The Water Report™

Water Rights, Water Quality & Water Solutions in the West

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COLUMBIA BASIN PROJECT WATER AUTHORIZATIONS

WATER AUTHORIZATIONS AT THE LARGEST FEDERAL RECLAMATION PROJECT

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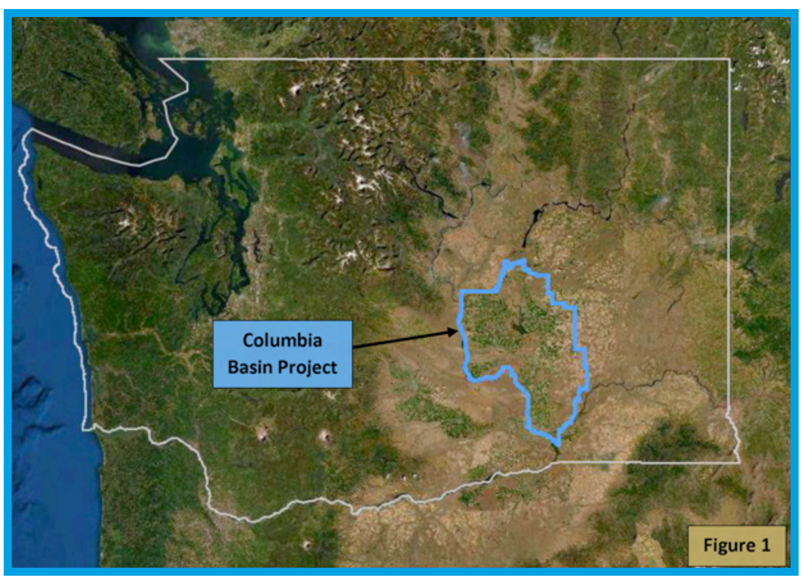
Introduction

The Columbia Basin Project (Project) is the largest federal reclamation project in the United States. The Project takes water from the Columbia River behind Grand Coulee Dam and distributes it, mainly for irrigation, over an approximately 2.5-million-acre area of arid land in central Washington State (Figure 1). The Project was designed, built, and is owned by the United States Bureau of Reclamation (Bureau). Prior to building the Project, the Bureau obtained water right permits under Washington State law. The Bureau distributes Project water through federal contracts to farmers, either directly or through three irrigation districts.

The region's soil and climate are good and the water supply is dependable. Combined with reliable Project infrastructure, these conditions create an optimal environment for irrigated agricultural.

While the farming is productive, the administrative and regulatory landscape is complex. There are multiple options for federal and state water authorizations with variable provisions and cost structures. Additionally, the Project is only about 65 percent developed. New authorizations, appropriations, and evaluations are being implemented to bring additional acreage into production.

This article presents an overview of Project water use authorizations to help interested parties navigate the regulatory and administrative requirements and better understand Project-specific vernacular.



Columbia Project Water

Grand Coulee Dam

Appropriation

Irrigation Infrastructure

Cost of Water

State Water Right

Storage Rights

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Columbia Basin Project Background

The Columbia is an immense river with average annual flows of about 175,000 **c**ubic **f**eet per **s**econd (cfs), as measured at the Dalles Dam. Completion of Grand Coulee Dam in 1942 harnessed the river for power and irrigation. The Columbia Basin Project Act of 1943 (Act) reauthorized the irrigation Project in accordance with Reclamation law (Reclamation Act of 1902 as amended). The Project was originally authorized by the Rivers and Harbors Act of 1935. The Act included authorization to build infrastructure to irrigate 1,029,000 acres in eastern Washington from water in Lake Roosevelt, behind Grand Coulee Dam. To meet the acreage authorization, the federal government initially claimed (i.e., withdrew) 3,158,000 acre-feet (acre-ft) of Columbia River water, making it unavailable for appropriation by others. The original withdrawal was subsequently authorized in multiple State-permitted and State-certificated water rights, with priority dates starting in 1938 for power-generation, irrigation, municipal, recreational, beautification, and commercial use.

Columbia River water is delivered to the Project area by irrigation infrastructure (Project works) built by the Bureau. The Bureau provides Project water to landowners through its contracts with the Quincy-Columbia Basin Irrigation District (QCBID), the East Columbia Basin Irrigation District (ECBID), and the South Columbia Basin Irrigation District (SCBID; districts). [*See* Columbia Basin Development League at: www.cbdl.org/about/our-partners/irrigation-districts/.]

The Bureau holds the water rights and owns the Project works but typically relies on the districts to contract with landowners within district boundaries. Farmers pay their district and the district, in turn, pays the Bureau according to the terms of a negotiated repayment contract or master water service contract. The cost of water is based on the subsidized (non-full) and non-subsidized (full) construction costs and estimated current-year **o**perations and **m**aintenance (O&M) costs of the Project works. While most categories of water are contracted through the districts, some are contracted directly between the Bureau and the landowner.

Bureau Water Rights

Columbia River water is a natural water of the State. To be put to beneficial use, a State water right is required. The Bureau withdrew Columbia River water from appropriation by others in 1938, in accordance with federal Reclamation Law. This withdrawal set water aside in preparation for construction of the Project. The federal withdrawal is recognized in State law under RCW (Revised Code of Washington) 90.40.100, *Columbia Basin Project – Water appropriated pursuant to RCW 90.40.030-Periodic Renewal not required.* The Bureau subsequently obtained State reservoir water rights for active storage in Lake Roosevelt of 6,400,000 acre-ft with a 1938 priority date (State certificate R3-*21869C) and a reservoir permit for dead storage of 3,162,000 acre-ft with a 1970 priority date (State certificate R3-*22472C).

Under the Washington State surface water code, RCW 90.03.370, a reservoir permit is required for impoundment and storage of water. That same statute requires that an entity apply for and receive a secondary use permit to put the stored water to beneficial use. The Bureau has obtained secondary use permits for four water rights totaling 3,318,000 acre-ft/year for irrigation of 720,000 acres (i.e., 69 percent of the total originally authorized Project acreage of 1,029,000 acres). *See* State certificate S3-01622C (590,000 acres) and State permits S3-28586 (50,000 acres), S3-30486 (10,000 acres), and S3-33091 (70,000 acres). Attributes of state irrigation water rights typically or often include an annual quantity in acre-ft/year and a total number of acres. The original two permits, S3-01622 for 590,000 acres and S3-28586 for 50,000 acres, have been built out and are close to full appropriation. That is, the water delivery infrastructure is complete and the water is being put to beneficial use. This combined total of 640,000 acres has been referred to as the first half of the Project. [Letter from James Cole, USBR Project Manager to Washington Department of Ecology dated December 23, 1986.]

The two other permits, with a combined total of 80,000 acres, were issued in 2008 and 2014 to develop the eastern portion of the Project under the currently designated project title of Odessa Groundwater Replacement Project (OGWRP). Amendment No. 1 to the Renewal Master Water Service Contract No. 159E101882. (October 11, 2019). The OGWRP generally represents the beginning of development of the long-awaited second half (i.e., the remaining acres) of the Project.

The secondary use permit concept is important with regard to Project completion. While the Bureau has withdrawn the necessary water and obtained reservoir permits to irrigate the full Project authorization of 1,029,000 acres, only 720,000 acres of this total has received a secondary use permit. Additional water use requires environmental review under the National Environmental Policy Act and State Environmental Policy Act before additional secondary use permits can be issued. The environmental review process has become more involved with time. Access to the remaining original authorized Project water likely lies

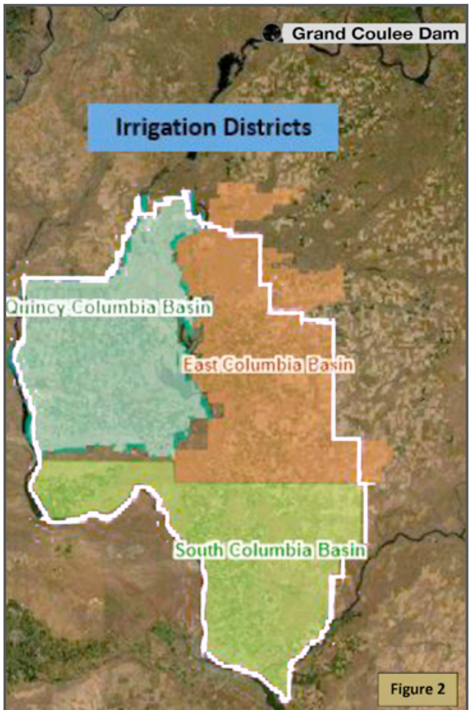


Figure 2

down a lengthy and complex path with a potentially uncertain outcome.

Irrigation Districts

Three irrigation districts (Figure 2) were formed around 1939 to support financing and payment of Project water. This process was formalized in the 1945 Repayment Contract between the Bureau and each of the districts. Note that the original Project boundary does not match the irrigation district boundaries due to recent acreage additions that expanded the ECBID boundary and therefore the Project boundary. When contracts were renegotiated in 1968, the Bureau transferred to the districts O&M responsibility for most of the Project facilities within their boundaries. Each district has its own Board of Directors, who represent geographical areas of their respective districts, and a staff of administrative, engineering, and watermaster personnel.

Project Infrastructure: Transmission and Storage

Project Works

Project infrastructure (or works) includes a series of dams, canals, wasteways, tunnels, and siphons to transmit and store water. The Bureau pumps water from Lake Roosevelt into Banks Lake, which is impounded by the North Dam and Dry Falls Dam. Banks Lake water flows through the Bacon siphons and tunnels to Billy Clapp Lake, which is impounded behind Pinto Dam. Water from Billy Clapp Lake flows into the Main Canal, where it bifurcates (at the "Bifurcation") into the East Low and West Canals. A third canal, the East High Canal, was originally envisioned as part of the Project, to supply the eastern portion of the ECBID (now known as the Odessa Subarea Special Study Area) with irrigation surface water, but it was never built.

The West Canal supplies water to the QCBID. The East Low Canal provides water to the ECBID and the SCBID. The Bureau constructed O'Sullivan Dam in the central part of the Project, creating Potholes Reservoir. Potholes Reservoir receives canal water and return flows from the northern part of the Project (QCBID and ECBID) and discharges the water through the Potholes Canal to the SCBID service area.

Return Flow

Reuse

Water reuse from return flow is an important element of the Project concept. In 2020, approximately 2.7 million acre-ft of Columbia River water was diverted by the Bureau at the Main Canal, but about 3.3 million acre-ft was delivered by the districts to farmers to serve 650,000+ acres of farmland. The difference between annual diversions from the river and annual deliveries to farmers represents irrigation return flows captured by Project infrastructure and reused. An interactive map of Project infrastructure is presented on the Columbia Basin Development League website at: https://www.cbdl.org/about/interactive-project-map/.

Proratable v. Interruptible Water

Farm Units

The original repayment contract between the Bureau and the irrigation districts was established in 1945. Water was first pumped for irrigation into the West and East Low Canals system beginning in 1952. The first Project water was delivered directly from the Columbia River to SCBID acres in 1948.

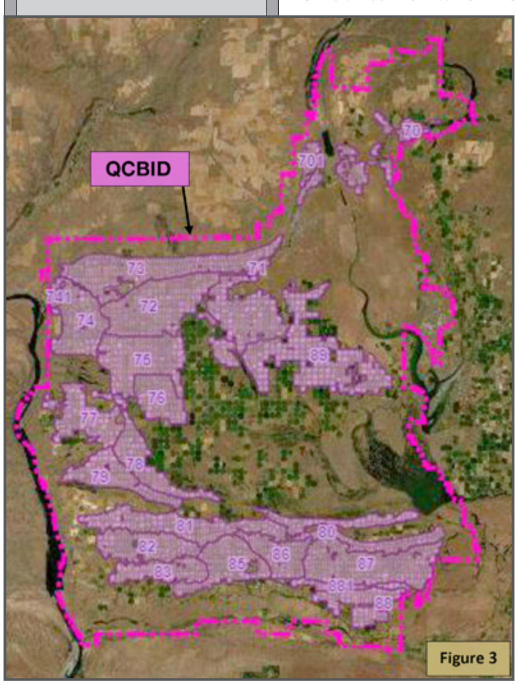


Figure 3

Water was distributed in a system of canals and laterals to "Farm Units" organized by "Irrigation Block:"

- Block: Irrigation Blocks, or Blocks, are areas of platted Farm Units that were ready to come on-line at about the same time as the Project was originally being built out. As new laterals were constructed and began serving a certain area, that area was designated as a distinct Block. Blocks were numbered sequentially as they were established. QCBID Blocks are shown in Figure 3.
- Farm Unit: Farm Units represent the original specifically platted areas of land sold to farmers by the Bureau. Within each Block, Farm Units comprise the basic unit of the original Project water allocations. Farm Units are identified by Block number and then by Farm Unit number (e.g., "Block 77 Farm Unit 59"). Farm Units in the QCBID average about 80 acres. Each segmented portion of the Blocks shown in Figure 3 represent an individual Farm Unit.

Farm Unit water is not interruptible, but is proratable. Interruption is the temporary cessation of water service to one water user in favor of another due to limited supply. This concept is not applicable to Farm Unit water since all of those contract holders have the same priority. Prorationing is the proportional reduction in water service to all water users (within a group) due to limited supply. Prorationing is uncommon and typically occurs within a Block or portion of a Block due to canal

Columbia Project Water

maintenance or temporary capacity limitation. All Farm Unit water has similar priority regardless of when the associated Block was built out.

Land and Repayment Classification and Water Cost

Land Classification

The Bureau has a land classification scheme based on soil, topography, and drainage characteristics. *See* 2005 USBR Technical Guidelines for Irrigation Suitability and Land Classification. There are six classes, four of which are typically applied to the Project lands. Class 4 lands have limited irrigation potential, typically suited for specialized or high value crops. Class 5 lands are temporarily non-arable but may be arable subject to additional investigation. Each Farm Unit is given a "share of system capacity" rating (water duty allocated to the Farm Unit is based on land classification and acreage):

- Class 1 (most irrigable, requiring the least amount of water): 3.0 acre-ft/acre
- Class 2: 3.5 acre-ft/acre
- Class 3: 4.0 acre-ft/acre
- Class 6: non-arable.

Water Duty

Farm Unit land cannot be reclassified; its water duty is established and firm. Class 6 land, which by definition did not receive Farm Unit water, can be reclassified at the request of the irrigation district and by approval of the Bureau as determined in the 1968 Repayment Contracts (see *1968 Repayment Contract* section below). Original land classification was based on arability using gravity-driven rill irrigation methods. Some of that land is currently considered arable under modern irrigation technology.

Payback Assessments

The cost for Farm Unit water is separated into a construction portion and an operations and O&M portion. The construction portion has a specific payback period and rate, established when each Block was developed. Because the Blocks were developed over time, the construction pay-back periods will end at different times (sometimes referred to as the "Reclamation and Reform Act" (or "RRA") clear date). Some Blocks have reached their RRA clear date and are receiving a reduced assessment (on the order of a few dollars per acre per year). The O&M portion is ongoing and based on a prorated percentage of the overall O&M costs borne by the district for a given year. For example, 2021 Farm Unit water assessments for the SCBID are $89.45 per Class 1 acre, $84.46 per Class 2 acre, and $79.75 per Class 3 acre (*see* www.scbid.org/rates).

Acreage Limitation

Farm Unit Eligibility and Acreage Limitations

According to the 1902 Reclamation Act, an individual must occupy the land and have less than 160 acres to be eligible to receive federal Reclamation water. The acreage limitation was later changed to 320 acres for a husband and wife. Eligibility requirements were reformed again in 1982 with the passage of the RRA, in part due to changes in irrigation technology and the associated capital investment that drives economies of scale.

