Task 1. Request for Proposals:

2026

After RO: Brine Management in the Desert

Task Sponsored by Bronze Sponsors: Hazen & Sawyer and Souder, Miller, and Associates

Task Sponsored by Iron Sponsors: Los Alamos Technical Associates and Pettigrew & Associates

Task Developed by: Cummins, Inc.; El Paso Water; EPA Office of Research and Development; Hazen and Sawyer; Los Alamos National Labs, Los Alamos Technical Associates; Pettigrew & Associates; Souder, Miller, and Associates; Spaceport America, UT Health Houston; and US Department of Agriculture.

Introduction

Reverse Osmosis (RO) is an effective and popular treatment for removing dissolved salts, organics, and other impurities from water. However, its broader adoption can be limited in inland areas because of the concentrated brine waste it produces. Your research has the potential to advance new strategies for managing RO waste streams, paving the way for wider and more sustainable use of RO technology. In particular, you will apply your solution to a site in Garfield, NM, where disposal of RO brine reject waters has proven difficult.

Problem Statement

Your team is invited to research, evaluate, and design an innovative and sustainable system for managing RO brine concentrate in inland areas. Specifically, apply your solution to the town of Garfield, NM, designing it to scale to a total water flow rate of 400 gpm, a reject-water flow rate of 40 gpm, and a 5-acre site that accounts for local geomorphologic features (see Fig. 1).

Potential management strategies may include:

- evaporation,
- re-purposing reject waters,
- brine valorization (recovering marketable constituents), and/or
- otherwise minimizing waste.

Solutions should emphasize long-term viability and environmental responsibility while considering opportunities to create new revenue streams that will offset treatment costs.

The bench-scale prototype will be demonstrated using concentrate waters from the Kay Bailey Hutchison Desalination Facility in El Paso, TX. The provided water will have a quality similar to that outlined in Table 1.

The following are outside the scope of this project and should not be incorporated into the design:

- *Secondary RO system,*
- *Deep-well injection,*
- *Fluoride management, and*
- *Zero-liquid discharge.*

Background

Reverse osmosis (RO) is used widely to remove dissolved salts, organics, and other impurities from water. It is the go-to process for:

- Producing ultra-pure water for specialized industrial applications,
- Desalinating seawater, brackish groundwater, produced water from oil & gas, etc.,
- Preparing water for reuse,
- Removing naturally occurring impurities, such as fluoride or organics, and
- Removing impurities introduced by industrial processes, such as product-rinse residuals or contaminants that become concentrated as recirculating water evaporates.

RO has particular advantages that make it ideal for treating water to meet a specified quality. However, it does have some significant drawbacks. Of the top three RO challenges listed below, this task will focus on #3.

1. Relatively high capital expenses and operational cost due to energy demands of running at high pressures.
2. Maintenance to mitigate membrane scaling and fouling.
3. Disposal of the waste streams (often termed *reject*, *brine*, or *concentrate*).

<u>Definition: Brackish Water</u>

Brackish water has a salinity that lies between that of freshwater and seawater. Its dissolved salt concentration typically ranges between 1,000 - 10,000 mg/L (or ppm) whereas seawater typically contains 35,000 mg/L dissolved salts.

<u>Challenge: Disposing of Reject Waters</u>

Even factoring in cost, maintenance, and other issues, engineers often find RO to be the most effective choice for water treatment. However, the difficulties of disposing of waste concentrates pose significant challenges, sometimes leading smaller inland communities and light industry to abandon RO in favor of less-effective water treatment alternatives.

This is less of an issue in coastal regions, where, with careful effluent management and seawater mixing, the reject can be piped offshore. Inland, especially in desert climates, disposal options are limited, and each comes with significant drawbacks.

