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WATER QUALITY CRITERIA & THE BIOTIC LIGAND MODEL

PROPOSED UPDATES TO STATEWIDE COPPER WATER QUALITY CRITERIA IN OREGON USING THE BIOTIC LIGAND MODEL

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Introduction

The federal Clean Water Act (CWA) requires states to adopt water quality criteria that are protective of designated uses, which includes protecting aquatic life from elevated copper exposure (USEPA 2007). Freshwater aquatic life criteria for copper proposed by the Oregon Department of Environmental Quality (ODEQ) were disapproved by the US Environmental Protection Agency (EPA) in 2013 because they were not deemed adequately protective. As a result, ODEQ is conducting a rulemaking to revise its copper standard. Concurrently, EPA has also proposed a draft rule for copper in Oregon waters that is set to be promulgated early next year, if the ODEQ rule has not yet been approved. Whether or not the EPA rule is finalized prior to the ODEQ rule, a new copper rule will be in place in 2017 that will be based on the bioavailability of dissolved copper predicted with the copper Biotic Ligand Model (BLM). Copper criteria established by the new rule will likely impact National Pollution Discharge Elimination Discharge System (NPDES) permitting and activities impacting waters listed as impaired under CWA §303(d) in Oregon.

While there are currently BLM-related proposals under consideration in several other states (see below) and EPA has approved site-specific application of the BLM in a number of cases, Oregon may end up being one of the first states to have an EPA-approved statewide application of the BLM to water quality criteria. As EPA has recommended that the BLM be used to update the aquatic life ambient freshwater quality criteria for copper it is likely that additional states will be grappling with a comparable range of issues in the foreseeable future. [An ODEQ summary of various states' BLM-related actions is available at: www.oregon.gov/deq/RulesandRegulations/Advisory/AC2Perf0116.pdf.]

Copper is naturally occurring in the environment, however elevated levels due to natural or anthropogenic sources are of great concern because even at low concentrations copper can be toxic to aquatic life (Nor 1987, Scannell 2009). Copper is ubiquitous among surface waters and has been observed to have harmful impacts on sensitive taxa such as salmonids at concentrations near background levels (McIntyre et al. 2008, 2012; Wisdom and Bucich 2011; NOAA 2007).

This article discusses salient features of the BLM, examines what is currently known about ODEQ's and EPA's BLM-based criteria proposals, and outlines the implications these actions have for the regulated community.

Biotic Ligand Model

"Bioavailability"

Receptor Tissue

Water Hardness

Copper Toxicity

"BLM"

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

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Subscription Rates:
$299 per year
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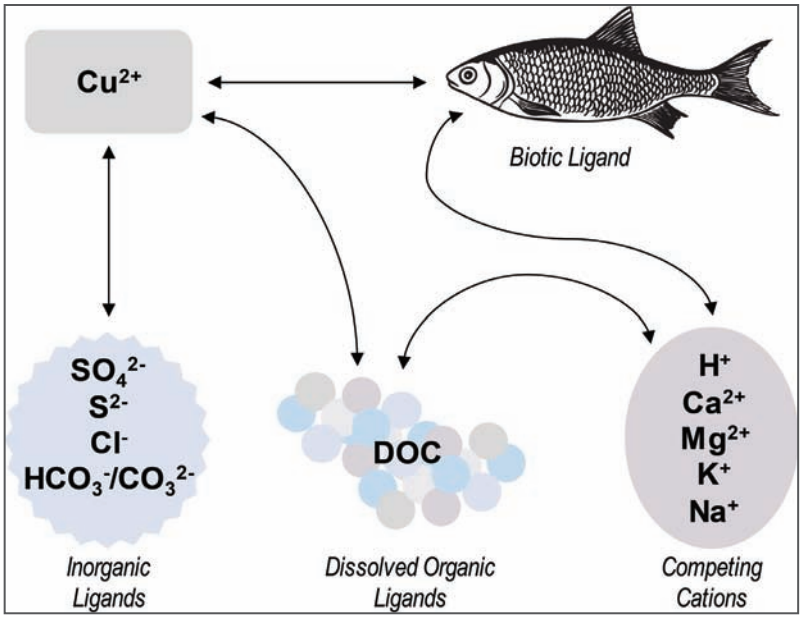
Addressing Bioavailability Using the Biotic Ligand Model

Elevated concentrations of copper can be potentially harmful to aquatic life (Nor 1987; Scannell 2009), however, not all measurable copper in water is available to bind to organisms and cause a toxic effect. The term "bioavailability" describes the portion of a substance that is available to bind to an exposed receptor (USEPA 2007, Wisdom and Bucich 2011). In the case of metals, the metal must be in a dissolved ionic form and not bound to particulates to bind to an aquatic organism's gill (i.e., the biotic ligand), which is why since 1993 EPA's Office of Water policy has been to set and measure compliance with water quality standards based on dissolved metal concentrations (Prothro 1993). Further research on the proportion of dissolved metals capable of binding to a gill surface has shown that dissolved metals can be subdivided into bioavailable (i.e., free cupric ion, Cu^{2+}) and non-bioavailable (i.e., bound to dissolved organic or inorganic matter) fractions (Wisdom and Bucich 2011; Di Toro et al. 2001; Santore et al. 2001). Only free cupric ions are bioavailable to bind to the biotic ligand. However, the proportion of ions that will actually bind to receptor tissue is also dependent upon the concentrations of other cations that compete with the bioavailable cupric ions for binding sites (USEPA 2007).

Copper criteria recommended by the EPA in 1985 first recognized the impacts of water quality parameters on the toxicity of copper by incorporating water hardness. Water hardness is a measure of the combined concentrations of magnesium and calcium (GEI 2015; USEPA 1985). Later EPA guidance allows for the adjustment of hardness-based criteria based on site-specific toxicity data (i.e., establishing Water-Effect Ratios). However, this site-specific approach can be costly to implement, and Water-Effect Ratios are typically water-body specific. As water quality research demonstrated that other common parameters in addition to hardness have substantial and predictable impacts on the toxicity of copper to a variety of aquatic organisms, EPA determined that modeling incorporating these additional parameters represented the best available science for predicting copper toxicity in the aquatic environment (USEPA 2003). As a result, in 2007 EPA recommended that the BLM be used to update the aquatic life ambient freshwater quality criteria for copper (USEPA 2007).

The BLM evaluates the potential toxicity of dissolved copper in the context of 11 water quality parameters including: temperature; pH; and **d**issolved **o**rganic **c**arbon (DOC); as well as the concentrations of calcium, magnesium, sodium, potassium, sulfate, chloride, alkalinity, and sulfide (Figure 1) (Di Toro et al. 2001, Santore et al. 2001). Within the dissolved metal fraction, the BLM accounts for the partitioning of copper binding among DOC, complexes with inorganic anions, and the biotic ligand (i.e., surface of the gill tissue). How this binding is apportioned depends on the relative concentrations of these three possible ligands, the metal's specific affinity for each, and the concentrations of other cations that bind competitively with DOC and the biotic ligand (GEI 2015; Wisdom and Bucich 2011; Di Toro et al. 2001; Santore et al. 2001). The impacts of these moderating factors are all taken into account to predict the amount of bioavailable cupric ion that will bind to the gill tissue, and the resulting exposure concentration is used to predict its associated aquatic toxicity. In criteria development, the toxic effect of interest (e.g., LC50) can be input with water quality parameters to "work backwards" to adequately protective acute and chronic concentrations of dissolved copper (USEPA 2007).

Figure 1. Conceptual diagram of the copper Biotic Ligand Model as described by Di Toro et al. 2001 and Santore et al. 2001 (adapted from Wisdom and Bucich 2011).



Biotic Ligand Model

Oregon's Rule

Rulemaking Process

Potential Precedent

Ambient Conditions

PLEASE NOTE:
The descriptions of the rulemaking process and proposed rules contained in this article are based on the authors' best understanding of the current status of this work from attendance at the meetings and review of publicly available materials. This summary article is not intended to represent the views of any of the advisory committee members, the technical review panel, or the organizations they represent. Both the EPA and ODEQ rules are still in development, and final versions could deviate substantially from the approaches being considered at the time rulemaking meetings were held.

ODEQ's Proposed Rule

The previous hardness-based copper criteria update proposed by ODEQ in 2004 was disapproved by EPA in 2013. EPA cited the fact that the proposed criteria did not incorporate the BLM method recommended in 2007 EPA guidance, and that the National Marine Fisheries Service (NMFS) concluded from their consultation that the hardness-based criteria were not adequately protective of endangered fish species (USEPA 2013; GEI 2015). In a subsequent 2016 communication, NMFS indicated that criteria implemented using the BLM would be adequately protective, as these refined criteria would not jeopardize the continued existence of endangered salmon and trout species (NOAA 2016). Based on the 2013 disapproval and these comments, ODEQ is proposing a new BLM-based rule for copper that is intended to be finalized at the end of 2016. ODEQ's rule would require statewide implementation of the BLM. To date, statewide implementation of the BLM has only been proposed by three other states (Kansas, Delaware, and Idaho), none of which have yet received EPA approval (ODEQ 2016a).

Concurrent with the Oregon rulemaking process, EPA is also proposing an update to the copper criteria for Oregon, and EPA's proposed rule differs from some of the implementation options being considered by ODEQ. Public comment on the EPA-proposed rule closed on June 2, 2016, and EPA's rule is expected to be finalized by January 2017. Both ODEQ and EPA agree that the ODEQ rule, when implemented, will replace and supersede the EPA rule; however, it is currently uncertain whether the ODEQ rule will be approved before the EPA rule is finalized. As a result, the EPA rule may go into effect as an interim rule before ODEQ's rule is finalized.

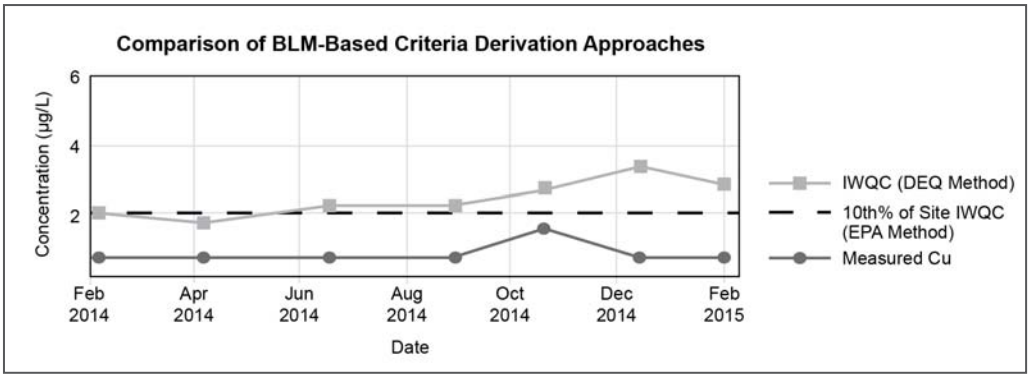
Even though the draft ODEQ rule for freshwater copper criteria is not yet available for public comment, the proceedings of the rulemaking advisory committee meetings held between December 2015 and April 2016 described several possible approaches that are still being considered. [For updates and publicly available draft documents *see* Copper Advisory Committee website: www.oregon.gov/deq/RulesandRegulations/Pages/Advisory/Awqcopper.aspx.]

It is useful to examine the options discussed by the advisory committee within the BLM paradigm and make comparisons to the proposed EPA rule because any outcome of this process will be a significant departure from previous approaches. There are few states that have proposed statewide adoption of BLM-based copper criteria, so this rule also has the potential to set a precedent for how new copper criteria are developed in other states, in addition to how criteria are developed for other metals.

Key Aspects of the Proposed Rules

One of the most critical changes to the way copper criteria will be developed under ODEQ's proposed use of the BLM is that the model itself, and the outcome it generates, will be the standard. For every sample collected, the unique combination of water quality parameters will be input into the BLM to generate an **i**nstantaneous **w**ater **q**uality **c**riterion (IWQC). Under the current ODEQ draft rule language, the contemporaneous dissolved copper concentration from that same sample will be compared to the IWQC to determine if an exceedance of the IWQC occurs at any sampling event. In this way, a criterion is a moving target over time that constantly changes in response to ambient water quality conditions (Figure 2).

Figure 2. Comparison of ODEQ and EPA proposed approaches to setting BLM-based water quality criteria for copper when all parameters are measured at an example site in Oregon.



The dark gray line (round symbols) indicates measured copper concentrations over time. The light grey line (square symbols) indicates BLM-based criteria (i.e., IWQC) which change over time, per ODEQ's proposed approach. The dashed line indicates EPA's proposed approach of taking the 10th percentile of the BLM-derived IWQC as the site criterion, in which the criterion does not change between regulatory updates. Adapted from ODEQ rulemaking advisory committee presentation; note this figure excerpt shows only one year of data for the Willamette River at Marion Street (Salem) monitoring site while the 10th percentile was calculated from two years of data (ODEQ 2016b).

Biotic Ligand Model

EPA Option Conservative

While the EPA proposed rule is also based on the BLM, the criteria generated would be inherently different because they do not vary with each sampling event. An EPA criterion would be a specific value that would remain constant until the next regulatory decision for that site. Per the EPA draft rule, the BLM would be used to calculate an IWQC for each sampling event, and then all resulting IWQC would be pooled and the 10th percentile selected as the criterion against which copper monitoring data are compared. In cases where fewer than 10 samples were collected, the lowest IWQC calculated would be selected as the criterion. Not only is a 10th percentile of the BLM IWQC at the conservative end of the distribution, but this approach also does not reflect the temporal variation in water quality and potential for exceedance per event that is captured by the ODEQ approach.

Site-Specific Data

Substantial discussion during ODEQ rulemaking committee meetings was focused on how to proceed when measured site-specific data are not available for all of the required input parameters of the BLM. There was general consensus among the committee members that missing data for geochemical ions could be estimated with sufficient accuracy for two primary reasons. First, all of the individual ion concentrations correlate strongly with specific conductance and can be reliably estimated using specific conductance measurements. Second, geochemical ion estimation is considered acceptable because the BLM is not very sensitive to these input parameters. Conversely, bioavailability of copper is highly dependent on pH and DOC. Therefore, the fact that these latter parameters cannot be accurately estimated from any of the other reliable surrogate measurements makes estimation based on other BLM input parameters inappropriate. Several options currently being considered by ODEQ and EPA for deriving BLM-based criteria when measured data are absent are shown in Table 1 (ODEQ 2016a,b,c; USEPA 2016).