"New Law" v. "Prior Law"

The provisions of the 1902 Act that were updated in the RRA are known as "New Law." Elements of the original 1902 Act that were left in place in the RRA are known as "Prior Law." The New Law provisions updated the acreage limitation for qualifying irrigation districts and individuals to a maximum of 960 acres. The acreage limitation applies to land ownership across all federal Reclamation projects in the west. There are at least three ways an entity can qualify for the 960 acreage limitation under New Law provisions:

- Irrigate land in a New Law district
- Make an irrevocable election to comply with New Law provisions (accomplished by filing a form with the irrigation district)
- Irrigate land in a separate New Law district

960 Acres Limitation

The ECBID has amended its contract with the Bureau to comply with New Law provisions and is therefore a New Law district. The QCBID and the SCBID are Prior Law districts. Many entities that farm in these latter two districts have demonstrated qualification as a New Law recipient and therefore are subject to the 960 acreage limitation.

Lease Water

Under New Law, a farmer is eligible to receive non-full cost water (subsidized at a prorated percentage of the calculated construction cost of the Project) for 960 acres. The farmer can also lease water in excess of 960 acres, but has to pay a full cost rate (100% of calculated construction costs).

Equivalency Formulae

The RRA allows for calculating the 960 acreage limitation based on Class 1 equivalency. An individual can own 960 acres of Class 1 land but significantly more acreage of Class 2 and 3 land with lower productive potential according to the following formula:

Class 1 = 100% (100 acres of Class 1 land would be considered 100 acres of Class 1 Equivalency)
Class 2 = 77.5% (100 acres of Class 2 land would be considered 77.5 acres of Class 1 Equivalency)
Class 3&4 = 54.3% (100 acres of Class 3 and/or 4 land would be considered 54.3 acres of

Columbia Project Water

Class 1 Equivalency)
(Formula based on conversations with the Bureau regional office in Boise)

Construction Obligation Payoff

Acreage limitation and Class 1 equivalency becomes moot once an irrigation block pays off its construction obligation (i.e., meets its RRA clear date). For example, the SCBID website lists Blocks that have met their RRA clear date (https://www.scbid.org/block-pay-out; note the ECBID does not have a website). An RRA clear date list is not provided on the QCBID website). The SCBID has a total of 22 Blocks, 12 of which are paid off as of the end of the 2020 irrigation season and no longer subject to RRA acreage limitations.

RRA Requirements

As Blocks reach their RRA clear date, farm size will likely increase, modifying land ownership patterns and the character of the Project community. Note that acreage under water service contracts (different from Farm Unit allotments; *see* below) do not have an RRA clear date and in some instances are automatically assigned a Class 1 equivalency of 100% regardless of land classification. If the land was not originally classified during Project inception, then the land under water service contract is considered 100% equivalent to Class 1, regardless of class determination after reclassification. If the land was originally classified but did not receive Farm Unit water, then it is eligible for Class 1 Equivalency calculation based on the land class formula. RRA requirements are complicated, especially for entities with multiple land holdings. Fortunately, irrigation district staff provide expert assistance to facilitate compliance.

Repayment Contracts

1968 Repayment Contract and Article 28 Water Service Contracts

In 1968, the irrigation districts entered into separate repayment contracts that replaced the 1945 Repayment Contract (as amended) in most respects. The 1968 Repayment Contracts transferred O&M responsibilities for certain portions of the Project infrastructure (known as the Transfer Works) from the Bureau to the irrigation districts while the Bureau retained ownership. The Bureau retained O&M responsibility for infrastructure that was common to all districts (known as the Reserve Works), including all Project elements north of the Bifurcation (i.e., Grand Coulee Dam, Banks Lake, the Main Canal, etc.). The Bureau also retained O&M responsibility of certain other specific Project elements (known as the Special Reserve Works), such as the O'Sullivan Dam.

O&M Responsibility

1968 Impoundments

The 1968 Repayment Contracts accomplished a number of other improvements:

- Allowed for reclassification of Class 6 land (i.e., addition of irrigable land within the districts)
- Allowed for land substitution (moving) of Farm Unit water (Article 10d)
- Allowed for districts to supply additional water that may be available (Article 28). Additional irrigation made available under Article 28 water service contracts includes:
  - QCBID: 23,400 acres
  - ECBID: 7,000 acres
  - SCBID: 21,907 acres

Drainage

- Outlined a program for the Bureau to construct a series of drainage works to address rising groundwater levels and wet areas
- Recalculated the construction cost repayment obligation to include proposed drainage works

Water Service Contracts

Article 28 **w**ater **s**ervice **c**ontracts (WSCs) are written between the district and the landowner for a period of 10 or 20 years, and are renewable and interruptible subject to canal capacity. The land must meet land classification requirements discussed above. Land can be reclassified from non-arable (Class 6) to irrigable with Bureau approval and submittal of a cultural resources assessment. As mentioned, WSCs count against RRA acreage limitations and do not have an RRA clear date. There are typically three basic types of Article 28 WSC with water duty assigned based on contract type (not on land classification):

Water Duty Assignments

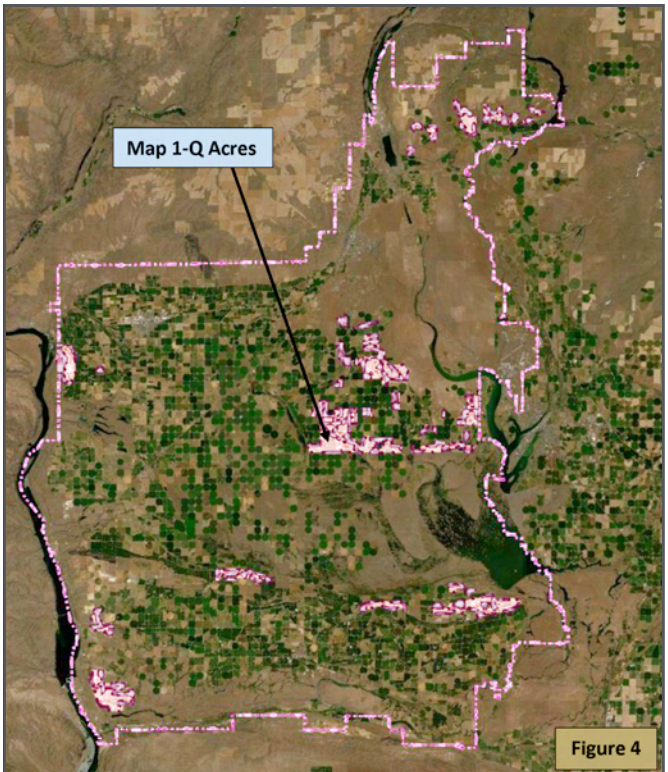
- Waste, Seepage, and Return Flow (WSRF) contracts serviced out of drainage and wasteway infrastructure (water duty typically 2.5 acre-ft/acre)
- Interruptible contracts serviced out of canal infrastructure (water duty typically 3.0 acre-ft/acre)
- Temporary or limited contracts (water duty typically 3.0 acre-ft/acre)

Additional water, above a Farm Unit base allotment or WSC water duty, can be applied for through the district as supplemental or excess water at an increased cost.

1976 Master Water Service Contract

1976 Master Water Service Contract and First Phase Water Service Contracts

Both the QCBID and the ECBID signed Master Water Service Contracts (MWSCs) with the Bureau in 1976 (note that a WSC is written with a landowner while a MWSC is between the Bureau and a district). The MWSCs were primarily intended to provide a mechanism to fund the construction of the Second Bacon Siphon from Banks Lake to Billy Clapp Lake and add an additional 136,000 to 200,000 acres capacity to the Project. The original MWSCs were written for a 40-year term from completion of the



Second Bacon Siphon (1982), after which they can be renegotiated. The SCBID did not sign a MWSC with the Bureau.

1982 Supplement to the MWSC

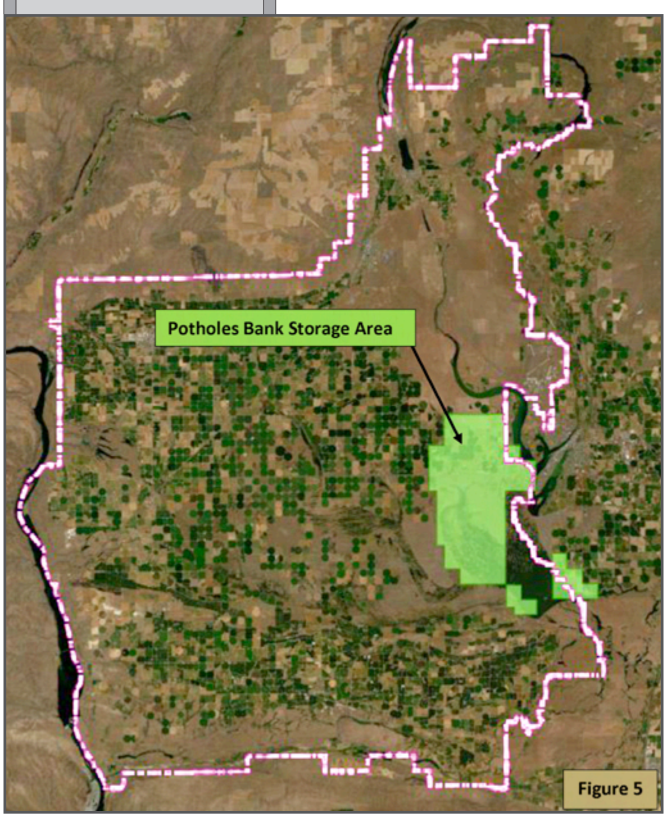
The 1982 Supplement to the MWSC between the Bureau and the QCBID documented the completion of the Second Bacon Siphon and the availability of 10,000 additional acres for irrigation in the district. These acres were termed First Phase Continuation Acres and were restricted to the areas designated on Map 1-Q (of the Supplement) (Figure 4). The ECBID similarly entered into a 1982 Supplement to its MWSC with the Bureau, making water available to an additional 10,000 acres — for both existing acres (for peaking demand) and to specified additional First Phase Continuation Acres.

Municipal and Industrial Water and Potholes Bank Storage Water

Municipal and Industrial (M&I) Project water is for non-agricultural use. The Bureau (not the irrigation districts) writes renewable water service contracts for M&I water, which comes directly from canals and wasteways and is therefore constrained by available conveyance capacity, restricting its use during the irrigation season (when water is flowing in canals). Typical M&I uses might include lawn watering or mixing with wastewater to meet permit discharge requirements. M&I assessments include a Bureau charge (2021 assessment is $48 per acre-ft) and a district charge (e.g., SCBID 2021 assessment is $21.77 per acre-ft). Note that non-agricultural water is assessed on a per-acre-ft basis while irrigation contracts are assessed on a per-acre basis with a prescribed water duty (e.g., 3 acre-ft/acre).

Storage Water (Groundwater Use)

Potholes Bank Storage Water (PBSW) is an additional type of renewable contract, written directly between the landowner and the Bureau. PBSW is available as groundwater in a limited area near the Potholes Reservoir. (The Potholes Reservoir and adjacent Storage Area is defined in Ecology Amended Order No. DE 75-54 dated February 1986). The contracts can be written for agricultural uses ($91.70 per acre) or for non-agricultural uses ($36.21 per acre-ft)(*see* 2020 assessment). PBSW contracts are restricted to land within the Potholes Bank Storage Area (Figure 5).



State Groundwater Management Subareas

Washington State's Department of Water Resources became part of the State's Department of Ecology (Ecology). This agency realized the need for a more comprehensive scheme to manage groundwater in the Project area. In 1969, the agency effectively curtailed new groundwater permits in the basin through promulgation of Washington Administrative Code (WAC) 508-14-010 and commissioned the development of a "digital" groundwater flow model as a tool for managing groundwater in the Project area. The model was built by the United States Geological Survey and was a basis for specific State water right allocation decisions. Subsequently, in 1973, Ecology established the Quincy Groundwater Management Subarea (Quincy Subarea) to provide a framework for managing groundwater. The Quincy Subarea is defined in Chapter 173-124 WAC and encompasses most of the QCBID service area and the portion of the ECBID service west of the East Low Canal. Similarly, Ecology established the Odessa Groundwater Mangement Area (Odessa Subarea) in WAC 173-128 and the 508-14 Subarea in WAC 508-14-030. Note that the subareas do not conform exactly to the Project area and that the Quincy Subarea does not conform to the boundaries of the QCBID.

Quincy Subarea and Artificially Stored Groundwater

RCW 90.44.130 authorizes Ecology to establish groundwater management subareas (Figure 6). The statute also allows entities to file a declaration for **a**rtificially **s**tored **g**round**w**ater (ASGW) within

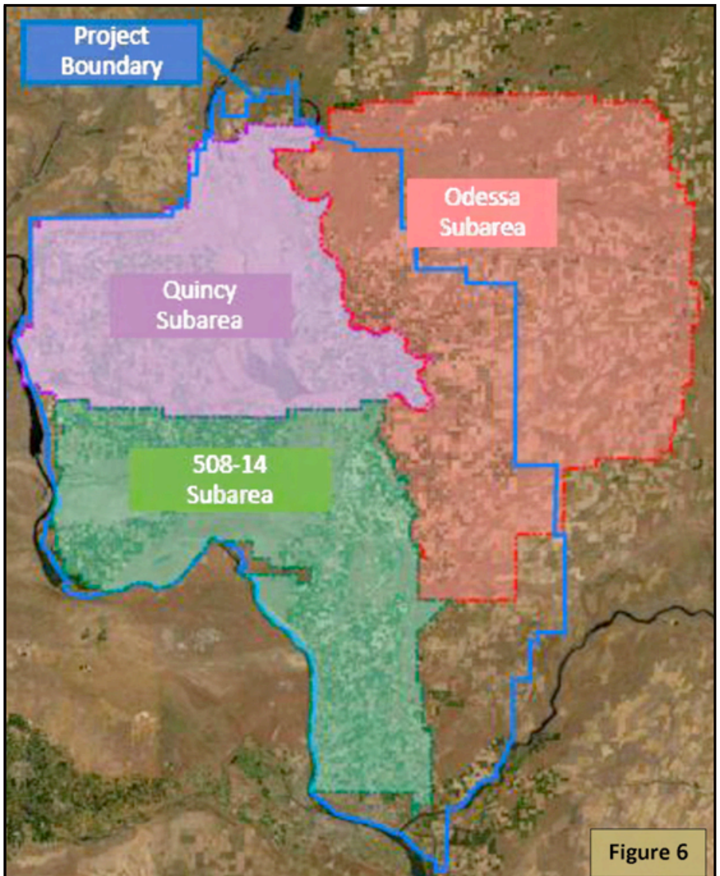


Figure 6

established subareas. The Bureau and nine individuals made such declarations in the Quincy Subarea. Ecology accepted the Bureau declaration for 3,498,000 acre-ft of ASGW and 614,142 acre-ft of withdrawn groundwater. All other declarations were rejected. The rationale for the declaration and acceptance was the loss of Project waters to seepage into groundwater and the necessity of recapturing that water to feed the Potholes Reservoir for use in the southern portion of the Project. The Ecology order of acceptance of the Bureau declaration for ASGW is presented in Docket Number 74-772 dated January 8, 1975.

With the federal declaration and acceptance by the State, a portion of the groundwater beneath the Project area became subject to federal reclamation law. This means that use of the water requires a water service contract (referred to as a license) with the Bureau and land is subject to RRA acreage limitations.

