Level 2

Whole Site Design

Prepared for: Bridget and Rudy [redacted]

Site: [redacted] Family Homestead

[redacted] Road

Paso Robles, CA 93446

Site Visit Date(s): 7/11/2020, 11/1/2020

Prepared by:

7th Generation Design

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Executive Summary

7th Generation Design was invited by the [redacted] family to visit and conduct an assessment of their 6.3 acre homestead located in Paso Robles, CA. The [redacted] Family Homestead (WFH) currently has approximately 5,365 sq-ft of structures (roof area; including a main house and horse barn) and 12,700 sq-ft of paved access roads. The predominant land features include:

- Approximately 1.92 acres of southwest facing steeply sloped former almond orchard, separated by an internal fence from the rest of the property and located above the main residence.
- 2.44 of moderate to steeply sloped land, into which the pad for the main residence has been cut.
- Approximately 1.1 acres of moderate to shallow sloping land towards the valley bottom near [redacted] [redacted] Road.
- A small .42 acre section with a northeasterly aspect across [redacted] [redacted] road.

The [redacted] family moved to Paso Robles, and this piece of land in particular, in order to pursue a simpler, slower-paced, more healthy lifestyle. The [redacted] family's vision for their new home is to create an inviting and beautiful place to live, work and learn for current and future generations. Key aspects of their vision include an accessory dwelling for hosting family and friends and different ambience zones around the living areas that allow for as much outdoor living as possible - these include a meditation garden, food forests, home and market gardens, small pond with bamboo grove, and potentially an outdoor education and community gathering space.

A primary goal for their first year on the land is to have a successful homeschooling experience for their two children, [redacted] and [redacted]. Areas for play, exploration, creation, observation and solitude are a major design focus for the property. Some elements ideas the [redacted] family expressed interest in towards this end include a natural pool, children's garden, zip line, and treehouse. The outdoor classroom and learning space may also serve as a location to begin an outdoor education program for children from the surrounding community.

The [redacted] family would like to be as off-grid as possible with regards to their own energy use patterns. Additionally, they would like to cycle as much of their own waste streams on-site as possible. They envision creating a landscape that is abundant with food, wildlife and beauty for them to share with family, friends and their surrounding community for generations to come.

Report Organization

This report is largely organized according to the Keyline Scale of Permanence, presented in order from things human beings are least able to change down to those things that we have greater agency with.

Climate and Geography > Water> Access > Structures>Living Systems>Boundaries>Energy>Economy

Each of the main chapters of the report begins with a contextual summary and general overview of the topic at hand (i.e. Water) and the general principles employed in its design and implementation when creating resilient and regenerative systems (i.e. Principles of Regenerative Hydrology, Hydrological Cycle Overview etc). Each chapter is then broken out into sections which are defined by ***function*** (i.e. Passive Water Harvesting, Drainage etc)***.*** Each of these chapter sections then lists

specific ***element*** recommendations (i.e. swales, infiltration basins etc) designed to serve that *primary function*, with links to other report sections detailing additional functions (i.e. tree establishment) performed by that element.

Gate

Animal Stalls

Driveway

Well House

Main Residence

Main Entry Gate

Shed

Gate

Cielo Vista

Sheds
Existing Animal Enclosures
Main Residence
Paved Roads
Wildlife Trails
Existing Water Distribution
Existing Storage Tanks

Gates
Gates
Gaps
Perimeter Fencing
WFH Parcel Boundaries
Contours 5ft
Septic Leach Field
Approximate Septic Line

0 50 100 ft

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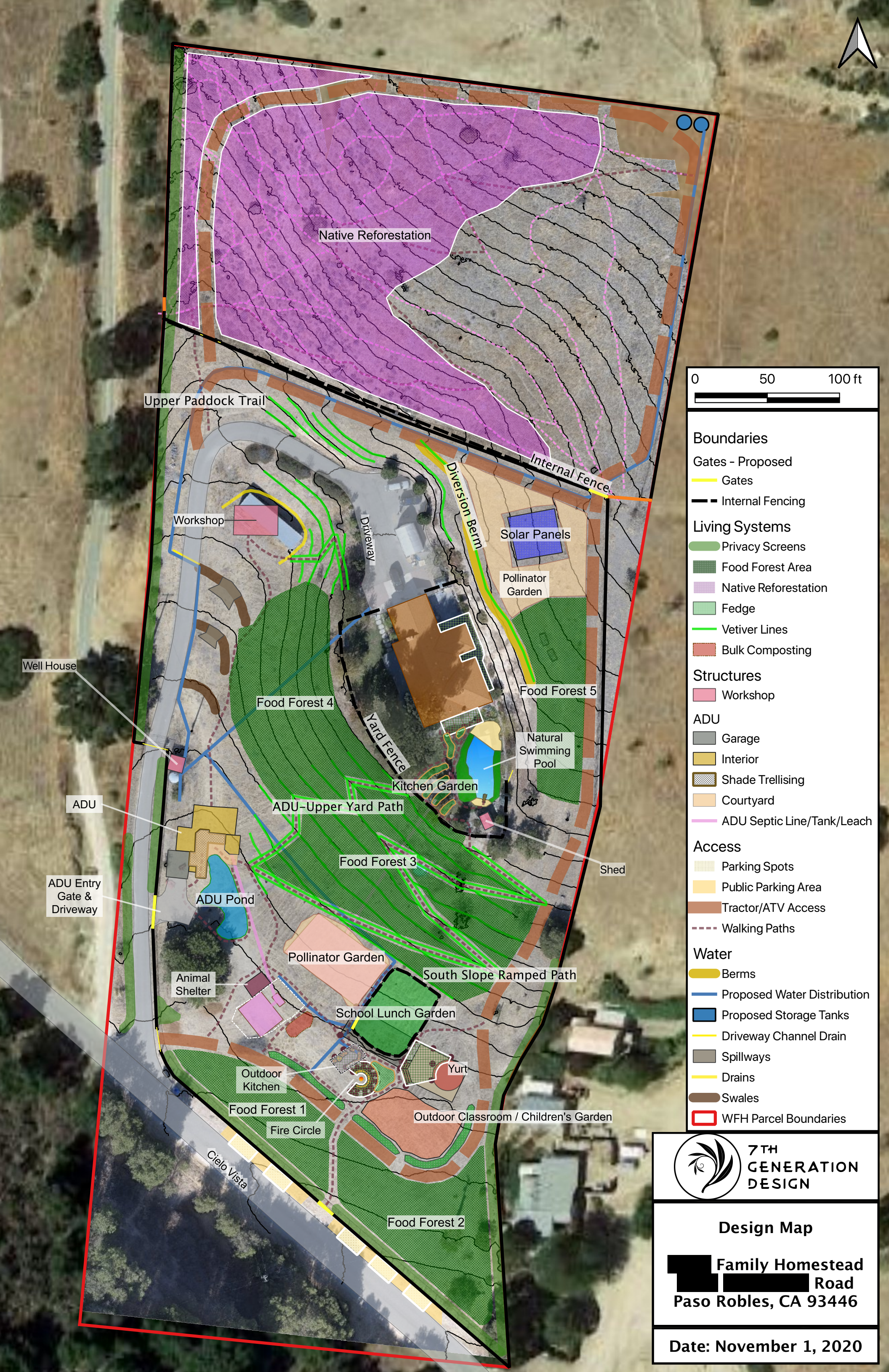
Basemap of Existing Conditions

[redacted] Family Homestead
[redacted] Road
Paso Robles, CA 93446

Date: November 1, 2020


Native Reforestation
Upper Paddock Trail
Internal Fence
Diversion Berm
Workshop
Driveway
Solar Panels
Pollinator Garden
Well House
Food Forest 4
Food Forest 5
Yard Fence
Natural Swimming Pool
Kitchen Garden
ADU
ADU-Upper Yard Path
Shed
Food Forest 3
ADU Entry Gate & Driveway
ADU Pond
Pollinator Garden
South Slope Ramped Path
Animal Shelter
School Lunch Garden
Outdoor Kitchen
Yurt
Food Forest 1
Outdoor Classroom / Children's Garden
Fire Circle
Cielo Vista
Food Forest 2
0
50
100 ft
Boundaries
Gates - Proposed
Gates
Internal Fencing
Living Systems
Privacy Screens
Food Forest Area
Native Reforestation
Fedge
Vetiver Lines
Bulk Composting
Structures
Workshop
ADU
Garage
Interior
Shade Trellising
Courtyard
ADU Septic Line/Tank/Leach
Access
Parking Spots
Public Parking Area
Tractor/ATV Access
Walking Paths
Water
Berms
Proposed Water Distribution
Proposed Storage Tanks
Driveway Channel Drain
Spillways
Drains
Swales
WFH Parcel Boundaries
7TH GENERATION DESIGN
Design Map
[redacted] Family Homestead
[redacted] Road
Paso Robles, CA 93446
Date: November 1, 2020

Native Reforestation
Internal Fence
Workshop
Driveway Shade Corridor
Driveway
Solar Panels
Pollinator Garden
Diversion Berm
Well House
Yard Fence
Natural Swimming Pool
Kitchen Garden
ADU
Shed
ADU Entry Gate & Driveway
ADU Pond
Bamboo Privacy Hedge
Pollinator Garden
Animal Shelter
School Lunch Garden
Outdoor Kitchen
Yurt
Fire Circle
Yurt Deck
Cielo Vista

0 50 100 ft

Living Systems
- Shade Plantings - Bamboo

Shade Plantings
- Leguminous
- Light Canopy
- Heavy Canopy
- Privacy Screens
- Native Reforestation

Agroforestry
- Fruit Tree - 25' Spacing
- Nut Tree - 40' Spacing
- Small Tree - 15' Spacing
- Fedge
- Vetiver Lines
- Bulk Composting

Access
- Parking Spots
- Public Parking Area
- Tractor/ATV Access
- Walking Paths

Water
- Berms
- Proposed Storage Tanks
- Driveway Channel Drain
- Spillways
- Drains
- Swales
- WFH Parcel Boundaries

7TH GENERATION DESIGN

Design Map

[redacted] Family Homestead
[redacted] Road
Paso Robles, CA 93446

Date: November 1, 2020

1. Site Work Up

1.1 General Site Information

Client(s): Bridget and Rudy [redacted] - [redacted] Family Homestead (WFH)

Address: [redacted] [redacted] [redacted] Road, Paso Robles, CA 93446

Parcel Number: [redacted]

Area: 6.32 acres

Latitude: 35°38'34.50"N

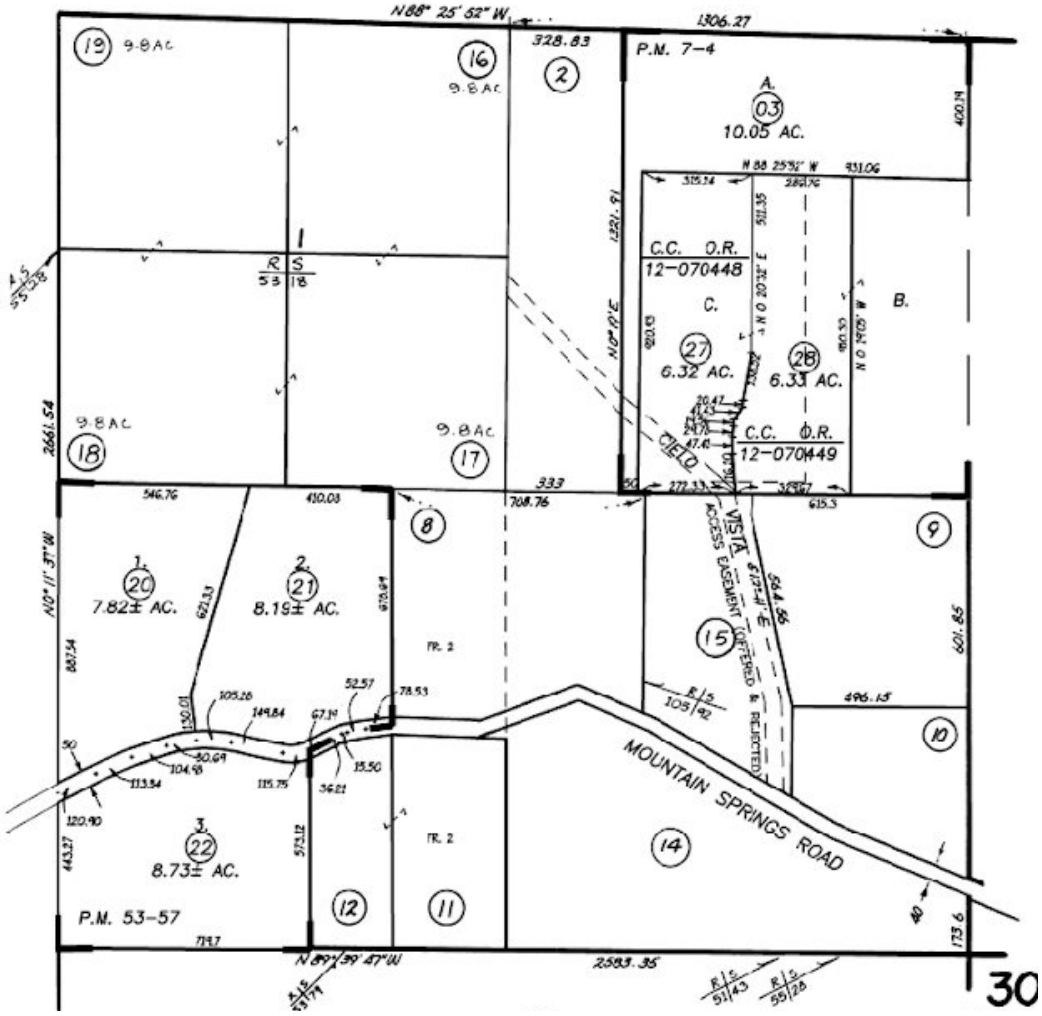
Longitude: 120°43'26.4"W

Altitude: 1,322'

Proximity to Ocean: ~ 16.6 miles as the crow flies

Figure 1.1.1
Satellite image of [redacted] Family Homestead

Figure 1.1.2
Parcel map of [redacted] Road (Parcel[redacted])



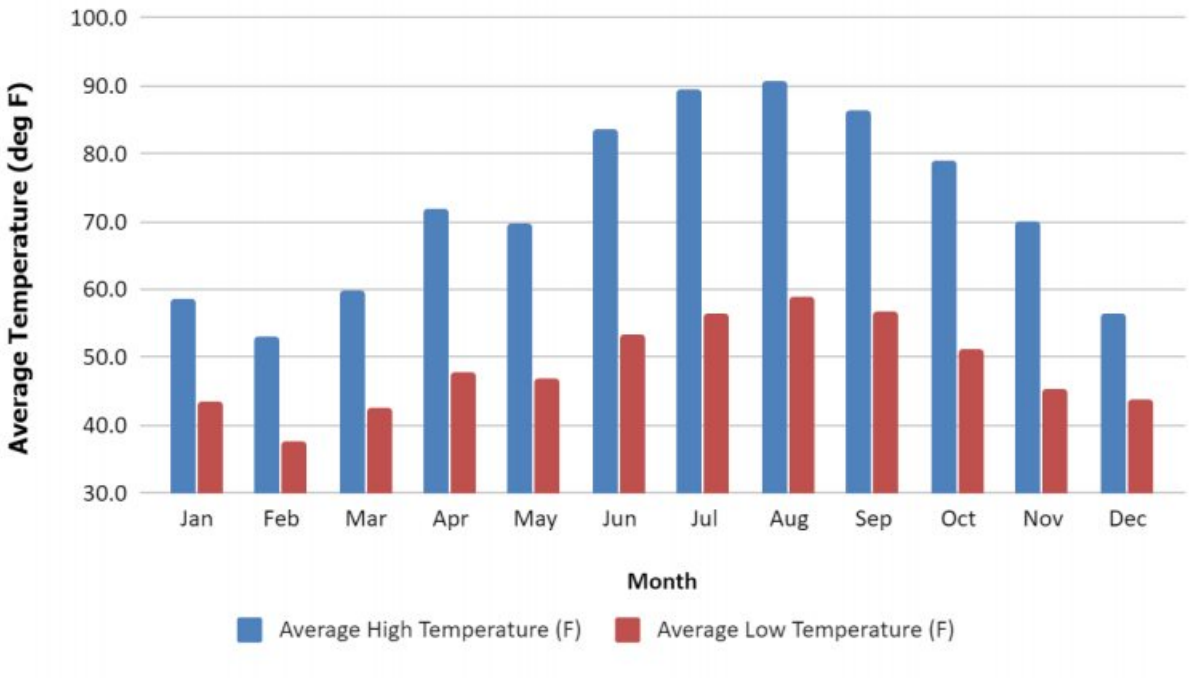
1.2 Climate

Temperature Data

The closest weather station to WFH with real-time and recorded daily temperature, humidity, wind speed, and precipitation weather data is Station KCAPASOR5 located at Radio Ranch Paso Robles, which is approximately 100 feet higher in elevation than and 1.3 miles away from WFH.

The monthly average high and low temperatures for 2019 at Radio Ranch Paso Robles are shown in Figure 1.2.1.

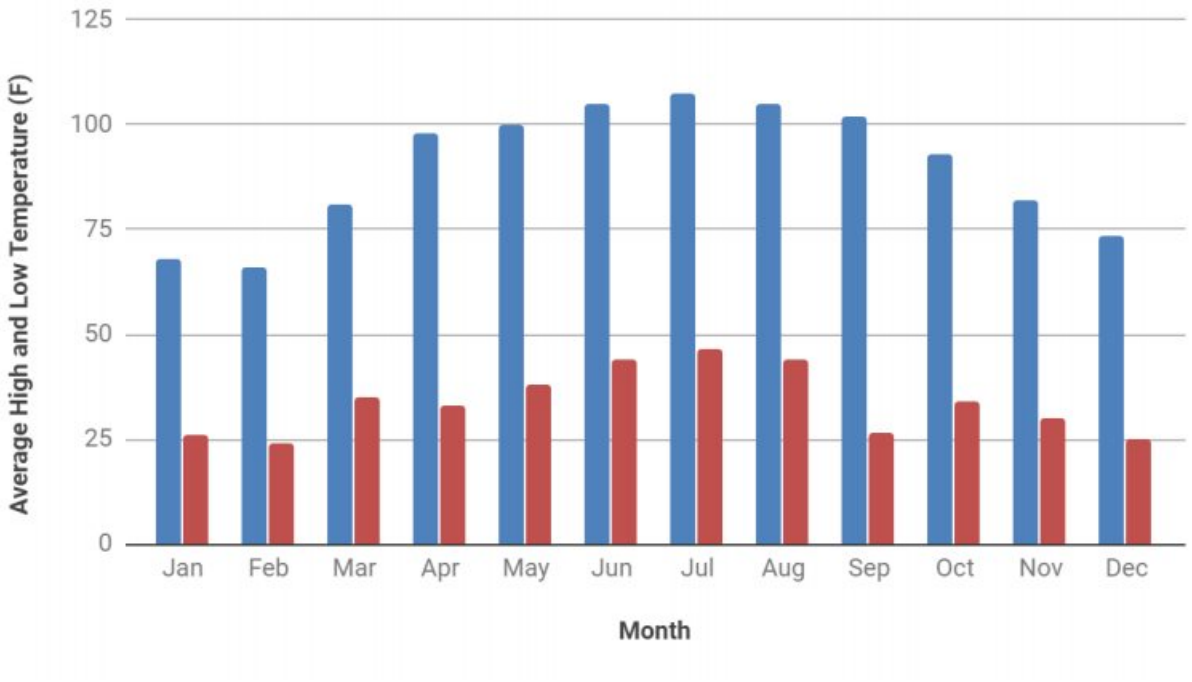
Figure 1.2.1
2019 average monthly temperatures for Radio Ranch Paso Robles (1.3 miles away from WFH)



The coldest months of the year were December through March; the hottest months were June through August.

For historical weather patterns beyond 2019, the closest source is the Paso Robles Regional Airport, 450 feet lower in elevation than and 5.2 miles away from WFH [Link 1, Link 2]. Annual temperature data for a typical meteorological year at the Paso Robles Regional Airport, developed from over 120 years of data, is shown in Figure 1.2.2. The record low is 0°F, 1913; the record high is 115°F.

Figure 1.2.2
Average monthly temperature data for Paso Robles Regional Airport (5.2 miles away from WFH)



The range between the high and low temperatures in Paso Robles is large, especially compared to San Luis Obispo and even more-so the coastal towns in the county. This is due to the 2,000 foot tall Santa Lucia mountain range that separates Paso Robles from the coast. The range serves as a tremendous climactic barrier-it blocks all significant influence of the maritime air, allowing Paso and other nearby towns to achieve the highest daytime highs and the lowest nighttime lows in the region.

Chilling Hours

Deciduous fruit trees, which lose their leaves in the fall and are dormant throughout the winter, need to accumulate a minimum number of hours below 45°F during their dormancy in order to set fruit the following year. Knowing the approximate amount of chilling hours an area experiences throughout the cold season enables better selection of fruit trees that are likely to do well in that area.

In what is called the *Below 45°F Model*, chilling hours are the total number of hours below 45°F accumulated each year while the tree is dormant. Paso Robles Regional Airport (5.2 miles away from WFH), the nearest location with historical hourly weather data, sees an average of **1,534 hours** below 45°F. The CIMIS weather station in Atascadero, CA (approximately 14 miles south of WFH) sees an average of 1,156 hours. A full chart of hourly temperature distribution for a typical meteorological year at Paso Robles Regional Airport is provided in Appendix C.

While the Paso Robles Regional Airport is located only 5.2 miles away from WFH, the elevations and surrounding topography of the two locations vary significantly and thus chill hours at WFH will inevitably vary. Comparison of the monthly average lows between Radio Ranch Paso Robles, 1.3 miles away from and 100 feet higher in elevation than WFH, and Paso Robles Regional Airport

indicate that the area surrounding WFH sees higher average low temperatures than Paso Robles Regional Airport. This makes sense, colder air typically sinks to the valley bottoms, resulting in colder temperatures than locations partway up the slope of neighboring foothills. Chilling hours can vary significantly even across the same piece of land; low spots, frost pockets, slopes and wind tunnels or wind buffered areas will all experience different chill hours. The best way to know for a specific site, especially before undertaking any capital-intensive agroforestry project or orchard planting, is to install temperature data loggers on-site and record hourly data during a winter season. However, on cold days and nights valuable information can be gained simply by walking up and down slopes with some bare skin exposed so that you can sense where a thermocline - a thin but distinct layer in the atmosphere in which temperature changes more rapidly with depth than it does in the layers above or below - might persist. Often, the difference in 10 feet of vertical elevation will make the difference between a citrus tree thriving or dying. Knowing these invisible lines in the landscape will inform better decisions about which types of plants will do best where.

When it comes to fruit tree selection, making selections for staple tree crops with a chilling hours buffer is suggested. For this site, trees that require 1,000 chilling hours or less are recommended. While it can be fun to push the boundaries for select plantings, for your staple tree crops staying within this range will create the greatest chance for successful harvests year after year.

Precipitation Data

Annual Precipitation Total

The total precipitation that fell in 2019 as measured by Radio Ranch, approximately 100 feet higher in elevation than and 1.3 miles away from WFH, was 22.3 inches.

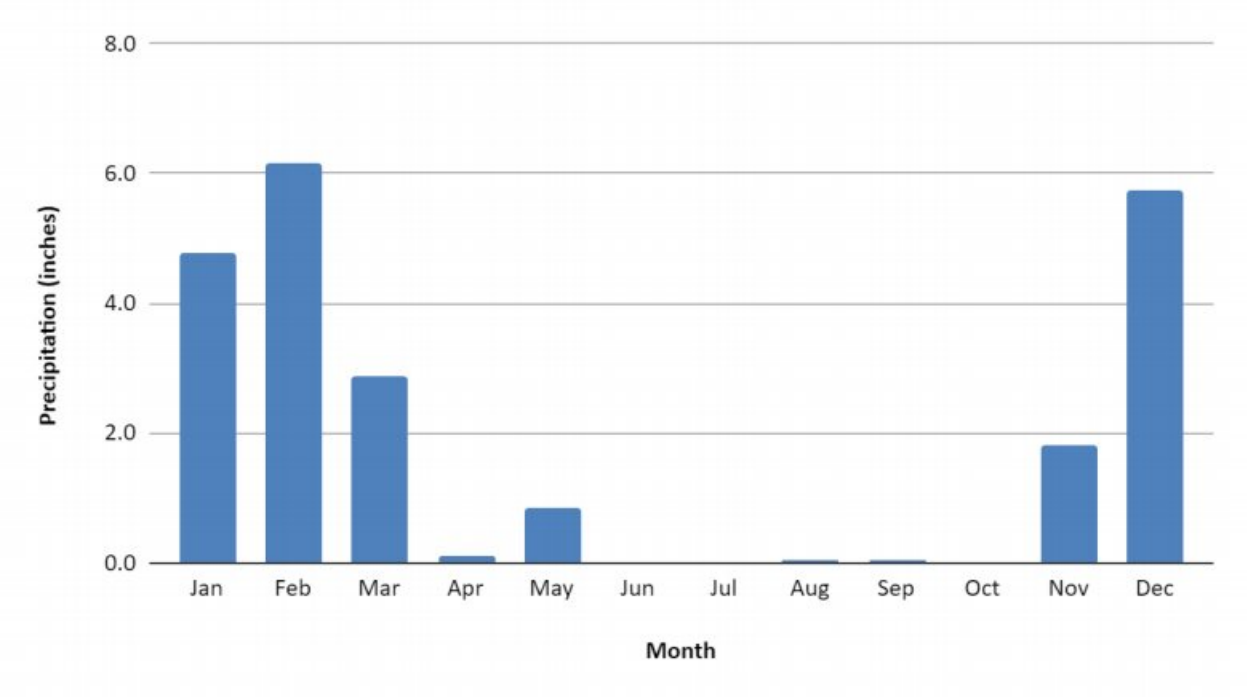
The average and mean amounts of annual rainfall recorded at Paso Robles Regional Airport (5.2 miles away from and 450 feet lower in elevation than WFH) from 1894-2016 are 15.21 inches and 14.77 inches, respectively [Link 1, Link 2]. The record high annual total during that period was 29.19 inches in 1941; the record low total was 2.78 inches in 2013.

Annual Distribution of Precipitation

There were 48 rainy days (>.1 inch) in 2019 at Radio Ranch Paso Robles, approximately 100 feet higher in elevation than and 1.3 miles away from WFH. Typically 80 - 90% of total annual rainfall falls between December and March, making this a brittle climate (see “Climate Brittleness”, below).

The monthly distribution of rainfall at Radio Ranch Paso Robles in 2019 is shown in Figure 1.2.3.

Figure 1.2.3
2019 monthly rainfall totals for Radio Ranch Paso Robles (1.3 miles away from WFH)



The average number of rainy days (>.1 inch) recorded at Paso Robles Regional Airport (5.2 miles away from and 450 feet lower in elevation than WFH) from 1894-2016 is 42. The longest period at Paso Robles Regional Airport without precipitation on record was 202 days (2/28/1997 - 9/18/1997). Periods without effective rainfall (moderate intensity rainfall that falls in sufficient amount that it can actually infiltrate and is not immediately lost to evaporation) can be much longer, on the the order of 240-270 days.

Rainfall Intensity and Recurrence Interval

Paso Robles Regional Airport has experienced 4-5"+ of rainfall in a 24 hour period numerous times during the recorded period from 1894-2016.

Table 1.2.1 lists rainfall intensity and the recurrence interval for the Paso Robles area. This information is helpful in determining capacity for installed earthworks, drains, basins and other structures or design elements that will need to be able to move, absorb or withstand these expected volumes and intensities if they are to last across generations.

Earthworks design is typically informed by the 1,000-year recurrence interval event - a rainfall event of certain intensity that has a 0.1% probability of occurring in any given year. This information is used to size spillways, drains, catchment basins and overflows to ensure that the system can endure such an event without damage.

In this case, the table below shows the median 1,000-year recurrence interval event to be 5.95 inches of rain in a 12-hour period and 7.96 inches of rain in a 24-hour period.

Table 1.2.1

Rainfall intensity and recurrence interval at [redacted] Family Homestead

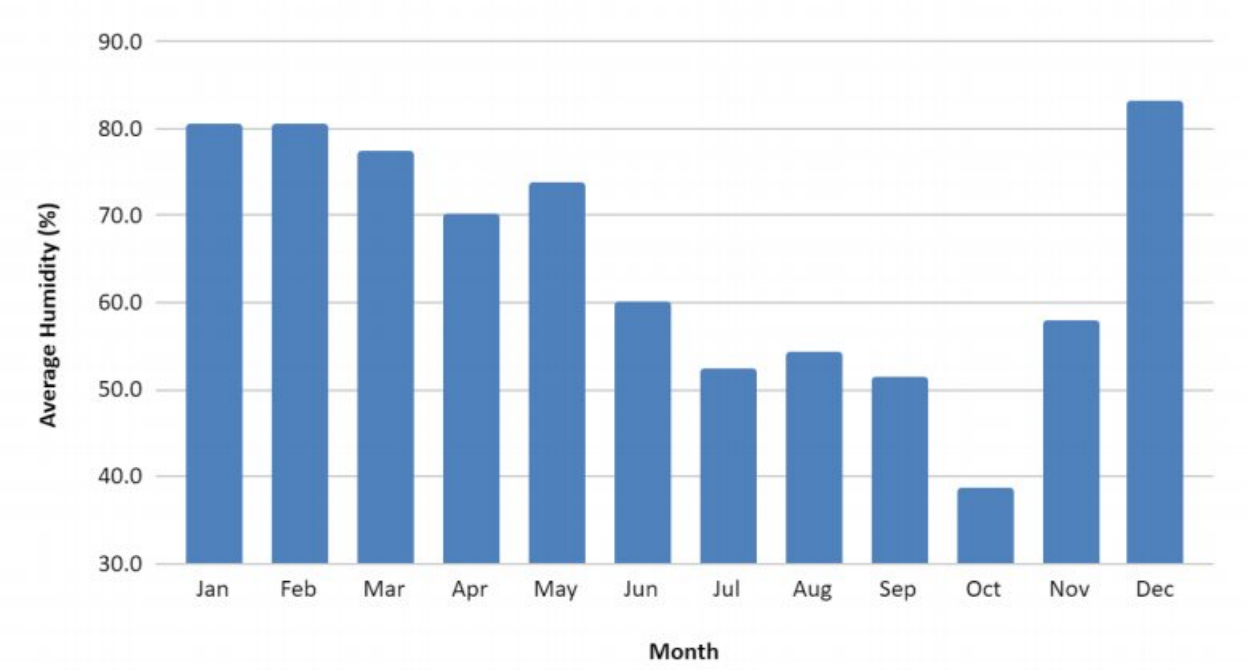
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.110 (0.095-0.129)	0.140 (0.120-0.165)	0.181 (0.155-0.213)	0.216 (0.183-0.257)	0.265 (0.215-0.329)	0.304 (0.241-0.388)	0.346 (0.265-0.455)	0.390 (0.289-0.531)	0.451 (0.318-0.647)	0.501 (0.339-0.749)
10-min	0.158 (0.136-0.185)	0.201 (0.172-0.236)	0.259 (0.222-0.306)	0.309 (0.262-0.368)	0.380 (0.308-0.472)	0.436 (0.345-0.556)	0.495 (0.380-0.652)	0.558 (0.414-0.760)	0.647 (0.456-0.927)	0.718 (0.486-1.07)
15-min	0.191 (0.164-0.224)	0.243 (0.208-0.285)	0.314 (0.269-0.370)	0.374 (0.317-0.446)	0.459 (0.373-0.571)	0.527 (0.417-0.673)	0.599 (0.460-0.788)	0.675 (0.501-0.920)	0.783 (0.552-1.12)	0.868 (0.587-1.30)
30-min	0.260 (0.224-0.305)	0.330 (0.284-0.388)	0.427 (0.366-0.504)	0.509 (0.431-0.606)	0.625 (0.508-0.777)	0.718 (0.568-0.916)	0.815 (0.626-1.07)	0.919 (0.682-1.25)	1.07 (0.751-1.53)	1.18 (0.799-1.77)
60-min	0.367 (0.316-0.431)	0.467 (0.401-0.549)	0.603 (0.516-0.712)	0.719 (0.609-0.857)	0.883 (0.717-1.10)	1.01 (0.802-1.29)	1.15 (0.885-1.52)	1.30 (0.963-1.77)	1.51 (1.06-2.16)	1.67 (1.13-2.50)
2-hr	0.562 (0.483-0.659)	0.710 (0.610-0.835)	0.914 (0.783-1.08)	1.09 (0.921-1.30)	1.33 (1.08-1.66)	1.53 (1.21-1.95)	1.73 (1.33-2.28)	1.95 (1.45-2.66)	2.26 (1.59-3.24)	2.51 (1.70-3.75)
3-hr	0.706 (0.608-0.829)	0.893 (0.767-1.05)	1.15 (0.982-1.35)	1.36 (1.16-1.63)	1.67 (1.36-2.08)	1.92 (1.52-2.44)	2.17 (1.67-2.86)	2.45 (1.82-3.33)	2.83 (2.00-4.06)	3.14 (2.12-4.69)
6-hr	1.01 (0.866-1.18)	1.28 (1.10-1.50)	1.65 (1.41-1.94)	1.96 (1.66-2.33)	2.39 (1.95-2.98)	2.74 (2.17-3.50)	3.11 (2.39-4.09)	3.50 (2.59-4.76)	4.04 (2.85-5.79)	4.48 (3.03-6.69)
12-hr	1.31 (1.13-1.53)	1.68 (1.45-1.98)	2.19 (1.88-2.59)	2.62 (2.22-3.12)	3.21 (2.61-3.99)	3.68 (2.91-4.69)	4.16 (3.20-5.48)	4.68 (3.47-6.37)	5.39 (3.80-7.72)	5.95 (4.02-8.89)
24-hr	1.70 (1.54-1.91)	2.22 (2.01-2.50)	2.92 (2.64-3.31)	3.50 (3.14-4.00)	4.31 (3.73-5.08)	4.94 (4.19-5.95)	5.60 (4.62-6.91)	6.28 (5.04-7.97)	7.22 (5.56-9.56)	7.96 (5.92-10.9)
2-day	2.07 (1.88-2.33)	2.73 (2.47-3.08)	3.62 (3.27-4.10)	4.37 (3.91-4.98)	5.41 (4.68-6.38)	6.24 (5.29-7.52)	7.10 (5.87-8.77)	8.01 (6.44-10.2)	9.28 (7.15-12.3)	10.3 (7.65-14.1)
3-day	2.29 (2.07-2.58)	3.04 (2.75-3.43)	4.09 (3.69-4.62)	4.97 (4.45-5.67)	6.22 (5.38-7.34)	7.23 (6.12-8.71)	8.29 (6.85-10.2)	9.43 (7.57-12.0)	11.0 (8.50-14.6)	12.3 (9.17-16.9)
4-day	2.47 (2.24-2.78)	3.30 (2.99-3.72)	4.45 (4.02-5.04)	5.44 (4.87-6.20)	6.85 (5.93-8.08)	7.99 (6.77-9.63)	9.21 (7.61-11.4)	10.5 (8.44-13.4)	12.4 (9.53-16.4)	13.9 (10.3-19.1)
7-day	2.91 (2.63-3.28)	3.88 (3.51-4.37)	5.23 (4.72-5.92)	6.39 (5.72-7.29)	8.05 (6.97-9.50)	9.40 (7.96-11.3)	10.8 (8.95-13.4)	12.4 (9.94-15.7)	14.6 (11.2-19.3)	16.4 (12.2-22.4)
10-day	3.25 (2.95-3.66)	4.34 (3.93-4.89)	5.85 (5.28-6.62)	7.15 (6.40-8.15)	9.01 (7.80-10.6)	10.5 (8.91-12.7)	12.1 (10.0-15.0)	13.9 (11.1-17.6)	16.3 (12.6-21.6)	18.4 (13.7-25.2)
20-day	3.94 (3.57-4.44)	5.27 (4.77-5.95)	7.14 (6.44-8.07)	8.73 (7.82-9.96)	11.0 (9.55-13.0)	12.9 (10.9-15.6)	14.9 (12.3-18.4)	17.0 (13.7-21.7)	20.1 (15.5-26.6)	22.6 (16.8-31.0)
30-day	4.62 (4.19-5.21)	6.20 (5.61-6.99)	8.40 (7.58-9.50)	10.3 (9.22-11.7)	13.0 (11.3-15.4)	15.3 (12.9-18.4)	17.6 (14.5-21.7)	20.1 (16.2-25.6)	23.7 (18.3-31.4)	26.7 (19.8-36.6)
45-day	5.44 (4.93-6.13)	7.32 (6.62-8.25)	9.93 (8.96-11.2)	12.2 (10.9-13.9)	15.4 (13.3-18.2)	18.0 (15.2-21.7)	20.8 (17.2-25.6)	23.7 (19.0-30.1)	27.9 (21.5-36.9)	31.3 (23.2-42.9)
60-day	6.35 (5.75-7.15)	8.55 (7.74-9.64)	11.6 (10.5-13.1)	14.2 (12.7-16.2)	17.9 (15.5-21.1)	20.8 (17.7-25.1)	24.0 (19.8-29.6)	27.3 (21.9-34.6)	31.9 (24.6-42.3)	35.6 (26.5-48.9)

**PDS: precipitation data server; PF: precipitation frequency*

Humidity

The 2019 average monthly relative humidity measured at Radio Ranch Paso Robles, approximately 100 feet higher in elevation than and 1.3 miles away from WFH, is shown in Figure 1.2.4.

Figure 1.2.4
2019 Monthly average relative humidity at Radio Ranch Paso Robles (1.3 miles away from WFH)



Humidity is highest during the winter and early spring rainy season from December through May, with monthly averages ranging from 75-85%. Monthly average humidity levels during the summer and early fall months ranges between 40-60%.

Fog

Offshore wind events during the fall and winter bring moist inland air towards the coast, where it gets trapped by the Santa Lucia mountain range. This moist air condenses over the cold inland land areas, causing fog in the Paso Robles area. This pattern is the inverse of the coastal pattern, where fog typically develops during onshore wind events in the spring and summer.

Climate Brittleness

Brittleness gauges climate vulnerability to desertification. The brittleness scale is subjective and has no formula for calculation, but can be thought of as a continuum, ranging from a 1 - very humid with moisture distributed throughout the year (tropical rainforest) to a 10 - very arid with long dry periods (desert). Brittleness classifications are used to inform management decisions for a given property or bioregion.

Where any given climate falls on the brittleness scale is determined not so much by total rainfall, but rather by the distribution of precipitation and humidity throughout the year. This pattern determines the degree of brittleness. Very brittle environments typically have a long period of non-growth (often due to long periods without precipitation and low humidity) and can be very arid. Brittle environments also tend to accumulate more dead plant material as biological breakdown of carbon-based plant tissues by insects, microbes and fungi all but cease during the long dry season. This can have a negative effect on the health and resilience of the vegetation due to increased risk of catastrophic fire (due to built up fuel levels) and decreased light penetration to young growing tips (blocked by dead, standing vegetation).

The climate at WFH is quite brittle. Long summer dry seasons and fairly short winter wet seasons predominate. There is minimal marine influence on the property (ocean 24 miles distant as the crow flies, and blocked by the Santa Lucia mountain range). Design and development of the property should utilize every possible chance to infiltrate water and retain it as long as possible on site. Dramatically increasing the number of trees on property will have the greatest effect in moderating climate extremes and creating soil that can retain more moisture for longer. Use of ruminant grazing animals should be carefully planned and attentively managed to ensure they are benefiting the larger processes of soil creation and establishment of perennial cover across the property.

Solar Data

Solar aspect describes the way that the sun moves across the sky at a location during the various seasons. Having an understanding of the sun's seasonal path is critical for properly siting various elements in the property design, designing housing and other structures for passive heating/ cooling, and situating solar panels.

Table 1.2.2 presents the solar aspect information for each season at WFH. A detailed solar aspect chart for WFH is included in Appendix B- Solar Charts. Additional charts are available through suncalc.org, sunearthtools.com.

Table 1.2.2
Solar aspect information for [redacted] Family Homestead

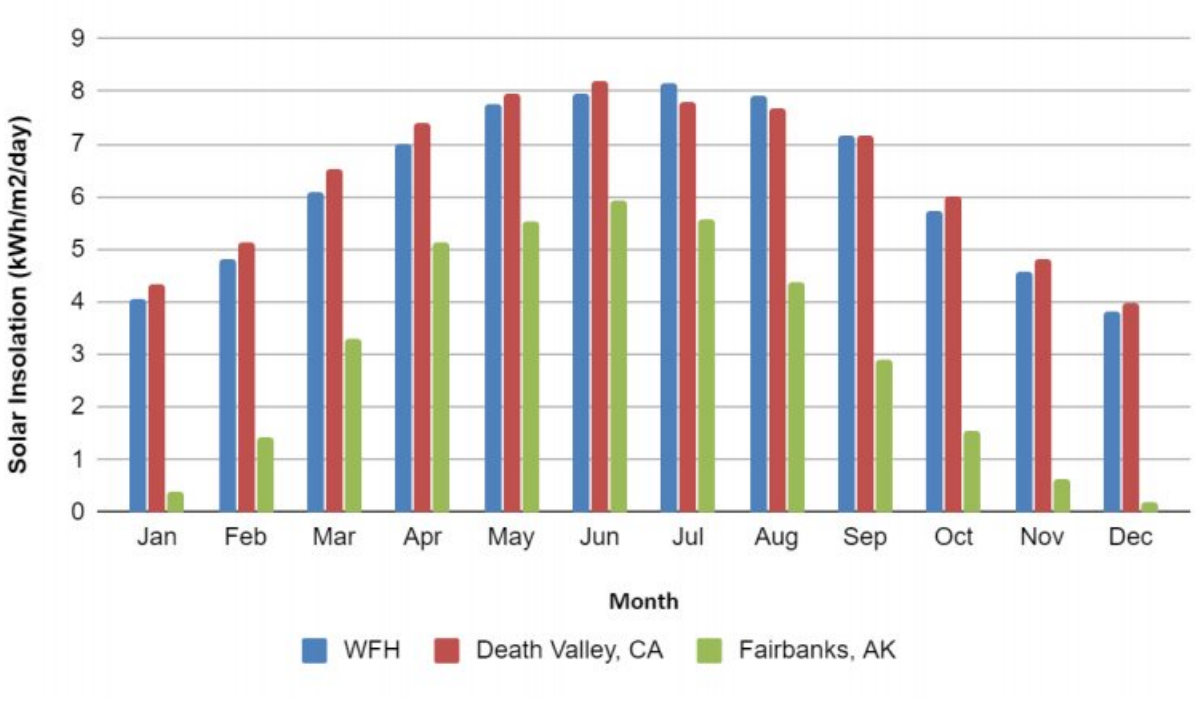
Season Change	Sun Angle*	Shadow Length**	Sunrise Location***	Sunset Location***
Winter Solstice	30.92°	1.67	118.62°	241.38°
Spring Equinox	55.42°	0.69	88.22°	272.03°
Summer Solstice	77.79°	0.22	60.01°	299.99°
Fall Equinox	55.03°	0.70	88.45°	271.43°

** Sun angles measured when highest in sky (peak solar activity) a.k.a. azimuth.*
*** Shadow length expressed as multiple of object height, taken at peak solar activity*
**** Exact locations of sunrise/sunset on the horizon from SET's Sunrise-Sunset Calendar - visit mooncalc.org to get similar data for lunar cycles.*

The longest day length is 14h34m27s on the Summer Solstice, and the shortest day length is 9h44m44s on the Winter Solstice.

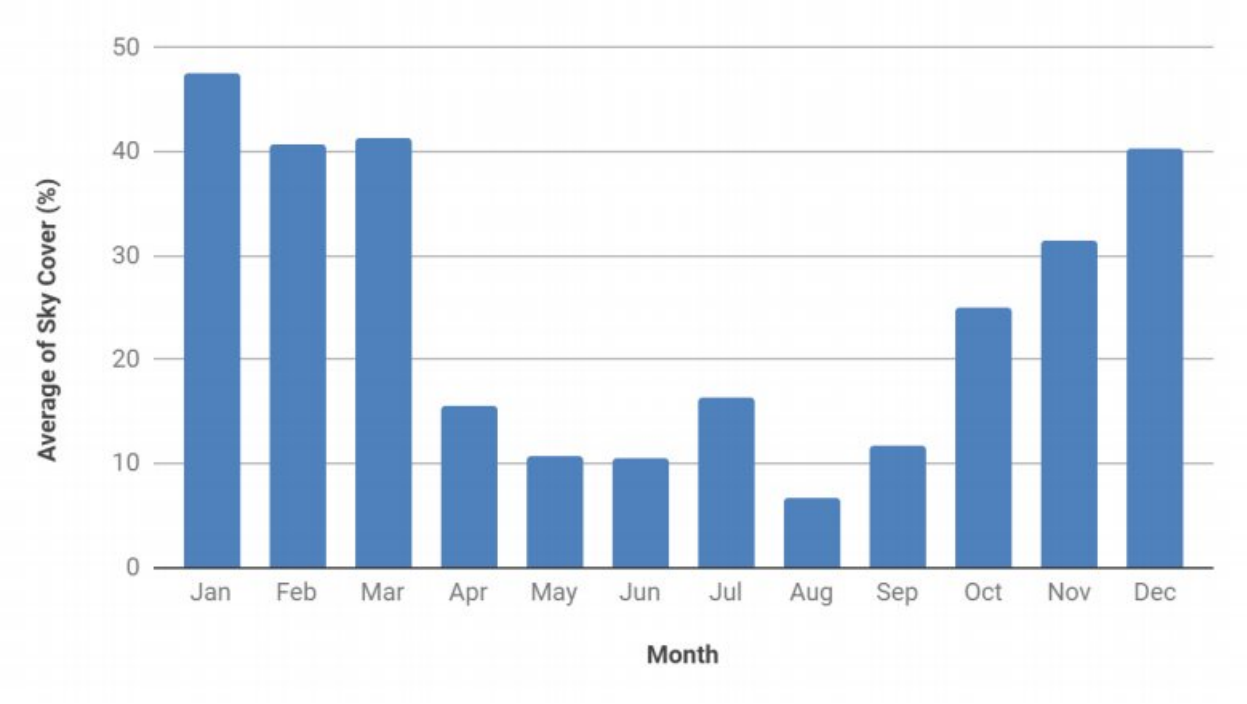
There are an average of 286 days of sun per year in Paso Robles. The average annual solar insolation (used to measure energy production of solar PV systems, in kWh/m2/day) is 6.25 kWh/m^2/day, compared to that of Death Valley, CA at 6.4 kWh/m2/day, and Fairbanks, AK at 3.1 kWh/m2/day- considered to be among the sunniest and least sunny places in the US, respectively. The monthly average solar insolation at a location 1.0 miles away WFH is presented in Figure 1.2.5, and also compared with Death Valley, CA and Fairbanks, AK. It is clear from the data that WFH is ideally located for solar PV electricity generation and solar water heating.

Figure 1.2.5
Monthly average of solar insolation (kWh/m2/day) measured at a station 1.0 miles away from WFH



The monthly average percent of sky cover as measured at Paso Robles Regional Airport, 5.2 miles away from WFH, is shown in Figure 1.2.6. A chart of the hourly distribution of cloud cover for a typical meteorological year at Paso Robles Regional Airport (5.2 miles away) is provided in Appendix C, Figure C-2.

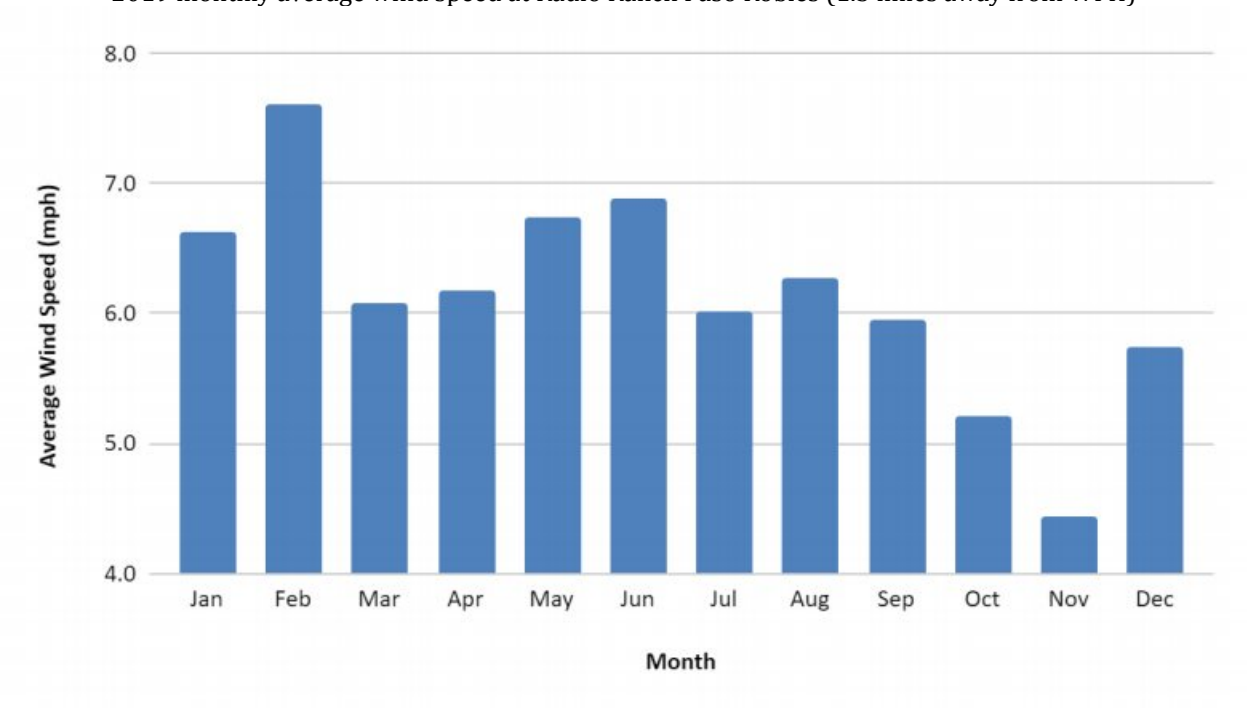
Figure 1.2.6
Monthly average of cloud cover, plotted over a typical meteorological year at Paso Robles Regional Airport (5.2 miles away)



Wind Data

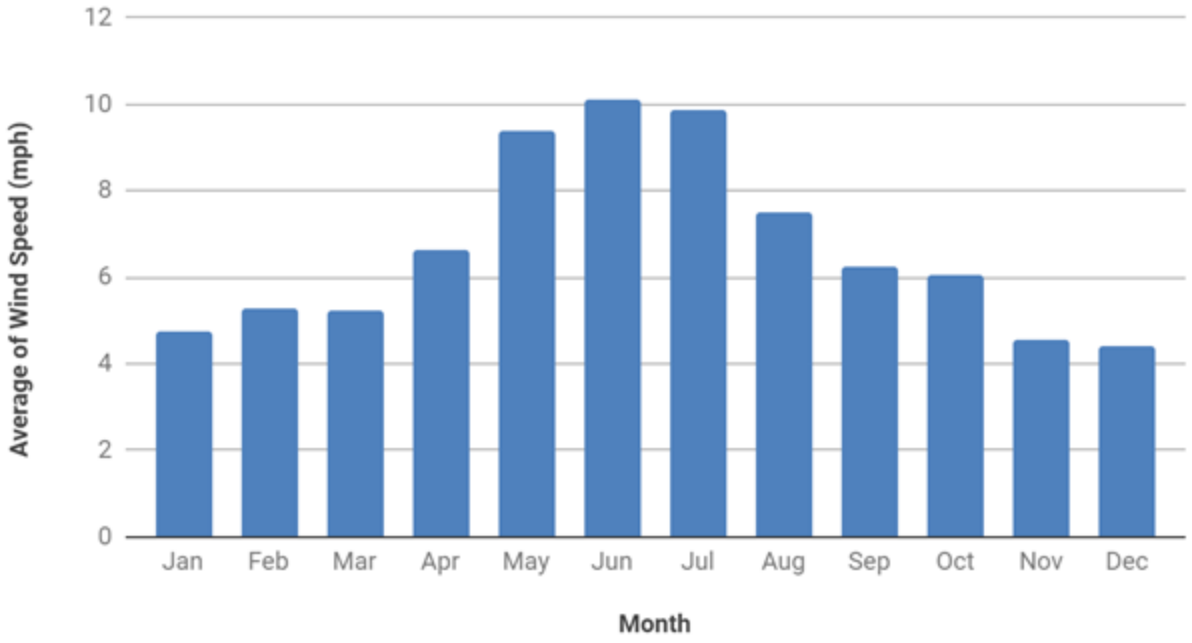
The monthly average wind speed from 2019 at Radio Ranch Paso Robles, approximately 100 feet higher in elevation than and 1.3 miles away from WFH, is shown in Figure 1.2.7. Average wind speed was highest during the winter and late spring months, the highest being 7.6 mph during the month of February. The lowest monthly average wind speed of 4.4 mph occurred during November.

Figure 1.2.7
2019 monthly average wind speed at Radio Ranch Paso Robles (1.3 miles away from WFH)



For more historical wind trends, the monthly average wind speed over the course of a typical meteorological year (developed from data compiled from 1894-2016) at Paso Robles Regional Airport, 5.2 miles away from and 450 lower in elevation than WFH, is shown in Figure 1.2.8. Average wind speeds are highest during the late spring and summer months, the highest being 10.1 mph during the month of June. The lowest monthly average wind speed of 4.4 mph occurs during December.

Figure 1.2.8
Monthly average wind speed and wind direction, plotted over a typical meteorological year at Paso Robles Regional Airport (5.2 miles away)



The prevailing wind blows onshore from Northwest to Southeast, over the Santa Lucia range. These prevailing winds are most present during the spring and summer months. Fall days see frequent warmer offshore wind events from Northeast to Southwest. Winter sees a mix of onshore and offshore winds during clear days and winds from South to North during the passage of storms.

Climate Zones

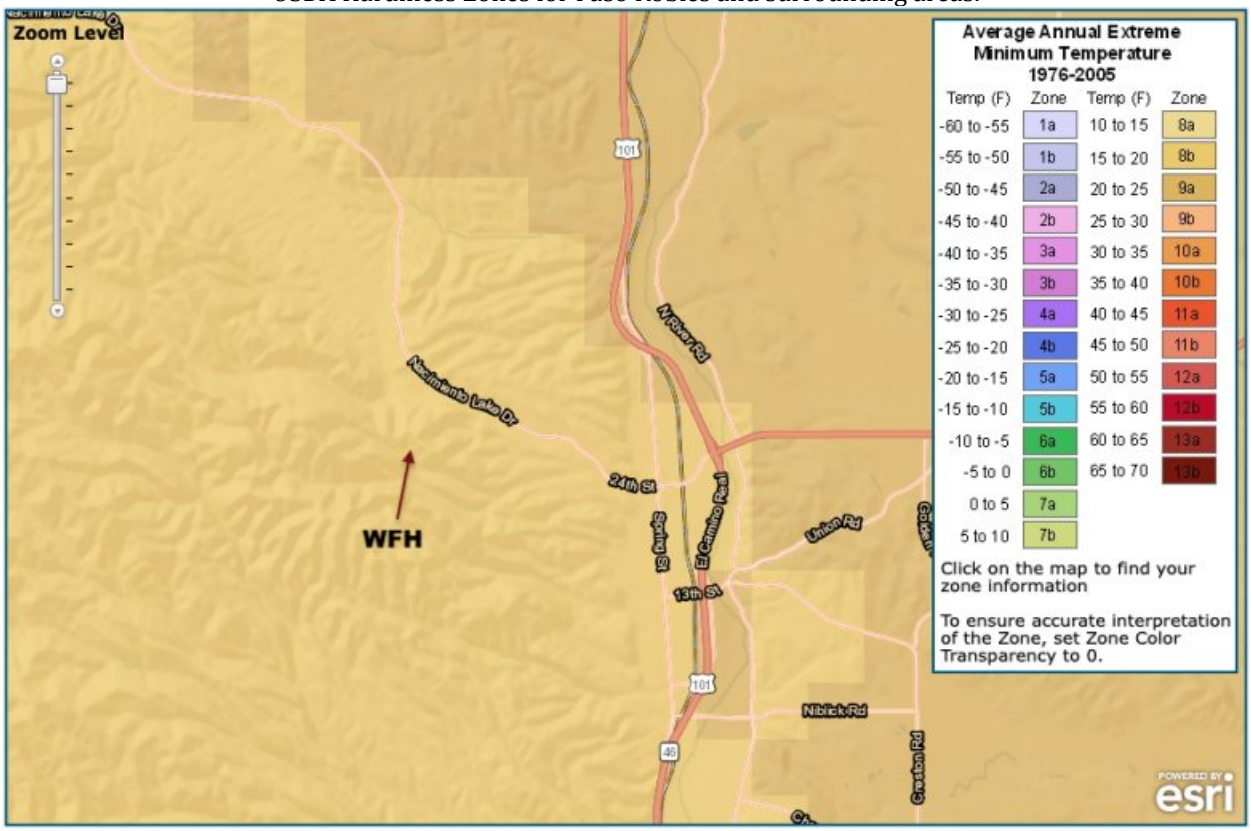
USDA Hardiness Zone

USDA Hardiness Zones gives an approximation of the lowest temperatures a site will experience in a given year. It is a helpful, if somewhat limited tool in determining what will survive (but not necessarily *thrive*) in an area. Hardiness zones can be determined for a given zip code at http://planthardiness.ars.usda.gov/PHZMWeb/. Microclimates and site specific characteristics will vary.

The USDA Hardiness Zone for [redacted] Road, Paso Robles 93446 is **8b**. This zone is characterized by cold-season low temperatures that do not generally fall lower than 15-20ºF, and extremes that rarely fall below 15ºF. Frost tender perennial plants are likely to suffer damage and/or not thrive in this climate. Potted frost-tender plants should be moved indoors or somehow protected.

Figure 1.2.9 below presents a map of USDA hardiness zones for the general area.

Figure 1.2.9
USDA Hardiness Zones for Paso Robles and surrounding areas.



Sunset Climate Zone(s)

Sunset climate zones take into account length of growing season, timing and amount of rainfall, winter lows, summer highs, wind and humidity. They provide a more detailed climate description than the USDA model, helpful in selecting which plants will not only survive but thrive with local climate variability. List of maps and climate zone descriptions.

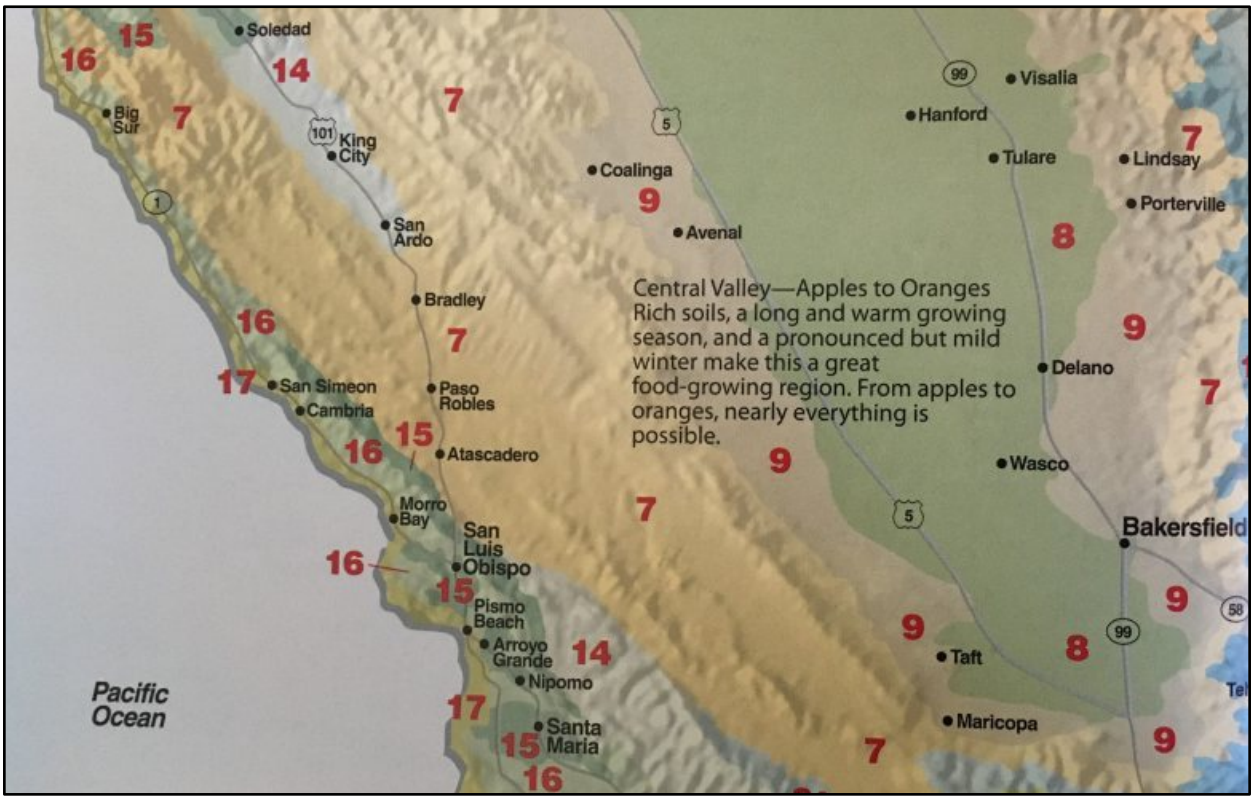
The Sunset Climate Zone(s) for WFH is Zone 7. Zone 7 encompasses several thousand square miles west of the Sierra Nevada and Cascade ranges, and in the mountains that separate the Southern California coast from interior deserts. Because of the influence of latitude, this climate lies mostly at low elevations in Oregon's Rogue Valley, middle elevations around California's Central Valley, and at middle to higher elevations farther south. Gray pines define the heart of Zone 7 around the Central Valley, but more adaptable incense cedars replace them farther north and south.

