

Waste to Watts

Repurposing Perched Groundwater for Data-Center Cooling

Google Henderson Data Center Water Project
Feasibility Study

Civil and Environmental Engineering
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November 2025

Abstract

Rapid AI expansion has pushed data-center cooling into a level of water and energy use that can no longer be ignored. In Southern Nevada, this strain is intensified by facilities that draw nearly one million gallons per day for cooling. At the same time, a shallow, high-TDS perched aquifer beneath the C-1 and Flamingo channels—frequently encountered during construction yet rarely used—remains an untapped non-potable resource. This project evaluates whether that underused water can be drilled, pumped, and treated through reverse osmosis (RO) and ion exchange to serve as a third alternative supply for the Google Henderson data center.

Using real groundwater collected from the Flamingo Channel, the team performed full water-quality analysis, IX bench testing, RO modeling, and constructability and sustainability assessments. Results show that RO reliably meets cooling-tower standards and enables an 80 gpm treated stream to offset ~23% of potable demand. These findings show that perched-groundwater reuse is not only technically viable but increasingly necessary as AI-driven cooling loads accelerate in water-scarce regions.

1. Introduction and Problem Statement

The amount of water and energy needed to sustain data centers supporting the exponential growth of artificial intelligence has become a current national challenge. Recent projections suggest that water consumption for hyperscale operators could reach roughly 64 billion liters per year by 2028, underscoring how cooling loads are beginning to show up at the national scale (Lawrence Berkeley National Laboratory, 2024). In Henderson, Nevada, nearly one million gallons per day of fresh water—enough to supply Boulder City—is used solely to cool data centers. That level of demand pushes local water supplies closer to their limit and introduces long-term constraints for both existing users and future development. This project evaluates whether underused brackish shallow groundwater can be redirected as an alternative cooling-tower water source. Doing so would save fresh water, reduce pumping loads on the municipal system, and add a third water supply to support continued economic development in Southern Nevada.

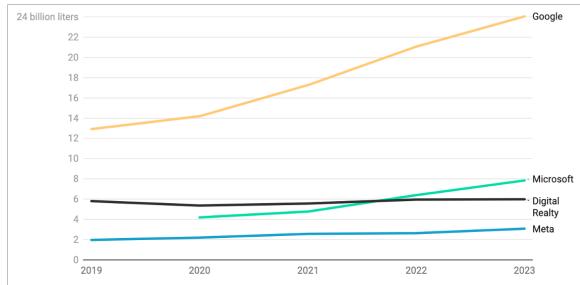


Figure 1: Projected cooling-water use by major data-center operators, adapted from Lawrence Berkeley National Laboratory (2024).

Cooling demand is driven by fundamental differences between dry and wet cooling technologies used in data-center infrastructure. Dry air-cooling systems avoid water use but typically require 10–15% more power to achieve the same heat rejection. Wet evaporative cooling systems, by contrast, cool efficiently with evaporation and reduce electrical demand, but they depend on a continuous supply of makeup water. For fa-

cilities operating at hyperscale loads, this energy–water trade-off determines whether cooling can remain sustainable in water-limited regions.

Southern Nevada faces this tension acutely. The region relies heavily on Lake Mead, where prolonged drought and overallocation have triggered repeated shortage declarations. Wet-cooled data centers compound this pressure by relying on potable municipal water for hundreds of millions of gallons per year in cooling-tower makeup. Local rebate and conservation programs highlight how carefully new water uses are scrutinized in this environment (Southern Nevada Water Authority, 2025). Without alternative non-potable sources, continued data-center expansion risks stressing distribution infrastructure, increasing water rates, and narrowing the margin of reliability for the broader community.