Inland brine disposal options typically include (drawbacks in parentheses):

1) Evaporation ponds (these require large land areas, specialty liners, and ongoing monitoring to ensure that the brine does not seep into the ground. In addition, the concentrated brine can pose hazards to wildlife attracted to the pond);

2) Zero-liquid Discharge (ZLD): traditionally defined as eliminating all liquid waste by recovering the water and solidifying remaining brine (ZLD is an energy-intensive process with high CAPEX; the process becomes increasingly challenging as the brine concentration rises; disposing of the solid waste can be challenging);

3) Deep-well injection to pump the reject into deep isolated aquifers (this requires significant geological studies and well drilling, not to mention the need to transport the concentrate to the wells either through pipelines or trucking).

4) Surface water discharge (the reject must be sufficiently treated and carefully monitored for compatibility with the groundwater).

Large water treatment facilities can often absorb the high costs of brine disposal through economies of scale, but small communities and light manufacturers rarely have the budgets to install and maintain such systems while still meeting environmental regulations. To highlight these differences, the following overview of a large-scale desalination project is provided to shed light on typical desalination processes, blending waters, etc., and as a point of comparison with the small-scale system your team is asked to design.

Example: Large-scale Disposal of Reject Waters [1, 2]

The Kay Bailey Hutchison Desalination Plant (KBHDP) in El Paso, TX, operated by El Paso Water (EPW), is an ideal example of successfully managing RO reject waters on a large scale. The plant was constructed to ease water scarcity in El Paso County, population 865,000. It is located in the desert southwest and is the world's largest inland desalination plant (and only 45 miles from the WERC Design Contest).

For over 100 years, El Paso has obtained their drinking water from two primary sources: 1) Pumping groundwater from aquifers: the Hueco Bolson[1] and the Mesilla Bolson, and 2) diverting water from the Rio Grande[2]. Now, EPW is adding desalinated water to the mix.

With annual rainfall averaging 9 inches, groundwater recharge cannot keep pace with the growing demand for potable water. The other major potential source of water, the Rio Grande, carries water only seasonally, from June to August. This is due to scheduled water releases from Elephant Butte Reservoir, about 83 miles north of El Paso. Downstream users, including EPW, receive specific allocations for municipal, agricultural, and other uses. However, ongoing drought conditions have significantly limited supply and EPW has not received its full allocation of Rio Grande water for about 10 years. (*For some light entertainment, watch an NMSU student-run news report of citizens of Las Cruces celebrating the return of water in the Rio Grande, "Water Comes Back to the Rio Grande":* https://www.youtube.com/watch?v=KHh994-Ilzk).

For decades, the Hueco and Mesilla Bolsons produced fresh water, but now many of their wells deliver brackish water. The brackish water is sent to the KBHDP for RO treatment, where salts and other minerals are removed.

Permeate, Concentrate, and Blending at the KBH Desalination Facility

1. Two water streams go into potable water production at the KBHDP:
    a. Blend Wells: EPW operates 16 blend wells that draw untreated, lower salinity groundwater. This water is blended with the treated water to adjust the chemistry of the final product.
    b. Production Wells: Another 16 wells extract brackish water from the two local aquifers. This water is used as the primary feed for the RO treatment system.
2. Pre-treatment: The brackish water from production wells is pre-treated using sand strainers, cartridge filters and anti-scalants to protect RO membranes and improve treatment efficiency.
3. RO treatment: The facility operates five RO trains, each capable of producing 3 MGD of desalinated water at a recovery rate of 82.5% [3]. 18 million gallons/day (MGD) of pre-treated brackish water is passed through the RO membranes, producing two water streams:
    a. Permeate (15 MGD): This is the purified water with most salts and minerals removed.
    b. Concentrate (3 MGD): Also known as reject or brine, this is the high-salinity wastewater left behind after RO filtration.
4. Blending: The 15 MGD of RO permeate is blended with 12.5 MGD of untreated water from the blend wells to adjust TDS and hardness to meet potable water standards.
    a. The blending process increases potable water production to 27.5 MGD (up from 18 MGD using brackish water alone), while also reducing treatment costs and extending the life of RO equipment by reducing system loads.

