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Water Rights, Water Quality & Water Solutions in the West

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ENDANGERED FISH REINTRODUCTION

COLLABORATION TRUMPS CONFLICT AT WHYCHUS CREEK

by Pamela Thalacker
Hydro Project Coordinator, Three Sisters Irrigation District (Oregon)

INTRODUCTION

In Central Oregon, ongoing innovation and collaboration between seven irrigation districts, a private utility company, and various federal, state, tribal, and public interest organizations is resulting in a historic re-introduction of anadromous fish runs in the Deschutes River Basin. The efforts described below center on Whychus Creek, a tributary of the Deschutes River.

Whychus Creek originates on the Deschutes National Forest in the Three Sisters Wilderness, on the east slope of the Cascade Range. The stream flows approximately 40 miles northeast, through the City of Sisters, and ultimately into the Deschutes River at river mile 123. Elevations range from 10,358 feet at the peak of South Sister (mountain) to 2,100 feet at the confluence with the Deschutes River. Although the upper watershed is in undisturbed wilderness, the lower watershed around the Sisters community has been managed for timber production and livestock grazing since 1870.

Prior to the construction of dams for hydropower on the Lower Deschutes River in the mid-20th century, Squaw Creek (renamed Whychus Creek in 2006) provided premiere spawning grounds for anadromous fish species — such as Chinook salmon and steelhead — in the Deschutes watershed. (Hereafter, Squaw/Whychus Creek will be referred to simply as "the Creek.") After dam construction the Creek was cut off from these historic fish runs.

One condition of the 2005 Federal Energy Regulatory Commission's (FERC's) re-licensing of Portland General Electric's (PGE's) Round Butte-Pelton dam complex was that fish passage above the dams be restored. For over a half-century, management decisions made for the Creek had assumed an absence of fish. As a result, the Creek was no longer the fish-friendly spawning ground it had been a century ago. The commitment that eventually formed in response to the relicensing condition was to not only get the fish back above the dams, but to actively restore spawning grounds and reinvigorate the historic fish runs.

From this commitment a number of organizations and collaborations were formed. Their enthusiasm and hard work have transformed the Creek significantly over the last seven years. After providing some relevant historical context, this article describes some of their accomplishments and "lessons learned."

HISTORICAL BACKGROUND

Historic Importance of the Creek as Fish Habitat

Summer steelhead (Oncorynchusmykiss) and spring Chinook (O. tshawytscha) — both listed species under the federal Endangered Species Act (ESA) — historically spawned in the Creek. Prior to construction of the Pelton-Round Butte Dam complex, the Creek provided an estimated 1/3 of the steelhead runs in the Deschutes River. In his 1995 report to Portland General Electric, Willa Nehlsen states that an estimated 1000 adults spawned in the Creek during the last run in 1953.

Fish Return

Land "Reclamation"

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

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

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260 North Polk Street,
Eugene, OR 97402

Agricultural Development

The land east of the Creek started being settled in the 1870s. By irrigating, farmers were able to "reclaim" the land and patent their farming claims through the federal Carey and Desert Lands Acts. The key component supporting this arrangement was water. With the large snowpacks in the late 1800s, farmers continued filing diversion claims on the Creek with the dream of irrigating over 24,000 acres. As the century turned, this dream was quickly crushed by Mother Nature. Subsequent snowpacks proved considerably smaller than necessary for dream-fulfillment and it became apparent that the Creek couldn't supply half the number of desired acres reliably.

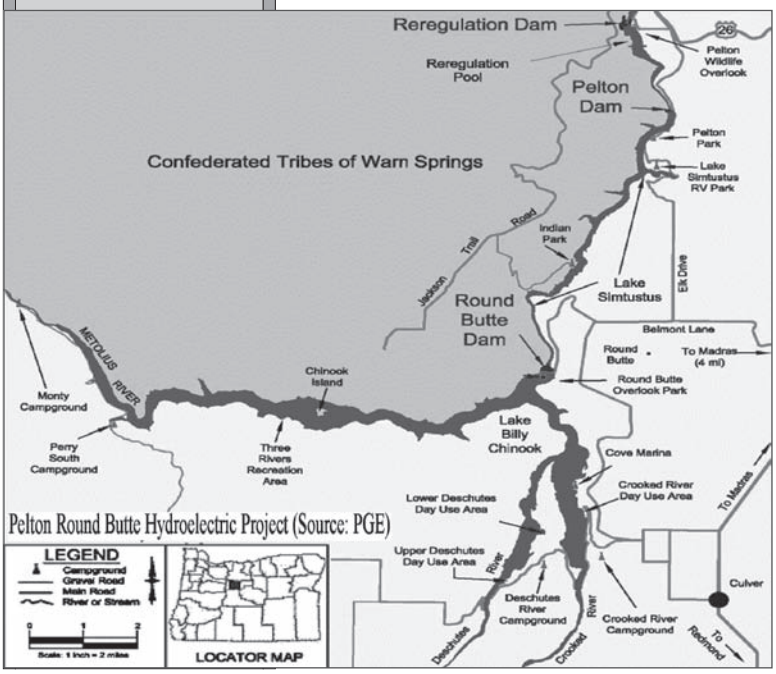
In 1909, the State of Oregon dealt with over 100 challenges and adjudicated all of the existing appropriation claims on the Creek. The Crook County Circuit Court adjudicated those rights in 1911 and 1914. When the dust settled, western water law's Prior Appropriation Doctrine had been used to establish over 16,000 acres of water rights with priority dates ranging from 1880 to 1913. As was common throughout the American West, the Creek was now legally over-appropriated, with more water rights established than the stream could regularly supply. The farmers diverting from the Creek were drying it up almost every year in the late summer months. Even though an investigator for the US Department of the Interior recommended that land grant patents not be issued to any lands having water rights with a priority date junior to 1895, pressure to settle the area prevailed and the patents were issued. A large number of homesteads failed because there was not enough water to serve the junior priority dates (1903-1913). [Editor's Note: a "junior" water right has a priority date later in time than a "senior" right and will be forced to stop diverting if there is insufficient water to supply senior water rights].

The Squaw Creek Irrigation Company (SCIC) formed in 1891 to combine efforts to maintain, improve, and enhance the ditches, canals, and flumes that conveyed water from the Cascade mountain range's "Three Sisters" (three Cascade peaks) watershed to the arid high desert lands of central Oregon to the east. These eastern regions later became known as Sisters, Cloverdale, and Lower Bridge areas. By the early 20th century, SCIC had become the largest company, with the most senior water rights, in the area. Smaller ditch companies like Plainview and McCallister had trouble competing for the water. In 1916, SCIC took advantage of a law that had been passed by the Oregon State Legislature the year before and formed Squaw Creek Irrigation District (SCID). Forming the SCID made the organization a quasi-municipality and gave it the authority to: establish district boundaries; issue bonds; and levy assessments through the county taxing authority. The district's name was changed from Squaw Creek Irrigation District to Three Sisters Irrigation District in 2005.

Construction of Pelton-Round Butte Hydropower Complex

UNINTENDED CONSEQUENCES — "LOST" FISH

Between 1957 and 1964, the Pelton-Round Butte Hydropower Complex was constructed by Portland General Electric (PGE). The involved dams were originally constructed with both upstream and downstream fish passage. However, the construction of the complex had unintended consequences on both river currents and water temperature. Water from the colder Metolius River sank to the bottom of the complex's reservoir — Lake Billy Chinook. This caused the warmer water from the Deschutes to flow over the top of the colder water and back up the Metolius. The Deschutes water that did make it to the dam where the downstream fish passage was located ended up swirling in eddies with no current for the fish to follow to and through the passage. The fish got lost in the lake.



With no downstream passage, there was no reason for upstream passage. In 1968, the dam operation gave up on the fish passage program and constructed a fish hatchery below the dams to maintain the fish population in the Lower Deschutes. The salmon and steelhead runs on the Deschutes and Crooked Rivers were no longer able to access the lower reaches of their traditional spawning grounds in the Upper Deschutes Basin (the Creek, as well as the Metolius, McKay, and the lower Crooked rivers).

Flood Control

Aerial photos taken in the 1940s and 50s indicate that the historic flow of the Creek had moved from meandering through the center of the Camp Polk Meadow to the area's south edge early in the 20th Century. Further flow alterations occurred when reactions to a devastating flood at Christmas in 1964 resulted in the US Army Corps of Engineers straightening and channelizing 18 miles of the Creek. These actions left no viable spawning areas in that stretch of the Creek that was once the most prolific spawning area.

Fish Return

FERC Relicensing

Hatchery/Wild Fish Ruling

Migration Investments

Involved NGOs

Water Markets

Land Conservation

Diversion Impacts

Barriers to Migration

FISH RUN REINTRODUCTION

AN OPPORTUNITY — AND A THREAT

Throughout the West, the ESA has had profound impacts on the setting of priorities for water and waterway management. In Central Oregon, the FERC relicensing process for the Pelton-Round Butte dam complex was obligated to address ESA concerns. This process changed the landscape for fish and farming in the Deschutes Basin.

Fortunately, instead of going to war in the courtrooms, PGE partnered with the Confederated Tribes of Warm Springs and agreed to reintroduce the anadromous runs of salmon and steelhead to the waters above the dams and started planting hatchery fingerlings in the Creek (as well as the Metolius, McKay, and Crooked rivers). The wild strains of steelhead were ESA-listed in 1998 and 1999. Compounding the issue, on August 14, 2007, Judge Michael Hogan of the US District Court in Oregon issued a decision that included this ruling: if a wild species is ESA-listed as endangered or threatened, then hatchery-raised species members are entitled to the same protection as wild members. Overnight the abundant Round Butte Hatchery steelhead became listed as threatened under the ESA. *See* Water Briefs, *TWRs* #30 and #43

As one outcome of the relicensing process, the Confederated Tribes of the Warm Springs Reservation of Oregon and PGE have committed more than $200 million for a comprehensive anadromous fish restoration program. This investment includes new facilities at the Pelton-Round Butte dams for upstream and downstream migration as well as significant restoration funding and support in watersheds upstream of the dams — including the Creek. With the return of these endangered anadromous fish to their historic spawning grounds becoming a reality, the alteration of the stream and surrounding landscape that had occurred over the last 50 years had to be rectified.

A Proactive Response: Strategic Planning

In reaction to turn-of-the-21st-century events, a groundswell began in Central Oregon. In response to the Pelton-Round Butte relicensing agreement, organizations such as the Deschutes River Conservancy (DRC), the Upper Deschutes Watershed Council (UDWC), and the Deschutes Basin Land Trust formed with the goals of: restoring historic stream flow; improving riparian habitat and spawning grounds; and restoring traditional river and flood plain function.

non-governmental organization (ngo) strategies

The Deschutes River Conservancy (DRC) was founded in 1996 by the Environmental Defense Fund, the Confederated Tribes of Warm Springs Reservation (CTWS), and local irrigation districts with the goal of restoring water quality and quantity throughout the Deschutes Basin using markets and incentives to engage local stakeholders in restoration.

The Upper Deschutes Watershed Council (UDWC) was formed in 1996 after the unanimous passage of Oregon House Bill 3441 — which established guidelines for the formation of watershed councils in Oregon to engage in consensus-based approaches to watershed improvement. Their goal is watershed restoration, watershed monitoring, and raising community awareness through education.

The Deschutes Land Trust was formed in 1995 to work cooperatively with landowners to conserve land for wildlife, scenic views, and local communities. They currently own and care for nearly 2000 acres of community preserves in Central Oregon.

The Upper Deschutes Model Watershed Program (Program) was formalized in 2006 as a partnership between the Bonneville Environmental Foundation, Upper Deschutes Watershed Council, Crooked River Watershed Council, Deschutes Land Trust, and Deschutes River Conservancy. The Program includes a ten-year, monitoring-intensive effort to evaluate changes in watershed conditions in the Creek and the Metolius and Crooked rivers. UDWC leads the Program for the Creek.

three sisters irrigation district's strategy

During the past century at least five dams were constructed in the vicinity of the current Three Sisters Irrigation District (TSID) diversion site on the Creek. Over the years, the operation and maintenance of these diversion structures caused channelization of the Creek, the undercutting of stream banks, and disconnection from the floodplain. The concrete dam structure established at the current diversion site in 1970 included a fish ladder, though the ladder did not meet standards set by the Oregon Department of Fish and Wildlife (ODFW) and the National Marine Fisheries Service (NMFS). Approximately 260 feet downstream of the concrete dam, the remains of a log crib dam (no longer in service) had left a sediment wedge upstream and a drop downstream and was potentially on the verge of failing and causing additional problems. Both of these structures created impassable migratory barriers for fish. In addition, the functioning diversion — which could divert up to 80% of the flow from the Creek — had no fish screen.

TSID was fully aware of the potential liability of not solving these problems before the return of endangered fish to this reach of the Creek.

Since the TSID diversion works is on land managed by the US Forest Service (USFS), TSID had (in addition to the NGOs described above) another potential partner interested in improving the reach surrounding their diversion. In 2008, a collaborative partnership was formed among TSID, UDWC, and USFS to rectify the situation.

Fish Return

Irrigation Diversions

Water Temperatures

Detrimental Impacts

Sprinkler Impacts

System Losses

Canal Piping

Leased Water Rights

Senior Rights Purchases

Banking Reallocation

Flow Restoration

The Creek maintains natural flows from its headwaters to approximately river mile 26.5, where a series of major irrigation diversions can remove up to 90% of the flow. TSID, the primary water user on the Creek, diverts up to 130 **c**ubic **f**eet per **s**econd (cfs) at a dam at river mile 26.5. Springs and return flow gradually re-water the Creek at approximately river mile 18, though flows remain insignificant as compared to the natural hydrograph. A large spring complex discharges into the Creek near its confluence with the Deschutes River at river mile three — which improves instream conditions dramatically. Thus, water management practices limit salmonid spawning and rearing in the Creek from river mile 26.5 to river mile three, altering Creek conditions from April through October of each year.

Low stream flow affects many aspects of ecological function in the Creek, including physical and biological parameters. Insufficient stream flow has led to elevated water temperatures throughout much of the creek. Temperatures in the creek have been recorded as high as 24°C / 75°F, which is well above the 18°C / 64°F maximum water quality temperature standard established by the State of Oregon to protect native fish. As a result, the Creek has been listed as temperature-impaired on Oregon's list of water quality impaired waters (i.e., it is on the "303(d) list" required under § 303(d) of the federal Clean Water Act) since 1998. In addition to poor water quality, fish habitat has suffered as a result of irrigation withdrawals. Detrimental impacts include: increases in the channel width to depth ratio; reduced pool habitat; loss of oxbows and sloughs; loss of riparian habitat; and diminished channel/floodplain connectivity.

