2027

Task 1: Request for Proposals:

Water Security on Tribal Lands: Reducing Disinfection Byproducts (THMs)

Task developed and sponsored by: Souder, Miller, & Associates

Introduction

Help improve water security for the Ute Mountain Ute Tribe's (UMUT's) water system in Towaoc[1], Colorado, by developing innovative ways to reduce harmful disinfection byproducts, particularly Trihalomethanes (THMs) in the Tribe's water system. When THMs reach unacceptable levels, potable water must be discharged from the pipeline, resulting in significant water loss each time the mains are flushed. Your solution could help the Tribe meet safe drinking water standards, conserve critical water resources, and serve as a model for other communities.

[1] *Pronounced TOY – ahk (Listen: https://www.youtube.com/watch?v=xelpvbxkUGA). The Ute Mountain Ute Language and Culture Department reports that the original Ute name, Togwayakh, roughly translates to "okay" or "it's okay."*

Problem Statement

Your team is invited to research, evaluate, and design an innovative solution to reduce disinfection byproducts in the Ute Mountain Ute Tribe's water system. Solutions may incorporate treatment steps at any point in the existing system, from the transmission line entry point in Cortez, CO, to the southernmost residential connections in the UMUT's Mancos Creek Community, including the transmission line inlet, Lower Tank Vault, storage tanks, distribution system, and residential or commercial service connections. The THMs in the bench-scale demonstration will include Chloroform, Bromoform, and Dibromochloromethane (See Table B-1).

When scaled for full implementation, the proposed solution should meet the following objectives.

- Employ innovative approaches to THM reduction. Do not incorporate mixing, air stripping, or aeration.
- Reduce the highest recorded total trihalomethane (TTHM) concentrations of 105 and 106 ppb to below the EPA Maximum Contaminant Level (MCL) of 80 ppb. Use the following performance thresholds.
  - Required performance: 25% reduction (≤79.5 ppb)
  - Enhanced performance: 35% reduction (≤68.9 ppb)
  - Exceptional performance: 40%+ reduction (≤63.6 ppb)
- Apply the proposed solution to both the Mancos Creek Community (105 ppb) and the UMUT Public Works locations (106 ppb). Evaluate whether different treatment approaches are warranted at each location, as the factors contributing to THM formation may differ across the two.
- Demonstrate long-term reliability and durability of the proposed full-scale solution, while minimizing footprint, operational complexity, maintenance, and overall cost.

Use the following influent conditions:

- Cortez Public Works:
  - Average Total Organic Carbon entering the Cortez WTP (Raw Water): 4.64 mg/L
  - Average Total Organic Carbon exiting the Cortez WTP (Finished Water): 2.51 mg/L
  - Average Alkalinity (as $CaCO_3$): 105.25 mg/L
- Total THM at the Lower Tank Vault (exiting the transmission line): 54 ppb
- Total THM at the UMUT Public Works (PW) facility (arrival conditions): 106 ppb
- Total THM at the Mancos Creek Community (arrival conditions): 105 ppb
- Average Daily Demand (ADD): 560,000 gpd
- Maximum Daily Demand (MDD): 1,077,250 gpd
- Maximum flow rate through the Lower Tank Vault: 1,500 gpm

Background

The project focuses on reducing trihalomethanes (THMs), such as chloroform, which have been rising in the Tribe's water system since 2004, at times exceeding EPA's drinking water limits by up to 32%. THMs form when chlorine reacts with dissolved organic matter during the disinfection process. THM formation increases with higher chlorine concentrations, greater organic content, and longer contact time. Because UMUT water is conveyed 22 miles from Cortez, Colorado, the contact time is extended and may favor additional THM formation and accumulation before reaching Towaoc. Water age increases again when stored in Towaoc's water tanks and/or travels through long distribution lines toward the southern end of the UMUT's water service area.

Disinfection

To prevent waterborne diseases in drinking water, water treatment must include disinfection to destroy pathogens that cause illnesses such as typhoid fever, cholera, amoebic dysentery, and salmonellosis [1]. Although a variety of disinfection methods are available – including chlorine dioxide, hydrogen peroxide, ozone, and UV light – chlorine-based compounds are widely used because they quickly and inexpensively neutralize pathogens [2, 3].

Two chlorine-based compounds, chlorine and chloramine, are commonly used for disinfection, and each serves specific water-system needs. We will focus on chlorine because the Cortez WTP uses it as its primary disinfectant.

Public drinking water systems refer to chlorine from two different vantage points:

1) **Primary disinfection** balances chlorine dose and contact time to reduce pathogens to acceptable levels.

2) **Residual Chlorine** is the amount of chlorine that remains in the water after sufficient contact time has elapsed for primary disinfection. A minimum concentration of residual chlorine must be maintained throughout the distribution system to continually combat pathogens after primary disinfection is complete.

Chlorine residuals decrease over time as chlorine reacts with organic matter, biofilms, and other constituents in the water. This chlorine demand, combined with the effects of residence time, causes residuals to decline and makes them a useful surrogate indicator of water age, although they do not directly measure THM concentrations

Many U.S. states, including New Mexico and Colorado, base their drinking water disinfection policies on the "Recommended Standards for Water Works," commonly known as the *Ten State Standards*, published by the Great Lakes-Upper Mississippi River Board. The document provides comprehensive guidance on the design, operation, and maintenance of drinking water systems. It recommends a minimum free chlorine residual of 0.2 mg/L throughout the distribution system [4]. The Maximum Residual Disinfectant Level (MRDL) established by the Environmental Protection Agency (EPA) for chlorine in drinking water is 4 mg/L (4 ppm) [5]. See also the EPA's *Stage 1 and Stage 2 Disinfection Byproducts Rules* for disinfectants and disinfection byproducts [6].

Trihalomethanes: Formation, Health Effects, and Regulatory Limits

The most noted disinfection byproducts from chlorine-based disinfectants are Trihalomethanes (THMs), a group of four compounds, often referred to as THM_4. In this document, when referring to the collective measured concentrations of all THMs in a sample, we will refer to Total Trihalomethanes (TTHMs). THM_4 refers to:

- Chloroform
- Bromodichloromethane
- Dibromochloromethane
- Bromoform

The primary factors that increase THM formation and accumulation include:

- Higher chlorine concentrations being used in treatment processes
- Higher concentration of dissolved organics in the water at the time of disinfection
- Higher water age: Longer contact time between chlorine and organics in the water
- Elevated temperatures

EPA-established Maximum Contaminant Level.