In Spanish – a language deeply rooted in the culture of the Las Cruces/El Paso area:

[1] *In Spanish, "Hueco" means "a depression;" and "bolson" means "a large purse." In the desert Southwest, a bolson specifically refers to a valley that collects water.*

[2] *"Rio" means "river", therefore calling it the "Rio Grande River" is technically redundant.*

   b. To give a sense of relative costs, in November 2023, EPW's estimated cost per acre-foot (almost 326K gallons) varied by source as: 1) Pumping groundwater: $150/acre-foot; drawing from the Rio Grande: $300/acre-foot; and desalination: $500/acre-foot [4].

5. Reject Disposal: EPW built a 22-mile pipeline to transport the 3 MGD reject to a permitted 4,000-foot-deep injection well. The well geologically isolates the reject waters, ensuring that the local surface and groundwater are not affected by the incoming brine. Such infrastructure is only possible because El Paso has both access to a geologically suitable injection site and the ability to spread the associated costs across a large urban population. For most communities, especially low-income areas, such a solution is geologically and financially out of reach.

<u>Case Studies in the Desert</u>

There are numerous potential applications for inland RO treatment, but low-income communities and small industries often face challenges managing their RO reject. It is illegal to simply pour the reject on the ground, as soils and ground- and surface-waters could become contaminated.

The real-world examples below, provided by engineers working in arid, inland regions, illustrate the variety of situations where the need for safe drinking water, waste reduction, and regulatory compliance creates significant challenges. This task will focus on the final scenario described: implementation in the town of Garfield, NM.

- *Tortilla Factory, El Paso, TX.* A tortilla factory in El Paso had purchased an off-the-shelf RO system to improve water quality during tortilla processing. Consulting engineers determined that there was no land space for an evaporating pond, and found other challenges with disposing of the reject.
- *Tile Manufacturer, El Paso, TX.* A small tile manufacturer in El Paso Texas experienced issues when trying to treat the rinse water from their tile manufacturing. Reject from RO systems proved difficult to manage.
- *Spaceport America, NM.* The spaceport uses its own ground wells for fresh water. While the water is potable, it has enough dissolved salts to cause premature corrosion of metal pipes, pumps, valves, and firefighting equipment. RO has been implemented as a solution to corrosion, but disposing of the 500-1000 GPD of reject is now problematic.
- *RO concentrate in the Town of Garfield, NM.* Your team is invited to explore innovative technologies, or combinations of technologies, to support the use of RO and provide effective management of its reject water for small towns, such as Garfield.

  Home to about 2500 residents and five chile processing plants, Garfield relies on water from five groundwater wells for its potable water supply. However, all five wells produce water having elevated fluoride levels, a common issue for many New Mexico communities.

  Fluoride concentrations in Garfield's wells reach up to 4.2 mg/L, exceeding the U.S. EPA limits for fluoride in drinking water [5]:
    - Secondary standard: 2.0 mg/L, to prevent cosmetic dental issues such as tooth discoloration.
    - Primary: 4.0 mg/L, to protect against skeletal fluorosis and other health effects.

  The five groundwater wells in Garfield have a combined flow rate of up to 400 gpm. Applying a common rule of thumb for RO systems – where reject water accounts for about 10% of the total flow – Garfield's RO reject water is expected to reach approximately 40 gpm.

  Your team will propose a solution that fits within a 5-acre management area that has been designated in Garfield for handling reject water (Fig. 1). The figure shows the five well locations, the water treatment tank area ①, the pump house ②, and the 5-acre management site. Note the geomorphology: the management site is bounded by a dry riverbed to the north-northwest and a moderately steep slope to the south. These features reflect the types of constraints common in arid regions and underscore the importance of carefully evaluating site suitability and potential environmental impacts.