Water Conservation

Prior to the 1960s, the only method of irrigating practiced by SCID farmers was flood irrigation. As a result SCID was diverting as much as 50,000 acre-feet annually. Although the Rain Bird sprinkler was invented in 1933 by a farmer and patented in 1935, it did not become popular in Central Oregon until the 1960s. The advent of inexpensive electricity and the search for better ways to stretch the available water brought sprinkler irrigation to SCID. The increased crop yields and better water management moved many SCID farmers to install sprinkler systems. The drought of 1977 (along with inexpensive electricity) motivated SCID to apply for supplemental well rights for the majority of its irrigated acres. SCID and the farmers sunk numerous wells to augment the scarce summer water. As a consequence, by the late 1970s SCID had reduced their annual diversion to 35,000 acre-feet annually.

Historically SCID had a 50% system loss. Even though it diverted 35,000 acre-feet from the creek, only 17,000 was delivered to the farmland. Motivated by serious drought in the early 1990s, the Oregon Conserved Water Statute of 1987, and the availability of financial assistance from private and governmental sources, SCID embarked on an aggressive conservation program. By partnering with numerous organizations such as DRC, the US Natural Resources Conservation Service (NRCS), the Oregon Watershed Enhancement Board (OWEB), and others, SCID started piping their open canals. Each project put 50%-60% of the conserved water permanently in stream and the remainder shored up deliveries to the farmland. SCID started with small projects that put from one to two cfs in stream. With the demonstrable success of each project, the momentum grew, the partnerships expanded, the projects got bigger and more ambitious — and the cumulative effect multiplied the benefits.

Leasing

DRC's Annual Water Leasing Program has operated in the Creek's watershed since 2002. Water leasing allows landowners and irrigation districts to maintain ownership over their water right, while affording an opportunity for it to be temporarily put to alternative use, such as instream. Instream leases may be for restoration or for mitigation. DRC's program is a flexible and low-cost tool for streamflow restoration and mitigation supply and currently protects from six to ten cfs in the Creek on an annual basis.

Permanent Water Acquisitions

Many of the most senior water rights on the Creek historically served small streamside parcels. These rights were developed prior to the creation of the Squaw Creek Irrigation Company and were served by small-scale diversions. Since 1998, DRC has worked to acquire these water rights through "willing buyer / willing seller" negotiations. Five acquisitions have resulted in the restoration of 6.67 cfs of senior water rights to the Creek. DRC has worked closely with the Upper Deschutes Watershed Council to coordinate removal of irrigation diversions and fish passage barriers in conjunction with the acquisition of the associated water rights.

Water Banking

Water banks provide multiple essential functions to facilitate efficient market activity for the reallocation of water rights necessary for restoration. For example, water banks are often involved in market discovery and definition, transaction due diligence and conveyance of title, contract administration, and providing regulatory compliance and reporting. Commonly used pricing structures include: fixed price; auction; clearing house; and option markets. Water banks can also alleviate potential supply

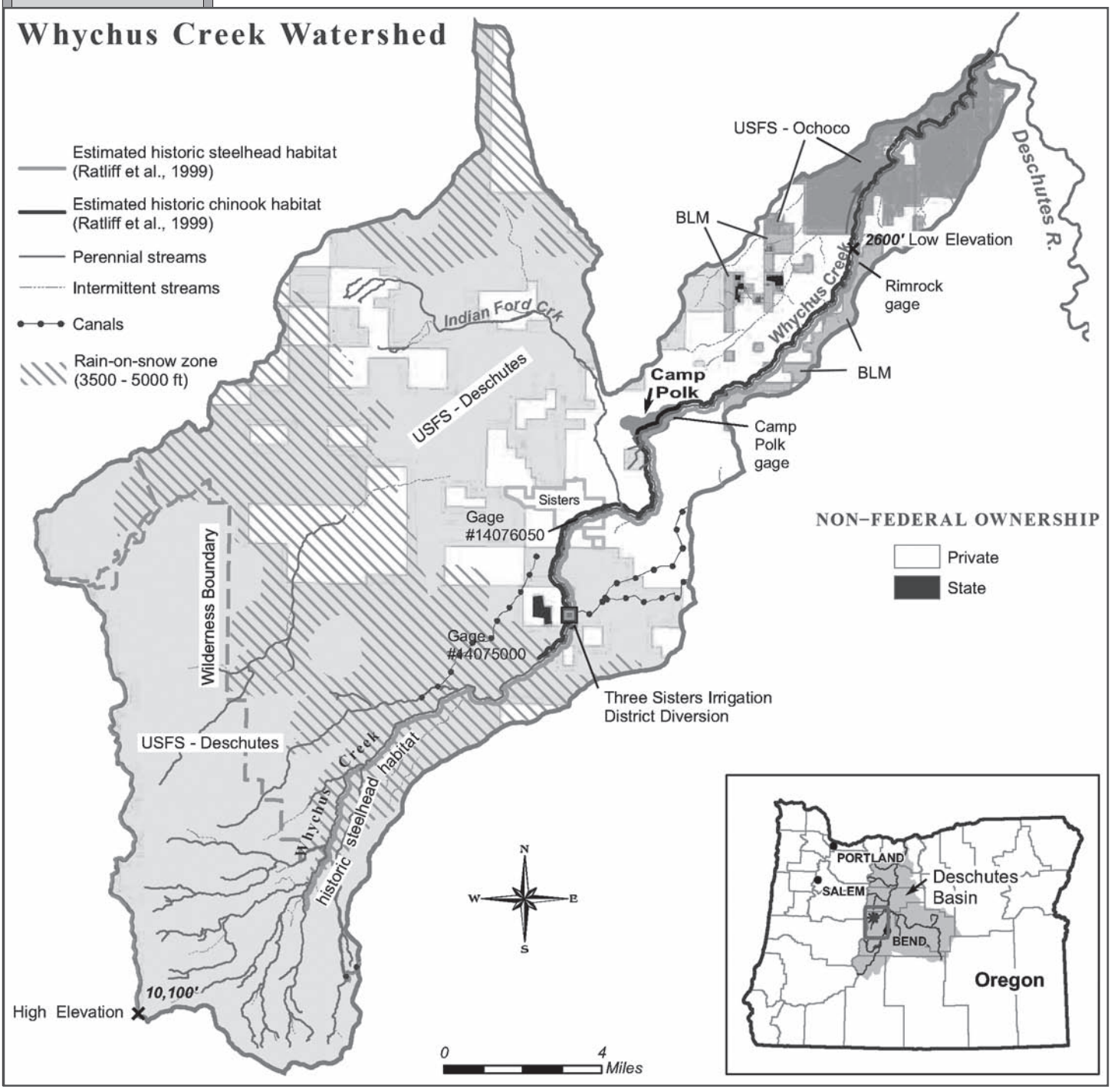
Fish Return

crises by identifying changing water needs early and fostering markets to address developing shortages. Coordination and prioritization of water needs — particularly for competing interests — ensures that available water supplies are managed efficiently. DRC did a feasibility study of a Whychus Water Bank for TSID and concluded that it was, in fact, feasible. Future plans include the creation of this bank.

Habitat Modeling

Habitat Restoration

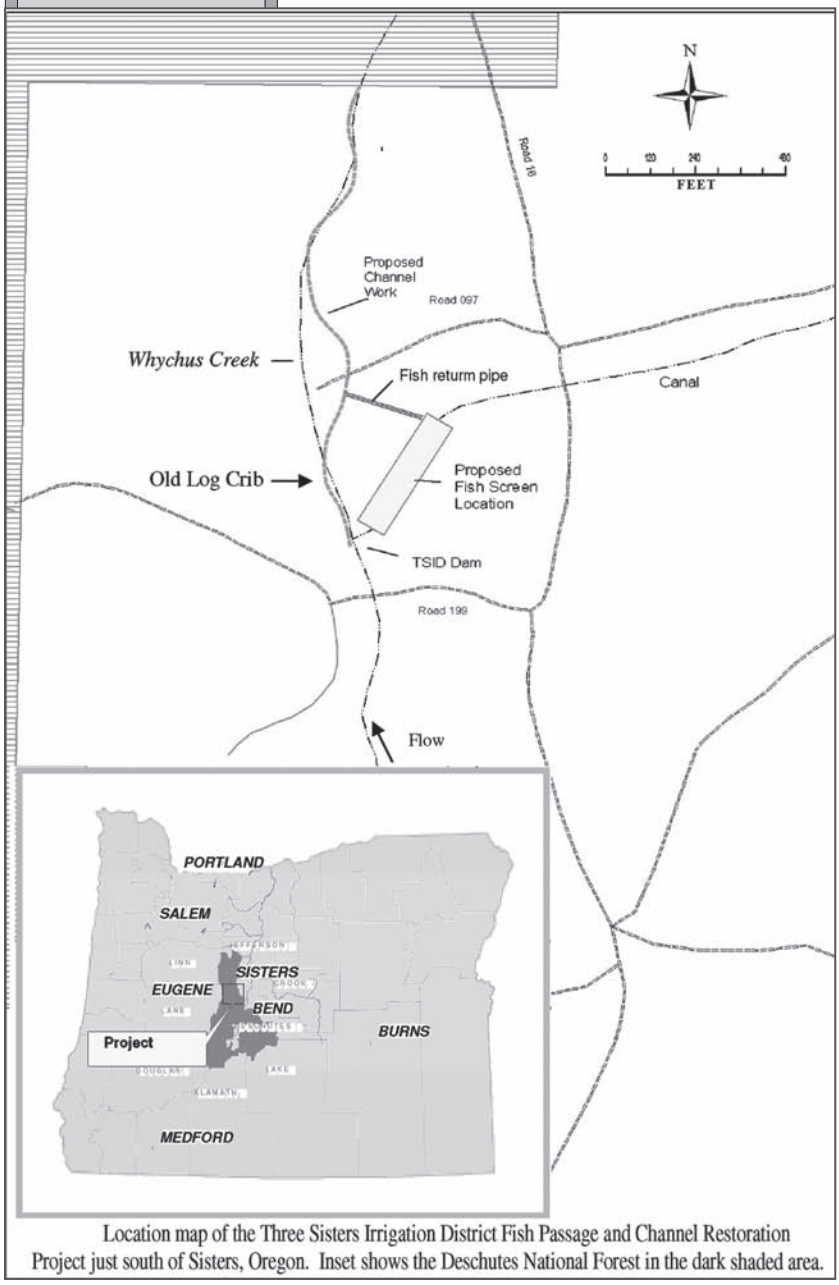
Channelization, riparian vegetation removal, and streamflow modification have all reduced the availability of pools, shade, instream structure, and other important habitat components in and around the Creek. While not all reaches of the Creek were affected, habitat modeling indicated that, of the 35.2 miles of the Creek's potential spawning habitat for steelhead trout, there remained: 0.0 miles of "good;" 28.4 miles of "fair;" and 6.8 miles of "poor" quality habitat.



Fish Return

TSID Diversion: Before & After

TSID Diversion Fish Screen and Stream Restoration: Case Study



Location map of the Three Sisters Irrigation District Fish Passage and Channel Restoration Project just south of Sisters, Oregon. Inset shows the Deschutes National Forest in the dark shaded area.

UDWC engaged Anderson Perry and Associates, Inc. to design the fish screen and River Design Group to design fish passage over the dam.

The collaborative group engaged in several years of planning and study. Starting in 2009, TSID installed Phase I of the three-phase project that would pipe four miles of open canal and place seven cfs of protected flow into the Creek — bringing the total protected minimum flow to over 20 cfs. The final task before running water in April 2010 was to pour the headwall that would connect the fish screen to the two 54" pipes that deliver water to the District.

To complete the instream work, it was necessary to dry up the affected reach of the Creek during construction. In September 2010, a cofferdam (i.e., a temporary structure allowing an enclosed area to be pumped out) was built on top of the diversion dam and the entire flow of the Creek was sent into the TSID diversion. A section of 54" pipe was brought up from the construction of Phase II of the Main Canal project and the flow was diverted into the pipe and down along the floodplain to re-enter the Creek below the restoration reach.

River Design then moved in to raise the stream up to the level of the top of the diversion dam over the 120 feet below the dam. At that point they started to rewind the stream back into the floodplain for the next 1300 feet. They reworked the undercut banks and reinforced them with coir (natural fiber) mat barriers and full-sized trees. The old log crib dam was removed and the stream floor and banks returned to a more natural state. 50 volunteers planted 46,000 native trees and shrubs along the new stream banks and throughout the now reconnected floodplain. A pipe was strategically placed along the bank to be connected to the fish screen and provide a return path to the stream for fish that entered the diversion.

Fish Return

Fish Screen Innovation

After only 30 days, water was returned to the restored stream and work began on the fish screen. The design committee had decided on a Farmer's Conservation Alliance horizontal fish screen. Self-cleaning and with no moving parts, plus meeting or exceeding all state and federal standards for fish protection, this screen proved an excellent choice for this application. That winter it snowed so much that some days the TSID work crew spent as much time shoveling snow as setting concrete forms. Even so, they poured 650 cubic yards of concrete to form the frame for the nearly 300' dual bay screen in less than 90 days.

In a race to the finish, the screen and weir gates that regulate flow across it were completed and water was turned into the diversion and across the screen on April 24, 2011 to open the TSID irrigation season.

The TSID diversion is now ready to receive the return of fish from the ocean.

TSID Fish Screen, photo by Pamela Thalacker, TSID

Preserve Acquired

Camp Polk Meadow, photographer: Jay Mather, Deschutes Land Trust

Camp Polk Meadow: Case Study

In 2000, the Deschutes Land Trust (Trust) partnered with PGE and acquired the 145 acre Camp Polk Meadow property. In 2011, the Trust added another six acres to the meadow — bringing it to 151 acres. This Preserve contains approximately 1.4 miles of the Creek and includes wetlands, meadows, aspen groves, and ponderosa pine stands. The stretch of the Creek that ran through Camp Polk Meadow was historically the Creek's highest quality spawning habitat for steelhead.

The Camp Polk site exemplified some of the most devastating effects of channelization. Restoration partners conducted extensive research at this site and created a comprehensive stream restoration plan. Channel straightening and berm construction had eliminated important habitat features, including: pools; oxbows; side channels; and riparian vegetation. In addition, the straightened channel had increased flow velocities and accelerated erosion. These changes had resulted in channel instability even many years after the US Army Corps of Engineers bulldozers left the creek. At one specific site, the Creek's banks were so unstable that more than 13 feet of bank erosion was measured during one month in 2007.

Starting in 2004, the Trust, UDWC, and USFS began extensive planning and study that would design a project to re-construct the Creek's historic path through the meadow.