The EPA has established a TTHM Maximum Contaminant Level (MCL) of 80 ppb (µg/L) due to the link between THMs and human birth defects and bladder cancer [5].

Flushing the System: Loss of Treated Water and Potential Harm to Ecosystems

If TTHM concentrations or microbial levels exceed legal limits, water mains or storage tanks must be flushed to remove aged water and restore water quality. Flushing the system results in significant losses of treated drinking water. This is an expensive outcome that is particularly problematic in water-scarce regions. In addition, discharging this water can harm local ecosystems, as Cl is acutely toxic to fish and other aquatic life, and THMs may contribute to adverse ecological effects in receiving waters.

Disinfection Byproducts: Applications to the Ute Mountain Ute Tribe Towaoc Water System

This design challenge focuses on Towaoc, Montezuma County, Colorado, home of the Ute Mountain Ute Tribe (UMUT). Towaoc is located about 20 miles south of Cortez, Colorado, along Highway 491 (Fig. 1).

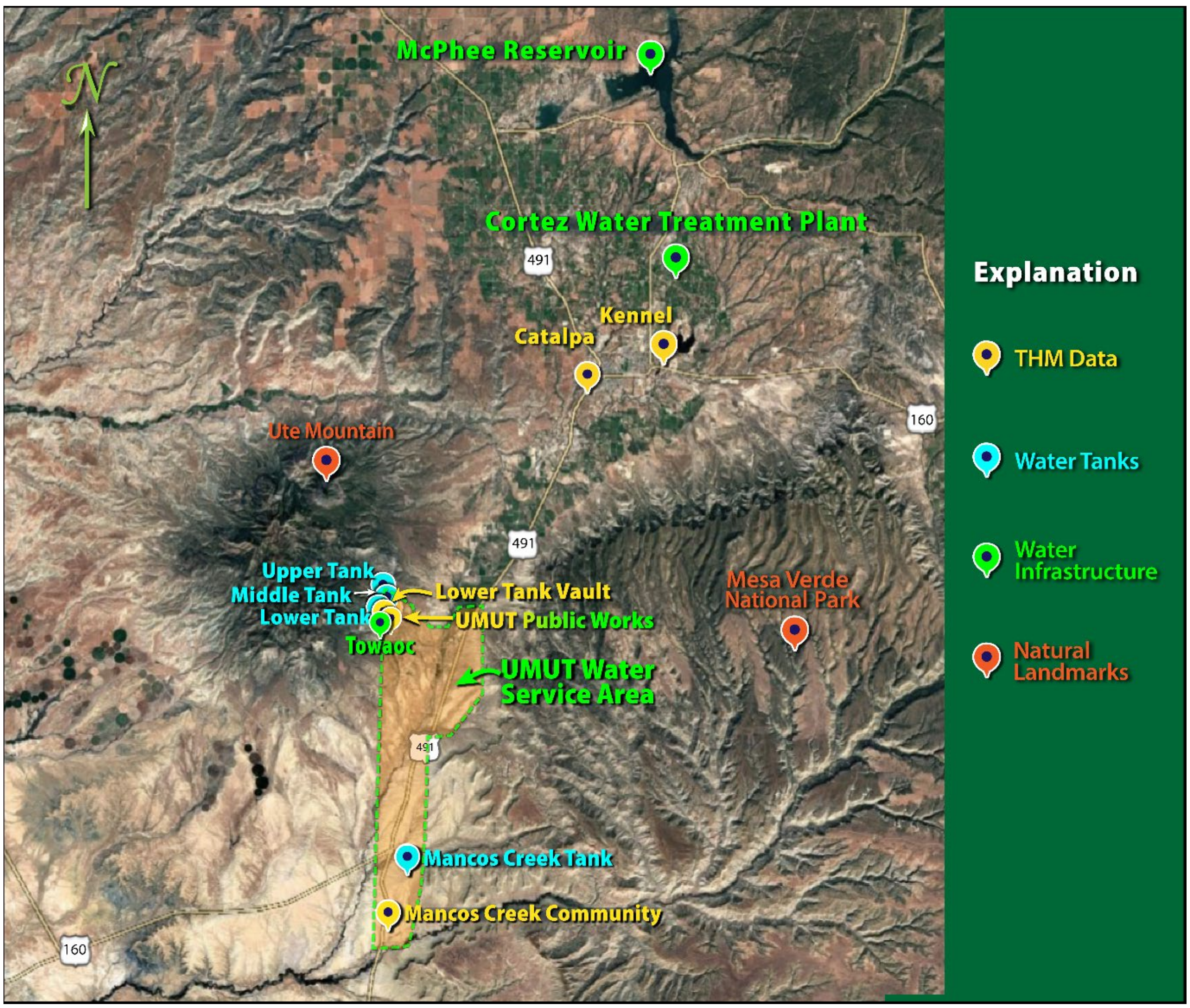

Fig. 1. Google Earth Map of 1) Natural landmarks; 2) Water infrastructure (McPhee Reservoir, Cortez Water Treatment Plant, UMUT Public Works (PW), and the UMUT water-service area); and 3) Water-sampling points (Kennel and Catalpa in Cortez, CO; Lower Tank Vault, UMUT PW, and Mancos Creek Community). UMUT PW is two-toned to reflect both its role in the infrastructure and as a THM sampling location. See Appendix D for enlarged maps showing additional detail.

Beginning in April 2024, the Tribe recorded elevated TTHMS levels at the inlet to their water system, with some concentrations far exceeding the EPA MCL. They seek to reduce THMs throughout the distribution lines in environmentally sustainable ways that are cost-effective, reliable, and feasible across their broad geographic region.

Ute Mountain Ute Tribe Towaoc Water System: Transmission, Disinfection, Storage, and Distribution

History. The UMUT's water distribution system in Towaoc was constructed by the Indian Health Service in 1968 [10]. Although the system was initially supplied by local wells, water quality was so poor that residents hauled their own potable water by truck from Cortez. To address this, the Bureau of Reclamation's *Dolores Project* developed McPhee Reservoir on the Dolores River, and in 1988 began supplying water to Towaoc through the Towaoc Pipeline Project. Water from the reservoir is treated at the Cortez Water Treatment Plant (WTP) and distributed to surrounding communities, including Towaoc [7]. After traveling a 22-mile pipeline from Cortez, the water enters the Towaoc system, where the Tribe evaluates and further treats it. By 1994, Towaoc residents were receiving clean, potable water directly to their homes for the first time. An overview of treatment processes at the Cortez WTP is provided in [8], and a schematic of the current UMUT water system is included in Appendix C.

