FIRST NATIONS
DEVELOPMENT INSTITUTE

WATER MONITORING GUIDE

FOR NATIVE PRODUCERS

PREPARED BY

High Water Mark, LLC

282 S. Camino del Pueblo, Suite 1E

Bernalillo, NM 87004

HIGH WATER MARK

ACKNOWLEDGEMENTS

The Water Monitoring Guide for Native Producers provides helpful guidelines, recommendations, and resources to Southwest Native farmers and ranchers seeking to effectively monitor and manage water resources for agricultural production.

This Water Monitoring Guide for Native Producers was made possible with generous support from the U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS). The contents of this publication do not reflect the view of the U.S. Department of Agriculture, nor does it mention of trade names, commercial products, or organizations that imply endorsement by the U.S. Government.

This publication was written by High Water Mark LLC, a consultant with First Nations Development Institute. We acknowledge and thank the farmers, ranchers, and tribal departments for their generous contributions to this guide.

Pueblo of Jemez

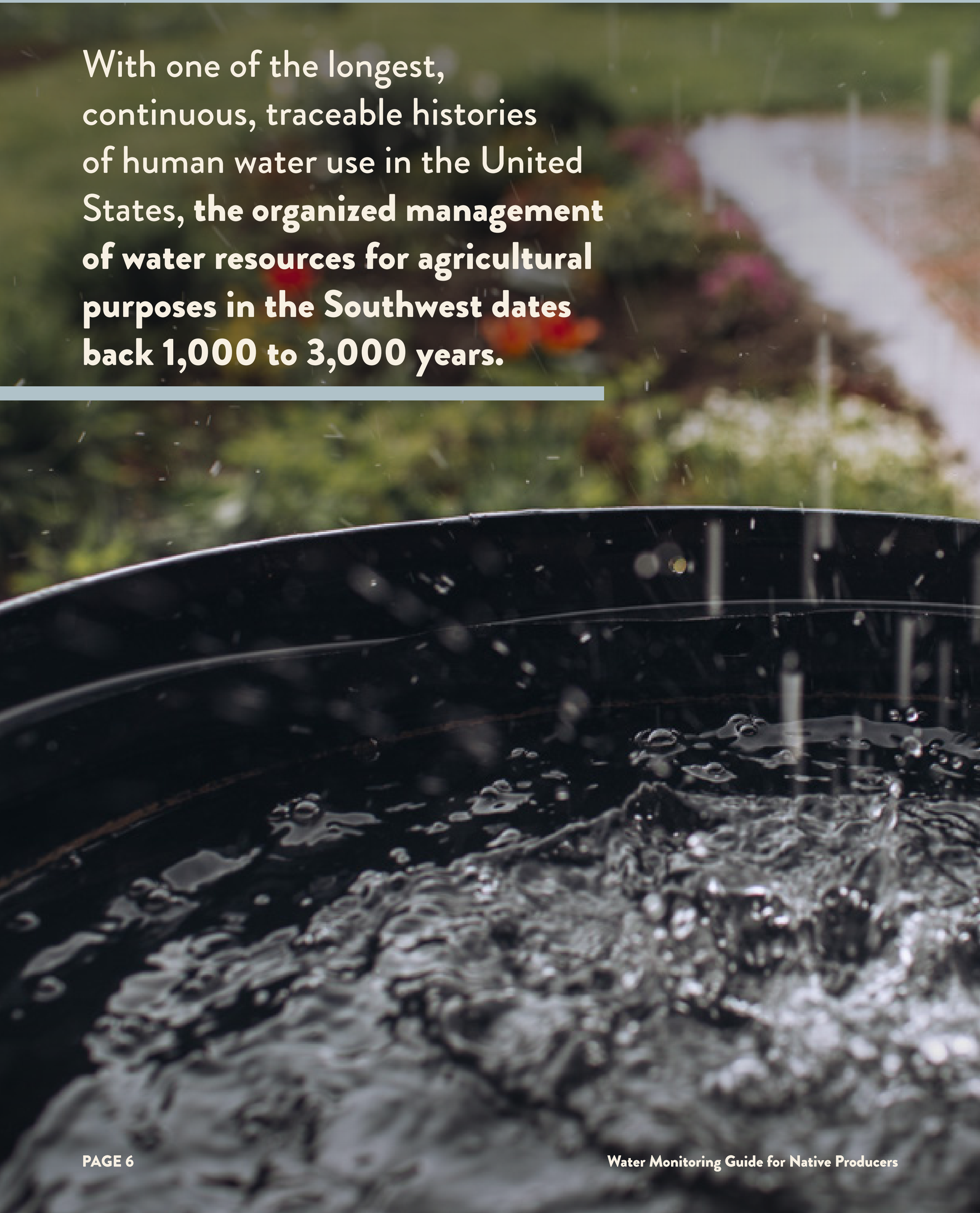
White Mountain Apache Tribe

Suggested citation: First Nations Development Institute (2023). "Water Monitoring Guide for Native Producers," Longmont, Colorado: First Nations Development Institute.

TABLE OF CONTENTS

APPENDICES

TABLES AND FIGURES



With one of the longest, continuous, traceable histories of human water use in the United States, **the organized management of water resources for agricultural purposes in the Southwest dates back 1,000 to 3,000 years.**

GLOSSARY

TERM	DEFINITION
Aquifer	A geologic formation or structure that transmits water in sufficient quantity to supply the needs for water development, such as a well
Confluence	Occurs when two or more flowing bodies of water join to form a single channel
Discharge	A volumetric flow rate of water that is transported through a given cross-sectional area. It is measured by the quantity of fluid flow over unit time
Drought	A deficiency of precipitation over an extended period, resulting in a water shortage
Native Producers	Farmers and ranchers who identify as Native American, Alaskan Native, or Native Hawaiian
Porosity	The ratio of the volume of openings (voids) to the total volume of material
Precipitation	Any liquid or frozen water (in the form of rain, snow, hail, etc.) that has fallen at a given location within a given time frame, expressed in inches or centimeters
Qualitative	Information or data not easily measured or counted. It typically answers the questions of "what, how, or why."
Quantitative	Information or data that is measurable and number-based. It answers the questions of "how much, how many, or how often."
Tributary	A stream or river that flows to a larger body of water, such as a larger stream or lake
Water Conservation	The practice of using water efficiently to reduce unnecessary water usage
Watershed	A land area that channels rainfall and snowmelt to creeks, streams, and rivers, which eventually flows to outflow points such as reservoirs, bays, and the ocean
Water Withdrawal	Water removed from the ground or diverted from a surface water source for use

ACRONYMS AND ABBREVIATIONS

ABBREVIATION	MEANING
CCR	Consumer Confidence Report
CFR	Code of Federal Regulations
CWA	Clean Water Act
EPA	Environmental Protection Agency
HUC	Hydrologic Unit Code
L	Liter
MCL	Maximum Contaminant Level
MG	Milligram
NASA	National Aeronautics and Space Administration
NMED	New Mexico Environment Department
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
POJ	Pueblo of Jemez
SDWA	Safe Drinking Water Act
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WMAT	White Mountain Apache Tribe

1. INTRODUCTION

Southwestern tribes and Pueblo communities revere water as the source of all life which provides physical and spiritual interconnection among humans, animals, plants, and supernatural deities. With one of the longest, continuous, traceable histories of human water use in the United States, the organized management of water resources for agricultural purposes in the Southwest dates back 1,000 to 3,000 years. Prominent irrigation structures and runoff collection systems provide testimony to a long history of managing precious water resources to support life in the arid Four Corners region. Today, tribes and Pueblos continue a successful legacy of water management, including strategic adaptation to climatic cycles in the maintenance of water resources for traditional cultural use, domestic use, agriculture, economic use, and many other uses that serve the diverse needs of each community.

Fundamental to effectively managing water resources in the Southwest are the individual and coordinated efforts and expertise of Native farmers and ranchers who continue to navigate and work directly with their ever-changing water resources and region-specific environmental conditions. Native farmers and ranchers have continued to maintain a wealth of invaluable traditional ecological and agricultural knowledge over the centuries and possess expertise in stewardship of their lands, plants, animals, and especially water resources. While maintaining agricultural operations, they also navigate the frontlines of the increasingly difficult challenges posed by climate change, the region's aridity, and the resulting complexity of water quality and quantity issues prevalent in the Southwest.

Increasing capacity and support for Native farmers and ranchers with their ongoing observation, assessment, and collaboration on the continued intentional use of water resources would ensure the short- and long-term preservation and revitalization of water resources that are essential for tribal community and cultural longevity now, and into the future.

1.1 PROJECT PURPOSE

The purpose of this guide is to provide background materials, recommendations, and resources that will help Southwest Native farmers and ranchers to effectively monitor and manage water resources for agricultural and livestock production.

Goals of the Water Monitoring Guide for Native Producers

Develop guidelines to expand water monitoring and innovative water conservation practices

Increase community and producer knowledge of local water systems

Engage community to pursue an active commitment to water resource protection

The examples provided in this guide highlight the experiences of two Southwest tribes: the Pueblo of Jemez in north-central New Mexico and the White Mountain Apache Tribe in east-central Arizona. The examples include their development of support systems and best practices for their Native producers and illustrate examples of water monitoring and water management practices. Sections 2, 3, and 4 provide background information and local data to support Native farmers and ranchers in learning and understanding local water systems, including: the hydrologic cycle, watershed components and processes, surface and groundwater sources, and other information central to developing sustainable water management strategies and best practices. Overall, this guide aims to support Native farmers and ranchers and local communities in their continued practice of foundational values and principles of tribal water stewardship and protection that have sustained our communities for millennia.

1.2 PROJECT NEED

Several water-related challenges exist for Native farmers and ranchers. Atop these concerns is a continuing water scarcity in the Southwest. The Southwest is the driest region of the U.S., with an average annual precipitation ranging from 13.4 to 15.7 inches.[1] This is less than half the average annual precipitation of the U.S., which is 33.7 inches. Most of the surface water in the Southwest is sourced from two primary water systems—the Colorado River and the Rio Grande, with their respective tributaries. Recent drought and

1 "Climate of the Southwestern United States," Earth@Home, Paleontological Research Institution, https://earthathome.org/hoe/sw/climate/

climate changes have greatly lowered the water levels of these two basins as evidenced by the clearly visible high-water mark around Colorado River lakes and entire stretches of the lower Rio Grande Basin. Due to increased demand, and water scarcity, the Rio Grande often runs dry before it reaches the Gulf of Mexico. These bodies of water become exhausted and transform into dry stream beds as the result of continued drought. This increased demand for water across the Southwest mirrors the growth of population. Historically, 80% to 90% of the water was allocated to agricultural uses. But in recent years, an increasing percentage has been directed to domestic consumption—a reflection of population growth in the desert Southwest placing increased demand on already over-allocated water resources.[2]

As Southwest farmers and ranchers are aware, frequent drought events significantly increase soil temperatures and evaporation, thus decreasing moisture content in soils and hindering overall plant vitality. As a result of climate change, these conditions are exacerbated with observed and projected impacts, including warmer temperatures, decreased water supply, lower soil moisture levels, increased frequency and intensity of wildfires, and heightened competition and demand for increasingly limited water resources. These conditions, paired with ineffective water and soil management, can significantly disrupt crop and livestock production. Other challenges exist for Native farmers and ranchers, many of which are perpetuated by local, state, and federal water policies not always in alignment with Indigenous values, impacting the water rights and access of tribes, Pueblos, and their producers. While there is a history of local, state, and federal water resource management partnerships, there is opportunity for improved coordination and collaboration of tribal water management, stewardship values, and expertise in the development of local, state, and federal regulations, laws, policies, and funding opportunities. Increased co-management of water resources is predicated upon the recognition of Pueblo and tribal nations' sovereign control of their land and natural resources. This increase in water resource co-management involves exploration by tribes and local, federal, and state partners for opportunities relating to cross-jurisdictional, cooperative, and participatory collaboration on decision-making, planning, and enforcement.

Increasing co-management of water resources supports the development of water quality and quantity issues. impacting Native farmers, ranchers, and producers. hese solutions could impact areas including including:

- Senior tribal water rights and adjudication
- Impacts of municipal growth and development
- Recognition of unique tribal beneficial uses of water
- Recognition and implementation of Traditional Ecological Knowledge (TEK)
- Contamination impacts from extractive and other industries
- Overall underdevelopment of tribal water delivery infrastructure, including dilapidated irrigation infrastructure

2 Jay Sharp, "Water in the Southwest Part Three: Surface Water," Desert USA, https://www.desertusa.com/desert-water/surface-water-southwest.html

- Tribal water-quality testing programs
- Staffing capacity for tribal water-resource management
- Government funding for tribal water and agricultural projects

With these long-term considerations, it is important that tribal governments support their Native farmers and ranchers to identify areas of immediate concern and opportunities regarding water management and preservation for agricultural purposes. Native farmers and ranchers can implement immediate and direct practices to significantly conserve water resources, revitalize ecosystem health, improve agricultural production both short- and long-term, and provide education to their communities on the critical importance of water preservation. With their knowledge, experience, expertise, and unique insight, Native farmers and ranchers can also inform tribal water management, assessment, planning, and the political and legal negotiations and discussions mentioned previously. Ultimately, coordination and mutually informative planning between producers and tribal governments and administrations is fundamental to ensuring comprehensive tribal water management, use, and preservation of the cultural, domestic, agricultural, and economic uses of water for generations to come.

2. BACKGROUND: UNDERSTANDING SOUTHWEST WATER RESOURCES

The Southwest region encompasses the following states: Arizona, Colorado, New Mexico, and Utah. The overall topography of the region varies from mountainous terrain to low plains and canyons to vast areas of natural forests. The Sonoran and Chihuahuan deserts encapsulate much of the land mass within the arid Southwest. These deserts are classified as "hot deserts,"[3] which translates to an area that experiences higher-than-normal temperatures and less-than-normal precipitation. It is common for this region to experience more than 300 days of sunshine a year.

Responsible stewardship of precious water resources begins with an understanding of the geographical features that determine how communities access water. Water is gathered from two main sources: surface water or underground aquifers (groundwater).

2.1 SURFACE WATER SOURCES

Surface water is the primary water source for farming communities. Surface water includes lakes, rivers, reservoirs, and acequias. Because the water flows from the highest point down to the lowest point within a

3 "The North American Deserts & Deserts of the World," *Desert USA*, https://www.desertusa.com/north-american-deserts.html

region, the quantities and velocities of water depend on the amount of precipitation the area receives. The area of land in which precipitation is drained through is referred to as a watershed. The boundaries of the watershed are defined by the topography of the region, via the high points or ridges.

Figure 1: Watershed Example (Source: UCOWR)

Figure 1 displays components of a watershed as defined by Universities Council on Water Resources (UCOWR). Streams and tributaries are shown in blue, while the entire watershed is outlined in orange and light orange. There are smaller watersheds or sub-basins, outlined in white, that are occupied within the boundaries of the overall watershed. From this watershed delineation, it is apparent what water contributions are being made by what sub-basin, which direction the water is flowing, and the locations of the confluence where tributaries join the larger stream.

It is recognized that Pueblos and tribes traditionally manipulated all four principal moisture resources available in their natural environment for agriculture: direct precipitation, intermittent runoff, groundwater, and permanently flowing rivers, springs, and seep waters.[4] Today, understanding the fundamentals of watersheds is beneficial to strategically structure farms and fields to maximize yields and to utilize surface-water resources efficiently and effectively. It is important to know that every water source has an associated watershed.

In general, watersheds are natural basin areas where water sources flow. For purposes of water planning and data management, government entities and hydrologists identify watersheds utilizing the Hydrologic Unit Code (HUC). Table 1 describes the various HUC scales.

4 Kurt F. Anschuetz, "Soaking It All In," *Academia*, https://www.academia.edu/30208452/Soaking_It_All_In

Table 1: Six Levels of Hydrologic Unit Codes (HUCs)[5]

HUC SCALES	AREA NAME	AREA DESCRIPTION
HUC 2	Region	Major land areas. There are a total of 21 regions in the U.S. This geographic area contains either the drainage area of a major river or the combined drainage areas of a series of rivers.
HUC 4	Subregion	There are between 3 and 30 subregions in the U.S. This could include the area drained by a river system, a portion of a river and respective tributaries, a closed basin, or group of streams.
HUC 6	Basin	An accounting unit. There are 352 of these in the U.S.
HUC 8	Sub-basin	Cataloging unit. There are 2,149 in the U.S. A geographic area that represents part or all of a surface drainage basin, a combination of basins, or a distinct hydrologic feature.
HUC 10	Watershed	Geographic area within a sub-basin that ranges from 40,000 to 250,000 acres. Previously referred to as HUC-11.
HUC 12	Liter	Geographic area within a watershed that ranges from 10,000 to 40,000 acres. Previously referred to as HUC-14.
Edwards, Pamela J., Karl W. J. Williard, and Jon E. Schoonover. 2015. "Fundamental of Watershed Hydrology." Journal of Contemporary Water Research & Education, 154(1): 3–20. Permission received.		

In addition to revisiting the natural features that form water conveyances, it is important to briefly revisit the water cycle. This cycle is a continuous movement of water within earth's atmosphere. Figure 2 is from NASA that describes the flow of events.

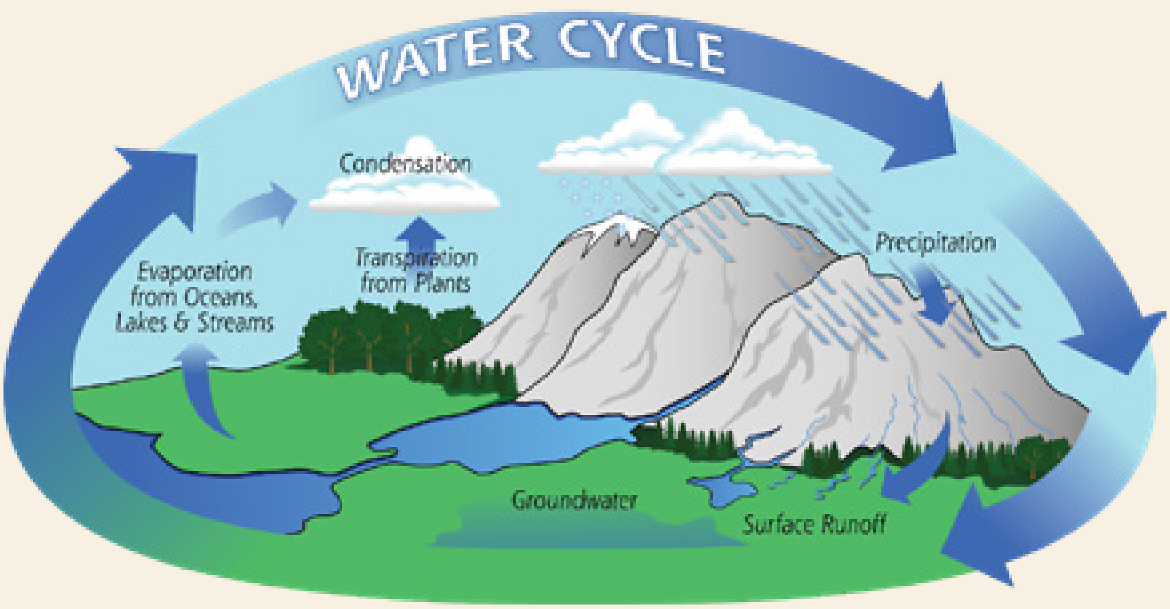


Figure 2: The Water Cycle (Source: NASA)

5 Edwards, Pamela J., Karl W. J. Williard, and Jon E. Schoonover. 2015. "Fundamental of Watershed Hydrology." Journal of Contemporary Water Research & Education, 154(1): 3–20.

To summarize, the water cycle includes the following processes: evaporation, condensation, precipitation, and infiltration. Evaporation occurs when temperatures begin to rise and water is changed from a liquid to a gas (water vapor). All water sources are subject to evaporation regardless of their location. The water vapor particles then cluster with other particles to form clouds. Once these clouds begin to condense with one another, water droplets begin to grow and eventually get too heavy for suspension, falling to the earth and causing precipitation. The precipitation then flows upon and infiltrates the earth's surface, finding its way into underground aquifers. The cycle then repeats itself. Durations and intensities of each process are dependent on the climate.

All water is essential to Earth and life. It is crucial to understand this complex cycle because any change in the cycle could cause adverse effects to the economy, energy production, health, recreation, transportation, agriculture, and drinking water, according to the National Oceanographic and Atmospheric Administration (NOAA).

2.2 GROUNDWATER SOURCES

Groundwater is obtained from sources located below the earth's surface. Water accumulates within saturated zones, also referred to as aquifers, and is tapped into via wells to provide water resources to communities. Groundwater sources vary in water quality and water quantity, and the porosities of the sand, soil, and rock can also vary greatly depending on geographic region. Depending on the porosity (extra or non-solid space within the total volume of the soil) value, oxygen within this space promotes the required respiration for plant or crop growth. Well-aerated soils provide more favorable growth conditions.

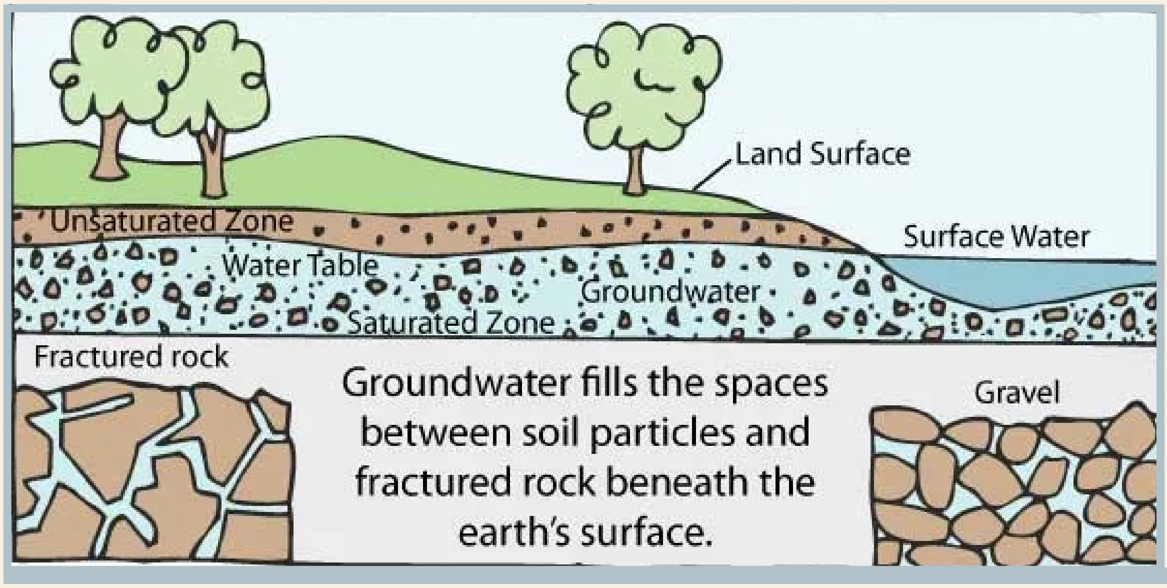


Figure 3: Groundwater Components (Source: USGS)

For example, rocks, such as pumice and shale, tend to have high porosity, depending on orientation under the surface, which allows water to flow freely through this medium. It is important to know that the value of porosity is influenced by the shape of the rock, range of rock size present, and orientation of the rock. Figure 3 displays specific elements pertinent to groundwater, according to the USGS.