Estimation Options

Table 1. Approaches for estimating BLM parameters when data are missing currently under consideration by ODEQ and EPA in proposed copper water quality criteria rule updates.

Parameter	Estimation Options Under Consideration for Missing Input Parameters	
	ODEQ	EPA
Geochemical ions	Estimate from specific conductance, or 10th percentile regional default	10th percentile regional default
pH	Measured data from a nearby or similar site considered to be "representative"	No estimation – site-specific measurements required
DOC	10th percentile regional default, or 25th percentile regional default	10th percentile regional default
Multiple	10th percentile regional default of all missing inputs, or 10th or 25th percentile of BLM criteria generated from measured regional data	10th percentile regional default of all missing inputs

Regional Default Values

Both ODEQ and EPA propose applying regional default values to the BLM when measured parameters are absent. While ODEQ and EPA delimit different geographic regions (and EPA considers stream order within regions), the proposed approach to developing regional default values for input parameters is the same; all available measured data for a given parameter would be compiled for a region, and a conservative percentile of the distribution (e.g., 10th percentile) set as the "default" value. Whenever measured data parameters are missing, the regional default would then be substituted as the input parameter for IWQC calculation. In EPA's proposed rule multiple default parameter values can be used as inputs when data are missing. The one exception is pH, which must be measured at the site for each IWQC calculated under EPA's proposed rule. The regional default values for DOC are of the most concern to the ODEQ rulemaking committee because the model is highly sensitive to this parameter, and ODEQ anticipates that DOC will be the parameter that is most often missing from routine water quality monitoring data (Table 2).

pH & DOC

Multiple Default Issues

ODEQ is currently considering EPA's proposed regional default value approach for input parameters, although ODEQ would also allow for pH values from a representative site to be substituted for measured data. However, members of ODEQ's rulemaking advisory committee have expressed concern about using multiple default values in combination to derive copper criteria. It is possible that combining default input parameters in this manner could result in water quality conditions that would never exist in a real water body (e.g., 10th percentile DOC, Ca, and Mg). This situation could result in an underestimate or overestimate of bioavailable copper concentrations for a given set of conditions, which would increase the probability of the derived criteria being either under- or overly-protective.

Table 2. Regional percentiles and summary statistics of measured DOC from the ODEQ water quality monitoring database.
Currently 10th and 25th percentile values are being considered as regional default input parameters when measured data are missing. The corresponding map indicates the geographic regions over which ODEQ proposes to aggregate water quality data.

ODEQ Physiographic Region	DOC (mg/L)			
	10th %	25th %	Median	Geometric Mean
Cascades	0.08	0.5	0.8	2.0
Coastal	0.83	0.9	1.4	1.8
Eastern	1.0	1.8	3.1	2.6
Willamette Valley	0.8	1.3	2.3	2.3

Adapted from ODEQ rulemaking advisory committee presentation (ODEQ 2016b).

Tiered Approach

ODEQ is also considering a tiered approach to derive criteria when data for either pH or DOC are lacking, but not both (Table 3). In cases where both pH and DOC data are missing, an IWQC would be generated for each sample in the ODEQ dataset for which all parameters are measured, and a conservative percentile of the IWQC for each region would be used as the criterion. This approach would generate criteria that reflect the sensitive end of the distribution of water bodies in each region by using observed water quality parameter data, rather than combining conservative parameter values that were not necessarily measured at the same time or location.

Table 3. Tiered approach for estimating IWQC with missing parameter data currently under consideration by ODEQ.

Tiers: (order of precedence)	DOC	pH	Alkalinity and Geochemical Ions
1	Measured	Measured	Measured
2	Measured	Measured	Estimated
3	Measured	Estimated	Estimated
4	Estimated	Measured	Measured or Estimated
5	Regional Default Criteria		

Adapted from ODEQ rulemaking advisory committee presentation (ODEQ 2016b).

Screening Tool

Because the model is highly sensitive to DOC and pH, the rulemaking committee has also discussed using regional default values as a screening tool only. In essence, if there is no reasonable potential for an exceedance when conservative default values are used, then compliance is achieved. Under this framework, measured copper values above the criteria estimated using default values should not be considered an exceedance but then would require further data collection so that site-specific criteria could be derived using measured parameter values. While such a provision does not appear in the EPA proposed rule, it is currently under consideration for inclusion in the rule language and permitting process by ODEQ.

Potential Implications for the Regulated Community

Site-Specific Parameters

Criteria Impacts

Ultimately, whether BLM-based criteria are more or less stringent than previous hardness-based criteria depends on the water quality parameters of a particular site (GEI 2015; ODEQ 2016a). In general, it seems likely that criteria for many sites will be less stringent statewide because the impact of DOC on reducing the bioavailability of copper was not previously considered in the hardness-based rule (GEI 2015). However, the waters in the Willamette Valley and Coastal regions of Oregon have relatively low pH and low DOC concentrations, suggesting BLM-based criteria could be lower than current hardness-based criteria in these regions where the majority of industrial permittees operate (GEI 2015, ODEQ 2016a). ODEQ performed a comparison of BLM and hardness-based criteria for 342 samples collected throughout Oregon where all BLM input parameters were measured, and found an almost even split between cases where the BLM-based chronic criteria were more stringent and those where hardness-based criteria were more stringent (52% vs. 48%, respectively, ODEQ 2016a). Individual NPDES industrial stormwater permit

Biotic Ligand Model

Industrial Stormwater

Permit Approaches

copper screening criteria will likely be impacted by the new BLM-based copper water quality standard. The current NPDES industrial stormwater permits use the previously described hardness-based approach to set copper effluent limits and benchmarks for individual and general stormwater permits. Issuance of the new general permit is scheduled for July 1, 2017. The timing of new permit issuance and the finalization of the Oregon BLM-based copper rulemaking may provide challenges from a regulatory perspective.

During the copper rulemaking advisory committee meeting on February 25, 2016, ODEQ identified four different approaches that are being considered for developing copper criteria that will be used for new individual permits.

These approaches, listed in order of increasing complexity and data requirements, include:

1) using regional default IWQC values described previously;
2) using a **f**ixed **m**onitoring **b**enchmark (FMB) approach;
3) calculating a 10th percentile criterion based on ambient water quality parameters (similar to the EPA-proposed approach for deriving criteria when all parameter data are available, described above); or
4) evaluating paired effluent and ambient water quality parameter data sets to develop mixing zone parameter values as a basis for model input.

The FMB is a probabilistic approach that is based on an acute exceedance frequency using the 99.9th percentile, or one exceedance every three years. The paired data set approach is similar to ODEQ's preferred method for deriving criteria (i.e., when all parameters are measured; Table 3), resulting in criteria that vary over time. The latter approach would provide the most accurate and site-specific representation of temporal variability of bioavailable copper, but would also require more resources to implement.

General Permits (Industrial Stormwater)

The 1200-COLS and 1200-Z are the two types of industrial stormwater general permits currently issued by ODEQ. The 1200-COLS permit will expire in September 2016 and is specific to industries within the Columbia Slough watershed in Portland. The 1200-Z permit will expire in June 2017 and covers all other industrial stormwater general permittees in the state not within the Columbia Slough watershed. In all likelihood, the new general permit will combine the two general permits into a single statewide general permit. Different approaches have been considered for establishing new general permit benchmarks for copper by incorporating the BLM into benchmark development. However, it appears likely that ODEQ will propose using the current hardness-based copper benchmark in the new 2017 general permit due to the limited time between finalization of a BLM-based rule and the permit renewal. This approach would be consistent with EPA's multi-sector general permit which currently uses a benchmark based on total, not dissolved, copper using the hardness-based approach.

Tiered Approach

Depending on the final rule, industries with individual permits may have the option of implementing a tiered approach for developing copper criteria. Under the tiered approach, permittees could initially use regional default input parameters to develop permit screening criteria, and only develop site-specific IWQC using paired parameter ambient and effluent data sets if reasonable potential for exceedance was identified using regional default values. Development of site-specific copper criteria would likely require two years of monthly parameter monitoring. Therefore, sites found to have reasonable potential for exceeding criteria would be required to collect more data to provide a sufficient dataset for input to the BLM. ODEQ is also considering a re-opener clause for permittees who initially have insufficient parameter data to run the BLM with measured values and exceed IWQC derived from regional default values, but who will have collected that data within two years of permit implementation. This re-opener clause for the first two years of permit coverage would allow for parameter data collection to "catch up" with the rule by letting permittees retroactively apply site-specific BLM criteria to effluent copper data collected prior to development of the site-specific model.

Parameter Monitoring (Re-Opener)

Varying Impacts

What this all means is that impacts on Oregon industries with individual NPDES permits may vary substantially from site to site. For facilities developing site-specific criteria, there will be increased costs associated with collecting the additional input parameter data. As discussed previously, Willamette Valley and Coastal regions of the state may be subject to meeting lower effluent limits than current permit criteria due to generally lower pH and DOC concentrations, which can result in greater bioavailability of copper.

BLM-Based Rule in 2017

Summary

Currently proposed updates to the freshwater copper **a**mbient **w**ater **q**uality **c**riteria (AWQC) represent a departure from previous methods used to determine water quality criteria for copper and other metals, and these changes will impact the regulated community across the state. Regardless of whether an ODEQ rule is approved before the EPA rule is promulgated, a BLM-based rule will be in effect in 2017. It is valuable to understand the range of options being considered under both ODEQ and EPA proposed rules so permittees can begin to evaluate their likelihood of complying with the new criteria under different scenarios.

Biotic Ligand Model

Background Levels

Criteria Impacts

To be prepared for these changes it would benefit the regulated community to consider:

- Becoming familiar with the BLM, required inputs, and regional default values that may apply to their site
- Investigating whether there may be reasonable potential of exceeding new criteria based on historical data
- Collecting data on the full suite of BLM parameters if they believe they could have copper exceedance under the most conservative scenario of the proposed rules
- Reviewing and providing input on the ODEQ proposed rule, which should become available for public comment in July 2016. *See*: www.oregon.gov/deq/RulesandRegulations/Pages/Advisory/Awqcopper.aspx

Managing copper in freshwater is a challenge for the regulated community because concentrations that are deemed potentially harmful to aquatic life are very close to background levels (NOAA 2007). Current best management practices are not able to consistently reduce dissolved copper to levels that may be required by the new copper AWQC (Wisdom and Bucich 2011). Therefore, it is critical that adopted criteria realistically reflect the bioavailability of copper under varying water quality conditions, are adequately protective of aquatic life, do not generate overly conservative criteria that would lead to unnecessary and costly corrective actions, and are practical to implement for the regulated community.

For Additional Information:
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Craig Heimbucher is an Oregon-licensed professional environmental engineer with 15 years of experience in the environmental field, both in the public sector and consulting. His focus is providing environmental solutions to public and private organizations with an emphasis on projects involving contaminated stormwater, soil, and sediment. He has extensive management experience with stormwater treatment, environmental compliance, and source control projects.

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Instream Flows

Market Scale

Factors & Strategies

Barriers to Expansion

WATER FOR INSTREAM FLOWS

WHAT FACTORS INFLUENCE THE EXPANSION OF ENVIRONMENTAL WATER MARKETS?

by Alex Bennett, Lillian Burns, Adriel Leon, Martin Merz, Patricia Song, & Gary Libecap
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In cooperation with the Daugherty Water for Food Institute & Mammoth Trading

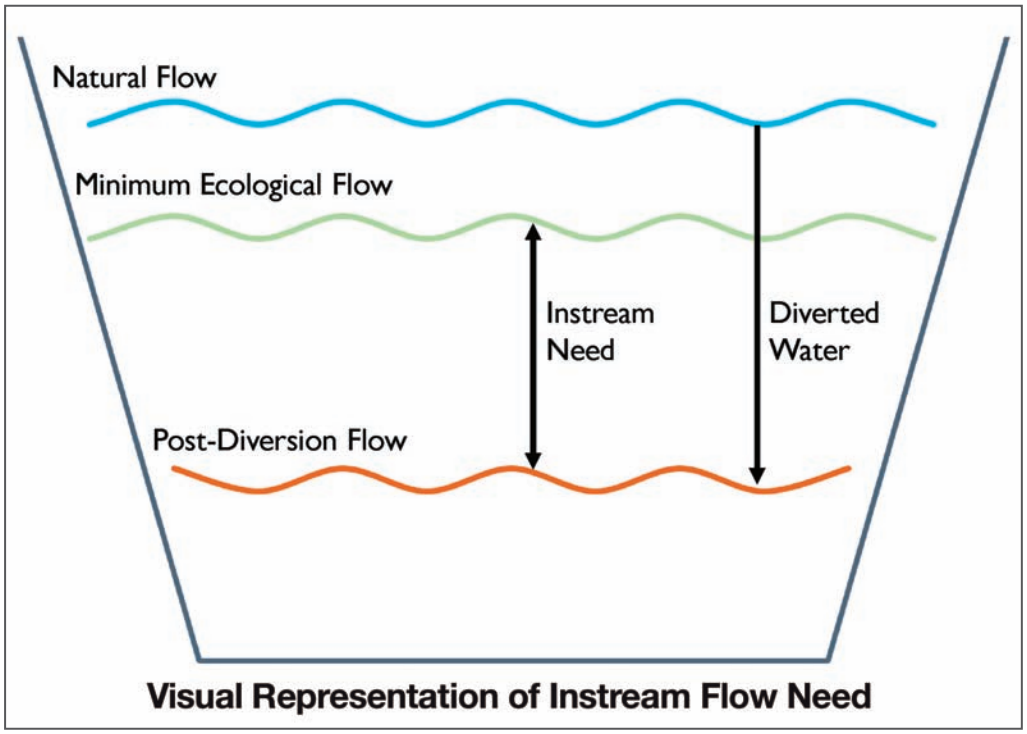
Introduction

Growing water demand in the western United States has resulted in the reduction of flows in thousands of streams and rivers that provide ecological benefits for fish and other wildlife. Environmental water markets provide a means of addressing this problem by redistributing water from existing uses, usually irrigation, to environmental flows. This local, bottom-up approach can be smoother, less contentious, and more flexible than centralized regulatory measures. In many regions, however, environmental water markets are not currently operating at a scale that is sufficient to adequately restore dewatered streams. How might these inadequacies be addressed?