Transmission from Cortez to Towaoc. The transmission line from the Cortez Water Treatment Plant to Towaoc consists of approximately 22 miles of primarily ductile iron pipe (iron pipe, lined with cement mortar, and sprayed with a seal coat), with some replacement sections made of HDPE. Interior pipe diameters range from 12 to 14 inches. The transmission line has three electrically actuated control valves in two buried control vaults.

Cortez has agreed to provide the Tribe with up to 1000 acre-ft/yr (892,682 gpd) of potable water. The Tribe's current average daily demand (ADD) of approximately 560,000 gpd remains well below this allocation, and demand has risen only 0.12% per year since 2020. Although the agreement does not restrict the volume of water that can be supplied on a given day, it specifies that only one storage tank can be filled at a time.

All water from the transmission line enters the UMUT distribution system at the Lower Tank Vault (LTV) in Towaoc. This underground structure regulates flow to the lower storage tank and to a second tank vault that directs flow to the middle and upper storage tanks.

Disinfection near the Lower Tank Vault. Prior to entering the UMUT system inlet at the LTV, the free chlorine residual averages 0.7 mg/L. A booster disinfection system adds approximately 0.5mg/L of chlorine, raising the residual to 1.2 mg/L. The system is housed in a 12' x 12' above-ground building, immediately before the LTV (See Figs. D-3 and D-4). As a sovereign nation, the UMUT may set some of its own water-treatment standards. They chose 1.2 mg/L to meet Colorado's minimum residual requirement of 0.2 mg/L at all points in the system. They are required to adhere to the EPA's MRDL of 4 mg/L. At a chlorine dose of 0.5 mg/L, the system can treat up to 3.6 MGD, well above the Tribe's current MDD of 1.08 MGD.

The system generates chlorine onsite through the electrolysis of a saltwater solution. This system replaced direct chlorine gas treatments due to safety and environmental concerns. Despite the system's advantages, it has experienced reliability and support issues during its 18 years of operation, including two outages that lasted several months. One failure required 12 months to resolve because of limited manufacturer support. In another case, a $15,000 replacement part became obsolete before installation due to service delays at the same time of design changes by the manufacturer. As a result, the Tribe is evaluating whether to retain the system at the LTV or relocate it to a smaller Ute community. Accordingly, teams may consider either of these options in their proposed solution.

Storage Tanks. Following disinfection, water flows from the LTV solely by gravity to four water storage tanks (Upper, Middle, Lower, and Mancos Creek). The combined capacity of the four tanks is 1,888,151 gallons. The *Ten State Standards* specify that water storage tanks be able to meet the ADD plus two hours of fire flow at 1,000 gpm [4]. Table A-4 lists the capacity of each tank and the number of connections each serves. The tanks are positioned at different elevations above the distribution system (Fig. C-1, Appendix C), allowing gravity to provide the pressure needed to deliver water to designated residents and businesses. Thus, the system operates without booster stations or distribution pumps. Note that the Lower Tank feeds the Mancos Creek Tank by an altitude valve.

Water Distribution. Water is delivered to individual homes and businesses through the UMUT distribution system through a network of 53 miles of pipe. Interior pipe diameters range from 2 to 8 inches. Table A-1 lists the pipe materials, lengths, and diameters throughout the Cortez and Towaoc systems. The maximum flow rate within the service area is 1,500 gpm at the LTV. The system also includes six mainline pressure-reducing valves (PRVs) that regulate pressure.

UMUT Water Service Area: Rising TTHM Concentrations

TTHM concentrations were measured at five locations throughout the Cortez/Towaoc water systems from 2023 to 2025 [10]. The data include samples from the Cortez side of the transmission line (at Kennel and Catalpa) and the Towaoc side (at LTV, UMUT PW, and Mancos Creek) (Fig. 2). TTHM values ranged from 59 to 106 ppb, with consistently lower concentrations measured in Cortez than in Towaoc. See Table A-2 for concentration values and Table A-3 for location coordinates.

Most notably, between 2023 and 2025, TTHM concentrations exceeded the EPA MCL in four of five samples collected at the UMUT PW facility and in four of six samples collected at the Mancos Creek Community. Summarizing the trends, by date, the THM concentrations:

- October 2023: exceeded the EPA MCL at all four sample locations.
- January 2024: dropped considerably at all locations.
- July 2024: increased again for two of the three samples taken
- October 2024: increased in Cortez, increased modestly in UMUT PW, and sharply decreased in Mancos Creek.
- January 2025: markedly increased in UMUT PW and Mancos Creek. To better understand these high values, the Tribe evaluated a sample from the LTV soon thereafter, resulting in a surprisingly low TTHM concentration of 53.8 ppb.