The Bureau declaration notwithstanding, Ecology retained authority to manage federally declared groundwater within the Quincy Subarea, though not all provisions of the State groundwater code (RCW 90.44) apply. The specific rules and regulations regarding groundwater management in the Quincy Subarea were promulgated in 1975 under WAC 173-134 (later amended to 173-134A). In the rule, Ecology defined two management units based on geology. The shallow management unit included the unconsolidated deposits and the upper 200 feet of basalt that is typically in the Wanapum Formation of the Columbia River Basalt Group (CRBG). The deep management unit is all strata below the shallow management unit and is typically associated with the Grande Ronde Formation of the CRBG. In the WAC 173-134A rule, Ecology determined that:

- Public groundwater (i.e., non-federal groundwater authorized for withdrawal under State permits and certificates) available in the deep management unit is quantified to be 97,901 acre-ft
- Public groundwater available in the shallow management unit is quantified to be 58,000 acre-ft
- All public groundwater had been appropriated as of 1982
- ASGW withdrawals are restricted to the shallow management unit and must be less than a total of 177,000 acre-ft for any given year

Permits for the withdrawal of ASGW water, known as Quincy Basin or "QB" permits, are issued by Ecology (Figure 7). The ASGW must be extracted from the shallow management unit; however, a user can apply for an exemption to this depth restriction. The exemption, if granted, allows an entity to install a well deeper than 200 feet into the basalt but no deeper than the geologic contact between the Wanapum and Grande Ronde Basalt Formations of the CRBG.

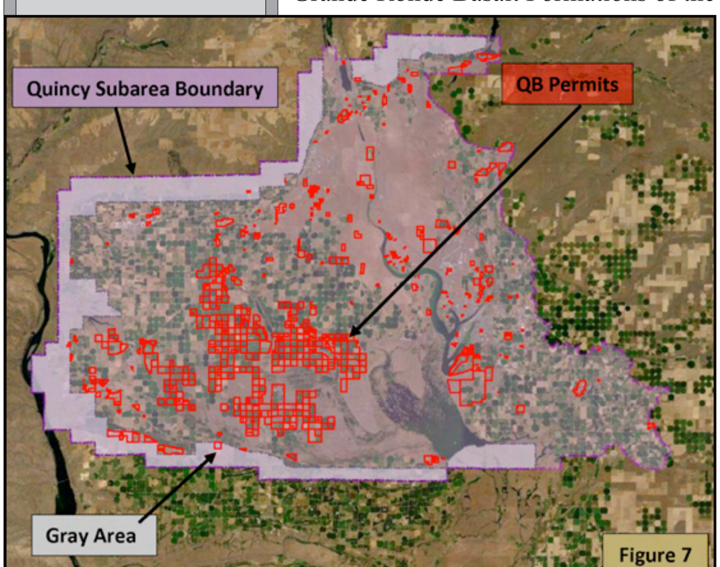
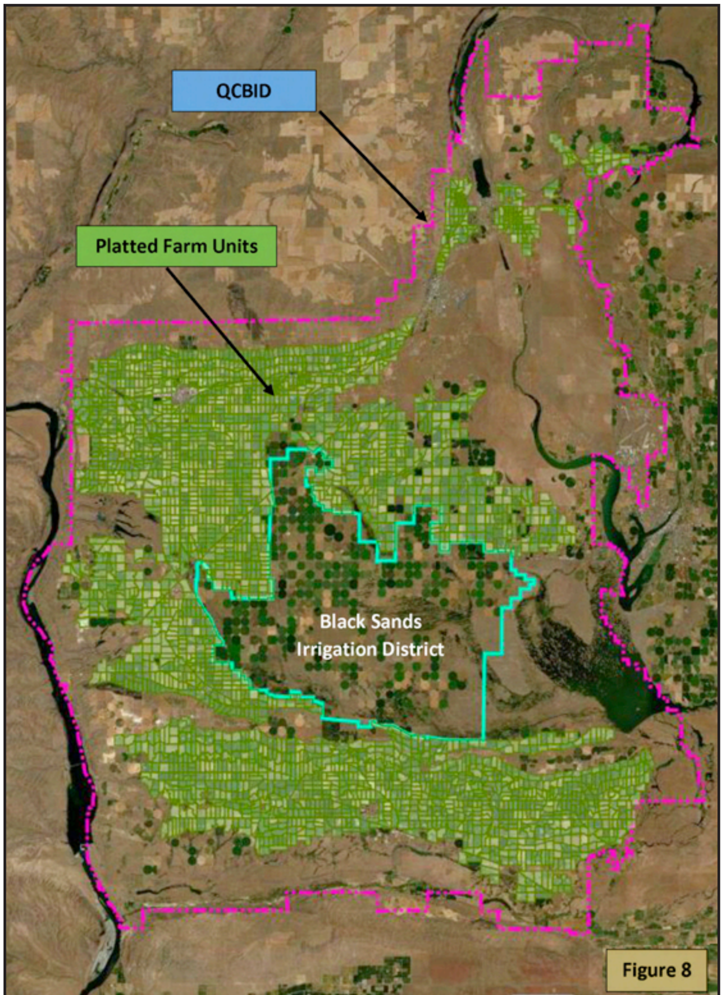


Figure 7

Additional QB permit attributes and provisions include:

- A specified purpose and place of use and point of withdrawal
- An assumed water duty of 3.5 acre-ft/acre
- A three-year development schedule (no extensions allowed) to put the water to beneficial use
- Construction completion inspection and approval by Ecology
- Execution of (and annual payment for) a water service contract with the Bureau for repayment (contracts must be renewed every 10 years). QB permits are subject to termination without a Bureau contract.

QB permits are issued by Ecology at no cost and have no termination date. QB permits can be amended (changed), including changes to the place of use within the Bureau declaration area, and there is an active secondary market for these permits. QB permits are interruptible subject to adequate return flow supply to the Potholes Reservoir. QB permits are maintained in a priority system where more senior permits are apparently less likely to be interrupted. We are not aware of an



instance where a QB permit has been interrupted. The complete allocation of 177,000 acre-ft (equal to about 56,000 acres) of QB permit water has been permitted and no further water is available (unless an existing permit is canceled). The acres irrigated under QB permits is in addition to the 720,000 acres authorized in Secondary Use Permits held by the Bureau. An entity can purchase an existing QB permit, however, and transfer it to their land through a change application filed with Ecology.

WAC 173-134A-080 prohibits the issuance of QB permits in specific portions of the Quincy Subarea adjacent to Project wasteways and in the Potholes Bank Storage Area (*see* discussion above).

The State legislature, in RCW 89.12.170, determined that there is a significant increase in the amount of groundwater in the Pasco Basin portion of the 508-14 Subarea resulting from Project activities (*see* Columbia Basin Project – Authorization for agreements to allocate water – Conditions). In March 2021, the legislature passed Senate Substitue Bill 5230 that amended RCW 89.12.170 to facilitate agreements between the State and the Bureau regarding allocation of this Project-related groundwater. It is our understanding that a program similar to the QB permit program may be developed relatively soon that will make additional water available in the 508-14 Subarea.

Quincy Subarea - The Gray Area

When the Bureau made a declaration for ASGW within the Quincy Subarea, the defined declaration area was slightly smaller than the Quincy Subarea. The difference between the two areas is known as the Gray Area (see Figure 7). QB permits are not allowed to be written for land in the Gray Area. However, Ecology's current policy allows the place of use to be in the Gray Area if the point of withdrawal is within the declaration area and any associated irrigation return flow is likely to flow toward the Potholes Reservoir.

"Rill" Irrigation

Quincy Subarea - Black Sands Irrigation District

"Rill" or "furrow" irrigation is a surface irrigation method where water is supplied to a field by gravity flow along small, closely spaced channels made with a tillage tool. The Black Sands area within the boundaries of the QCBID was originally not considered arable using the rill irrigation method predominantly used at the time of Project development. The geologic material beneath the Black Sands area was too well-draining to support rill irrigation.

Arable Reclassification

The Black Sands area was assigned a Class 6 land classification and was therefore not eligible for platted Farm Unit water. Consequently, Project infrastructure was not extended to this area. The adoption of center-pivot irrigation turned the Black Sands area into productive land, which was reclassified as arable. The land is now heavily farmed under center-pivot irrigation and groundwater wells using QB permits and State groundwater certificates. With the development of the QB permit program, the Black Sands Irrigation District (BSID; Figure 8) was formed to represent the interest of farmers in this area, including negotiating the cost and terms of ASGW repayment water service contracts for QB permit water. The BSID is not contracted with the Bureau to distribute Project water.

Expansion Deferred

East Columbia Basin Irrigation District – Odessa Groundwater Replacement Project

The Odessa Subarea, defined in WAC 173-128A, comprises 1.8 million acres overlapping the eastern portion of the ECBID (Figure 9). Farmers moved into the portion of the Odessa Subarea within the ECBID in anticipation of receiving Project surface water from the East High Canal that has yet to be built. Some farmers began dryland farming, while others received permits from Ecology to drill deep wells with the understanding that the East High Canal would eventually be built to bring Project water to the land. The State-issued permits were considered temporary (pending arrival of federal water); however, expansion of the Project into the Odessa Subarea has been deferred for over 40 years and, as a result, the underlying

Odessa Aquifer Decline

Odessa aquifer is being depleted. Today, well depths exceed 2,000 feet in places and groundwater levels

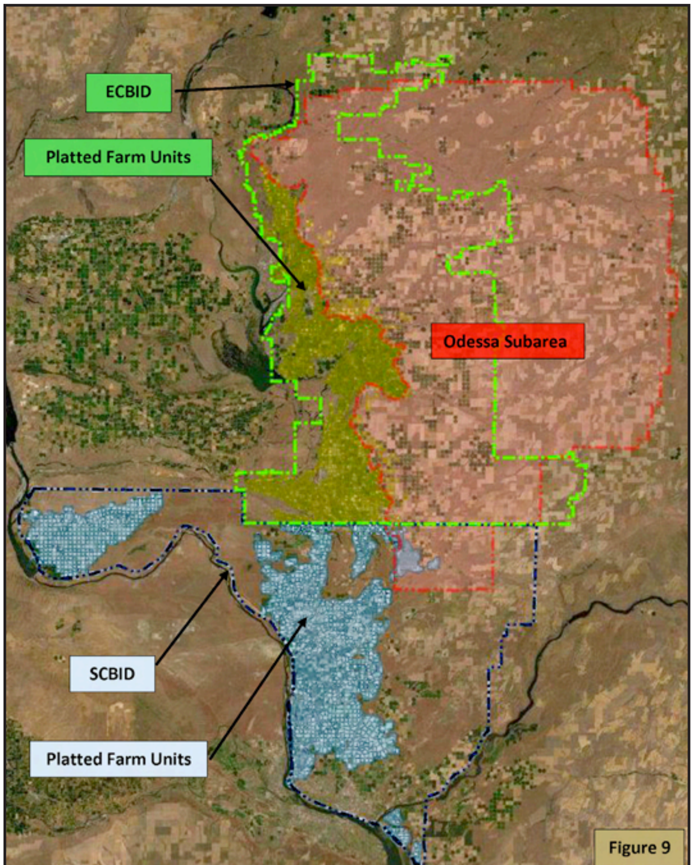


Figure 9

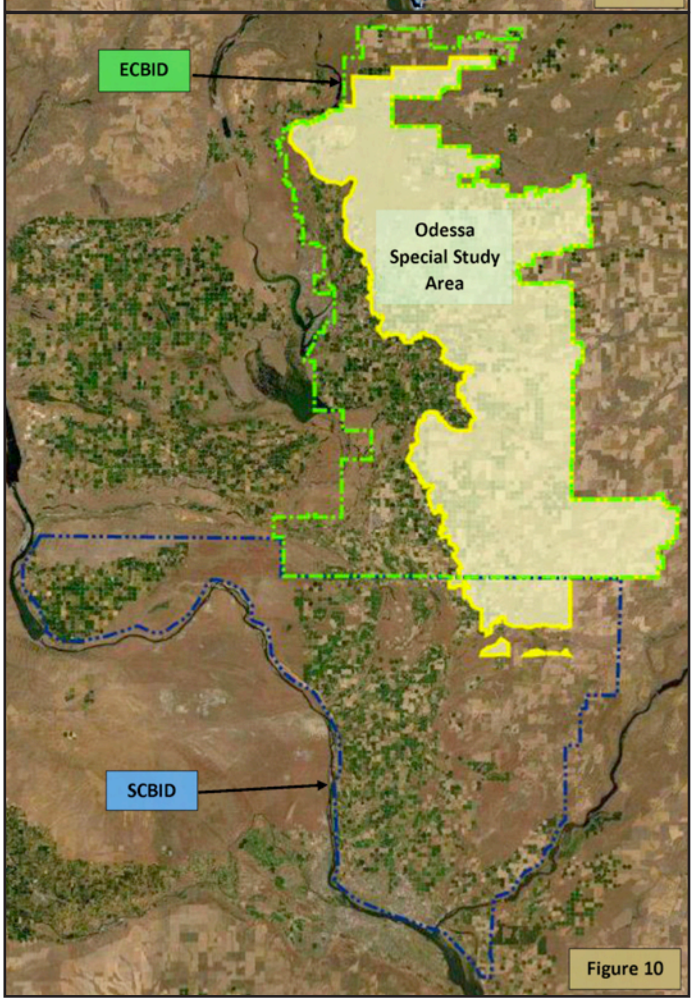


Figure 10

are dropping by up to 10 feet per year. As wells continue to fail, drilling more and deeper wells is not a viable alternative. Water quality from these deep wells is another concern, as it is often high in temperature and contains a high concentration of salts and other minerals. The decline of the aquifer not only threatens irrigators in the region; there are also a number of communities at risk of losing their groundwater-sourced domestic water supplies.

To address the risk to communities and farmers who rely on the Odessa aquifer, the Washington State legislature tasked Ecology with finding alternatives to groundwater for agricultural users, as part of the Columbia River Water Management Program (RCW 90.90.020). Ecology worked with the Bureau to identify solutions, releasing the *Odessa Subarea Special Study Final Environmental Impact Statement* in 2012. In April 2013, the Bureau announced its choice of "Modified Partial-Replacement Action Alternative 4A." When fully developed, Alternative 4A would provide Project surface water to 70,000 acres of Odessa Subarea land currently irrigated from deep-well groundwater under State permits and certificates. Once the landowner signs a water service contract for Project water, their existing State water right is relegated to standby-reserve status in accordance with RCW 90.44.510.

Alternative 4A evolved into the OGWRP program discussed earlier, and the replacement acreage grew to 90,000 acres. Infrastructure upgrades required to deliver the additional surface water for the program are at various levels of completion. ECBID and the Bureau have widened 46 miles of the East Low Canal (and expanded siphon capacity) to accommodate the additional water volume. The plan also calls for eight new distribution systems (or "laterals"). To date, only one distribution system, EL 47.5 (for East Low, mile 47.5), has been funded and completed. OGWRP proponents expect full buildout to take several decades. The authorization for OGWRP water delivery and contracts is provided in the 2015 Renewal Master Water Services Contract (and supplements; RMWSC) and the 2019 Amendment #1 to the RMWSC between the ECBID and the Bureau.

Farmers who wish to receive Project surface water under OGWRP must meet four listed criteria. (*See* 2017 Bureau; *Odessa Subarea Special Study Area – Odessa Groundwater Replacement Program* -EL47.5 Project and Amendment to the Renewal Master Water Service Contract). First, the irrigated land must be located within the boundaries of the Project. Second, the land must have a valid State-issued groundwater right that will be retired (relegated to standby-reserve) upon delivery of Project surface water. Third, the land must be located within the Odessa Subarea Special Study Area boundary (Figure 10). Finally, the landowners must be eligible to enter into a WSC with the district. The water duty for an OGWRP WSC is 3 acre-ft/acre. Capital construction costs for OGWRP water are up to $190 an acre (maximum, not-to-exceed amount) plus an O&M assessment (set at $54.67 an acre for 2021). Construction debt service is normalized across the OGWRP portion of the District resulting in uniform capital costs per acre.