In parallel, shallow brackish groundwater intercepted by the engineered C-1 channel near the data-center site represents an overlooked local resource. This perched aquifer contains elevated total dissolved solids (TDS), typically 1,500–5,700 mg/L—far higher than Lake Mead’s ~650 mg/L—and is composed primarily of sulfate, calcium, magnesium, sodium, and chloride. Because this chemistry accelerates corrosion in stormwater infrastructure, the water is currently treated as a nuisance and is not used for any beneficial purpose. However, its continuous availability, proximity to the data center, and separation from potable sources make it a strong candidate for treatment and reuse.

This study investigates whether this brackish groundwater can be treated through ion exchange (IX) and/or reverse osmosis (RO) to meet cooling-tower water-quality requirements and reduce potable demand at the Henderson data center. The core question is straightforward: *Can this underused shallow groundwater be treated to a suitable quality and deployed as a supplemental cooling-tower water source, thereby conserving fresh water and improving long-term system resilience?*

2. Perched Groundwater Resource and Site Context

Right under our feet in the Las Vegas Valley is a shallow aquifer that most people think of as a nuisance—but for this project, it represents one of the only untapped water sources sitting directly beside a rapidly expanding data-center corridor. The valley’s groundwater system is split into two distinct layers. The upper layer, extending from the surface to roughly 200 ft, forms a perched aquifer with elevated total dissolved solids (TDS) and high concentrations of sulfate, chloride, calcium, magnesium, and sodium, consistent with findings from regional shallow-groundwater studies (Water Resources Division, 2016). Because of this aggressive chemistry, the shallow zone is rarely used intentionally; instead, it is usually discovered the hard way. Construction crews routinely hit this water during trenching or utility work and must dewater sites just to keep foundations stable, highlighting both how shallow it is and how consistently it is recharged.

Below this lies the region’s primary deep aquifer, between about 200 ft and 700 ft, which contains much higher-quality water. This deeper system is heavily regulated and reserved for municipal use, meaning industrial facilities—including data centers—cannot draw from it. As a result, most wet-cooled facilities in southern Nevada rely almost entirely on potable municipal water, and very few new wet-cooled systems are permitted due to scarcity-driven restrictions and long-term supply concerns.

The shallow aquifer intercepted by the engineered C-1 channel near the Henderson data center is one of the rare non-potable sources located directly adjacent to major industrial cooling demand. Hydrologically, it is replenished primarily by seasonal snowmelt from surround-

ing mountains. While the total volume stored across the shallow system is substantial, it is thinly distributed and yields only modest flow rates—typically 0.1 to 0.2 MGD per well. To avoid inducing seepage, destabilizing channel walls, or exceeding local withdrawal limits, this project adopts a conservative extraction rate of 80 gpm (0.1 MGD), informed by regional return-flow and dewatering practices (Cole, 2025).

Although this flow rate cannot fully replace the data center’s cooling-tower makeup demand—over 300 gpm—it can operate as a valuable third supply alongside potable water and any future recycled-water connections. In a region where new wet-cooling permits are rare and water allocations are tightly controlled, the ability to repurpose a local, non-potable groundwater source offers a meaningful pathway to reduce potable demand without increasing strain on the municipal system.



Figure 2: Interpolated TDS distribution in the shallow aquifer near the C-1 channel, highlighting high-salinity zones intersecting the data-center corridor.

3. Methodology

3.1 Overview of Approach

This project followed a sequential, lab-to-field workflow designed to answer a simple question: can the shallow perched groundwater beneath Henderson be treated to a cooling-tower standard and used to offset potable demand at the data center? To get there, our team moved step-by-step through aquifer analysis, field sampling, bench-scale testing, resin-column design, RO modeling, sustainability evaluation, and constructability review using HeavyBid (Bentley Systems, 2024).

3.2 Aquifer Context

The Las Vegas Valley sits on a two-layer groundwater system. The **shallow perched aquifer** spans approximately **0–200 ft**, is highly mineralized, and appears discontinuously across the valley—often flooding excavations during construction (Water Resources Division, 2016). Below it, the **deep regional aquifer (200–700 ft)** contains high-quality supply water already fully allocated for municipal use.

