

The Land Atlas

Manley Farms

A field guide to reading your own land

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About this guide

The Land Atlas is a free field guide from Manley Farms for reading a piece of land - its water, soil, climate, topography, energy, wildlife, fire risk, regulations, and infrastructure - and turning that read into a first-year plan. It leans on free public data (USDA NRCS Web Soil Survey, USGS, NWS/NOAA, NASA, FEMA, and your state and county agencies) and shows you how to use it.

Everything here is general reference, not professional, legal, or engineering advice. Zoning, permits, setbacks, water and mineral rights, and environmental rules vary by jurisdiction and change over time. Verify anything that carries legal or financial weight with your county planning department, the relevant state agency, and a qualified professional before you act on it. See the full disclaimer at manleyfarms.com/disclaimer.

Part I - Water, Soil, and Climate

The Land Atlas - Section Group A Manley Farms field guide to reading your own land

Before you site a barn, plant an orchard, or write a check for ground that “looks good in summer,” you need three baseline reads: how water moves through the parcel, what the soil will actually support, and what climate the land experiences - not the airport ten miles away. This section teaches those three reads with free public data, field checks, and ranges you can act on.

Nothing here replaces a licensed hydrogeologist, a soil scientist, a water-rights attorney, or your county extension agent. Where a number, permit rule, or map layer can vary by state or county, the text says so. **Verify against the governing agency, NRCS field office, state water office, and local extension before you stake money or dirt on a decision.**

Reading Your Water

The first question on any parcel is where water comes from, where it goes, and what it does on the way through. Too much water in the wrong place and not enough in the right place fail more land projects than bad soil or short seasons.

Why water first

A realtor walk-through in August shows a small clear creek and dry pasture. By November the same creek can be three feet higher, through the fence, into the coop. That happens when nobody asked how big the watershed above the parcel is, what the FEMA flood map says, or what the creek does after a wet fall.

You are not trying to become a hydrologist. You are trying to leave the weekend with a water map of *your* ground: entries, exits, stops, legal hooks, and the free data that backs the story.

The three water questions

Answer all three before you finish this chapter.

1. **Where does water enter this parcel?** Rain falls on every acre, but most water that *moves* across your land fell uphill on ground you do not own. It arrives as sheetflow, ditches, creeks, seeps, and springs.
2. **Where does water leave this parcel?** Surface flow (creeks, ditches, culverts), groundwater recharge (infiltration and subsurface flow), and evapotranspiration (soil and plants returning

water to the air). You can walk the first two; the third is estimated from climate data later in this section group.

3. **Where does water stop on this parcel?** Pools, ponds, wetlands, tile blowouts, beaver work, and low corners. Every stop has a reason - soil, grade, pipe, dam, or obstruction.

Write those three answers in one page. That page becomes your water baseline.

Watersheds above you

A **watershed** (drainage basin) is the land area that drains to a common point. Your parcel sits somewhere in one or more nested basins.

What to pull (free):

Source	What you get	Where
USGS StreamStats	Delineated basin area, estimated peak flows, basin characteristics	streamstats.usgs.gov
USGS National Map / topo	Ridgelines, named streams, contour shape of the bowl above you	apps.nationalmap.gov / topoView
EPA How's My Waterway / WATERS	Downstream path, assessment units, impaired waters flags	mywaterway.epa.gov
County GIS	Parcel lines overlaid on streams and drainages	Your county assessor / GIS site
Manley Farms Streamflow Watch	USGS gauges + precip forecast context for working parcels	manleyfarms.com tools

Steps:

1. Print or download a topo for your section. Trace the high ground (ridgelines) that surrounds the bowl draining toward your low point.
2. In StreamStats, click a pour point on the creek at your downstream property line (or the outlet of your main drainage). Generate the basin report. Record **drainage area** (sq mi or acres).
3. Classify land cover above you from aerial imagery (NAIP via USDA, or county basemap): mostly forest, pasture, cropland, development, or mixed.
4. Note any major upstream risks: recent timber harvest, new subdivision, active mines, large livestock ops, or burned ground.

How to use the numbers (patterns, not laws of physics):

- A **small basin** (on the order of tens to a few hundred acres) means your own land use moves the needle more.
- A **large basin** (many square miles) means you are downstream of decisions you do not control. Peak flows, sediment, and timing of runoff are largely written upstream.

- Steep, sparsely vegetated basins rise fast after storms. Flat, well-vegetated basins rise slower and stay higher longer.

Always cross-check StreamStats estimates against nearby USGS gauges and local flood history. StreamStats is a model; a wet decade or a burned watershed can change behavior.

Water rights basics (doctrine map, not legal advice)

Whether you can *use* water that crosses your land is a legal question. Doctrine varies by state. This is orientation only - confirm with your state water office and, for anything expensive, a water-rights attorney.

Region (rough)	Common doctrine	Practical implication
Much of the arid West	Prior appropriation (“first in time, first in right”)	Senior users take their full entitlement before junior users in shortage. Priority date on a certificate or claim often matters more than who owns the land today.
Much of the humid East	Riparian (reasonable use by landowners adjoining the stream)	Rights attach to stream-adjacent land; “reasonable” is fact-specific and state-defined.
Many states	Hybrid / regulated riparian	Permits or registration for larger withdrawals even where riparian ideas still appear in case law.

What to request (usually free or low cost, public record):

1. **Water right / water claim report for the parcel and point of diversion** from your state water resources agency (names vary: Department of Ecology, Water Resources Board, Division of Water Rights, DNR, DEQ).
2. **Well construction logs** for on-parcel and neighboring wells (state well-log databases).
3. Any **ditch company, irrigation district, or association** documents if surface delivery is organized.

Typical use classes people confuse:

- **Domestic / household** wells are often allowed under statutory exemptions with daily volume caps. Caps and construction permits are state-specific - read your state’s exemption statute, do not assume a number from another state.
- **Stockwater** often has special treatment; thresholds and sources differ by state.
- **Irrigation** of commercial crops almost always needs a perfected right or permit in prior-appropriation states.
- **Ponds / impoundments** often need a right (West) and/or dam-safety or wetland permits (nationwide). “It’s on my property” is not a water right.

Rule: map the water first; only then ask what you may legally divert, store, or pump. Chapter-level regulatory work belongs with your deed, title report, and state records - not with a field guide alone.

Wells and springs

Wells

If the parcel has a well, collect:

Record	Why it matters
Drill year, depth, casing diameter	Capacity and age of the system
Static water level at drill time vs recent measured level	Declining aquifers show as dropping levels over years
Yield (gpm) and drawdown notes	Whether the well supports house + livestock + garden under peak demand
Water quality tests (bacteria, nitrate, arsenic, etc.)	Health and treatment decisions - retest after idle periods or floods

How to pull free context:

1. Search your **state well log database** for the parcel and for nearby sections. Compare depths and yields - one strong neighbor log does not prove your hole will match.
2. USGS NWIS groundwater: waterdata.usgs.gov/nwis/gw - real-time and historical water levels at monitored wells. Use the nearest long-record well as a climate-of-groundwater reference, not as your well's exact twin.
3. If buying: require a **current pump test and water quality panel** as a contingency. Historical logs are not performance guarantees.

Field check: after a heavy pump run (laundry, irrigation, livestock fill), measure recovery. Slow recovery and cloudy first-draw water after storms can signal shallow, surface-influenced aquifers that need different risk management.

Springs and seeps

Feature	Field signature	Notes
Seep	Green patch, soft ground, seasonal wetness at slope breaks	Often tracks rain; may dry in late summer
Spring	Persistent flow; often cooler water; may be named on deeds	Year-round flow is a strong asset <i>and</i> a legal/regulatory signal
Developed spring	Box, pipe, collection works	Ask for permits, water rights, and maintenance history

Mark both on the parcel map. A named spring on a deed is not automatically your exclusive right to divert. Confirm with the state water office.

USGS streamflow and nearby gauges

Primary free source: USGS National Water Information System - waterdata.usgs.gov/nwis

Steps:

1. Open the map, zoom to your basin, and list gauges on your stream or the nearest mainstem.
2. For each useful gauge, record: site number, drainage area, period of record, and whether it is real-time.
3. Pull **daily mean discharge** for a wet year, a dry year, and the most recent complete water year.
4. Note **flood peaks** and the date of the peak of record. Walk your parcel with those dates in mind - neighbors remember the big ones.

How to read discharge without drowning in hydrology:

- Compare your StreamStats basin area to the gauge's basin area. A gauge ten times larger than your local creek is a timing and weather signal, not a scale model of your ditch.
- Rising limbs after rain show how “flashy” the system is. Steep rises mean short warning times for culverts and livestock.
- Late-season baseflow (midsummer low) is a proxy for how much the channel depends on groundwater.

Related free tools:

- NOAA AHPS / National Weather Service river forecasts where available:
water.weather.gov/ahps
- USGS WaterWatch for regional wet/dry context: waterwatch.usgs.gov
- Manley Farms Streamflow Watch for gauge + precip context aimed at field operators

Drainage on the parcel (what you walk after a storm)

Walk after the first real storm of the wet season - not in the middle of the cloudburst. Boots, notebook, phone camera, printed parcel map.

Inventory checklist:

- **Perennial streams** - flow most of the year; cut banks, bed, ordinary high water marks
- **Seasonal streams** - wet months only
- **Ephemeral channels / washes** - only during and shortly after storms
- **Ditches** - straighter, often along roads or field edges; ask neighbors original purpose
- **Culverts** - diameter, condition, sediment choke, outlet scour
- **Swales** - broad, shallow conveyances without a cut channel

- **Seeps and springs** - as above
- **Wetlands indicators** - cattails, sedges, rushes, willows, prolonged ponding; hydric soils if you dig
- **Ponds** - natural or built; berms, spillways, inlets

For each feature note flow direction, approximate width/depth at ordinary high, and whether it is perennial / seasonal / ephemeral.

Drainage health (working rules of thumb - verify with NRCS / extension for design):

Observation	Suggests
Surface water gone within ~24 hours on non-wetland ground	Drainage generally adequate for many agricultural uses
Standing water >48 hours after rain on non-wetland ground	Drainage problem, compaction, slow subsoil, or broken tile
Mottled orange/gray subsoil (redox features)	Seasonal saturation - matches “somewhat poorly” / “poorly” drainage stories
Ruts forming where they did not form years ago	Compaction + wet traffic; rethink timing of equipment

Options if drainage is poor and the area is not regulated wetland: live with it (wet-site plants, seasonal pasture), deep-rooted covers to improve structure over years, surface ditches, or subsurface tile. **Ditching, filling, and tiling can trigger Clean Water Act, state wetland, and drainage-district rules.** Call your NRCS field office and county planning office *before* you dig.

Ponds

Treat every pond as three questions: hydrology, structure, and legality.

1. **Hydrology:** Is it spring-fed, stream-fed, runoff-only, or well-filled? Runoff-only ponds can go dry in drought years even if they look permanent in a wet spring.
2. **Structure:** Berm condition, freeboard, spillway capacity, trees on dams (roots can fail embankments), fencing for livestock access.
3. **Legality:** Impoundment volume, in-stream vs off-stream, dam safety thresholds, wetland impacts, and water rights for storage. Thresholds are state-specific; do not invent an acre-foot cutoff from a blog.

Useful free layers:

- USGS topo and aerials for historical pond presence
- NRCS / county soils for suitability of embankments and seepage risk (see soil chapter)
- State dam inventory maps where published
- FEMA flood maps if the pond sits in or near a mapped floodplain

Practical storage language: one acre-foot is the volume covering one acre one foot deep (about 325,851 gallons). That unit appears on water rights and dam paperwork. Confirm any design volume with a licensed engineer when failure would flood a road, home, or neighbor.

Flood risk (FEMA and local truth)

Free map: FEMA Flood Map Service Center - msc.fema.gov

Common zone labels	Meaning (simplified)
Zone X (unshaded)	Outside the 0.2% annual chance floodplain (often called 500-year)
Zone X (shaded)	Between 1% and 0.2% annual chance in many products
Zone A / AE / AH / AO	Special Flood Hazard Area - 1% annual chance ("100-year") concepts
Zone V / VE	Coastal high hazard with wave action

Interpret carefully:

- "100-year flood" means roughly a **1% chance per year**, not "once a century and you are done." Over a 30-year period the chance of at least one 1% event is on the order of one in four - a probability lesson, not a promise about your parcel.
- FEMA maps lag real development and real storms. If the ground flooded last decade and the map is dry, believe the ground and re-check with county emergency management.
- Base Flood Elevation (BFE) on AE panels matters for building elevations and insurance. Read the panel legend; do not guess.

Mark FEMA zones on your parcel sketch. Print the FIRM panel for the binder.

