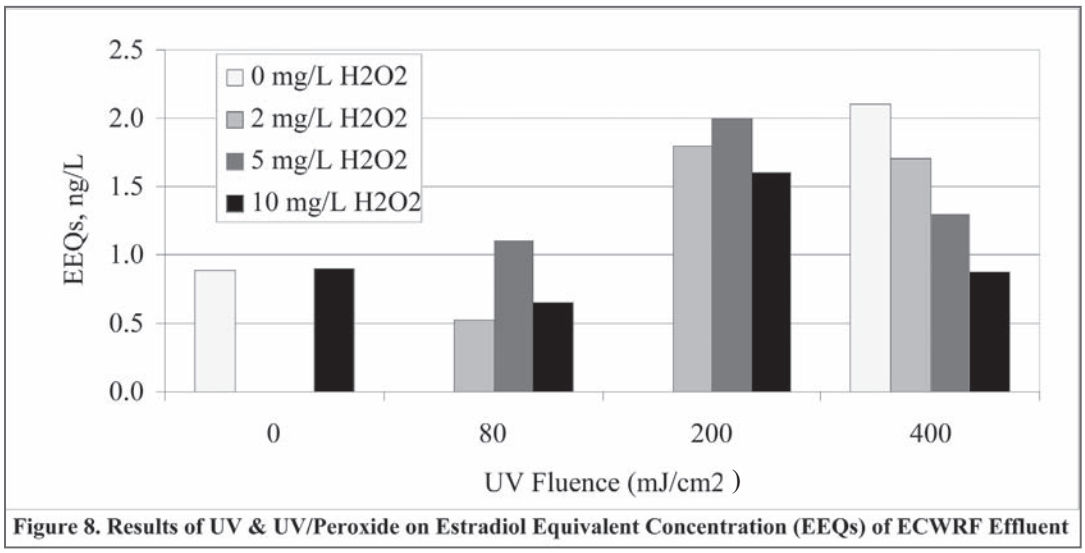


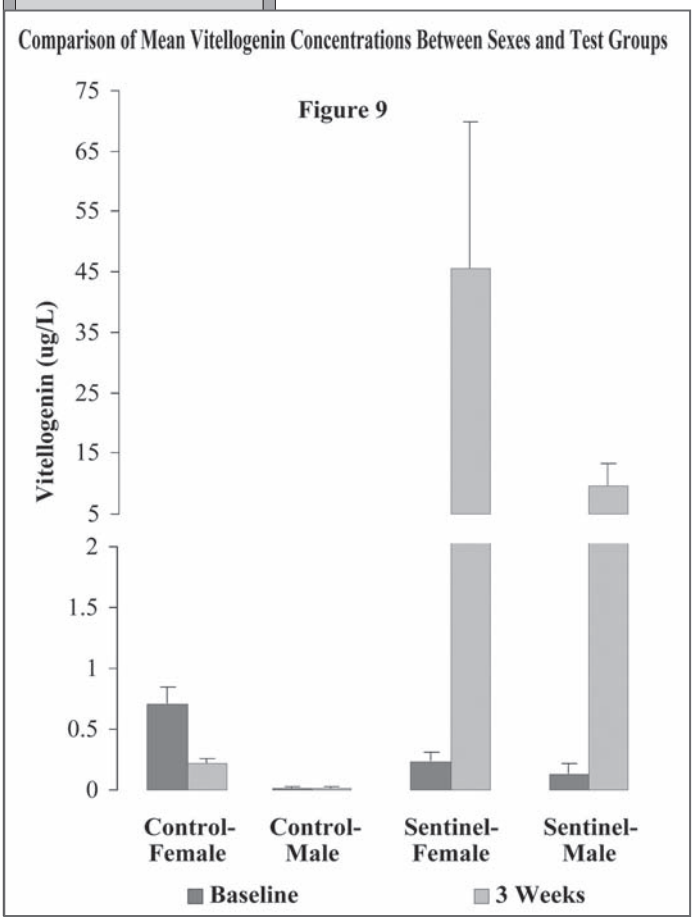
Figure 8. Results of UV & UV/Peroxide on Estradiol Equivalent Concentration (EEQs) of ECWRF Effluent

Field Study

Sex Ratio Investigation Results

A summary of the fish collected from East Canyon Creek for the sex-ratio investigation is presented in Table 9 (next page). This field investigation took place November 10, 2008. There were 71 fish collected from the creek downstream of the treatment plant. The total number of female fish in this group was 38 or 53.5 percent, which was less than the 60 percent threshold required to initiate additional sampling in the upper reaches. Of the 71 fish captured, 43 were released back to the stream and 28 were harvested for sampling purposes. In addition, two blood samples and three tissue samples were collected from upper reach fish for comparison.

Blood plasma samples were collected from 24 brown trout, two of which were upper reach males. The rest of the samples were collected from male and female brown trout captured below the discharge point. Table 10 (next page) displays the results of vitellogenin analysis on the plasma samples. Vitellogenin was collected from four sexually mature female fish that were pulled from East Canyon Creek, and used to build a standard curve against which all other samples were compared. At times the concentration of vitellogenin detected exceeded the upper limit of the standard curve, which was 4 mg/mL. Vitellogenin was only detected in one downstream male fish out of 18 sampled.