Hot summers and mild but pronounced winters give Zone 7 sharply defined seasons without severe winter cold or enervating humidity. The climate pleases plants that require a marked seasonal pattern to do well—flower bulbs, peonies, lilacs, and flowering cherries, for example. Deciduous fruit trees do well also; the region is noted for its pears, apples, peaches, and cherries.

Gardeners in a few spots around the San Francisco Bay will be surprised to find their gardens mapped in Zone 7. These areas are too high and cold in winter to be included in milder Zones 15 and 16. In the mildest parts of Zone 7—in the extreme southern Salinas Valley, for example—you can get away with growing borderline plants such as citrus, oleanders, and almonds if you choose a

spot with good air drainage to take the edge off winter chill. At weather-recording stations in Zone 7, typical winter lows range from 35 to 26°F (2 to –3°C),with record lows averaging from 18 to -0° F (–8 to –18°C).

Figure 1.2.10
Sunset Climate Zones for California's Central Coast



Koppen Geiger Climate Classification

The Koppen Geiger Climate Classification System is a widely used climate classification system, useful in tracking large scale climate changes over time. Helpful visualizations are available as .kmz files in Google Earth. Knowing your KGCC rating can be especially helpful in quickly finding climate analogues around the world as a starting place for researching biological systems, management practices and species that will have a high likelihood of success at your location. The Koppen Geiger Climate Classification System map, viewable by county, is available at http://koeppen-geiger.vu-wien.ac.at/.

The Koppen Geiger Climate Classification for San Luis Obispo County is **Csb/BSk.**

- **Csb:** The **C** stands for warm temperate, the lower case **s** for precipitation mode of 'summer dry' and the lower case **b** for a temperature rating of 'warm summer'. This is generally considered a Mediterranean climate.
- **BSk:** The B stands for Arid, the s stands for Steppe, and the k stands for 'cold arid'. This is generally considered a semi-arid, dry-steppe type environment.

Growing Season

The growing season for climate-adapted native plants typically occurs during and immediately following the rainy season (December through March) and tapers by the end of spring (Early June), entering some sort of stasis come the hot, dry months of summer. For non-native, food producing, or other plant varietals the growing season is quite long with an average of 286 sunny days in a typical meteorological year at Paso Robles Regional Airport.

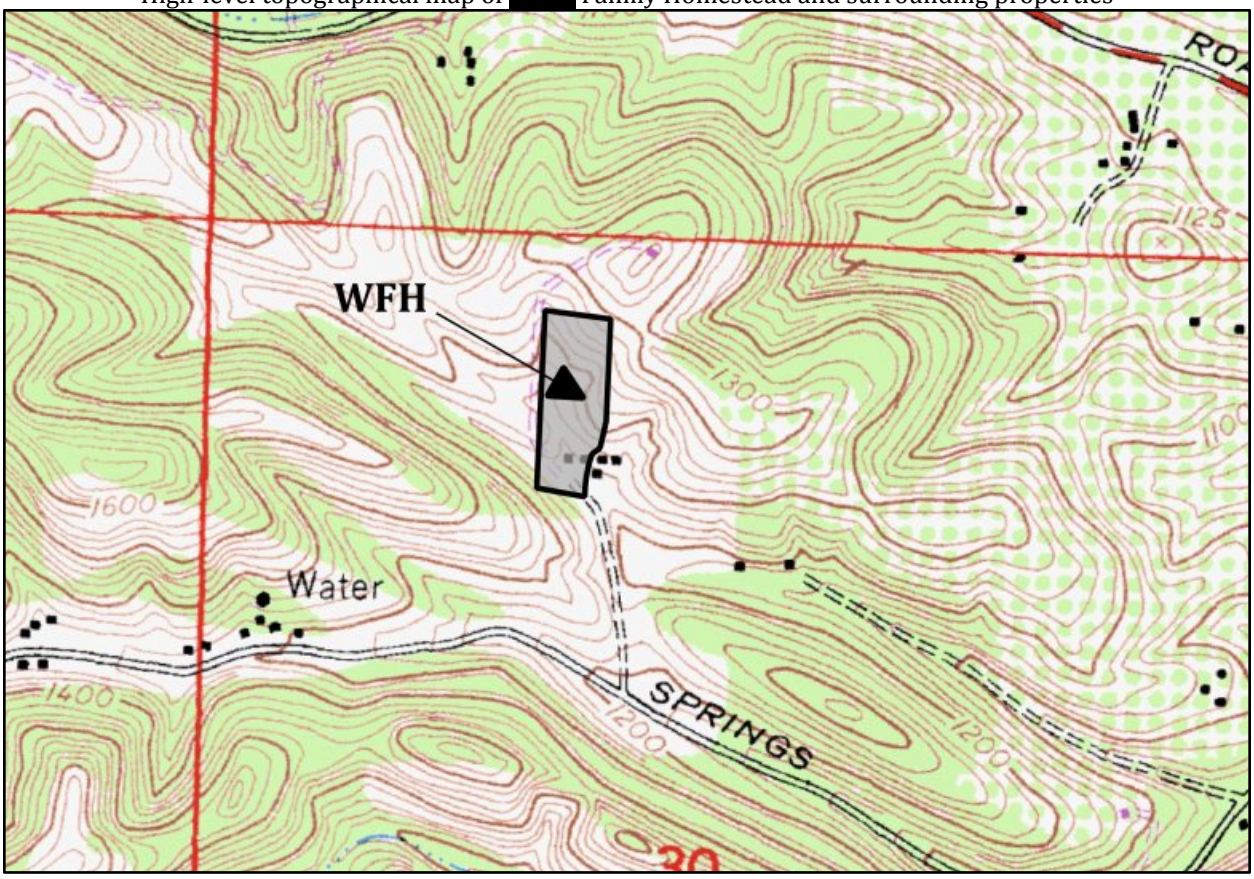
1.3 Topography

Topography describes the variation in elevation across a landscape. Topographic maps use contour lines to show the shape of the earth's surface in addition to the geographic features included on typical maps, including roads, railroads, rivers, streams, lakes, buildings, built-up areas, boundaries, place or feature names, mountains, elevations, survey control points, vegetation types, and much more.

A contour line joins points of equal height. Contours make it possible to show the height and shape of mountains, depths of the ocean bottom, and steepness of slopes. Basically, contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface, usually mean sea level.

Figure 1.3.1 presents the high level topographical map for WFH and the surrounding properties of [redacted] Rd.

Figure 1.3.1
High-level topographical map of [redacted] Family Homestead and surrounding properties



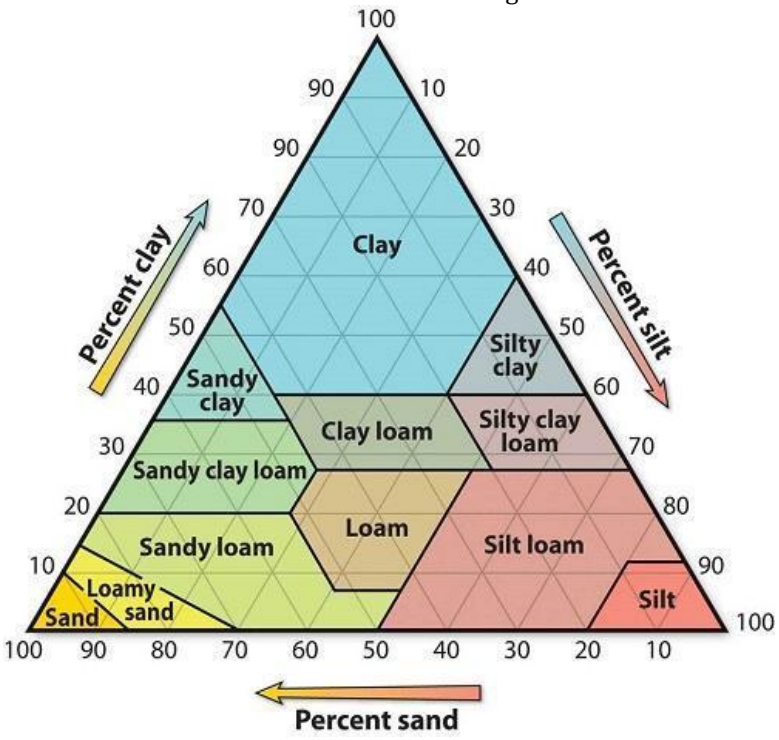
WFH lies in a valley bowl, with a large portion of the property on a southwest-facing slope. Natural grades are as steep as 35-40%. Some of the machined-made slopes are steeper at 44-60%.

1.4 Soil Data

Fertile soil is the foundation for a healthy landscape. Soil data provides information for the landowner of what actions will be required to facilitate healthy development of the landscape. This information can be used to determine the best methods to organically build soil to optimal levels.

The soil texture classification triangle is shown in Figure 1.4.1, depicting the different proportions that occur between the three main particles that comprise soil: sand, silt, and clay. The percentages of each of these result in soil classifications such as “loam”, “sandy loam”, etc.

Figure 1.4.1
Soil Classification Triangle



Soil Condition Summary

All of the predominant soil types present on-property and up-watershed are predominantly of shale and/or sandstone origin. Soil pH is notably alkaline in these soil strata, with Natural Resources Conservation Service (NRCS) data suggesting an average pH of 8.2.

All NRCS soil layer data indicates that all soil types on the property and up-watershed are either fragile or moderately fragile, with high run-off potentials and low soil-moisture holding capacity, meaning they are quite susceptible to erosion. There was some evidence of the down-valley sediment migration from the up-valley vineyards and properties. Potential for high inbound sediment loads in the event of heavy rain events falling on pre-saturated soils should be taken into account and designed for in order to mitigate future issues with sediment deposition.

The fragility and general high-erodibility of the soil types present, along with low water holding capacities indicate that plant and tree roots will be among the most effective ways to infiltrate and store water. Care will need to be taken during wet periods with grazing animals to time their presence to allow the land to dry somewhat (and to dry significantly on the steeper slopes), so as to avoid physical damage on steeper slopes (>20%).

Soil organic matter content is quite low in its present state. Establishment of perennial plants and tree cover throughout the property is recommended to increase soil organic matter, particularly with drought hardy pioneer tree species that can be managed by coppicing, pollarding and/or chop-and-drop to rapidly increase soil carbon levels and consequent moisture holding capacity. Highly targeted and well-managed animal grazing at certain times of the year will also help to increase soil fertility and process perennial biomass into milk, meat and manure.

The Natural Resources Conservation Service (NRCS) map for WFH is provided in Figure 1.4.2. Detailed descriptions of the soil classifications shown on the map follow.

Figure 1.4.2
NRCS Web Soil Survey Data for [redacted] Family Homestead and surrounding areas

198—Santa Lucia-Lopez Complex

15-50 percent slopes - shallow soils, very high run-off, low infiltration rate once thoroughly wetted, low water storage capacity.

Composition:

- Santa Lucia and similar soils: 30 percent
- Lopez and similar soils: 25 percent
- Minor components: 45 percent
- **Santa Lucia:** Composed of residuum weathered from shale, typically 21-25" to unweathered bedrock, good capacity for infiltration (0.57 to 1.98" /hr) in most limiting layer, run-off is high, not considered prime agricultural soil, has very low ability to store water in the soil profile (~ 2.3").
    - Hydrologic Soil Group: C

    - **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
    - Landscape Capability Classification: **6e**
    - **Class 6** soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
    - **Subclass e** is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.
- **Lopez:** Composed of residuum weathered from shale, typically 14-18" to weathered bedrock, moderately high to high capacity for infiltration (0.57 to 1.98" /hr) in most limiting layer, run-off is very high, not considered prime agricultural soil, has very low ability to store water in the soil profile (~ 1.6").
    - Hydrologic Soil Group: D
    - **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This Hydrologic Soil Group has the highest runoff potential. They have *very low infiltration rates when thoroughly wetted* and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and *shallow soils over nearly impervious material* (as is the case at WFH).
    - Landscape Capability Classification: **6e**
    - **Class 6** soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
    - **Subclass e** is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

199—Santa Lucia-Gazos Complex

50-70 percent slopes - shallow soils, very high run-off, low infiltration rate once thoroughly wetted, low water storage capacity.

Composition:

- *Santa Lucia and similar soils:* 30 percent
- *Gazos and similar soils:* 20 percent
- *Minor components:* 46 percent
- **Santa Lucia:** Composed of residuum weathered from shale, typically 21-25" to unweathered bedrock, good capacity for infiltration (0.57 to 1.98" /hr) in most limiting layer, run-off is high, not considered prime agricultural soil, has very low ability to store water in the soil profile (~ 2.3").
    - Hydrologic Soil Group: C
    - **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- Landscape Capability Classification: **7e**
    - **Class 7** soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.

        - **Subclass e** is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.
- **Gazos:** composed of residuum weathered from shale, typically 28-32" to weathered bedrock, moderately high capacity for infiltration (0.20 to 0.57 inches/hr) in most limiting layer, run-off is very high, not considered prime agricultural soil, has low ability to store water in the soil profile (~ 3.9").
    - Hydrologic Soil Group: C
        - **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
    - Landscape Capability Classification: **7e**
        - **Class 7** soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.
        - **Subclass e** is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

Infiltration Tests

Infiltration tests were performed at several locations on property. The number of seconds were measured for 1 gallon of water to infiltrate into a 80.5 sq in area of soil, and that infiltration rate was extrapolated over the larger area this test site represented. The data gathered from these tests in summarized in Table 1-3, and is available in full detail in the WFH Water Catchment Calculator Google Spreadsheet.

Table 1.4.1
Infiltration test results for various locations at WFH.

Infiltration Test Location	Time Elapsed (sec)	Infiltration Rate (gal/sq.ft./min) Standing Water	Infiltration Rate (in/min) Standing Water	Infiltration Per Acre Per Min (gal/acre/min) Standing Water	Infiltration Per Acre Per Hour (gal/acre/hr) Standing Water
Perc 1 - Lower Pasture	240	0.45	0.72	19,480	1,168,815
Perc 2 - Fill Slope	110	0.98	1.57	42,502	2,550,142
Perc 3 - West Upland Drainage	5	21.47	34.44	935,052	56,103,116

*NOTE: The infiltration rate values are very high due to the exceedingly low water retention capacity of the native soil profile. Once the thin surface soil layer is saturated, the infiltration rate would effectively be zero and then surface sheet flow would begin, increasing risk of erosion damage depending on the intensity of the precipitation event.

Figure 1.4.3
Locations of the infiltration tests performed on the WFH property.

1.5 Existing Vegetation

Existing Vegetation - Wild / Nativized		
Common Name	**Scientific Name**	**Notes**
Coyote Brush	*Baccharis pilularis*	CA native, excellent habitat, viewscreen, low-level windbreak, very fire-resistant
Milk Thistle	*Silybum marianum*	Invasive, medicinal seeds, edible stalks and roots, highly flammable when dry
Star Thistle - Yellow star thistle, geeldissel, golden star thistle, St. Barnaby's thistle	*Centaurea solstitialis*	Invasive, crowds out native grasses, toxic to horses, highly flammable when dry
Black Mustard	*Brassica nigra*	Invasive, tall, yellow flowers, early season growth before other plants, seeds can be used to make mustard, highly flammable when dry
Doveweed, Turkey Mullein	*Croton setiger*	CA native, indicative of low nutrient soils, drought tolerant, native people used it to stupefy fish
Kotolo / CA Monarch / Woolly Pod Milkweed	*Asclepias eriocarpa*	CA native, food for Monarch butterflies, perennial herb, hairy leaves, produces large woolly fruit, toxic if ingested.
White Horehound	*Marrubium vulgare*	Non-native, medicinal, pollinator attractor, drought hardy, beautiful,
Narrow Leaf Milkweed	*Asclepias fascicularis*	Food for Monarch butterflies, poisonous if ingested, flowering perennial, beautiful in dried arrangements
Black Locust	*Robinia pseudoacacia*	Thorny, nitrogen-fixing, prolific spring blooms that are edible and fragrant
Mexican Elderberry	*Sambucus mexicana*	Medicinal, beautiful blooms, important bird food source - a great ally in the landscape!
Coast Live Oak	*Quercus agrifolia*	CA native oak, mast producer, attracts a variety of birds and butterflies

Blue Oak / Iron Oak / Mountain Oak	*Quercus douglasii*	Most drought-tolerant deciduous oak in CA, produces acorns with a slight sweetness
Woodbine / False Virginia Creeper / Thicket Creeper	*Parthenocissus vitacea*	CA native, mature fruit looks like a grape but is toxic, climbing vine, drought hardy, invasive
Loblolly Pine	*Pinus taeda*	East coast native, blooms in late winter, early spring
CA Black Walnut	*Juglans californica*	CA native, deciduous, fragrant, nuts edible but difficult to extract from thick shell, traditionally used to make Nocino and black dyes

Existing Vegetation - Planted		
Common Name	**Scientific Name**	**Notes**
Oleander	*Nerium oleander*	Very drought hardy, beautiful blooms, all parts poisonous - will affect horses, cattle, sheep, dogs, humans, goats
Thornless Honey Locust	*Gleditsia triacanthos*	Nitrogen-fixing, edible as browse for grazing animals, creates light dappled shade, deciduous
Magnolia	*Magnolia grandiflora*	Requires irrigation in this climate, intensely fragrant, evergreen
Fruitless Plum	*Prunus spp.*	Dark purple foliage, ornamental specimen
White Mulberry	*Morus alba*	Heavy producer, can be propagated from cuttings, good high-protein browse for grazing animals, berries can be dried or eaten fresh
Almond	*Prunus dulcis, Prunus amygdalus*	Annual nut producer, same family as peaches and other stonefruit, can be dry farmed
Callery Pear / Bradford Pear	*Pyrus calleryana*	Adapted to wide variety of soils, inedible fruit taken by birds after frost

Carob (fruitless variety)	*Ceratonia siliqua*	Slow growing, very drought adapted, evergreen foliage

Based on the existing vegetation found during the Level 1 Site Survey, it can be broadly concluded that much of the property at one time had unrestricted grazing animal access. The fact that the broad, open areas of the Upper and Lower Paddocks are both dominated by annual grasses and a variety of "invasive" and "non-native" plant species - Yellow Thistle, Milk Thistle, Black Mustard - indicate that these areas experienced persistent grazing pressure without adequate recovery. The few perennial plants that are present in these areas - Coyote Brush, Doveweed, both Milkweeds - further indicate the low organic matter and low nutrient levels of the soil.

A number of very valuable trees and plants already exist on the property. Elderberry is a potent medicinal and can be propagated from cuttings and seed. Similarly, the fallen White Mulberry in the south east corner of the Lower Paddock can be propagated from cuttings and seed and is an amazing plant for browsing animals, birds, critters and humans alike. The Oaks and Black Walnut can also provide excellent seedstock for longer-term reforestation with locally adapted species.

1.6 Land History

The Salinan people inhabited the area in which Paso Robles is located for thousands of years prior to the arrival of the Spanish. The area where Paso Robles is today is known to the Salinan as The Springs due to the large number of natural hot springs in the area. The Salinan tribal council is still active in Northern San Luis Obispo county and the Morro Bay area. The Salinan are an officially recognized tribe by the state of California and are petitioning for federal recognition. Their traditional language of Hokan is the oldest known spoken language in California. Archaeological evidence indicates that the Salinan have inhabited this region for over 10,000 years. For more information, visit the Salinan Tribal Council website.

The Salinan were quickly and brutally incorporated into the mission system following the arrival of the Spanish. The General History of Mission System from the Native American Heritage Commission of California is well worth reading .

In August of 1857 the Paso de Robles Land Grant of 25,933 acres was purchased by brothers Daniel and James Blackburn and Lazarus Godchaux from Petronilo Rios. Daniel became the owner of the land west of the Salinas River that eventually became the town of Paso Robles. At the time of purchase there was no town, only a small wooden log shack built around the spring that was located on the northeast corner of what ultimately become 10th and Spring Streets. The spring went dry in 1906 but later became active again in 2003 following an earthquake.

The first post office was established in 1867, and the first train reached the town in 1886, which opened up the original land grant to additional prospective buyers. Paso Robles became a health resort, and many people came to enjoy the hot mineral springs and mud baths.

Paso Robles once had the highest concentration of almond orchards in the world, and some of these orchards still exist, though many have been replaced by vineyards.

Property Specific

Due to the presence of the horse stalls and the high and very well-built fencing around the lower portion of the property, it is assumed that the land was used as a horse paddock for some time by prior owners (most likely before the main residence was built in 2004). There are a number of deceased almond trees located in the upper pasture, and some closer to the house that are still producing. This pattern is evident on the surrounding properties as well, indicating at one time a large portion of the southwest facing slopes within the small valley in which WFH is located was in almond production. Given the past (and unfortunately still current) practice of tilling the ground in and amongst these old almond trees to reduce weed pressure, the land has likely suffered a severe loss of top soil over the past 100+ years in particular. Rebuilding this living layer via soil and water-centric management practices will be a key factor in creating an abundant and beautiful home landscape at WFH for current and future generations.

The scar on the fill slope due south of the house (where the giant thistle patch is) had what appears to be a trench running through it during the construction of the home, as visible in the images below taken in March of 2004. By August of the same year both this trench and a similar one near the animal housing have been filled in, though the scald is still clearly visible in the landscape.

Past Google Earth satellite photos taken of [redacted] shortly after construction. Left: March 2004. Right: August 2004.

2. Water

The water used on most properties for household and landscape is typically piped in from a municipal water company or pumped from a drilled well. While, for many landowners, the day-to-day consistency of these sources provide a convincing case for water security, others are quickly realizing the hard way that these water sources are not as secure as once thought. Landowners on a municipal water supply are subject to the pricing and whims of the utility, which is subject to the whims of the environment, electrical grid, and water supply. Well owners are also subject to the whims of the electrical grid (or solar/wind systems) – but additionally, in many areas owners are coming to find their flow rate dropping or even disappearing altogether as underground aquifers are depleted.

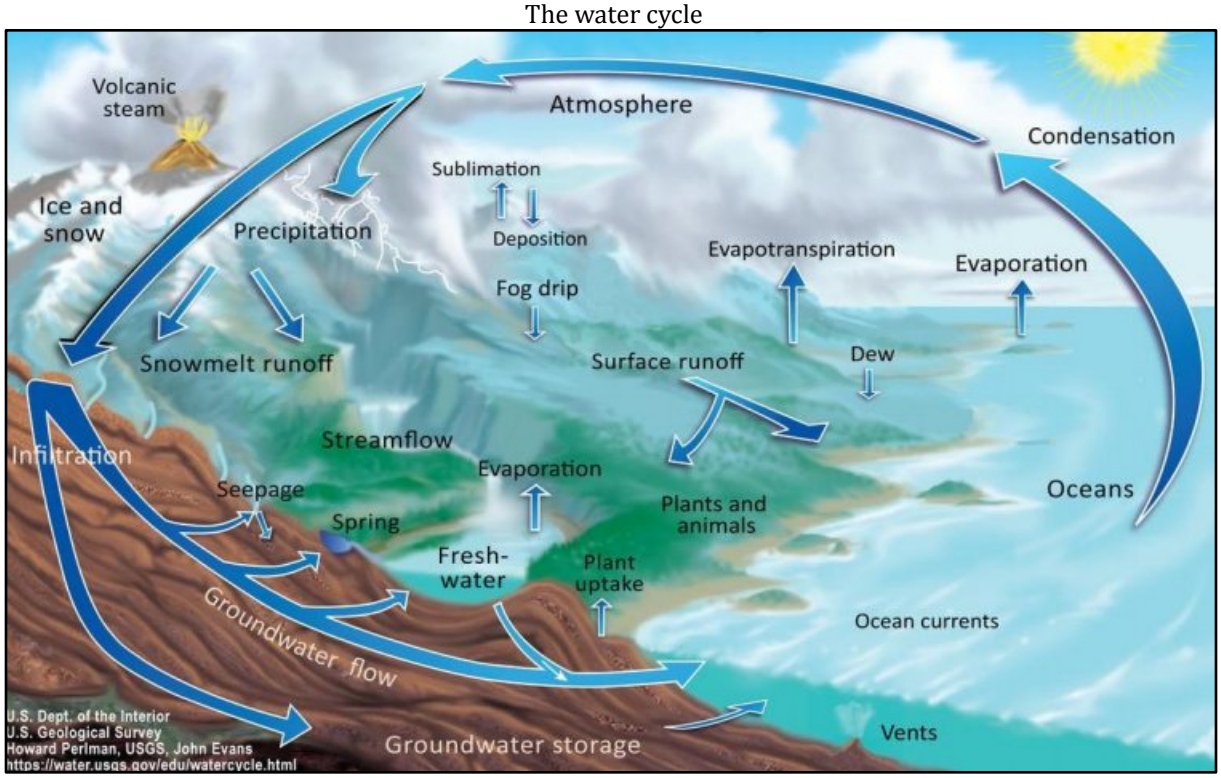
Additionally, conventional property development in the past century was geared towards moving rainwater away from structures and off-property as quickly as possible in an effort to prevent damage. While this seemed to work at first, unfortunately in the long-term this has resulted in major erosion issues (exacerbated by the clearcutting of land and overgrazing with cattle), landscape dehydration, and aquifer depletion.

These issues speak to the critical need for landowners to work with water and embrace its presence on-site rather than fight it by designing for and implementing rainwater harvesting strategies - to work towards regenerating the hydrological cycle on the landscape.

The Four R's of Regenerative Hydrology

The actions of regenerative hydrology can be expressed in terms of sound fiscal budget management. The 4 R's of a water budget - receive, recharge, retain, and release - are equivalent to income, deposit, savings, and expense. Landowners should ensure that the water balance of local watersheds is in the blue and not in the red, that liquid assets continually produce a high-quality return on investment, and re-invest returns back into local watersheds to continue building principal.

Figure 2.0.1
The water cycle



Receive = Income

Watersheds only receive water as snowfall, rainfall, dew condensation and fog precipitation. Annual precipitation is the only true source of ***income*** to re-supply a property's water budget allowance. Everything else (drafting fossil aquifers, importing from other areas) is drawing down on principal.

Regenerative hydrology advocates the adaptive management of watershed lands to optimize rehydration by promoting land use patterns that enhance the receptive capacity of a watershed in times of excess and the retentive capacity in times of drought.

Recharge = Deposit

Recharge processes are critical for the landscape to annually refresh itself via the deposit slip called infiltration. The capacity to make water deposits depends on the watershed's recharge potential. Precipitation received by the watershed must percolate and be absorbed, or else there is no replenishment of the water savings account.

Recharge potential and functions are impaired by the hardening and paving over of natural recharge areas, the disconnection of rivers from their floodplains, the deforestation of native vegetation, and the draining of wetlands.

To increase recharge, a landowner can:

- Limit impervious surfaces and the wholesale conversion of native vegetation.

- Implement stormwater pacification techniques designed to slow, spread, and sink water into earthen storage.
- Protect open space in known groundwater recharge areas. If site conditions are not conducive to recharge, then the landowner is wise to ensure proper bio-filtration of all surface waters prior to their discharge and deposit into rivers, wetlands, lakes, estuaries, and oceans.
- Most Importantly - Landowners can plant trees and establish perennial vegetation wherever bare soil exists. Trees are far and away the best producers of future rainfall, in addition to being the best protectors of soil *from* the impacts of rainfall as well as the most effective means by which to infiltrate precipitation into the soil and increase soil moisture to the benefit of all lifeforms. Trees and perennial vegetation are *critical* to increasing the recharge capacity of the landscape.

Retention = Savings

The retention of recharged precipitation is like a savings account asset that yields interest. The storage of water is often the most challenging aspect of water supply management. Regenerative hydrology strategies should appropriately slow water down, increasing the residence time of water storage in our watersheds. This will optimize the amount of water available for local expense by living processes.

A landowner is wise to avoid overdrafting of their local watersheds. To be in the blue, a healthy albeit challenging goal is to never extract out of storage (groundwater) in amounts greater than what is annually received and recharged. While this can go on for a while, eventually a penalty must be paid. In situations where this is currently occurring, landowners can take steps to mend the broken hydrological cycle to ensure that as much water as possible is being returned and put to highest use in the landscape before it leaves.

Release = Expenditure

Ideally, expenditure of water assets will go to further increase the reception, recharge and retention capacities (the first 3 R's) of the watershed.

Water is released naturally to the ocean, land and atmosphere in a process known as the water cycle. Through seasonal snow and ice melts, groundwater springs and seeps, water is returned to creeks and rivers. Solar evaporation and evapo-transpiration by plants help to form new clouds and feed the cycle anew. The infinite nature of this cycle is to continually flow and be in flux as the expense of one stage produces income for the next.

Common modern development practices (creating impervious surfaces, channelizing stormwater, etc.) tend to increase the rate and volume of storm water's return to the ocean via excessive runoff and heightened flood discharges. This directly reduces the landscape's ability to retain water and diminishes the amount of water available for later release during the dry season when it is most needed.

Water Patterning Strategies for Regenerative Hydrology

Slow, Spread, Sink, Grow

1. **Slow The Water Down -** By slowing the movement of water over a landscape, its erosive potential is reduced and infiltration is allowed to occur. Common methods for achieving this are increasing vegetative cover (grasses, trees, plants), installing earthworks (swales, catchment basins, net-and-pan, boomerangs, keyline plowing etc.) and limiting/reducing the use of hardscape and consequent concentrated run-off flows, and when possible using permeable surfaces.
2. **Spread The Water Out -** Part of slowing water down is to spread it over as much surface area as possible, and reduce any peaks in concentration. The more surface area the water can touch the greater the opportunity for it to sink in and be put to work in the landscape. Common methods for spreading water include those mentioned above as well as geological and biological flow spreaders (plants and/or rocks arranged to pacify and spread overland flows).
3. **Sink The Water Into Soil -** If Steps 1 and 2 have been designed well, this part will take care of itself. For this, an emphasis is placed on permeable surfaces where hardscape is necessary and encouraging vegetation where it is not (plant and tree roots are the best infiltration mechanisms we have).
4. **Grow Biomass -** Slowing water down, spreading it out, and encouraging infiltration into living soil creates the greatest amount of living edge possible for water to interact with. It is here that the landscape and its stewards reap the greatest rewards, as evaporation is reduced, solar energy conversion to biomass is maximized and life expression is steered towards abundance.

Rainwater harvesting falls into two major categories—passive water harvesting and active water harvesting. Very simply, passive water harvesting works by shaping the earth to slow the velocity of runoff, infiltrate it into the soil, and direct it to where it can be beneficially used by vegetation. Active water harvesting, in contrast, uses rain barrels, cisterns, and other types of containers to store rainwater for later distribution. The stored water can be used outdoors to irrigate vegetation or indoors for non-potable (toilet flushing, laundry washing) and potable (with appropriate filtration) uses. Both passive and active water harvesting systems can "extend" the rainfall season and maximize the use of water that falls on property. Passive systems are more cost effective than active systems per gallon harvested, but yield fewer options for water use.

Most landowners opt for a combination of active and passive water harvesting. Below is a summary of the rainwater calculations for the WFH property, existing passive and active water harvesting systems in place, as well as recommendations of strategies to increase water harvesting capacity.

Context

Rainwater Harvesting Potential

A watershed, also known as a drainage basin or catchment, is an area bounded by hills, ridges, and valleys where any rainfall and runoff leads to a single outlet. Watersheds can be as small as a footprint, the roof of a house, a small urban residential property, a broad-acre farm, or large enough to encompass all of the land that drains water into rivers that drain into the ocean (such as the portion of the San Luis Obispo watershed draining into San Luis Obispo Creek, ultimately draining into Avila Bay). It all depends on the outflow point; all of the land that drains water to the outflow point is the watershed for that outflow location.

[redacted] Family Homestead is located at the bottom of a larger valley bowl. The property has 6.3 acres of on-property catchment area comprised of built structures, hardscape, and softscape summarized in Table 2.0.1. The total effective catchment for the property (on-property catchment + off-property run-on) is ~ 10.7 acres (464,350 sq. ft.), with run on coming from the surrounding uphill properties to the North and West and the old tractor road cut on the property to the east. An additional ~131 acres of up-canyon catchment is located above the WFH property but does not provide any run-on potential to the majority of the property (though some could be harvested via curb cuts in the lower south east corner of the property).

Table 2.0.1
Summary of catchment areas within WFH boundaries

Catchment Name	Area (sq. ft.)	Surface Type
Structures - House Roof	4,718	Roofs
Structures – Barn Roof	647	Roofs
Total Effective Catchment	464,350	Ag/Bare-Packed Soil/Rough

During a mean rain year of 14.77 inches, the total volume of rainfall that lands within WFH property lines is 2.53 million gallons; the total volume that lands on structure roofs (Main Residence + Animal Housing) is 47,414 gallons. The Total Effective Catchment (illustrated in Fig. 2.0.2 below) of 10.7 acres receives an estimated 4.29 million gallons of direct rainfall each year. Based on runoff estimates for the terrain, an estimated 900,000 - 2,140,000 gallons of this water is lost to runoff during an average rain year from the Total Effective Catchment. Detailed calculations are available on the Catchment and Runoff Calculation spreadsheet.

Figure 2.0.2
Primary watershed feeding into WFH property

In a mean rainfall year of 14.77 inches, over 52.5 million gallons of rain falls on the 131 acres up-canyon from WFH. Based on runoff estimates for the terrain, an estimated 10.5 - 26.2 million gallons of this water is lost to runoff during an average rain year, which ultimately passes through WFH land via the [redacted] [redacted] road easement. This watershed ultimately feeds into the Salinas Valley watershed and the Salinas River via the San Marcos Creek watershed. Macro scale views of this watershed can be viewed at the San Luis Obispo County Interactive Data Viewer.

Figure 2.0.3
WFH location within the Mustard Creek - Salinas River Watershed.

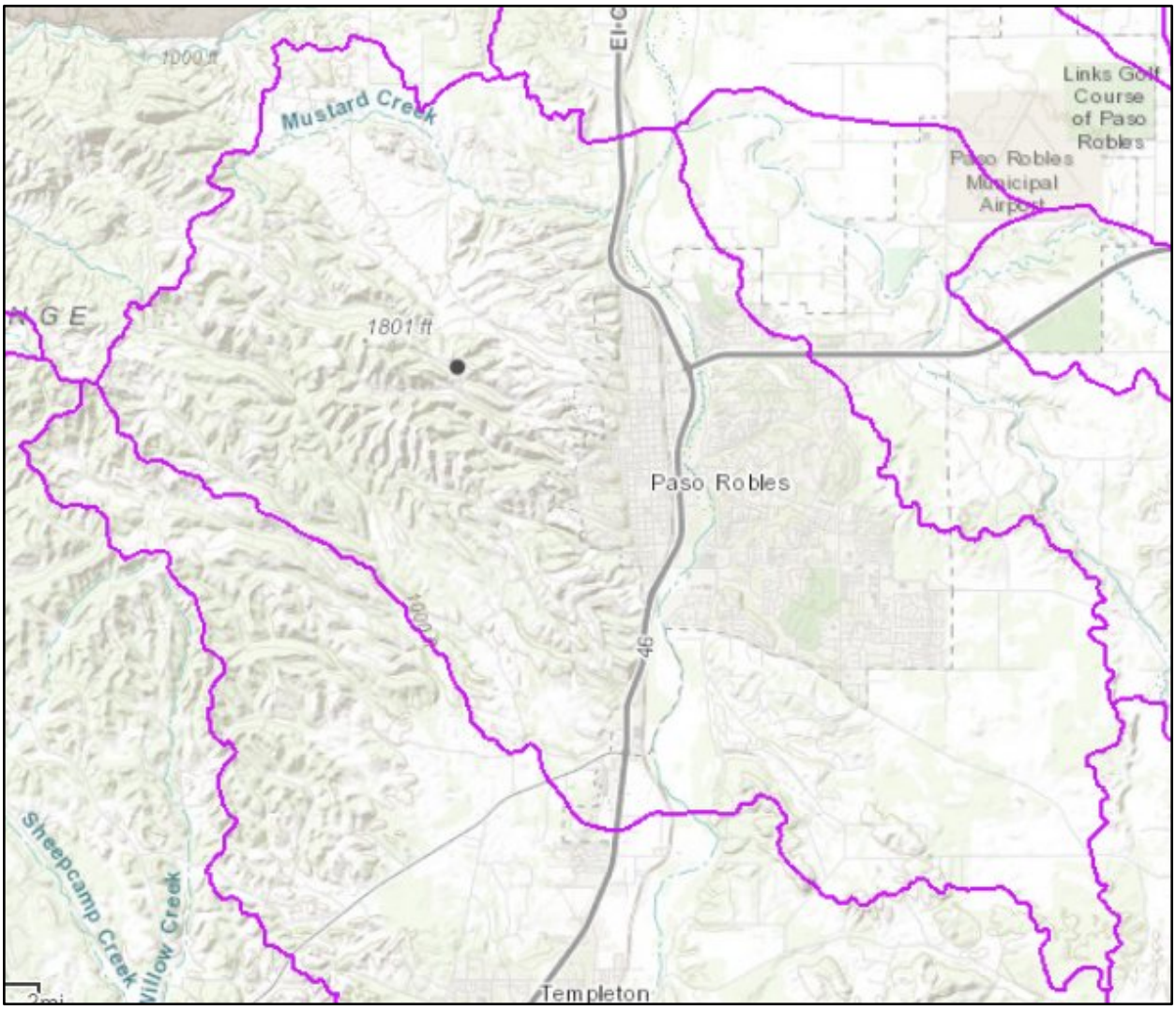
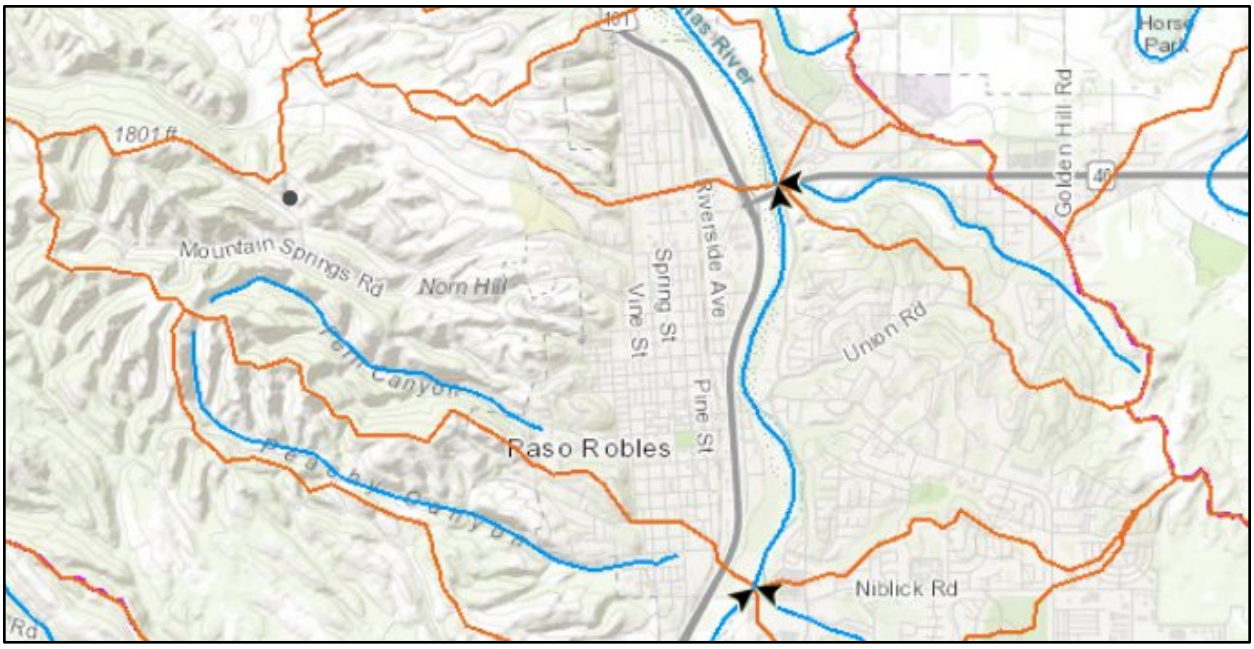


Figure 2.0.4
WFH Subcatchment location within the Mustard Creek Subwatershed within the Salinas River Watershed.

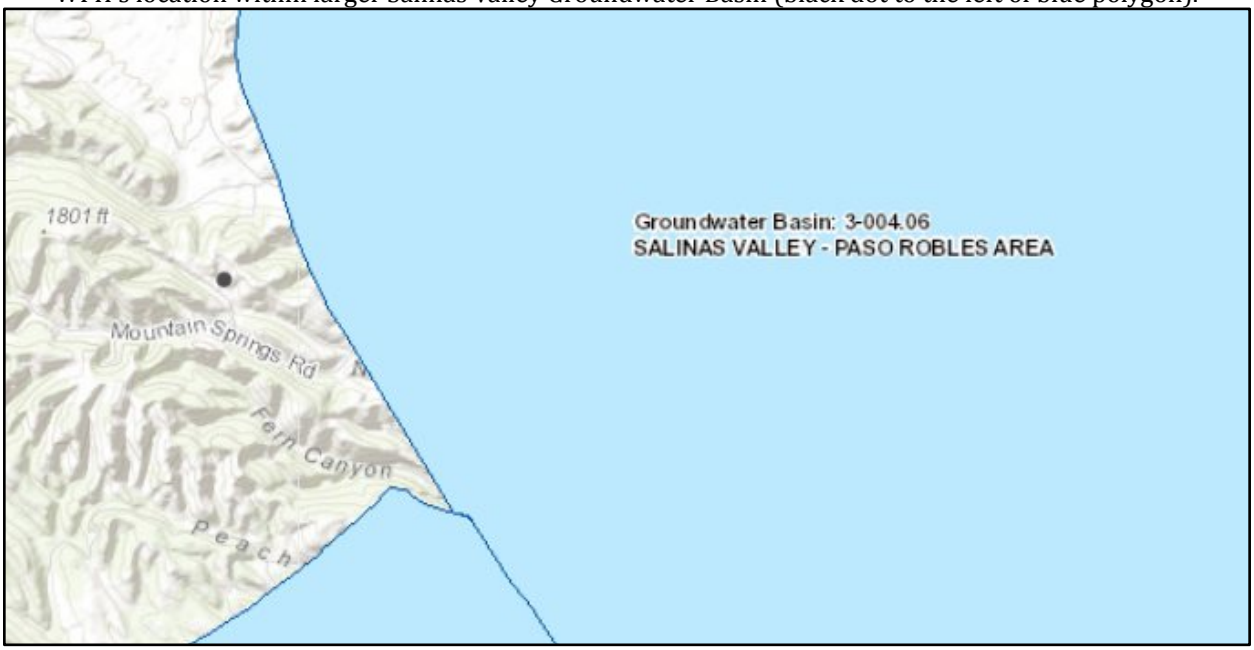


Aquifer

Additional information about the aquifer underneath [redacted] Family Homestead can be gathered from the following websites:

- Principal Aquifer Map of U.S.
- California Groundwater Basin Boundary Assessment Tool
- California Water Management Planning Tool

Figure 2.0.5
WFH's location within larger Salinas Valley Groundwater Basin (black dot to the left of blue polygon).



WFH is located just adjacent to the boundary of the Salinas Valley Groundwater Basin, which is currently classified as Critically Overdrafted. Groundwater overdraft occurs when groundwater use exceeds the amount of recharge into an aquifer, which leads to a decline in groundwater level.

Wells

WFH has a dedicated well, located near the existing house. The well depth is currently unknown, though should be available for look up soon via the California Department of Water Resources Digitized Well Database[1]. The well had a recorded sustained flow rate of 14.7 gpm in April of 2019 . During the course of the 4 hour pump test, the pumping level dropped from 83'0" to 95'4". Within 17 minutes of the cessation of pumping the water level had risen back to 85'. The well is configured with a 2,500 gallon storage tank located adjacent to the pump house by the main entry gate. The most recent water quality test for *E. coli* bacteria performed in April of 2019 came back absent the presence of colony forming units (<1 CFU/100mL). Additional information regarding well water tests can be found at: California State Water Resources Control Board - Private Well Water Quality Testing Resources[2]. The well is located approximately 150' uphill from and west of the leach field serving the Main Residence.

Municipal Water

The property is not currently tied to any municipal water systems.

2.1 Passive Rainwater Harvesting

Passive water harvesting works by shaping the earth to slow the velocity of runoff, infiltrate it into the soil, and direct it to where it can be beneficially used by vegetation. Passive water harvesting features include swales and berms, dry stream beds, infiltration basins, retention ponds, pumice wicks, French drains, and of course, healthy, humus rich soils. They are typically less expensive, simpler to build, lower maintenance, and longer lasting than active water harvesting systems.

Existing Conditions

While over 4.29 million gallons of water falls within the Total Effective Catchment for WFH during an average rain year, a large percentage of this water (estimated 21-50%) exits the property via runoff or evaporates before being able to be utilized by living systems due to the predominance of thin absorptive soil layers, fast-growing, short-lived annual grasses and a lack of tree cover. The infiltration rate of the soil is quite high, but its capacity to hold water is very low. Additionally, organic matter content is very low, further reducing the soil's capacity to retain water for productive use later into the growing season. Wind exposure and bare soil without cover or shade currently create high evaporation conditions.

Recommendations

In order to improve water infiltration and retention on-site, the following opportunities have been identified:

- Sheet Flow Diversion Berm Remodel - above the house and below the solar panel location, to take erosive pressure off of the current outlet onto the cut slope and driveway hardscape below.

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[1] https://www.waterboards.ca.gov/water_issues/programs/gama/online_tools.html

[2] https://www.waterboards.ca.gov/gama/well_owners.html

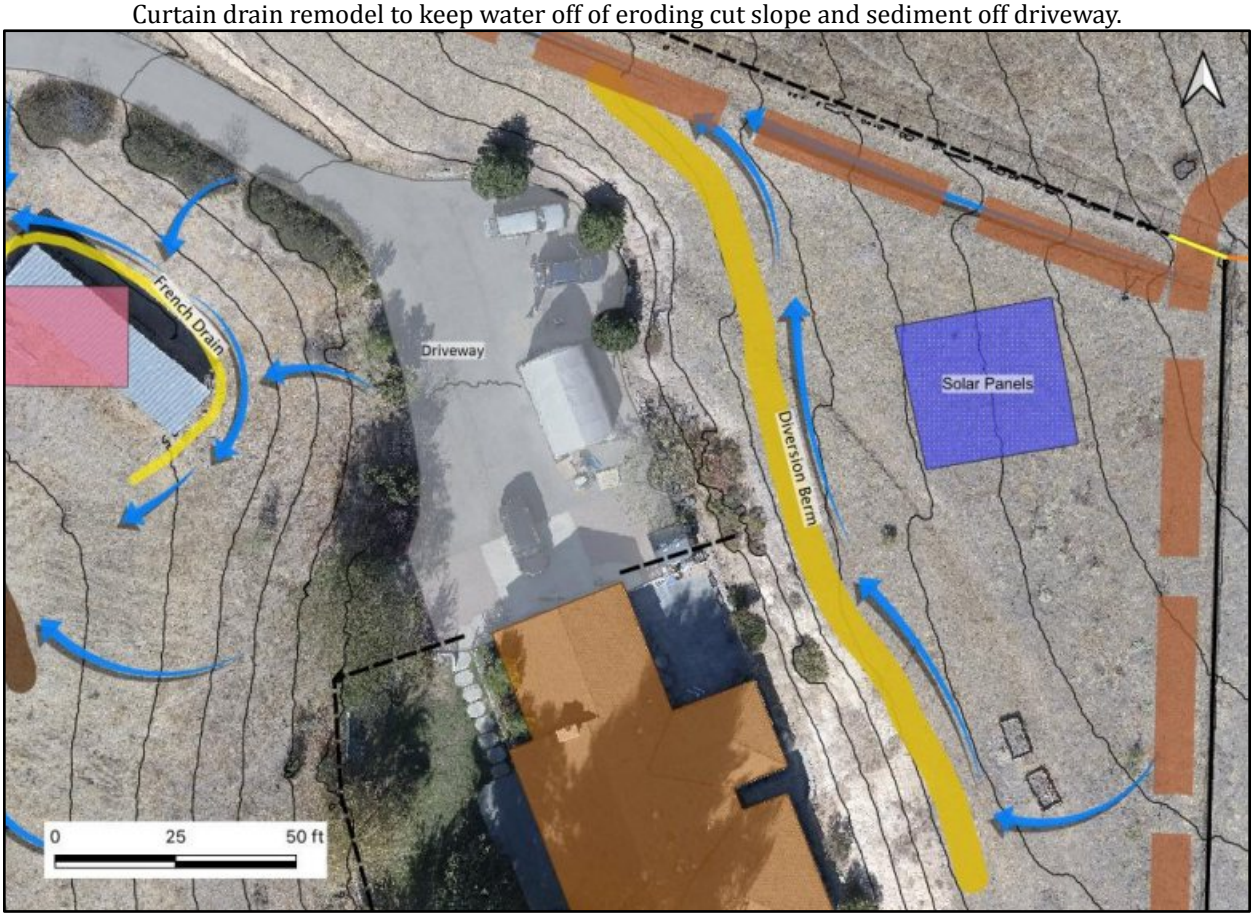
- French Drain Installation Above Shop - around the foundation of the future shop.
- Channel Drain Installation Across Driveway - through driveway just below the future shop location to direct run-off water from upper acreage into small swale system.
- West Valley Swale System Installation - install three small swales below the shop to infiltrate potential run-off and create tree growing opportunity.
- Pacify and infiltrate run-off from the Main Residence.
- Directing downspouts directly to planted infiltration basins for ADU and Shop.

Sheet Flow Diversion Berm Remodel

The steep cut slope that borders the northern edge of the upper driveway is actively eroding and depositing sediment onto the driveway and increasing the instability of the earth wall. To amend this, the curtain drain that was previously installed should be remodeled to shift incoming sheetflow onto the tractor access road paralleling the fence. This will prevent sheet flow run-off from further eroding the fragile edge, keep sediment off of the driveway, and preserve the current landform.

Figure 2.1.1

Curtain drain remodel to keep water off of eroding cut slope and sediment off driveway.



As illustrated the berm is 187’ long and need not be any taller than 12” - even 6” in height is plenty so long as there is a constant grade of at least 1% (not more than 2%) sloping toward the tractor road to insure that water continues to travel north towards the tractor road and around the eroded

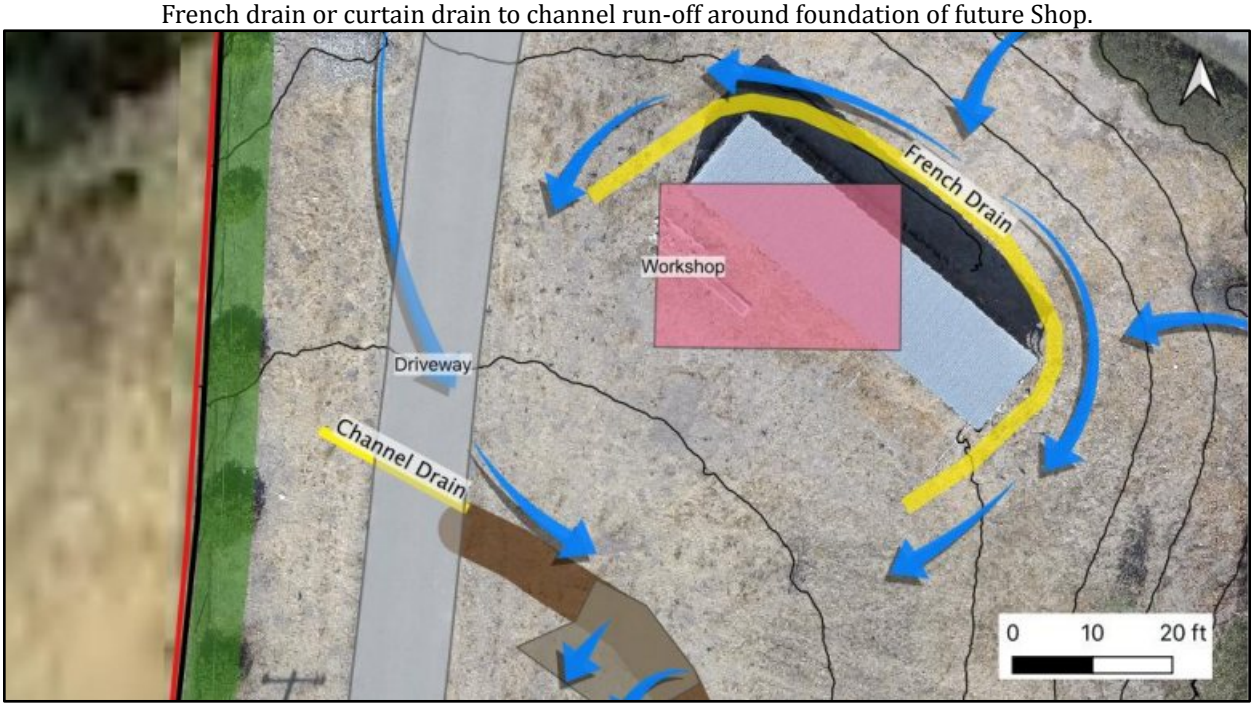
cut slope above the driveway. See Section 5.3 - Erosion Control - Sheetflow Diversion Berm Planting for details regarding planting the berm.

French Drain Installation Above Shop

As part of the construction of the foundation for the new Shop, a French drain or curtain drain should be installed to keep water from pooling against the foundation. Once the final footprint for the Shop is known, the drain can be installed. Even a simple curtain drain, sunken just below the grade of the foundation and buffering it by several feet, will be enough to remove water from the area, as the potential inflows are low and the native soil infiltration rate is high. Both types of drains should have between a 1-2% grade.

Figure 2.1.2

French drain or curtain drain to channel run-off around foundation of future Shop.



Channel Drain Installation Across Driveway

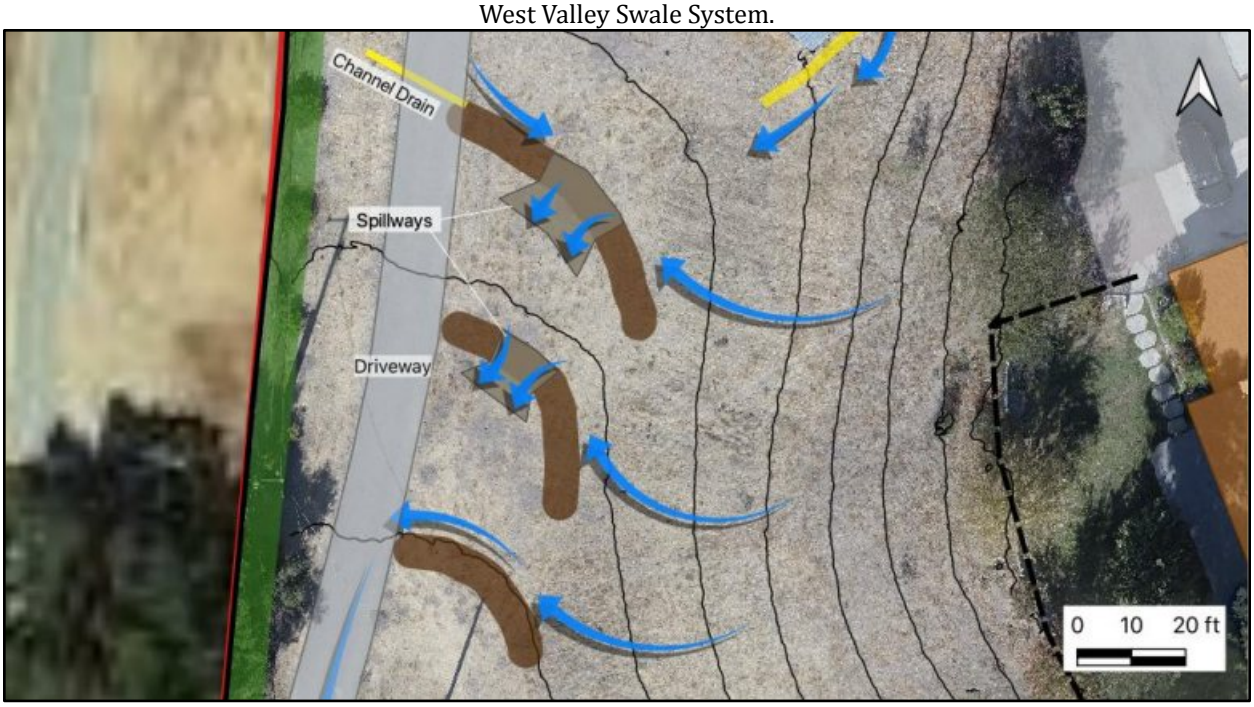
A channel drain installed across the driveway just below the elevation of the shop will serve to collect and channel run-off from the west valley and the driveway into the West Valley Swale System. The channel drain should have a rock lined collection basin constructed on its western end to collect sheetflow, pacify it, allow it to drop its sediment, and then discharge that water over a small level sill into the channel drain, where it can then transit across the driveway and into the top swale (see Figure 2.1.2 above). Channel drains are often used in driveways, sidewalks, and decorative hardscape as a low-profile and traffic-able way to drain water without impeding access.

Figure 2.1.3
Channel drain.

West Valley Swale System

The open area below the Shop location and immediately east of and adjacent to the driveway has the potential for a small, three tier swale system to enhance water infiltration and create an excellent tree growing system. The top, middle and bottom swales, respectively, are 55', 50' and 40' long as illustrated, for a total length of 145' of swales. Assuming a 1' depth at the level sill spillways and a 2' wide swale bottom, together they have a bank full capacity of 2,259 gallons (853, 778, and 628 gallons respectively) and a bank full infiltration potential of over 20,000 gallons per minute (this number will decrease towards zero once soil is saturated during a prolonged or heavy rain event). This swale system has a potential functional catchment of 7.71 acres, which, during a 1" rain event (depending on how intense it is and the saturation levels of the soil) sheds an estimated 42,000 - 104,000 gallons of water as surface run-off. During a typical rain year of 14.77 inches this translates to 618,000 - 1.54 million gallons that can be channeled through these swales and potentially infiltrated into the soil.

Figure 2.1.4
West Valley Swale System.



The bottom swale in the system is shown discharging back onto the driveway hardscape in order to move any excess water around the ADU directly downgrade from the swale. A small berm on the side of the driveway will help to keep water on the pavement from this point until it is past the ADU.