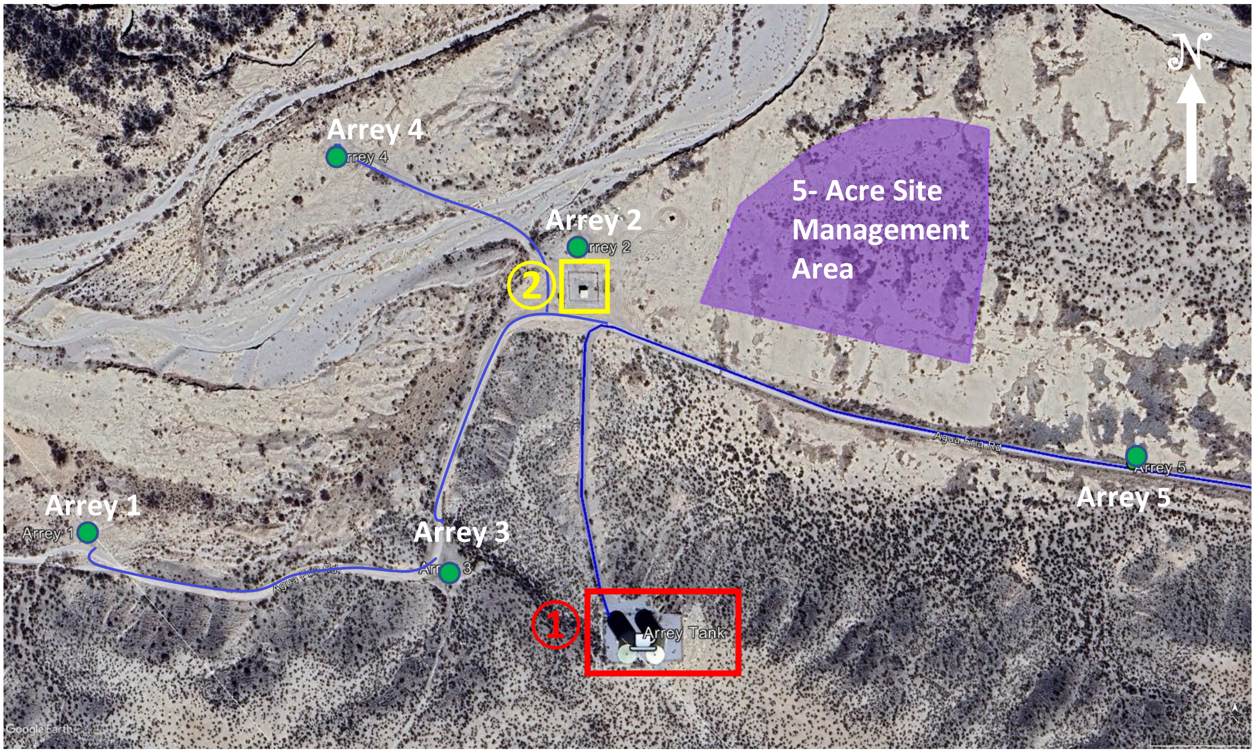

Fig. 1. The purple area outlines the 5-acre reject-management site for this task. Arrey 1 through Arrey 5 represent the water wells, each producing varying levels of fluoride. The blue lines show the access roads to the water management infrastructure. Access to Arrey 4 is limited during monsoon storms. Garfield's water tanks are within the red rectangle at ①. Their pump house is within the yellow rectangle at ②. The sloping land south of the road and the dry river bed to the N-NW illustrate the geomorphological constraints for managing the RO reject water.

Consulting engineers deemed RO to be Garfield's best treatment option for fluoride removal. The next step was to plan reject water management. Injection wells were considered, but ruled out due to the extremely high cost of geological assessments, protective well construction, and regulatory compliance. The feasibility of evaporation ponds was then evaluated, but rejected because the available land area was too small to keep up with reject flow rates. Ultimately, the idea of using RO to remove the fluoride was rejected.

Task-specific Considerations

Many inland towns and small industries could benefit from RO treatment if the above-listed limitations could be overcome. Your team may be the ones to develop breakthrough technology that enables more widespread RO use in inland areas, especially in smaller communities with limited resources. Because Garfield presents interesting geomorphological constraints, your team will use their site as the model for your system, using real reject waters from RO processes at the KBHDP (see below), but note that your technology could be extended to many other inland regions.

<u>Potential Solutions</u>
As noted in the task Problem Statement (page 1), your team may implement any combination of brine management strategies to manage RO waste streams in inland areas. The emphasis is on innovative, practical, and sustainable systems that minimize waste and maximize value.