Water chapter action list

- ☐ Watershed area and land cover above the parcel recorded
- ☐ Surface water features mapped after a storm walk
- ☐ FEMA FIRM pulled and zones marked
- ☐ Nearest USGS gauges bookmarked; wet/dry/peak notes taken
- ☐ Well logs and any water-right documents requested
- ☐ Ponds/springs inventoried with structure + legal follow-ups listed



Wetland-looking areas flagged for NRCS / Corps / state confirmation before disturbance

Free water data sources (quick index)

Agency / tool	Use
USGS StreamStats	Basin delineation and flow estimates
USGS NWIS / WaterWatch	Gauge and groundwater data
FEMA MSC	Flood zones
NOAA / NWS AHPS	River forecasts
EPA How's My Waterway	Downstream water quality context
State water resources office	Rights, claims, permits
State well log database	Well construction history
NRCS field office	Drainage, wetland, conservation practice advice
County GIS / assessor	Parcel + hydro layers

Reading Your Soil

Soil is the part of the parcel you cannot buy more of on a human timescale. Texture, depth, drainage, and organic matter decide what grows, what floods, where septic systems fail, and whether an orchard is a plan or a fantasy.

Start with the map that already exists

The **USDA NRCS Web Soil Survey** is the national free soil map most consultants start from.

- **Web Soil Survey (WSS):** websoilsurvey.sc.egov.usda.gov
- **Soil Data Access / related apps:** same underlying SSURGO data; Manley Farms Soil Profile Quicklook is a friendlier drawing interface to related NRCS data where available

How to run Web Soil Survey (weekend method):

1. Open WSS → **Start WSS**.
2. **Area of Interest (AOI):** navigate to your parcel. Define AOI with the rectangle/polygon tools using deed lines or a GPS track. Keep AOI tight - giant county-sized AOIs make reports noisy.
3. Open the **Soil Map** tab. Note **map unit symbols and names** (example style: "Aloha silt loam, 0 to 3 percent slopes"). Print or export the map.

4. Open **Soil Data Explorer** → **Suitabilities and Limitations** and **Soil Properties and Qualities**.

Pull at least:

- Drainage class
- Depth to restrictive feature
- Available water capacity
- pH (surface)
- Organic matter (where rated)
- Hydrologic soil group (A/B/C/D) - runoff behavior
- Farmland classification
- Construction / septic / roads ratings if you will build

5. Export a **Soil Report** PDF into your binder.

Truth in labeling: SSURGO map units are mapped at a scale that can miss small pockets. Your shovel is the ground-truth. Agreement is good. Disagreement is information - mark it.

What you are reading in a hole

Dig at least three holes in representative spots (main field, upper slope, low corner). Two feet deep if tools and soil allow. Clean wall, ruler in the photo.

Signal	What to note
Color	Dark topsoil vs lighter subsoil; sharp boundary depth
Mottles	Orange/rust mixed with gray → seasonal wetness
Gleyed (blue-gray) colors	Prolonged saturation
Structure	Crumbly aggregates vs massive sticky clay vs single-grain sand
Roots	Depth they stop; mats above a pan
Fragments	Gravel, cobble, basalt pieces - limits tillage and available water
Smell	Persistent rotten-egg smell can indicate anaerobic wet conditions

Topsoil depth rules of thumb (general agricultural language, not a grade for your title policy):

Approx. dark topsoil depth	Working read
~6 inches or less	Thin - protect cover; avoid aggressive tillage
~8-12 inches	Common working depth for many fields
~12-18 inches	Strong for many crops and pastures
24+ inches	Uncommon gift - do not waste it

Confirm with lab organic matter and local extension norms for your region.

Texture: ribbon test and jar test

Texture = relative amounts of sand, silt, and clay. It drives drainage, trafficability, nutrient holding, and irrigation frequency.

Ribbon test (field)

1. Moisten a sample from ~6 inches depth (not the organic surface crust alone).
2. Knead out roots and gravel.
3. Ribbon between thumb and forefinger.

Ribbon result	Likely texture family
Will not ribbon; gritty	Sand / loamy sand
Ribbon < ~1 inch; gritty	Sandy loam
Ribbon ~1-2 inches; slightly gritty	Loam / silt loam (common productive soils)
Ribbon ≥ ~2 inches; sticky; little grit	Clay loam / clay

Jar test (home quantitative estimate)

1. Sieved soil to 1/3 of a clear quart jar; water nearly full; ~1 tsp dish soap.
2. Shake hard 2 minutes; set level.
3. Mark sand layer after ~1 minute; silt after ~2 hours; clay after ~24 hours (times are approximate - clay can take longer).
4. Convert layer heights to percentages; plot on the **USDA texture triangle** (NRCS publishes it free).

Expect field methods to be approximate. For fertilizer money and certification paperwork, use a lab.

Drainage class (NRCS language)

NRCS rates map units on a standard drainage scale. Match the report to what you see after storms.

Drainage class	Working meaning
Excessively / somewhat excessively drained	Water leaves fast; drought stress risk on coarse soils
Well drained	Often ideal for buildings and many crops
Moderately well drained	Periodic wetness in lower profile
Somewhat poorly drained	Extended wet periods; mottling common
Poorly / very poorly drained	Wet most of season or ponded; wetland questions likely

If the map says “well drained” and you hit water at 12 inches in March, something site-specific is going on: compaction, clay lens, seepage, or a mapping unit that does not match that hole.

Depth to restrictive layer

Restrictive layers stop roots and water:

- Bedrock
- Duripan (cemented; common in arid West)
- Fragipan (dense; common in some glacial landscapes)
- Claypan
- Plow pan (human-made, often ~6-10 inches from repeated tillage at the same depth)

Record **depth to restriction** from WSS and from your holes. Shallow restrictions change orchard rootstock choice, septic design, and drought resilience.

Organic matter, pH, and nutrients (what labs are for)

Organic matter (OM)

OM improves structure, water holding, and biology. Color is a rough screen only:

Moist topsoil color (rough)	Possible OM ballpark
Near black	Often higher OM
Dark chocolate	Moderate to good
Medium brown	Common cultivated range
Pale / yellow-gray	Often low

Lab OM is cheap relative to bad fertilizer guesses. **Exact water-holding claims vary with texture and depth** - use extension calculators for your soil rather than memorizing a single national number.

pH

Most agronomic crops prefer roughly **6.0-7.0**, with important exceptions (for example many blueberries prefer more acid conditions; alfalfa prefers near-neutral to slightly alkaline). Field kits are useful for screening; labs are better for lime rates.

pH band (approx.)	Common issues
< 5.5	Acidity stress, Al toxicity risk in some soils; lime may be indicated after testing
5.5-6.5	Common in higher-rainfall / forested soils

pH band (approx.)	Common issues
6.5-7.5	Broad agronomic comfort zone for many crops
7.5-8.5	Alkalinity; micronutrient availability issues possible
> 8.5	Often salinity/sodicity questions - get a lab and extension involved

Lime and sulfur rates are soil-specific. Do not copy a neighbor's tonnage.

When to pay for a lab test

Basic agronomic panel (typical extension / university lab; prices commonly on the order of tens of dollars per sample - confirm current fees):

- pH, buffer pH / lime requirement where offered
- Organic matter
- Plant-available P and K
- Ca, Mg, S as offered
- CEC and base saturation where offered

Add-ons when history warrants: micronutrients; heavy metals (old orchard lead arsenate, urban fill, industrial adjacency).

Sampling method that keeps the report honest:

1. Define management zones (do not mix a wet corner with a dry ridge into one bag if you will manage them differently).
2. 15-20 cores per zone, mixed in a clean bucket, subsample to the lab bag.
3. Depth: often 0-6 or 0-8 inches for tilled ground; shallower for long-term pasture; deeper for some orchard diagnostics - follow the lab's instructions.
4. Avoid sampling immediately after lime/fertilizer. Avoid extreme wet mud.

Your **county extension office** will name preferred labs and help interpret results. That call is free and better than internet generic charts.

Suitability: crops, buildings, septic, roads

WSS ratings are screening tools, not construction stamps.

Decision	Soil questions to pull
Annual crops / gardens	Texture, drainage, AWC, frost heave, flooding frequency
Pasture / hay	Drainage, slope, rooting depth, trafficability
Orchard / vineyard	

Decision	Soil questions to pull
	Depth, drainage, aspect (climate chapter), available water
House / barn pad	Shrink-swell, drainage, flooding, frost action, bearing (still need geotech for real builds)
Septic	Depth to saturation / restriction, percolation reality, setbacks - county health rules control
Roads / lanes	Ponding, soft clay seasons, frost

Slope and erosion (national conservation-style guidance - adjust with local NRCS):

Slope (approx.)	Use caution
0-3%	Low erosion from slope alone
3-8%	Annual crops need cover and residue management
8-15%	Prefer perennials; aggressive erosion control if annual
15-25%	Permanent cover preferred
>25%	Forest / native cover / careful silvopasture - not clean tillage

Plants as free soil sensors

Unplanted vegetation is a live report:

Pattern	Often associated with
Sedges, rushes, cattails, willows	Prolonged wetness / wetland conditions
Sheep sorrel, extensive moss, bracken (context-dependent)	Acid / lower fertility stories - confirm with tests
Dense plantain on paths	Compaction / traffic
Vigorous nettles, lambsquarters, pigweed	Higher fertility / disturbance
Salt-tolerant desert shrubs / saltgrass (arid West)	Salinity - lab confirm

Lists are clues, not diagnoses. Climate and seed sources also drive what shows up.

Soil chapter action list

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Web Soil Survey AOI and map units printed

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- ☐ Drainage class, restrictive depth, AWC, hydrologic group recorded per unit
- ☐ Three shovel pits photographed with scale
- ☐ Ribbon (and optional jar) texture estimates logged
- ☐ Lab samples planned for zones you will invest in
- ☐ Extension contact noted for interpretation
- ☐ Suitability flags for build / septic / orchard marked on the parcel map

Free soil data sources (quick index)

Source	Use
USDA NRCS Web Soil Survey	Official map units and interpretations
NRCS Soil Data Access	Programmatic / advanced queries
USDA texture triangle	Classify sand/silt/clay %
County extension / land-grant lab	Test kits, lime/fertilizer interpretation
NRCS field office	Conservation planning, drainage, EQIP/practice technical help
NAIP imagery (USDA)	Field boundaries, wet signatures, management history clues

Reading Your Climate

The forecast on your phone is usually for an airport, a co-op, or a model grid cell. Your parcel has elevation, aspect, cold-air drainage, and canopy your phone does not feel. Climate reading means stacking regional normals, station records, and on-parcel observation.

Four nested scales

1. **Regional climate** - broad pattern (for example humid continental, Mediterranean, semi-arid). Sets the seasonal script.
2. **Local climate** - your valley or 10-20 mile context (rain shadow, lake effect, coastal influence).
3. **Mesoclimate** - the parcel as a whole (dominant aspect, elevation band, forest cover).
4. **Microclimate** - the frost pocket, south barn wall, wind gap, and creek corridor.

Maps cover (1) and parts of (2). You build (3) and (4) with walks and simple instruments.

Hardiness zones (and what they are not)

USDA Plant Hardiness Zone Map (2023 update and any later revisions): based on **average annual extreme minimum temperature**, not summer heat, not rainfall, not frost-free days.

- Zones are **10°F bands**, split into **a/b** 5°F halves.
- Use the map at planthardiness.ars.usda.gov (or the current USDA-hosted viewer).

Zone tells you	Zone does not tell you
Ballpark winter minimum plants must survive	Length of winter cold
Relative cold risk vs another county	Summer heat load
A starting plant list filter	Drought, humidity, or soil limits
	Your frost pocket one zone colder than the ridge

Optional complement: **American Horticultural Society Heat Zone** ideas (days above a heat threshold) where heat - not winter cold - is your limiting factor. Verify current official sources if you use heat-zone products.

Practical use: buy plants rated for your zone or colder, then adjust for frost pockets and thermal belts on the parcel.

Frost dates and season length

For gardens, orchards, and many field crops, two dates matter more than the zone number:

- **Average last spring frost** (often defined around 32°F)
- **Average first fall frost** (32°F)

Frost-free season $\approx$ days between those averages. Many decision tools also publish thresholds at 28°F and 36°F because “killing frost” and light frost are different events - read the definition on the table you use.

Free sources:

Source	Notes
NOAA NCEI / Climate Data Online	Station normals and extremes - ncei.noaa.gov / CDO
Applied Climate Information System (ACIS) / RCC portals	Station tools widely used for freeze dates - e.g. xmacis.rcc-acis.org and related RCC sites
NWS climate pages for local WFO	Local normals, records, frost/freeze products
PRISM (Oregon State)	

Source	Notes
	Gridded precip and temperature that respect terrain - prism.oregonstate.edu
State climate office	Best local interpretation

Station vs parcel adjustments (pattern recognition - measure to confirm):

Setting	Common frost bias vs valley airport
Closed valley floor / frost pocket	Later last spring frost; earlier first fall frost
Mid-slope thermal belt	Often milder nights than the floor
Ridge top	Windier; can be colder or less prone to pooling depending on night type
Near large water body	Moderated extremes; season edges may shift
North aspect / cold air drainage path	Longer frost risk

Differences of **one to several weeks** between a valley floor and a nearby slope are common in complex terrain. Do not treat the co-op station as gospel for a draw half a mile away.

