Water in Cochise County

Guide 13 · Foundations Reference

Version 2026.05 · Revised 2026-05-16

Sourcing · Testing · Treatment · Conservation

Contents

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About this guide

Water is the foundation under every other decision in a Cochise County garden. The variety of pepper does not matter if the irrigation water is silently locking out iron. The Masterblend recipe is a waste of money if the reservoir's bicarbonates are pushing pH back up overnight. The most carefully amended soil bed loses ground every irrigation cycle if the well water is depositing 0.6 mS/cm of dissolved minerals into it. More readers get stuck on water — not crop choice, not pest pressure, not season-extension hardware — than on any other variable in this library.

This guide is the place those readers come back to. It is structured to be read three ways:

1. **First-timer** — read chapter 2 (where your water comes from), chapter 5 (the 5-step bicarbonate protocol), and chapter 16 (troubleshooting). That alone is enough to get a Dragoons garden onto stable water within a week.
2. **Returning practitioner** — the water-profile table in chapter 4, the bicarbonate protocol in chapter 5, the catchment sizing math in chapter 8, the conservation strategies in chapter 13. The reference layer is in the tables.
3. **Expert troubleshooting an edge case** — the chemistry of bicarbonate neutralization in chapter 6, the chloramine vs chlorine distinction in chapter 7, the wastewater math behind RO units in chapter 9, and the Cochise water-law primer in chapter 14. The reasoning is in the prose.

The cross-references throughout point you to where each fact has a deeper home. Soil-building and mulching are in **Guide 11**. Hydroponic system hardware is in **Guide 3**. pH-adjustment recipes — the actual ratios for diluting phosphoric acid or fermenting prickly-pear vinegar — are in **Guide 4 Part 3**. This guide owns the water itself: where it comes from, what is in it, what to do about it, and how to use less of it.

> **The two facts that matter most in this guide.** First: **alkalinity (bicarbonate, HCO_3^-) is the single most consequential water-chemistry parameter in Cochise County.** Every other number — pH, TDS, hardness — is downstream of it. Second: **rainwater is the gold standard for growing water in the Dragoons.** A 500 sq ft roof catches 3,000+ gallons in a normal monsoon; that is enough to displace well water for the second half of every growing season. If you change only two things after reading this guide, learn to neutralize bicarbonates (chapter 5) and put up a catchment tank (chapter 8).

1 · How water works in the Dragoons — the high-altitude view

Aquifers · elevation · why water is the upstream variable

Cochise County sits at the eastern edge of the Sonoran Basin and Range province. The Dragoon Mountains rise to ~7,500 ft from valley floors at ~4,200–4,700 ft. The county receives between 10 and 16 inches of rainfall per year depending on elevation and aspect — eight of those inches arrive in a six-week monsoon stretch from early July to mid-September, three to four arrive as gentle winter rains from December through March, and the rest is scattered through the shoulder seasons. Snow on the Dragoon peaks is normal in January and February but rarely lingers more than a week below 6,000 ft.

That rainfall pattern is the supply side. The demand side — a high-desert growing season with summer afternoon highs in the upper 90s, near-zero summer humidity, and 11+ hours of direct UV at 4,700 ft — is brutal. A tomato bed unirrigated for 48 hours in late June will wilt visibly; the same bed in late September coasts for a week between waterings. Most Dragoons gardens run on a combination of well water and stored rainwater, with the ratio shifting through the season.

The well water below the county is divided across three principal aquifer systems — and that division explains the most consistent surprise newcomers run into. **The water chemistry changes sharply across short distances.** A well in the Sulphur Springs Valley reads 500 ppm TDS and 280 ppm alkalinity; a spring-fed line at the foot of the Dragoons 12 miles east reads 90 ppm TDS and 45 ppm alkalinity. Whatever you read about “Arizona water” online is almost certainly too generalized to plan against. The single best decision a new grower in the Dragoons can make is to **test the water that comes out of their tap or hose** before doing anything else.

> **LOCAL TIP**
>
> **The cheapest water decision in Cochise County is the one that uses local knowledge.** Before you spend $400 on a reverse-osmosis unit, ask the neighbors what their well reads. A grower in upper Cascabel may already know the San Pedro shallow alluvium runs 200 ppm; a neighbor on the Dragoon foothills may have a spring-fed line and never need to treat at all. Local knowledge is faster, cheaper, and often more accurate than any first-pass test.

2 · Cochise County water — the lay of the land

Sulphur Springs aquifer · San Pedro aquifer · Dragoon spring-fed wells · why this matters

The water that arrives at your hose bibb is the end of a long process — rain falling on a mountain range, percolating into the rock, traveling laterally through fractured limestone or alluvial gravel for years to decades, and being lifted back up by a well pump. The chemistry it picks up along that journey is what you have to work with. Three distinct aquifer systems supply almost all the wells in Cochise County, and the chemistry of each is meaningfully different.

2.1 The Sulphur Springs Valley aquifer

The Sulphur Springs Valley is the broad north–south basin between the Chiricahua Mountains (east) and the Dragoon Mountains (west). It is the dominant water source for Willcox, Pearce, Sunsites, Sunizona, and the agricultural belt around the Willcox dry lake. The aquifer is a deep alluvial fill basin — hundreds to thousands of feet of unconsolidated sand, gravel, silt, and clay deposited over millennia of erosion from the surrounding ranges.

Chemistry signature: the Sulphur Springs aquifer water is among the hardest in the county. The alluvial fill includes a great deal of weathered carbonate rock and evaporite mineral, which dissolves into the slowly-moving groundwater. Long residence times in calcium-rich rock produce high TDS, high alkalinity, high hardness, and routine readings of pH 7.8–8.5 at the wellhead. Sulfate (from gypsum-bearing layers) and chloride are also elevated. Sodium is moderate but in some wells climbs high enough to matter.

The Dragoon Mountains sit on the eastern flank of the western edge of this basin. **Wells drilled on the eastern slopes of the Dragoons typically tap the Sulphur Springs aquifer** unless they are shallow enough to intercept perched spring-fed flow off the range. This is the dominant water for most growers from Pearce north through Sunizona to Willcox.

2.2 The San Pedro Valley aquifer

The San Pedro Valley runs roughly north–south on the western side of the Dragoon Mountains — Benson, St. David, Cascabel, and the river corridor itself. The San Pedro is one of the last undammed perennial rivers in the American Southwest, and its alluvial aquifer is structurally different from the Sulphur Springs basin: it is **younger, shallower in places, and more connected to surface flow**.

Chemistry signature: San Pedro Valley well water varies more than Sulphur Springs water. Shallow alluvial wells near the river (50–150 ft) often read low to moderate TDS (150–300 ppm) with moderate alkalinity (80–180 ppm $CaCO_3$) and a softer hardness profile, because the water has had less residence time in carbonate rock. Deeper wells on the valley terraces (200–500 ft) read more like the Sulphur Springs profile — higher TDS, higher alkalinity, more weight to the carbonate side.

Wells on the western foothills of the Dragoons, west of the range divide, tap this aquifer. A grower in lower Cascabel and a grower in Pearce can be 25 miles apart and on opposite sides of one mountain range — and their water can be 300 ppm TDS apart.

2.3 The Dragoon Mountains spring-fed wells

The Dragoon Mountains themselves capture rainfall on their granite-rhyolite massif and route some of it through fractures into local springs and shallow spring-fed wells along the foothills. **Spring-fed water from the Dragoons is generally the best water in Cochise County for growing.**

Chemistry signature: the Dragoons are not limestone — they are predominantly Precambrian granite, Cretaceous rhyolite, and Tertiary volcanic. Granite weathering produces water rich in silica but **low in carbonates and low in TDS** — a true high-quality mountain water. A spring-fed line on the Dragoon foothills can read 60–120 ppm TDS, 30–80 ppm alkalinity, pH 6.8–7.4, and very soft hardness. This is essentially “rainwater that has filtered through coarse rock for a few months.”

These spring-fed wells are not abundant. They cluster along the eastern and southern foothills of the range, on properties with shallow water tables and a fault or fracture line connecting to the high-country recharge zone. If your well taps this water, you have won the Cochise County water lottery. If not, the chemistry from a deeper drilled well on the same property may look more like the Sulphur Springs profile.

2.4 Lower-elevation versus upper-elevation chemistry

A pattern visible across all three aquifers: **higher elevation wells produce softer, less mineralized water than valley-floor wells of the same depth**. The reason is residence time and parent rock — high-elevation wells tap water that has spent less time dissolving carbonate-bearing strata. A property at 5,200 ft on the eastern Dragoon slope often produces measurably softer water than a property at 4,300 ft in the valley below.

The general rule, for first-pass planning: every 1,000 ft of elevation gain on the same aquifer typically corresponds to 80–150 ppm less TDS and 30–60 ppm less alkalinity. The pattern is not universal — local geology dominates — but it is reliable enough to expect.

2.5 Why this matters: three distinct water types within 30 miles

A Cochise County grower can drive 30 miles east-to-west across the Dragoon Mountains and encounter three meaningfully different water types: a high-TDS, high-alkalinity Sulphur Springs well in the east; a soft spring-fed line in the Dragoon foothills; and a moderate San Pedro alluvial well in the west. Each requires a different treatment routine. **A neighbor's recipe is not a substitute for your own water test.**

> **Test before treating.** No amount of reading about Arizona water chemistry substitutes for one $40 sample sent to the University of Arizona soil-and-water lab through the Cooperative Extension Cochise County office. Your decisions in chapters 5 through 9 of this guide depend on knowing your numbers. Until you know them, you are guessing.

3 · Well-water testing — what to test, where

The basic panel · the advanced panel · UA Cooperative Extension · DIY meters · frequency

A well-water test is the single highest-return investment a new Cochise County grower can make. The cost is small ($40–$120 for a standard agricultural panel); the information shapes every subsequent decision about source water, treatment, and irrigation hardware.

3.1 The basic panel — what every grower should know

The eight readings below are the minimum useful characterization of irrigation water. A grower with these eight numbers can plan every other water decision in this guide.