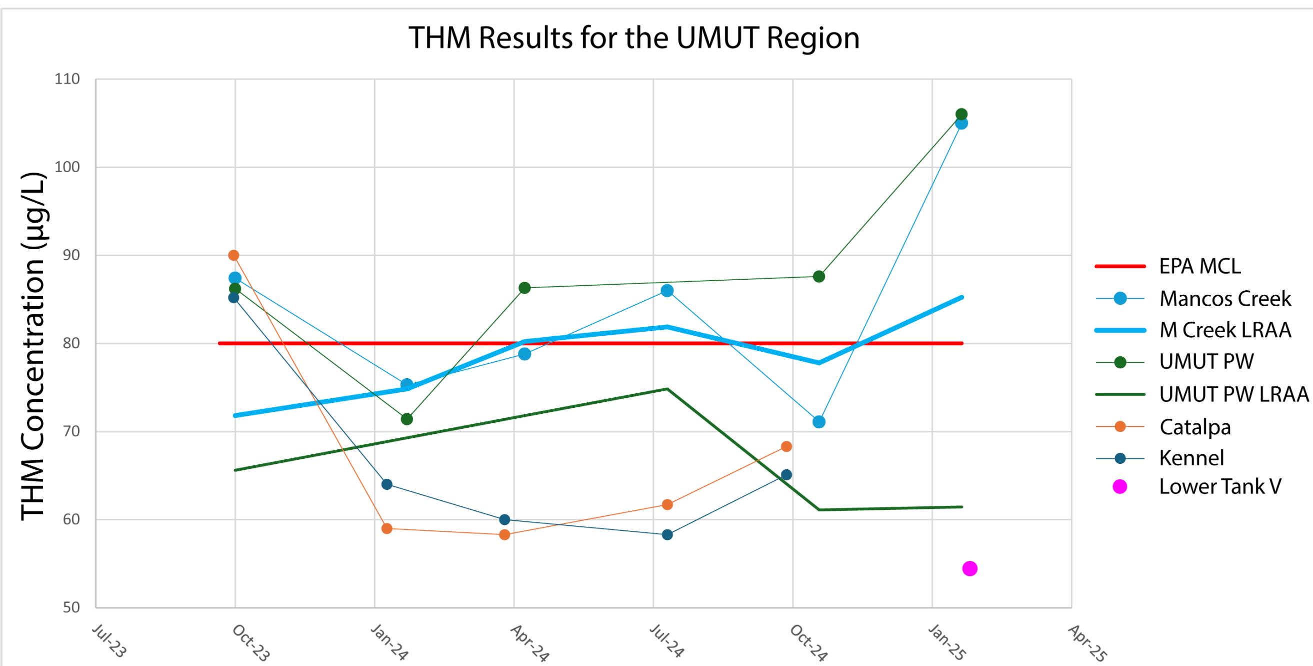

Fig. 2. TTHM concentrations (µg/L) measured from October 2023 through February 2025 and plotted using data reported in Table A-2 [10]. The two lower curves (Catalpa and Kennel) represent samples collected on the Cortez side of the transmission line and reflect lower TTHM concentrations than the upper two curves. Both sample sets show an ultimate rise in TTHM levels.
LRRA = Location Running Annual Average; PW=Public Works; V=Vault. The red horizontal line indicates the EPA MCL of 80 ppb.

Conserving drinking water while ensuring its safety is a critical priority for the Ute Mountain Ute Tribe. When TTHMs exceed acceptable levels, the Tribe has been required to flush affected water from the distribution system. With 75 miles of waterlines, flushing can result in the loss of hundreds of thousands of gallons of treated drinking water, an especially significant concern in this arid region.

Addressing this challenge begins with understanding the factors contributing to THM formation and accumulation within the UMUT drinking water system. These factors were introduced in general terms on p. 2 and are discussed below in the context of the study site. They include:

1) Chlorine treatment and Storage tanks: The Cortez WTP uses a multi-barrier treatment approach that includes pretreatment, parallel granular media and membrane filtration, chemical addition, disinfection, and residuals management. Following treatment, water is routed through Storage Tanks 1 and 2 to provide the required disinfection time before being held in Storage Tank 3 in preparation for transmission to Towaoc.

2) Organic content: Low organic content is critical for reducing the potential for THM formation. The Cortez WTP reduces total organic carbon (TOC) from 4.64 mg/L in the raw water to 2.51 mg/L in the finished water. Although TOC concentrations at the end of the transmission pipeline are not currently available, the relatively low chlorine residual of 0.7 measured there may indicate increased water age, continued chlorine demand, or a combination of both.

3) Water Age: A water age of at least 4.5 days is experienced everywhere in the distribution system [10].

   a. *Transmission Line Residence Time and Flow Rates:* Additional THMs continue to form as the water travels through the 22 miles of uninterrupted pipeline between Cortez and UMUT PW. When water-flow rates are low, THMs are more likely to form and accumulate.
   b. *Storage Time:* Once it reaches Towaoc, the water is treated at the LTV, then stored in tanks, providing additional time for THM formation and accumulation. The Tribe's water system has four in-service water storage tanks (Upper, Middle, Lower, and Mancos Creek) with a combined capacity of 1,888,151 gallons. See Table A-4 for storage tank capacities and Table A-5 for estimated water ages across the Towaoc region.
   c. *Towaoc Distribution Line Residence Time:* Water flowing through the transmission line, and as far as 11 miles south of Towaoc to the remote Mancos Creek Community, experiences extended residence times, allowing for additional THM formation and accumulation. Estimated water ages range from 109 hours at the UMUT PW Middle Tank to 1,314 hours at the Mancos Creek Community (Table A-5).

4) Seasonal conditions: Seasonal factors can influence THM formation and accumulation. Although not required, teams may use predictive modeling to account for seasonal variability and develop strategies that adapt to changing conditions. Because the region experiences only two primary seasons, the resulting model may be relatively simple.

   a. *Winter:* Cooler temperatures slow THM formation, but lower water demand reduces water-flow rates within the transmission and distribution lines.
   b. *Summer:* Higher temperatures accelerate THM formation, but heavier water usage increases water flow rates within the transmission and distribution lines.

Traditional Chloroform Removal

According to the most recent water quality data from the Tribe's Public Works Department, chloroform constitutes approximately 90 percent of the TTHM levels, accounting for 94.3 ppb out of the total 105. Due to the high volatility of chloroform, it is common engineering practice to install tank mixers and blowers to increase mass transfer and volatilization rates. Active mixing prevents thermal and chemical stratification, bringing chloroform to the water's surface, where the blowers introduce fresh air into the tank's headspace while exhausting THM-laden air. A system of this type commonly operates with a 0.5 hp motor and an impeller rotating at over 1,000 RPM.

Mixer/blower suppliers report a 30 – 40% reduction in TTHMs, although some vendors guarantee this level of effectiveness only when a spray aerator is incorporated into the system. Using the more conservative estimate of a 30% reduction, a concentration of 106 ppb would decrease to 74.2 ppb, a value below the EPA MCL of 80 ppb.

Innovative Chloroform Removal

The Tribe is seeking innovative alternatives to this mixer/blower-type system because its capital expense will be high ($400,000 for all four tanks). Incorporating spray aerators would increase the cost to $700,000 for all four tanks. The operation of the four systems is expected to increase annual energy costs by a modest $15,000/year, compared with the Tribe's current treatment system [10].

At a minimum, the innovative technology should reduce the TTHM concentration from 106 ppb to the EPA MCL of 80 ppb or lower. Assuming 106 ppb represents the highest expected TTHM concentration, a 25% reduction (to 79.5 ppb) would be sufficient to meet the MCL. However, THM concentrations may exceed 106 ppb under some conditions, and water traveling 11 miles from the LTV to the Mancos Creek Community may experience water ages of 1,300 hours or more. Therefore, teams are encouraged to seek treatment strategies that provide a greater margin of safety than minimally complying with the EPA MCL. The following performance targets are provided to help evaluate proposed solutions, based on an initial THM concentration of 106 ppb.