Potential solutions include, but are not limited to:

- *Evaporation:* Evaporation ponds are currently the most common strategy for reducing reject water volumes, but their only benefit is volume reduction. They require large land areas, are costly to maintain, and raise environmental concerns including leakage risks, wildlife exposure to the increasingly concentrated brine, and safe disposal of residual solids. For these reasons, evaporation is best used as a supporting element rather than a primary solution.
- *Repurposing:* Disposal needs can be reduced by using reject waters directly, or after minimal treatment, in local industries or applications (e.g., agriculture, construction, manufacturing). If implementing this option, proposals must account for resulting product viability as well as the feasibility and costs of transporting reject waters to end-users.
- Brine valorization: Perhaps the most innovative option is to extract and recover valuable constituents from the waste stream. Although this approach is challenging, it has the potential to both reduce waste volume and create economic opportunities by producing valuable salts, minerals, or other products. In some cases, it can may also yield additional purified water, providing the triple benefits of waste reduction, resource recovery, and water recovery.

Your team may find that a combination of these approaches will best suit the goal of reducing brine waste streams while promoting sustainability and cost-effectiveness.

<u>Reject Water Samples: KBH Desalination Facility</u>
Whenever possible, WERC provides teams real water samples to support realistic bench-scale demonstrations, but because Garfield, NM does not currently operate an RO system, your team will be provided with RO concentrate from KBHDP. Table 1 lists the average KBHDP reject compositions, based on a 2020 study of the facility [6]. Because the facility is actively treating well water, the concentrations in your sample may differ slightly from the values in Table 1.

To simplify your reject management plans, your team's design will not address fluoride management. Assume that fluoride from Garfield's wells has already been diverted to a separate waste stream and is handled by a third party prior to entering your system. Consistent with this, the KBH facility treats water that is naturally low in fluoride, so the provided reject will contain negligible fluoride levels.

TABLE 1. AVERAGE COMPOSITION OF THE REJECT CONCENTRATE FROM KBH DESALINATION FACILITY IN 2020 [6]

Reject Constituent	Concentration (mg/L)
Conductivity	12,900 μS/cm
pH	8.1
Bromide	1.3
Fluoride	3.3
Chloride	3,690
Calcium	582
Magnesium	153
Nitrate	0.8
Potassium	84
Silica	142
Sodium	1,990
Sulfate	680

Design Requirements

Your proposed design should answer the Problem Statement given on page 1 and include specific details and outcomes as follows:

- Research the options for decreasing the volume of reject waters in Garfield, NM. Your team may consider strategies such as: reducing the volume of reject water, repurposing the concentrate, recovering marketable constituents, or otherwise reducing waste.
- Develop an innovative, cost-effective solution that will scale to treat RO reject at a rate of 40 gpm and fit within the designated 5-acre site in Garfield, NM.
- Do not: address fluoride management, use a second RO system to further treat the concentrate, or implement deep-well injection.
- Include a Process Flow Diagram (PFD) that outlines the primary processes involved in your treatment system. Include all inputs (such as influent, chemicals, energy required, etc.) and outputs (such as valuable constituents recovered and waste generated).
- Develop a community engagement plan as you design your system to ensure that Garfield, NM community needs are met (see Team Manual).
- Outline a plan for proper disposal of waste products generated by your water treatment process(es).
- Present a Techno-Economic Analysis (a.k.a. Techno-Economic Assessment) to manage 40 gpm of reject water, based on the composition of water shown in Table 1.