Recent research conducted by the students and faculty at the Bren School of Environmental Science & Management, in cooperation with Richael Young and Nicholas Brozovic at the Daugherty Water for Food Institute and Mammoth Trading, sought answers to these questions: what factors influence the development of successful environmental water markets and what strategies can be employed to broadly expand such efforts?

This article provides an overview of this project's findings and recommendations. The full report — "*Factors Influencing the Expansion of Environmental Water Markets*" — can be found on our website: www.bren.ucsb.edu/~envmarkets.

To begin our research, interviews with 51 individuals representing irrigators, irrigation district officials, NGO representatives, government agency officials, and for-profit firms in Arizona, California, Colorado, Idaho, Montana, Nebraska, Nevada, Oregon, and Washington were conducted during the summer of 2015. This allowed the team to access a range of involved stakeholders' perspective to gain a deeper understanding of how environmental water markets operate and what barriers obstruct their expansion. Although the interviews had a structured format, they were allowed to be free flowing in order to capture the wide range of individual responses. Comments and takeaways from the interviews were organized by themes, which included funding sources cultural barriers, and navigating seasonal and interannual water cycles. Common strategies for expanding environmental water markets were identified by analyzing the interviews.



Visual Representation of Instream Flow Need

Instream Flows

Funding Characteristics

Use Restrictions

Regulatory Drivers

Private Capital

Negotiations

Irrigation Infrastructure Impacts

Resource Pooling (Districts)

Funding Successful Environmental Water Markets

One of the critical factors in the success of any market is securing funding sources that are sufficient to allow a market to exist. For successful environmental water markets, funding must be consistent and at a scale that can allow flow restoration to produce meaningful ecological outcomes. Other important funding characteristics, such as designated use restrictions and the diversity of an environmental water buyer's funding portfolio, can impact the success and longevity of a water market in a basin.

Designated use restrictions for particular funding sources — i.e., where a funder places boundaries on the projects and geographic areas for which the funding can be used — can detract from environmental water buyers' flexibility and hinder environmental water market development. A diverse portfolio of funding sources leads to more overall funding stability by hedging against fluctuations from any one source, allowing environmental water buyers to focus on long-term goals of developing environmental water markets that lead to meaningful ecological outcomes.

Funding for environmental water markets generally comes from direct federal or state appropriations, regulatory-driven funding sources, and philanthropic donations. Regulatory-drivers are one of the strongest factors behind funding, arising from compliance with federal and state regulations, such as the Endangered Species Act (ESA). These regulations mandate mitigation of negative habitat impacts and can drive government agencies and private entities to allocate long-term funding for environmental water transactions. Long-term regulatory-driven funding sources, such as the Columbia Basin Water Transaction Program, provide relatively consistent backing from year-to-year. Such consistency offers a high degree of stability to water buying or leasing organizations and allows for the development of programs with long-term strategic goals. Alternatively, programs that depend upon short-term funding sources, such as annual federal or state appropriations or private grants, necessarily focus solely on shorter-term goals.

Increasing the overall magnitude of funding is an important component in expanding the scope of environmental water markets. Currently, there is not enough flow-restoration money from government or private philanthropic organizations to address the challenge of maintaining streams across the American West. The addition of private capital, however, could expand environmental water markets to the scale necessary to address the problem across the region. This can happen through corporate actions, such as Coca-Cola's Replenish campaign, which pledges to fully offset their water withdrawals — partially through supporting environmental water transactions. Other private organizations could partner with Coca-Cola in this process. Instream flow transactions may also attract private investors, where returns may come from brokerage fees or from the leasing or sale of incidental benefits, such as improved fishing sites.

Supply of Environmental Water from Existing Water Right Holders

The potential suppliers of environmental water are existing water right holders, typically irrigators. The water amounts covered under these water rights can be left in flow-deficient streams, either temporarily (via leases) or permanently (via sales). Parties interested in restoring streams — such as nonprofits, government agencies, or private investors — negotiate transactions with water right holders to shift water towards ecological instream benefits. The success of such negotiations depends upon larger-scale factors such as state laws that vary dramatically, but also on local water use characteristics, such as irrigation infrastructure characteristics and the presence of irrigation institutions.

Shared irrigation infrastructure, even without formal institutional limitations, can be a significant factor in water market activity. Irrigation conveyance systems are often very basic, and are designed to provide irrigators easy access to the water when the ditch is full. If an irrigator along a ditch chooses to sell or lease their water, they must come to an agreement with their fellow ditch users as to whether their water transfer will impact the other users' access to the water. Often, if a consensus cannot be reached, the default is for the transfer to not occur. Environmental water buyers can address this structural problem through piping ditches and other infrastructure upgrades to reduce water loss and any impact on other irrigators from any market exchange. Further, by offering financial incentives to other water right holders on the same ditch, or actively seeking their participation in the transfer, environmental water buyers can preemptively address these potential problems.

Irrigation districts and ditch companies are more organized than are disaggregated irrigators, and hence, negotiations focused on such districts may achieve lower transaction costs. If the irrigation district leadership is supportive of environmental water market transactions and individual member irrigators are willing to participate, environmental water buyers will be positioned to negotiate large transactions through one source. This resource pooling can allow for negotiations based more on solid economic arguments, such as water values and quantities required, as opposed to years of trust building and discussion with individual water right holders. Conversely, if irrigation district managers are unwilling to cooperate and work with environmental water buyers, they effectively can block them from accessing water within their jurisdiction. Accordingly, strong, collaborative relationships between irrigation district managers and environmental water market practitioners are of great importance.

Instream Flows

Transaction Cost Barrier

Expedited State Process

Review Time Variance

Cultural Gap

Creative Exchanges

Chronic Low-Flow v. Drought

Lowering Transaction Costs

A central barrier to the development of environmental water markets is high day-to-day transaction costs associated with administering environmental water market programs. Transaction costs can be related to searching for opportunities to engage in water transactions, negotiating them, implementing projects, and monitoring results. Monitoring includes insuring that the negotiated water is left in the stream and that it is not intercepted illegally downstream. Initially high transaction costs reflect the need to invest in building relationships and setting groundwork for a long-term, successful market.

High transaction costs can also be attributed to state legal requirements for environmental transfers: the more arduous and drawn out the regulatory process an environmental water buyer must go through for leases and purchases, the more time and resources it will take. There are stark differences between states regarding the transaction review process and policies surrounding environmental water transactions. For example, both Oregon and Washington State have relatively successful expedited review processes for environmental water leases, which is one reason why more transactions take place in the Pacific Northwest. In contrast, long-term transfers in Colorado are required to go through water court — where stakeholders may end up negotiating for years. In other states, water transferred from irrigation to environmental use cannot be protected instream, where users downstream can divert the water that is meant for the environment. It is important for groups to continue to push for the creation, expansion, and implementation of laws favorable to environmental-flow markets.

There are strategies that environmental water buyers can employ to lower their transaction costs and expand environmental water markets within any legal framework in the western United States.

Environmental Water Transaction Review Time in Western States

State	Average Review Time
California	1.3 years; 4 months (short term)
Colorado	6.5 years
Idaho	3.8 months
Montana	1.5 - 2 years
Oregon	2.8 years ; 30 - 40 days (short term)
Texas	1 year
Utah	1 - 2 years
Washington	0.5 - 6 years
Wyoming	1 year

Adapted from Szeptycki et al., 2015

Strategies for Expanding Environmental Water Markets

There is often a very wide cultural gap between conventional, urban-based environmental groups and the traditional close-knit, rural agricultural communities. Many of the interviewees discussed this gap and general mistrust as a barrier to expanding environmental water markets. The degree to which water buyers can align themselves with agricultural communities and establish themselves as trusted community members affects their success in developing and implementing transactions. Investing in a deep understanding of current farmer operations, crop schedules, values, fallowing options, and other factors, will help buyers identify creative and mutually-beneficial exchanges that keep farms in business and restore streamflow when it is needed. [*See* Martinsson & Gutwein, *TWR* #147, May 15, 2016]. A water right is an asset. Farmers can often generate more profit from this asset by leaving it instream part-time when the value of agricultural productivity is low — while continuing to meet their personal and community needs. Environmental water transactions provide for this flexibility. Often, the only missing component is trust and the opening of a dialogue. If environmental water buyers can overcome being seen as outsiders, more communication will develop and more mutually beneficial transactions can be realized.

The interviewees also discussed drought response. Rivers in the West are often fully- or over-allocated for human use to the extent that ecosystem health is threatened not just during drought years. Droughts naturally intensify the problem. Nevertheless, spending time and money responding to drought can be a distraction from longer-term goals of restoring water in streams and managing water more sustainably. It is generally agreed upon that drought response is appropriate in certain scenarios, but that funding and effort should be focused on projects that address chronic low-flow concerns.

Instream Flows

10 Legal Elements Most Relevant to Environmental Flow Transactions
Western States Compared (Szeptycki et al., 2015)

	Arizona	California	Colorado	Idaho	Montana	Nevada	New Mexico	Oregon	Texas	Utah	Washington	Wyoming	✓ (out of 12)
State law explicitly recognizes fisheries habitat, recreation, or other environmental purposes as beneficial uses	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
Transfers of existing diversionary rights to instream or other environmental uses allowed by state law	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
Transfers of water rights for environmental purposes explicitly recognized by statute	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	10
Private parties can hold instream flow rights		✓			✓	✓			✓	✓			5
Permanent transfers of diversionary rights to instream or other environmental uses allowed	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	11
State law explicitly recognizes short-term leases and provides form of expedited review for approval		✓	✓	✓	✓	✓		✓			✓		7
Transfers of rights for environmental uses are subject to significant limitations that do not apply to other water rights transfers, including geographic limitations, limitations as to purpose, or more stringent procedural requirements		✓	✓		✓			✓	✓		✓		6
The state has a conserved water statute that explicitly allows some portion of water saved by irrigation efficiency improvements to be dedicated to environmental purposes		✓			✓		✓	✓	✓		✓		6
State allows the instream uses to be added to a water right, along with diversionary uses, so that the holder of the right may "stack" instream and diversionary uses on a single water right and allocate water between the two uses each year without the need for additional state review or approval		✓							✓				2
The state's law provides some mechanism for protecting informal short-term private transactions, such as split season agreements or forbearance agreements, from any risk of forfeiture or abandonment			✓	✓			✓				✓		4
Number of Elements (out of 10)	4	9	7	5	8	5	5	7	8	5	8	4	

Instream Flows

Management Party

Motives

Recommended Actions

The interviews also focused on market administration: they were asked whether it is more logical for government agencies, nonprofit organizations, or private businesses to administer environmental water markets. The main argument against government management is that a water right can be exposed to unwanted scrutiny and even relinquishment (loss of the water right). This disincentivizes individuals — who have not had their water right recently adjudicated or otherwise examined — from entering the market. In contrast, a nonprofit organization or for-profit business can serve as a buffer between water right holders and regulators. A third party that is required only to report negotiated exchanges can be more effective. Individuals feel less at risk when a non-regulatory entity is involved.

There are differences between for-profit businesses and nonprofit organizations in what their real or perceived motives are in the eyes of water right holders. The motivation of nonprofit organizations as market administrators can seem suspect to water right holders. Even if there is honest motivation to build a sustainable future for farming operations and rivers, farmers may perceive that the primary focus is on conservation outcomes, even at the expense of the agricultural community. The reality for environmental water buyers is that most basins do not have a market facilitator, so any organization wishing to transact water from an area will often function as both administrator and buyer. Businesses as market administrators are perceived as more transparent in their effort to make a profit by facilitating transactions, which can be less threatening to water right holders.

Conclusion

MOVING FORWARD WITH ENVIRONMENTAL WATER MARKETS

Many factors have obstructed environmental water markets from expanding to a scale that can adequately address widespread flow restoration needs. In order to understand these obstructions and identify how they might be overcome, this project analyzed the demand for and supply of environmental water, legal constraints, and current market approaches to reveal strategies that can expand environmental water markets.

The following are some of the project recommendations for environmental water buyers:

- Utilize diverse funding sources whenever possible to allow for maximum flexibility of approaches.
- Respond to drought only in certain scenarios, but focus on longer-term flow restoration goals.
- Align with agricultural communities and learn about their operations in order to identify cooperative approaches for reallocations to streamflow.
- Identify a market administrator that facilitates seller trust.

To expand environmental water markets to meet the scale of the need for restored streamflow in the western US, water buyers can utilize these strategies, and continue to develop and implement other creative approaches to working closely with landowners and moving water back to streams.

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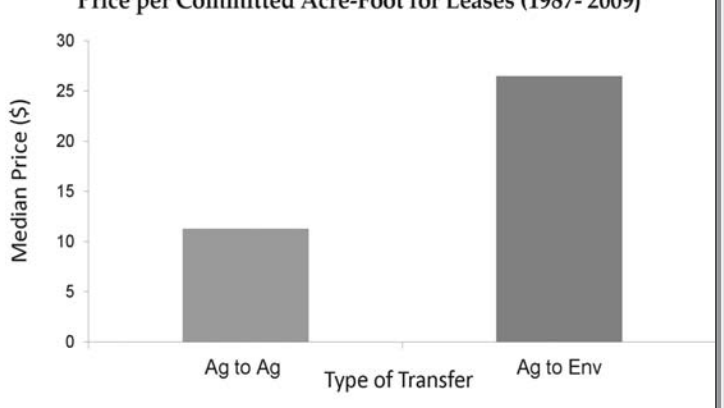

Median price ($) for Agriculture to Agriculture and Agriculture to Environment Transactions across 11 Western United States (AZ, CA, CO, ID , NM, NV, MT, TX, UT, WA, and WY). Data from the Water Strategist and the Water Intelligence Monthly.