Farmers with land adjacent to proposed laterals are well positioned to participate in the program. Farmers with Odessa aquifer State groundwater water rights located too far from a surface water delivery system or outside the Special Study Area (but within the larger Odessa Subarea) may also benefit from OGWRP through "infill." That is, they can sell their water right and change the place of use to a dryland location within the Special Study Area near a built or proposed lateral.

Columbia Project Water

Conclusion

The productivity of the Project is due in large part to a dependable water supply from the Columbia River. Water is supplied by a mosaic of state and federal water authorizations, each authorization having a seemingly unique combination of attributes, provisions, and requirements. Add to that mosaic the administrative discretion of Bureau, district, and Ecology managers — which changes over time with staff turnover — and your head may start to spin. While regulatory managers of Project water authorizations are knowledgeable and willing to answer questions, they are busy and, in some instances, understaffed. We are certain these managers can provide nuance and insight, particularly in their specific area of expertise, well beyond what we are able to supply here. With that in mind we hope that this primer will provide a useful background for entities with an interest in Project area agriculture.

For Additional Information:

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EVAPOTRANSPIRATION ESTIMATION

COMPARISON OF EVAPOTRANSPIRATION METHODS USED IN WASHINGTON STATE

by Nigel Pickering, Abhilash Chandel, Lav Khot, Mingliang Liu, Troy Peters, Sunil Kadam, Behnaz Molaei, Jon Yoder, Kirti Rajagopalan, Claudio Stockle & Georgine Yorgey, Washington State University
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Introduction

Crop Yields & Return Flow

Evapo**t**ranspiration (ET) is the loss of water from plant and soil surfaces to the atmosphere, primarily driven by solar energy, air temperature, dryness of the air, and lateral input of heat via wind. ET is an important driver of crop yields and the amount of return flow.

There are multiple historical and emerging methods that are used for estimating crop **e**vapo**t**ranspiration (ET) in the State of Washington. Each method utilizes different data and underlying formulas.

ET Information Uses

The needs for reliable ET information are diverse, including for: irrigation system design; crop irrigation management; water trading or leasing; and regulatory purposes. Methods that provide long-term historical averages of ET for specific crops are most suitable for irrigation system design or regulatory purposes that require understanding of long-term consumptive water use. Methods that provide spatial crop ET estimates are most appropriate for precision irrigation applications, understanding ET over larger areas, or ET over defined historical periods.

This article provides a summary of ET estimation methods that have, to-date, been researched and validated in Washington State — including their underlying input data needs and geographic coverage. Also discussed are the potential improvements of these methods in the future as pertinent data collection technologies mature and considerations for wider adoption occur.

This article is based on work at *Technology for Trade* — a large multidisciplinary project led by Washington State University (Yoder et al., 2021). The project is furthering the development of three information technologies (remote consumptive use estimates, seasonal forecasts, and water markets), and exploring how these technologies interact with the institutions that govern water use. *See*: https://wrc.wsu.edu/project/technology-for-trade/

Irrigation Indices & Their Uses

Consumptive Use

Water withdrawals in a watershed can affect downstream water availability differently depending on how much water is consumed. Within an agricultural or landscaping setting, ET is the largest component of consumptive use. Consumptive use for crops or lawns can differ substantially depending on location, weather, soil type, growth stage, and irrigation technology being used (Ecology, 2005).

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Estimation and measurement of ET is useful for both farm-level and watershed-level water monitoring and management. By subtracting **e**ffective **p**recipitation (Pe), knowledge of ET allows an estimate of **c**rop **i**rrigation **r**equirement (CIR), also called **i**rrigation **w**ater **r**equirement (IWR). Along with irrigation **a**pplication **e**fficiency (Ea), CIR is used for determining the **t**otal **i**rrigation **r**equirement (TIR) of a crop. The TIR consists of both consumptive use and return flow. The **c**onsumptive **u**se (CU) of irrigation can be estimated by adding the ET and the portion of the applied water that is consumed by direct evaporation to the atmosphere, or %CU (Ecology, 2005).

Total Irrigation Requirement (TIR)

In summary:

Total Irrigation Requirement (TIR) = (ET - Pe) / Ea, or CIR / Ea

Consumptive Use (CU) = TIR x %CU

Unfortunately, the terminology and definitions in use by different ET methods are not well-defined or not well understood by practitioners, leading to conclusions that ET = CIR = CU, which is not the case. In some instances, the differences may be small, but in others they are significant.

Consumptive Use Applications

Farmers and irrigation engineers use TIR to design irrigation systems including pipes, pumps, and sprinklers. The Washington State Department of Ecology (Ecology) uses TIR along with aerial photography to determine the validity of water rights (Ecology, 2004). Water bankers and water right appraisers use CU in quantifying water rights available for trade. CU is used for water trading in most Washington basins to limit impairment to river flows and existing water rights with the restriction that the water trade must not augment current CU. Because water right valuations and trades are tied to estimates of CU, it is important that methodologies, terms, assumptions, and data sets be well understood and accurate.

Water Right Evaluations

The 1992 Washington Irrigation Guide (1992 WIG) (NRCS, 1985/1992) is the standard reference used by Ecology for most irrigation water right evaluations. Different Washington State and federal entities maintain weather platforms that can be used for estimating ET including AgriMet by the United States Bureau of Reclamation, AgWeatherNet (AWN) by Washington State University (WSU), and a limited set of eddy covariance flux towers by WSU. Remote-sensing techniques using satellites and drones are becoming more available for estimating ET over larger areas and within field extents.

ET Data Sets Vary

For water professionals, it can be challenging to understand which tools are best for each situation. Many of the ET data sets vary geographically and reflect average conditions during different weather time periods. Those that include more recent data also incorporate the effects of climate change. Moreover, the ET estimation methodologies vary in applicability. For example, the method used in the 1992 WIG uses only air temperature and percent daylight but is applied widely in the United States. In addition, some ET estimates are long-term averages or drought-condition estimates for particular crops, while other estimates are for individual years. Finally, some of the information from historic publications has been lost to time and cannot be reliably reproduced.

Measurement Methods

Researchers have developed several methods to continuously measure ET rates including:

- Weighing Lysimeter — which uses a large soil scale that measures mass changes in water to calculate ET
- Bowen ratio — which uses fixed ratio of sensible heat to latent heat to estimate ET from net radiation and soil heat flux
- Eddy covariance — which uses covariance between measured three-dimensional wind speed and water vapor to estimate ET
- Scintillometer — which measures electromagnetic radiation attenuation over a fixed path length to determine the refractive index of air above a crop and then estimates ET

Despite being the best available direct measurements, these methods are not free from some degree of uncertainty. Various ET estimation methods have been developed based on these direct measurements. They can provide extended spatial coverage and include more climatic regions (*see* Sidebar, next page).

Long-Term Average ET Estimates Based on Point Data

Early Washington State Methods

Circular 512

Circular 512 (WSU, 1969) was the first publication of CIR in Washington that received widespread use. Circular 512 relied on a Modified Blaney-Criddle (BC) method to estimate ET from 30 years of data across 38 geographic locations in Washington for 17 crops. The specific weather years used in this reference are not cited but are estimated to range from 1937 to 1967 based on cited references. Circular 512 provided CIR estimates for normal and drought years. For example, alfalfa in Ellensburg required a CIR of 30 inches in average years and 36 inches in a 20-year drought.

Normal & Drought Years

The next widespread CIR methodology (WSU, 1982) (XB 0925, in print today as EB 1513) significantly expanded the number of crops beyond those explored in Circular 512. XB 0925 relied on the FAO24-BC method (Doorenbos and Pruitt, 1977) to estimate ET from 26 years of data across 40

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XB 0925

Irrigation Guide Update

Widespread Use

geographic locations in Washington for 39 crops. The 26-year period used was from 1948 to 1973 but not all stations had complete data. This dataset overlaps that of Circular 512, so even though Circular 512 did not cite the number of years used for each station, it is reasonable to assume similar methodology and data was used. XB 0925 again provided estimates for normal and drought years. For example, alfalfa in Ellensburg used seven years of data and required a CIR of 30 inches in average years and 33 inches in a 20-year drought. Some of the changes from Circular 512 are modest while others are substantial; in a handful of cases they are more than 50%.

The 1992 Washington Irrigation Guide (1992 WIG)

The Washington Irrigation Guide (1992 WIG) (NRCS, 1985/1992) updated Circular 512 and XB 0925/EB 1513 and was based on the work of Larry James and his student at WSU (Erpenbeck, 1981). The 1992 WIG relied on both the Blaney Criddle (BC) method modified by the Food and Agriculture Organization (FAO24-BC) and another similar version by the Natural Resources Conservation Service (NRCS-BC) to estimate ET. The exact period for the weather data used in the 1992 WIG is unknown but estimated to be from 1951 to 1980. The publication included ET and CIR estimates across 126 geographic locations in both eastern and western Washington for 25 crops (*see* Figure 1 for pasture). The summary information in the WIG remains in widespread use, even though information on weather years, crop coefficients, and methodologies remain uncertain.

Basics of ET Estimation Methods

Estimations of ET can be achieved with several methods, but the most biophysically sound are based on the crop/soil surface energy balance, the understanding that incoming energy equals outgoing energy. More complex, but complete methods rely on a suite of weather-related inputs. Simpler methods rely on fewer data inputs, with the simplest requiring only air temperature. Simple methods are generally easier to apply but less accurate. Some methods also provide ET for specific drought conditions, for example, for a 20-year drought (one that occurs on average once every 20 years).

The energy balance ensures energy is conserved and can be written as:

$$R_n - \lambda E - H - G = 0$$

Where:

R_n = Net radiation (MJ m^{-2} s^{-1}) = (in-out) short-wave radiation + (in-out) long-wave radiation

G = Soil heat flux (MJ m^{-2} s^{-1}) = heat loss to soil

H = Sensible heat flux (MJ m^{-2} s^{-1}) = heat loss to atmosphere

λE = Latent heat flux (MJ m^{-2} s^{-1}) = water vapor loss to atmosphere

λ = latent heat of vaporization (MJ kg^{-1})

The Food and Agriculture Organization (FAO) Blaney-Criddle (FAO24-BC) equation (Doorenbos and Pruit, 1997) does not use the energy balance approach, but it makes use of empirical relationships based mainly on temperature and daylight percentage adjusted regionally for relative humidity, sunshine hours, and daytime wind. This equation is typically applied on a monthly timestep only.

The FAO24-BC equation for reference crop evaporation is:

$$ETo = c\,[p\,(0.46T + 8)\,]$$

Where:

ETo = reference crop evapotranspiration for the month (mm/d)

T = mean daily temperature for the month (°C)

p = mean daily percentage of total annual daytime hours for a given month and latitude

c = adjustment factor for minimum relative humidity, sunshine hours and daytime wind

The Penman-Monteith (PM) equation is a well-accepted energy balance method that estimates reference ET from a well-watered crop/soil. The PM equation is given below. Note that dividing λE by λ gives evapotranspiration (kg m-2 s-1 or mm s-1).

$$\lambda E = \frac{\Delta(R_n - G) + \rho C_p VPD/r_a}{\Delta + \gamma[1 + r_s/\,r_a]}$$

Where:

VPD = Vapor pressure deficit (a function of humidity and temperature)

r_s = Surface resistance (a function of stomatal conductance, canopy architecture and development, and soil surface conditions)

r_a = Aerodynamic resistance (a function of wind speed, canopy height, and roughness)

The calculation of PM potential ET requires daily or hourly weather data (solar radiation, temperature, humidity, and wind speed). Although some parameters can be estimated relatively easily, others are unknown, making assumptions necessary. The FAO introduced a version of the PM equation (FAO56-PM) for daily ET calculations for a hypothetical short-grass reference crop (ETo) with specified parameters (Allen et al., 1998). The American Society of Civil Engineering (ASCE, 2005) implemented a similar approach (ASCE-PM) for an alfalfa reference crop (ETr), which more closely resembles many agricultural crops.

Converting from reference ET to actual ET requires application of a crop coefficient to correct for lack of full cover and crop senescence. Lysimeter data has allowed the determination of crop coefficients (K) as the ratio of observed ET in lysimeters for specific crops to the reference crop ET calculated from weather measurements in the vicinity of lysimeters.

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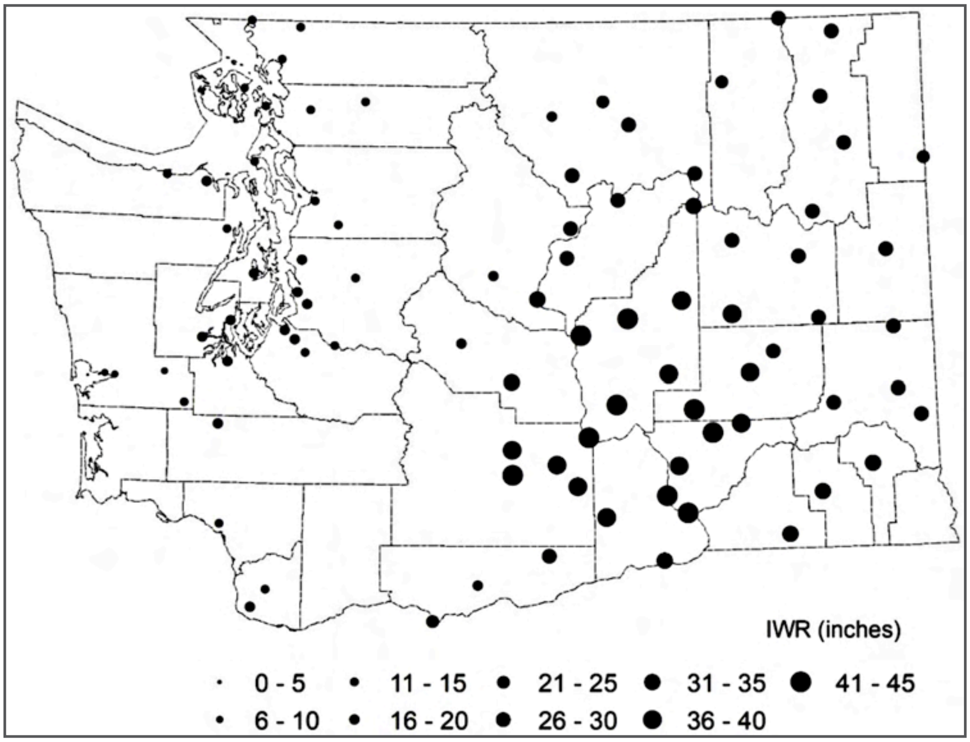
1992 WIG

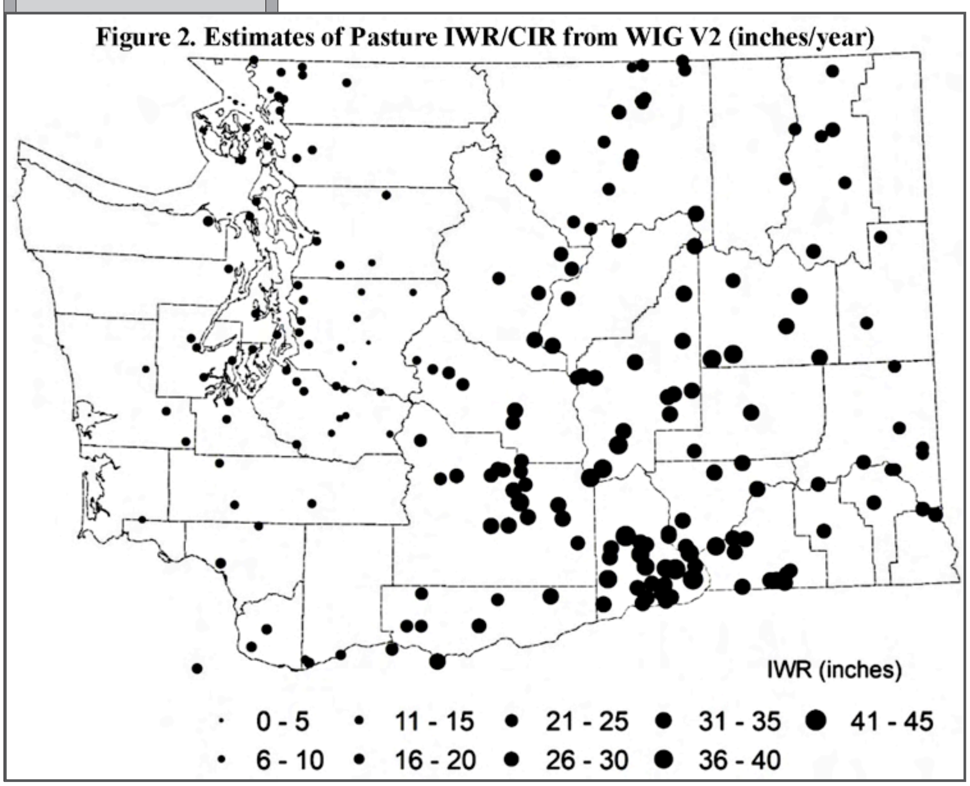
The primary advantage of the 1992 WIG at the time was that it relied on a greatly expanded number of geographic stations and a more recent data set. Limitations, which have become more obvious over time, include the fact that the crop coefficients used are not available and the actual crop ET estimates need to be estimated (CIR + effective precipitation). Additionally, drought estimates were not provided in the 1992 WIG requiring practitioners to refer back to XB 0925 and Circular 512 if ET estimates for non-average water years are desired.

