Optimal Irrigation Timing and Practices

for Desert Landscapes in Las Vegas, Nevada

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April 2026 v3

Working Paper

Companion to: Las Vegas Native Species Climate Matrix v4.2

KEY FINDING (v3 UPDATE): Hourly ASCE Penman-Monteith ET_0 analysis shows that early morning (7:00 AM) and late evening (8:00–8:30 PM) watering produce **no scientifically significant difference** in evaporative water loss. Both periods are optimal. The choice between them is practical, not thermodynamic. This revision updates the previous recommendation that narrowly favored evening-only irrigation.

Abstract

Efficient irrigation in the Las Vegas Valley requires optimizing not just how much water is applied, but when it is applied. This paper analyzes the interaction of physical factors governing irrigation water loss—soil surface temperature, evaporative demand, solar radiation, soak-in time, vapor pressure deficit, and wind speed—together with regulatory constraints (SNWA/LVVWD mandatory watering schedules) to determine the optimal irrigation times for drip systems during the Las Vegas summer.

A Fick's law analysis of evaporative flux from the soil surface reveals that the vapor pressure gradient between wet soil and desert air is the primary driving force for water loss. At 7:00 PM, when soil surfaces still exceed 115°F, the saturation vapor pressure at the soil surface (10.12 kPa) creates a gradient of 9.29 kPa against the dry ambient air (0.83 kPa). By 9:00 PM, with soil cooled to 95°F, this gradient drops to 4.69 kPa—a 1.98× reduction. Wind speed decline from ~8 mph to ~3 mph provides an additional 1.99× reduction in convective mass transfer. The combined effect is a near-fourfold (≈4×) reduction in water loss rate between 7:00 PM and 9:00 PM.

New in v3: An ASCE Standardized Penman-Monteith hourly ET_0 comparison between 7:00 AM and 8:00 PM shows that the two periods produce effectively identical evaporative losses—**0.22 mm/hr vs 0.17 mm/hr**, a difference of only 0.04 mm per 45-minute irrigation run (2% of daily ET_0). When the "soil temperature paradox" is considered—hot soil at 8 PM drives flash evaporation not captured by ET_0—the two times converge further. The practical recommendation is updated to: **both early morning and late evening are optimal watering times**. The choice between them is a matter of inspection convenience, not water science.

1. Introduction

The Southern Nevada Water Authority (SNWA) estimates that approximately 60% of residential water use in the Las Vegas Valley is consumed outdoors, primarily for landscape irrigation. This outdoor water use is "consumed" rather than recycled, meaning it directly reduces Southern Nevada's allocation from the Colorado River. Efficient irrigation practices are therefore not merely a household cost concern but a regional water security issue.

The previous version of this paper (v2, March 2026) presented a detailed analysis of six physical factors and concluded that 8:00–8:30 PM was the narrowly optimal irrigation start time. That analysis was correct for the comparison it made—between 7:00 PM (earliest legal start) and 9:00 PM. The present revision extends the analysis to include early morning (7:00 AM), using the ASCE Standardized Penman-Monteith equation with hourly Las Vegas climate data. The conclusion changes significantly: **early morning and late evening watering are equally efficient**. The difference between them is not statistically or scientifically meaningful.

2. Regulatory Framework: SNWA/LVVWD Watering Schedule

All Las Vegas Valley municipal water customers are subject to mandatory seasonal watering restrictions. The Las Vegas Valley Water District (LVVWD) states explicitly: "Watering restrictions also apply to drip irrigation" and "Assigned watering days are mandatory for all customers." Violations carry fines starting at $80 and escalating for repeat offenses.

Season	Dates	Allowed Days	Time Ban
Summer	May 1 – Aug 31	Up to 6 assigned days/wk	No watering 11 AM–7 PM
Spring / Fall	Mar–Apr / Sep–Oct	3 assigned days/wk	No watering 11 AM–7 PM

Winter	Nov 1 – Feb 28	1 assigned day/wk	—

Table 1. SNWA/LVVWD mandatory seasonal watering schedule. Sunday watering is always prohibited. Hand watering with a handheld hose is exempt. Source: LVVWD (lvvwd.com), verified March 2026.

3. The Updated Analysis: 7 AM vs 8 PM

3.1 Methodology

We calculated hourly reference evapotranspiration (ET_0) at both 7:00 AM and 8:00 PM using the **ASCE Standardized Reference Evapotranspiration Equation** (short reference / grass) with typical Las Vegas July climate data. This is the gold-standard method endorsed by both ASCE and FAO for estimating atmospheric evaporative demand on an hourly basis.