The rate at which water percolates through soil and rock is referred to as groundwater recharge. Although difficult to quantify, in general, porosities of various rock and soils contribute to this rate of recharge. All forms of precipitation will replenish these aquifers naturally. However, there are some occurrences that affect the rate of recharge (which vary greatly depending on the region's climate and weather events):

- Evaporation of water
- Transpiration by plants
- Surface water runoff

Oftentimes, the roots of plants are located on the top layer of the soil, which is above the water table. This top layer of soil is relatively wet, but not completely saturated, whereas, the soil below the water table is fully saturated. During rain events, the topsoil layer gets wet and saturated; but when there are no rain events, the top layer of soil will dry out, eventually leading to soil erosion if the duration persists for an extended time. When there are no rain events, the natural mechanism of the plant is to find water by any means. This leads to the plant extending its roots into its saturated zone below the water table. Depending on the severity and duration of dry periods, the plant will continue to draw water from this source, which could ultimately lead to the drawdown of the water table. Figure 4 below displays this event.

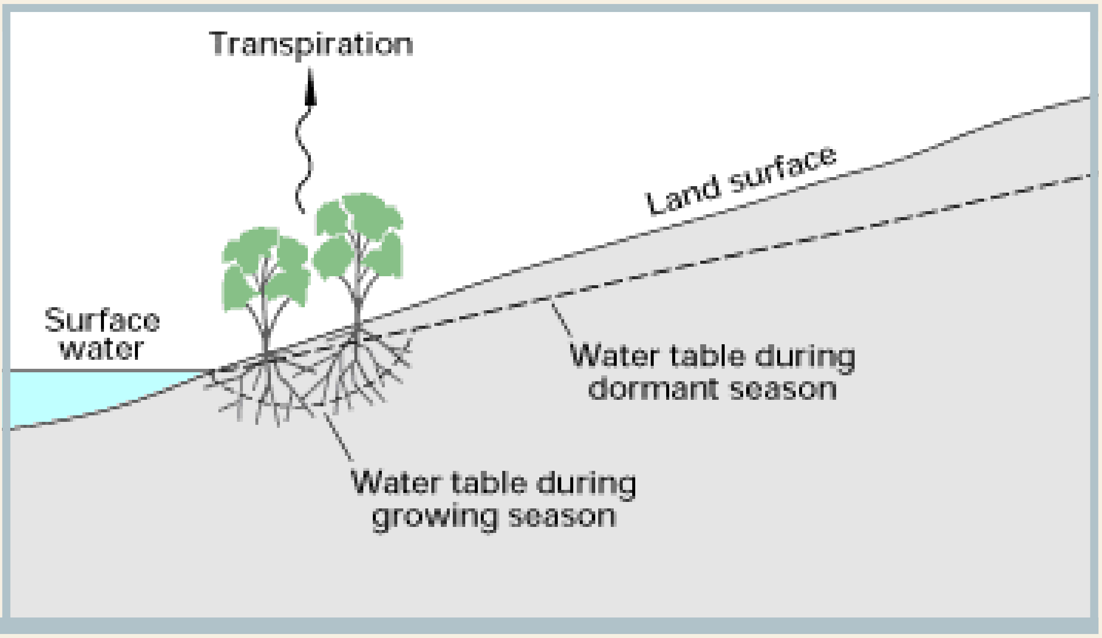


Figure 4: Plant Transpiration and Groundwater (Source: USGS/ Water Science School)

In order to access this groundwater source, a well must be drilled so water can be pumped out. But before any drilling occurs, a geohydrological assessment must be performed. This assessment will evaluate factors such as whether the groundwater has been contaminated, has potential for contamination, and at what level of risk is posed by contamination. To determine this, the site's history, hydrogeological setting, state of contamination, and beneficial uses need to be evaluated.

In the United States, groundwater is the source of drinking water for about half the total population and nearly all of the rural population, also providing over 50 billion gallons per day for agricultural needs.[6] Groundwater depletion, a term often defined as long-term water-level declines caused when groundwater pumping exceeds the recharge rate, is a key issue associated with groundwater use. For example, increased groundwater pumping to support population growth in south-central Arizona (including the Tucson and Phoenix areas) has resulted in water-level declines of between 300 and 500 feet in much of the area.[5] Threats to water quality caused by saltwater intrusion and contamination impacts from oil, gas, and mineral extraction also contribute to compromised groundwater sources.

Overall, surface water quantities are heavily dependent on precipitation events and snowpack melts in mountainous areas. In the Southwest, precipitation is not prominent when compared to other states; therefore, groundwater sources are relied on more. Even then, groundwater sources are more abundant, but if this resource is depleted, it will take significant time to recharge the aquifer.

3. WATER USERS

3.1 NATIVE PRODUCERS

Protection and preservation of agricultural practices continue to be a central priority of tribes and Pueblos. The cultural and economic survival and well-being of tribes are intrinsically connected to agriculture and stewardship. Many Native farmers and ranchers contribute to the cultural maintenance and revitalization, economic self-sufficiency, and nutrition of their communities, and many others.

The operations of Native producers can vary in many aspects, such as operation scale and purpose, location, methods of production; implementation of specific traditional agricultural and ecological knowledges; and use of, and access to, natural resources, including land and water. **Although operations of Native producers may be unique, each maintains depth of experience in responding to climate and environmental conditions and has an important role in maintaining the legacy of Southwest tribal water conservation and stewardship by utilizing water resources effectively and efficiently.**

6 Water Science School, "Groundwater Decline and Depletion," *USGS*, June 6, 2018, https://www.usgs.gov/special-topics/water-science-school/science/groundwater-decline-and-depletion

Over hundreds of generations, Southwest Pueblos and tribes have developed expertise, diverse techniques, and technologies in water conservation and stewardship for agricultural purposes. For example, Pueblo farmers have traditionally interacted with the physical environment to enhance water absorption properties of local watersheds to capture and protect precipitation, runoff, and groundwater moisture for crops. Today, many Native farmers continue utilizing a host of similar tactics and others for managing valuable moisture resources. This includes, but is not limited to, strategies like rainwater harvesting, soil regeneration and moisture conservation, dryland farming, waffle gardening, intercropping, and many others. Figure 5 shows some general examples of sustainable agricultural food practices tribes use today that were developed over centuries of agricultural practice.

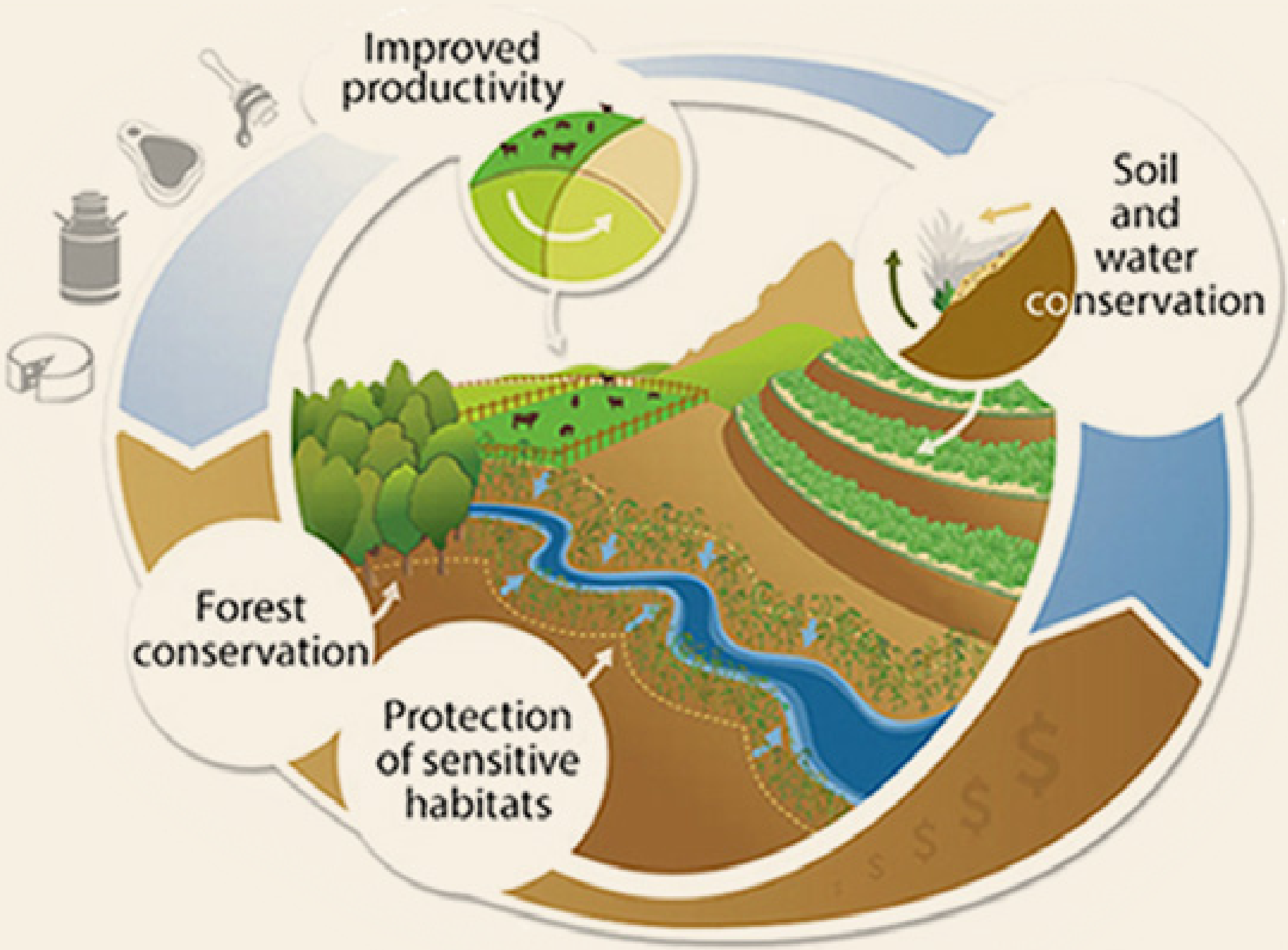


Figure 5: Examples of Sustainable Agricultural Practices[7]

7 Food and Agriculture Organization of the United Nations. *Incentives for Ecosystem Services (EIS)*. 2016.

3.2 INDIGENOUS REGENERATIVE AGRICULTURE

Diverse farming and ranching systems are essential to today's regenerative agriculture movement – but the concept is far from new. With a better understanding of where water supply is sourced, it is important to turn to discussion of how the supply is being utilized and by whom. By broad definition, a water user is an individual who obtains water from a public water supply or source. From this definition, every person is a water user. This guide focuses on Native water users in the agricultural and ranching communities who continue to steward the land.

4. FOUNDATIONAL TOPICS SURROUNDING WATER RESOURCE MANAGEMENT

There are multiple foundational factors critical to understanding current opportunities to advance water resource preservation. The four we will investigate further include the following:

- **WATER STANDARDS/REGULATIONS**
- **CURRENT AND FUTURE WATER USAGES**
- **COMMUNITY INVOLVEMENT**
- **WATER CONSERVATION**

I. Water Standards/Regulations

Understanding the basics of federal, state, and/or local water standards is important to managing water resources. If water standards are not specified or adopted for the region, federal agency standards are observed. Many of the Southwest's tribes and Pueblos have developed tribal water codes to administer pollution control, conservation, permitting, and overall water management and use. Various Pueblos and tribes have independently promulgated Environmental Protection Agency (EPA) -approved tribal water quality standards, similar to states under the Clean Water Act. Many have implemented comprehensive water quality monitoring programs, water quality ordinances, assessments, and reports to identify non-point sources of pollution, wetlands protection programs, water infrastructure efficiencies and deficiencies, and other water-related programs and projects.

II. Current and Future Water Uses

Knowing current and future water use information, such as how much water is being utilized for irrigation or how much water is needed to sustain a herd of cattle, is essential for farmers and ranchers for future planning.

III. Community Involvement

The interactions and engagements among the public, surrounding communities, and local, state, and federal agencies are critical to safeguarding water resources. Funding opportunities, resources, and guidance are all attributes that can be achieved through these engagements. The outreach and education of water resources are also major areas for farmers and ranchers to contribute to and engage other community members.

IV. Water Conservation

Development of water conservation practices is most important among this list, especially for farmers and ranchers in the Southwest region. As mentioned, water conservation is the practice of utilizing water resources effectively and efficiently. Freshwater is a limited resource, and quite often, significant amounts of water resources are wasted by water users. By developing specific water conservation goals and metrics of success, and evaluating progress, farmers and ranchers will be able to fully meet the overall objectives.

These four foundational topics are explored in Section 6 for two Southwest tribes: the Pueblo of Jemez in New Mexico and White Mountain Apache Tribe in Arizona.

5. WATER CONSERVATION PLANNING AND STRATEGIES

For Native producers, water conservation planning is a significant matter that requires community understanding and involvement. Planning for water conservation is a monumental task, especially when trying to conserve in an area as arid as the Southwest. It is important to establish a set of rules and/or guidelines that are straightforward and simple to follow. The planning could be broken down into broad categories:

- Water conservation of surface water sources from farming and ranching; and
- Water conservation of the community system (which in most cases, if not all, are groundwater sources).

5.1 EXAMPLE APPROACHES

There are a multitude of approaches, practices, and/or ideas that could be implemented to achieve the goal of water conservation. A few of these practices are listed for both surface and groundwater usages:

Conservation Planning (Surface Water)	Rethink flood irrigation
	Reuse and recycle water resources
	Install rain catchment systems on housing developments
	Eliminate invasive species (be thorough and extract from roots)
	Monitor surface water sources (flow rate, precipitation events, and amounts,
	Conduct surveys on known water sources and report water infrastructure damage
Conservation Planning (Groundwater)	Use less water
	Do not take baths (showers use less water)
	Do not use water from community water systems for irrigating personal gardens
	Be conscious of water usage
	Transfer knowledge by educating others on water conservation
	Report known leaks to either utilities or public works departments
	Use landscape planning (utilizing xeriscape methods)

In particular, water conservation for farmers and ranchers requires an investigation into more than just water quantities and qualities, but soil and soil health must be addressed to maintain adequate production. Soil regeneration is the process of incorporating science to restore and rejuvenate the soil in a variety of practices.

Soil health may be the most important factor for farming success, especially in the arid Southwest. Soil – with its physical, biological, and chemical makeup – is the foundation for which all plants are nourished and harvested. Today's soil in the Southwest is challenged by the effects of modern human inhabitance, such as salinization, pollution, soil loss, and reduced water retention. Soil health is an important focus for Native farmers and ranchers interested in regenerative and sustainable crop and livestock production, which integrates values and principles historically practiced by ancestral tribes and Pueblo people. Soil health, according to New Mexico State University's College of Agricultural, Consumer, and Environmental Sciences, defines soil health as the "state of the soil being in sound physical, chemical, and biological condition, having the capability to sustain growth and development of land plants"[8]. Taking into consideration major challenges regarding lack of water quantity in the Southwest, the soil health definition for Southwest Native farmers and ranchers includes an emphasis on soil to retain and filtrate valuable water resources.

Knowledge of how to build soil health in the Southwest is not widespread. Although there are a variety of resources that address soil health, five general principles exist that can be adapted to our region. These principles include strategies that Native farmers and ranchers can easily and immediately implement into their farming practices. These five principles include:

1. Soil Armor – Keep the Soil Covered with Vegetation

In the Southwest, a major effect of soil degradation is the high temperature and rate of soil erosion by wind and temperature. Soil armoring is important for reducing water and wind erosion, decreasing water evaporation, moderating soil temperatures, reducing the impact of energy from raindrops, suppressing weed growth, and providing a habitat for surface dwellers (which are an important part of the soil food chain).

2. Minimize Soil Disturbance

Minimizing soil disturbance helps soil armor remain intact. Physical and chemical disturbance to soil is usually caused by mechanical tilling, which buries crop residues, overstimulates microbial breakdown, and contributes to excessive carbon release into the atmosphere. Therefore avoiding crop tilling practices maintains soil armor.

3. Increase Plant Diversity

Diverse crop rotations provide more biodiversity to benefit the soil food web, which improves rainfall infiltration and soil nutrient cycling while reducing disease and pests. Crop rotations can also be designed to include crops for high water users, low water users, tap root, fibrous root, high carbon crops, low carbon crops, legumes, and non-legumes.

4. Maintain Continual Live Plant Root

A continual living plant root (either from a commodity crop, cover crop, or forage crop) provides carbon to feed the soil food web in exchange for nutrients for plant growth. This process is also important for soil aggregate formation, which increases soil pores for improved water and air exchange.

5. Integrate Livestock

Lastly, livestock integration balances the soil carbon/nitrogen ratios to healthy levels by converting high carbon forages to low carbon organic material and reducing nutrient transport from the soil.

---

8 John Idowu et al, "Soil Health—Importance, Assessment, and Management," *New Mexico State University*, December 2019, https://pubs.nmsu.edu/_circulars/CR694B/index.html

There is no direct method to judge the status of soil health. However, it is possible to measure specific soil properties to detect whether a soil is healthy or not. Such measurements may be quantitative or qualitative, or a combination of both.

Start with a quantitative soil health assessment of your farm fields or rangelands, contact your local New Mexico State University Extension (**https://aces.nmsu.edu/county/**) or University of Arizona Extension agent (**https://extension.arizona.edu/**), Soil and Water Conservation District, or USDA NRCS office to seek further guidance and assistance. Apart from the quantitative soil health assessment, there are also qualitative measures that can be used in the field to monitor the state of your soil health. Farmers and ranchers can do simple objective assessments of soil health by regularly checking topsoil for its relative moisture, physical composition (sand, clays, and silt), presence of mycelium, organic materials, and living components like earthworms.

There are numerous simple **"Do-It-Yourself" tests** to support immediate on-the-ground assessment. The "In-Field Soil Health Assessment Worksheet," currently being developed by the New Mexico NRCS, provides useful field-based observational measurements for farmers and soil managers. The in-field assessment includes observations, such as soil cover, residue breakdown, surface biological and physical crusts, water ponding, compaction measurement, water-stable aggregates, soil structure, soil color, plant roots, biopores, and biological diversity. All these measurements are rated in the field on a worksheet to help identify areas of soil constraints. Based on the issues identified, the farmer or rancher can modify or select appropriate management practices to address the constraints.

5.2 PASTURE ROTATION

Pasture rotation is a system where large pastures are divided into smaller paddocks, allowing livestock to easily be moved from one paddock to the other. By utilizing this method, cattle are concentrated on a smaller area of the pasture for a prescribed number of days, then moved to another section of pasture. This practice of frequently moving cattle allows grasslands to recover after periods of intense grazing.

Without this grazing method, cattle tend to collect and remain around favored water sources and pastures, causing overgrazing that damages the vegetation and hinders their recovery. Grass density is reduced, shorter grass means less shade and increased evaporation, more days on the same pasture causes soil compaction, thus decreasing moisture absorption properties of soils, and more precipitation runs off the landscape causing erosion. Ecologically fragile grasslands in the Southwest have sustained considerable damage by being subjected to continuous grazing by domestic livestock, and the warmer temperatures and decreased precipitation resulting from climate change will only increase their vulnerability.

Rotational grazing improves pastures over time, resulting in greater grass density, diversity of desirable grass species and nutritional value, greater retention of precipitation through absorption instead of runoff, and eliminating the waste of forage. The primary advantage of rotational grazing is that forage production increases from 30% to 70% by minimizing overgrazing. Grazing stimulates new plant growth, both above ground and in the development of deeper roots, both of which contribute to a healthier plant. Growing plants photosynthesize, pulling CO2 (Carbon Dioxide - greenhouse gases) from the atmosphere, discharging oxygen back into the atmosphere, and drawing carbon into plant roots to eventually boost soil biomass and fertility. Continuous grazing, on the other hand, interrupts this cycle because cattle will graze the grass down below the level at which it cannot recover quickly, causing the rangeland to become degraded rather than improved. The simplest form of rotational grazing is to move livestock between pastures every set number of days. This repeats with the herd being moved several times from one pasture to the next until the herd is eventually reintroduced to the first pasture, where the grass has now been "rested" for a sufficient interval of time to recover. This cycle is represented in Figure 6.

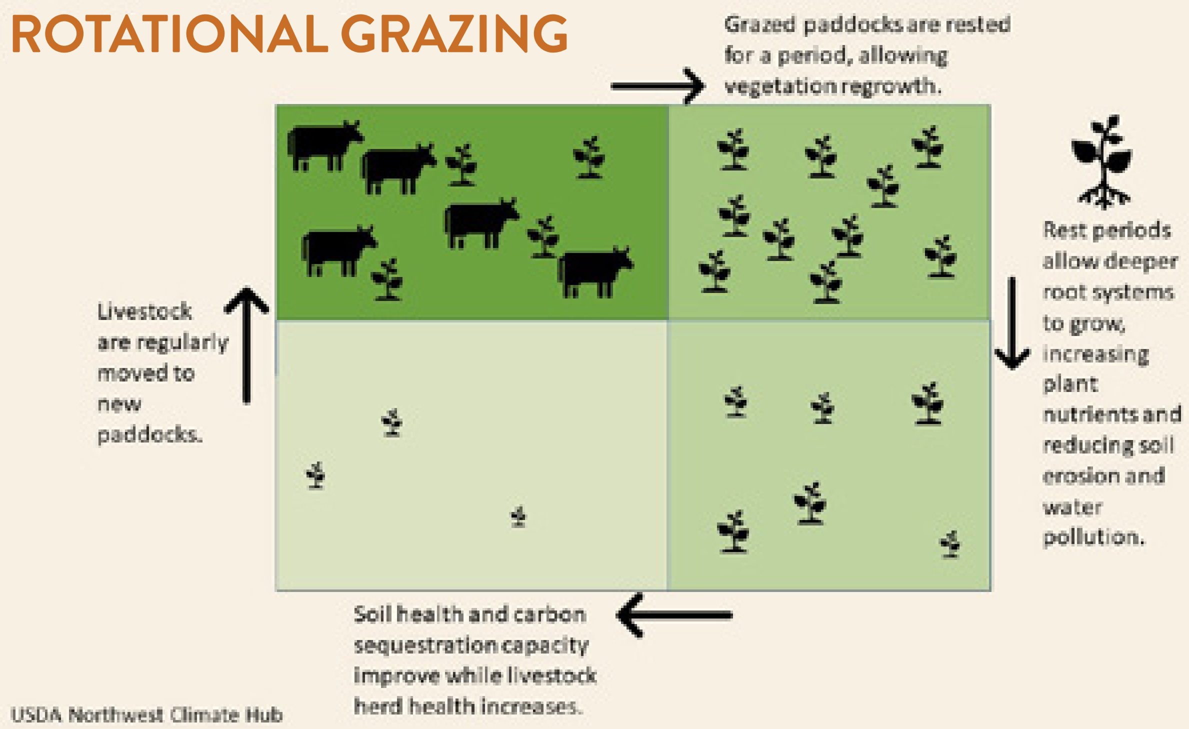


Figure 6: Rotational Grazing Example (Source: USDA Northwest Climate Hub)

The size of the pasture and the related stocking needs will determine the rotational schedule in conjunction with weather conditions, nutrient practices, and the pasture quality. Depending on each grower's situation and local conditions, the rotational schedule may be a period of three- to five-week intervals. Some proponents of raising quality grass-fed beef advocate for a daily rotational schedule, although the associated labor makes this impractical for many producers. Other advisors advocate actively monitoring forage conditions and moving the herd when grass length is grazed to 2-3" in height. Cooperative Extension Services (CES) offer resources to assist producers in determining rotation schedules based on local range conditions, forage health, number of paddocks and paddock sizes, stocking rates, etc.