DISCUSSION OF STUDY RESULTS

Testing of Advanced Treatment Technologies

GAC filtration and ozone/peroxide proved to be the most effective treatment technologies for reducing the concentration of EDCs leaving the ECWRF treatment plant. Using the data provided from the testing of these three technologies an estimate of full-scale treatment costs was prepared for a new 27.2 million liter per day (7.2 mgd) facility (Figure 10 - next page). The estimate is based on vendor quotes in 2008 US dollars, a building cost of 250 US dollars per square foot, and interest rate of six percent over a 20-year service life. From the testing result it was assumed that GAC filtration would require two carbon exchanges per year, an ozone dose of 5 **p**arts **p**er **m**illion (ppm) would treat most compounds, and a UV dose of 400mJ/cm^2 would be delivered using low pressure high output lamps.

Because the GAC filtration testing was shown to be effective SBWRD is considering the conversion of existing granular media filters to EDC contactors. This may be a viable alternative to SBWRD as the infrastructure is already in place and treatment may be limited to only the low stream season to avoid frequent carbon exchanges.

Table 9. Results of Sex Ratio Investigation on Downstream Brown Trout Population

Description	Number	Percentage
Total Fish Captured	71	
Male Fish	33	46.5%
Female Fish	38	53.5%
Released (Sexually Mature)	43	
Harvested (Gender by Necropsy)	28	

Effluent Impact

Sentinel Study Discussion

The sample size for each test group was reduced by mortalities, lost tags, and indeterminate gender. The blood sample taken from each fish at the beginning of the study was helpful for establishing a baseline vitellogenin concentration, but the sampling is invasive and believed to be the cause of the mortalities. Approximately 20 percent of the fish in each test group expired. The fact that a similar number of mortalities occurred in each group suggests that the mortalities were for similar reasons and not the result of a toxicity issue. This is especially true in regard to the fish placed in the effluent.

Many of the mortalities pulled from the pens showed signs of continued bleeding from the tail. Abrasion was likely the cause of the lost tags. Although fish in the two groups were handled similarly, the limnocorral for the sentinel fish resulted in a more constricted holding area. The tighter area likely caused the loss of more tags in the sentinel fish. Similar numbers of indeterminate gender fish were found within the two groups as a result of using immature trout.

A significant increase in vitellogenin was seen in the sentinel fish after three weeks of effluent exposure. Vitellogenin blood levels increased by orders of magnitude for both male and female sentinels, whereas the levels remained unchanged or decreased for those at the hatchery. Given that vitellogenin has been identified as a biomarker of environmental estrogen exposure, it is reasonable therefore to conclude that estrogenic microconstituents in the effluent are the cause of this observed increase. A comparison of mean vitellogenin concentrations between sentinel males and control males provides further support to this conclusion. The increase does not appear to be the result of stress on the sentinels as total length and total weight increased similarly between the two test groups. GSI, an indicator of reproductive health, although low (immature fish) for both test groups, is also statistically similar.

Table 10 - Vitellogenin Concentrations from East Canyon Creek Brown Trout

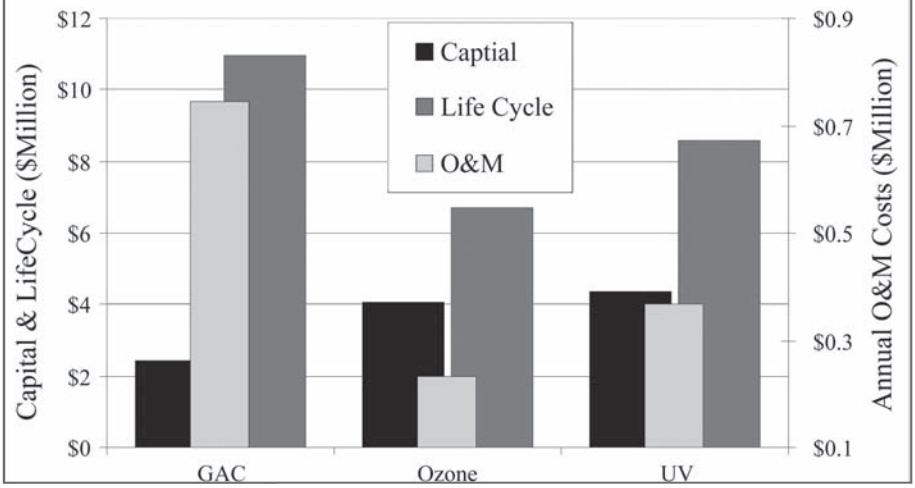
Description	Number of Samples	Number of Detections	Vitellogenin Concentration (mg/mL)
Lower Reach Fish			
Female (Identified for Lab)	3	3	1.08, 3.15, >4[1]
Female (Blind Sample)	1	1	>4[1]
Male (Blind Sample)	18	1	0.04
Upper Reach Fish			
Male (Blind Sample)	2	0	<0.00001
Total	24		

1) Sample result exceeds 4.0 mg/mL at 1:10,000 dilution

Estrogenic activity as measured by the E-Screen bioassay was found in the effluent water samples as high as 1.00 ng/L, although no steroid hormones were detected above the method reporting limits. The E-Screen bioassay identifies estrogenic activity but does not identify the source. The same can be said for an observed increase in vitellogenin. Thus, both the bioassay and biomarker suggest the presence of an environmental estrogen.