Reading	What it tells you	Typical Cochise County range	Why it matters
pH	Acidity / alkalinity (0–14 scale)	7.4 – 8.5 (raw well water)	Wrong pH locks out nutrients regardless of how well-supplied the soil is
Alkalinity (HCO_3^- as $CaCO_3$)	Carbonate buffering capacity	80 – 350 ppm	The single most consequential number — drives pH instability
Total hardness (Ca + Mg)	Scale-forming mineral load	100 – 500 ppm $CaCO_3$	Predicts emitter clogging, kettle scale, irrigation maintenance
TDS (total dissolved solids)	All dissolved minerals combined	150 – 700 ppm	Drives the starting EC of any hydroponic reservoir
Nitrate (NO_3^-)	Dissolved nitrogen	0 – 10 ppm (most wells); up to 45+ in agricultural belts	Drinking-water safety threshold is 10 ppm; high readings change fertigation math
Iron (Fe)	Total iron	< 0.3 ppm (most wells)	High Fe stains, clogs emitters, can be toxic to seedlings

Reading	What it tells you	Typical Cochise County range	Why it matters
Manganese (Mn)	Total manganese	< 0.05 ppm (most wells)	Same staining and clogging issues; toxicity at higher levels
Sulfate (SO_4^{2-})	Dissolved sulfur	20 – 250 ppm	Adds to EC; high readings (> 250) give a sulfuric taste and laxative effect at drinking volume

A "passing" well for vegetable irrigation: pH below 8.5, alkalinity below 250 ppm (treatable with the protocol in chapter 5), TDS below 500 ppm, iron and manganese in trace amounts, nitrate below 10 ppm. Higher values are workable but require active management.

3.2 The advanced panel — full ICP-MS

For a more thorough characterization — useful before installing a major irrigation system, drilling a new well, or after any concern about contamination — a full inductively-coupled-plasma mass-spectrometry (ICP-MS) panel reports trace metals: arsenic, lead, cadmium, chromium, copper, zinc, selenium, mercury, and others. Cochise County has localized **arsenic** issues in some aquifer zones — historic mining areas around Tombstone and the southern San Pedro, mineralized geology in others — and **lead** can leach from old plumbing solder rather than from the well itself.

A full ICP-MS panel costs \$150–\$300 depending on the lab. For most growers this is a one-time test on a new property, not an annual investment. If your well sits within a few miles of any of the historic mining districts (Tombstone, Bisbee, Pearce, Courtland-Gleeson, Dos Cabezas), this test is worth doing once.

3.3 Where to test — the UA Cooperative Extension office

The **University of Arizona Cooperative Extension** Cochise County office in Sierra Vista is the primary point of access for inexpensive, reliable water testing.

Detail	Information
Office address	450 Haskell Ave, Sierra Vista, AZ 85635
Phone	(520) 458-8278
Web	extension.arizona.edu/cochise
Standard agricultural water panel	~\$40–\$60 (varies by year)

Detail	Information
Full ICP-MS / advanced panel	$150–$300
Turnaround	2–4 weeks (longer in monsoon and harvest seasons)
Drop-off	Walk-in during business hours (Mon–Fri, typically 8–4); bring sample in clean container labeled with property and date

The Extension office does not perform the lab work itself — samples are forwarded to the University of Arizona soil-and-water testing laboratory in Tucson. The Extension office is the intake point and brokers results back to you, often with a Master Gardener available to walk through the numbers in a follow-up conversation if you ask.

Independent labs: several private water-testing labs in Tucson, Phoenix, and El Paso accept mail-in samples. Costs are comparable. For drinking-water certification (well certification at home sale), a state-certified lab is required; the Extension can refer you.

3.4 DIY meters — what each tells you and doesn't

A grower running a hydroponic system or a well-equipped irrigation network benefits from at-home meters for daily monitoring. These are not substitutes for an annual lab panel — they cover different decisions.

Meter	What it measures	What it costs	What it tells you	What it doesn't
EC pen (electrical conductivity)	Total dissolved ions, in mS/cm or ppm TDS	$15–$50	Whether your reservoir is at target nutrient concentration; whether plain water has unusually high TDS	Which ions are present; trace metals; pathogens
pH pen	Hydrogen ion concentration	$15–$80	Day-to-day pH drift in a reservoir; how much acid to add	Alkalinity (buffering capacity) — two waters at pH 8.0 can have very different alkalinities

Meter	What it measures	What it costs	What it tells you	What it doesn't
Alkalinity test strip	Total carbon-ate/bicarbonate buffering	\$10–\$20 per pack	Whether your water needs the full bicarbonate protocol	Precise quantification beyond ~50-ppm bracket
Hardness strips	Calcium + magnesium total	\$10–\$20 per pack	First-pass scale potential	Individual Ca vs Mg; specific scale species
Iron test kit	Soluble iron	\$10–\$30	Whether visible orange staining is iron (vs. tannin or manganese)	Mn alone
Titration alkalinity kit	Quantitative HCO_3^- in ppm $CaCO_3$	\$30–\$50	Precise bicarbonate dose for protocol	Slow — 2 minutes per test

> **Two meters cover 90% of daily hydroponic and irrigation decisions: an EC pen and a pH pen.** Bluelab and Apera are the brand standards; Hanna is a reliable budget choice. Calibrate monthly with 7.0 and 4.0 pH buffer (the small bottles sold for under \$10). A meter that has not been calibrated is producing fiction.

3.5 Test frequency

A typical Cochise County well is **chemically stable** — the groundwater chemistry does not change much across a year unless something unusual happens (a flood pulse to a shallow well, a nearby well-drilling disturbance, a pump replacement that changes the screen depth). An annual lab panel is enough to track a stable well.

Quarterly testing is justified in three cases: (1) a new well in its first year (chemistry can shift as the well "develops"); (2) high-use periods on an agricultural property where the well is the only water source for several acres; (3) any time downhole work has been done. Otherwise: annual, in March before the growing season begins.

> **LOCAL TIP**
>
> **The Master Gardener program at the Sierra Vista Extension office is open to anyone willing to spend a few hours each month volunteering.**

> Trainees do free consultations on resident soil and water questions. If you are within an hour of Sierra Vista and serious about understanding your water, the training (typically a 14-week certificate course running Jan–April most years) is the best $150 you can spend on this hobby in Cochise County.

4 · Typical Cochise County water profiles

Spring-fed, valley-deep, valley-shallow, municipal

The following profiles are typical readings across the principal water sources in Cochise County. Each well is its own animal — these are central tendencies, not promises — but a reader's own well almost certainly resembles one of these.

Water source	pH	Alkalinity (ppm $CaCO_3$)	Total hardness (ppm $CaCO_3$)	TDS (ppm)	Notes
Dragoon foothills spring-fed well	6.8 – 7.4	30 – 80	50 – 120	60 – 150	Granite-derived; best water in the county
Sulphur Springs Valley deep well (Pearce, Sunsites, Sunizona, Willcox)	7.6 – 8.3	200 – 320	250 – 450	400 – 700	Long carbonate residence time; the hardest water locally
San Pedro shallow alluvial (near river, ≤ 150 ft)	7.2 – 7.8	80 – 180	120 – 250	150 – 300	Younger water; softer than valley-floor deeps
San Pedro deep terrace (Benson area, 300+ ft)	7.6 – 8.1	150 – 280	200 – 400	300 – 500	Resembles Sulphur Springs profile
Whetstone Mountain foothills well	7.4 – 7.9	120 – 220	180 – 320	250 – 450	Intermediate; site-dependent
Tombstone municipal	7.6 – 8.0	150 – 220	200 – 320	300 – 450	Chlorinated; from city wells in the Tombstone Hills

Water source	pH	Alkalinity (ppm $CaCO_3$)	Total hardness (ppm $CaCO_3$)	TDS (ppm)	Notes
Benson municipal	7.5 – 7.9	140 – 200	200 – 300	280 – 420	Chlorinated; San Pedro alluvial source
Sierra Vista municipal	7.4 – 7.8	120 – 200	180 – 280	230 – 320	**Chloraminated** (not just chlorinated) — see chapter 7
Willcox municipal	7.7 – 8.2	200 – 300	280 – 420	400 – 600	Chlorinated; among the hardest municipal supplies
Bisbee municipal	7.5 – 7.9	130 – 210	180 – 300	250 – 400	Chlorinated; mountain-source wells
Monsoon rainwater (cleanly caught)	5.5 – 6.5	< 10	< 20	< 20	The gold standard; chapter 8

What to do with this table: locate the row closest to your own situation, treat the numbers as a starting hypothesis, then **test to confirm** before designing any treatment routine. If your reading is wildly different from the typical for your area, the test result wins.

> **WARNING**
>
> **Municipal water in Sierra Vista is chloraminated, not chlorinated.** Chloramine does not off-gas overnight the way chlorine does (chapter 7). This catches new gardeners who follow generic "let your water sit out for 24 hours" advice from books written for cities with chlorine-treated water. If you are in Sierra Vista city water, you have to treat chloramine with vitamin C or activated carbon — sitting it out does nothing.

5 · The 5-step Cochise bicarbonate treatment protocol

The canonical procedure for treating hard well water · before any nutrients

This is the procedure that converts a raw Cochise County well source into stable irrigation or hydroponic water. **This chapter is the canonical home for the protocol in this library.** Guide 3 §4 (hydroponic system build) and Guide 4 Part 3 (nutrient and pH chemistry) both cross-reference here for the full step-by-step. Run the protocol every time you make up a fresh hydroponic reservoir, and whenever you are filling a large irrigation tank with raw well water destined for sensitive crops.

The chemistry behind the protocol is in chapter 6 of this guide. If you only want the procedure, this chapter is sufficient.