Growing degree days (GDD)

GDD estimates heat accumulation for crop development.

Simple daily form (common teaching version):

$$\text{GDD} = \max(0, (T_{\text{max}} + T_{\text{min}}) / 2 - T_{\text{base}})$$

- **Tbase** is crop-specific. **50°F** is a common base for many warm-season crops (for example corn). Cool-season systems often use lower bases (often discussed around 40-45°F depending on crop and extension sheet).
- Some systems cap **Tmax** (for example corn methods) - **use the method your extension service publishes** for the crop you grow.

Illustrative seasonal totals (base 50°F, order-of-magnitude orientation only - verify local normals):

Seasonal GDD (base 50, rough)	Orientation
Low (~1200 or below)	Warm-season long-season crops often limited; cool-season and forages dominate many systems
Mid (~1800-2400)	Many temperate grain / mixed systems possible depending on moisture

Seasonal GDD (base 50, rough)	Orientation
High (3000+)	Long warm seasons; heat-loving crops more realistic if water allows

Do not treat those bins as hard laws. Cultivar maturity ratings, irrigation, and latitude photoperiod matter. Use your state climate office or extension GDD trackers for operational decisions.

Microclimate note: south-facing slopes can accumulate substantially more GDD than north-facing slopes at the same elevation. Aspect is not a footnote.

Precipitation and evapotranspiration (ET)

Precipitation

Mean annual rainfall is the least useful single number. Prefer:

Metric	Why
Monthly / seasonal distribution	Mediterranean winters vs summer monsoon vs continental peaks
Driest and wettest years in the record	Risk, not just average
Days with measurable precip vs heavy events	Equipment windows, erosion, spray timing
Snowfall vs liquid	Roof load, access, spring recharge timing

Free sources: NCEI station data, PRISM maps, NWS, state climate offices, CoCoRaHS volunteer gauge network (cocoahs.org) for dense local observations.

Evapotranspiration

Reference ET (ET_o) estimates atmospheric demand. Crop ET is ET_o adjusted by crop coefficients. Irrigation scheduling is demand vs effective rain vs soil storage (see soil AWC).

Free / low-cost sources (availability varies by region):

- Spatial CIMIS / state ET networks (strong in parts of the West)
- NWS / NOAA products and some university AgWeather networks
- OpenET and related satellite-based ET products for landscape context (understand resolution limits)
- USDA / university irrigation guides for crop coefficients

Working idea: if peak summer ET_o runs high and July-August rain is near zero, your soil AWC and irrigation right determine survival - not the hardness zone.

Microclimates you can map on foot

Walk on three kinds of days:

1. **Clear, calm dawn in spring or fall** - cold air pools; frost and dew show first in sinks.
2. **Hot still midsummer afternoon** - heat sinks on south/west walls and rock.
3. **Windy late-winter day** - exposure on ridges and gaps; shelter on lee slopes and forest edges.

Mark warm pockets, frost pockets, wind tunnels, and snowdrift lines on the same map you used for water.

Cold-air drainage and frost pockets

On clear calm nights, ground cools, air densifies, and cold air drains downhill into basins and behind barriers.

Signs: first frost in the pocket while slopes stay clear; orchard failure in the hole and success 20-40 vertical feet higher; fog lingering in the bowl after sunrise.

Responses:

- Put frost-tender crops and homesites out of the pocket when possible
- Keep a drainage gap at the low end - dense windbreaks can trap cold air
- Use the pocket for cold-tolerant or late-spring cool-season production

Thermal belts

Mid-slopes above the cold pool often run warmer on radiation nights than either the valley floor or the ridgetop. Classic orchard country uses this on purpose. Confirm with min/max thermometers on calm nights rather than assuming.

Rain shadows (terrain-scale moisture)

Windward slopes wring moisture; leeward slopes dry out. Mountain ranges create dramatic examples; even local ridges can shift seasonal totals. **PRISM** maps make this visible at farm-relevant scales. Compare PRISM at your coordinates to the nearest airport normal - differences of 10-30% are not rare in complex terrain.

Building a minimum climate kit

Kit level	Typical tools	Purpose
Minimum	Min/max thermometer in a shaded ventilated screen ~4-5 ft up; rain gauge; notebook	Season length and rain truth

Kit level	Typical tools	Purpose
Better	Consumer weather station (temp, RH, rain, wind) with logging	Correlate to NWS forecasts
Serious	Research-grade station (for example Davis-class)	Multi-year normals on-site

Siting rules of thumb: not over asphalt; not against a south wall; not under dense canopy unless you are studying canopy climate on purpose; grass or natural surface preferred. Follow NWS / CoCoRaHS siting guidance when you can.

One year of daily notes beats ten years of “I think spring was early.”

Climate chapter action list

☐

USDA hardiness zone recorded (map year noted)

☐

Last spring / first fall frost averages from a named station + definition of threshold

☐

Seasonal precip distribution and wet/dry year range recorded

☐

GDD method and base temperature chosen from extension for your main crop

☐

PRISM or equivalent terrain-aware precip/temp checked

☐

Frost pockets / thermal belts / wind exposures marked on parcel map

☐

Decision made on thermometer / gauge placement for year-one measurement

Free climate data sources (quick index)

Source	Use
USDA Plant Hardiness Zone Map	Winter minimum zones
NOAA NCEI / CDO	Station climate normals and extremes
RCC ACIS / xMACIS tools	Freeze dates and station products
PRISM Climate Group	Terrain-aware grids
NWS local office	Forecasts, local climate pages, freeze warnings
NASA POWER / other reanalysis portals	Research-scale solar and met variables - know the resolution limits
CoCoRaHS	Dense daily precip observations

Source	Use
State climate office + county extension	Interpretation for crops and livestock
OpenET / state ET networks	Evapotranspiration context where available

Closing this section group

Water tells you what will flood, dry, and legally constrain use. Soil tells you what will root, drain, and hold fertility. Climate tells you how long the season is and how hard the atmosphere pulls water out of the ground. Read them in that order on a new parcel: **water first, soil next, climate as the schedule and stress test.**

When map and hole disagree, believe the hole and update the binder. When law and a creek disagree, believe the state water record and a lawyer. When the airport and your frost pocket disagree, believe the thermometer you hung in the pocket.

That is reading your own land - not as a vibe, but as a set of checkable signals.

Manley Farms - The Land Atlas - Section Group A Verify local regulations and agency data before capital decisions. This guide is educational, not professional engineering, legal, or agronomic advice.

Part II - Topography, Energy, Wildlife, and Fire

Chapter 1: Reading Topography

Topography dictates water flow, soil deposition, microclimatic temperatures, wind exposure, and structural access. Reading terrain correctly from topographical maps and digital elevation data prevents costly engineering errors, failed septic systems, eroded access roads, and mispositioned agricultural infrastructure.

1. Understanding Contour Lines and Intervals

Contour lines join points of equal elevation above a reference datum (typically mean sea level). Understanding contour geometry enables precise calculations of slope, drainage areas, and landforms without field surveying.

Key Contour Rules

- **Contour Interval (CI):** The vertical elevation change between adjacent contour lines. Common intervals on USGS 7.5-minute quadrangle maps are 10 feet or 20 feet; 1-meter or 2-meter intervals are typical on modern LiDAR-derived topographic maps. Always verify the interval in the map legend.
- **Index Contours:** Every fifth contour line is printed heavier and includes an elevation number.
- **Spacing and Slope:** Closely spaced lines indicate steep terrain; widely spaced lines indicate flat or gently sloping terrain. Evenly spaced lines indicate a uniform slope.
- **V-Shapes and U-Shapes:** V-shaped contours pointing uphill identify valleys, draws, and drainage channels (water flows down out of the point of the V). U-shaped contours pointing downhill identify ridgelines and spurs.
- **Concentric Rings:** Closed concentric contour lines represent hills or peaks. Closed rings with internal hachure marks (short ticks pointing inward) represent depressions or sinks.

Calculating Slope Percentage and Angle

Slope percentage expresses the ratio of vertical rise to horizontal run.

$$\text{Slope Percentage (\%)} = \left(\frac{\text{Rise (Vertical Elevation Change)}}{\text{Run (Horizontal Distance)}} \right) \times 100$$

To calculate slope angle in degrees:

$$\theta \text{ (degrees)} = \arctan \left(\frac{\text{Slope Percentage}}{100} \right)$$

Vertical Rise	Horizontal Run	Slope (%)	Slope Angle (Degrees)	Practical Site Interpretation
10 ft	200 ft	5%	2.9°	Ideal for structures, septic drainfields, and tilled crops. Low erosion risk.
10 ft	100 ft	10%	5.7°	Maximum recommended grade for standard residential driveways and unpaved farm roads.
10 ft	50 ft	20%	11.3°	Steep slope. Requires terracing or contour planting. Heavy equipment operation caution.
10 ft	33 ft	30%	16.7°	Threshold for severe erosion risk. Conventional septic drainfield limits exceeded.
10 ft	20 ft	50%	26.6°	Very steep. Structural building requires specialized engineering; high landslide potential.

Note: Always verify local county building codes and NRCS slope limitations before siting permanent structures or roads.

2. Slope, Aspect, and Microclimates

The direction a slope faces (aspect) and its position relative to terrain profiles determine local moisture regimes, frost risk, and solar radiation exposure.

```
[ WINDWARD RIDGE CREST ] <- High wind, shallow soils, high evaporation
\
\ [ UPPER SLOPE / SHOULDER ] <- Well-drained, moderate soil depth
\
\ [ MID-SLOPE THERMAL BELT ] <- Warmest night temps, reduced frost
```

	\
	\ [FOOTSLOPE / BENCH] <- Deep soil accumulation, moisture retention
	\
	[VALLEY BOTTOM] <- Cold air drainage, frost pocket, high moisture

Solar Aspect Characteristics (Northern Hemisphere)

- **South Aspect (135° to 225°):** Receives maximum annual solar radiation. Higher soil temperatures, rapid snowmelt, elevated evapotranspiration rates. Ideal for solar arrays and winter crop warming; vulnerable to summer drought and elevated wildfire hazard.
- **North Aspect (315° to 45°):** Receives minimum direct solar radiation. Cooler soil temperatures, retained winter snowpack, higher soil moisture retention. Well-suited for timber production, shade-tolerant forage, and cool-season storage.
- **East Aspect (45° to 135°):** Receives morning sun with lower air temperatures. Lower thermal stress on crops and livestock; rapid dew drying reduces fungal plant pathogens.
- **West Aspect (225° to 315°):** Receives intense afternoon sun during peak ambient temperatures. High evaporation rates and thermal stress; increased wind exposure in regions dominated by westerlies.

Thermal Belts and Cold Air Drainage

During clear, calm nights, radiational cooling causes dense cold air to flow downhill (katabatic winds) into valley bottoms and depressions, forming frost pockets. * **Valley Bottoms:** Collect cold air. Higher frost frequency, shorter growing season, damp conditions. Siting orchards, vineyards, or homes here increases heating costs and frost-freeze damage risk. * **Thermal Belt (Mid-Slope):** Positioned above the valley cold-air pool and below the exposed, windy ridge crest. Temperatures at night in the thermal belt can be 5°F to 15°F (2.8°C to 8.3°C) warmer than the valley floor. Ideal for home sites, sensitive crops, and orchards.

3. Drainage and Catchment Mapping

Water follows gravity perpendicular to contour lines. Mapping drainage catchments ensures effective water harvesting and prevents structural flooding.

Step-by-Step Catchment Mapping

1. **Locate the Target Point:** Identify the proposed site for a farm pond, culvert, or swale on a topographic map.
2. **Trace the Ridge Lines:** Identify the highest elevation contours surrounding the target point. Draw a boundary line along the ridge crests, connecting local peaks and saddles.

3. **Confirm Flow Paths:** Verify that all surface runoff within the drawn boundary flows toward the target point (perpendicular to contour lines).
4. **Calculate Drainage Area:** Calculate the enclosed acreage using map grid squares or digital GIS measurement tools.

Drainage Flow Classifications

- **Ephemeral Draws:** Channels that carry water only during and immediately after heavy precipitation events. Contours show subtle V-shapes.
- **Intermittent Streams:** Channels that carry water seasonally when groundwater levels are elevated. Marked on USGS quad maps as dashed blue lines.
- **Perennial Streams:** Channels that flow year-round under normal climate conditions. Marked as solid blue lines.