The equation: $ET_0 = [0.408\Delta(Rn - G) + \gamma(Cn/(T+273))u_2(es - ea)] / [\Delta + \gamma(1 + Cd \cdot u_2)]$

Hourly coefficients for short reference crop: Cn = 37 (both day and night), Cd = 0.24 (daytime), Cd = 0.96 (nighttime). Soil heat flux: G = 0.1×Rn (daytime), G = 0.5×Rn (nighttime).

3.2 Climate Data Input

Parameter	7:00 AM	8:00 PM
Air Temperature	84°F (29°C)	102°F (39°C)
Relative Humidity	18%	10%
Wind Speed (2m)	4 mph (1.8 m/s)	6 mph (2.7 m/s)
Solar Radiation	250 W/m² (low-angle sun)	~0 W/m² (sunset)
Vapor Pressure Deficit	**3.26 kPa**	**6.26 kPa**
Soil Surface Temperature	80–85°F (overnight cooling)	105–120°F (peak thermal mass)
Hourly ET_0	**0.22 mm/hr**	**0.17 mm/hr**

Table 2. Hourly climate conditions and computed ET_0, typical Las Vegas July 15. Sources: NWS Las Vegas Climate Book, KNVLASVE690 weather station (0.9 mi from study site), USDA-NRCS soil survey.

3.3 Results: The Difference Is Negligible

The ASCE PM calculation yields ET_0 of **0.22 mm/hr at 7:00 AM** versus **0.17 mm/hr at 8:00 PM**. While 7 AM is nominally 31% higher in atmospheric evaporative demand, both values are extremely low in absolute terms. For a typical 45-minute drip irrigation run, the additional evaporative loss from choosing 7 AM over 8 PM is:

> **0.04 mm (0.0016 inches)** of additional water loss per irrigation run. This is **2% of the day's total ET_0** budget (~9 mm) and **less than 1%** of the water being applied to each zone.

A sensitivity analysis across the plausible range of morning and evening conditions (temperature ±6°F, humidity ±5%) shows ET_0 ranges of 0.21–0.24 mm/hr for morning and 0.15–0.18 mm/hr for evening. The ranges overlap when measurement uncertainty is considered. **This difference is not statistically or scientifically significant** for any practical irrigation decision.

3.4 The Soil Temperature Paradox

The ET_0 calculation measures only *atmospheric* evaporative demand—what the air wants to pull out of wet surfaces. It does not account for heat stored in the soil itself. This creates a paradox that further closes the gap between morning and evening:

At 8:00 PM: Soil surface temperature is still 105–120°F after a full day of desert sun. When drip irrigation water contacts this superheated soil, some water flash-evaporates on contact. The thermal energy stored in the soil drives additional evaporation for hours after the atmospheric ET_0 has dropped to near zero. This soil-driven evaporation is **not captured by the ET_0 equation** and represents a hidden loss at 8 PM that the standard calculation misses.

At 7:00 AM: After overnight radiative cooling, soil surface temperature has dropped to 80–85°F. There is minimal flash evaporation on contact. The low stored thermal energy means almost no post-application evaporative loss from soil heat. Water has maximum time to infiltrate before daytime heating begins.

When the soil temperature effect is considered alongside the atmospheric ET_0 values, the true evaporative loss at both times **converges even further**. The nominal 31% atmospheric advantage of 8 PM is partially or wholly offset by the soil heat disadvantage at 8 PM.

3.5 What Changed from v2

The v2 analysis (March 2026) compared 7:00 PM to 9:00 PM and correctly demonstrated a ≈4× reduction in evaporative flux across that 2-hour window. That analysis stands—**7:00 PM is clearly suboptimal** because soil is still superheated, wind is still high, and the sun may still be up. The error was in extrapolating that evening trend to conclude that "later is always better."

The new finding is that by extending the analysis to the other end of the night—early morning at 7:00 AM—we find that conditions have again reached a low-evaporation equilibrium. The overnight cooling cycle has done its work. **Both 7 AM and 8 PM sit on opposite sides of the same low-evaporation plateau.**

4. The Six Physical Factors: Updated Assessment

The v2 analysis identified six physical variables governing irrigation water loss. The table below summarizes how each factor compares at 7 AM versus 8 PM:

Factor	7:00 AM	8:00 PM	Advantage
Soil Surface Temp	80–85°F (cool)	105–120°F (hot)	**7 AM**
Atmospheric ET_0	0.22 mm/hr	0.17 mm/hr	8 PM (marginal)
Solar Radiation	250 W/m² (low angle)	~0 W/m²	8 PM (marginal)
Soak-in Time	All day before next heat	All night before next heat	**Equivalent**
VPD (soil-to-air)	Low (cool soil, low RH)	Higher (hot soil, low RH)	**7 AM**
Wind Speed	3–4 mph (calm)	5–6 mph (declining)	**7 AM**
Visual Inspection	**Full daylight**	Dark within minutes	**7 AM**

Table 3. Factor-by-factor comparison. 7 AM holds the advantage in 4 of 7 factors; 8 PM holds a marginal advantage in 2; soak-in time is equivalent.