Fish Return

Restoration Goals

Created Meanders

Camp polk project goals included:

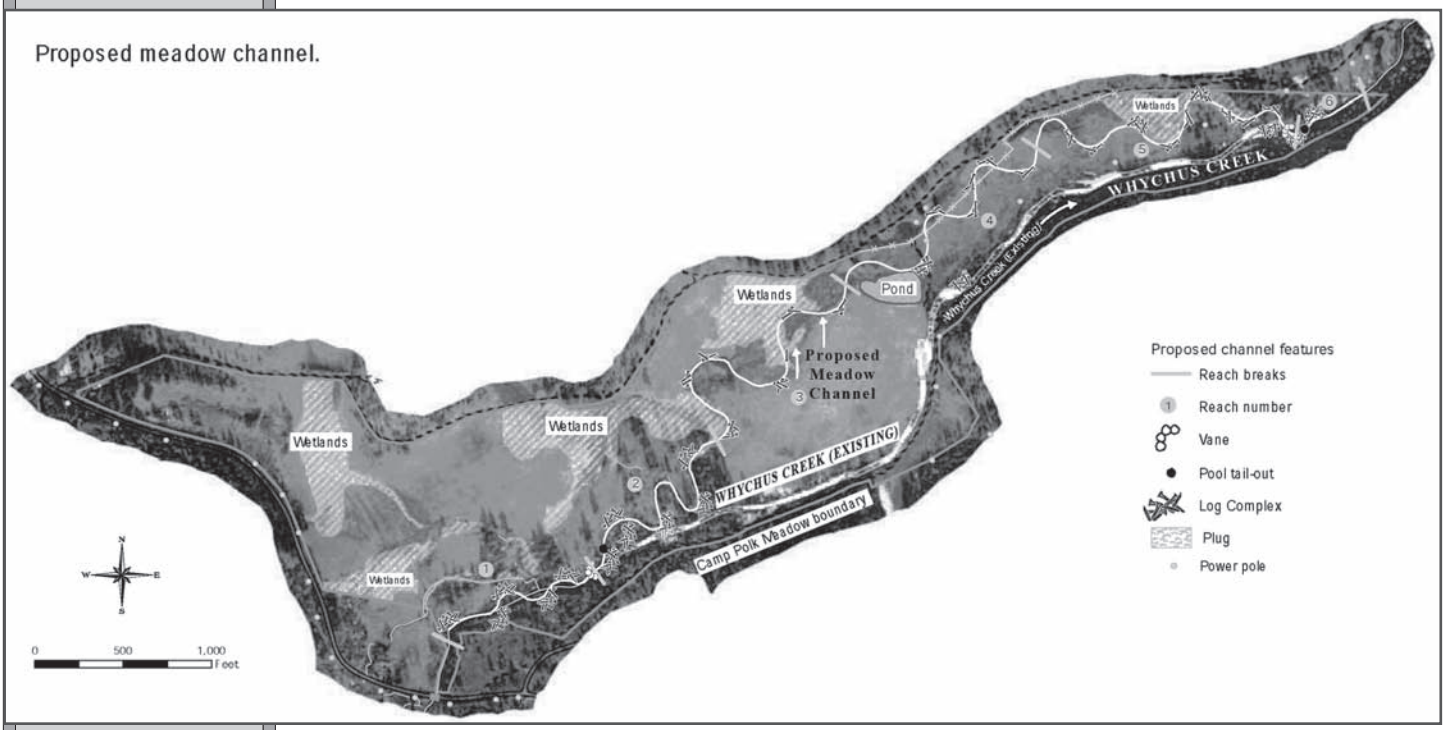
- Replacing the 1.4 miles of channelized creek running along the south edge of the meadow with 1.7 miles of meandering and pooling spawning habitat
- Restoring functioning meadow hydrology, including floodplain connectivity, an increase in the groundwater table, and enhanced summer base flow
- Restoring and enhancing riparian wetland habitat along the stream corridor, providing channel stability, and reducing stream temperatures to meet Oregon State water quality criteria

The work began in 2009. A route resembling the historic, meandering stream path was carved out through Camp Polk Meadow. Nearly 200,000 native plants were placed around the edges of the restored channel and water was brought over from the channelized creek to irrigate them. These plants were allowed to grow so they would stabilize the banks of the new stream and reduce sediment flow once full flow was re-routed into it. "Mini-plugs" (small earthen dams) were installed along the route to prevent erosion and create pools to support the vegetation. Log jams were placed strategically along the curves of the streambed to assist with bank stabilization until the plants could fully mature.

In 2011, crews returned to the meadow to carve out side channels, remove the plugs, and eliminate access roads. At this time there was a 98% survival rate on the plants that had been installed along the stream banks and numerous beavers had taken up residence in the new habitat.

In March of 2012, the water was redirected from the existing channel into the restored channel. The existing channel was decommissioned by filling it with rocks, trees and soil. Camp Polk Meadow now sits awaiting the return of fish that were planted in the Creek over the last several years.

Camp Polk Meadow Restoration Map:



Fish Return Projections

REINTRODUCTION OUTLOOK

While the long-term success of reintroduction remains uncertain, the commitment to its success is clear. The attention and resources brought to restoring watersheds in the upper Deschutes Basin has restored the habitat needed to support all native salmonids, including resident redband trout.

In 2010, a total of 44,000 spring Chinook, 7,700 steelhead, and 49,700 kokanee were passed downriver. These fish are expected to produce the first significant number of adult fish to return to the dam complex the summer and fall of 2013. Half of these fish will get passed above the dams to continue to their newly restored historic spawning grounds and half will be sent to the hatchery to produce new fry to continue the planting program in the Deschutes tributaries.

Fish Return

In the 2011 spring migration, more than 225,000 sockeye, 30,000 Chinook and 10,000 steelhead smolts passed through the Round Butte facility.

Last year, more than 30 Chinook salmon, sockeye salmon and steelhead that were reared upstream and passed through the Round Butte fish passage facility on their way to the Pacific Ocean returned. All the collaborating partners are eagerly looking forward to watching those numbers increase each year.

CONCLUSION: LESSONS LEARNED

Partnership Importance

Developing a cooperative conservation watershed partnership is a long-term investment of both time and money. Without the "Bridging the Headgates" partnership between NRCS and US Bureau of Reclamation (Reclamation), the feasibility and design work for this project would never have happened. It was that foundation work that brought about the collaborative effort to restore the Creek.

TSID has been working with DRC for over a decade to foster and expand the watershed partnership (see the brochure "*Whychus Creek-Progress in Restoration*" — available at: http://publications.restorethedeschutes.org/2010_WhychusRestore/).

WaterSMART Program

Reclamation's WaterSMART vision for sustainability and certainty is right on target for developing balance for water resources in the West (www.usbr.gov/WaterSMART/).

Cooperative Conservation

Sustainable agriculture and healthy rivers can coexist when there is voluntary cooperation. Litigation and court orders cannot solve the environmental challenges we are all facing. It will be essential in the future for federal, state, and local agencies to coordinate (and not duplicate) required activities like NEPA, permitting, and land use. Streamlining government requirements saves precious time and planning dollars that sometimes are too much for small projects to move forward. Developing a broad cooperative conservation watershed partnership is critical to achieving the win-win scenario.

Adult steelhead and salmon could be moved above the Round Butte-Pelton dam complex as early as 2012. The addition of 1,000-2,000 spawning adults in the Creek has the potential to double the steelhead run in the Deschutes River. Those additional numbers would take the ESA-listed steelhead population from low viability to high viability. This would be a milestone in addressing the Middle Columbia Steelhead Recovery Plan. This achievement will demonstrate Reclamation's success in complying with the new Columbia River biological opinion. Reclamation's WaterSMART program, which creates certainty and sustainability for agricultural, municipal, environmental, and recreational water needs through win-win partnerships is succeeding in the Deschutes Basin.

The re-introduction of anadromous fish runs in the Deschutes Basin is skeptically considered by some to be a grandiose and costly experiment. In reality, the collaboration among the seven Central Oregon irrigation districts, Reclamation, the Deschutes River Conservancy, Natural Resource Conservation Service, the Oregon Watershed Enhancement Board, the Confederate Tribes of Warm Springs, Portland General Electric, the Upper Deschutes Watershed Council, the US Forest Service, the National Marine Fisheries Services, and the US Fish and Wildlife Service, all the state natural resource agencies, and all the other funding and technical providers— is making real progress toward real success.

For Additional Information:
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Pamela Thalacker, with her husband Marc, moved to their ranch in Central Oregon in 1988. They quickly became involved in their irrigation district and as volunteers performed a remapping of the District under Oregon House Bill 3111, which re-adjudicated the District water rights. From there, she was elected to the District's Board of Directors and served as President for several years. When Marc was hired as District manager in 1997, she retired from the Board of Directors, but remained involved in the District as a volunteer. In 2011 she was appointed Hydro Project Coordinator for the hydropower plant that Three Sisters Irrigation District plans to put online in 2013.

Columbia Basin Treaty

THE COLUMBIA RIVER, BASIN, AND TREATY

UPCOMING TREATY DATE IS FOCUSSING BASIN WATER MANAGEMENT ISSUES

by Stan Miller
Spokane County Water Resources Program, retired
&
American Water Resources Association, Washington Section, Board Member

Editors' Introduction: The United States and Canada signed the Columbia River Treaty in 1961. After ratification and adoption of Treaty protocol, the Treaty came into effect in September, 1964. The Treaty contains no termination date, but the Treaty may be terminated with 10 years written notice by either party on or after September 16, 2024 — i.e., with written notice given on or after September 16, 2014. The 2014 date is serving to focus even more attention on an already contentious region for water management, and *The Water Report* is happy to be a media sponsor for the upcoming *The Columbia River, Basin and Treaty* conference. The conference is being presented by the Washington Section of the American Water Resources Association and will be held September 11-13, in Ellensburg, Washington (see agenda, page 16).

In the article below, Stan Miller provides both background and current context for the some of the very complex issues confronting Columbia River Basin stakeholders in light of Columbia River Treaty reconsiderations.

BACKGROUND

Multiple-Use Studies

In 1925, the US Congress passed an updated version of the Rivers and Harbors Act; the first Rivers and Harbors Act was passed in 1824 and appropriated funding to improve navigation on the Ohio and Mississippi Rivers. The 1925 law directed the US Army Corps of Engineers (Corps) to determine the cost of conducting "multiple-use studies on the nation's rivers." In 1927 the law was again "updated" with a directive for the Corps to implement the studies described in the 1925 law for a number of river basins, including the Columbia River. During the next decade scores of reports were prepared and published, termed "308" reports after the section of the law authorizing them (USACE, 1932, USACE, 1942).

The "308" report on the Columbia River, titled *Columbia River and Minor Tributaries* (USACE, 1932*)*, revealed the potential of that river system for hydroelectric power, navigation, flood control, and irrigation.

As a hydroelectric power resource in the report to Congress, the Corps noted 10 sites suited for hydropower development in the US. At the time the report was issued the Chelan County Public Utility District was constructing one of those dams at Rock Island, a few miles downstream of Wenatchee, Washington. The report cautioned that power production should be added in increments so that the supply did not exceed demand. Today all 10 of those dams, plus additional dams in Canada, are in place.

Navigation

From a navigation standpoint the report divided the river into three sections: the lower (tidewater section to about River Mile [RM] 140); the middle section (from tidewater to the Snake River at about RM 320); and the upper section (from the Snake River to the Canadian Border at about RM 745). Improvements already underway were deemed adequate for the lower section. The Cascade Locks at the Cascade Gorge solved the main problem on the middle section. It was noted however that construction of any dams for hydropower in the middle section should include features such as locks that would improve barge navigation. Finally, the report concluded that the upper section was not suitable for any but local transportation purposes and should not be further considered for navigation purposes.

Flooding

This early report minimized the problem of flooding on the river, suggesting that the problem could be solved through local initiatives for levee construction and adding some storage to appropriate hydroelectric dams. This was nearly two decades before the floods of May 1948, when everyone's perception of the hazards of the Columbia came into sharp focus.

Irrigation

The report noted that there were some two million acres of land along the river that could benefit from irrigation. The report further noted, however, that implementing an irrigation project in the 1930s was not feasible. The benefits gained were far outweighed by the costs. The population base of the region was not big enough to support the kinds of crops that would be grown and the cost of building dams to provide power and storage for an irrigation system was huge. The report did state that in any future power project constructed in an area suitable for irrigation, a portion of the power be earmarked for sale, at the cost of production, to support irrigated agriculture.

Columbia Basin Treaty

Hydropower History

Grand Coulee Dam

Early Implementation of "308" Report Provisions

Soon after the 1932 "308" Report was issued, Congress acted on the recommendations for hydropower development. Both Bonneville Dam and Grand Coulee Dam were authorized in 1933. Privately funded Rock Island Dam, now operated by the Chelan County Public Utility District, was authorized in 1929 and came on line with a generating capacity of 60,000 kW in 1933. Total capacity today exceeds 600,000 kW.

Both Bonneville and Grand Coulee were considered part of President Franklin D. Roosevelt's New Deal to help pull the United States out of the "Great Depression." Bonneville Dam's first powerhouse was completed in 1937 and delivered about 525 megawatts of power. Being a much larger project, Grand Coulee did not deliver power until 1942, which was just in time to add power to an aluminum production binge in the Northwest as part of the World War II war effort.

Coincidental to the initial power output of Bonneville Dam, the Bonneville Power Administration (BPA) was created to coordinate federal, and to an extent privately produced, power production on the Columbia and to market that power.

In his autobiography *Where Water Falls*, Senator Clarence C. Dill (Dill, 1970) describes his discussions with President Roosevelt concerning the construction of Grand Coulee Dam. Though Roosevelt had gone on record in favor of the dam and the associated irrigation project numerous times, he ended up dragging his feet on the overall high dam / irrigation project. His basis was that the $450,000,000 price tag was too high for a dam that would produce nearly two megawatts of power in a region with little population. Ultimately Roosevelt compromised, agreeing to construct a "low dam" that would produce a marketable amount of power but would not serve as a source of water or power for irrigation. It was this $60,000,000 project that Roosevelt funded out of the monies provided through the Public Works Administration.

The year 1948 was a watershed year in planning for Columbia River flow management. In June of that year the river flooded and effectively destroyed Vanport, Oregon's second largest city. For over a week, beginning the last few days of May, the Columbia raged with a flow exceeding 900,000 cubic feet per second (cfs); flow peaked at around 1.2 million cfs, nearly three times the normal flow for the period. The "308" report of 1932 obviously missed the mark on what was needed to prevent flooding on the lower river. At the time of the flood the Corps was working on a new "308" Report for the Columbia and Tributaries. The new report, released in October 1948 (USACE, 1948), revealed a plan to control flooding by managing flows in the Columbia. The plan called for the construction of reservoirs, primarily in the upstream states of Idaho and Montana that would hold an aggregate of 20 million acre-feet (AF) of water. This storage target required the construction of nearly 15 million AF of new storage to add to the existing 5.1 million AF at Grand Coulee. This amount of storage would allow damping of the peak flows like those that occurred in May and June to a point where flooding on the lower river would be avoided.