The results for the individual microconstituents, however, are inconclusive as to the source. Perhaps there are low levels of hormones that are evading detection or present in concentrations just lower than the method reporting limit. Given that the hormones are the most potent estrogens and certainly a component of domestic wastewater, they are thought to be the source of the estrogenic activity. However, there are other microconstituents present in the effluent as seen by the routine detection of other target analytes for this study (i.e., carbamazepine, sulfamethoxazole and triclosan). One of these compounds, a compound not tested, or a complex mixture of compounds could be the source of the estrogenic activity.

Figure 10. Comparison of full-scale treatment costs of three EDC treatment technologies



Endocrine Disruptors

Hatchery Water

Estrogenic activity and one target microconstituent (ibuprofen) were detected in hatchery water samples. These samples results were revisited by analytical labs and verified as passing internal quality control standards. Contamination of the samples cannot be ruled as out a possibility because a trip or field blank was not included with these samples. However, results are similar for the hatchery on two separate sampling events so perhaps this indicates that the well water used at the hatchery has been impacted by some anthropogenic source. Despite these detections in the hatchery water, the measured estrogen activity in the hatchery was always lower than that measured for the effluent, and there was no observed increase in hatchery fish vitellogenin. This suggests that the concentration of estrogen if present was of low enough concentration so as to not trigger the biological response of vitellogenin production.

Sex Ratio Investigation Discussion

No Skewed Sex Ratio

After conducting a field investigation on the downstream brown trout population, it does not appear as though there is a skewed sex ratio towards a greater number of female fish. Although five more females were counted than males in the sample set of 71 fish, the difference is not considered to be statistically significant (53.5% female to 46.5% male) based on a likelihood probability ratio using chi-square analysis.

During the planning stages of the Sex Ratio Investigation there was a concern that there would not be enough fish to support the designed sample size of 70. Once in the field, though, it was evident that there is a robust population of brown trout. It is also important to note that Utah Department of Natural Resources' records indicate that East Canyon Creek has not been stocked with brown trout in over ten years (Eric Wagner, personal communication, Oct. 2008). Also, because of a small dam exists in the river above the treatment plant, any fish movement or migration is thought to occur in the downstream direction only. Thus, it seems reasonable to conclude that brown trout collected downstream have been exposed to effluent for some time, although the concentration varies as a function of dilution. At the time of the Sex Ratio Investigation stream flow exceeded the effluent discharge by a factor of approximately 4 to 1.

Stream Dilution

Although the effluent induced vitellogenesis in the sentinel fish, vitellogenin was only detected in one downstream male out of 18 sampled. In contrast, vitellogenin was detected in high concentrations (mg/mL versus µg/mL measured in the Sentinel Study) for the ripe females that were preparing eggs for the spawn. In other words, much more vitellogenin was found in mature fish in the creek than in the one year old sentinel fish. Aside from the one detection for which there is no clear explanation, the lack of vitellogenin in the majority of downstream males suggests that exposure to any estrogenic activity was sufficiently dilute so as to not induce a measurable response. SBWRD will consider collecting blood samples again from the downstream brown trout, during a time of lower stream flow.

CONCLUSION

Effective Treatments

GAC filtration and ozone/peroxide were the most effective treatment technologies tested in this study for reducing the measurable concentrations of EDCs in wastewater treatment plant effluent. Ozone/peroxide proves to be the most cost effective treatment over a 20 year life-cycle cost analysis. However, future testing may look at the conversion of existing granular media filters at ECWRF as a cost effective means to begin EDC treatment.

Downstream Risk

The induction of vitellogenesis was observed in sentinel trout held in the effluent of the East Canyon Water Reclamation Facility demonstrating that downstream fish are at risk for estrogen exposure. The estrogenic activity of the effluent, measured at concentrations as high as 1 ng/L of estradiol equivalents (E-Screen bioassay), affected this biological response. A variety of microconstituents were detected in the effluent, however, the analysis failed to identify the specific compound(s) responsible for the estrogenic effect. Effluent does not appear to have altered the sex ratio of the downstream brown trout population. Once diluted with stream flow, the effluent estrogenicity was no longer potent enough to induce vitellogenesis in downstream males. A future study will include a field investigation conducted at time of lower stream flow and less dilution of the effluent. Biomarkers (vitellogenin) and bioassays will continue to used as cost effective indicators of estrogenicity potential.

Dilution Critical

SBWRD was glad to find that there was no evidence of a skewed ratio of females to males in the downstream reaches of East Canyon Creek. However, measurable estrogenic effects were seen in fish placed directly in the effluent. Although no evidence of long-term impacts of feminization was found, potential exists for ECWRF effluent to induce these effects. The amount of dilution available for effluent discharged into East Canyon Creek is critical in minimizing potential estrogenic effects to fish. SBWRD remains committed to treating for EDCs at ECWRF but may do one more study to determine what level of dilution is required to minimize effects to trout and then only treat for EDCs when stream flows do not provide this minimum level of dilution. This operation strategy would minimize the cost of EDC treatment.