- Required goal: 25% reduction (≤79.5 ppb)
- Enhanced performance: 35% reduction (≤68.9 ppb)
- Exceptional performance: 40%+ reduction (≤63.6 ppb)

Task 1 Team Goals

Your team's goal is to develop a completely innovative solution for reducing THM formation and accumulation to well below the EPA MCL for the UMUT water distribution system. Solutions may incorporate treatment steps at any point within the existing treatment, storage, or distribution systems—from the entrance to the transmission line in Cortez to the inlet at the LTV, and as far south as the Mancos Creek Community

Carefully consider strategies for minimizing both capital and operational costs, as well as maintenance. While not an exhaustive list, the following options may provide useful starting points.

- **Disinfectant modifications:** Evaluate the effect of changing disinfectant type, dosage, application timing, booster station operation, and/or disinfection location.
- **THM formation conditions:** Explore ways to inhibit the formation and/or accumulation of THMs.
- **Water Age:** Investigate operational or infrastructure modifications that would reduce water age in areas of the system with the longest residence times.
- **THM removal:** Explore innovative means of removing THMs from the UMUT PW water system.
- **Monitoring and predictive control:** Explore:
    - The use of monitoring, modeling, and predictive tools to identify conditions that promote THM formation and accumulation. These tools may be used to improve understanding of system behavior, evaluate alternative designs, and/or predict the impacts of seasonal or operational changes.
    - How the implementation of real-time monitoring, automation, and control systems could support operational adjustments to maintain treatment effectiveness under varying system conditions.

Design Requirements

Your proposed design should answer the Problem Statement given on page 1 and provide these specific outcomes:

- Review the literature for existing THM mitigation efforts and develop your own innovative solution, based on the applicable data. Additionally, you may implement predictive tools to inform your initial design decisions.
- Base your full-scale design on water demands within the Towaoc distribution system, using an average daily demand (ADD) of 560,000 gpd and a maximum daily demand (MDD) of 1,077,250 gpd. Assume a maximum flow rate of 1,500 gpm when filling the Lower Tank.
- Develop a full-scale solution that reduces the highest measured TTHM concentration (106 ppb) to levels at or below the EPA MCL of 80 ppb (at minimum, reflecting a 25% THM reduction). Enhanced performance will achieve a 35% reduction, and exceptional performance will reduce THM concentrations by 40% or more.
- The solution may include replacing the UMUT Public Works' disinfection system at the Lower Tank Vault.
- Include a Process Flow Diagram (PFD) for the selected THM mitigation process. The PFD must include mass and energy balances (input and output rates, including waste streams, reactants, reaction rates, etc.).
- Units of measure used in the team's report shall adhere to customary engineering practice. Note that engineering practice does mix units. Units are stated according to the entity that sets the standards:
    - THM concentrations: Report in EPA's established units (ppt & ppb within the text; and µg/L in tables).
    - Flow rates: gallons per minute (gpm), gallons per day (gpd), or million gallons per day (MGD).
    - Residence/Detention time: hours
    - Costs: Cost per year ($/yr) or cost per gallon ($/gal) basis.
    - Chemicals: lb/yr
- Develop a bench-scale prototype to demonstrate your design's full-scale capabilities. (See *Bench-scale Demonstration*, below.) Demonstrate the system's durability and potential for long-term operation with minimal maintenance, validated through extended bench-scale studies conducted at your institution.
- Report your system's expected full-scale treatment rates and thresholds, extrapolated from your bench-scale prototype, and compare this with Towaoc's ADD and MDD.
- Report the residence/detention time, if any, needed. Discuss how variations in input flow rates will affect your system's performance, noting the minimum and maximum flow rates listed above.
- Identify and address the fate of any waste products generated by your technology.
- Report the expected energy requirements to operate the system (in Kwh/year).
- Present a Techno-Economic Analysis for implementing the full-scale THM mitigation system, scaled to treat 560,000 gpd.

  Include your estimate of capital expenses (CAPEX) and operational expenses (OPEX) for a full-scale solution and appropriate graphical representation(s) of your cost data. Report all costs for a full-scale operation on a cost/yr basis. Include any waste-stream disposal.
    - CAPEX typically includes, but is not limited to, equipment, pipes, pumps, etc. Do not include costs of buildings and appurtenances to the treatment process.
    - OPEX should be calculated as the cost/year to treat the water at the design's performance levels. Include, on an annual basis: materials needed, including consumables (chemicals, sacrificial components, liner repair, etc.). Additional operating costs: engineering professional labor rate of $150/hr; operator labor rate of $70/hour; solids disposal costs ($50/ton), waste disposal, energy costs: electricity rate of $0.09/kWh, and research an industrial natural gas rate ($/MM BTU), and any additional operating costs your team identifies.
    - Visualization tools: Use tools such as sensitivity analyses, graphs, and other visuals to illustrate how key parameters impact system performance and economics.

- Develop a Community Relations Plan and/or a Public Involvement Plan (see *Team Manual*) that meaningfully engages the Ute Mountain Ute Tribe in:
    - Technology assessment: Selecting the best approach.
    - Development activities: Designing and refining the chosen approach.
    - Deployment activities: Implementing, operating, and evaluating the approach.
- To qualify for the P2 (*Pollution Prevention*) Award, document success in improving energy efficiency, pollution prevention, and/or waste minimization, as it applies to your project. Place this in a separate "Pollution Prevention" section of the report.
- Reflect on alternative designs and situations in which those designs might be more viable than your chosen design, depending on the given region and factors that may change over time.
- Address any intangible benefits of the selected treatment process.
- Address safety aspects of handling the water, volatiles, waste streams, and any final products at all relevant points in your treatment system. These issues should be addressed:
    - for both the full-scale design and the bench-scale demonstration
    - In both the written report and the Experimental Safety Plan (ESP)

Bench Scale Demonstration

The bench-scale unit shall demonstrate a process that can be scaled to a full-scale system having a maximum flow rate of 1,500 gpm. Testing will use a synthetic solution representative of THM-containing water from the UMUT water system. Preliminary solution chemistry is provided in Appendix B. The final formulation will be distributed to teams in early Fall 2026.