Columbia Basin Treaty

Storage Needs

Flow Variability

Given that the flood control storage plan was released less than six months after the flood, it was obvious that the report was already in the late stages of development. The original intent of the plan was to outline the needs for developing the river to its full power production potential outlined in the 1932 report. The wide seasonal variations in Columbia River flow made storage essential to fully use all the water flowing down the system. It was largely coincidental that the storage needed for leveling flow to maximize power production and better fit supply to regional demands was consistent with that needed for flood protection.

To illustrate the nature of the flow variability it is worthwhile to consider a few river flow statistics. Flow for the Columbia at the Dalles, Oregon, averaged about 103,000 cfs for the months of October through February. This is just over one quarter of the average flow of some 490,000 cfs in June. These averages are for the period 1879 through 1969, before significant flow controls were implemented and pre-dating any Columbia River Treaty benefits. Thus they represent the data available during the early years of planning for management of the river. Similarly, at the International Boundary the average monthly flow of the Columbia River ranged from a low of about 39,000 cfs for January to a high of 288,000 cfs for June. These averages are for the period of 1938 through 1969, again pre-dating the effect of the Treaty.

By the mid-1950s, with five of the eventual eleven main stem dams in the US online, the conflict between the fall /winter peak demand for power and the peak availability for "run of the river" power in May and June was reaching critical proportions.

"DSI" Power Curtailments

BPA sells the electricity output of the Columbia River Power System to public utilities around the Pacific Northwest. This electricity is called "firm power" — as it is delivered 24 hours a day without interruption. BPA also sells power directly to a small number of industries in the Northwest (historically primarily aluminum plants). Referred to as "Direct Service Industries" (buying directly from BPA as opposed to buying from a utility) or "DSIs," their power allotments are subject to curtailment (i.e., are "non-firm") in times of shortage. The mid-1950s brought frequent and longer periods of such curtailment.

Power "Leveling"

In 1954, E. E. Marts (Marts, 1954) from the University of Washington reviewed the information in the 1942 "308" Report: *Columbia River and its Tributaries* (USACE, 1948). In this report the Corps called for the construction of five dams to meet the 20 million AF of storage needed for both power "leveling" and flood control: Hells Canyon on the Snake and Albani Falls on the Pend Oreille in Idaho; Libby on the Kootenai, Hungary Horse on the Flathead, and Glacier View on the North Fork Flathead River in Montana. Grand Coulee Dam on the main stem Columbia in Washington and its 5.1 million AF of storage came on line in 1942 (once started, the low dam at Grand Coulee approved by FDR was expanded to include the full blown high dam and irrigation project in a "seamless" construction cycle). The US Bureau of Reclamation (Reclamation) finished Hungary Horse Dam in 1953 (1.1 million AF of storage) and the Corps completed Albani Falls Dam in 1955 (approximately 3 million AF of storage). These three facilities provide a little less than half the needed storage.

Upstream Impacts

However, building these dams with their attendant impacts in headwater areas with low populations and little need for power was beginning to draw resistance (Muckelston, 1982). What could or would downstream beneficiaries do to compensate upstream populations for negative impacts? The idea for Glacier View Dam was abandoned when the National Park Service protested the flooding of part of Glacier National Park and the loss of winter elk habitat. Approval of Libby Dam was on hold because the Canadian Government would not agree to flooding over 40 miles of the Kootenay Valley in British Columbia. Only Hells Canyon Dam (completed by Idaho Power in 1971) with its 3.9 million AF of storage was still on the table. This still left the "system" some 8 million AF short of the needed storage.

ENTER: THE COLUMBIA RIVER TREATY

Canadian Storage

With the storage problem stalemated in the US at about 65% of that needed by the goals set for power and flood control, basin water resources managers began to think about Canada. With over half the flow of the Columbia as measured at the Dalles coming from only15% of the drainage area in Canada (Lang, undated), it made sense to look to Canada for help in managing downstream flow problems. Once again the problem of assessing downstream beneficiaries for upstream costs and impacts became the key issue. In the case of Canada the problem was somewhat simplified; rather than several states, negotiations only needed to include the government of British Columbia. Here Senator Dill reenters the picture. Dill served only one term in the Senate, refusing to run again after successfully completing his mission of getting Grand Coulee Dam started, and stayed active in regional water politics through his Spokane-based law firm. Among his activities Dill pursued the development of Canadian storage for the purpose of "leveling" production. In his memoir, he recalls a 1957 conversation with attorney Edward Allen, a friend serving on the International Salmon Commission, about how the US and Canada divided up the salmon runs available in international waters. Dill thought that the fifty-fifty split on fisheries could be applied to the River benefits as well (Dill, 1970). He floated the idea that the value of half of the "excess" power produced

Columbia Basin Treaty

from water stored in Canada be returned to Canada. He discussed the idea with W.A.C. Bennett, Premier of British Columbia, and the leadership of the Grant, Chelan, and Douglas County Public Utility Districts, and received a positive response. In return, Canada would build storage equal to 15 million AF. These early conversations led to years of discussion culminating in the final Columbia River Treaty (Center for Columbia River History, Undated). Though the International Joint Commission agreed on the general Treaty provisions by 1960, it would be 1964 before all the necessary congressional approvals were in place.

Treaty Provisions

In general, the Treaty called for the construction of three dams in Canada: Mica and Arrow Lakes (Keenleyside) on the main stream Columbia, and Duncan Dam on the Duncan River, a tributary of the Kootenay in Southeastern British Columbia. The treaty also allowed the construction of Libby Dam in Montana and the commensurate flooding of almost 40 miles of the Kootenay Valley in British Columbia. To finance the construction, the US agreed to provide $254 million in advance payment for the extra power produced and $64 million for Flood Control. Included in this deal was the creation of over 15 million AF of storage in Canada and an additional 3.9 million AF behind Libby Dam.

Flexibility Terms

From the discussion above it is obvious that the Treaty deals primarily with power generation and flood control. Though on the face of it the Treaty seems quite limited in scope, the variable nature of river flow demands that any document establishing guidelines for managing those flows requires flexibility. The Columbia River Treaty handles this through a prescribed process for evaluating snowpack and precipitation annually and creating specific actions to be followed each year. Through these annual negotiations, water for non-specified purposes has been incorporated into the process. Releases to help meet minimum flows for salmon passage and for irrigation use have been included in recent years. The Treaty was enacted with no firm termination date. Instead, the Treaty contains a provision that would allow either party to the Treaty to terminate the Treaty after 60 years (2024) with a ten year pre-notification. The pre-notification is less than two years away (2014). Unless renegotiated, the pre-paid flood control provisions of the Treaty lapse. From 2024 on, flood control storage could be "purchased" on a yearly basis.

Flood Control Storage

ANCILLARY FACTORS: IRRIGATION & HABITAT

Annual Operations

As important as they are today, two factors that received little attention in the Treaty are provisions for the timely release of water to assist in salmon migration and to assure water is available to serve irrigation in the Columbia Basin Project. As these issues have gained importance in the management of Columbia River flows during the last two decades, they have been "handled" through the annual operations agreements that produce storage and release criteria consistent with each years' varying snowpack and precipitation regime.

Columbia Basin Project Irrigation

Reclamation Irrigation Project

Grand Coulee Dam was completed as a high dam capable of generating about 2,000 megawatts power and providing water to Reclamation to irrigate the Columbia Basin Project (CBP). Though water was not delivered to the first irrigation blocks until 1951, Reclamation acquired water rights for irrigating a major portion of the planned 1 million plus acres when instream water rights for power generation were obtained (Simonds, 1998). An assessment prepared by the Montgomery Water Group (Montgomery, 2003) reports that there are just over 3.1 million AF of water rights held by Reclamation for the CPB. The priority date for these rights is May 16, 1938.

Irrigated Acreage

Since the first deliveries of water, irrigated acreage in the basin has gradually increased. In the last four decades irrigated acreage has increased by nearly 40%. In spite of the fact that there has been gradual growth in CBP's irrigated acreage, that growth has leveled off in recent years. There are a number of factors leading to the slower increase in irrigated acres but with drought year withdrawals approaching the water right limit, the risk of curtailment of supply for new users is part of the driving force. Today over 670,000 acres are irrigated with CBP water (USBR, undated); during a dry year like that of 1994 most of the allocated water is used (Montgomery, 2003). Though CBP's irrigation acreage growth has slowed there has been a large increase in non-CBP irrigation in the basin.

Groundwater Use

As growth in CBP irrigation began to slow, deep well irrigation began to grow rapidly around the eastern edge of the active project in the late 1960's and early 1970's. Coincidental to the construction of the Third Powerhouse at Grand Coulee Dam there was talk of (and actual construction on parts of) the East High Canal. The headworks of the Main Canal at Coulee City were expanded and the Bacon Siphon and Tunnel were expanded to handle approximately 19,300 cfs, up from 13,200 cfs in the original system built in the 1940s (Simonds, 1998). The East High Canal was to serve several hundred thousand acres in a new "block" of irrigated land topographically higher and to the east of the current irrigated tracts. Farmers who installed deep wells in anticipation of replacing that source with "ditch water" were literally left high and dry when the Reagan Administration cancelled the expansion. With the wells being drafted such that the water table is dropping tens of feet per year in the so-called Odessa–Lind Groundwater Management Area (GWMA), water supply in that region is reaching crisis conditions (USBR, undated).

Dropping Water Table

Columbia Basin Treaty

Power Water Right

Spilled Water Issues

System Conflicts

Flood Control Use

Conflict Management

In 2006, the Washington Department of Ecology established the Office of the Columbia River (OCR) to seek solutions to the Odessa–Lind problem and other water supply/use situations in Central and Eastern Washington (note: the second day of the conference will address the issues associated with the Odessa–Lind GWMA and region). In addition to the Odessa–Lind GWMA, the OCR is assisting with projects to increase irrigation efficiency, reduce losses during transportation of water, and similar issues.

While 3 million AF is only about 4% of the total flow of the river at the International Boundary, it must be kept in mind that in 1969 the Grand Coulee dam obtained a continuous water right of 184,000 cfs for production of power at the third powerhouse (Montgomery, 2003). This alone is nearly twice the annual average flow at the boundary. Producing the full 6,000+ megawatts that Grand Coulee is capable of requires drafting storage of tens of thousands of cfs, except during mid-May through mid-July high flows. Currently, the storage provided by Canadian reservoirs allows the refilling of Franklin D. Roosevelt Lake (Grand Coulee's Reservoir) several times per year such that meeting both power and irrigation needs is not a problem in essentially all water years.

Habitat Maintenance

In the early part of the 20th Century, hydroelectric installation and flood control planners viewed any water spilled over a dam as either a waste or a potential flooding threat. Dams were either built as run-of-the-river or reservoir storage facilities. In a simplified view this implied two separate operating scenarios. In run-of-the-river situations the dam provided a (usually) small amount of head and a power generation system that was flexible enough to use the full range of expected flows. Only in the case of extremes would water be spilled. For dams with reservoirs, the reservoir capacity was, if possible, designed to store the peaks of the runoff hydrograph so that the power plant could run at a steady pace year round. Again, practicality demanded that some of the extreme flows be allowed to spill. Even in dams with fish passage installed, those systems were designed to use as little water as possible.

As we learned more about anadromous fish, it became apparent that just being able to get past a dam did not guarantee fish survival. We learned that spilling water over dams increased dissolved gases to levels toxic to fish. We also learned that fish need "flood" flows to sense the time to head out to sea as well as to get "over the falls" on the way up stream. This new knowledge required that we modify the way rivers are managed to ensure successful fish runs. Engineers are working out ways to spill water over dams such that the dissolved gas accumulation is acceptable. Attention is being paid to when water is released as well as how much.

So far the annual operating agreements developed under the current Columbia River Treaty seem to provide the flexibility needed for managing fish habitat.

THE FUTURE

There are a number of scenarios that could be considered for the future. The 2012 AWRA Washington Section Conference will examine a number of these in detail. Three will be discussed briefly here. For the sake of brevity the discussions here are of a very general nature and do not attempt to consider many of the ramifications of the views presented. Plan to attend the conference to get into a more complete discussion.

Some hints for future actions needed in the basin are suggested in a paper by Keith Muckelston of Oregon State University. Muckelston addresses three issues of conflict within the Columbia River system: Irrigation versus Hydropower, Dams versus Salmon, and Upstream–Downstream Conflicts. Of these the only one to have had any significant success in resolution was the matter of Upstream–Downstream Conflicts. The success he sees in this arena comes not from agreements among US states and Tribes but rather through the international cooperation contained in the Columbia River Treaty.

First on the list for discussion is the "do-nothing" scenario with regard to the Columbia River Treaty. The most significant factor in this view is that the flood control provisions in the present treaty go away. In the initial funding allocation to Canada some seven million AF of storage was dedicated to preventing floods on the lower Columbia River. After 2024, the mandated use of that storage for flood control goes away. Unless a renegotiated treaty addresses this element, the US could be in a position where the storage available south of the border needs to be used for flood control. This could force drafting large reservoirs like Lake Roosevelt, Lake Kocanuska, or Hells Canyon to meet flood control storage needs rather than power supply, irrigation, or habitat needs.

Second is how we manage the real and perceived conflicts between power, irrigation and habitat. This can be broken into two parts. Inherent in the existing management scheme of power, irrigation, and salmon is an acceptance of the concept that low cost power to drive the irrigation will be available for the Columbia Basin Project (this was embodied in the 1932 USACE "308" Report). As the Bonneville Power Administration struggles to meet the demands of an ever less generous federal government, this

Columbia Basin Treaty

Tribes' Voice

Climate Change Considerations

could change. Regarding the conflict between power and habitat as the concern for providing appropriate amounts of water at appropriate times, it may become harder to meet these three primary needs for water simultaneously. Affording Native American Tribes a significant voice in salmon management adds a third leg, along with the US and Canada, to the stool of sovereigns involved in the discussion.

Finally, there is the impact of climate change on river flow. This is especially significant in that the 50% of the Columbia's flow that originates in Canada is largely based on melting snow and ice for summertime base flow. Regardless of whether precipitation decreases or increases, long term changes in the ice fields that form a good share of the Columbia's Canadian source water will impact streamflow both in terms of seasonality and in terms of overall volume.

The recent report on water supply and demand in the Columbia River Basin (Ecology, 2011) indicates that there will be an average increase in river flow in the basin of about 3% by 2030. However, this flow increase occurs due to an increase of about 17% for the months of November through May. Summer flows, those measured from June through October when some instream needs and most out-of-stream uses are highest, shows a decrease in flow of about 14%. These results are consistent with other reports on the potential effects of climate change on rivers in the Northwest. The implication of this is that while there appears to be water available to supply additional needs in the system, it will require significant storage to make that water available when needed.

CONCLUSION

The Columbia Basin faces many water supply / water use challenges. Many are associated with the Columbia River Treaty and the upcoming deadline for notification regarding renegotiation of that treaty. Some are related to improving the efficiency of water use for a range of practices. Some relate to ways we can adapt to an altered water cycle caused by changing climate. At this year's three-day conference presented by the AWRA Washington Section attendees will learn about these topics and more.