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ASR

SMALL SYSTEM AQUIFER STORAGE & RECOVERY

SMALL SYSTEM UTILIZATION FOR DRINKING WATER

by Bob Mansfield, Buffalo Geological Consulting

Introduction

ASR Size

A brief look at **a**quifer **s**torage and **r**ecovery (ASR) projects around the country reveals that they are usually large and often complicated by source and receiving water quality issues. Such projects involve a myriad of governmental, public, and private interests. For these reasons alone ASR has a reputation for being expensive and has been mostly utilized by large municipal water systems.

However, a small Oregon public utility district utilized a single well for ASR. In so doing they increased their water system storage capacity by 600% and accomplished this for considerably less cost than the steel, above-ground reservoir that they originally considered.

Background

Water Storage Need

The McNulty Water Public Utility District (McNulty or PUD) is located in the foothills of the Oregon Coast Range immediately west of St. Helens. Six groundwater wells provide water to over two thousand customers. In 2000, a planned expansion of service resulted in the permitting and drilling of the their sixth water supply well. This well, named the Robinette, was drilled to a total depth of 616 feet and screened across the regional basalt aquifers within the Columbia River Basalt Group (CRBG) formations — the same aquifers tapped by McNulty's other municipal wells and by almost all of the surrounding public water systems. Also planned during the expansion was a 500,000 to 1,000,000 gallon above-ground reservoir that would have essentially doubled the existing water storage capacity. The additional storage was needed to satisfy excess system demand during the dry season, provide backup in case one of the wells went out of service, and assure a ready-reserve for emergencies such as fire suppression.

Low Recharge Well

Something was wrong, however, with the new well. Following construction of the Robinette, a 24-hour step-drawdown test was performed. Little recovery was observed. Based upon subsequent use and other testing, it became apparent that the aquifer the Robinette was installed into exhibits very low recharge. Over a hundred day period, recovery was estimated to only be approximately 0.64 feet per day. During the years to follow, additional testing confirmed the disappointing results — once drawn down, water levels in the well took years to recover.

Concept & Concerns

Project Advantages

In 2007, the idea of using the Robinette for ASR was seriously considered. Given the slow recharge rate of the aquifer , injected water should be slow to leak out.

Other advantages were also identified:

- McNulty source water quality is excellent and requires no treatment. In fact, McNulty's water won awards for "best tasting water" at state and national levels.
- Wells in the PUD's system draw from the same CRBG aquifers and their water can be easily injected during periods of low demand.
- The resulting aquifer-to-aquifer transfer promised a minimum of chemical incompatibility.
- The PUD has infrastructure in place to withdraw water from the aquifer via the Robinette and distribute it to the rest of the system. Additionally, if the ASR project proved successful, then the deferred million-gallon storage tank could possibly be eliminated.
- The PUD could provide system water to neighboring well owners if their domestic wells needed to be used for ASR observation purposes.
- The Robinette well has an existing water rights certificate from the State of Oregon for quasi-municipal use since it was originally intended as a municipal water supply well. Accordingly, the Oregon ASR application process could be considered as an increment — something in addition to, but not supplanting, rights otherwise held by the PUD.

Isolated Aquifer Concern

The PUD, though, was worried about the geological unknowns. Why the aquifer recharges so slowly was not understood. All the other nearby wells completed in the CRBG aquifer recharge very quickly. We had no lack of theories regarding the geological conditions that could create an isolated zone with high secondary porosity; however, we had no data. No information existed to help determine the vertical and horizontal extent of the isolated aquifer. The nature of the boundary conditions that restrict communication between the regional aquifer and the isolated zone were a mystery. The PUD had good reason to be concerned about how much water could be stored and recovered from an apparent anomaly.

ASR

Regulatory Issues

The PUD's concerns were not restricted to science. How rigorous would Oregon's regulatory requirements be? If the agencies required additional geologic characterization as a prerequisite, how much could the McNulty afford? If observation wells were required would they generate more questions than they answered? How far into the project could the PUD allow itself to venture without full knowledge of all the downstream project costs? Having to resolve an unexpected issue halfway into the project could easily catapult expenses to unacceptable levels.

To address these concerns, the project was structured as a proof-of-concept test and priority given to only those activities considered absolutely necessary to prove the concept. The project commenced with the implicit understanding that the requirements — both geological and regulatory — had to be determined as early as possible. If at any point the projected costs exceeded those to construct an above-ground reservoir, the ASR project would be abandoned.

Path to the Permanent License

ASR projects in Oregon are authorized under Oregon Administrative Rules (OAR) 690-350 and jointly administered by the Oregon Water Resources Department (OWRD), Oregon Health Authority (OHA), and the Oregon Department of Environmental Quality (ODEQ). If surface water is involved, the Oregon Department of Fish and Wildlife (ODFW) also becomes a party.

Pre-Application Conference

The first and one of the most important steps was the pre-application conference between the applicant and the Oregon agencies involved. It is here the project's overall goals, scope, and testing plans were outlined. In such a pre-application conference, agency representatives explain what each of their departments will require and the level of effort they expect. The PUD expressed their desire to prove up at least a million gallons of underground storage as an alternative to an above-ground reservoir and suggested 8,000,000 gallons as the maximum potential storage volume for the ASR. The PUD also guaranteed that the project would not be expanded beyond a single injection well. The agency personnel accepted the PUD's self-imposed limits on the project and encouraged the team to submit a Limited License Application. Figure 1 shows the timeline of the McNulty ASR project and important benchmarks.

Limited License

Following the conference, Buffalo Geological Consulting prepared an ASR Limited License Application complying with the topics listed in OAR 690-350-0020. The application form itself is only one page; however, a number of supplemental reports are required covering matters such as: geology; hydrogeology; ASR system design; water quality for both source and receiving aquifers; proposed testing program; and etc. These supplemental reports can be extensive and some require a licensed professional to complete.

The PUD's Limited License #015 was granted after review. On Figure 1, dark grey denotes where progress was up to the PUD. The time when the project was in the hands of the agencies is light grey and includes review, revisions, and public comment periods. The Limited License term provides a substantial period for feasibility (cycle) testing, is valid for five years, and can be extended if requested.

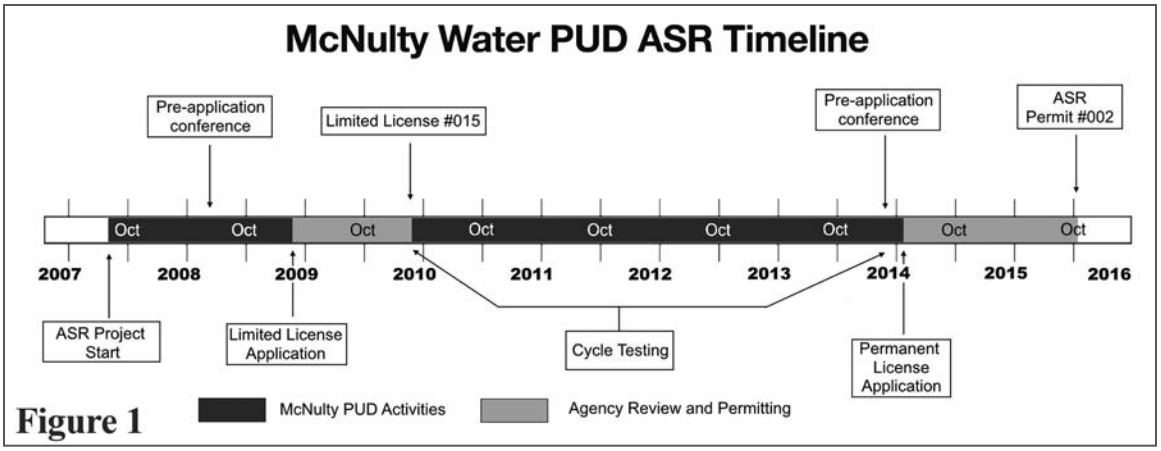


Figure 1

Testing Plans

Each testing cycle required the submittal of a Detailed Testing Plan prior to execution with the content and format largely up to the PUD. Essentially, the testing plans inform the agencies of the specific goals and benchmarks of the test cycle and propose a schedule.

At the end of each water year an ASR Annual Report was prepared to present the pertinent findings for the year's physical tests and water quality analytical results. By the end of 2014 we had completed all our planned testing and requested the required pre-application conference. During the meeting we presented a summary of all the data acquired during the years of cycle testing and the parameters that we wanted to

ASR

Permanent License

"Cycle Testing"

Storage & Discharge

Maximum Volume

Routine Operation Testing

Achieved Benefits

have included in the permanent license. The Oregon regulatory agencies were satisfied with the testing results and we prepared the Permanent ASR License Application following the topics in OAR 690-350-0030. As was the case with the Limited License, a number of months were spent collaborating with the agencies to provide additional information before the application was deemed complete. The McNulty PUD was granted ASR Permit #002 in October 2015.

Cycle Testing

In the context of ASR, "cycle testing" refers to a single complete sequence of: (a) source water injection into the receiving water aquifer; (b) a storage period of arbitrary duration; and (c) a period of recovery when water stored in the aquifer is withdrawn for use. Cycle tests are usually scheduled to take place within a "water year" — i.e., a 12-month period starting and ending in a dry month (October 1 for an Oregon water year). For McNulty's ASR project, each cycle was designed to explore certain aspects of the project such as upper and lower limits on aquifer water elevations, the equipment and infrastructure of the project, and variables affecting water quality.

Cycle Testing Summary

2001 - 2008: Testing Cycle 1

The various pumping and evaluation tests conducted on the Robinette well between 2001 and 2008 were considered as Testing Cycle 1 even though they did not occur under the Limited License.

2011: Testing Cycle 2

Cycle 2 was the first of three injection/storage/discharge cycles conducted during the Limited License time period. The Detailed Testing Plan called for injecting source water until five million gallons were injected or a static water level of 252 feet below ground level was achieved. Following injection, storage for approximately five months was proposed, followed by discharge into the water distribution system. The water quality of the receiving water aquifer was assessed through three separate sampling events and showed a decrease in total dissolved solids.

2012: Testing Cycle 3

The primary goal was to inject water towards the maximum authorized storage volume of eight million gallons. The injection phase of Cycle 3 commenced in January 2012 and proceeded smoothly until April when injection was halted to assess irregularities in the transducer readings. A new transducer was ordered and a backup system consisting of a compressor, automated air bubbler and signal connection to the SCADA was installed. When injection initially commenced, water levels increased at a much higher rate than anticipated and injection was halted to determine the reason. Analysis suggested that the well screen plugged to some extent. Two weeks of discharge pumping improved the specific capacity of the well. Injection resumed and reached its maximum volume of 6,800,000 gallons in September 2012. Water quality changes through Cycle 3 were minor. [Editor's Note: SCADA (Supervisory Control And Data Acquisition) is a system for remote monitoring and control that operates with coded signals over communication channels].

2013: Testing Cycle 4

Cycle 4 was a simulation of a year of routine operations using the Robinette ASR aquifer to provide: seasonal storage for extra water demands in the late summer and fall; reserve capacity for known extra demands such as the County Fair; extra storage for unknown short-term, high volume demands such as fire fighting; and a backup supply for other water supply well outages.

A number of upgrades and improvements to SCADA telemetry and hardware were installed and tested, including additional HMI (Human Machine Interface) controls created to expand the operator's ASR management options to prevent plugging during injection.

Project Results

This project is a success for all the stakeholders. For the McNulty PUD and its customers the results greatly exceed the PUD's initial needs.

Results included:

- The maximum storage volume tested is approximately 6,800,000 gallons, the volume recoverable between the maximum and minimum ASR aquifer water levels. This volume is far in excess of the one million gallon storage capacity initially needed and six times the storage capacity of the PUD's existing above-ground reservoirs.
- The specific storage for the ASR aquifer is over 32,000 gallons per foot of water elevation.
- Injection and recovery (discharge) pumping rates are nominally set at 45 and 245 gallons per minute respectively. Improvements in injection rates are expected when permanent injection plumbing is installed in the ASR well.

ASR

- Water quality of the receiving water aquifer is excellent, exhibiting slight variations in chemistry depending on the blend of source water from McNulty's other municipal wells.
- In the event of a major earthquake, water stored underground may be considerably safer than in above-ground storage. The ASR well is cased to the bottom of the hole, making borehole collapse less likely during a severe earthquake. The well is screened across confined aquifers in basalt. The combination of the confined aquifers, basalt matrix, and robust construction of the well provides a high degree of resistance to physical damage, water quality, and aquifer changes in the event of a major earthquake. Consequently, the Robinette well is a key component in providing access to a large ready reserve of water for emergency purposes during a natural disaster.
- Natural surroundings are important to the community and the residents of the area have the aesthetic benefit of observing no change to the bucolic scenery outside their windows. Figure 2 shows the Robinette well house. It is only four feet high, a maximum height agreed to so as not to impair the view. Six million gallons of water stored invisibly underground is equivalent to a dozen half-million gallon above-ground reservoirs — tanks that now will never need constructing.

Figure 2: Robinette Well House

Problems, Solutions and Lessons Learned

After successfully implementing the ASR for McNulty, our review revealed some management and technical issues faced in this project.

Agency Cooperation

Identify Regulatory "Fatal-Flaw" Intangibles Early

It was important to know early on if the regulatory agencies would approve a project with definite limitations, especially in hydrogeologic characterization. The PUD was sensitive to the costs involved with drilling additional wells to explore the characteristics of the aquifer and this constraint was specifically discussed during the pre-application conference with the state agencies. Because the PUD limited the project to a single well and placed conservative maximums on the target storage volume and other variables, agency representatives agreed that as long as these limits were not exceeded, the project could proceed as planned. The PUD had assurances that, barring unforeseen hydrogeological circumstances, additional aquifer characterization was not required. During the project we maintained close coordination with the regulatory agencies. We kept them informed of all developments above and beyond the expected tests to make sure that no surprises occurred and to let them know we were conducting the project as initially proposed. Fortunately, the regulators were enthusiastic about the venture and were instrumental in resolving issues in a way to keep the project moving forward.