Effective pasture rotation requires that each paddock has water, shade, and nutrients to support the animals confined to the paddock. Technology improvements, including electric and virtual fences, and pipelines to convey water from wells or surface-water sources to troughs and drinkers in newly defined pastures, are helping producers to cost-effectively address the challenges associated with subdividing pastures. In some cases, labor-intensive, supplemental feeding by hauling hay and water are necessary to allow overgrazed pastures to recover. The goal is to create a healthy landscape, and then implement stocking rates and management activities that allow for sustainable livestock production.

5.3 WATER CONVEYANCE

For centuries, Southwestern farmers have relied on irrigation ditches to convey water from its source to their fields. Today, water is a coveted resource that thrusts farmers into intense competition with a multitude of other water users, and there is intense debate over what ater conservation and water use practices are considered wasteful. Agriculture, historically, has been a significant user of water resources. However, today, farmers face pressures from new demands to support residential and economic activities. Accordingly, irrigation systems and practices have attracted increased scrutiny.

For decades, irrigators in the Southwest have been faced with the decision of whether to line their water conveyance systems with concrete or to keep their systems earthen. There are pros and cons of both lined and unlined irrigation ditches.

Concrete-lined ditches have higher initial costs for construction, depending on the length of the ditch. Lined ditches reduce water loss through seepage, thereby conveying more water to the end user. When constructed through sandy, coarse gravel, or other unstable soil materials, the addition of concrete linings to ditches reduces the "caving in" of the ditch banks that could otherwise cause the ditch to fail, thus reducing maintenance and rehabilitation costs. But concrete-lined ditches also reduce groundwater recharge and reduce moisture available to support fruit trees, medicinal plants, and other beneficial species of the riparian habitat that would otherwise flank an unlined ditch.

Earthen ditches produce slower water velocities, increasing water seepage into surrounding soils, and thus causing water loss from the perspective of water users at the end of the ditch line who may be receiving less than their "fair share." Unlined, earthen ditches may be beneficial from an overall river and floodplain management perspective. Field studies document that water seepage from earthen ditches contributes to the recharging of surrounding shallow aquifers and enhances riparian vegetation and wildlife habitat along the ditch. But earthen ditches produce their own maintenance issues, including the need for annual cleaning to remove unwanted weeds and sediment buildup, and to rebuild ditch walls prior to the irrigating season. They are also vulnerable to overtopping due to storm events and may have unstable soil characteristics.

During periods of drought, the shared need for scarce water has generated emotionally-charged water allocation debates. When considering changes to water resources management in agricultural corridors, it is important to analyze all potential impacts of changes and to understand the many factors that influence the hydrologic cycle of irrigated agriculture.

Figure 7 displays major components of an irrigated agricultural corridor. The figure highlights the interactions between surface and groundwater along an irrigated corridor between an unlined ditch and a river.

As shown from the arrows, the water is constantly traveling, being introduced, and being depleted. For instance, the crops receive water from precipitation and also from the main irrigation ditch supplied from a diverted river. The water not consumed by the crops or surrounding riparian vegetation typically evaporates or seeps into the ground. Figure 7 displays the existence of multiple water flow paths and the possible directions that could be taken within an irrigated field. The rates and volumes of water moving throughout this field vary by time of day, time of year, and location of the field.

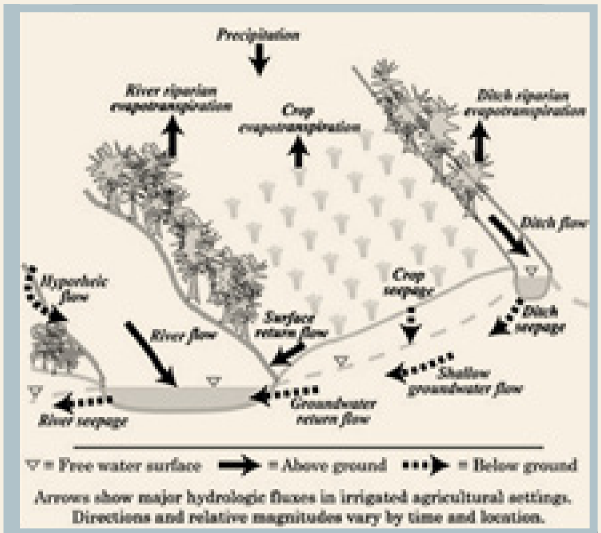


Figure 7: Hydrologic Budget Components of an Irrigated Agricultural Corridor[9]

5.4 WATER REUSE

Due to the scarcity of water in the Southwest, water reuse has become an important alternative method for livestock and irrigation watering. Some water sources of potential reuse include: wastewater, storm water, and agriculture runoff and return flows. Some of these water sources require treatment to be considered safe for consumption. In particular, wastewater treatment and use has been increasingly more common in the Southwest. Advancements in technologies have transformed and simplified the process of turning wastewater into drinking water, making it more mainstream. Additionally, the EPA promulgates overarching methods and regulations for the utilization of wastewater reuse for livestock and irrigation watering. Generally, wastewater

9 Fernald, Alexander G., and Steven J. Guldan. "Water Task Force: Report 2." *River, Acequia and Shallow Groundwater Interactions.* New Mexico State University, 2004.

programs exist throughout the state, where regulations vary. Table 2 displays the water reuse for consumption by livestock specifications for New Mexico and Arizona, according to the EPA.

Table 2: Wastewater Utilization Water Standards for Livestock Consumption

RECYCLED WATER CLASS/ CATEGORY	SOURCE WATER TYPE	WATER QUALITY PARAMETER	WATER QUALITY SPECIFICATION	SAMPLING/ MONITORING REQUIREMENTS
		New Mexico[10]		
Class 2 Reclaimed Water (Livestock Watering)	**Domestic Wastewater**	5-day biochemical oxygen demand (BOD_5)	• 30 mg/L (30-day average) • 45 mg/L (single sample maximum)	Minimum of 6-hour composite and 1 test per week for major WWTP; grab sample and 1 test per month for minor WWTP
		Total Suspended Solids (TSS)	• 30 mg/L (30-day average) • 45 mg/L (single sample maximum)	
		Fecal Coliform	• 200 organism/ 100mL (30-day average) • 400 organisms/ 100 mL (single sample maximum)	Grab sample at peak hourly flow; 1 test per week for major WWTP, 1 test per month for minor WWTP
		Total Residual Chlorine (TRC) or UV Transmissivity	• None, monitor only	Grab sample or reading at peak hourly flow; record values at peak hourly flow when fecal coliform samples are collected
		Arizona[11]		
Class B (Dairy Animals)	**Reclaimed Wastewater**	Fecal Coliforms	• 30 mg/L (30-day average) • 45 mg/L (single sample maximum)	Measured after disinfection and immediately before discharge to reclaimed water distribution system
Class C (Non-Dairy Animals)	**Reclaimed Wastewater**	Fecal Coliforms	• 30 mg/L (30-day average) • 45 mg/L (single sample maximum)	Measured after secondary treatment and before discharge to a reclaimed water distribution system. Secondary treatment includes a series of wastewater stabilization ponds, including aeration, with or without disinfection. The total retention time in wastewater stabilization ponds is at least 20 days.

10 New Mexico (Treat Municipal Wastewater for Consumption by Livestock). See 'References' page for full citation.
11 Arizona (Treat Municipal Wastewater for Consumption by Livestock). See 'References' page for full citation.

For New Mexico, "Class 2 Reclaimed Water" is reclaimed wastewater that is suitable for uses in which public access and exposure is restricted. The treatment requires a minimum of conventional secondary wastewater treatment, which includes disinfection. After treatment, the water quality parameters must be sampled and meet the required threshold outlined in the water quality specification column. Sampling requirements are also outlined for each parameter.

For Arizona, Class B is reclaimed water that requires secondary treatment and disinfection. Class C is reclaimed water that requires secondary treatment with optional disinfection.

Additionally, the use of reclaimed wastewater is supported by means of state legislation and the Clean Water Act (CWA). Table 3 describes the technical basis for wastewater use for livestock consumption by the EPA for both Arizona and New Mexico.

Table 3: Wastewater Utilization for Livestock Consumption per EPA – Technical Basis

STATE	MEANING
New Mexico	The NMED provides guidance for the above-ground reuse of reclaimed domestic wastewater. Class 2 reclaimed wastewater is approved for water reuse for consumption by livestock in areas where public access is restricted. All applicable provisions of the CWA, including its implementing regulations, must be met in addition to any state water-quality standards. Treatment requirements and performance standards are applied for the removal of microbial contaminants, chemicals, and other relevant indicators related to consumption by livestock, summarized in Table 2 previously. New Mexico developed its specifications and/or removals of microbial contaminants, chemicals, and other relevant indicators based on a comparison to other state reuse approaches, NPDES limits, and related New Mexico surface-water limits.
Arizona	Approval of reclaimed wastewater for consumption by livestock (dairy or non-dairy animals) is supported by Arizona Administration Code Title 18 Chapter 11 – Department of Environmental Quality – Water Quality Standards. Arizona defines agricultural consumption by livestock as the use of surface water as a water supply for consumption by livestock. All applicable provisions of the CWA, including its implementing regulations, must be met in addition to any state water-quality standards. Treatment requirements and performance standards are applied for the removal of microbial contaminants and chemicals related to consumption by livestock and are summarized in Table 2 previously. The technical basis for developing the specifications and/or removals of microbial contaminants and chemicals is not explicitly specified.

To adequately support livestock and irrigation growth and provide overall sustainability, water quantities need to be secured and water conservation needs to be occurring. For supplemental purposes, wastewater reuse technology can be utilized to further enable this goal, depending on funding resources and state regulations.

6. HIGHLIGHTED AREAS

As part of this guide, we will highlight two Southwestern tribes and explore their methods in managing their water resources, what standards are being upheld, what specific practices are being utilized for water conservation purposes, and how each community gets their members involved. The Pueblo of Jemez in north-central New Mexico and the White Mountain Apache Tribe in east-central Arizona are tribes located within the Southwest region, both of which historically and currently experience the variety of climates the Southwest has to offer. These tribes continue to persevere and thrive under the circumstances.

6.1 PUEBLO OF JEMEZ OF NEW MEXICO

The Pueblo of Jemez is a federally recognized tribe located in north-central New Mexico within Sandoval County, approximately 47 miles northwest of Albuquerque, New Mexico. The Jemez Pueblo boundaries (outlined in red) are shown in Figure 9, via Google Earth.

Figure 8: Pueblo of Jemez Official Logo

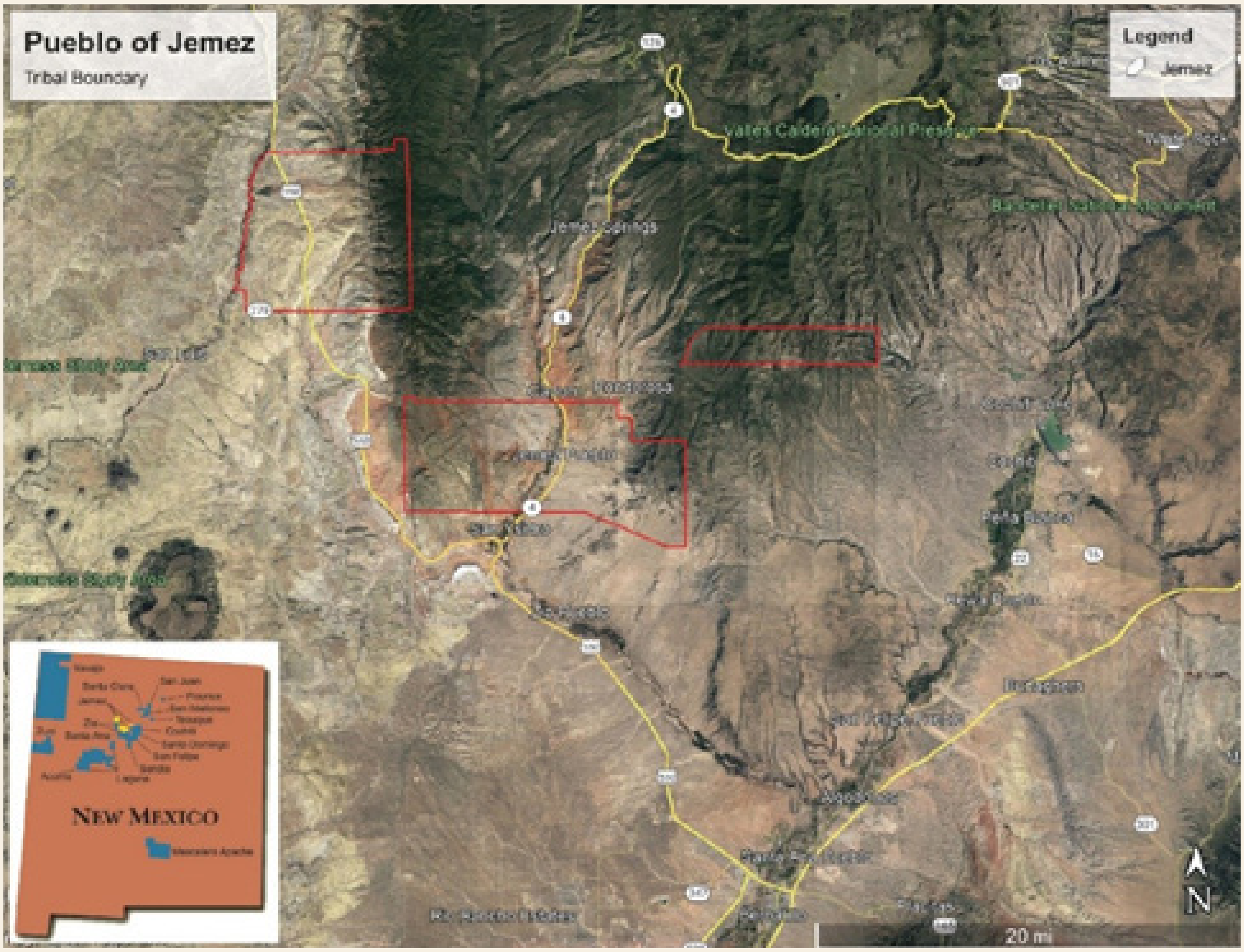


Figure 9: Pueblo of Jemez Tribal Boundary (Source: Google Earth)

The Pueblo of Jemez encompasses approximately 89,000 acres of land, where approximately 2,000 acres are utilized for agricultural and irrigable purposes. Farming is nothing new to the Pueblo. In fact, one of the oldest traditional techniques utilized is “dry farming.” This technique solely relies on precipitation to fall directly on irrigation fields and ranches without the use of external water sources. But more on this in the next few sections.

The geographical location of the Pueblo is advantageous to the community (especially to farmers and ranchers) because it is located in a mountainous landscape and climate on the flank of the Jemez Mountains, just north of the Pueblo. Typically, mountainous regions experience lower temperatures and more-than-normal amounts of moisture events. The lower the temperatures, the less heat is being retained, which makes the natural evaporation process less frequent. The total heat content is related to the amount of matter present.[12]

12 “If heat rises, why does the temperature decrease at higher elevations?” *Scientific American*, December 22, 2003, https://www.scientificamerican.com/article/if-heat-rises-why-does-th/

The highest mountain elevation of the cluster of Jemez Mountains is 11,561 feet. Snow and other forms of precipitation accumulate atop the mountain range and act as a storage reservoir. In the springtime, the snow melts and offers fresh and plentiful water to the Pueblo and respective valleys below. The vegetation and surrounding soil seem to come alive during this time.

6.1.1 Pueblo of Jemez Watershed and Related Information

Through an application created by the EPA called "How's My Waterway[13]," we can visualize what the watersheds look like in relation to tribal boundaries. This application provides the conditions of local waters in a user-identified area based on data provided by federal, state, local, and tribal entities. Figure 10 displays these watersheds (HUC 10).

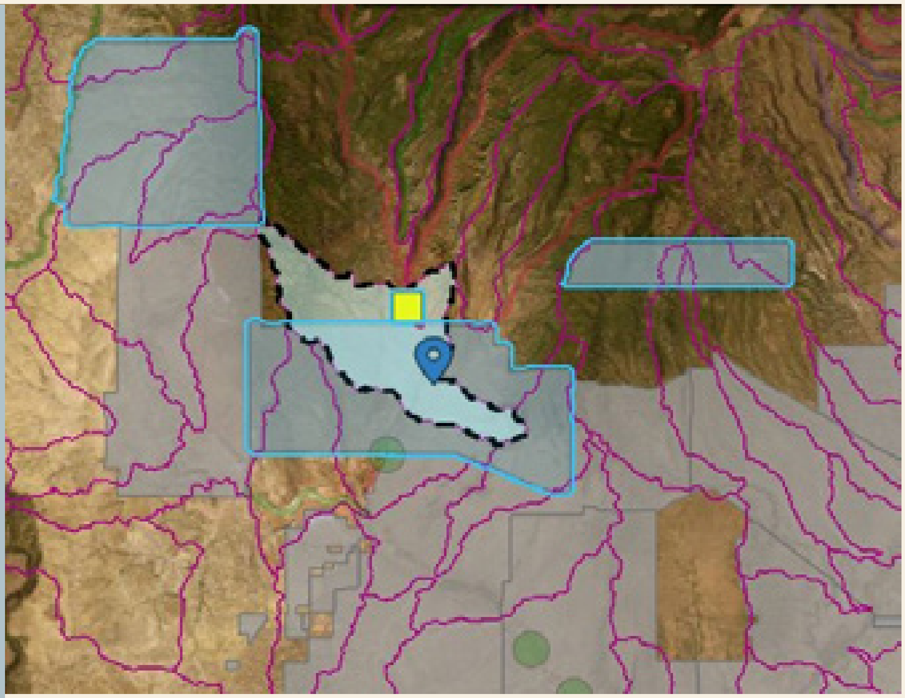


Figure 10: Pueblo of Jemez – Watersheds (HUC 10) (Source: EPA's "How's My Waterway")

There are multiple HUC 10 watersheds within the tribal boundaries. While continuing to use the EPA "How's My Waterway" application, you can click on one of the watersheds and view pertinent information specific to that watershed. Figure 11 is a screenshot of the information you will see.

Vallecita Creek is one of 17 watersheds that intersect the tribal boundaries of Jemez. The purple dots in the figure are the current monitoring locations, whether it be a well, a spring, or other water source. These are all monitored by USGS. Although faint to see, the yellow square displays the USGS stream gauge (08324000 JEMEZ RIVER NEAR JEMEZ, NM).

The EPA "How's My Waterway" application is used to view watersheds and their respective waterbodies, monitoring locations, and permitted discharge locations. Additionally, the USGS gauges have pertinent information and data collected continuously. These USGS gauges are installed near a stream or water source

13 "How's My Waterway?" *United States Environmental Protection Agency*, https://mywaterway.epa.gov/

and produce two types of information: gauge height and discharge rate. The available data through this application dates back decades and is as recent as the date you accessed the application. The application can be accessed through the following link: **<https://maps.waterdata.usgs.gov/mapper/index.html>**. Through the link, you select the USGS gauge you want information from and click "Access Data." You will be redirected to the "Stream Site," where it will have specific information about that specified gauge. Figures 11 displays the "How's My Waterway" interface.

The hydrographs that display gauge height and discharge rate for this particular gauge are displayed in Section 7.4.

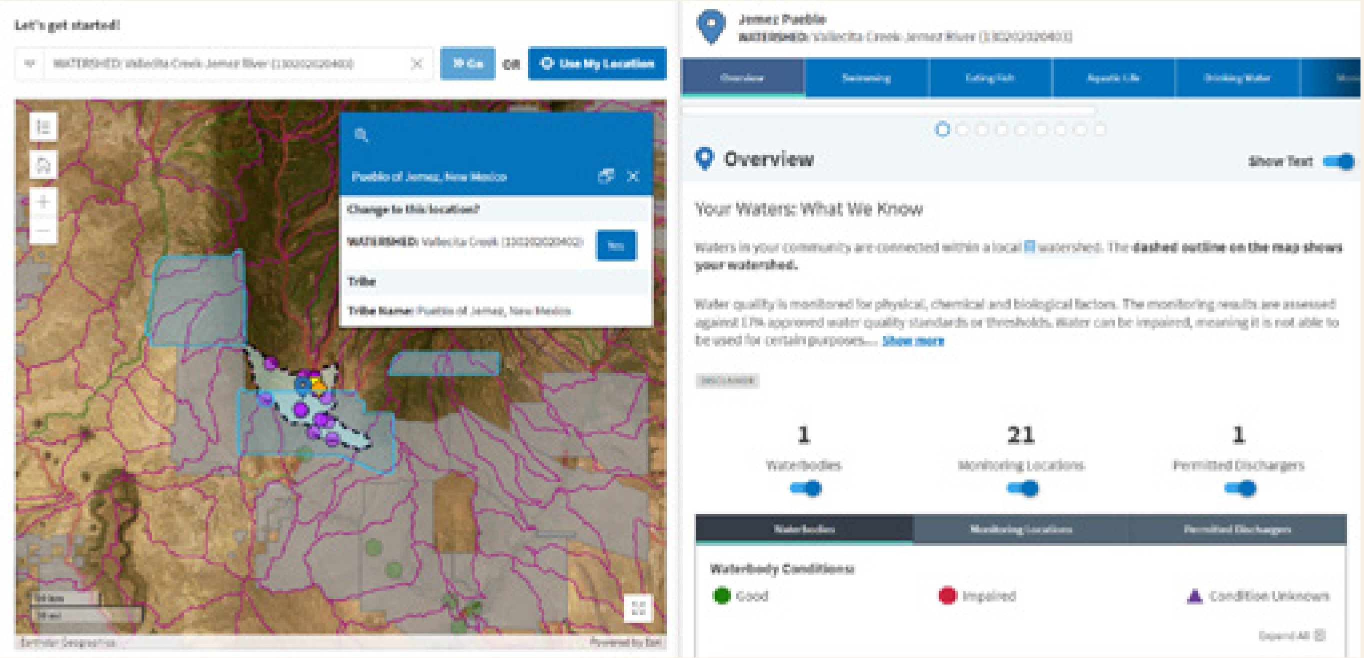


Figure 11: Pueblo of Jemez - Vallecita Creek Watershed (Source: EPA's "How's My Waterway")

6.1.2 Current Water Standards

Currently, Pueblo of Jemez follows the EPA's National Primary Drinking Water Regulations (NPDWR). The regulations are a set of enforceable standards applied to public water systems. For reference, the complete table of NPDWR can be found in Appendix A.

Every year, the EPA requires that all community water suppliers provide Consumer Confidence Reports (CCRs), per the Safe Drinking Water Act (SDWA) requirements. These CCRs are water quality or drinking water reports that provide crucial information about the quality of your drinking water, where your water is sourced from, what contaminants (organic/inorganic) are contained in the water source, along with comparisons to standards set by regulatory agencies. As an example, the 2022 CCR was gathered for the Pueblo of Jemez and is attached as Appendix B. From this, the Pueblo did not incur any violations in the year 2022.