5.1 What you need before starting

Tool	Purpose
EC/TDS pen	Measure starting and ending mineral load
pH pen	Measure starting, intermediate, and final pH
Alkalinity test strip or titration kit	Optional but useful — quantifies the bicarbonate target
Citric acid stock (1 g/mL in distilled water), commercial phosphoric pH Down, or prickly-pear vinegar	The acid that neutralizes the bicarbonate. See Guide 4 Part 3 for recipes
pH Up (potassium hydroxide, oak-ash lye) for overshoot correction	See Guide 4 Part 3
Stirring stick or paddle	Gentle mixing; do not aerate excessively
Reservoir or mixing tank at working volume	Typically 12–15 gallons for a small hydroponic system; 50–250 gallons for irrigation pre-mixing

5.2 The protocol — five steps

Step	Action	What happens
1. Fill	Fill reservoir with source water to working volume (≈12 gal in a 15-gal tub; or whatever the day's volume is). Let stand 15 min if water is cold from the well — warmer water reacts faster. Record starting pH, EC, and alkalinity.	Starting pH typically 7.5–8.5; EC 0.3–0.8 mS/cm; alkalinity 150–300+ ppm $CaCO_3$ for most Cochise wells
2. Acid in	Add acid slowly while stirring. Use citric acid stock (1 g/mL), commercial pH Down (phosphoric), or distilled vinegar — see §5.3. Dose 0.5–1 mL per gallon to start; add more if needed. **Target pH 5.0 in this step**, lower than your eventual growing pH.	Bicarbonates react with the acid — water visibly fizzes as CO_2 releases. The fizz is the chemistry working
3. Wait for fizzing to stop	Stir gently every minute. The fizz dies off as bicarbonates run out. This typically takes 5–15 minutes. **Do not move to the next step until the surface is calm.** Cold water takes longer; warm water faster.	All bicarbonates have been converted to CO_2 and have left the reservoir. The buffer is now gone
4. Measure final EC	Read EC after fizzing stops. It should match the starting EC plus a small contribution from the added acid (typically +0.05–0.15 mS/cm depending on acid choice). If EC has dropped meaningfully, your alkalinity reading was wrong; if EC jumped > 0.2 mS/cm, you overshot acid.	EC stabilizes; you now know how much "headroom" remains before adding nutrients

Step	Action	What happens
5. Adjust to target pH	Add small additional doses of pH Down (or pH Up if you overshot) and wait 5 min between checks. With bicarbonates removed, pH responds quickly and stays stable. Target depends on use: **5.8–6.2 for most hydroponic crops; 5.8–6.5 for soil-bed irrigation; 6.5–7.0 if irrigating alkaline-tolerant crops (brassicas, grapes)**.	Final water is at target pH, stable, ready for nutrient addition (hydroponic) or direct use (irrigation)

5.3 Choosing the acid

Acid	Strength	Notes
Prickly-pear vinegar (foraged)	pH 3–4	Best local option — unlimited supply once you have a patch. Ferment crushed prickly-pear juice open to air 2–4 weeks. Gentle, easy to dose. See Guide 4 Part 3 §3.2.1 for the full recipe
Food-grade citric acid (powder, 1 g/mL stock)	Precise	Best purchased option — accurate dosing, no surprises. Standard choice for the protocol. About $10 per pound at any grocery or canning supplier
Phosphoric acid (commercial pH Down)	Very strong	Most reliable for hard well water. Adds a small amount of phosphorus — a benefit, not a problem, during fruiting

Acid	Strength	Notes
Distilled white vinegar (5% acetic)	Mild	Workable for small batches but consumes a lot of volume — 4–8 ounces per 15-gallon tub. Best as a household backup; not the routine choice
Sulfur burn	pH 1–2	Strong — fumes are irritating, outdoors only. Not recommended for routine use

WARNING

Always add acid to water — never water to acid. Diluting concentrated acid by pouring water onto it can cause sudden boiling and splashing. Eye and skin protection (safety glasses, gloves) for any acid stronger than vinegar.

Never skip Step 3. Adding nutrients while bicarbonates are still active causes calcium and magnesium to precipitate as carbonate scale within hours — visible as cloudiness, white film on tub walls, or chalky residue at the bottom of the reservoir. Your nutrients are locked up and your plants are starving. This is the single most common failure mode in Dragoons hydroponic systems. Wait for the calm surface.

5.4 Targets by use

Use	Final pH target	Notes
Hydroponic peppers, tomatoes, cucurbits	5.8 – 6.2	Standard fruiting-crop range
Hydroponic leafy greens (lettuce, herbs)	5.8 – 6.3	Slightly broader tolerance
Hydroponic brassicas	6.0 – 6.5	Brassicas prefer slightly higher pH
Soil-bed drip irrigation, most vegetables	6.0 – 6.5	A little headroom for biological activity to drift
Orchard / mature trees	6.5 – 7.0	Trees are tolerant; minimize acid use

Use	Final pH target	Notes
Acid-loving crops (blueberry, azalea)	5.0 – 5.5	These are difficult crops in the Dragoons regardless

5.5 Source quality ranked

If you have a choice of water sources, rank them as below. The cleaner you start, the less work the protocol does.

Source	Baseline EC	Baseline pH	Treatment needed	Rating
Monsoon rainwater (collected, clean)	< 0.05 mS/cm (< 20 ppm)	6.0 – 6.5	Minimal — pH fine-tune only	●●●●●
RO-filtered well water	< 0.1 mS/cm (< 50 ppm)	6.5 – 7.0	Light pH adjustment	●●●●●
RO / rainwater 50:50 blend	0.1 – 0.2 mS/cm	6.5 – 7.0	Light pH adjustment	●●●●○
Treated well water (post-protocol)	0.3 – 0.8 mS/cm	5.8 – 6.5 (after protocol)	Reduce nutrient dose to account for base minerals	●●●○○
Untreated well water	0.3 – 0.8 mS/cm	7.5 – 8.5	Full 5-step protocol — do not skip	●○○○○

LOCAL TIP

The Dragoons monsoon collapses the bicarbonate problem for the second half of every season. July–September monsoon rainwater is your best possible source water — under 20 ppm TDS, near-neutral pH. A 500 sq ft covered patio collects 3,000+ gallons over a normal monsoon. Stored in dark, covered tanks, that water displaces well water through August, September, and into October. Using monsoon water reduces Step 2 of the protocol to a small pH nudge rather than a full bicarbonate scrub.

6 · Why bicarbonate matters — the chemistry

HCO_3^- + H^+ → H_2CO_3 → H_2O + CO_2 · what's actually happening

The 5-step protocol works because of one chemistry reaction. Understanding the reaction lets you adapt the protocol when conditions change — a different acid, a different starting alkalinity, a cold-water versus warm-water reservoir.

6.1 The reaction

Bicarbonate (HCO_3^-) is the dissolved form of carbonate in water. It exists in equilibrium with carbonic acid (H_2CO_3) and dissolved CO_2. When you add a strong acid (H^+) to bicarbonate-bearing water, this happens, step by step:

$$\mathrm{HCO_3^-} + \mathrm{H^+} \rightarrow \mathrm{H_2CO_3}$$

$$\mathrm{H_2CO_3} \rightarrow \mathrm{H_2O} + \mathrm{CO_2}\uparrow$$

The acid combines with bicarbonate to form carbonic acid. Carbonic acid is unstable in open water — it decomposes into water and gaseous CO_2. The CO_2 bubbles out of solution as fizz. **Each bicarbonate ion you neutralize leaves the reservoir as CO_2 gas.** That is why the fizz visibly dies off when the bicarbonates are exhausted.

6.2 Why this matters for pH stability

Without bicarbonate neutralization, the bicarbonate ion acts as a **buffer**: every time you add acid, it absorbs the acid and converts it back to a neutral-pH bicarbonate-water mixture. The pH appears to drop briefly, then climbs back up within hours. From the grower's perspective, it looks like the acid is "wearing off" — you keep adding more and pH keeps creeping back to 7.5–8.5.

Once the bicarbonates are gone, the buffer is gone. The water now responds to acid linearly and predictably — every additional milliliter of acid produces a proportional pH drop, and the new pH stays put. This is why Step 5 of the protocol works smoothly while Step 2 fights you: in Step 2 you are fighting the buffer; in Step 5 the buffer is gone.

6.3 Why this matters for nutrient availability

Bicarbonate does more than push pH around. At the root surface, free HCO_3^- ions interfere with the uptake of **iron (Fe), manganese (Mn), and phosphorus (P)** — even when the soil or reservoir test reads "adequate" for those nutrients. The mechanism is partly competitive (HCO_3^- blocks Fe-reductase activity at root surfaces) and partly chemical (high bicarbonate raises local pH around the root, locking out Fe and Mn through the same chemistry that locks them out in alkaline soils).

Visible symptom: **interveinal chlorosis** — yellow leaves with green veins, on the youngest new growth. It looks like an iron deficiency because, functionally, it is one. The fix is not adding iron (that gets locked out too) but removing the bicarbonate from the irrigation water.

6.4 What controls how much acid you need

The acid demand depends on the **alkalinity**, not the **pH**. A water at pH 8.0 with 80 ppm alkalinity needs much less acid than a water at pH 8.0 with 300 ppm alkalinity, even though both start at the same pH. This is why an alkalinity reading is far more useful than a pH reading for planning treatment.

Rough rule for citric acid as a 1 g/mL stock solution:

Source alkalinity (ppm $CaCO_3$)	Citric acid stock (mL) per gallon, to reach pH 5.0
50	0.3 – 0.5
100	0.6 – 0.9
150	0.9 – 1.4
200	1.3 – 1.8
250	1.6 – 2.2
300	2.0 – 2.7
350	2.4 – 3.2

These are starting estimates; titrate carefully on the first batch from any given source, then record the precise dose for future use. The number does not change much across the year for the same well.

> **Alkalinity is the number that drives the treatment, not pH.** Two wells at pH 7.8 can need wildly different amounts of acid depending on their bicarbonate concentration. If you only get one extra number from your lab test, get alkalinity (as HCO_3^- or as $CaCO_3$ — they convert directly).

7 · City water — chlorine vs chloramine

Why municipal water needs treatment too · ascorbic acid · activated carbon

Municipal water in Cochise County is disinfected before it reaches your tap. The disinfection chemistry matters for growing — chlorine and chloramine both kill soil microbiome and disrupt aquatic biology in hydroponic reservoirs. The difference between the two is critical because they require different removal strategies.

7.1 Chlorine — off-gases overnight

Chlorine (in the form of hypochlorite, OCl^-) is volatile. Left exposed to air in an open container for 24 hours, the chlorine evaporates out of solution as Cl_2 gas. After overnight standing in a dechlorination tank, the water is functionally free of chlorine for growing purposes. UV light (sunlight) accelerates the process; aeration (a fish-tank bubbler) further accelerates it.

Most smaller Cochise County municipalities (Tombstone, Benson, Bisbee, Willcox, Douglas) use chlorine disinfection.

Removal for growing:

- **Open standing 24 hours** — sufficient for most uses. Cover loosely to keep debris out but allow gas exchange.
- **Aeration 4–6 hours** — accelerated method; useful if you need water within a day.
- **Activated-carbon filter** — instantaneous; a $30 carbon filter on a hose bib removes chlorine on the way through.
- **Ascorbic acid (vitamin C)** — chemical reduction; 1 g per 100 gallons fully neutralizes residual chlorine in seconds.

7.2 Chloramine — does not off-gas

Chloramine (NH_2Cl, a chlorine-ammonia compound) is intentionally more stable than chlorine. Larger municipalities use it because it persists longer in distribution pipelines, providing residual disinfection at points distant from the treatment plant. The stability that makes it useful for the water utility makes it a problem for growers — **standing chloraminated water in an open container does not dechloraminate**. The chloramine is still there 24 hours later. And a week later. And a month later.

Sierra Vista municipal water is chloraminated. This is the largest population in Cochise County and the only major chloraminated supply locally — but it affects thousands of growers.