Because the perched aquifer is thin and locally recharged from snowmelt, only certain locations can sustain extraction. Screening of valley monitoring wells identified one viable withdrawal point along the engineered C-1 channel with shallow depth, reliable recharge, and direct proximity to the data-center corridor.

3.3 Water Collection and Field Sampling

To characterize the raw groundwater, the team performed multiple sampling runs along the C-1 channel, collecting high-TDS perched water from accessible interception points. Samples were transported to the lab in pre-cleaned vials and diluted before testing due to extremely high TDS (up to 5,700 mg/L). These samples formed the basis of all resin loading estimates and RO modeling.



Figure 3: Field collection of shallow perched groundwater from the C-1 channel.

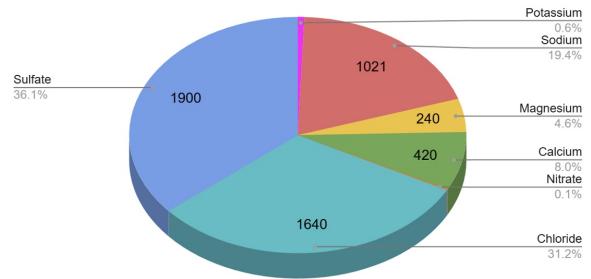


Figure 4: TDS composition of perched groundwater showing dominant dissolved ions.

3.4 Bench-Scale Laboratory Testing

Laboratory work centered on **sulfate removal** and **hardness reduction**. Testing included:

- Sulfate measurement using Hach DR900 spectrophotometry
- Hardness titration using EDTA
- TDS tracking
- Breakthrough detection through incremental effluent sampling

Samples were diluted **10×–20×** to ensure that sulfate and hardness concentrations fell within measurable ranges for both the DR900 spectrophotometer and the EDTA titration curves. During each run, effluent was collected in timed increments so that sulfate and hardness loading could be plotted against bed volumes treated, allowing the team to distinguish between early ion leakage, mid-cycle resin equilibrium, and the onset of true breakthrough. Together, these laboratory results established the baseline resin capacities, removal efficiencies, and operating conditions used later to size the full-scale IX system.



Figure 5: Mixed-resin IX column used for sulfate and hardness removal during bench-scale testing.



Figure 6: Hardness titration vials following EDTA analysis of IX effluent.

3.5 Small Column Design and Resin Rationale

A dual-resin column was built to simulate IX performance under realistic loading. Four factors guided the design: influent strength, EBCT, service flow, and dual-resin behavior.

Resin Selection

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- **CG8 Cation Resin** — 2.0 meq/mL capacity
- **SBG1 Anion Resin** — 1.4 meq/mL capacity

Column Parameters

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- 100 mL burette (0.5 in. ID)
- 80 mL total resin (41 mL CG8, 39 mL SBG1)
- EBCT: 2.35 min
- Service flow: 3.2 gpm/ft³

Standard IX behavior and regeneration assumptions followed guidance from SAMCO Technologies and Myande Group.



Figure 7: Prepared C-1 groundwater samples used for sulfate, hardness, and TDS testing.

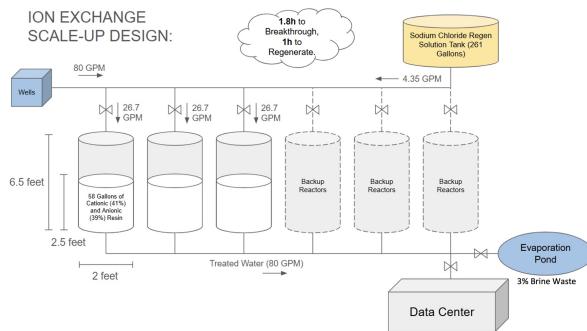


Figure 8: IX scale-up layout showing Pentair vessels, resin beds, and treatment flow path.

