EXECUTIVE SUMMARY

January 8, 2020
Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Umatilla County, Oregon

Beginning August 2020, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) propose to conduct a 2-year groundwater recharge study of the Umatilla Indian Reservation (UIR) and surrounding area in the upper Umatilla River Basin (not located on a Federal facility). The study's goal is to better understand groundwater availability and develop groundwater management policy to support First Foods, the Tribal community and economic development on the UIR for the next seven generations. To accomplish this goal, the CTUIR in partnership with the US Geological Survey (USGS) will employ environmental tracers to define recharge areas that contribute to basalt aquifers, assess residence time and mixing of basalt aquifers, and qualify aquifers as renewable or nonrenewable resources. This information will be used to update and develop policies that (a) protect groundwater resources from overdraft like that observed for many decades in the lower Umatilla River Basin and neighboring communities; and (b) provide information to assist in planning, development, conservation, and management of groundwater resources for long-term sustainable use. Additionally, the information gained will support on-going negotiations with the State of Oregon to settle CTUIR's water rights and the development of an agreement for groundwater co-management.

Environmental tracers of stable isotopes (deuterium 2H, oxygen 18O), radioisotopes of carbon (14C) and tritium (3H), and general-mineral water chemistry will be used to examine spatial, temporal, and vertical aspects of groundwater flow, residence time, recharge sources, and aquifer mixing or comingling of individual aquifers. Understanding spatial-temporal variability of basalt groundwater is necessary to inform sound policy development. This project builds on work completed by CTUIR and USGS to collect environmental-tracer data from 34 wells and 4 springs (2017/18), assess bulk recharge to basalt aquifers (2018), develop a hydrogeologic conceptual model and groundwater budget (2017).

Photo 1: Columbia River Basalt Group outcrop along the Umatilla River. Photo by Vicki McConnell, Oregon Department of Geology and Mineral Industries.

Funds will be used to (1) collect new water samples from precipitation for stable isotopes and general-mineral to develop a local meteoric water line and track spring-fed groundwater flow, respectively, laboratory analysis of samples and reporting with policy recommendations ($94,349), and (2) contract with USGS to complete data analysis and interpretation of 2017/18 isotope data, develop models describing groundwater age, mixing and flow, synthesize this project's data and historical data to better understand groundwater system, and report preliminary findings ($94,040); total budget request is $188,389. The Oregon Water Resources Department and the USDA Agricultural Research Service will assist with technical review and data collection, respectively. The project supports the Funding Opportunity Announcement goals of assisting Indian tribes to manage, develop, and protect water in an environmentally and economically sound manner.

1. BACKGROUND

1.1 CTUIR Location and Governance History

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) is a federally-recognized Indian tribe with more than 3,000 enrolled Tribal members, approximately half of which live on the Umatilla Indian Reservation (UIR). In 1855, tribal ancestors of CTUIR members signed a treaty with the United States to reserve a homeland—the UIR—and to secure in perpetuity certain pre-existing rights throughout the 6.4 million acres ceded to the United States as well as other lands accessed for the exercise of those rights aboriginally. These reserved rights include, but are not limited to, the right to fish at all usual and accustomed sites, hunt, gather roots and berries, and pasture animals on unclaimed lands. In 1949, the CTUIR adopted a Constitution and Bylaws that established a governing body, the Board of Trustees (BOT), which oversees policy matters for the CTUIR and government operations through an Executive Director. Today, the CTUIR government operates from the Nixyáawii Governance Center (NGC) located within the 172,000-acre UIR that flanks the Blue Mountains of northeastern Oregon (Figure 1).

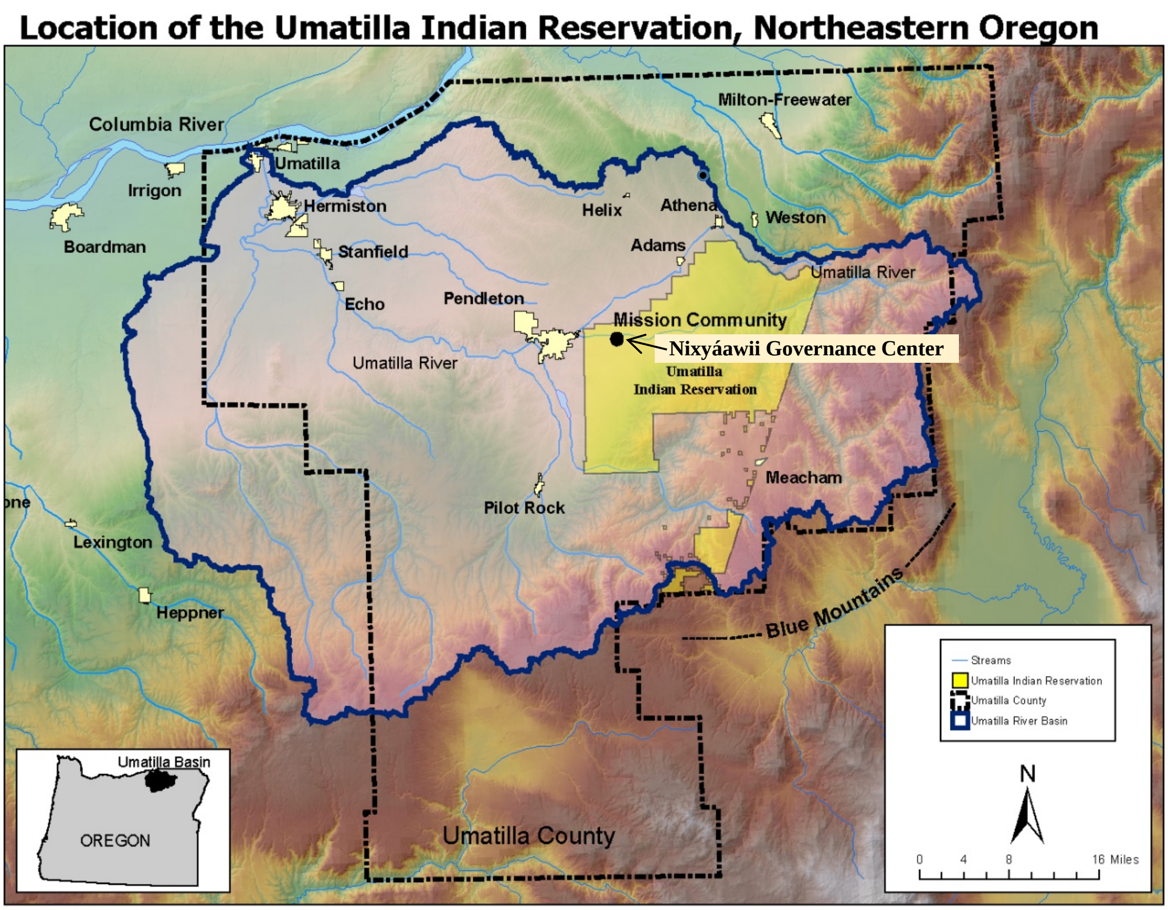

Figure 1: Location of the Umatilla Indian Reservation (272-square miles), Nixyáawii Governance Center, Umatilla County and neighboring communities in relation to the Umatilla River watershed (2,500-square miles), Columbia River and the Blue Mountains.