Pacify And Infiltrate Main Residence Run-Off

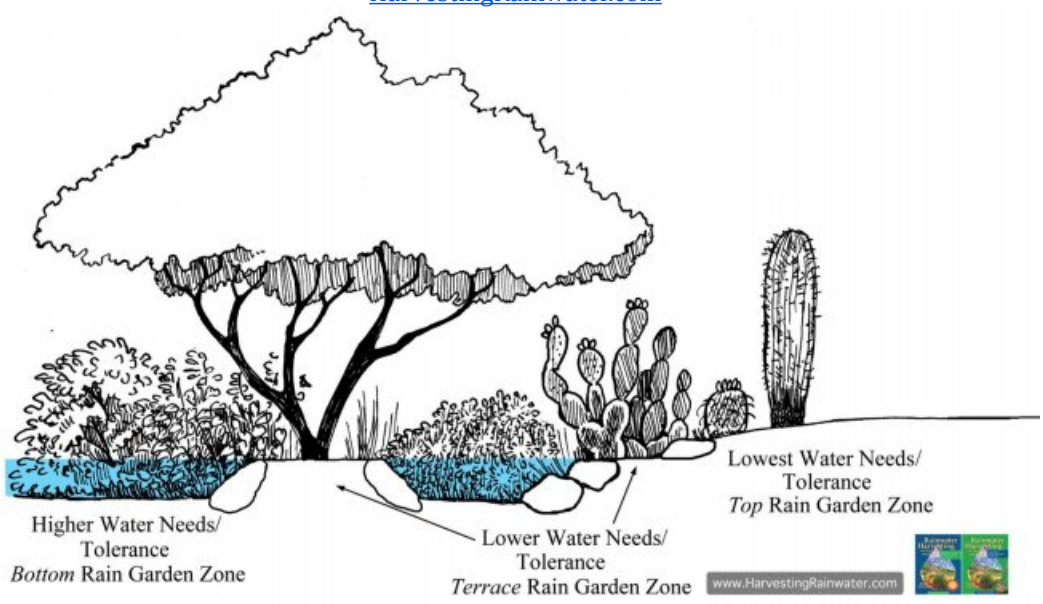
The gutters on the Main Residence currently discharge directly into drains. This water drains out onto the fill slope below the house via a buried pipe. The water can be better utilized by constructing a splash apron (a pile of rocks anchored by larger stones and ultimately by vegetation) beneath the outlet of the drain pipe, which will dissipate the energy of the water, before gently discharging it into vegetative elements (such as the recommended vetiver grass plantings).

Figure 2.1.5
Examples of stoneworks constructed by 7th Generation Design to dissipate the energy in inbound water flows.

Direct Downspouts From ADU And Shop To Planted Infiltration Basins

Rain gardens (planted infiltration basins) should be part of the planning and construction process for the ADU and Shop buildings. Plan for slightly sunken basins at or near downspout locations. These rain gardens will serve to infiltrate rain water and help to create thriving gardens around the buildings, which themselves will serve to beautify the structures and moderate the microclimate in the immediate vicinity. By virtue of the garden being in a slight depression, water use during the dry season can be further reduced, as the depressions themselves will be cooler and can be deeply mulched.

Figure 2.1.6
Examples of sunken rain gardens / infiltration basins. Image Credit: Brad Lancaster - HarvestingRainwater.com[3]



[3] www.HarvestingRainWater.com

2.2 Active Rainwater Harvesting

Active rainwater harvesting uses rain barrels, cisterns, and other types of containers to store rainwater for later distribution. The stored water can be used outdoors to irrigate vegetation or indoors for non-potable (toilet flushing, laundry washing) and potable (with extensive filtration and disinfection) uses. Active water harvesting systems can "extend" the rainfall season and maximize the use of collected water, but are also significantly more expensive than passive systems.

Existing Conditions

The only water storage on-site is the 2,500 gallon tank fed from the well - no rainwater storage systems currently exist.

Recommendations

The following active water harvesting elements and steps are recommended:

- Re-locate and install additional water tank at highest point on property to provide gravity-pressurized water to entire property.

Relocate And Install Additional Raintank At Top Of Property

By relocating the current water storage tank that is adjacent to the well house to the top of the property and augmenting it with an additional tank or tanks, gravity pressurized water can be fed to the entire property (see Table 2.2.1). This will increase resilience during power outages (when the pressure pump would be inoperable), which are becoming increasingly common due to the high fire risk faced throughout much of California, or pump failure (replacement of which can often take multiple days). Placing the tanks at the top of the hill will also create a water supply that can be utilized for firefighting or fire risk mitigation (leaving on sprinklers, irrigating landscape elements, sprinklers on roofs etc) throughout the property, even when the power may have already been cut as a precaution. Such tank placement would also enable the use of a WEEDS Fire Sprinkler system to protect structures, even in the absence of the home owners (see Living With Fire - Part 3: Home Construction And Retrofitting For Fire Survivability[4] on the 7th Generation blog for more information on this system).

The proposed trenching for the water supply lines to and from the tank(s) (see Figure 2.2.1) follows the east edge of the driveway from the well house, heading uphill. It crosses the driveway immediately adjacent to the Channel Drain (they can utilize the same trench/cut in the road surface) and then follows the tractor access above the Main Residence to the east fenceline, which it parallels until reaching the proposed tank location. The length of line from the well house to the proposed tank location as illustrated is 625'.

The distribution line from the tanks would utilize the same trench all the way back down to the well house, where it can be tied into the existing line that leads from the well house up to the Main Residence. Into this line a T can be installed and a line can be run across the slope towards the school zone, where smaller supply lines can be trenched to serve animal housing, the Outdoor Kitchen, the Yurt and associated gardens and food forest elements.

[4] https://www.7thgenerationdesign.com/living-with-fire-part-3-rev2/

Figure 2.2.1
Proposed location of water tanks in property's northeast corner.

Table 2.2.1
Gravity pressure calculations to various locations based on proposed tank location.

Location	Head From Tanks	Equivalent PSI*	Supply Line Length	Line Loss (2" HDPE @ 30gpm)	Estimated Actual PSI
Main Residence	95'	41	801'	6.16 psi	~ 35
ADU	145'	63	675'	5.2 psi	~ 57
Yurt	150'	65	900'	6.9 psi	~ 58

*The equivalent psi presented in Table 2.2.1 are the maximum pressures available at each listed end-use location due to the elevation difference from the source. It does not take into account pressure drop due to friction losses[5] in the distribution piping, which can vary widely depending upon design variables such as instantaneous end-use flow rates, pipe diameter, pipe length, and pipe material. Line loss estimates and total resulting pressure at various property end-uses for a 2" diameter HDPE supply pipe from the water tanks at an estimated total instantaneous flow of 30 GPM are provided. However, those assumptions can be fine tuned as part of a more in-depth water distribution system design and the pipe sizes likely reduced, resulting in reduced materials and cost.

2.3 Waste Water

Waste water is generally divided into two categories, greywater and blackwater. Greywater is relatively clean water that has been used for washing, cooking, bathing, food preparation and general use around the home. Blackwater is water that has been used to flush toilets or otherwise come into contact with human waste products.

Greywater is relatively clean water that has been used in bathroom sinks, showers, tubs, and washing machines. The average person in the United States produces between 20 and 45 gallons of greywater per day[6], which, for a typical 4-person home, equates to between 29,200 and 65,700 gallons annually. It is a valuable resource, often wasted down sewer drains or filling up septic tanks, that can be utilized to provide a consistent source of moisture to landscaped areas.

The key things to remember for the safe use of greywater are:

- Don't store greywater. When greywater is stored, the nutrients in it start to break down, creating bad odors.
- Minimize contact with greywater. Greywater could potentially contain a pathogen if an infected person's feces got into the water, so a system should be designed for the water to soak into the ground and not be available for people or animals to drink.
- Infiltrate greywater into the ground quickly, don't allow it to pool up or run off.
- Keep the system as simple as possible, avoiding pumps and filters that need upkeep. Simple systems last longer, require less maintenance, require less energy and cost less money.

[5] https://www.hunterindustries.com/sites/default/files/tech_friction_loss_charts.pdf

[6] https://www.thegreywaterguide.com/how-much-greywater.html/

- Install a 3-way valve for easy switching between the greywater system and the sewer/ septic.

Existing Conditions

The greywater produced at the Main Residence is currently piped into the septic system.

Recommendations

In order to improve greywater harvesting on-site, the following is recommended:

- Main Residence Greywater Audit
- Outdoor Kitchen Greywater

Main Residence Greywater Audit

In order to make a decision whether or not a certain type of greywater system is viable from a cost:benefit standpoint, some data points need to be harvested. First, a monthly water use log should be kept to identify patterns of use across the whole house. This will help to identify points of high and low usage as well as total usage. With this information in hand, a greywater site assessment should be performed to identify the various options available and and make estimates for the projected cost of each (in terms of money, lifestyle change) as well as the benefits (how much can water consumption/costs be reduced, how much food/shade/beauty can be grown with the water available etc).

NOTE: If pipes are embedded within the foundation (as they are likely to be), then an application of greywater in the landscape will have to occur downslope from the house (provided it can be separated from blackwater before reaching the septic tank).

7th Generation Design recommends Art Ludwig's OasisDesign.net[7] as an excellent starting place for all things greywater. Excellent information is provided on conducting your own greywater site assessment[8], Laundry To Landscape[9] systems, and water wisdom in general.

Outdoor Kitchen Greywater

The Outdoor Kitchen proposed as one of the elements within the school zone can be made to easily feed shade trees planted nearby its ultimate location. Sunken basins like the one illustrated in Figure 2.1.6 should be constructed and planted according to how much greywater is produced by the Outdoor Kitchen.

2.4 Open Water Bodies

Open water bodies can be naturally occuring or man-made, and include creeks, rivers, bogs, ponds, lakes, and swimming pools. These water bodies, in most cases, have associated riparian habitats that are highly diverse and productive, given their location at the intersection between the terrestrial and the aquatic. Open water bodies can be a tremendous benefit to the local ecology,

[7] http://oasisdesign.net/

[8] Greywater Site Assessment Form: http://oasisdesign.net/greywater/createanoasis/GWSiteAssessmentForm.pdf

[9] Art Ludwig's Laundry To Landscape systems: https://youtu.be/eaHgvPj9_nA

providing water, food and habitat to a broad range of creatures and bringing them all into close contact and relation with one another (humans included).

Existing Conditions

There are no existing open water bodies at WFH.

Recommendations

The following open water bodies are recommended:

- Natural Swimming Pool within footprint of existing lawn.
- Pond connected to ADU courtyard.

Natural Swimming Pool

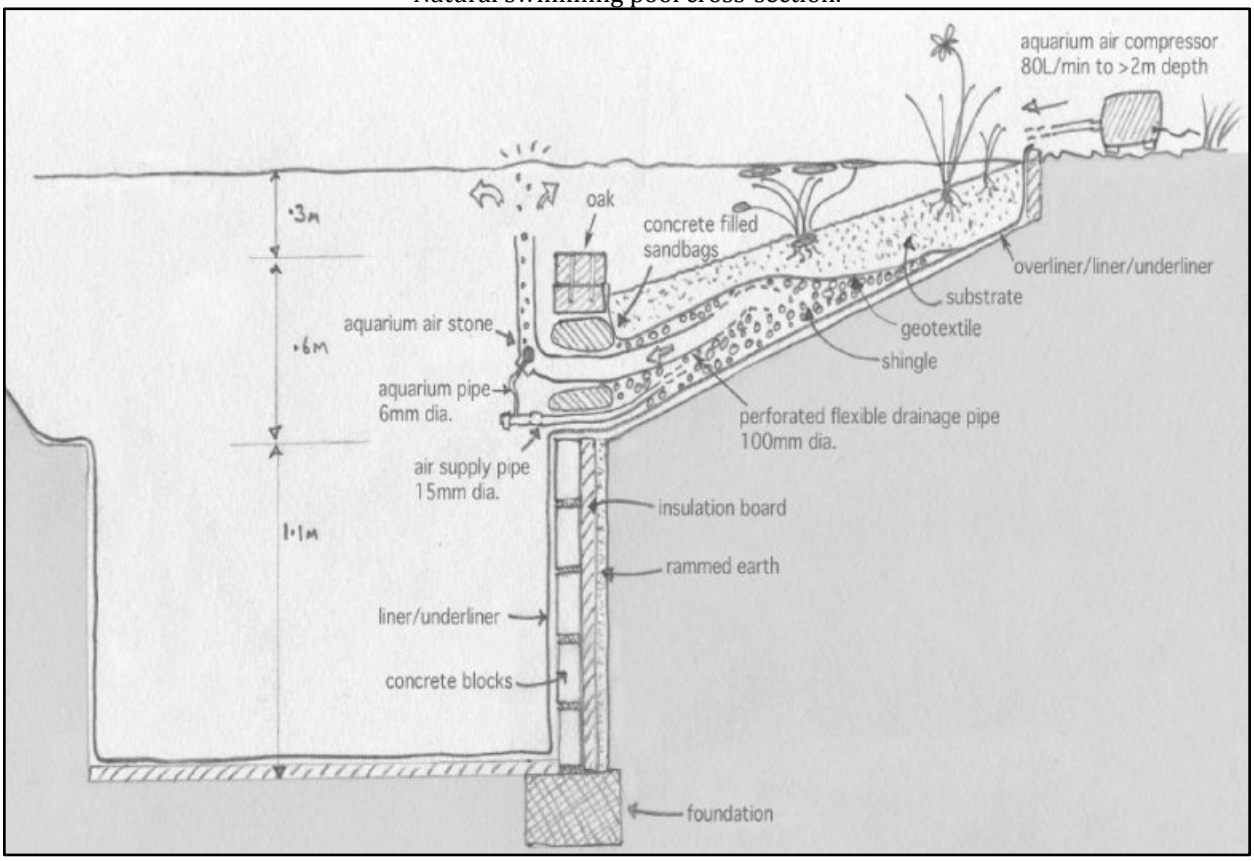
The [redacted] family has expressed an interest in having a way to cool off during the long warm season at WFH. They would also like to incorporate food production, ecological habitat, and beauty. A natural swimming pool performs all of these functions and more.

Natural swimming pools are gaining in popularity as awareness continues to grow about the negative health consequences of swimming in chlorinated or otherwise sterilized water. Natural swimming pools mimic the water filtration and purification processes found in nature while also providing a dedicated swim zone. Natural pools can come in many different shapes and forms while still adhering to a consistent set of design principles that ensure high water quality, safety, fun and beauty.

Figure 2.4.1
One of David Pagan Butler's natural swimming pools in the UK.

Natural swimming pools utilize riparian plantings to filter and purify the water and decrease available nutrient levels to maintain clarity. However, simply depending on natural temperature fluctuations and air movement to circulate the water column adequately to create a reliable safe and clean swimming environment would be insufficient in most cases. The design detailed in the figure below, developed by David Pagan Butler, utilizes air lift pumps - essentially air stones set inside vertically arranged pipes - to lift water while simultaneously aerating it (good for plants and desired aquatic creatures) and pulling it through the established root net of the riparian plantings (in the "regeneration zone"). Air lift pumps have no moving parts (only bubbles!) and are so gentle that frogs and fish can pass through unharmed, unlike typical submersible pumps. Figure 2.4.2 below illustrates a cross-section of a natural pool and its various components when constructed in this style.

Figure 2.4.2
Natural swimming pool cross-section.



By using air to lift the water column ever so slightly (6"), a subtle but consistent vacuum is created that actively pulls water through the riparian root zone before aerating it and lifting it to the upper water strata of the pool. There are no submersible pumps, noisy and expensive pump houses, and large electric bills. A typical natural pool can be cycled using a single 60 watt air compressor, which can be run off a set of solar panels and a small battery bank. Additionally, air lift pumps can be used to lift water through a natural, gravity-fed water filtration system to keep the pool clean of debris.

Natural swimming pools built in this style are much more affordable, in both construction and lifetime maintenance costs, when compared to mainstream, hard bottom swimming pools. They are also healthy to swim in and require absolutely no chemicals.

Two important things to keep in mind when constructing a natural pool are 1) surface flows are not good to introduce directly into the pond (i.e. having surface run-off channeled into the pond is a bad idea due to high nutrient levels) and 2) this type of soft bottom pool can only be constructed in areas where the water table does not rise above the height of the bottom of the pool (because the pool bottom is pond liner held down by the weight of the pool water, should ground water "push up" from underneath the pond liner will rise and the shape and function of the pool will be degraded.

Location

The natural swimming pool is proposed to occupy a section of the existing lawn area. The east and west sides are both comprised of regeneration zones - the vegetated portions of the water body that perform the biological filtration functions necessary for clean swimming water. At the north end is a larger beach area approximately 290' square feet in area for laying out and sunning and watching the goings on in the pool. At the south end is another small beach section approximately 60 square feet in area that allows a second entry/exit point to the pool. This is the deep end, with a small dock for diving or jumping. The swim zone as illustrated is 620 square feet in area, and the combined regeneration zone area totals 533 square feet. This illustration is a general layout of the pool and varying elements can sized as desired. The only relationship that must be maintained is an approximate 1:1 between swim zone and regeneration zone.

Figure 2.4.3
Proposed natural swimming pool footprint within the existing lawn area.

For a detailed write up on the regeneration zone of the natural swimming pool, including recommended species and multi-function aquatic plant guilds, see Section 5.2 - Tending The Wild - Biofiltration - Natural Swimming Pool Regeneration Zone.

Natural Swimming Pool Resources

David Pagan Butler of the U.K. has been largely responsible for popularizing natural pools during the past decade. His websites, manual and YouTube channel are excellent resources for inspiration as well as the nuts and bolts of actually building a natural swimming pool.

- David's Organic Pools YouTube Channel[10]
- David's Website: OrganicPools.co.uk[11]
- David's DIY Natural Pool Manual[12]
- Performing annual cold-season maintenance[13] on a natural pool.

ADU Pond

The pond adjoining the ADU courtyard has a number of design constraints, many of which are as yet unknown due to the unknown shape, orientation and final size of the ADU, as well as final septic requirements and the ultimate location of the ADU septic line, tank and leach field. Figure 2.4.4 contains a hypothetical illustration of how the various elements might be arranged relative to one another.

The ADU footprint as illustrated is approximately 1,200 square feet, including the accessory bedroom unit on the southeast corner. The two units are arranged in a rough horseshoe shape to, among other things, allow both units to enjoy a long view over the pond while also having visual privacy from one another. The pond as illustrated is 1,030 square feet in area and 60' long along its longest axis. Its shape on the east side is constrained by the hypothetical placement of the septic line. The crenellations of the pond on the west side are to allow for planting of shade trees or bamboo closer to the center of the water body, thereby decreasing its exposure to direct sunlight and wind, limiting evaporative loss and algal growth potential.

Once the final size and shape of the ADU is known, and the septic system has been approved, final sizing and shaping of the pond can be determined. Pond circulation and filtration should be performed in similar fashion to the Natural Swimming Pool, utilizing air lift pumps and shallower regeneration zones in addition extensive surface vegetation. For a climate like WFH's, it is recommended to have at least half and up to two thirds of the water surface covered with floating vegetation to help limit evaporative loss, keep water temperature low and hospitable for fish and other aquatic creatures, and help reduce the potential for algal bloom by shading the water column.

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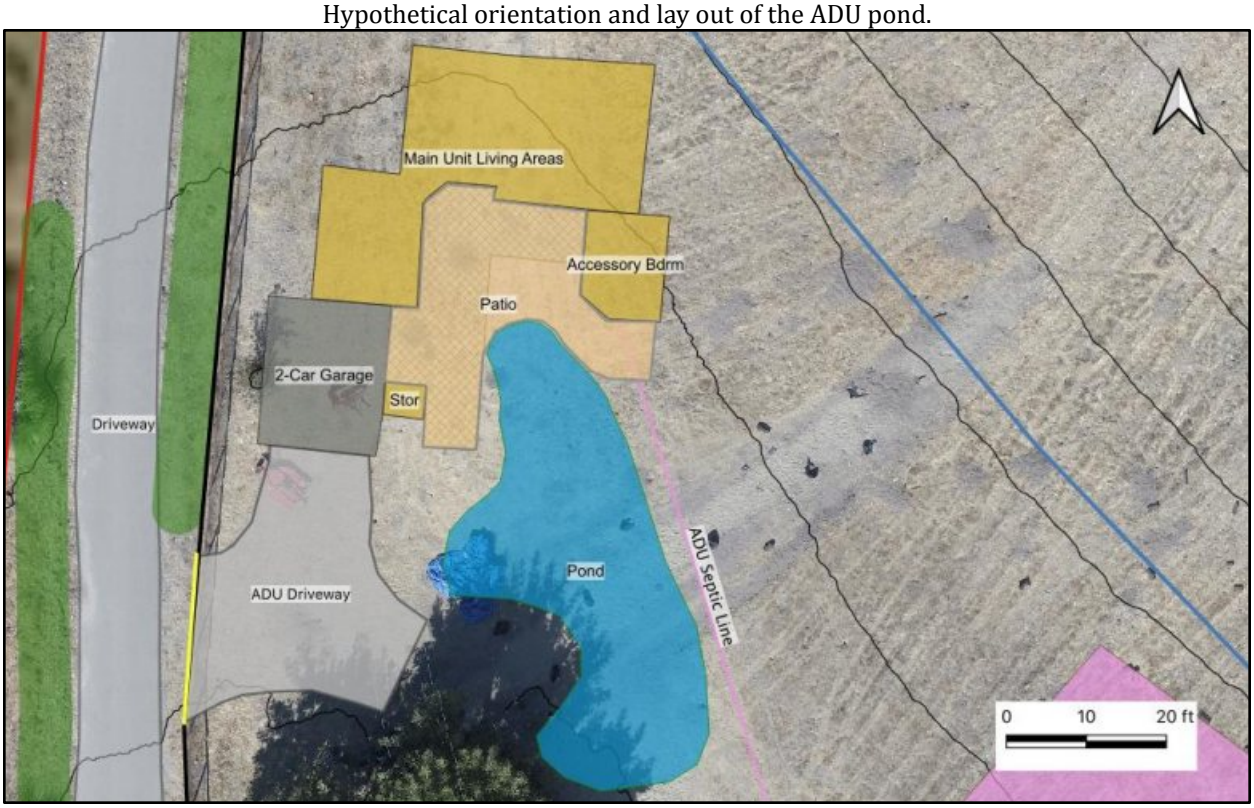
[10] Organic Pools YouTube Channel: https://www.youtube.com/user/davidpaganbutler

[11] David Pagan Butlers Organic Pools Website: http://organicpools.co.uk/

[12] Natural Pools Construction DIY Manual by David Pagan Butler: http://organicpools.co.uk/DIY%20DVD.htm

[13] Natural Pool Annual Cold Season Maintenance: https://www.youtube.com/watch?v=7CGqOPVzTYo

Figure 2.4.4
Hypothetical orientation and lay out of the ADU pond.



See Section 5.4 - Privacy Screens - Bamboo Privacy Hedge For ADU Pond for more on potential bamboo privacy screen plantings options to complement the ADU Pond and create an excellent visual privacy barrier between the southeastern edge of the ADU zone and the School Zone. See Section 5.5 - Shade Plantings - ADU Shade Plantings for the west side crenellations of the ADU Pond.

3. Access

Access patterning is a critical design component for creating low-maintenance, low-input properties. It can often be a limiting factor when selecting appropriate management strategies. Additionally, access routes present huge opportunities for passive water harvesting on-property. While access routes, especially roads, are costly to create or modify, a well-designed and placed access route can result in lower long-term maintenance costs, and efficient movement of people, animals, and materials around a property – while a poorly designed access route can lead to huge erosion issues, extensive maintenance costs (until the route ultimately becomes infeasible to maintain and access is lost), the sacrifice of water harvesting opportunities, and large amounts of unnecessary energy expenditure over the lifespan of the access route (in fuel and human/animal calories burned).

Site topography and its resultant influence on the movement of water through and within the site is the primary influencer of access route placement. How water interacts with any access route, be it a hard top road or a deer trail, will determine the route's long term stability and required level of maintenance. The following list summarizes the rules of thumb for good access design:

- Harmonize with the patterns of water already present in the landscape when planning, installing or remodeling access routes. This will always lead to better performance and lower maintenance costs. Good access at minimum maintains watershed function, and ideally improves it.
- Cross valleys, whenever possible, along dam/pond walls or following contour; traverse a landscape on contour as much as possible; and ascend and descend the landscape along ridge lines (these areas have the least potential to accumulate water in destructive volumes).
- Drain water from access routes as often as possible, and always at first chance and last chance locations (areas immediately before and after stretches where drainage is not feasible). Erosive runoff water should be diverted from the access roads as shallow, non-erosive flows using rolling dips, crowning, cut-off drains, and water bars into passive water harvesting systems such as swales, infiltration basins, biological flow spreaders and multi-level perennial vegetation.
- Maintain access routes regularly - A stitch in time saves nine.

For reporting purposes, access routes have been divided into two categories: roads and human/ animal access paths.

3.1 Vehicle Access

Roads refer to any access routes that are designed and built to accommodate vehicle use. Roads typically have a specially prepared surface designed to sustain vehicle traffic during four-seasons- in urban and suburban areas with heavy vehicle traffic this surface is usually asphalt or concrete laid on a compacted base course, but most Homestead and farm roads still utilize dirt and gravel road surfaces.

Existing Conditions

A paved driveway leads up the western border of the property from [redacted] [redacted], with a keypad/ remote-operated electric gate halfway up, next to the well house. The lower portions of the property

can be accessed by vehicles either by entering through the vehicle gate located at the property's southwest corner or by transitioning off the paved driveway above the well house and following the shallower slopes to the lower areas. The tractor is able to traverse the 35% grade up the western border of the property and has an access track paralleling the west fenceline up to the fenced corner above the Main Residence. The tractor can also access this corner and the gate leading to the northernmost fenced 2 acre section via the pull off at the northwest corner of the paved driveway.

Figure 3.1.1
Existing access routes for [redacted] Family Homestead

Recommendations

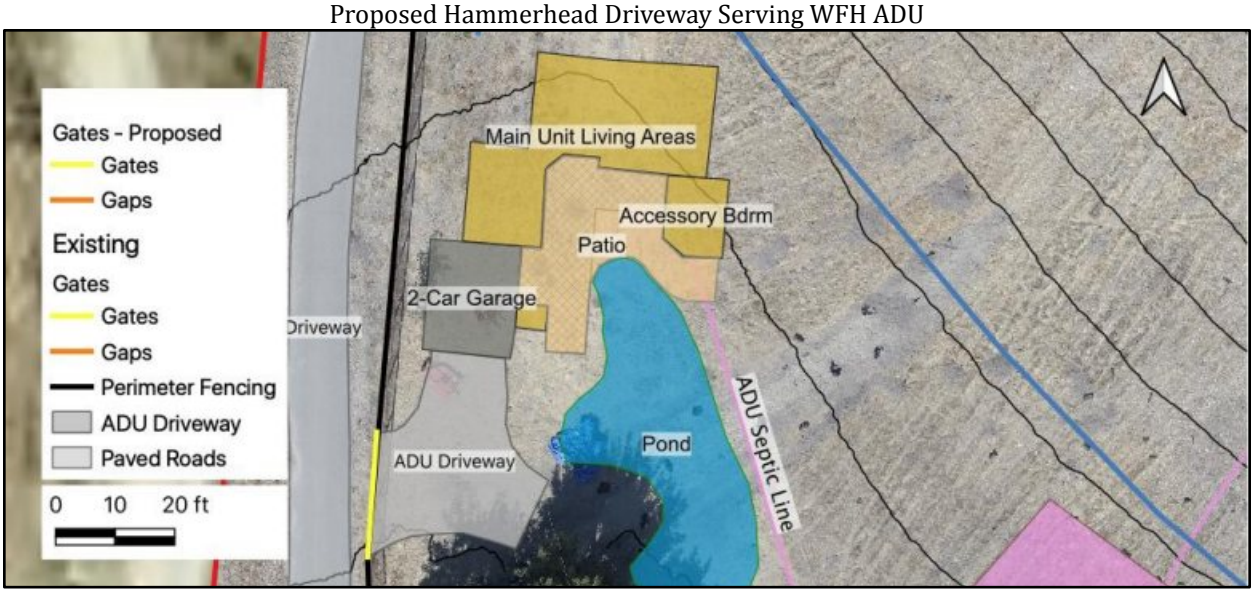
The following is recommended to improve road access on the property:

- Hammerhead driveway serving ADU and installation of vehicle gate.
- Dedicated tractor access around perimeter of property.

Hammerhead Driveway Serving ADU + Vehicle Gate

A small hammerhead paved driveway is proposed for serving the ADU garage and facilitating easy backing out as well as providing additional parking for guests. As pictured the driveway is 663 square feet, and the vehicle gate is 20' wide (this can be made narrower, though the extra width may be helpful with turning into the ADU Driveway from the narrow driveway.

Figure 3.1.2
Proposed Hammerhead Driveway Serving WFH ADU



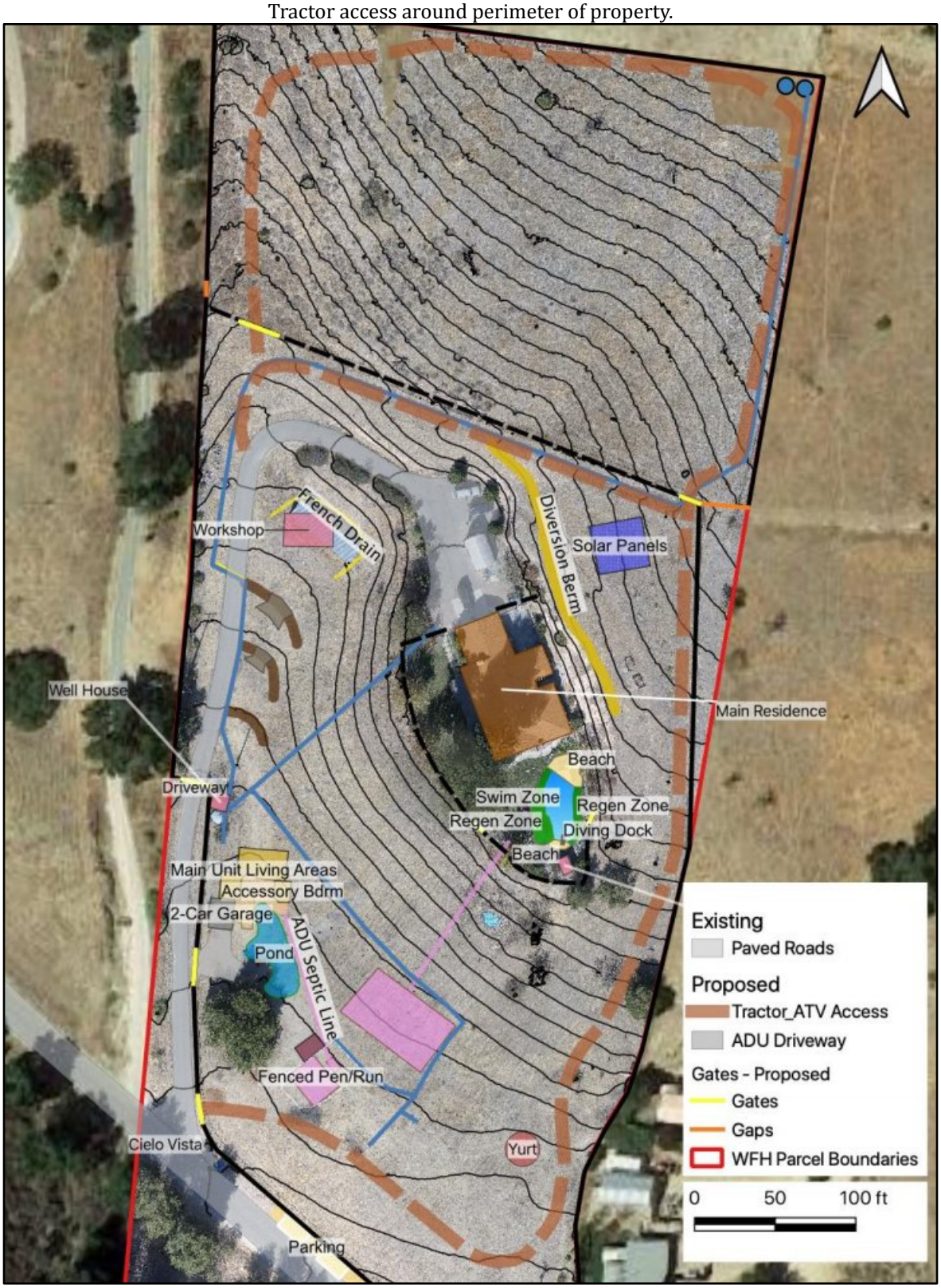
Dedicated Tractor Access

Tractor access to the property's perimeter is important for maintenance, mowing and generally maximizing the functionality of the tractor on the WFH property. Dedicated tractor access is proposed:

- From vehicle gate at southwest corner of property through School Zone.
- Through gate at northeast fence corner (gate needs to be installed to facilitate easy access to top of property) separating northern 2 acres from lower homestead hub, continuing up to proposed water tank location.
- Continuing across northern border of property and down through west valley bottom to existing access gate.

The major changes required to permit whole-perimeter tractor access are 1) installation of a gate at the northeast fence corner, and 2) some grading for the tractor roads in the back 2 acres. The lower tractor access through the School Zone will be guided by placement of built and growing elements. See Figure 3.1.2 on following page for gate placement and tractor access outline.

Figure 3.1.3
Tractor access around perimeter of property.



3.2 Human/Animal Walking Paths

The paths described in this section are only built or recommended for human and animal walking access. They may be large enough to accommodate a wheelbarrow or handcart, though in many cases may only be suitable for foot traffic due to steepness.

Existing Conditions

There are few dedicated footpaths on the property at present. The steep natural grades present in the Upper Paddock (back 2 acres) and the steep machined grades on the fill slope of the house pad would all benefit from improved footpath access to make for easier tending and interaction.

Recommendations

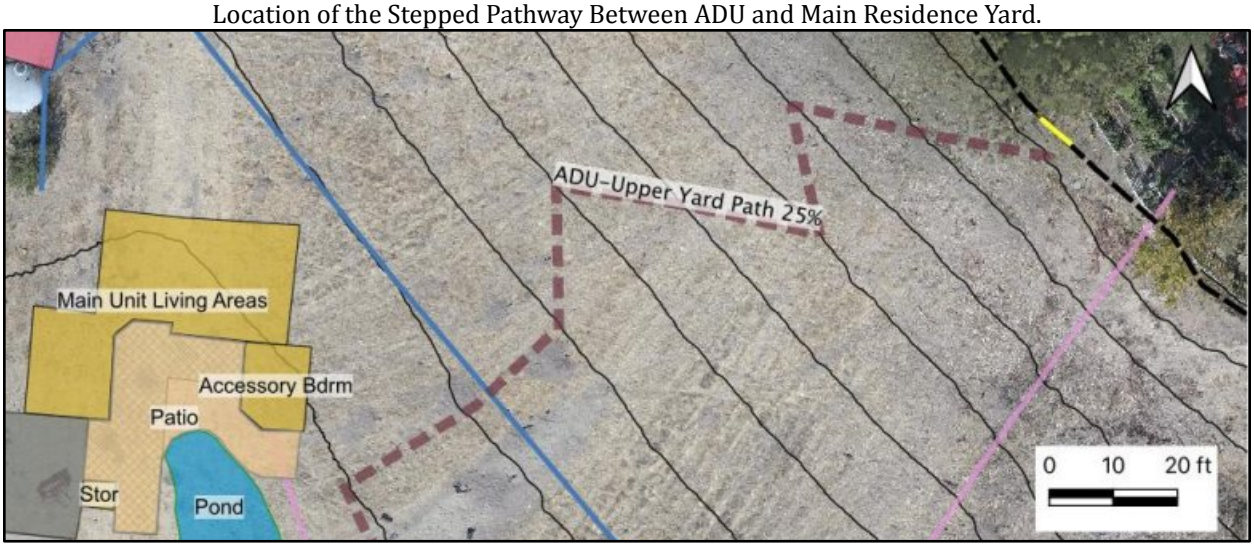
The following new walking paths, or modifications to existing walking paths, are recommended:

- Lower Paddock: Switchback footpaths for steep slope access.
    - Stepped Pathway Between ADU and Main Residence Yard - 25% Grade
    - Stepped Pathway Between Shop and Main Residence Garage - 25% Grade
    - South Slope Ramped Path - 8% Grade
- Upper Paddock:
    - Linking of existing wildlife trails in Upper Paddock.

Stepped Pathway Between ADU and Main Residence Yard

A stepped pathway adhering to a 25% grade should be installed to connect the ADU to the Main Residence yard. This pathway will be a primary route for rapid yet comfortable travel between the Main Residence and the ADU and School Zone, and allow the quickest route down from the Main Residence to check on livestock or other living elements that might require daily or twice daily attention. The path as illustrated has a 25% grade, which equates to a 6" rise for every 24" of horizontal travel (or 7.5" rise for every 30" horizontal travel), a gentle and generous stepped incline. As illustrated, the pathway is 167' long and travels a straight line distance of 125', gaining 40' in altitude from bottom to top.

Figure 3.2.1
Location of the Stepped Pathway Between ADU and Main Residence Yard.



The path can be constructed of a variety of different materials, ranging from stone to timbers, depending on the desired aesthetic and degree of uniformity to the pathway. Whichever medium is chosen, the pathway should be secured with vetiver grass planted immediately uphill and downhill of it (adjacent to the timbers or stones). 7GD has installed a stone pathway held together simply by gravity (built from the bottom up, rocks keyed into one another) and secured by vetiver grass on an even steeper fill slope than the one present at WFH. For more details on this project see the project page[14] on the 7GD website. See Section Section 5.3 - Erosion Control Plantings - ADU-Upper Yard Stepped Pathway Stabilization With Vetiver Grass for details on stabilizing this pathway with vetiver grass.

Stepped Pathway Between Shop and Main Residence Garage

A stepped pathway also adhering to a 25% grade should be installed to connect the future Shop with the upper driveway and the Main Residence Garage. As illustrated the pathway is 75' long and covers a straight line distance of 45', and gains ~22' in altitude from bottom to top. See Section Section 5.3 - Erosion Control Plantings - Shop-Garage Stepped Pathways Stabilization With Vetiver Grass for details on stabilizing this pathway with vetiver grass.

[14] https://www.7thgenerationdesign.com/biological-erosion-control-with-vetiver-grass/

Figure 3.2.2
Shop - Main Residence Stepped Pathway location.

Ramped Pathway Traversing Slope Below Main Residence

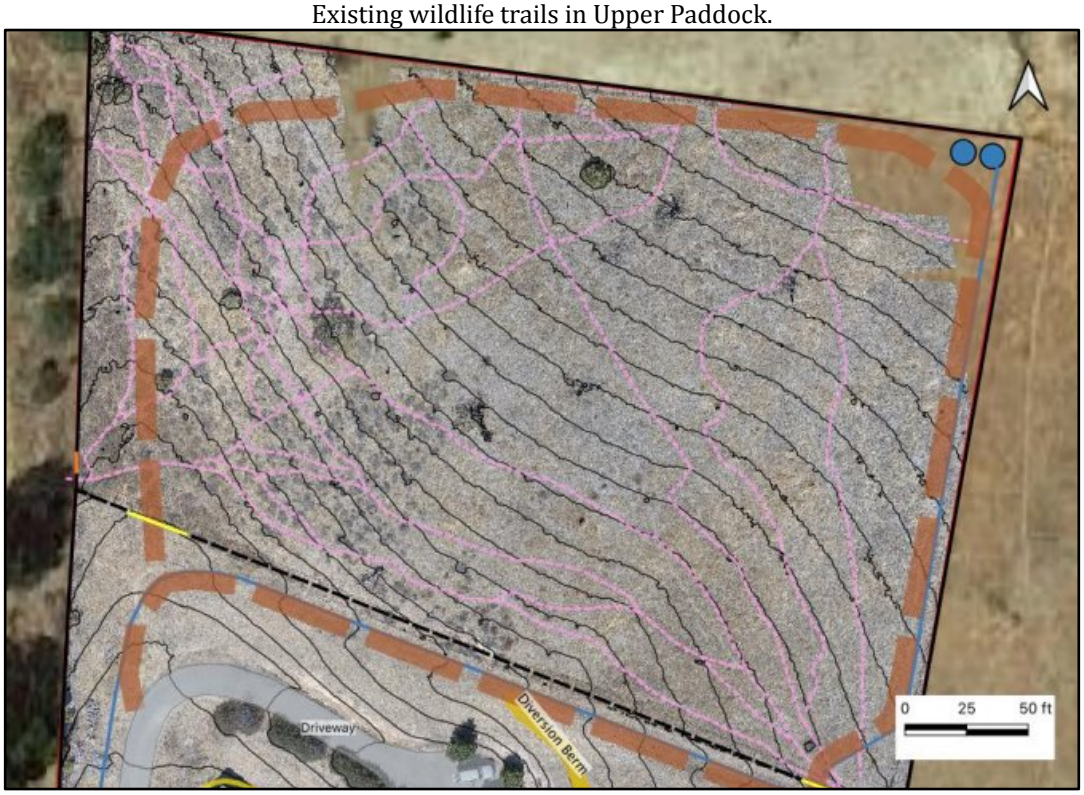
A path with an 8% grade (8' of rise over every 100' horizontal travel, /2.4" rise over 30" horizontal travel) traversing the south-facing slope above the School Zone is recommended to provide more gently-sloped access between the ADU zone and the Main Residence yard a ramped pathway that adheres to. As illustrated, the pathway is 500' long, and covers a straight line distance of 150', gaining 40' in altitude from bottom to top. Edging for a ramped pathway like this can be formed using long wood timbers (recommended minimum 8" high to allow for a decently wide pathway) - old fence posts, scrap lumber, or larger timbers can be purchased. The pathway should have vetiver grass planted on the immediate uphill and downhill sides of it - to keep loose soil from sliding onto it from above and to secure the edging timbers on the downhill side. See Section 5.3 - Erosion Control Plantings - Ramped Pathway Traversing Slope Below Main Residence Stabilization With Vetiver Grass for details on the vetiver planting.

Figure 3.2.3
Ramped Pathway Traversing Slope Below Main Residence location adhering to an 8% grade.

Linking Existing Wildlife Trails In Upper Paddock

To increase accessibility to the Upper Paddock additional walking trails can be installed between the existing wildlife thoroughfares. Many of the tracks already do a great job of following and transitioning between different contours. Figure 3.2.4 below illustrates the trails already worn into the slope.

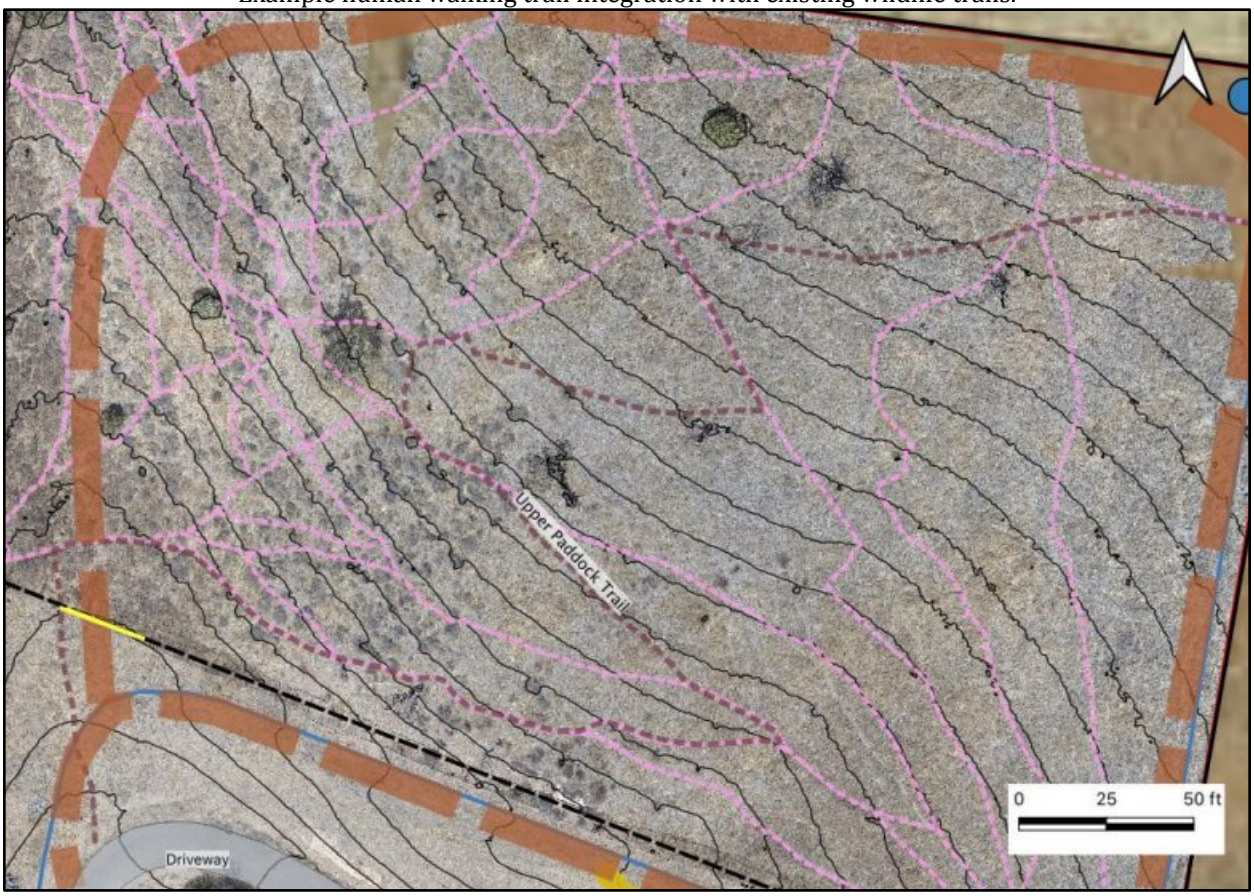
Figure 3.2.4
Existing wildlife trails in Upper Paddock.



By selecting certain trails that pass by desired locations on the slope or follow preferred grades (steep vs. gentle) and linking and expanding them with man-made trails coming from the two access gates, the accessibility of the entire paddock can be improved while seamlessly integrating with the natural traffic flows that have already developed. Figure 3.2.5 below illustrates one potential overlay of human-reinforced pathways amidst the existing wildlife trails.

Trail formation in the Upper Paddock already has a good framework to start from, and will continue to evolve organically as tree plantings are established and "places" are created/grown on the slope. Future season grazing by goats will also reinforce existing trails and likely create new ones as they seek out desired forages on the slope. The trail picture in figure 3.2.5 is 818' long as illustrated, covers a straight line distance of 375', and gains an altitude of 110' from bottom to top.

Figure 3.2.5
Example human walking trail integration with existing wildlife trails.



4. Structures

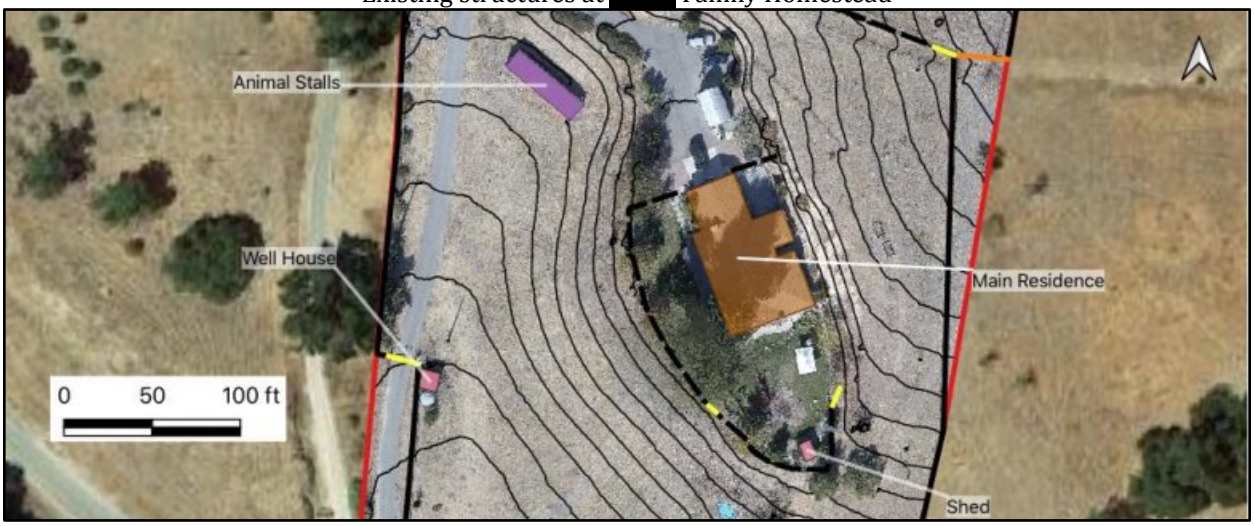
In a good design, homes, sheds, animal shelters, greenhouses, and other buildings are placed in relation to on-site water patterning and desired/necessary frequency of access. This interconnected, efficient approach to element placement saves large amounts of energy over the lifetime of the site. Siting a home for a view (for example, at the highest point on the property) is often costly from an energy efficiency standpoint, as inefficiencies increase due to the reliance on mechanical sources to bring pressurized water to the site, comfort levels decrease due to higher wind speeds and greater temperature swings, and the cost of placing and maintaining a road up a slope is greatly increased.

Designing with a consideration for the entire site provides foresight that enables expansion to happen intentionally and consciously. When site patterns are examined, such as topography, natural water features, access, and environmental and human sectors, the ideal positions for the various design elements quickly reveal themselves. Even if a home or other structures were already present in less than ideal locations when the land was purchased, any future structures can be placed with these principles in mind.

Context

The existing structures at WFH are shown in Figure 4.0.1. A summary of any applicable county/city building codes and restrictions, as well as an analysis of environmental and human sectors at the main residential sites on the property, is provided below.

Figure 4.0.1
Existing structures at [redacted] Family Homestead



Restrictions - Building Codes / Permits / Legal Barriers

Building Code Restrictions and Permits

SLO County has especially stringent regulations on building. These codes should be thoroughly researched and taken into account when planning for the placement of additional structures on-property. Building permits information, forms, and submissions can be accessed at the SLO County Planning & Building website.

Septic Codes

Septic systems/hookups are required at this site.

Washing Machine Greywater

SLO County does have a recommended system for greywater disposal from a washing machine[15], the designers at 7th Generation Design view it as simplistic while simultaneously overengineered. A more nuanced approach as outlined at OasisDesign.net[16] is highly recommended.

Zoning ordinances

[redacted] Family Homestead is zoned as Residential Rural (RR). Further information regarding the various types of allowed land uses for RR land and the requisite permits that need to be filed with the county can be found starting on page 45 of the SLO County Land Use Ordinance document. Specific information about the RR zoning category is found in Section 22.22.060 of the Land Use Ordinance document (pg. 286).

The property is permitted one primary dwelling and an accessory dwelling of up to 1,200 square feet. There is the opportunity for farm housing depending upon how the land is utilized.

Additional zoning and regulatory requirements can be looked up using the SLO County GIS Viewer[17] and typing in the WFH parcel number #026-302-027.

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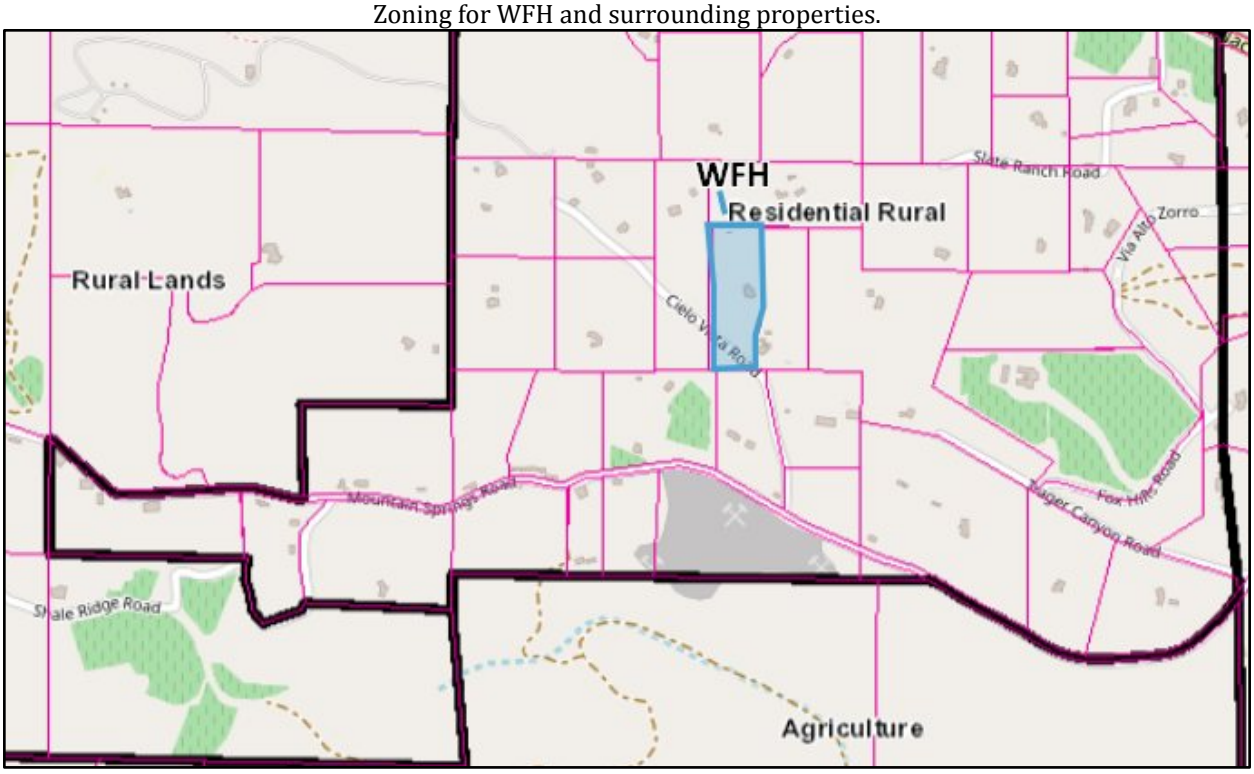
15 https://www.slocounty.ca.gov/Departments/Planning-Building/Building/Building-Forms-Documents/Onsite-Wastewater-Treatment-Systems-(Septic-System/Washing-Machine-Greywater-Disposal-Guide.aspx

16 http://oasisdesign.net/greywater/

17 WFH Parcel Map SLO GIS Viewer: https://gis.slocounty.ca.gov/Html5Viewer/Index.html?configBase=/Geocortex/Essentials/REST/sites/PL_LandUseView/viewers/PL_LandUseView/virtualdirectory/Resources/Config/Default&apn=026-302-027

Figure 4.0.2
Zoning for WFH and surrounding properties.



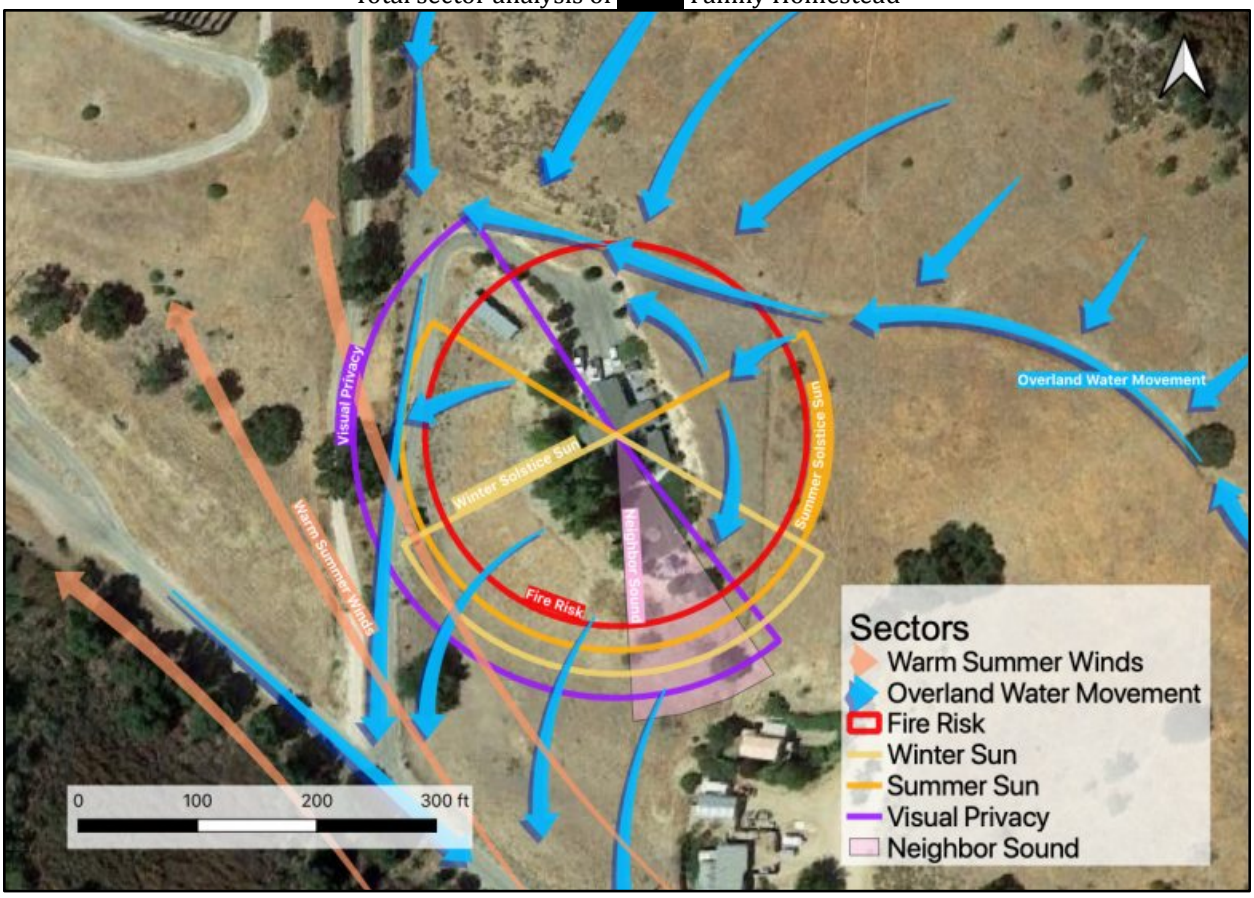
Easements
The following easements exist at WFH:

- [redacted] Road passes through the southwest corner of the property.

Home-Owners Associations
The property is not associated with any home-owners associations.

Sector Analysis
A sector analysis examines the natural environmental factors that affect a site. The sector analysis and a brief written summary of the sectors affecting [redacted] Family Homestead is provided below.

Figure 4.0.3
Total sector analysis of [redacted] Family Homestead



Solar Aspect & Access

- Sunrise and sunset angles are shown for Summer and Winter solstices respectively. Additional solar aspect data (azimuths, day length, specific sunrise/sunset headings) can be found in the Solar Data section and in Appendix C - Solar Aspect Charts.
- The Main Residence is oriented northwest by southeast lengthwise. Opportunities for solar thermal water heating are available on the home roof. Solar PV electricity generation would be best located above the house just below where the new orchard has been planted.

Overland Water Movement

- Evidence of overland water movement was found in the West Valley Drainage, indicating that despite high infiltration rates, significant amounts of water can move over the surface once the thin soil layers become saturated (which can happen quite suddenly).

Physical Access

- [redacted] Road approaches the property from the southeast. This is the sole way in and out of the valley by vehicle at this time.

Visual Privacy / Exposure

- Neighbors with direct lines of sight onto the WFH property to the northwest, west, southwest and southeast, totaling approximately 180 degrees of view in which visual

privacy is a design consideration. The neighboring homes to the north and northeast do not look directly onto the WFH property, but their property lines do.

Wind

- See Wind Data section for detailed seasonal wind information.

Fire Risk

- Fire could approach the property from all directions. However, due to the barren condition of the neighboring properties and the surrounding vineyards, risk of catastrophic fire is quite low, provided an on-site presence is able to be maintained and any embers blown up against structures are extinguished in short order. Fast moving grass fires are the most likely fire vector, though do not pose a great danger to existing structures - wind-borne embers are the greatest threat.
- As additional vegetation is established on the property, careful attention should be paid to spacing, composition and species selection to ensure that fire danger is not increased. More information on this topic is available in Living With Fire - Part 2: Regenerative Firescaping - Protecting Your Home With Good Design on the 7th Generation Design website.

Security

- Vehicles are able to access the property via Cielo Vista road, which passes through the lower portion via easement, and then the private driveway leading to the Main Residence.
- The entire lower perimeter of the property is fenced with 6' tall horse fencing.
- A vehicle gate is located midway up the private driveway and is controlled by remote access code or from within the Main Residence. A manually opened vehicle access gate is located at the bottom of the driveway at the southwest corner of the Lower Paddock.
- The main residence is elevated well over 50' above [redacted] [redacted] Road and the lower driveway, and has excellent lines of sight from the edges of the Main Residence pad.

Neighbor Sounds

- Sound from the air conditioning units attached to structures on the property to the southeast was readily audible down in the Lower Paddock during the site visit. It is unknown to the design team if typical conversation level voices will carry up the hill to the Main Residence and surrounding outdoor areas or vice versa.

4.1 Homes

Homes for the purposes of this report are permanent structures intended to provide shelter and comfort for humans.

Existing Conditions

The single-story Main Residence has a roof area of approximately 3,750 square feet. It is oriented along a northwest by southeast axis lengthwise. The south facing wall adjacent to the lawn area has minimal roof eave overhang, and consequently has significant exposure to high-intensity summer sun. The cut slope that was formed when the home site was excavated is down to bare rock, which is currently uncovered by vegetation and exposed to the sun for most of the day, creating a thermal gain that may be influencing the lack of use of the northeast side of the house.