3.6 RO Modeling Using DuPont WAVE

RO performance was modeled using DuPont's WAVE (ROSA) software (DuPont Water Solutions, 2023). Modeling included:

- Flux and recovery
- Membrane rejection performance
- Blending strategies to match Lake Mead's ~ 650 mg/L TDS
- Concentrate flow and brine-pond sizing

Assumptions were cross-checked with industry summaries of RO fundamentals (Puretec Industrial Water, 2024).

3.7 Envision Pre-Assessment Method

Sustainability was evaluated using the Envision v3 framework (Institute for Sustainable Infrastructure, 2018). Review focused on applicability within:

- Quality of Life
- Leadership
- Resource Allocation
- Natural World
- Climate & Resilience

This ensured that the concept was examined through recognized sustainable-infrastructure criteria.

3.8 Cost and Constructability: HeavyBid Estimating

Constructability and cost were evaluated using **HeavyBid**, incorporating:

- Well drilling and development
- Treatment pad and concrete foundations
- IX/RO skid installation and process piping
- Electrical and controls
- Brine-pond excavation and liner
- Labor, equipment, and mobilization

The resulting estimate reflects realistic regional heavy-civil practices.

3.9 3D Site Modeling and Infrastructure Layout

A 3D model was developed integrating process equipment, access routes, pump pads, and brine-pond footprint. P&IDs and hydraulic profiles were used to verify land availability and confirm constructability.

4. Results

4.1 Bench-Scale IX Performance

Bench-scale column testing demonstrated that the mixed **CG8–SBG1** resin system could remove both sulfate and hardness effectively, but only for a limited operational window. Sulfate removal held until roughly **23 BV** and reached breakthrough near **35 BV**, while hardness began to break around **30 BV** and completed breakthrough at approximately **40 BV**. These curves confirmed strong resin affinity but also revealed the high ion load carried by the C-1 channel water.

A total of **40 L** of diluted influent was processed, significantly exceeding the originally expected 17-L design loading. Although the column performed better than anticipated, scaling this result to an **80-gpm** facility-level flow revealed that IX would require multiple full-size reactors operating in parallel, with short cycles and frequent regeneration events. When projected to a year of continuous cooling demand, the resin turnover, brine production, and maintenance burden became increasingly unrealistic for a large-scale facility. This recognition marked the shift away from a purely IX-based approach and toward an RO-dominant strategy capable of delivering a more stable long-term operating profile.

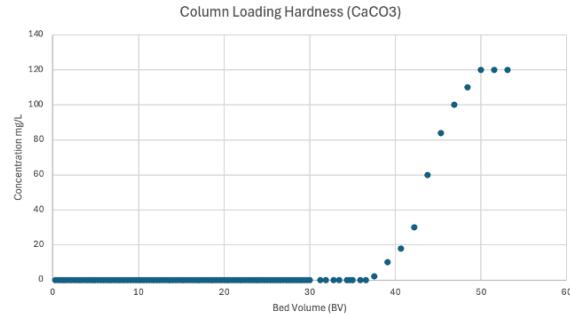


Figure 10: Column loading curve for hardness (as CaCO_3) illustrating reduced bed life relative to the full-scale demand.

4.2 Scale-Up Implications

Using the measured breakthrough data, resin capacities were translated to full reactor sizing. A single reactor operating at the project's 80 gpm design flow reached breakthrough in roughly 1.8 hours and required over 250 gal of sodium chloride brine per regeneration cycle. Flow balancing, redundancy, and continuous operation would require multiple 24 ft \times 80 in pressure vessels online simultaneously.

While technically feasible, resin demand, regeneration frequency, and brine management made IX a high-maintenance and high-cost path for continuous service.