1.2 Water Rights Settlement

In 2011, the Secretary of the U.S. Department of the Interior appointed a Federal Water Rights Negotiation Team, which includes BOR and USGS representatives, to participate in negotiations between the CTUIR, State of Oregon and basin stakeholders and settle the CTUIR's water rights in the Umatilla River Basin. The CTUIR has an unquantified and unadjudicated reserved water rights for enough water to fulfill the purposes for which the UIR was created by the Treaty of 1855 and instream flows for Treaty reserved fishing rights (Winters Doctrine). This settlement will identify and secure a quantity of water, among other demands, to support groundwater resources to meet CTUIR's economic, cultural, and social needs to maintain its homeland and way of life. The Tribal Negotiation Team (TNT) is aware of the project proposal, supports the project, and does not think it will conflict with ongoing negotiations with State and Federal agencies. The Federal negotiation team will be meeting with State and Tribal representatives on January 16, 2020. At this time, the project proposal will be discussed. The TNT does not anticipate a conflict with negotiations and the work described in this proposal.

Currently, basalt groundwater is the primary source of water for all UIR residents, supporting domestic, commercial, municipal, and irrigation (DCMI) uses. To prevent competition for groundwater and depletion of aquifers within and beyond the UIR, the CTUIR anticipates that the water rights settlement will include a groundwater co-management agreement between the CTUIR and OWRD. This proposed project is needed to inform the Negotiation Team about groundwater availability and provide data-supported information for development of a groundwater co-management plan.

1.3 Water Supply Concerns and Needs

<u>Basalt Aquifers and Community Use</u>

Most wells in the study area tap basalt aquifers and, to a much lesser degree, the sand and gravel deposits that overlay the basalts. The entire region is characterized by a thick sequence of flat-lying basalt flows belonging to the Miocene Columbia River Basalt Group (CRBG; see Photo 1, above). Individual basalt flows range in thickness from 5 to more than 100 feet and are laterally extensive. The thin zone between basalt flows is called the interflow zone. This interflow zone is where aquifers may occur, and it is characterized by vesicular and brecciated flow tops and bottoms that can store and transmit water. The basalt flow interiors, however, are typically dense and act as confining layers to aquifers. Although there may be as many as 300 basalt flows and interflow zones, very few interflow zones are aquifers. Basalt aquifers can be very permeable, allowing easy groundwater extraction; however, they also have limited storage. Recharge to basalt aquifers is thought to result from contact of the interflow zones with source waters at or near the surface or along fault avenues, aquifer mixing from leaky confining layers, or commingling of aquifers via an open well bore below casing that taps more than one aquifer.

Currently, there are 875 wells on the UIR that are used for DCMI purposes. The shallow basalt aquifer is the first basalt aquifer encountered during drilling and is used primarily for domestic purposes. On the UIR, depth of this aquifer ranges between 25 to 400 feet or so, with average depths ranging from 200 to300 feet. Deeper aquifers are typically greater than 400 feet and may be as much as 1,900 feet deep on the UIR.

CTUIR Municipal Well System

The CTUIR municipal well system in the Mission community consists of 5 wells: MW 1 and 2 are 300- and 315-feet deep, respectively, and MW 3, 4, and 5 are 1,100-, 1,067-, and 975-feet deep, respectively, each having at least a 400-foot seal. These wells serve approximately 725 households and commercial developments such as the Wildhorse Resort and Casino (WRC). Annually, approximately 750-acre feet (or 245-million gallons) of water is currently withdrawn. In the next few years, this demand is expected to increase to support another 100 or more people, with occupation of proposed housing subdivisions and WRC expansion. A sixth-deep municipal well was drilled but it is not yet in production, pending funds to complete expansion of WRC.

A pumping test performed on MW 1 indicates that this shallow aquifer is leaky confined, shares a common aquifer with shallow wells in the Mission Basin, and is most likely connected to the Umatilla River. Conversely, a test on MW 4 indicates that the deep aquifer is confined, separate from the shallow aquifer, shares the same aquifer as MW 3 and 5, and does not appear to be connected to surface waters. Currently, no significant water-level declines have been noted in shallow and deep monitoring wells on the UIR since monthly monitoring began 1979 to present.

Preliminary analysis of data collected from nearby basalt wells indicates the presence of groundwater that was recharged thousands of years ago. Given the ancient recharge ages observed in the region, recharge and movement of groundwater in the basalts is of primary concern to CTUIR. It drives the questions: Do the shallow- and deep-basalt aquifers on which the UIR community relies receive recharge, and should these aquifers be managed separately? This project will greatly improve our understanding of recharge limitations and opportunities that will enable development of sound management strategies to address these questions.

Critical Groundwater Areas

In every region of the Umatilla River Basin where basalt aquifers have been tapped by high-capacity wells, groundwater levels have declined. This aquifer mining began in the mid-1950s and has prompted the Oregon Water Resources Department (OWRD) to establish Critical Groundwater Areas (CGAs) throughout the lower Basin. Umatilla County has four of the seven CGAs in Oregon. One management tool for CGAs includes curtailment of use by junior groundwater right holders. Nearly 75% of groundwater rights have been curtailed in the lower Umatilla Basin (750 square miles) in an effort to achieve a sustainable annual yield. Groundwater declines have also been observed in the cities and towns of Pendleton, Adams, Athena, and Pilot Rock, which border the UIR (Figure 1).

Figure 2 shows a 3D diagram with a NW-SE section of the 2500-square mile Umatilla Basin from the Columbia River to the Blue Mountains. The diagram shows that the upper part of the Basin is underlain by the same geologic units/aquifers as the CGAs. Although the UIR has not experienced the same severity of water-level decline as in the CGAs, the UIR shares these aquifers and is vulnerable to the expansive groundwater depression in the lower Basin. Many homeowners on the NW end of the UIR have had to deepen their wells to maintain adequate water supplies.