Recommendations

- Shade the south-facing wall of the Main Residence with an attached pergola.

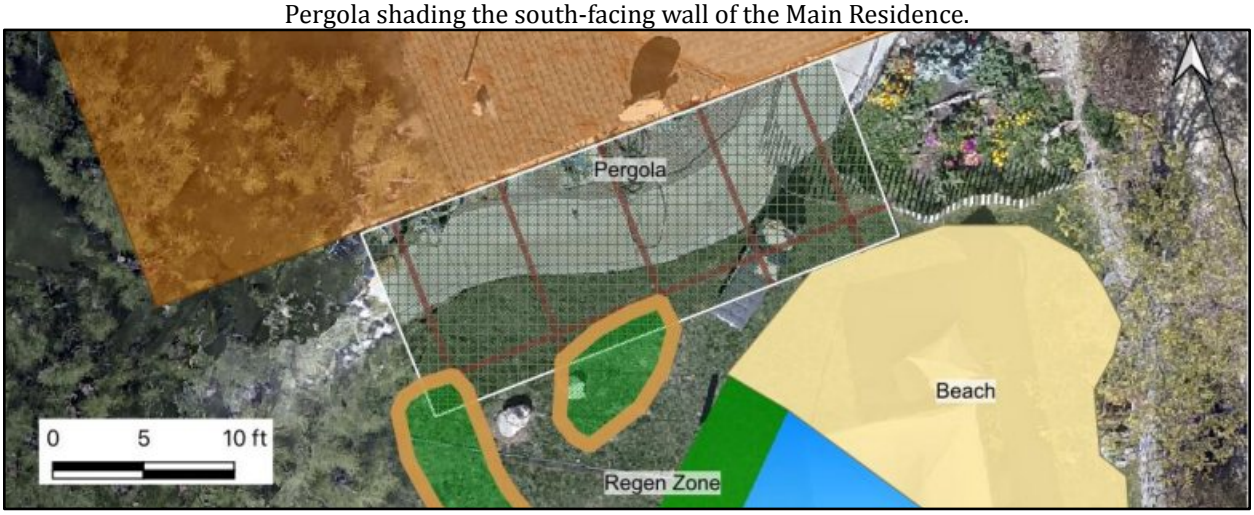
- Shade the northeast side of the building with an arching pergola joining the roof edge with the plantable area above the retaining wall at the base of the cut slope on the northeast side of the house.
- ADU orientation and layout factors and considerations.

South Wall Pergola Shade

The south wall of the Main Residence would benefit from shade to mitigate thermal gain during the first half of the day during the warmer seasons. The north edge of the pergola can be attached to the house via a header board or can be made free standing with posts, and can be supported by three posts along its southern side as illustrated in Figure 4.1.1 below. The trellised walkway formed by the pergola can grow seasonally deciduous vines - see Section 5.5 - Shade Plantings - Main Residence Shade Structure Plantings for specific recommendations for different perennial and annual vines to grow on the structure. Gardening in wicking beds or other raised beds/containers could be integrated with the shade structure to enable vertical growing of annual vine crops.

Figure 4.1.1

Pergola shading the south-facing wall of the Main Residence.

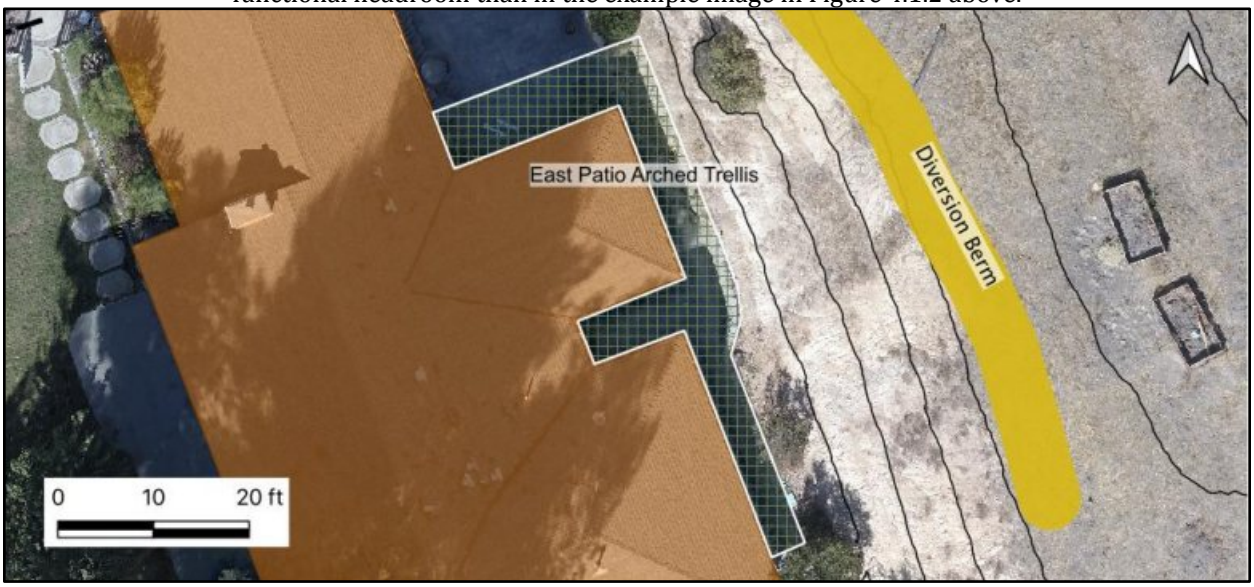


East Patio Arched Trellis

To limit some of the thermal gain from the exposed rock cut slope, an arched trellis could be constructed along the eave of the eastern patio overhang that would curve down into the raised planting strip behind the cinder block retaining wall. see Section 5.5 - Shade Plantings - Main Residence Shade Structure Plantings for specific recommendations for different perennial and annual vines to grow on the structure. A similar concept is shown in Figure 4.1.2 below.

Figure 4.1.2
Green seasonal screen attached to existing eaves creates a pleasant place to be during the heat of the day.

Figure 4.1.3
Location of east patio arched trellis - attached to the eave of the roof and concavely curved to allow more functional headroom than in the example image in Figure 4.1.2 above.

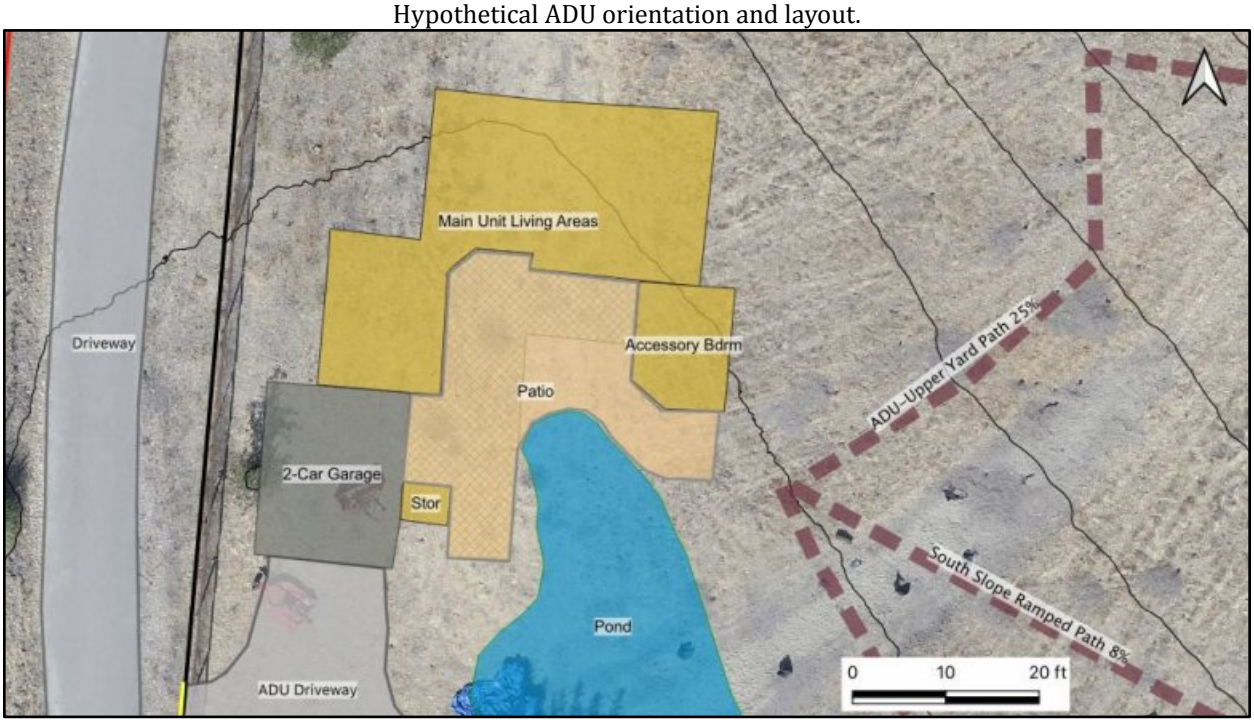


ADU Orientation, Layout And Design Considerations

The exact size, shape, orientation and layout of the ADU is unknown as of the writing of this report. Given that this process will likely take a fair amount of time and will be influenced by legal and code restrictions that may curtail certain design choices, a list of pertinent design considerations is offered here. These various design criteria are all human-centric, and in many cases may run afoul of existing construction practices and code, however their essence may yet be woven into the final design, despite these obstacles, to create a place that people are drawn to, that nourishes the human

body, mind and spirit and integrates seamlessly with place. These design criteria and others have been employed in the design recommendations for the Yurt Zone, Outdoor School Zone, Fire Circle, and Outdoor Kitchen as well.

Figure 4.1.4
Hypothetical ADU orientation and layout.



In short, the ADU should have the following qualities and characteristics:

- Roughly horseshoe-shaped to create a shared inner courtyard between the primary residence and the additional small attached guest quarters.
- Sleeping areas to the north and east.
- Kitchen area accessible to both primary residence and guest quarters without guests having to transit through private space.
- Long view over the ADU pond that is integrated into the courtyard footprint.
- Shade trellis over the main entry and along the western edge of the courtyard, for afternoon shade.
- Both the primary residence and the guest quarters have views of and access to the courtyard while maintaining visual privacy from one another.
- Visually shielded parking with privacy screen and shade plantings.
- East side courtyard access to the Stepped Bathway between ADU and Main Residence Yard.

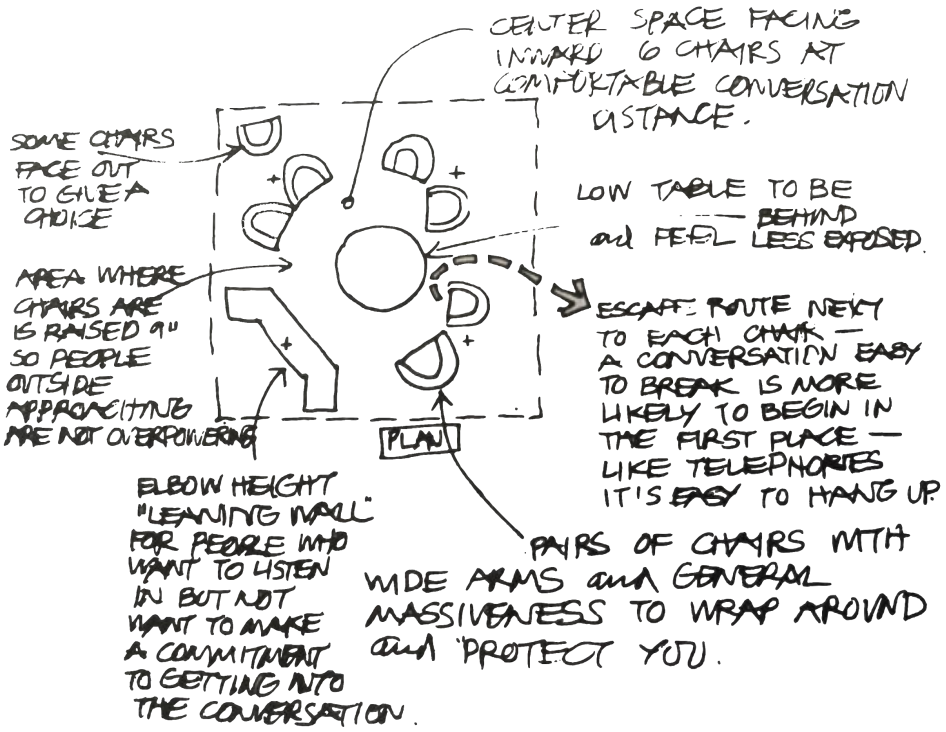
Excerpts From *A Pattern Language - Towns, Buildings, Construction*

69 - Public Outdoor Room[18]

"There are very few spots along the streets of modern towns and neighborhoods where people can hang out, comfortably, for hours at a time. In every neighborhood and work community, make a piece of the common land into an outdoor room - a partly enclosed place, with some roof, columns, without walls, perhaps with a trellis; place it beside an important path and within view of many homes and workshops."

Create a space that strikes the subtle balance of being defined yet not *too defined*, any activity which is natural to the home or village can develop freely and yet has something to start from. Curiosity will lead people here, and the environment should be such that they are invited to stay. Seats can be arranged to allow for multiple avenues of approach and escape - each seat should have its own way in and out to make for easy people flow in and out of conversational space. Have a table or firepit in the middle. Make the seating area slightly raised relative to avenues of approach so that people approaching from outside are not overpowering. Set these seats so they can have a view into adjoining communal spaces like outdoor kitchens, courtyards, fire circles, gardens etc.

Illustration 4.1.5
Outdoor Space Design Principles - Illustration 69 from *A Pattern Language*



Have A Counter Where People Can Sit, Watch, Talk and Eat

People of all ages want to know what is cooking. People want to talk while food is being cooked, and want to feel like they are part of the process even if they aren't the ones preparing the meal. People

[18] Public Outdoor Room - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 348-352

will put themselves in positions to see what is going on and engage with it, whether this archetypal human interaction is planned for or not. By having a counter with a good view of the kitchen heart, but not necessarily in it, people can feel invited to stop, pull up a seat, chat, and move on at their leisure while not disrupting the workings of the kitchen crew by being in the way. Children can sit and see how it all gets done (and develop an appreciation for all the work involved) and smell the creation as it develops. The counter can also act as a "leaning wall" for people who might want to listen in on the goings on, but not make the commitment to getting involved in the conversation. Posts holding up the roof structure can serve a similar function.

97 - Shielded Parking[19]

"Put all large parking lots...behind some kind of natural wall, so that the cars and parking structures cannot be seen from outside. Make the entrance to the parking lot a natural gateway to the building which it serves, and place it so that you can easily see the main entrance to the building from the entrance to the parking."

The parking area should be visible but the cars should not. Employ evergreen plantings, earth berms or built walls to make the entrance to the parking area self-evident, yet obscure the parked cars from ready view. Parking lanes planted with trees can perform this function while also providing shade during the warmer months.

105 - South Facing Outdoors[20]

"People use open space if it is sunny, and do not use it if it isn't, in all but desert climates. Always place buildings to the north of the outdoor spaces that go with them, and keep the outdoor spaces to the south. Never leave a deep band of shade between the building and the sunny part of the outdoors."

Bands of shade can actually act as barriers that people rarely cross, let alone seek out, except in the most extreme conditions. Especially in the northern hemisphere, this design principle makes particularly good sense.

106 - Positive Outdoor Space[21]

"Outdoor spaces which are merely "left over" between buildings will, in general, not be used. Make all outdoor spaces which surround and lie between your buildings positive. Give each one some degree of enclosure; surround each space with wings of buildings, trees, hedges, arcades, and trellised walks, until it becomes an entity with a positive quality and does not spill out indefinitely around corners."

Spaces can be "felt", and positive spaces are known to be convex in nature. They are held by the buildings that frame them, and typically offer something for people to put their backs to while facing "into" the space. Note in the illustration below, for the non-convex figure, there is no welcoming place to be on the outside.

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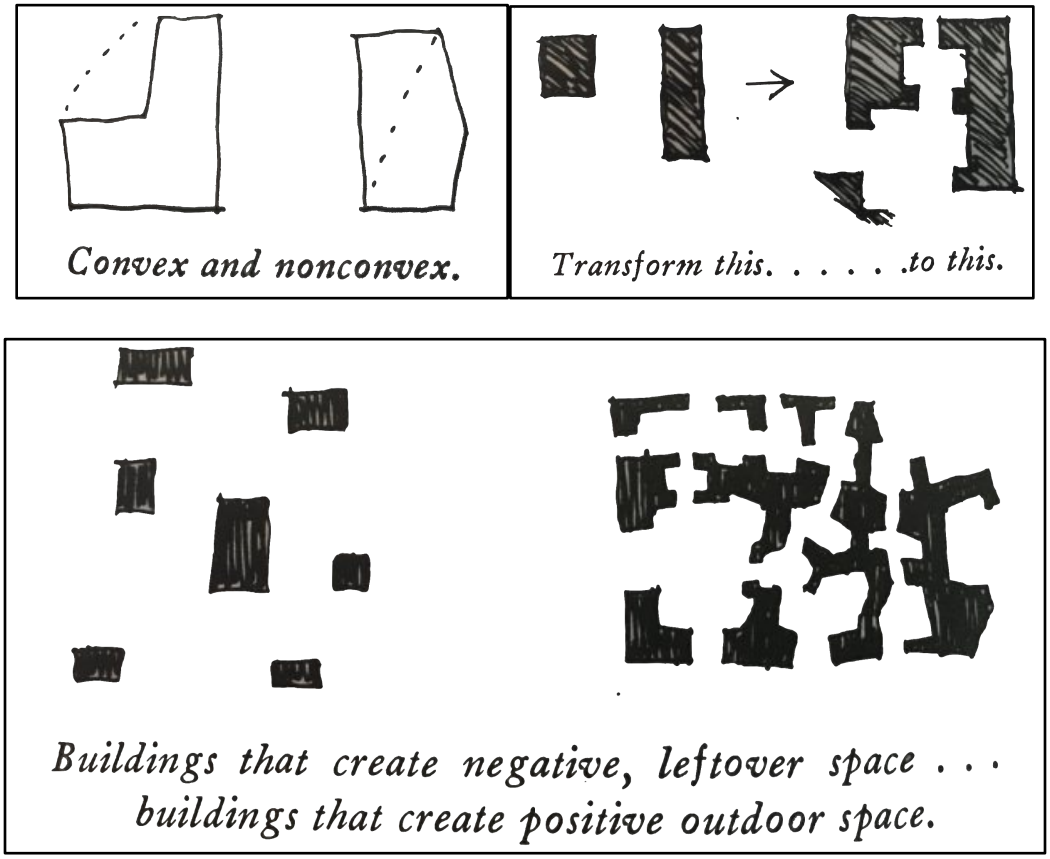
[19] Shielded Parking - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 477-479

[20] South Facing Outdoors - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 513-516

[21] Positive Outdoor Space - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 517-523

Illustration 4.1.6
Outdoor Space Design Principles - Illustration 106 from *A Pattern Language*

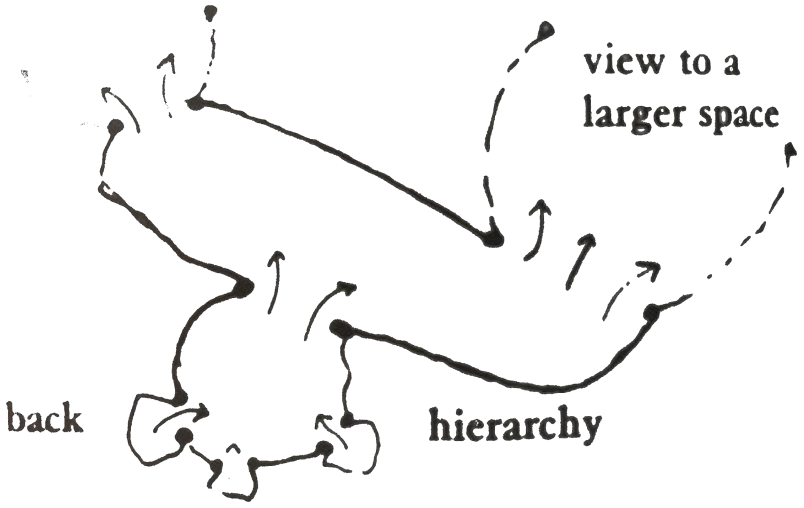


114 - Hierarchy of Open Space[22]

"Outdoors, people always try to find a spot where they can have their backs protected, looking out towards some larger opening, beyond the space immediately in front of them. Whatever spaces you are shaping - whether it is a garden, terrace, street, park, public outdoor room, or courtyard, make sure of two things. First, make at least one smaller space, which looks into it and forms a natural back for it. Second, place it, and its openings, so that it looks into at least one larger space. Where you have done this, every outdoor space will have a natural "back"; and every person who takes up the natural position, with his back to this "back", will be looking out towards some larger distant view." ~ p.559

[22] Hierarchy Of Open Space - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 557-560

Illustration 4.1.7
Hierarchy of open space - Illustration 114 from *A Pattern Language*



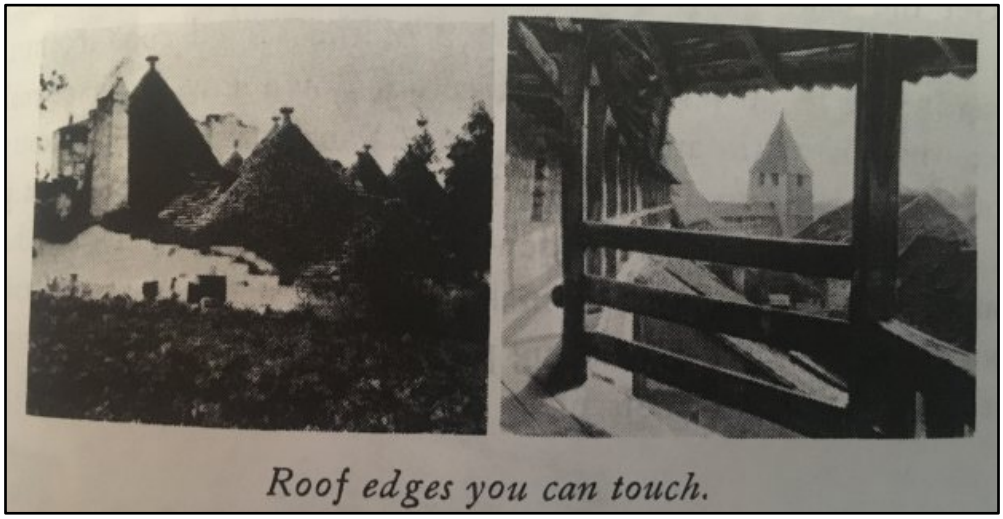
This principle can be applied well to link positive outdoor space of the built environment with the vegetative elements surrounding it.

117 - Sheltering Roof[23]
"The roof plays a primal role in our lives. The most primitive buildings are nothing but a roof. If the roof is hidden, if its presence cannot be felt around the building, or if it cannot be used, then people will lack a fundamental sense of shelter."

The space under the roof on the outside of the building must be useful space that evokes a feeling a *surroundedness*. Build the roof so that the entire surface of the roof is visible from the outside. A sheltering roof is also placed on the building so that it can be touched - from the outside. If it is pitched or vaulted some part of it must come down low to the ground, next to the edge of an oft-frequented path, so it becomes natural to touch the roof as you pass it.

[23] Sheltering Roof - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 569-574

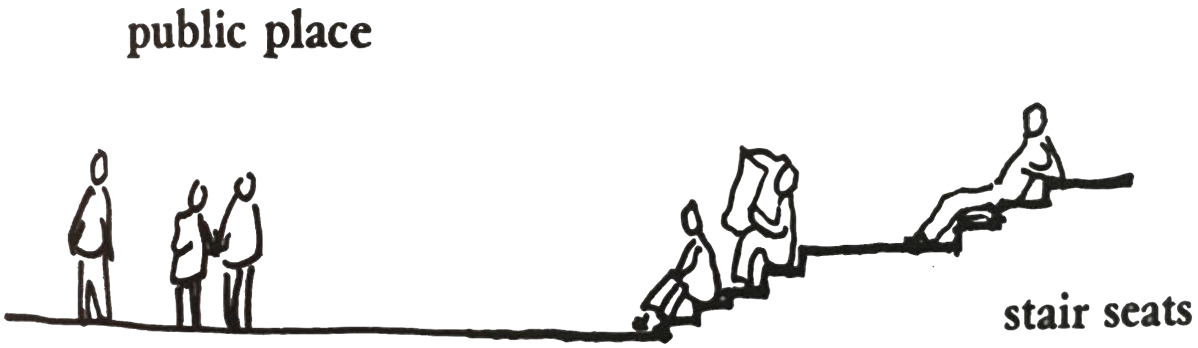
Illustration 4.1.8
Examples of sheltering roofs - Illustration 117 from *A Pattern Language*



125 - Stair Seats[24]
"In any public place where people loiter, add a few steps at the edge where stairs come down or where there is a change of level. Make these raised areas immediately accessible from below, so that people may congregate and sit to watch the goings on."

For the front (south side nearest the driveway turnaround) and potentially the back (north side, headed towards the barn), place broad steps connecting the building to the earth, where people can hang out, lean on a railing or take a seat. This setting is conducive to active participation, as people can be at rest but closely connected to what might be happening below them. It also allows a mix of standing, leaning and sitting people to all share in the same conversational space but still be close enough to eye level with one another that it isn't awkward.

Illustration 4.1.9
Stair seats provide people a place to sit, lean and lounge while remaining connected to the action of the public space while being slightly above it - Illustration 125 from *A Pattern Language*



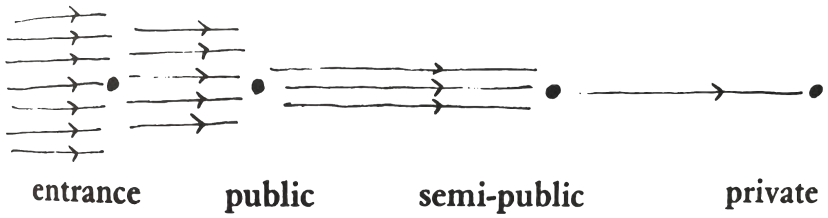
[24] Stair Seats - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 603-605

127 - Intimacy Gradient[25]

"Unless the spaces in a building are arranged in a sequence which corresponds to their degrees of privateness, the visits made by strangers, friends, guests, clients, family will always be a little awkward. Lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domains."

Illustration 4.1.10

Intimacy gradient from most public to most private - Illustration 127 from *A Pattern Language*



The intimacy gradient principle reminds us to lay out floor plans in a way that balances spaces for the types of activities that require more privacy with those that are more public facing and communal. Rooms and alcoves should be arranged so that new arrivals pass first through very public to less public and ultimately into private space.

128 - Indoor Sunlight[26]

"If the right rooms are facing south, a house is bright and sunny and cheerful; if the wrong rooms are facing south, the house is dark and gloomy. Place the most important rooms along the south edge of the building, and spread the building out along the east-west axis. Fine tune the arrangement so that the proper rooms are exposed to the southeast and southwest sun...give the common area a full southern exposure."

129 - Common Areas At The Heart[27]

"No social group - whether a family, a work group, or a school group - can survive without constant informal contact among its members. Create a single common area for every social group. Locate it at the center of gravity of all the spaces the group occupies, and in such a way that the paths which go in and out of the building lie tangent to it."

Illustration 4.1.11

Common areas at the heart with tangential main access pathways - Illustration 129 from *A Pattern Language*

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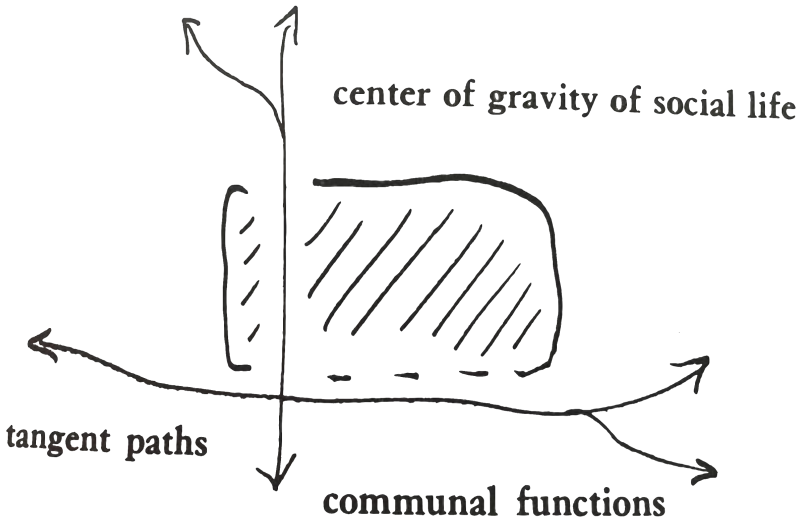
[25] Intimacy Gradient - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 610-613

[26] Indoor Sunlight - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 614-617

[27] Common Areas At The Heart - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 618-621



Make the common area tangential to the lines of ingress/egress from the building, so that it is easy to stop and linger for bits of conversation before fully entering or departing the building. There are three characteristics for a successful common area, 1) it must be the "center of gravity" within the building - a place equally accessible to everyone that can be felt as the center, 2) it must be "on the way" to and from the more private rooms, so that everyone passes it on their way in and out of the building and no one has to go out of their way to get to it, and 3) it must have the right components - typically a kitchen and eating space, since eating is a universally shared activity.

130 - Entrance Room[28]

"Arriving in a building, or leaving it, you need a room to pass through, both inside the building and outside it. This is the entrance room. At the main entrance to the building, make a light-filled room which marks the entrance and straddles the boundary between indoors and outdoors, covering some space outdoors and some space indoors. The outside part may be like an old-fashioned porch; the inside like a hall or sitting room."

The average adult needs a five foot diameter of space to take off a winter coat without feeling like a sardine. Have storage space off to the side, as children are wont to shed layers, bags, toys quickly upon entering a building, especially if there are dramatic differences between indoor and outdoor temperatures. Plan for this clutter by dedicating space for it. Have areas to sit and lace up boots, as well as waist high shelves both immediately inside and outside the entryway for people carrying packages to set them down before opening or closing the door.

4.2 Shops/Sheds/Outbuildings/Gathering Spaces

Shops, sheds, and other outbuildings are permanent structures designed to provide indoor working space, storage or another function besides overnight accommodation.

Existing Conditions

A small pump house located adjacent to the remote operated gate on the driveway houses the well head and pumping equipment. A small garden shed is located on the pad of the Main Residence beyond the southeast corner of the lawn.

Recommendations

The following outbuilding structures are recommended for WFH:

- Shop
- Yurt
- Fire Circle
- Outdoor Kitchen

Shop

The Shop should be constructed where the old animal stalls are located. This location keeps the shop space private from the more public Outdoor School Zone, while also being distant enough from both the Main Residence and the ADU such that machinery noise will not be a nuisance to occupants of those structures. The pad on which the animal stalls sit is already level with room for additional building if so desired. The shop is proposed to be oriented with its long axis running east-west. This will minimize the amount of wall area exposed to the harsh, intense later afternoon sun and help to minimize heat gain inside the structure. Deep roof eaves are recommended on the east, south and west sides to create a shade buffer and prevent warm season sun from directly hitting the walls of the structure.

This location also allows for easy materials drop-off and pick-up, being conveniently located adjacent to the main driveway. The structure as illustrated is 20x30' in size. To heat the structure during the colder months, a batch box shop heater integrated with a mass bench is recommended for quick and lasting radiant heat (see Section 7.1 - Wood Fire Rocket Systems For Space Heating).

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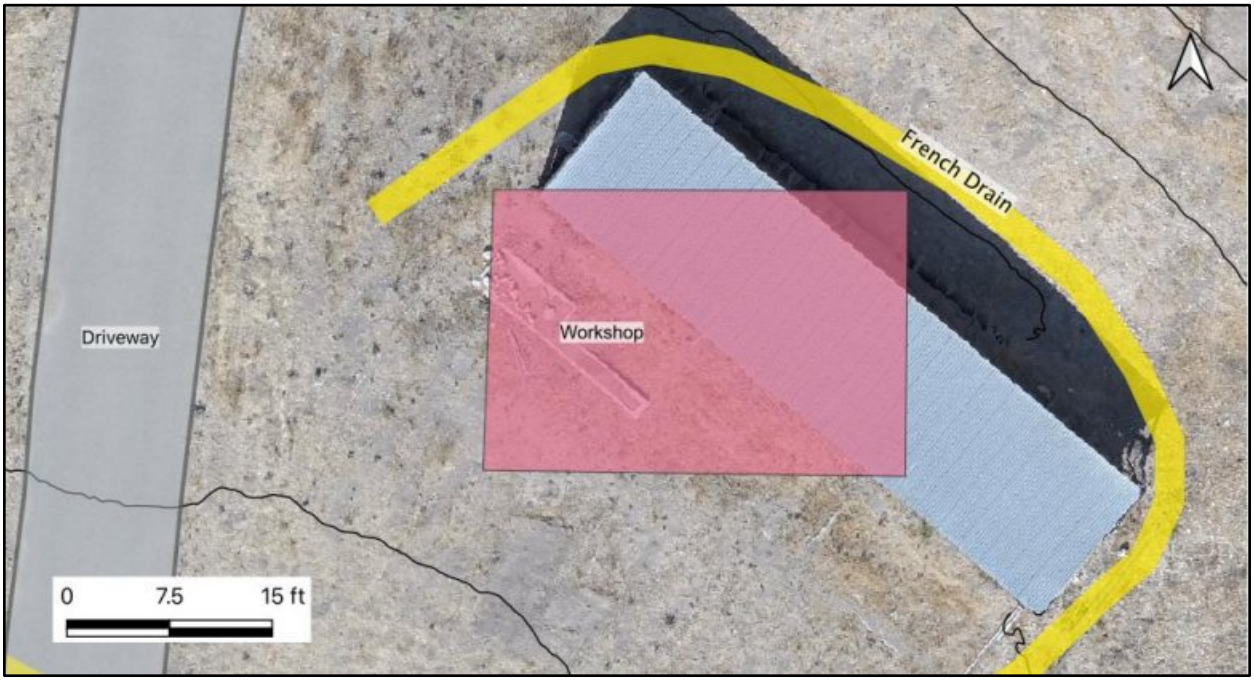
[28] Entrance Room - *A Pattern Language - Towns - Buildings - Construction* by Christopher Alexander et. al. Oxford University Press, 1977. Pgs. 622-626

Figure 4.2.1
Common areas at the heart with tangential main access pathways.

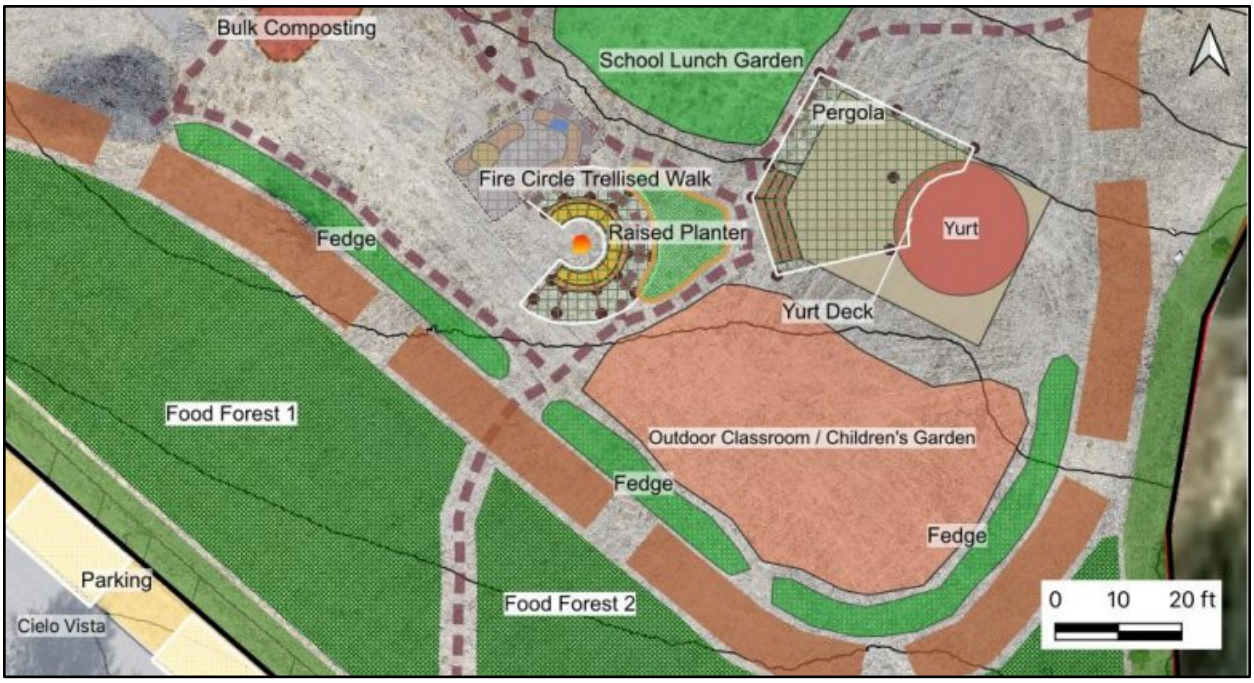


Yurt

A yurt is proposed in the Outdoor School Zone in the southeast corner of the property. The Yurt will serve as a community gathering space, potential indoor classroom during inclement or excessively hot weather, and as a multi-functional space for activities ranging from yoga classes to workshops. The Yurt as illustrated in Figure 4.2.2 is 20' in diameter, occupying ~314 sq. ft of space. To better integrate the yurt with its surroundings and provide a functional indoor-outdoor space, it should be placed upon a deck on it's own slightly raised circular platform (~1-2 steps above deck height) to ensure intentional transition between indoor and outdoor spaces. The deck to the west of the Yurt should be covered by a pergola trellised with deciduous vines to create warm season shade and let in low-angle sun during the cooler months. This will also help to cool the yurt, along with the recommended shade plantings (see Section 5.5 - Yurt Deck Shade Plantings for specific recommendations).

The yurt deck is located atop a small dip in the landform, which will allow it to be at or just above grade on the north side while having some accessible space underneath it on the south side for storage of bulkier items or totes containing supplies or equipment for school activities. Primary access to the deck is via a set of broad stairs from the west, though additional sets of stairs can be added as needed around its perimeter.

Figure 4.2.2
Location of the Yurt, Fire Circle and Outdoor Kitchen in the Outdoor School Zone.

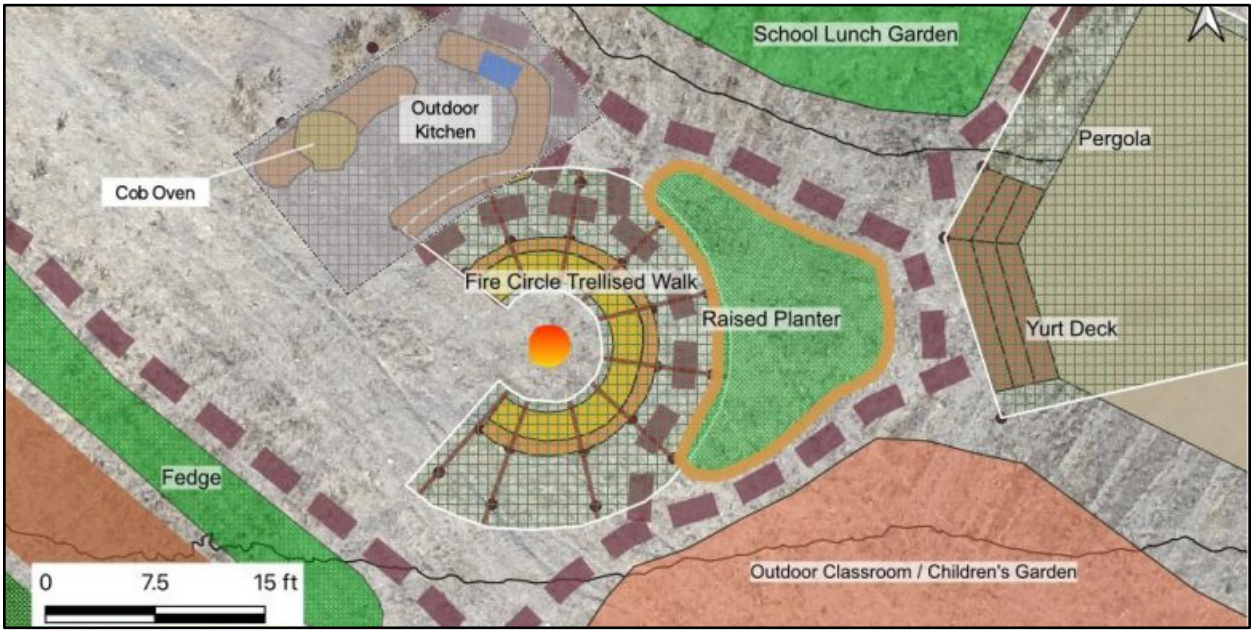


Fire Circle

A fire circle with an earthen bench and earth-bag backrest is recommended due west of the yurt stairs, on the other side of a recommended raised earth-bag planter. The circle has a 9' inner diameter and ~15' outer diameter. One third of its circumference is open to the West to connect it with the open area and Outdoor Kitchen just above it. This opening allows for free movement in and out of the circle, and the earth-bag backrest will also be wide enough to be used as a seat, and stable enough to be climbed over and leaned on - creating additional seating underneath the trellised walkway around the perimeter of the fire circle seating. The west-facing opening makes the sunset long-view to the west accessible to those in the fire pit, and allows for good flow between the fire circle and the proposed footprint for the Outdoor Kitchen.

The Fire Circle being located here also welcomes anyone coming up the proposed pathway from [redacted] into the most public-facing and communal part of the Outdoor School Zone - the place where they are most likely to find people at any given time. Additional travel down the pathway is required to reach the Yurt Deck and then to enter the Yurt, creating a natural intimacy gradient for new arrivals to be invited into (or not) as is appropriate to the event or activity being held. The fire circle is sized this way to accommodate 12 people sitting on its bench - 9' inner diameter being chosen as this size circle accommodates 12 people comfortably while also keeping all circle members within easy-listening distance (no raising of the voice required) and able to see subtle facial expression from someone across the circle. Any larger than this and these subtleties begin to be lost.

Figure 4.2.3
Close up view of the fire circle layout and orientation.



Outdoor Kitchen

The Outdoor Kitchen (Figure 4.2.3 above) serves the Outdoor School Zone and associated community gathering spaces (Fire Circle and Yurt) as a place for a group of people to prepare and enjoy a meal together. Long, organically shaped curving countertops set on earth-bag or cob foundations are recommended, to allow for setting out a buffet line, handling a surge of pot luck dishes, or to be used as a counter for leaning, talking and eating should stools be made available. The long, curved counter directs traffic around the outside, allowing watchers to connect with the cooks preparing the food but not be directly in the way.

A cob oven is proposed on the western side of the kitchen, it's open hearth facing the fire circle. This orientation allows those sitting around and within the fire circle to watch the pizza-making magic and fire within from their seats, while also providing the pizzaiolo with ample room to maneuver hot pizzas (and other dishes) out of the oven to the serving counter.

A large farm sink should be set into one of the counter tops to serve as a hand and produce washing station during meal times, and a dish depository afterwards. Grills and/or oven burners can also be integrated into the countertop, depending on desired cooking capabilities.

The Outdoor Kitchen should have a solid roof to protect open countertops and the cob oven underneath from rain. Vines can be trellised onto the roof to further shade the structure. Post and beam architecture integrated with the earth-bag counter tops will keep the structure open to the air. If hot water is desired for the sink, solar water-heating panels can be mounted to the roof to provide preheated water to a water heater, both described further in Section 7.1 - Moving Heat.

The Outdoor Kitchen could be placed in other locations as well - by no means is this the only way to place it. It should be placed in close relationship with communal sitting and activity areas where it ultimately ends up, at a conversational distance so that those in the kitchen are able to prepare food while also remaining connected to the happenings of the group nearby.

4.3 Animal Enclosures

Animal enclosures are designed to provide shelter for animals, and may potentially also provide storage for feed. They can be either permanent, portable or temporary.

Existing Conditions

There is a small animal stall located southwest of the Main Residence.

Recommendations

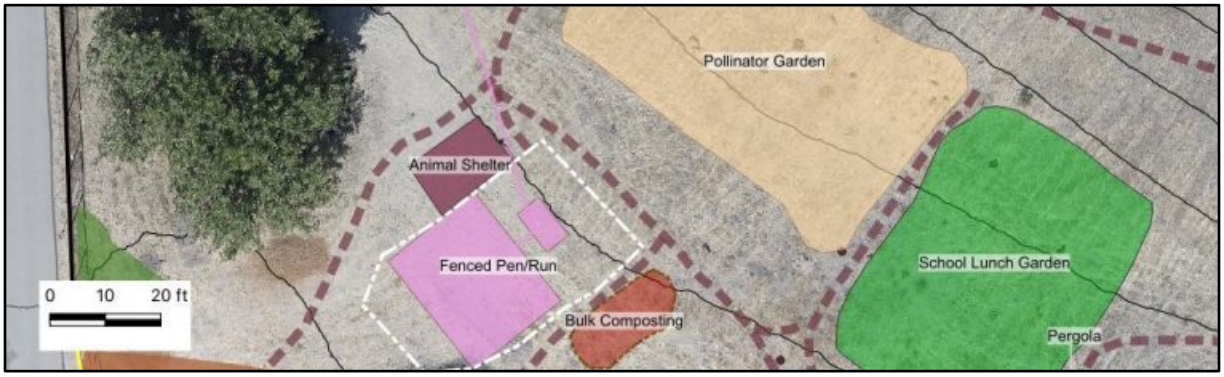
- Construct new Animal Shelter at the west end of the Outdoor School Zone.

New Animal Shelter Integrated With Outdoor School Zone

The new animal shelter is located on the western edge of the Outdoor School Zone, close to the bottom of the Stepped Pathway from the ADU to the Main Residence Yard (Section 3.2) to allow for relatively quick access from the Main Residence for daily tending without crossing the entire Outdoor School Zone. The Animal Shelter and its attached fenced pen/run can be easily accessed at this location by the tractor or another vehicle via the tractor access route. The fenced pen/run is set atop the proposed location for the septic tank and leach field serving the ADU to allow for future maintenance of those elements.

Figure 4.3.1

Proposed animal shelter location and attached fenced pen/run.



5. Living Systems

This chapter on Living Systems pertains to the biological components of all existing and proposed elements and systems at WFH. This includes but is not limited to vegetative systems (terrestrial and aquatic), animal/insect growing systems, mycological systems and bacterial systems.

There exist abundant possibilities for what can be grown on any piece of land. The process of whittling down the mountain of possibilities to readily implementable, maintainable and in some cases marketable elements will require intimate examination of the landowners' values, desires and goals for their life on this property. The Minimum Holistic Goal created at the outset of this consultancy will serve as a valuable lens through which to evaluate the congruence of any and all elements within the landowners' shared vision. Understandably, the 7GD team will have injected some personal biases into interpreting the landowners' shared vision, and by no means are the elements detailed here the "best" or only way to proceed. Each element is a suggestion, a jumping off point, for future iterations, followed by many enjoyable years of tending and adjusting this landscape as it matures.

The contents of this chapter are organized and presented through a functional lens. Each recommended element has a detailed write-up associated with it, and is located in the section pertaining to its primary function. Secondary functions are linked to additional sections within the chapter and report. The purpose of this format is to help illustrate the **web of connections** between the various recommended living elements, so that as the design evolves throughout the implementation and establishment phase, an understanding of necessary functions that must be performed for the land to be in a generative state are central to the decision-making and SADIMEA design iteration process[29].

Context

WFH is located in what broadly qualifies as a Mediterranean climate. It is located in Sunset Climate Zone 7 for California, also known as California's Gray Pine Belt, which is characterised by hot summers and mild but pronounced winters that create sharply defined seasons. Plants and trees that appreciate a marked change of the seasons do well here. Sunset Zone 7 is noted as a successful growing region for pears, apples, peaches, cherries and other deciduous fruits. The Koppen Geiger Climate Classification further reinforces the Sunset Zone with a Csb/BsK rating - Csb standing for warm temperate climate characterised dry summers that are dry and warm to hot, and BsK signifying an arid steppe climate. Paso Robles has a long growing season of 286 sunny days per year, though lack of water restricts plant growth and production for most of the year. WFH is located in USDA zone 8b, indicating that winter low temperatures generally do not fall lower than 15-20°F. When choosing productive tree species it is recommended to select species requiring less than 1,000 chill hours in order to set fruit, based on the historical chill hour record. The climate is brittle, with periods of 240-270 days without effective precipitation common in most years.

The soils are largely composed of weather shale residuum, likely with an alkaline pH (~ 8.2 based on NRCS soil reports). Soil organic matter content is currently very low, and top soil is nonexistent in many areas. Revegetation and reforestation with drought hardy trees and shrubs will play a critical role in restoring soil health and increasing water retention capacity in the soil profile to sustain vegetative production longer into the dry seasons. The water storage capacity of the native

[29] SADIMEA Design Iteration Process: https://www.7thgenerationdesign.com/process/

soil profile is low, and there is a shallow depth to a restrictive layer. Despite relatively fast infiltration rates, the soil is likely to reach saturation quickly, at which point sheet flow will commence. Erosion is the primary risk to soils of the type found at WFH, which further underscores the need for revegetation and rain impedance over all sections of bare earth.

A diversity of wildlife already inhabits the WFH property and surrounding area, many of which will act as potential pests for plants and predators for future livestock. Proper predator/pest deterrence and exclusion methods will be a necessary and important part of establishing all and maintaining many of the living systems elements implemented at WFH.

Existing Conditions

Most of the landscape at WFH is currently dominated by annual grasses and herbs. Dead almond trees are present in the Upper Paddock, along with a couple that are still alive in the Lower Paddock near the Main Residence, speaking to the property's past use as an orcharding zone. Top soil is thin to non-existent, and soil organic matter content is very low. There are very few trees growing on the property, and their establishment will be critical to restoring the soil's health and creating functional (self-sufficient) living systems. There are some live oaks still growing on the property, and a beautiful black walnut at the bottom of the Lower Paddock. The Upper Paddock has a smattering of coyote brush growing in the draw of the West Valley Drainage. Most of the species that are present - annual weeds like black mustard and bull thistle, and native perennials like doveweed - all indicate low soil fertility. A single fallen white mulberry is still alive in the lower southeast corner of the property. This will be a valuable source of cuttings for the propagation of additional mulberry trees in the near future. For a complete list of existing vegetation at WFH, see Section 1.5 - Existing Vegetation.

5.1 Soil-Building and Fertility

Soil is the thin, living layer that exists at the interface between the biological and geological. Soil is different from dirt, in that soil is alive and capable of feeding new life. As such, no system can ever be regenerative (i.e. truly sustainable) if it does not create soil by default. Healthy, fertile soil is *the* essential building block for creating a beautiful, productive and profitable landscape. Methods and techniques for creating and stewarding it will infuse into the selection, design, and management of every element in this design.

Discussed below are elements of the design with a soil-building as their *primary function*.

Existing Conditions

There are no existing soil building elements at WFH.

Recommendations

Recommended soil-building elements include:

- Reforestation of Upper Paddock with CA native and dryland agroforestry species - see Section 5.6 - Reforestation for native species reforestation recommendations and planting strategies and Section 5.2 - Food Production - Silvopasture for recommended food-producing plantings in the Upper Paddock.
- Vetiver Grass plantings - primarily for slope stabilization, but also a tremendous source of biomass - see recommended vetiver grass plantings in Section 5.3 - Erosion Control Plantings.

- Livestock - goats pulsed through the property on a seasonal basis to control weeds and brush, mitigate fire risk, and prune perennial understory once well established.
- Nutrient cycling systems (vermicomposting, compost tea, thermophilic composting, charcoal and biochar)

Livestock

Livestock is commonly defined as domesticated animals raised in an agricultural setting to produce labor and commodities such as meat, eggs, milk, fur, leather, and wool. In recent years, animals are playing a reduced role in the landscape due to being placed in confinement, and fewer farms now include livestock as part of their overall operation. However, animals bring far more value to a landscape and homestead than their typically-recognized labor and commodities. Animals, plants, and soils have played a synergistic role together over geological time. Animals convert high carbon annual crop residue to low carbon organic material, balancing the carbon/nitrogen ratio of the soil. Cows, goats, and sheep grazing on annual and/or perennial plants with short exposure periods followed by long recovery periods allows the plants to regrow and harvest additional sunlight and CO2, promoting more vigorous long-term growth. Chickens, ducks, and pigs till the soil and control pest populations and disease.

In the context of this report, livestock is defined as any domesticated animal whose movement on the landscape is managed by occupants. The general infrastructure needs of various types of common livestock is summarized in Table 5.1.1.

Table 5.1.1

General infrastructure needs of various types of common livestock. From *Silvopasture* by Steve Gabriel.

Animal	Water (gal/ animal/day)	Fencing	Shelter
Chickens & Turkeys	0.2 - 0.5	Electrified poultry netting	Should be locked in at night to avoid predation; taller structure needed for roosting habit
Ducks & Geese	0.5 - 1.5, for drinking and cleaning beaks from rooting; need clean water daily	Electrified poultry netting	Should be locked in at night to avoid predation; more floor space needed for nesting habit
Pigs	1.0 - 6.0	High-tensile wire, hog panels, electrified pig netting or woven wire with openings less than 2”x2”	Three-sided shelter, low to ground
Sheep & Goats	0.5.-2	Electrified woven wire or netting, high-tensile for perimeter	Sheep need shelter only from inclement weather, goats are much pickier
Cows	15 - 20 for steers in hot weather, 20-40 for milking cows	Single- or multi-stranded high-tensile electrified wire	Minimal depending on breed, shade is ideal

Goats

Goats are curious, explorative and deceptively smart creatures, with an ability to thrive on almost any forage - much more so than cows and sheep. These can be great strengths, but also can be great

curses in certain contexts - especially that of rotational grazing in a newly established agroforestry system. Mark Shepard, owner of New Forest Farm and author of "Restoration Agriculture", shares that "goats can be the bane of a new restoration agriculture farmer… they are fence jumpers. They can jump over or go through any normal electric fence that humans can contrive. Build it higher and they'll find a way over, under, or through it if they have an eye for your chestnut tree. I personally do not recommend goats in an agroforestry system until that system is quite mature - 15 years old or more. Goats pose an unacceptable risk in the establishment phase of an edible woody cropping polyculture."

Goats' ability to "eat anything", however, can be leveraged in marginal areas of a homestead (where they cannot see and are distanced from newly planted high-value trees) for the clearing of brush and the production of high-quality meat and dairy products on the coarsest, most degraded forage at much less risk.

Functions
The goats can play a valuable role in accelerating soil formation and increasing soil fertility in the proposed agroforestry and reforestation zones by timing their presence with seasonal growth flushes of both endemic and introduced species. Because goats are known for maximizing their browsing height by standing on their hind legs and even climbing onto objects or into the trees themselves, the breed size should be taken into account based on the desired management and shaping of high value trees.

Food
Because brush recovers more slowly from browsing than grass and forbs do from grazing, it can be more difficult to establish a permanent goat grazing system utilizing on-site resources entirely. Given the size of the WFH property, a portion of the goats dietary needs can realistically be sourced on site, but they will likely need some form of either purchased or intensively grown supplementation. See the list of California native species that goats browse[30] for an expanded species list.

Water
Water, like shelter, will need to move with the animals as they are rotated throughout the landscape. Mobile watering troughs that are kept full by float valve can be placed on the hill. These tanks can be filled when the goats are being shifted through a nearby area, and ideally will be able to serve several or more grazing cells. Alternatively, water access points can be installed as extensions of the current water system to supply the mobile troughs. Ultimate positioning of these additional spigots will depend upon developing a complete grazing plan (knowing what parts of the property need to be managed with goats) integrated with fuels reduction needs. The final location of the Water Tanks will also influence where spigots can be located while also being fed by gravity.

Shelter
Goats are considered the neediest of the ruminants when it comes to shelter from the elements. They don't develop thick coats like sheep and cattle, as most breeds originate from warmer, drier climates. They will require protection from driving winds and shade when browsing in intense sun. Shelter should be mobile and light enough to rotate with the goats as they are moved throughout

[30] Las Pilitas CA Native Livestock - Best Browse Plants: https://www.laspilitas.com/garden/browse-plants.html

the landscape. For permanent shelter and predator protection at night, the goats are proposed to be housed within the lower section of the property in the proposed Animal Housing located in the Outdoor School Zone. They will need a roofed structure for shelter from rain and sun and side walls to protect them from driving winds.

Fencing
See Section 6.2 - Animal Confinement/Exclusion for specific fencing recommendations for goats.

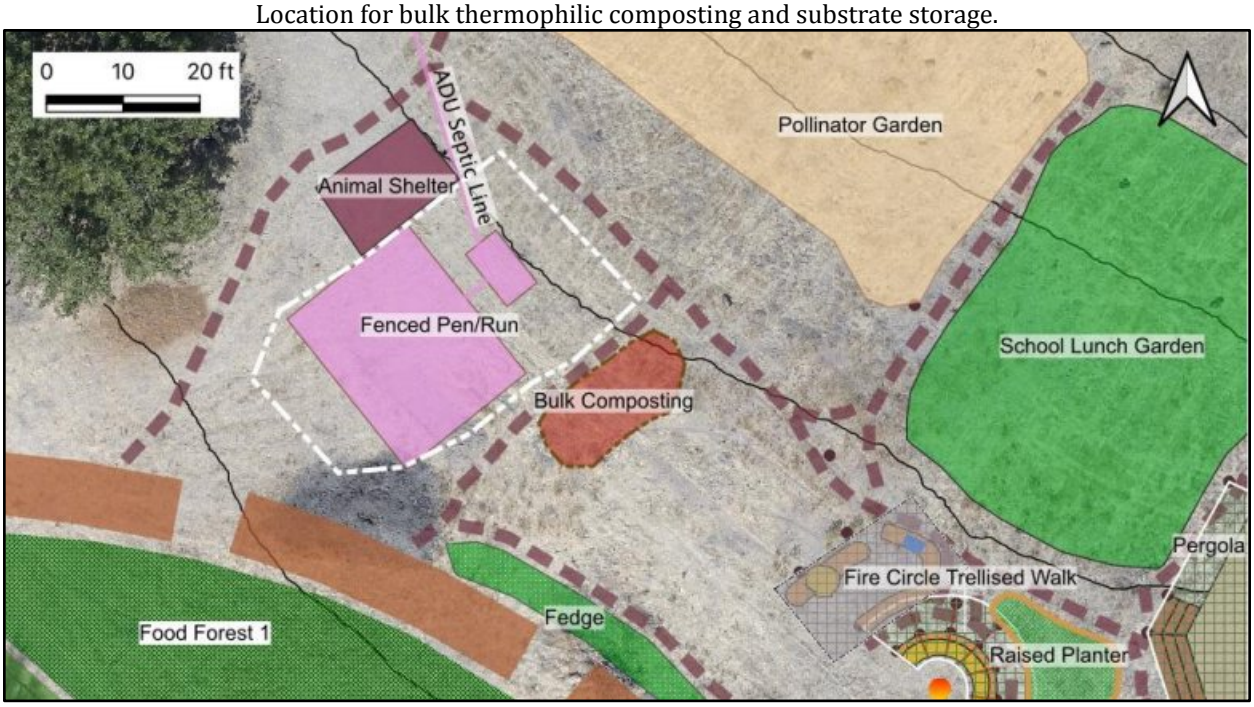
Nutrient Cycling
Nutrient cycling is an essential component to any regenerative system. It is used here to reference the many ways to build fertility, create soil, cycle nutrients and take responsibility for "waste" streams within a given landscape. Every place will have its own unique mix of nutrient cycling systems that, when operated in concert with one another, will increase the resilience over the large whole. Nutrient cycling is especially important for regenerative enterprise to reduce the amount of external inputs required, as oftentimes profit is measured by what is *not spent* in operating the enterprise.

Thermophilic Composting
Standard thermophilic composting is a labor intensive but tried and true method for producing compost. Piles should be constructed in layers of carbonaceous material and nitrogenous material and wetted as they are constructed. Minimum size is approximately 4' tall x 4' wide x 4' deep to provide enough mass to get up to thermophilic temperatures (larger is better if possible). Tarping piles in between turnings can help abate moisture loss. If actively managed and kept well hydrated a pile can produce finished compost in 21-28 days depending on the feedstocks. For much greater detail on thermophilic composting, compost recipes and day-by-day instructions see Nutrient Cycling For Homesteads - Part 4: Thermophilic Composting[31].