6.1.3 Water Usages

Water demands for the Pueblo of Jemez can be divided into two main categories: non-agricultural and agricultural. An assessment of existing and projected demands for each of these categories is presented in this section.

6.1.3.1 Non-agricultural Water Use

Non-agricultural water use includes the following sectors: domestic, municipal, commercial, religious, industrial, and recreational. The most important water use sector for the Pueblo of Jemez is municipal use, which consists of residential, commercial, and public purposes. For non-agricultural water usage, groundwater is utilized for all the municipal and domestic water supply within the Pueblo. The Jemez Community Water System currently serves approximately 520 residential units, 20 administrative units, and four academic institutions. According to the Water Needs Assessment Master Plan prepared in 2002, the service population was 1,900. Wells and springs also provide water for livestock and wildlife. As the resident population and economy of the Pueblo grows, non-agricultural water use can also be expected to increase.[14]

6.1.3.2 Agricultural Water Use

There are approximately 2,400 acres of presently or historically irrigated lands. All the cropped lands are surface-irrigated with furrows, basins, or borders. The crops are primarily used by Pueblo members or their livestock and are generally not produced for commercial purposes. There is an ongoing effort to encourage traditional farming and the Pueblo has recently had an increase in irrigated allotments. In general, the amount of irrigated acreage is limited by the highly variable water supply. The Pueblo of Jemez irrigation system is a gravity flow system of ditches and pipelines that divert from the Jemez River. The main diversion is located on the Jemez River approximately one mile north of the Pueblo of Jemez boundary. A second diversion is located on the reservation and diverts water to the east side of the river. The irrigation system has 23 miles of ditches, with 18 miles being concrete-lined or piped.[15]

6.1.4 Community Involvement

The Pueblo of Jemez youth are actively involved in the 4-H program. The 4-H youth development program is a dynamic, non-formal education program that provides opportunities to learn life skills, gain knowledge and experience, and make contributions in areas such as environmental education, community service, and current youth issues. The 4-H program provides opportunities for young people to develop leadership

---

14 Small-Scale Water Efficiency Project for the Pueblo of Jemez (2017)
15 Small-Scale Water Efficiency Project for the Pueblo of Jemez (2017)

and management skills, positive self-esteem, effective communication skills, a solid sense of personal responsibility, and the ability to make sound decisions. The life skills learned in a 4-H program enable youth to become productive, well-informed, self-reliant, responsible adults.

To "learn by doing" is fundamental to any conventional educational program and is a major element of the 4-H youth development program. The Pueblo of Jemez youth join activities in agriculture and horseback riding, and are geared toward more natural resource-based ideologies.

These fundamental values in the 4-H program typically address the personal qualities young people need to become productive citizens in the world, today and tomorrow. Some of the values include:

- Develop leadership talents and abilities to participate effectively as members of a group;
- Develop personal standards and a philosophy of life-based lasting values. This includes making the world a better place for others, while emphasizing honesty, integrity, and high standards for the individual and group;
- Develop an appreciation for the importance of science, agriculture, home residence, and their relationship to the total economy. Education is the underlying foundation of 4-H programming due to its direct tie to state land-grant universities.

The community also offers cooking demonstrations hosted by Roots Wellness Walatowa. They use ingredients from the community field where their goal is to share simple and healthy alternatives to enhance the well-being of the community at large. They also host Fall Harvest Markets, where they partner with the Jemez Public Health Program. This entire experience enables the community to enhance engagement and community health.

6.1.5 Water Conservation Practices

Every spring, hundreds of tribal members gather to clean irrigation ditches that stretch for miles within the reservation boundary. The cleaning is done in preparation for spring planting and the irrigation season. Every enrolled tribal male member, age 18 and older, must participate in this annual event, or pay a fine to the Pueblo for not participating. College students and military service personnel who are out of the area are exempt. Families are grouped together through patrilineal lineage and are assigned certain sections in the various ditch routes. Traditionally, all family groups are mobilized together as one organized force to clean the ditches. Various farming and gardening implements are used to clean out the sand, mud, rocks, foliage, and various debris from the ditches and culverts.

On occasion, after the cleaning is done, a foot race is held from the ditch-cleaning stopping point to the plaza at the Pueblo. The two moieties of the Pueblo of Jemez, the Pumpkins and Turquoise, compete in the kick race. A wooden cylinder, typically the size and weight of a D-sized battery, is given to one person of each moiety and is placed on the foot and flung. Wherever it lands, the person nearest to it then kicks it further. The first moiety that arrives to the plaza wins the race. This event has religious, sacred, and traditional values that carry significance for water resources and the irrigation ditch system. The Pueblo of Jemez community use a method that benefits the tribe in the use and distribution of water. After the irrigation ditches are cleaned out, the Tribal Administration oversees the progress made in the implementation of the program. The Tribal Administration also negotiates any issues pertaining to water rights with state and federal entities.

6.2 White Mountain Apache Tribe of Arizona

The White Mountain Apache Tribe (WMAT), Figure 12, is located within the Fort Apache Indian Reservation on the east-central portion of Arizona. Communities within the reservation include Cibeque, Carrizo, Cedar Creek, Forestdale, Hon-Dah, McNary, East Fork, and Seven Mile. The White Mountain Apache Tribe is considered the Western Apaches, out of multiple federally recognized Apache nations throughout the Southwest. The major population center and capital of Fort Apache Indian Reservation is Whiteriver, Arizona, where approximately 80% of the WMAT population resides. Figure 13 displays the tribal boundary for White Mountain Apache Tribe.

Figure 12: White Mountain Apache Tribe of Arizona Official Logo

On November 9, 1891, by U.S. Executive Order, the White Mountain Apache Reservation is now known as the Fort Apache Indian Reservation. The White Mountain Apache Reservation originally included the San Carlos Apache Reservation, but was separated by an act of Congress in 1897.[16] The tribe once embraced the nomadic lifestyle, but now occupies permanent housing locations, and developed farming and ranching practices to become self-sustaining. WMAT depends on livestock, agriculture, tourism, and various tribal enterprise developments for their livelihood and source of revenue. The Fort Apache Indian Reservation consists of approximately 1.67 million acres (or over 2,600 square miles), where elevation ranges from 2,600 feet in Salt River Canyon to over 11,400 feet at the top of the sacred mountain peak, Mt. Baldy (Dził Łigai Sí’án). In fact, Mt. Baldy is the highest point within the reservation and supplies water to not only WMAT,

16 White Mountain Apache Tribe v. Bracker, 448 U.S. 136 (1980)

but to communities at lower elevations. The reservation is engulfed with alpine forests, meadows, pine trees, medicinal plants, and natural springs. The forests surrounding the reservation naturally promote wildlife, including big game such as bighorn sheep, elk, deer, and antelope.

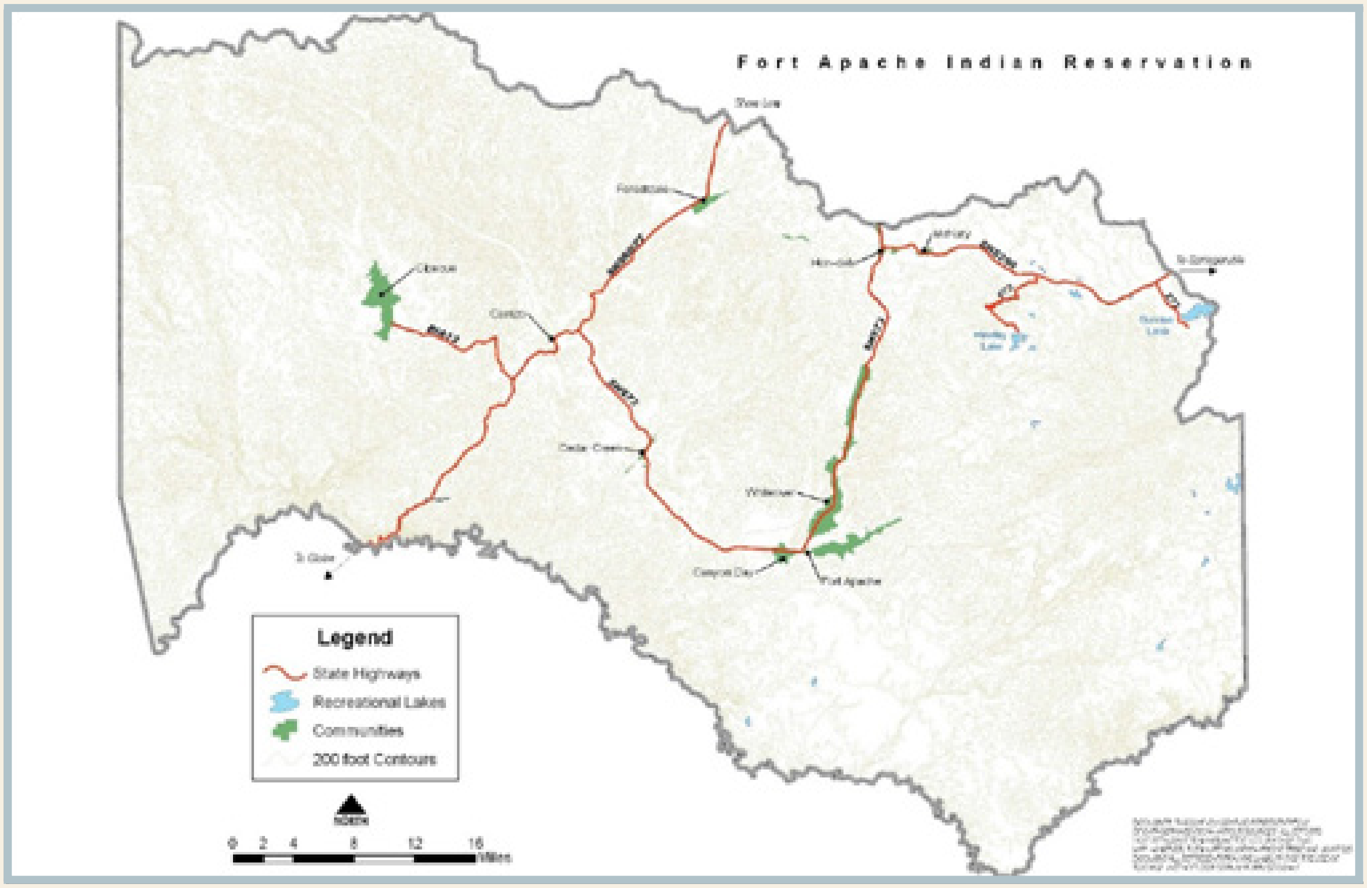


Figure 13: White Mountain Apache Tribal Boundary (Source: WMAT Homepage)

6.2.1 White Mountain Apache Tribe Watershed and Related Information

Traditionally, water is a precious and valuable resource, known from all walks of life. Below are two quotes from cultural leaders from White Mountain Apache Tribe, from the WMAT Environmental Code, Chapter 3 – Water Quality Protection.

> ***It's good we have that water. We need to live. It's good we have that spring, too. We need it to live right.***
> – Apache Elder, speaking on the significance of a spring in Cibeque, tú nchaa hal íí'

> ***Dził Łigai Si'áń Ndee bi Tú diyini – Water for the Apache people comes from the White Mountain.***
> – Apache Farmer, on behalf of the Apache Culture Advisory Group

To better understand the water drainage system within the reservation, the “How’s My Waterway” map application, developed by the EPA, was used. Figure 14 displays the HUC 10 watersheds within the Fort Apache Indian Reservation. There are multiple HUC 10 watersheds within the reservation shown below.

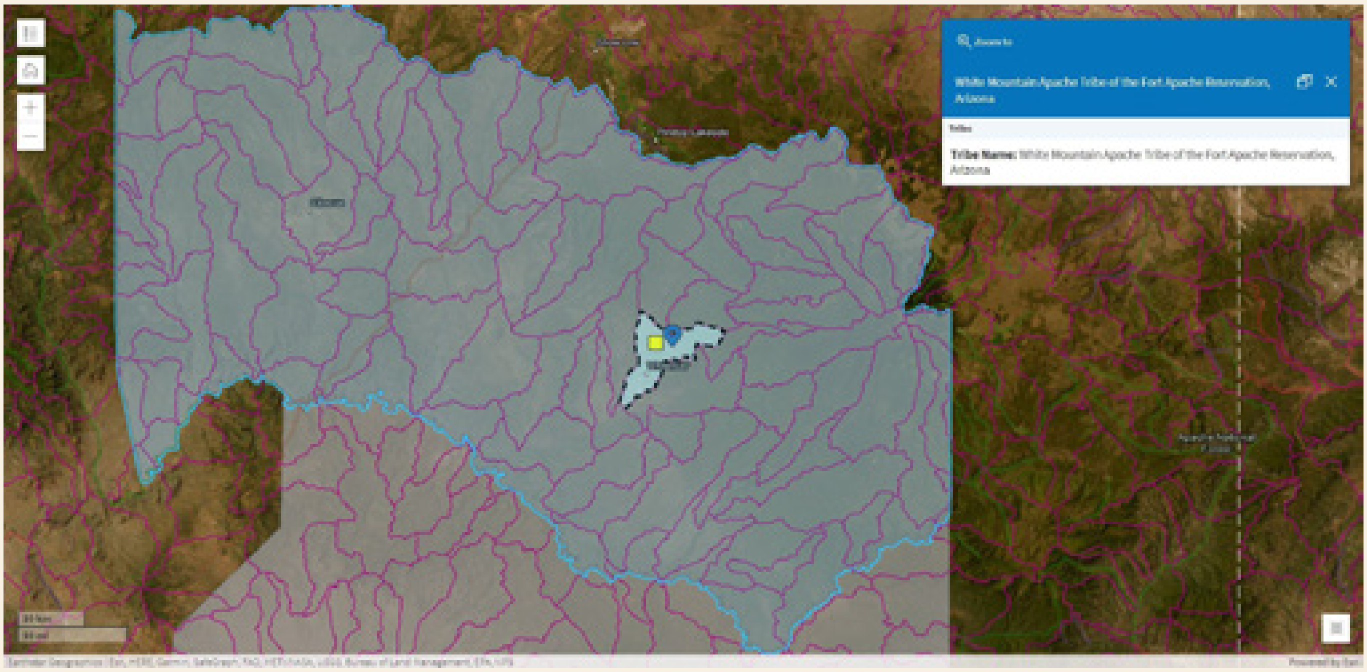


Figure 14: White Mountain Apache Tribe – Watersheds (HUC 10) (Source: EPA’s “How’s My Waterway”)

Each HUC 10 watershed has unique properties and drainage patterns. The watershed outlined with the dotted line is called Gold Gulch – North Fork White River, where Whiteriver, Arizona is located. The blue point is a watershed identifier and the yellow square identifies a USGS gauge location. The White River (body of water) feature is located south of Whiteriver (town). The major perennial tributaries to the White River include the North Fork White River (NFWR) and East Fork of the White River (EFWR). Other waterways in the vicinity of Whiteriver include: Diamond Creek, Bear Wash, Cedar Creek, Carrizo Creek, Cibeque Creek, and Amos Wash.

The “How’s My Waterway” map application was used to explore the watershed named the Gold Gulch watershed, which incorporates Whiteriver, as displayed in Figure 15. From the figure, the purple dots represent the past and current monitoring locations, typically placed in spring or well locations. While using the online “How’s My Waterway” application, the purple dots can be engaged to view water-quality information for that selected location.

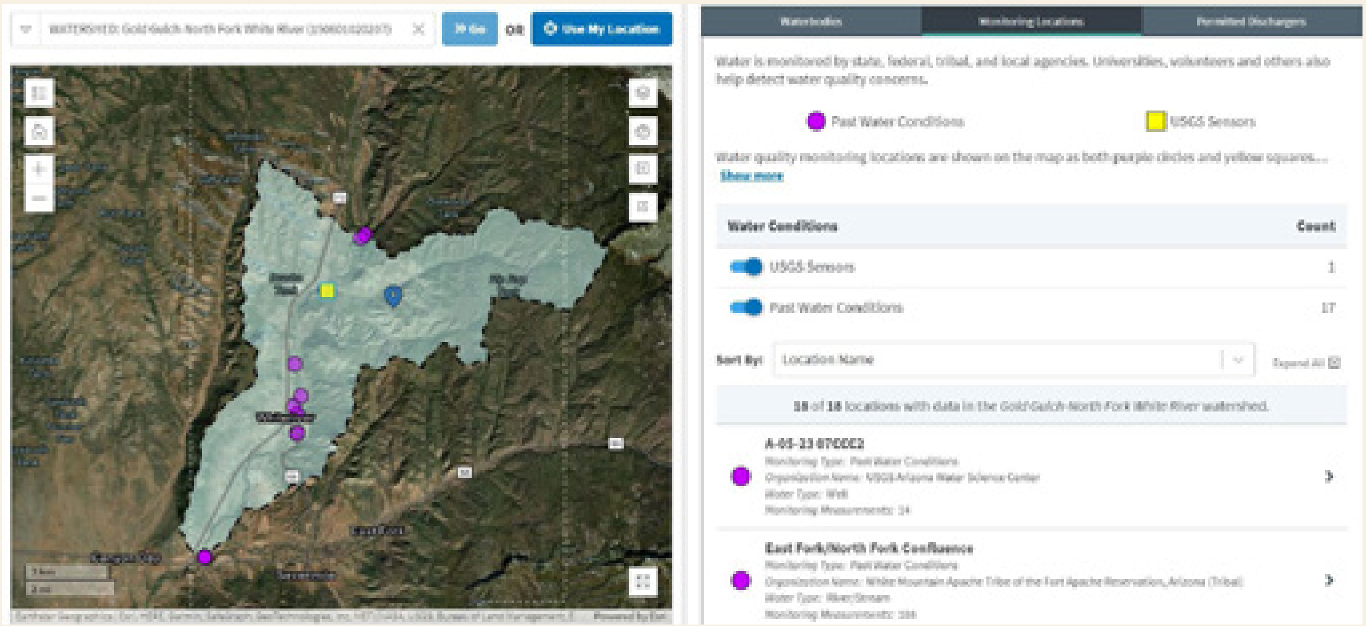


Figure 15: White Mountain Apache Tribe – Gold Gulch-North Fork White River Watershed (Source: EPA's "How's My Waterway")

Within this watershed is a USGS gauge at the location marked by the yellow square. This USGS gauge is called N-Fork White River Blw Gold Gulch at Whiteriver, Arizona (gauge number 09491980). This gauge produces significant information, such as gauge height and water-quality information available to various WMAT departments and to other water users in the area.

EPA's "How's My Waterway" application is a very useful tool for understanding watersheds and locating areas utilized for monitoring. In addition to this application, the White Mountain Apache Tribe uses temperature data loggers as a form of monitoring. Temperature data loggers are used to monitor temperature fluctuations in surface waters. The more drastic the temperature fluctuations are, the worse it will be for aquatic life.

Because water is a precious resource, there are ways in which we regulate it. The White Mountain Apache Tribe has demonstrated great progress in developing and applying standards and regulations for overall conservation and preservation.

6.2.2 Water Standards

Conservation and preservation practices are key components central to the establishment of tribal sovereignty of White Mountain Apache Tribe. For these practices to be sustainable, rules and regulations must be established to ensure that future generations have access to the same water resources, with minimal to no complications with water quantities and quality. White Mountain Apache Tribe has enacted an

Environmental Code, effective May 18, 2015, that includes four main chapters catering to subjects, such as hazardous substances, solid waste, water quality, and tribal plan and project review. Chapter 3 – Water Quality Protection, provides guidelines consistent with the Clean Water Act (CWA).

In pursuance of sovereign authority of WMAT, *as authorized and recognized in Section 518 of the CWA and U.S. Code Title 33 § 1377, the WMAT Tribal Council enacts a Water Quality Ordinance ("Ordinance") for all waters within exterior boundaries of the Fort Apache Indian Reservation.* The purposes of this ordinance are as follows:

- *To promote the health of tribal waters and the people, plants, and wildlife that depend on them through holistic management and sustainable use;*
- *to designate the existing and attainable uses for which the surface water of the White Mountain Apache Tribe shall be protected;*
- *to prescribe water-quality standards to sustain the designated uses; and*
- *to assure that degradation of existing water quality does not occur.*

Chapter 3, Section 3.5 describes the specific Water Quality Standards White Mountain Apache Tribe adheres to. These standards outlined from Section 3.5 of the WMAT Environmental Code shall be maintained at all times and applied to all perennial, ephemeral, and intermittent streams, and all ponds, lakes, standing waters, sub-surface waters, wetlands, and springs. The Water Quality Standards for WMAT will be further explored in Section 8 of this guide.

In addition to the adherence to the tribally led Environmental Code, there are other federal regulations the tribe must abide by, such as the Clean Water Act and Safe Drinking Water Act. Provisions from the Safe Drinking Water Act highlight the Consumer Confidence Report (CCR) as the public's right-to-know. The CCR serves as an annual water-quality report for the community water system, with the main goal of protecting the health of consumers. This CCR is provided to its consumers and is to be utilized for you to make informed choices about the water you drink, to make you aware of where water comes from, what elements and minerals are contained in the water, and to educate about the importance of applying preventative measures to ensure a safe drinking-water supply. According to the EPA, the CCR must be reported annually by July 1. As an example, the 2021 Consumer Confidence Report for White Mountain Apache Tribe is attached as Appendix B.

6.2.3 Water Usages

The water usages on WMAT are broken up into two broad categories: non-agricultural water uses and agricultural water uses. High Water Mark LLC conducted an evaluation (based on research and interviews) or water use on the reservation.

6.2.3.1 Non-Agricultural Water Use

White Mountain Apache Tribe has been successful in utilizing its water resources efficiently and effectively while also maintaining water flow for residential properties, tribal buildings, the local hospital, farming and ranching activities, and two fish hatcheries. The water the tribe manages has been steady; but with climate change looming, the effects are periodically being felt. Along with the dry Southwest, White Mountain Apache Tribe experiences drought during certain times of the year. This forces the tribe to explore other avenues of securing water for tribal members, livestock and crops. About 70% of the drinking water for the reservation is drawn from surface water sources and the other 30% is from groundwater sources.

6.2.3.2 Agricultural Water Use

The Land Operations Department for WMAT primarily uses surface water sources for cattle, horses, and other livestock. The main source of water for their livestock is through water conveyances filled by natural precipitation. Although not major water producers, older windmills are still utilized within the reservation. The Land Operations Department for WMAT indicated there is only one certified well driller in the entire state of Arizona. Consequently, the well driller possesses a backlog of jobs that will take about two years to complete; making it extremely difficult to get a well drilled and forcing the tribe to rely on the surface waters as their primary water source for livestock. In Atiint Cibecue District, there are approximately 400-500 head of cattle grazing over 215,000 acres. Water requirements for adequate livestock watering are substantial. Moreover, this water requirement increases during the months of drought. During times of drought, water conservation practices have been implemented to protect precious water quantities.

White Mountain Apache Tribe farmers have grown a variety of food commodities for decades. Historically, the tribe cultivated corn, beans, squash, and other traditional vegetables. The primary farming method used by WMAT is dry farming. This particular method utilizes no external water inputs onto farming fields. Instead, the primary water sources utilized are natural precipitation, water received during monsoon seasons, and heavy winters that create runoff in the springtime. Recently, the tribe has experienced heavy snowfall during an unusual springtime snow event in 2023. The amount of runoff from this snowmelt has prescribed the tribe additional water quantities.