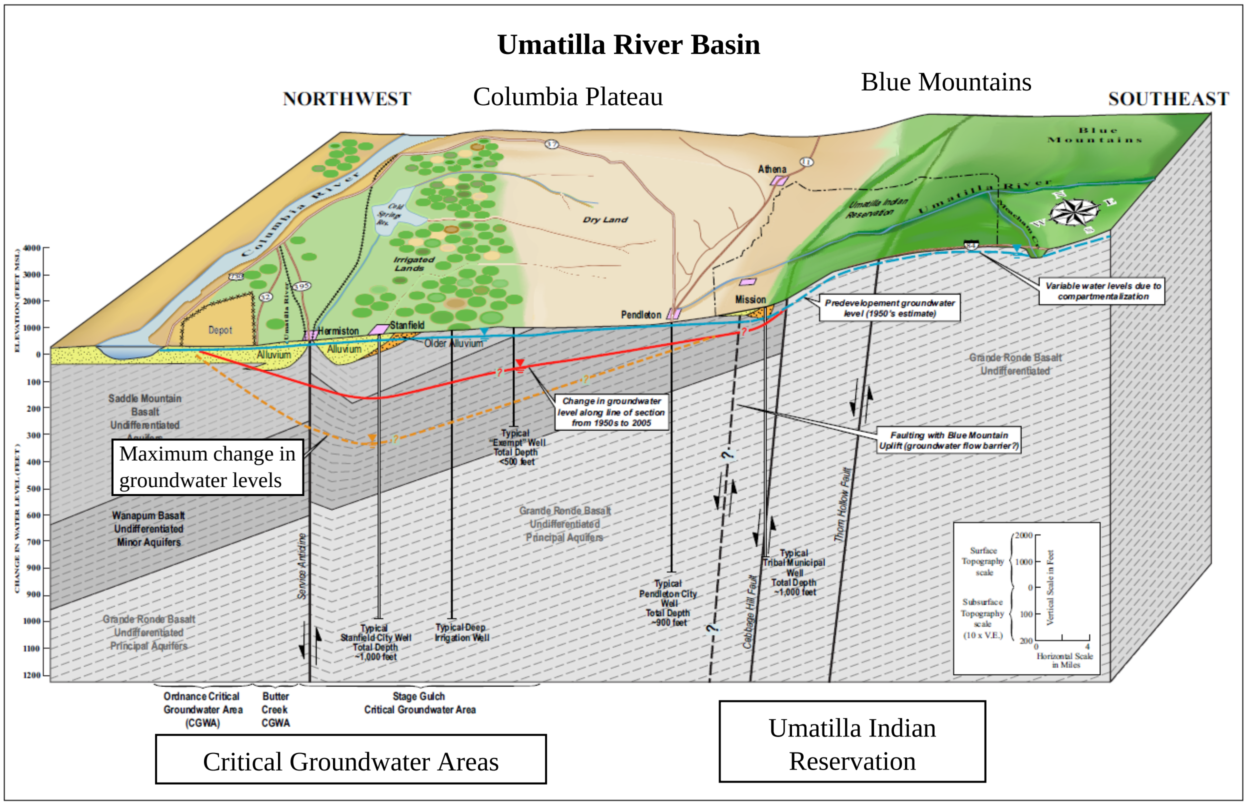

Figure 2: A NW-SE cross-section illustration of the shared basalt geology, typical irrigation and municipal well depths, and groundwater-level declines in the Umatilla River Basin. Most of the lower basin is designated as Critical Groundwater Area by OWRD. The City of Pendleton has also experienced water-level declines of 100 feet.

Impacts to Streamflows and Water Quality

Groundwater and surface water are connected and, in general, prolonged groundwater pumping from wells will eventually deplete stream baseflow[1], which may in turn, cause cumulative, extensive and long-lasting impacts. A reduction in baseflow affects water quality as well, such as cold-water refugia for Treaty-reserved fishery and ESA-listed Mid-Columbian Steelhead. The dynamics between the shallow basalt aquifer and the Umatilla River on the UIR are not fully understood, especially the location, timing and magnitude of impact from groundwater pumping. It is certain, however, that the shallow-basalt aquifer receives recharge from the alluvial materials above (aquifer test). The Umatilla River is listed as impaired under Section 303(d) of the Clean Water Act for elevated temperatures. If shallow-basalt aquifer discharge to streams is reduced, water quality is likely to be further degraded due to increased water temperatures.

General Groundwater Management

A Secretary of State Performance Audit of OWRD (December 2016) identified the need for enhanced groundwater protection and more data collection and analysis. Until studies can provide adequate information on the inter-relationship between surface water and groundwater and the long-term impacts of groundwater pumping, OWRD lacks the justification to refrain from issuing groundwater rights in areas outside the boundaries of CGAs and within the

[1] Stream baseflow is supported entirely by groundwater discharge.

boundaries of the UIR. As a result, OWRD continues to issue groundwater permits without knowing the impacts from exercising them in combination with existing permits in the Basin. Examples of adverse impacts from excessive pumping include reduced streamflows and fish habitat, impaired water quality, and infringement on Tribal reserved water rights.

The information gained from this project will assist CTUIR and OWRD policymakers in defining a sustainable yield, which may change with varying environmental conditions and factors. For example, policymakers need to consider the cumulative effects of: Groundwater withdrawals on the ability of aquifers to recover annually; the interaction with streamflows and instream temperatures (water quality); and the economics of pumping. Insight into recharge mechanisms and the long-term impacts of groundwater development would aid policymakers in deciding how to maximize water resource development without causing significant water-level declines or harm to natural resources that are central to tribal culture.

There is also concern that the basalt aquifers receive limited recharge in the modern era, possibly substantially less than current withdrawal amounts. Understanding and characterizing aquifers, their recharge sources and rates, and their withdrawal rates is extremely important in long-term protection of Tribal water rights and the management of a potentially non-renewable resource (or essentially in terms of seven generations). To compound the uncertainty, recharge may be further limited by a changing climate where there is less snowmelt and correspondingly less opportunity for water infiltration to recharge aquifers. Several climate models for the Pacific Northwest predict warmer winter temperatures with less snow and higher evaporation rates in the Blue Mountains.

This longstanding problem was addressed by CTUIR leader Antone Minthorn in a 1986 presentation to the Oregon Water Resources Commission, *"Water resources planning and management is needed to prevent further intense competition for water, rights infringement, waste of water, and overdrafting, and to promote multiple use of the resource."*

At this time, however, there is insufficient data and information to determine long-term water availability for CTUIR's water supply, the impacts of aquifer development both on the UIR and in areas down-gradient from the UIR, or the impacts from groundwater development on surface waters. The CTUIR needs a method to identify basalt aquifers that receive recharge annually (renewable groundwater resource) and those that are, for all practical purposes, not receiving recharge (nonrenewable resource).

1.4 Relationship of Project to Tribal Water Resources Management Goals

<u>Department of Natural Resources Mission</u>
In 2007, the CTUIR's Department of Natural Resources (DNR) adopted a holistic mission to: *"… protect, restore, and enhance the <u>First Foods</u> - water, salmon, deer, cous, and huckleberry - for the perpetual cultural, economic, and sovereign benefit of the CTUIR."*

Tribal First Foods are distributed throughout the UIR and CTUIR's ceded territory and are considered the minimum ecological "products" necessary to sustain CTUIR culture. Water ("cuus") is the first of the First Foods and is an essential factor in supporting all the subsequent foods. Consequently, water management within the First Foods context takes into account both water quality and water quantity needed to sustain ecological health[2]. The work detailed in this proposal is a groundwater data collection and assessment effort that supports DNR's mission.

Tribal Water Code (Resolution No. 05-027, March 3, 2005)
This project directly supports the CTUIR's sovereignty and strengthens implementation of the Tribal Water Code (WC, https://ctuir.org/water-code). The WC was adopted by the Board of Trustees in 1981 (Interim WC), and amended in 1995, 1999, and 2005. The WC provides goals, policy direction, regulations, and administrative rules and standards for managing, developing, prioritizing, using, and protecting CTUIR's treaty-reserved water rights. Under the WC, CTUIR has the full authority over all water resources within UIR boundaries, including water quality and quantity. The rules and regulations are enforceable by the Umatilla Tribal Court exercising its civil authority (Section 1.04. Jurisdiction).

As part of the WC Statement of Policy (Section 1.05), *"the primary goals of water management are to conserve the quantity and maintain or improve the quality of water resources; protect and restore cold clean pure water consistent with the Tribal Water Quality Standards; maximize the beneficial use of water resources; promote diversity and protection of beneficial uses; promote the orderly economic development of the Reservation; and coordinate water use with land use and other planning on the Reservation.*" It also states, "*Development of water resources shall be controlled and regulated to prevent the depletion of aquifers and the overdraft of groundwater. Management of water resources shall protect and improve the quality of the groundwater resources.*"

Section 1.10 establishes the CTUIR Tribal Water Commission (TWC) as the liaison between the CTUIR Board of Trustees and DNR and other bodies or agencies having functions relating to water appropriation, water quality, or water management. In addition, the TWC establishes policies and provides oversight for DNR in the administration of the WC. On December 17, 2019, the Water Commission endorsed and recommended that the proposed project be presented to the Board of Trustees for their approval and support in a request for funding.

Tribal Water Program-Plan of Operations (Resolution No. 93-46, October 20, 1993)
In 1986 the Board of Trustees adopted the Tribal Water Program (not to be confused with DNR's Water Resources Program), which provides guidance in managing, developing, using, and protecting the CTUIR's treaty-reserved water rights and water resources. The Program's intent was to establish overall Tribal policy in water management, water resources development, and water rights protection. All Tribal departments were involved in its development and applied the goals and objectives to their programmatic planning, development, and implementation activities where applicable. In 1993, the Board of Trustees revised and adopted the Tribal Water Program-Plan of Operations (Plan).