  Include your estimate of capital costs (CAPEX) and operational costs (OPEX) and include appropriate graphical representation of your cost data.
    - Capital expenses: typically include, but are not limited to, engineering costs, equipment, pipes, pumps, wiring, etc. Do not include costs of buildings needed to house your design.
    - Operating expenses (OPEX): calculate based on the number of gallons of reject water managed per year, minus the cost of marketable constituent recovery.
        - Include the cost of materials needed, including consumables (chemicals, sacrificial components, etc.)
        - In addition to other operating costs your team identifies, include these operating costs: staff labor rate of $70/hour; solids disposal costs ($50/ton); energy requirements (research an industrial natural gas rate and state in $/MM BTU; use an electricity rate of $0.09/kWh).
    - Visualization tools: Use tools such as sensitivity analyses, graphs, and other visuals to illustrate how key parameters impact system performance and economics.
- Reflect on alternative designs and situations in which those designs might be more viable than your chosen design, recalling that an optimal solution depends on outside factors–the “best” design may be dependent on region and may change over time.
- To be eligible for consideration for the P2 Award (Pollution Prevention Award), if applicable, document success in energy efficiency, pollution prevention, and/or waste minimization. Place this in a separate “Pollution Prevention” section of the report.
- Address any intangible benefits of the selected treatment process.
- Address safety aspects of your design. Safety issues for both the full-scale design and the bench-scale demonstration should be addressed in both the written report and the Experimental Safety Plan (ESP)

Bench Scale Demonstration

The Bench-scale demonstration will serve to illustrate the design considerations listed above. The ultimate goal of your bench-scale demonstration is to show effective management of reject waters from RO. Your chosen strategies should prioritize and demonstrate both economic and implementation feasibility. Your team will demonstrate the functionality and effectiveness of your system during the bench-scale demonstrations on Tuesday, April 14, 2026.

Prior to the contest, your team will: build a working bench-scale prototype that scales up to the reject-water flow rate of 40 gpm, with consideration for the spatial and geomorphological constraints at the 5-acre Garfield, NM site. Conduct early testing using a team-mixed synthetic solution of chemistry shown in Table 1; conduct the final home-lab tests on the KBHDP reject water that WERC will ship to the team.

Prior to the contest, WERC will provide: In March 2026, WERC will ship 1 gallon of reject concentrate from the KBHDP to all registered teams. Until that date, teams are urged to mix their own synthetic solution for preliminary testing using Table 1 as a guide.

At the contest, your team will provide:
All materials and supplies needed for testing your system. However, if there are materials or chemicals that would be difficult/unsafe to transport during travel to the contest, your team may request that WERC provide these. (See 30% Project Review, below).

At the contest, WERC will provide:

- Up to 18 L of reject concentrate from the KBHDP. Request the volume needed in your 30% Project Review.
- 125-mL sample collection bottles. Teams are not required to completely fill the bottles.

Analysis at the contest: Under the supervision of WERC contest staff, teams will collect:

- One pre-treatment sample, using a 125-mL bottle, of the provided KBHDP reject water immediately prior to implementation in your team's management system.
- Any marketable products or waste streams derived from the original reject. Submit requests for appropriate sample collection methods in your 30% Project Review.
- Additional testing to evaluate volume reduction, such as volume decrease, TDS, etc., as outlined by your 30% Project Review.

30% Project Review. An important step in preparing for your bench-scale demonstration is completing your 30% Project Review. Due in late January, or a date requested by your team, it outlines the general design and functionality of your treatment system and provides detailed plans for how your system will be demonstrated and tested during the contest in Las Cruces. The 2026 Team Manual gives general guidelines for the 30% Review.

Specific to this project:

- Pay particular attention to the Process Flow Diagram (PFD). This is the most important part of the report. It serves as a robust outline of all processes and balanced inputs and outputs involved in your brine management system;
- Specify whether you will need an indoor or outdoor bench-scale demonstration area, or indicate if you are flexible;
- Request, if needed, additional reject water to be shipped to your team in March, 2026. Include a justification for needing more than one gallon;
- Submit a draft of your bench-scale demonstration setup. The draft should be a 3-D view, drawn to-scale, with dimensions labeled. Consider that the contest is held at a banquet facility, without typical lab resources (e.g., no fume hoods, ovens, etc.). WERC typically provides your team with an 8' folding table within a 10' x 10' booth area, with access to 120V power. See the Team Manual for more bench-scale parameters.
- Please keep us updated if your bench-scale setup changes.