Figure 1. Estimates of Mean Pasture Irrigation Water Requirements from 1992 WIG (inches/year)



The 1992 WIG relied on both the Blaney Criddle (BC) method modified by the Food and Agriculture Organization (FAO24-BC) and another similar version by the Natural Resources Conservation Service (NRCS-BC) to estimate ET.

Figure 2. Estimates of Pasture IWR/CIR from WIG V2 (inches/year)



The 2014 WIG Update

In an effort to update the 1992 WIG, a new revision was developed using more recent and complete historical weather data and the ASCE-PM equation (Peters et al., 2014). Thirty years of daily historical weather data (1985 to 2014) was used from AgWeatherNet (the Washington State University agricultural weather network), AgriMet (an agricultural weather network run by the US Bureau of Reclamation), some COOP (cooperative) weather stations for temperature and precipitation information, and "ASOS" (**a**utomated **s**urface **o**bserving **s**ystem) weather stations for mostly air-travel-related information. This expanded the station coverage to about 240 weather stations. An additional study compiled the latest crop coefficient data available for 60 different crops that are grown in Washington. These data are available in a variety of formats for different climatic regions in Washington. Figure 2 shows the estimated annual IWR/CIR values for pasture.

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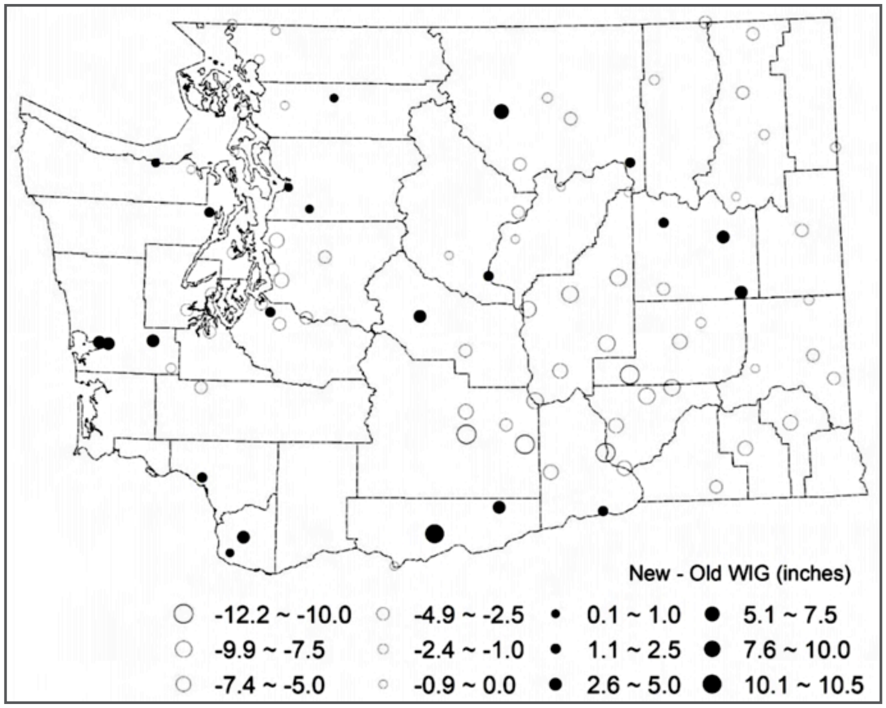
Irrigation Water Requirement (IWR)

For similar locations, differences in between IWR/CIR for the new and old WIG for grass are shown in Figure 3 (New - Old). The addition of other weather data in the new WIG (solar radiation, wind and humidity) caused some notable changes both up and down in the estimates.

The new WIG data are currently available on the web (Historic Average Water Needs Estimate). These data have not been adopted officially by Ecology, but can be used as another source of ET and CIR information by water practitioners in Washington.

Figure 3. Differences between the WIG and WIG V2 (New - Old) for Pasture.
Negative numbers show decreases in estimated IWR/CIR for grass, and positive numbers show increases



Spatial and Temporal ET Estimates Based on Remote Sensing

Satellite-Based Imagery Approach

Energy Balance Approach

Satellite-based estimation of ET also uses an energy balance approach. High orbiting satellites equipped with multi-spectral and thermal sensors provide the necessary data to estimate ET. Among several existing approaches (e.g. SEBAL, ALEXI, and METRIC), METRIC (Mapping EvapoTranspiration at High Resolution with Internalized Calibration) is the most widely used in the United States. In METRIC, the energy balance is estimated from: satellite data for radiation; surface temperature; and the Normalized Difference Vegetation Index — and then combined with other data including wind speed above the ground surface to estimate ET. Readers interested in further details are referred to Allen et al., (2007).

Satellite-Based

Satellite-based METRIC determines both ET and crop coefficients for dates of satellite passes. To estimate daily ET, the crop coefficients are interpolated for all the days of the growing season and used as multipliers for the ASCE-PM ET method using weather data from GridMet (4x4 km) (Abatzoglou, 2013) for regional applications, or ground weather stations for field applications.

METRIC ET outputs are obtained at 30 m/pixel (Landsat) or 1 km/pixel (MODIS), the latter too coarse for some applications (Chávez et al., 2021). Images from Landsat 7 and 8 satellites are infrequent but can be combined to have an effective frequency of eight days. Furthermore, satellite-based imagery and derived ET may often be affected by cloud cover or atmospheric dynamics.

ET Overestimation

To evaluate the accuracy of METRIC estimations, observed ET determined with methods such as lysimeters and eddy covariance flux towers are often used as reference, with many evaluation studies available in the literature (Allen et al., 2007; Folhes et al., 2009; Singh et al., 2011; Madugundu et al., 2017). Satellite-based ET evaluations show errors for daily ET normally fluctuating between 1% and 30% with the worst results attributed to extended data gaps. In general, lower errors were reported when daily ET was averaged over longer periods. Overestimation of ET is common early and late in the growing season. Errors arise from current technology limitations including frequency of satellite passes; 30x30 m spatial resolution which is not suitable for sparse canopies (*see* Figure 4); cloud interference; weather data availability; and lack of on-the-ground information about crop type and growing season. Rapid progress is being made, which is mitigating some of these limitations.

Error Causes

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Irrigation Scheduling

Corrections

Drones: On-Demand Imagery

Satellite: 30 m/pixel

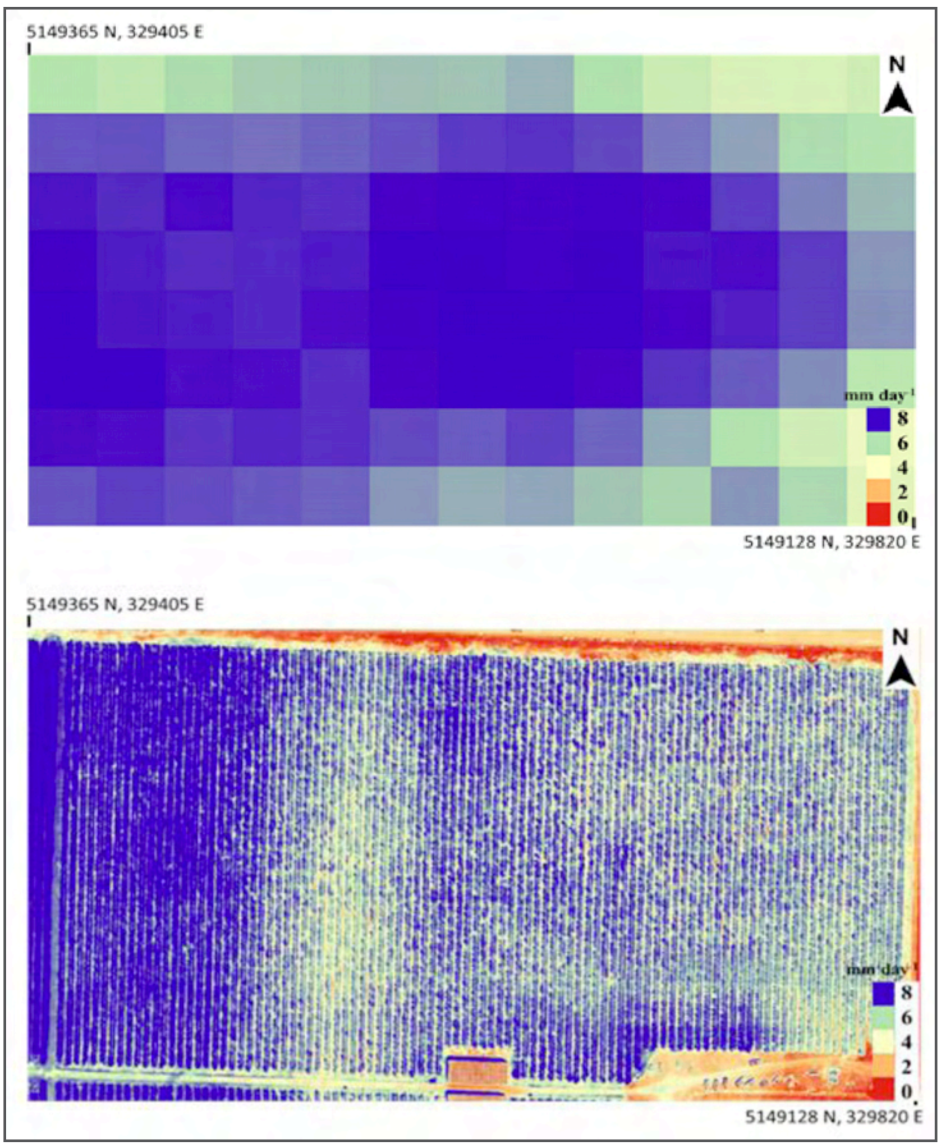
Drone: 7 cm/pixel

Drone-Based Imagery Approach

This approach ingests high resolution drone imagery data into energy balance models (e.g. the METRIC model) instead of using satellite data. Drones equipped with multi-spectral (visible and near-infrared) and thermal infrared imaging sensors provide the model input data. Drone-based imagery can be used to map ET and crop water use at a high spatial resolution, particularly in perennial row and irrigated field crops (*see* Figure 4). Such maps can help growers with irrigation scheduling decisions. Typically, drones are deployed to capture aerial imagery that is ground-referenced and mosaiced into larger images. These processes correct the images for spectral reflectance variations due to: changing light conditions; lens distortion; camera tilt; perspective; and topographic relief. These corrections occur prior to their use as the inputs to energy balance models or estimates of crop-coefficients from vegetation index. The outputs are field-scale, high-resolution, instantaneous ET maps (e.g. ~ 10 cm/pixel). Such maps can then be used with crop coefficient maps to estimate actual ET (daily, weekly, monthly or seasonal) by multiplying it with the local reference ET.

Drone-based remote sensed imagery inputs have been widely used with the modified versions of the METRIC energy balance model (Chavez et al., 2012; Elarab et al., 2016; Chandel et al., 2020; 2021; Chavez et al., 2021). Spatial resolution up to mm/pixel of ground area can be obtained in the drone imagery-derived ET maps. As drone imagery can be captured on-demand and in favorable environmental conditions, cloud cover and other related interferences that limit the usability of satellite-based data can be avoided. On the other hand, because the user must arrange for data collection, cost often limits the spatial and temporal extent of data collected.

Figure 4. Satellite Imagery-based (30 m/pixel) and Drone Imagery-based (7 cm/pixel) Crop ET Mapping (mm/day) of a commercial apple orchard block from central Washington



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Spacial Variability

The drone imagery coupled with energy balance approaches can aid in mapping spatial variability of ET at very high resolution (Figure 5), allowing the separation of plant transpiration (T) from ET. Such separation is important for block-level irrigation related decisions for high-value perennials (e.g. grapes, apples). Researchers have evaluated drone-based ET for corn and soybean with lysimeters (accepted as the standard measurement of ET) and reported daily ET errors of 2.4 plus/minus 9.3% compared to lysimeters (Chávez et al., 2012). As these methods have been only recently applied in research settings, they are not yet commercially available to practitioners. However, it is likely that consultants and others will offer such estimates in the near- to medium-term.

Combined Crop Model and Satellite Imagery ET Estimation: CropSyst

CropSyst Model

Combining crop model ET algorithms and satellite-based data provides an avenue for overcoming some of the temporal limitations of satellite-based remote sensing methods. Process-oriented dynamic crop growth simulation models can calculate daily ET by considering: weather; crop canopy and root development; and soil profile water changes.

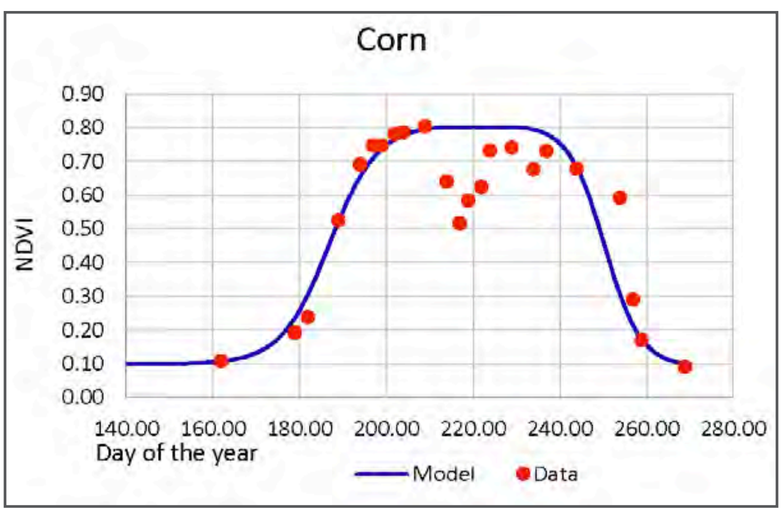
CropSyst, a cropping systems model developed at Washington State University (Stöckle et al., 1994, Stöckle et al., 2003), has been modified to implement a simple, customized, ET model. Because the CropSyst model includes many processes to simulate crop responses to the environment and management — not all of which are needed for ET estimation —only selected algorithms of crop growth related to water were extracted.