The Plan's Objectives include: (A) administer and enforce Tribal water laws; (B) review and update water laws; (C) determine all water resource characteristics; (D) maintain or improve water quality and quantity sufficient to meet Tribal treaty and cultural resource rights; (E) prevent aquifer depletion; (F) restore riparian zones, wetlands, and overall watersheds to improve streamflow required to meet instream flow needs; and (G) coordinate management activities with public and Tribal agencies. Also identified in the Plan is the need to develop and utilize a fine-

[2] Quaempts, E. J., Jones, K. L., O'Daniel, S. J., Beechie, T. J., & Poole, G. C. (2018). Aligning environmental management with ecosystem resilience: a First Foods example from the Confederated Tribes of the Umatilla Indian Reservation, Oregon, USA. *Ecology and Society*, Vol. 23, ISS. 2.

grid transient flow model of the UIR and surrounding area to predict impacts of water and land management activities on streamflows and groundwater availability.

This proposed project addresses these objectives to: (a) identify aquifers and assess recharge to basalt aquifers; (b) recommend Tribal policies that will restrict development that threatens aquifer recharge areas; (c) develop and implement policies which regulate groundwater development and prevent over-appropriation on and adjacent to the Reservation; (d) determine groundwater availability on and adjacent to the Reservation; (e) establish a program to monitor the aquifers underlying the UIR; and (f) correlate data from off- and on-reservation into a conceptual model for water management.

1.5 Project Location

The project location is the upper Umatilla River Basin (Figure 3). The study area is divided into two distinct physiographic areas, a gently undulating, lowland plateau to the west (950 to 2,500 feet in elevation) and the Blue Mountains and associated foothills to the east (2,500- to 5,800-foot elevation). Precipitation in the Basin ranges from 7 inches, semiarid in the lower Basin (Columbia Plateau) to as much as 50 inches, Mediterranean hot summer in the upper Basin (Blue Mountains). Precipitation on the UIR ranges from 13 inches near UIR west boundary to 34 inches in the mountains. Most of the precipitation falls during winter and spring.

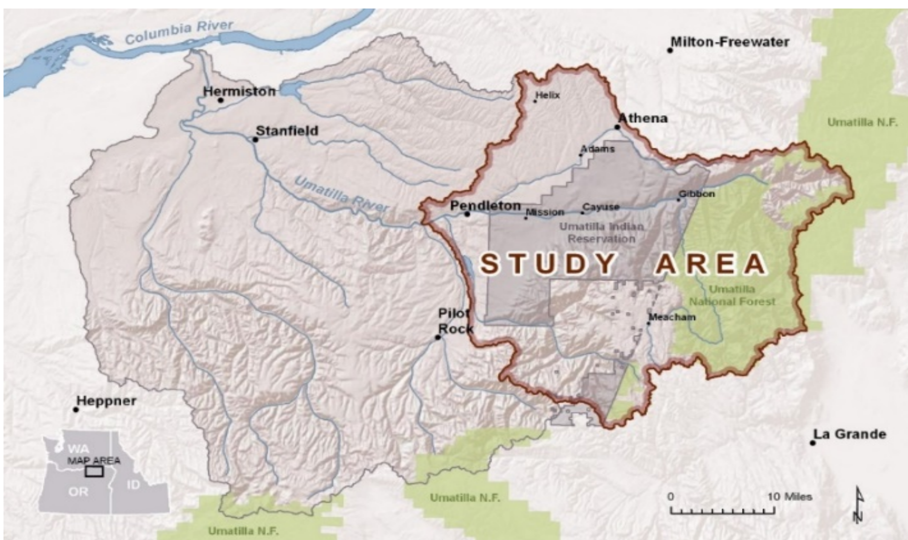

Figure 3: Map of study area, upper Umatilla River Basin (913 sq. miles).

In the Blue Mountains, streams have deeply incised the CRBG flows, whereas in the plateau region, stream incision is less pronounced. There is a veneer of sedimentary material overlying the basalts having low permeability with the exception of the recently deposited alluvium and loess.

1.6 Working Relationship with the US Bureau of Reclamation

Table 1 identifies on-going and completed projects that have been conducted by the CTUIR for the US Bureau of Reclamation (BOR).

Table 1: Past and Current Working Relationships between CTUIR and Bureau of Reclamation

Performance Period	BOR Office	Project Description
01/01/1995 to 12/31/1999	Boise ID and Yakima WA Offices	NEPA Assessment of Impacts-Federal Irrigation District Boundary Expansion
01/01/2012 to 12/31/2020	Umatilla Field Office	Umatilla Basin Project, Phases 1 and II Implementation

03/27/2015 to 09/30/2024	Boise ID Office	Oversight & Monitoring for Fish Habitat Improvement in Grand Ronde
09/13/2012 to 06/30/2017	Boise ID Office	Evaluation & Coordination of Pacific Lamprey
09/11/2017 to 09/30/2020	Boise ID Office	Water Quality Monitoring and Lab Analysis of Samples

1.7 Past Accomplishments in Study Area

The CTUIR, in cooperation with federal, state, and local agencies, has conducted a series of studies over the past several decades to advance the understanding of the hydrologic system in the Umatilla Basin. The purpose of these studies is to improve groundwater management for sustainable use. In the future and when funding is available, the CTUIR in cooperation with OWRD and other agencies hopes to build a scientifically sound and data-supported transient-state numerical model to simulate future conditions (a more than 5-year, $5-plus-million effort).

A conceptual model (the first step in numerical modeling) has been completed. In 2017[3] and 2018[4] two USGS reports were published describing the groundwater budget and total aquifer recharge, respectively, of the study area. Figure 4 illustrates a simplified current understanding of the geologic system with a plan and cross-section view.

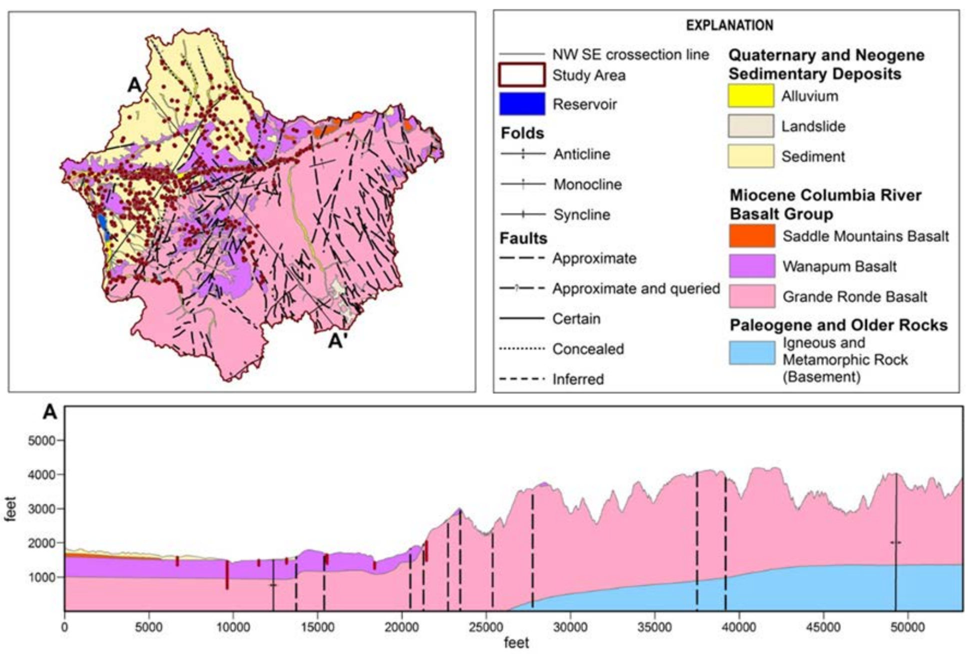

Figure 4: Top left, map of simplified geology in the study area. Top right, an explanation of rock units and structure. Below, NW-SE geologic section (A-A') showing wells (red vertical lines), faults (dashed lines) and folds (solid lines). Note that the wells are drilled into formations belonging to the CRBG, both shallow & deep aquifers.