Bulk thermophilic composting is best located on relatively flat ground with ample space to allow for flipping piles sequentially and storing up ample materials to make new piles. The Bulk Composting Zone is proposed for the flat, sunny patch just over the east fenceline of the proposed Animal Pen. Located here, the cleanings from the pen can be easily cleaned out and added to material piles in preparation for preparing bulk compost batches. The tractor will also have ready access to the Animal Pen to allow for easy loading/removal of spent bedding material and manure. This zone also has ample space for the tractor to be used in flipping and turning large thermophilic piles, or in the creation of "lasagna" style piles (new material is steadily layered on top of old, wetted and tarped, and allowed to decompose more slowly).

[31] https://www.7thgenerationdesign.com/nutrient-cycling-for-homesteads-part-4-thermophilic-composting/

Figure 5.1.1
Location for bulk thermophilic composting and substrate storage.



Johnson-Su BioReactor

The Johnson-Su BioReactor is a rather new composting method, building upon ancient principles with new and efficient design. It is worth mentioning because of its "do nothing" nature and the incredibly high value of the finished output. Do-nothing may be a slight over exaggeration, however, once set up, this system can be let go for a year with hardly any management (other than occasionally checking moisture levels) The final product is the highest quality, most fungi-rich worm castings the 7th Generation Design team has seen. Linked here[32] is a video with David Johnson discussing this system as well as a link to the BioReactor page[33] on his website.

A Johnson-Su BioReactor (JSBR) is a 4' diameter, 6' tall wire mesh cage lined with shade cloth or weed mat set upon a pallet. Seven 6.5' tall 4" diameter PVC pipes are inserted before the cage is filled to create future aeration channels. The cage is then filled with a mix of materials, the more diverse the better, following general Carbon:Nitrogen composting recommendations (~35:1, though this is flexible). If using animal manures that have been dried they need to be rehydrated thoroughly, and any other material should be wetted prior to addition. Once full, an automated sprinkler is placed on top of the pile, and set to run 1-2 minutes per day to keep the entire pile hydrated. 24-48 hours after initial filling the pipes are removed, leaving air columns penetrating to the bottom of the cylinder, thus ensuring that no point in the entire system is more than 1' from air (key to excellent thermophilic compost). The pile will go through the thermophilic stage remarkably fast (12-14 days) at which point it will cool and the fungal population will begin to surge. After the

[32] David Johnson YouTube walkthrough of Johnson-Su BioReactor construction and operation: https://www.youtube.com/watch?v=DxUGk161Ly8

[33] Johnson-Su BioReactor website: https://regenerationinternational.org/bioreactor/

initial thermophilic stage has completed, composting worms from a Flow-Through Vermicomposter are added to the pile.

Figure 5.1.2
Johnson-Su BioReactor being filled (left) and in operation (right). The vertical pipes in the image at left will be removed after the media gets up to thermophilic temperatures to allow for a hyper-aerated (and thus fast) thermophilic phase.

The Johnson-Su BioReactor is worthy of note due to the extremely high quality of output and low time demands once set up. The final output worm castings are of the same consistency as a clay slip, which means they can be blended into an aerobic compost tea, expanded, and applied as a fungal-rich nutrient spray over any patch of ground where healthy biology needs to be established. The finished castings could also be sold as a high-value inoculum for gardeners and growers to make their own compost teas. Instruction and plans for making a JSBR are available through CSU Chico Center For Regenerative Agriculture And Resilient Systems website[34].

JSBR's have a long maturation period, and that they are not meant to be moved after being filled and during their maturation process. If implemented at WFH they should be filled in a location that is shaded from direct sun (this will help to keep temperatures lower in the pile and decrease moisture fluctuations, making the internal environment more hospitable for the worms over the course of the year). Each JSBR needs to be set upon a pallet to allow for optimum air flow as well as make moving the entire unit once it has matured much easier (using forks on the tractor bucket). By the time the JSBR has finished it will have been reduced to less than half its original volume.

Vermicomposting

Vermicomposting is process of using various species of worms, (usually red wigglers, white worms, and other earthworms) to break down organic matter. Worm castings, the end-product of this process, has been shown to contain reduced levels of contaminants and a higher saturation of nutrients than the organic materials before vermicomposting, and can be applied directly in the soil as an high-value soil amendment or utilized to brew compost tea and inoculate charcoal to make biochar.

[34] Johnson-Su BioReactor DIY Instructions: https://www.csuchico.edu/regenerativeagriculture/bioreactor/bioreactor-instructions.shtml

A healthy vermicomposting system can provide a surplus of worms that can be transplanted to colonize each Johnson-Su BioReactor after it has gone through its thermophilic phase, and if scaled large enough excess worms could also be harvested and sold.

The worms can process a range of different inputs.

- **YES:** vegetable and fruit scraps (raw and cooked), egg shells, garden weeds, cardboard (soaked, torn into small pieces – non-glossy, remove tape and adhesive labels), newspaper.
- **NO:** oils, fats, raw meats, bones, citrus rinds and citrus fruit, alliums (garlic, onions etc), pet feces.
- **SOME:** Lawn clippings (add in very thin layers), nut pressings (from making almond milk etc).
- **A LITTLE:** Cooked meat, cooked fish, bread, pasta, pastries, dairy products (not liquid milk – can cause anaerobic conditions due to excess liquid, but cheeses, yogurts OK).

For more information on vermicomposting and flow-through vermicomposters we recommend reading Nutrient Cycling For Homesteads - Part 1: Vermicomposting[35].

A flow-through vermicomposter (FTV) is recommended for vermicomposting. An FTV, once set up, never requires the operator to bait the worms to a different corner, and then excavate the material while trying to minimize worm loss. With an FTV system, the operator instead only feeds the worm bed from the top, keeps the media moist, and collects worm casting as they fall out from the bottom. This type of system, depending on size, can take 6-12 months to begin producing worm castings, but once it does the output is continuous as long as inputs are consistent and the worm population is stable and active. Figure 5.1.3 below illustrates how this system works.

[35] https://www.7thgenerationdesign.com/nutrient-cycling-for-homesteads-part-1-vermicompost/

Figure 5.1.3
Home-scale flow-through vermicomposter. This system can be scaled up to handle larger nutrient inflows in a modular fashion.

A hinged lid (latchable, to exclude vermin) allows the operator to add organic material at the top. The tray based harvest system pictured is a prototype - other systems generally let castings fall onto a concrete pad. The tray based system is meant to keep the castings hydrated and to minimize potential worm fallout through the bottom of the unit. The unit should be fully shaded during the summer and have some buffer from drying winds - either a skirt of plastic sheeting or wooden boards is recommended for this purpose.

A small, homescale FTVC is recommended initially for WFH. Should additional capacity be desired at a future date (perhaps with the arrival of livestock on the property), additional FTVs can be added. This system is recommended for siting adjacent to sources of potential feedstocks (animal pens, crop gardens) and near a water source. The FTV should be located in a shady spot protected from direct sun that has some wind shelter (optimal temperatures for compost worms range from 65-85°F, and they can die at 95°F and above and slow their activity significantly at 50°F and below). It should be placed along a north-facing wall or somewhere where it might only receive early morning sun but then be shaded the rest of the day. The FTVC will require (depending on size) watering on a weekly basis, perhaps every 2-3 days, during the warm season.

Charcoal and Biochar

Charcoal is the pure carbon that remains after dry organic matter has gone through pyrolysis - heating in the absence of oxygen. Charcoal is a very valuable product on the farm or homestead, and has a vast number of potential applications, both on-property and off, including but not limited to:

- As a persistent (lasts for thousands of years) soil amendment, in the form of biochar, to enhance water-holding capacity, nutrient retention and bioavailability, micro-fauna habitat within the soil (bacteria and fungi).
- As a high-quality fuel source for cooking and crafting.
- As a water filtration medium for producing potable water on-site.
- As a value-added product in the form of biochar used to boost soil fertility, and potentially sell to the local community.

The Nutrient Cycling For Homesteads - Part 6: Biochar[36] article on the 7th Generation Design website provides further information on the amazing uses and benefits of charcoal and biochar.

Below are several specific methods well-suited to converting the various types of wood slash generated during annual fire maintenance into charcoal.

Compost Tea

Compost tea is a nutrient- and microbe-rich liquid that is aerobically brewed to maximize the number of beneficial microbes, fungi and bio-available nutrients for the soil food web and plants. It is one of the most effective and lowest cost ways to boost biological function quickly when establishing living systems.

A compost tea brewing system is recommended to supply the various growing systems with high quality microbial and fungal teas. The brewing area should be located a shaded area, where it can either be directly injected into irrigation lines or easily transferred into mobile sprayers (handpump, backpack, or ATV/tractor based).

Brewing setups span a range of sizes. For a kitchen garden, a simple 10 gallon brewing setup like the one detailed in the 7th Generation Design article Nutrient Cycling For Homesteads - Part 3: Compost Tea[37] is ample. For larger scale applications, an air-lift vortex brewer[38] is recommended as a low-energy way to brew large amounts of highly-aerobic compost tea. The vortex brewer does not require a pump, but instead utilizes a 60 watt air compressor, which injects air into 3-4 separate circulation lines that ultimately work to create a whirlpool effect in the tank, resulting in very high oxygen saturation levels and thus maximum expansion of desired biology during each brew.

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[36] Nutrient Cycling For Homesteads - Part 6: Charcoal and Biochar : https://www.7thgenerationdesign.com/biochar/

[37] https://www.7thgenerationdesign.com/nutrient-cycling-for-homesteads-part-3-compost-tea/

[38] DIY Instructions Vortex Compost Tea brewer: https://www.7thgenerationdesign.com/wp-content/uploads/2020/08/VORTEX-BREWER-BUILD-KIT-INSTRUCTIONS.pdf

Figure 5.1.4
Vortex brewer.

A mobile spraying set up that can be attached to a tractor and driven by the PTO[39] or ATV and powered by the battery[40] is recommended for applying compost tea to broad acreage. For locations where a vehicle cannot reach there are units that come with an extendable hose that can be walked from the machine and power source to the desired point of application.

Compost tea is the preferred medium to be used when hydrating and charging charcoal to make biochar. It will be appreciated by all growing systems, annual and perennial alike, and will play a vital role in jump-starting healthy soil biology.

5.2 Food Production

In nature, food is produced at or very near the point of consumption. The creature that does the eating has to go to the food. The modern food system, with vast monocultural production systems and thousand mile supply chains, (dys)functions in exactly the opposite manner - food is grown or produced far away, and brought to the eater via a very complex and fragile energy-intensive system. A critical piece of recreating a regenerative food supply (i.e. modeling natural pattern) is living in close proximity to, and often in relationship with one's food supply.

This section explores climatically and energetically regenerative ways to produce food close to home. Discussed below are elements of the design with food production as their *primary function*.

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[39] PTO-driven compost tea sprayer
https://www.compostwerks.com/equipments/compost-tea-sprayers-87829/product/98-100-gallon-pto-compost-tea-sprayer

[40] 12 Volt 15 Gallon ATV mounted sprayer: https://www.homedepot.com/p/Chapin-15-Gal-12-Volt-EZ-Mount-Spot-Sprayer-for-ATV-s-UTV-s-and-Lawn-Tractors-97200B/301459922

Existing Conditions

There is currently a small, temporary kitchen garden located in the Upper Yard. Some fruit trees have been planted on the ridge above the Main Residence, and are currently one year in place. An apricot tree is growing in a sunken well planter along the west side of the Main Residence.

Recommendations

Recommended food-producing elements include:

- Gardens
    - School Lunch Garden as part of the Outdoor School Zone.
    - Main Residence Kitchen Garden adjacent to the Natural Swimming Pool.
    - Pollinator Garden in the Outdoor School Zone and around the solar panels.
- Orchards & Food Forests
    - Food forestry blocks around the Outdoor School Zone and Main Residence.
- Agroforestry systems and native reforestation in the Upper Paddock.

Gardens

Food gardens are biological systems specifically designed and tended to maximize production of nutritious food and tend to be intensively managed (require frequent interaction) and small in size (not extensive). Food production can take many forms, and includes both terrestrial and aquatic systems.

School Lunch Garden

The school lunch garden is proposed for the area just uphill and west of the Yurt Deck. This location gets excellent southern exposure, has a gentle slope that will allow for easy transit between beds, while also ensuring ample solar access to each growing bed. As illustrated the garden area has a footprint of 2,130 square feet, and an elevation change from top to bottom of 8-9'. The lower third of this area is recommended to have the option to hang shade cloth over it as seasonally appropriate to enable growing a broader range of annual crops over more of the year - things that will appreciate lower ground temperature and decreased light intensity (like leafy greens). The shadecloth can extend from the pergola shade structure over the Yurt Deck to posts set into the ground on the west side of the garden. The shade will also make day-time garden activities more enjoyable, even when the sun is high. The School Lunch Garden should be fenced with a welded-wire fence and the bottom 2' should also have chicken wire to exclude rabbit and other burrowing garden pests - see Section 6.2 - Animal Confinement/Exclusion - Permanent Fencing Around School Lunch Garden for details.

The School Lunch Garden is primarily envisioned to be an active part of the daily and seasonal curriculum for any on-site children's education program - an opportunity to get kids connected with and ideally growing and tending some of their own food, which can be harvested and prepared for the daily lunch in the adjacent Outdoor Kitchen.

Figure 5.2.1
Recommended location for the School Lunch Garden.

Kitchen Garden

The Kitchen Garden that serves the Main Residence is recommended for the western edge of the current lawn area, adjacent to the Natural Swimming Pool and an easy walk from the kitchen. The Kitchen Garden is also located along the walkway from the Main Residence to the start of the Stepped Pathway Between ADU and Upper Yard, a main traffic corridor between the Upper Yard and the ADU, Animal Shelter, and Outdoor School Zone. Placing the Kitchen Garden next to a frequently traveled access route increases the number of passive visual inspections it will receive on any given day, and make for quick maintenance or harvest while passing.

The raised beds for the kitchen garden can take a number of different forms. Given the proximity of the beds to the Natural Swimming Pool, a thick, solid edge capable of doubling as a bench seat to enjoy the view of the aquatic ecosystem and watching the action in the pool may be desirable. If this functionality is desired, earth-bag construction is recommended for the raised bed walls. See the Earth-Bag Primer following this section for basic information on building with earth-bags. The bag thickness and weight will also help the walls to buffer the large temperature swings experienced throughout much of the growing season in Paso Robles. Unlike wood, metal or plastic raised beds, the earthen walls would remain relatively stable in temperature on the inside of the bed, where maintaining a consistent soil temperature for growing plants is advantageous.

Wicking beds are another option worth considering and perhaps integrating with earth-bag wall construction. Wicking beds utilize capillary action to maintain consistent soil moisture even when temperatures are very high. They have a subterranean water reservoir from which plants can draw water *as needed*, instead of being drenched and then dried out as often happens with irrigation cycles. See the Wicking Beds Primer following this section for more detailed information on the design and function of wicking beds.

Figure 5.2.2
Recommended location for the Kitchen Garden.

Earth-bag Primer

Earth-bag construction was pioneered by Nader Khalili, founder of the California Instituteof Earth Art and Architecture (Cal-Earth[41]), starting back in the 1980's. Earth-bag construction is a well-documented building method that combines natural and industrial materials in a low-tech way to create seismically stable[42], fireproof, inexpensive structures with excellent thermal performance well suited to dryland climates. Earth-bag dome structures also have a history of permitting[43] in Southern California and around the world, which may be helpful precedents to draw upon should a permitted structure be desired.

Determining the composition of the native soil at WFH will be a helpful step towards determining what, if any, amendments might need to be added to the soil to make a solid earth-bag. A simple jar test will reveal the soil composition; take a 1 quarter mason jar and fill it ⅓ full with mineral soil from a likely building site, add 1 drop of dish soap to help flocculate soil particles, shake vigorously for 1-2 minutes, then let sit undisturbed for 24 hours. The resultant layers in the jar will give an approximate idea of how much sand, silt, clay and organic material make up the soil. For earth-bag construction, a clay content between 10-35%, with the remainder sand, is an ideal building mix.

When constructing earth-bag walls, such as those recommended for the kitchen garden raised beds and Fire Circle perimeter, that are to be left exposed to the elements (not covered with a roof), typically a small percentage of cement is incorporated into the soil mixture, often approximately

[41] California Institute Of Earth Art and Architecture: https://www.calearth.org/

[42] earth-bag Construction Seismic Stability: https://www.engineeringforchange.org/news/build-earth-bag-structure-seismic-zone/

[43] earth-bag construction engineering firm: https://www.structure1.com/projects/earth-bag-houses/

10%. The extra hardness gives the earth-bag wall four-season capability while still maintaining the desirable characteristics of earthen constructions - namely good thermal mass and breathability. Walls are then typically plastered with earthen or composite plasters and finished with a lime plaster.

Figure 5.2.3

(Left): Earth-bag raised bed in progress, and *(Right):* Completed raised bed with plaster. Images: Earthbag Building[44]

Additional resources for learning more about earth-bag construction.

- Excellent, detailed YouTube video detailing a full build of an earth-bag building.
- EarthBagBuilding.com[45] - has a large library of pre-made earth-bag home plans available for purchase, and information on codes and permitting[46], and a list of DIY books[47] available on the subject.
- EarthBagPlans[48] - repository of small earth-bag home plans available for purchase.
- NaturalBuildingBlog.com[49] - lots of earth-bag related articles and resources here.

Wicking Beds Primer

Wicking beds are fully contained, self-watering planting beds that use capillary action to maintain consistent soil moisture. Wicking beds typically have a reservoir of water stored sub-surface that is passively drawn on by plants as they need it. Figure 5.2.4 below illustrates one method of wicking bed construction.

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[44] http://www.earthbagbuilding.com/projects/shariplanter.htm

[45] http://earth-bagbuilding.com/index.htm

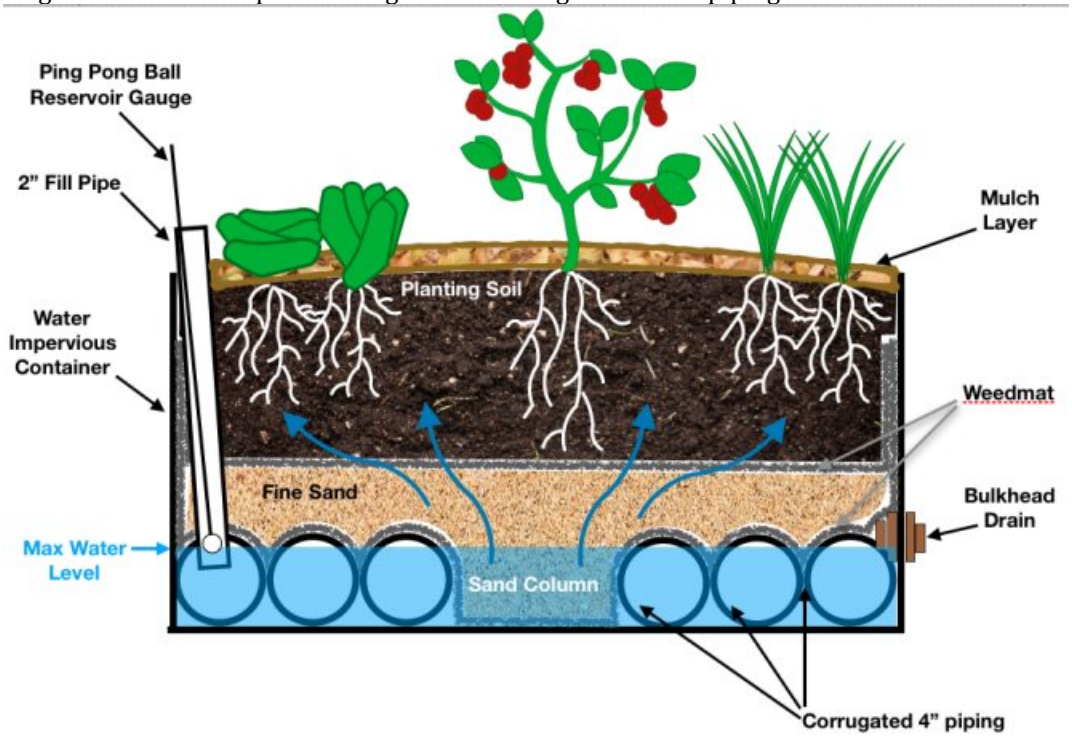
[46] http://earth-bagbuilding.com/faqs/codes.htm

[47] http://www.earth-bagbuilding.com/resources.htm

[48] https://earth-bagplans.wordpress.com/

[49] http://www.naturalbuildingblog.com/

Figure 5.2.4
Wicking bed construction profile using flexible corrugated vented piping to create the water reservoir.



Wicking beds are appropriate in very dry climates, where they can save enormous amounts of water by limiting evaporation loss occurring during surface irrigation and by eliminating water dissipation into surrounding dry soils. Wicking beds are very appropriate for low-maintenance home gardens, as the subsurface water reservoir allows beds to go weeks, even months between fill ups. Similar design principles can also be applied to larger production based systems, but the cost can be prohibitive. Depending on conditions (arid to semi-arid), it may be absolutely necessary.

Wicking beds can be designed to fit almost any garden bed shape, size, or style. They are commonly built in pre-made containers – like galvanized livestock watering troughs, polyethylene or rubber feed troughs – as well as in custom built wooden raised beds (the bottoms are lined with pond liner). Wicking beds can even look like standard in-ground garden beds by excavating the bed footprint and laying pond liner down to create the water retention basin. Any option where pond liner is used to retain the water needs to take into account the presence of ground vermin, as they are likely to chew through pond liner. Bottoms of raised beds should be lined with gopher wire and have layers of old carpet or rug lain atop it to prevent the pond liner from tearing on the gopher wire. All it takes is one hole and the wicking function of the bed will be ruined. For these reasons it is recommended to build wicking beds in galvanized or rubber livestock troughs, or if building a wooden raised-bed, to have a rot-resistant wooden bottom (black locust, cedar, redwood) on the bed capable of excluding rodents and ground vermin.

For a step-by-step construction guide, see the Wicking Bed Construction And Performance[50] post on the 7th Generation Design blog.

Orchards & Food Forests

An orchard is an intentional planting of fruit- or nut-producing trees or shrubs that is maintained for food production. While many commercial orchards are planted for a single variety of fruit in a linear grid-shape with no understory for ease of mechanical harvesting, this typically leaves the trees vulnerable to pests and disease (thus requiring expensive and potentially harmful chemical inputs), leaves the soil exposed (increasing water needs and fertilization needs), reduces the water harvesting and retention capacity of the area (increasing water needs), and minimizes the diversity of yields.

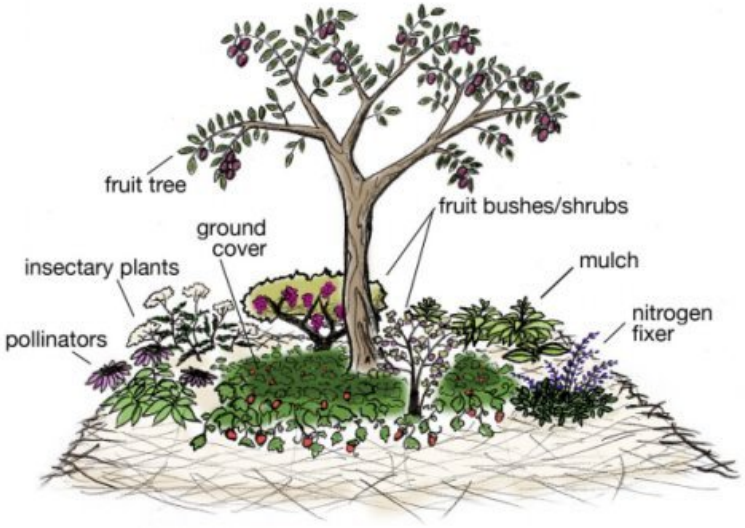
A food forest mimics natural patterns to create a functioning and vibrant ecology while favoring preferred human-centric species of trees, plants and fungi. A food forest is planned with the goal of ultimately creating self-sufficiency in that the forest provides for its own fertility, water, pest control, composting, pollination, reproduction and much more.

A resilient orchard can incorporate elements of natural pattern from the food forest, while also maintaining slightly more regularity than would otherwise be found in a completely wild system. Maintenance of tractor access lanes, or a consistent tree spacing, can be very helpful if certain production goals are to be met. Much like in a food forest, trees in a resilient orchard should have a dense underplanting of support species. This underplanting of complementary support species, known as a "guild", provides many important functions that will increase yields while minimizing long term input and maintenance costs, such as:

- Living mulch shades the soil, protecting soil life and reducing evaporation,
- Shade for young tree trunks (protection from sun scald),
- Nutrients, in the form of decomposing biomass and varied root exudates capable of supporting a more diverse array of soil microbiota,
- Fertilizer, via nitrogen-fixing and dynamic accumulating plants,
- Insectary (pollinators and pest predators),
- Diverse mycorrhizal web that provides minerals, additional micronutrients and information exchange with surrounding trees and plants (fungi).

[50] Wicking Bed Construction And Performance: https://www.7thgenerationdesign.com/wicking-bed-construction-and-performance/

Figure 5.2.5
Fruit Tree Guild



There are two physically distinct plant profiles that will perform all of the above functions. Firstly, herbaceous/shrubby plants that grow vertically up to several feet and can be readily chopped and dropped at the foot of the tree, and second a creeping, low-growing, low-to-no water groundcover that will not compete with feeder roots from the tree (i.e. not a super aggressive or nutrient-hungry plant). At a bare minimum this function list will require at least two species of plants, and certainly more can be used.

A food forest, in order for it to remain maximally productive, actually needs to be maintained in a slightly juvenile state instead of being allowed to grow until reaching a completely stable, but less productive, climax community. This is where management comes in. Part of keeping a food forest productive is maintaining space, creating intentional disturbance, and generally cutting back vegetation so as to maximize the conversion of sunlight into desired end products - which can range from fruit to nuts to carbon to medicine and more.

Food Forest 1

Food Forest 1 is proposed for the area between the existing vehicle access gate in the Lower Paddock SE corner and the proposed School Entry Gate in the middle of the southern fenceline and up to the tractor access road running through the Lower Paddock. As illustrated in Figure 5.2.6 it is ~4,200 square feet in area. This area has a south-facing slope and full sun, and has an approximate 10' height differential from its highest to lowest point. Because Food Forest 1 and Food Forest 2 frame the public view of the Outdoor School Zone and border the main entry pathway to the heart of the area, they are an excellent place for demonstration plantings as they will by default receive the most attention.

Trees are illustrated in Figure 5.2.6 at 25' in-row spacing, and slightly less between rows as they are laid out on contour. The actual spacing should be determined by the climax size of whichever species are ultimately chosen to fill these two areas. See Food Forest Species at the end of this section for a list of recommended guild species.

Figure 5.2.6
Food Forests 1 and 2, bordering the southern fenceline and buffering the Outdoor School Zone from [redacted] Road. Trees shown at 25' in row spacing.

Food Forest 2

Food Forest 2 as illustrated in Figure 5.2.6 is ~7,400 square feet in area, and has ~15' of elevation change from its lowest to highest points. Tree illustrations are at 25' in-row spacing and slightly less between row due to contour variance. Ultimate tree spacings will depend upon the species and cultivars selected. See Food Forest Species following this section for a list of recommended guild species.

Food Forest 3

Food Forest 3 is comprised of the area located between the proposed Stepped Pathway Between the ADU and Upper Yard and the Ramped Pathway Traversing Fill Slope Below Main Residence and the triangles of land abutting the tractor access road up the eastern edge of the property, and is outlined by the yellow dashed line in Figure 5.2.7 below. As illustrated, Food Forest 3 is ~8,300 square feet in area and has an elevation change of ~35' from bottom to top. The trees in the illustration are for visual demonstration, and are spaced at 25' in-row spacing and slightly less than that for between-row spacing as the contours vary slightly in their proximity to one another. Actual tree spacing will depend on the species chosen and their projected climax size as well as desired interplantings. See Food Forest Species following this section for a list of recommended guild species.

Figure 5.2.7
Food Forest 3, on the south-facing slope below the Main Residence.

Due to the steepness of the slope throughout most of Food Forest 3, and the fragility of the fill soils, further use of vetiver grass is recommended during the establishment phase for desired tree species. Either continuation of the vetiver lines running on contour branching off the sides of the Stepped Pathway Between ADU and Main Residence Yard or the planting of vetiver "boomerangs" both uphill and downhill of the desired tree planting locations is recommended. Continuation of the vetiver lines on contour will create natural terraces over time and make for easier access to the trees during maintenance and harvest times, however this will also require the greatest number of vetiver slips and effort to establish. By pre-flagging tree locations a year in advance and growing vetiver in small arcs immediately uphill and downhill of these locations, the fragile soil uphill of the tree will be prevented from sliding down and piling up against the young trunks, and the grassy clumps on the downhill side will act to shade the young trunks, buffer wind, and create a small, semi-level bench around the tree into which its guildmates and support species can be planted. This approach will require fewer vetiver slips, but will not create uniform terraces across the slope. Figures 5.2.8 and 5.2.9 illustrate how each approach would look in preparation for planting desired trees.

Figure 5.2.8
Vetiver grown on 5' contour lines across the desired tree planting zone 1 year prior to planting.

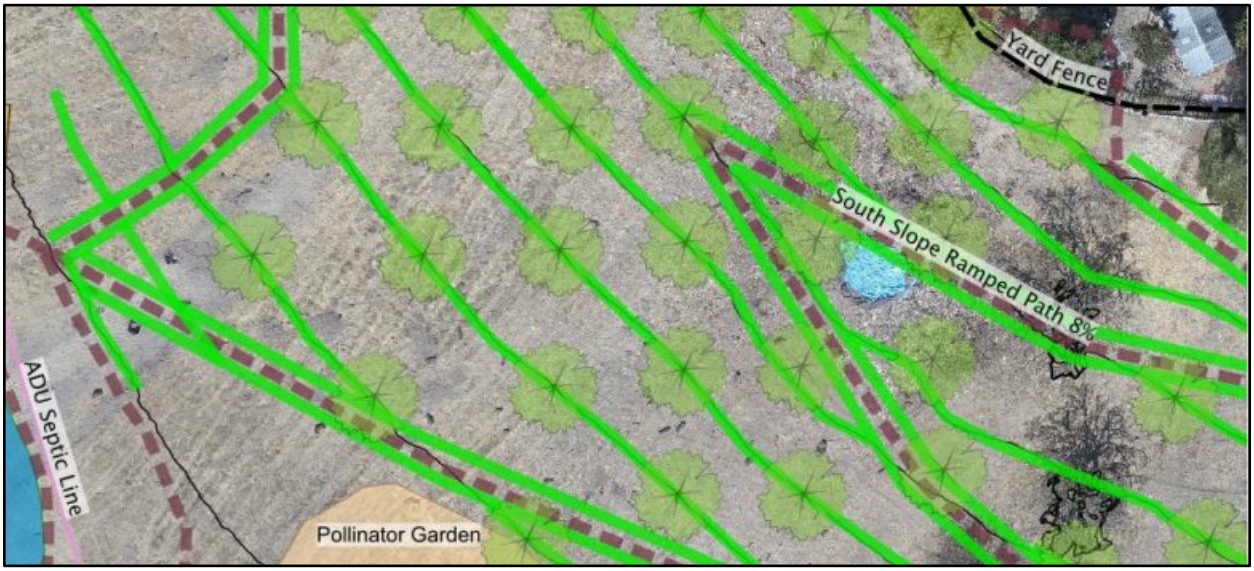
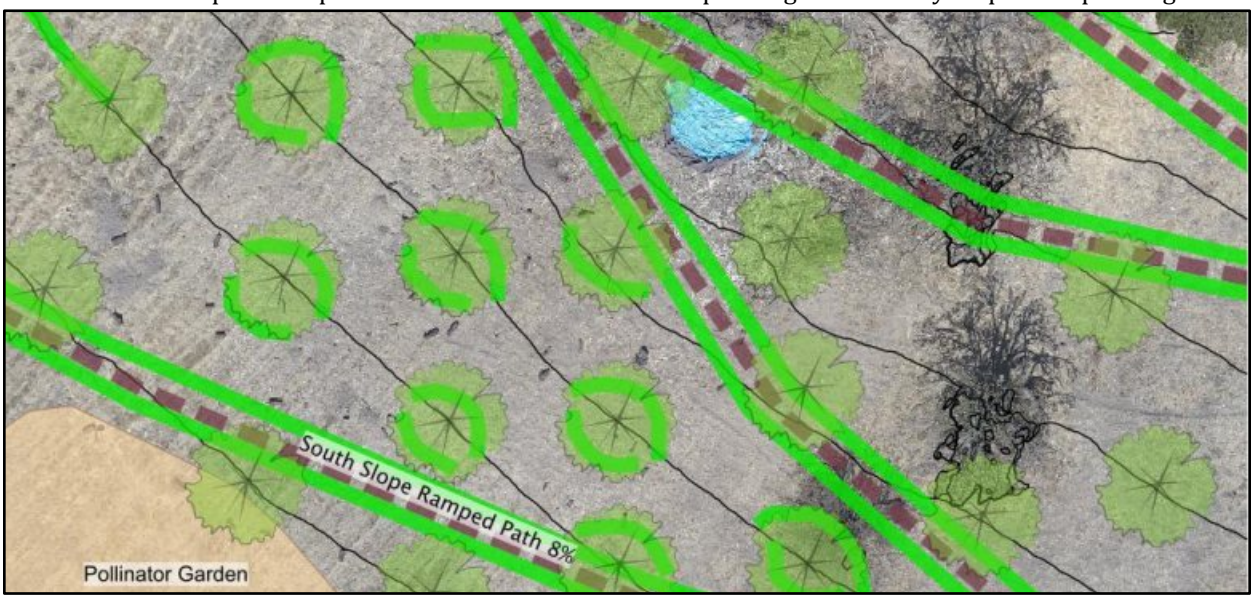


Figure 5.2.9
Vetiver arcs planted uphill and downhill of desired tree planting locations 1 year prior to planting.



Food Forest 4

Food Forest 4 is located on the west-facing fill slope below the Main Residence. This slope is steep and fragile just like Food Forest 3, and similar soil stabilization methods as recommended for Food Forest 3 should be undertaken in Food Forest 4 prior to planting long-term productive species. Food Forest 4 is its own independent block due to its dominant westward solar aspect. Species selected for this block should very drought-hardy and heat tolerant, as this area will experience the highest of the high temperatures and be late to warm during the shoulder seasons. This slope will also benefit from its own independent irrigation zone to meet the more particular requirements of the species that will be planted here.

Figure 5.2.10
Location of Food Forest 4 on the west-facing slope below the Main Residence.

The trees illustrated in Figure 5.2.10 are for visual demonstration,with two different spacings - the light green at 25' in-row spacing and the dark green at 15' in-row spacing. Actual tree spacing will depend on the species chosen and their projected climax size as well as desired interplantings. See Food Forest Species for a list of recommended species for creating guilds.

Food Forest 5

Food Forest 5 is located on the narrow strip of land above the Main Residence and proposed Natural Swimming Pool location. Some orchard-style plantings have already been made here. It is recommended that tree plantings in this area stop 30' short of the solar panel ground mount installation to ensure that a tree with a 15' climax height will not project shadows onto the panels during the lowest winter sun angles, when shadow lengths are 1.67x object height. Should trees with a projected canopy height taller than 15' be planted, their positioning relative to the panels should be adjusted accordingly. Trees are illustrated in Figure 5.2.11 at 25' in-row spacing and laid out on contour.

Figure 5.2.11
Location of Food Forest 5 on the south-facing ridge crest above and east of the Main Residence.

This location has especially thin soils being located on the south face of the ridgeline crest. Significant support plantings would best be planted at least 1 year ahead of selected productive trees to create windbreaks, shade, living ground cover and healthy soil biology that will increase the likelihood of successful establishment of long-term desirable fruit and/or nut trees.

Food Forest Species

The table below contains a list of species for all different aspects of food forest guild construction that should perform well in the climate found at WFH. This list is by no means exclusive, and there are many more varietals and species that could work for WFH. Species listed here are selected primarily based on USDA Zone, heat tolerance, and chilling hour requirements (if applicable). For additional in-depth information on each species listed, including ecological functions, human uses, livestock palatability and sourcing links, see the WFH - Living Systems Calculator[51] spreadsheet associated with this report. **NOTE:** Available harvest window information is based on published information from suppliers (when available) or our own direct observation. Ripening and harvest times will vary from place to place, and the dates listed should be taken as a general indicator of when a certain varietal will be ready to harvest.

[51] https://docs.google.com/spreadsheets/d/1q-56fCWTosyAfiLGipMIKUb13-rk3WELP04SlGXVQbw/edit?usp=sharing

Table 5.2.1
Recommended species list for food forest guild formation.

Common Name	Scientific Name	Spread (ft)	Height (ft)	Harvest Start	Harvest End
Fruit / Nut Trees					
Apples					
Anna Apple	*Malus spp.*	15 - 25	15 - 25	5/10	8/10
Arkansas Black Apple	*Malus spp.*	15 - 25	15 - 25	11/25	1/1
Lady Williams Apple	*Malus spp.*	15 - 25	15 - 25	12/15	1/30
Akane Apple	*Malus spp.*	15 - 25	15 - 25	8/22	10/15
Dorsett Golden Apple	*Malus spp.*	15 - 25	15 - 25	7/15	10/1
Fuji Apple	*Malus spp.*	15 - 25	15 - 25	11/1	12/15
Gala Apple	*Malus spp.*	15 - 25	15 - 25	7/1	8/20
Liberty Apple	*Malus spp.*	15 - 25	15 - 25	11/15	
Sierra Beauty Apple	*Malus spp.*	15 - 25	15 - 25	10/25	
Yellow Newton Pippin Apple	*Malus spp.*	15 - 25	15 - 25	12/25	
Calville Blanc D'Hiver Apple	*Malus spp.*	15 - 25	15 - 25		
Golden Delicious Apple	*Malus spp.*	15 - 25	15 - 25		
Hudson's Golden Gem Apple	*Malus spp.*	15 - 25	15 - 25		
Jonathan Apple	*Malus spp.*	15 - 25	15 - 25		
Mollie's Delicious Apple	*Malus spp.*	15 - 25	15 - 25		
Mutsu Apple	*Malus spp.*	15 - 25	15 - 25		
Newtown Pippin Apple	*Malus spp.*	15 - 25	15 - 25		
Pink Pearl Apple	*Malus spp.*	15 - 25	15 - 25		
Roxbury Russet Apple	*Malus spp.*	15 - 25	15 - 25		
Esopus Spitzenburg Apple	*Malus spp.*	15 - 25	15 - 25		
Granny Smith Apple	*Malus spp.*	15 - 25	15 - 25	11/15	12/15

Wickson Crabapple	*Malus spp.*	15 - 25	15 - 25	11/20	1/1
Pink Lady	*Malus spp.*	15 - 25	15 - 25	11/1	12/30
Citrus					
Calamondin	*Citrofortunella mitis*				
Oroblanco Grapefruit	*Citrus grandis x Citrus paradisi*			12/1	4/1
Mandarin	*Citrus reticulata*	15 - 20	15-20		
Kumquat	*Fortunella sp.*	5 - 10	5 - 10		
Moro Blood Orange	*Citrus x sinensis*	15 - 20	15-20		
Stonefruits					
Arctic Supreme Peach	*Prunus persica*	15 - 25	15 - 25	7/1	
Babcock Peach	*Prunus persica*	15 - 25	15 - 25	7/15	
Suncrest Peach	*Prunus persica*	15 - 25	15 - 25	7/25	
Peachy Keen Peach	*Prunus persica*	15 - 25	15 - 25	6/10	6/30
Arctic Glo Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	7/1	7/30
Arctic Jay Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	7/1	7/25
Arctic Queen Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	8/10	
Fantasia Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	8/1	
Snow Queen Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	6/20	7/15
Autumn Royal Apricot	*Prunus armeniaca*	15 - 25	15 - 25	9/1	9/30
Flora Gold Apricot	*Prunus armeniaca*	15 - 25	15 - 25	6/5	6/22
Harcot Apricot	*Prunus armeniaca*	15 - 25	15 - 25	6/15	
Tilton Apricot	*Prunus armeniaca*	15 - 25	15 - 25	7/5	7/25
Santa Rosa Plum	*Prunus salicina "Santa Rosa"*	12 - 15	12 - 15	6/15	7/5
Figs					

Black Mission Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Brown Turkey Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Celestial Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Italian Honey Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Violette de Bordeaux Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Kadota Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Excel FIg	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
White Genoa Fig	*Ficus carica*	10 - 15	8 - 20	8/10	11/5
Other Fruits					
Fuyu Persimmon	*Diospyros kaki L.*	15 - 25	15 - 25	11/15	12/30
Mulberry - Pakistani	*Morus macroura*	40	40	4/15	6/30
Mulberry - White	*Morus alba*	25 - 35	35 - 80	7/15	9/25
Mulberry - Black	*Morus nigra*	18 - 20	18 - 20	7/15	8/20
Pendolino Olive	*Olea europaea*				
Jujube	*Ziziphus ziziphus / spinacristi / jujuba*	15 - 25	15 - 30		
Pineapple Guava	*Feijoa sellowiana*	10 - 15	12 - 20		
Pomegranate	*Punica granatum*	6 - 18	6 - 18	9/1	9/25
Carob	*Ceratonia siliqua*	30 - 40	30 - 50		
Blue Elderberry	*Sambucus mexicana*	6 - 20	8 - 20		
Thornless Opuntia Prickly Pear	*Opuntia cacanapa ellisiana*	6	6	9/10	9/30
Moringa	*Moringa oleifera*	20 - 30	30 - 40	5/15	11/5
Shinsheiki Asian Pear	*Pyrus pyrifolia*	15	15		
Loquat	*Eriobotrya japonica*	12 - 24	12 - 30	5/20	8/15
Soap Nut Tree	*Sapindus mukorossi*	65	65		
Nuts					
English Walnut	*Juglans regia*	50 - 70	70 - 100	9/1	11/1
California Black Walnut	*Juglans nigra*	40 - 70	60 - 100	9/1	11/1

Chinese Chestnut	*Castanea mollissima*	40 - 60	40 - 60	9/15	10/20
American Chestnut	*Castanea dentata*	40 - 60	60 - 100	10/15	11/15
All-in-one Almond	*Amygdalus communis L. var. dulcis "All-in-One"*	15	15		
American Hazelnut	*Corylus americana*	10 - 15	8 - 12		
Nitrogen Fixing Support Trees & Shrubs					
		Spread (ft)	**Height (ft)**	**Bloom Start**	**Bloom End**
Black Locust	*Robinia pseudoacacia*	20 - 35	35 - 80	5/15	6/20
Honey Mesquite	*Prosopis glandulosa*	30 - 40	25 - 35		
Mimosa	*Albizia julibrissin*	20 - 40	30	5/20	9/10
Chilean Mesquite	*Prosopis chilensis*	30	30		
Velvet Mesquite	*Prosopis velutina*	12 - 35	12 - 35		
White Mesquite	*Prosopis alba*		24 - 30		
Leucaena	*Leucaena leucocephala*	6 - 10	6 - 10	5/15	9/15
Thornless Honey Locust	*Gleditsia triacanthos*	35 - 50	75 - 135		
False Indigo Bush	*Amorpha fruticosa*	6	6 - 10	6/1	8/25
Silver Bush Lupine	*Lupinus albifrons*	3 - 5	3 - 5		
Goumi	*Elaeagnus multiflora*	6 - 10	6		
Understory Plantings					
Lemon Balm	*Melissa officinalis*	1 - 3	1 - 3		
Rugosa Rose	*Rosa rugosa*				
Dwarf Yaupon	*Ilex vomitoria 'Stoke's Dwarf'*	4	3		
Yaupon	*Ilex vomitoria*				
Goji Berry	*Lycium barbarum*	4	4	7/15	9/1
Cape Honeysuckle	*Tecomaria capensis*	6 - 8	8 - 20		
Lemon Verbena	*Aloysida citrodora*	1 - 4	2 - 6		
Comfrey	*Symphytum officinale*	2 - 6	1 - 5	4/10	7/20

Borage	*Borago oficianalis*				
Hot Lips Salvia	*Salvia spp.*				
Tansy	*Tanacetum vulgare*	1.5	2 - 4	7/1	9/30
Salad Burnett	*Sanguisorba minor*	1.5	1		
Chives	*Allium schoenoprasum*	1	1		
Lab Lab Purpurea	*Dolichos lab lab*		5 - 8		
French Sorrel	*Rumex acetosa*	1	1		
Morrocan Mint	*Mentha spicata*				
Naked Lady	*Amaryllis belladonna*		1.5 - 2	8/15	10/1
Daffodil	*Narcissus pseudonarcissus*	1	1.5		
Baby Sun Rose	*Aptenia cordifolia*	3	0.8	5/1	7/30
San Diego Dudleya	*Dudleya edulis*	1	1	4/20	7/20
Woolly Yarrow	*Achillea tomentosa*		0.16	5/10	6/20
Thyme - Creeping	*Thymus vulgaris*	2 - 3	.3		

Agroforestry

Agroforestry is a catch all term for managing multi-species tree-based systems for the production of valuable products (food, fiber, fodder, fuel, timber, medicine and more) often in concert with livestock and annual crops. There are six main types of agroforestry practices, between which there can be considerable overlap (often multiple types of agroforestry are practiced side by side or layered on top of one another).

- **Silvopasture -** The intentional mixing of trees, animals and forage.
- **Forest Farming -** Cultivating non-timber crops under the canopy of an existing forest (mushrooms, shade-loving crops, certain livestock).
- **Alley Cropping -** Growing traditional field or row crops (hay, grain, vegetables) in between rows of trees.
- **Windbreaks -** Growing a multistoried hedge of trees to mitigate the effects of wind.
- **Riparian Buffers -** Tree and woody shrub plantings along a water's edge.
- **Forest Gardening -** Growing a diverse set of edible and medicinal plants in a way that mimics forest ecology and evolves into a forest.

The benefits created by agroforestry practices are both economic and environmental. Agroforestry can increase farm profitability in several ways:

- the total output per unit area of tree/ crop/livestock combinations is greater than any single component alone,
- crops and livestock protected from the damaging effects of wind are more productive, and
- new products add to the financial diversity and flexibility of the farming enterprise.

There are four key characteristics of an agroforestry system that distinguish it from other farming or forestry practices. They are:

- **Intentional:** Combinations of trees, crops and/or animals are intentionally designed and managed as a whole unit, rather than as individual elements which may occur in close proximity but are controlled separately.
- **Intensive:** Agroforestry practices are intensively managed to maintain their productive and protective functions, and often involve annual operations such as cultivation, fertilization and irrigation though are by no means required to.
- **Interactive:** Agroforestry management seeks to actively guide the biological and physical interactions between the tree, crop and animal components. The goal is to enhance the production of more than one harvestable component at a time, while also providing conservation benefits such as non-point source water pollution control or wildlife habitat.
- **Integrated:** The tree, crop and/or animal components are structurally and functionally combined into a single, integrated management unit. Integration may be horizontal or vertical, and above- or below-ground. Such integration utilizes more of the productive capacity of the land and helps to balance economic production with resource conservation and improvement.

Silvopasture

Dedicated silvopasture plantings are recommended for the eastern portion of the Upper Paddock should plantings specifically designed for livestock integration be desired. By no means do the plantings have to be constrained to the footprint or spacing outlined in Figure 5.2.10 below - the image is there to illustrate one way such a silvopasture layout might be spaced and organized. Four contour planting lines with trees spaced on 40’ centers in-row spacing and slightly closer between rows is shown, as well as a denser planting regimen at 15’ in-row spacing and slightly less between rows above that closer to the proposed water tank location. Ultimately these planting patterns can be interwoven amongst the recommended native reforestation plantings, or they can occupy distinctly different sections of the Upper Paddock. The 40’ spacings as shown are ideal for trees like chestnut and walnut, both of which can grow quite large at climax size, however such spacings would leave ample open space in between the climax trees for many years. This open space should be planted with support species and/or other species selected to provide browsable forage for future livestock until eventually shaded out by the climax species.

For additional learning on planning, implementing and managing silvopasture systems, Steve Gabriel’s book *Silvopasture - A Guide To Managing Grazing Animals, Forage Crops, And Trees In A Temperate Farm Ecosystem* is highly recommended. While written from a different climate, this book provides the principles for sound silvopasture systems management and explains the thinking that will bring those principles to life in any context where silvopasture is being implemented.

Figure 5.2.12
Recommended silvopasture zone (should such plantings be desired).

Alley Cropping

Food Forest zones 1 and 2 could be alley cropped with certain annual or perennial crops if so desired. The grade of these two areas is manageable enough to construct small terraces or plant direct on contour amongst the trees. The other food forest zones are either too steep (3 and 4) or too narrow to make alley cropping feasible.

Tending The Wild

Tending the wild refers to gently assisting the surrounding ecology to create micro and macro habitats suitable for desired and sometimes edible wild species - plant, animal, insect and fungi alike.

Biofiltration - Natural Swimming Pool Regeneration Zone

The following plant list is designed for use in the constructed wetlands, greywater reed beds, riparian filtration belts and natural swimming pool regeneration zones. The list is by no means complete. Many of the plants listed below are monocotyledonous grasses that thrive in wet habitats because they are capable of moving oxygen down to their submerged root zones. This helps to oxygenate the water and create an environment more suitable to aerobic macro- and microorganisms capable of metabolizing and transforming excess nutrients into biomass.

- *Typha latifolia*[52] (Bulrush, Cattail)
- *Cyperaceae*[53] (Sedges - choose rhizomatous type roots, not fibrous or mat-forming roots))
- *Phragmites australis*[54]
- *Phragmites communis*
- *Schoenoplectus lacustris*[55] (Club Rush, Tule)
- *Scirpus spp.*[56]
- *Alisma plantago-aquatica*[57] (Water Plantain)
- *Juncus effusus*[58] (Common Rush, Soft Rush)
- *Iris pseudacorus*[59] (Yellow Flag Iris)
- *Mentha aquatica*[60] (Water Mint)
- *Glyceria maxima*[61] (Tall Sweet Grass)
- *Nymphea alba*[62] (Water Lily)
- *Sparganium erectum*[63]
- *Stratiotes aloides.*[64]
- *Hydrocharis morsus-ranae*[65]
- *Acorus calamus* [66](Calamus, Sweet Flag)
- *Myriophyllum spp.*[67] (Watermilfoil)

The above plants are very effective at converting excess nutrients found in greywater and other water bodies into large amounts of biomass. This biomass will need to be harvested from the reed

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[52] *Typha latifolia* Wikipedia: https://en.wikipedia.org/wiki/Typha_latifolia

[53] *Cyperaceae* Wikipedia: https://en.wikipedia.org/wiki/Cyperaceae

[54] *Phragmites australis* Wikipedia: https://en.wikipedia.org/wiki/Phragmites

[55] *Schoenoplectus lacustris* Wikipedia: https://en.wikipedia.org/wiki/Schoenoplectus

[56] *Scirpus spp.* Wikipedia: https://en.wikipedia.org/wiki/Scirpus

[57] *Alisma plantago-aquatica* Wikipedia: https://en.wikipedia.org/wiki/Alisma_plantago-aquatica

[58] *Juncus effusus* Wikipedia: https://en.wikipedia.org/wiki/Juncus_effusus

[59] *Iris pseudacorus* Wikipedia: https://en.wikipedia.org/wiki/Iris_pseudacorus

[60] *Mentha aquatica* Wikipedia: https://en.wikipedia.org/wiki/Mentha_aquatica

[61] *Glyceria maxima* Wikipedia: https://en.wikipedia.org/wiki/Glyceria_maxima

[62] *Nymphea alba* Wikipedia: https://en.wikipedia.org/wiki/Nymphaea

[63] *Sparganium erectum* Wikipedia: https://en.wikipedia.org/wiki/Sparganium

[64] *Stratiotes spp.* Wikipedia: https://en.wikipedia.org/wiki/Stratiotes

[65] *Hydrocharis morsus-ranae* Wikipedia: https://en.wikipedia.org/wiki/Hydrocharis

[66] *Acorus calamus* Wikipedia: https://en.wikipedia.org/wiki/Acorus_calamus

[67] *Myriophyllum spp.* Wikipedia: https://en.wikipedia.org/wiki/Myriophyllum

beds, constructed wetlands or regeneration zones seasonally in order to maintain optimal function and prevent clogging with dead organic material.

Pollinator Gardens

Dedicated pollinator habitat and forage plantings are proposed for two separate areas at WFH - the footprint atop the existing leach field in the Outdoor School Zone (see Figure 5.2.6) and the buffer area that needs to be kept at a manageable height around the solar panel ground mount installation (see Figure 5.2.9). These areas, planted densely and with a variety of pollinator forages that yield year-round, will help to ensure that WFH is a known and reliable food source amongst local pollinator populations, which will greatly benefit the numerous surrounding productive plantings. See Appendix C - Living Systems - Pollinator Forage Species List for a comprehensive list of pollinator forages well adapted to WFH's climate, including trees. See also the list of CA native plants that are great for attracting bumble bees and other CA native bees from Las Pilitas Nursery[68].

Table 5.2.2 below contains a list of pollinator forages appropriate for planting atop a leach field (no tree roots) and that are relatively low-growing or can be kept low with seasonal pruning.

Table 5.2.2

Additional trees and plants to bolster bee forages throughout the year at WFH.

Common Name	*Scientific Name*	Importance	Nectar (N) / Pollen (P)	Period	Notes
Lavender	*Lavandula spp.*	Moderate	N / P	April - August	Lavender blooms are a preferred forage when in bloom, beautiful color, fragrance, cut flowers, medicinal. Will do better with some compost and supplemental irrigation, but doesn't require it once established.
CA Aster	*Aster chilensis*	Major	N / P	May - November	Very long bloom season, densely flowering shrub, should be cut back to ground each year, will grow back up to 5-6 feet in 1 year. Will appreciate some compost and irrigation.
California Buckwheat	Eriogonum fasciculatum foliolosum	Major	P	March - September	Prolific bloomer, well adapted to dry, rocky slopes, known as a quality honey bee forage.
Black Sage	Salvia mellifera	Moderate	N	February - August	Drought-deciduous woody perennial, fragrant.
Golden Currant	Ribes aureum gracillimum	Minor	N / P	February - March	CA native currant, does best in part sun / dappled shade as an understory planting.
California Poppy	*Eschscholzia californica*	Moderate	P	March - July	Bright orange blooms, drought-adapted, once sown and established for a single season will continue to reseed and grow back each spring.

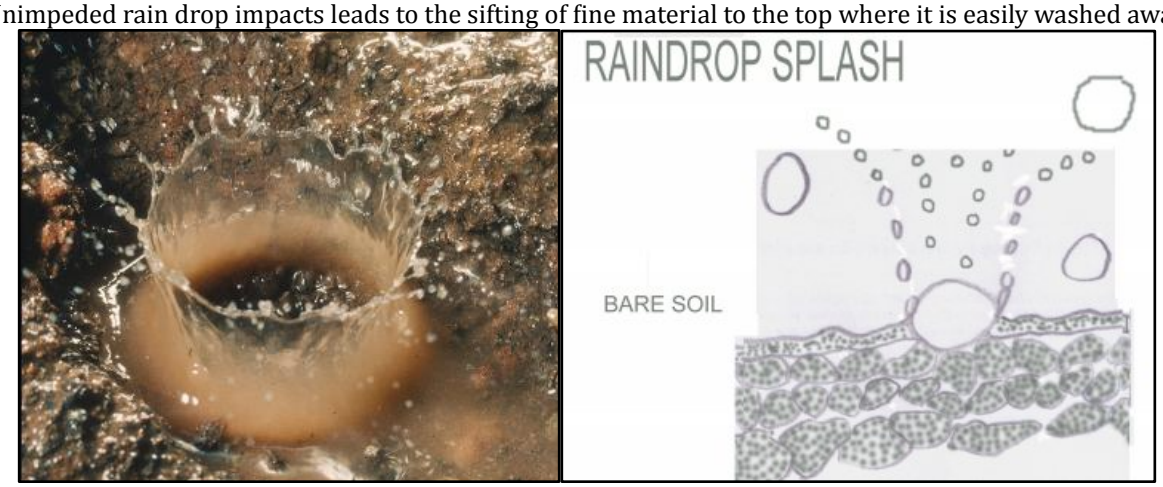
[68] Las Pilitas Nursery Bumble Bee & Native Bee Forages List: https://www.laspilitas.com/wildlife/California_Bumble_bees.html

White Sage	*Salvia apiana*	Major	N	May - July	Highly medicinal for pollinators and humans alike, fragrant, greenish-white foliage.
Ligustrum	*Ligustrum spp.*	Moderate	N / P	May - September	
Telegraph Weed	*Heterotheca grandiflora*	Major	P	July - November	Very common on roadsides and highway ditches, very drought adapted, annual grows up to 3-5 tall, stick leaves, yellow flowers.
Western Clematis	*Climatis ligusticifoila*	Moderate	N / P	August - October	Beautiful vining perennial, prolific blossoms
Purple Sage	*Salvia leucophylla*	Major	N	May - July	Drought-adapted perennial woody herb, drought deciduous, fragrant.
Saw Toothed Goldenrush	*Hazardia squarrosa*	Moderate	P	August - October	Yellow flowers, a honey bee favorite.
Yerba Santa	*Eriodictyon spp.*	Moderate	N	May - September	Tough as nails, medicinal herb with running rhizomatous roots, very drought hardy, fragrant.
Fennel	*Foeniculum vulgare*	Major	P	June - September	Nativized, grows wild along roadsides and in disturbed areas, yellow flowers excellent source of pollen for bees.
Yarrow	*Achillea millefolium*	Moderate	P	June - August	Drought-adapated, umbelliferous flowers attract beneficial wasps, medicinal, excellent living mulch and mineral-rich chop ‘n drop.
Tansy	*Tanacetum vulgare*	Moderate	P	July - September	Annual, herbaceous, does great in a hot spot if it has a little supplemental water.

5.3 Erosion Control Plantings

Vegetation reduces and prevents erosion in several ways. First, vegetation creates impedance, whereby the rain drops are intercepted prior to hitting any soil, and their energy is greatly reduced. Second, vegetation increases roughness, meaning that instead of being able to flow straight downhill, water has to twist and turn around every bit of vegetation it encounters, increasing its transit time through the landscape and thus increasing the opportunity for it to be infiltrated. Third, the roots of vegetation actually create infiltration channels for water to move down into the soil profile. This improves infiltration rates and the ability of the land to absorb and retain water that would have otherwise run off quickly.

Figure 5.3.1
Unimpeded rain drop impacts leads to the sifting of fine material to the top where it is easily washed away.



Existing Conditions

There are currently no erosion control plantings at WFH.

Recommendations

Plantings for erosion control are recommended in the following areas:

- Planting of Sheetflow Diversion Berm with vetiver grass for long term stabilization.
- Stabilization of the fill slope below the Main Residence with vetiver grass.
- Stabilization of the Stepped Pathway Between ADU and Main Residence Yard with vetiver grass.
- Stabilization of the Stepped Pathway Between Shop and Main Residence Garage with vetiver grass.
- Stabilization of the Ramped Pathway Traversing Slope Below Main Residence with vetiver grass.

Vetiver Grass Primer

Vetiver grass is a sterile, non-running, clumping perennial grass known for its incredibly deep root system. In addition to its amazing erosion control and self-terracing capabilities, vetiver grass is also incredibly productive in terms of biomass produced per annum. Vetiver grass is native to India, though is now employed throughout the world as a biological remediator. Vetiver grass clumps can grow up to 2 feet in diameter and up to 6' tall within their first growing season in Central CA, depending on water supply. It is very drought hardy once established, though supplemental irrigation is required to get it through its first season. To explore the full range of vetiver's ecological benefits, see the 7th Generation Design Vetiver Grass YouTube playlist[69] or visit Vetiver.org.

Vetiver can be cut several times a year after the first year, using a simple rice knife, and the biomass can be dried for use as animal bedding or pyrolization into fine charcoal (ideal for use in the third chamber of the recommended Slow Sand Water Filter). The fresh cut grass can be fed as cut fodder to the goats and/or horse. The grass can be lain in thick bundles around the bases of newly planted

[69] All Things Vetiver Grass YouTube Playlist: https://www.youtube.com/playlist?list=PLJy8-1MQvUQy8cDNwlL052u6HwPF-xp_l

trees to provide an excellent evaporation-blocking mulch, or it can be used as a non-woody bulk carbon input for thermophilic compost piles or Johnson-Su BioReactors.

Vetiver grass is unique in its fantastic ability to handle sheet flow and sediment build up. Because the clump is so dense, it creates a backstop behind which sediment can build up. Instead of this killing the plant, vetiver is capable of rooting into this new build up even when buried via nodes on mature stems. In this way, over time vetiver 'self-terraces' creating level contour paths of sediment held in place by its thick culms and dense, deep root system.