Note: All Columbia River flow data used and discussed in this article, unless otherwise credited is from the US Geological Survey website: http://waterdata.usgs.gov/wa/nwis/

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Stanley A. Miller's water resources career began in 1975 as a graduate student in Environmental Science at Washington State University. After completing the degree in 1977 he began work with a team of Spokane County staff to develop a plan to protect the Spokane Valley-Rathdrum Prairie Aquifer. That work led to the first "Aquifer Protection Plan" developed for a designated "sole source" aquifer in the US. After the plan was completed the team dissolved but Mr. Miller became the lead in the County's new Water Resources program with the primary goal of implementing the plan. While working to implement the groundwater protection plan, the major activities were writing grant applications for projects leading to and developing ordinances for groundwater protection and hazardous waste site clean up management. During his 20+ year career at the County Mr. Miller served on several committees and task forces organized by the Washington State Department of Ecology and US EPA to develop policy and regulations for water quality protection. His areas of special expertise lay in stormwater management, ground disposal of water and waste, and public involvement. In the late 1990's, Spokane County's Water Resources Program became the lead for several watershed planning projects conducted under Ecology's Watershed Planning Program. The plan for the combined Little Spokane/Middle Spokane Rivers (WRIA 55 & 57) was among the first half dozen plans completed in the State. Since his retirement from Spokane County in April of 2004, Mr. Miller has continued his involvement with Spokane and regional water resources issues through volunteer efforts with local non-profit organizations and independent consulting.

Columbia River, Basin & Treaty Conference

Ellensburg, Washington

September 11-13

Agenda Includes*

September 11 – Field Trip to Key Columbia River Treaty Sites

Includes visits to the Waterville Plateau, Grand Coulee Dam, Banks Lake, Bacon Siphon and Tunnel, Quincy Canal and Soap Lake, Weber Siphon

September 12 – The Columbia River Treaty

Keynote - A World Prematurely Dammed: Improving on the CRT & Other Hydrological Anachronisms: Robert W. Sandford, *Canada Forum on Leadership for Water*

The Columbia River Treaty (CRT) in Context: Professor Barb Cosens, *University of Idaho* and *Universities Consortium on Columbia River Governance*

Treaty Review in the U.S. and Canada: Matt Rea, *United States Army Corps of Engineers* or Nancy Stephan, *Bonneville Power Administration*; Kathy Eichenberger, *British Columbia Ministry of Energy and Mines*

Native American Tribal Roles in CRT Review: Paul Lumley, *Columbia River Inter-Tribal Fish Commission*

Columbia Basin Trust: Gary Merkel (invited), *Columbia Basin Trust*

Post-2012 Expectations for Tributary Headwaters Management: John Tracy, *Idaho Water Resources Research Institute*

Fish, Wildlife and Recreation: Susanne Skinner, *Center for Environmental Law and Policy*

Social-Cultural Impacts in British Columbia: Eileen Pearkes, author

Hydro Power: Suzanne Grassell, *Chelan PUD* and *Columbia River Treaty Power Group*

Local Government: Paul Jewell, *Kittitas County Commissioner* and *Columbia River County Commissioners Policy Advisory Group*

Climate Change and the Columbia River Treaty: Deborah Harford, *Simon Fraser ACT* and Dr. Allen Hamlet, *University of Washington*

September 13 – The Columbia River Basin

Yakima Integrated Water Resources Management Plan: Phil Rigdon (invited), *Yakama Nation*; Urban Eberhart, *Kittitas Reclamation District*; Michael Garrity, *American Rivers;* Paul Jewell, *Kittitas County Commissioner* and *Columbia River County Commissioners Policy Advisory Group*

Office of the Columbia River Projects: Derek Sandison, *Office of the Columbia River*

New Columbia River Water Rights in Oregon: Ruben Ochoa, *Oregon Water Resources Department*

Restoration in the White Salmon and Klickitat Basins: Bill Sharp, *Yakama Nation Fisheries*

Restoration in the Methow and Wenatchee Basins: Brandon Rogers, *Yakama Nation Fisheries*

Hydro and Wind Power Issues: Adam Price, *United States Army Corps of Engineers*

Water Banking: Yakima and Dungeness Rivers: Susan Adams, *Washington Water Trust*

Instream Flows for Restoration in the Columbia Basin: Jason McCormick, *Washington Water Trust* and Jason Hatch, *Trout Unlimited-Washington Water Project*

** Agenda subject to change. Please see the registration website for agenda updates.*

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Questions? Contact Tyler Jantzen, tyler.jantzen@ch2m.com

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Reclaimed Water Treatment

Treatments Study

Water Supply Source

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RECLAIMED WATER TREATMENT

ASSESSING OPTIMAL METHODS TO REDUCE TRACE ORGANIC COMPOUNDS AND PATHOGENS

by Jeff Bandy, PhD, (Carollo Engineers);
Andrew Salveson, PE, (Carollo Engineers); Keith Bourgeous, PhD, PE, (Carollo Engineers);
&
Karl Linden, PhD (University of Colorado at Boulder)

INTRODUCTION

The WateReuse Research Foundation (WRRF - see sidebar) evaluated a wide range of conventional and emerging cost-effective technologies for their ability to remove various hormones, pharmaceuticals, and pathogens in secondary effluent. WRRF Project 02-009 (Project) was funded by WRRF, the US Bureau of Reclamation, and the Southwest Florida Water Management District. Substantial financial and in-kind support was also provided by utilities and manufacturers. The research team included researchers from Duke University, the University of Colorado at Boulder, the US Department of Agriculture, and Carollo Engineers. The Project focused on reuse water treatment technologies for simultaneous trace organic chemical destruction and inactivation of indicator organisms on both the bench and pilot scales. The Project also included an economic evaluation of the tested technologies. The final report will be available by the fall of 2012.

BACKGROUND

RECLAIMED WATER AS SOURCE OF SUPPLY

Many regions of the United States are experiencing rapid population growth and facing myriad demands on their water supplies, including drinking, irrigation, industrial, and ecosystem preservation uses. To meet these challenges, water purveyors are turning to reclaimed water as an alternative water supply source. In most cases, treatment of reclaimed water to state-specific regulated standards for disinfection and water quality (typically measured/represented by **t**otal **s**uspended **s**olids (TSS) or turbidity) is sufficient for public health and safety, based on the concurrent removal of microorganisms.

Although ongoing research supports the adequacy of current regulations, such levels of treatment are not sufficient for some consumers and uses. Concurrent with an increased need for reclaimed water is intensifying public concern over potential risks associated with exposure to emerging pathogens and unquantified chemical constituents. This concern over reclaimed water quality originally centered on indirect potable reuse (IPR) applications. The "Toilet to Tap" mentality prevailed over various IPR projects in the West, where public discomfort often overturned projects that had been approved by regulatory bodies.

Many chemical constituents of concern may be present in water supplies, including potential endocrine-disrupting compounds (EDCs), pharmaceutically active compounds (PhACs), n-nitrosodimethylamine (NDMA), and other pollutants (halogenated solvents, standard disinfection by-products (DBPs), and pesticides. Due to the recent focus in the literature and the mainstream press on these chemical constituents, some IPR projects have been abandoned, while others have been subjected to stricter treatment guidelines and higher costs. Increased public scrutiny of IPR projects nationwide has now extended to nonpotable public contact reuse, classified as "tertiary recycled water" in California, "A" and "A+" water in Arizona, and reclaimed water with "high-level disinfection" standards in Florida.

In the western United States, various agencies have faced lawsuits because of the discovery of NDMA and potential EDCs in their reclaimed water supplies, with concerns ranging from groundwater contamination due to NDMA percolation from irrigation to perceived public endangerment from contact with turf irrigated with reclaimed water. Concerns in the East are similar, often focusing on groundwater contamination issues (especially because of high water tables, porous soil strata, and unconfined aquifers) and issues that are unique to Florida, such as the potential impact of millions of gallons per day (mgd) of reclaimed water in places of global ecological significance (e.g., the Everglades).

Utility partners Orange County Water District (CA), the sanitation districts of Los Angeles County (CA), and the Dublin San Ramon Services District (CA) have all had to address public concerns over various chemical constituents and have invested time and effort in research on advanced technologies for higher levels of treatment. Utility partner City of Phoenix (AZ) has a substantial reclaimed-water program that includes direct irrigation of food crops and considers future advanced treatment to be critical to their continued successful long-term operation.

Reclaimed Water Treatment

Performance & Costs

Whether the threat of contamination is real or perceived, the reclaimed-water industry must have tools that can be readily implemented in full-scale designs to reduce or eliminate pathogens and detected chemical constituents at a reasonable cost. Existing technology for IPR projects has been proven to reduce pathogens and chemical constituents to levels below detection and to protect public health. One example of such a multi-barrier application is the sequential of microfiltration (MF), reverse osmosis (RO), and an advanced oxidation process (AOP), which commonly utilizes ultraviolet light (UV) with hydrogen peroxide (H_2O_2). This process, although effective, is expensive both to build and to operate. Other, less costly technologies with the potential to remove and/or destroy both pathogens and chemical constituents are currently available. The focus of this report is on comparing the performance of these alternative, non-RO technologies and on estimating the costs for implementation of these technologies.

DISINFECTION TECHNOLOGIES

Ozone & Ozonation

Current reclaimed-water disinfection methods include filtration, most commonly followed by chlorine disinfection (gas or sodium hypochlorite), and in some cases by UV disinfection. Although current approaches are effective for meeting pathogen guidelines, little information on chemical constituent destruction exists, particularly at the treatment levels typically used for reclaimed-water disinfection applications. There is a growing knowledge base for ozone (O_3) as a reclaimed-water disinfection method. Co-investigator Carollo had completed earlier work with the California Department of Public Health (CDPH) testing O_3 and O_3/peroxide treatments for reclaimed-water disinfection, and in 2008 the CDPH approved a *Ct* (Concentration times Time — defined as the integral of the concentration of the disinfectant over the measured contact time) of 1 mg-min/L for O_3 to meet bacterium/protozoon/virus recycled-water standards in California (Ishida et al., 2008). Other research has shown that ozonation has been proven to meet reclaimed-water bacterial standards at low doses (<5 mg/L O_3) and substantially reduce specific PhACs (Huber et al., 2005).

Reclaimed Water Disinfection Regulations

State Regulations

The focus of this Project, as it pertains to disinfection, is on treatment to a level that allows applications of reclaimed water with unrestricted public contact. For such applications, most states have strict coliform limits, with the underlying assumption that the destruction of the indicator organism results in the destruction of various pathogens of concern. Some states, including California, set chlorine disinfection and UV dose requirements. Others, such as Florida, have sliding chlorine dose requirements based upon influent fecal coliform concentrations. The majority of states rely upon utilities to set dosage requirements that will result in the regulated coliform levels being met.

Reclaimed Water Regs

Examples of some reclaimed-water regulations are shown in Table 1. The majority of states using reclaimed water expect pathogen-free water, although this may not be a reasonable expectation with current treatment processes. Most states have requirements for effluent quality, but do not specify treatment. California and Florida, among others, currently specify treatment dose values for chlorine disinfection and California specifies dose values for UV, O_3, and pasteurization disinfection (Table 2). These microbiological treatment targets for California and Florida are listed and should be kept in perspective as the various treatment technologies from this Project are discussed.

Virus Requirements

The virus requirements in California stem from research conducted by the Sanitation Districts of Los Angeles County in the 1970s, published as *The Pomona Virus Study* (Sanitation Districts of Los Angeles County, 1977). It is important to note that the 5-log (99.999%) reduction of poliovirus witnessed during that study was in seeded, not indigenous poliovirus.

The Florida Department of Environmental Protection (FDEP) has established guidelines for *Giardia*, *Cryptosporidium*, and *Enterovirus* in reclaimed-water effluents (Table 3), including periodic monitoring and reporting requirements based on risk assessment principles (FDEP, 1999; York, 2002). Florida is the only state with reclaimed-water effluent pathogen guidelines. To the best of our knowledge, no state has regulations on effluent pathogen concentrations.

State Regs Overview

Table 1. Overview of Reclaimed-Water Requirements for Several States (for the Highest Quality of Nonpotable Reuse)

State	Bacteria	Virus/Protozoa
California Tertiary Recycled	2.2 MPN/100 mL total coliform	5-log inactivation/kill virus expected, pathogen-free water
Arizona Class A and Class A+ Water	ND fecal coliform per 100 mL, 7-day median	Pathogen-free water expected
Texas Type I Reclaimed	20 CFU/100 mL fecal coliform	No standard
Florida High-Level Disinfection	ND fecal coliform per 100 mL, 75% of the time	Pathogen-free water expected

Notes: MPN: most probable number; ND: non-detect; CFU: colony-forming units.

Reclaimed Water Treatment

Technology Performance Criteria

The primary goal of the Project was to evaluate and compare the performance of various technologies in destroying pathogens and chemical constituents. The bacterial and pathogen guidelines discussed above are key considerations for this comparison. Candidate treatment technologies need to demonstrate the following:

- Dose required to meet 2.2 MPN/100 mL total coliform and ND fecal concentrations
- Dose required for 5-log reduction in seeded poliovirus or equivalent level of disinfection

Performance Determinations

Determining the treatment level required to meet both coliform and seeded virus standards is straightforward for O_3 and UV processes because, the disinfection dose required to attain effluent coliform concentrations also results in meeting California virus standards (Ishida et al., 2008; Janex et al., 2000; Warriner et al., 1985). Demonstrating performance that meets FDEP protozoan and virus guidelines requires more information, such as the concentration of various pathogens in clarified and filtered treatment water, upstream of disinfection.

Chemicals Concerns

Although a California State Water Resources Control Board expert panel recently concluded that there are no expected health impacts from potential EDCs or other chemical constituents in reclaimed water used for nonpotable purposes (California State Water Resources Control Board, 2010), public perception and aquatic health concerns remain. The solution to these issues must answer the following question: what cost-effective treatment most effectively and efficiently reduces trace chemical constituents? For comparison purposes, the Project team selected a target of 90% destruction of chemical constituents to allow comparisons between technologies; however, wastewater contains trace levels of a wide variety of chemical constituents, many of which are not easily filtered or oxidized. This 1-log destruction target was based upon the removal of 90% of the hormonal activity of the water, as measured by the estradiol equivalency test (estradiol is synthetic estrogen, used, e.g., in birth control pills).