Although a conceptual model and budget has been completed, there are many uncertainties related to groundwater flow, recharge, and evapotranspiration processes. The current project will

[3] Herrera, Ely, Mehta, Stonewall, Risley, Hinkle and Conlon, 2017, Hydrogeologic framework and selected components of the groundwater budget for the upper Umatilla River Basin, Oregon: US Geological Survey, prepared in cooperation with CTUIR, 57 p., SIR 2017-5020, https://pubs.er.usgs.gov/publication/sir20175020
[4] Pischel, Johnson and Gingerich, 2018, Deep aquifer recharge in the Columbia River Basalt Group, upper Umatilla River Basin, northeastern Oregon: US Geological Survey, 32 p., SIR 2018-5110, https://pubs.usgs.gov/sir/2018/5110/sir20185110.pdf

fill data gaps in groundwater-flow paths and recharge, and provide constraints to a numerical model. The work done by Herrera and others (2017) and Pischel and others (2018) assessed total recharge to the basalt aquifers as distributed proportionally by precipitation across the landscape. This work, however, did not distinguish individual aquifers, their relative depths, or effective recharge to the deeper aquifers. Because many of the components used to calculate recharge are difficult to measure or quantify, the estimates provided in the 2017 and 2018 reports are of limited use in developing policy on groundwater withdrawals and management.

2. TECHNICAL PROJECT DESCRIPTION

2.1 Environmental Tracers

Environmental tracers of stable isotopes (deuterium 2H, oxygen 18O), radioisotopes of carbon (14C) and tritium (3H), and general-mineral water chemistry will be used to examine spatial, temporal, and vertical aspects of groundwater flow, residence time, recharge sources, and aquifer mixing or comingling of individual aquifers. Understanding spatial-temporal variability of basalt groundwater is necessary to inform sound policy development.

This project will pursue three major tasks: (1) develop local meteoric water line (LMWL) from stable isotopes of deuterium and 18-Oxygen in precipitation, from which to assess groundwater recharge sources (rain, snow) and mechanisms (local/isolated, dispersed); (2) assess general chemistry from springs and well waters as it relates to chemical evolution of groundwater in contact with basalt rocks (relative ages); and (3) using results from tasks 1 and 2 together with data from 2017/2018 and additional historic and regional data, conduct analysis and identify aquifers, characterize flow paths, and assess groundwater availability from estimates of the elapsed time since groundwater was recharged and the relative proportions of old and young water from wells across the study area. This project will complete the sampling work envisioned in 2017 and 2018 (described below) and will enable future aquifer characterization and identification with low-cost analysis of stable isotopes and general chemistry of groundwater.

<u>2017 and 2018 Data Collection and Sampling</u>
In 2017 and 2018, grant funding from the US Bureau of Indian Affairs to CTUIR ($153,770 and $35,000, respectively) and from the USGS Indian Water Rights program (IWR, $100,000 and 35,000), in a 50:50 cost share, was utilized for a study to protect Tribal water rights in the face of climate change. The USGS led with planning, data collection, and data QA/QC; CTUIR assisted with field work, site selections, and funding for laboratory analysis. Innovative techniques using environmental tracers were employed to better understand the spatial, temporal, and vertical aspects of groundwater flow, residence time, recharge sources, and aquifer mixing or comingling from separate aquifers.

Three transects were explored in 2017 across the study area from the lowland plateau to mountain ridgelines. Water samples were collected from 34 wells and 4 springs and analyzed for two general categories of recharge: modern recharge (the past 60 years) using atmospheric tracers of chlorofluorocarbons (CFC), sulfur hexafluoride (SF6) and radioisotopes of tritium/helium-3 (3H/3He); and older recharge (over 500 years) using radiocarbon 14C. Stable isotopes to assess recharge area and analytes necessary for correction and mixing (e.g., noble gases and general minerals) were also assessed. Given the expense of sample analysis (approximately $4,000/sample) and time for collection (1/2 day per sample per two-person crew), the focus of the 2017/2018 effort was to collect as many samples for laboratory analysis as possible with available funding. Preliminary data analysis by USGS was conducted on a well-by-well basis to ensure data quality and consistency of results, but a regional synthesis and interpretation of the data was not within the scope and funding. Recommendations included additional funding to complete the data synthesis and analysis, and development a LMWL for the stable isotope analysis.

Stable Isotopes

Stable isotopes of hydrogen (2H-deuterium) and oxygen (18O) in water can provide information on recharge source areas by elevation. Deuterium and 18O are two naturally occurring forms of the same element that do not change over time; they have remained essentially constant through geologic time. Radioisotopes like carbon 14 (14C) and tritium (3H), however, change over time; they are used for age-dating from their known exponential-decay rates to stable forms.

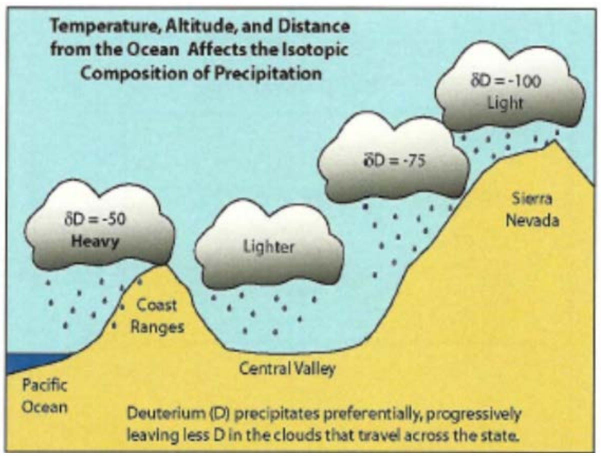

Figure 7: Illustration of changes in deuterium observed in meteoric waters. https://www.buttecounty.net/waterresourceconservation/Special-Projects/Stable-Isotope-Recharge-Project

Deuterium and O18 are present at very low levels in sea water, in the parts-per-thousand range, and have atomic masses that are greater than those of their most common isotopes, hydrogen (1H) and oxygen-16 (16O), respectively. The ratios of 2H:1H and 18O:16O in meteoric water samples fall on a global meteoric water line (GMWL) depending on the fractionation of isotopes. The fraction is influenced by temperature, latitude, and humidity. In addition, changes with elevation, season, and distance from the ocean, and evaporation processes affect the stable isotope fractionation (Figure 7). These latter changes cause a shift of the GMWL.

Figure 7 illustrates the changes in deuterium as meteoric waters move inland in California. It is necessary to create a LMWL for the study area to assess isotope fractionation as it relates to elevation and season. Once precipitation enters the groundwater system the stable isotope retains its fractionation signature relative to elevation and precipitation type (rain or snow). Using this signature, the project will relate the stable isotope fractionation in groundwater and springs to the source elevation in the study area from the LMWL.

Figure 8A is a plot of the global meteoric water line and an example of a local meteoric water line; Figure 8B is a plot of example stable isotopes from groundwater in relation to the LMWL. By plotting Deuterium or 18O versus elevation and precipitation type (rain or snow), it may be possible to correlate groundwater results to elevation. Figure 8C is an example of a conceptual model with groundwater groups and flow paths as a result of stable-isotope analysis. This project would enable development of graphics such as Figure 8 with an additional plot of deuterium vs. elevation to track or correlate the elevation to source area of the stable isotope in groundwater and springs.