Once established for a full growing season, vetiver grass clumps are effectively drought and frost hardy due to their deep root system (which can grow up to 9-15' deep depending on the soil type). Vetiver tolerates a wide range of soil types, from dense clay to steep volcanic hillsides to sandy, alkaline and acidic soils, as well as high levels of salt.

For erosion control on moderate-steep slopes, vetiver grass slips are typically planted on contour in a narrow trench (3-6" wide), approximately one every 4-6 inches. When planted at this spacing and provided with establishment irrigation, the vetiver slips will grow into a solid wall of culms that acts as a 'biological retaining wall' - a self-repairing structure that gets stronger and more effective as it gets older instead of vice versa. Once the planting trench is dug, it is underlain with burlap (mainstream methods suggest using aviary wire to hold back ground vermin until plants are establish, but this is non-biodegradable and good success has been observed using burlap for the same purpose) and then filled with compost or rotted steer manure (1 cubic foot of rotted manure fills ~ 6' of trench). The high nitrogen compost or manure helps the young slips to grow rapidly and set their roots.

In drier climates with cold wet winters, slips should be planted immediately after spring rains cease and the danger of heavy frost has passed. Establishment irrigation is recommended during the first dry season to help the slips grow vigorously and set deep roots. Each line of vetiver should have its own designated ¼" drip line with emitters spaced every 6". These can be effectively run up to 50' lengths. Each line can have its own ¼" valve to make seasonal shut off very simple.

Figure 5.3.2

Left: Vetiver grass contour strips cut to 18" high after first growing season. *Right:* 6' tall vetiver grass anchoring natural stone pathway on a 65% grade slope of very fragile and formerly eroding fill soil.

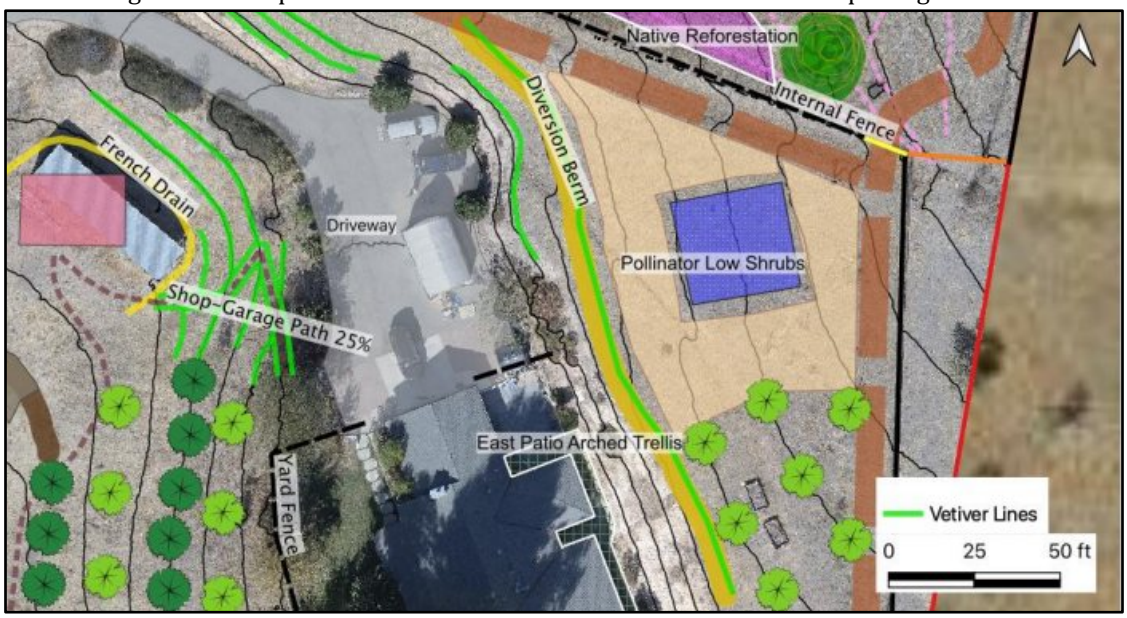
Visit the 7th Generation Design Portfolio Page[70] to see detailed before and after photos of a vetiver grass installation from the summer of 2017.

Sheetflow Diversion Berm Stabilization With Vetiver Grass

The sheetflow diversion berm proposed to prevent sheet flow run-off from cascading over the exposed cut edge above the driveway will need to be biologically stabilized if it is to last and maintain its function over the long term. A single line of vetiver grass planted along the apex of the berm along its entire length is recommended. As illustrated the line atop the berm is 190' long. A shorter 65' line planted just above the eroding edge is also recommended.

Figure 5.3.3

Vetiver grass line atop the sheet flower diversion berm below the solar panel ground mount.



Fill Slope Stabilization With Vetiver Grass

The fragile fill slope below the Main Residence should be biologically stabilized with vetiver grass to prepare it for useful and productive tree plantings. Vetiver plantings on contour will help to limit the amount of material that can sluff downslope and pile up against the trunk of a young tree. The grass will also help to cool the soil, provide ample mulch when cut, and cool the trunks of small trees during their establishment year. Planting vetiver on 5' contours is recommended to allow for the natural self-terracing effect over time. This will turn each contour line into its own level pathway leading off from where it intersects either the ADU - Upper yard Stepped Pathway, the Ramped Pathway Traversing Slope Below Main Residence, or the Stepped Pathway Between Shop and Main Residence Garage. In this way, over time, much of what is currently difficult to access, fragile slope will become easy to access productive growing area. See the top image in Figure 5.2.7, depicting Food Forest 3, to see how this would look at a 5' contour interval.

Because of the large number of vetiver slips called for to stabilize such an area, a stepwise process is recommended to minimize the amount of vetiver that need to be purchased. The ADU - Upper Yard

[70] https://www.7thgenerationdesign.com/biological-erosion-control-with-vetiver-grass/

Pathways and its associated vetiver plantings is recommended to become renewable source for additional vetiver slips in years to come.

1. YEAR 1: Install the ADU - Upper Yard Pathway - either rocks, timber, or masonry - once the exact ADU footprint is known and plant vetiver grass to stabilize. The vetiver lines branching off from the pathway at 5' intervals up its entire length (see Figure 5.3.4 in the next section) will serve to stabilize the general area around the pathway *and* become the stock from which additional vetiver slips can be harvested to continue stabilizing the fill slope. Grow out the vetiver for an entire season to get it very well established.
2. YEAR 2: Harvest every other contour planting line on each side of the pathway, dividing these now mature clumps into individual vetiver slips. Cut slips to size, grow in water for several weeks until fresh root nodules begin forming. Replant the lines that were harvested, and use the remaining slips to stabilize the next area of the slope.
3. YEAR 3: Harvest the contour rows that previously went unharvested the year prior, and replant them with individual slips once the grass clumps have been divided.
4. **Continue harvesting alternate contour rows stemming from the ADU - Upper Yard Pathway each year.

Stepped Pathway Between ADU and Main Residence Yard Stabilization With Vetiver Grass

The Stepped Pathway Between ADU and Main Residence Yard follows a 25% grade along its entire length, leading from the ADU to the kitchen garden at the edge of the Upper Yard. The length of the pathway is 167' long as illustrated in Figure 5.3.4 below The path should be stabilized on both sides by vetiver grass. Additional on-contour vetiver lines extending out from the path 15 - 25' on both sides should be planted to stabilize the area around the path. These lines will also function as the "vetiver farm" at WFH so that no additional vetiver needs to be purchased for additional plantings during subsequent years. The amount of linear feet to be planted with vetiver in this system is ~695', which translates to ~2,085 vetiver slips.

Figure 5.3.4

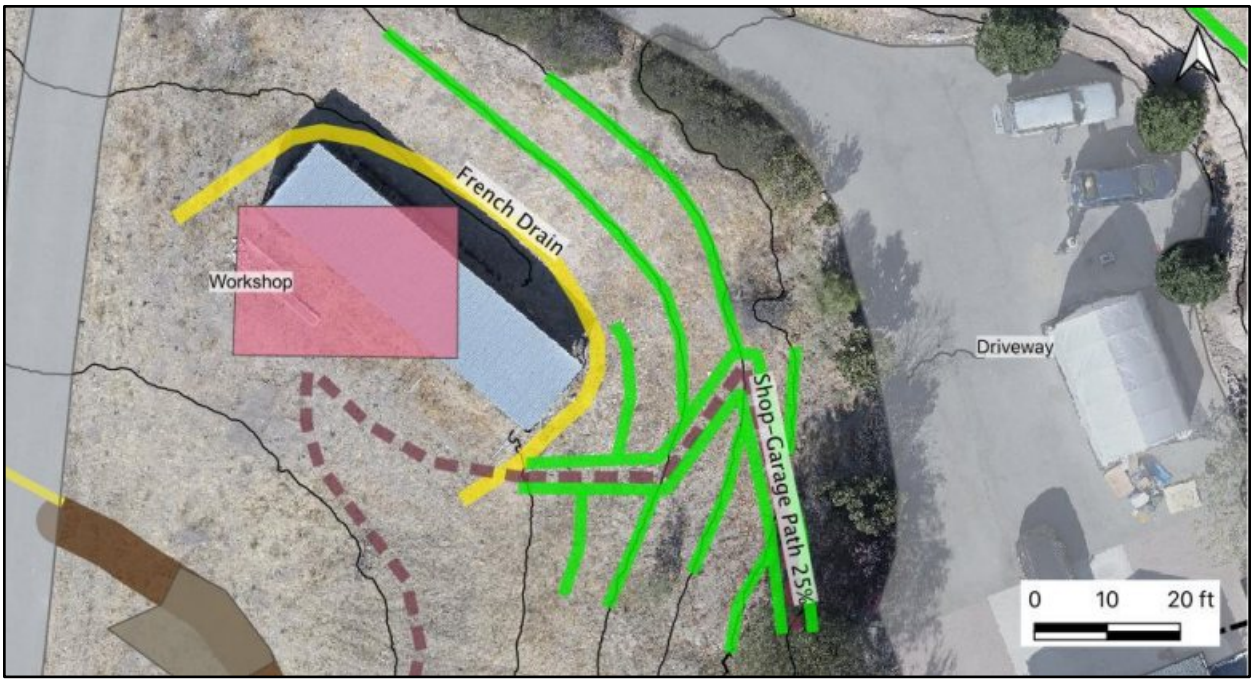
Vetiver grass lines adjacent to and spreading out on contour from the ADU - Upper Yard Pathway.

Stepped Pathway Between Shop and Main Residence Garage Stabilization With Vetiver Grass

The Stepped Pathway Between Shop and Main Residence Garage follows at 25% grade along its entire length and leads from the upper driveway in front of the garage down to the future Shop site. The length of the pathway is 75' as illustrated. The path should be stabilized on both sides by vetiver grass. Additional on-contour vetiver lines extending out from the path 15 - 25' on both sides should be planted to stabilize the area around the path. Vetiver lines can continue on contour and wrap around the slope north of the Shop footprint to help stabilize and cool this fragile heat-trap. As illustrated, including the longer on-contour vetiver runs, there is 360' linear feet of vetiver planting for this installation, which equates to ~1,080 vetiver slips.

Figure 5.3.5

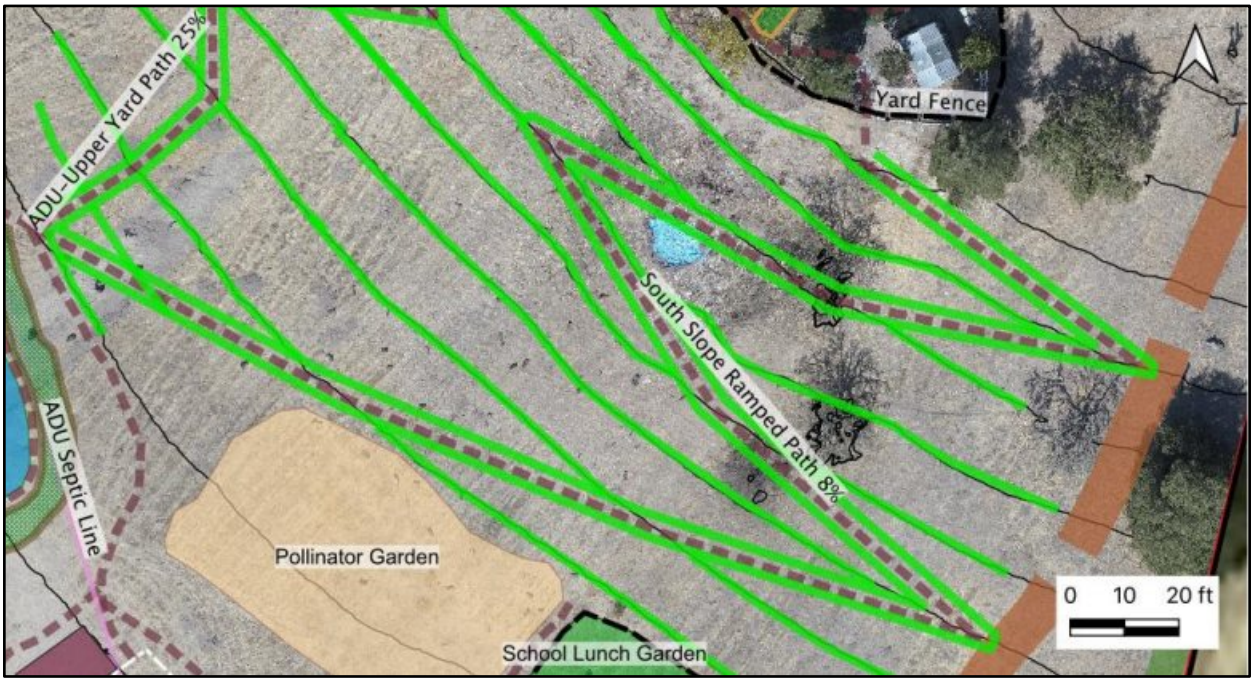
Vetiver grass lines adjacent to and spreading out on contour from the Shop-Garage Stepped Pathway.



Ramped Pathway Traversing Slope Below Main Residence Stabilization With Vetiver Grass

The Ramped Pathway Traversing Slope Below Main Residence follows an 8% grade across the south-facing slope below the Main Residence. As illustrated the pathway is 500' long. The path should be stabilized on both sides by vetiver grass. Additional on-contour vetiver lines extending out from the path both sides should be planted to stabilize the area around the path and to improve access to the entire slope and prepare it for long-term productive tree plantings (see Section 5.2 - Food Production - Orchards & Food Forests - Food Forest 3 for tree integration with on-contour vetiver terraces). At a minimum, vetiver should be planted on the immediate uphill and downhill sides of the pathway right after or in tandem with construction. This would require 1000' linear feet of planting, or approximately 3,000 vetiver slips. The interstitial spaces around the path can be planted out during subsequent years as additional vetiver slips are propagated from the WFH "vetiver farm" surrounding the Stepped Pathway Between ADU and Main Residence Yard.

Figure 5.3.6
Vetiver grass lines adjacent to and spreading out on contour from the Ramped Pathway Traversing Slope Below Main Residence.



5.4 Privacy Screens

Privacy screens are plantings of trees/shrubs that serve to block either an unwanted view from a location or the unwanted viewing of a location. The same characteristics that define a good windbreak species (fast-growing, dense growth habit, known size etc) also define a good privacy screen species.

Existing Conditions

The trees and shrubs that line the perimeter of the Main Residence pad provide good privacy for the home and yard from the south. Otherwise, there are no major privacy screens onsite.

Recommendations

Privacy screen plantings are recommended in the following locations:

- Native hedge along the lower property perimeter fences.
- Edible hedge ("Fedge") in between lower utility access road and outdoor classroom area
- Bamboo hedge between ADU pond and Outdoor School Zone

Native Privacy Screen

A native wildlife hedge is recommended for planting along the lower property perimeter fences as shown in Figure 5.4.1. Composed of a mix of native shrubs and cultivars, it will thrive with little-to-no water or fertility inputs once established with one year of regular watering.

Figure 5.4.1
Proposed locations of privacy screen along property southern fences

Figure 5.4.2
Fencing along driveway to main gate.

CA native species that have been selected for their drought-tolerance, beauty, habitat and food desirability for wildlife, year-round leaves, and dense growth pattern are provided in Table 5.4.1.

Table 5.4.1
Recommended plants for wildlife hedge along perimeter fences.

Common Name	Scientific Name	Plant Size	Notes	Photo
California Lilac Ray Hartman	*Ceanothus* 'Ray Hartman'	Height: 10-15'' Width: 10-15''	Blue flowers, good fragrance	
Holly-leafed Cherry	*Prunus ilicifolia*	Height: 10-20' Width: 10-20'	White flowers in spring, large red cherries in fall (edible but mostly skin and seed, loved by birds)	
Toyon (Christmas Berry)	*Heteromeles arbutifolia*	Height: 6-8' Width: 6-8'	White flowers in summer, red berries in winter	
Coffeeberry	*Rhamnus californica*	Height: 6-8' Width: 6-8'	Dark-green foliage, black berries	

CA Wild Grape	*Vitis californica*	Height: 10-30' Width 10-30'	Light green foliage in spring, brilliant reds and yellows in fall, excellent bird forage.	

The recommended species should be alternately planted in a line approximately 5 feet from the existing fence, with the exception of the California Wild Grape, which if desired can be planted at the base of the fences at a 20' spacing to climb and eventually cover the fence. The shrubs should be spaced rather densely, with centers placed approximately 1-2' less than half the combined width of the neighboring plants (if planted in a line) or even more ideally staggered in two lines. For example, when placing a Ceanothus 'Ray Hartman' (mature width 15') next to a Coffeeberry (mature width 8') in a line, they should be planted approximately 8-10' apart from each other to ensure dense coverage. Silver bush lupine should be sporadically tucked into the hedge on the south side of the hedge to provide nitrogen fixation into the soil. Eventually, live oaks will be seeded by the wildlife enjoying the native screen - these can be left to serve as a long-term climax species that will live beyond the 15-30 year life of the shrubs.

How to Plant California Native Plants

Las Pilitas Nursery in Santa Margarita, CA offers the following in-depth guide for planting native plants. The most efficient approach is to pick an area to plant, mulch, and water all at once. Depending on the size of the area, multiple low-flow sprinklers or microspray emitters may be needed. Once that area is planted and watered, move to an adjacent area, moving across the landscape.

- Dig a hole of a size into which the plant will fit, not larger than.
- Carefully remove the plastic bag or plastic pot from around the plant and recycle bag/ pot.
- Disturb the root ball as little as possible, but gently run a finger along edge so roots are not coiling.
- Carefully place the plant into the hole, slightly higher (1-2 mm) than the surrounding soil. Do not add amendments, do not add fertilizer. Backfill the hole with the soil.
- The first watering: water lavishly unless planting is immediately followed by an extensive rain. Las Pilitas recommends watering an area for 8-12 hours with a sprinkler if planting in the spring/summer/fall. Water the plant, and the ground around the plant in a circle one foot past the drip line. Dig into this area after watering, to ensure that the moisture made it to at least 18 inches deep.
- Subsequent waterings: DO NOT USE DRIP IRRIGATION. Use micro spray emitters or low volume sprinklers instead, so that the plant will be irrigated in a pattern more similar to rainfall. Do not water against the crown (the main stem of the plant at the soil surface) of the plant. Water should fall in the area of the drip line of the plant and beyond. Again, check that the water made it down at least 18 inches; 24+ inches would be better. Let

the top inch or so dry out between waterings. Check at least a few times until an understanding is developed for the water and soil conditions

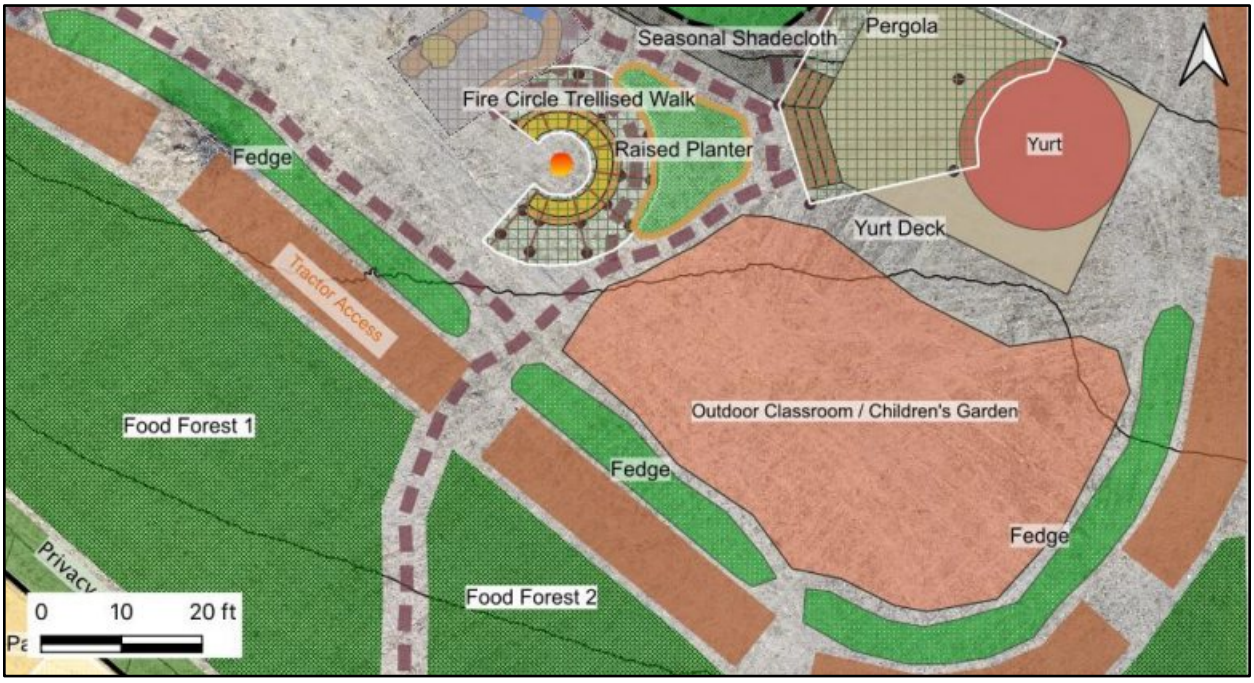
- The first year, check the soil, down about an inch or two, once a week; if it is dry, water it to 18 inches deep; if it is moist, provide no additional water. The second and succeeding year-water, if needed, during the months of November through April, abstaining from watering in the summer. In really dry years, add extra water once a week either between plants or an overhead sprinkler like a summer shower. This may need to occur throughout the year if the rainfall is below normal.
- Place evergreen oak leaf mulch, shredded redwood bark, or shredded cedar bark 2-4 inches deep on top of the soil around the plant in a four-foot-diameter circle.
- If unable to get plants in the ground immediately, poke a few holes in the bottom of the bag, place in morning sun or part shade, water once or twice a week if needed.

Edible Hedge on North Side of Lower Utility Access Road

A food hedge ("fedge") is recommended for planting along the north side of the lower tractor access road to provide a barrier and visual screen between the classroom zone and [redacted] [redacted], as illustrated in Figure 5.4.3. The fedge can have gaps in it at appropriate locations to allow for seamless access to Food Forests 1 and 2, and gates can, if desired, be set in amongst the fedges to help define the outdoor space. Trellises over these access points covered with flowering or fruiting vines can help to distinguish them as destinations for those experiencing the space for the first time.

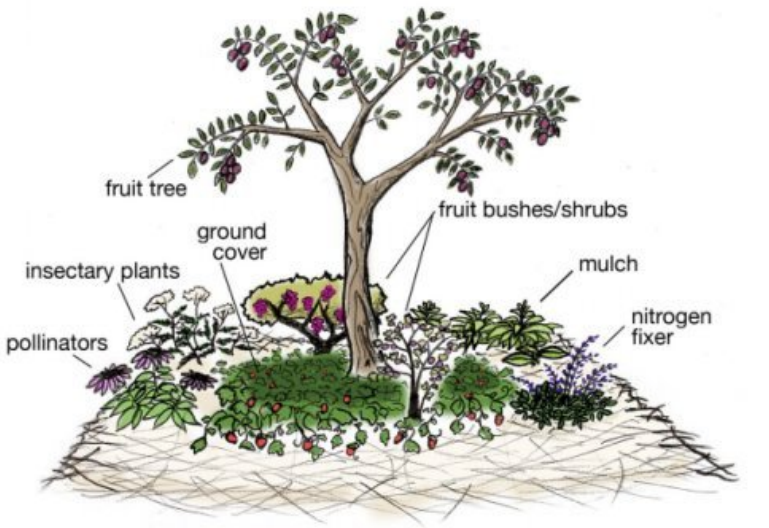
Figure 5.4.3

Recommended edible food hedge ("fedge") location between lower tractor access road and classroom zone.



In a fedge, groundcovers, shrubs, trees, and vines, selected with a focus on providing human food, are integrated together in a dense planting scheme. Support species that provide soil fertility (nitrogen-fixing and mulch-producers) and groundcover for weed abatement are also included. An example of how these different plants can be integrated together in one space is illustrated in Figure 5.4.4.

Figure 5.4.4
Fruit Tree Guild



The recommended trees for the fedge at WFH are listed in detail in Table 5.4.2. Size described is if left to grow to full maturity without pruning.

Table 5.4.2
Recommended trees for WFH fedge.

Name	Scientific Name	Size	Description
Loquat Tree (Japanese Plum)	*Eriobotrya japonica*	Height: 10-20’ Width: 10-20’	Whirls of glossy foliage and a naturally attractive shape. Large clusters of attractive fruit stand out against the dark-green, tropical-looking foliage.
Brown Turkey Fig Tree	*Ficus carica* ‘Brown Turkey’	Height: 10-20’ Width: 10-20’	Large fig with brown skin, pink flesh and sweet, rich flavor. Used fresh. Widely adapted to coast or inland climates. Small tree, prune to any shape. Cold hardy to zone 7. 100 hrs. Self-fruitful.
Pineapple Guava	*Feijoa sellowiana*	Height: 10-15’ Width: 10-15’	Versatile, evergreen, and easy to grow with an upright branching form, edible flowers, and tropical fruit! Fleshy white flower petals have showy red accents, contrasting nicely with the gray-green foliage. Tasty guava-like fruit ripens in late fall. Easily trained as espalier, a hedge, or a small specimen tree for landscape or container.
Fuyu Persimmon Tree	*Diospyros kaki* ‘Fuyu’	Height: 15-20’ Width: 15-20’	Fuyu' (or 'Fuyugaki')–oblate, faintly 4-sided, 2 in (5 cm) long; 2 3/4 in (7 cm) wide; skin deep-orange; flesh light-orange; firm when ripe; non-astringent even when unripe; with few seeds or none.
Pomegranate	*Punica granatum*	‘Wonderful’: Height: 8-12’ Width: 6-8’	Suits areas with a long hot dry summer and cool winter (hardiness zones 8-11), and soils with a wide range of pH.

New Century Asian Pear Tree	*Pyrus pyrifolia* 'New Century'	Standard Rootstock: Height: 18-20' Width: 12-13'	Juicy, sweet, refreshing, crisp like an apple. Easy to grow. Keeps well. Bright yellow skin. Vigorous, heavy-bearing (usually by 2nd year).
All-in-one Almond Tree	*Prunus dulcis* 'All in One'	Height: 12-15' Width: 15-20'	Great almond tree for home orchards. Heavy crops of soft-shelled nuts with sweet, flavorful kernels. Hot summer required to ripen. 15 ft. tree, very winter- and frost- hardy.
Cripps Pink Apple Tree	*Malus domestica* 'Cripps Pink'	Semi-dwarf rootstock: Height: 12-15' Width: 12-15'	Hot-climate apple from Western Australia. Very crisp, sweet tart, distinct flavor, good keeper. Skin is reddish-pink over green when ripe. White flesh resists browning. Harvest begins late October in Central CA, about three weeks after Fuji. Self-fruitful. 300-400 hours. USDA Zones 6-9.
Blue Elderberry	*Sambucus nigra caerulea*	Height: 10-15' Width: 10-15'	Mexican elderberry or Tapiro,(Sambucus mexicana) is a deciduous shrub to tree with butter-yellow flowers in Apr.-Aug. followed by purple berries in September-October. It likes full sun to part shade, garden water. It will take extreme drought after it gets its roots down. Its bluish-black berries are excellent in jelly, fair in pie. It is an excellent wildlife plant.

Understory species, listed in detail in Table 5.4.3, should be interplanted amidst the recommended trees, both in the understory and on the margins on the west and east side of the trees. Edibles include Golden Currant and Dwarf Yaupon (caffeinated leaves used for tea); Nitrogen fixers include False Indigo Bush, Goumi (also edible), and Silver Bush Lupine (native); brambles include thornless Blackberry (edible); vines include Perlette Grape (edible); herb layer includes Comfrey (medicinal, mulch producer), Yarrow (native, insectary), and Creeping Thyme (groundcover).

Table 5.4.3
Understory species for fedge.

Name	Description
Yaupon (Stoke's Dwarf)	Dwarf evergreen shrub with tight branches that create a tidy spreading mound that is excellent for low hedges, borders, or around foundations. Leaves containing caffeine that can be used for tea. The twiggy branches covered with fine-textured, glossy, dark green foliage take well to shearing. A tough plant that tolerates a range of soil conditions and can withstand drought or flooding.
Golden Currant	Golden currant is a deciduous shrub that produces edible fruits. California thrashers, with their curved beaks, Robins, Phainopeplas, and Solitaires, love the berries. Bumblebees and hummingbirds love the flowers. Also, monarchs love the flowers in early spring. The fruit varies from to 3/8 inch, yellow to pale red, about 1/3 seed.
False Indigo Bush	Native N-fixer, Its spreading tendency and fibrous root system make it useful for bank stabilization. Easily grown in average, medium to wet, well-drained soils in full sun to light shade. Tolerant of occasional flooding. Also tolerates poor, sandy, somewhat dry soils. With most of its foliage in the upper third of the tall, bushy plant, Amorpha fruticosa can form thickets in dense plantings.

Silver Bush Lupine	A nitrogen-fixing shrub. It grows up to 2-6 m tall. It suits areas with a long hot dry summer and cool winter. It can grow in soils with a wide range of pH.
Goumi	This close relative of the autumn berry produces huge amounts of healthy fruits in large clusters. The dark red berries are easy to harvest as they grow all along the branches. Each plant is quite different with ripening going from summer to fall. The leaves and flowers of this species are larger and more ornamental than autumn berry but otherwise very similar in appearance, and the flavor of the fruit is as good or better, with the same antioxidant properties. Worth growing just for making juice, jelly, and drying. This strain produces a more varied ripening time, fruit size and different colored fruits too. Nitrogen fixing. Durable in a variety of soils except wet. Full sun is ideal.
Blackberry - Triple Crown Thornless	This cultivar can produce 30 pounds of large, very sweet, shiny blackberries per plant, making it, with Chester, by far the most productive. Fruit has superb flavor both eaten fresh and used to make jelly, toppings or juice. Vigorous canes, up to 2" in diameter and 15' long, thrive in areas of the country too cold for other blackberries and produce huge crops in July and early August. Grow it like a vining blackberry, at 8' spacing, or for those with less space, cut new canes the first summer at 6' tall and snip the laterals back to 2' long in winter. With this method, use a 3' spacing and a top wire to tie the upright canes.
Perlette Grape	Perlette is a large grape with white, thin skin. The flesh is firm, crisp, and juicy. The Perlette Grapes are very similar to Thompson Seedless, but with a wider climate range. An excellent fruit for table use as well as raisins. Cane pruning. Ripens Mid-July. Grows in zones: 5 - 10
Comfrey	This coarse, spreading, perennial herb grows up to 4 feet tall and likes moist, somewhat shady locations. It has a long history as a medicinal herb but no culinary uses. Excellent plant for soil building guilds and shading root zones of establishing trees. Prolific biomass that can be used as chop and drop mulch, cut forage for all manner of livestock. Bees love the bell-shaped flower clusters. Long history of medicinal use for mending broken/damaged bones, healing wounds.
Yarrow	Shade- and drought-tolerant. Tolerates pH down to 4, low growing, pollinator and predatory insect attractor, self propagates via rhizomes. Western Yarrow is a small perennial that spreads by rhizomes. It varies by locale from 1-4'. The cream-colored (off-white?) flowers are in 3- 4"clusters.
Woodland Strawberry	Wood Strawberry is a perennial, with white flowers, edible red fruits, and spreads by horizontal above-ground stems (stolons). Fragaria californica, (F. vesca), Woodland Strawberry makes a good groundcover for dry to damp shady areas or sunny areas with moderate water.

Bamboo Hedge Between ADU Pond and Outdoor School Zone

A bamboo privacy hedge is recommended for shielding the ADU Pond and attached courtyard, as well as the ADU itself, from direct view from the Outdoor School Zone. The hedge will also serve as a windbreak for the pond by blocking up-valley winds, thus helping to reduce evaporative losses, and will stabilize the downhill side of the footpath(s) leading from the bottom of the Stepped Pathway Between ADU and Main Residence Yard towards the Animal Shelter and Outdoor School Zone. Bamboo also has excellent soundscape qualities, and the gentle rustling of the culms and their leaves along with the innate beauty of bamboo will help to create a beautiful and peaceful envelope

around the ADU Pond and courtyard. Per the illustration, space should be left for a walking path around the perimeter of the pond and for additional shade tree plantings within the bamboo perimeter to further shade the water body.

Figure 5.4.5

Proposed bamboo privacy screen around the ADU pond and attached courtyard.

The types of bamboo chosen for the screen will depend upon a number of factors, such as:

- Height: How tall should the bamboo screen be at maturity? What length of view is desired from the various places it might be enjoyed - the ADU courtyard, edges of the pond, inside the ADU itself?
    - Most bamboo species have a fairly pre-determined climax height, which is very helpful when how much light and view is desired in a given space.
- Color: Is there a desired color pallet for the landscaping surrounding and the hydroscaping within the ADU Pond?
    - Many types of variegated bamboo are available with a wide range of colors.
- Shape: What shape will fit the pond aesthetic and integrate with the ADU courtyard and building?
    - Bamboos come in many different variations on a theme - they can be weeping, gnarled, twisted, completely vertical or something in between, and of course can grow in clumps or running colonies.
- Climate Tolerance
    - Bamboos range greatly in their cold and heat tolerance.

Table 5.4.4
Selected bamboo varieties for bamboo plantings around the ADU pond and courtyard.

Common Name	Scientific Name	Height (ft)	Notes
Mexican Weeping Bamboo	*Otatea acuminata spp. aztecorum*	20	Clumping bamboo with a weeping habit, bushy stalks.
Moso Bamboo	*Phyllostachys edulis*	40 - 50+	Beautiful giant, large culms, festooned with masses of the smallest leaves. Culms can reach 7" diameter at the base and 5" at chest height. Edible shoots, preferred timber bamboo for flooring.
Mountain Bamboo	*Thamnocalamus tessellatus*	12 - 15	One of best clumping bamboos for a sunny location, upright, from South Africa, thick culms in relation to its height, wind tolerant and used in coastal landscapes.
Water Bamboo	*Phyllostachys heteroclada*	30 - 35	Popular for screens and groves because of its vigor, has air canals in the rhizomes and roots which allow it to grow in wet soils where other bamboos would suffer, dark gray-green culms at maturity, very straight and tall, running. Excellent choice for aquatic edges where significant shade is required or beneficial.
Arrow Bamboo	*Pseudosasa japonica*	18	Excellent hedge or windscreen, this bamboo grows very straight culms with very small changes in diameter at each node, thus it was used in making arrows for archery. Culms are dense and not hollow once mature. Performs well as a screen (visual, wind) due to its numerous, thick, long leaves (5-13" length, nearly 2" thick). Running type.
Black Bamboo	*Phyllostachys nigra*	15	Culm is green at first, darkening over time, after 1-2 years it turns to a shiny, jet black culm. It does well in pots and prefers partial shade, but likes to be sheltered from wind. Culms are prized for crafts
Chinese Timber Bamboo	*Phyllostachys vivax*	40 - 45, 60+	Shoots from this bamboo are among the best eating, and are prolific in the late spring. Unlike most bamboos, P. vivax can achieve large size and diameter in a relatively small area.
Fargesia Scabrida	*Fargesia sp.*	14	The young culms have dark orange sheaths, opening gradually to reveal steel-blue and lavender culms, aging to an olive green. The leaves are dark green and slender, with a graceful, airy arrangement. Fairly upright habit, vigorous growth, and more sun-tolerant than most other Fargesia.
Yellow Groove Bamboo	*Phyllostachys aureosulcata*	25	This exotic bamboo can be identified by two different features: about 10% of the culms at the base possess a zig-zag shape and the internode furrows are marked with a yellow stripe. The zigzag is quite striking, specially since it regains a very upright stature overall. Very attractive bamboo as a specimen in ground or in a large pot.Makes a great screen candidate. Very cold hardy and thrives in heat.

Temple Bamboo	*Semiarundinaria fastiuosa*	20	Erect, dark green culms, taking on a crimson tint when exposed to solar heat. Column-like shape; supple, dense foliage, concentrated around the culm, from top to bottom. Short upright branches with long leaves. Fastiuosa's straight shape allows it to be great to use for decorative effects. It's a wonderful bamboo when used as a screen because it's an excellent windbreaker. Very formal looking bamboo. The wine coloring it achieves with age just adds to the beauty and interest. Great for a bamboo "avenue", such as an entry driveway Great for narrow screens, due to its short branches. Great for a live bamboo walled outdoor room. One of our most popular screening bamboos. Very Cold Hardy.
Red Sheath Bamboo	*Phyllostachys rubromarginata*	30	An excellent candidate for privacy screens. The canes are very strong with thick walls. Rubro is quick to establish and is regarded as one of the most prolific shooters, in terms of new growth in the spring. Rubromarginata's height and density makes it an excellent windbreaker and privacy screen! Very dark green year round. Noted for its good quality wood. Very sweet edible shoots, you can break off a shoot and eat it raw, tastes like a sweet pea. It tolerates cold and dry winds. Rubro is an excellent bamboo for a tall compact screen Very fast grower.
Giant Japanese Timber Bamboo	*Phyllostachys bambusoides*	45	Also known as the "Giant Japanese Timber Bamboo." The canes are an attractive dark green color with longer leaves. Can withstand very dry and cold environments. Culms get lighter in color as they age. Slow Spreading. Madake is a must have for bamboo lovers, the sheer size is very impressionable in height and diameter. Prefers direct sun and will need plenty of water with good drainage for the first year of growth.
Bissetii Bamboo	*Phyllostachys bissetii*	15	Shiny, dark green culms and leaves. Bissetii can withstand dry and cold environments. This beautiful bamboo also grows well in pots. It's very vigorous and dense, making it an exceptional privacy screen and windbreaker. Under direct sun the culms will achieve a golden color to their culms. In more shaded applications they will remain greener in color.
Golden Bamboo	*Phyllostachys aurea*	15	Ornamental Value, short base internodes, culms prized for crafts because of this feature Great in pots. Takes neglect very well, very hardy bamboo. Drought tolerant once established Good Screen candidate.

An excellent, local resource for seeing different types of bamboo growing at mature sizes is Paso Bamboo Farm and Nursery[71].

5.5 Shade Plantings

Species within shade plantings are typically fast-growing, umbrella-shaped trees specifically selected to provide shade for human occupants, animals, or structures underneath or nearby. This provides relief from sun exposure, more even lighting for gatherings/workshop/events, and respite from hot weather. Deciduous trees (trees that lose their leaves in the fall and enter dormancy for the winter) are often desirable in shade plantings in a coastal California climate as, in addition to tempering the light and heat during warmer months when they are leafed out, they also allow light and radiant warmth from the sun into a space during the colder winter months.

[71] https://www.pasobamboo.com/

Existing Conditions

There are several large trees surrounding the Main Residence on the west side. There is a large black walnut tree with an excellent shade canopy near the southwest property corner in the Lower Paddock.

Recommendations

Shade plantings are recommended in the following areas:

- Main Residence south wall and east side pergola shade vine plantings.
- Shade plantings around the ADU and ADU Pond.
- Shade planting throughout the Outdoor School Zone.
- Driveway shade trees to reduce heat gain on the hardscape.
- Shade plantings around the future Shop.

Table 5.5.1 below contains a short list of recommended tree and vine shade plantings. The list is by no means exclusive.

Table 5.5.1

Recommended shade planting species. See the WFH - Living Systems Calculator - Agroforestry Species spreadsheet for additional details on each, including sourcing information.

Recommended Shade Species				
Common Name	**Spread**	**Height**	**Description**	**Image**
Black Locust	20 - 35	35 - 80	*Robinia pseudoacacia.* Feathered foliage, creates dappled shade underneath, n-fixer, edible flowers taste like peas and have wonderful fragrance. Trunk and branches do have thorns. Drought hardy once established, good soil builder.	
Honey Mesquite	30 - 40	25 - 35	*Prosopis glandulosa*. Light, wispy foliage creates wonderful dappled shade. Excellent, drought hardy, tough shade tree, N-fixer, deep root system. Pods are carbohydrate rich and make excellent livestock food.	

Mimosa	20 - 40	30	*Albizia julibrissin*. Deciduous. Fine, feathery foliage creates wonderful dappled shade - excellent for hammocking during the summer. Brilliant white and pink pixie blossom look like miniature fireworks and have an incredible fragrance. Amazing bee forage,	
Southern Catalpa	25 - 40	30 - 40	*Catalpa bignonioides.* Deciduous. Large leaves, long tendril-like pods, white flowers. Can be a bit messy, but a beautiful tree when in bloom.	
Thornless Honey Locust	35 - 50	75 - 135	*Gleditsia triacanthos.* Deciduous. Light shade from a very tall tree, best as a layered shade tree, lets through enough light to grow fruit trees and grass in its understory if desired. Nitrogen fixing. Pods are carbohydrate rich and make an excellent late season livestock forage. Brilliant fall color changes.	
Southern California Grape	10	10	*Vitis girdiana.* Recommended for pergolas and other shade trellising. A deciduous vine which can grow to over 10 meters (30 feet) in length. It climbs on other plants or covers the ground with twisted, woody ropes of vine covered in green leaves. In the fall the leaves turn many shades of orange and yellow, and bunches of small and often sour but edible purple grapes hang from the vines.	

Dusky Coral Pea	20 - 30	20 - 30	*Kennedia rubicunda.* Recommended for pergolas and other shade trellising. Evergreen vine. Drought hardy leathery dark green foliage. Brilliant crimson flowers are pea-shaped. Australian native.	
Scarlet Trumpet Vine	40 - 50		*Distictis buccinatoria.* Recommended for pergolas and other shade trellising. Evergreen. Large, crimson, orange or pink trumpet shaped flowers are prolific but have no smell. Foliage is thick and can cast a dense shade when overhead on a trellis. Very drought hardy, needs little care beyond pruning once established.	
Wisteria	40- 60+	40 - 60+	*Wisteria floribunda*. Recommended for pergolas and other shade trellising. Deciduous. Nitrogen fixing, produces long pannicles of amazingly fragrant blossoms in very early spring/ later winter.	
Lilac Vine.			*Hardenbergia violacea.* Recommended for pergolas and other shade trellising. Evergreen. Brilliant and prolific purple flowers bloom in late winter, bees love it! No fragrance. Casts very deep shade when overhead on a trellis. Very drought hardy, leathery dark green foliage, lance shaped leaves.	

Blue Oak	30	30 - 50	*Quercus douglasii.* Medium-sized deciduous trees growing up to 50-82 feet tall, usually with a somewhat irregularly-shaped crown, and a trunk 1.5-3 feet in diameter. The tallest recorded oak was found in southern Alameda County, at 94 feet. The bark is light gray with many medium-sized dark cracks; from a distance, it can appear almost white. The name Blue Oak derives from the dark blue-green tint of its leaves, which are deciduous, 1.5-4 inches long, and entire or shallowly lobed.	
Chilean Mesquite	30	30	*Prosopis chilensis.* Semi-evergreen. Soft, fine, feathery foliage, creates very pleasant shade underneath. N-fixing, pods are good livestock forage. Very drought hardy.	
California Black Oak	50	50	*Quercus kelloggii.* Deciduous. Black Oaks are very drought tolerant.	
Cork Oak	40 - 70	40 - 70	*Quercus suber.* Evergreen. Cork Oak is used to make wine corks, and has a beautiful color and texture to its bark.	

Peruvian Pepper Tree	20 - 40	30 - 50	*Schinus molle.* Wispy, draping foliage, fragrant, excellent late winter time bee forage. Droppings are allelopathic to some plants, but calla lilies and ivy grow very well underneath its shade. Very drought hardy. Peppercorns can be used culinarily.	
Mexican Weeping Bamboo		20	*Otatea acuminata spp. Aztecorum.* Unique, clumping bamboo with tufted foliage, fountain shaped.	
Chinese Elm	50 - 60	40 - 50	*Ulmus parviflora*. Semi-evergreen. Brings a massive amount of shade to any landscape. Natural umbrella-shaped, great for families, a mature Chinese Elm tree is good for climbing or attaching a tire swing. Easy care.	

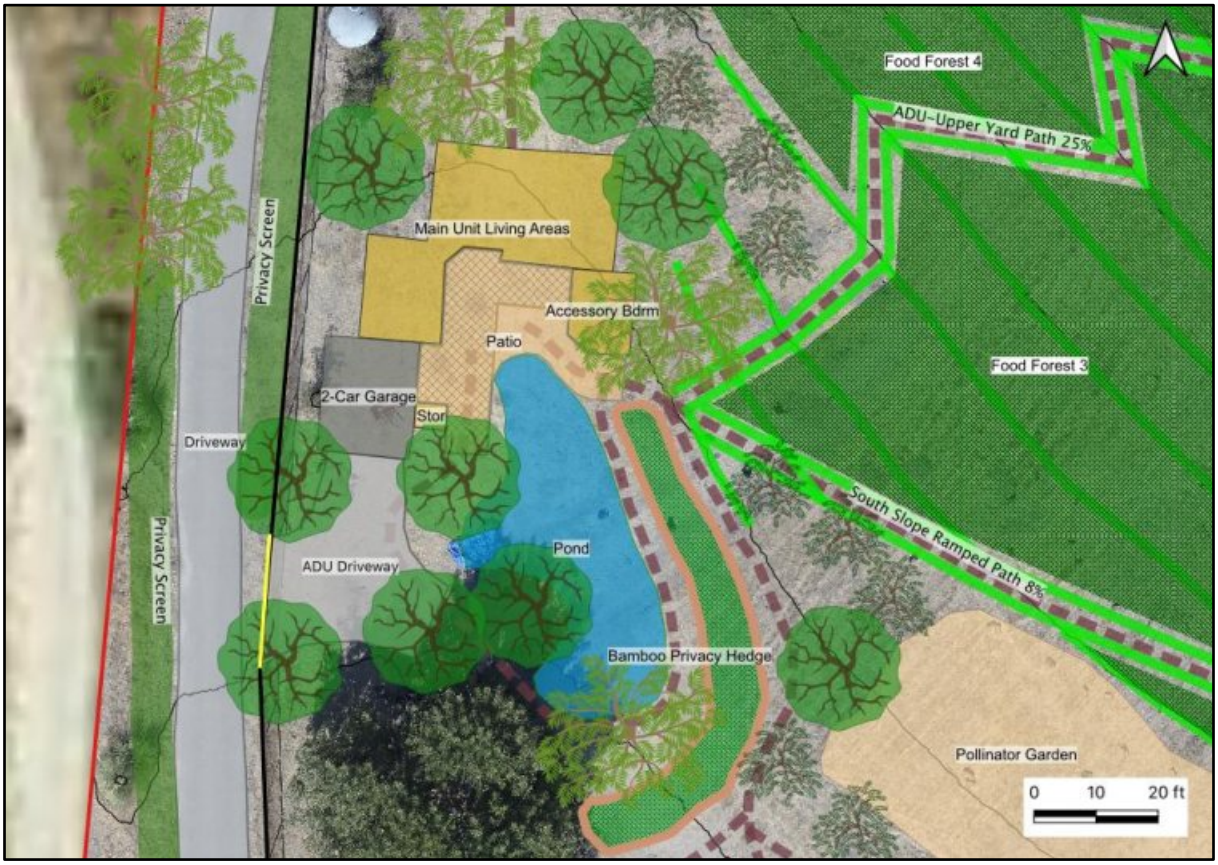
Main Residence Pergola & Trellis Shade Plantings

The pergola extensions recommended along the south wall and northeast-facing sides of the Main Residence should be trellised with perennial vines. The south wall would benefit from a deciduous vine to let in more winter sun to that section of the house. The northeast side pergola is long and could have several different types of vines, both evergreen and deciduous, depending on how that space is being utilized. Deeper, more permanent shade may be desired around certain sections, while others may appreciate allowing in the light and heat reflected from the rock face during certain times of the year. See Figures 4.1.1 and 4.1.3 for recommended locations of the pergolas. See Table 5.5.1 for recommended shade vine species.

ADU Shade Plantings

The ADU will benefit from shade plantings, especially on its west and south sides, to help moderate heat gain by the structure and reduce light intensity in the courtyard and most frequented window locations. Trees with umbrella shaped canopies (Oaks, Chinese Elm, Mimosa) will help to reach over and create shade above the driveway hardscape and help limit the heat island effect near the ADU. Trees should be planted in concert with the crenelated edges of the ADU Pond to help cast shade over the water body during high summer sun.

Figure 5.5.1
Hypothetical shade plantings around the ADU.



Outdoor School Zone Shade Plantings

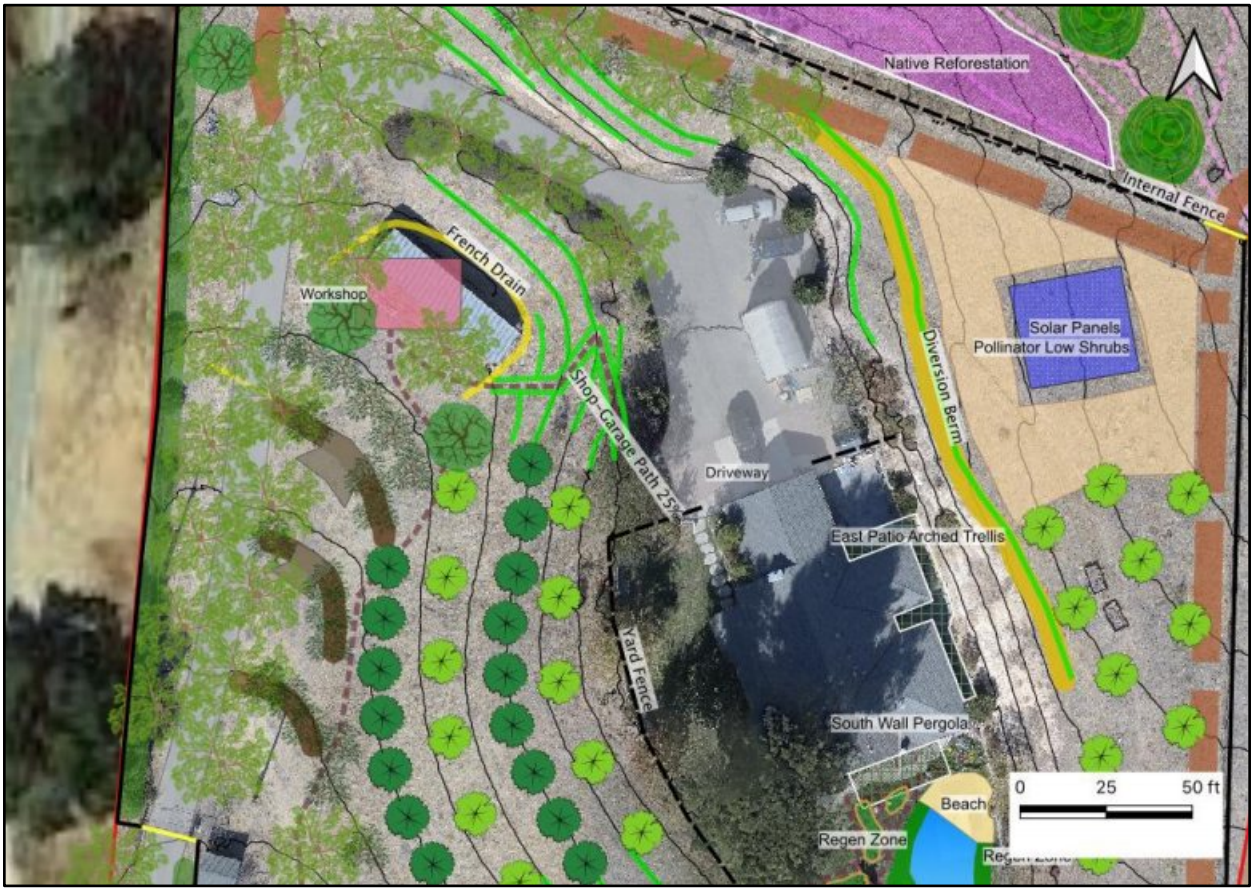
The Outdoor School Zone should have shade plantings throughout to help moderate temperatures in the otherwise completely exposed area. The pergola over the Yurt Deck should be planted with perennial vines, and can be either deciduous or evergreen depending on whether or not year round shade is desired for this location. Once the deck is built and water/electrical is trenched to the location, trees should be planted to help create a shaded cradle for the structure. A mix of evergreen and deciduous trees is recommended, their exact locations becoming evident as the mainframe of the structure continues to evolve. A screen of dappled shade trees (Black Locust, CA Pepper) should be planted along the southern edge of the Yurt Deck to create an effective souther shade screen. The trellised walk around the Fire Circle should have a deciduous vine (Wisteria, Grape) grown over it. The eastern end of the fenced livestock pen/run should have a screen of trees wrapping around its front, covering the Bulk Compost Zone with dense shade, and continue around to the west to fully shade the run perimeter and provide additional windbreak for the animals. The entry path into the Outdoor School Zone from the Stepped Pathway Between ADU and Main Residence Yard should have leguminous and bee-friendly tree plantings along its length, ideally trees from which the prunings or fruit fall can be fed to the nearby livestock (Moringa, Black Locust, nut trees, mulberries etc).

Figure 5.5.2
Outdoor School Zone shade plantings.

Driveway Shade Corridor

The driveway is currently a major heat island. To help reduce the heat gain here and to create a beautiful entry corridor upon entering the main entry gate, the driveway should be lined with shade trees that have umbrella like canopies. Chinese Elm, Southern Catalpa and Mimosa are excellent candidates that are relatively fast growing, and Live Oaks or CA Pepper can be layered in over time as long-term replacements.

Figure 5.5.3
Driveway shade corridor.



Shop Shade Plantings

The Shop should have deciduous shade trees planted along its western wall to allow some later afternoon winter sun to help warm the interior. Plantings to the south and east can be integrated with the edge of Food Forest 4. The berms of the swales and their interstitial spaces should be planted with trees as well, which will further help to reduce heat gain in front of the shop on what is currently open ground. See Figure 5.5.3 above.

5.6 Reforestation

While there are a large number of precise and varying definitions for a forest, incorporating factors such as tree density, tree height, land use, legal standing, and ecological function, for the purposes of this report, a forest is a large area dominated by trees. They provide a crucial and irreplaceable role in Earth's ecology: they are the second largest storehouse of carbon and producer of oxygen on the planet, provide habitat for a myriad of plants, animals, and fungi, and provide food, fuel, shelter, and water (through their immense influence on climate and the water cycle) for humans.

Existing Conditions

There are no forestry elements currently in existence at WFH.

Recommendations

The following forestry elements are recommended:

- Reestablishment of the native central oak woodland plant community on the steep slope north of the main homestead hub (Upper Paddock).

Re-establish Native Central Oak Woodland Plant Community In Upper Paddock

The Upper Paddock is currently dominated by annual weeds and grasses, with some perennial vegetation established - mostly coyote brush - in the West Valley Drainage. Reforesting the Upper Paddock will help to mitigate fire risk (if managed properly), moderate the microclimate on property, reduce erosion issues and stabilize the soil, drastically reduce the invasion of foreign annuals (weeds), and rehabilitate the soil conditions. The area recommended for reforestation is illustrated in Figure 5.6.1; an image showing an intact central oak woodland plant community is shown in Figure 5.6.2 (also evident on the hillsides when looking south from WFH).

Figure 5.6.1

Area on the northern portion of WFH property recommended for re-establishment of the native central oak woodland plant community.

Figure 5.6.2

Central oak woodland plant community

Native pioneer plants should be first established to cover the soil and provide nurse habitat for the oaks, which will be planted in their midst. The coyote brush will be of great help in successfully establishing trees in the drainage, and ultimately across the broader, more exposed portions of the slope, as it makes an excellent nurse plant. Coyote brush is very good at creating a cool microclimate at its base, even during peak summer sun (try grabbing a handful of the foliage on a hot day and see what you feel!). The shade, wind buffer, and general cooling effect of the brush will help young seedlings get established. Intentionally spreading the coyote brush seeds around the disturbed soil at the entrances to ground squirrel holes this winter may also help to get additional coyote brush shrubs established across broader portions of the slope, where they will help to stabilize the soil and create additional nurse opportunities for establishing desired tree species.

A mix of the species suggested in Table 5.6.1 (both male and female, for the dioecious species), planted in the winter, spring, or early summer, is recommended. Due to the large area recommended for re-establishment, phasing the planting using "resource islands" is recommended. In this, a circular area that can be covered by a single sprinkler, approximately 40 ft, should be planted. This size is manageable enough that if deer, rabbits, or squirrels become an issue during plant establishment, a fence can be placed around the area at the edge of the sprinkler radius. Water the area for a year to establish the plants, and then move the sprinkler (and fence, if used) to a new area for establishment. Within a few years, there will be islands everywhere, and the interstitial areas can be filled in. For information on how to plant natives, see Section 5.4 - Privacy Screens - How to Plant Native Plants.

Table 5.6.1
Suggested CA native pioneer plants for re-establishment of central oak woodland plant community.

Common Name	Scientific Name	Plant Diameter (for spacing)
Black Sage	*Salvia mellifera*	4-5'
California Sagebrush	*Artemisia californica*	4-5'
California Buckwheat	*Erigonium fasciculatum*	4-5'
Silver Bush Lupine	*Lupinus albifrons*	4-5'
Coyote Brush	*Baccharis pilularis spp. consanguinea*	5-6'
Big Berry Manzanita	*Arctostaphylos glauca*	6-8'
Toyon	*Heteromeles arbutifolia*	6-8'
Hollyleaf Redberry	*Rhamnus ilicifolia*	6-10'
Buckbrush Lilac	*Ceanothus cuneatus*	8-10'
Coffeeberry	*Rhamnus californica*	8-10'
Hollyleaf Cherry	*Prunus ilicifolia*	15-20'

In time, the animals enjoying their new habitat will inadvertently help plant new live oak trees (*Quercus agrifolia*) within the guild when they forget about some of their acorn stashes, which will

be supported on many levels by the surrounding, already-established vegetation - however, live oaks can also be planted by hand in the resource islands after the first year.

Integration Of Zone 4 Agroforestry Plantings

Non-native selected productive species can be integrated into the native reforestation as well. For these plantings, since they are typically more nutrient-hungry than native oak trees, preceding them with drought-hardy, leguminous trees is recommended. This will play a major role in preparing the soil for longer term overstory species targeted at food production for humans and animals, like chestnuts and walnuts. Table 5.1.1 below lists recommended species for reforesting the Upper Paddock. Trees and shrubs should be planted from seed or as one-year whips grown in some sort of air pruning bed or container. Gopher baskets are recommended to help the trees establish. Establishment irrigation should be provided either by the Groasis Waterboxxes - recommended in Section 5.7 - Irrigation - Water Batteries - or via pre-installed drip system (fed from relocated water tanks atop the property - if tanks are not relocated here then some sort of pressure pump will be necessary to pump irrigation water to the Upper Paddock at pressures high enough to operate drip emitters).

Table 5.6.2
Recommended nitrogen-fixing pioneer species for the Upper Paddock.

Common Name	Scientific Name	Soil-Building Attributes
White Mesquite	*Prosopis alba*	Carbohydrate-rich pods, very drought-adapted, deep root system, nitrogen-fixing, good browse for goats, excellent firewood.
Honey Mesquite	*Prosopis glandulosa*	Carbohydrate-rich pods, very drought-adapted, deep root system, nitrogen-fixing, good browse for goats, excellent firewood.
Chilean Mesquite	*Prosopis chilensis*	Carbohydrate-rich pods, very drought-adapted, deep root system, nitrogen-fixing, good browse for goats, excellent firewood.
Black Locust	*Robinia pseudoacacia*	Fast-growing N-fixer, edible blossoms, excellent bee forage, goats enjoy browsing, rhizomatous root system, will sucker when cut, excellent coppice tree,
Leucaena	*Leucaena leucocephala*	Tough, small tree / shrub that does well on exposed slopes. Pods can be eaten by humans and animals alike. Makes excellent cut forage for livestock, readily suckers and regrows following coppicing.
False Indigo Bush	*Amorpha fruticosa*	Can grow in full sun to light shade, has a fibrous root system good for erosion control. Prolific blooms, pollinator attractor, nitrogen-fixer, biomass can be cut annually and used to make charcoal. Drought-hardy but also likes persistently moist soils.