6.2.4 Community Involvement

The management of water resources, farming fields, and ranches requires massive effort from not one individual, but from a community. White Mountain Apache Tribe has made efforts for community involvement in key traditional areas, such as agriculture and ranching. Farming and ranching practices have been taught from generation to generation and are essential to the tribe's traditional values.

With the assistance of outside funding sources, the community was able to inch its way toward establishing food sovereignty. Within the bounds of the reservation, there lies a 7-acre farm named Ndéee Bikíyaa, or "The

People's Farm." The farm was created to support the community in promoting healthy food and nutrition, and educating the importance of farming with respect to traditional White Mountain Apache Tribe culture.[17] Although Ndéee Bikíyaa is only 7 acres, it provides a unique perspective on traditional agriculture and acts as the lead organization in achieving food sovereignty for the White Mountain Apache Tribe. Since its origin, the surrounding community has expressed its interest and needs regarding the crops selected for cultivation (corn, squash, melons, etc.) and how the farm and surrounding communities could benefit from one another.

The food produced from the farm gets distributed to local markets, schools, and various programs. Throughout the year, Ndéee Bikíyaa organizes programs for community members to get hands-on farming lessons to further push the envelope of food sovereignty. Additionally, another unique aspect of Ndéee Bikíyaa is that it welcomes individuals from the Rainbow Treatment Center to learn about the farming processes and to participate in growing crops. The partnership between the farm and the treatment center has allowed the community to become a collective striving toward one goal of food sovereignty within a "food desert."

6.2.5 Water Conservation Practices

To ensure water resources for future generations, the implementation of water conservation practices is a necessary component. The CCR for White Mountain Apache Tribe outlines some conservation practices that could be beneficial for community water systems, but not necessarily for farming or ranching. Because farming and ranching utilizes surface-water sources, there are other environmental elements to consider when attempting to conserve water. For example, some direct influences on surface waters are temperature, precipitation, soil characteristics, wildlife uses, and water infrastructures.

According to the USDA, below is a list of general water conservation strategies for agriculture:

Planting Cover Crops

- With taller crops used as cover for agricultural products below, they reduce the amount of sunlight and heat in reaching the soil. This could reduce evaporation, cool the soil surface, and improve the soil health.

Residue and Tillage Management (No-Till)

- This refers to the method of planting by creating a narrow channel just big enough for the seed to be planted. This method does not create soil disturbance, meaning the structural integrity of the soil is not compromised. These types of fields generally have higher levels of organic matter, higher infiltration rates, and higher water retention capacity.

17 Elizabeth M. Hoover, "Ndee Bikiyaa, "The People's Farm," White Mountain Apache Tribe, AZ," *From Garden Warriors to Good Seeds: Indigenizing the Local Food Movement*, September 19, 2014, https://gardenwarriorsgoodseeds.com/2014/09/19/ndee-bikiyaa-the-peoples-farm-white-mountain-apache-tribe-az/

Irrigation Pipeline

- This refers to the conversion of an open channel to pipeline. By funneling irrigation water through a pipeline, it reduces the chances of evaporation occurring. Water quantities would be more secure by eliminating water loss and increasing water delivery efficiency.[18]

These three USDA strategies are a few methods that could be utilized for water conservation. However, there are elements of nature that influence water conveyances, such as precipitation and climate, that are out of our control. Fortunately, there are some elements that we can control, such as soil characteristics (if the irrigation system is not concrete-lined) and the overall condition of water infrastructure. Additionally, human activity can have a positive or negative influence on the soil. Overgrazing, overusing the land, and not allowing adequate time for revegetation and soil regeneration are examples of negative impacts. Methods of soil conservation, such as crop rotation, establishing cover crops, and adopting a soil health management system, are examples of positive influences. The interaction between soil and water is one of the major components to be addressed when discussing water conservation.

Most water conveyances consist of vegetation that runs adjacent to the water source. This is a natural feature that seeks to combat and prevent soil erosion. Although native plant species are naturally present, there is also the presence of natural invasive species. Generally, invasive species compete with native species, degrade water quality in the area, "soak up" water, and decrease water quantities. The presence of invasive species, for example Russian olive and Tamarisk, can potentially harm aquatic life and plant species in the vicinity. White Mountain Apache Tribe has taken strides to remove invasive species wherever and whenever it can. The important aspect of invasive species removal is to remove them from the roots below the subsurface.

7. WATER QUANTITY MONITORING

Water quantity is the timing and total yield of water from a watershed and is measured by total yield and peak flow over a specified period. Water quality is the suitability of water for drinking, recreational uses, and as habitat for aquatic organisms and other wildlife.[19] It is measured by the amount of sediment, water temperature, and concentration of chemical compounds, including nitrate-nitrogen, bacteria, salinity, turbidity, and other nutrients in the water.

18 Erika Cross, "Doing More With Less Water," USDA, March 22, 2022, https://www.farmers.gov/blog/

19 J. Richardson et al., Bioenergy from Sustainable Forestry: Guiding Principles and Practice, *New Zealand Journal of Forestry Science 32(3)*, January 2002, http://dx.doi.org/10.1007/0-306-47519-7

There are four different causes of water scarcity: dry climate, drought, drying of the soil due to activities such as deforestation and overgrazing by livestock, and water stress due to increasing populations that rely on limited levels of runoff.

Measurements of groundwater levels, reservoir levels, aquifer properties, or stream flow are examples of data describing how much water is available.

7.1 METHODOLOGY

There are many methods for determining water quantities for both surface and groundwater sources. These values for quantities can be found through online sources or manually tested. Tables 4 and 5 describe the methods.

Traditionally, management of water resources has focused on surface water or groundwater as if they were separate entities. As the development of land and water resources increases, it is apparent that the development of either of these resources affects the quantity and quality of each other. Nearly all surface water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with groundwater. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from groundwater systems, and in others, the surface water body is the source of groundwater recharge and causes changes to groundwater quality. As a result, withdrawal of water from streams can deplete groundwater or conversely, pumpage of groundwater can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of groundwater quality, and conversely, pollution of groundwater can degrade the surface water. Thus, effective land and water management requires a clear understanding of the linkages between groundwater and surface water as it applies to any given hydrologic setting.

7.1.1 Surface Water

Two methods can be utilized to determine surface water quantities: stage measurement and flow measurement. There are online methods that could be utilized for this determination (see Section 6.1.1); but there are also manual methods that could be utilized for a more practical or in-field use, which will be discussed here. Table 4 displays these methods.

Table 4: Methods for Quantifying Surface Water

	METHOD	
TOPIC	**STAGE MEASUREMENT**	**FLOW MEASUREMENT**
Description	Quantifying by water level	Quantifying by water source discharge rate
Online	See Section 6.1.3, "Alternative Methods"	See Section 6.1.3, "Alternative Methods"
Manual	Manual measurements via graduated vertical staff gauge	Manual measurements via flow method, venturi channel, or current meter rotor
Source: https://www.ruvival.de/measuring-surface-water/		

A common tool used to measure water levels in lakes, rivers, reservoirs, and other surface water bodies is a USGS-style staff gauge. These gauges provide a visual indication of water level and are designed for high accuracy and readability. An example of this staff gauge is shown in Figure 16.

These staff gauges are essentially a ruler, but are installed in bodies of water. These are easy to read and provide for a quick visual reference of water levels. The construction of these gauges is straightforward. Additionally, the selection gauge face materials is important because you would not want any natural algae or bacterial growth to hinder your measurement readings. Therefore, stainless steel or special enameling metal should be utilized.

Flow measurements are essentially the rates at which a water source passes through a given area. There are plenty of devices developed that can give these measurements. The locations these devices are placed in have a significant impact on the accuracy of the data. If the device is submerged in a stream or water body, it is essential that the water body be stable and flows regularly. Additionally, all velocities at all verticals are at a right angle with respect to the cross-section, and parallel to each other. The simple equation below can be utilized to calculate discharge rate:

Figure 16: Example Staff Gauge on a Wisconsin Stream (Source: USGS)

Q=V x A

Whereas: **Q = discharge rate [volume/time]**
V = velocity (distance between cross-section/time)
A = cross-sectional area (length times width)

The velocity (V) component may be a little tricky to get when dealing with a not-so-constant water flow. The natural rigidity of most waterways also plays a role in determining accurate velocities. Additionally, velocities differ along the cross-sectional area. For example, natural rigidity of the stream bed causes friction, which causes velocities to be slower. Therefore, it is important to report these velocities at different heights to get a more accurate approximation.

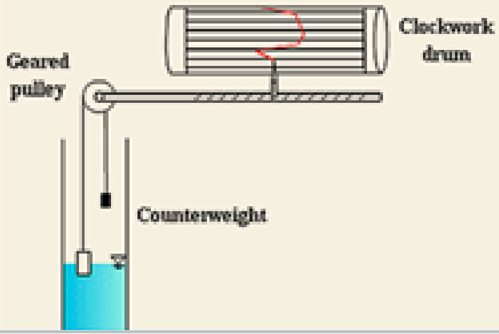
These water-level heights and discharge-rate measurements are gathered manually. Online methods will be explored in Section 6.1.3.

7.1.2 Groundwater

Now that we understand how to quantify surface water, we will look at groundwater. There are a few manual methods that can be utilized to quantify groundwater. The goals are to determine groundwater-level measurements (height of water level) as well as discharge rate via water wells.

Before an actual well can be drilled and put into service, both groundwater level and well discharge measurements must be gathered to determine if it could sufficiently support the community. So a "test well" or "observation well" will be drilled to determine these measurements. Table 5 displays the methods that will achieve these goals.

Table 5: Methods for Quantifying Groundwater[20]

MEASUREMENTS		
TOPIC	**GROUNDWATER LEVEL**	**WELL DISCHARGE**
Self-Testing (manual)	Lower a weighted line with measurement tick marks into the observation well. Read measurement. An example water level measuring device is shown here: 	Filling a calibrated volume within a certain time. For instance, a 1-gallon bucket can be filled entirely, and with a stopwatch handy, the discharge rate (gallon/minute) can be determined. 
Automatic Device	A float-operated recorder is a common automatic stage recorder that measures displacement of float (buoyancy). This float is attached to a counterweight over the pulley of a recorder. The displacement due to rising and lowering of water-surface elevation causes angular displacement of the pulley and hence of the input shaft of the recorder. This angular displacement is linked to the linear displacement of a pen to record over a drum. A simple diagram of this mechanism is displayed below. 	Utilizing a flow meter (mechanical, electrical, or electronic) to determine the fluid flow within the observation well. The water will need to be pumped out and piped so the flow meter could be attached to the pipe to ensure accuracy. Keep in mind that the presence of turbulence in the water flow can affect the measurement's accuracy. 

20 World Meteorological Organization (WMO). *Guide to Hydrological Practice (Hydrology-From Measurement to Hydrological Information)*. Vol. 1. 2008, Updated in 2020.

Surface water and groundwater are both limited sources. Surface water is limited by the amount of precipitation, surface runoff, and other environmental factors surrounding climate change. Groundwater sources are primarily limited by the size of the aquifer that water is being pumped from and the rate at which the well is being recharged. Groundwater recharge is the rate at which water is replenishing underground aquifers.

In most cases, well recharge is difficult to quantify due to the number of factors that are attributed to that mechanism. Soil and land attributes, environmental factors, and well-pumping rates, elevation, slope, and temperature are factors that affect the well recharge rate. Now that we understand how to quantify different water sources, alternative methods for this quantification will be explored in the subsequent section.

7.1.3 Alternative Methods (NOAA and USGS)

There are plenty of online resources that could be utilized to determine water quantities. There are two resources that should immediately be considered: The National Oceanic and Atmospheric Administration (NOAA) and USGS. Firstly, NOAA[21] provides pertinent information related to weather, climate, forecasts, and warnings for any given area. For purposes of determining water quantities, the amount of precipitation accumulated will be the primary use of the NOAA website. A screengrab of observed precipitation for the southwest region is shown in Figure 17.

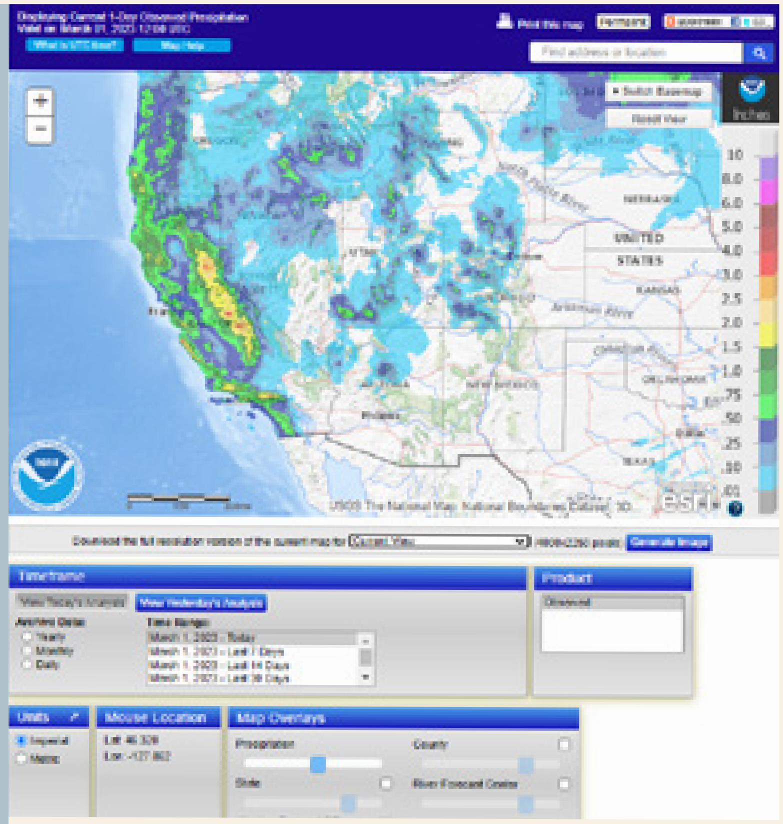


Figure 17: Southwest Region Observed Precipitation (Source: NOAA)

Through the NOAA website, you will be able to access precipitation data for any area identified. There is also archived data that could be accessed and used to evaluate past storm events. It would be very informative to review data within the monsoon months to gauge what maximum precipitation amounts are expected. The monsoon season typically occurs during the middle of June to the end of September.

21 "Advanced Hydrologic Prediction Service," *National Oceanic and Atmospheric Administration*, https://water.weather.gov/precip/

7.2 SAMPLING LOCATIONS

Now that we know what information we are searching for from agency websites, you may be wondering how or why agencies chose those locations for sampling and/or monitoring. This section serves to answer those questions. The predominant principle for water sampling and/or monitoring site selection is to produce accurate data that best represents current conditions, regardless of time of year and extreme fluctuations of water flow. General guidelines for selecting water sampling sites for surface and groundwater, according to the USGS[22], are described below.

Surface Water Location Sampling Determination

- Consider study objectives, types of data and quality of data needed, equipment needs, and sampling methods
- Obtain all available historical information
- Consider physical characteristics of the area (such as acreage, shape, land use, tributary, geology, hydraulic conditions, climate, and water depth)
- Consider chemical and biological characteristics of the area (aquatic and terrestrial)
- When sampling a stream or river, consider sampling upstream, downstream, and at an area in the middle of those two locations, to get a more accurate representation of the stream or river in question

Groundwater Location Sampling Considerations

Sampling locations for groundwater are already prescribed for both monitor wells and domestic water-supply wells. These areas have dedicated and designated spigots for sampling to occur.

- Monitor wells: These are observation wells designated for sampling purposes. The utilization of low-capacity pumps or other types of sampling devices allows for easier sampling. Groundwater levels and flow conditions are also gauged at these locations.
- Domestic water-supply well: Unlike monitoring wells, water-supply wells often inflict higher pressures. Therefore, high-capacity pumps are equipped to this type of well and allow for easier sampling. Due to the higher pressures and velocities, additional safety precautions and equipment will be necessary to ensure the safety of persons performing sampling procedures.

Appropriate methods and quality-assurance measures are to be taken to ensure water quality sampling locations are accurately represented. Generally, water sampling methods and techniques depend on the size of the stream and/or water conveyance. For locations within a watershed, it would be best to obtain samples from both the top and bottom of the watershed to ensure contaminants are not intruding into waters of surrounding communities that also rely on the surface water. Multiple quality control water samples must be taken to ensure data quality objectives and requirements are met. Note: From the USGS, it is a fundamental

---

22 A4. "Collection of Water Samples," in *National Field Manual for the Collection of Water-Quality Data*, U.S. Geological Survey, September 2006, https://pubs.usgs.gov/twri/twri9a4/twri9a4_Chap4_v2.pdf

fact to sample a location with a known quality. Additionally, the quality of the analytical results is contingent on the quality of the sample.

7.3 MONITORING FREQUENCY

States and tribes turn their data into information about whether their waters meet water quality standards. States report this information to the EPA every two years under Section 305(b) of the Clean Water Act. The EPA, in turn, summarizes these state water-quality assessment reports into a national report to Congress called the National Water Quality Inventory. This report now includes a database of state-by-state assessment information that can be viewed down to the waterbody level.

7.4 WATER QUANTITY MONITORING FOR THE PUEBLO OF JEMEZ

Figure 18 is the hydrograph displayed from the USGS gauge 08324000 (JEMEZ RIVER NEAR JEMEZ, NEW MEXICO). The data shown is over the course of a year from the USGS stream site.[23] The top (darker colored orange) line represents the streamflow or discharge rate while the bottom (lighter colored orange) line represents the gauge height.

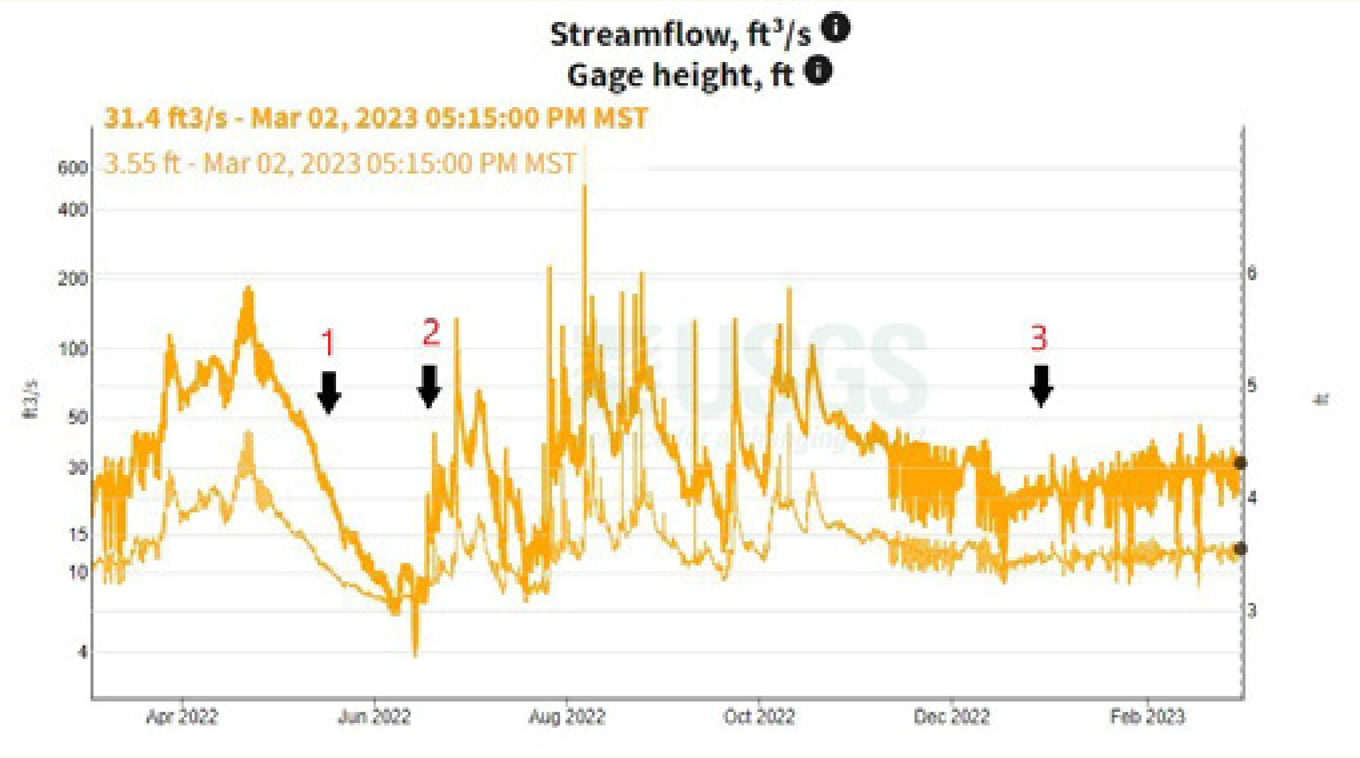


Figure 18: USGS Stream Monitoring at Gauge 08324000 (Source: Water Data – USGS)

23 "Jemez River Near Jemez, NM - 08324000," USGS, 2024, https://waterdata.usgs.gov/monitoring-location/08324000/#parameterCode=00060&period=P365D&showMedian=true

There are three areas of significance from Figure 18 that represent changes in the stream.

1. Approximately between May and June 2022, the stream experienced a decline in both discharge and gauge height. This could be due to many factors, but primarily environmental factors. Especially during the hot summer months, the rates of evaporation are more prominent due to the increase in temperatures.
2. There is a sharp increase in the discharge rate. These few spikes identified in this location in the graph are most likely due to the increase of rain showers, which coincides with the start of monsoon season for New Mexico.
3. This location outlines the area that shows no signs of an increase or decrease in discharge nor gauge height. This could possibly be due to colder weather that freezes any precipitation (rain or snow) in the area that maintains the stream flow during December 2022 and March 2023.

Overall, there are factors that influence the health of the streams, such as ecological and climate changes.

7.5 WATER QUANTITY MONITORING FOR THE WHITE MOUNTAIN APACHE TRIBE

The Land Operations Department for WMAT utilizes 10 livestock associations, with each association overseeing an average of 100,000 acres. This large area requires a combination of on-the-ground and online monitoring to ensure smooth operations of irrigation ditches for livestock and crop production. In conjunction with the Bureau of Indian Affairs (BIA), the tribe has initiated the utilization of rainfall, water, and weather-monitoring technologies through a company named OneRain. This company provides environmental monitoring to effectively understand water-related missions–from flood, dam safety, stormwater, wastewater, and overall water resource management–to optimize water resources. Some information received from this application includes gauging, telemetry, remote sensing, visualization, analysis, notification, and control. The tribe utilizes this OneRain application for the water dams located throughout the reservation and for gauging water levels of dams and reservoirs. The information gathered from the application is analyzed and the information is relayed through a weekly update to the Tribal Council. This weekly update provides information on the status of the dams, water levels, and photos.

In addition to the OneRain application, the USGS gauge 09491980 information could be utilized to understand water quantities within the reservation. Typically, the USGS gauge information includes gauge height and discharge rates, but gauge 09491980 only includes gauge height and DCP battery voltage.