<u>*Before the contest:*</u>

- Your team will submit the 30% Project Review, build and test the bench-scale prototype using the recipe for a synthetic solution provided in Appendix B, and obtain ESP approval to operate the prototype at the contest. Collect data from your bench-scale prototype and report it in the contest deliverables.
- WERC can ship difficult-to-obtain items to your team, if needed. Email werc@nmsu.edu to request materials.

<u>*At the contest, your team will provide:*</u> A working bench-scale prototype that demonstrates the proposed full-scale THM mitigation system. Teams are responsible for providing all materials and supplies needed to demonstrate the system, except for the synthetic solution.

<u>*At the contest, WERC will provide:*</u> Basic booth setup (see *Team Manual)*, synthetic solution (Table B-1), sample-collection bottles, and any items requested by your team in the 30% Project Review.

<u>*Contest Bench-scale testing:*</u> Demonstrate the functionality and effectiveness of the THM-mitigation system during the bench-scale demonstrations on Tuesday, April 6, 2027. Task 1 teams will likely demonstrate their solutions outdoors, due to the nature of THM volatiles.

- <u>Up to</u> 18 liters (5 gallons) of synthetic solution will be available for each team's bench-scale demonstration. This is a maximum allowance; most teams will require less. Request the desired volume in the 30% Project Review. On Monday morning, WERC will share the lab analysis of the provided synthetic solution,
- All bench-scale prototypes may operate from 10 am on Monday to 2 pm on Tuesday. Overnight operation is generally not permitted; however, exceptions may be requested in the 30% Review and the ESP.
- As needed, WERC will collect your team's final effluent samples and submit them to the NMSU analytical testing lab for analysis. Some measurements will be collected onsite during the bench-scale demonstrations (See *Contest Analytical Testing Techniques*, below.)

Contest Analytical Testing Techniques

- **THM:** Headspace gas chromatography-mass spectrometry and other analyses, as needed (WERC sends to NMSU lab)

- **Standard water treatment parameters** (Measurement instruments available in the bench-scale demo area).
  - pH
  - Turbidity
  - ORP – Oxidation Reduction Potential

- **Performance parameters** (Arranged and measured by the team)**:**
  - Flow rates
  - Residence time

30% Project Review

Submission date: Dec. 31, 2026

Early submission: You may submit earlier if you wish to receive feedback sooner.

Submission Form: Use the submission form provided on the Team Site (*URL TBD*)

The 30% Project Review outlines the general design and functionality of your THM-removal system, as well as the details for demonstrating and testing your system during the contest in Las Cruces. Pay particular attention to preparing the Process Flow Diagram (PFD); it should be a complete representation of your design.

Submit the 30% Project Review as early as possible. Although the review is not scored, your team will receive early feedback from the judges. You are allowed to change your plans after submitting this report. Include as many items listed below as possible. The more detail provided in your review, the better direction you will get from the judges.

Submit the following project-specific details (See *Team Manual* for more information):

1. Top 3 task design requirements and how your design correlates with each.
2. Complete Process Flow Diagram (PFD). This important deliverable must show all process inputs and outputs.
3. Preliminary data.
4. Outline of planned bench-scale demonstration processes.
5. 3D drawing of planned bench-scale prototype, drawn to scale, all dimensions labeled, and all accompanying supplies and equipment included in the drawing.
6. Volume of synthetic solution needed to run your bench-scale demonstration.
7. Preliminary estimate of full-scale (not bench-scale) costs. Include CAPEX and OPEX.
8. Potential safety considerations and associated mitigation strategies for the bench-scale demonstration.

Contest Deliverables (See *Team Manual*)

Each team shall submit:

- 30% Project Review
- Experimental Safety Plan (ESP) and Required Short Course.
- Technical Report—Design, data, business plan, regulatory, community plan, and 3 independent audits.
- Bench-Scale Demonstration—Working model with measurable performance
- Oral Presentation—Summary of design and key findings
- Poster Presentation—Visual summary of system and results
- Flash Pitch: a separately judged 3-minute investor pitch for your project, tailored to an appropriate audience (e.g., investors, community leaders, funding agencies, or the public).

Evaluation Criteria

Each year, the WERC Environmental Design Contest and its sponsors award more than $35,000 in cash prizes. Awards include task-specific prizes and overall contest awards. See the *Team Manual* for details.

As a team, read aloud the *2027 Team Manual* for a comprehensive understanding of the contest evaluation criteria. Find the Team Manual and other important resources on the WERC website: https://werc.nmsu.edu/team-info/guidelines.html

Judges' evaluation of your entry will include consideration of the following points specific to this task.

- The % TTHM removed by your prototype
- The TTHM measured in your treated water.
- The THM removal rate.
- The flow rate maintained during your process.
- The potential for real-life implementation in Towaoc, including effectiveness, expected reliability, and maintainability.
- The cost effectiveness of your solution as compared with other options your team identifies.
- The thoroughness and quality of the economic analysis.
- The originality and innovation represented by the proposed technology.
- Other specific evaluation criteria that may be provided at a later date (watch the FAQs).

Dates, Deadlines, FAQs (*dates subject to change—watch website FAQs*)

Today	Email us to reserve a spot for your team and join the email list for this task. Registration is limited to the first 34 teams.
Weekly	Check FAQs weekly for updates: Task-specific FAQs: 2027 Tasks/Task FAQs General FAQs: WERC General FAQs
Nov. 1 – Dec. 31, 2026	Early Bird Registration (discount applies)
Dec. 31, 2026	30% Project Review Due
Dec. 1, 2026 – March 1, 2027	Mandatory On-demand Course: *Preparing the Experimental Safety Plan*. See WERC's website and Team Manual for information.
February 15, 2027	Final date to register a team.
March 1 – 5, 2027	Email ESP to Juanita Miller. Include requests for chemicals, materials, etc.
March 26, 2027	Technical Report due
April 4 – 7, 2027	Contest in Las Cruces

Contacts:

ESP and Safety Officer: Juanita Miller, miljgh@nmsu.edu
Program Manager: Ginger Scarbrough, gscarbro@nmsu.edu (for non-ESP questions)

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[10] Souder, Miller, and Associates. Internal Report. September 2025.

[11] Souder, Miller, and Associates. Internal Database. July 2026.