Estrodiol Equivalency Test

Overview of Treatment Technologies

By using rigorous selection criteria, candidate treatment technologies were selected and tested at bench scale at Duke University and at four pilot sites in Florida, North Carolina, and California. The initial process involved the review of 22 established and emerging wastewater treatment technologies, including emerging technologies such as electron beam radiation, ultrasound, and electrodialysis reversal. After detailed review and a kickoff workshop with the Foundation's Project Advisory Committee and Project stakeholders, the research team selected several market-ready technologies for detailed bench-scale evaluations, including:

Evaluated Technologies

- UV (low-pressure (LPUV) and medium-pressure (MPUV))
- Ozone (O_3)
- Chlorine (free and preformed monochloramines)
- Peracetic acid (PAA)
- Advanced oxidation processes (AOP, including LPUV/H_2O_2, LPUV/PAA, O_3/H_2O_2)
- Ultrafiltration (UF)

Table 2. California and Florida Disinfection Treatment-Based Standards for Tertiary Recycled Water and High-Level Disinfection

Method	California	Florida
Chlorination	450 mg-min/L	25 mg-min/L for fecal coliform counts < 1000 MPN/100 mL 40 mg-min/L for fecal coliform counts 1000 < 10,000 MPN/100 mL 120 mg-min/L for fecal coliform counts > 10,000 MPN/100 mL
UV	100 mJ/cm^2 following sand or cloth filtration; 80 mJ/cm^2 following MF or UF	No uniform standard
Ozone	1 mg-min/L	No standard
Pasteurization	10-second contact time at 179 °F	No standard

Table 3. Florida Reuse Pathogen Guidelines

Pathogen	Units	Average	Maximum
Giardia	Viable Cysts/100 L	1.4	5.0
Cryptosporidium	Viable Oocysts/100 L	5.8	22
Enterovirus	PFU/100 L[a]	0.044	0.165

[a] PFU = **p**laque **f**orming **u**nits.

The performance of these technologies was evaluated using bench-scale microbial inactivation tests on important indicator, surrogate, and pathogenic organisms (including indigenous total and fecal coliforms, indigenous aerobic spore-forming bacteria, spiked MS2 bacteriophage, reovirus, coxsackievirus, and adenovirus). Removal and transformation of a suite of spiked chemical constituents, including several potential endocrine-disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCP), were evaluated using gas chromatography–mass spectrometry (GC-MS). Reduction in estrogenic activity following treatment was also measured using the yeast estrogen screen (YES) bioassay (often referred to as estradiol equivalency (EEQ)).

To complement the bench-scale work, pilot-scale treatment technologies tested included O_3, O_3/H_2O_2, TiO_2/UV, LPUV/H_2O_2, MPUV/H_2O_2, and MPUV/PAA. Removal of indigenous coliform, spiked coliphage (MS2), spiked N-nitrosodimethylamine (NDMA), estrogenic activity (as measured by the YES bioassay), and indigenous chemical constituents

Reclaimed Water

were determined for the pilot technology. For the UV-related AOP treatment technologies studied here (UV/H_2O_2, UV/PAA, and TiO_2/UV), the base technology provides a robust disinfection barrier, so disinfection and chemical constituent destruction occur simultaneously. At UV dose levels often used for AOP applications, complete inactivation of indigenous pathogenic microorganisms can be achieved, as these doses often exceed 400 mJ cm^{-2}. However, the cost of such high UV dose levels may in some cases limit potential application, and thus the ability of UV AOP technologies to destroy chemical constituents at reduced dose levels was also investigated.

Table 4. Qualitative Review of Evaluated Disinfection/Oxidation Technologies

Technology	Bacteria	Viruses	Protozoa	Chemical Constituents
UV	++	+	++	-
O_3	++	++	-	++
UV AOP	++	++	++	++
O_3 AOP	++	++	-	++
Free Chlorine	+	++	- -	+/-
NH_2Cl	+/-	-	- -	- -
TiO_2/UV^b	++	+	Untested	+
PAA	+	- -	- -	-

Notes: ++ excellent; + very good; +/- good; - fair; - - poor.
[a] Performance is for typical reclaimed water dose values tested for this project.
[b] UV wavelength at 254 nm.

O_3 contrasts with UV treatment with respect to trace organic chemicals and pathogens. As noted in the literature review, prior research, as well as this study, demonstrates that O_3 readily destroys a number of targeted chemical constituents at low doses but requires higher doses to produce robust pathogen disinfection, specifically for oocysts and spores.

The disinfection/oxidation technologies tested all provided substantial reduction of both pathogens and chemical constituents, with the exceptions of PAA and chloramines, whereas free chlorine had mixed results. Table 4 provides a qualitative summary of the treatment technology performance documented for this Project and in the literature reviewed for this Project.

True Cost

Pilot Testing of Advanced Wastewater Treatment Technologies

Bench top testing of a range of technologies, described in detail in the body of this report, was performed concurrently with and subsequently to the pilot testing documented here. Proof of technology at the bench scale is valuable to the industry, while proof of a technology of pilot or full-scale systems provides additional value, as the true cost to implement a technology can often be determined through these demonstrations.

Pilot-Scale Test Sites

This portion of the report is focused on the pilot-scale testing of different technologies at four different utilities. Each facility pilot tested a different technology. The same microbial and analytical parameters were tested at each facility. The relevant sites and tested technologies were:

- The Dublin San Ramon Services District (DSRSD) in California – An ozonation reactor, with and without hydrogen peroxide was evaluated. The specific reactor was a High Pressure Oxidation System (HiPOx™), manufactured by Applied Process Technology (APT Water).
- The Charlotte Mecklenburg Utilities (CMU) Sugar Creek Wastewater Treatment Plant in North Carolina – A titanium dioxide and UV reactor, the PhotoCat, manufactured by Purifics, was evaluated.
- Pinellas County Florida's South Cross Bayou Water Reclamation Facility (Pinellas) – An in-vessel UV reactor, provided by Trojan Technologies, was evaluated, with and without H_2O_2.
- The City of Bradenton's wastewater treatment facility in Bradenton, FL – An in-vessel UV reactor, provided by Aquionics, was evaluated with and without H_2O_2 and with and without peracetic acid.

Objectives

The main objective of pilot testing for this Project was to provide proof of disinfection for stringent reclaimed water standards. The second objective was to measure the reduction in estrogenicity, as measured by the YES assay. The third objective was to measure the destruction of spiked and background-level chemical constituents.

Filtration

These pilot studies showed that various methods of filtration (including sand, multimedia, and microfiltration) have the capability to remove chemical constituents and microbiological targets such as pathogenic protozoa. Performance is linked to the removal of particulate material in the case of adsorbed chemicals and particle-associated coliform and size exclusion in the case of *Giardia* and *Cryptosporidium*. Thus, filtration can be viewed as a method of treatment and of pretreatment ahead of disinfection (to clean the water ahead of disinfection allowing for more efficient disinfection).

Ozonation

UV/H_2O_2, O_3, O_3/H_2O_2, and UV/TiO_2 were all capable of reducing the concentrations of spiked chemical constituents and indigenous microbes to background levels, while the pilot system using UV/PAA did not perform as well. The cost of PAA is an additional barrier to UV/PAA being adopted for advanced wastewater treatment in the near term. Based on the performance and cost comparisons between these pilot-scale oxidation technologies in the full WRRF report, ozonation is the lowest cost treatment based upon the specific performance criteria described above.

Reclaimed Water Treatment

Pathogen Destruction

Filtration Technology

Major Findings

ECONOMIC ANALYSIS & SUMMARY

An economic analysis was performed to determine the cost of treatment across the various technologies for meeting a given set of water quality objectives (Table 5, next page). This specific scenario looked at pathogen destruction to the highest reclaimed-water standard (bacteria and viruses and 90% destruction of estrogenic activity). Other treatment objectives could be used as a basis of comparison, including the removal of difficult-to-oxidize constituents (such as TCEP and NDMA), or the removal of triclosan (an antibacterial found in some hand cleaners and toothpaste), 17-ß-estradiol, and caffeine. Estimated reduction of chemical constituents is included in Table 5.

Chlorination is included in the Table 2 cost comparison as a cost baseline, even though performance to the treatment goals was not reliably demonstrated. The industry standard **b**est **a**vailable **t**echnology (BAT) for removal of chemical constituents and pathogens is microfiltration (MF) or UF coupled with reverse osmosis (RO) and an AOP process and is also included in the table as a reference. This allows an understanding of the relative cost of this BAT compared with the other tested technologies, even though this BAT provides treatment well in excess of the stated goals for this Project. PAA (without UV), MF, UF, and sand filtration costs are not provided in Table 2, as these technologies did not meet the stated performance objectives. The results of the economic analysis would differ under a scenario with different end treatment goals. Of the technologies evaluated, ozone was the most cost-effective technology capable of meeting the stated treatment objectives (Table 5).

An additional portion of this Project examined the removal of particulates, pathogens, and chemical constituents by filtration technologies. Clear links were made between the removal of particulates, pathogens, and chemical constituents, suggesting that a multiple barrier to both pathogens and chemical constituents can be obtained by optimizing the filtration process for particulate removal and combining that process with one of the disinfection/oxidation technologies studied under this project.

CONCLUSION

MAJOR FINDINGS AND IMPLICATIONS

The major findings and implications of this study are as follows:

- Chlorination and chloramination performance was mixed. Free chlorine provided substantial virus and bacteria destruction and had mixed results for destruction of chemical constituents. Chloramination provided substantial destruction of bacteria but did not show similar performance for viruses and chemical constituents.
- PAA may be a good substitute for chlorine if coliform bacteria are the primary target; otherwise, its poor performance against spores and viruses, high cost, and slow reactivity with EDCs compared to free chlorine limit its applicability.
- UF and MF are proven barriers to most of the microorganisms tested in this study, and sorption of hydrophobic chemical constituents to particulate matter aided their removal by UF and MF.
- UV and O_3 are robust disinfectants, with particularly high effectiveness against parasitic protozoa in the former case and viruses in the latter. The combination of H_2O_2 and these base technologies in advanced oxidation processes had no consistent synergistic or antagonistic effect on disinfection. Human enteric and respiratory virus disinfection by the candidate technologies was unchanged by the addition of H_2O_2, indicating the primary role of UV light or ozone in these processes.
- Ozonation quickly mitigates the overall estrogenic effect of EDCs, but its selectivity also means that it reacts slowly with NDMA, TCEP, and other compounds with electron-withdrawing characteristics. In these cases, the addition of H_2O_2, which promotes the formation of hydroxyl radicals, improves the degradation of such compounds.
- UV photolysis is an especially important component of UV/H_2O_2 advanced oxidation when target compounds are photoliable, such as NDMA and triclosan. When direct photodegradation is not a feasible option, indirect photolysis via hydroxyl radicals can destroy target compounds. At UV doses relevant to disinfection in wastewater reuse, with the addition of H_2O_2, measurable destruction of chemical constituents and hormonal activity was documented.

For Additional Information:
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Dr. Jeff Bandy joined Carollo Engineers (Boise, Idaho office) in January 2009. His projects focus on validation, commissioning, and troubleshooting of drinking water and wastewater UV disinfection systems. His graduate work at Duke University included the WRRF 02-009 project detailed herein and an EPA funded study on the treatability of Candidate Contaminant List 3 nitrosamines via the UV/H2O2 advanced oxidation process. Dr. Bandy received his Ph.D. in Civil and Environmental Engineering from Duke University, an MS in Civil and Environmental Engineering from Duke, and a BS in Ceramic and Materials Engineering from Clemson.

Table 5. Treatment and Costs of Reclaimed Water Disinfection Alternatives (10 mgd design/5 mgd operational flow)

Treatment Technology	Dose	Annual O&M Cost	Project Cost (Const. + Eng. and Support)	Primary Treatment Targets[a]			Additional Treatment Targets[a,b]			
				Destruction of 90% EEQ (Bulk Hormonal Measurement)	Disinfection of Bacteria to California/ Florida Requirements	Disinfection of Virus to California Requirements	Destruction/Removal of Triclosan	Destruction/Removal of 17-ß-Estradiol	Destruction/ Removal of TCEP	Destruction/ Removal of NDMA
Sodium hypochlorite (NaOCl)	450 mg-min/L	$219,000	$7,532,000	Chloramines/No	Chloramines/No	Chloramines/No	Chloramines <10%	Chloramines <10%	<10%	0%, chloramination can form NDMA
	120 mg-min/L	$260,000	$3,030,000	Free Chlorine Mixed Results	Free Chlorine Mixed Results[c]	Free Chlorine/Yes	Free Chlorine Mixed Results	Free Chlorine Mixed Results		
UV[d]	100 mJ/cm^2	$229,000	$7,880,000	No	Yes	Yes	~35% to 45%	~30% to 40%	<10%	~30%
Reverse osmosis with advanced oxidation (UF/RO/AOP)	>350 mJ/cm^2, 5 ppm H_2O_2	$2,470,000	$45,601,000	Yes	Yes	Yes	>90%	>90%	>80%	>90%
UV plus hydrogen peroxide (MPUV/H_2O_2)	100 mJ/cm^2, 15 ppm H_2O_2	$509,000	$8,923,000	Yes[e]	Yes	Yes	Not tested at this peroxide dose, ~80% to 90% expected[5]	~80% to 90%[5]	Not tested at this peroxide dose, <20% expected[e]	~30%[5]
UV plus peracetic acid (UV/PAA)	100 mJ/cm^2, 8 ppm PAA	$1,645,000	$9,563,000	Yes[e]	Yes	Yes	Not tested at this dose, ~90% expected[e]	Not tested at this dose, ~90% expected[e]	Not tested at this dose, ~20% expected[e]	Not tested at this dose, ~30% expected[e]
Ozone (O_3)	1 mg-min/L	=	=	Yes	Yes	Yes	>90%	>90%	<10%	~20% to 50%
	Dose—9 mg/L	$276,000	$9,094,000							
	Dose—6.6 mg/L	$217,000	$8,828,000							
Titanium dioxide with UV (TiO_2/UV)[f]	139 kW/mgd	$311,000	$15,941,000	Yes	Yes	Yes	~40% to 60%	Not tested	~25% to 30%	Not tested

[a] Unless otherwise noted, destruction shown demonstrated as part of this study.

[b] NDMA formation from chloramination is well demonstrated in the literature (Najm and Trussell, 2001).

[c] Disinfection to reclaimed water standards with both chloramine and free chlorine is well documented in the industry. Likely, higher *Ct* values than tested here would result in obtaining the target effluent standards.

[d] Costs shown are for MPUV.

[e] Limited data. More testing recommended at the listed dose values.

[f] Estimated cost for TiO_2/UV includes filtration credit and assumes that disinfection credit can be demonstrated at the dosage shown and ceramic membrane fouling can be controlled.

RECLAIMED WATER TREATMENT

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WATER BRIEFS

WATER RIGHTS FORUM NV

SUBJECT MATTER JURISDICTION

On May 31, the Nevada Supreme Court (Court) issued a decision that adopted a broad view of statutory language regarding subject matter jurisdiction of a water rights case. *IN RE: Nevada State Engineer Ruling No. 5823*, Case No. 52963, 128 Nevada, Advance Opinion 22 (May 31, 2012). The Court overturned a district court decision, which had dismissed a case filed by protestors to a water rights application due to the fact that they had filed their appeals in Churchill County — where their rights or interests allegedly would be affected — as opposed to Lyon County, where the applicants' groundwater appropriations lie. Churchill County and the Pyramid Lake Paiute Tribe (the Tribe) protested the groundwater applications before the State Engineer.