Farm Pond Catchment Requirements

As a general rule, farm ponds require a specific watershed area to maintain water storage without overflowing or drying out.

$$\text{Required Watershed Area (Acres)} = \text{Target Pond Surface Area (Acres)} \times \text{Regional Ratio}$$

- **Humid Regions (> 40 in / yr precipitation):** 5 to 10 acres of watershed per surface acre of pond.
- **Semi-Arid Regions (15–25 in / yr precipitation):** 20 to 35 acres of watershed per surface acre of pond.
- **Arid Regions (< 15 in / yr precipitation):** 50+ acres of watershed per surface acre of pond.

Note: Verify specific runoff coefficients and site suitability with your local USDA Natural Resources Conservation Service (NRCS) Field Office or Extension Agent.

4. Siting Infrastructure from Topographical Maps

Proper site selection balances elevation, slope, and proximity to resources.

RECOMMENDED TOPOGRAPHIC SITING	
[WIND POWER]	--> Ridge Crests (Maximum Wind Speed, High Exposure)
[HOMESTEAD / ORCHARD]	--> Mid-Slope Thermal Belt (5-10% Slope, Warm Night Air, Good Drainage, Above Frost Pockets)
[ACCESS ROAD]	--> Contoured Along 2-8% Slopes (Avoids Direct Fall Lines)

	[SEPTIC SYSTEM] --> Stable Bench (100 ft+ Buffer from Water, <15% Slope)
	[FARM POND] --> Natural Valley Draw / Keypoint (Adequate Catchment Area)
+-----+	+-----+

Siting Checklist

- **Home / Structure Siting:** Select a mid-slope bench with a 2% to 8% slope facing South or Southeast. Ensure the site sits safely above 100-year floodplains and outside steep landslide hazard zones (> 30% slope).
- **Access Roads and Driveways:** Align roads along natural contour lines at grades between 2% and 8%. Avoid long stretches exceeding 10% grade. Cross natural drainage draws at right angles using properly sized culverts.
- **Septic Drainfields:** Requires well-drained soils on slopes under 15%. Maintain minimum setback distances: 100 feet from surface water and wells, 10 feet from property lines, and 4 feet of vertical separation above seasonal high water tables or bedrock. *Check county environmental health codes for mandatory local setbacks.*
- **Gravity-Fed Water Systems:** Water pressure builds at a rate of 0.433 pounds per square inch (psi) per foot of vertical elevation drop (9.81 kPa per meter).

$$\text{Static Water Pressure (psi)} = \text{Vertical Elevation Drop (ft)} \times 0.433$$

To achieve a standard household operating pressure of 40 to 60 psi, the water storage tank must be elevated 92 to 138 feet vertically above the fixtures.

5. LiDAR and Digital Elevation Model (DEM) Sources

LiDAR (Light Detection and Ranging) provides bare-earth elevation data capable of penetrating dense forest canopy to reveal hidden micro-topography, historic erosion, property ditches, and old road beds.

Primary Free Data Sources

- **USGS 3D Elevation Program (3DEP):** Provides high-resolution bare-earth DEMs (1-meter and 1/3-arc-second resolution) across the United States. Download directly via the USGS National Map Viewer (apps.nationalmap.gov/downloader).
- **USDA NRCS Geospatial Data Gateway:** Offers elevation, soil, and land cover data filtered by state and county (datagateway.nrcs.usda.gov).
- **State & County GIS Portals:** Many state agencies (e.g., Washington Lidar Portal, Oregon DOGAMI) host direct-download 1-meter bare-earth LiDAR datasets.

Basic Processing in Open-Source QGIS

1. **Import DEM:** Open QGIS (free, open-source GIS software) and drag the downloaded `.tif` or `.dem` raster file into the canvas.
 2. **Generate Hillshade:** Navigate to `Raster > Analysis > Hillshade`. Set Azimuth (light direction) to 315° and Altitude to 45° . This highlights micro-terrain textures, old logging roads, and swales.
 3. **Generate Slope Map:** Navigate to `Raster > Analysis > Slope`. Select “Express slope as percent” to visualize steep hazard zones.
 4. **Extract Contour Lines:** Navigate to `Raster > Extraction > Contour`. Set the contour interval (e.g., 2 meters or 5 feet) to generate vector contour lines for farm layout.
-

Chapter 2: Energy Potential Assessment

Evaluating solar, wind, and micro-hydro potential before investing capital ensures realistic payback schedules and proper system sizing.

1. Solar Site Assessment Basics

Solar photovoltaic (PV) and thermal performance depend on daily solar irradiance, shading, panel orientation, and ambient temperature.

Solar Resource Metrics

Solar irradiance is measured in Peak Sun Hours (PSH). One Peak Sun Hour equals an irradiance of 1,000 Watts per square meter (W/m^2) for one hour.

Daily Energy Output (kWh) = System Capacity (kW) $\times$ Peak Sun Hours (hours/day) $\times$ Derate Factor

- **Derate Factor:** Accounts for inverter losses, wiring friction, panel soilage, and temperature losses. Use a conservative derate factor of 0.75 to 0.80.

Data Sources for Solar Potential

- **NREL PVWatts Calculator:** Interactive tool provided by the National Renewable Energy Laboratory (`pvwatts.nrel.gov`). Calculates monthly and annual kWh energy production based on address, array size, tilt, and azimuth.
- **NREL National Solar Radiation Database (NSRDB):** Provides historical solar irradiance data (GHI, DNI, DHI) for advanced system design (`nsrdb.nrel.gov`).

SUMMER TILT = Latitude - 15° (Higher sun path)

\



Siting and Tilt Angles (Northern Hemisphere)

- **Azimuth:** True South (180°) yields maximum total annual kWh production. South-Southwest (200°–220°) optimizes afternoon production to align with peak electrical loads.
- **Fixed Tilt Angles:**
 - **Year-Round Optimum:** Set tilt angle equal to site latitude (e.g., 45° tilt at 45°N latitude).
 - **Winter Optimization (Off-Grid Focus):** Set tilt to Latitude + 15° to capture low winter sun and shed snow.
 - **Summer Optimization:** Set tilt to Latitude – 15°.
- **Shading Restrictions:** Solar arrays must be free of shade from 9:00 AM to 3:00 PM solar time year-round. Use a Solar Pathfinder or mobile AR app (such as Sun Seeker) to plot the solar sky path against surrounding trees and structures.
- **Ground Mount Considerations:** Verify soil bearing capacity and frost depth. Anchors (ground screws or concrete piers) must extend below the local frost line (12 to 48+ inches depending on USDA climate zone) to prevent frost heaving.

2. Small Wind Energy Assessment Basics

Wind power increases with the cube of wind velocity. A small change in wind speed creates a dramatic change in available power output.

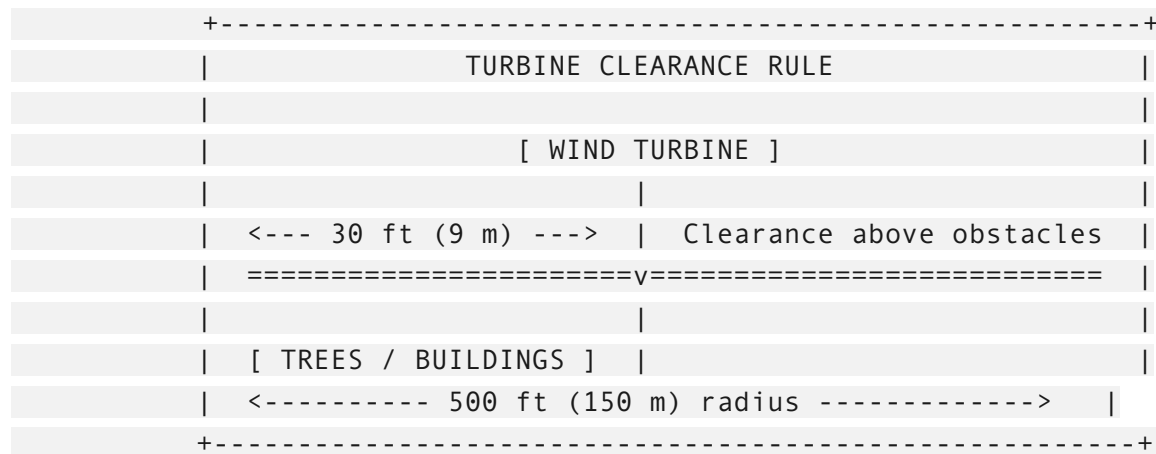
Theoretical Wind Power Equation

$$P_{\text{wind}} = \frac{1}{2} \times \rho \times A \times v^3$$

- P_{wind} = Power in Watts (W)
- ρ = Air density (standard sea level value is 1.225 kg/m³; decreases with altitude and temperature)
- A = Swept area of rotor blades in square meters ($A = \pi \times r^2$)
- v = Wind velocity in meters per second (m/s)

Key Wind Feasibility Thresholds

- **Minimum Average Wind Speed:** Small wind turbines generally require a minimum average annual wind speed of 4.5 m/s to 5.5 m/s (10 to 12 mph) at hub height to be economically viable.
- **Cut-In Wind Speed:** The minimum speed at which the turbine begins generating power, typically 3.0 m/s to 3.5 m/s (6.7 to 7.8 mph).
- **Rated Wind Speed:** The speed at which the turbine reaches maximum output, typically 10 m/s to 13 m/s (22 to 29 mph).



Wind Tower Height and Obstacle Clearance Rules

Wind speed increases with height above ground due to reduced surface friction (wind shear). * **The 30/500 Rule:** The bottom of the wind turbine rotor blades must sit at least **30 feet (9 meters) above** the top of any obstacle (trees, barns, structures) located within a **500-foot (150-meter) radius**. *

Setback Requirements: Standard zoning ordinances require tower setbacks equal to the total height of the tower plus rotor radius, plus 10% to 20% distance from property lines, inhabited structures, and overhead utility lines. *Check local county zoning codes prior to anemometer or tower placement.*

* **Data Sources:** NREL Wind Prospector (maps.nrel.gov/wind-prospector) and the Global Wind Atlas (globalwindatlas.info).

3. Micro-Hydro Assessment Basics

Micro-hydro systems (typically under 100 kW) represent one of the most reliable off-grid power sources because they generate continuous base-load power 24 hours a day, provided a suitable stream is available.

System Requirements

A viable micro-hydro site requires two fundamental variables: 1. **Head (H):** The vertical drop from the water intake (forebay/penstock inlet) down to the turbine, measured in feet or meters. 2. **Flow (Q):** The volume of water available, measured in gallons per minute (GPM) or liters per second (L/s).

Theoretical Power Calculation Formula

$$P_{\text{net (Watts)}} = \frac{Q \text{ (GPM)} \times H_{\text{net}} \text{ (ft)} \times \eta}{5.3}$$

- Q = Water flow rate in Gallons Per Minute (GPM)
- H_{net} = Net vertical head in feet (Gross Head minus pipe friction losses)
- η = Combined efficiency of turbine, generator, and drive system (typically 0.50 to 0.70, or 50% to 70%)
- 5.3 = Empirical unit conversion constant

SI Metric Equivalent Formula:

$$P_{\text{net (Watts)}} = 9.81 \times Q \text{ (L/s)} \times H_{\text{net}} \text{ (m)} \times \eta$$

Field Measuring Flow Rates

- **Container / Stopwatch Method (Small Streams, < 100 GPM):** Divert the stream flow into a container of known volume (e.g., a 5-gallon bucket) and time how long it takes to fill using a stopwatch.

$$\text{Flow (GPM)} = \left(\frac{\text{Volume (Gallons)}}{\text{Time (Seconds)}} \right) \times 60$$

- **Weir Method (Medium Streams):** Construct a temporary wooden weir plate across the stream with a 90° V-notch cut into the top edge. Measure the height of the water level upstream of the notch and reference standard Francis/Cipolletti weir tables to determine GPM.

Penstock Pipe Friction Loss and Net Head

Gross head is measured using a sight level, pressure gauge, or differential GPS. As water flows through the penstock pipe, internal surface friction reduces available pressure. * **Friction Loss Factor:** Friction losses depend on pipe inside diameter, length, flow rate, and pipe smoothness (e.g., PVC vs steel). * **Target Friction Loss:** Size the penstock pipe internal diameter so total friction loss remains below **10% to 15%** of the gross head.

Gross Head (ft)	Flow Rate (GPM)	Penstock Pipe Size (PVC)	Pipe Length (ft)	Estimated Friction Head Loss (ft)	Net Head (ft)	Net Continuous Power Output (Watts)
50 ft	30 GPM	2-inch	300 ft	2.1 ft	47.9 ft	162 W (3.8 kWh/day)
100 ft	50 GPM	2-inch	400 ft	5.8 ft	94.2 ft	533 W (12.8 kWh/day)
150 ft	100 GPM	3-inch	500 ft	4.2 ft	145.8 ft	1,650 W (39.6 kWh/day)
200 ft	200 GPM	4-inch	600 ft	6.4 ft	193.6 ft	4,383 W (105.2 kWh/day)

Calculations based on an assumed system efficiency (η) of 0.60. Verify exact friction losses using Hazen-Williams pipe tables.