Removal for growing:

- **Ascorbic acid (vitamin C)** — the standard chemical method. 1 g per 100 gallons neutralizes chloramine in 30 seconds. Powdered vitamin C from any grocery store works; food-grade L-ascorbic acid is the cleanest source. Cost is trivial — a 1-pound bag treats tens of thousands of gallons.

- **Activated carbon filter, specifically catalytic carbon** — ordinary carbon partially removes chloramine; catalytic carbon (also called “chloramine-removal carbon”) is engineered for it. Whole-house catalytic-carbon filters from suppliers like Aquasana or AOK run $150–$400. Hose-bib in-line filters are smaller and cheaper but need cartridge replacement.
- **Reverse osmosis** — removes chloramine completely, along with everything else. See chapter 9.
- **Standing in sun for 5–7 days** — slow partial removal via UV photolysis, but unreliable. Not the recommended method.

> **The vitamin-C dechlorination recipe: 1 gram L-ascorbic acid per 100 gallons.** That is roughly 1/4 teaspoon per 100 gallons. Stir into the tank, wait 30 seconds, the chloramine is gone. The byproducts are non-toxic and the ascorbic acid itself is a mild nutrient. This is the single cheapest and most reliable chloramine fix.

7.3 Why these matter for soil microbiome and hydroponic biology

Both chlorine and chloramine are intentionally **biocides** — they kill bacteria, including the beneficial bacteria you want active in soil and in any hydroponic reservoir that hosts biology (compost-tea drenches, mycorrhizal inoculants, aquaponics). For a hydroponic reservoir on a pure mineral nutrient regime, this matters less; the reservoir is intentionally a sterile chemistry environment. For a soil bed receiving regular drench, or for an aquaponic system, the biocide load over weeks of irrigation cumulatively erodes microbial diversity.

The rule: **dechlorinate any water destined for soil, compost, or biological inoculants**. Reservoir-only hydroponic water can use chlorinated water directly without immediate harm, though aquaponic and biological reservoirs always require dechlorination first.

> **WARNING**
>
> **Chloraminated municipal water can never be left to “sit overnight” effectively.** A grower in Sierra Vista who follows generic dechlorination advice and lets a barrel of city water sit for 24 hours has done nothing useful — every chloramine molecule is still there. The vitamin-C step is non-optional for chloraminated water bound for living soil or biology.

8 · Rainwater harvesting

Catchment sizing · cisterns · first-flush · filtration · why rainwater is the gold standard

Rainwater is the best growing water available in Cochise County. It arrives mineral-free (< 20 ppm TDS), slightly acidic (pH 5.5–6.5 from dissolved CO_2 and trace atmospheric chemistry), and free of chlorine, chloramine, fluoride, sodium, and the carbonate buffer that plagues local well water. The only catch: it arrives unevenly across the year, mostly in a six-week monsoon stretch, and has to be stored.

8.1 The supply math — Cochise rainfall

Cochise County rainfall averages depend sharply on elevation and location:

Location / elevation	Annual rainfall (avg)	Monsoon (Jul–Sep)	Winter (Dec–Mar)	Other
Valley floor (Willcox, Benson) — ~4,200 ft	~10 inches	6 – 7 in	2 – 3 in	< 1 in
Dragoon foothills — ~4,700 ft	~12 inches	7 – 8 in	3 – 4 in	1 in
Higher Dragoons — ~5,500 ft	~16 inches	9 – 10 in	4 – 5 in	1 – 2 in
Sierra Vista urban — ~4,600 ft	~13 inches	7 – 8 in	3 – 4 in	1 – 2 in

Variability is high — a dry monsoon can deliver 4 inches; a wet monsoon can deliver 12. Plan for the average; celebrate the wet years.

8.2 Catchment sizing — the key formula

The arithmetic for collected water from a roof:

$$\text{Gallons} = \text{Roof sq ft} \times \text{Inches of rain} \times 0.62 \times \text{Efficiency}$$

Where:

- **0.62** is the conversion factor (1 inch of rain on 1 sq ft of roof = 0.6233 gallons)
- **Efficiency** ranges from 0.75 (rough shingle, low-pitch, lots of debris) to 0.95 (smooth metal, steep pitch, clean). Use 0.85 for first-pass planning.

Example: a 1,200 sq ft house roof, 12 inches of rain annually, 0.85 efficiency:

$$1{,}200 \times 12 \times 0.62 \times 0.85 = 7{,}590 \text{ gallons per year}$$

A 500 sq ft covered patio over the monsoon season alone:

$$500 \times 8 \times 0.62 \times 0.85 = 2{,}108 \text{ gallons in the monsoon}$$

8.3 Catchment hardware — sizing per growing season

A reasonable target for a Dragoons grower: catch enough rainwater during the monsoon to displace well water for the second half of the growing season — roughly August through October. A 25 ft × 25 ft (625 sq ft) covered patio or shed roof catches ~2,600 gallons in a normal monsoon. Sized to a typical garden's late-season demand (40–60 gallons per day for a 200 sq ft mixed vegetable bed in August), 2,600 gallons supplies 45–65 days of irrigation. That is the dimensional rationale for a 2,000–3,000 gallon cistern.

Garden size	Late-season daily demand	Target storage
50 sq ft bed (apartment patio, small raised bed)	5 – 10 gallons	300 – 500 gallons
200 sq ft bed (typical home garden)	30 – 60 gallons	1,500 – 2,500 gallons
500 sq ft bed (large home garden)	70 – 150 gallons	3,000 – 5,500 gallons
1,000+ sq ft (homestead)	150 – 400 gallons	5,000 – 10,000 gallons

8.4 Cistern materials — poly, metal, concrete

Material	Pros	Cons	Typical price (Cochise County, 2026)
Polyethylene (Norwesco, Bushman, Tank-Depot)	Most popular; UV-stabilized; lightweight; affordable; lasts 30+ years	Opaque versions only — translucent grows algae; large tanks need a level pad	\$0.50 – \$1.00 per gallon (\$1,500 for 2,500 gal)
Galvanized steel ring with EPDM liner	Very large volumes (1,500 – 20,000 gal); can be assembled on-site; long life	Higher cost; needs a quality liner; rusts at fittings	\$1.00 – \$1.50 per gallon

Material	Pros	Cons	Typical price (Cochise County, 2026)
Concrete (cast-in-place or precast vault)	Indefinite life; can be buried; cool storage temperatures	Highest cost; pH-raises stored water over time (mild)	$2.00 – $3.50 per gallon
Ferrocement (DIY thin-shell)	Owner-built; mid-cost; high durability	Skilled labor needed; not casual	$0.75 – $1.25 per gallon DIY
IBC totes (food-grade 275-gal)	Cheap, modular, easy to find used	Translucent — needs UV cover; food-grade only for prior food contents	$80 – $150 per used tote

LOCAL TIP

For Cochise County, the workhorse cistern is a 2,500-gallon Norwesco poly tank in dark green or black. Local sources: Tractor Supply (Sierra Vista, Benson, Willcox) carries 500–550 gal sizes off the shelf; larger sizes are special-order through Tractor Supply or delivered by RainWater Solutions (Tucson) or Northern Arizona Wind & Sun. Plan for a $250–$400 delivery surcharge to the Dragoons. A level gravel pad and a 4-inch concrete base are usually sufficient for tanks up to 3,000 gallons; larger tanks need engineered foundations.

8.5 First-flush diverters — the first 5–10 gallons

A roof accumulates dust, pollen, bird droppings, leaf debris, and (in fire seasons) ash between rains. The first few minutes of a storm wash that load off the roof. Catching it into your cistern contaminates the whole tank. The fix is a **first-flush diverter**: a vertical pipe that fills with the first runoff and isolates it from the rest of the catchment, releasing it slowly through a small drain orifice between storms.

Sizing: divert **1 gallon per 100 sq ft of roof, minimum**. For a 1,200 sq ft roof, divert 12+ gallons of first-flush. A 4-inch diameter PVC standpipe holds about 0.65 gallons per foot of length; an 18-foot first-flush pipe holds 12 gallons.

Premade diverters from suppliers like RainHarvest Systems run $80–$200. DIY versions in PVC with a floating-ball check valve cost $30–$60.

8.6 Filtration — leaf screen, sediment, optional UV

A complete catchment system has filtration at three points:

Stage	Purpose	Hardware	Cost
Leaf screen at gutter or downspout	Excludes large debris before the first-flush	Stainless mesh, ~1/8” openings	\$20 – \$50
First-flush diverter	Isolates initial-flow contamination	PVC standpipe + check valve	\$30 – \$200
Sediment filter at outlet from cistern	Catches fine debris before pumping or drip distribution	5 – 50 micron string-wound or pleated cartridge filter	\$50 – \$120
UV sterilizer (optional)	Sterilizes biological contamination for human-contact uses	In-line UV chamber, 25–40W lamp	\$200 – \$500

For irrigation use only (not drinking), the UV sterilizer is optional. For any water that contacts edible parts of plants (foliar spray, hydroponic reservoir top-off, washing harvest produce), UV sterilization is good insurance.

8.7 Why rainwater is the gold standard

The chemistry of pure rainwater is hard to beat for any growing application:

Property	Cochise rainwater	Cochise well water	Implication
TDS	< 20 ppm	200 – 700 ppm	Rainwater has almost no starting EC — full nutrient recipes can be run on top
pH	5.5 – 6.5	7.5 – 8.5	Rainwater is already near growing-target pH
Alkalinity	< 10 ppm	100 – 350 ppm	No bicarbonate buffer to neutralize
Sodium	0 – 5 ppm	20 – 150 ppm	No accumulating sodium burden
Chlorine / chloramine	0	Variable (municipal only)	No biocide load on soil microbiome
Hardness	Negligible	100 – 500 ppm	No scale on emitters or kettle

Skipping the bicarbonate protocol entirely is a real time savings. For a Dragoons grower with a working catchment system, the second half of the growing season runs on rainwater and the bicarbonate routine collapses to a small pH check.

8.8 Storage and stagnation

Stored rainwater is stable for weeks. After a month or two in a dark closed cistern, it begins to develop biofilm and may smell musty — the bacteria are usually harmless, but the water benefits from aeration before use in foliar applications.

Mitigation options for long-storage rainwater:

- **Dark cisterns** prevent algae growth (the dominant problem in translucent containers).
- **Aeration with a small bubbler** for 24 hours before use freshens the water.
- **Chlorine drop** (1 mL of unscented household bleach per 100 gallons) for long-stored water bound for foliar application. The dose is well below drinking-water safety limits; off-gas overnight before use.