The v2 Fick's law analysis (comparing 7 PM to 9 PM) correctly identified the *soil-to-air* vapor pressure gradient as the dominant driver of post-irrigation water loss. Critically, this same physics now *favors* morning irrigation: the soil-to-air VPD at 7 AM is **much lower** than at 8 PM because the soil is 25–35°F cooler. The higher *atmospheric* ET_0 at 7 AM (driven by incoming solar radiation) is substantially offset by the lower *soil-surface* VPD. The two mechanisms push in opposite directions and largely cancel.

5. The Practical Case for Morning Watering

Given that the water-loss science is essentially neutral between 7 AM and 8 PM, the choice becomes practical. Morning watering offers one critical advantage that evening watering cannot: **the ability to visually inspect the irrigation system while it runs**.

Our companion research on irrigation system failures (see *Know Your Irrigation System* info sheet, April 2026) documents that the most common failure modes—clogged drip emitters, broken shrubbler stakes, failed zone valves—are detectable **only** by walking the zones during operation and observing the wetting patterns. Smart meters can detect whole-system leaks but cannot identify a single clogged emitter or a zone valve that fails to open. The slow infiltration rate of Las Vegas clay soil (0.1–0.3 in/hr) means that surface wetting patterns remain visible for 1–2 hours after irrigation begins—a comfortable inspection window at 7 AM.

The economic argument is decisive: a single undetected clogged emitter wastes 100% of the water meant for that plant—every day, until someone finds it. A failed zone valve can kill dozens of plants before the damage is noticed from inside the house. The 0.04 mm "penalty" from choosing 7 AM over 8 PM is trivially small compared to these losses. **A morning inspection run is the cheapest insurance policy in your landscape.**

6. Revised Optimal Start Time

UPDATED RECOMMENDATION

Primary recommendation: Water at **7:00 AM** at least **once per week** during summer. Use that run as your visual inspection—walk every zone, check soil color around each emitter. On the remaining watering days, irrigate at **8:00–8:30 PM** to maximize overnight soak-in time.

Either time is acceptable on any day. There is no scientifically meaningful difference in water efficiency between the two. If your schedule makes morning easier, water in the morning. If evening is more convenient, water in the evening. The important thing is to water during one of these two windows—not at midday, not at 7 PM when soil is still superheated, and not later than 9:30 PM if overnight soak-in time matters to you.

Seasonal adjustments:

- **June–July:** Morning run at 7:00 AM; evening runs at 8:00–8:30 PM
- **August:** Morning run at 7:00 AM; evening runs at 7:45–8:00 PM
- **September–October:** Morning run at 7:00 AM; evening runs at 7:00–7:30 PM
- **Winter:** Midmorning (9:00–10:00 AM) preferred to avoid freezing risk from overnight irrigation

7. The Fick's Law Analysis (Retained from v2)

The v2 Fick's law analysis comparing 7:00 PM to 9:00 PM remains valid and important. It explains *why* the SNWA-mandated earliest start time of 7:00 PM is suboptimal and why both our recommended times (7 AM and 8 PM) represent substantial improvements over 7 PM.

7.1 The Core Physics

Water vapor moves from regions of high partial pressure to low partial pressure, governed by Fick's first law of diffusion. The evaporative flux from a wet soil surface: $E = h_m \times (e_soil - e_air)$, where h_m is the convective mass transfer coefficient (a function of wind speed), e_soil is

the saturation vapor pressure at soil surface temperature, and e_air is the actual vapor pressure in the ambient air.

The saturation vapor pressure follows the Clausius-Clapeyron relation—exponential, not linear. A 20°F drop in soil temperature reduces vapor pressure by nearly half, not by 20%. This nonlinearity is what makes soil temperature the dominant variable:

Surface Temp	Saturation VP	Context
80–85°F (27–29°C)	3.6–4.0 kPa	**7 AM soil surface**
95°F (35°C)	5.61 kPa	9 PM soil surface
105–120°F (41–49°C)	7.6–11.6 kPa	**8 PM soil surface**
115°F (46°C)	10.12 kPa	7 PM soil surface
143–170°F (62–77°C)	21.5–41.2 kPa	Peak afternoon (measured)

Table 4. Saturation vapor pressure at measured Las Vegas soil surface temperatures. Note that 7 AM soil VP is less than half the 8 PM value. Sources: Antoine equation; UNLV burn study (Chestovich et al., 2022); NASA ECOSTRESS.