Regulatory, Environmental, and Water Rights Permitting

- **Non-Consumptive Use:** Micro-hydro diversions are classified as non-consumptive because water is returned to the stream channel below the turbine.
- **Instream Flow Rules:** Regulators require a continuous minimum bypass flow in the natural stream bed to protect aquatic life.
- **Permitting Agencies:** Micro-hydro installations require permits from state agencies (e.g., State Department of Water Resources, Department of Ecology, or Fish and Wildlife Service). Self-built unpermitted diversions can incur severe fines. *Consult your state water rights office before diverting surface water.*

Chapter 3: Wildlife and Habitat Management

Active rural land ownership requires balancing wildlife habitat preservation with livestock protection and agricultural damage mitigation.

1. Assessing Habitat Components

All wildlife species require four basic habitat components arranged within accessible proximity: **Food**, **Water**, **Cover**, and **Space**.

[COVER] (Thermal, Nesting, Escape)

[FOOD]	-----+----- [WATER] (Perennial/Intermittent)
	[SPACE] (Home Range & Corridors)

Structural Habitat Diversity

- **Vertical Structure (Layers):** High-quality forest habitat contains multiple canopy strata: herbaceous ground layer, shrub understory, midstory trees, and dominant canopy trees.
- **Snags (Dead Standing Trees):** Provide critical nesting cavities, roosting sites, and foraging perches for woodpeckers, owls, bats, and insectivorous birds. **Management Target:** Retain 3 to 5 hard snags per acre greater than 12 inches Diameter at Breast Height (DBH) in forested areas where safety allows.
- **Coarse Woody Debris (CWD):** Downed logs and large branches maintain soil moisture, harbor beneficial fungi, and provide thermal cover for amphibians and small mammals. **Management Target:** Retain 2 to 4 down logs per acre greater than 10 inches in diameter and 10 feet in length.
- **Edge Effects and Ecotones:** The transition zone between two distinct habitat types (e.g., forest edge bordering a pasture) is an ecotone.
 - **Feathered Edges:** Avoid abrupt “hard” edges (e.g., dense timber directly adjacent to bare pasture). Create a 30-to-50-foot wide transitional “feathered edge” of soft shrubs, brambles, and small trees to reduce predation and thermal stress.

2. Beneficial vs. Damage-Causing Wildlife Species

Integrating wildlife into land management requires encouraging beneficial species while implementing non-lethal exclusion for destructive species.

Beneficial Species Management

+-----+-----+	
	BENEFICIAL SPECIES ROSTER
[INSECTIVOROUS BATS]	--> Consume 1,000+ flying insects/hr per bat.
	Install bat houses 15-20 ft high facing South/SE.
[RAPTORS & OWLS]	--> A Barn Owl pair consumes 1,000+ rodents per season.
	Mount owl nest boxes 15-20 ft high on poles/barns.
[NATIVE POLLINATORS]	--> Mason bees & bumblebees increase crop yields.

| Maintain bare soil patches & native flowering forage. |
+-----+

- **Insectivorous Bats:** A single Little Brown Bat (*Myotis lucifugus*) can catch 600 to 1,000 mosquito-sized insects per hour. **Action:** Mount bat houses 15 to 20 feet above ground on metal poles or building sides receiving 6+ hours of direct morning sun. Avoid mounting on trees reachable by climbing predators.
- **Raptors and Owls:** Barn Owls (*Tyto alba*) and Red-Tailed Hawks (*Buteo jamaicensis*) provide effective biological rodent control. A single pair of nesting barn owls and their brood consume over 1,000 gophers, voles, and mice per nesting season. **Action:** Erect hunting perches (15-foot T-poles) along field borders and install barn owl nest boxes inside unheated outbuildings or on 20-foot isolated poles.
- **Native Pollinators:** Native solitary bees (e.g., Mason bees, Leafcutter bees) are significantly more efficient per-bee pollinators than non-native honeybees. **Action:** Provide undisturbed bare soil patches for ground-nesting bees, leave hollow-stemmed perennials over winter, and plant native blooming plants ensuring continuous nectar from early spring to late autumn.

Agricultural Damage Management

8-FOOT WOVEN WIRE DEER FENCE SPECIFICATION	
8 ft	+-----+ Top Wire
	[] [] [] [] [] [] [] [] [] [] [] [] [] [] []
6 ft	[] [] [] [] [] [] [] [] [] [] [] [] [] [] []
	[] [] [] [] [] [] [] [] [] [] [] [] [] [] [] Fixed-Knot
4 ft	[] [] [] [] [] [] [] [] [] [] [] [] [] [] [] High-Tensile Wire
	[] [] [] [] [] [] [] [] [] [] [] [] [] [] []
2 ft	[] [] [] [] [] [] [] [] [] [] [] [] [] [] []
	[] [] [] [] [] [] [] [] [] [] [] [] [] [] []
0 ft	===== Ground Line

Species	Primary Agricultural Damage	Damage Threshold / Indicators	Integrated Mitigation Controls
Ungulates (Deer, Elk)	Browsing fruit trees, crop damage, buck rubbing on nursery stock.	Terminal leader browsing higher than 2.5 ft; sharp clean diagonal bites on twigs.	8-foot fixed-knot woven wire perimeter fence; rigid plastic mesh tree guards (24–36 in height); non-lethal repellant sprays.
Feral Hogs (<i>Sus scrofa</i>)	Soil rooting, pasture destruction, pond bank degradation, disease transmission.	Deeply plowed, upturned sod across pastures; wallows along water edges.	Heavy-duty 34-inch steel hog panels topped with barbed wire; continuous trapping programs; night control where legal.

Species	Primary Agricultural Damage	Damage Threshold / Indicators	Integrated Mitigation Controls
Voles (<i>Microtus spp.</i>)	Girdling young fruit tree roots and bark beneath snowpack.	Gnawed bark at or below soil surface; shallow surface runways in grass.	Maintain 3-foot vegetation-free bare dirt rings around tree trunks; install 1/4-inch hardware cloth trunk guards sunk 2 inches into soil.
Pocket Gophers (<i>Geomyidae</i>)	Root pruning, irrigation ditch blowout, machinery damage from dirt mounds.	Crescent-shaped dirt mounds with plugged side-entrance holes.	Deep subsoiler root pruning at orchard borders; mechanical trapping; encouraging barn owl population density.

3. Wildlife Corridors and Fencing Specifications

Unplanned fencing fragments wildlife habitat, blocks seasonal migrations, and causes high animal mortality through leg entanglement.

Identifying Movement Corridors

- **Riparian Buffers:** Streamside vegetation corridors serve as primary wildlife movement highways across agricultural landscapes. Maintain a minimum 50-to-100-foot vegetated buffer on both sides of stream channels.
- **Ridge Lines and Draws:** Animals select paths of least energy expenditure. Saddles, ridgelines, and vegetated draws are high-volume travel paths.

WILDLIFE-FRIENDLY FENCE SPECIFICATIONS			
42 in Max	+-----	+	Smooth or Barbed Top Wire
12 in Min		Gap prevents leg entanglement when jumping	
30 in	+-----	+	Barbed Middle Wire
18 in Min	+-----	+	SMOOTH Bottom Wire
0 in	=====		Ground Surface
	<----- Allows fawns, calves & pronghorn to crawl ----->		

Wildlife-Friendly Fencing Guidelines

Standard 5-strand barbed wire fences trap jumping deer and scrape the backs of crawling pronghorn or fawns. Modern wildlife-friendly fence standards allow livestock containment while permitting safe wildlife passage.

- **Maximum Top Wire Height: 38 to 42 inches** above the ground. Lower top-wire height prevents deer and elk legs from tangling when jumping.
- **Minimum Top-to-Second Wire Gap:** At least **12 inches** of vertical space between the top wire and the wire immediately below it. This prevents leg entrapment when animals swing their hind legs over the fence.
- **Minimum Bottom Wire Height:** At least **16 to 18 inches** above the ground surface.
- **Smooth Bottom Wire:** The bottom wire must be **smooth galvanized wire** (no barbs). Pronghorn, fawns, and small mammals crawl under fences rather than jumping over them; smooth bottom wire prevents severe back skin lacerations.

Reference: Specifications adapted from USDA NRCS Fence Standard 382 and state Department of Fish and Wildlife land management guidelines.

Chapter 4: Fire History and Wildfire Risk Assessment

Understanding historical fire regimes, mapping local burn histories, and establishing engineered defensible space reduces structural ignition risks during wildland fire events.

1. Wildland Fire Regimes and Ecology

Wildfire severity depends on historical fire frequency, vegetation fuel types, local topography, and ambient weather.

Fire Return Intervals (FRI) and Severity Classes

- **Frequent, Low-Severity Regime (FRI 1 to 15 Years):** Typical of dry ponderosa pine, oak woodlands, and longleaf pine forests. Low-intensity surface fires burn light grass and pine needle litter, clearing understory brush while leaving mature thick-barked trees unharmed. Fire suppression in these zones creates dangerous fuel accumulation.
- **Mixed-Severity Regime (FRI 30 to 100 Years):** Typical of mixed-conifer forests. Features a combination of low-intensity surface fires and localized high-intensity crown fires depending on topography and drought conditions.
- **Infrequent, High-Severity Stand-Replacing Regime (FRI 100 to 300+ Years):** Typical of subalpine fir, lodgepole pine, and coastal Douglas-fir forests. Fires occur under extreme wind and drought conditions, killing entire forest stands over massive acreage.

Fuel Hour Classifications

Wildland fuels are categorized by how rapidly their internal moisture content responds to changes in atmospheric relative humidity.

Fuel Class	Size / Diameter Range	Typical Fuel Types	Environmental Sensitivity
1-Hour Fuels	Up to 1/4 inch diameter	Dead grass, pine needles, dry leaves.	Ignites rapidly; responds to hourly changes in relative humidity. Key driver of fire spread rate.
10-Hour Fuels	1/4 inch to 1 inch diameter	Small twigs, brush stems.	Responds to daily humidity cycles.
100-Hour Fuels	1 inch to 3 inches diameter	Dead branches, small fallen limbs.	Responds to multi-day wet/dry weather cycles.
1000-Hour Fuels	3 inches to 8 inches diameter	Heavy logs, large downed timber.	Responds to seasonal drought; burns intensely with high heat release.

2. Defensible Space and Home Ignition Zones (HIZ)

Creating defensible space around structures reduces radiant heat exposure and prevents windborne embers from igniting the home.

+-----	
	HOME IGNITION ZONES (HIZ)
	[ZONE 0: 0-5 ft] --> Non-Combustible Zone (Gravel, pavers, zero woody vegetation)
	[ZONE 1: 5-30 ft] --> Lean, Clean & Green (Mowed lawn, isolated tree canopies)
	[ZONE 2: 30-100 ft] --> Reduced Fuel Zone (Tree canopy spacing 12+ ft, limbed up)
	[ZONE 3: 100-200+ ft] --> Extended Management Zone (Thinning brush on steep slopes)
+-----	

Defensible Space Zone Specifications

Zone 0: The Non-Combustible Ember-Resistant Zone (0 to 5 Feet)

- **Objective:** Eliminate any combustible materials directly adjacent to home walls, decks, and under eaves where windborne embers land.
- **Requirements:** Install crushed stone, gravel, or concrete pavers instead of bark mulch. Remove all dead leaves, pine needles, and firewood stacks. Do not plant woody shrubs directly under windows or eaves. Ensure metal gutters are cleared of organic debris.

Zone 1: The Lean, Clean, and Green Zone (5 to 30 Feet)

- **Objective:** Prevent direct flame contact and high radiant heat flux against the structure.
- **Requirements:** Keep lawns mowed to a maximum height of 4 inches. Single trees must be pruned to maintain at least **18 feet of horizontal clearance** between mature canopy edges. Remove ladder fuels (shrubs under tree canopies).

Zone 2: The Reduced Fuel Zone (30 to 100 Feet)

- **Objective:** Break up continuous fuel continuity to force crown fires down to the ground as lower-intensity surface fires.
- **Requirements:** Maintain a minimum of **12 feet between individual tree canopies** or small clusters of trees. Prune lower tree branches up **6 to 10 feet from the ground** (or no more than 1/3 of the total tree height for young trees) to eliminate ladder fuels.

Zone 3: Extended Management Zone (100 to 200 + Feet)

- **Objective:** Disrupt heavy wildland fuel loads on properties bordering dense timber or steep terrain.

Slope Adjustment Multipliers for Defensible Space

Fire spreads significantly faster uphill because flames lean toward the slope, preheating fuels above them. Increase Zone 2 and Zone 3 distances on sloping ground.

$$\text{Adjusted Distance} = \text{Flat Distance (100 ft)} \times \text{Slope Multiplier}$$

Slope (%)	Slope Angle	Defensible Space Multiplier	Required Zone 2/3 Distance
0% to 10%	0° to 5.7°	1.0×	100 feet
10% to 20%	5.7° to 11.3°	1.5×	150 feet
20% to 40%	11.3° to 21.8°	2.0×	200 feet
>40%	>21.8°	3.0×	300 feet

Reference: Standards derived from NFPA 1144 (Standard for Reducing Structure Ignition Hazards from Wildland Fire) and Firewise USA guidelines.