For Additional Information:
Clint Rogers, Carollo Engineers, 801/ 233-2519 or CRogers@carollo.com;
Mike Luers, 435/ 649-7993 x223, mluers@sbwrd.org or www.sbwrd.org

Endocrine Disruptors

Acknowledgments

Carollo Engineers would like to recognize and thank SBWRD, particularly Michael Luers, Michael Boyle, and plant operations staff, for funding and assisting in this research effort. Special thanks to the following: Dr. Chris Wilson, Eric Wagner, and Anna-Marie Forest of the Fisheries Experiment Station, Utah Department of Natural Resources, Logan, UT, for providing trout for the Sentinel Study and conducting the field investigation of brown trout, Dr. Erin Snyder of Total Environmental Solutions, Inc., Boulder City, NV for technical guidance in the development of the work plan, Dr. Nancy Denslow and Dr. Kevin Kroll of University of Florida Center for Environmental and Human Toxicology, Gainesville, FL, for vitellogenin assay of wild brown trout, Dr. James Nagler of University of Idaho, Department of Biological Sciences, Moscow, ID, for vitellogenin assay of sentinel trout, Dr. William Doucette, Utah State University, Utah Water Research Laboratory, Logan, UT, for microconstituent analysis of fish tissues, Debbie Frank of MWH Labs, Monrovia, CA, for water sample microconstituent analysis, and Dr. Jocelyn Hemming of Wisconsin State Laboratory of Hygiene, Madison, WI, for E-Screen bioassay analysis of water samples.

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J. Clinton Rogers is a licensed professional engineer specializing in water and wastewater treatment process design. Clint graduated from Utah State University in Logan, Utah with a masters and bachelors degree in environmental engineering. He is employed in the Salt Lake City office of Carollo Engineers, and was the field engineer for the EDC research done at SBWRD.

Mike Luers has over twenty-nine years of experience in working with environmental issues. He holds the position of General Manager of the Snyderville Basin Water Reclamation District (SBWRD). SBWRD provides wastewater services to the entire Park City and Snyderville Basin area and is responsible for reclaiming over 1.2 billion gallons of wastewater per year. SBWRD currently operates one of the first tertiary reclamation facilities in the State of Utah. Mike holds a Bachelors Degree in Fisheries and Wildlife Management, a Masters Degree in Environmental Biology and a MBA.

WATER BRIEFS

WELL AUGMENTATION CO
CONJUNCTIVE USE DECISION

On November 23 in a 58-page opinion, Justice Martinez of the Colorado Supreme Court (Supreme Court) issued a decision on appeal from the District Court for Water Division One (water court) concerning the water court's approval of a proposed plan for augmentation to allow multiple groundwater diversions (Case No. 08SA224). "Water court approval of a plan for augmentation allows a water right with a junior priority date to divert out-of-priority, provided that the junior right supplies additional augmentation water to offset the out-of-priority depletion...In the context of plans for augmentation, the water rights included in the plan are augmented, and the court cannot approve a plan if senior vested rights will be harmed through out-of-priority diversions made by the water rights included in the plan, regardless of ownership of the rights." Slip Op. at 21-22.

The Applicant in the case is the Well Augmentation Subdistrict of the Central Colorado Water Conservancy District (WAS). After it was formed in 2004, WAS became the primary applicant in the case. WAS represents 215 wells that withdraw water from the alluvium of the South Platte River in locations from Brighton to Fort Morgan, Colorado. The WAS augmentation plan submitted to the water court sought to provide augmentation water to offset the out-of-priority depletions of 215 structures that divert groundwater from the South Platte River basin.

The Supreme Court held that the water court did not err in requiring the Applicant to provide replacement water for post-pumping depletions, made before the filing of the augmentation plan application, that have a continuing injurious effect on surface waters (i.e. replacement of pre-2003 pumping depletions that caused injury to vested surface water rights). The court also affirmed the water court's decision that replacement obligations in the Box Elder Creek basin must be determined based on surface water conditions that would exist in the basin absent groundwater pumping in the area — as opposed to being based upon present hydrological conditions. This issue involved potential hydrological connections to the South Platte River.

Another issue involved whether the State and Division Engineers have discretionary authority to implement a groundwater seniority system, termed a "well call" by WAS (Applicant), when the water court declined to include such a provision in the decree. The Supreme Court declined to issue an opinion on that issue, since they viewed it as advisory, based on the water court's decision and the fact that the Applicant did not request the Supreme Court to order the State Engineer to implement a "well call" system. Finally concerning the proper standard of review, the Supreme Court reversed the water court's determination that substitute water supply plan appeals under section 37-92-308(4), C.R.S. (2009), should be reviewed de novo ("de novo" means considering the matter anew, the same as if it had not been heard before and as if no decision previously had been rendered). The court rejected de novo review and held that section 37-92-308(4) appeals should be reviewed pursuant to the standard of review set forth in Colorado Administrative Procedure Act, § 24-4-106, C.R.S. (2009).

For info: Case available at: http://www.courts.state.co.us

EXEMPT WELLS PETITION MT
RANCHERS RIGHTS THREATENED

Use of small permit-exempt wells has skyrocketed in the Montana's high-growth counties — almost 30,000 wells were drilled between 2000 and 2008, mainly for new subdivisions. Faced with the potential threat such wells pose for senior water rights, ranchers and other water users in Montana have filed a petition with the Montana Department of Natural Resources and Conservation (DNRC) requesting the agency to protect their valuable water rights. Water users from the Yellowstone, Gallatin, and Clark Fork River basins filed the request that DNRC change a rule that allows multiple small individual wells to be drilled without obtaining a permit and without any review of their impact on other water right holders or nearby streams and groundwater. The petitioners are represented by Western Environmental Law Center (WELC) attorney Matthew Bishop. A similar petition from the Gallatin County Commission was rejected by DNRC in 2006.