4.3 RO Treatment Performance

Reverse osmosis modeling using DuPont WAVE produced significantly stronger performance under the same 80 gpm feed rate (DuPont Water Solutions, 2023). A three-stage arrangement achieved:

- **Permeate flow:** 68 gpm
- **Recovery:** 85%
- **Permeate TDS:** \sim 115 mg/L
- **Concentrate flow:** 12 gpm

A one-stage RO, modeled for comparison, achieved only 75% recovery and a higher con-

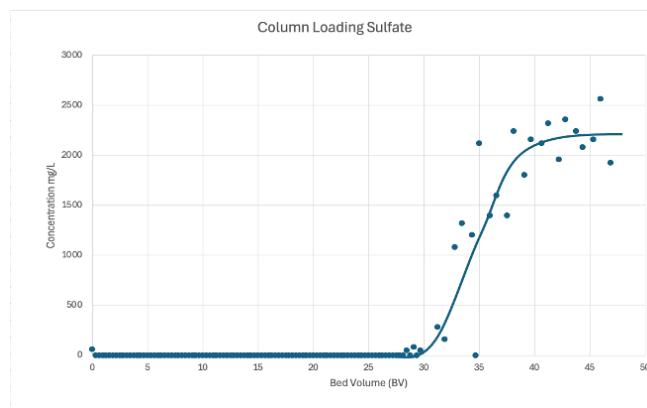


Figure 9: Column loading curve for sulfate showing breakthrough behaviour as a function of bed volumes.

centrate discharge, reinforcing that a multi-stage system is the most efficient configuration for this water quality.

Given that RO alone produces permeate cleaner than municipal potable water, IX polishing was determined to be unnecessary for cooling-tower reuse.

4.4 Potable Water Offset

Cooling-tower makeup for the study area requires approximately 290 gpm of potable water under current conditions. Introducing an 80 gpm RO permeate stream reduces potable demand to roughly 222 gpm, representing a **23% reduction**. On an annual basis, this corresponds to roughly:

4×10^7 gallons of potable water offset per year.

This reduction is achieved without altering tower operation, cycles of concentration, or temperature range—purely through source substitution.

4.5 Construction Cost Results

A HeavyBid-based estimate produced an order-of-magnitude construction cost of approximately \$305,550 (Bentley Systems, 2024). Major cost drivers included well drilling and casing, treatment installation, site earthwork, and electrical and controls. Although the cost breakdown is expanded in Section 5, these results confirm that the treatment system can be constructed at a relatively modest scale compared to the long-term operational savings from reducing potable water use.

5. Implementation, Cost, and Sustainability

5.1 Construction Phasing and Schedule

The 19-week construction plan follows four streamlined phases aligned with the senior design schedule:

1. **Permitting & Mobilization** – site surveys, utility locates, environmental clearance, and contractor setup.
2. **Wells & Conveyance** – drilling two shallow wells (0–200 ft), casing and development, pump installation, and trenching for the raw-water pipeline.
3. **Treatment Installation** – RO skid placement, electrical drops, SCADA integration, concrete pads, and chemical feed setup.
4. **Commissioning & Tie-In** – pressure testing, pump verification, RO startup, and connection to the cooling-tower makeup line.

The critical path is driven by drilling, pump procurement, electrical/controls, and RO commissioning. Parallel activities help maintain the 4–5 month delivery window.

5.2 Order-of-Magnitude Capital Cost

A HeavyBid-style estimate produced the following cost distribution:

- **Mobilization (15%)** – surveys, site access, temporary facilities.
- **Drilling & Casing (29%)** – well construction, development, and test pumping.
- **Earthwork & Treatment Installations (39%)** – trenching, concrete pads, RO system, chemical feed, and brine piping.
- **Electrical, Controls, Testing & Demobilization (17%)** – MCC power, SCADA, RO testing, and site restoration.

The total capital cost is approximately **\$305,550**, consistent with similar single-train RO installations and justified by long-term potable-water savings.

5.3 Sustainability and Envision Pre-Assessment

A preliminary Envision analysis showed strong alignment with sustainable water-resource management:

- **Quality of Life** – reduces potable demand and supports regional water security.
- **Leadership** – early adoption of high-TDS groundwater reuse for data-center cooling.
- **Resource Allocation** – repurposes an underused aquifer and improves efficiency compared to dry cooling or potable-only supply.
- **Natural World** – reduces corrosion impacts by diverting high-TDS flows away from storm channels.
- **Climate & Resilience** – diversifies supply amid drought-driven pressure on Lake Mead.