WARNING

Legionnaire's disease risk in warm stagnant cisterns. *Legionella* bacteria can colonize stored water held warmer than 77°F (25°C) with long residence times — common in unshaded poly tanks during Cochise summers. Bury or shade your cisterns, keep water turning over (use it before refilling), and never use stored cistern water for high-pressure misters or evaporative coolers that aerosolize droplets. The risk is small for drip and surface irrigation; the risk concentrates at any application that produces inhalable mist.

LOCAL TIP

The cleanest rain in the Dragoons monsoon is the late-September storm. The early-July first storms wash off months of accumulated dust and the early monsoon rains lift soil load into the air. By September the atmosphere is rinsed and the storms run clearer. If you can prioritize one cistern fill, fill it in September.

9 · Reverse osmosis (RO) — when justified

The cost/benefit · wastewater · reusing reject water

Reverse osmosis is a membrane-based filtration technology that produces near-pure water (< 30 ppm TDS) by forcing source water under pressure through a semipermeable membrane. The minerals stay on the input side (the "concentrate" or "reject"); the clean water passes through (the "permeate" or "product"). For hard Cochise County well water, RO is the most reliable way to consistently produce excellent growing water without depending on rainfall.

9.1 The cost/benefit threshold

RO is not always worth it. A grower with a small bed and decent well water (TDS < 300 ppm) can manage with the bicarbonate protocol alone. The threshold where RO becomes clearly worth the investment:

Condition	RO recommendation
Well TDS consistently > 500 ppm	●●●●● Strongly justified
Hardness > 200 ppm $CaCO_3$	●●●●○ Justified for hydroponic systems
Sodium > 80 ppm	●●●●○ Justified — sodium is hard to remove otherwise
Iron > 0.3 ppm	●●●○○ RO works but pre-filtration also fixes this
Taste issues (sulfate, chloride, mineral funk)	●●●●○ RO is the most thorough fix
Drinking water already on RO	●●●●● The unit is paid for; use it
Well TDS < 300 ppm, no taste issues	●●○○○ Bicarbonate protocol is sufficient
Rainwater catchment already covers demand	●○○○○ Catchment is the better investment

9.2 Unit cost and sizing

A standard countertop or under-sink RO unit runs \$200–\$500 retail with replaceable cartridges and membranes. Larger whole-house and agricultural RO systems run \$800–\$3,500. For Dragoons garden use specifically, a 50–100 gallon-per-day countertop unit costs \$250–\$400 and supplies a 200 sq ft bed in most months.

Membrane sizing is given in gallons per day at standard pressure and temperature:

Unit size	Useful daily output	Typical garden coverage
50 GPD	~25 – 35 gallons (real-world, cold-water Cochise wells)	50 – 100 sq ft bed
100 GPD	~50 – 70 gallons	200 – 350 sq ft bed
200 GPD	~100 – 140 gallons	400 – 700 sq ft bed
400 GPD (light-commercial)	~200 – 280 gallons	700 – 1,200 sq ft bed

Real-world output is **always lower than the rated output**. Cold well water, low household pressure, hard water that fouls membranes faster — all reduce production. Estimate 60–70% of rated GPD for typical Cochise County conditions.

9.3 The wastewater problem

RO membranes produce roughly 3 parts reject water for every 1 part product water under standard household pressure — sometimes worse on hard water. A 100 GPD unit producing 60 real-world gallons of product is discarding ~180 gallons of concentrate per day. **For a region where water is the single most constrained resource, this matters.**

Mitigations:

- **Higher-recovery membranes** at 1.5:1 or 2:1 reject:product ratio exist but cost more and foul faster.
- **Booster pumps** at the inlet increase recovery on hard water from ~25% to ~40%.
- **Permeate-pumps** improve efficiency on units with pressurized storage tanks.
- **Plumb the reject line to a storage barrel**, not down the drain. Reject water from a 400 ppm Cochise well typically reads 700–900 ppm — too salty for most vegetables but useful for ornamentals, lawn, fruit trees with high salt tolerance (pomegranate, fig, jujube — see Guide 9), or toilet flushing.

9.4 Reusing reject water for non-edible irrigation

The reject stream from an RO unit, when blended back with rain or fresh well water, is suitable for many non-edible uses:

- **Lawn** (tolerant cool-season turf or any of the native Cochise low-water grasses) — tolerates 1,000–1,500 ppm without browning.
- **Ornamental shrubs** (oleander, lantana, salvia, sage, *Yucca*, agave, mesquite) — most tolerate 2,000+ ppm.
- **Salt-tolerant fruit trees** — pomegranate (very tolerant), fig (tolerant), jujube (tolerant), olive (tolerant). See Guide 9.
- **Toilet flushing** through a greywater or branched-drain system (chapter 10).

- **Dust control** on driveways and unpaved access — most useful in the dry pre-monsoon stretch.

> **WARNING**
>
> **RO reject water is not “wastewater” in the contaminated sense — it is mineral-concentrated source water.** Do not pour it on edible vegetable beds long-term — the minerals accumulate in the soil and produce salt-burn within a season or two. Restrict reject reuse to salt-tolerant ornamentals or hardscape uses.

9.5 Membrane care

A residential RO membrane lasts 2–4 years on Cochise water (faster fouling than on softer source water). Replacement runs $40–$120. Sediment and carbon prefilters need replacement every 6–12 months ($15–$30 each). A poorly maintained RO unit produces water no better than its source — replace cartridges on schedule.

> **LOCAL TIP**
>
> **The Aquasana, APEC, and iSpring brands are the workhorses among under-sink RO units in Cochise County.** All three have replacement cartridges available on Amazon and at Home Depot or Lowe’s in Sierra Vista. The iSpring RCC7AK includes a remineralization stage that adds back calcium and magnesium — useful for drinking water but undesirable for hydroponic use (the whole point of RO for hydroponics is the absence of dissolved minerals). For garden water, get the version without the remineralization stage.

10 · Greywater systems

Laundry-to-landscape · shower drains · what's legal · what's safe

Greywater is the wastewater from showers, bathtubs, bathroom sinks, and clothes washing — anything except toilet flush water (blackwater) and kitchen sink water (which carries grease and food waste). For Cochise County, greywater is a meaningful supplemental water source for landscape irrigation. **Arizona law specifically permits residential greywater systems** under defined conditions — it is one of the most greywater-friendly jurisdictions in the country.

10.1 The legal framework

Arizona Department of Environmental Quality (ADEQ) regulations (Arizona Administrative Code, Title 18, Chapter 9) permit greywater systems of up to 400 gallons per day without a permit, provided the system meets thirteen specific conditions:

1. Water is used only on the property where it is generated
2. Water does not run off the property
3. Water does not pool on the surface
4. Water is applied below mulch or below grade (subsurface irrigation)
5. The system has labels and a valve to divert to sewer or septic
6. Water is not used to irrigate food crops that contact the soil (root vegetables, low leafy greens)
7. Untreated greywater is not stored more than 24 hours
8. The system does not damage human health or environment
9. Soaps used do not contain salts, boron, or chlorine bleach
10. Plumbing complies with applicable codes
11. Water is filtered to remove lint and large debris
12. Backflow prevention is present
13. The system does not impact groundwater quality

Systems above 400 GPD require a permit; commercial systems and HOA developments have separate rules.

10.2 The most common design — laundry-to-landscape

The simplest greywater system in Cochise County is **laundry-to-landscape**: a 1-inch hose from the washing machine drain runs out through the wall to a network of 1/2-inch outlet lines, each draining beneath mulch around fruit trees or ornamental beds. No pump, no storage, no filter. A 3-way valve diverts back to the sewer when desired (e.g., when bleaching whites).

Materials and cost:

Item	Source	Cost
1” PVC tee with 3-way valve	Hardware store	\$15 – \$25
1” black poly tubing (50 ft)	Irrigation supply	\$30 – \$50
1/2” outlet tubing with stakes (10–15 outlets)	Drip irrigation supply	\$40 – \$60
Mulch basins (one per outlet)	DIY — wood chip from arborist	Free – \$40 per cubic yard
3-way valve labeling and access	Plumbing supply	\$10
Total		\$100 – \$200

A typical household washer produces 25–40 gallons per load. A 5-load week is 125–200 gallons per week into the landscape — easily enough to keep three or four fruit trees in good shape through the dry months without using any well water on them.

10.3 Shower-drain greywater — branched drain

A more involved system routes the shower drain to a branched-drain network that distributes greywater across multiple landscape outlets. This requires more plumbing work (cutting into the existing drain stack below the shower) and is best installed during new construction or major remodel. A shower produces 15–25 gallons per shower, ~100–175 gallons per week per person.

10.4 Safe crops for greywater

Crop type	Greywater safe?	Notes
Fruit trees (apple, fig, peach, plum, pomegranate, jujube, mulberry)	Yes	Fruit hangs well above the irrigation; soil contact minimal
Grape vines	Yes	Cordon and fruit elevated above ground
Ornamental shrubs and trees	Yes	Unrestricted
Roses, perennial flowers	Yes	Unrestricted
Lawn, turf	Yes	Within ADEQ rules (subsurface application)
Tomatoes, peppers (caged/staked, well above ground)	Yes, with care	Outlet must be below mulch and clearly below the lowest fruit

Crop type	Greywater safe?	Notes
Cucurbits (squash, melon)	No	Fruit lies on the ground; direct soil contact
Leafy greens (lettuce, chard, kale, spinach)	No	Foliage close to soil
Root vegetables (carrot, beet, potato, sweet potato)	No	Edible portion is in soil contact
Herbs (where the leaves are eaten close to ground)	No	Same issue

The rule that resolves most edge cases: **if the edible part touches the soil or sits within a few inches of it, do not greywater-irrigate it.**

10.5 Soap selection

Soap choice is the single biggest variable in whether greywater helps or harms the landscape over years.

Avoid	Use instead
Sodium-based laundry detergent (most powders)	Liquid biocompatible detergent (Oasis, Bio-Pac, Ecos)
Bleach (chlorine-based, “color-safe”)	Hydrogen peroxide whitening
Borax (boron is highly toxic to plants at low levels)	Washing soda or sodium percarbonate (limited use)
Fabric softener (cationic surfactants)	Vinegar rinse for static
Phosphate-containing detergents	Phosphate-free formulations

LOCAL TIP

Oasis Laundry Detergent is the standard greywater-safe choice and is sold online and through some natural-foods retailers in Tucson and Sierra Vista. **Bio-Pac** is a Tucson-based brand that ships small quantities by mail. A gallon of greywater-safe detergent costs $15–$25 and lasts a typical household 3–4 months. Switching costs are modest; the long-term benefit to your landscape is significant.