- Determine bench-scale testing parameters:
  - List any valuable constituents your system will recover along with the analytical testing procedures needed to verify recovery;
  - Describe anticipated waste streams and how their volume and composition should be evaluated by WERC;
  - Indicate the expected reduction in reject water volume and outline how this will be measured;
  - Include any other testing parameters that are unique to your project.
- If your team is interested in a tour of the EPW KBHDP facility during your stay in Las Cruces, indicate this, and we will coordinate the visit.

Experimental Safety Plan (ESP) and Required Short Course

See team manual for details. Due date is listed below.

Technical Report Requirements

The written report must address in detail the items highlighted in the Problem Statement, Design Requirements, Evaluation Criteria, and the 2026 Team Manual. The written report should demonstrate your team's insight into the full scope of the issue and include all aspects of the problem and your proposed solution.

The report must include 3 independent Audits. The report will be evaluated for quality of writing, logic, organization, clarity, reason, and coherence. Standards for publications in technical journals apply. Refer to the Team Manual.

Evaluation Criteria

Each year, the WERC Environmental Design Contest and its sponsors award more than $30,000 in cash prizes. Awards include task-specific prizes as well as overall contest awards. See the Team Manual for details.

Read the 2026 Team Manual, as a team, for a comprehensive understanding of the contest evaluation criteria. For a copy of the Team Manual, Public Involvement Plan, and other important resources, visit the WERC website: https://werc.nmsu.edu/team-info/guidelines.html

Your team's response to this task includes five components, all scored according to the rubrics in the Team Manual:

- Written report,
- Formal oral presentation,
- Bench-scale prototype demonstration,
- Poster concisely conveying the essence of your work through text and graphics,
- Flash Pitch: a separately judged 3-minute investor pitch for your project

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

- Potential for real-life implementation, including effectiveness, cost, expected reliability, and maintainability within low-income communities or small businesses.
- The cost/benefit of your solution, measured against those for other teams.
- Thoroughness and quality of the economic analysis.
- 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 get on the email list for this task. Registration is limited.
Weekly	Check FAQs weekly for updates: • Task-specific FAQs: 2026 Tasks/Task FAQs • General FAQs: 2026 General FAQs
November 1, 2025 - December 31, 2025	Early Bird Registration (discount applies)
December 1, 2025 – January 30, 2026	30% Project Review Due (or as arranged with WERC).
December 1, 2025 – February 16,2026	Mandatory On-demand Course: Preparing the Experimental Safety Plan. See website and Team Manual for information.
February 17, 2026	Final date to register a team w/o permission.
March 9 -13, 2026	Experimental Safety Plan (ESP) due to Juanita Miller. Include requests for chemicals, materials, etc.
April 2, 2026	Technical Report due
April 12 – 15, 2026	Contest in Las Cruces

Contacts:
ESP and Safety Officer: Juanita Miller, miljgh@nmsu.edu
All other questions and concerns: Ginger Scarbrough, werc@nmsu.edu

References

[1] Desalination: El Paso Water. 2025. https://www.epwater.org/our-water/water-resources/desalination (Accessed 7/03/25).

[2] Water Resources: El Paso Water. 2025. El Paso Water | Water Resources (Accessed 7/23/25).

[3] Worth Its Salt: El Paso Water Utilities Kay Bailey Hutchison Desalination Plant. Texas Water Development Board. (Accessed 8/1/2025) https://www.twdb.texas.gov/innovativewater/desal/worthitssalt/doc/Worth_Its_Salt_Jan2014_KBH.pdf (Accessed 8/1/2025).

[4] Incoming $100 Million Facility Looks to Turn Brine Waste into Water, Expand El Paso's Water Supply. El Paso Matters. 2023. New El Paso facility seeks to turn brine into drinkable water - El Paso Matters (Accessed 8/1/2025).

[5] Drinking Water Regulations and Contaminants. United States Environmental Protection Agency (EPA). https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminants (Accessed 7/1/2025).

[6] Tarquin, A., Walker, W.S., Delgado, G. and Bustamante, A. Water Environ Res, 92: 369-377. 2020. https://doi.org/10.1002/wer.1176 (Accessed 8/1/2025).