The statute at issue is similar to judicial review laws in many western states. NRS 533.450(1) provides for judicial review "in the nature of an appeal" to "[a]ny person feeling aggrieved by any order or decision of the State [Water] Engineer…affecting the person's interests." An appeal "must be initiated in the proper court of the county in which the matters affected or a portion thereof are situated." *Id*.

The Court interpreted the language as follows: "But this does not signify, as the district court held, that only a single court in a single county will do-much less that the 'matters affected' must be judged from the perspective of the applicant, not a protester. On the contrary, the phrase 'or a portion thereof' contemplates multiple potential forums: If 'a portion' of the 'matters affected' being situated in the forum county satisfies the statute, so too, should the remainder of the 'matters affected' qualify the counties in which they are situated." *Adv. Op*. at 11.

"Nothing in NRS 533.450(1)'s text, in short, vests exclusive jurisdiction in the court of the county where all or part of the applicant's water rights lie (unless perhaps the clause of exception applies to the applicant's rights, which isn't suggested here). Instead, the statute's wording plainly contemplates more than one permissible forum, depending on the location, nature, and origin of the interests assertedly affected." *Adv. Op*. at 13.

For info: Case available at: www.nevadajudiciary.us/images/advanceopinions/128nevadvopno22.pdf.pdf

WATER AVAILABILITY US

CLIMATE CHANGE IMPACT

Climate change projections indicate a steady increase in temperature progressing through the 21st century, generally resulting in snowpack reductions, changes to the timing of snowmelt, altered stream flows, and reductions in soil moisture, all of which could affect water management, agriculture, recreation, hazard mitigation, and ecosystems across the nation. Despite some widespread similarities in climate change trends, climate change will affect specific water basins in the US differently, based on the particular hydrologic and geologic conditions in that area. The US Geological Survey (USGS) has released a study projecting changes in water availability due to climate change at the local level. So far, USGS has applied these models to fourteen basins.

For info: www.usgs.gov/newsroom/article.asp?ID=3205#.T-taCq7oTma

EMERGING CONTAMINANTS AZ

ADVISORY PANEL FORMING

On June 15, the Arizona Department of Environmental Quality (ADEQ) sent out notice that it is seeking 15 members for a panel being formed to examine emerging contaminants and develop approaches to ensure the continued safety of the state's drinking water. The Advisory Panel on Emerging Contaminants will survey new chemicals and pathogens that threaten the continued safety of drinking water, like chemicals from pharmaceuticals and personal care products and pathogens like the Naegleria parasite, Legionella bacterium and Hepatitis A virus. The panel will provide a forum for the open discussion and prioritization of emerging contaminant issues of critical interest to Arizona, promote research on them and provide operational guidelines for minimizing risks to Arizona's drinking water supplies. The panel is expected to begin its work in early September and meet four or five times a year.

Anyone with expertise in emerging contaminants and interest in being appointed to the panel can send a resume to ADEQ Senior Hydrologist Chuck Graf at cgg@azdeq.gov or by mail to Chuck Graf, Senior Hydrologist; Arizona Department of Environmental Quality; 1110 W. Washington St.; Phoenix, AZ 85007. The deadline for ADEQ receiving resumes is July 30.

For info: ADEQ, 602/ 771-2215 or ms15@azdeq.gov

GREEN INFRASTRUCTURE US

PERMITTING & ENFORCEMENT

EPA recently released a series of six fact sheets on incorporating green infrastructure measures into National Pollutant Discharge Elimination System wet weather programs. The series builds upon existing EPA authority, guidance, and agreements to describe how EPA and state permitting and enforcement professionals can work with permittees to include green infrastructure measures

WATER BRIEFS

as part of control programs. The six fact sheets and four supplements address stormwater permits, total maximum daily loads, combined sewer overflow long-term control plans, and enforcement actions.
For info: http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries

DREDGE MINING HALTED CA

GOVERNOR CONTINUES MORATORIUM

On June 27, California Governor Jerry Brown continued the current moratorium on the controversial gold-mining technique known as "suction dredge mining" until the state develops regulations that pay for the program and protect water quality, wildlife and cultural resources. The new law also directs the state's Department of Fish and Game, which regulates suction dredge mining, to work with public-health, water and tribal authorities in a review of the practice. Suction dredge mining for gold uses machines that vacuum up gravel and sand from river bottoms. The Karuk Tribe and numerous environmental groups fought to keep the moratorium in place.

The new law continues the current moratorium on suction dredge mining until new rules "fully mitigate all identified significant environmental impacts" and a "fee structure is in place that will fully cover all costs" to administer the program. Assembly Bill 1018 clarified the existing temporary moratorium on the practice that was set to expire in 2016. *See* Water Briefs, *TWR* #91.

Legislative analysis found that the suction dredge mining program has cost California taxpayers more money than it earns; it lost close to $1 million in 2009. The new law requires any new permit programs to cover all program costs and be revenue neutral.

Earlier in June, the 9th Circuit ruled that recreational gold mining using suction dredges requires miners to analyze whether they'll harm protected species like salmon, steelhead trout or California red-legged frogs. The 7-4 ruling by the U.S. 9th Circuit Court of Appeals found that the US Forest Service violated federal endangered species protections by approving the mining practice along the Klamath River without consulting wildlife officials under an ESA Section 7 consultation. *Karuk Tribe of California v. USFS, et al*., Case No. 05-16801 (June 1, 2012). *See also* Water Briefs, *TWR* #100.
For info: Craig Tucker, Karuk Tribe, (916) 207-8294 or www.karuk.us

GROUNDWATER CLEANUP CA

SUPERFUND SETTLEMENTS

EPA on May 15 issued a press release involving three settlements totaling $6,605,080 that will help pay for groundwater cleanup at the South El Monte portion of the San Gabriel Valley Area 1 Superfund Site in Los Angeles. Since EPA began cleaning up this site in 2008, approximately 4,600 pounds of contaminants have been removed from the groundwater. EPA has recovered a total of $25 million for the South El Monte cleanup, with the latest $6.6 million to pay for extraction and treatment of groundwater polluted with industrial solvents such as TCE (trichloroethylene) and PCE (perchloroethylene), a chemical once common in dry cleaning operations. The three settlement claims were brought by the US Department of Justice on behalf of EPA and the California Department of Toxic Substances Control against eleven current or former landowners and operators of business facilities that contributed to the contamination in South El Monte. The eleven responsible parties are Quaker Chemical Corporation; Art Weiss, Inc.; Astro Seal, Inc.; Craneveyor Corp.; EBA, Inc. D/b/a Earl Butler & Associates; M&T, LLC; Mary Brkich; New Air, Inc.; Pacific Coast Drum Co.; Seachrome Corporation; and Linderman Living Trust A.

Thus far, more than ten billion gallons of water have been treated to provide safe drinking water for the local communities. The San Gabriel Valley Area 1 Superfund site was placed on the National Priorities List in 1984, and overlays approximately eight square miles of solvent-tainted groundwater in the areas of South El Monte, El Monte and Rosemead. EPA signed an interim Record of Decision with the goal of containing contaminated groundwater at the site in 2000 and issued an Explanation of Significant Differences to address new contaminants in 2005. The San Gabriel Basin Water Quality Authority implements the cleanup under a Cooperative Agreement with EPA. The agreement funds groundwater extraction and treatment systems operated by the City of Monterey Park, San Gabriel Valley Water Company, and Golden State Water Company.
For info: EPA website: www.epa.gov/region9/southelmonte; Consent Decrees at: www.justice.gov/enrd/Consent_Decrees.html

FRACKING REPORT US

IMPACTS OF HYDRAULIC FRACTURING

On June 21, the Pacific Institute released a new analysis that assesses the risks and concerns around hydraulic fracturing. *Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction* is a detailed assessment and synthesis of existing research on fracking as well as the results of interviews with representatives from state and federal agencies, industry, academia, environmental groups, and community-based organizations from across the United States.

As noted in the Executive Summary of the report, "key water-related concerns identified by the interviewees included (1) water withdrawals; (2) groundwater contamination associated with well drilling and production; (3) wastewater management; (4) truck traffic and its impacts on water quality; (5) surface spills and leaks; and (6) stormwater management.

The Executive Summary goes on to lay out the report's focus: "Much of the media attention about hydraulic fracturing and its risk to water resources has centered on the use of chemicals in the fracturing fluids and the risk of groundwater contamination. The mitigation strategies identified to address this concern have centered on disclosure and, to some extent, the use of less toxic chemicals. Risks associated with fracking chemicals, however, are not the only issues that must be addressed. Indeed, interviewees more frequently identified the overall water requirements of hydraulic fracturing and the quantity and quality of wastewater generated as key issues."

"Most significantly, a lack of credible and comprehensive data and information is a major impediment to identify or clearly assess the key water-related risks associated with hydraulic fracturing and to develop sound policies to minimize those risks. Due to the nature of the business, industry has an incentive to keep the specifics of their operations secret in order to gain a competitive advantage, avoid litigation, etc. Additionally, there are limited number of peer reviewed, scientific studies on the process and its environmental impacts. While much has been written about the interaction of hydraulic fracturing and water resources, the majority of this writing is either industry or advocacy reports that have not been peer-reviewed. As a result, the discourse around the issue is largely driven by opinion. This hinders a

WATER BRIEFS

comprehensive analysis of the potential environmental and public health risks and identification of strategies to minimize these risks."
For info: Full Report at: www.pacinst.org/reports/fracking/full_report.pdf

STORMWATER PLANNING US
LOCAL GOVERNMENT ASSISTANCE

On June 5, EPA issued a new framework to help local governments meet federal Clean Water Act (CWA) obligations. The *Integrated Municipal Stormwater and Wastewater Planning Approach Framework* assists EPA regional offices, states, and local governments to develop voluntary storm and wastewater management plans and implement effective integrated approaches that will protect public health by reducing overflows from wastewater systems and pollution from stormwater. EPA's framework outlines new flexibility to pursue innovative, cost-saving solutions, like green infrastructure, and will help communities as they develop plans that prioritize their investments in storm and wastewater infrastructure.

An integrated planning process has the potential to identify a prioritized critical path to achieving water quality objectives of the CWA by identifying efficiencies in implementing competing requirements that arise from separate wastewater and stormwater projects, including capital investments and operation and maintenance requirements. This approach can also lead to more sustainable and comprehensive solutions that improves water quality as well as supports other quality of life attributes that enhance the vitality of communities.
For info: http://cfpub.epa.gov/npdes/integratedplans.cfm

COLUMBIA TOXICS WA/OR
EFFLUENT & STORMWATER STUDY

The US Geological Survey (USGS) recently released a study that assesses contaminant concentrations directly contributed to the Columbia River through **w**aste**w**ater-**t**reatment-**p**lant (WWTP) effluent and stormwater runoff from adjacent urban environments and to evaluate instantaneous loadings to the Columbia River Basin from these inputs. Because toxic contamination is a significant concern in the Columbia River Basin in Washington and Oregon, the study was undertaken to help water managers and policy makers make decisions about future sampling efforts and toxic-reduction activities. The Reconnaissance was prepared in cooperation with the Columbia River Inter-Tribal Fish Commission and the Lower Columbia Estuary Partnership. The citation for the study is: *Reconnaissance of Contaminants in Selected Wastewater-Treatment-Plant Effluent and Stormwater Runoff Entering the Columbia River, Columbia River Basin, Washington and Oregon, 2008–10*: USGS Scientific Investigations Report 2012–5068, 68 p.

Nine cities were selected in Oregon and Washington to provide diversity in physical setting, climate characteristics, and population density — Wenatchee, Richland, Umatilla, The Dalles, Hood River, Portland, Vancouver, St. Helens, and Longview. Samples were collected from a WWTP in each city and analyzed for anthropogenic organic compounds, pharmaceuticals, **p**oly**c**hlorinated **b**iphenyls (PCBs), **p**oly**b**rominated **d**iphenyl **e**thers (PBDEs — brominated flame-retardants), organochlorine or legacy com-pounds, currently used pesticides, mercury, and estrogenicity. Of the 210 compounds analyzed in the WWTP-effluent samples, 112 (53 percent) were detected, and the detection rate for most compound classes was greater than 80 percent. Despite the differences in location, population, treatment type, and plant size, detection frequencies were similar for many of the compounds detected among the WWTPs. By contrast, the occurrence of **p**olycyclic **a**romatic **h**ydrocarbons (PAHs) was sporadic, and PCBs were detected at only three WWTPs.

The stormwater-runoff samples were analyzed for a slightly different set of contaminants, with the focus on those expected to be related to road and land runoff — PCBs, PBDEs, organochlorine com-pounds, PAHs, currently used pesticides, trace elements, mercury, and oil and grease. A complex mixture of compounds was detected in stormwater runoff, with detections of 114 (58 percent) of the 195 com-pounds analyzed. The detection patterns and concentrations measured in the stormwater-runoff samples, however, were more heterogeneous than in the WWTP-effluent samples. This reflects differences in various factors, including suspended-sediment concentrations and known contamination sources present in some watersheds. Trace elements and PAHs, which are related to automobiles and impervious surfaces, were the most widespread compound classes detected in stormwater runoff, a typical finding in stormwater runoff in urban areas. With a better understanding of the presence of these contaminants in the environment, future work can focus on developing research to characterize the effects of these contaminants on aquatic life and prioritize toxic-reduction efforts for the Columbia River Basin.

This report presents the results of a study to: (1) assess contaminant concentrations directly contributed to the Columbia River through WWTP effluent and stormwater runoff from adjacent urban environments; (2) evaluate instantaneous loadings to the Columbia River Basin from inputs of this type; and (3) provide information to water managers and policy makers to help with decision making about future sampling efforts and reduction activities. The data from this study provide an initial assessment of a broad array of contaminants that to date have little information available on different sources in the Columbia River Basin. These data will be a useful first step to: (1) identify the contaminants of highest interest, (2) indicate the most important sources of these contaminants; and (3) prioritize contaminant-reduction efforts.
For info: Study available at: http://pubs.usgs.gov/sir/2012/5068/

CSO CONTROL PLANS US
POST-CONSTRUCTION COMPLIANCE

On May 25, EPA issued final guidance on conducting effective post-construction compliance monitoring to assess the performance of measures implemented under long-term **c**ombined **s**ewer **o**verflow (CSO) control plans, as provided in EPA's 1994 CSO Control Policy. This guidance will assist CSO permittees in developing post construction compliance monitoring plans that collect sufficient data for evaluating the effectiveness of CSO controls and assessing compliance with the requirements of the federal Clean Water Act, as required by the 1994 Combined Sewer Overflow Control Policy (59 Fed. Reg. 18688). EPA developed a draft of the guidance, and received comments from state National Pollutant Discharge Elimination System authorities and other stakeholders.
For info: Mohammed Billah, EPA, 202/564-2228, billah.mohammed@epa.gov or website: http://cfpub.epa.gov/npdes/home.cfm?program_id=5

WATER BRIEFS

WETLAND PLANT LIST US

WETLAND DELINEATIONS

Effective June 1, 2012, a new wetland plant list (NWPL) will be made available by the US Army Corps of Engineers (Corps), in cooperation with EPA, US Fish & Wildlife Service (FWS), and the US Department of Agriculture Natural Resources Conservation Service (NRCS). NWPL is used to determine whether the hydrophytic vegetation parameter is met when conducting wetland determinations under Oregon's Removal-Fill Law, the federal Clean Water Act, and the Wetland Conservation Provisions of the Food Security Act. The NWPL (and the information implied by its wetland plant species status ratings) is used extensively in wetland delineation, wetland restoration and research, and the development of compensatory mitigation goals, as well as in providing general botanical information about wetland plants. The geographic area of NWPL covers all 50 US states, the District of Columbia, and the US Caribbean and Pacific islands that are considered to be territories of the US.