3. Mapping Past Burns and Wildfire History

Historical burn maps reveal localized fire corridors, vegetation recovery stages, and post-fire erosion hazards.

Free Online Data Sources

- **USGS Monitoring Trends in Burn Severity (MTBS):** Provides historic perimeter maps and burn severity rasters (1984–present) for all fires across the US greater than 1,000 acres in the west or 500 acres in the east (mtbs.gov).
- **WFIGS (Wildland Fire Interagency Geospatial Services):** Offers active and historical wildfire perimeter GIS shapefiles (data-nifc.opendata.arcgis.com).
- **NASA FIRMS (Fire Information for Resource Management System):** Displays near-real-time satellite thermal detections (MODIS and VIIRS) for active fire monitoring (firms.modaps.eosdis.nasa.gov).

Evaluating Post-Fire Hazards

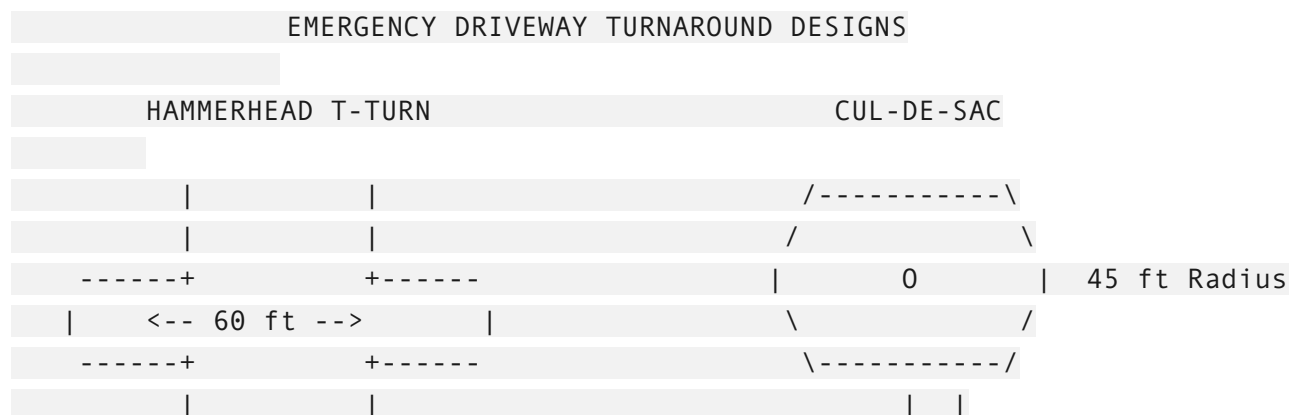
- **Soil Hydrophobicity:** Severe wildland fires burn surface organic layers and volatilize plant resins, which drive down into the soil profile and condense into a waxy, water-repellent layer 1 to 2 inches below the surface. Test soil by dropping clean water onto bare soil; if water beads for longer than 10 to 60 seconds without absorbing, the soil is hydrophobic.
- **Post-Fire Flash Flood and Debris Flow Risk:** Hydrophobic soils cannot absorb rainfall, increasing peak surface runoff rates by 10 × to 100×. Properties located in valley bottoms below high-severity burn scars face severe debris flow risks during intense storm events for 2 to 5 years post-fire.

4. Wildland-Urban Interface (WUI) Infrastructure Requirements

Building in WUI hazard zones requires hardened structural materials, dedicated emergency water supplies, and adequate emergency vehicle access.

Emergency Road and Driveway Access Standards

Structure access roads must accommodate heavy fire apparatus (water tenders and type-1 engines).



	Driveway		

- **Minimum Clear Width:** **12 to 14 feet** unencumbered width for single-lane driveways; **20 feet** for two-way access roads.
- **Vertical Clearance:** Minimum **13.5 feet** cleared of overhanging tree branches.
- **Maximum Road Grade:** Maximum continuous grade of **10% to 12%**. Short pitches up to 15% may be permitted if paved. *Verify local fire district apparatus grade limits.*
- **Apparatus Turnarounds:** Driveways exceeding 150 feet in length must provide an approved turnaround within 50 feet of the primary structure:
 - **Hammerhead T:** Minimum 60-foot crossbar length.
 - **Cul-de-Sac:** Minimum 45-foot radius turning circle.

Water Supply for Fire Suppression

Rural properties outside municipal water networks require dedicated static water storage for fire protection. * **Minimum Dedicated Volume:** 2,500 to 10,000 gallons of dedicated emergency water storage (separate from domestic consumption). * **Fire Hose Outlets:** Tanks must feature a **4.5-inch NH (National Hose)** male threaded outlet or a **2.5-inch NH** draft connection with a Storz quick-connect fitting compatible with the local rural fire department's suction hoses. Locate the connection within 150 feet of the main driveway for engine access.

Structure Hardening Checklist

- **Roofing:** Install Class A fire-rated roofing materials exclusively (e.g., metal standing seam, concrete tile, heavy asphalt composition shingle). Eliminate open wood shakes.
- **Siding:** Non-combustible fiber-cement lap siding, masonry, stucco, or heavy timber.
- **Vents:** Cover all soffit, attic, gable, and crawlspace vents with **1/8-inch (3.2 mm) corrosion-resistant metal mesh screen**. Standard 1/4-inch mesh allows windblown embers to penetrate into attic spaces.
- **Glazing:** Install dual-pane windows with at least one pane of **tempered glass**. Tempered glass resists thermal shock and prevents window failure during high radiant heat exposure.

Disclaimer: The guidance, dimensions, and equations provided in this chapter serve as general site-assessment principles. Specific building codes, fire safety mandates, water rights, and environmental regulations vary by state, county, and local jurisdiction. Always consult your local County Building Department, NRCS Field Office, State Department of Forestry, or Local Fire District prior to site development or capital expenditure.

Part III - Regulatory, Infrastructure, and the Parcel Workbook

This section group provides the technical frameworks, infrastructure assessment standards, parcel profiling templates, and year-one execution roadmap required to evaluate and manage rural land. All legal requirements, zoning codes, utility connections, and environmental thresholds detailed here must be verified against your local governing jurisdiction, county planning department, or state natural resource agency.

Chapter 1: Regulatory and Legal Frameworks

Land usability is governed by legal boundaries, public land use codes, private deed restrictions, and water and mineral rights. Before making capital investments in clearing, road building, or construction, a landowner must audit the legal and regulatory constraints attached to the parcel.

Zoning and Permitting Basics

Local zoning ordinances dictate how land can be used, the density of structures permitted, minimum lot sizes, and animal stocking limits.

Common Rural Zoning Classifications

- **Agricultural (A-1, A-2, EFU - Exclusive Farm Use):** Designed to preserve agricultural production. Primary uses include farming, livestock grazing, timber management, and single-family dwellings directly tied to farm management. Minimum parcel sizes frequently range from 5 to 80+ acres.
- **Rural Residential (RR-1, RR-5):** Designed for low-density residential development with limited agricultural activity (e.g., small livestock operations, gardens). Minimum lot sizes typically range from 1 to 5 acres.
- **Forestry / Resource Management (F-1, F-2):** Intended for commercial timber production, watershed protection, and wildlife habitat. Residential construction is often strictly regulated or requires demonstrating active forest management.

Allowed Uses vs. Conditional Uses

- **Uses Permitted by Right:** Activities authorized directly by the zoning code without public hearings or discretionary approvals (e.g., standard crop cultivation, barn construction adhering to setbacks).

- **Conditional Use Permits (CUP):** Uses permitted only after formal review by the county planning commission. Examples include commercial agritourism, farm-stand retail operations, food processing facilities, or secondary dwellings. CUP processes require public notices to neighboring landowners, formal site plans, and compliance hearings.

Setbacks and Environmental Buffers

Structure placement is restricted by mandatory distance buffers from property lines, rights-of-way, and environmental features: - **Property Line Setbacks:** Front setbacks typically range from 20 to 100 feet from public road rights-of-way. Side and rear setbacks range from 10 to 50 feet. - **Stream and Riparian Buffers:** Setbacks from waterbodies prevent erosion and protect water quality. Non-fish-bearing seasonal streams usually require a 25 to 50 foot vegetated buffer. Perennial fish-bearing streams, wetlands, and rivers frequently require 100 to 200+ foot structural setbacks under state forest practices or environmental protection standards.

Building Codes and Agricultural Exemptions

- **International Residential Code (IRC):** Governs residential dwellings, requiring full compliance with structural framing, electrical, plumbing, insulation, and egress codes.
- **Agricultural Exemptions:** Many rural counties offer building permit exemptions for structures dedicated exclusively to agricultural storage, equipment housing, or livestock shelter (barns, pole buildings, shade structures). Exempt structures cannot be used for human habitation or commercial public access. Exemption requires filing an affidavit with the county building department prior to construction.

County Verification Workflow

1. Obtain your Assessor Parcel Number (APN) or Tax Lot ID from the county tax assessor website.
2. Request an official Zoning Verification Letter from the county planning department confirming permitted uses, minimum lot sizes, and active overlays.
3. Review the County Land Use Code (LUC) for specific performance standards regarding noise, runoff, setback lines, and temporary structures.

+-----+	
	COUNTY REGULATORY VERIFICATION
+-----+	
	Step 1: Pull APN & Plat Map -----> County Assessor / GIS Portal
	Step 2: Obtain Zoning Letter -----> County Planning & Zoning Department
	Step 3: Verify Setbacks & Buffers ----> County Land Use Code & GIS Layers
	Step 4: Confirm Ag Permit Exemptions -> County Building Department
+-----+	

Easements, Rights-of-Way, and Encumbrances

An encumbrance is any legal right or interest held by a third party that limits the land owner's use or title.

Common Types of Easements

- **Appurtenant Ingress/Egress Easements:** Grants a neighboring landlocked parcel the legal right to cross your property for access. The easement document specifies width (typically 20 to 60 feet), location, maintenance responsibilities, and allowed uses.
- **Utility Easements:** Granted to power companies, water districts, or telecommunications providers. These grant the utility the right to install, inspect, and maintain infrastructure across a defined corridor (typically 15 to 50 feet wide). Trees and permanent structures are prohibited within utility easement corridors.
- **Conservation Easements:** Voluntary, legally binding agreements between a landowner and a land trust or government agency. They restrict development, subdivision, or commercial timber harvest in perpetuity to protect ecological values, often in exchange for property tax reductions or income tax deductions.

Unrecorded Access and Prescriptive Rights

- **Prescriptive Easements:** Created when a third party uses a specific path or road across a parcel without explicit permission, but openly, continuously, and adversely for a statutory period (typically 7 to 20 years depending on state law).
- **Adverse Possession:** A legal doctrine where continuous, open, exclusive, and hostile occupation of land can result in a title transfer for the occupied portion.

Encumbrance Audit Checklist

- Obtain a Preliminary Title Report during land acquisition and review Schedule B-II (Exceptions from Coverage).
- Review recorded survey plats at the County Clerk or Auditor office.
- Conduct a physical perimeter walk to identify unrecorded roads, fence lines offset from boundaries, utility lines, or neighboring encroachments.

Water Rights and Mineral Rights

Title to surface land does not automatically grant unrestricted rights to the water flowing across it or the minerals underneath it.

Water Rights Doctrines in the United States

- **Riparian Doctrine (Common in Eastern US):** Landowners whose property touches a natural waterbody have a right to make reasonable use of the water, provided it does not unreasonably interfere with downstream users. Water rights cannot be sold separately from the land.
- **Prior Appropriation Doctrine (Common in Western US):** Governed by the rule “first in time, first in right”. Water rights are allocated based on historic priority dates and are separate from land ownership. Senior rights holders have priority over junior holders during droughts. Water must be put to continuous beneficial use (irrigation, stock watering, domestic use); failure to use the water over a statutory period (typically 5 consecutive years) can lead to forfeiture.

Groundwater and Domestic Well Exemptions

- **Permitted Wells:** Commercial irrigation or high-capacity wells require formal water right applications, pump testing, hydrologic impact studies, and meter reporting.
- **Exempt Wells:** Most western states permit small-scale groundwater extraction without a formal water right permit for domestic home use, non-commercial gardens (typically up to 1/2 acre), and livestock watering. Allowed flow rates are usually capped at 15 gallons per minute (GPM) or daily volume limits (e.g., 5,000 gallons per day). Verify exact thresholds with your state Department of Water Resources or Ecology.

Surface Water Diversions

Direct pumping from rivers, streams, or ponds requires a state water right certificate or permit. Unpermitted surface diversion is illegal in prior appropriation states, even if the stream originates on your property.