Consultants Limited

Limit the Number of Consultants

Small ASR applications can benefit by selecting a limited team of consultants experienced in engineering and geology, and possessing additional talents or skills as the project demands require. Two senior consultants: John Borden (John Borden Consulting) and Bob Mansfield (Buffalo Geological Consulting) performed all the engineering and geologic tasks. Where help in specialized matters were needed, additional professionals were hired on an ad hoc basis. Most small water systems have at least a trained operator and often have retained a professional engineer. McNulty personnel assisted the ASR consultants and the knowledge they gained made it easier for them to utilize the ASR system efficiently after the project was completed and the ASR consultants were no longer involved.

Deferred Upgrades

Constrain Engineering and Science to That Only Absolutely Necessary

For any project, the level of effort for engineering and science depends on the situation and scope. We wanted to prove the usefulness of the concept in as economical way as possible so only the most necessary ASR-related equipment was installed. It was understood that engineering upgrades and improvements, especially regarding the down-hole equipment in the ASR well, could be deferred until after the project had proved successful. For instance, the injection equipment installed in the Robinette well consisted solely of a PVC drop pipe with a restrictor at the bottom to prevent cavitation in the injection tube and introduction of air bubbles into the aquifer. This was reasonable for testing purposes but was never considered permanent. [Editor's Note: Cavitation is the sudden formation and collapse of low-pressure bubbles in liquids by means of mechanical forces, such as those resulting from rotation of a marine propeller].

Isolated Aquifer

Hydrogeological assessment was similarly curtailed. The regional aquifer is in the Columbia River Basalt Group (CRBG) and our basic conceptual model suggests the portion of the aquifer tapped by our well is part of, but somehow isolated from, the regional aquifer. The physical extent of the ASR aquifer is undetermined. If fractures provide the primary porosity for storage it is possible that the Robinette

ASR

Observation Well

Unknowns

Quality "Fingerprint"

Wells Blend

intercepts a zone of very limited areal extent, possibly as small as a few hundred yards radius. If interflow zones between basalt flows account for the storage, then the horizontal dimensions of the ASR aquifer might be considerably larger. One nearby domestic well was utilized for observation. The well's owner allowed McNulty to acquire the well for ASR observation in exchange for connection to the McNulty water system where he benefited by higher quality and a larger quantity of water. The observation well is screened in the water-bearing zone above the CRBG aquifer and consequently is not suitable for observation of the confined aquifer. However, it is the nearest well to the ASR injection well and serves to monitor the overlying water-bearing zone for any exfiltration from the ASR's aquifer.

The temptation to conduct additional investigation to understand the nature of the ASR aquifer was powerful. There were many times during the project that both the consultants and regulators yearned for additional information. However, the question that we had to keep asking ourselves was, what actual value would knowledge of the geologic details of our unusual aquifer provide? The answer is that regardless of how much geological information could have been compiled, the injection and recovery performance of the aquifer would not have been affected.

Water Quality is a Paramount Concern

We paid close attention to water quality. The PUD's water is award-winning and we were determined to maintain the high standards. The PUD is fortunate to have ten years of analytical data on the three main source water wells collected prior to the start of the ASR project. The data is in addition to the routine sampling required by Oregon's drinking water program. Analyses of water from these wells were performed as a condition of an ODEQ solid waste permit for a nearby industrial landfill. The analytical results include anions, cations, and leachate parameters. We used the years of results to carefully "fingerprint" the characteristics of the groundwater from each well. The ASR injects water that is a blend of three wells and while all are high quality, there are slight differences between them that are noticeable when anion and cation distribution is plotted on water quality diagrams (such as a Piper or Durov). Plots of the recovered water confirm that the ASR aquifer water chemistry is directly controlled by the blend. Figure 3 shows the plottingfield of a Durov-type water quality diagram. Sample plots from each of the source water wells cluster in separate areas on the diagram due to the differences in their ionic makeup. Samples from the ASR well plot close to those of source water well #2 because of that well's dominant contribution to the injected blend during the time when the samples were obtained.

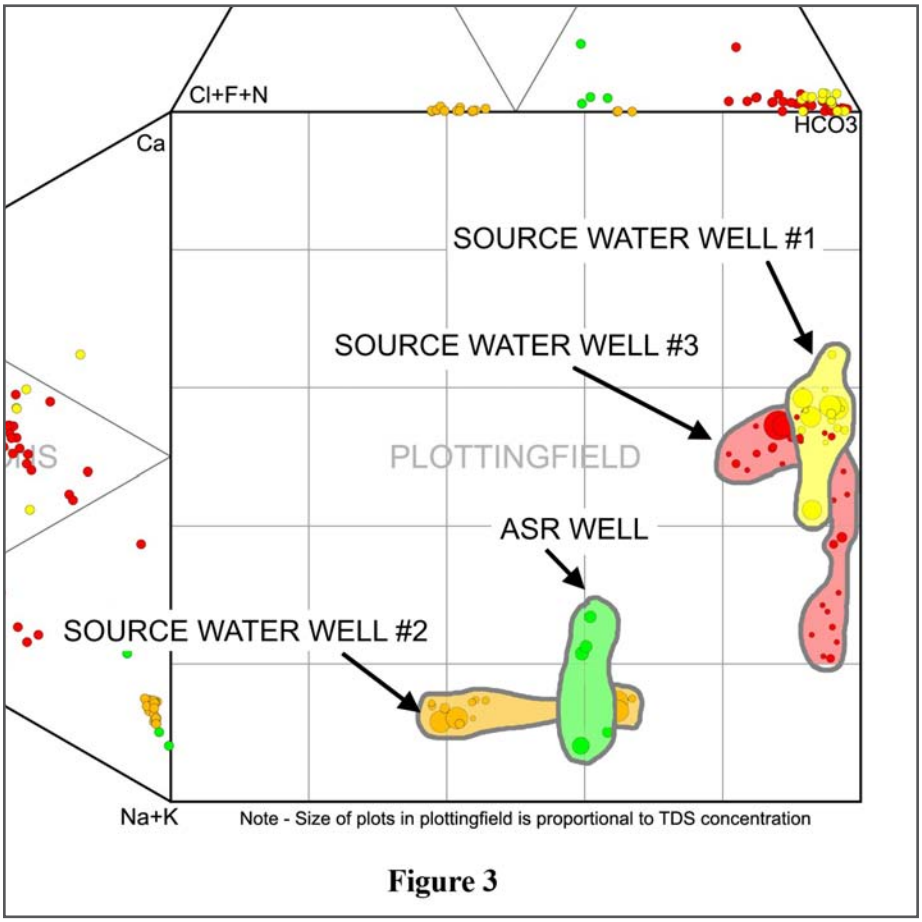


Figure 3

ASR

Forfeiture Issue

Water Rights and Legal Issues

No legal issues regarding water rights were encountered. The ASR injection well (the Robinette) has a water rights certificate for quasi-municipal use since it was originally intended as a municipal water supply well. However, one question that occurred to us was how to protect the Robinette water rights. In Oregon, water rights must be exercised (used) to be retained. Specifically, any portion of a water right certificate that is not exercised for a period of five consecutive years is subject to forfeiture. We worried that if the amount of water recovered each year was less than that injected there would be no actual withdrawal of natural groundwater and thus the Robinette could ultimately lose its water rights. ASR Permit #002 addresses this question as follows: "Any water withdrawn from the ASR well identified in this permit shall be debited against the quantity available in the aquifer by virtue of ASR storage or considered a draft on natural groundwater under existing groundwater rights." In other words, the allocation of the source water is up to the PUD.

Computer Controls

SCADA and Its Importance for ASR

SCADA (**s**upervisory **c**ontrol **a**nd **d**ata **a**cquisition) refers to a computer system that automates processes, monitors conditions, and makes simple decisions. SCADA use is ubiquitous in water utilities, power plants, oil and gas processes, manufacturing facilities, etc. In fact, any business that automates production makes use of a SCADA in some form or another. For example, if you take a tour of the Jack Daniels distillery near Lynchburg, Tennessee your overall-wearing guide will tell you that their product is "old-time whiskey made as our fathers made it." However, look for a glass-enclosed room as you walk through the old mash house. It houses the very modern SCADA computers that automate their fathers' old-time operations from grain handling to heat-shrinking the "Old No. 7" label around the necks of the bottles.

McNulty PUD SCADA System

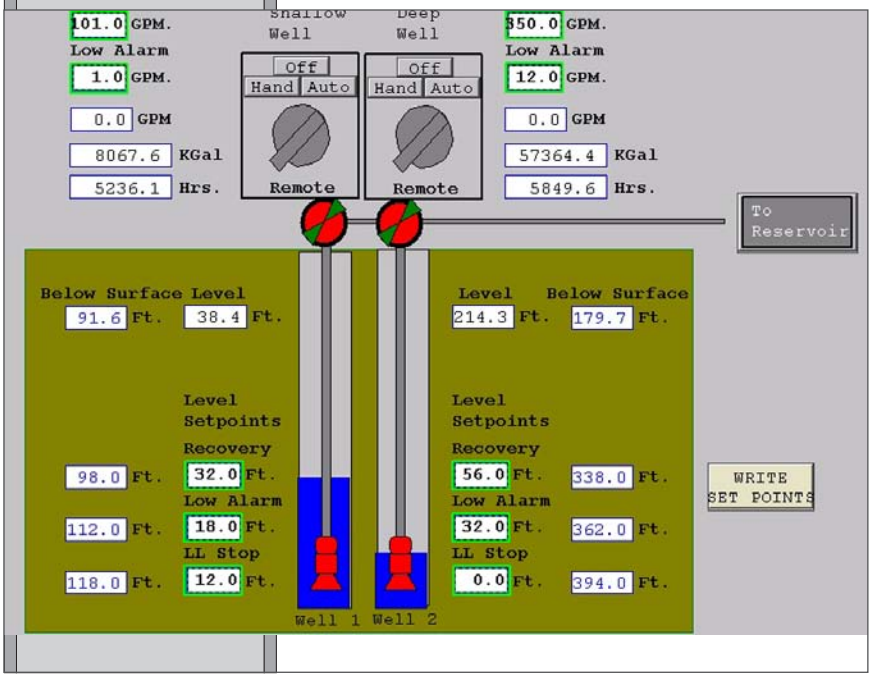
The McNulty SCADA is a valuable component of their water system in general and, as we were to find, the ASR project in particular. The PUD purchased a SCADA system in 2007 to automate the routine functions of their water supply system. Rockwell Automation supplied the various SCADA components through a Portland, Oregon vendor who performed the installation and provides ongoing maintenance and support.

Components

The design of McNulty's SCADA is typical and consists of:

- Sensors at the various wellheads, pumps, and reservoirs to measure water levels, pressures, flow rates, and totals
- Remote terminal units (RTU's) to collect and send the sensor data to the central computer
- Telemetry, either wire or wireless, to communicate with the remote units
- The main SCADA computer terminal, sometimes referred to as a "human-machine interface" or HMI, located in McNulty's office
- Operating software that provides: system programming, system monitoring and control, and database management

Operation



SCADA Primarily for the System Operator

The SCADA's primary job is to operate the system as the operator has programmed. The current state of the system is always available on the HMI terminal using a combination of text and graphics on various screens. Figure 4 shows one of the SCADA screens. Well graphics show real-time water levels. Pump symbols animate when pumps are active. Switches can be clicked on or off as desired to operate remotely from the main computer. Displays of alarms are available. It is intended that an operator need only glance at the computer screen or call up a graph to know current conditions and whether the system is operating as it should. Remote access via the Internet is an option. John Borden and I formerly monitored the functions of the ASR project from afar, thereby reducing the frequency of site visits. We could log on and view the various real-time information screens. We also could perform trend graphing to see water levels for selected time spans.

ASR

Data Mining

Hydrologic History

Analytical Tools

Back-Flushing

Specific Capacity (SC)

Database History

Pumping Duration

Big Data Analytics for the Engineer and Geologist

Unlike system operators, engineers and geologists have different needs. Their work often involves poring thorough historical data to assess long-term trends, analyze past performance, and evaluate subtle relationships to discover unexpected correlations. That activity used to be called data mining; however, the current buzz-phrase is Big Data Analytics.

If there are insights to be gained by data mining, the SCADA database easily qualifies as a valuable source of information. The SCADA polls it's sensors at rates up to six times a minute and records every measurement or reading in daily files along with time stamps accurate to the millisecond. Daily files may contain 8000 or more records and with 50 tags (sensors, totalizers, etc.) monitored, one day's file may contain 400,000 separate measurements.

By mid-point in the ASR project the hard drive in the McNulty HMI computer contained almost a billion measurements. Where, as here, a physical characterization of the ASR aquifer was deemed too expensive, a thorough analysis of the hydrologic history of the Robinette using the historical SCADA information was certainly a feasible and economic option.

The limited reporting capabilities supplied with the typical SCADA system are intended for operations, not data mining. A common complaint is that the SCADA operating software offers few, if any, of the types of analytical tools that engineers and/or geologists use. While it is possible to create specialized programs with the scripting capabilities inherent in the SCADA operating software, it is a difficult way to create and test code because it is a process that requires a site visit and time at the terminal keyboard to program and debug changes. The usual solution is to purchase a user-friendly reporting software package from a third-party that can read the historical database and either provide the answer, or write the data to a csv (comma separated values) file able to be imported into a spreadsheet for further processing. Unfortunately, McNulty didn't have a reporting package.

The Plugging Problem

During Testing Cycle 3 in 2012, the Robinette well unexpectedly experienced plugging during injection. Back-flushing the well with the higher discharge pumping rate for two weeks cleared the screen and we realized that periodic back-flushing during the entire injection cycle was necessary to keep the screen clean. I decided to calculate the **s**pecific **c**apacity (SC) of the well throughout its history to see what it was shortly after drilling, how it changed with time, and how it was affected by injection.