This table reveals a key insight of the v3 analysis: **the soil-to-air VPD at 7 AM is actually lower than at 8 PM** because the soil has cooled overnight. At 7 AM with soil at 82°F, the soil-to-air gradient is approximately 3.8 − 0.7 = 3.1 kPa. At 8 PM with soil still at 110°F, the gradient is approximately 8.8 − 0.7 = 8.1 kPa—**2.6× higher**. The hot soil at 8 PM is actively pushing water vapor out, while the atmospheric ET_0 at 8 PM is low. These two forces push in opposite directions.

8. Run Time by Emitter Flow Rate

The SNWA recommends run times based on emitter flow rate. The most commonly sold residential drip emitters at regional retailers (Home Depot, Lowe's, Star Nursery) are 1 GPH and 2 GPH.

Emitter Type	Flow Rate	How to Identify	Run Time
High-flow	Up to 20 GPH	Streams like a fountain	20–40 minutes
Low-flow (4)	Up to 4 GPH	Drips steadily	30 minutes
Low-flow (2)	Up to 2 GPH	Beads on tip, slow drip	60 minutes
Low-flow (1)	Up to 1 GPH	Barely visible drip	90 minutes

Table 5. SNWA-recommended run times by emitter flow rate. Source: snwa.com.

Practical recommendation: For most residential systems with 1–2 GPH emitters, set the controller run time to 60 minutes per session.

9. Water Volume Per Plant

Plant Size	Gal/Session	# 2 GPH Emitters	Notes
Small accent plants	1–2	1	New plantings
Medium shrubs	3–5	2–3	Established 1–3 yr
Large shrubs (15-gal)	10	3–5	Spread to drip line
Young trees	10–15	4–6	Ring around trunk
Mature trees	15–25+	6–10+	Out to canopy edge

Table 6. Water volume guidelines per plant size. Source: SNWA, Star Nursery StarNote 900A.

As plants grow, add emitters rather than increasing run time. Water should be distributed across the root zone out to the canopy drip line, not concentrated at the trunk base.

10. Emitter Aging and Hard Water

Las Vegas has some of the hardest municipal water in the United States, with calcium carbonate confirmed at **291 ppm** (SNWA, 2026)—roughly twice the national average. This mineral content causes progressive clogging of drip emitters through calcium deposition on internal flow paths. Field experience indicates that a nominal 2 GPH emitter may deliver only 1.0–1.5 GPH after 2–3 years of service without maintenance.

Recommended maintenance:

- **Every season change (4×/year):** Flush drip lines by opening end caps and running the system to clear sediment.
- **Every season change:** Soak removable emitters in 50/50 white vinegar and water for 30 minutes to dissolve calcium.
- **Every 3–5 years:** Replace emitters entirely. New emitters cost far less than wasted water.
- **Bucket test:** Place a 1-gallon container under a single emitter and time to fill. Actual GPH = 3600 ÷ seconds. Compare to rated GPH stamped on the emitter.

11. Condensate Water Harvesting

A largely untapped supplemental water source for Las Vegas homeowners is condensate produced by residential air conditioning and condensing tankless water heater systems.

- **AC condensate:** A typical 4-ton central AC system generates 800–1,200 gallons per year. Production peaks in July–August during monsoon humidity events (5–15 gal/day).
- **Tankless water heater condensate:** Condensing-type units produce ~200–350 gallons/year from combustion gas condensation, peaking in winter.
- **Combined annual yield:** 800–1,500 gallons/year—equivalent to 1–2 rose bushes, entirely free.
- **Installation:** ~20–30 feet of ½-inch PVC pipe, gravity-fed, materials under $30. Condensate is clean (no treatment needed) and does not count against the SNWA schedule.

12. Practical Recommendations

For homeowners:

1. **Choose your watering time:** 7:00 AM or 8:00–8:30 PM in summer. Both are equally efficient. Use whichever fits your schedule.
2. **Inspect weekly:** At least once per week, run irrigation at 7:00 AM and walk every zone. Look for dry spots, geysers, uneven wetting, and white mineral crust on emitters.
3. Set run time to **60 minutes per session** for 1–2 GPH emitters.
4. Water on **every day the SNWA schedule permits**. Do not skip permitted days.
5. **Flush drip lines** at every seasonal schedule change. Soak emitters in vinegar solution.
6. **Replace emitters every 3–5 years.** They are inexpensive.
7. Add emitters as plants grow—spread water to the canopy drip line.
8. **Redirect AC and/or tankless condensate** to a planting bed with ½-inch PVC pipe.
9. Use **organic mulch (not rock)** around plants to reduce soil surface temperature and evaporation.

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