Severed Mineral Rights (Split Estate)

- **Fee Simple Title:** Includes ownership of both the surface rights and sub-surface mineral rights (oil, gas, gravel, metals, coal).
- **Split Estate:** The mineral rights have been severed from the surface estate by a prior deed reservation.
- **Dominant Estate Rule:** In most US legal jurisdictions, the mineral estate is legally dominant over the surface estate. The mineral owner (or lessee) has the legal right to use as much of the surface as is reasonably necessary to extract minerals, including building access roads, drill pads, and pipelines, unless limited by a surface use agreement or state split-estate statutes.

Water and Mineral Verification Workflow

1. Search your state Department of Water Resources or State Engineer online database by section, township, and range for registered water rights and well construction logs.
2. Audit deed history for mineral reservations (“reserving unto grantor all mineral rights”).

3. Search the BLM Mineral and Land Records System (MLRS) for active federal mining claims or energy leases adjacent to or on your parcel.

Key Free Regulatory Data Sources

Source / Agency	Platform / Tool	Primary Use	Data Provided
County Assessor / GIS	County Interactive Web Mapping	Parcel Boundary Audit	APN, parcel acreage, zoning designation, tax assessment history
State Water Resources Dept	State Water Rights & Well Log Database	Water Right Verification	Well depth, static water level, yield (GPM), permit priority dates
BLM	Mineral & Land Records System (MLRS)	Mineral Rights Search	Federal land status, active mining claims, oil/gas leases
USDA NRCS	Web Soil Survey (WSS)	Land Capability Assessment	Soil suitability for septic fields, building foundations, ag capability class
FEMA	Flood Map Service Center (MSC)	Flood Risk Evaluation	FIRM panel maps, 100-year flood zone (Base Flood Elevation) boundaries

Chapter 2: Infrastructure Assessment

Infrastructure provides the physical systems required to live on and operate a parcel: access roads, power grid or off-grid generation, water supply, fencing, and outbuildings. Evaluating existing infrastructure or estimating new installation costs prevents severe budget overruns.

Access and Road Construction

Legal access must be accompanied by physical, drivable access capable of handling passenger vehicles, delivery trucks, and emergency equipment.

Road Specifications and Surface Types

- **Dirt / Native Material:** Lowest initial cost. Suitable only for low-gradient paths (<5% slope) and dry seasonal access. Highly vulnerable to rutting, erosion, and mud during wet periods.

- **Gravel / Crushed Aggregate:** Standard for rural driveways and access roads. Constructed with a cleared subgrade, geotextile subgrade fabric, a 4 to 6 inch compacted base of 1.5-inch minus crushed rock, and a 2 to 3 inch top course of 3/4-inch minus crushed aggregate.
- **Paved / Asphalt:** High installation cost (\$25 to \$50+ per linear foot). Necessary for steep slopes (>10% grade) to prevent washout, or heavy traffic corridors.

+-----+ CROSS-SECTION: RURAL GRAVEL ROAD +-----+	
(2-4% Crown Slope)	
___/=====___	<- 2-3" Top Course (3/4" Minus Crushed Rock)
___/===== ___	<- 4-6" Base Course (1.5" Minus Crushed Rock)
=/=====\=	<- Heavy-Duty Woven Geotextile Fabric
=====	<- Compacted Native Subgrade
[Side Ditch] [Side Ditch]	
+-----+	

Road Geometry and Drainage Standards

- **Width:** Minimum 12 feet for single-lane driveways with 14-foot overhead clearance. Turnouts (minimum 10 feet wide by 30 feet long) should be placed every 400 to 500 feet. Fire district standards frequently require 16 to 20 foot clear widths.
- **Maximum Grade:** Driveway grades should not exceed 10% for extended runs. Short pitches up to 12% to 15% are allowable if paved or constructed with heavy rock, but pose challenges for two-wheel-drive vehicles and emergency vehicles.
- **Road Crown and Ditches:** Roads must be crowned with a 2% to 4% slope from center to shoulder to shed water. Roadside ditches must convey runoff to natural drainages or relief culverts.

Culverts and Stream Crossings

- **Culvert Sizing:** Minimum 12 to 18 inch diameter corrugated metal pipe (CMP) or dual-wall high-density polyethylene (HDPE) pipe for simple driveway ditch crossings.
- **Installation Slope:** Culverts should match the natural ditch grade (minimum 1% to 2% slope) and extend at least 1 to 2 feet beyond the road fill slope on both ends.
- **Armoring:** Culvert inlets and outlets require rock riprap (6 to 12 inch stone) to prevent headcutting and outlet scour.
- **Stream Crossings:** Permanent stream crossings require calculating peak 100-year storm flows. Fish-bearing streams require bottomless arch culverts or bridges engineered to maintain natural stream velocity and bed material under state Department of Fish and Wildlife guidelines.

Power Systems (Grid vs. Off-Grid)

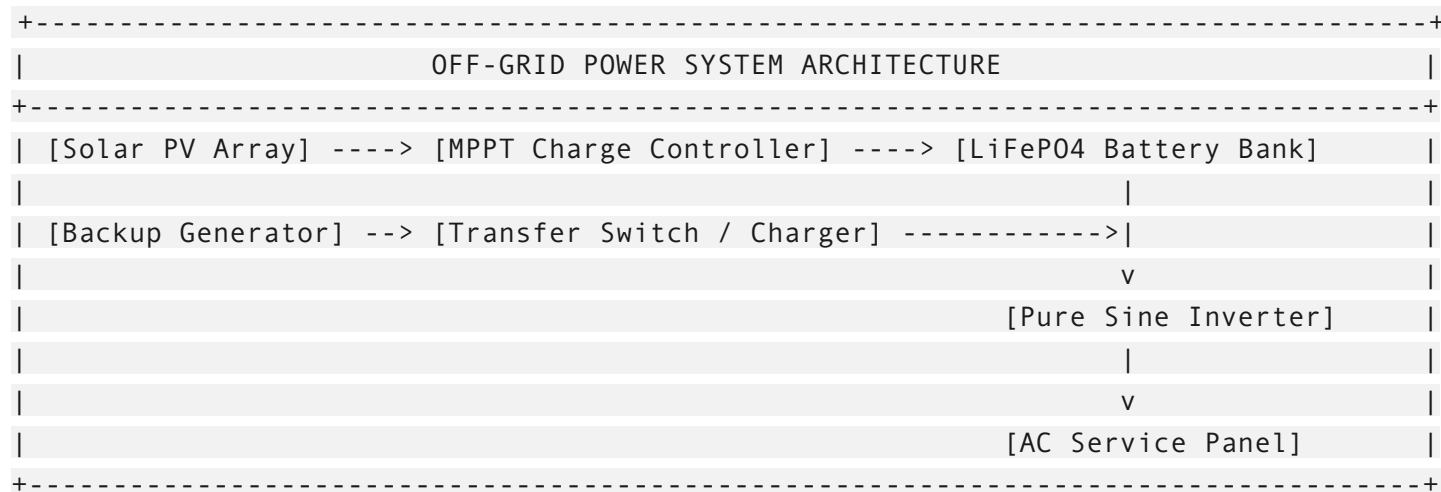
Providing electricity requires evaluating the distance to existing utility distribution lines versus the capital cost and maintenance of an independent renewable power system.

Grid Interconnection Evaluation

- **Overhead Line Extension:** Cost ranges from \$10 to \$30+ per linear foot depending on terrain, tree clearing requirements, and soil/rock conditions.
- **Underground Line Extension:** Cost ranges from \$15 to \$45+ per linear foot. Requires trenching to depth (typically 36 to 48 inches) and placing conduit. Preferred in high-wind or wildfire-prone zones.
- **Transformer Drops:** Utility companies require a step-down transformer near the point of service (pad-mounted or pole-mounted), costing \$2,000 to \$5,000+.
- **Utility Rights-of-Way:** Utility providers require a signed easement granting a 20 to 50 foot cleared corridor along the power line route.

Off-Grid Solar Photovoltaic (PV) Sizing

Off-grid solar systems must be sized to meet daily kilowatt-hour (kWh) consumption and peak surge loads during winter months with lowest solar irradiance.



- **Daily Energy Audit:** Sum the watt-hours of all planned appliances. An energy-efficient homestead typically consumes 5 to 15 kWh per day (compared to the US national single-family average of ~29 kWh/day).

- **Array Sizing Formula:**

$$\text{Array Size (kW)} = \frac{\text{Daily kWh Consumption}}{\text{Regional Peak Sun Hours}} \times 0.75 \times \text{System Efficiency}$$

Example: For 10 kWh/day in a zone with 4.0 peak sun hours/day:

$$10/(4.0 \times 0.75) = 3.33 \text{ kW PV Array}$$

- **Battery Storage Capacity:** Lithium Iron Phosphate (LiFePO₄) is the current industry standard due to long cycle life (3,000 to 5,000+ cycles at 80% Depth of Discharge). Battery banks should provide 2 to 3 days of autonomy without solar input. *Example:* For 10 kWh daily use with 2 days autonomy:

$$\text{Required Storage} = 20 \text{ kWh usable capacity}$$

- **Inverter Sizing:** Inverters must be sized to handle total simultaneous continuous AC wattage plus surge starting watts for inductive motors (well pumps, air compressors, refrigerators). Well pumps frequently require a 4,000 to 6,000 watt surge.
 - **Backup Generator Integration:** An automated diesel or propane backup generator is required to recharge battery banks during extended periods of snow, fog, or heavy cloud cover.
-

Water Systems (Wells, Springs, Catchment)

Securing clean, high-yield water is a primary condition for land settlement and agricultural production.

Drilled Groundwater Wells

- **Drilling Costs:** Drilling costs range from \$35 to \$75+ per foot, including steel or PVC casing. Total turn-key well installation (drilling, casing, drive shoe, screen, submersible pump, pressure tank, wiring, and sanitary seal) typically costs between \$8,000 and \$25,000+ depending on depth.
- **Yield Thresholds:**
 - *Minimal Domestic:* 3 to 5 GPM continuous yield handles single-family household needs.
 - *Low-Yield Solutions:* Wells producing 1 to 2 GPM require a intermediate storage system (1,000 to 3,000 gallon atmospheric storage tank) with a secondary booster pump to handle peak household demand.
 - *Agricultural / Commercial:* 10 to 50+ GPM required for market livestock, orchard, or field irrigation without extensive storage reservoirs.
- **Sanitary Requirements:** Wells must be set back at least 50 feet from septic tanks, 100 feet from septic drainfields, and 100+ feet from livestock confinement pens.

Developed Springs

- **Spring Box Construction:** Captures natural groundwater daylighting on slopes. Constructed using a reinforced concrete or food-grade polyethylene enclosure sunk into the water-bearing gravel layer, sealed against surface water intrusion with puddled clay or bentonite.
- **Flow Monitoring:** Spring output varies dramatically between spring snowmelt and late-summer drought. Measure flow rate at the end of dry season (August/September) before relying on a spring as a sole water source.

Rainwater Harvesting Systems

- **Harvesting Yield Formula:**

$$\text{Annual Yield (Gal)} = \text{Annual Rainfall (Inches)} \times \text{Roof Footprint (Sq Ft)} \times 0.623 \times \text{Efficiency} \\ (0.85-0.90)$$

Example: 30 inches of annual rain on a 2,000 sq ft roof yields:

$$30 \times 2000 \times 0.623 \times 0.85 = 31,773 \text{ Gallons/Year}$$

- **Components:** Roof catchment surfaces (pre-painted metal preferred; avoid asphalt shingle for drinking water), leaf diverters, first-flush diverters (10 gallons per 1,000 sq ft of roof area), food-grade storage cisterns, and a multi-stage filtration system (5-micron sediment filter + activated carbon block + UV disinfection system for potable use).

Fencing and Boundary Enclosures

Fencing controls livestock movement, marks legal boundaries, and protects crops from wildlife depredation.

Fencing Options Comparison

Fence Type	Typical Post Spacing	Primary Application	Advantages	Limitations
Woven Wire (Field Fence)	8 to 12 feet	Sheep, goats, pigs, calves, perimeter security	Excellent containment; predator deterrence	High materials cost; labor intensive installation
High-Tensile Electric	15 to 30 feet	Cattle, rotational grazing paddocks	Low cost; fast installation; long service life	Requires continuous energizer power; requires regular weed clearing
Barbed Wire (4-5 Strand)	10 to 14 feet	Cattle range pasture	Traditional standard; durable in brush/timber	Unsafe for horses; ineffective for small livestock
Fixed-Knot High Game	12 to 20 feet	Deer/elk exclusion (8 ft height)	Maximum exclusion protection for orchards/gardens	Very high initial cost; requires heavy corner bracing

Corner Assembly Standards (H-Braces)

The structural integrity of any wire fence depends entirely on the corner and end brace assemblies. - **H-Brace Construction:** Consists of two 8-inch diameter pressure-treated wooden posts set at least 3.5 to 4 feet into undisturbed ground, spaced 2 times the height of the fence apart. - **Cross Member:**

A 4-inch diameter horizontal post connected between the two upright posts. - **Diagonal Tension Wire:** A high-tensile wire looped diagonally from the top of the inner post to the bottom of the corner post, twisted tight with an in-line strainer or twitch stick.