Canopy Cover

CropSyst algorithms were coded for field ET estimation, including a method for assimilating remote sensing data as input to the model. Specifically, canopy cover (the fraction of solar radiation intercepted by crop canopies) is estimated from the Normalized Difference Vegetation Index (NDVI) and assimilated into the model. This greatly improves estimation of ET when the timing and extent of canopy development is not known from ground measurements, which is the case in regional applications. It allows for the estimation of the beginning and end of the growing season. NDVI data points, collected by the Sentinel2 low-orbit satellite over a corn center pivot field can be used to fit a realistic envelope to the measured points (*see* Figure 5). This growth curve can then be used as input to the ET model. Crop ET is based on the Food and Agriculture Organization (FAO) FAO56-PM equation, with daily crop coefficients calculated from canopy cover. The FAO56-PM ET is adjusted by root water uptake that depends on soil water content to provide actual crop ET — an approach that has been proved reasonably accurate (*see* Stöckle and Jara, 1998, and Jara and Stöckle, 1999).

Although this combined approach is currently in the research stage and being tested with data, it is anticipated that a version available for practitioners will be available in the near term.

Figure 5. Sentinel2 NDVI Data for a Corn Field with envelope used as input to the crop ET model



What's Next for Crop ET Estimation

Evolving Methods

Methodologies for crop ET are quickly evolving, with multiple new methods emerging or in the process of development. Even estimates of crop ET using a single method will continue to change over time, as they incorporate new climatological data, new science on crop coefficients, and data from new weather stations. The suitability of a particular ET estimation method depends on its proposed use, the advantages and disadvantages of the method, and approximate accuracy (*see* Table 1).

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Error Reduction

Use of older crop ET methods like the FAO24 Blaney-Criddle method are not the state of the science and could have the potential to undermine the accuracy of permitting, design, and planning decisions. Measured ET with the ASCE or FAO56 Penman-Monteith equations give reliable performance (Lopez-Urrea et al., 2006; Allen, 1986; Benli et al., 2010). Comparison of satellite-based ET estimates to PM values has errors for daily ET from 1 and 30% with the worst results when there are extended satellite data gaps. Comparison of drone -based and lysimeter ET estimates have reported daily errors of -7 to 12%. Combining crop model ET methods and imagery has the potential to further reduce the errors associated with imagery and fill in data gaps between satellite passes.

Increasing Accessibility

Accessibility to satellite-imagery is continually increasing while platforms for automating the use of these immense data sets for easy estimation of crop ET are improving rapidly. One platform is the Earth Engine Evapotranspiration Flux (EEFlux), which is designed using the Google Earth Engine to implement the METRIC algorithm and automate the process of data entry and calibration (https://eeflux-level1.appspot.com). Meanwhile, OpenET is an interface that will likely provide access to multiple ET methods including METRIC in coming years (www.openetdata.org). Accessibility, especially via online interfaces where a user can specify the ET estimates most appropriate for their application, will likely lead to increased familiarity and use of both existing and emerging ET methods.

Improving Data

Discussions between federal agencies such as NASA, State water resource agencies, and universities working on research in this area will also hopefully improve the availability of suitable data for ET estimation. The lack of low-orbit satellites with both multi-spectral and thermal infrared imaging sensors is one obvious data gap. Improved data and knowledge about current and emerging ET estimates will contribute to continued progress in the development of accurate ET techniques and more common usage of the best available technologies.

Table 1. Comparison of Different ET Estimation Approaches: Limitations & Advantages

Crop Water Use Information Source	Who Should Use	Spatial Extent	Temporal Extent	Strengths	Limitations
Circular 512, XB0925, 1985 WIG, 1992 WIG	Those interested in historical ET estimations.	Select temperature stations	Annual average	Historic standard	Method relies on temperature and percent sunshine. Weather datasets are 50 years or more old, and no longer represent current climate.
2014 WIG Update	Irrigation system designers, regulators, water right practitioners	Select weather stations	Annual average	Includes radiation and other weather variables, more stations, updated methods. Historical data is relatively recent, reflecting current experience of climate change.	Not updated annually. Date range can't be specified by the user.
Satellite-based	Regulators & Water Right Practitioners	30x30 meter pixels, statewide	Currently every eight days combining Landsat 7 and 8 revisits (daily interpolation possible)	Can provide ET estimates over larger spatial extents (e.g. watershed, state). Estimates can be developed for any location.	Only a "snap-shot" in time. Very large "pixels" Requires expertise to download and process data.
Drone-based	Growers to identify problem areas of the field, and for irrigation scheduling	10x10 cm/pixel or higher coverage, field/block scale	User specifies drone flight frequency (daily interpolation possible)	Can provide ET estimates at plant level. Necessary for variable rate irrigation and "precision farming".	Only a "snap-shot" in time. Maturing yet evolving technology. Requires expertise to download and process data. Users need to collect data, so coverage can be limited temporally and spatially.
Crop model based	Growers for irrigation scheduling	Field	Daily	Integrates strengths of crop models with satellite data	Requires expertise to parameterize the model for different crops.

Evapo Transpiration

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Evapo Transpiration

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Water Bank

ARIZONA WATER BANKING

RECOVERY OF WATER STORED BY THE ARIZONA WATER BANKING AUTHORITY

Edited from Arizona Water Banking Authority Information

Introduction

Back-Up Water Supplies

The Arizona Water Banking Authority (Water Bank or AWBA), has been storing water underground for 25 years to protect against future shortages on the Colorado River. The AWBA was established in 1996 to store the unused portion of Arizona's annual Colorado River entitlement in Central and Southern Arizona. The AWBA stores water in underground aquifers to earn long-term storage credits. These credits can be recovered (pumped) during a shortage to provide back-up water supplies (known as "firming") for Arizona water users. It increasingly appears that the Colorado River Basin will be facing shortage sin 2022, so the capability to recover this supply is more important than ever.

Long-Term Storage Credits (LTSCs)

With the storage of CAP-delivered water underground from its inception in 1996 through 2019, the Water Bank has accrued 4.28 million acre-feet (MAF) of **l**ong-**t**erm **s**torage **c**redits (LTSCs): 3.67 MAF for Arizona uses and 0.61 MAF on behalf of the State of Nevada (on behalf of the Southern Nevada Water Authority - SNWA). The AWBA has stored water at two dozen recharge facilities located in the Phoenix, Pinal, and Tucson Active Management Areas (AMAs). Of the 3.67 MAF of intrastate LTSCs, 1.92 MAF are in the Phoenix AMA, 1.04 MAF are in the Pinal AMA, and 0.71 MAF are in the Tucson AMA. The AWBA has also accrued nearly 614,000 acre-feet of LTSCs on behalf of SNWA with more than two-thirds of these LTSCs accrued in the Pinal AMA. The AWBA firms water supplies for Central Arizona Project (CAP) Municipal and Industrial (M&I) subcontract holders and communities along the Colorado River. The storage of Central Arizona Project water serves to mitigate Arizona reductions in supply due to Colorado River shortages.

Colorado River Shortages

Interstate Water Banking

As the agent for the State of Arizona, the AWBA is responsible for meeting the State's Indian firming obligations under the Arizona Water Settlements Act (AWSA). The Water Bank also assists with meeting the State's water management objectives under the Groundwater Code and provides the mechanism for interstate water banking with the other Lower Basin States. By storing water, the Water Bank helps to ensure long-term water supplies for Arizona and neighboring states. In total, nearly 12 million acre-feet of water have been stored underground in multiple locations around Arizona over the years. In addition to the Water Bank, entities storing that water include cities, tribes, and private organizations.

Methods

Storage of water underground generally uses one of the following methods. An Underground Storage Facility (USF) is a facility that physically stores water in the aquifer through direct recharge (*see* Figure 1); a Groundwater Savings Facility (GSF) is an indirect recharge facility that uses surface water (CAP water) instead of pumped groundwater (*see* Figure 2).

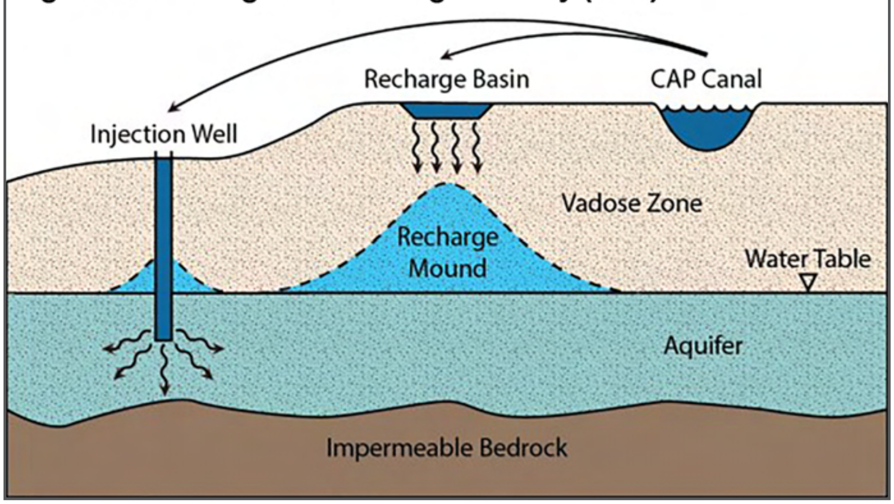
2021 Update to Recovery Plan

Recovery Implementation

With the increasing likelihood of Colorado River shortages and the additional reductions required under the Lower Basin Drought Contingency Plan (completed and signed in 2019), stakeholders expressed a desire for additional clarity in recovery implementation. The Lower Basin of the Colorado River Basin is comprised of the states of Arizona, Nevada, and California; the Upper Basin States are Wyoming, Colorado, Utah and New Mexico. The drought contingency plans for the Upper and Lower Colorado River basins are designed to help stabilize the river system, and to help reduce the risk of the system reservoirs falling to critically low levels. (Plans available at: https://new.azwater.gov/lbdcp).

The Water Bank, along with the Arizona Department of Water Resources (ADWR) and the Central Arizona Water Conservation District (the governing entity for the Central Arizona Project), convened the "Recovery Planning Advisory Group" in January 2018. That advisory group (RPAG) sought to ensure that stakeholder perspectives are considered as recovery planning

Figure1: Underground Storage Facility (USF)



Water Bank

2021 Update

Credits Recovery

Update Highlights

Planning: Through 2045

"Firming" Objectives

Direct Recovery Projects

Utilization Rates

Credit Exchange

concepts are updated. According to the Water Bank, the contributions of RPAG members and other stakeholders played an important role in furthering the concepts reflected in the recently completed 2021 Update. That update, the "Recovery of Water Stored by the Arizona Water Banking Authority: A Joint Plan by AWBA, ADWR and CAP" is now available online. [Available at: https://new.azwater.gov/sites/default/files/media/2021_Update_Joint_Recovery_Plan.pdf].

Officially known as the "2021 Update to the Joint Recovery Plan" the "2021 Update serves as a companion document to an earlier version prepared in 2014. The 2014 Plan — also a collaborative effort among the Water Bank, ADWR and CAP — provides a roadmap for the recovery of Water Bank water-storage credits. [2014 Plan available at: https://waterbank.az.gov/sites/default/files/media/Joint_RecoveryPlan04-14-14withsignedpreface_0.pdf].

The 2021 Update to the Joint Recovery Plan (Joint Update) represents a collaborative effort among the AWBA, Central Arizona Water Conservation District (CAWCD, referred to in this plan as CAP), ADWR, and RPAG, to improve planning-level certainty, refine key recovery concepts and prepare for the recovery of AWBA Long-Term Storage Credits (LTSCs). It includes an update on recovery planning activities that have occurred since the completion of the 2014 Joint Recovery Plan (2014 Plan), an updated analysis of projected AWBA firming volumes, estimated recovery capacity needs, and an updated operational timeline to further refine the procedural steps for recovery implementation.

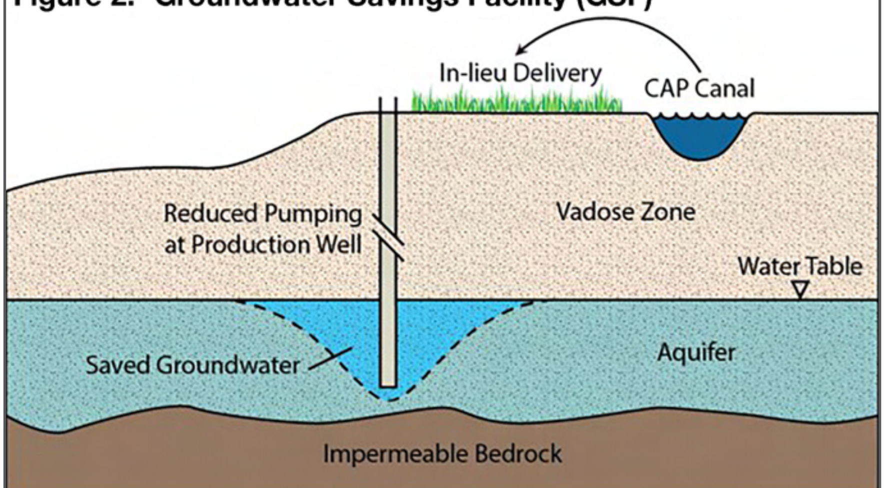
Highlights of the 2021 Update to the Joint Recovery Plan are:

- Provides an analysis of projected Water Bank firming volumes and estimated recovery capacity needs
- Builds on previous planning efforts outlined in the 2014 plan
- Discusses recovery concepts intended to increase flexibility and fully use existing infrastructure
- Provides an updated operational timeline to further refine the procedural steps for recovery
- Identifies future activities and commitments by AWBA, ADWR, and CAP

The range of possible future AWBA firming and recovery needs identified during the planning period (through 2045) frames the likelihood, timing, and magnitude of recovery activities. Modeling results suggest that the probability of firming and the annual firming volumes are low in the near term but will likely increase steadily through 2045. Reductions to Tribal CAP Non-Indian Agriculture (NIA) supplies are expected to be the first reductions requiring AWBA firming since these supplies have a lower priority. While firming volumes are much higher for CAP municipal and industrial (M&I) supplies, shortage reductions to these supplies are more likely to occur in the mid to long-term planning periods. Similarly, firming for on-River Fourth Priority (P4) M&I may not be needed until the latter portion of the planning period and volumes are expected to be relatively small.

Future activities include CAP efforts to secure additional short and long-term recovery partnership agreements and perform feasibility studies for future direct recovery projects. The AWBA is committed to further analysis of credit distribution, credit balances, and credit utilization rates for each of its firming objectives. All three agencies will continue to work in collaboration with the RPAG and continue monitoring the factors that influence Colorado River supplies. This includes joint technical work to perform updated recovery modeling and analysis in response to the work of the Arizona Reconsultation Committee (convened in 2020) and further analysis of the estimated AWBA credit balance utilization rates over the next one hundred years.

Figure 2: Groundwater Savings Facility (GSF)



Next Steps

The 2021 Update notes what is expected as their "Next Steps" at page 37: "Successful recovery depends on the effective implementation of various recovery opportunities using methods such as credit exchange, indirect recovery and direct recovery. AWBA and CAP will continue to pursue recovery opportunities to secure recovery capacity for intrastate recovery and interstate ICUA on behalf of SNWA. With changing hydrologic conditions, continued analysis and coordination will be needed to ensure additional recovery agreements are in place and new infrastructure can be planned for appropriately."

For Additional Information:
2021 Update available at Water Bank website: https://waterbank.az.gov/

WATER BRIEFS

EVAPOTRANSPIRATION US

RECENT GLOBAL RISE

A team of researchers at NASA's Jet Propulsion Laboratory at the California Institute of Technology has found that global evapotranspiration rose by ten percent from 2003 to 2019. In their paper published in the journal Nature, the group describes the original approach they took to measuring global evapotranspiration.