For many years in Montana and throughout the West, small individual wells have been exempt from permitting requirements, based on the belief that a single well's withdrawal didn't negatively impact nearby water users. In recent years in Montana, however, developers have used the exempt well loophole to supply water for new subdivisions rather than applying for a new water use permit through the DNRC. In some cases, a single subdivision will install hundreds of wells, according to WELC. The ranchers and other landowners who filed the petition are concerned that the cumulative effect of dozens or hundreds of wells depletes surface water in the streams, and will threaten the security of their senior water rights.

"I don't think it is right that the DNRC can ignore the Prior Appropriation Doctrine in Montana," said Polly Rex, one of the petitioners and a shareholder of the Mendenhall Ditch Company. "Our Ditch Company's priority date is May 1, 1893. Yet a new subdivision two miles away is drilling individual wells more than 100 years later without any regard for its impact on my senior water rights."

WELC also noted that the lack of regulation and monitoring of exempt wells raises concerns about the potential for drinking water contamination, negative impacts to healthy streams and fisheries, and the ability of Montana's communities to plan for adequate water supplies to meet population projections. In support of their assertions, WELC cited the following facts: approximately half of Montana's population depends on groundwater for domestic use; Kalispell, Missoula, Bozeman, and Helena regions accounted for 70% of exempt wells drilled from 2000 to 2008, with roughly 5,000 wells recorded by each of the area's DNRC offices; there were 29,880 permit-exempt wells drilled in Montana between 2000 and 2008 — during this same period less than a dozen groundwater wells obtained a water use permit; and by one estimate, 3 out of 4 lots created in Montana are using permit-exempt wells and septic systems — half of these lots are less than two acres.

For info: Matthew Bishop, WELC, 406/ 324-8011 or www.westernlaw.org; DNRC: http://dnrc.mt.gov/

WATER BRIEFS

SECTION 404 OVERHAUL US
EPA ENFORCEMENT CHANGES URGED

On October 26, the Office of Inspector General (OIG) released an Evaluation Report of EPA's enforcement of Section 404 of the Clean Water Act (CWA). Section 404 provides for the regulation of the discharge of dredged and fill material into "waters of the United States," including streams and wetlands. OIG was highly critical of the agency's enforcement efforts, concluding that "EPA lacks a systematic framework for identifying [section] 404 violations" and that, "without an effective framework or strategy, EPA cannot be assured that it is sufficiently protecting wetlands and other surface waters from [section] 404 violations."

The Report echoed some of the findings of EPA's own Action Plan, and recommended, among other things, that EPA: 1) create a national tracking system for complaints and referrals from the US Army Corps of Engineers (Corps); 2) improve communication between EPA's headquarters/regions and the Corps' headquarters/districts; and 3) leverage other CWA program resources to identify section 404 violations.

Although the Corps is responsible for issuing permits for dredge and fill activities under section 404, both EPA and the Corps share section 404 enforcement duties under a 1989 Memorandum of Agreement ("MOA"). Under the 1989 MOA, EPA serves in the lead enforcement role with regard to repeat violators, flagrant violations, instances where EPA requests a case, and situations where the Corps determines that an EPA penalty is warranted. The Corps serves in the lead enforcement role regarding all other unpermitted activities and all other violations of section 404 permits.

OIG's Report concluded that EPA has not proactively utilized its section 404 enforcement power, but rather has primarily relied on tips and referrals from citizens and other agencies. The Report attributed this largely to EPA's limited field presence, and concluded that EPA lacks sufficient tools and procedures to carry out its section 404 duties. Among the deficiencies noted was that EPA's enforcement database does not contain complete violation histories and that EPA staff cannot directly access the Corps' enforcement records. The Report also suggested that the 1989 MOA does not provide clear guidance as to when the Corps will refer a case to EPA for enforcement, and recommended that this MOA be revised.

In response, EPA indicated that it plans to comprehensively evaluate its wetlands program and the Report's recommendations. EPA also may expand the role of its inspectors to investigate potential section 404 violations, and develop a regional pilot program to implement and test OIG's recommendations.

For info: Report at: www.epa.gov/oig/reports/2010/20091026-10-P-0009.pdf

ENDOCRINE DISRUPTERS NV
LAKE MEAD POLLUTION

The Center for Biological Diversity (Center) submitted evidence to the Nevada Division of Environmental Protection (NDEP) on November 12 demonstrating that Lake Mead, Las Vegas Bay, and Las Vegas Wash are being polluted by unregulated endocrine-disrupting chemicals. The Center is requesting that the state include these waterbodies on Nevada's list of impaired waters pursuant to section 303(d) of the Clean Water Act (CWA) and establish and enforce limitations thereafter.

Lake Mead is the largest reservoir in the United States, part of a beloved national recreation area, and the sole source of Las Vegas' drinking water. It is also federally designated critical habitat for the razorback sucker and home to many other rare species.

According to the Center, endocrine disruptors are entering Lake Mead's water in costly concentrations via wastewater effluent and urban and agricultural runoff. The highest concentrations of endocrine disruptors are found in Las Vegas Wash and Las Vegas Bay. This area is known spawning habitat for the razorback sucker and is a scant six miles upstream from the uptake structures for Las Vegas' drinking water. Monitoring of these waterbodies has detected a variety of endocrine-disrupting chemicals, including organochlorine compounds, dioxins, polycyclic aromatic hydrocarbons, and other endocrine disruptors born from pesticides, pharmaceuticals, and personal-care products.