Building and Structure Assessment

Evaluating existing rural outbuildings, barns, and residential structures determines whether to repair, retrofit, or demolish.

Structural Inspection Checklist

- **Foundations:** Inspect for vertical or diagonal settling cracks wider than 1/4 inch, spalling concrete, or unreinforced fieldstone foundation failure.
 - **Structural Framing:** Check sill plates for wood rot, subterranean termite damage, or carpenter ant infestation using an awl. Inspect roof rafters and trusses for sagging or broken webbing.
 - **Roof Covering:** Metal roofs require checking washer seal integrity on exposed screws (washers degrade after 15 to 20 years). Asphalt shingle roofs require inspecting for granule loss, curling, or missing shingles.
 - **Hazardous Materials:** Structures built prior to 1978 frequently contain lead-based paint. Buildings constructed prior to 1980 often contain asbestos siding, pipe insulation, or floor tiles. Refurbishment or demolition must comply with EPA and state environmental containment regulations.
-

Key Free Infrastructure Data Sources

Source / Agency	Platform / Tool	Primary Use	Data Provided
NREL	PVWatts Calculator	Solar Power Sizing	Solar radiation, monthly kWh generation estimates by tilt/azimuth
USGS / State Agencies	NWIS & State Well Logs	Water Well Research	Depth, static water levels, geology, and flow rates of nearby wells
NOAA / NCEI	Climate Data Online (CDO)	Rain Catchment Sizing	Historical precipitation averages, monthly normals, extreme weather data
USDA NRCS	Web Soil Survey	Excavation & Roads	Soil engineering properties, frost action, road subgrade suitability

Chapter 3: The Parcel Profile Workbook

This workbook is a structured template for recording critical legal, physical, and environmental metrics for your property. Complete each table using verified data from county records, physical field measurements, and official mapping tools.

1. General Parcel Identification

Field	Parcel Record Data	Verification Source
Property Name / Identifier		Owner record
Assessor Parcel Number (APN)		County Assessor Tax Bill
Physical Address		County 911 Addressing / Post Office
County / State		Public record
Total Parcel Acreage		Recorded Deed / Survey Plat
Zoning Classification Code		County Planning Verification Letter
Latitude / Longitude		GPS / Google Earth / USGS Mapping
Fire Protection District		County Tax Code Area
School District		County Tax Record

2. Boundary and Title Audit

Audit Item	Status / Record Details	Action Required / Notes
Survey Monuments Located	☐ Yes ☐ No ☐ Partial	Locate and flag all corner pins
Date of Last Recorded Survey		Obtain copy from County Auditor
Surveyor Name & License #		Recorded on survey map
Ingress/Egress Easements	☐ Present ☐ None	Review width, maintenance clauses
Utility Easements	☐ Present ☐ None	Map width and restricted corridors
Conservation Easements	☐ Present ☐ None	Review restricted land use clauses
Mineral Rights Ownership	☐ Intact ☐ Severed	Review deed reservation language
Water Rights Registered	☐ Yes ☐ No	Note permit # and priority date
Title Policy Number		Keep in legal file

3. Zoning and Regulatory Matrix

Parameter	County / State Standard	Parcel Specific Notes
Front Property Line Setback		Feet from right-of-way
Side Property Line Setback		Feet from boundary
Rear Property Line Setback		Feet from boundary
Surface Water Setback Buffer		Feet from stream/wetland edge
Max Building Height Limit		Feet above finished grade
Ag Permit Exemption Threshold		Max square footage without permit
Allowed Livestock Units		Animal units per acre limit
Septic System Requirements		System type approved for site

4. Topography, Soil, and Hazard Profile

Environmental Metric	Observed / Dataset Value	Primary Source
Dominant Soil Map Units		USDA Web Soil Survey
Soil Texture & Drainage Class		USDA Web Soil Survey
Agricultural Capability Class		USDA Web Soil Survey (Class I-VIII)
Elevation Range (Min / Max)		USGS Topographic Map
Slope Percentage Range		GIS Slope Layer / Inclinator
FEMA Flood Zone Designation		FEMA Flood Map Panel #
National Wetlands Inventory (NWI)	☐ Present ☐ None	NWI Mapper / Field Observation
Wildfire Hazard Risk Level		State Forestry / Local Fire Dept

5. Water and Utility Inventory

Water Source Log

- **Primary Source Type:** ☐ Drilled Well ☐ Spring ☐ Rainwater ☐ Surface Diversion
- **Well Depth:** _____ Feet
- **Casing Diameter:** _____ Inches
- **Static Water Level:** _____ Feet below ground level
- **Tested Flow Rate:** _____ Gallons Per Minute (GPM)

• **Water Test Metrics:**

- pH Level: _____
- Total Dissolved Solids (TDS): _____ ppm
- Nitrate Level: _____ mg/L
- Coliform Bacteria: [] Present [] Absent

Electric Power Log

- **System Type:** [] Grid Connected [] Off-Grid Solar [] Hybrid
- **Utility Provider Name:** _____
- **Nearest Transformer Pole #:** _____
- **Off-Grid Array Capacity:** _____ kW (PV)
- **Battery Storage Capacity:** _____ kWh (LiFePO4 / Lead Acid)
- **Backup Generator Specs:** _____ kW (Fuel Type: _____)

6. Existing Infrastructure and Structures Log

Structure / Asset	Dimensions / Spec	Condition Rating (1-5)	Primary Repairs Needed
Primary Access Road	Feet long / Gravel		
Drainage Culverts	Count: ____ / Dia: ____"		
Perimeter Fencing	Feet long / Type: ____		
Barn / Outbuilding 1	Sq Ft / Pole Barn		
Outbuilding 2	Sq Ft / Storage Shed		
Septic Tank & Drainfield	Gallons / Tank type		

Chapter 4: Year-One Action Plan

The first year of land ownership should focus on baseline data gathering, legal verification, securing basic access and utilities, and preventing soil erosion. Avoid making major unalterable land modifications (such as clearing forest or pouring permanent foundations) until you have observed the property through all four seasons.

+-----+ YEAR-ONE IMPLEMENTATION TIMELINE +-----+		
Q1 (Months 1-3)	: Legal Audit, Boundary Search, Water/Soil Baseline Tests	
Q2 (Months 4-6)	: Access Road Repair, Water Well/Spring Drop, Power Connection	
Q3 (Months 7-9)	: Septic Installation, Site Clearing, Fence Corner Assemblies	

Phase 1: Months 1 to 3 - Baseline Verification & Legal Audit

Focus on confirming property boundaries, verifying legal rights, establishing health and safety baselines, and applying for applicable tax classifications.

- **Step 1: Locate and Mark Property Corners**

- Walk the entire perimeter using a survey plat map, compass, or GPS receiver.
- Locate existing iron pins, brass caps, or stone monuments. Place high-visibility T-posts and surveyor flag tape at all corner points.
- *Risk if skipped:* Building structures, fences, or roads across property lines creates costly boundary disputes and removal liabilities.

- **Step 2: Submit County Legal and Tax Applications**

- Request an official Zoning Verification Letter from the county planning department.
- File for special land use tax assessments (e.g., Agricultural Open Space, Forest Land Deferral) before county annual deadlines to lower property tax rates.

- **Step 3: Conduct Water Quality and Flow Testing**

- Collect water samples from wells or developed springs in sterile containers. Send to a certified state laboratory for microbiological (coliform/E. coli), nitrate, lead, and heavy metal testing.
- Perform a 4-hour continuous flow test on wells to establish true sustained yield (GPM) and drawdown recovery rates.

- **Step 4: Execute Agricultural Soil Sampling**

- Pull composite soil samples (0 to 6 inch depth for pastures, 0 to 12 inch depth for deep-rooted crops) across distinct management zones.
 - Send samples to a university or certified agricultural testing laboratory for baseline analysis: pH, Organic Matter percentage, cation exchange capacity (CEC), phosphorus, potassium, calcium, magnesium, and heavy metals.
-

Phase 2: Months 4 to 6 - Access and Primary Infrastructure

Establish reliable physical access and secure primary water and power connections.

- **Step 1: Upgrade or Repair Primary Access Road**

- Clear overhanging limbs to a height of 14 feet to allow truck access.
- Grade the road surface to re-establish a 2% to 4% crown shedding water into roadside ditches.
- Install geotextile fabric and add a 4 to 6 inch layer of compacted 1.5-inch minus crushed aggregate to soft sections.

- Clean existing culvert inlets or install new HDPE culverts armed with riprap rock at outfalls.
 - **Step 2: Develop Primary Water Supply**
 - Drill new well or install replacement submersible pump, pressure tank, and sanitary well head cover.
 - If developing a spring, construct a sealed spring box and lay underground supply piping to storage locations below the frost line.
 - **Step 3: Install Utility Power or Off-Grid Generation**
 - Complete utility grid interconnection trenching and pole drop, or install initial off-grid solar PV array, inverter, and battery storage enclosure.
 - Install a temporary weather-proof AC power pedestal for construction tools and equipment.
-

Phase 3: Months 7 to 9 - Site Preparation and Enclosures

Prepare building sites, install wastewater systems, and construct boundary fencing.

- **Step 1: Soil Percolation Testing and Septic Permitting**
 - Coordinate with the County Health Department to dig test pits (typically 6 to 8 feet deep) for soil profile evaluation and percolation rate testing (perc test).
 - Obtain septic tank and drainfield installation permits based on approved soil absorption capacities.
 - **Step 2: Clear Site Following Contour Lines**
 - Clear brush and invasive trees from designated building pads, garden zones, or pasture paddocks.
 - Work along natural topography contour lines. Leave vegetated buffer strips on slopes >10% to prevent sheet erosion during heavy rains.
 - **Step 3: Build Perimeter Fence H-Braces and Line Enclosures**
 - Set 8-inch pressure-treated wooden posts in concrete or compacted gravel for corner and end H-brace assemblies.
 - Install perimeter woven wire or high-tensile electric fencing along surveyed boundary lines to enclose livestock paddocks or crop zones.
-

Phase 4: Months 10 to 12 - Soil Amendments & Year-One Review

Initialize agricultural production, complete pre-winter maintenance, and review year-one metrics.

- **Step 1: Apply Soil Fertility Amendments**
 - Apply agricultural limestone (calcitic or dolomitic) to raise soil pH to optimal crop ranges (typically 6.0 to 6.8 for pastures and gardens), allowing 3 to 6 months for lime to react in the soil.

- Seed high-biodiversity cover crop mixtures (e.g., cereal rye, hairy vetch, crimson clover) on exposed soil zones to build organic matter and prevent winter erosion.

• **Step 2: Pre-Winter Infrastructure Audit**

- Clear fallen leaves and debris from all road ditches, culvert inlets, and roof gutters before autumn rain or snow events.
- Inspect freeze-proof hydrants, drain external water lines, and insulate pump houses.
- Inspect fence wire tension and test electric fence energizer voltage across all line ends.

• **Step 3: Complete Workbook Annual Update**

- Log all final well depth readings, road maintenance costs, soil lab metrics, and structure repairs into the Parcel Profile Workbook.
- Establish the Year-Two capital investment plan based on verified year-one performance data.

Year-One Priority & Budget Execution Matrix

Action Item	Recommended Target	Estimated Cost Range	Priority Level	Key Risk if Delayed / Skipped
Boundary Flagging & Monument Search	Month 1	\$0 - \$500 (DIY) / \$1,500+ (Surveyor)	Critical	Encroachment liabilities; fencing wrong parcel
Zoning & Permitting Verification	Month 1	\$0 - \$150	Critical	Fines; unpermitted structure teardown orders
Water Quality & Flow Testing	Month 2	\$150 - \$400	Critical	Health hazards; insufficient water for home/crops
Lab Soil Fertility Testing	Month 2	\$30 - \$100 per sample	High	Wasted crop input costs; crop failure
Road & Culvert Installation/Repair	Months 4-5	\$15 - \$45 per linear foot	Critical	Stuck vehicles; road washout; emergency refusal
Water System Installation (Well)	Months 4-5	\$8,000 - \$25,000+	Critical	Lack of potable water; construction delay
Power Infrastructure Drop	Month 6	\$2,000 - \$15,000+	High	Dependence on noisy, expensive fuel generators
Septic System Site Evaluation	Month 7	\$500 - \$1,500	High	Inability to obtain residential building permit

Action Item	Recommended Target	Estimated Cost Range	Priority Level	Key Risk if Delayed / Skipped
Perimeter Fencing (H-Braces)	Months 8-9	\$2 - \$8 per linear foot	Medium	Livestock escape; wildlife crop destruction
Pre-Winter Drainage Cleanout	Month 11	\$0 (Sweat Equity)	High	Winter road destruction; culvert blowouts

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