Evapotranspiration is the transfer of water from the ground to the air from both evaporation and transpiration, water emitted by plants. It is one of the main components of the planet's water cycle. Scientists have been predicting for several years that Earth's water cycle will gain energy as the planet heats up due to global warming — but proving it has been difficult because there is no reliable way to measure changes in evapotranspiration — until now, most efforts have been far too localized. In this new effort, the researchers found a way to calculate global evapotranspiration over periods of time using information from satellites.

Instead of attempting to measure evapotranspiration directly, as has been done in other efforts, the researchers used satellite data to measure other parts of the water cycle and then used that data to calculate the degree of evapotranspiration. And rather than using satellite imagery of clouds and groundwater, the researchers used data collected by the Gravity Recovery and Climate Experiment and its follow-up study GRACE-FO. Both were involved in measuring changes to large amounts of water on the surface. Notably, neither system needed to be able to see the ground below, which meant that measurements were not interrupted by cloud cover. The data from the satellites was in the form of changes in gravity that correspond with changes in large amounts of water — the satellites were actually pulled by such changes. Next, the researchers obtained data for the other parts of the water cycle. Then, using data from both sources, they were able to calculate the rate of evapotranspiration for the years 2003 to 2019. And as they did so, they noted that the rate rose slightly each year, and that over the entire span of time, the rate had risen by approximately ten percent.

For info: https://phys.org/news/2021-05-global-evapotranspiration-rose.html

WATER TRANSFERS CO

TRANSACTION COST

Recent research by Philip Womble of Stanford University and Michael Hanemann of Arizona State University published in the journal Water Resources Research examines transaction costs in Colorado's water market in an effort to quantify factors that affect the total cost of securing regulatory approval. The research team conducted a survey of 100 water attorneys and engineers whose fees make up the bulk of transaction costs. They asked these water professionals to provide estimates of their fees for various hypothetical (but realistic) water transfers. The hypothetical water transfers and corresponding survey responses varied by the following characteristics: 1) transfer volume; 2) water right seniority or reliability; 3) river basin location of the water transfer; and 4) degree of conflict and opposition in the regulatory process.

Key takeaways from the research effort on Colorado water market transaction costs are:

Competition and Complexity Increase Deal Costs: Transaction costs are roughly twice as expensive in the fast growing and more urbanized Front Range region where water competition is high and demands are diverse compared to the more rural parts of the state. The Front Range has greater water supply deficits and more complex water rights administration, which influences the cost of gaining regulatory approval.

Small Deals Are Disadvantaged: Small volume water transfers face greater impediments because transaction costs exhibit substantial economies of scale, with higher unit costs for smaller transfers. Transaction costs were found to exceed the market price of the water rights for small transfer volumes of approximately 20 to 30 acre-feet. This explains why many municipal water utilities pool multiple water acquisitions (of the same asset) together before applying for regulatory approval, and why few observed water transfers are for small volumes of water.

An Established Regulatory Path Motivates Market Activity: Most water transactions in Colorado involve assets that have a well-worn regulatory path. Historical (approved) changes provide precedence that reduces regulatory uncertainty and risk, and low regulatory risk keeps buyers interested. For example, the only water assets that are accepted by municipal utilities for new water service typically have at least two, and often have four or more, previous regulatory approvals. The flip side of this also holds true. Uncertainty in transaction costs can be an impediment to water market activity. Buyers are known to be cautious when evaluating water assets that do not have a track record of previous regulatory approvals.

Deal Costs are on the Rise: Nearly all survey participants said that transaction costs have increased more than the rate of inflation during their careers. The most common reason given for this cost increase was growing competition for scarce water resources. Other reasons for observed cost increase included more strident legal opposition, more complex hydrologic analyses, and disputes over relatively small amounts of water — so small that the arguments are often well beyond the precision of available measurement devices and the underlying hydrologic analyses.

Transaction costs are a necessary pill to swallow for most trades in the Colorado water market, with long-term benefits to the health of Colorado's water market and water management. These transaction costs can be daunting for market participants, in part because of their uncertainty and the feel of an open checkbook. The research by Womble and Hanemann shaves away some of this uncertainty by providing some useful benchmark cost estimates for changing water rights and realizing the benefits of water trades.

WATER BRIEFS

Please refer to the peer-reviewed journal articles below for an expanded discussion of the research findings: Womble, P. and W.M. Hanemann (2020a). *Water markets, water courts, and transaction costs in Colorado*. Water Resources Research, 56, e2019WR025507; and Womble, P. and W.M. Hanemann (2020b), *Legal change and water transaction costs in Colorado*,
Water Resources Research, 56, e2019WR025508.
For info: WestWater Research at: www.waterexchange.com; Water Resources Research at: https://agupubs.onlinelibrary.wiley.com/journal/19447973

WATER SYSTEMS MAP TX

INTERACTIVE TOOL

The RGK Center for Philanthropy and Community Service, University of Texas at Austin (RGK Center), recently published the article "Surveying the Landscape: Faculty Develops an Interactive Map of the Texas Water Policy System," which details the need for and work behind the Texas Water Systems Map. RGK Center faculty and staff are collaborating with Texas Water Foundation to develop an interactive map of the Texas water systems landscape. The Texas Water Systems Map is the first comprehensive policy system map of the Texas water sector and will help equip decision-makers and stakeholders with the knowledge to better understand the complex water landscape at the state and local levels.

"Systems maps are a tool to explore the system — in this case, the policy and governance of Texas water," said Patrick Bixler, Ph.D., an assistant professor at the LBJ School of Public Affairs and core faculty member at the RGK Center. "They help different stakeholders understand and communicate about the interconnections in the system, and assists in identifying knowledge gaps, intervention points, and insights." The Texas Water Systems Map is the first system map that captures how different water entities interact and are related to each other in one comprehensive, accessible tool.

Dr. Bixler, LBJ School PhD candidate Regina Buono, and Ethan Tenison, Project Manager of Data Initiatives at the RGK Center, developed the interactive map using cognitive modeling and data analysis. The idea for the map has been several years in the making and was developed out of collaboration among several organizations.
For info: Systems Map available at: www.texaswater.org/texas-water-systems-map

GW SUSTAINABILITY CA

FIRST ASSESSMENTS

The California Department of Water Resources (DWR) on June 3rd released its first assessments of groundwater sustainability plans developed by local agencies to meet the requirements of the Sustainable Groundwater Management Act (SGMA). DWR has completed its assessment and approved plans for the Santa Cruz Mid-County Basin in Santa Cruz County and 180/400 Foot Aquifer Subbasin in Monterey County. The **g**roundwater **s**ustainability **a**gencies (GSAs) for these critically over-drafted basins will continue implementing their plans to achieve SGMA's goal of groundwater sustainability within 20 years.

DWR has also notified GSAs for the Cuyama Valley Basin and Paso Robles Subbasin that their plans lack specific details and are not yet approved. DWR is requesting a consultation meeting with the GSAs to discuss actions necessary to improve the plans. DWR is committed to working with local agencies and providing technical and financial support to help them bring their basins into balanced levels of pumping and recharge.

DWR is releasing plan assessments as they are completed, rather than waiting to release the assessments at the end of the two-year review period in January 2022, to provide early feedback and guidance that can inform other GSAs as they develop their plans. SGMA initiated a new era of local groundwater management. For the first time in California's water history, local agencies and groundwater users are required to form GSAs and develop and implement plans to guide how they will achieve groundwater basin sustainability goals over the next 20 years. SGMA lays out a process designed for continuous improvement — gathering information to fill data gaps, updating plans, and promoting science-based adaptation. Plans will be updated as new information becomes available and as conditions change in groundwater basins. DWR will review annual reports and also assess each plan every five years to determine if the GSAs are on track to meet their basin's goal.

Despite the long-term timeline, SGMA requires near-term actions that will help the state manage water resources during dry and drought years. For example, GSAs have been required to submit annual progress reports since 2020 with the most up-to-date monitoring and plan implementation information for their groundwater basins, including groundwater levels and use. This data can be accessed on the SGMA Portal. By tracking conditions and implementation performance, the state and local agencies can better manage water resources during average and wet years to ensure groundwater will be available as a buffer during dry years.

In addition to and aligned with plan evaluation, DWR continues to support GSAs by providing planning, technical and financial assistance. Recently, DWR announced $26 million in grant funding for project investments to improve water supply security, water quality, and the reliability of groundwater. These efforts align with the Administration's budget proposal for significant additional funding for projects to improve groundwater conditions and advance safe drinking water efforts for groundwater-dependent communities. Additional information, including a video message from DWR on the assessments, is available at the website listed below.
For info: https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Groundwater-Sustainability-Plans

WATER BRIEFS

DROUGHT BARRIER CA

SALTWATER INTRUSION

In response to worsening drought conditions, on June 3rd the California Department of Water Resources (DWR) began construction on a temporary emergency drought barrier on the West False River in the Sacramento-San Joaquin Delta. The barrier will help slow the movement of saltwater into the central Delta and prevent contamination of water supplies for Delta agriculture and municipal supplies for millions of Californians who rely on Delta-based federal and state water projects for at least some of their supplies. The emergency barrier will also help conserve critical water supplies in upstream reservoirs for later use by avoiding the need to send large volumes of water into the Delta to repel salinity this summer.

On June 1, a temporary urgency change petition to modify State Water Project and Central Valley Project water rights conditions was approved by the State Water Resources Control Board (SWRCB), which will allow for water to be conserved for later instream uses and water quality requirements. These modifications are needed to help protect cold water pools for salmon and steelhead and maintain water quality while ensuring some water supplies are maintained if drought conditions persist next year.

DWR is working to get the temporary emergency drought barrier in place as soon as possible. The approximately 800-foot-wide temporary barrier consisting of nearly 90,000 cubic yards of rock will span the West False River and prevent salty tides and slower moving salinity from intruding into the interior Delta. Construction is expected to be completed by July 1. The barrier will be removed no later than November 30. The barrier will block watercraft passage on West False River until its removal.

On April 21, Governor Gavin Newsom signed an emergency order directing state agencies to take immediate action to bolster drought resistance across the state. The installation of a West False River drought salinity barrier during the 2012-16 drought proved to be an effective tool for reducing the intrusion of saltwater into the central and south Delta, and helped preserve freshwater supplies for future critical uses including drinking water and the environment. The West False River drought salinity barrier is just one of many actions DWR is taking to mitigate drought impacts consistent with the emergency order.

For info: DWR's Drought Webpage at: https://water.ca.gov/Programs/All-Programs/Drought

PURCHASE OF WATER CA

SUPPLEMENTAL SUPPLY

On May 26, the Nevada Irrigation District (NID) announced that to ensure an adequate water supply, NID is making arrangements to purchase supplemental water from Pacific Gas & Electric (PG&E). NID's press release noted that the importance of finding additional water supplies continues to increase as the drought intensifies. Based on its analysis and forecasts, the purchase of supplemental water is necessary to safeguard public health and safety supplies in the event that the 2021/2022 winter is dry. The intent of the purchase is to bolster carryover storage heading into the 2022 water year.

NID's Board of Directors approved a budget amendment of $600,000 for the purchase during its May 26 meeting. The action will enable NID to purchase nearly 16,000 acre-feet of water from PG&E throughout the summer.

Chip Close, NID's Operations Manager, detailed the water conditions during the May 26th meeting. Seasonal precipitation at Bowman Lake was only 51 percent of average, at 33.95 inches. The forecasted carryover storage could drop to 106,700 acre-feet, a level not seen since 2001. As a result of grim precipitation and a runoff that has tapered off, reservoir storage is affected. It is currently the third driest year NID has experienced since 1900: "The outlook for carryover storage is bleak," Close said.

The funds for the PG&E purchases are being transferred from three departments: Operations ($70,000), Recreation ($200,000) and Engineering ($350,000). Each department has found ways to accommodate the transfers with no impact to water delivery to customers or District projects. For example, the Recreation Department was able to transfer $200,000 by withholding the purchase of a generator for the Scotts Flat Campground. The transfer of funds will be offset by a donation of a repurposed generator from the water division.

NID's normal water supply originates as snowmelt found in 70,000 acres of high elevation watershed near the headwaters of the Yuba River, Bear River and Deer Creek. NID moves supplies to one of its 29 reservoirs, and later releases water destined for drinking to one of six water treatment plants for filtration and purification. All of the water passes through hundreds of miles of canal and pipe to become drinking or irrigation water for 25,000 homes, farms and businesses. The annual result is three billion gallons of high quality drinking water and enough irrigation water for 30,000 acres of agricultural land. NID also delivers water for power. NID is a leader among Northern California water agencies in the production of clean, renewable hydropower. It operates seven hydroelectric plants and nine miles of overhead powerlines that deliver 82 megawatts of renewable energy to the power-grid (enough electricity to power 60,000 homes). Revenue from hydropower sales offsets water rates

For info: NID website: www.nidwater.com/

BORDER PROGRAM US/MEX

US-MEXICO ENVIRONMENTAL

The US Environmental Protection Agency (EPA), in partnership with Mexico's Ministry of the Environment and Natural Resources (SEMARNAT, by its acronym in Spanish), is pleased to announce the signing of the "U.S.-Mexico Environmental Program: Border 2025" (Border 2025) that advances the two countries commitments to protect the environment and public health

WATER BRIEFS

along the US-Mexico border. "Today [May 25], the United States and Mexico memorialized our shared commitment to tackle the urgent environmental issues of our time, and to improve health conditions for underserved and vulnerable communities living along our border region," said EPA Administrator Michael S. Regan. "Signing this framework will help ensure sustained progress by increasing the role of the public in our discussions and our projects."

As the Border 2020 framework concluded, Administrator Regan of EPA and Secretary Maria Luisa Albores of Mexico's SEMARNAT reviewed what has become a period of intense cooperation on the environment. The Border 2020 Progress report highlights activities in areas such as climate change and reducing water pollution, as well as efforts to clean sites and respond to environmental emergencies in border cities. EPA and SEMARNAT have built a solid foundation for future efforts that will be needed as the border area continues to develop and grow.

The border area's population growth, fueled in part by dramatic industrial growth, is expected to double over the next 20 years. Infrastructure and ecosystems are expected to face serious challenges concerning water quality and quantity, waste management, and air pollution. The vision of sustaining growth without damage to the environment or the well being of future generations will depend on vigorous action today.

Border 2025 is the latest cooperative effort implemented under the 1983 La Paz Agreement. The framework proposes a five-year (2021-2025), binational environmental program that includes four strategic goals to address the environmental and public health challenges focusing on improving air and water quality, promoting clean land, strengthening preparedness, and response to environmental emergencies. The program encourages meaningful participation from communities and local stakeholders within 100 kilometers (62 miles) on either side of the 2000-mile border between the US and Mexico.

For info: Border 2025 at: www.epa.gov/usmexicoborder/border-2025-framework; Joshua Alexander, 415/ 972-3258 or alexander.joshua@epa.gov

URBAN PARK GRANTS US

ECONOMICALLY UNDERSERVED

On May 10, Secretary Deb Haaland of the Department of the Interior announced that the National Park Service (NPA) would distribute $150 million to local communities through the Outdoor Recreation Legacy Partnership (ORLP) grant program. The program, established in 2014, enables urban communities to create new outdoor recreation spaces, reinvigorate existing parks, and form connections between people and the outdoors in economically underserved communities.

The ORLP program, funded through the Land and Water Conservation Fund (LWCF), is a nationally competitive grant program that delivers funding to urban areas — jurisdictions of at least 50,000 people — with priority given to projects located in economically disadvantaged areas and lacking in outdoor recreation opportunities. Shawn Benge, National Park Service deputy director for operations noted that, "To help create more equitable access to the outdoors, we have opened the ORLP grant program to more communities by removing the cap on the number of proposals states can submit on behalf of local jurisdictions and by increasing the maximum grant from $1 million to $5 million."