Either in tandem with or following the pioneer legume trees and shrubs by 1-2 years (depending on growth) a range of additional CA native and non-native drought adapted trees - chestnuts, walnuts, mulberries, persimmons, jujubes, loquats and other trees that can handle high and dry conditions - can be sown or planted.

5.7 Plant Propagation

Propagation of plants and trees in large quantities for planting throughout the WFH landscape represents a major way to keep costs down while establishing ecosystems.

Existing Conditions

There are currently no plant propagation elements at WFH.

Recommendations

The following plant propagation elements are recommended at WFH:

- **Automated misting beds** for propagation high-value perennial plants from cuttings.
- **Air pruning beds** for propagating trees and certain perennial plants from seed.

Automated Misting Beds

Many plants can be propagated from cuttings if environmental conditions are amenable. Generally a section of stem (hardwood or softwood, depending on time of year and species) is cut with at least two nodes on it. The stem section is placed upright, with at least one node below the surface of the rooting medium, and if kept adequately moist (but not too wet) in an environment with low evapotranspirative stress (shaded, no wind, gentle airflow) the cutting will strike root and grow as a new plant.

Because the genetics of a stem cutting are the exact same as the parent plant from which the cutting was taken, plants grown from stem cuttings are also called clones. The entire process is called cloning, or clonal propagation.

Taking cuttings is a commonly used method to propagate many woody plants, especially shrubs. Typically, stem cuttings of tree species are more difficult to root. The four main types of stem cuttings are herbaceous, softwood, semi-hardwood, and hardwood. These terms reflect the growth stage of the stock plant from which the cutting is taken. Cuttings require consistent moisture and protection from temperature extremes, as they have no roots (at least initially) by which to take in water. The rooting media also needs to drain well in order to prevent the growth of fungus, molds and other anaerobic pathogens while the cuttings are at their most vulnerable.

The automated misting bed allows for mass propagation by cutting or root division of valuable plants without creating a concomitant linear increase in the amount of time needed to tend to them.

The DIY Automated Mist Propagation[72] article on the 7th Generation Design website explains the broad concept and details the nuts and bolts of this system. Essentially the goal is to create a consistently moist soil medium that is just right for encouraging young cutting to strike roots. Grow lights and bottom heat could be added to allow for off season and early season propagation in a colder climate.

Automated Air Pruning Beds

An air-pruning bed paired with RootMaker air-pruning pots is an excellent system for producing healthy, vigorous tree seedlings. Air-pruned plants have healthy, non-circling fibrous root balls that are primed to do very well once planted in their permanent location, as opposed to plants grown in conventional pots that have a circling root. The root ball of a Sequoia tree grown in an air-pruning pot vs a conventional pot is shown in Figure 5-35 below.

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[72] DIY Automated Mist Propagation Bed: https://www.7thgenerationdesign.com/diy-build-your-own-automated-misting-bed/

Figure 5.7.1
Air pruned root ball vs conventionally potted root ball.

An air pruning bed need be no deeper than 12" to allow for easy removal of seedlings when they are ready to be potted up. The sides of the bed can be made with 2x12" boards, and should be around 36" wide to allow for easy access to the whole bed. The bottom soil holding layer is shade cloth laid over 1/2" hardware cloth laid over 6x6" concrete wire remesh, stapled on top of a table frame onto which the soil containing box is set. This will help to ensure that the mesh will not tear from its attachments when under load with wet soil. For a video walkthrough of an air prune bed system and a deep dive into the science behind air pruning techniques see the DIY Air Prune Beds[73] post on the 7th Generation Design blog.

Figure 5.7.2
Air pruning bed construction and operation. Left to Right: Footings and frame with (2) 2x6" soil containing boxes stacked on to; bottom soil holding layer of shade cloth over ½" mesh over 6" remesh; bed filled with soil, seeded, covered with mulch and protected with a squirrel excluder; mid-summer growth.

Tree seeds can be planted as close as 1 - 2" apart depending on seed size. Some may need scarification or stratification prior to germination, but once this process is completed they can be set into the bed to a depth of about 3 times the width of the seed and lightly covered with soil or wood chip mulch. A mist based irrigation system can be used until sprouts emerge, at which point it may be beneficial to switch irrigation to ¼" drip lines with emitters every 6" laid at the soil surface

[73] DIY Air Prune Beds - Video and blog post: https://www.7thgenerationdesign.com/air-prune-beds/

or even beneath the mulch to help prevent any potential for molding from excessive moisture on the young stems and leaves.

Many animals love tender tree sprouts (not to mention buried tree seeds)! An 18 - 24" high wire mesh cage should be set on top of the air pruning bed frame until seedlings have set several sets of true leaves and the trunk has hardened somewhat. This cage can be removed once they are tougher and less tasty.

Once the seedlings are ready to be potted up or planted out, they can be gently but firmly shaken out of the air pruning bed. For trees that go dormant this would be easiest to do when they have entered dormancy. Keep the soil medium light and friable so they can be shaken out even when not dormant. The soil medium can be a range of different substrates, and should be tailored to whatever variety of tree(s) is being grown in the bed.

For growing plants in pots while still creating a healthy, air-pruned root structure, air pruning pots and tree bags are recommended. A rack of RootMaker[74] pots - specially designed air pruning pots that create the maximal density of active root tips while eliminating risk of circling roots - is shown in Figure 5.7.3. For more information on the science behind RootMaker air pruning pots, watch Root System Basics[75]. Growing in pots is far more expensive than growing in air prune beds, and should therefore be utilized for specific purposes (like growing air-pruned vegetable starts or plants for sale).

Figure 5.7.4
Rootmaker Pots

5.8 Irrigation

Irrigation is the process of applying controlled amounts of water to plants at needed intervals. Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall, and is also used in other applications such as cooling livestock and dust suppression.

[74] Root Maker Pots: https://rootmaker.com/

[75] Dr. Carl Whitcomb's video on Root Building Basics: https://www.youtube.com/watch?v=LdGzn8kbULc

Existing Conditions

Irrigation lines are in place for the ornamental landscaping around the Main Residence as well as some of the driveway edge plantings.

Recommendations

The following irrigation system elements are recommended at WFH:

- Piped irrigation systems with automated control - recommended to minimize (and ideally eliminate) time spent watering the following systems:
    - Agroforestry Systems
    - Food Gardens
    - Nursery
- Passive Irrigation Water Batteries - may be a better choice than piped irrigation in the development of some agroforestry elements and shade tree plantings.

A detailed irrigation system design for a given element is dependent upon the implementation-level design of that element, once the following information is known:

- Number of different watering regimens required.
    - i.e.) Water amounts and application frequency are different for seedlings in the greenhouse compared with established crops in the garden compared to establishing trees in air pruning beds.
- Number of different application points/areas and their water needs.
- Standing pressure of supply water and flow rates.
- Degree of control required (Manual program adjustment at controller, WiFi, smart sensor integration etc).

General information on the recommended systems is provided below.

Piped Irrigation

Irrigation is commonly provided through the distribution of pressurized water (supplied by pumps or gravity) through pipes to emitters such as sprinklers and drippers. The most commonly used pipes are rigid PVC and flexible "black roll pipe" high-density polyethylene (HDPE). HDPE is the more environmentally-friendly option[76] of the two and is generally recommended by 7th Generation Design except in areas when the higher puncture resistance of of PVC is required.

The flow of pressurized water through the pipes is controlled by either manually-actuated or timer-controlled electrically-actuated valves. The valves and timers can either be powered by an AC-grid connection or solar PV- or AC grid-charged batteries. Timer-controlled valves eliminate time spent on repetitive valve-opening by hand, and are generally recommended by 7th Generation Design for piped irrigation applications in rural, broad acre contexts.

[76] Environmental Impact of HDPE vs PVC:
https://www.plasticboards.com/recycling-plastic-building-materials-pvc-vs-hdpe/

Single Zone

If all that is needed is a single valve in a location to run an automated irrigation system of some type, and there is no power nearby, the DIG LEIT Solar Valve and Timer unit[77] is highly recommended. It can be attached to any standard hose thread and is fully programmable.

Figure 5.8.1
DIG Leit Solar-Powered Single-Zone Valve. Image: DIG

Multiple Zones

If multiple different irrigation zones require tending, then the use of an Off-Grid Irrigation System (OGIS)[78] using a small solar panel unit and DC timers and valves is recommended. For a detailed walk through on how to build a system like this, see the step-by-step YouTube tutorial[79]. The system shown in the video was built for application in a Mediterranean climate that rarely freezes, and then only lightly. A system with similar components can be designed for use in the climates provided that the system is insulated and low-pressure drains are built into the system to drain irrigation lines following each use.

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[77] DIG LEIT Solar Valve And Timer Unit for off-grid irrigation applications: https://www.dripworks.com/dig-leit-solar-timer-with-3-4-valve

[78] Off-Grid Irrigation System (OGIS) Introduction Video: https://www.youtube.com/watch?v=gTyQ_gD83Bk&t=70s

[79] Off-Grid Irrigation System (OGIS) step-by-step DIY video tutorial: https://www.youtube.com/watch?v=tfVaDG-ZVdY&t=4s

Figure 5.8.2
The Off-Grid Irrigation System (OGIS) developed by 7th Generation Design.

Using the timer detailed in the OGIS video linked above, these systems are capable of down to the second irrigation window lengths, making them perfect for mist bed propagation systems as well as overhead mist watering systems for vegetable starts within a greenhouse or shadehouse.

Water Batteries

Setting up piped irrigation for dense agroforestry plantings across broad acreage gets expensive quickly. Additionally, damage caused to pipes and emitters resulting from the inclusion of grazing animals in an agroforestry setting can pose costly and time-consuming maintenance issues.

One solution to this is a water battery like the Groasis Waterboxx, shown in Figure 5.8.3. The Waterboxx is positioned around each seed or seedling and is pre-charged with several gallons of water. The water is contained inside a covered container that sits around the tree seedling or tree seed. A wick from the internal reservoir leaches out some 50mL per day of water - not enough to make the tree lazy, just enough to create a water column of moisture directly beneath the soil upon which the Waterboxx sits. There is not enough water in this column for the tree to thrive, but there is enough to continually stimulate the taproot to continue growing deeper into the soil (a very desirable trait in drought-prone climates). The water reservoir also serves as a thermal mass that condenses warmer, moisture laden air on the Waterboxx's surface, which refills the reservoir at night when conditions are right. These devices are meant to be filled once and left for a year or longer, and they will continue to self-fill by condensing moisture from the air during diurnal temperature fluctuations and funneling that condensate into the reservoir.

Figure 5.8.3
Groasis Waterboxx

An animated walkthrough of how the Groasis Waterboxx works is available here[80].

Though the members of the 7GD team have not yet had the opportunity to personally test the Groasis Waterboxxes, after research and conversations with distributors, there are several benefits of utilizing them in an agroforestry system over conventional irrigation:

- If one fails or gets punctured by a wayward grazing animal, it affects only one tree, whereas if an irrigation supply line gets chewed by rodents, stepped on by a cow, or an emitter pops out at a single tree, the entire system's performance is degraded if not completely shut down. Integrating animals into pasture with irrigation tubing is guaranteed to be a costly and time-intensive endeavor.
- Capitalizing on the far lower cost of seeds vs seedlings, the ability to plant two seeds in each Waterboxx increases the establishment success rate of each planting to 99%, versus 85% for planting just a single tree. This equates to more trees established in a shorter amount of time when looking at a 3+ year time horizon.
- They allow time for observation and adjustment. As an example, 200 Waterboxxes in rotation every year would allow for an annual review of how things went the year prior - and allow time and space for the incorporation of new knowledge and understanding of the landscape, new species that have popped up on the radar, and changes in future land use ideas and desires etc.

Though the Waterboxxes are pricey up front, a quantity can be purchased that fits the landowner's budget, used to start a block of trees, and then reused the following year for an entirely new block. This can continue year after year until the property is populated with the desired number of trees. As an example, if 2,000 trees are planned for establishment over a 10 year period, only 200 boxes are required. In this example, based on current Waterboxx pricing, the per tree establishment cost (irrigation, protection) at the end of that 10 year period comes to approximately $3.10 - approximately 75% less than the estimated per tree establishment cost if using conventional poly irrigation line and drip emitters.

[80] https://www.youtube.com/watch?v=HRF2bUBPA90&t=1s

6. Boundaries

Boundaries within a landscape can occur in numerous forms. They can be physical (gates, fences, masonry walls, terrain, dense vegetation etc.), legal (property lines, easements etc.) and energetic (felt within the landscape). Understanding what boundaries exist, and how they can or will need to be reinforced, removed or modified, along with what boundaries are required that are not yet in place, is essential to managing a healthy, thriving landscape, no matter the size. Boundary markers help to determine what types of management are required where, and consequently what the energetic, financial and material cost of that management will be, and are therefore essential when planning an enterprise.

Two of the most universally recognizable boundaries are walls and fences. Walls and fences serve several important functions, including confining and protecting animals and crop areas, providing visual barriers, supporting trellised growing systems, blocking wind, collecting snow and much more. While most walls are made from masonry blocks or concrete and are permanent, there are many different materials that make up permanent, semi-permanent, and temporary fencing:

- **Permanent Fencing -** Permanent fences are typically used for boundary and subdivision fences on land that's owned by the user—and whose usage is not likely to change. They are usually constructed of strong wood, steel or fiberglass posts that support high-tensile solid wires, welded wires, woven wires, wood slats, rope or wide tape—of which one or more strands are electrified. They are more reliable and durable than other options but more expensive to install. A professional installer is often needed.
- **Semi-Permanent Fencing -** Semi-permanent fences are typically used for applications that require seasonal or annual movement. They can also be a barrier that is assembled until a more permanent one is installed. This allows for testing of fence and gate locations to see what works best. The construction could consist of electrified net or multiple electrified strands under low tension, or possibly made of pallets or straw bales. These require more maintenance than permanent fences, but often reduce up-front costs to establish barriers.
- **Portable Fencing -** Portable (temporary) fencing is typically used in applications that require daily or weekly movement. They should be quick to install and remove and eliminate the need for large end and corner posts, and the fence strands (whether single, multiple or a mesh/netting) must be only hand-tensioned. They must also be electrified properly.

Within each of these categories are dozens of different fencing options. The choice of fencing for any given area should be made based on what purpose it serves.

Table 6.0.1
Typical fencing types for managing livestock.

Fence Type	Best For	Components	$/linear foot	Pros	Cons
High-Tensile Wire	Perimeter fences	Permanent posts (often rot-resistant timber), high-tension wire	$0.89-$1.50	Long lifespan	Immobile, technical installation
Woven / Welded Wire	Permanent perimeter fences, paddocks/ corrals	Woven or welded wire, sunken posts (T-posts)	$1.50-$3.00	Strong	Expensive
Electrified Portable Net Fencing	Cell grazing	Woven poly-wire mesh, fiberglass stakes	$0.75-$1.25	Affordable, flexible	Steep learning curve to effective use, mowing alleys
Electrified Single Strand / Rope / Tape	Large livestock already trained to electric fence	Strand and temporary fence posts with non-conductive attachment points	$0.20-$.050	Cheapest	Least durable

NRCS Fencing Grant Information

Federal cost-share funding is available for internal fencing improvements through the NRCS Environment Quality Incentives Program[81] (EQIP). Farmers or ranchers working to implement a Grazing Management Plan can submit their plan and apply for funding assistance with various types of fencing installation. For more information look up Code 110 - Grazing Management Plan[82].

6.1 Security/Privacy

Various types of visible and invisible boundaries can be employed to enhance physical security and visual/acoustic privacy.

Existing Conditions

The WFH property is currently surrounded by a fence along its entire perimeter with the exception of the small triangle of property on the south side of [redacted] [redacted] Road and a~20' wide gap on the east side of the property. The "homestead hub" southern portion of the property is bounded by a metal permanent fence; the steep northern portion of the property is bounded by barbed wire fence. Intentional entry points include the Main Entry Gate on the driveway, the utility access gate next to [redacted] [redacted] Road, and the access gate on the north end of the main homestead hub to the steep northern portion of the property.

[81] NRCS EQIP Program: https://www.nrcs.usda.gov/wps/portal/nrcs/main/ca/programs/financial/eqip/

[82] NRCS Grazing management Plan- Code 110: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ca/programs/financial/eqip/?cid=stelprdb1247016

Recommendations

The following boundary elements for security and visual/acoustic privacy are recommended:

- Close the gap in the fencing on the east side of the property.
- Plant a privacy screen along the homestead hub perimeter fences.
- Enclose ADU courtyard with bamboo.

Close Fence Gap on East Side of Property

There is a ~20' wide gap between the north block barbed-wire fence and homestead hub welded wire fence on the eastern side of the property. If the neighbors to the east keep livestock that ever wander into the WFH northern property block, barbed wire should be extended between the corner posts to exclude them. If a new fence is installed provisions should be made to maintain the existing wildlife movement corridors that currently utilize this corner. If fencing is required for future livestock seasonal rotational grazing in the Upper Paddock perhaps the gap could be filled by temporary fencing, and be left open for the portions of the year when livestock are not present in this section of the property.

Figure 6.1.2

Existing gap in the fence along the eastern property line and the south east corner of the Upper Paddock.

Plant a Privacy Screen Along Homestead Hub Perimeter Fencing

This recommendation is described in detail in Section 5.4: Privacy Screens - Native Privacy Screen.

Enclose ADU Courtyard with Bamboo

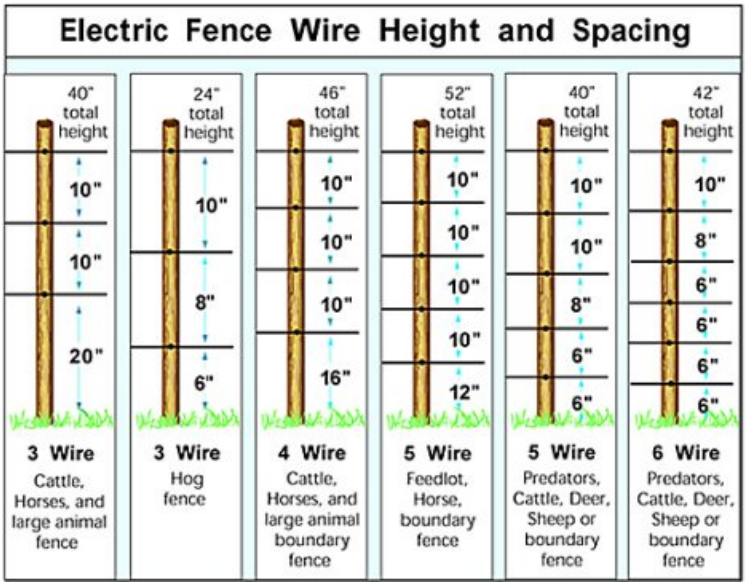
This recommendation is described in detail in Section 5.4: Privacy Screens - Bamboo hedge Between ADU Pond and Outdoor School Zone.

6.2 Animal Confinement/Exclusion

Confining livestock animals to where their presence is desired and beneficial is an important part of managing a healthy population. Likewise, excluding them from where their presence is not desired or beneficial is critically important to prevent ecological and financial damage.

There are many different types of fencing that can be used to confine or exclude animals, ranging from 8'+ permanent metal to 1- or 2-strand electro-wire ('polywire'). For confinement in permanent pens and exclusion from sensitive areas such as gardens, permanent fencing using woven or welded wire is typically recommended; for temporary confinement or exclusion in a rotational grazing situation or initial growing period of hardy perennials, polywire fencing may be sufficient.

Figure 6.2.1
Polywire fence spacing



Existing Conditions

The fencing around the "backyard" of the main residence is used at times to effectively confine the dogs. There is also a dilapidated and currently-unused barn onsite. The homestead hub perimeter fencing serves to discourage larger animals from entering, and the barbed wire fence (if the gap on the eastern side was closed) would serve to exclude curious cows from neighboring properties. No other boundaries for animal confinement or exclusion exist on the property.

Recommendations

The following boundary elements for animal confinement or exclusion are recommended:

- Permanent fencing around proposed animal pen located near outdoor classroom zone.
- Eight foot temporary fencing around reforestation "resource islands".

Permanent Wire Fencing Around Proposed Animal Pen

The pen/run next to the proposed animal shelter, illustrated in Figure 6.2.2, should be bounded by a woven-wire fence supported by either metal or wooden posts. The size of the fencing necessary will be determined by the animals confined - either 4' or 6' fencing will likely be needed.

Figure 6.2.2
Proposed animal shelter location and attached fenced pen/run.

Permanent Wire Fencing Around School Lunch Garden

The School Lunch Garden should be enclosed with permanent woven wire fencing supported by either metal or wooden posts. The fencing will help to exclude some garden pests. The lowest 2' of the fence should also have chicken wire or some other finer meshed fence along the entire bottom, ideally dug into the ground and extending out from the fence perimeter by at least 8", to deter small herbivores that can slip through or burrow underneath the larger fence like rabbits. The fencing should be 4 - 6' in height, and the posts should be at least 7-8' tall above ground. The additional pole height above the fence will allow for the running of single wires along the top of the fence should additional deterrence for fence-jumping garden pests be necessary (deer primarily). These poles will also provide excellent and very useful attachment points for hanging shade cloth, attaching trellising wires that can cross the garden to support vining crops in the beds, attaching outdoor lighting, mountinging beneficial insect hotels and potentially hanging bird netting should that be desired or necessary (bird netting is a last resort, as birds *will* get stuck in the netting). The fence itself will provide excellent vertical space to be covered with productive crops, and will help to create a wind protected zone within the garden, thereby reducing evapo-transporative stress on the crops plants.

Figure 6.2.3
Proposed animal shelter location and attached fenced pen/run.

Figure 6.2.4
Woven wire fencing is recommended for animal enclosures as it can handle being pushed against by animals without welds breaking or being bent permanently out of shape.

Temporary Wire Fencing Around Reforestation "Resource Islands"

The main threats to the native seedlings during their first year of establishment in the resource islands will be deer and rabbits. Depending on the presence of rabbits or deer observed onsite, fencing may or may not be required. If they do threaten the resource islands, however, fencing will be required to protect the investment until the plantings establish enough to tolerate browsing.

An 8’ tall fence is required to exclude deer - this can be created using 10’ t-posts (sunken 2’ into the ground) and 8’ tall polypropylene deer fencing[83]. (The 100’ roll will be enough to encircle one ~30’ diameter resource island; the 330’ roll will be enough to encircle two ~50’ diameter resource islands). A t-post pounder[84] and t-post puller[85] will be worthwhile investments for this project.

Figure 6.2.5

8’ tall polypropylene mesh fencing supported by 10’ t-posts (sunk 2’ into the ground) will be sufficient to exclude deer from the resource islands.

To provide rabbit protection, metal chicken wire can be attached to the bottom 2’ of the fencing.

[83] https://www.deerbusters.com/heavy-duty-deer-fence/

[84] https://www.tractorsupply.com/tsc/product/countyline-t-post-pounder

[85] https://www.tractorsupply.com/tsc/product/t-fence-post-puller

7. Energy Systems

Energy is a challenging concept to define. Attempts often start by listing specific energy *sources*: electricity, natural gas, propane, etc. These sources of energy do work: they move things, whether those things are people, electrons, water, heat, etc. **Energy is the ability to do work.**

Toby Hemenway, author of *The Permaculture City*, proposes that it is useful to think of energy as a sector - an influence coming from off the design site, as other influences from off-site such as road noise, winds, etc are similarly defined as sectors. There are three ways to interact with sector energies: we can 1) harvest, collect, or store them, 2) deflect or block them, or 3) let them pass by unaltered. These three approaches to energy as a sector are a useful starting point for designing energy systems.

Another useful approach to designing energy systems outlined in *The Permaculture City*, that works well in conjunction with the sector approach above, is to start with what jobs the energy needs to do - what functions it will perform. This is a whole-systems, pattern-based approach, as opposed to the detail-centric approach that typically is used to design energy systems of listing the items that will need energy and then matching them to an energy source. There are three jobs that energy typically performs: **moving heat**, **moving things**, and **moving electrons**

This whole-systems approach to energy design provides a much greater opportunity to identify the ways that the energies already present on-site can be harvested and stored (such as sun, in the form of radiant heat and also in a condensed form like wood), deflected (such as wind), or left to pass by in order to meet an energy function like heating, as opposed to the modern approach of placing a gas-fired heater wherever heat may be required. This design approach has been utilized in preparing the energy recommendations at WFH.

Context

The sources of energy that currently serve the [redacted] Family Homestead include:

- PG&E AC-grid electrical supply
- Propane (stored on-site in tank)

The long term vision of WFH is to be able to minimize or eliminate reliance on imported energy sources by providing the comforts of modern life (indoor temperature moderation, pressurized water systems, tools, etc) for the residents and guests using locally available energy sources. While there are already several elements in place on property that were not originally designed with this lens for minimizing energy consumption, maximizing efficiency, and matching locally-available energy sources to appropriate end-uses, there is still much that can be done to design, create, and support both highly efficient and specific energy end-use systems and an overall lower energy pattern of habitation.

Readily available energy sources already present on the land include solar energy.

7.1 Moving Heat

Moving heat is typically done in two ways: first, releasing and concentrating heat in furnaces, heaters, and stoves so that it can be delivered to living spaces, for household water, or for cooking food, and second, removing heat via cooling equipment such as air conditioners and refrigerators. This work can be done with a wide array of fuels and forces, including burning liquid and gas fuels, wood, or coal; by electricity; by expansion and compression of gas; via friction; and using the sun.

Existing Conditions

The cooking, space heating and cooling, and water heating systems that currently exist onsite are housed in the Main Residence and fueled by the utility AC-grid electrical connection and on-site propane tank.

Recommendations

The anticipated heat transfer needs as WFH continues to develop include:

- Cooking, space heating and cooling, and water heating in the ADUs.
- Cooking and water heating in the Outdoor Kitchen.
- Space heating and cooling in the yurt.
- Space heating in the woodshop.

The systems recommended to perform these functions in various spaces are summarized in Table 7.1.1 below.

Table 7.1.1
Recommended systems for moving heat at WFH.

Space	Water Heating System	Space Heating/ Cooling Systems	Cooking System
ADUs	Tank-style propane water heater with supplemental solar-heating.	Passive solar design, woodstove, backup propane furnace	Propane cooking appliances, solar oven
Outdoor Kitchen	Batch box rocket water heater (wood-fired) + backup on-demand propane/biogas water heater	None	Portable propane-fueled cookstove, cob oven (wood-fired), solar oven
Yurt	None	Passive solar design	None
Woodshop	None	Passive solar design, batch box rocket heater (wood-fired), backup indoor catalytic propane heater	N/A

For any future structures built, including a future home, the following elements are recommended to minimize active space heating and cooling requirements:

- Passive solar strategies

Cooking

Cooking food in a timely manner requires a concentrated energy source. Wood, coal, liquid, and gas fuels are the primary concentrated energy sources for residential and small-scale use. Of those, wood and biogas renew the most quickly, and thus are the best options in terms of sustainability. Propane is the fuel that has the largest selection of turnkey residential appliances (like ranges and ovens), which can be converted to be fueled by biogas.

Initially purchasing or utilizing portable propane "camp-style" cookstoves that can be set on top of a table and configured with a propane tank will provide cooking capabilities within a new space very quickly, and also be available for residents when building a fire sounds unappealing or any guests who may feel daunted by unfamiliar wood-fired systems. Highly-efficient wood-fired cooking systems can then be designed and built, which can serve as the table for the portable propane cookstove when immediate cooking capability is still periodically needed. Onsite biogas production can eventually be investigated, and, if found to be feasible, any propane-fueled stoves converted.

Propane-Fueled Cooking Appliances

Recommended for:

- ADUs

A conventional propane-fueled range and oven is recommended for the ADUs to provide family and guests with familiar systems when needed.

Portable Propane-Fueled Cooking Systems

Recommended for:

- Outdoor Kitchen

A portable propane "camp-style" cookstove set on top of a table and configured with a propane tank is recommended for the outdoor kitchen to provide cooking capabilities within the new spaces very quickly and allow residents and guests to quickly cook with familiar systems when needed. While many are familiar with the Coleman-style camp stoves, Partner Steel[86] makes a far more durable, long-lasting, and domestically-made option.

[86] https://partnersteel.com/cook-partner

Figure 7.1.1
Partner Steel portable propane cooktop

Portable Solar-Fueled Cooking Systems

Recommended for:

- Outdoor Kitchen, ADUs, Main Residence

During the warmer periods of the year, when the solar resource is abundant and standing around a hot oven or cooktop may not sound desirable, a solar oven is recommended for cooking. Solar ovens use reflective material to focus the radiant heat of the sun towards an enclosed pot.

Solar cookers have a bit of a reputation for being a novelty item that sounds good in principle but doesn't work well, but they have come a long way in recent years. Some, like the Hanes Solar Cooker 2.0[87] shown in Figure 7.1.2, have a cooking sleeve that insulates and elevates the pot so sunlight can be reflected onto the bottom of the pot. The adjustable sleeve eliminates the need for plastic cooking bags. This model boils a liter of water in about 50 minutes, is adjustable for high and low sun, and is packable and lightweight.

[87] https://www.hainessolarcookers.com/

Figure 7.1.2
The Hanes Solar Cooker 2.0 and Dutch Oven

Wood-Fired Dual-Chamber Cob Oven

Recommended for:

- Outdoor Kitchen

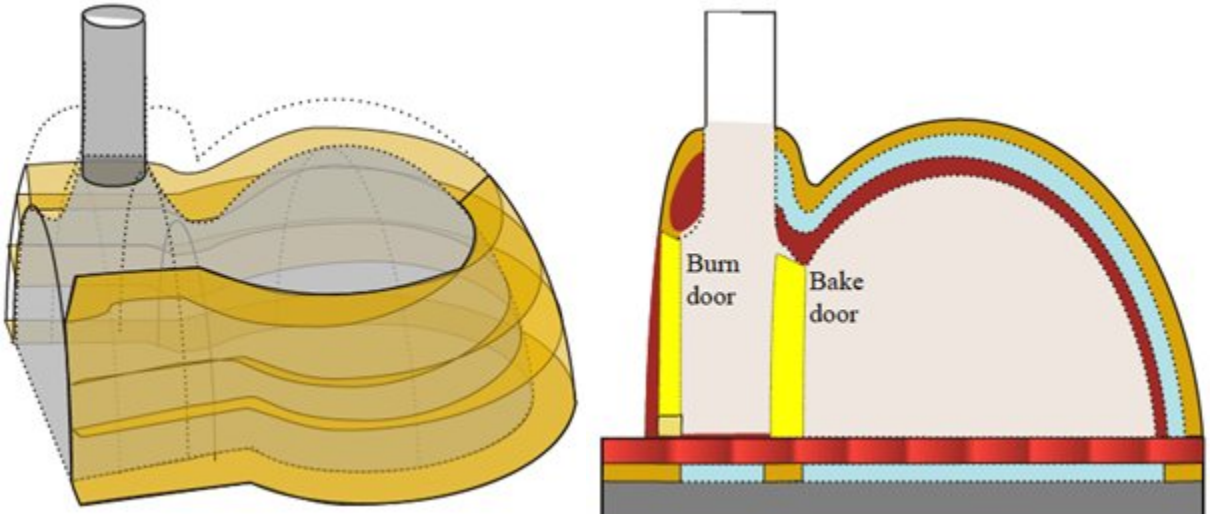
Dual-Chamber Cob Ovens like the one illustrated in Figure 7.1.3 eliminate the smokiness typically associated with these types of ovens, allowing the chef to breathe clean air while tending the fire. Essentially, these ovens employ a two-door system linked with a strategically placed chimney that improves draw and airflow and makes for a cleaner, hotter, faster burn. These ovens get up to temperature faster and have a four times cleaner burn that traditional cob ovens. Plans for making a dual chamber cob oven are available through Permies.com[88]. Watch Ernie Wisner's video walkthrough[89] of this system to see it in action.

These ovens store heat in their massive walls, and are well suited to cooking pizzas and calzones, baking bread, and various types of slow cooking where the fire is lit, the mass brought up to temperature, and then the item to be slow cooked is set inside and the door shut for however long it needs to cook. Slow-cooked beans and yogurt making are good examples, and when not in use, the dry, dark, and potentially cool inside can be used for curing ferments when outside temperatures fluctuate too wildly. Pizza ovens are also an excellent community building tool and have a gravity all their own when organizing a work party with the promise of wood-fired pizzas at day's end.

[88] https://permies.com/t/52989/double-chamber-cob-oven-plans

[89] https://youtu.be/TvrUrnEIQoo

Figure 7.1.3
Dual-Chamber Cob Oven 3D and Profile View



Space Heating and Cooling

"Active" space heating and cooling requirements (heating or cooling provided by fuel that requires human energy to obtain) can be minimized by building a structure with insulative materials that match its location's climate. Architectural design, siting, and orientation can maximize the radiant heat provided by the sun inside a space to passively warm the interior space during colder months, and minimize the radiant heat entering a space during the warmer months, further reducing active space conditioning requirements. While focusing on the climate-appropriate design and construction of any future housing should certainly be prioritized if possible, active heating requirements at the minimum will still likely exist to some degree. Additionally, there are typically existing structures onsite that were not designed and built to maximize these active space conditioning-reducing strategies, or there are time constraints that require the purchase of pre-fabricated or more conventionally-built structures as opposed to the cheaper but more extensive methods used in natural building.

Conventional active space-heating systems include wood stoves, liquid and gas fuel-fired heaters, and electric heaters. Wood is often locally available (or fuelwood-producing systems can be designed at a site to make it so), renews more quickly than liquid or gas fuel, and as with cooking, can be maximized using rocket technology to improve combustion efficiency. Of these options, electric heating is the most inefficient, and should not be used at a site with sustainability goals except in the most unique of circumstances.

Conventional active space-cooling systems include electricity-powered fans, electricity-powered and water-fueled evaporative coolers ("swamp" coolers) and electricity-powered direct expansion ("DX") units.

Passive Strategies for Space Conditioning in Future Structures

Recommended for:

- ADUs, Woodshop

For any future structures built, like the ADUs and woodshop, passive strategies for space conditioning should be considered during the design phase. Passive strategies for influencing the temperature of an interior space are those that don't consume fuel. The main strategies for this include 1) keeping heat where it's wanted via insulation and leak proofing, 2) storing heat with thermal mass, and 3) controlling solar gain (how much sunlight gets inside).

Keeping Heat Where It's Wanted

Ensuring that any existing and future structures are properly insulated and leak-proofed (except where air intake or exhaust vents are intentionally placed) is hands down the biggest bang-for-the-buck strategy for controlling the temperature of indoor spaces. In modern construction methods, this is typically done using batts of insulative material held against the roof, floor, and exterior walls. In natural construction, this involves selecting natural construction materials and methods that are insulative. Earth-bag, cob, and clay-straw slip wall construction are both highly-insulative natural building techniques, while polewood wall construction (log-cabin style, etc) is among the least. Double-pane windows should be utilized, especially in new construction, where the payback is much more attractive than upgrading from existing single pane windows to double pane. In terms of leak-proofing, doors and windows are the primary offenders. The small cracks around the windows and under the doors add up - older structures often have enough leaks to amount to several square feet, which is the same as having a fair-sized window open all of the time. Windows should be properly sealed, and weather-stripping used to seal any door leaks.

Storing Solar Heat with Thermal Mass

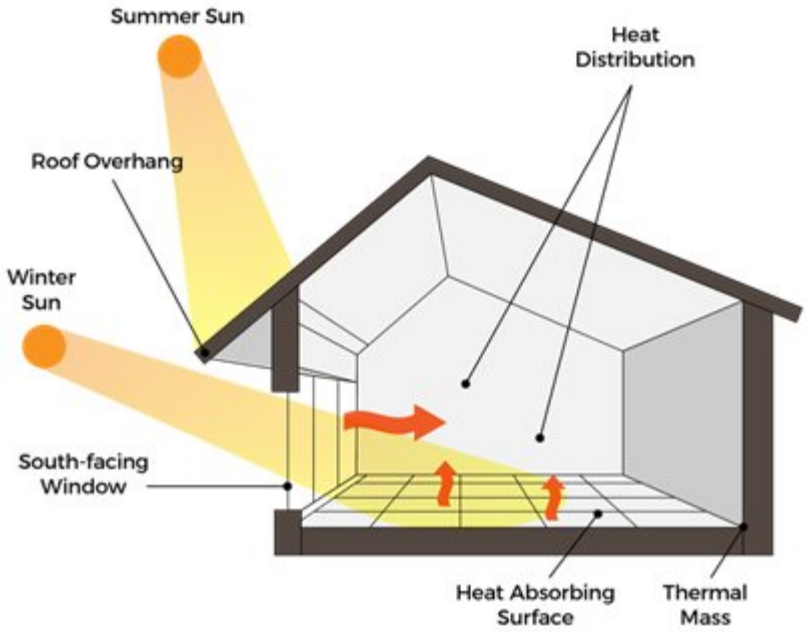
A material that has thermal mass is one that has the capacity to absorb, store and release heat energy. Its density and levels of conductivity help to keep the internal temperature of a building stable. They are generally dense materials, such as concrete, stone, brick, cob, ceramics, and water.

Objects that have thermal mass have inherent qualities for both heating and cooling. When thermal mass is used for its heating capacity, when exposed to sunlight, the thermal mass absorbs the sun's heat energy. The heat energy that is absorbed will slowly spread (conductivity) through the mass and then radiate or release the heat energy throughout the evening and night - particularly nice during the winter months. If dense objects with thermal mass are kept out of the sun, they will absorb the warmth from the surrounding air, helping to cool a space. Getting sunlight onto thermal masses during the winter months and keeping it off of them during the summer - "controlling solar gain" - are described below.

Controlling Solar Gain

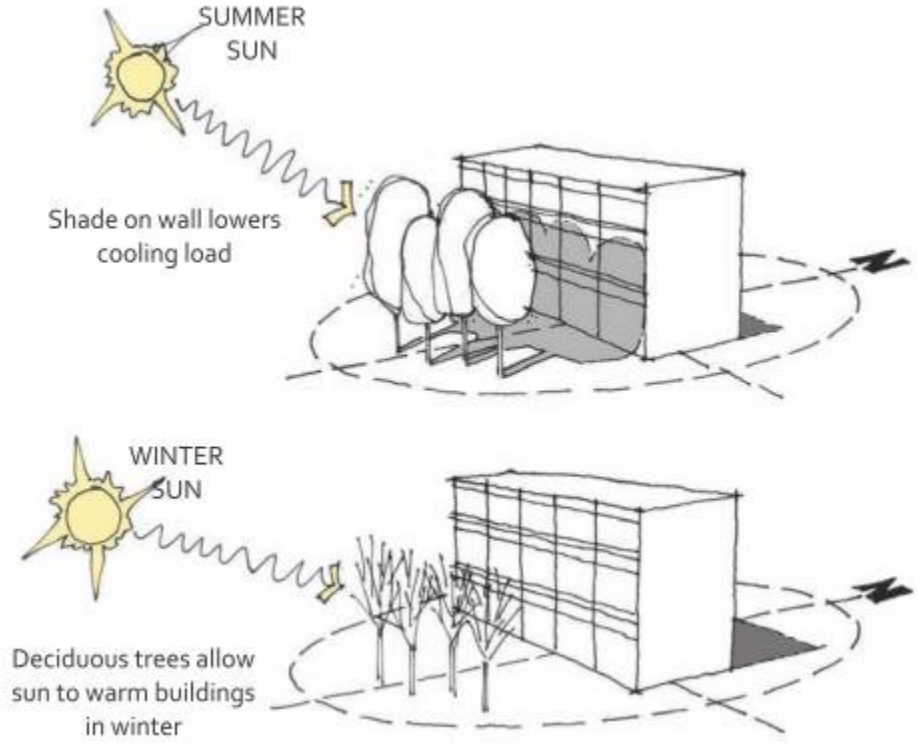
In order to get sun on interior thermal masses during the winter but keep it off during the summer, roof overhangs can be utilized to take advantage of the sun's seasonal angles. This is shown in the figure below.

Figure 7.1.4
Utilizing architecture to provide summer cooling and winter heating.



One design challenge here is that the sun is at the same angle in the spring and fall, but the fall is warmer in many areas than the spring. Deciduous trees on the south side of the structure, or a trellis over the south-facing windows with a deciduous vining plant, can be utilized here to provide sun during the spring and shade during the fall, as shown in Figure 7.1.5.

Figure 7.1.5
Using deciduous plants to provide summer cooling and winter heating.



Another design approach here is to control the size and placement of windows. Most passive solar experts recommend that the glassed area equal no more than 8 to 12% of structure's total floor area, with 70-85% of that on the south-facing wall, 10-15% on the east wall to catch morning sun, and 5-10% on the west wall to avoid overheating on hot afternoons.

More extensive resources on passive solar design are available, including the National Institute of Building Sciences web page on passive solar design[90].

Earth Tubes
Recommended for:

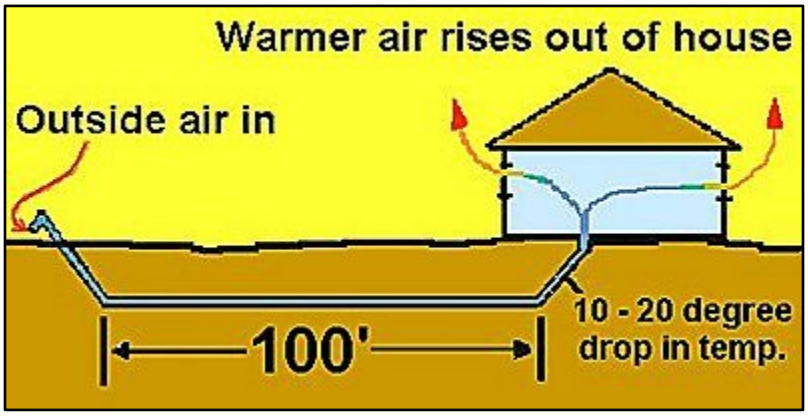
- ADUs, Woodshop, Yurt

In addition to properly siting structures to minimize cooling requirements and employing structural design strategies to maximize passive cooling and heating, subterranean earth tubes can be utilized for additional passive cooling.

This method utilizes 4" conventional, thin wall plastic sewer drain vent pipe to passively heat or cool a structure's fresh air intake with zero-energy consumption. Fresh air enters the series of non-porous pipes embedded around a structure's foundation, where it is then piped underground and heat is either transferred to it from the surrounding soil (in the case of heating) or transferred from it to the surrounding soil (in the case of cooling).

[90] http://www.wbdg.org/resources/passive-solar-heating

Figure 7.1.10
Passive cooling using subterranean tubes.



The ventilation of air from the home is necessary to ensure that suction is created at the fresh air intake and air is pulled through the system correctly. This can be achieved through the use of a solar chimney or exhaust fan, both discussed in Section 7.3. Incoming air can also be humidified and filtered by placing trays or screens of hydrated charcoal just prior to the tube's entry into the living space (this type of design has a long history in Middle Eastern countries).

Wood-Fired Stoves for Space Heating

Wood-fired stoves have been used for centuries to provide heating and cooking, however in recent years there have been significant advances in design that allow for greater heat output and lowered emissions output with less fuel input.

One company in particular is at the forefront of this progression, WoodStock Soapstone Company[91]. They have two main models, both made in the USA: the Survival model[92], shown below, which with an output of 27,294 Btuh and an efficiency rating of 79.4% heats up to 1,000 sq. ft, and their Absolute Steel model[93], which with an output of 48,000 Btuh and an efficiency rating of 77% heats up to 1,800 sq.ft.

[91] https://www.woodstove.com/index.php/wood-stoves

[92] https://www.woodstove.com/index.php/new-survival-hybrid

[93] https://www.woodstove.com/index.php/new-absolute-steel-hybrid

Figure 7.1.6
High-Efficiency Wood-Fired Stove by Woodstock Soapstone Company

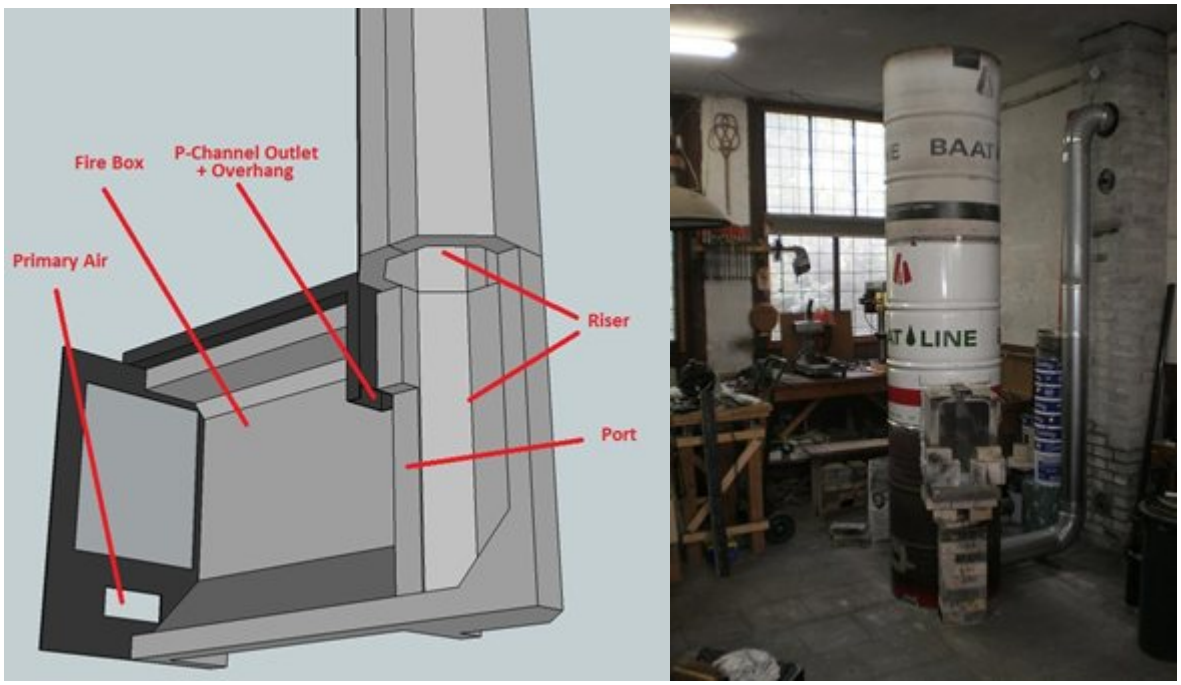
Wood-Fired Batch Box Rocket Space Heater

Recommended for:

- Woodshop

Wood rocket systems are an important technology for maximizing the use of the energy contained in wood and making it a feasible replacement for the more modern conventions of gas-fired heating. The Batch Box style of rocket heater enables a large load of wood to be set into the combustion chamber at a single given time, thus providing a long total combustion window before the stove must again be fed. This design is very efficient and burns very clean and hot. The shop heater application detailed on YouTube with the inventor Peter Vandenberg shows the double bell system capable of heating a large space quickly. These systems can be engineered to release heat quickly into a space, as shown in Figure 7.1.7 on the right, or to charge a thermal mass for long term temperature moderation.

Figure 7.1.7
Schematic of the batch box rocket stove system and a double bell, massless batch box shop heater. Images courtesy of Peter Vandenberg.



Critical to the Batch Box design's efficiency is the use of a secondary air injection channel that draws in and mixes pre-heated, oxygen rich air into a low-pressure zone at the exit from the burn chamber to the heat riser. Typically a metal tube called a P-Channel is used, although fire bricks can be utilized as well. This injection of oxygen creates a secondary combustion so complete that there is zero smoke when operating at design temperatures. Designs for Batch Box Rocket Heaters[94] are available online for free as open source plans. Dimensions and ratios must be kept very exact in building a batch box chamber, lest the burn dynamics within the chamber be degraded.

Propane-Fired Space Heaters

Recommended for:

- ADUs
- Woodshop

While the wood stove and batch box rocket heaters described above will provide heat for the ADUs and Woodshop using locally-available fuel (wood), the residents may desire an option for those moments when they'd simply like to flip a switch or turn a knob rather than build a fire. In that case, propane-fired heaters are recommended.

There are many options for the ADU that will ultimately depend on the layout of the space. A forced air furnace is the typical choice for gas-fired indoor heating, especially in large structures with many rooms; however, in a smaller space like the ADUs, especially if it has a relatively open floor plan, indoor vent-free radiant heaters are a smaller, more efficient option that can be easily stored during

[94] http://batchrocket.eu/en/designs

the warmer periods to free up space. The Mr. Heater Blue Flame Catalytic Heaters[95], shown below, are available in 10,000, 20,000, and 30,000 Btuh models, for heating up to 300, 700, and 1,000 sq. ft., respectively, and can either sit on the floor or be mounted on the wall in a central location.

Figure 7.1.8
Mr. Heater Indoor Catalytic (Vent-Free) Propane-Fired Heater

The same heater is recommended for the woodshop for moments when supplemental heat is desired at the turn of a knob.

DC Electric Motor-Driven Compression Refrigerators/Freezers

Recommended for:

- ADUs

Refrigerators and freezers remove heat from a small, enclosed space for the preservation of organic materials like food or medicine. For the ADUs, refrigerators with DC-powered compressors that can be hardwired to the ADU off-grid battery bank are recommended. Further information on these are provided in 7.3 - Refrigerant. For grid-tied structures, refrigerators with conventional AC-powered compressors are recommended.

Water Heating

Hot water for bathing, clothes- and dish-washing, while not a necessity, is a luxury most would have a hard time sacrificing. In modern home design, hot water systems are often very energy intensive in order to ensure that hot water is available 24/7/365 in all locations throughout the home with no input on the part of the landowner besides a monthly payment to the gas company and replacement of a water heater every 10 years. If there is a need to have hot water available in this way, there isn't

[95] https://www.tractorsupply.com/tsc/product/mr-heater-vent-free-30-000-btu-liquid-propane-blue-flame-heater-f299730?cm_vc=-10011

a whole lot of opportunity for reducing energetic and environmental footprint besides utilizing on-demand water heaters. However, if expectations and habits can shift in such a way that a resident can bundle their primary hot water needs into a block every evening, and plan ahead enough during the overcast days enough to gather a few small sticks, light a fire, and wait 30 minutes for that hot water, it becomes possible to not only have hot water with a small fraction of the energy used in a conventional system, but to utilize local energy sources in obtaining it.

Propane-Fueled Tankless-Style Water Heaters

Recommended for:

- ADU
- Outdoor Kitchen

Propane-fueled tankless-style water heaters are recommended to provide hot water to the anticipated low-use (<40 gallons per day) locations listed above. Modulating models that can accept preheated water are recommended if solar-preheated water will be supplied to the water heaters (see below).

Solar-Fueled Water Preheating Using Heat-Exchanging Panels and Storage Tank

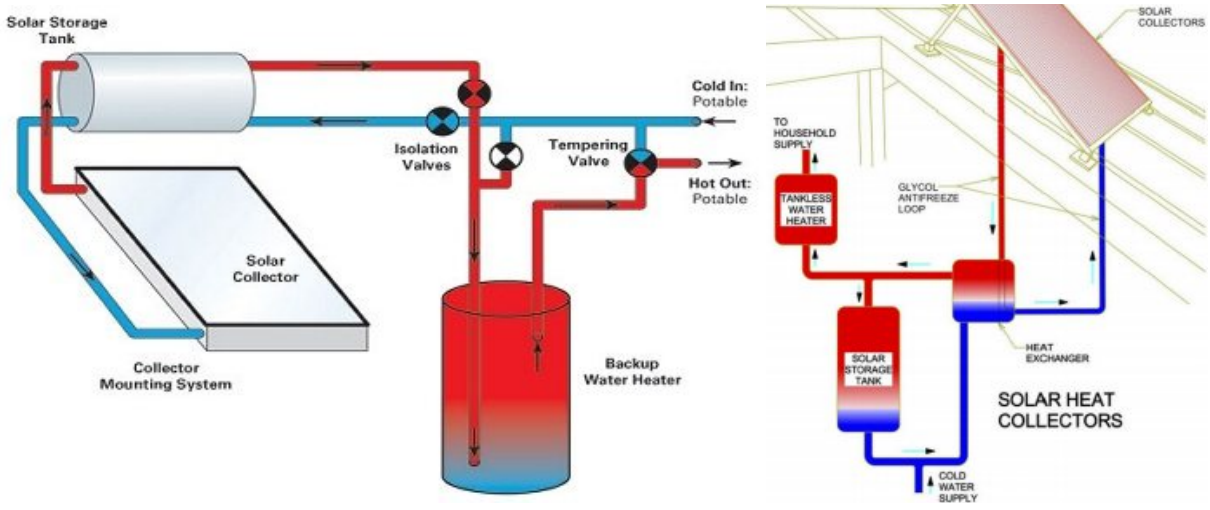
Recommended for:

- Main Residence, ADU

Roof-mounted solar water heating panels configured with storage tanks, as illustrated in Figure 7.1.9, should be installed to provide preheated water to the locations listed above.

Figure 7.1.9

Left: Open-loop system using tank-style water heater, Right: open-loop system using tankless water heater (Image Credit: RCM CAD Design)



When the sun is shining, water in the storage tank will be preheated. In a properly-designed system, water temperatures in the storage tank can exceed 120°F after a typical sunny day, and no additional propane-fired water heating is necessary. A tempering valve should be used downstream of the preheat water tank to limit outlet temperatures to 120°F.

With this arrangement, the more that residents can consolidate their hot water use into the late afternoon and early evening, the greater the propane use reduction for the water heaters will be.

Wood-Fired Rocket Mass Water Heater

Recommended for:

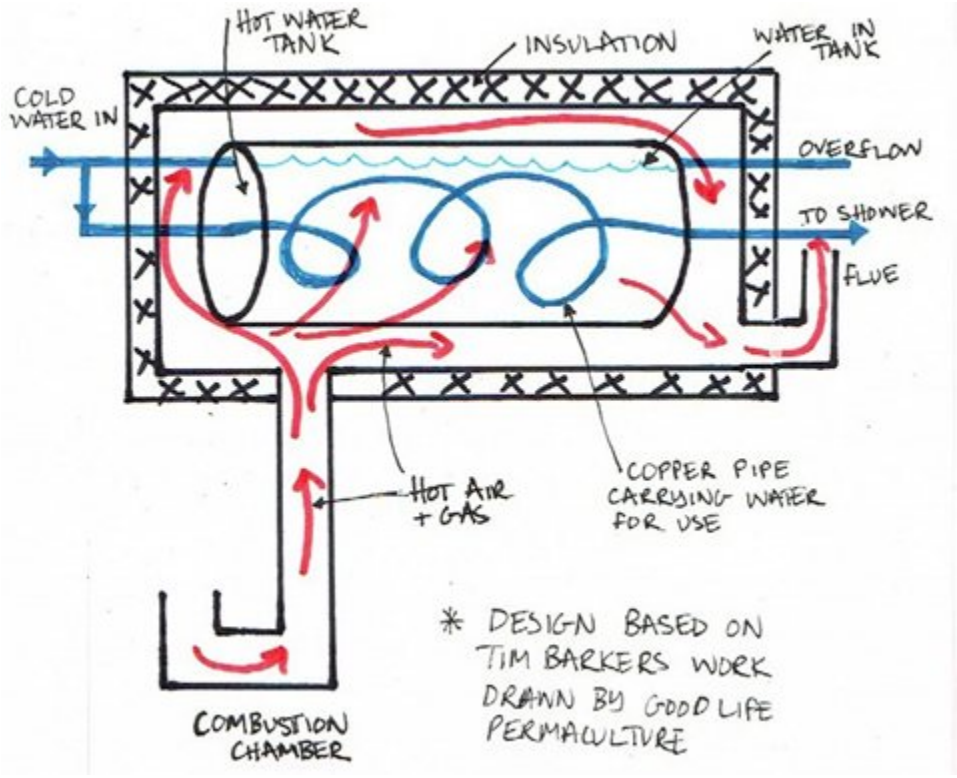
- Outdoor Kitchen

As an alternative to the propane-fueled on-demand water heater recommended for the Outdoor Kitchen above, a wood-fired rocket mass water heater can be used.

Rocket mass water heaters function by heating a large mass of unpressurized water with the hot exhaust. The heat from this water mass is then transferred to pressurized water contained within an internal copper coil. Figure 7.1.10 below details the schematic for such a system. Geoff Lawton's video walkthrough[96] of the system in use at Zaytuna Farm provides an excellent overview of how the system works.

Figure 7.1.10

Rocket stove hot water heater schematic. Note how the heated water is contained in a non-pressurized container, thereby eliminating the risk of explosion. Credit to Tim Barker for the design and Good Life Permaculture for the drawing.



Preheating to the unpressurized water mass can be achieved by circulating water from the unpressurized water mass through a solar hot water heating panel using a solar PV-powered

[96] https://youtu.be/1oDpmmsqHwQ

electric pump. This is only cost-effective if hot water is regularly used at the location (multiple days per week).

Figure 7.1.11
Integration of solar hot water heating system with rocket-heated unpressurized water mass.

7.2 Moving Things

Moving things typically includes spinning fans and motor parts, compressing gases in refrigerators, pumping water, and raising and lowering objects. This is most often achieved by making a shaft spin in a motor or pump, and then translating that rotational energy into linear force or a pressure change. Electricity is the most common power source for this, but fluids (liquid and gaseous) such as water, compressed air, or wind will also do the job. Internal combustion engines, steam, and other turbines are also commonly used to move things, as well as human and animal muscles.

Existing Conditions

The existing systems for moving things onsite include:

- Water:
  - Electricity-powered well and booster pumps
- Animal and material transportation:
  - Personal vehicles; diesel fuel-powered tractor
- Maintenance tasks:
  - Diesel fuel-powered tractor
  - Various human-, electricity-, and liquid fuel-powered equipment
- Refrigerant:
  - Electricity-powered compressor motors
- Air:
  - Electricity-powered fans

Recommendations

Recommendations for systems to move things that are site-wide and not space-specific include:

- Water: solar PV-powered well pump capable of pumping to proposed new water tank(s) location

Recommendations for moving things that are space-specific are summarized in Table 7.2.1 below.

Table 7.2.1
Recommended systems for moving things at WFH

Space	Refrigerant (refrigeration)	Air
ADUs	Electricity-powered compression refrigerator*	None
Woodshop	None	Solar chimney and electricity-powered exhaust fan

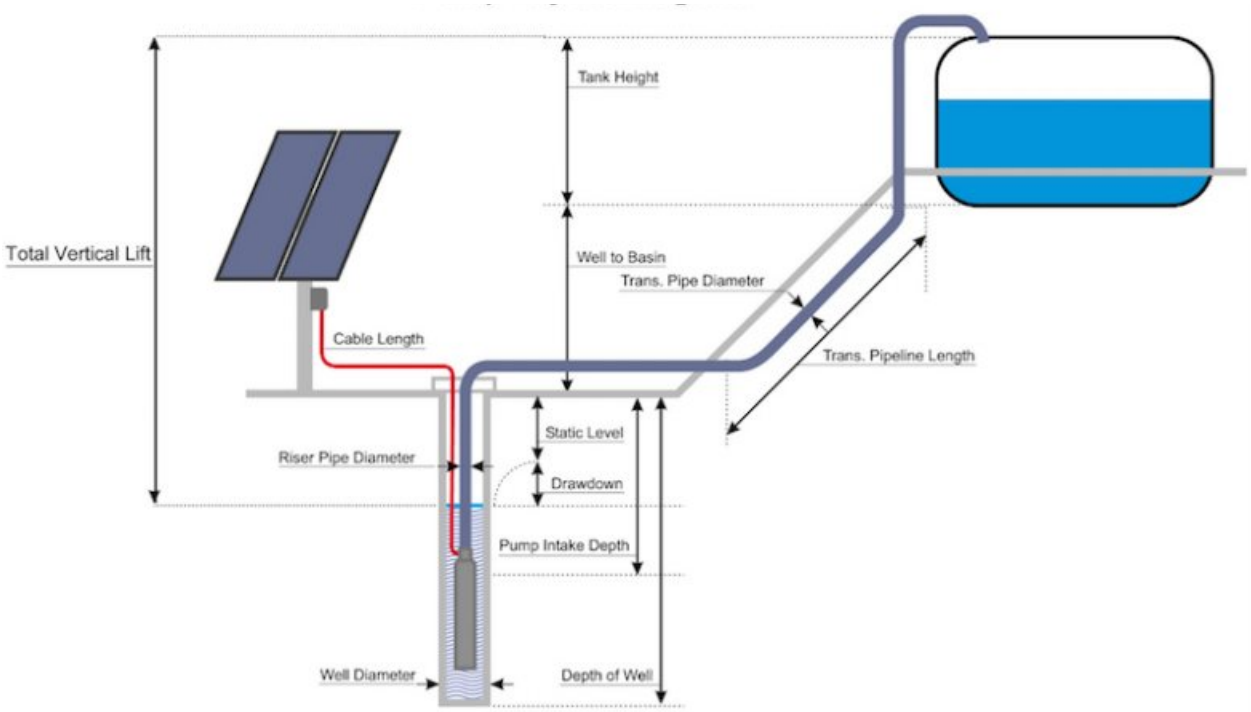
Water

DC Electric Motor-Driven Well Pump Powered by Solar PV Array

An appropriately-sized direct current (DC) submersible well pump powered by a solar photovoltaic array mounted on top of the well utility shed is recommended to supply domestic water from the well to the water tank(s) in their proposed location. Utilizing a solar PV array to pump water to an elevation where it can be stored in tanks and then distributed to the various property end-uses via gravity eliminates the need for batteries (so long as enough storage is available to serve the property during extended rainy and overcast periods) and provides the greatest level of water security that can be had from a well. There will be no interruptions to the water supply during grid-related power outages and no recurring cost (beyond the initial cost of the pump and panels).