Wetlands are evaluated using three factors — soils, hydrology, and vegetation in accordance with the 1987 Wetland Delineation Manual and Regional Supplements. NWPL is used in evaluating the vegetation factor. The NWPL is a list of wetland plants and their assigned indicator statuses. An indicator status reflects the likelihood that a particular plant occurs in a wetland or upland. The five indicator statuses are: Obligate (OBL) plants that always occur in standing water or in saturated soils; Facultative Wet (FACW) plants that nearly always occur in areas of prolonged flooding or require standing water or saturated soils but may, on rare occasions, occur in non-wetlands; Facultative (FAC) plants that occur in a variety of habitats, including wetland and mesic to xeric non-wetland habitats but commonly occur in standing water or saturated soils; Facultative Upland (FACU) plants that typically occur in xeric or mesic non-wetland habitats but may frequently occur in standing water or saturated soils; and Upland (UPL) plants that almost never occur in water or saturated soils.

Any field work completed on or after June 1, 2012, will need to use the new list. However, work performed before this date may also use the new list. In Oregon, the State's Department of State Lands will accept determinations and delineations based on the former indicator status list only if the field work was completed before June 1. It is important that any delineation work performed before June 1 reference which list was used.

The wetland plant list was first published by FWS in 1988 and contained 6,728 species. The latest list contains 8,200 species, an increase of 1,472 species, or 22 percent. The majority of the increase is a result of new taxonomic interpretations. The new list also includes changes in plant indicator status (OBL, FACW, FAC, and FACU designations) from 1988 for 807 species, or 12 percent of the list (not including the new species added to the list). The specific changes include: 35 percent (282 species) were rated wetter; 36 percent (290 species) were rated drier; and the remaining 30 percent (235 species) were changes to the former FAC-group.

With the publication of a Federal Register notice on May 9 (Federal Register, Vol. 77, No. 90, May 9, 2012), NWPL became the sole reference resource for the hydrophytic vegetation parameter for wetland delineation purposes as required by the Clean Water Act (CWA) and the Food Security Act (FSA) of 1985. In 2006, the Corps, EPA, FWS, and NRCS agreed to transfer lead responsibility for updating the "National List of Vascular Plant Species that Occur in Wetlands" from FWS to the Corps. The list had not been updated since 1988. Scientists at the Corps Cold Regions Research and Engineering Lab (CRREL) were designated to lead the effort. Experts from the four Federal agencies were involved in all aspects of producing the final and draft lists at both the national and regional levels.

For info: NWPL's interactive website: http://geo.usace.army.mil/wetland_plants/index.html; 2012 NWPL list is available at: http://wetland_plants.usace.army.mil/

NEPA LITIGATION US

NEPA CASES ANALYSED

The National Environmental Policy Act (NEPA) introduced the environmental impact statement (EIS), transformed decision making by federal agencies, and spurred the growth of an extensive body of environmental law. A revised second edition of *The NEPA Litigation Guide* has just been released; it takes a close look at the litigation of NEPA cases, including jurisdiction and related issues, standard and scope of judicial review, and the specific concerns of litigators. Written by experienced practitioners and scholars, this comprehensive guide identifies key NEPA issues and offers solutions to the challenges faced in practice. The *Guide* is edited by Albert M. Ferlo, Karin P. Sheldon, Mark Squillace.

This edition includes a new chapter on climate change and its relationship to the NEPA process. The updated chapters highlight recent cases and provide information on new policies, such as monitoring and mitigation, from the Council on Environmental Quality (CEQ), the body created by the statute to provide guidance and oversight to other federal agencies on NEPA compliance. In the book, experts summarize hundreds of key cases involving: procedural or timing questions; the public participation process; alternatives analysis; and limits of knowledge. It also includes appendices which include the act itself, CEQ regulations, and the Forty Most Asked Questions, plus a table of cases and detailed index to assist in further research.

For info: ABA Webstore: http://apps.americanbar.org/abastore/index.cfm

WATER UTILITIES US

STRATEGIC DIRECTIONS REPORT

The engineering firm Black & Veatch recently released the report *Strategic Directions in the U.S. Water Utility Industry.* The report demonstrates that water utilities face a number of interconnected challenges. Financial issues are front and center with water utility leaders. Challenges include aging infrastructure, new regulatory standards, and changes to traditional funding streams. Customers will have to pay more in the future, according to Black & Veatch.

The report deals with other challenges. Sustainability is being embraced by utilities nationwide to balance environmental, economic and community needs. An asset management framework allows an organization to know what assets they have, the condition of each, and when each asset will need to be repaired or replaced. It is an integrated planning program that maximizes the efficiency of all utility resources — assets, revenue, capital investments, and people.

Black & Veatch noted that its first annual water utility industry survey polled industry leaders to identify trends and changes within the industry. Leaders from across Black & Veatch's management consulting and global water businesses analyzed survey results and provided their insights on what is driving these changes.

For info: Report at: http://bv.com/survey/2012-water-utility-report

CALENDAR

July 16-18 CO
CUAHSI 3rd Biennial Colloquium on Hydrologic Science & Engineering, Boulder. Center Green Campus (UCAR). Sponsored by Consortium of Universities for the Advancement of Hydrologic Science, Inc.. For info: www.cuahsi.org/biennial2012/index.html

July 17-18 CO
Colorado Water Law in a Nutshell Program, Gunnison. Western State College. For info: www.western.edu/academics/water

July 17-19 NM
Managing Water, Energy & Food in an Uncertain World - 2012 UCOWR/NIWR Conference, Santa Fe. La Fonda Inn. For info: UCOWR, 618/ 536-7571 or www.ucowr.org

July 17-20 DC
First Stewards Symposium: Impact of Climate Change on Indigenous Coastal Cultures, Washington. Smithsonian's National Museum. For info: Leonda Levchuk, National Museum of the American Indian, 202/ 633-6613 or www.firststewards.org

July 18 MT
Future Implementation of the 1964 Columbia River Treaty Workshop, Kalispell. Red Lion Inn, 20 North Main Street. Sponsored by Bonneville Power Administration & Army Corps of Engineers. For info: www.crt2014-2024review.gov/

July 18-20 CO
Water Taboos: Addressing Our Most Challenging Issues - 37th Annual Colorado Water Workshop, Gunnison. Western State College. For info: Jeff Sellen, WSC, 970/ 943-3162, jsellen@western.edu or www.western.edu/academics/water

July 18-20 MD
Stormwater Symposium 2012, Baltimore. Sheraton City Center. For info: www.wef.org/Stormwater2012

July 19-21 CA
Rocky Mt. Mineral Law Foundation 58th Annual Institute, Newport Beach. Marriott Hotel. For info: Dave Phillips, RMMLF, 303/ 321-8100 x 101, dphillips@rmmlf.org or www.rmmlf.org

July 31-Aug. 4 OR
Ecosystem Services Come of Age: Linking Science, Policy & Participation for Sustainable Human Well-Being Conference, Portland. Doubletree Hotel. Sponsored by Ecosystem Services Partnership. For info: www.espconference.org/ESP_Conference

August 1-3 ID
NWRA Western Water Seminar, Sun Valley. Sponsored by National Water Resources Ass'n. For info: www.nwra.org/

August 4 OR
RiverFeast, Smith Rock. Ranch at the Canyons. Sponsored by Deschutes River Conservancy. For info: www.deschutesriver.org/get-involved/events/2012_riverfeast

August 6 OR
Risky Business: Probability, Perception & the Portland Harbor Superfund Site Lecture, Portland. Bagdad Theater, 3702 SE Hawthorne Blvd. Sponsored by City of Portland Rivers Office. For info: www.omsi.edu/node/3111

August 6-8 CA
Overview of Environmental Statistics Course, Davis. 1137 Lab, UC Davis. For info: UC Davis Extension, 800/ 752-0881 or www.extension.ucdavis.edu/landuse

August 6-10 UT
Sediment Transport in Stream Assessment & Design Course, Logan. Utah State - Intermountain Ctr. For River Rehabilitation & Restoration. For info: http://cnr.usu.edu/icrrr/

August 7-8 TX
TCEQ 2012 Public Drinking Water Conference: Information & Tools for Public Water Systems & Utilities, Austin. DoubleTree Hotel Austin. For info: www.tceq.texas.gov/drinkingwater/conference.html

August 9-10 AZ
Arizona Water Law Conference, Phoenix. Biltmore Resort. For info: CLE International, 800/ 873-7130 or www.cle.com/

August 10 CO
Conservation Easements Conference, Denver. Grand Hyatt Hotel. For info: CLE International, 800/ 873-7130 or www.cle.com/

August 12-14 WA
2012 Agricultural & Applied Economics Ass'n Annual Meeting, Seattle. For info: www.aaea.org/2012am/

August 13-17 CA
Geomorphic & Ecological Fundamentals for River & Stream Restoration Course, Lake Tahoe. Sagehen Creek Field Station. For info: http://sagehen.ucnrs.org/courses/geomorph.htm

August 14 NM
City of Santa Fe-Buckman Direct Diversion & WTP (Luncheon), Albuquerque. O'Neil's Pub on Central, 11:30am-12:30pm. Sponsored by AWRA State Section. For info: http://state.awra.org/new_mexico/index.html

August 15 CA
ACWA's 2012 Regulatory Summit, Rohnert Park. Doubletree by Hilton Sonoma Wine Country. For info: Ass'n of California Water Agencies, www.acwa.com/events/acwa-regulatory-summit

August 15-17 CO
2012 Summer Conference of the Colorado Water Congress, Steamboat Springs. Sheraton Steamboat Resort. For info: http://www.cowatercongress.org/SummerConference/index.aspx

August 16-17 MT
2012 Summer Watershed Forum, Helena. Holiday Inn. Sponsored by Montana Watershed Coordination Council. For info: http://mtwatersheds.org/

August 19-23 CO
StormCon 2012 (Conference), Denver. Sheraton Downtown Hotel. For info: www.StormCon.com

August 24 CA
Habitat Conservation Planning Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or www.extension.ucdavis.edu/landuse

August 26 CA
APWA Public Works Congress & Expo, Anaheim. Convention Ctr. Sponsored by American Public Works Ass'n. For info: http://apwa.net/congress

August 26-29 MI
National Tribal Environmental Council Annual Conference, Acme. Grand Traverse Resort & Spa. For info: NETC: http://ntec.org/annualmeeting.html

August 26-31 Sweden
World Water Week: Water & Food Security, Stockholm. Hosted by the Stockholm Intern'l Water Institute. For info: www.worldwaterweek.org/

August 27-28 WA
Water Law in Washington Seminar, Seattle. WA State Convention Ctr. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

September 5-7 AL
2012 Alabama Water Resources Conference, Orange Beach. Perdido Beach Resort. For info: http://auei.auburn.edu/conference/

September 6 CA
Wetlands Regulation & Mitigation Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension, 800/ 752-0881 or www.extension.ucdavis.edu/landuse

September 6 GA
Stormwater Law & Regulation in Georgia Seminar, Atlanta. Cobb Galleria Centre. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

September 9-12 FL
27th Annual WateReuse Symposium, Hollywood. Westin Diplomat Resort. For info: www.watereuse.org/symposium27

September 10-11 NM
New Mexico Water Law Conference, Santa Fe. Hilton Historic Plaza. For info: CLE International, 800/ 873-7130 or www.cle.com/

September 11-13 WA
AWRA Washington State Conference: The Columbia River, Basin & Treaty, Ellensburg. Sponsored by American Water Resources Ass'n - WA Section. For info: http://waawra.org/

September 12 OR
Oregon BEST FEST: Clean-Tech Innovation Conference, Portland. Leftbank Annex. Sponsored by Oregon BEST. For info: http://oregonbest.org/bestfest/home

September 12-13 MT
Montana Water Law Conference, Helena. Great Northern Hotel. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

September 13-14 CO
Water-Energy Nexus: Acquisition, Use & Disposal of Water for Energy & Mineral Development Conference, Denver. Westin Hotel. Sponsored by Rocky Mt. Mineral Law Foundation. For info: Mark Holland, RMMLF, 303/ 321-8100 x106, mholland@rmmlf.org or www.rmmlf.org

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

CALENDAR

(continued from previous page)

September 14 CA
California Environmental Quality Act (CEQA) Seminar, Santa Monica. DoubleTree Suites. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

September 14-16 CO
Boulder Conference on Culture, Politics & Climate Change, Boulder. University of Colorado. For info: www.climateculturepolitics.org/

September 18-20 MT
Wetland Restoration & Management - Focus on Monitoring for Success Course, Bozeman. MSU. Sponsored by Montana Water Center & Montana DEQ. For info: http://watercenter.montana.edu/training/wetlands/

September 16-21 Korea
World Water Congress & Exhibiton, Busan. Haeundae Beach. Sponsored by International Water Ass'n. For info: www.iwa2012busan.org

September 19-20 OR
Sustainable Stormwater Symposium, Portland. World Trade Ctr. Sponsored by Oregon Section - American Society of Civil Engineers Environment & Water Resources Group and Oregon Chapter of American Public Works Ass'n. For info: www.stormwatersymposium.org/

September 19-21 ID
East or West, Water Defines Us All: 2012 Pacific Northwest Chapter - Society of Wetland Scientists Conference, Boise. The Grove Hotel. For info: www.sws.org/regional/pacificnw/nat_meetings.html

September 23-26 TN
Ground Water Protection Council Annual Forum + Water Pro Conference (National Rural Water Ass'n), Nashville. Gaylord Opryland Resort. For info: www.waterproconference.org

September 24-25 ID
Idaho Water Law Seminar, Bosie. TENTATIVE. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

September 24-26 CO
Fifty Years of Watershed Modeling Conference, Boulder. For info: www.engconfintl.org/12ao.html

September 27 WA
Water Right Transfers Conference, Seattle. WA State Convention Ctr. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

September 28 OR
New Water Year Celebration, Corvallis. OSU. For info: http://water.oregonstate.edu/