For info: Rob Mrowka, Center, 702/ 249-5821, rmrowka@biologicaldiversity.org or www.biologicaldiversity.org (Nov. 16 press release contains the Center's letter to NDEP)

CWA ENFORCEMENT CO
RIVER/WETLANDS DAMAGE AGREEMENT

On December 1, EPA reached an agreement with Bucklen Equipment Company, Inc. (Bucklen) to resolve alleged violations of the Clean Water Act (CWA) in Weld County, Colorado. The alleged violations include unauthorized discharges of pollutants to the Cache la Poudre River and its adjacent wetlands within the City of Greeley. Under the consent agreement, the company will pay a penalty of $16,000 and remove any remaining gravel piles from wetlands along the river.

In August 2008, the US Army Corps of Engineers (Corps) received information that Bucklen Equipment was conducting extensive excavation activities in the Cache la Poudre River, including the removal of islands and grading of the river's floodplain. Subsequent investigation by the Corps and EPA found that the company had deposited dredged and fill material in an area encompassing 1,400 feet of the river's length without authorization. The Corps and EPA identified areas that had been dredged and filled in both the river and adjacent wetlands.

EPA will inspect the area next summer to determine if the area has properly recovered following Bucklen's removal of any remaining piles of fill in wetlands along the banks of the Cache la Poudre River. If it appears that additional work such as re-contouring or planting vegetation is required, Bucklen may be directed to submit and implement a restoration plan.

For info: Monica Heimdal, EPA, 303/312-6359 or www.epa.gov/compliance/civil/cwa/index.html

IRRIGATION CONTROLS US
EPA SPECIFICATION COMMENT

EPA released its Draft WaterSense Specification for Weather-Based Irrigation Controllers on November 19, marking the first irrigation product to be considered for the WaterSense label. The specification is open for public comment through January 18, 2010. WaterSense is an EPA partnership program that seeks to enhance the

WATER BRIEFS

market for water-efficient products and services. WaterSense is both a label for products and a resource to help people use water more efficiently.

When the specification is finalized, homeowners and irrigation professionals can use WaterSense labeled irrigation controllers that create or modify irrigation schedules to meet landscape water needs based on real-time weather data. Replacing a standard clock timer controller with a WaterSense labeled controller could save more than 11,000 gallons of water per year. If every home with an automatic irrigation system were to install a WaterSense labeled irrigation controller, it would save nearly 150 billion gallons per year across the US, as well as more than $400 million in homeowners' utility costs.
For info: www.epa.gov/watersense/specs/controltech.htm

CLIMATE WORK GROUP US
WATER UTILITIES

EPA recently convened a Climate Ready Water Utilities Working Group under the National Drinking Water Advisory Council. The working group's charge includes developing criteria for climate ready water utilities; conducting a gap analysis on climate change-related tools, training and products to address utilities' short- and long-term needs; and identifying mechanisms that would facilitate the adoption of climate change adaptation and mitigation strategies by the water sector. The working group had its first of five in-person meetings on Dec. 3-4, 2009 in Washington, DC.
For info: Lauren Wisniewski, EPA, 202/ 564-2918, wisniewski.lauren@epa.gov or www.epa.gov/safewater/ndwac/#current

CONSTRUCTION SITES US
EPA STORMWATER RULE

EPA on November 23 issued a final rule to help reduce water pollution from construction sites. EPA believes this rule, which takes effect in February 2010 and will be phased in over four years, will significantly improve the quality of water nationwide. The final rule requires construction site owners and operators that disturb one or more acres to use best management practices to ensure that soil disturbed during construction activity does not pollute nearby waterbodies.

In addition, owners and operators of sites that impact 10 or more acres of land at one time will be required to monitor discharges and ensure they comply with specific limits on discharges to minimize the impact on nearby waterbodies. This is the first time EPA has imposed national monitoring requirements and enforceable numeric limitations on construction site stormwater discharges.
For info: Enesta Jones, EPA, 202/ 564-7873 or www.epa.gov/waterscience/guide/construction

ECOLOGY RULES WA
GROUNDWATER & INSTREAM FLOW

On November 25, Ecology Director Ted Sturdevant signed the sixth Upper Kittitas Emergency Groundwater Rule, which continues a restriction on new groundwater withdrawals in upper Kittitas. The restriction applies unless the water use is fully mitigated to offset impacts to senior water rights and stream flows.

In another action, a new water management rule for eastern Jefferson County intended to balance current and future demands for water with protection of valuable natural resources was signed November 30 by Director Sturdevant. The instream flow rule encompasses most of the Quilcene-Snow watershed, known as Water Resource Inventory Area 17 (WRIA 17). It takes effect Dec. 31, 2009.
For info: Kittitas rule: www.ecy.wa.gov/programs/wr/cro/kittitas_wp.html; Quilcene-Snow rule: www.ecy.wa.gov/programs/wr/instream-flows/quilsnowbasin.html

INSTREAM FLOWS CO
TRUST AGREEMENT APPROVED

On November 18, the Colorado Water Conservation Board (CWCB) formally approved a trust agreement that will be used for instream flows in the Roaring Fork River basin. After nearly a five-hour hearing, the Colorado Water Conservation Board voted unanimously to approve the Pitkin County Trust Agreement that came about as the result of collaborative efforts among Pitkin County, CWCB, and the Colorado Water Trust (CWT). Pitkin County agreed to allow numerous water rights it owns to stay in local rivers, rather than be used for irrigation or other uses. It will do this by placing those water rights into a trust to be managed by CWCB for use in Colorado's Instream Flow Program. Under Colorado law, CBWB is the only entity that can hold water rights for instream flows. If all of the water rights in the trust agreement are used for instream flows, the Roaring Fork River basin could see up to a 19 cubic feet per second (cfs) increase in flows during the summer months (that figure is only an estimate that does not consider needs of Pitkin County or changes that may be required in the water court process).