Isotopic studies are most effectively used with known recharge sources and geologic formations. Springs are natural groundwater discharge points that occur where the geology is known, spring type can be identified, and are easy to sample (no pumping needed). This project will collect 15 additional spring samples for stable isotopes and general mineral to help identify the relationships between stable isotopes, elevation, and general mineral evolution of groundwater.

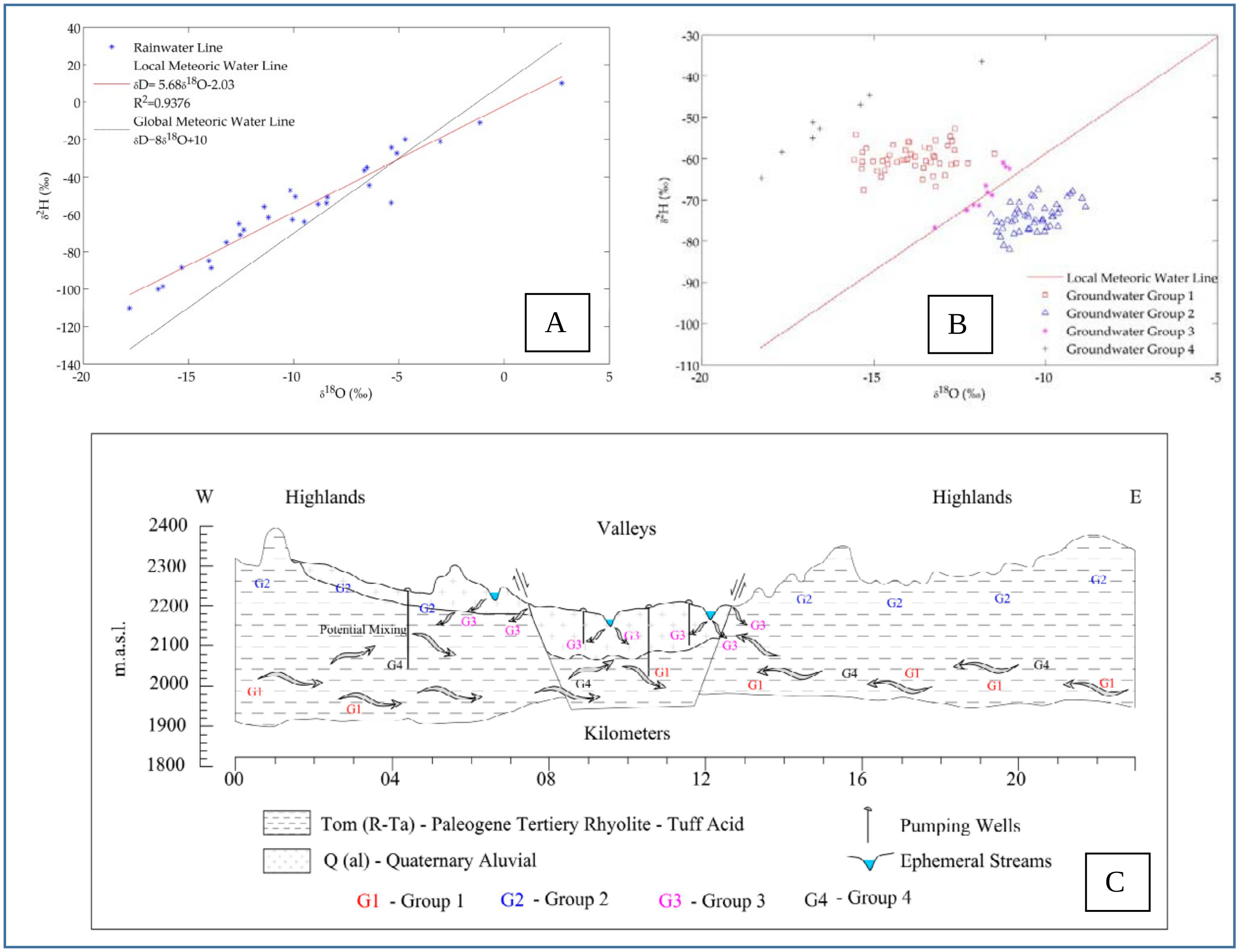

Figure 8: A. Example plot of GMWL and LMWL. B. Example plot of delD vs. del18O groundwater sampling groups and the LWML. C. Example cross section illustrating the groundwater flow conceptual model and associated groundwater clusters from B.
https://www.researchgate.net/publication/318870287_Identifying_Groundwater_Recharge_Sites_through_Environmental_Stable_Isotopes_in_an_Alluvial_Aquifer

Seasonal and spatial sampling of precipitation is recommended to assess recharge sources and define isotope fractionation at various elevations. With these relationships, it will be possible to back-trace the elevation of recharge (source) of the groundwater samples. Analysis of water chemistry is recommended to compliment the isotopic data and assess the chemical evolution of groundwater as it is flows through basalts over time. Together, recharge source by elevation and groundwater flow paths can be better defined and characterized.

Combining the age and recharge-area data with traditional dissolved ion chemistry (from 2017/18, historical sources and springs) along with recent quantification of the groundwater budget will provide unprecedented information on the groundwater-flow system in the basalts underlying the study area. It may be possible to identify basalt aquifers having modern recharge (renewable resources) and those with limited to negligible recharge (nonrenewable resources). This has important implications to groundwater management and sustainability. Without this study and associated data analysis, it will not be possible to identify basalt aquifers as renewable or nonrenewable resources, and if renewable, the degree of influence on instream flows and associated impacts from groundwater development. If nonrenewable, the study may indicate the available supply and thus the potential need for use limitations based on CTUIR priorities.

2.2 Project Work Plan

This project's primary goal is to advance tribal water resources management and regulation of groundwater resources to support First Foods, CTUIR tribal members, UIR community, and economic development for seven generations. CTUIR will accomplish this goal with a better understanding of groundwater recharge and movement through the basalt aquifers in the upper Umatilla River Basin. The CTUIR, in concert with expertise and experience of USGS staff, will analyze a wide array of hydro-geochemical data to characterize the nature of groundwater (age and mineral composition) and recharge mechanisms. Table 2 outlines the scope of work, activities and deliverables, subtasks, responsible agency personnel, and timeline relative to semiannual reporting.

Objective 1: Project Planning & Management (approximately 5%). Close collaboration and communications between the BOR and Project Manager, and between team members and contract services, will enhance project success. CTUIR will be responsible for this task. BOR and USGS will also be involved with cooperation and funding agreements. CTUIR's Cultural Resources Protection Program will review project scope and specific site selections prior to data collection. No ground-disturbing activities or impacts to cultural, historical, or natural resources are anticipated.

Objective 2: **Education & Outreach (approximately 5% CTUIR time each year)**. Successful policy development and implementation comes from community input and support. This project will share results with the Tribal Water Commission, Tribal members, and UIR community though presentations, education & outreach at community events, festivals, and Nixyáawii Community School science program.

Objective 3: **Data Collection and Reporting for LMWL (25%).** Analyze stable isotopes from precipitation and springs, and water chemistry (general mineral) from springs. Analysis includes: (A) Developing a LMWL from isotope data to identify elevation of recharge source waters; and (B) developing a Piper diagram of general minerals in groundwater and springs to assess the evolution of groundwater as it flows in the subsurface with time and contact with basalt rocks. A computer program called Grapher will be used to develop the diagram and other plots.
The CTUIR will develop a sampling plan with field protocols and QA/QC (USGS will review and assist), and expects to collect 15 water samples (1L) from springs for water chemistry and

stable isotope analysis. Analytes include sodium (Na), calcium (Ca), magnesium (Mg), nutrients (nitrate and phosphate for anthropogenic influence), iron (Fe), manganese (Mn), Fluoride (F), silica (Si), alkalinity (HCO3), chloride (Cl), sulfate (SO4), total dissolved solids (TDS) and pH. In-situ measurements of pH, specific conductance and temperature will be collected by CTUIR. The BOR's Boise water-quality lab will analyze the samples. A cooperative agreement between CTUIR and BOR's Boise office will be established in the first year of project. CTUIR will follow BOR sampling protocols.