Appendix A – Supporting Water System Data and Water Quality Information

Table A-1. Pipe lengths, diameters, and materials in the transmission lines from Cortez, CO and within the distribution lines within the Towaoc water system [10].

Cortez to Towaoc Pipe Length	**Cortez to Towaoc** Pipe Diameter (in.)	**Cortez to Towaoc** Pipe Material	**Towaoc** Pipe Length (mi.)	**Towaoc** Pipe Diameter (in.)	**Towaoc** Pipe Material
19.3 miles	12 and 14	Ductile Iron	13.3	2	PVC
10, 461 ft. (~ 2 mi.)	14	HDPE	1	3	PVC
3,840 ft. (~ 0.7 mi.)	14	HDPE	17.1	4	Fiberglass
–	–	–	10.5	6	PVC
–	–	–	11.2	8	PVC
–	–	–	12.5	12	PVC
–	–	–	6.4	14	PVC
Total: 22 Miles			Total: 72 Miles		

Table A-2. TTHM concentrations (µg/L) sampled from October 2023 to February 2025.
July 2024 data from UMUT PW is considered anomalous and was not graphed in Fig. 2 [10].

Sample Location	Oct. 2023 (µg/L)	Jan. 2024 (µg/L)	April 2024 (µg/L)	July 2024 (µg/L)	Oct. 2024 (µg/L)	Jan - Feb 2025 (µg/L)
Kennel	85.2	64	60	58.3	65.1	–
Catalpa	90	59	58.3	61.7	68.3	–
UMUT PW	86.2	71.4	86.3	0.5	87.6	106
UMUT Lower Tank Vault	–	–	–	–	–	53.8
Mancos Creek	87.4	75.3	78.8	86	71.1	105

Table A-3. Sampling Locations. Listed North (Cortez, CO) to South (Mancos Creek Community) [11].

Sample Location	Latitude	Longitude
Kennel (Cortez, CO)	37.3524861	-108.5454889
Catalpa (Cortez, CO)	37.3369896	-108.5977524
UMUT Lower Tank Vault	37.209581	-108.733703
UMUT Public Works (PW)	37.2096495	-108.7337241
Mancos Creek Community	37.0423860	-108.7336507

Table A-4. UMUT Tank Storage Capacities and Connections [10].

Tank	Storage capacity (gal)	# Residential Connections	# Non-residential Connections
Upper	289,073	66	None
Middle	688,084	327	2 higher-use (detention center and school)
Lower	885,262	254	82 higher-use (4 casinos, Travel Center, construction company, youth shelter, and 75 RV Park connections.
Mancos Creek	25,768	8	None

Table A-5. Estimated water age in storage tanks and distribution lines within the UMUT water service area. Water ages represent the time from leaving the treatment plant, stored in the Cortez storage tanks, traveling through the transmission line, and reaching the location listed below [11].

Location	Volume (gallons)	Residential Demand	Commercial Demand	Water Age (hours)
Upper Tank	289,073	139	0	315
Middle Tank	688,048	327	1	109
Lower Tank	885,262	254	8	137
Mancos Creek Tank	27,463	8	0	1,266
Chief Ignacio Street	n/a	139	0	316
Chairmans Home	n/a	1	0	170
Rodeo Drive	n/a	60	0	112
Sunrise Drive	n/a	1	0	508
Dry Wind Road	n/a	1	0	470
Mancos Creek Community	n/a	8	0	1,314

A water age of at least 4.5 days is experienced everywhere in the distribution system, with some areas seeing water ages of multiple weeks.

The data in Table A-5 was estimated based on water usage across a simplified system that included the 22-mile transmission line from Cortez to Towaoc, the Upper, Middle, Lower, and Mancos Creek Tank, and downstream nodes representing higher demand areas and long extensions to low demand areas (such as single homes) [10].

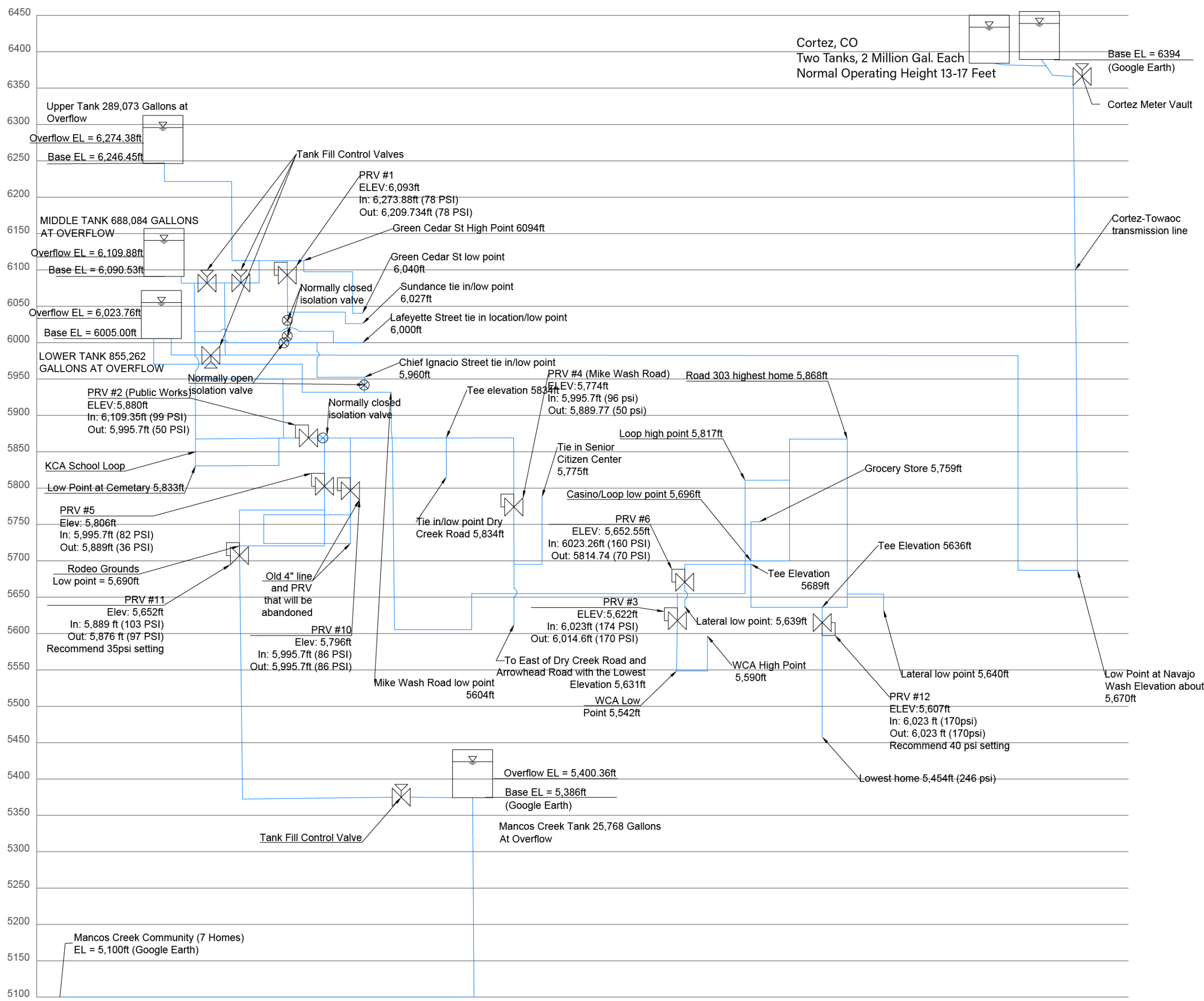
Appendix B – Preliminary Synthetic Solution Chemistry for Analytical Testing