Figure 19 is a hydrograph produced for the USGS gauge 09491980 (N-FORK WHITE RIVER BLW GOLD GULCH AT WHITERIVER, ARIZONA). Only the gauge height is represented.

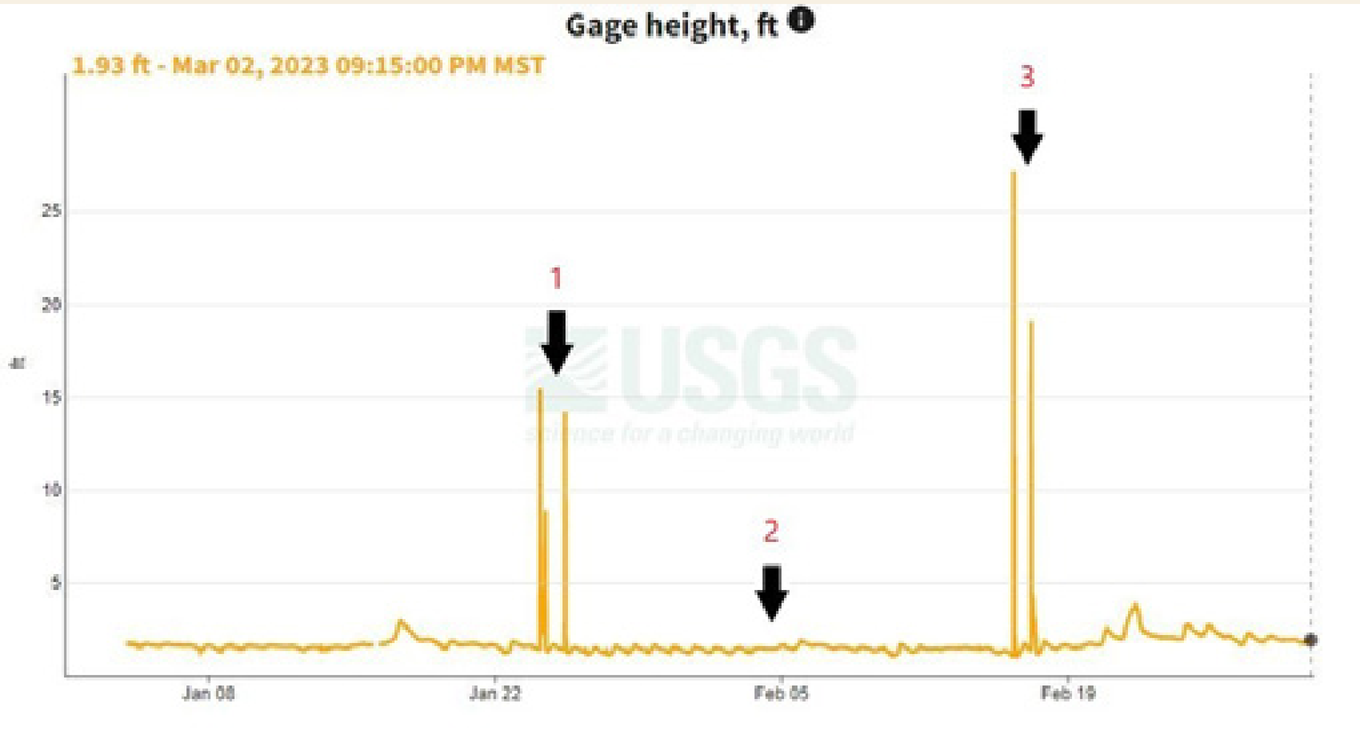


Figure 19: USGS Stream Monitoring at Gauge 09491980 (Source: Water Data – USGS)

There are three areas from the graph that represent significant changes in the stream.

1. On January 24th, a spike occurred. Information from the National Weather Service (NWS) indicates there was between 0.25 to 0.5 inches of precipitation that fell in the vicinity of the gauge. On January 25th, there was no measurable precipitation that fell, but this may be attributed to the residual effects of the previous storm event.
2. From January 26th to February 15th, the tributary has been running steady, between 1.1 to 1.9 feet.
3. On February 16th, the gauge height was measured at 27.13 feet. From the NWS, there have not been significant precipitation values reported. Mount Baldy collects snow and when temperatures get hot enough, snowmelt occurs. This high gauge height value may be attributed to the snowmelt from Mount Baldy and other mountains in the area.

At WMAT, there has been discussion of quantity vs. quality. Historically, Southwest tribes have undergone water scarcity that has posed a real threat to people. Today, WMAT is making strides to overcome these issues by developing and repairing water infrastructure (irrigation ditches, headgates, etc.) to their fields. The tribe has made it known that the water development currently pursued must be community-based.

8. WATER QUALITY MONITORING

The development and enforcement of water quality standards is in part an expression of tribal sovereignty. It is also linked to a greater recognition that our communities are not isolated, that water resources are used by neighbors both upstream and down, and that there are increasing activities that raise concern for the quality of water that is used for residential, agricultural, and ranching purposes.

In the case of the Pueblo of Jemez, recent wildfires that impacted upstream watersheds have impacted the Rio Jemez which is the primary source of irrigation water for Pueblo farms. Additionally, upstream communities have farming activities, water treatment facilities, and recreational activities that all produce discharges that flow into the river. While the potable water relied upon by most of the residential community is from groundwater, and subject to treatment and testing by the Pueblo's Utility Authority, there are a host of upstream activities that are of increasing concern to Pueblo farmers.

For the White Mountain Apache Tribe, the reservation includes all the headwaters of the tributaries to the White River, the primary drainage that flows through several communities that contain the tribal population. However, much of the high country is utilized for tourism purposes (fishing and water sports in the abundant lakes) and for open-range ranching. These activities produce concerns that upstream activity by humans, fishponds, and livestock contributing contaminants to surface waters that are used for potable residential use and irrigation.

Furthermore, the tribe's "People's Farm" is generating vegetable produce for meals for the tribal youth program, elder meal programs, and participants in local substance treatment programs. Future plans include providing People's Farm produce to the single on-reservation grocery store that serves the residential areas. But this step would involve testing to certify that the produce meets safety standards, including water quality.

Monitoring water quality is very important for maintaining ecosystem health and the livelihood of the population. It reflects the health of surface water bodies as a snapshot in time (weeks, months, and years). Therefore, best practices and efforts are needed to monitor and improve water quality.

Overall water quality regulations are more specific and outline more parameters when it is for human utilization. The water-quality regulations for livestock and crop production are just as significant as the drinking-water regulations. For normal and productive animal operations, the health and well-being of livestock is important for not only the animal, but for its consumption, as well. There are well-established water-quality regulations for federal, state, and local levels, which are meant to combat water-quality issues and promote a healthy lifestyle. A general guideline recommends specific limits on a variety of substances commonly found in livestock water, such as: salinity, sulfates, and other elements and compounds. Tables 6 to 8 outline this general guideline.

Salinity is the amount of salt dissolved in a body of water. High salinity levels are an unfortunate occurrence that is found in arid parts of the Southwest (most of New Mexico and parts of Arizona). The unsafe salinity levels could differ from the age of the animal, its stage of production, and the amount of water consumed each day.

Table 6 displays the classification and description of each salinity level and the effect on the animal.[24]

SALINITY LEVEL (mg/L)	DESCRIPTION/EFFECT
Less than 1,000	Considered low. Excellent for all classes of livestock.
1,000 - 2,999	Very satisfactory for all classes of livestock. Temporary, mild diarrhea in livestock may be noticed in animals not accustomed to this level of salinity.
3,000 - 4,999	Satisfactory for livestock. Livestock not used to saline water may refuse it or have temporary diarrhea.
5,000 - 6,999	Marginal quality for beef cattle, sheep, swine, and horses. Water this saline should not be used for pregnant or lactating animals.
7,000 - 10,000	Considerable risk for pregnant or lactating cows, horses, sheep, or immature animals of any class. Avoid use for all animals if possible; however, older animals may subsist on water of this quality under certain conditions.
Over 10,000	Because of high risks associated with such saline water, regard it as unusable under any condition.
Source: Sallenave, R. 2016. Water quality for livestock and poultry (Revised). Guide M-112. http://aces.nmsu.edu/pubs/_m/M112.pdf. New Mexico State University Cooperative Extension Service.	

Sulfate is a salt or ester (or compound) of sulfuric acid. When cattle consume high levels, the sulfates tend to bind to a compartment in the animals' stomach that prevents their bodies from absorbing minerals. Some consequences of the consumption of these sulfates include diarrhea, reduced fertility and milk production, stunted growth, a depressed immune system, or polio. Table 7 displays the classification, description, and effects of each respective level.

24 Sallenave, R. 2016. Water quality for livestock and poultry (Revised). Guide M-112. https://pubs.nmsu.edu/_m/M112.pdf. New Mexico State University Cooperative Extension Service.

Table 7: Sulfate Levels and Effects[24]

SULFATE LEVELS (mg/L)	DESCRIPTION/EFFECT
Less than 500	Considered safe for all ages and types of cattle.
500 – 1,499	Generally safe. Trace mineral availability may begin to be reduced. May decrease performance of confined cattle.
1,500 – 2,999	Marginal. Can cause temporary diarrhea. May be considered poor for confined cattle during hot weather. Sporadic cases of polio may be seen in confined cattle. Performance may be reduced.
3,000 – 4,000	Poor water. Not recommended for use for pregnant or lactating cows or cattle in confinement. Sporadic cases of polio are probable, especially in confined cattle. Performance of grazing cattle may be affected.
More than 4,000	Dangerous. Health problems and substantial reduction in performance are expected.
Source: Sallenave, R. 2016. Water quality for livestock and poultry (Revised). Guide M-112. h ttp://aces.nmsu.edu/pubs/_m/M112.pdf. New Mexico State University Cooperative Extension Service.	

Other water characteristics, such as nitrates and various metals, must be considered for livestock water consumption. The Maximum Contaminant Level (MCL) is given for each of these elements and compounds, which is measured in milligrams per liter (mg/L). Table 8 displays the classification, description, and effects of each level to be considered.

The regular routine testing of water quality is necessary so the salinity, sulfate, and other elements and compound levels do not exceed suggested limits. It is recommended that water-quality tests should be performed annually for compliance and to prevent any health issues for humans and animals alike. The sample should be taken to a certified laboratory for analysis.

Generally, if there are visible problems with the livestock or if they are ill, one of the first actions is to evaluate the water they are drinking for odor and color. If there is no odor nor change in color, the water is generally safe to consume. But if there is an odor and a change in color, there is a high probability the water is contaminated and/or it possesses high concentrations of various minerals. In this case, the water should not be consumed, and water testing is highly recommended. Mitigation and/or cleanup is necessary to ensure water quality for consumption.

In addition to water quality for livestock, water quality for crop production is important, too. Typically, when noxious weeds or invasive species are present, herbicides are utilized to remove existing plants and discourage new growth. Depending on which brand, strength of herbicide, and how much is applied, the water quality can be altered. Herbicides can alter the water and influence biological impairments at sufficient concentrations.[25] These herbicides typically transfer from one water body to another through surface runoff. This transmission is important to be aware of to ensure proper water quality throughout the irrigation fields and beyond.

25 "Herbicides," *U.S. Environmental Protection Agency*, https://www.epa.gov/caddis-vol2/herbicides #:~:text=Herbicides%20may%20cause%20biological%20impairments,invertebrates%20(see%20Table%202).

Table 8: Element and Compound Maximum Contaminant Levels and Effects

ELEMENTS & COMPOUNDS	MCL (mg/L)	DESCRIPTION/EFFECT
Selenium	0.05	Sometimes found in the soil; too much selenium can cause "blind staggers" or "bob-tailed disease," leading to loss of mane and tail in horses, switch of cattle, and body hair of swine. Affected animals may recover if removed quickly from the contaminated source.
Fluoride	-	MCL not given, but 2.0 mg/L recommended. Fluoride interacts with copper in dietary minerals. Excessive levels can cause loss of tooth enamel, resulting in rapid, uneven wear. Secondary effects disturb metabolism, causing semi-starvation conditions.
Arsenic	0.2	Elevated levels can produce antibiotic-like effects such as growth stimulation. Arsenic is, however, stored by the body and can reach acute toxicity levels, causing death.
Copper	0.5	In combination with phosphorus, copper plays a role in bone development. Ruminants are more susceptible to copper toxicity. Problems with copper can occur when dietary molybdenum is either excessive or deficient.
Nitrate-N	100	High nitrate levels may indicate high levels of biological pathogens (bacteria that can cause gastrointestinal disease). Excessive nitrate/nitrite intake can lead to problems in fetal development.
Cadmium	0.05	Cadmium is considered very toxic. In young animals, increased dietary intake of cadmium can cause anemia. Reproductive problems related to cadmium have been observed in most livestock classes.
Boron	5.0	Slower growth rate is known to be one of the effects of too much boron in livestock water. Higher levels (150-300 mg/L) can cause inflammation and edema in the legs of cattle, causing subsequent weight loss.
Chromium	1.0	Carbohydrate metabolism in animals requires dietary chromium. Symptoms of elevated chromium intake vary among classes of animals, but primarily appear as skin and soft tissue problems.
Lead	0.1	It is unusual to find lead in natural waters. Studies indicate pregnant goats will abort fetuses as a result of moderate levels of lead intake.
Mercury	0.01	Mercury is not essential to animal nutrition and is not readily absorbed. Mercury can cause acute poisoning, much the same as arsenic. In cattle and sheep, dietary intake of 0.2 mg of mercury per kilogram of body weight will cause incoordination, unsteady gait, and eventual death.
Zinc	25	Normal growth and development of all animals require adequate levels of dietary zinc. Levels of 40-100 mg/L zinc in the diet are normal.
Source: NMSU Water Quality for Livestock and Poultry (revised in Dec. 2016 by Rossana Sallenave)		

8.1 BASELINE DATA

With the daily utilization of water resources, baseline information should be collected to understand where these resources are being utilized and by whom. Assessing these water resources could prove beneficial and significant to any sort of planning or expansions the tribes intend to pursue. Some examples of pertinent baseline information to be gathered include, but are not limited to: description of local physical conditions, community population information, and demographics.

The USGS has identified baseline standards for all major categories of water use. These baseline standards or guidelines are provided to assist state water-resource agencies in determining areas where work could be proposed. The baseline standards are broken down into three tiers: Tier 1 outlines the baseline goals, while Tiers 2 and 3 are additional data that complements Tier 1. Table 9 identifies the baseline standards for the farming and ranching communities.

Table 9: Baseline Standards for Water-Use Data

CATEGORY	TIER 1	TIER 2	TIER 3
Irrigation - Crop	• Aggregate annual withdrawals reported by water source, by water type, acres irrigated, and method of irrigation • Aggregate areas may be sub-county levels, but are feasible to summarize to county or watershed	• Site-specific withdrawals by well or diversion from surface-water feature, or delivery from reclaimed wastewater • Monthly withdrawals reported by water source, type, acres irrigated, crop, and method of irrigation	• Site-specific daily withdrawals • Consumptive use and conveyance and conveyance loss estimates by aggregate areas (sub-county, watershed – HUC 8 or up to HUC 12) • Site-specific return flows
Livestock	• Annual withdrawals for major facilities, reported by water source and by water type	• Site-specific annual and monthly withdrawals for all facilities reported by source of water, and by water type • Site-specific animal counts and animal type	• Improved and verified coefficients for water use per head for animal type, confined or open-range, seasonal variability, and other variables • Water withdrawals from sources supported by USDA programs to protect streams
Water-Use Database	• Monthly and annual withdrawal data are reported to the state agency and stored in an electronic format	• Withdrawal data are entered electronically into a database. Automatic QA/QC checks are integrated into the electronic database and/or data entry routines	• Withdrawal data include water source, water type and location (county and HUC-12). Data is made available for export by the state agency for download
Source: USGS – Water Resource Mission Area (August 2021)			

In addition to Table 9, other factors can influence these goals. When discussing overall water usages, the livestock and crop production is one water-use sector out of many that are typical within tribes. For example, there are water withdrawals that occur 1) within facility or community systems, 2) by water source, and 3) by water type. Some examples are included below:

1. Facility or system withdrawals for the following categories – public supply, self-supplied industrial, irrigation-crop, thermoelectric, irrigation-golf course, livestock (major facilities), mining, and aquaculture
2. Withdrawals, deliveries or returns by water source – groundwater, surface water, reclaimed wastewater, wastewater effluent, and/or recycled water. For groundwater sources the aquifer should be identified
3. Withdrawals by water type – fresh or saline

When discussing water issues or lack of water quantities, it is important to consider the "bigger picture" of what water resources are available, where these water resources come from, and how these water resources are being utilized. Groundwater and surface water resources are being utilized through various processes. Typically, groundwater resources get treated and dispersed throughout community water systems. Surface waters generally do not get treated, but are utilized for irrigation, and in some cases, for household use through rainwater catchment systems.

If the water source is identified as a private well, there are no state or federal agencies that monitor or regulate the water quality. Although, generally, if a well is being utilized for livestock purposes, it should be tested about once a year. If the well is being utilized for crop irrigation or livestock watering, the water should be tested for minerals and elements, such as nitrates, sulfates, salinity, and various metals to determine if the water is safe to consume or not. There are resources that conduct free water testing so the contents of the water are known. For example, the New Mexico Environment Department implements 10 "water fairs" throughout the year. These "water fairs" encourage people to bring a sample of their water to get tested for arsenic, electrical conductivity (salinity), fluoride, iron, nitrate, pH, and sulfate.[26]

Look out for two main elements during testing: nitrogen (N) and phosphorus (P). Both elements occur naturally in the environment. But when livestock and agriculture is present, these levels tend to increase. The conversion of nitrogen to nitrate occurs naturally in soil and water and is an important component to all living things. Although when nitrate levels get too high in water, consuming the water can pose a potential health risk to livestock and humans. Excess nitrate levels in water can be caused by human activities, such as fertilizers, on-site sewage systems, wastewater treatment effluent, animal wastes, industrial wastes, and food processing. Additionally, crops harvested after stressful weather events, such as drought, typically have high nitrate content. Because nitrate levels vary based on the time of year, it is recommended to test for nitrate

26 "Water Fairs," New Mexico Environment Department, 2024, https://www.env.nm.gov/gwqb/water-fairs/

during irrigation periods, high rainfall, or snowmelt when leaching of excess nitrate into the groundwater is most likely to occur.

The other element, phosphorus (P), can affect plant life and overall aquatic life if near an open water source. Generally, high concentrations of phosphorus have the potential to inhibit both plant nutrient uptake and soil biological activity. When exposed to an aquatic environment, the phosphorus can produce nuisance growth of algae and aquatic weeds that can accelerate the aging process in lakes and/or other water sources. It is important to know that some algae species can be toxic if an animal were to ingest it.

8.1.1 Potable/Non-Potable Water Standards

Potable water is water that is treated to meet the minimum health requirements to be classified as drinking water and is suitable for consumption. These waters meet the National Primary Drinking Water Regulations (NPDWR). Generally, non-potable water is not safe for consumption and requires treatment before consumed. Although, in certain instances, non-potable water could be utilized for livestock and irrigation watering. In fact, the mineral and nutrient content contained in non-potable water could be beneficial to the overall growth of crops, depending on plant species.

8.2 WATER-QUALITY MONITORING FOR THE PUEBLO OF JEMEZ

The Pueblo of Jemez is actively pursuing watershed restoration activities, including the thinning and burning of excess fuel loads. It will improve watershed functions by increasing stream discharge during spring snowmelt periods. In addition, water-quality improvements may occur due to shifts in the type and extent of understory vegetation cover on watersheds (increased grasses and forbs). Restoration of willow and alder communities, including the reintroduction of beavers, along perennial streams should also improve water quality (especially temperature and turbidity). To monitor stream-water quantity and quality during restoration treatments, Pueblo of Jemez will install flumes and gauging stations for discharge monitoring, and water quality instruments (sondes) to measure water temperatures, dissolved oxygen, pH, conductivity and turbidity. Pueblo of Jemez will use paired watersheds (treated and untreated) measured before and after treatments to determine the degree to which treatments have achieved the predicted increases in discharge and water quality. For watersheds that do not have sufficiently long data sets prior to treatment, Pueblo of Jemez will use hydrology models to estimate discharge under current watershed conditions, and compare these estimates to the observed discharge amounts after forest restoration treatments.

Stream-water quality was greatly influenced by post-fire flooding from the Las Conchas fire and the Thompson Ridge fire. These fire effects were far greater than any impact Pueblo of Jemez would have seen from watershed restoration activities. Additional dynamics of other variables (dissolved oxygen, pH, conductivity) also occurred during each flood. These changes led to large trout killings in the flooded areas, although the native fish species appeared to survive in good shape.

8.3 WATER-QUALITY MONITORING FOR WHITE MOUNTAIN APACHE TRIBE

Water quality standards are of utmost importance when preserving the lives of humans, animals, and plants. Current water-quality standards, outlined in the Water Quality Protection Ordinance, for White Mountain Apache Tribe were approved on September 27, 2001.[27] Through the Tribal Council and other tribal entities, the tribe possesses the exclusive jurisdiction to regulate and adjudicate all water-quality matters within the boundaries of the reservation. All water-quality standards are created to ensure tribal waters are free of contaminants that may pose health concerns to humans, and animal and/or plant life.

In addition to the Water Quality Protection Ordinance, the tribe's Environmental Code has been enacted, effective May 18, 2015.[28] The Code informs the tribe on four main elements: hazardous substances, solid waste, water quality, and the overall tribal plan and project review processes. "All methods of sample collection, preservation, and analysis used in determining water quality and maintenance of these standards shall be in accordance with procedures prescribed by the latest edition of the EPA's Guidelines Establishing Test Procedures for the Analysis of Pollutants (40 CFR Part 136) and by approved tribal quality assurance plans."[29]

Tables 10 and 11 describe water-quality standards adopted by WMAT specific to irrigation and livestock and wildlife. These water-quality standards are in place for overall water-quality protection for water that is utilized for agriculture and ranching purposes.

Table 10: Irrigation Water-Quality Standards for White Mountain Apache Tribe

WATER CONTAMINANTS	WATER QUALITY LIMIT (mg/L)
Dissolved Aluminum (Al)	5.0
Dissolved Boron (B)	0.75
Dissolved Cadmium (Cd)	0.01
Dissolved Chromium* (Cr)	0.1
Dissolved Cobalt (Co)	0.05
Dissolved Copper (Cu)	0.2
Dissolved Lead ({b)	5.0
Dissolved Molybdenum (Mo)	0.01
Dissolved Selenium (Se)	0.13
Dissolved Vanadium (V)	0.1
Dissolved Zinc (Zn)	2.0
*The standards for chromium shall be applied to an analysis which measures both the trivalent and hexavalent.	

Table 11: Livestock and Wildlife Water-Quality Standards for White Mountain Apache Tribe

WATER CONTAMINANTS	WATER QUALITY LIMIT (mg/L)
Dissolved Aluminum (Al)	5.0
Dissolved Boron (B)	5.0
Dissolved Cadmium (Cd)	0.05
Dissolved Chromium* (Cr)	1.0
Dissolved Cobalt (Co)	1.0
Dissolved Copper (Cu)	0.5
Dissolved Lead (Pb)	0.1
Total Selenium (Se)	0.002
Dissolved Vanadium (V)	0.1
Dissolved Zinc (Zn)	25.0
Radium-226+ Radium-228	30.0 pCi/L
*The standards for chromium shall be applied to an analysis which measures both the trivalent and hexavalent.	