Funding applications are now being accepted in Grants.gov through September 24. States may apply for the grants, whether on behalf of themselves or eligible urban jurisdictions. Interested jurisdictions should contact their state lead agency for LWCF. A list of contacts can be found at LWCF's contacts page. Project sponsors must match the grant award 1:1 with non-federal dollars. A total of $150 million in funding is available during this grant cycle.

For info: NPS's LWCF webpage at: www.nps.gov/subjects/lwcf/index.htm

TROUT RESTORATION WA

INCREASED SURVIVAL RATES

In an effort to return numbers of bull trout to self-sustainable levels, in late May the Yakama Nation Fisheries and their partners released 531 bull trout into Kachess Reservoir and 61 bull trout into Gold Creek, a tributary to Keechelus Reservoir. Through the Upper Yakima Bull Trout Restoration and Monitoring Project, the Yakama Nation seeks to increase current bull trout population size and range by rescuing stranded juvenile bull trout during low water conditions, rearing the juveniles for up to one year to increase survivability, and re-introducing the reared fish back into good quality historic habitats, thus reducing future losses and increasing natural reproductive potential.

"This year's releases have been a great success with increased survival rates ranging from 89% to 95%," said Joe Blodgett, Yakima/Klickitat Fisheries Program Project Coordinator. "We're really seeing that an adaptive management approach will result in maintaining bull trout viability while the Yakima Basin Integrated Plan [YBIP] works to restore degraded spawning and rearing habitat." Led by Yakama Nation Fisheries, the project is a component of the YBIP to ensure the persistence of bull trout above Reclamation's dam in the upper Yakima basin. Future actions may include maintaining other at-risk populations in the basin and re-introduction of bull trout in watersheds where bull trout have been lost.

Funded by Washington's Department of Ecology and the US Bureau of Reclamation, this project adds to the goals of the YBIP to foster watershed health and ecosystem restoration in the basin. "We are really beginning to see these great results from our Bull Trout Enhancement MOU we signed in 2015 among the YBIP partners, and I am especially thankful for the Yakama Nation and State Fish & Wildlife staff who have made these words of commitment on paper come forward into reality," said Tom Tebb, Director of Ecology's Office of Columbia River.

WATER BRIEFS

This is the second season a team of biologists from Yakama Nation, Mid-Columbia Fisheries, Washington Department of Fish and Wildlife, Kittitas Conservation Trust, and other partners have rescued the juvenile bull trout from the isolated pools within the dewatering reaches of Gold Creek and the upper Kachess River, reared them in rearing tanks over the winter, and released them in the spring.

For info: YBIP website: https://yakimabasinintegratedplan.org/

CLIMATE EMERGENCY CA

FISH KILL ON KLAMATH

The Karuk Tribe in northern California issued a press release on June 1 declaring a climate emergency due to a "massive fish kill…currently underway in the Klamath River that could result in losing an entire generation of salmon." The Tribe goes on to point out that, hydrological conditions in the Klamath River Basin are the worst in modern history, although in recent years this has become an all-too-common refrain. Ecosystems and economies all along the California/Oregon border are strained to their breaking point. "Our monitoring traps are full of dead juvenile salmon. The few fish still alive are infected with disease. It's a catastrophic blow to the fishery and Karuk culture," said Toz Soto, Fisheries Program Manager for the Karuk Tribe.

The disease-causing parasite Ceratonova shasta (C. shasta) has been linked to Klamath salmon declines for decades. A complex of dams in the mid-Klamath disrupt natural flow patterns and cause warmer than normal water temperatures. This creates an ideal habitat for the parasite to flourish downstream of the dams. However, these dams don't control how much water is in the Klamath River, as that is a function of how the Bureau of Reclamation (BOR) manages irrigation diversions from Upper Klamath Lake in Oregon, 50 miles upstream.

The current BOR operations plan calls for "flushing flows" to scour the river channel and dilute parasites during disease outbreaks. This year, historically low inflows to Upper Klamath Lake led BOR to rule out a flushing flow to the river.

Officials made drought declarations in the Klamath Basin in eight out of the last 12 years. The Karuk Tribe says this year's crisis is not an aberrant weather pattern but reflects a change in climate. "It's time to face the reality of climate change which means we must change how we manage the Klamath's water resources," noted Karuk Chairman Russell 'Buster' Attebery. "We need long-term solutions to adapt to this new climate immediately, or it will be the end for salmon and the cultures that depend on them."

Tribal officials have asked Congress to provide disaster relief funds to all affected communities to address economic hardship, and ecological breakdown. In order to protect as many fish as possible, the Karuk Tribe urges state and federal agencies to broker temporary water transactions to keep critical stream reaches wet, but also point to long-term solutions to recover fisheries and make the ecosystem resilient in the fact of climate change.

Some relief for salmon is on the horizon. An agreement is in place to remove the lower four Klamath River dams in 2023. The dams offer no irrigation diversions or flood protection and the parent company Berkshire Energy has agreed to removal. "Dam removal will improve water quality, disrupt the habitat for disease vectors, and allow salmon to access historic spawning grounds," says Attebery. "We are praying the fish can hang on until then."

For info: Craig Tucker, Karuk Tribe, Natural Resources Policy Consultant, 916/ 207-8294 or www.karuk.us/

WATER PROTECTION LAW AZ

SURFACE WATER POLLUTION

On May 5, Governor Doug Ducey signed legislation to ensure clean water in nearly 800 Arizona streams, lakes and rivers that are critical for drinking, fishing, and recreation. "Living in the desert, the value of water is something we in Arizona know well, and we have taken great steps to protect it, including the Groundwater Management Act and the Drought Contingency Plan," said Governor Ducey. "But just having water is not enough. We need to ensure our water supplies are clean and safe. That's why I signed into law another landmark Arizona water protection bill — the Surface Water Protection Program providing protections for nearly 800 Arizona streams, lakes, and rivers."

House Bill (HB) 2691 implements the Arizona Surface Water Protection Program by creating a list of rivers, streams, and lakes used for drinking, recreation, and fishing that are protected from harmful discharge of any pollutant. Specifically, the legislation:

- Preserves important water quality safeguards and provides clarity and consistency to the regulated community
- Promotes transparency by providing a defined list of protected Arizona waters that will be protected through a permitting program, as well as Geographic Information System map functionality, on the Arizona Department of Environmental Quality (ADEQ) website
- Provides an opportunity to develop meaningful and impactful best management practices that will protect these important waterways.

"With this legislation Arizona will protect its most important waters that are not currently regulated by the federal government in a streamlined and locally responsive way," said ADEQ Director Misael Cabrera. Governor Ducey applauded the US Environmental Protection Agency's 2020 decision to improve the federal Clean Water Act and committed that Arizona welcomes the need to protect State surface waters.

HB 2691 is the first Arizona-specific water quality protection bill enacted since the Aquifer Protection Permit program in 1991, and together, these two programs will serve to protect the quality of both Arizona's surface and groundwater resources. More information on the Surface Water Protection Program, including the draft list of protected waters, is available on ADEQ's website shown below.

For info: ADEQ's website at: https://azdeq.gov/woaz

CALENDAR

June 14-15 WI
Strategic Communications: H2O Workshop, Milwaukee. Saint Kate - The Arts Hotel. Presented by National Assoc. of Clean Water Agencies. For info: www.nacwa.org/conferences-events/event-at-a-glance/2021/06/14/nacwa-events/strategic-communications-h2o-workshop

June 15 WEB
NEPA, ESA and Fundamentals of Environmental Law (ELI Summer School, 2021), 12:00 pm - 2:00 pm Eastern Time. Presented by the Environmental Law Institute; Register by June 11. For info: www.eli.org

June 15 WEB
Enforcement and Compliance History Online (ECHO) Webinar, 1:30 pm - 2:30 pm Eastern Daylight Time. Presented by EPA Office of Enforcement & Compliance Assurance - Register at: https://echo.epa.gov/help/training#upcoming. For info: https://echo.epa.gov

June 15-16 Canada
Grey to Green 2021 Conference: Designing for Tomorrow - Green Infrastructure & the Post COVID-19 Recovery, Toronto. Virtual Platform. Biophilic Design, Integrated Stormwater Management Practices, Urban Agriculture, Green Roof and Green Wall Best Practices & More. For info: https://greytogreenconference.org

June 16 WEB
Financing Nature-Based Climate Action Event, 10:00 am - 11:00 am Pacific Time. Presented by the Center for Law, Energy, & the Environment (Berkeley Law). For info: https://berkeley.zoom.us/webinar/register/WN_52lkmYX5TF-CAHz15HzSUQ

June 17 WEB
Columbia Basin Long-Term Water Supply and Demand Forecast - Interactive Online Workshop, 8:30 am - 11:30 am Pacific Time (Register in Advance; Comments Accepted until July 2nd). Presented by Washington State University & Washington Dept. of Ecology. For info: https://ecology.wa.gov/Research-Data/Scientific-reports/Columbia-River-reports/Supply-demand-forecast

June 17 WEB
AWRA-WA June 2021 Virtual Lunch Meeting: Legislative Update, 12:00 pm Pacific Time; Speakers Robin McPherson & Dave Christensen of Depart. of Ecology. Presented by American Water Resources Association - Washington Chapter. For info: www.waawra.org/event-4343307

June 17-18 WEB
Climate Change in theWest, Virtual Event. "Land, People, Markets, & Law Conferece". Presented by the American Bar Association - Section of Environment, Energy & Resources Law. For info: https://www.americanbar.org/groups/environment_energy_resources/events_cle/section_calendar_archive/

June 21 CO
Watershed Summit 2021, Denver. Denver Botanic Gardens. Virtual Week of June 28th. Presented by the Colorado Water Conservation Board, Denver Water, Aurora Water, One World One Water Center, Resource Central & Denver Botanic Gardens. For info: www.botanicgardens.org/our-impact/water-stewardship/watershed-summit

June 22 WEB
Basics of the Clean Water Act (ELI Summer School, 2021), 12:00 pm - 2:00 pm Eastern Time. Presented by the Environmental Law Institute; Register by June 18. For info: www.eli.org

June 23-24 TX
Hydraulic Fracturing & Production Chemicals 2021, Houston. Hotel Derek. For info: https://www.hydraulic-fracturing-chemicals.com/?join=VR

June 23-25 WY
Western States Water Council Summer 2021 (196th) Meetings, Cody. Buffalo Bill Village, 17701 Sheridan Avenue. In-person and Zoom Meetings. For info: https://westernstateswater.org/events/wswc-summer-2021-meetings/

June 24-25 WEB
Tribal Energy in California and the Southwest Conference, Live Online Interactive Broadcast. For info: Law Seminars International, 206/ 567-4490, registrar@lawseminars.com or www.lawseminars.com

June 28-29
Colorado 2021 Water Educator Network Symposium (via Zoom) & Project WET Workshop (Basalt, Roaring Fork Conservancy's River Center) "Impactful Public Awareness Strategies" & WET Program Certification, For info: www.watereducationcolorado.org/2021-water-educator-events/

June 30 WEB
Toxic Substances Control Act Reform: Five Years Later Webinar, ELI, Bergeson & Campbell, P.C., and George Washington UniversityMilken Institute School of Public Health Co-Sponsored Annual Conference. Presented by the Environmental Law Institute; Must Register by June 28. For info: www.eli.org

June 30-July 1 TX
Annual Texas Groundwater Conference, Austin. Omni Austin Hotel Southpark. Presented by the American Groundwater Trust. For info: https://agwt.org/civicrm/event/info?id=323&reset=1

June 30-July 1 WEB
Western Governors' Association 2021 Annual Meeting, TBA. For info: https://westgov.org/

July 11-14 WA
Utility Leadership Conference & Annual Meeting, Seattle. Hyatt Regency Seattle. Presented by National Assoc. of Clean Water Agencies; 50th Anniversary Gala on July 11th. For info: www.nacwa.org/conferences-events/event-at-a-glance/2021/07/11/nacwa-events/utility-leadership-conference-51st-annual-meeting

July 13 WEB
Hazardous Waste and Sites (ELI Summer School, 2021), 12:00 pm - 2:00 pm Eastern Time. Presented by the Environmental Law Institute; Register by July 9. For info: www.eli.org

July 14 WEB
Corrosion Control Research Virtual Event, American Water Works Association Event. For info: https://www.awwa.org/Events-Education/Events-Calendar/

July 19-20 WEB
AWRA Summer Conference: Connecting Land & Water for Healthy Communities, American Water Resources Association Event. For info: www.awra.org

July 19-26 WEB
Virtual 67th Annual Rocky Mountain Mineral Law Institute, Presented by Rocky Mountain Mineral Law Foundation. For info: www.rmmlf.org/programs

July 26-27 Alberta
Montney & Duvernay Shale Water Management 2021: Water Strategies for Northern Alberta & BC, Grande Prairie. Stonebridge Hotel. For info: www.alberta.shale-water-management.com/?join=VR

July 27 WEB
Environmental Justice (ELI Summer School, 2021), 12:00 pm - 2:00 pm Eastern Time. Presented by the Environmental Law Institute; Register by July 23. For info: www.eli.org

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

(continued from previous page)

July 28-30 — OR
2021 Association of Clean Water Agencies Summer Conference, Redmond. Eagle Crest Resort, 1522 Cline Falls Road. Presented by OACWA. For info: https://oracwa.org/event/acwa-annual-conference-2/

August 3-5 — TN
Association of Clean Water Administrators Annual Meeting, Memphis. The Guest House at Graceland. For info: www.acwa-us.org/event/annual-meeting-2021/

August 12-13 — NM/WEB
Natural Resource Damages: 14th Annual Advanced Conference on Litigating, Santa Fe. TBA. Live Online Via Interactive Broadcast. For info: Law Seminars International, 206/ 567-4490, registrar@lawseminars.com or www.lawseminars.com

August 24-25 — WEB
2021 Symposium on the Settlement of Indian Reserved Water Rights Claims, Virtual Symposium. Presented by the Western States Water Council & the Native American Rights Fund. For info: https://westernstateswater.org/events/2021-symposium-on-the-settlement-of-indian-reserved-water-rights-claims/

August 25 — WA/WEB
Contaminated Properties in the Northwest: Navigating the Redevelopment Process - Live Webcast, Seattle. Washington Athletic Club, 1225 6th Avenue. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

August 25-26 — ND
Bakken Oil & Gas: Shale Water Management 2021 - Cost-Effective Water Strategies for North Dakota, Bismarck. TBA. For info: www.bakken.shale-water-management.com/?join=VR

August 25-26 — FL
The Water Expo, Miami. Miami Airport Convention Center. Servicing the US & Latin America. For info: www.thewaterexpo.com/

August 26-27 — AZ
Arizona Water Law Conference: Water Shortages, Replacement Supplies & Emerging Policies, Scottsdale. Hilton Hotel. For info: CLE International, 800/ 873-7130 or www.cle.com

August 26-27 — WA
Fourth Annual Water Law in Central Washington Conference, Ellensburg. Red Lion Hotel and Conference Center. For info: The Seminar Group, 800/ 574-4852, info@theseminargroup.net or www.theseminargroup.net

August 29-Sept. 1 — MO
American Public Works Association Public Works Expo, St. Louis. Americas Center. For info: https://pwx.apwa.net

August 31-Sept. 2 — TX
10th Annual Texas Groundwater Summit, San Antonio. Hyatt Regency Hill Country Resort. Texas Alliance of Groundwater Districts Event. For info: https://texasgroundwater.org/news-events/events/texas-groundwater-summit/