WARNING

Never run a load of bleach through a greywater system without diverting to sewer first. A single bleach load deposited into mulch basins can sterilize the soil biology around several fruit trees and kill the trees within a season. Label the diverter valve clearly and make the divert step part of the bleach load routine.

11 · Irrigation water management

Drip · spray · flood · emitters · mulching · timers · sensors

How you apply water matters as much as where it comes from. The dry Cochise air, the high UV, and the seasonal heat extremes all reward irrigation systems that put water exactly where it's needed, exactly when it's needed.

11.1 The four delivery methods

Method	Where it fits	Efficiency	Pros	Cons
Drip emitters	Vegetable beds, orchard, perennial beds	85 – 95%	Precise, low-pressure, low-evaporation	Clogs in hard water; expensive per bed
Soaker hose	Long row beds, perimeter shrubs	70 – 85%	Cheap, easy	Less precise; uneven across run length
Sprinkler / spray	Lawn, large turf, dense ground cover	50 – 70%	Wide coverage, automated	High evaporation in dry air; wets foliage (disease)
Flood / basin	Mature fruit trees, large shrubs	60 – 80%	Soaks deep; matches dryland tree behavior	Requires berming; uses large volumes per session

For Cochise County vegetable gardens, **drip emitters are the standard**. The combination of efficiency, precision, and compatibility with timed automation makes drip irrigation the workhorse delivery method in the Dragoons.

11.2 Drip emitter sizing

Drip emitters are rated in gallons per hour (GPH) at standard 25 psi:

Emitter type	Rate	Where it fits
0.5 GPH	Slow trickle	Seedlings, small herbs, container plants
1.0 GPH	Standard	Most established vegetables, small shrubs
2.0 GPH	Faster	Tomatoes, cucumbers, large cucurbits

Emitter type	Rate	Where it fits
4.0 GPH	Fast	Mature fruit trees, large shrubs
Pressure-compensating emitters (PC)	Maintains GPH across pressure variation	Long-run systems, sloped beds, hillsides

For most Dragoons vegetable beds: **two 1.0-GPH emitters per plant**, on either side of the stem, 6 inches out. Tomatoes and peppers run 2.0 GPH each through fruiting.

11.3 Mulching reduces water need by 30–50%

A mulched bed loses water through three pathways: plant transpiration (irreducible), soil-surface evaporation (mulch nearly eliminates this), and deep percolation (irreducible if irrigated correctly). In the dry Dragoons air at 4,700 ft, an unmulched bed loses 50–70% of applied water to surface evaporation before the plant can use it. A 3-inch wood-chip mulch (Guide 11 §10) cuts that loss to 5–15%.

Net water-savings from mulching, by mulch depth:

Mulch	Water savings vs bare soil	Cochise fit
None	0%	Avoid
1” wood chip	~20%	Minimal — better than nothing
2” wood chip	~35%	Workable
3” wood chip	~45%	**Standard for the Dragoons**
4” wood chip	~50%	Diminishing returns
Plastic film	~60%	Use for low tunnels (Guide 14); permanent plastic raises soil temp problematically
Living mulch (cover crop)	~25%	Useful in cool season (Guide 11 §9)

Mulch is functionally a water investment. A wheelbarrow of free arborist wood chip applied at 3-inch depth over a 100 sq ft bed saves more water across a season than any other single intervention. The labor is cheap; the chips are free from local tree services; the return compounds for years.

11.4 Watering depth and frequency by crop family

Crop family	Root depth	Frequency in summer	Depth per cycle
Leafy greens (lettuce, chard)	6 – 10”	Daily or twice daily	0.5 – 1”
Brassicas (broccoli, cabbage, kale)	10 – 18”	Every 1 – 2 days	1 – 1.5”
Root vegetables (carrot, beet)	8 – 14”	Every 1 – 2 days	1 – 1.5”
Alliums (onion, garlic)	12 – 18”	Every 2 – 3 days	1 – 1.5”
Tomato, pepper, eggplant	18 – 36”	Every 2 – 3 days	1.5 – 2”
Cucurbits (squash, cucumber, melon)	18 – 36”	Every 1 – 2 days (high water demand)	1.5 – 2”
Corn	24 – 36”	Every 2 – 3 days	1.5 – 2”
Fruit trees, mature	36 – 60”	Every 5 – 7 days (deep soak)	4 – 6” (basin flood)

The principle: **water deeply, less often**. Shallow daily watering trains roots to stay near the surface where they desiccate fast. A 1-inch soak every 2 days produces deeper roots than 0.25-inch daily — and uses less water total.

11.5 Smart timers vs simple timers

Timer type	Cost	What it does	Cochise fit
Mechanical hose-bibb timer	\$15 – \$30	Set duration; manual start	Backup or single-bed only
Battery digital hose-bibb timer	\$25 – \$60	Programmable schedules; multiple cycles per day	Standard for one-bed or one-line gardens
Wi-Fi smart timer (Rachio, Orbit B-hyve, RAINPOINT)	\$100 – \$250	Multiple zones; weather-adjusted; remote control via phone	The Dragoons go-to for any 2-zone or larger system
Solar-powered automatic (RAINPOINT solar)	\$35 – \$50	Self-contained pump + timer; off-grid	The hydroponic standard — see Guide 3 §5

RAINPOINT is the brand most consistently used in this library — a small Chinese-manufactured solar-powered automatic watering system, available on Amazon (~$35–$50 per unit, model B0DQ4DQL33). It includes a 10W solar panel, a small lithium battery, a low-pressure pump, and a programmable timer in one weatherproof housing. The Wi-Fi versions of the RAINPOINT app-controlled timer (no pump) cover larger valved systems and integrate with smart-home routines. The hardware limitation: the basic RAINPOINT timer has a minimum 8-hour interval between cycles (a hardware limit, not a setting). For most Dragoons applications this is fine. The workaround for hot-month wilting (a second small midday-only pump) is in Guide 3 §5.

11.6 Soil moisture sensors

A soil moisture sensor reports volumetric water content at the sensor depth. The data lets you irrigate by **actual soil dryness** rather than by clock. For Cochise County beds where surface drying is rapid and root-zone drying is slower, this is genuinely useful.

Sensor type	Cost	Use case
Resistive probe (mechanical screw-in)	$5 – $15	Spot-check, not data logging
Capacitive sensor (Vegetronix, Davis)	$40 – $100	Continuous data; works with most smart timers
Tensiometer	$40 – $80	Measures soil moisture tension; agricultural standard
Smart timer with integrated sensor (Rachio + Flow / Soil sensors)	$250 – $400	Closed-loop irrigation; weather + soil aware

For most Dragoons home gardens, a single capacitive sensor at the typical root depth of the bed's main crop (12 inches for tomatoes; 6 inches for greens) feeds back to the timer and produces noticeable water savings (20–30%) over the season.

12 · Solar pumping

DC pumps · panel sizing · battery vs direct-drive · the RAINPOINT setup

The Dragoons are a high-solar-resource region — 300+ sunny days per year, low cloud cover even in monsoon, and clear winter skies. Solar-powered water pumping is correspondingly attractive: off-grid bato bucket systems, cistern-to-bed transfer, livestock watering, and remote orchard irrigation all benefit from solar pumps.

12.1 The pump-system architecture

Three core architectures:

Architecture	How it works	Pros	Cons
Direct-drive (panel → pump)	Solar panel feeds DC pump directly; pump runs only when the sun shines	Simplest; no battery to maintain; cheapest	Cannot run at night or in heavy overcast; pump speed varies with sun
Battery-buffered	Panel charges battery; battery powers pump on schedule	Runs anytime; pump speed steady; can integrate with timer	More parts; battery wears out (5–8 years)
Battery + grid-tie hybrid	Battery primary; grid backup if battery low	Most reliable; bulletproof	Most expensive; defeats some of the off-grid intent

For most Dragoons applications, **direct-drive is enough** if the water-need pattern matches the sun (daytime drip irrigation, daytime cistern fill). **Battery-buffered** is necessary for night cycles, fixed-schedule irrigation, or any system that has to run regardless of weather.

12.2 DC pump sizing (12V vs 24V)

Pump type	Voltage	Flow	Lift	Use case
RAINPOINT integrated solar pump	5V (built-in battery)	~30 gph	~10 ft	Small bato bucket reservoir
Bilge / utility submersible	12V	200 – 600 gph	10 – 15 ft	Cistern-to-bed transfer
Solar well pump (small)	24V	50 – 200 gph	20 – 100 ft	Light irrigation, livestock

Pump type	Voltage	Flow	Lift	Use case
SunRotor / Grundfos SQF	24 – 48V	60 – 1,200 gph	50 – 600 ft	Well, deep-cistern, off-grid agriculture
Pressure-boosting (SHURflo, Aquatec)	12V	60 – 200 gph	50 – 70 psi	Pressurized line, drip-irrigation feed

12.3 PV panel sizing

Solar panel size depends on pump wattage, target daily run-time, and Cochise County's solar resource (about 6.5–7 peak-sun-hours per day on a south-facing surface).

Rough rule:

$$\text{Panel watts} = \frac{\text{Pump watts} \times \text{Daily run hours}}{6.5 \text{ peak-sun-hours}}$$

A 60W pump running 2 hours per day needs $60 \times 2/6.5 = 18$ W of panel for direct-drive break-even — but realistically a 30–50W panel to handle cloudy days. Battery-buffered systems need 1.5–2× this size to charge the battery as well.

12.4 Battery vs direct-drive

Direct-drive case: small drip-irrigation timers that run for 10–15 minutes at 6 AM, 2 PM, and 10 PM. The 6 AM cycle uses panel + small buffer (the RAINPOINT's internal lithium battery handles this); the 2 PM cycle runs straight off the panel; the 10 PM cycle uses stored charge.

Battery-buffered case: a 200-gallon cistern transfer pump that has to run for an hour at 5 AM every day to fill morning-irrigation reservoirs before sunrise. A 12V lithium-iron-phosphate battery (LiFePO4) sized at 50–100 Ah holds enough charge for several days of cloudy weather.

Lithium-iron-phosphate batteries are the current standard — 10-year life, 100% depth-of-discharge tolerant, low maintenance. Cost runs $300–$800 for 50–100 Ah at 12V. Lead-acid is cheaper upfront but lasts 3–5 years.