A well's SC is the industry standard measure of efficiency and is calculated by dividing the pumping rate by the drawdown. Because the SCADA records water levels and pumping rates with an accurate time hack, every pumping event saved in the SCADA database was an opportunity to calculate the well efficiency.

I created a complete duplicate of the SCADA database to store on my office computer. I used the computer programming language PERL (Practical Extraction and Reporting Language) to create programs for the direct reading of the historical database. PERL is an old language created in 1987 by Larry Wall, but remains valuable even today for its flexibility and power and is routinely used for data mining and statistical analysis in large part because of its **reg**ular **ex**pression (regex) engine. It isn't as sexy as newer, similar programs such as Python, but I am familiar with it and used it in the past for database work. Being free from having to be at the site or logged onto the system, the trial and error associated with programming was done at leisure and resulted in creation of a wide array of specialized analytical tools not available with the SCADA or even third-party reporting products. Once I could read the database its history was open for any value or group of values to be extracted and utilized.

For determining specific capacity, literature suggests a well should be pumped continuously for at least 24 hours; however, in a working water supply well long-term pumping is rare and maximum use of shorter-term pumping events must be used. Where comparisons are to be made for the same well, each SC needs to be calculated at the same time after pumping starts — a time long enough that the drawdown is established but short enough to include as many pumping events as possible. The calculated SC will be somewhat higher than that derived in 24 hours but it will be consistently higher and therefore useable. Using the off-site database, I wrote a program to perform sensitivity analyses on specific capacity calculations for years of Robinette historical data to determine the shortest pumping duration that generates a reliable SC. (The shortest pumping time used for the Robinette is 33 minutes. The geologists among the readers may think that is way too short and that the drawdown must still be developing. However, the Robinette's drawdown and recovery curves are almost square waves and 33 minutes is more than adequate.) Another program used the 33-minute time to identify every qualifying Robinette pumping event in the historical database and generate a SC for that event.

ASR

Discharge Efficiency Assessments

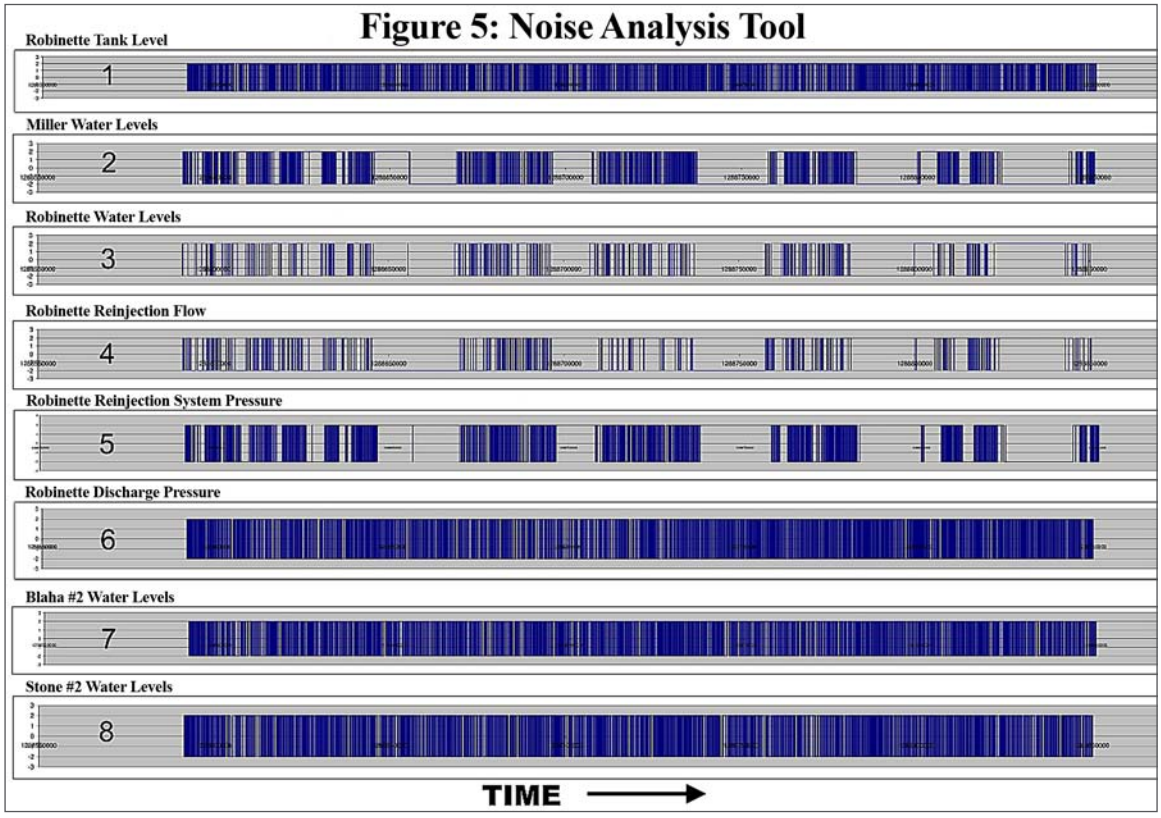
The highest SC was 6.4 gpm/fts (**g**allons **p**er **m**inute per foot of drawdown.) Just prior to plugging the SC had declined to 2.7 gpm/fts and the two weeks of discharge pumping had improved SC to 3.5 gpm/fts. Graphing the values for SC against both injection and discharge pumping established the relationship between the SC and the type and frequency of pumping. From these analyses we could schedule just enough discharge pumping during injection to maintain well efficiency while maximizing injection. The plugging problem was solved. More importantly, this tool was used constantly through the remainder of the project because every pumping event became an opportunity to quantitatively assess the efficiency of the well.

Dropped Data Question

Noise Analysis: Another Tool

Another one-time but useful tool was a noise analysis program I wrote to help shed light on dropped data. Some tags associated with the ASR project were not being updated regularly and hours could go by before a new measurement made it to the SCADA. We weren't sure if the sensors were faulty or there was a problem in the telemetry. I knew that even if the physical property being measured is unchanged, like a stagnant water level, noise in the sensor loop always changes the polled value ever so slightly. Data are recorded to the 8th decimal place and noise always changed the values past the 5th or 6th decimal place. So, if there is absolutely no change in the SCADA reading for a sensor — not even the slight changes due to noise — it doesn't mean that the data are unchanged, rather that the changes are not getting through. Figure 5 shows eight bar graphs for tags in the suspected area of the problem. The time span is 72 hours. A vertical line is drawn on each bar at the exact time a tag value changes in the SCADA. Tags 1, 6, 7, and 8 are normal, displaying a dense pattern caused by constant sensor changes and noise. However, tags 2, 3, 4, and 5 are not only intermittent but the lapses all occur at roughly the same time. The graphs suggested that the sensors were fine and pointed rather to some sort of telemetry failure common to the four intermittent tags — a clue that helped the vendor to isolate and fix.

Figure 5: Noise Analysis Tool



Historical Data Issue

Beware Software Upgrades

Near the end of the ASR project, the Portland SCADA vendor recommended updating to a new Rockwell operating software package. The decision made sense for system operations but caused severe unintended consequences. The new software seamlessly handled the operational functions of the SCADA (as one would expect), but could not read the older database files. The new software saved historical data in a new proprietary format that was incompatible with the previous format. Suddenly seven years of archived historical data files were now "officially" unreadable. We were astonished that Rockwell would

field an update knowing that it was not backwardly compatible, and frustrated at their policy at making the new database format proprietary. Collateral damage included the new third-party reporting package recently purchased for their staff by the PUD that was now almost useless because it was unable to read the new historical format.

There are always work-arounds for every problem and the SCADA vendor did so by creating two separate historical databases; one using the old format and one using the new. My part in the project was ending but I still had some work products to deliver that required extracting data from daily files created with the new software. I wondered if I could adapt my programs so I examined the new format. It is definitely unique and I can't conceive of why Rockwell took that approach but a half hour's work with a hex editor and PERL and I was able to decipher the encoding so my work continued as if nothing had changed.

Conclusions

The use of underground storage for drinking water is becoming more common in the United States but small and medium water supply systems that may benefit from underground storage have avoided ASR due to cost concerns. The McNulty PUD achieved the reuse of a problematic well and gained six times the water storage capability that they originally desired at a fraction of the cost. This project demonstrates that the benefits of ASR can be an affordable alternative to above-ground storage tanks for small as well as large sized water supply districts.

A few days ago I talked to the engineer who is managing McNulty's water system. He said they experienced a significant power failure just before Christmas that knocked-out the control panels at several of the other system wells. Yet they were able to sustain their system for about a week drawing water from the ASR — a great demonstration of the value of this asset. It doesn't get any better than that.

For Additional Information:
Bob Mansfield, Buffalo Geological Consulting, 800/ 710-2833 or buffalo@buffalogeo.com

Bob Mansfield is the owner and principal consultant of Buffalo Geological Consulting. He has 40 years of experience in the dual disciplines of hydrogeology and petroleum exploration with expertise in the nature and dynamics of earth fluids: water, oil, and gas. Mr. Mansfield has a degree in Geological Sciences from the University of Buffalo, Buffalo, New York; is a registered geologist in California, Oregon and Washington; a member of various professional societies; and the recipient of a "Best Speaker" award at the Houston Geotech Convention.

WATER BRIEFS

CLEAN WATER ACT SCOPE US JURISDICTIONAL DETERMINATION

On May 31, the US Supreme Court (Court) unanimously ruled that landowners and developers can challenge a determination from the US Army Corps of Engineers (Corps) that federal Clean Water Act (CWA) protections apply, by filing an appeal of the determination in the federal court system. The Court ruled that the Corps' "jurisdictional determination" may be appealed immediately under the Administrative Procedure Act as a "final agency action" — instead of waiting until the entire CWA permitting process is complete or proceeding without a permit and arguing in an enforcement action that a permit was not required. *USACE v. Hawkes Co., Inc.*, 578 U.S. ___ (2016).

The Water Report will report on this case in further detail as part of a Clean Water Act update to be published in our July 15th issue.

For info: Decision available at: www.supremecourt.gov/opinions/15pdf/15-290_6k37.pdf

DROUGHT ENFORCEMENT CA DISMISSALS PROPOSED

In a dramatic turnaround, the California State Water Resources Control Board (State Water Board) issued a draft order on May 26 dismissing the administrative civil liability complaint against Byron-Bethany Irrigation District (BBID) and dismissing the draft cease and desist order against the West Side Irrigation District (WSID). "The actions brought by the State Water Resources Control Board's (State Water Board or Board) Division of Water Rights (Division) Prosecution Team (Prosecution Team) sought to impose enforcement orders against BBID and WSID for the allegedly unauthorized diversion of water from the southern portion of the Sacramento-San Joaquin Delta during the summer of 2015." After reviewing the evidence before it, the State Water Board decided to "decline to issue the proposed orders." Draft Order WR 2016 at 1.

The drought enforcement actions by the State Water Board previously resulted in substantial attention since the complaint against BBID proposed a penalty of over $1.5 million. BBID and WSID requested that their enforcement proceedings be consolidated and the hearing officers consolidated the portions of the hearings to address the availability of water for diversion under BBID and WSID's claims of right during the relevant time periods. The evidentiary hearing began on March 21.

A threshold issue of the State Water Board's authority to impose a penalty for illegal water use was addressed in the Draft Order. After discussing recent legislation and case law regarding its authority, the State Water Board concluded that "the Board is authorized to impose penalties pursuant to Water Code section 1052 when a diversion is made when water is unavailable under the priority of the diverter's claimed right. We see no relevant distinction between the Board's authority to prevent the diversion of water that is not authorized because it is in excess of the quantity, place of use, or purpose of use of a diverter's right, and a diversion that is not authorized because water is not available under a diverter's priority of right. Any of these diversions is outside of the scope of the water right." *Id*. at 9-10. The detailed discussion of the agency's authority is worth reading for anyone involved with enforcement issues (*see id*. at 5-11). "We conclude that the Board has the authority to take enforcement action pursuant to Water Code section 1052 against the unauthorized diversion of water under claim of a pre-1914 water right. The allegations in the ACL Complaint against BBID state a legal basis on which the Board may act if the Board finds those allegations are supported by the weight of the evidence." *Id*. at 11.

The decision to dismiss the civil liability complaint against BBID, and the cease and desist order against WSID, was based on the factual finding by the State Water Board that the Prosecution Team failed to carry its burden of proof on the question of water availability. "The Prosecution Team bears the burden of proof in an enforcement proceeding. To prove its case, the Prosecution Team must demonstrate by a preponderance of the evidence the existence of each fact that is essential to the cause of action. (Evid. Code, § 500.)" *Id*. The evidentiary portion of the enforcement proceeding was closed after the Prosecution Team presented its case.

"The burden of proof rests on the Prosecution Team to demonstrate by a preponderance of the evidence that water was unavailable to serve the priorities of right claimed by BBID and WSID." *Id*. at 12. Ultimately, the State Water Board found that "inconsistencies in the water availability analysis that the witnesses could not adequately explain preclude us from finding that the Prosecution Team has carried its burden of proof." *Id*. at 14. The Draft Order lays out the weaknesses in the evidence presented in detail and noted that, "[C]umulatively, these discrepancies appear to be significant." *Id*. at 15. "Without adequate testimony to explain and support the manner in which the water availability analysis was constructed and used, and given the potential magnitude of the discrepancies in the water availability analyses on which the Prosecution Team based its case, we are unable to find that the Prosecution Team has carried its burden of proof." *Id*. at 16.

The decision is a draft order and must be approved by the full State Water Board at its June 7th meeting.

For info: Draft Order available at: http://somachlaw.com/wp-content/uploads/2016/05/5-26-16-Draft-Order.pdf

DROUGHT REGULATIONS CA "STRESS TEST" APPROACH

Following a winter that provided some relief, the State Water Resources Control Board (State Water Board) is replacing the prior percentage reduction-based water conservation standard with a localized "stress test" approach that mandates urban water suppliers act now to ensure at least a three year supply of water to their customers under drought conditions.