27 "Water Quality Standards Regulations: White Mountain Apache Tribe," *U.S. Environmental Protection Agency*, 2023, https://www.epa.gov/wqs-tech/water-quality-standards-regulations-white-mountain-apache-tribe

28 WMAT Environmental Code (2015)

29 WMAT Environmental Code (2015) – Section 3.7 Part A.

These water-quality standards were established to protect the natural resources and livestock throughout the reservation. The guidance for natural resources and livestock drinking water originates from the Clean Water Act through the WMAT Environmental Protection Office. The surface water for human consumption is treated by the WMAT Utility Department and is regulated through the Safe Drinking Water Act.

As part of the natural resources, soil becomes an integral part of creating a successful farm. Recently, the WMAT utilized a basic soil testing kit to test for fundamental soil characteristics, such as phosphorus, potassium, nitrogen, and pH levels. The WMAT farming community anticipates the incorporation of soil testing as a routine soil health check, as funding becomes available.

9. SUMMARY FOR NATIVE PRODUCERS

The Stewarding Native Lands program of First Nations Development Institute supports Native ecological stewardship with the purpose of improving Native control of, and access to, ancestral lands and resources to ensure the sustainable, economic, spiritual, and cultural well-being of Native communities.

Critical to this effort is the responsible management of lands and natural resources in a manner that supports the health and economic well-being of Native communities. In the "thirsty" Southwest, "water is life" because it is a precious, coveted resource, and nowhere is this more critical than for the Native farmers and ranchers who are trying to make a living, while providing food resources for their communities.

This guide promotes a conversation about water, the most critical resource that can "make or break" our farms and ranches. In conversations with farming and ranching producers at the Pueblo of Jemez and White Mountain Apache Tribe, much has been learned about historical and current practices, challenges, and strategies that are working to preserve the viability of farming and ranching in these communities.

10. RESOURCES

INTERVIEWS CONDUCTED:

- March 8, 2023: Range Program Manager (Jemez)
- March 14, 2023: Land Operations Program Manager (White Mountain Apache Tribe)
- March 16, 2023: Cibeque Livestock Rancher (White Mountain Apache Tribe)
- March 23, 2023: Rancher (Jemez)
- March 24, 2023: Rancher (Jemez)
- April 12, 2023: Natural Resources Director (Jemez)
- June 1, 2023: Farmer-Production Team (White Mountain Apache Tribe)
- June 13, 2023: Tribal Hydrologist (White Mountain Apache Tribe)

DOCUMENT RESOURCES:

https://independent.academia.edu/KurtAnschuetz (The Continuous Path: Pueblo Movement and the Archaeology of Becoming. United States, University of Arizona Press, 2019.)

https://water.usgs.gov/wsc/map_index.html (Science in your watershed – Locate your watershed)

https://mywaterway.epa.gov/ (Viewing watersheds through the EPA)

https://enviroatlas.epa.gov/enviroatlas/datafactsheets/pdf/Supplemental/HUC.pdf (Hydrologic unit codes)

https://dep.wv.gov/wwe/getinvolved/sos/documents/basins/hucprimer.pdf (Hydrologic unit codes)
https://www.usgs.gov/special-topics/water-science-school/science/aquifers-and-groundwater (USGS groundwater)

https://mywaterway.epa.gov/community/White%20Mountain%20Apache%20Tribe%20of%20the%20Fort%20Apache%20Reservation,%20Arizona%7C-110.13281401661031,%2033.92844243271024/overview (WMAT EPA My Waterway)

https://www.fao.org/land-water/overview/integrated-landscape-management/incentives-for-ecosystem-services/en/

https://www.essearth.com/what-are-staff-gauges/

https://www.usgs.gov/media/images/staff-gauge-a-wisconsin-stream

https://pubs.nmsu.edu/_m/M112/ (NMSU Water Quality for Livestock and Poultry – revised 2016)

https://www.usgs.gov/mission-areas/water-resources/science/summary-baseline-standards-water-use-data (USGS – Water Resource Mission Area)

https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=31441.wba (USDA – Agricultural wastes and water, air, and animal resources)

https://www.ers.usda.gov/amber-waves/2022/november/study-examines-how-and-where-u-s-cow-calf-operations-use-rotational-grazing/

FOOTNOTES:

1. "Climate of the Southwestern United States," Earth@Home, Paleontological Research Institution, https://earthathome.org/hoe/sw/climate/
2. Jay Sharp, "Water in the Southwest Part Three: Surface Water," Desert USA, https://www.desertusa.com/desert-water/surface-water-southwest.html
3. The North American Deserts & Deserts of the World," *Desert USA*, https://www.desertusa.com/north-american-deserts.html
4. Kurt F. Anschuetz, "Soaking It All In," *Academia*, https://www.academia.edu/30208452/Soaking_It_All_In
5. Edwards, Pamela J., Karl W. J. Williard, and Jon E. Schoonover. 2015. "Fundamental of Watershed Hydrology." Journal of Contemporary Water Research & Education, 154(1): 3–20.
6. Water Science School, "Groundwater Decline and Depletion," *USGS*, June 6, 2018, https://www.usgs.gov/special-topics/water-science-school/science/groundwater-decline-and-depletion
7. Food and Agriculture Organization of the United Nations. I*ncentives for Ecosystem Services (EIS)*. 2016.
8. John Idowu et al, "Soil Health—Importance, Assessment, and Management," *New Mexico State University*, December 2019, https://pubs.nmsu.edu/_circulars/CR694B/index.html
9. Fernald, Alexander G., and Steven J. Guldan. "Water Task Force: Report 2." *River, Acequia and Shallow Groundwater Interactions.* New Mexico State University, 2004.
10. "Summary of New Mexico's Water Reuse Guideline or Regulation for Consumption by Livestock," *United States Environmental Protection Agency*, https://www.epa.gov/waterreuse/summary-new-mexicos-water-reuse-guideline-or-regulation-consumption-livestock
11. "Summary of Arizona's Water Reuse Guideline or Regulation for Consumption by Livestock," *United States Environmental Protection Agency*, https://www.epa.gov/waterreuse/summary-arizonas-water-reuse-guideline-or-regulation-consumption-livestock
12. "If heat rises, why does the temperature decrease at higher elevations?" *Scientific American*, December 22, 2003, https://www.scientificamerican.com/article/if-heat-rises-why-does-th/
13. "How's My Waterway?" *United States Environmental Protection Agency*, https://mywaterway.epa.gov/
14. Small-Scale Water Efficiency Project for the Pueblo of Jemez (2017)
15. Small-Scale Water Efficiency Project for the Pueblo of Jemez (2017)
16. White Mountain Apache Tribe v. Bracker, 448 U.S. 136 (1980)
17. Elizabeth M. Hoover, "Ndee Bikiyaa, "The People's Farm," White Mountain Apache Tribe, AZ," *From Garden Warriors to Good Seeds: Indigenizing the Local Food Movement*, September 19, 2014, https://gardenwarriorsgoodseeds.com/2014/09/19/ndee-bikiyaa-the-peoples-farm-white-mountain-apache-tribe-az/
18. Erika Cross, "Doing More With Less Water," USDA, March 22, 2022, https://www.farmers.gov/blog/doing-more-with-less-water
19. J. Richardson et al., Bioenergy from Sustainable Forestry: Guiding Principles and Practice, *New Zealand Journal of Forestry Science 32(3)*, January 2002, http://dx.doi.org/10.1007/0-306-47519-7https://water.weather.gov/precip/
20. World Meteorological Organization (WMO). *Guide to Hydrological Practice (Hydrology-From Measurement to Hydrological Information)*. Vol. 1. 2008, Updated in 2020.
21. "Advanced Hydrologic Prediction Service," *National Oceanic and Atmospheric Administration*, https://water.weather.gov/precip/
22. A4. "Collection of Water Samples," in *National Field Manual for the Collection of Water-Quality Data*, U.S. Geological Survey, September 2006, https://pubs.usgs.gov/twri/twri9a4/twri9a4_Chap4_v2.pdf
23. "Jemez River Near Jemez, NM - 08324000," USGS, 2024, https://waterdata.usgs.gov/monitoring-location/08324000/#parameterCode=00060&period=P365D&showMedian=true
24. Sallenave, R. 2016. Water quality for livestock and poultry (Revised). Guide M-112. https://pubs.nmsu.edu/_m/M112.pdf. New Mexico State University Cooperative Extension Service.
25. "Herbicides," U.S. Environmental Protection Agency, accessed [date], https://www.epa.gov/caddis-vol2/herbicides#:~:text=Herbicides%20may%20cause%20biological%20impairments,invertebrates%20(see%20Table%202).
26. "Water Fairs," New Mexico Environment Department, 2024, https://www.env.nm.gov/gwqb/water-fairs/
27. "Water Quality Standards Regulations: White Mountain Apache Tribe," *U.S. Environmental Protection Agency*, 2023, https://www.epa.gov/wqs-tech/water-quality-standards-regulations-white-mountain-apache-tribe
28. WMAT Environmental Code (2015)
29. WMAT Environmental Code (2015) – Section 3.7 Part A.

APPENDICES

30. A: National Primary Drinking Water Regulations (Table)
31. B: Consumer Confidence Reports for POJ and WMAT
32. APPENDIX A: National Primary Drinking Water Regulations - Table
33. APPENDIX B: Consumer Confidence Reports for Pueblo of Jemez and White Mountain Apache Tribe

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	**zero**
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	**zero**
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	**zero**
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	**0.006**
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	**0**
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	**7 MFL**
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	**0.003**
Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	**2**
Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	**zero**
Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	**zero**
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	**0.004**
Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	**zero**
Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	**zero**
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	**0.005**
Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	**0.04**

LEGEND: DISINFECTANT · DISINFECTION BYPRODUCT · INORGANIC CHEMICAL · MICROORGANISM · ORGANIC CHEMICAL · RADIONUCLIDES

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	**zero**
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	**zero**
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	**zero**
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	**0.006**
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	**0**
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	**7 MFL**
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	**0.003**
Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	**2**
Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	**zero**
Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	**zero**
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	**0.004**
Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	**zero**
Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	**zero**
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	**0.005**
Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	**0.04**

LEGEND: DISINFECTANT · DISINFECTION BYPRODUCT · INORGANIC CHEMICAL · MICROORGANISM · ORGANIC CHEMICAL · RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	MRDLG=4[1]
Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	0.8
Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
Copper	TT[8]; Action Level=1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
Cryptosporidium	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
p-Dichlorobenzene	0.075	Anemia; liver, kidney, or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero

LEGEND DISINFECTANT · DISINFECTION BYPRODUCT · INORGANIC CHEMICAL · MICROORGANISM · ORGANIC CHEMICAL · RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	**0.007**
cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	**0.07**
trans-1,2, Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	**0.1**
Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories	**zero**
1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**
Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	**0.4**
Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	**zero**
Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	**0.007**
Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	**zero**
Diquat	0.02	Cataracts	Runoff from herbicide use	**0.02**
Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	**0.1**
Endrin	0.002	Liver problems	Residue of banned insecticide	**0.002**
Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	**zero**
Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	**0.7**
Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	**zero**
Fecal coliform and *E. coli*	MCL[5]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	**zero[6]**

LEGEND DISINFECTANT · DISINFECTION BYPRODUCT · INORGANIC CHEMICAL · MICROORGANISM · ORGANIC CHEMICAL · RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[4]
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a
Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
Hexachloro-cyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
Lead	TT[5]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
Legionella	TT[7]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, and gardens	0.0002
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock	0.04
Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1
Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	zero
Picloram	0.5	Liver problems	Herbicide runoff	0.5
Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	0.05
Simazine	0.004	Problems with blood	Herbicide runoff	0.004
Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	zero
Total Trihalomethanes (TTHMs)	0.080	Liver, kidney, or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07

LEGEND: DISINFECTANT; DISINFECTION BYPRODUCT; INORGANIC CHEMICAL; MICROORGANISM; ORGANIC CHEMICAL; RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.2
1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero
Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
Uranium	30µg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero
Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

LEGEND

DISINFECTANT · DISINFECTION BYPRODUCT · INORGANIC CHEMICAL · MICROORGANISM · ORGANIC CHEMICAL · RADIONUCLIDES

NOTES

1 Definitions
- **Maximum Contaminant Level Goal (MCLG):** The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Contaminant Level (MCL):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Residual Disinfectant Level Goal (MRDLG):** The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Maximum Residual Disinfectant Level (MRDL):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Treatment Technique** (TT): A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:
- **Cryptosporidium:** 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- **Giardia lamblia:** 99.9 percent removal/inactivation
- **Viruses:** 99.9 percent removal/inactivation
- ***Legionella:*** No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- **Turbidity:** For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- **HPC:** No more than 500 bacterial colonies per milliliter
- **Long Term 1 Enhanced Surface Water Treatment:** Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, Cryptosporidium removal requirements, updated watershed control requirements for unfiltered systems).
- **Long Term 2 Enhanced Surface Water Treatment:** This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional Cryptosporidium treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- **Filter Backwash Recycling:** The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:
- **Haloacetic acids:** dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- **Trihalomethanes:** bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

NATIONAL SECONDARY DRINKING WATER REGULATION

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

FOR MORE INFORMATION ON EPA'S SAFE DRINKING WATER:

visit: **epa.gov/safewater**

call: **(800) 426-4791**

ADDITIONAL INFORMATION:

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at: **(800) 490-9198**, or email: **nscep@bps-lmit.com**.

WHITE MOUNTAIN APACHE TRIBE

WATER QUALITY REPORT

CARRIZO WATER SYSTEM	**PUBLIC WATER SYSTEM# 090400244**
CIBECUE WATER SYSTEM	**PUBLIC WATER SYSTEM# 090400243**
HONDAH/MCNARY WATER SYSTEM	**PUBLIC WATER SYSTEM# 090400076**
MINER FLAT WATER SYSTEM	**PUBLIC WATER SYSTEM# 090400693**

This report is a snapshot of your water quality. Included are details about where your water comes from, what it contains, and how it compares to standards set by regulatory agencies. We are committed to providing you with information because informed customers are our best allies.

Do I need to take special precautions?

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. The Environmental Protection Agency (EPA) and Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Water Drinking Hotline (800-426-4791).

Why are there contaminants in my drinking water?

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline (800–426–4791).

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity including:

microbial contaminants, such as viruses and bacteria, that may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife; inorganic contaminants, such as salts and metals, which can be naturally occurring or result from urban stormwater runoff, industrial, or domestic wastewater discharges, oil and gas production, mining, or farming; pesticides and herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses; organic chemical contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, and septic systems; and radioactive contaminants, which can be naturally occurring or be the result of oil and gas production and mining activities.

In order to ensure that tap water is safe to drink, EPA prescribes regulations that limit the amount of certain contaminants in water provided by public water systems. Food and Drug Administration (FDA) regulations establish limits for contaminants in bottled water which must provide the same protection for public health.

WATER QUALITY REPORT

CARRIZO WATER SYSTEM PUBLIC WATER SYSTEM# 090400244

1 GROUNDWATER SOURCE

Contaminants	MCLG	MCL	Your Water	Range	Sample Date	Violation	Typical Source
DISINFECTANTS							
	MRDLG	**MRDL**					
Chlorine (ppm)	**4**	**4**	**0.0508**	**0.01-0.1**	**2021**	**N**	**Drinking water additive used for Disinfection**
INORGANIC CONTAMINANTS							
Barium	**2**	**2**	**0.034**	**NA**	**2019**	**N**	**Discharge of oil drilling wastes and from metal**

(ppm)							refineries; erosion of natural deposits
Fluoride (ppm)	4	4	0.33	NA	2019	N	Erosion of natural deposits; water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
Sodium (ppm)	NA	NA	27	NA	2020	N	Erosion of natural deposits; salt water intrusion
LEAD AND COPPER RULE							
		Action level				A.L. Exceeded	
Copper (ppm) 90th Percentile	1.3	1.3	0.32	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives

MICROBIOLOGICAL TESTING					
CALENDAR YEAR	SAMPLING REQUIREMENTS	SAMPLING CONDUCTED	TOTAL E-COLI POSITIVE	ASSESSMENT TRIGGERS	ASSESSMENTS CONDUCTED
2021	1 SAMPLE DUE MONTHLY	12 OUT OF 12	0	0	0

Significant Deficiencies

Significant deficiencies are defects in a water system's infrastructure, design, operation, maintenance, or management that cause, or may cause interruptions to the "multiple barrier" protection system and adversely affect the system's ability to produce safe and reliable drinking water in adequate quantities

The following is a list of significant deficiencies that have yet to be corrected. Your public water system is still working to correct these deficiencies and interim milestones are shown, as applicable.

Deficiency Title: Tank Overflow Protection

Date identified: 5/26/202 Overall Due Date: 11/30/2021

Deficiency description: The storage tank's overflow has a flap gate that tends to get stuck in the open position because of buildup of sediment from regular overflows. This makes the stored water vulnerable to contamination.

Corrective Action Plan: To prevent insects, birds, and animals from entering the tank, fit the end of the overflow pipe with either a weighted flap gate that seals tightly, and insect screen, or both. The screen may be installed to come off if it becomes clogged in an overflow event. Corrective Action Plan: To prevent insects, birds, and animals from entering the tank, fit the end of the overflow pipe with either a weighted flap gate that seals tightly, an insect screen, or both. The screen may be installed to come off if it becomes clogged in an overflow event. The overflow must terminate above ground (i.e. not in an area that could be flooded) or have an adequate air gap. Due to the recurring problem of the flap gate not fully closing, an option is to add a noncorrodible screen or replace the flap gate with a noncorrodible screen. A larger mesh size, such as 12 mesh, should be considered as the risk of clogging is increased for this tank because it is operated on a timer and regularly overflows, and over time, the concrete flume fills with sediment. Flumes should be monitored and cleaned if sediment accumulates.

Deficiency Title: Lack of Source Redundancy

Date Identified: 5/26/2020 Overall Due Date: 11/30/2022

Deficiency Description: The system has only one active source. Should this source fail, the system is in danger of using all stored water and becoming dewatered. Dewatering of the distribution system will create a partial vacuum in the distribution piping that will draw contaminants into the mains. Well 1 and Well 2 were drilled in 1990 and 1993 respectively, approximately 500 feet apart. Investigations in 2016 indicated Well 1 has holes in the casing and sediment filled the well from 50 feet to 20 feet depths. Well 1 is no longer usable, leaving Well 2 as the only well for the water system. Since both wells were drilled at similar times in similar aquifers, Well 2 may develop similar problems as Well 1.

Corrective Action Plan: A second source should be developed and put online

WATER QUALITY REPORT

CIBECUE WATER SYSTEM **PUBLIC WATER SYSTEM# 090400243**

3 GROUNDWATER SOURCES

Contaminants	MCLG	MCL	Your Water	Range	Sample Date	Violation	Typical Source
DISINFECTANTS							
	MRDLG	**MRDL**					
Chlorine (ppm)	**4**	**4**	**0.4352**	**0.01-2.1**	**2021**	**N**	**Drinking water additive used for Disinfection**
DISINFECTION BY-PRODUCTS							
	MCLG	**MCL**					
Total Trihalomethanes TTHMs (ppb)	**NA**	**80**	**3.6**	**NA**	**2021**	**N**	**By-product of drinking water chlorination**
INORGANIC CONTAMINANTS							
Barium (ppm)	**2**	**2**	**0.055**	**NA**	**2019**	**N**	**Discharge of oil drilling wastes and from metal refineries; erosion of natural deposits**
Sodium (ppm)	**NA**	**NA**	**9.8**	**8-9.8**	**2019**	**N**	**Erosion of natural deposits; salt water intrusion**
LEAD AND COPPER RULE							
		Action level				**A.L. Exceeded**	
Copper (ppm) 90th Percentile	**1.3**	**1.3**	**0.32**	**0 sites over Action Level**	**2019**	**N**	**Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives**

Lead (ppb) 90th Percentile	0	15	1.3	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; discharges from industrial manufacturers; erosion of natural deposits

MICROBIOLOGICAL TESTING					
CALENDAR YEAR	SAMPLING REQUIREMENTS	SAMPLING CONDUCTED	TOTAL E-COLI POSITIVE	ASSESSMENT TRIGGERS	ASSESSMENTS CONDUCTED
2021	3 SAMPLES DUE MONTHLY	12 OUT OF 12	0	0	0

Additional Information for Lead

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. PWS system is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline at 1-800-426-4791 or at http://www.epa.gov/your-drinking-water/basic-information-about-lead-drinking-water.

Significant Deficiencies

Significant deficiencies are defects in a water system's infrastructure, design, operation, maintenance, or management that cause, or may cause interruptions to the "multiple barrier" protection system and adversely affect the system's ability to produce safe and reliable drinking water in adequate quantities

The following is a list of significant deficiencies that have yet to be corrected. Your public water system is still working to correct these deficiencies and interim milestones are shown, as applicable.

Deficiency Title: Lack of Seals for Hatch Covers

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: The hatch cover for West Storage Tank (ST003) has a broken hinge that keeps it from closing tightly and expanding the gasket. The instrument hatch for East (Green) Storage Tank (ST004) does not have a gasket. This makes the water stored in the tanks vulnerable to contamination.

Corrective Action Plan: To protect stored water from contamination, gaskets should be installed on all water storage tank hatch covers. The gasket should provide an airtight seal to prevent the entry of dust and insects into the storage tank. The gasket material should be suitable for contact with potable water (e.g. NSF Standard 61 certified material, food grade). For more information on the NSF Standard 61 certification, please consult the following website:

http://www.nsf.org/services/by-industry/water-wastewater/municipal-water-treatment/nsf-ansi-standard-61

The hinge on ST003's hatch cover should be repaired so it will close tightly and seal all openings. A gasket should be provided for ST004's instrument hatch.

WATER QUALITY REPORT

HONDAH/MCNARY WATER SYSTEM **PUBLIC WATER SYSTEM#**

090400076

3 GROUNDWATER SOURCES

Contaminants	MCLG	MCL	Your Water	Range	Sample Date	Violation	Typical Source
DISINFECTANTS							
	MRDLG	**MRDL**					
Chlorine (ppm)	**4**	**4**	**0.2716**	**0.01-1.99**	**2021**	**N**	**Drinking water additive used for Disinfection**
DISINFECTION BY-PRODUCTS							
	MCLG	**MCL**					
Five Haloacetic Acids HAA5 (ppb)	**NA**	**60**	**19.4**	**NA**	**2021**	**N**	**By-product of drinking water chlorination**
Total Trihalomethanes TTHMs (ppb)	**NA**	**80**	**2.1**	**NA**	**2021**	**N**	**By-product of drinking water chlorination**
INORGANIC CONTAMINANTS							
Barium (ppm)	**2**	**2**	**0.034**	**NA**	**2019**	**N**	**Discharge of oil drilling wastes and from metal refineries; erosion of natural deposits**
Arsenic	**10**	**2.6**	**NA**	**NA**	**2019**	**N**	**Erosion of natural deposits; runoff from orchards; glass and electronics production wastes**
Sodium (ppm)	**NA**	**NA**	**12**	**6.2-12**	**2019**	**N**	**Erosion of natural deposits; salt water intrusion**

Chromium (ppb)	100	100	1.1	NA	2017	N	Discharge from steel and pulp mills and chrome plating; erosion of natural deposits
Nitrate -reported as Nitrogen- (ppm)	10	10	0.5	0.31-0.5	2021	N	Runoff and leaching from fertilizer use; leaching from septic tanks, sewage
LEAD AND COPPER RULE							
		Action level				A.L. Exceeded	
Copper (ppm) 90th Percentile	1.3	1.3	0.32	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Lead (ppb) 90th Percentile	0	15	0.58	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; discharges from industrial manufacturers; erosion of natural deposits

MICROBIOLOGICAL TESTING					
CALENDAR YEAR	SAMPLING REQUIREMENTS	SAMPLING CONDUCTED	TOTAL E-COLI POSITIVE	ASSESSMENT TRIGGERS	ASSESSMENTS CONDUCTED
2021	3 SAMPLES DUE MONTHLY	12 OUT OF 12	0	0	0

Additional Information for Lead

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. PWS system is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline at 1-800-426-4791 or at http://www.epa.gov/your-drinking-water/basic-information-about-lead-drinking-water.