The synthetic solution will be formulated to represent water entering the UMUT distribution system. While the composition has not yet been finalized, the final recipe is expected to be similar to that presented in Table B-1.

TABLE B-1. THE BENCH-SCALE APPARATUS SHALL TREAT WATER OF THE FOLLOWING CHEMISTRY [11]

Constituent	Per L of Synthetic Solution
Total Organic Carbon (Raw Water)	4.64 mg/L
Total Organic Carbon (Finished Water)	2.51 mg/L
$CaCO_3$	105.25 mg/L
Chloroform	94 µg/L
Bromoform	5.3 µg/L
Dibromochloromethane	5.3 µg/L
Other constituents may be added in Fall 2026	TBD
Other constituents may be added in Fall 2026	TBD

Appendix C – Existing Towaoc Water Model Schematic



NOTE: This schematic is intended to assist in identifying high and low pressure areas, pressure zones, and interconnection between pressure zones. It may not include all laterals or connections. It does not include all isolation valves

Fig. C-1. Schematic water model of the current UMUT water system, illustrating the distribution network, major infrastructure components, and associated elevations [11].

Appendix D – Enlarged Map Views

Fig. D-1. Enlarged view from the Cortez WTP to the UMUT Public Works building.

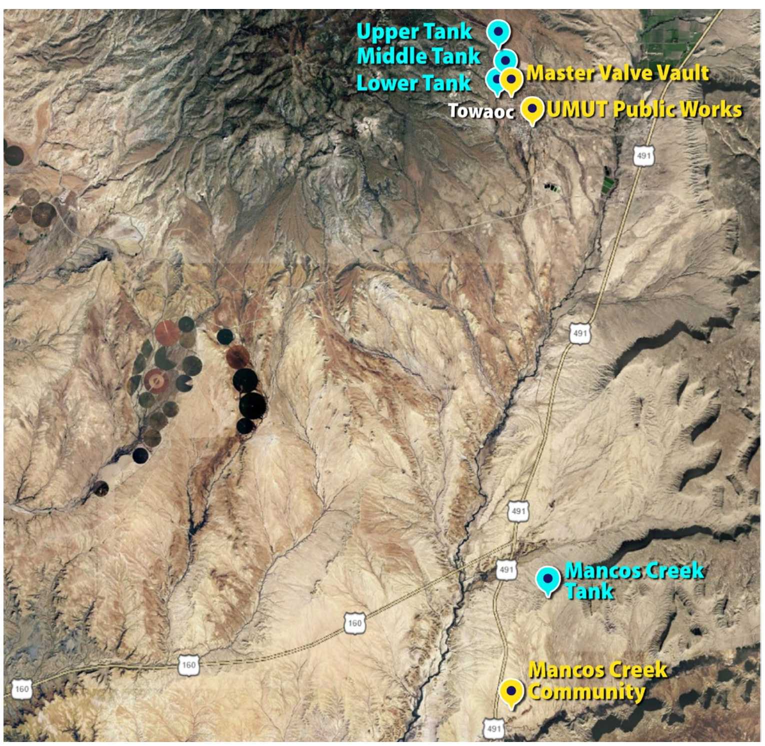


Fig. D-2. Enlarged view of the UMUT water service area.

Fig. D-3. Towaoc infrastructure. Locations shown for the Upper, Middle, and Lower Tanks, LTV, Chlorination system, and UMUT PW.

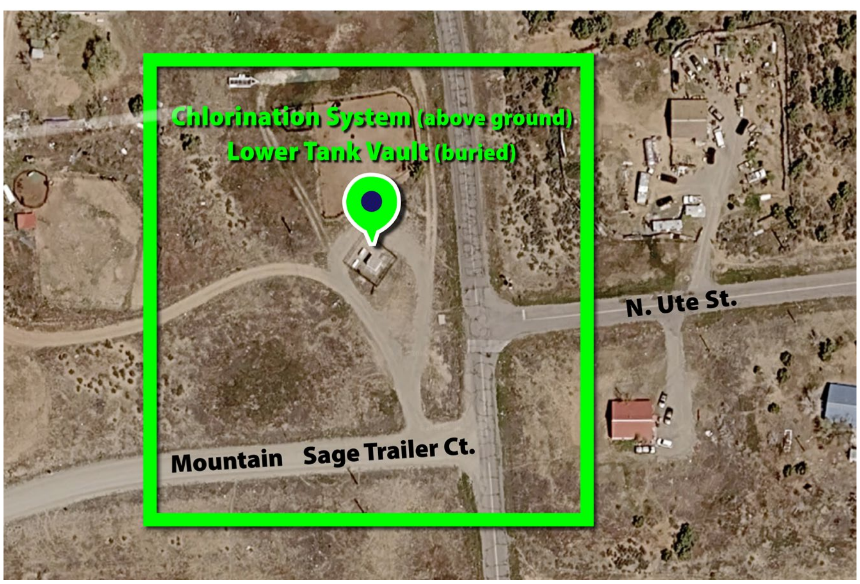


Fig. D-4. Enlarged image locating the LTV and the chlorination system.