For stable isotopes, the CTUIR plans to collect a maximum of 60 samples (10 mL each) of precipitation using rain and snow gages attached to fences at 20 sites positioned spatially and vertically along elevation bands in the study area. Landowners will be contacted for permission. Samples will be collected seasonally in the first year with 10 summer, 10 fall, 20 spring, and 20 winter (less in summer and fall due to greatly reduced precipitation at lower elevations). To minimize evaporation losses, precipitation samples will be obtained the day of or day after the event. The USGS will assist in site selection. OWRD will collaborate and review site selections.

In addition, to understanding isotope fractionation by storm variability, approximately 10 to 20 samples will be collected at one location belonging to the USDA-Agricultural Research Service (ARS) bordering the UIR. ARS personnel will collect water samples (10mL) for CTUIR following major storm events. The CTUIR intends for the USGS Reston Stable Isotope Lab (RSIL) to analyze the stable isotopes of 2H, 1H, 18O and 16O. All samples will be shipped at the end of year because holding times can be years (as long as lids are sealed tightly). This information will be used to develop LMWL, a Piper diagram of evolved water, and will aid in completing Objective 4. The CTUIR will be responsible for completing this task; USGS will assist in analysis and data collection effort.

Objective 4: Isotope Analysis and Data Synthesis (35%). The proposed work will be done by the USGS, which will interpret and synthesize geochemical data collected in 2017 and 2018. Interpretation of this data will augment the water budget and recharge studies completed in 2017 and 2018. USGS will also utilize geochemical data collected in 2016 by the National Water-Quality Assessment program from nearby basalt wells that have not yet been interpreted. Additional work will include integration and reinterpretation of approximately 100 samples for stable isotopes of groundwater collected in the upper Umatilla River Basin in the late 1980s along with the precipitation samples collected from this project, and geochemical samples from the region collected in the late 1970s.

Objective 5: **Finalize Groundwater Recharge Assessment (30%)**. The USGS will be responsible for data analysis and interpretation of results, with a preliminary report containing tables and figures and a summary of analyses. This information will be published by the USGS with new funds. The CTUIR will expand on the preliminary report to produce a final deliverable product to BOR that addresses groundwater management implications and provides recommendations for policy revisions and measures in the Water Code. OWRD will review and comment on the preliminary report and final report to BOR.

Table 2: Project Objectives, Tasks, Activities, Personnel by Agency, and Schedule (Semiannual)

Objective 1: Project Planning & Management (<5%)		**Personnel**	**Year 1**		**Year 2**	
Activity/Deliverable	**Subtasks**		**1/2**	**1**	**3/2**	**2**
Administer Grant	Project management/administration	CTUIR/USGS	X		X	X
	Prepare USGS Funding Agreement	CTUIR/USGS	X			
	Prepare USBR Cooperation Agreement	CTUIR/USBR	X			
Reporting	Compliance related to cultural, historical and natural resources	CTUIR/CRPP	X			
	Financial reports, semiannual	CTUIR Admin	X	X	X	X
	Interim performance reports, semiannual	CTUIR	X	X	X	X
	Final performance report	CTUIR/USGS				X
Objective 2: Education & Outreach, Each Year (<5%)		**Personnel**	**Year 1**		**Year 2**	
Activity/Deliverable	**Subtasks**		**1/2**	**1**	**3/2**	**2**
News articles in Confederated Umatilla Journal	Announce grant award and purpose, prepare news article on findings and water resources management	CTUIR	X			X
Report to the Tribal Water Commission and community	Present PowerPoint on hydrologic principles, groundwater conditions, and study results; prepare poster for conference (June 2020)	CTUIR/USGS	X	X		X
Nixyáawii Community School	Provide instructional materials on hydrology and groundwater management	CTUIR		X		X
Update USGS website for Umatilla Basin	Share data and information with public and agencies; update website with findings	USGS				X
Objective 3: Data Collection and Reporting for LMWL (25%)		**Personnel**	**Year 1**		**Year 2**	
Activity/Deliverable	**Subtasks**		**1/2**	**1**	**3/2**	**2**
Data Collection	Develop QA/QC sampling plan	CTUIR	X			
	Coordinate site selection and sampling plan with USGS, ARS, OWRD	CTUIR/USGS /ARS	X			
	Identify landowners and install gauges	CTUIR	X			
	Collect 10-summer, 10-fall, 20-winter and 20-spring stable isotope (SI) samples; first set collected with the USGS	CTUIR (4x) USGS (1x)	X	X		
	Collect 10-20 continuous SI samples at ARS station	ARS/CTUIR	X	X		
	Collect 15 spring-site samples for general mineral and SI	CTUIR	X	X		
	Collect 2 SI samples from alluvial wells	CTUIR	X	X		
Laboratory Analysis	Send SI samples to USGS RSIL	CTUIR/USGS		X		
	Send general mineral samples to BOR Lab	CTUIR/BOR		X		
	Archive SI sample results in USGS NWIS database	USGS		X		
	Review sample results, archive SI and general mineral results to CTUIR database	CTUIR		X		
Field Data Analysis	Document process, prepare GIS layers, metadata files	CTUIR		X		
	Develop local meteoric water line and compare to global meteoric water line	CTUIR/USGS		X		

	Develop Piper diagrams of general mineral type (Grapher software) and assess water evolution	CTUIR/USGS		X		
Reporting	Draft report on geochemical evolution from general mineral analysis and water types	CTUIR		X		
	Report findings (interim report)	CTUIR		X		
Objective 4: Isotope Analysis and Data Synthesis (35%)		**Personnel**	**Year 1**		**Year 2**	
Activity/Deliverable	Subtasks		**1/2**	**1**	**3/2**	**2**
Data Analysis	Develop dataset of all environmental SI data in study area	USGS		X		
	Interpret SI data from wells and springs w/r/t to depth and location within flow system and w/r/t to meteoric waters	USGS/CTUIR		X		
Reporting	Prepare preliminary interpretive figures and tables summarizing results of SI analysis	USGS		X		
	Finalize interpretive figures and tables summarizing results of SI analysis	USGS			X	X
Objective 5: Finalize Recharge Assessment (30%)		**Personnel**	**Year 1**		**Year 2**	
Activity/Deliverable	Subtasks		**1/2**	**1**	**3/2**	**2**
Data Analysis	Interpret and correct carbon-14 data collected in study area, 2017-2018; integrate with interpretations of other carbon-14 data collected in the region between 2015 and 2019	USGS			X	
	Interpret dissolved noble gas data collected in study area, 2017-2018; integrate with interpretations of other gas data collected in the region between 2015 and 2019	USGS			X	
	Develop mixing models describing groundwater age	USGS			X	
	Synthesize groundwater age models, interpretations of SI data, major ion data, and recent interpretations of the groundwater budget and recharge dynamics to improve understanding of groundwater flow system, residence time, and recharge mechanisms	USGS			X	
Reporting	Prepare preliminary interpretive figures and tables summarizing results of SI analysis	USGS			X	X
	Present results to CTUIR in a PowerPoint presentation					
	Prepare a final report in FY22	USGS				X
Report Findings with Management Implications	Summarize findings, flow patterns, recharge conditions, implications for groundwater management	CTUIR/USGS				X
	Develop recommendations for changes to WC to the Water Commission	CTUIR				X