Recognizing persistent yet less severe drought conditions throughout California, the emergency regulation (adopted May 18th) will replace the February 2nd emergency water conservation regulation that set specific water conservation benchmarks at the state level for each urban water supplier. The new regulation, in effect through January 2017, requires locally developed conservation standards

WATER BRIEFS

based upon each agency's specific circumstances. These standards require local water agencies to ensure a three-year supply assuming three more dry years like the ones the state experienced from 2012 to 2015. Water agencies that would face shortages under three additional dry years will be required to meet a conservation standard equal to the amount of shortage. For example, if a water agency projects it would have a 10% supply shortfall, their mandatory conservation standard would be 10%.

All of the projections and calculations used to determine the new conservation standards will be disclosed publicly. They will include information provided by regional water distribution agencies (wholesale suppliers) about how regional supplies (including imported water, recycled water, groundwater, stormwater, and desalinated water) would fare during three additional dry years. The regulation requires urban water suppliers to continue their monthly conservation reporting.

The adopted regulation also keeps in place specific prohibitions against certain water uses. Those prohibitions include watering down a sidewalk with a hose instead of using a broom or a brush, or overwatering a landscape to where water is running off the lawn, over a sidewalk and into the gutter. Prohibitions directed to the hospitality industry also remain in place. Prohibitions against homeowners associations taking action against homeowners during a declared drought remain as well.

For info: State Water Board website at: www.swrcb.ca.gov/

TRIBAL WATER LEASE ID

GROUNDWATER/STORAGE

On May 6, the Shoshone-Bannock Tribal Council formally ratified a landmark water lease agreement with the Idaho Ground Water Appropriators (IGWA) to lease 45,000 acre-feet of water. The lease helps to settle a longstanding feud between surface water and groundwater right owners in the Upper Snake River Basin of Idaho. Following a decade of litigation and conflict, the Surface Water Coalition, representing senior priority surface water rights, signed a 2015 settlement agreement with IGWA, which represents eight large groundwater districts in southern Idaho. The lease between the Shoshone-Bannock Tribes (Tribes) and IGWA has a term of five years, with a two-year extension. Financial terms were not disclosed. The Shoshone-Bannock Tribes are located on the Fort Hall Reservation in Southeastern Idaho, between the cities of Pocatello, American Falls, and Blackfoot.

The settlement agreement requires mandatory reductions in groundwater use as well as an obligation to provide additional streamflow in the Snake River for mitigating the effects of IGWA's groundwater use. The Tribes will be providing the bulk of this streamflow mitigation obligation through dedicated water releases from its storage rights in American Falls and Palisades reservoirs. Since 1998, the Tribes have developed and operated an active water marketing program which has provided water for instream flows, hydropower, and now mitigation as benefits to Idaho and its water users. Elese Teton, Director of the Tribal Water Resources Department, said that "the Tribes are pleased to finalize this lease agreement with IGWA and to utilize the Tribal Water Bank to help implement solutions to one of the most important water conflicts facing the Upper Snake River Basin." WestWater Research provides ongoing consulting and advisory services to the Tribes in managing the water marketing program.

The Water Report plans to publish an extended article detailing this lease and tribal water marketing in a later issue. The Shoshone-Bannock Tribal Water Resources Department is hosting a workshop on tribal water rights and water marketing on August 11th in Fort Hall, Idaho (see *TWR* Calendar).

For info: Tribes website at: www.shoshonebannocktribes.com/shoshone-bannock-water-resources.html; WestWater Research website at: www.waterexchange.com/

STOCK POND SETTLEMENT WY

EPA & LANDOWNERS SETTLE SUIT

In a Consent Decree filed on May 9th, EPA and Andy Johnson (plaintiff) agreed to settle a long-running battle over a dam and stock pond constructed by Johnson on his land in Uinta County, Wyoming. The federal government had ordered Johnson to remove the pond. Potential fines under the federal Clean Water Act (CWA) of $37,500 per day were also at stake. EPA and Johnson arrived at the settlement to dismiss the case, with the only requirement being that Johnson will provide mitigation by planting willows around the pond and temporarily fencing off part of it from livestock. Appendix A of Consent Decree, *Johnson vs. EPA,* Case No. 2:15-cv-00147-SWS (May 9, 2016). Under the terms of the settlement, Johnson's pond will remain; no fines will be paid; Johnson didn't concede to federal jurisdiction to regulate their pond; and the government won't pursue any further enforcement actions based on the pond's construction. Each party to the Consent Decree is to bear its own costs, attorneys' fees and expenses that were incurred.

Johnson's saga began in 2013, when he dammed a small creek that runs across his eight-acre property and built a stock pond to provide access to water for his small livestock herd, pursuant to a permit issued by the Wyoming State Engineer's Office. *Complaint* at 5. The federal government asserted that Johnson's actions violated the CWA because he had not obtained a permit from the Army Corps of Engineers to build the stock pond. EPA's compliance order demanded that he take out the pond, restore the property to its prior condition pursuant to a federally approved restoration and mitigation plan, and threatened him with fines of $37,500 per day if he did not comply. Ultimately, Johnson sued EPA, represented by the Pacific Legal Foundation (PLF) and local counsel, arguing that the order was illegal because "stock ponds" are expressly exempt from the CWA. "This work was exempt from the Clean Water Act, pursuant to its exemption for the 'construction or maintenance of farm or stock ponds.' 33 U.S.C. § 1344(f)(1)(C)." *Complaint*, page 1.

Johnson also challenged EPA's assertion of jurisdiction. Under US Supreme Court precedent, the federal government can regulate waters only if they have a "significant nexus" to navigable waters. *See Rapanos v. United States*, 547 U.S. 715 (2006).

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The Complaint described Johnson's system at page 5: "A small perennial stream segment called Six Mile Creek crosses the property…The water that runs through this stream is return flow from agricultural runoff. Previously, the site along this stream contained neither adjacent wetlands, riparian vegetation, nor any significant wildlife or fisheries habitat. The creek ultimately empties into a controlled irrigation canal and reservoir, and the water is diverted for agricultural use."

Under the settlement, however, the underlying issues of the lawsuit were not decided. "Nothing in this Consent Decree shall constitute an admission of wrongdoing or the concession of any fact or question of law by any party." *Consent Decree* at 4.

For info: Consent Decree available from TWR upon request; Johnson's Complaint at: www.pacificlegal.org/document.doc?id=2036

STORMWATER RUNOFF US

INFRASTRUCTURE RESEARCH

On May 4, EPA announced $3.9 million in funding to two institutions to research innovative, cost-effective technologies to manage stormwater runoff and combined sewer overflows. Colorado School of Mines received $1.95 million to develop a decision support tool to help communities evaluate alternative stormwater treatment technologies that consider diverse climates, regional practices, and policies across the country. The tool will evaluate options and risks as well as life cycle costs associated with improving stormwater runoff management using green, gray, and hybrid infrastructure. Colorado School of Mines will also create resources and hold workshops to conduct training sessions for these tools. The Water Environment Research Foundation in Alexandria, Virginia also received $1.9 million to develop a life cycle cost and analysis framework, a publicly accessible tool and database, and a guide for decision makers that includes case studies.

The awardees will focus on the most cost-effective options like green infrastructure — practices that enhance natural ecological functions, such as growing gardens on roofs or building artificial ponds — to help manage stormwater and combined sewer overflows. Green infrastructure can replenish groundwater, provide flood control, add green spaces and parks, and revitalize neighborhoods.

For info: Cathy Milbourn, EPA, 202-564-7849, milbourn.cathy@epa.gov or www.epa.gov/research-grants/water-research-grants

WATER TRANSFERS CA

ACCESS TO WATER MARKETS

On May 9, The Association of California Water Agencies (ACWA) released "*Recommendations for Improving Water Transfers and Access to Water Markets in California*." The report presents a suite of recommendations for improving the transfer process and access to the voluntary water market, especially for smaller water agencies. ACWA called voluntary water transfers a vital management tool that will be increasingly valuable in the future as market-oriented solutions provide a valuable part of the water management strategy for California.

Enhancing the voluntary water market is a key priority for ACWA and other organizations this year. ACWA is actively engaged in discussions with stakeholders, the Brown Administration, the California Legislature, and the appropriate state and federal agencies, including the California Department of Water Resources.

ACWA's recommendations were developed by a Water Market Technical Advisory Committee that included ACWA member agency representatives with special expertise in water transfers and representatives from the Public Policy Institute of California and the Environmental Defense Fund. The recommendations note that improving the transfer process and enhancing access to the market would have several benefits, including: Helping to protect existing local and regional investments in drought-resilient strategies; Improving coordination among water agencies; Incentivizing significant investments in water use efficiency projects and programs; Increasing water supply reliability for urban and agricultural water users; Increasing the quantity or improving the timing of water available for transfers by providing information to buyers and sellers who might not otherwise have sufficient information to participate in water markets; and Enhancing the state's water supplies and potentially increasing the amount or improving the timing of water available for environmental uses.

For info: ACWA Report: www.acwa.com/sites/default/files/post/regulatory-affairs/2016/04/acwa-water-transfers-and-markets-recommendations_april-2016.pdf

TEXAS WATER PLAN TX

MANAGEMENT STRATEGIES

On May 19, the Texas Commission on Environmental Quality adopted the 2017 State Water Plan. To ensure the ongoing vitality of its economy, Texas' citizens, water experts, and government agencies collaborate in a comprehensive water planning process. They plan so that Texans will have enough water in the future to sustain its cities and rural communities, farms and ranches, and homes and businesses while also preserving the agricultural and natural resources that have defined Texas for generations. The 2017 State Water Plan notes that Texas' population will continue its rapid growth. The plan also provides a roadmap for how to address the water needs that accompany that growth by identifying water management strategies and their associated costs for communities all across the state. The information in this plan is critical to ensuring that Texas has adequate and affordable water supplies both now and in the future.

Texas' state water plans are based on future conditions that would exist in the event of a recurrence of the worst recorded drought in Texas' history — known as the "drought of record" — a time when, generally, water supplies are lowest and water demands are highest. Texas' population is expected to increase more than 70% between 2020 and 2070, from 29.5 million to 51 million. Water demands are projected to increase less significantly, by approximately 17% between 2020 and 2070, from 18.4 million to 21.6 million acre-feet per year.

Texas' existing water supplies — those that can already be relied on in the event of drought — are expected to

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decline by approximately 11% between 2020 and 2070, from 15.2 million to 13.6 million acre-feet per year. Water user groups face a potential water shortage of 4.8 million acre-feet per year in 2020 and 8.9 million acre-feet per year in 2070 in drought of record conditions.

Approximately 5,500 water management strategies recommended in this plan would provide 3.4 million acre-feet per year in additional water supplies to water user groups in 2020 and 8.5 million acre-feet per year in 2070. The estimated capital cost to design, construct, and implement the approximately 2,400 recommended water management strategy projects by 2070 is $62.6 billion. If strategies are not implemented, approximately one-third of Texas' population would have less than half the municipal water supplies they will require during a drought of record in 2070.

If Texas does not implement the state water plan, estimated annual economic losses resulting from water shortages would range from approximately $73 billion in 2020 to $151 billion in 2070. Through the SWIFT and other financial assistance programs, the TWDB has provided $1.9 billion in financial assistance to approximately 60 state water plan projects recommended in the 2012 State Water Plan.

For info: Texas State Water Plan at: www.twdb.texas.gov/waterplanning/swp/2017/index.asp

TREATMENT AS STATE US CWA TRIBAL REGULATION

Section 518 of the Clean Water Act (CWA) authorizes EPA to treat eligible Indian tribes with reservations in a similar manner to states (TAS) for a variety of purposes, including administering each of the principal CWA regulatory programs and receiving grants under several CWA authorities. EPA's revised interpretation of CWA section 518, published on May 16, 2016, streamlines the process for applying for TAS for CWA regulatory programs, including the water quality standards program. This reinterpretation facilitates tribal involvement in the protection of reservation water quality as intended by Congress.

Since 1991, EPA has followed a cautious approach that requires applicant tribes to demonstrate inherent authority to regulate waters and activities on their reservations under principles of federal Indian common law. The agency has consistently stated that its approach was subject to change in the event of further congressional or judicial guidance addressing tribal authority under section 518 of the Clean Water Act.

Based on such guidance, and after considering public comments, EPA concludes definitively that section 518 includes an express delegation of authority by Congress to Indian tribes to administer regulatory programs over their entire reservations, subject to the eligibility requirements in section 518. This final interpretive rule will reduce burdens on applicants associated with the existing TAS process and has no significant cost.

For info: EPA website: www.epa.gov/wqs-tech/revised-interpretation-clean-water-act-tribal-provision

COLORADO'S SOURCE WEST GROUNDWATER CONTRIBUTION

According to a USGS report released on May 9, more than half of the streamflow in the Upper Colorado River Basin originates as groundwater. On average, 90% of streamflow in the Colorado River Basin originates in the Upper Basin, which is the area above Lees Ferry, Arizona. This water has a multitude of uses that include irrigation, municipal and industrial purposes, electric power generation, mining activities, recreation, and supporting habitat for livestock, fish and wildlife. The entire Colorado River Basin currently supports 50 million people, and that amount is expected to increase by 23 million between 2000 and 2030.

Scientists used a new method to more accurately estimate the percentage of groundwater that supports streamflow. Researchers studied long-term records of water chemistry and streamflow data at 146 sites in the Upper Colorado River Basin in Colorado, Utah, New Mexico and Arizona. These data were then analyzed to create a model to predict and map where streamflow originates in the basin. On average, 56% of the streamflow in the basin originated from groundwater.

"These findings could help decision makers effectively manage current and future water resources in the Colorado River Basin," said Matthew Miller, a USGS scientist and lead author of the study. "In light of recent droughts, predicted climate changes and human consumption, there is an urgent need for us all to continue to think of groundwater and surface water as a single resource."

The model estimates the amount of water lost during stream transport to the Lower Colorado River Basin, which is due largely to withdrawals for irrigation and evaporation to the atmosphere. In the high elevation headwaters of the Colorado River Basin, there is a greater percentage of snowmelt and precipitation contributing to the surface water streamflow. As water flows further into the basin at lower elevations, a greater percentage of streamflow is from groundwater.