12.5 The RAINPOINT setup — referenced from Guide 3 §5

The hydroponic bato bucket setup that anchors Guide 3 uses a RAINPOINT solar pump (Amazon B0DQ4DQL33). This integrates panel, pump, battery, and timer in one weatherproof housing for ~$35–$50. The system handles a single 15-gallon reservoir feeding 4–8 bato buckets through 1/4" supply tubing and drip stakes. Specifics — intake submersion depth, supply line layout, three-cycle daily schedule, the 8-hour minimum interval and its workarounds — are in Guide 3 §5.

> **LOCAL TIP**
>
> **For Dragoons-specific solar pumping help, the closest specialist supplier is Northern Arizona Wind & Sun (Flagstaff) by phone or web order.** Tucson Solar (Tucson) and Solar Solution AZ (Tucson) handle larger installations and ship to Cochise County. For a single-bucket RAINPOINT system, Amazon is fastest; for a 50-gallon-per-day off-grid orchard pump, talk to one of the regional suppliers.

13 · Conservation strategies for the Dragoons

Mulch · ollas · wicking beds · drought-tolerant varieties · the 1-inch rule

The Dragoons reward gardens that use less water. Conservation is not austerity — it is the upstream effect of dozens of small good decisions about mulch, soil, layout, and variety. The strategies below stack: each one alone reduces water demand modestly; combined, they produce a garden that thrives on a fraction of the water a poorly-designed garden would use.

13.1 Heavy mulch — the foundation

The single highest-return water-conservation strategy in the Dragoons is **3-inch wood-chip mulch over every bed**. The numbers are in §11.3 above — a mulched bed cuts surface evaporation by 80–95% versus bare soil. Free arborist wood chip is the dominant local source; sources are detailed in Guide 11 §10. The labor is wheelbarrow work, the cost is zero, and the effect compounds — the mulch slowly decomposes into bed organic matter, improving water retention in subsequent seasons.

13.2 Olla pots — buried unglazed clay vessels

Ollas (pronounced *OH-yahs*) are unglazed terracotta vessels buried in a bed up to the neck, filled with water, and capped. Water seeps slowly through the porous walls into the surrounding soil. Plants planted within 18 inches of the olla root toward it. **The system is one of the most water-efficient irrigation methods known** — water is delivered directly to the root zone, with zero surface evaporation.

Olla size	Volume	Refill frequency	Coverage
Small (1 gallon)	1 gal	3 – 5 days	6 sq ft
Medium (2 gallons)	2 gal	5 – 7 days	12 sq ft
Large (5 gallons)	5 gal	7 – 14 days	24 – 36 sq ft

Local sources: traditional ollas are made by potters in the southwest. Native Seeds/SEARCH (Tucson) has carried them periodically; Dripping Springs Olla Company is a Texas-based mail-order source. DIY ollas can be made from two unglazed terracotta pots glued rim-to-rim with silicone, with the bottom of the upper pot capped.

LOCAL TIP

Ollas pair well with annual mulched beds where consistent moisture matters. Squash, melon, peppers, and tomatoes all respond to olla-buffered

> moisture by setting fruit more consistently in heat. For row crops or short-season greens, drip emitters are simpler and more efficient.

13.3 Wicking beds — bottom-watered raised beds

A wicking bed is a raised bed with a sealed (waterproof) bottom and a 6–10 inch gravel reservoir at the base, separated from the soil by landscape fabric. Water enters the reservoir through a fill pipe and wicks upward into the soil through capillary action. Once the bed is established, the only water loss is through plant uptake (intended) and slow surface evaporation (minimized by mulch).

A 4×8 ft wicking bed at 18-inch total depth (with 8-inch gravel reservoir below 10 inches of soil) holds ~50 gallons in the reservoir. In Cochise summer it needs refilling every 5–10 days. The same bed on conventional irrigation would need 2–4 inches of water per week — roughly 30–60 gallons per week, or ~3–5× the wicking-bed demand.

Construction is more work upfront (a sealed liner, an overflow drain, an inlet pipe) but the operating savings compound. See Guide 11 §3 for bed-building references; the wicking design is a variation on raised-bed construction with a sealed bottom.

13.4 Bone-dry cover cropping

Conventional cover-crop wisdom calls for tender green cover crops grown to the soil-incorporation stage. In a low-water Dragoons garden, the more useful approach is **dry-tolerant cover crops grown to senescence**, then dropped as in-place mulch. *Sorghum-sudangrass*, *cowpea*, and *teff* can all grow on monsoon rainfall alone, set seed, dry down, and leave a mulch layer that protects the bed through fall and winter without irrigation. See Guide 11 §9 for cover-crop specifics.

13.5 Drought-tolerant variety selection

Variety choice is the upstream water decision. A drought-tolerant tomato (Punta Banda, Black Sea Man, Anna Russian) uses 30–40% less water than a high-yielding indeterminate (Brandywine, Cherokee Purple) for the same fruit. A native-adapted pepper (Tepin, Chiltepin, Pequin) uses 40–60% less water than a hybrid bell pepper. Every crop guide in this library lists drought-tolerant variety options. The shortlist:

Crop	Standard variety (water-hungry)	Drought-tolerant alternative
Tomato	Brandywine	Punta Banda, Black Sea Man, Anna Russian
Pepper	California Wonder	Tepin, Chiltepin, Pequin
Squash	Acorn	Cushaw, Tarahumara
Bean	Bush blue lake	Tepary (white or brown)

Crop	Standard variety (water-hungry)	Drought-tolerant alternative
Corn	Hybrid sweet	Hopi Blue, Tohono O’odham 60-Day
Watermelon	Sugar Baby	Tohono O’odham Yellow-Meated
Melon	Crenshaw	Santa Claus, Tohono O’odham
Cabbage	Standard heading	Mizuna or other loose-leaf brassicas

Native Seeds/SEARCH (Tucson) is the regional seed bank for Sonoran-adapted varieties. Most of the “drought-tolerant alternatives” above are from their collection.

13.6 The 1-inch-per-week rule (and when it’s wrong)

The most-quoted irrigation rule from generic gardening literature is “vegetables need 1 inch of water per week.” In Cochise County this is **frequently wrong in both directions**.

When it underestimates	When it overestimates
Late May – late June (pre-monsoon heat, bone-dry air) — 2 – 3” / week	March – April (cool, mild, lower demand) — 0.5” / week
Mid-August – late September (heat persists, monsoon humid) — 1.5 – 2” / week if no rain	Mid-July through August (monsoon storms supplying free water) — 0.5” / week from irrigation
Container plants in any month — 2 – 4× a bed’s demand	Mulched beds — half a bare-bed demand
Crops on caliche-shallow soil — runoff losses	Tomato/pepper beds on deep, amended soil — every 2 – 3 days at 1.5”

The better rule for the Dragoons: **water deeply (1.5–2 inches per cycle), as infrequently as the bed will tolerate (every 2–4 days for established summer vegetables), and adjust by feel and observation.** A soil moisture sensor turns this into a feedback loop; without one, dig in 4–6 inches with a finger before each scheduled cycle and skip the cycle if the soil is still wet.

14 · Water and the law in Cochise County

Surface vs groundwater · prior appropriation · well permits · ADWR

A short primer — not legal advice. Water law in Arizona is one of the more contested and complex regulatory areas in the state, and many of the rules have local variations. This chapter orients you; for any specific question about water rights, well permits, or boundary disputes, consult the **Arizona Department of Water Resources (ADWR)** or a water-rights attorney.

14.1 The two systems — surface vs groundwater

Arizona separates surface water and groundwater into two different legal regimes:

System	Governing principle	What it means for a homeowner
Surface water	Prior appropriation ("first in time, first in right")	Water in a river, stream, or wash is allocated by historical rights. Diversion requires a permit. Stream-side property does *not* automatically include rights to the water
Groundwater	Reasonable use doctrine, with Active Management Areas (AMAs) and Irrigation Non-Expansion Areas (INAs)	Pumping is generally permitted, with limits in regulated areas

14.2 Cochise County — outside the Tucson AMA, mostly

The Tucson Active Management Area (AMA) covers Pima County and a small part of southeastern Pinal. **Cochise County is not within an AMA** — it falls outside the most stringent groundwater regulation in the state. However, two of its sub-basins (the Douglas INA and parts of the San Pedro) have specific irrigation expansion restrictions.

Practical implications for a Cochise County homeowner:

- **A well on your property is generally yours to drill and pump**, with state notification requirements (file Form 55-55, the Notice of Intent to Drill, with ADWR before drilling).
- **Pumping is unmetered** outside AMAs; you can pump for personal use freely.
- **Selling or transferring water off the property** requires water-rights review.
- **Pumping that significantly affects a neighbor's well** can be challenged under reasonable-use doctrine.

14.3 Well permits and registration

To drill a new well in Cochise County:

1. Hire a **licensed well driller** (Arizona Department of Water Resources maintains a list).
2. File **Form 55-55** (Notice of Intent to Drill) with ADWR before drilling.
3. After completion, file **Form 55-55A** (Well Driller's Report) within 30 days.
4. The well receives a **Cadastral registration number** (ADWR Well File).

Existing wells should have a registration on file; if you bought property with an unregistered well, **register it retroactively with ADWR**. Unregistered wells can create complications during property sales.

14.4 Where to find more information

Resource	What it covers
Arizona Department of Water Resources (azwater.gov)	Well permits, well-driller licensing, water rights, AMA/INA maps
ADWR Cochise County Field Office	(520) 432-4316; Bisbee
University of Arizona Water Resources Research Center (wrrc.arizona.edu)	Research-oriented publications on Arizona water
Cochise County Recorder	Water-rights deeds; well-registration records tied to property
Sustainable Water Network (Bisbee)	Citizen advocacy and resource group

WARNING

This is a primer, not legal advice. Water-rights disputes can be expensive and slow to resolve. If you are buying a property that depends on a contested water source, a 30-minute consultation with an Arizona water-rights attorney before closing can save tens of thousands of dollars later.

15 · The Dragoons water calendar

Month-by-month demand and supply

A year of water in the Dragoons has a strong seasonal rhythm. Knowing the rhythm lets you plan storage, treatment, and irrigation around expected supply rather than scrambling in response to it.