*CTUIR: DNR Water Resources Program with Umatilla Basin Hydrologist, Water Resources Technician II, and Water Code Administrator/Water Resources Specialist
*CRPP: CTUIR DNR Cultural Resources Protection Program
*CTUIR Admin.: CTUIR DNR Administration Manager

*USGS: US Geological Survey scientists from Oregon Water Science Center
*ARS: US Department of Agriculture Agricultural Research Service
*BOR: US Bureau of Reclamation Water Laboratory, Boise, ID
*OWRD: State of Oregon Water Resources Department

2.3 Project Benefits

Project success depends on several key elements: Development of a LMWL from stable isotopes of precipitation at various elevations and seasons, analysis of water chemistry data to characterize water evolution and associated age and recharge source, and analysis and interpretation of radioisotopes for age dating and characterizing aquifer mixing and recharge sources. With these three elements completed, it will be possible to identify basalt aquifers that receive recharge from modern sources and those that do not receive measurable recharge and are, for all practical purposes, a non-renewable resource. With the information gained, the CTUIR will develop recommendations to update the WC and Tribal policy for sustainable groundwater management in an environmentally and economically sound manner.

Benefits:

- Improve CTUIR's understanding of the groundwater flows paths in and between basalt aquifers (mixing) and between surface water and groundwater, groundwater availability and recharge mechanisms (renewable/nonrenewable resources);
- Identify and characterize basalt aquifers by (1) age using radioisotopes for age dating and aquifer mixing, and stable isotopes and water chemistry as surrogates for age; and (2) recharge area using stable isotope signature relative to a LMWL.
- Inform CTUIR policy development and rule-making in the WC regarding management and development of groundwater resources to maximize use, protect instream flows, reduce competition for groundwater, and conserve groundwater to protect and promote First Foods, Tribal economy, and long-term use of water resources;
- Improve CTUIR's capacity to conduct research by developing effective and inexpensive methods to identify aquifers (stable-isotope and general-mineral analysis of groundwater);
- Improve spatial and vertical distribution of groundwater monitoring program to fill data gaps and to evaluate water-level stability in identified and grouped basalt aquifers;
- Improve/update assumptions built into the conceptual model and support calibration of a numerical model;
- Strengthen communication between CTUIR and the community and increase community awareness of CTUIR's approach to water resources management for the welfare of Tribal people and First Foods;
- Improve collaboration with OWRD scientists for a shared understanding of the hydrologic system, which will be necessary in developing a groundwater co-management plan;
- Move CTUIR and OWRD toward cooperative and sustainable management of water resources in the Umatilla River Basin
- Improve OWRD's understanding of basalt hydrology in the region to make better decisions in permitting and management; and
- Inform the water rights negotiation team of groundwater availability and development of a CTUIR-OWRD groundwater co-management agreement.

Outcomes:

- A local meteoric water line to establish the relationship between stable isotopes and recharge source by elevation. Stable isotope samples collected from 96 wells and 4 spring sites (from1980s, 2017, 2018) and from15 springs (this project) will be evaluated for recharge elevation and source depending on sample distance from source elevation and water type;
- A low-cost method using stable isotopes and water type as age surrogates that can be quickly used to evaluate groundwater aquifers, recharge sources, and linkages to modern, mixed, or considerably older source waters;
- A Piper diagram and other plots showing the evolution of groundwater over time, which will used as additional evidence of residence time and age-dating source waters; and
- Recommendations to update Tribal policy with appropriate rules and revisions to the Tribal Water Code.
- A USGS Scientific Investigations Report describing the relationship between groundwater age, major ion chemistry, and position within the flow system, will be produced, providing foundational information about the groundwater system, recharge to basalt aquifers, and implications for water withdrawal across the study area.

2.4 Project Team

The CTUIR has a history of successfully managing its land and water resources to safeguard First Foods and the cultural heritage to which they are inextricably connected. The CTUIR has competent staff and capacity to implement all aspects of the proposed project with the exception of synthesis and interpretation of radioisotope-data, modeling and synthesis of historic data. The USGS will apply their experience and expertise to isotope analysis as it relates to groundwater recharge, aquifer mixing, and groundwater flow. Because USGS provides objective and reliable scientific information and their work is defensible, OWRD and CTUIR will depend on their services in analyzing the data and interpreting results. This data-driven analysis and information gained by USGS's participation will support (a) a CTUIR-OWRD groundwater co-management agreement, and (b) policy development related to Tribal water resources planning, monitoring, and management. The CTUIR must partner with the USGS to complete the scope of work.

Key staff members are: Umatilla Basin Hydrologist, is the project manager (PM) and lead for CTUIR. USGS Hydrologist is the lead for data analysis and characterization of groundwater recharge and the groundwater flow system. The PM will oversee project implementation and manage all tasks, costs, schedule, and quality of work.

CTUIR Water Resources Program-Umatilla Basin Hydrologist, has worked in this position since 1995 and is responsible for the planning and implementation of hydrologic studies, data collection and analysis, and water resources monitoring programs on the UIR and in the Umatilla Basin. Duties and responsibilities include analysis of technical issues involving water quality and quantity, water availability, and management of groundwater and surface water resources; advice and recommendations to Tribal policymakers. The hydrologist was lead in the development of the upper Umatilla Basin conceptual model. For this project, the hydrologist will develop a

QA/QC data collection plan, select monitoring sites (with USGS and OWRD collaboration) for precipitation and spring sampling, analyze data for LWML and chemical evolution of groundwater using Grapher, and prepare all written communications to BOR and USGS.

CTUIR Water Resources Program- Water Resources Technician II, has worked in this position since February 2017. For this project, the technician will be responsible for obtaining land owner approvals, rain and snow gauge installations, data and sample collections, chain-of-custody reporting for water samples and mailings, and assist in data analysis and archiving data in MS Access database.

CTUIR Water Resources Program-Water Code Administrator/Water Resources Specialist II, has worked as Water Resources Specialist since 1994 and Water Code Administrator since April 2016. For this project, the administrator will be responsible for the development of recommendations to improve policy, procedures, and implementation of the Water Code. In addition, the administrator will assist with obtaining land owner approvals and rain and snow gauge installations.

US Geologic Survey, Portland Water Science Center-Team Lead-Hydrologist, has worked for the USGS since 1997. He has expertise in surface water and groundwater, statistical analysis, mathematical modeling, environmental tracers and stable isotopes, and springs as window to groundwater systems.

US Geologic Survey, Portland Water Science Center-Research Hydrologist, has worked for the USGS since 1995. He has expertise in groundwater modeling, aquifer testing and groundwater characterization, drought and climate effects on groundwater availability, environmental tracers and stable isotopes.

Oregon Department of Water Resources, Hydrogeologist, Salem office, will participate in project to review and comment on site selections, data collection and semi-annual and annual reports to BOR.

US Department of Agriculture-Agricultural Research Service-Dave Robertson will assist with sample collection at the ARS meteorological station, including retrieving and labeling samples from rain gauges following major storms throughout the year. It is anticipated that fewer than 20 samples will be collected altogether.

3. EVALUATION CRITERIA

In addition to Evaluation Criteria A-Project Need, B-Project Benefits, and C-Project Implementation, which are discussed in proposal above, this project aligns with Criterion D-Alignment with Department of the Interior Priorities. Specifically, (A) utilize science (information and methodology gained) to identify best management practices (recommended water code revisions/update) to protect, conserve and develop groundwater resources for sustainable use by Tribal people, First Foods, and economic development, and adapt to changes in the environment (climate change and drought); and (B) by partnering with OWRD in review of activities and reports, this project expands the lines of communication with OWRD in management of groundwater resources.