Water data were analyzed using the USGS Spatially Referenced Regressions On Watershed attributes (SPARROW) water-quality modeling framework. Information on SPARROW modeling applications, data, and documentation can be accessed online. The USGS study was published in the journal Water Resources Research. Matthew P. Miller, Susan G. Buto, David D. Susong, Christine A. Rumsey. *The importance of base flow in sustaining surface water flow in the Upper Colorado River Basin*. Water Resources Research, 2016; DOI: 10.1002/2015WR017963

For info: Matthew Miller, 801-908-5065, mamiller@usgs.gov or www.usgs.gov/news/news-releases

TRIBAL FISHING RIGHTS WA COAL TERMINAL REJECTED

On May 9, Seattle District Commander Col. John Buck of the US Army Corps of Engineers (Corps) issued a decision determining that the potential impacts to the Lummi Nation's (Lummi) usual and accustomed (U&A) fishing rights from the proposed Gateway Pacific Terminal (GPT) at Cherry Point, Washington, are greater than de minimis. Because the Corps' Seattle District determined the effects to the Lummi's rights are

more than de minimis and because the Lummi maintain their objections to this proposal, the project cannot be permitted by the Corps.

In 2015, the Seattle District received a request from the Lum mi Nation for the Corps to deny a Section 404/10 permit application requested for the GPT Project proposed by Pacific International Holdings, LLC (PIH). The Lummi cited impacts to their usual and accustomed treaty rights and included affidavits about their fishing practices and statements about potential impacts from the construction and operation of the terminal. The Lummi Nation signed the Treaty of Point Elliot in 1855, which established the Suquamish Port Madison, Tulalip, Swinomish, and Lummi reservations and guaranteed fishing rights in perpetuity at each tribes' Usual and Accustomed (U&A) fishing areas. The GPT project area for a deep-water marine terminal is included in the Lummi Nations U&A fishing area.

"I have thoroughly reviewed thousands of pages of submittals from the Lummi Nation and Pacific International Holdings," said Col. Buck. "I have also reviewed my staff's determination that the Gateway Pacific Terminal would have a greater than de minimis impact on the Lummi Nation's U&A rights, and I have determined the project is not permittable as currently proposed." Both the Lummi Nation and Pacific International Holdings, LLC, provided voluminous information regarding fishing practices, potential impacts, and mitigation to support their positions. The district's evaluation of effects of the proposal on the Lummi's U&A fishing rights is undertaken to fulfill the federal government's responsibility to protect treaty rights. The Corps may not permit a project that abrogates treaty rights. Corps' Press Release, May 9, 2016.

The Memorandum for Record (*Memorandum*) also detailed the extent of the Lummi Nation's U&A treaty right to include access. "Thus the de minimis review, whether the impacts rise to the level of legal significance, applies to both Lummi's U&A treaty right to access as well as their right to take fish. If the impact to either is greater than de minimis, in other words the impact is legally significant, the Corps would be required to deny the permit because only Congress can abrogate a treaty right." *Memorandum* at 20.

Near the end of the *Memorandum*, the decision discussed mitigation efforts proposed by PIH to minimize the impacts on the Lummi Nation. "Based upon the foregoing, there remains (sic) impacts to the Lummi's exercise of fishing rights that I consider to be greater than de minimis. While the Corps can and did consider avoidance and minimization measures as factors in whether the impacts are greater than de minimis, the Corps determined the proposed mitigation does not reduce the impacts to the Lummi U&A treaty fishing right to a de minimis amount. Furthermore, this proposed regulation on the time and manner of fishing at the U&A fishing ground is an impairment or limitation that is only appropriate by an act of Congress or for the conservation of the fishery resource. Additionally, should herring fishing return to the area, it too would be impacted in a greater than a de minimis manner restricting as noted above." *Memorandum* at 31.

Finally, the *Memorandum* summarized its Determination at pages 31-32: "The work proposed in this application has been analyzed with respect to its effects on the treaty rights described above. Based upon the facts and findings, the Corps' determination is that the proposed overwater structure would have greater than a de minimis impact on the Lummi Tribe's access to its usual and accustomed fishing grounds for harvesting fish and shellfish. Each of the following impacts resulting from the construction of the GPT facility would violate the Lummi's U&A treaty fishing rights by: 1. Impairing and eliminating part of their U&A treaty fishing and crabbing area (with or without the herring); 2. Impairing and eliminating the time and manner in which the Tribe can fish in their U&A; and 3. Impairing and eliminating potential future herring fishing at the site."

If in the future the Lummi Nation withdraws its objections to the proposal, the proponent could reinitiate processing of the application. A number of other tribes have expressed concern about effects of the proposal on their treaty rights, so if processing of the application resumes, consultation with those tribes would occur as needed to collect information and make decisions with respect to effects of the proposal on their rights. Corps' Press Release, *supra*. Given the Lummi Nation's consistent opposition to the project, it appears very unlikely that such a withdrawal would occur.

For info: Corps' Memorandum of Record & other Project information at Ecology website: www.ecy.wa.gov/geographic/gatewaypacific/

NPDES REGS **US**

EPA PROPOSES UPDATES COMMENT PERIOD OPEN

On May 18, EPA proposed revisions to the National Pollutant Discharge Elimination System (NPDES) regulations that would make specific targeted changes to the existing regulations and would not reopen them for other specific or comprehensive revision. EPA is seeking comment on proposed changes that include: eliminating regulatory and application form inconsistencies; improving permit documentation, transparency and oversight; clarifying existing regulations; and deleting outdated provisions.

EPA is also asking for public comment on potential ways to enhance public notice and participation in the permitting process.

With these proposed revisions and requests for public comment, EPA aims to clarify who is regulated; more clearly identify applicable requirements for compliance; and improve transparency by providing permitting authorities and the public with improved information about NPDES permitted dischargers. The public comment period for the proposed NPDES Updates Rule will be open until July 18.

For info: www.epa.gov/npdes/npdes-application-and-program-updates.

CALENDAR

June 15 TX
Dam Safety Workshop, Luling. Zedler Mill, 1170 S. Laurel Avenue, 8am-2pm. Presented by TCEQ. For info: Natalie Myhra, 512/ 239-3143 or events@tceq.texas.gov

June 15-17 CA
Bay-Delta Tour 2016, Bay Delta. Sacramento-San Joaquin Delta. For info: www.watereducation.org/general-tours

June 16 WA
Water Rights in Central Washington: Self-Assessment & Acquisition, Wenatchee. Coast Wenatchee Center Hotel. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

June 16 DC & WEB
NEPA, ESA & Fundamentals of Environmental Law Course, Washington. Environmental Law Institute, 1730 M Street NW, Ste. 700. For info: http://www.eli.org/events/

June 16 OR
Oregon's Integrated Water Resources Strategy Open House, Salem. ODFW Headquarters, 4034 Fairview Industrial Drive SE, 5:30-7pm. Hosted by Oregon Natural Resource Agencies (WRD, DEQ, DFW and Dept. of Ag). For info: www.oregon.gov/owrd/LAW/docs/IWRS/2016_06_Open%20_House_Flyer.pdf

June 19-22 IL
ACE16 - Innovation: Making Connections & Overcoming Barriers - American Water Works Association Annual Conference and Exposition, Chicago. McCormick Place. For info: www.awwa.org/conferences-education/conferences/annual-conference.aspx

June 20 CA
Tribes and CEQA Seminar: New Rules for Tribal Consultation Under AB 52, Cabazon. Morongo Casino Resort. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

June 20 OR
Oregon's Integrated Water Resources Strategy Open House, Newport. Best Western Agate Beach Inn, 3019 N. Coast Hwy., 5:30-7pm. Hosted by Oregon Natural Resource Agencies (WRD, DEQ, DFW and Dept. of Ag). For info: www.oregon.gov/owrd/LAW/docs/IWRS/2016_06_Open%20_House_Flyer.pdf

June 22 TX
Dam Safety Workshop, Lufkin. Pitser Garrison Convention Ctr., 8am-2pm. Presented by TCEQ. For info: Natalie Myhra, 512/ 239-3143 or events@tceq.texas.gov

June 22 OR
Oregon's Integrated Water Resources Strategy Open House, Medford. Medford Public Library, 205 S. Central Ave., 5:30-7pm. Hosted by Oregon Natural Resource Agencies (WRD, DEQ, DFW and Dept. of Ag). For info: www.oregon.gov/owrd/LAW/docs/IWRS/2016_06_Open%20_House_Flyer.pdf

June 23 OR
Oregon's Integrated Water Resources Strategy Open House, Bend. Riverbend Community Room, 799 SW Columbia Street., 5:30-7pm. Hosted by Oregon Natural Resource Agencies (WRD, DEQ, DFW and Dept. of Ag). For info: www.oregon.gov/owrd/LAW/docs/IWRS/2016_06_Open%20_House_Flyer.pdf

June 28-30 CA
Toward Sustainable Groundwater in Agriculture: 2nd International Conference Linking Science and Policy, Burlingame. Hyatt Regency S.F. Airport. Presented by Water Education Foundation & UC Davis Robert M. Hagan Endowed Chair. For info: http://www.watereducation.org/internationalgroundwater2016

June 29 CA
Israel-California Water Conference, Marina del Rey. Ritz Carlton. For info: http://www.israeliwaterinnovation.com/

June 30 DC
Basics of the Clean Water Act Course, Washington. Environmental Law Institute, 1730 M Street NW, Ste. 700. For info: http://www.eli.org/events/

June 30 OR
Oregon's Integrated Water Resources Strategy Open House, Beaverton. Beaverton Community Center, 12350 SW Fifth Street. Hosted by Oregon Natural Resource Agencies (WRD, DEQ, DFW and Dept. of Ag). For info: www.oregon.gov/owrd/LAW/docs/IWRS/2016_06_Open%20_House_Flyer.pdf

July 8 CA
Using Deep Infiltration & Drywells for Groundwater Recharge Seminar, Sacramento. CalEPA Bldg., 1001 I Street, 10 am. RSVP. For info: Matthew Freese, 916/ 341-5485, mfreese@waterboards.ca.gv or www.waterboards.ca.gov/water_issues/programs/stormwater/storms/seminar_series.shtml

July 10-13 CO
Water Environment Federation (WEF) & International Water Association (IWA) Nutrient Removal and Recovery Conference, Denver. The Hyatt. Presented by Water Education Foundation. For info: http://www.awwa.org/conferences-education/conferences/sustainable-water-management.aspx

July 11-13 CA
2016 AWRA Summer Specialty Conference: GIS & Water Resources IX, Sacramento. Hilton Sacramento Arden West. Presented by American Water Resources Ass'n. For info: www.awra.org/meetings/Sacramento2016/

July 13-14 CO
Water Quality in the Distribution System, Denver. EUCI Offices. Presented by EUCI. For info: events@eucievents.com

July 13-15 ND
Western States Water Council Summer (181st) Council Meeting, Bismarck. Radisson Hotel. For info: http://www.westernstateswater.org/upcoming-meetings/

July 13 NM
Hydrology & the Law Seminar, Santa Fe. La Fonda Santa Fe Hotel. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

July 14-15 NM
Natural Resources Damages Seminar, Santa Fe. La Fonda Santa Fe Hotel. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

July 18-19 WA
Washington Water Law Seminar, Seattle. TBA. For info: Law Seminars Int'l, 800/ 854-8009, registrar@lawseminars.com or www.lawseminars.com

July 18-19 CO
Endangered Species Act, Wetlands, Stormwater & Floodplain Regulatory Compliance for Utilities, Denver. Hyatt Regency Denver Tech Center. Presented by EUCI. For info: events@eucievents.com

July 21 DC
Hazardous Waste & Sites Course, Washington. Environmental Law Institute, 1730 M Street NW, Ste. 700. For info: http://www.eli.org/events/

July 21-23 CA
Rocky Mt. Mineral Law Foundation 62nd Annual Institute, Squaw Valley. The Resort at Squaw Creek. For info: www.rmmlf.org

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

(continued from previous page)

July 22 HI

Hawaii Water Law, Honolulu. Hilton Waikiki Beach. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

July 28 WA

Pacific Northwest Environmental Summit - 1st Annual, Seattle. Washington Athletic Club. Presented by Environmental Business Int'l, 2020 Environmental Group, in association with the Northwest Environmental Business Council. For info: http://www.environmentalbusiness.org/#!pacific-northwest-summit/goucr

August 3 TX

Dam Safety Workshop, Denton. University of North Texas in University Union, 1155 Union Circle, 8am-2pm. Presented by TCEQ. For info: Natalie Myhra, 512/ 239-3143 or events@tceq.texas.gov

August 3-5 ID

Western Water Seminar, Sun Valley. Sun Valley Resort. Presented by National Water Resources Ass'n. For info: www.nwra.org/upcoming-conferences-workshops.html

August 11 ID

2016 Tribal Water Rights Workshop: Marketing of Water Rights to Create Tribal Benefits, Fort Hall. Sho Ban Hotel & Events Ctr. Hosted by the Shoshone-Bannock Tribal Water Resources Dept. For info: Elese Teton, Tribal Water Resources Dept., 208/ 239-4580 or www.waterexchange.com/tribal-water-rights-workshop/

August 11-12 AZ

Arizona Water Law Conference: "Statewide Water Planning", Scottsdale. Hilton Scottsdale Resort & Villas. For info: CLE Int'l, 800/ 873-7130 or www.cle.com

August 22-25 IN

Stormcon - 15th Annual Surface Water Quality Conference & Expo, Indianapolis. Indiana Convention Center. For info: www.stormcon.com/

August 24-26 CO

Colorado Water Congress Summer Conference, Steamboat Springs. Sheraton Steamboat Resort. For info: http://www.cowatercongress.org/summer-conference0.html

August 29-31 MN

International Low Impact Development Conference, Portland. Holiday Inn. Organized by Environmental & Water Resources Institute of the American Society of Civil Engineers - Urban Water Resources Research Council. For info: http://www.lidconference.org/about/