The scoring summary below reflects a strong Silver-level alignment based on the Envision v3 framework (Institute for Sustainable Infrastructure, 2018).

Credit Category	Applicable	Submitted	Percentage
Quality of Life	200	140	70%
Leadership	180	145	81%
Resource Allocation	200	160	80%
Natural World	230	200	87%
Climate and Resilience	190	155	82%
Total Points / %	1000	800	80%

Figure 11: Envision v3 pre-assessment scoring summary showing strong alignment with Silver-level performance across all applicable credit categories.

6. Discussion

The workflow we built for this project makes one thing clear: the challenge with using perched groundwater is not whether the water exists, but whether the quality can realistically be brought into a range that cooling towers can handle. The shallow aquifer has water everywhere, but the chemistry is rough—high sulfate, high chloride, and hardness levels that would destroy a tower in weeks. Once we started running the chemistry and the bench-scale column tests, it became obvious that any solution had to be built around a treatment train that could actually take that load. RO ended up being the most practical fit for how this data center operates. It delivers predictable water quality, stays stable under high TDS, and doesn't come with the constant regeneration cycles and salt handling that IX would require at full scale.

Another takeaway from the process is that you don't need to offset the entire cooling load to make a real impact. Even supplying 80 gpm into a system that normally runs around 290–300 gpm already cuts potable-water use by roughly 23%. For a region like ours, where every gallon pulled from Lake Mead has a footprint, that percentage matters. It also shows that data centers can ease pressure on the potable system without having to commit to a complete overhaul of their cooling strategy. A blended supply works, and it works well when the alternative source is consistent and backed by the right treatment.

Residuals management also became a bigger part of the conversation as the design matured. Any

time you push recovery higher or tighten water targets, the concentrate becomes the part of the system you have to think hardest about. In our case, an evaporation pond makes sense because the land is available and the climate supports it. At another location, that same option might not be viable. So the residuals piece isn't an afterthought—it's a limiting factor that can shape what kind of treatment approach makes sense for a given site.

Sustainability findings backed this trajectory. The Envision pre-assessment confirmed that the project's greatest strengths align with resource efficiency, alternative water supply creation, reduced strain on municipal infrastructure, and long-term regional resilience (Fig. 11). In other words, the engineering solution and the sustainability metrics point to the same conclusion: even a modest, well-treated groundwater source can meaningfully improve system reliability in a drought-prone region.

Overall, the path we followed—starting at the channel, collecting our own water, running the bench tests, modeling the treatment, and then stepping out into construction and sustainability—builds a framework that other data centers can use when exploring alternative water sources. As cooling demands grow with AI and regional water supplies stay tight, projects like this show that there's value in looking at water that people normally ignore. With the right design and the right constraints in place, perched groundwater becomes more than a nuisance—it becomes part of the solution.

7. Conclusion

At its core, this project tackles a simple but urgent reality: cooling the cloud now demands more water than our region can comfortably spare. In a valley where every gallon matters, the *Waste to Watts* concept shows that the shallow, brackish groundwater sitting beneath the C-1 channel is not just a nuisance to construction crews—it is an untapped resource with real engineering value. By capturing roughly 80 gpm of this water, treating it through a high-recovery RO system, and delivering permeate that performs on par with potable supplies, the system reduces cooling-tower demand on municipal water by nearly one-quarter while keeping the towers in efficient wet-cooling mode.

More importantly, the workflow behind this project demonstrates a replicable path forward: define the scale of the potable-water problem, characterize the alternative resource, validate treatment through lab and modeled performance, integrate the new water source into existing cooling infrastructure, and evaluate construction, cost, and sustainability at a level that makes implementation realistic. What emerges is not a theoretical fix—it is a practical, buildable framework that data centers across arid regions can adopt as pressure on freshwater supplies continues to grow.

8. References

9. References

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