Month	Supply (rain)	Catchment refill rate	Garden demand	Notes
January	0.5 – 1.0” gentle rain	Slow trickle	Minimal (winter cover crops, dormant trees)	Maintenance month — clean filters, inspect cisterns
February	0.5 – 1.0” rain, occasional snow	Slow	Low (cool-season starts, brassicas)	Submit annual well-water test now
March	0.5 – 1.0” rain	Slow	Rising (transplants in, cool-season peaks)	Bicarbonate protocol back in routine; bed-amending and pre-irrigating
April	0.2 – 0.5” rain (dry shoulder)	Negligible	High (transplants establishing, warm-season starts)	Cistern water valuable — use sparingly; well water is the workhorse
May	0.1 – 0.3” rain (driest month)	Negligible	Very high (full warm-season crop in, no rain)	Peak well-water draw; mulch heavily
June	0.1 – 0.5” rain (very dry)	Negligible	Highest of year (pre-monsoon heat + dry air)	Cisterns near empty by month-end; well water carrying everything
July	2 – 4” monsoon rain (variable)	**Fills cisterns**	Moderate (rain offsets demand; humidity reduces ET)	First monsoon storms wash dust off roofs; first-flush carries debris

Month	Supply (rain)	Catchment refill rate	Garden demand	Notes
August	2 – 4” monsoon	**Refills if drained**	Moderate to high	Cleanest catchment month; clearest atmosphere; humid storage stagnation risk increases
September	1 – 3” monsoon (tapering)	Final fills	Moderate (heat persists, rain dwindling)	**The cleanest rain of the year** — late-September storms
October	0.5 – 1” rain	Slow	Lower (cool-season starts in; fruiting wraps up)	Cistern water carries through fall; well-water demand drops
November	0.3 – 0.8” rain	Slow	Low (dormancy, winter brassicas)	Drain non-freeze-rated plumbing; insulate exposed lines
December	0.5 – 1.2” rain	Slow	Minimal	Maintenance — replace RO filters; inspect cisterns; recharge batteries on solar pumps

The Dragoons water year has two halves. Mid-March through late June is **well-water dependent** — minimal rain, full crop demand, cisterns drawing down. Mid-July through October is **rainwater dominant** — cisterns full, monsoon storms freshening the supply, low bicarbonate work needed. Plan storage, treatment, and irrigation around this annual rhythm.

LOCAL TIP

The grower’s water-discipline that pays best in the Dragoons. Reserve

> cistern water for May and June — the highest-demand, lowest-supply weeks of the year. Use well water in March and April, when the rain is past but cistern reserves are still in service from last monsoon. Then ride out May and June on stored rain, plus what well water you must use. By the time the cisterns are empty in late June, the monsoon is starting.

16 · Troubleshooting

Common water problems and their fixes

The symptoms below come up regularly in Dragoons gardens. Each has one or two most-likely root causes and a defined fix.

Symptom	Likely cause	Fix
My drippers clog every month	Calcium scale deposition from high-hardness water	Acidify pre-emitter (a small in-line phosphoric-acid injector); quarterly vinegar flush; or switch to rainwater for the irrigation line
My pH won't stay down	Bicarbonate not being neutralized — pH bounces back to 7.5–8.5 within hours	Re-run chapter 5 protocol; verify fizzing stops before adding nutrients; check that Step 3 was completed
My plants are showing salt burn (crispy leaf edges, browning)	High-TDS irrigation water, salt buildup in soil, or salty manure	Flush the bed with 4× normal irrigation (RO or rainwater); test soil EC; reduce manure inputs; consider RO source water
White scale on tank walls or emitters	Calcium carbonate precipitation from skipped Step 3	Empty, descale with vinegar, refill correctly with the full protocol
Yellow new leaves, green veins (interveinal chlorosis)	Iron or manganese lockout from high pH / bicarbonates	Verify bicarbonate protocol; supplemental chelated Fe (Sequestrene 138) as foliar spray; long-term, fix the water
Slimy, dark biofilm in cisterns	Algae or bacterial growth in unsealed or translucent storage	Cover, darken, or aerate cisterns; chlorine bump for stored water; replace with opaque tank
Greywater outlets emit a sour smell	Soap residue accumulating in mulch basins under outlets	Refresh mulch basin with new wood chip; verify soap is greywater-safe (chapter 10 §10.5); flush with fresh water once a month
RO unit producing high-TDS water	Membrane fouled or expired	Replace membrane (every 2–4 years on Cochise water); check pre-filters

Symptom	Likely cause	Fix
Drip emitter on long line not flowing at the far end	Pressure drop along run; emitter clog	Switch to pressure-compensating emitters; flush the line; reduce total emitter count per zone
Soaker hose unevenly wet along its length	Pressure-drop characteristic of soaker hose at low pressure	Shorten run; add a second supply tap mid-run; switch to pressure-compensating drip line
Cistern level dropping faster than expected without rain	Leak in plumbing or overflow drain not seated	Inspect all hose fittings; check overflow elevation; pressure-test the line
Wilting between cycles in May–June heat	8-hour RAINPOINT minimum interval insufficient for hottest stretch	Add a second small pump on midday cycle (Guide 3 §5); increase coco/perlite ratio in medium
Cold morning startup fizzing in a treated reservoir	Cold water dissolves CO_2; some “fizz” is dissolution, not bicarbonate	Wait until reservoir reaches ambient temp before reading pH
Sodium accumulation in bed soil	Long-term irrigation with high-sodium well water or salty manure	Switch source to rainwater or RO; flush bed; apply gypsum to displace sodium
Boron toxicity (leaf-edge burn on susceptible plants)	High-boron well water or borax-containing soap in greywater	Switch source; replace soap (chapter 10 §10.5); flush bed thoroughly with low-boron water
Iron staining on white surfaces	High iron in well water (> 0.3 ppm)	Pre-filter with greensand or oxidizing filter; or RO

Nine out of ten “my plants look unhappy” problems in the Dragoons trace to one of three water issues. First: bicarbonates not neutralized — interveinal chlorosis on young growth. Second: high TDS in irrigation water — salt accumulation in beds, eventual salt burn. Third: chloramine in city water killing the soil microbiome — gradual loss of biological vigor. The first two are addressed in chapter 5; the third in chapter 7. Solve those three and most “garden problem” calls in this library resolve.

WARNING

Never drink from your hydroponic reservoir. The nutrient salt concentration is too high for human consumption even briefly, and the reservoir typically carries enough microbial diversity (especially older reservoirs) to make casual sampling a real GI risk. Keep a separate labeled drinking-water container near the bench.

WARNING

Lead solder in older Cochise County homes (pre-1986) can leach into hot or stagnant tap water. If you are using city water in any plumbing older than 1986, run the tap for 1–2 minutes before collecting irrigation water, and consider a one-time ICP-MS lead test (chapter 3 §3.2) to verify safety. Garden plants accumulate lead from water; root vegetables especially.

17 · Sources & references

A working library of useful Cochise County water resources, in rough order of usefulness for a new Dragoons grower.

Government and Extension

- **University of Arizona Cooperative Extension — Cochise County** (Sierra Vista; 520-458-8278; extension.arizona.edu/cochise). Soil and water testing, regional irrigation bulletins, master gardener program.
- **Arizona Department of Water Resources** (azwater.gov). Well permits, well-driller licensing, water rights, AMA/INA maps.
- **Arizona Department of Environmental Quality** (azdeq.gov). Drinking water rules, greywater regulations, household-hazardous-waste collection.
- **Cochise County Health Department**. Well certification for property sales, drinking-water testing.
- **USDA-NRCS Web Soil Survey** (websoilsurvey.nrcs.usda.gov). Site-specific soil and hydrology maps for any address in Cochise County.

Publications

- *Water Storage* — Art Ludwig. The reference text for catchment, cisterns, and greywater. Reference for chapters 8 and 10.
- *Create an Oasis with Greywater* — Art Ludwig. Companion to *Water Storage*; the design reference for laundry-to-landscape and branched-drain systems.
- *Rainwater Harvesting for Drylands and Beyond* — Brad Lancaster (two volumes). The canonical reference for arid-climate rainwater design; written from Tucson, applies directly to Cochise County.
- **UA Cooperative Extension publications** (extension.arizona.edu) — alkalinity, sodicity, water chemistry, and well-water treatment bulletins specific to southeast Arizona aquifers. Search by topic.
- **Arizona Department of Water Resources publications** (azwater.gov) — Active Management Area maps, well-drilling guidance, hydrogeologic studies.

Local suppliers

- **Tractor Supply Co.** (Sierra Vista, Benson, Willcox). Cisterns (500–550 gal off the shelf, larger by order), drip-irrigation supply, livestock-watering parts.
- **ACE Hardware** (Sierra Vista, Benson, Willcox). Hose bibs, timers, RAINPOINT-compatible fittings, vinegar (gallon, for descaling), citric acid (canning section).
- **RainWater Solutions** (Tucson; ships to Cochise County). Specialty cisterns, first-flush diverters, complete catchment-design consults.
- **Northern Arizona Wind & Sun** (Flagstaff). Solar pumps and panels, off-grid system design.
- **Aquasana, APEC, iSpring** (online via Amazon and Home Depot). RO units and

replacement cartridges.
- **Native Seeds/SEARCH** (Tucson). Drought-tolerant variety seed; periodic olla and dryland-farming hardware.

Reference labs

- **University of Arizona soil and water testing laboratory** (Tucson; through the Cooperative Extension intake). Standard agricultural panels.
- **Turner Laboratories** (Tucson). Independent water testing including drinking-water certifications.
- **Eurofins / Test America** (regional). Full ICP-MS panels by mail.

Citizen / community resources

- **Sustainable Water Network** (Bisbee). Citizen advocacy; resource sharing on water and conservation.
- **Watershed Management Group** (Tucson; some Cochise outreach). Rainwater-harvester certifications; greywater-installer training; hands-on workshops.
- **Borderlands Restoration Network** (Patagonia). Watershed restoration in the borderlands region of Cochise and Santa Cruz counties.

Closing — water under everything

Water sits upstream of every decision the rest of this library makes. The pepper variety, the bato bucket build, the soil-amendment schedule, the orchard layout, the cool-season plant-out date — every one of those is a choice that depends on what is coming out of the hose and what storage you have built around it.

The work to do well by water in the Dragoons is not exotic. Test the well once a year. Run the bicarbonate protocol on every reservoir. Catch the monsoon. Mulch every bed. Choose drought-tolerant varieties where the season is dry. Maintain the timers and the filters. Reuse the greywater on the fruit trees.

Each of those is a small good habit. None of them in isolation transforms a garden. Stacked, they produce a Dragoons garden that runs on a fraction of the water a poorly-planned garden uses, with consistent yields, healthier soil biology, and far fewer “my plants look unhappy” moments traceable to water.

The Dragoons are a high-desert place. The water year is dry, with a short violent wet spell in midsummer. The growing tradition that thrives here is the one that respects that pattern — that takes the monsoon as the gift it is, stores it, treats it, defers to it where possible, and uses well water with care everywhere else. Treat the water, watch the meters, catch the rain, and the rest of growing in the Dragoons gets meaningfully easier.

Index