The trust agreement was fought by the Basalt Water Conservancy District, Starwood Metropolitan District, the Willow Creek Ditch and Herrick Ditch Company, and the Roaring Fork Land and Cattle Company. Those parties requested the hearing before the CWCB.

The trust agreement is governed in part by House Bill 08-1280, a groundbreaking bill passed by the Colorado legislature in 2008 that provides protections against abandonment claims and removes penalties that might accrue to water users who loan or lease their water to the CWCB for use in the Instream Flow Program. See Beattie, *TWR* #66. The agreement is a groundbreaking project for the state's instream flow program — among other things, it is the first use of House Bill 1280. The trust agreement also provides a model for other water users in the state that have water rights that are not currently being used, such as municipalities that have developed water supplies beyond their immediate needs.

If this transaction is approved, more than thirty additional water rights will be submitted by Pitkin County for acceptance into CWCB's instream flow program. Furthermore, Pitkin County will add water rights to the trust agreement that it will acquire by using the proceeds from its new Healthy Rivers and Streams Fund. Thus, the trust agreement will form the foundation for a long-term relationship between Pitkin County and CWCB to increase the water available in local streams.
For info: John Ely, Pitkin Co. Attorney, 970/ 920-5190; Linda Bassi, CWCB Stream & Lake Protection Section, 303/ 917-5916; Amy W. Beatie, CWT, 303/ 525-4736

CALENDAR

December 15-16 OR
Introduction to Aquatic Toxicology Course: Understanding Impacts of Organic Chemicals & Metals, Portland. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

December 15-16 NC
Sustainable Land Development Conference, Asheville. Grove Park Inn. For info: www.ldbreakthroughs.com/

December 16 OR
Developing Oregon's Integrated Water Resources Strategy Presentation, Portland. Lucky Lab Beer Hall, 1945 NW Quimby. Sponsored by Oregon Section of American Water Resources Assoc. For info: Brenda Bateman, OWRD, 503/ 986-0879 or brenda.o.bateman@wrd.state.or.us

December 16 CA
CEQA Streamlining Toolbox Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or website: http://extension.ucdavis.edu

December 16-17 CA
Western Governors' Association Winter Meeting, San Diego. Hotel del Coronado. For info: Karen Deike, WGA, 303/ 623-9378 or www.westgov.org

December 17-18 AK
Low Impact Development Methods for Ecological Stormwater Management Course, Anchorage. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

January 5 WA
Water, Energy & Life: Fresh Views from the Water's Edge: The Water Center Seminar, Seattle. Anderson Hall, UW Seattle Campus. For info: http://water.washinngton.edu/Outreach/Events/Tuesday/Tuesday.html

January 5-7 Ecuador
Sixth Int'l Conf. on Environmental, Cultural, Economic & Social Sustainability, Cuenca. University of Cuenca. For info: Conf. website: http://onsustainability.com/conference/

January 8 OR
Environmental Cleanup Seminar, Portland. For info: Holly Duncan, Environmental Law Education Center, 503/ 282-5220, email: hduncan@elecenter.com or website: www.elecenter.com

January 12-13 CO
2010 Tamarisk Symposium, Grand Junction. For info: www.colostate.edu/Depts/CoopExt/TRA/2010Tamarisk.shtml

January 13 WA
State Environmental Policy Act (SEPA) Seminar, Seattle. Renaissance Hotel. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

January 13-14, 20-21
Underground Storage Tank Inspection Training, Online. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

January 15 WA
Introduction to the State Environmental Policy Act (SEPA) Course, Seattle. NWETC Hdqtrs, 650 South Orcas Street. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

January 20-22 DC
The New Green Economy: Aligning Science, Education & Markets Conference, Washington. International Trade Center. 10th National Conference on Science, Policy & the Environment. For info: Conf. website: http://ncseonline.org/conference/greeneconomy/

January 21-22 CA
NEPA Seminar, San Francisco. For info: CLE International, 800/ 873-7130 or website: www.cle.com

January 21-22 NC
Stormwater Management in the Carolinas, Charlotte. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

January 21-22 AK
EPA's Numeric Limits to Construction Site Stormwater Discharge & BMPs Course, Anchorage. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

January 25-26 TX
2010 UIC Conference, Austin. Intercontinental Hotel. Sponsored by Ground Water Protection Council. For info: GWPC website: www.gwpc.org/meetings/uic/uic.htm

January 25-26 TX
Wind Energy Seminar, Austin. For info: CLE International, 800/ 873-7130 or website: www.cle.com

January 26-27 CA
Intro to Managing Environmental Data w/ Microsoft Access 2007 Course, Los Angeles. Japanese American Cultural & Community Ctr, 224 South San Pedro Street. For info: NWETC, 206/ 762-1976 or website: www.nwetc.org

January 27 CA
Thresholds of Significance in Environmental Planning Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or http://extension.ucdavis.edu