Significant Deficiencies

Significant deficiencies are defects in a water system's infrastructure, design, operation, maintenance, or management that cause, or may cause interruptions to the "multiple barrier" protection system and adversely affect the system's ability to produce safe and reliable drinking water in adequate quantities

The following is a list of significant deficiencies that have yet to be corrected. Your public water system is still working to correct these deficiencies and interim milestones are shown, as applicable.

Deficiency Title: Cross-connection Control Program

Date Identified: 5/26/2020 Overall Due Date: 6/1/2022

Deficiency Description: WMATAT does not have a cross connection control program implemented. Several high risk facilities do not have adequate cross connection protection.

Health-based Violations

The table below lists the health-based violations the water system incurred during the last calendar year. While you should have received notification of the violation at an earlier date, we are required to list them in this report

Contaminant	Violation	Begin/End Date	Steps taken to correct the violation	Return to Compliance	Return Date	Action/ Comments
Revised Total Coliform Rule (RTCR)	Sampled 2 of 3 routine monitoring locations	06/01/2021-06/30/2021	Reported samples in the following month	**Yes**	08/09/2021	Full set of results received in July

What should I do as a consumer?

There is nothing you need to do at this time

What is being done by the Utility?

We will work with our regulatory official to complete all required contaminant monitoring as directed

WATER QUALITY REPORT

MINER FLAT WATER SYSTEM **PUBLIC WATER SYSTEM#**

090400693

10 GROUNDWATER SOURCES

1 SURFACE WATER SOURCE

Contaminants	MCLG	MCL	Your Water	Range	Sample Date	Violation	Typical Source
DISINFECTANTS							
	MRDLG	**MRDL**					
Chlorine (ppm)	**4**	**4**	**0.7022**	**0.04-1.57**	**2021**	**N**	**Drinking water additive used for Disinfection**
DISINFECTION BY-PRODUCTS							
	MCLG	**MCL**					
Five Haloacetic Acids HAA5(ppb)	**NA**	**60**	**16.4**	**ND-27**	**2021**	**N**	**By-product of drinking water chlorination**
Total Trihalomethanes TTHMs(ppb)	**NA**	**80**	**34**	**8.6-42**	**2021**	**N**	**By-product of drinking water chlorination**
INORGANIC CONTAMINANTS							
Barium (ppm)	**2**	**2**	**0.1**	**NA**	**2020**	**N**	**Discharge of oil drilling wastes and from metal refineries; erosion of natural deposits**
Arsenic	**0**	**10**	**7.8**	**6.8-8.7**	**2021**	**N**	**Erosion of natural deposits; runoff from orchards; glass and electronics production wastes**

Sodium (ppm)	NA	NA	12	7.4-12	2020	N	Erosion of natural deposits; salt water intrusion
Antimony (ppb)	6	6	1.7	NA	2020	N	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
LEAD AND COPPER RULE							
		Action level				A.L. Exceeded	
Copper (ppm) 90th Percentile	1.3	1.3	0.21	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Lead (ppb) 90th Percentile	0	15	1.5	0 sites over Action Level	2019	N	Corrosion of household plumbing systems; discharges from industrial manufacturers; erosion of natural deposits
SURFACE WATER TREATMENT PLANT							
	Process Limit	Process Value	Your Water	Range	Sample Date	A.L. Exceeded	
Highest 5% of Turbidity results Above 0.3 NTU Limit (% Reported)	Less than 5% Results exceed 0.3 NTU	5	11	NA	2021	YES	Soil Runoff
Maximum Turbidity Reported (NTU)	No results Exceed 1 NTU	1	0.68	NA	2021	NO	Soil Runoff
MICROBIOLOGICAL TESTING							
CALENDAR YEAR	SAMPLING REQUIREMENTS		SAMPLING CONDUCTED		TOTAL E-COLI POSITIVE	ASSESSMENT TRIGGERS	ASSESSMENTS CONDUCTED

2021	15 SAMPLES DUE MONTHLY	12 OUT OF 12	0	0	0

Additional Information for Lead

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. PWS system is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline at 1-800-426-4791 or at http://www.epa.gov/your-drinking-water/basic-information-about-lead-drinking-water.

Additional Information for Arsenic

While your drinking water meets the EPA standard for arsenic, it does contain low levels of arsenic. The EPA standard balances the current understanding of arsenic's possible health effects against the costs of removing arsenic from drinking water. The EPA continues to research the health effects of low levels of arsenic which is a mineral known to cause cancer in humans at high concentrations and is linked to other health effects such as skin damage and circulatory problems.

Additional Information for Turbidity

Turbidity is a measure of the clarity of water. We monitor this as an indicator of the effectiveness of our filtration system.

Health-Based Violations in 2021

WMATUA Miner Flat surface water treatment plant violated the Surface Water Treatment Rule when a series of elevated turbidity readings. Turbidity is a measure of cloudiness of the water and an indicator removal of contamination. Turbidity readings at the surface water treatment plant exceeded a level of 0.3 units over 6 days in July, 2021, we are required to meet this turbidity level 95% of the time, but the plant met this level only 79% of the time. The normal operation of the treatment was disrupted during power surges. During the event, we maintained the required level of disinfection with chlorine. The surface water treatment plant has met turbidity standards since the July event.

As a consumer of the water, there is nothing you need to do at this time.

Significant Deficiencies

Significant deficiencies are defects in a water system's infrastructure, design, operation, maintenance, or management that cause, or may cause interruptions to the "multiple barrier" protection system and adversely affect the system's ability to produce safe and reliable drinking water in adequate quantities

The following is a list of significant deficiencies that have yet to be corrected. Your public water system is still working to correct these deficiencies and interim milestones are shown, as applicable.

Deficiency Title: Tank Vent Protection Screen

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: All the Miner Flat PWS storage tank vents have been fitted with screens. However, the tanks listed above either have only large-mesh screens that will not deter insects or have insect screens that have tears or corrosion problems.. (ST050 Chlorine Contact Tank, ST008 Over-the-Rainbow, ST010 Tan, ST015 Upper East Fork, ST020 Cedar Creek (Coyote), ST022 Seven-up) (Photos 35, 73, 80, 90, 99 and 10.

Corrective Action Plan: Inspect and replace the vent screens at the storage tanks listed above. Vent screen should fit properly, be made of non-corrodible material and be of fine enough mesh to prohibit the entry of insects and birds (16-24 mesh). Special vent designs may be necessary to prevent vents from clogging or freezing over. If the operator suspects that the tank vent tends to become clogged or frozen over, the problem should be addressed by an engineer familiar with water tank vent design

---

Deficiency Title: Tank Overflows

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: The end of the overfly pipes of storage tanks do not have adequate protection to keep insects and vermin from gaining access to the stored water. All the tanks' overflow pipes have been fitted with screens or flap gates, however, many of the flap gates no longer close properly due to rust or wear. Some of the screens are torn. (ST001, ST023 Miner Flat; ST008 Over-the-Rainbow; ST009 Rainbow City; ST010 Tan; ST012 Seven Mile; ST016, ST017 Canyon Day; ST021 Cedar Creek (Coyote)) (Photos 50, 73, 79, 82, 92, and 101)

Corrective Action Plan: Fit the end of the overflow pipe with a weighted flap gate that seals tightly, an insect screen or both. The screen may be installed to come off in the event that it becomes clogged in an overflow event. The overflow must terminate above ground (i.e. not in an area that could be flooded) or have an adequate air gap.

It is recommended that WMATUA consider installation of noncorrodible screens with a mesh size of 12-mesh or smaller. Due to the obvious problems with flap gates that fail to close properly, SGEC recommends replacing flap gates with noncorrodible screens. It seems likely that the screens will require less maintenance time for the operators

---

Deficiency Title: Sealing of Tank Access Hatch

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: All the Miner Flat PWS tank access hatch openings have been fitted with sealing gaskets. A few of the gaskets need to be replaced or repaired and ST005's hatch cover has a broken hinge that will prevent proper sealing. (ST050 Chlorine Contact, ST004 Powerline, ST005 Cradleboard, ST008 Over-the-Rainbow, ST020 Cedar Creek (Coyote and ST022 Seven-up) (35, 61, 64, 73, 99 and 104)

Corrective Action Plan: To protect stored water from contamination, gaskets should be installed on all water storage tank hatch covers. The gasket should provide an airtight seal to prevent the entry of dust and insects into the storage tank. The gasket material should be suitable for contact with potable water (e.g. NSF Standard 61 certified material, food grade). For more information on the NSF Standard 61 certification, please consult the following website: http://www.nsf.org/services/by-industry/water-wastewater/municipal-water-treatment/nsf-ansi-standard-61

ST005's hatch cover hinge needs to be repaired to prevent unauthorized entry and ensure sealing of its gasket.

Deficiency Title: Direct Opening into Tank – Instrument Hatch

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: ST008's instrument hatch's raised sill has an oversized hole to accommodate a conduit. The openings around the conduit offer opportunities for runoff, insects and other contaminants to gain entry to the tank's interior. (ST008 Over-the-Rainbow) (Photo 74)

Corrective Action Plan: The opening should be sealed with caulk or some other flexible and weather resistant material. The seal should be waterproof and will likely require on-gong maintenance.

Deficiency Title: Direct Opening into Tank - Targets

Date Identified: 5/26/2020 Overall Due Date: 11/30/2021

Deficiency Description: ST007 (Diamond Creek) and ST013 (Upper East Fork) have targets that do not have sealed housings for their cables. Thus, the cables penetrate the tanks' roofs through a small opening that is vulnerable to insects and runoff. (Photos 70 and 86)

Corrective Action Plan: The openings should be sealed. It is likely that the target assemblies will need to be replaced with cable assemblies that have sealed and protected housings as found on the other WMATUA tanks.

Deficiency Title: Lack of Cross-Connection Control Program

Date Identified: 5/26/2020 Overall Due Date: 8/6/2022

Deficiency Description: WMATAT does not have a cross connection control program implemented. Several high risk facilities do not have adequate cross connection protection. Lack of cross connection/backflow prevention program

---

Deficiency Title: Undersized Tank Vents

Date Identified: 5/26/2020 Overall Due Date: 9/30/2022

Deficiency Description: The tanks' vents are too small provide adequate transfer of air. (ST013, ST014 Upper East Fork) (Photos 85 and 88)

Corrective Action Plan: The existing under-sized vents should be replaced with properly designed vents that are large enough to provide adequate transfer of air as the water levels rise and fall in the tank. The vents should be downward-turned and screened to prevent the entry of insects and provide protection against windblown dust. The vent screen should fit properly, be made of non-corrodible material and be of fine enough mesh to prohibit the entry of insects and birds (16-24 mesh). Special vent designs may be necessary to prevent vents from clogging or freezing over. If the operator suspects that the tank vent tends to become clogged or frozen over, the problem should be addressed by an engineer familiar with water tank vent design.

Deficiency Title: Lack of a Tank Vent

Date Identified: 5/26/2020 Overall Due Date: 9/30/2022

Deficiency Description: ST007 (Diamond Creek) does not have a dedicated vent. Therefore, as air moves in and out of the tank, it must vent through the overflow and/or opening in the roof for its target cable. If the overflow were to plug or freeze, venting would likely be inadequate, and a line break could cause structural damage to the tank. (Photo 69)

Corrective Action Plan: The pipe at the top of the tank's roof should be converted to a dedicated vent. The vent should be downward-turned and screened to prevent the entry of insects. Vent screen should fit properly, be made of non-corrodible material and be of fine enough mesh to prohibit the entry of insects and birds (16-24 mesh). Special vent designs may be necessary to prevent vents from clogging or freezing over. If the operator suspects that the tank vent tends to become clogged or frozen over, the problem should be addressed by an engineer familiar with water tank vent design.

Deficiency Title: Pumping Facility Lack of Redundancy - Major

Date Identified: 5/26/2020 Overall Due Date: 11/30/2022

Deficiency Description: The four booster stations are designed as duplex pumping stations. However, for a variety of reasons, each of the booster stations has only one pump that is operational. Many of these pumping stations have been operating with only one pump for years. This leaves the PWS vulnerable to water delivery failure if the operational pump fails and could result in the dewatering of the distribution system downgradient from the pumping facility. Dewatering of the distribution system will lead to a backsiphonage situation, producing a significant public health risk. (PF003 Canyon Day, PF004 East Fork) (Photos 110-112)

Corrective Action Plan: Rehabilitate, repair, or replace the second pump at each station.

Health-Based Violations in 2021

WMATUA Miner Flat surface water treatment plant violated the Surface Water Treatment Rule when a series of elevated turbidity readings. Turbidity is a measure of cloudiness of the water and an indicator removal of contamination. Turbidity readings at the surface water treatment plant exceeded a level of 0.3 units over 6 days in July, 2021, we are required to meet this turbidity level 95 % of the time, but the plant met this level only 79% of the time. The normal operation of the treatment was disrupted during power surges. During the event, we maintained the required level of disinfection with chlorine. The surface water treatment plant has met turbidity standards since the July event.

As a consumer of the water, there is nothing you need to do at this time.

DEFINITIONS

ppm	**parts per million, or milligrams per liter (mg/l)**
ppb	**parts per billion, or microgram per liter (ug/l)**
positive samples	**the number of positive samples taken that year**
%positive samples/mo.	**% of samples taken monthly that were positive**
ND	**Not Detected**
NA	**Not Applicable**
MCLG	**Maximum Contaminant Level Goal: the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety**
MCL	**Maximum Contaminant Level: the highest level of a contaminant that is allowed in drinking wster; MCLs are set as close to the MCLGs as feasible using the best available treatment technology.**
MRDL	**Maximum Residual Disinfectant Level**
MRDLG	**Maximum Residual Disinfectant Level Goal**
TT	**Treatment Technique: a required process intended to reduce the level of a contaminant in drinking water**
AL	**Action Level: The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.**
90^{th} Percentile	**Statistical value used to determine if Action Level is exceeded. Determined by calculating the value at which 90% of the samples tested were below that value.**

How can I get involved?

Please feel free to contact the number below for more information or for Translated copy of the report if you need it in another language.

Please share this information with all the other people who drink this water, Especially those who may not have received this notice directly (for example, People in apartments, nursing homes, schools, and businesses). You can do this posting this notice in a public place or distributing copies by hand or mail.

FOR MORE INFORMATION PLEASE CONTACT:

Alfred Walker, Director

Thomas Pacheco, Regulatory Compliance Officer

P.O. Box 517 Whiteriver, Arizona 85941

Phone: (928) 338-4825

Fax: (928) 338-3945

PUEBLO OF JEMEZ

2022 CONSUMER CONFIDENCE REPORT

PWS ID# 063500110

Issued: July 2023

Is My Water Safe?

IMPORTANT INFORMATION ABOUT YOUR DRINKING WATER

We are pleased to present this year's Annual Water Quality Report (Consumer Confidence Report) as required by the Safe Drinking Water Act (SDWA). This report is designed to provide details about where your water comes from, what it contains, and how it compares to standards set by regulatory agencies. This report is a snapshot of last year's water quality. We are committed to providing you with information because informed customers are our best allies.

Do I need to take special precautions?

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/Centers for Disease Control (CDC) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Water Drinking Hotline (800-426-4791).

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. [Name of PWS] is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using the water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline or at http://www.epa.gov/safewater/lead.

Where does my water come from?

The Jemez Pueblo Community Water System consists of two production wells which pumps water to the Water Treatment Plant. Once the water enters the Water Treatment Plant it is chlorinated. After chlorination the water passes through filter media to remove iron, manganese, and arsenic and is sent to the Pueblo's three water storage tanks. Water then leaves the storage tanks and is carried by the distribution system to your house. Our current active wells are scheduled for a Source Water Assessment soon.

WHO IS WORKING FOR ME?

Public Works staff have a direct role and responsibility in the operation and maintenance of our community water supply.

- Todd Loretto, Director ; Water Level 2/ Wastewater Level 2
- Jarrick Shendo, Interim Utilities

Supervisor; NM JP, Water Level 2

- Ryan Gachupin, Utilities Technician Water Level 1
- Lyle Vigil, Utilities Technician Water Level 1
- Warren Casiquito, Utilities Technician Water Level 1/Wastewater 1
- D'Yanna Seonia, Administrative Assistant

Why are there contaminants in my drinking water?

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity:

microbial contaminants, such as viruses and bacteria, that may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife; **inorganic contaminants**, such as salts and metals, which can be naturally occurring or result from urban storm water runoff, industrial, or domestic wastewater discharges, oil and gas production, mining, or farming; pesticides and herbicides, which may come from a variety of sources such as agriculture, urban storm water runoff, and residential uses; **organic chemical contaminants**, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban storm water runoff, and septic systems; and **radioactive contaminants**, which can be naturally occurring or be the result of oil and gas production and mining activities. In order to ensure that tap water is safe to drink, EPA prescribes regulations that limit the amount of certain contaminants in water provided by public water systems. Food and Drug Administration (FDA) regulations establish limits for contaminants in bottled water which must provide the same protection for public health.

DISINFECTANTS & DISINFECTION BY-PRODUCTS:

Contaminants	MCL	MCLG	Highest Detected in Our Water	Range	Sample Year	Violation	Typical Source
Chlorine (ppm)	MRDL= 4	MRDLG =4	0.82	0.2-0.82	2022	No	Water additive to control microbes
TTHMs (ppb)	80	No goal for total	57.7 (Avg)	43.5-84.7	2022	No	By-product of drinking water disinfection
HAA5s (ppb)	60	No goal for total	8.11 (Avg)	6.73-10.4	2022	No	By-product of drinking water chlorination

INORGANIC CONTAMINANTS:

Contaminants	MCL	MCLG	Highest Detected in Our Water	Range	Sample Year	Violation	Typical Source
Arsenic *(ppb)	10	0	5.5 (Avg)	2.8-6.7	2022	No	Erosion of natural deposits
Barium (ppm)	2	2	0.34	0.34-0.34	2018	No	Discharge of drilling wastes
Fluoride (ppm)	4	4.0	1.1	1.1-1.1	2018	No	Erosion of natural deposits

***Arsenic** - While your drinking water meets EPA standards for arsenic, it does contain low levels of arsenic. EPAs standard balances the current understanding of arsenics possible health effects against the costs of removing arsenic from drinking water. EPA continues to research the health effects of low levels of arsenic, which is a mineral known to cause cancer in humans at high concentrations and is linked to other health effects such as skin damage and circulatory problems.

RADIOACTIVE CONTAMINANTS:

Contaminants	MCL	MCLG	Highest Detected in Our Water	Range	Sample Year	Violation	Typical Source
Beta/photon emitters (pCi/L)	50	0	7.25	7.25-7.25	2019	No	Decay of natural and man-made deposits
Radium 226/228 (pCI/L)	5	0	1.03	1.03-1.03	2019	No	Erosion of natural deposits

LEAD AND COPPER:

Contaminants	AL	ALG	90th Percentile	# of Sites Exceeding AL	Sample Year	Violation	Typical Source
Lead (ppb)	15	0	1.5	0	2022	No	Corrosion from household plumbing systems
Copper (ppm)	1.3	1.3	0.21	0	2022	No	Erosion of natural deposits; corrosion from household plumbing

TOTAL COLIFORM

Contaminants	MCL	MCLG	TC Positive	E. coli positive	Sample Year	Violation	Typical Source
Total Coliform (TCR)	1 positive/ month	0	0	0	Jan-Dec 2021	No	Naturally present in the environment

Pueblo of Jemez
Public Works
Department
139-C Bear Head Canyon Rd
Jemez Pueblo, NM 87024

IMPORTANT INFORMATION

Governors Office.......... (575) 834-7359

Public Works Office.......(575) 834-7942

Report Leaks.................(505) 500-5433 or

(505) 366-1036

Line Spots/NM One Call.................811

Term	Definition
NA	Not Applicable
ppm	Parts per million, or milligrams per liter (mg/L)
ppb	Parts per billion, or micrograms per liter (µg/L)
MCLG	Maximum Contaminant Level Goal: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
MCL	Maximum Contaminant Level: The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
MRDLG	The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
AL	Action Level: The concentration of a contaminant which, if exceeded, triggers treatment or other require-ments which a water system must follow
ALG	Action Level Goal: The level of a contaminant in drinking water below which there is no known or expected risk to health. ALGs allow for a margin of safety.
pCi/L	Picocuries per Liter: Picocuries per Liter (a measure of radioactivity)
90% Percentile	A value at which 90% of all samples collected tested at or below this value

Did you know that the average U.S. household uses approximately 400 gallons of water per day or 100 gallons per person per day? Luckily, there are many low-cost and no-cost ways to conserve water. Small changes can make a big difference – try one today and soon it will become second nature.

- **Take short showers - a 5 minute shower uses 4 to 5 gallons of water compared to up to 50 gallons for a bath.**
- **Shut off water while brushing your teeth, washing your hair and shaving and save up to 500 gallons a month.**
- **Use a water-efficient showerhead. They're inexpensive, easy to install, and can save you up to 750 gallons a month.**
- **Run your clothes washer and dishwasher only when they are full. You can save up to 1,000 gallons a month.**
- **Water plants only when necessary.**
- **Fix leaky toilets and faucets. Faucet washers are inexpensive and take only a few minutes to replace. To check your toilet for a leak, place a few drops of food coloring in the tank and wait. If it seeps into the toilet bowl without flushing, you have a leak. Fixing it or replacing it with a new, more efficient model can save up to 1,000 gallons a month.**
- **Adjust sprinklers so only your lawn is watered. Apply water only as fast as the soil can absorb it and during the cooler parts of the day to reduce evaporation.**
- **Teach your kids about water conservation to ensure a future generation that uses water wisely. Make it a family effort to re-duce next month's water bill!**

Visit www.epa.gov/watersense for more information.

FIRST NATIONS
DEVELOPMENT INSTITUTE

NATIONAL HEADQUARTERS

First Nations Development Institute
2432 Main Street
Longmont, CO 80501
Tel: 303.774.7836
Fax: 303.774.7841
info@firstnations.org

NEW MEXICO FIELD OFFICE

First Nations Development Institute
8421 Osuna Rd. N.E.
Albuquerque, NM 87111
Tel: 505.312.8641
Fax: 303.774.7841

CALIFORNIA FIELD OFFICE

First Nations Development Institute
141-B Spring Street
Claremont, CA 91711
Tel: 303.774.7836
Fax: 303.774.7841