January 27-29 CO
Colorado Water Congress' 52nd Annual Conference, Denver. Hyatt Regency Tech Center. For info: CWC: http://colowc.com

January 28 WA
Wetlands in Washington Seminar, Seattle. Renasissance Hotel. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

January 28 OR
Solar Power: Projects & Permitting Seminar, Portland. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

January 28 CA
Climate Change Adaptation Planning Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or http://extension.ucdavis.edu

January 28 CA
Managing Environmental Data w/ Microsoft Access 2007 Course, Los Angeles. Japanese American Cultural & Community Ctr, 224 South San Pedro Street. For info: NWETC, 206/ 762-1976 or website: www.nwetc.org

January 28 CA
Environmental Planning & Design Issues for Development Projects On or Near Airports Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or http://extension.ucdavis.edu

January 28-29 WA
Endangered Species Act Seminar, Seattle. Washington State Trade & Convention Ctr. Webcast Available. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 1-2 TX
Texas Wetlands Seminar, Austin. For info: CLE International, 800/ 873-7130 or website: www.cle.com

February 2-4 WA
River Restoration Northwest 2010 Stream Restoration Design Symosium, Stevenson. Skamania Lodge. For info: Rob Sampson, USDA, Rob.Sampson@id.usda.gov or http://rrnw.org

February 3-4 WA
NEPA: Writing the Perfect EA/FONSI or EIS Course, Seattle. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

February 4 CA
Land Use for Real Estate Professionals Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or http://extension.ucdavis.edu

February 4 IL
Carbon Credits Seminar, Chicago. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 4-5 AZ
Solar Power Seminar, Phoenix. For info: CLE International, 800/ 873-7130 or website: www.cle.com

February 5 CO
Promise & Peril of Oil Shale Development Symposium, Denver. Sponsored by Natural Resources Law Center. For info: NRLC, 303/ 492-1286, nrlc@colorado.edu or www.colorado.edu/law/centers/nrlc/OilShale.pdf

February 7-9 WA
Harvesting Clean Energy 10th Annual NW Conference, Kenniwick. For info: Dana Colwell, 800/ 942-4978, Eana.Colwell@wsu.edu or www.harvestcleanenergy.org

February 9-11 WA
Facilitation Skills for Scientists & Resource Managers Course, Seattle. For info: NWETC, 206/ 762-1976 or website: http://nwetc.org

February 10 WA
TMDLs in the Spokane Basin Seminar, Spokane. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

The Water Report
Water Rights, Water Quality & Water Solutions in the West
260 N. Polk Street • Eugene, OR 97402

CALENDAR

(continued from previous page)

February 10-11 WA
Construction Site Erosion & Pollution Control, Shoreline. For info: UW Engineering website: www.engr.washington.edu/epp/cee/wet.html

February 16 GA
Carbon Credits Seminar, Atlanta. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 16-18 WA
Creating Thriving Rural & Urban Communities Through Ecological Restoration Conference, Marysville. Tulalip Convention Ctr. For info: www.ser.org/sernw/Conference2009.asp

February 17 WA
UW Water Center's 20th Annual Review of Research, Seattle. UW Seattle Campus. For info: http://water.washington.edu/Outeach/Events/AnnualReview/annualreview.html

February 17 GA
Solar Power Seminar, Atlanta. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 17-19 CA
ABA Water Law Conference, San Diego. US Grant Hotel. Sponsored by American Bar Association. For info: ABA website: www.abanet.org/environ/calendar/

February 18 OR
Future of Oregon's Water Supply & Management Seminar, Portland. World Trade Center, 121 SW Salmon. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 18-19 GA
Georgia Wetlands & Water Law Seminar, Atlanta. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 18-19 Ontario
2010 International Conference on Stormwater & Urban Water Systems Modeling, Toronto. For info: Computational Hydraulics Int'l website: www.computationalhydraulics.com/

February 21-24 Costa Rica
21st Century Watershed Technology: Improving Water Quality & the Environment, San Jose. Ramada Plaza Herradura. Sponsored by American Society of Agricultural & Biological Engineers. For info: ASABE website: www.asabe.org/meetings/water2010/index.htm

February 21-25 SC
2010 Land Grant & Sea Grant National Water Conference, Hilton Head Island. Marriott Hilton Head Resort. Sponsored by National Water Program. For info: NWP website: www.usawaterquality.org/

February 23-25 DC
Assn of California Water Agencies Washington, DC, Conference, Washington Court Hotel. For info: ACWA, 916/ 441-4545 or website: www.acwa.com

February 25-26 MD
Water Quality in the Chesapeake Seminar, Baltimore. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

February 25-28 OR
Public Interest Environmental Law Conference, Eugene. UO Law School. For info: www.pielc.org/pages/home.html

February 26 OR
27th Annual Benefit Dinner & Auction: The Freshwater Trust, Portland. Art Museum. For info: www.thefreshwatertrust.org

February 26 OR
Water Quality Seminar, Portland. For info: Holly Duncan, Environmental Law Education Center, 503/ 282-5220, hduncan@elecenter.com or www.elecenter.com

March 2-4 NV
2010 NWRA Annual Conference, Las Vegas. Golden Nugget Hotel. Sponsored by Nevada Water Resources Association. For info: NVWRA, 775/ 473-5473 or website: www.nvwra.org/

March 3 WA
Convervation in Practice: UW College of the Environment Colloqium, Seattle. UW. For info: http://depts.washington.edu/cbcomm/colloquium