If a solar PV array is chosen to provide water pumping, a well pump driven by a direct current (DC) motor is recommended, as it will eliminate the typical inefficiencies that result from inverting the direct current produced by solar PV array to the alternating current required for typical well pumps. The water storage system should be sized to provide water to the critical property end-uses (residences) for an extended period of rainy/overcast weather - 3 weeks of winter water requirements (which likely is close to 1 week of summer use due to summer irrigation requirements) is recommended at a minimum. This solar photovoltaic system could potentially be integrated with the recommended ADU rooftop-mounted solar PV array as well (see Section 7.3) to provide additional power to the ADUs when the tanks are topped off.

Figure 7.2.1
Configuration of a solar PV-powered water pumping and storage system. Image by Backwoods Solar.



Alternatively, if using the electrical utility grid connection to pump water is desired instead of an off-grid system, an AC motor-driven well pump should be used.

Refrigerant

DC Electric Motor-Driven Compression Refrigerators/Freezers Hardwired to Battery Bank in Off-Grid Structures

Recommended for:

- ADUs

Appropriately-sized direct current (DC)-powered compressor refrigerators and freezers, powered by the recommended ADU solar photovoltaic system-charged DC battery bank (see Section 7.3), are recommended to provide for refrigeration needs in the ADUs. Utilizing a DC refrigerator will eliminate the typical inefficiencies that result from inverting the DC produced by batteries to the alternating current required by most refrigerators.

Figure 7.2.2

Left: SunDanzer 10.2 cubic foot Upright DC-powered refrigerator (also available in 15 cubic foot). *Right:* SunDanzer 8.0 cubic foot chest refrigerator (also available in 1.8 cf and 5.6 cf, and all sizes in freezer models)

Air

Ventilation is the intentional introduction of outdoor air into a space. Ventilation is mainly used to control indoor air quality by diluting and displacing indoor pollutants; it can also be used to control indoor temperature, humidity, and air motion to benefit thermal comfort.

The intentional introduction of outdoor air is usually categorized as either mechanical ventilation, natural ventilation, or mixed-mode ventilation (hybrid ventilation).

- Mechanical (active) ventilation is the intentional fan driven flow of outdoor air into a building. Mechanical ventilation systems may include supply fans (which push outdoor air into a building), exhaust fans (which draw air out of a building), or a combination of both. Mechanical ventilation is often provided by equipment that is also used to heat and cool a space.
- Natural (passive) ventilation is the intentional passive flow of outdoor air into a building through planned openings (such as louvers, doors, windows, and earth tubes). Natural ventilation does not require mechanical systems to move outdoor air. Instead, it relies entirely on passive physical phenomena, such as wind pressure, or the stack effect (movement of air using temperature differential). Natural ventilation openings may be fixed, or adjustable. Adjustable openings may be controlled automatically (automated), controlled by occupants (operable), or a combination of both.
- Mixed-mode ventilation systems use both mechanical and natural processes. The mechanical and natural components may be used at the same time, or at different times of day, or in different seasons of the year. Since natural ventilation flow depends on

environmental conditions, it may not always provide an ideal amount of ventilation. In this case, mechanical systems may be used to supplement or regulate the naturally driven flow.

Solar Chimney

Recommended for:

- ADUs, Woodshop, Yurt

A solar chimney is a type of natural (passive) exhaust system that can be used, when coupled with an intake, to maintain a consistent introduction of fresh air into a structure. In its simplest form, the solar chimney consists of a black-painted chimney. During the day, solar energy heats the chimney and the air within it, creating an updraft of air in the chimney. The exhaust of air out of the chimney will create negative pressure in the structure, and thus a suction of fresh intake air at any other openings. The intake openings can be thoughtfully situated and designed to provide cooled intake air when desired (by placing operable windows or vent openings on the north-facing shady side of the structure, or using earth tubes).

Figure 7.2.3

Solar chimney. Image: Energy Education California

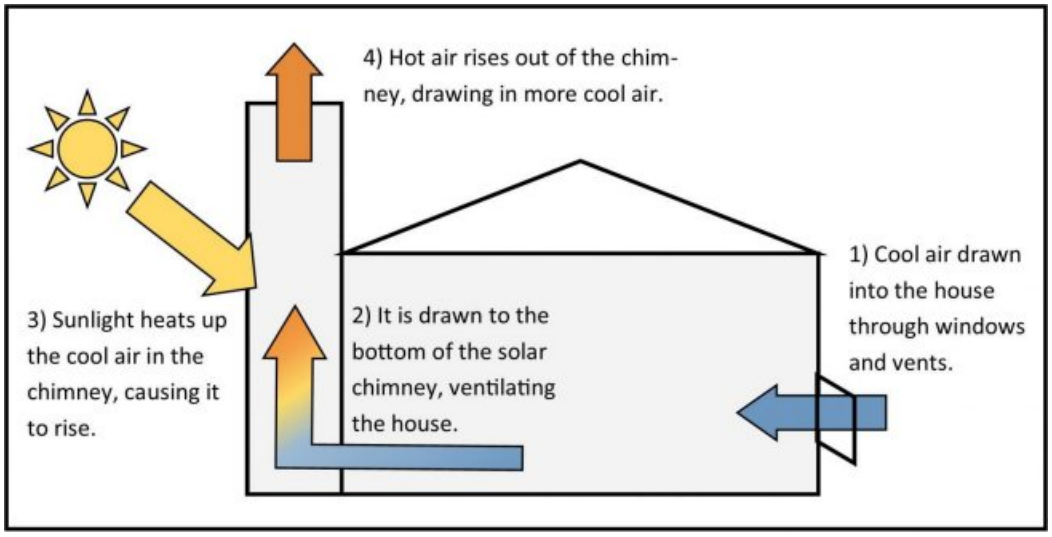
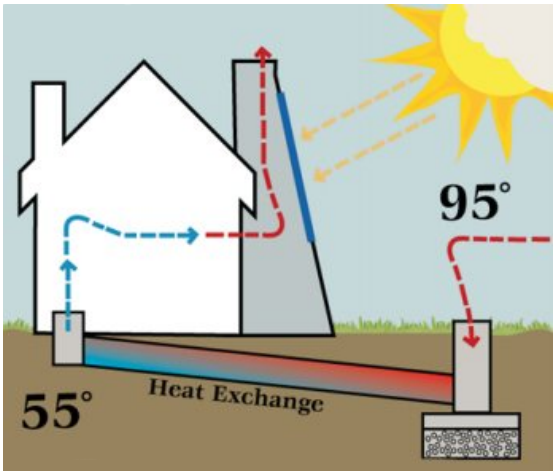


Figure 7.2.4 illustrates the integration of an earth tube system with a solar chimney to provide cooling for a structure.

Figure 7.2.4
Solar chimney integrated with earth tubes. Image: Energy Education California



For the ADUs and Woodshop, roof-mounted solar chimneys are recommended to provide exhaust. Earth Tubes and/or an operable intake(s) on the north side of the structures will bring in cool air when desired; earth tubes and/or an operable intake(s) on the south side of the structures will bring in warmed air when desired. Operable intakes could be doors that are propped open, windows, or vents.

Supplemental exhaust can be provided by a switch-operated exhaust fan, described below.

Electric Motor-Driven Exhaust Fans Hardwired to Battery Bank in Off-Grid Structures

Recommended for:

- ADUs, Yurt, Woodshop

Small DC electric motor-driven fans installed in-line with the solar chimneys (or roof vents) and hardwired to the ADU off-grid battery bank are recommended to provide supplemental ventilation for the ADUs and Yurt. These fans can be turned on using a simple wall switch if a higher air exchange rate than the solar chimney provides is ever desired.

For the grid-tied Woodshop, an AC electric motor-driven exhaust fan powered by the grid connection should be used in a similar fashion.

7.3 Moving Electrons

Electricity is the primary energy form here, and it's doing tasks that are almost impossible to do in other ways, such as computing and communicating over long distances.

Existing Conditions

A utility-supplied AC grid connection is available at WFH, which is currently run to the well house and Main Residences to power all electricity-using lighting, appliances, and personal communications and computing equipment.

Installation of a PV array on the knoll above the Main Residence is in progress - this PV array will be tied to the grid and net-metered.

Recommendations

The anticipated needs for moving electrons as the development of WFH include:

- Electricity supply to lighting, devices, and equipment in future ADUs, Classroom Zone (Outdoor Kitchen and Yurt), Woodshop
- Increased electricity security (on-site production and storage in the event of grid-failure)

The following is recommended at WFH:

Table 7.3.1
Recommended systems for moving electrons at WFH

Space	Main Residence	Woodshop	ADUs	Classroom Zone (Outdoor Kitchen and Yurt)
Electricity Generation	Solar PV array on knoll above main residence to supplement existing grid connection, propane generator backup Tied into existing grid connection		Solar PV array on ADU roof, backup power from grid connection and propane generator	
Electricity Storage	Grid-tied battery bank for load-shifting and backup		Off-grid battery bank (housed in Well House)	
Interior and Exterior Lighting	AC-powered LED lamps		DC-powered LED lamps (hardwired to battery bank)	
Devices and Appliances	AC-powered devices wherever possible		DC-powered devices and appliances (hardwired to battery bank) wherever possible; AC appliances wired to inverter	

Electricity Generation

Solar PV Arrays
Recommended for:

- Knoll above Main Residence

- ADU Roof

Solar photovoltaic (PV) arrays are recommended at the locations noted above to generate electricity from the on-site solar resource.

The recommended solar PV array on the knoll above the Main Residence will be tied in with the grid connection and net metered.

The recommended PV array on the ADU roof will supply power to the off-grid battery bank in the well house and the lighting, appliances, and devices used in the ADUs and Classroom Zone (Outdoor Kitchen and Yurt). If the energy system recommendations in this chapter are followed (wood/gas heating and cooking, passive cooling, DC-powered lighting, devices and appliances hardwired directly to battery bank where possible), a single 1,000-2,000 watt array is estimated to be sufficient to cover daily electrical needs of all three spaces (more will be required if electricity-powered DX cooling is used in any spaces). The exact system voltage, wattage, and wiring configuration recommended for each location is dependent upon several factors, and can be specified in a Level 3 energy system implementation planning phase.

An additional PV array installation is already in progress above the Main Residence, and will be tied to the grid for net-metering.

Propane Generator for Backup Battery Bank Charging

Recommended for:

- Main Residence proposed battery bank
- ADU off-grid battery bank

A generator is recommended as yet another level of power generation redundancy to provide battery bank charging in the event of a grid failure and solar array failure or prolonged periods of overcast skies. A generator is a machine that converts rotational energy (typically produced by an internal combustion engine) into electricity. There are two main types of generators: conventional and inverter. Conventional generators provide AC electricity directly, although it can be of poor quality under constantly varying loads (like variable speed motors or loads turning on and off quickly) and poor efficiency under part load, while inverter generators produce very clean high quality AC power for varying loads and operate with relatively constant efficiency. Both generators are comparably efficient at full load. Conventional generators are also cheaper, more simple to repair, louder, and bulkier than inverter generators.

Figure 7.3.1

Left: Conventional generator, and *Right:* Inverter Generator. Images by Sportsman Generators

Generators are also mainly available in three different fuel types: gasoline, diesel, and propane (there are also dual-fuel models available that run on both gasoline and propane). These are compared in Table 7.3.1 below.

Table 7.3.1

Comparison of generator fuel types.

Fuel Type:	Gasoline	Diesel	Liquid Propane Gas
Cost	Low	Slightly higher on a per-watt basis, but not available in lower-wattage outputs	Low
Fuel System Installation and Storage Cost	Varies (low cost in small sizes)	Varies (low cost in small sizes)	Moderate (if adequately sized tank already at site)
Fuel Storage Duration	Low	Low	High
Fire and Safety Concerns	High (highly flammable, vapors poisonous)	Low (high flash point)	Low-Moderate (rare leak or tank explosion risk)
Environmental Impacts	High (spill risk, exhaust not clean)	High (spill risk, exhaust not clean)	Low (clean burning)
Fuel Availability	Moderate (easy to purchase)	Moderate (must be delivered and stored)	Moderate (must be delivered and stored
Cold Starting and Operation	Poor (forms gum deposits)	Moderate (hard starting at cold temperatures)	Excellent (no tank vaporization issue)

Engine Life and Durability	Poor/Moderate (depends on engine type)	Excellent	Moderate

7th Generation Design generally recommends propane-fueled generators due to their low cost, ability to store fuel indefinitely, and relatively clean-burning exhaust.

To charge the battery banks and power any DC devices hardwired to the battery bank (in the ADUs, Woodshop, and Classroom Zone) using the generator, a converter/battery charger will be required.

Electricity Storage

Install Battery Banks

Recommended for:

- Main Residence (grid-tied)
- Well House (for off-grid battery bank serving ADUs, Classroom Zone)

Battery banks are recommended to store the energy generated by the solar arrays during sunny periods and utility connection during off-peak periods (or the propane generator, during outages and prolonged periods of overcast weather).

When integrated with a grid-tied structure (like the Main Residence and Woodshop), energy can be drawn from the batteries for on-site end uses when utility time-of-use on-peak rates are higher in order to reduce costs. This time-based shifting of energy sources in order to maximize off-peak electricity rates is called "load shifting". A battery bank used in this type of system can also provide backup electricity storage in the event of power outages, which are becoming more common in this era of utilizing rolling blackouts as wildfire prevention. A unique type of inverter called a "storage-ready" or "hybrid" inverter, like the Outback SkyBox Hybrid System[97], may be required to take advantage of load-shifting depending upon which battery bank system is used in a grid-tied setting.

The battery bank serving the off-grid structures (ADUs, Classroom Zone) can be configured to an automatic transfer switch to provide automatic backup charging of the batteries using the grid power supply if the battery level gets too low (during prolonged periods of overcast weather, or in the event of solar array failure).

Most battery bank systems in recent decades were constructed with lead-acid batteries. However, the use of much longer-lived, though initially more expensive nickel-iron batteries is recommended at WFH to create a battery bank with a near indefinite lifespan. Nickel iron batteries were first patented by Thomas Edison in the early 1900's, and have been around for the past century in a number of different industrial applications. They have been enjoying a resurgence amongst off-gridders and homesteaders in recent years. Nickel iron batteries have incredibly long lifespans when properly cared for, some are still operating today from the 1940's. Nickel-iron batteries can also handle repetitive deep discharges, up to 80% with no ill-effect on battery life (as compared to the 50% recommended for lead-acid batteries, meaning a smaller capacity bank can be used), as

[97] https://www.outbackpower.com/products/true-hybrid-energy-system/skybox

well as overcharging, and they operate well in both extreme cold and extreme heat. For more information regarding the design and emplacement of Ni-Fe battery banks, visit IronEdison.com[98].

Figure 7.3.2
Iron Edison Nickel Iron Battery Bank

Another option worth looking into is the Lithium Iron RE-Volt battery manufactured by Iron Edison. The RE-Volt is a sealed, maintenance-free battery solution with 20-year life expectancy, and is completely recyclable upon end-of-life. An integrated battery management system prevents damaging overcharging or over discharging. Up to fifteen batteries can be paralleled, providing up to 150 kWh of capacity.

Figure 7.3.3
Iron Edison ReVolt Battery Bank

Interior and Exterior Lighting

LED Light Bulbs
Recommended for:

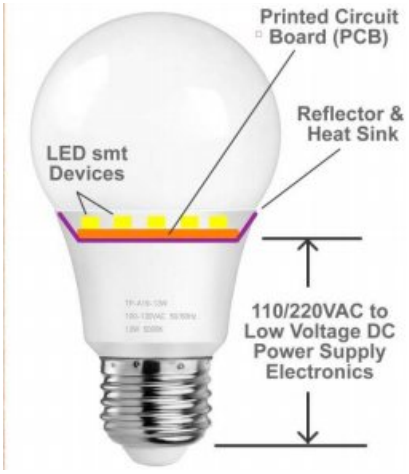
[98] Iron Edison Nickel-Iron Batteries: https://ironedison.com/nickel-iron-ni-fe-battery

- Primarily AC grid-powered structures (Main Residence): conventional AC LED lamps with built-in converter
- Primarily off-grid battery bank-powered structures (ADUs, Woodshop, Classroom Zone): DC LED lamps hardwired to battery bank

Light Emitting Diode (LED) lamps use approximately 90% and 30% less energy than comparably bright incandescent and fluorescent lamps, respectively, and have a lifespan that is many times longer. The LEDs in all LED lamps run off of direct current electricity (DC). In a house wired for the AC, LED lamps with a built in converter that converts the AC supplied to the fixture to the DC required by the LEDs must be used, at an efficiency cost. Since most houses are wired for AC, this is the type of LED lamp typically found in stores. Figure 7.3.4 illustrates the parts of an LED lamp with this built-in converter.

Figure 7.3.4

Conventional LED light bulb showing large portion of unit dedicated to converting from 110VAC to DC. Necessary for a grid-tied structure, but introduces unnecessary efficiency losses in a battery-powered application.



In a battery-powered off-grid application, the DC-driven LED can be powered directly from the DC battery bank, eliminating any inversion (DC to AC) or rectification (AC to DC) inefficiencies and thus reducing the battery bank and solar PV size requirements. LED light fixtures designed to be hardwired directly to a battery bank, like the one shown in Figure 7.3.5, are not typically found in stores, but can be found online.

Figure 7.3.5

DC LED light fixture designed to be wired directly to a DC battery bank in an off-grid application, eliminating losses through the inversion from battery bank DC to 110VAC and subsequent conversion back to DC.

Any incandescent and fluorescent lamps in existing structures powered by the site AC grid connection should be replaced with more energy-efficient and longer-lasting LED lamps with the built-in converter upon reaching end of life. Retrofitting existing lamps with LEDs typically pays for itself in 2-5 years with the reduced utility and maintenance costs.

In proposed structures that will be powered by solar PV-charged battery banks, light fixtures with DC-powered lamps that are hardwired directly to the battery bank should be used.

Devices and Appliances

Most if not all computing and communications devices (including computers and phones) run off of direct current electricity (DC). In a structure supplied with and wired for grid AC, "rectifiers" (also sometimes called transformers, converters, or power supplies) must be used to convert the AC supplied to the outlet to the DC required by the devices, at an efficiency cost. These are the black "wall warts" found at the end of the power cords for older devices, the hot and heavy plastic-encased units found spliced into the middle of computer charging cords, and the universally-recognized square white wall plug used to charge a certain manufacturer's cell phones and tablets.

Figure 7.3.6
Conventional device charging unit showing large portion of unit dedicated to converting from 110VAC to DC. Great for a grid-tied structure, but introduces unnecessary efficiency losses in a battery bank-powered off-grid structure.

Since most houses are wired to the AC-grid, nearly all devices come out of the box ready to accept an AC power supply and rectify it to DC. However, in a structure wired with a DC power supply (like a battery bank, solar PV array, or both), these rectifiers can either be bypassed or devices designed specifically for a DC power supply can be chosen. These devices are often marketed to the RV world, where battery banks are consistently found.

USB-Powered Devices Hardwired to Battery Bank in Off-Grid Structures

Recommended for:

- Off-grid structures (ADU, Classroom Zone)

Any device with a charging cord that has a USB plug requires 5VDC. These are often cell phones, tablets, small speaker units, flashlights, and other smaller devices. In a battery-powered structure (ADUs and Classroom Zone), USB charging outlets that are hardwired directly to the battery bank and convert the battery bank voltage to 5VDC should be used, like the one in Figure 7.3.7 below.

Figure 7.3.7
DC USB charging wall fixture designed to be wired directly to a DC battery bank, eliminating losses through the inversion from battery bank DC to 110VAC and subsequent conversion back to DC.

Computers, TVs, Modems, Routers, Cordless Tools, etc. Hardwired to Battery Bank in Off-Grid Structures

Recommended for:

- Off-grid structures (ADU, Classroom Zone)

The 12VDC automotive socket is another fairly standardized DC charging plug that can supply more power than USB plugs, the levels of power required for laptop charging, TVs, etc. These 12VDC automotive sockets can be installed at various locations in an off-grid structure much like the typical AC outlet and hardwired to a battery bank. A 12VDC automotive socket (with additional USB sockets) designed for installation in a wall or cabinet is shown in Figure 7.3.8.

Figure 7.3.8

An eTrailer.com 12VDC automotive socket and 5V USB socket wall fixture designed to be wired directly to a DC battery bank, eliminating losses through the inversion from battery bank DC to 110VAC and subsequent conversion back to DC.

As a result of (currently) low demand, almost no major computing device manufacturers make power supply cords that utilize the 12VDC automotive socket, instead providing cords for AC grid-connected outlets. Utilizing these with a DC battery bank requires both inversion from DC to AC and then rectification from AC to DC, at a significant efficiency cost. Fortunately, some third-party manufacturers have designed prefabricated units that plug into a 12VDC automotive socket and convert from the 12VDC supplied by the battery bank to the DC voltage required by the device, with the appropriate charging plug required by the device. Two of these units are shown in Figures 7.3.9.

Figure 7.3.9

(Left): A Gissaral charging unit designed to charge an Apple Laptop directly from a 12VDC automotive socket. *(Right)*: A Padarsey charging unit designed to charge laptops (and other devices, like modems) from a wide variety of manufacturers from a 12VDC automotive socket.

Several tool manufacturers have also developed cordless tool DC-to-DC battery chargers that utilize 12VDC automotive sockets, eliminating the losses through the inversion from battery bank DC to 110VAC and subsequent conversion back to DC required if using a typical AC outlet-powered charging unit with an off-grid system. One such unit is shown in Figure 7.3.10

Figure 7.3.10

A DeWalt charging unit designed to charge DeWalt 20V cordless tool batteries directly from a 12VDC automotive socket.

AC Devices Powered by Pure Sine Wave Inverter

Recommended for:

- Off-grid structures (ADUs, Classroom Zone)

There are some appliances that have not yet been designed or manufactured for a DC power source. These include clothes washing machines, clothes dryers, and specialized equipment.

In any existing grid-tied structures, AC devices can be utilized as normal.

In any proposed off-grid structures, an inverter can be used to invert the DC supplied by the batteries to AC. There are two types of inverters: modified sine wave and pure sine wave. Pure sine wave inverters are the more expensive of the two, but produce a better quality output (minimizing risk of damage to electronics) at a higher efficiency, and thus are recommended by 7th Generation Design for all applications.

An inverter can be purchased as a standalone unit, like the unit shown below, or in combination with an AC-to-DC charger, allowing for charging of the batteries by a generator or grid connection.

Figure 7.3.11
AIMS 48V 1500W Continuous/3000W Peak Pure Sine Wave Inverter

8. Economy

Economy here refers to all of the elements and the relationships between them (combined to form enterprises) that serve to generate surplus (wealth) in order to provide for a certain desired quality of life in a given place. Special attention is given to the unique advantages present within any landscape - the things it is innately "good at", the processes that want to happen, and the ecosystems that want to grow - and aligning those characteristics with the forms of production detailed in the Minimum Holistic Goal to create a quality of life that is at once desirable and sustainable. Truly sustainable economic systems by definition must be regenerative, in that they create greater capacity for life expression as a result of their existence. In this way the three guiding ethics of permaculture, Care of the Earth, Care for People and Reinvestment of Surplus towards those first two ends can be realized.

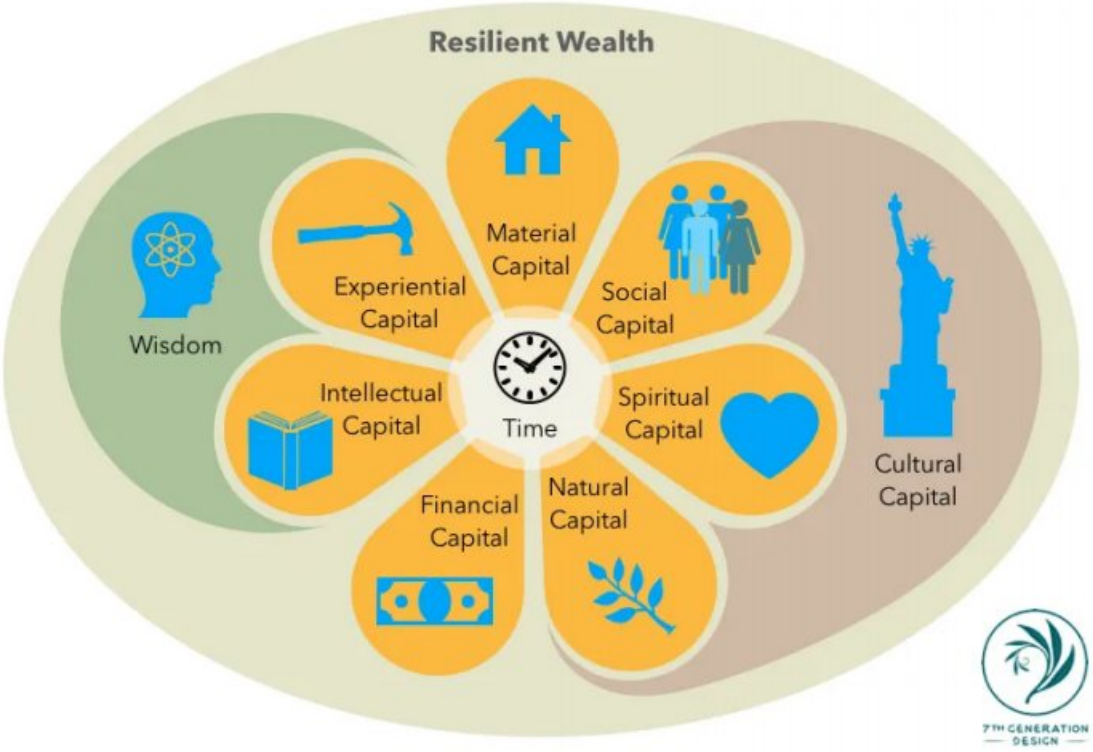
Wealth and the 8 Forms of Capital

The function of any enterprise is to create wealth, which is defined here as having access to required forms of capital when needed on the path to realizing an individual's, group's, or project's purpose. Ethan Roland of Appleseed Permaculture identified 8 primary forms of capital that can be acquired through any enterprise. They are, as described by Toby Hemenway in his book "The Permaculture City",:

- **Material Capital** – the raw and processed non-living resources, such as rock, lumber, buildings, tools, fuel, and so forth, as well as stored up goods that our activities generate.
- **Intellectual Capital** – what we know and have learned; the stored knowledge and ideas that are available to us.
- **Experiential Capital** – "street smarts" or the "school of hard knocks", this is the difference between what a novice and a master knows. This is Grandma's biscuit recipe, for which there is no recipe, only the feel of the dough in the hands.
- **Cultural Capital** – the shared art, music, myths, stories, ideas, and world views of a community; collectively held as a holistic sum of individual beliefs, thoughts and actions.
- **Social Capital** – the goodwill from others that your service to your community creates, the favors you owe and are owed, and the connections and network that you have.
- **Natural Capital** – plants, animals, soil, and the collective properties of ecosystems, such as purifying and circulating water and storing nutrients.
- **Spiritual Capital** – our capacity to live into the fullest, most authentic expression of ourselves, and our ability to connect with and receive guidance from something greater than ourselves.
- **Financial Capital** – the money, currency and other financial assets we have acquired.

The 7th Generation Design twist on his concept is illustrated in Figure 8.0.1.

Figure 8.0.1
The 8 Forms of Capital as interpreted by 7th Generation Design



Financial capital is the predominant form of capital recognized and valued in modern society, and will undoubtedly be required on some level in the from-scratch development of any regenerative system. As such, enterprises with either a primary or initial focus on generating financial capital are primarily discussed in this chapter. However, these enterprises have the opportunity to generate far more than financial capital, and as GFR and its elements and ecosystem develops, the need for financial capital will likely decrease and these primary forms of capital generated by the proposed enterprises may shift.

Enterprise Planning

Much like with any system that involves multiple elements that relate to each other, taking the time to properly design, test, and iterate an enterprise is critical in ensuring that the relationships between the various elements are maximally beneficial with regards to creating the desired outcome. Below are some of the different methods for visioning, planning and organizing enterprises that abide by the permaculture ethics; Care for the Earth, Care for People, Reinvestment Of Surplus into Earth Care and People Care.

The Chaordic Stepping Stones

The Chaordic Stepping Stones is a spiral planning process that helps create the minimal structure needed to start and complete a successful project - whether that be a home garden or a business enterprise. Excess structure often retards innovation and contribution, overloads certain individuals/components, and stifles learning, while too little structure can lead to ineffective and uncoordinated action, overwhelm and frustration. Both too little and too much structure can mean

the end of even the most well-intentioned project. Below are the nine steps that comprise the Chaordic Process, a description of each, as well as the objective for each step.

1. **Need: The compelling reason for doing anything. It is the thing served by the work you will be doing.**
    1.1. **OBJECTIVE:** *Create a condensed Need Statement that clarifies the reason for which any project is being undertaken.*
2. **Purpose: From the need flows the Purpose.**
    2.1. **OBJECTIVE:** *Create a concise Statement of Purpose for this project/organization.*
3. **Principles: Crisp, co-owned and well understood statements of how we agree to operate together.**
    3.1. **OBJECTIVE:** *Create a list of the Principles that govern your team's decisions, actions and methods of communication.*
4. **People: Map the network of people involved and that need to be brought in.**
    4.1. **OBJECTIVE:** *Create a 'people map' for the project, complete with names, needs and feedback loops.*
5. **Concept: A high level look at the shape and patterns of our endeavor.**
    5.1. **OBJECTIVE:** *Establish procedures for conducting meetings and brainstorm patterns of workflow.*
6. **Limiting Beliefs: Questions the unquestioned models of behavior that may limit us fulfilling our true potential.**
    6.1. **OBJECTIVE:** *Acknowledge potential pitfalls in advance, commit to help all team members overcome limiting beliefs.*
7. **Structure: Create the structure that will channel our resources - time, money, energy, commitment, zones of stewardship, and attention etc.**
    7.1. **OBJECTIVE:** *Identify necessary structures - legal, formal, informal etc.*
8. **Practice: The 'nuts and bolts' of how we work with one another in alignment with Need, Purpose and Principles.**
    8.1. **OBJECTIVE:** *List the ways you will work with one another and the community within which the project is held to optimize the contributions of all vested parties.*
9. **Harvest: Describe what fruits the project will yield that will create the desired impact in the world.**
    9.1. **OBJECTIVE:** *List what your work together will yield, how it will meet the need and fulfill the purpose, and how you will know when it is 'ripe for the picking'!*

For a complete walkthrough of the entire Chaordic process, including all the guiding questions for each step, see the accompanying blog post[99] on the 7th Generation Design website.

Cynefin Management Model

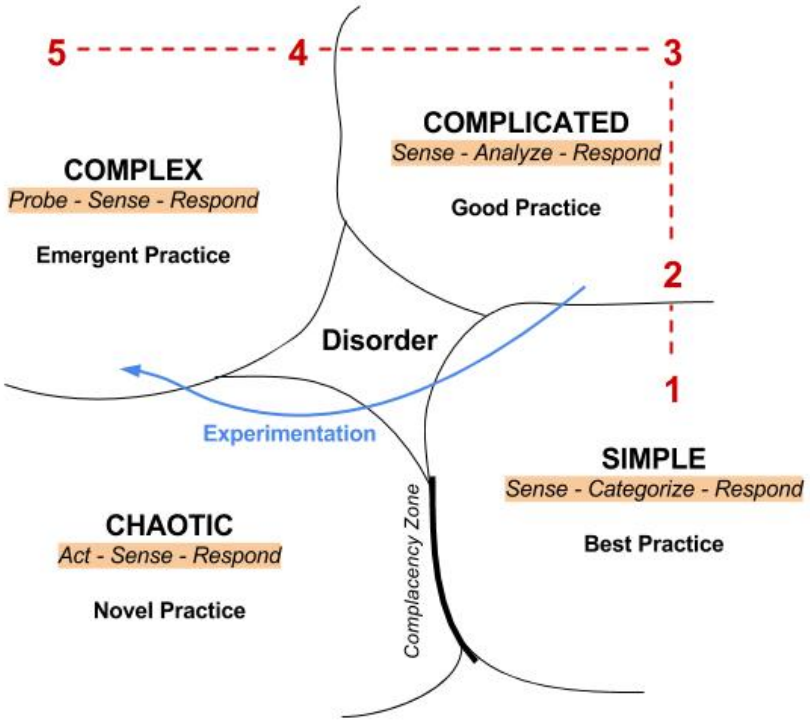
Cynefin is a helpful tool when deciding *how* to go about managing a system within its unique context. This is more of a high level tool, meant to be quickly employed to help grasp the nature of a given situation and which management approach, if adopted, will have the greatest likelihood of success. Cynefin helps to identify whether the situation is Simple, Complicated, Complex or Chaotic,

[99] https://www.7thgenerationdesign.com/the-chaordic-stepping-stones/

each of which has its own prescriptive management approach. To learn the ins and outs of Cynefin see Cynefin - Making Sense Amidst Disorder[100] on the 7th Generation Design blog.

- **Simple:** Sense - *Categorize* - Respond, what is often called "best practice", where cause and effect relationships exist and are predictable and repeatable.
- **Complicated:** Sense - *Analyze* - Respond, often called "good practice" or "due diligence", cause and effect relationships exist, but are not immediately visible, requires expertise.
- **Complex:** *Probe* - Sense - Respond, "emergent practice", cause and effect are only visible in hindsight, outcomes are emergent and unpredictable.
- **Chaotic:** *Act* - *Sense* - Respond, "novel practice", no cause and effect relationship can be determined, chaotic environments always resolve themselves, but not always in a desirable way.
- **Disorder:** the central zone, where we are most of the time, not knowing which space we are in.

Figure 8.0.2
Graphical representation of the Cynefin Sense-Making Model.



Holistic Management

Holistic Management begins with a Minimum Holistic Goal and grows from there into an entire management discipline. This path can get very technical, or can be utilized at a conceptual level, whichever is appropriate to the situational context and people involved. See the 7th Generation

[100] https://www.7thgenerationdesign.com/making-sense-amidst-disorder/

Design PDF for a look at the entire Holistic Management System In 1 Page[101]. Recommended reading includes Allan Savory's *Holistic Management*[102].

Memorandums of Understanding

An excellent book about the people side of regenerative agriculture - Joel Salatin's 'Fields of Farmers'[103]. In the book Joel details complete set ups for establishing Memorandums of Understanding with 'vested entrepreneurs' within the Polyface ecosystem. Joel's process provides an excellent starting place for constructing working agreements that are clear, concise and win-win-win - for the owners, partners on the land, and of course the land itself.

8.1 Enterprise Potentials

Enterprises are undertaken with the intent of generating a certain return (often in the form of financial capital). Generative enterprises will also generate some (or all) of the other forms of capital in concert with a healthy financial bottom line.

Existing Conditions

There are currently no on-site enterprises at WFH. Plans are being developed and research being conducted regarding starting a nature-based education program hosted in-part or in-whole on the WFH property.

Recommendations

The following enterprise potentials are worth further exploration at WFH:

- Nature-based and permaculture-inspired children's education program.

Nature-Base Permaculture-Inspired Children's Education Resources

There are a number of excellent initiatives and individuals doing excellent work in the nature-based permaculture-inspired education space. Below are some links to individuals and organizations already involved in this work.

- Matt Powers - *The Permaculture Student - K-12 Education Program*[104]
- Children In Permaculture - Resources Page[105]
    - CiP's Resource Catalog[106] - an extensive list of additional permaculture resources for children's education programs.

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[101] https://drive.google.com/file/d/12y3VIo1zwnpO1O6s7FMYzs5Ez1oZ1Cb_/view?usp=sharing

[102] Allan Savory's Holistic Management on Amazon: https://www.amazon.com/gp/product/B00CAKIN34/ref=as_li_tl?ie=UTF8&tag=7gd-20&camp=1789&creative=9325&linkCode=as2&creativeASIN=B00CAKIN34&linkId=0396c3a5e50e55929e39c1ae11568815

[103] https://www.shareasale.com/m-pr.cfm?merchantID=30889&userID=2273807&productID=819895133

[104] https://matt-powers.mykajabi.com/the-permaculture-student-online-k-12

[105] http://childreninpermaculture.com/resources/

[106] http://childreninpermaculture.com/catalogue-of-resources/

- Scott Mann's *The Permaculture Podcast*[107] has an extensive list of podcast interviews with people involved in permaculture-inspired childhood education programs.

8.2 Regenerative Economics

The [redacted] Family Homestead is being developed during an era characterized by rapid change. There are many emerging and already present protocols, technologies and trends that could prove incredibly valuable if appropriately employed or leveraged within a developing ecosystem of regenerative enterprises such as the one beginning at WFH. This section provides a surface level introduction to a few of these protocols, platforms and technologies, enough to illustrate basic concepts and broad potentials, as well as provides links for further learning should any of them be of interest.

Cryptocurrencies

Cryptocurrencies and their underlying distributed ledger technology (i.e. blockchains, directed acyclic graphs) are revolutionizing the world of money, finance, and commerce, from the local to the global scale. Cryptocurrencies, like Bitcoin (the most well known and largest), Bitcoin Cash (a fork of Bitcoin that is faster and cheaper to use), DASH (a relative of Bitcoin that is faster, cheaper and allows for true privacy and anonymity) and many others with different use cases represent a real-time, open-source experiment in allowing individuals to declare financial sovereignty from national currencies and take full control of their financial future.

Why mention cryptocurrencies as part of a permaculture system?

The old financial paradigm is crumbling beneath the weight of mal-incentives, centralization and money creation methods that quite literally create money out of thin air, vampirically drawing value from all of the current holders of that currency. National fiat currencies are opaque in their creation, centralized in their control and governance, and act as a wealth transfer mechanism from the many to the few. They are inflatable (lose value over time), non-fungible (certain units of the same nominal value may not be exchanged for other units of the same value - i.e. "dirty money"), censorable (rules set on how they can be accepted and for what), and backed only by debt (i.e. the unrealistic prospect of exponential growth, indebting future generations etc.).

Old-paradigm debt-backed national fiat currencies are antithetical to the permaculture ethics; care for the earth, care for people, and reinvestment of surplus back to the first two.

Society is in the beginning phases of a global financial revolution that is not yet a decade old. Cryptocurrencies empower individuals to become their own sovereign banker. As an example comparison, the characteristics of DASH (stands for Digital Cash) alongside a Federal Reserve Note (the U.S. Dollar) are presented in Table 8.2.1.

[107] https://www.thepermaculturepodcast.com/archives/#pce

Table 8.2.1
DASH (Digital Cash) vs. U.S. Federal Reserve Note

Characteristics	U.S. Federal Reserve Note	DASH - Digital Cash
Fixed currency supply?	NO - The Fed creates more dollars whenever it wants by purchasing government-issued debt	YES - only 18.9 million DASH will ever exist
Fungible? (every unit is the same as every other unit)	NO - physical bills are marked, traceable, can be tied to certain individuals, digital dollars are one of the most monitored currencies in the world	YES - any unit of Dash is the same as any other unit of DASH (cannot be blacklisted)
Transparent?	NO - The Federal Reserve is a private bank unbeholden to oversight	YES - entire financial eco-system is on a public blockchain, anyone can verify transactions occurred as they were meant to
Divisible?	YES - down to 1/100th of a unit (a penny)	YES - DASH is divisible out to 1/millionth of a unit, allowing for micro-transactions and access no matter the currency price
Secure?	NO - the money in your bank account does not technically belong to you (see Cyprus bail ins), current legislation has paved the way for future bail-ins	YES - Only you control the private keys to your DASH, far greater security available through cold storage, 2 Factor Authentication, hardware wallets and more.
Fast?	NO - it still takes days to transfer from bank to bank, or to wait for a check to clear	YES - DASH supports InstantSend functionality, block times are 2.5 minutes, avg. transaction time is 1.3 seconds
Store of Value?	SORT OF - The dollar is the slowest falling currency currently of all national fiat currencies, therefore it has the appearance of strength, but ultimately the purchasing power of the dollar declines every year - this is by design, it has to function this way	YES - DASH is capped at 18.9 million DASH that will ever exist. It is a deflationary currency, over time it will appreciate in value instead of depreciate.
Private?	PARTIALLY - Only cash-based peer-to-peer transactions are private. Digital dollar transactions are not private, heavily tracked, and rely upon 3rd parties that we are forced to trust.	YES - DASH is completely peer-to-peer (P2P), and gives the individual user the choice of transacting transparently, privately, or anonymously.

Anonymous?	NO - forced trust of 3rd parties or P2P cash transactions prohibit anonymity	YES - Transact securely across the globe with anyone in the world, neither individual has to know the other.
Cost of Fee For Use	HIGH - transaction fees are high (3% credit cards, up to 10%+ for remittance, every movement is taxed)	VERY LOW - Send $.10 or $10,000,000 worth of DASH across the planet in seconds for a few pennies.

In summary, cryptocurrencies have the potential to enable new types of commerce, quite literally the construction of "parallel economic eco-systems" that can exist amidst and interact with the current dominant paradigm, while also allowing for the creation of new economic models and new ways of relating to one another that are aligned with the permaculture ethics.

More Resources for Continued Learning

- Introduction to Cryptocurrencies and Blockchain Technology
    - How Do Cryptocurrencies Work?[108] - excellent YouTube video describing how blockchain technology works to create secure, trusted and distributed (decentralized) networks.
    - DASH School[109] - hosted by Amanda B. Johnson, this video series breaks down how cryptocurrencies, and DASH in particular, work. There are hundreds of cryptocurrencies out there - the 7th Generation Design team believes DASH is one to watch (along with others) due to its focus on fast, inexpensive transactions (thereby not pricing out the rest of the world) with privacy and anonymity as options. It is also aiming directly at business adoption (POS systems, payment gateways, remittance systems etc.) and will be releasing a new interface soon called Evolution that will make interfacing with cryptocurrencies as simple and familiar as PayPal or Venmo - i.e. they are focusing on mass adoption.
        - Dash.org[110] - main website, wallet downloads, links to resources etc.
- Where Are We In The Larger Story?
    - Mike Maloney's Hidden Secrets of Money[111] - Excellent multi-part series on the history of money and debt and how modern society got where it is.
    - Peak Prosperity's Crash Course[112] - Chris Martenson's Crash Course takes a very data-based look at the intersection of economy, energy and environment in the age of limits. This course does an excellent job illustrating where American society is in the narrative of debt-backed national fiat money, resource depletion and energy

[108] https://www.youtube.com/watch?v=bBC-nXj3Ng4&t=9s

[109] https://www.youtube.com/playlist?list=PLiFMZOlhgsYKKOUOVjQjESCXfR1cCYCod

[110] https://www.dash.org/

[111] https://www.youtube.com/watch?v=DyV0OfU3-FU&list=PLE88E9ICdipidHkTehs1VbFzgwrq1jkUJ

[112] https://www.peakprosperity.com/crashcourse

complexity. He advocates for the 8 Forms of Capital model[113] as a needed change to the current financial paradigm.

- Up and coming projects and platforms worth examining (these are still very YOUNG projects, but the 7th Generation team thinks they are worth watching and getting into if someone is thinking about selling goods or services).
    - OpenBazaar[114] - decentralized peer-to-peer web store platform that accepts bitcoin as payment and has no central servers and no fees.

[113] https://www.7thgenerationdesign.com/creating-resilient-wealth/

[114] https://www.openbazaar.org/

Appendix A - Water Catchment Calculations

Catchment Calculations

Catchment Name	Area (sq. ft.)	Run-off Coefficient	Direct Precipitation Totals (gal)	Low Run-Off Estimate (gal)	High Run-Off Estimate (gal)	Infiltration Medium Designation	Infiltration Throughput (gal/min) Standing Water
Driveway	12,672	Drives and Walks	116,666	87,500	99,166	Concrete Pad	
Main Residence	3,750	Roofs	34,525	25,894	32,799	Roof	
Barn	650	Roofs	5,984	4,488	5,685	Concrete Pad	
Total Effective Catchment	464,350	Ag - Bare Packed Soil/ Rough	4,275,100	855,020	2,137,550	Perc 2 - Fill Slope	453,076
Upper Catchment	306,228	Ag - Bare Packed Soil/ Rough	2,819,329	563,866	1,409,664	Perc 3 - West Upland Drainage	9,967,662
Up Canyon Catchment	5,706,360	Ag - Bare Packed Soil/ Rough	52,536,364	10,507,273	26,268,182	Perc 3 - West Upland Drainage	122,491,802

Earthwork Specific Catchment Calculations

Catchment Name	Area (acres)	Area (sq. ft.)	Run-off Coefficient	Direct Precipitation Totals (gal)	Low Run-Off Estimate (gal)	High Run-Off Estimate (gal)	Infiltration Medium Designation
% Total Property Area =>	**7.71**	**335,848**		**3,092,026**	**618,405**	**1,546,013**	
WVSS Potential Catchment	7.71	335,848	Ag - Bare Packed Soil/ Rough	3,092,026	618,405	1,546,013	Perc 3 - West Upland Drainage

Earthwork Infiltration Potentials

Designation	Infiltration Medium Designation	Length (ft)	Depth From Sill (ft)	Width (ft)	Volume At Bank Full (cubic ft.)	Volume At Bank Full (gallons)	Bank Full Infiltration Rate Of Earthwork/min (gallons)	Bank Full Infiltration Rate of Earthwork /hr (gallons)
		145			**302**	**2,259**	**20145**	**1,208,689**
WV Top Swale	Perc 3 - West Upland Drainage	55	1	2	114	853	7641	458,468
WV Mid Swale	Perc 3 - West Upland Drainage	50	1	2	104	778	6946	416,789
WV Bottom Swale	Perc 3 - West Upland Drainage	40	1	2	84	628	5557	333,432

Percolation Tests

Infiltration Test Location	Time Elapsed (sec)	Infiltration Rate (gal/sq.ft./min) Standing Water	Infiltration Rate (in/min) Standing Water	Infiltration Per Acre Per Min (gal/acre/min) Standing Water	Infiltration Per Acre Per Hour (gal/acre/hr) Standing Water	Infiltration Per Acre Per Hour (Acre feet / hour)
Roof	NA	0.00	0.00	0	0	0.0
Concrete Pad	NA	0.00	0.00	0	0	0.0
Perc 1 - Lower Pasture	240	0.45	0.72	19,480	1,168,815	3.6
Perc 2 - Fill Slope	110	0.98	1.57	42,502	2,550,142	7.8
Perc 3 - West Upland Drainage	5	21.47	34.44	935,052	56,103,116	172.2

Appendix B - Soils

Access the NRCS WFH Soil Report online via the NRCS Web Soil Survey Portal[115].

Appendix C - Living Systems

Access the live Google spreadsheet version of the WFH - Living Systems Calculator HERE.

Pollinator Forage Species List

Locally adapted pollinator forages.

Common Name	*Scientific Name*	Plant Type	Spread (ft)	Height (ft)	Bloom Start	Bloom Finish
Blue Elderberry	*Sambucus mexicana*	Tree, Shrub	6 - 20	8 - 20	4/15	7/30
Red Willow	Salix laevigata	Tree	45.00	45.00	2/15	5/30
Black Locust	Robinia pseudoacacia	Tree	20 - 35	35 - 80	5/15	6/20
Chamise	Adenostoma fasciculatum	Shrub	5 - 10	13.00	2/1	6/15
California Buckwheat	Eriogonum fasciculatum foliolosum	Shrub	3 - 6	2 - 6	3/1	9/30
Black Sage	Salvia mellifera	Shrub	3 - 6	3 - 4	2/15	8/15
Golden Currant	Ribes aureum gracillimum	Shrub	3 - 6	3 - 6	2/10	3/20
Big Berry Manzanita	Arctostaphylos glauca	Shrub	7 - 10	7 - 10	1/15	4/25
Coffee Berry	*Frangula californica*	Shrub	5 - 15	5- 15	5/1	7/15
Vinegar Weed	*Trichostema lanceolatum*	Herbaceous	0.50	1.50	6/15	9/25
Yellow Star Thistle	*Centaurea solstitialis*	Herbaceous	1.00	1.50	6/15	9/25
Poison Oak	*Toxicodendron diversolibum*	Groundcover,Bush,Vine	3 - 30	3 - 30	3/1	6/15
Western Clematis	*Clematis ligusticifolia*	Vine	15.00	15.00	8/15	10/15
California Grape	*Vitis californica*	Vine	10.00	10.00		
Sylvetta Arugula	*Eruca sativa*	Vegetable	2.00	2.00	6/10	9/15
Jerusalem Artichoke	*Helianthus tuberosus*	Tuber		6 - 8		
Weeping Blue Broom	*Psoralea fleta*	Tree,Shrub	12.00	12.00	6/20	8/20

115 https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx?aoicoords={(-120.74819%2035.70324,-120.74819%2035.72019,-120.71427%2035.72019,-120.71427%2035.70324,-120.74819%2035.70324))&marker=(-120.69126%2035.62509)

Toyon	*Heteromeles arbutifolia*	Tree, Shrub	4 - 5	6 - 8	6/1	9/15
Holly Leaf Cherry	*Prunus ilicifolia*	Tree, Shrub	14.00	14.00	3/1	4/1
Peruvian Pepper Tree	*Schinus molle*	Tree	20 - 40	30 - 50	1/1	12/31
Southern Catalpa	*Catalpa bignonioides*	Tree	25 - 40	30 - 40	4/15	5/15
Silver Wattle	*Acacia dealbata*	Tree	6 - 25	10 - 90	2/1	4/20
Cat Claw	*Acacia greggii*	Tree	8.00	12.00	3/1	4/15
White Alder	*Alnus rhombifolia*	Tree	20 - 30	20 - 50		
Mimosa	*Albizia julibrissin*	Tree	20 - 40	30.00	5/20	9/10
Black Willow	*Salix nigra*	Tree	30 - 60	30 - 60		
White Sage	*Salvia apiana*	Shrub	2 - 3	1 - 5	6/20	8/20
Yerba Santa	*Eriodictyon californicum*	Shrub	3.00	3 - 10	3/20	6/20
Immigrant Forage Kochia	*Bassia prostrata*	Shrub	1 - 3	1 - 3		
White Chaparral Currant	*Ribes indecorum*	Shrub	6.00	6.00	1/15	3/20
Canyon Gooseberry	*Ribes menziesii*	Shrub	6.00	6.00	2/10	4/10
Yarrow (Pink)	*Achillea millefolium rosea*	Herbaceous, Groundcover		1 - 3		
Yarrow	*Achillea millefolium californica*	Herbaceous, Groundcover		.5 - 1.5		
Comfrey	*Symphytum officinale*	Herbaceous	2 - 6	1 - 5	4/10	7/20
Sainfoin	*Onobrychis viciifolia*	Herbaceous	.5 - 1.5	.75 - 3		
Comfrey	*Symphytum officinale*	Herbaceous	2 - 6	1 - 5	4/10	7/20
Agastache	*Agastache urticifolia*	Herbaceous	3.50	2.00		
Woolly Thyme	*Thymus lanuginosus*	Groundcover	Continuous	0.20	5/15	7/15
Buckbrush Lilac	*Ceanothus cuneatus*	Bush	6 - 9	6 - 9	2/1	7/10
Goumi	*Elaeagnus multiflora*	Bush	6 - 10	6.00		
Goji Berry	*Lycium barbarum*	Bush	4.00	4.00	6/10	8/10
Tansy	*Tanacetum vulgare*	Herbaceous	1.50	2 - 4	7/1	9/30
Franciscan Manzanita	*Arcostaphylos hookeri*	Groundcover	6.00	2.00		
California Aster	*Aster chilensis*	Bush	3 - 5	3 - 5	5/20	11/15

Food Forest Species

Common Name	Scientific Name	Spread	Height	Harvest Start	Harvest End
Fruit / Nut Trees					
Apples					
Anna Apple	*Malus spp.*	15 - 25	15 - 25	5/10	8/10
Arkansas Black Apple	*Malus spp.*	15 - 25	15 - 25	11/25	1/1
Lady Williams Apple	*Malus spp.*	15 - 25	15 - 25	12/15	1/30
Akane Apple	*Malus spp.*	15 - 25	15 - 25	8/22	10/15
Dorsett Golden Apple	*Malus spp.*	15 - 25	15 - 25	7/15	10/1
Fuji Apple	*Malus spp.*	15 - 25	15 - 25	11/1	12/15
Gala Apple	*Malus spp.*	15 - 25	15 - 25	7/1	8/20
Liberty Apple	*Malus spp.*	15 - 25	15 - 25	11/15	
Sierra Beauty Apple	*Malus spp.*	15 - 25	15 - 25	10/25	
Yellow Newton Pippin Apple	*Malus spp.*	15 - 25	15 - 25	12/25	
Calville Blanc D'Hiver Apple	*Malus spp.*	15 - 25	15 - 25		
Golden Delicious Apple	*Malus spp.*	15 - 25	15 - 25		
Hudson's Golden Gem Apple	*Malus spp.*	15 - 25	15 - 25		
Jonathan Apple	*Malus spp.*	15 - 25	15 - 25		
Mollie's Delicious Apple	*Malus spp.*	15 - 25	15 - 25		
Mutsu Apple	*Malus spp.*	15 - 25	15 - 25		
Newtown Pippin Apple	*Malus spp.*	15 - 25	15 - 25		
Pink Pearl Apple	*Malus spp.*	15 - 25	15 - 25		
Roxbury Russet Apple	*Malus spp.*	15 - 25	15 - 25		
Esopus Spitzenburg Apple	*Malus spp.*	15 - 25	15 - 25		
Granny Smith Apple	*Malus spp.*	15 - 25	15 - 25	11/15	12/15
Wickson Crabapple	*Malus spp.*	15 - 25	15 - 25	11/20	1/1

Pink Lady	*Malus spp.*	15 - 25	15 - 25	11/1	12/30
Citrus					
Calamondin	*Citrofortunella mitis*				
Oroblanco Grapefruit	*Citrus grandis x Citrus paradisi*			12/1	4/1
Mandarin	*Citrus reticulata*	15 - 20	15-20		
Kumquat	*Fortunella sp.*	5 - 10	5 - 10		
Moro Blood Orange	*Citrus x sinensis*	15 - 20	15-20		
Stonefruits					
Arctic Supreme Peach	*Prunus persica*	15 - 25	15 - 25	7/1	
Babcock Peach	*Prunus persica*	15 - 25	15 - 25	7/15	
Suncrest Peach	*Prunus persica*	15 - 25	15 - 25	7/25	
Peachy Keen Peach	*Prunus persica*	15 - 25	15 - 25	6/10	6/30
Arctic Glo Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	7/1	7/30
Arctic Jay Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	7/1	7/25
Arctic Queen Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	8/10	
Fantasia Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	8/1	
Snow Queen Nectarine	*Prunus persica nucipersica*	15 - 25	15 - 25	6/20	7/15
Autumn Royal Apricot	*Prunus armeniaca*	15 - 25	15 - 25	9/1	9/30
Flora Gold Apricot	*Prunus armeniaca*	15 - 25	15 - 25	6/5	6/22
Harcot Apricot	*Prunus armeniaca*	15 - 25	15 - 25	6/15	
Tilton Apricot	*Prunus armeniaca*	15 - 25	15 - 25	7/5	7/25
Santa Rosa Plum	*Prunus salicina "Santa Rosa"*	12 - 15	12 - 15	6/15	7/5
Figs					
Black Mission Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25

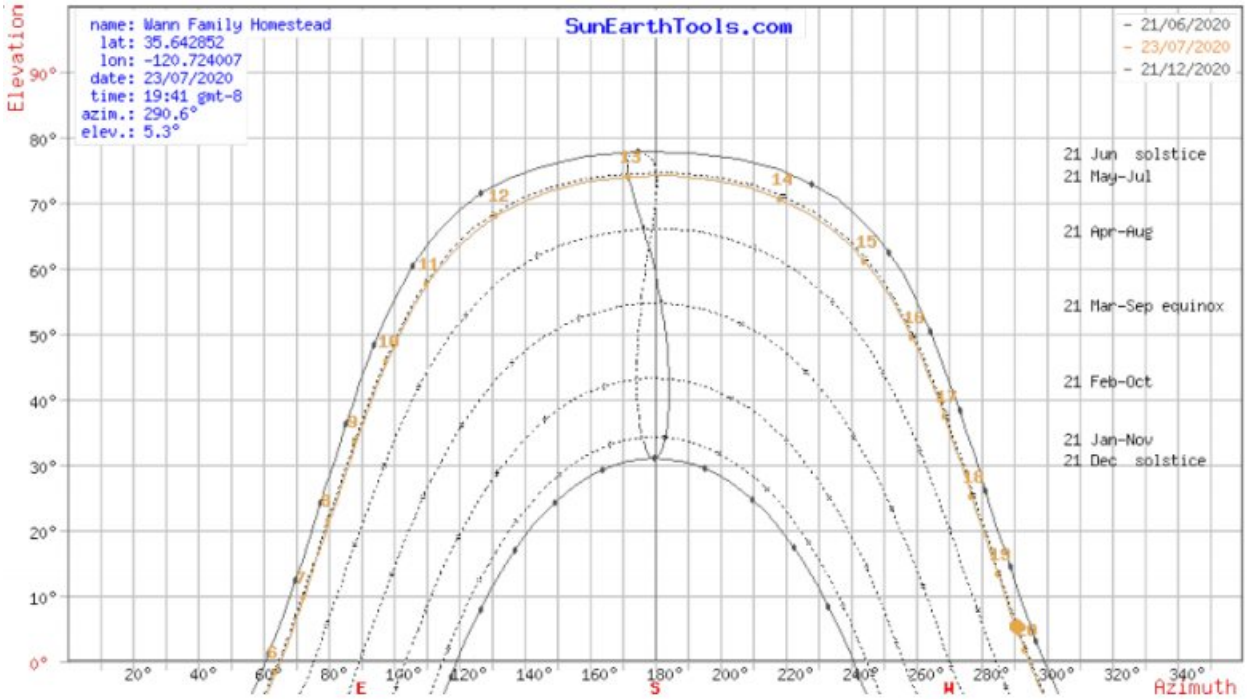
Brown Turkey Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Celestial Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Italian Honey Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Violette de Bordeaux Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Kadota Fig	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
Excel FIg	*Ficus carica*	6 - 15	8 - 20	8/1	10/25
White Genoa Fig	*Ficus carica*	10 - 15	8 - 20	8/10	11/5
Other Fruits					
Fuyu Persimmon	*Diospyros kaki L.*	15 - 25	15 - 25	11/15	12/30
Mulberry - Pakistani	*Morus macroura*	40	40	4/15	6/30
Mulberry - White	*Morus alba*	25 - 35	35 - 80	7/15	9/25
Mulberry - Black	*Morus nigra*	18 - 20	18 - 20	7/15	8/20
Pendolino Olive	*Olea europaea*				
Jujube	*Ziziphus ziziphus / spinacristi / jujuba*	15 - 25	15 - 30		
Pineapple Guava	*Feijoa sellowiana*	10 - 15	12 - 20		
Pomegranate	*Punica granatum*	6 - 18	6 - 18	9/1	9/25
Carob	*Ceratonia siliqua*	30 - 40	30 - 50		
Blue Elderberry	*Sambucus mexicana*	6 - 20	8 - 20		
Thornless Opuntia Prickly Pear	*Opuntia cacanapa ellisiana*	6	6	9/10	9/30
Moringa	*Moringa oleifera*	20 - 30	30 - 40	5/15	11/5
Shinsheiki Asian Pear	*Pyrus pyrifolia*	15	15		
Loquat	*Eriobotrya japonica*	12 - 24	12 - 30	5/20	8/15
Soap Nut Tree	*Sapindus mukorossi*	65	65		
Nuts					
English Walnut	*Juglans regia*	50 - 70	70 - 100	9/1	11/1
California Black Walnut	*Juglans nigra*	40 - 70	60 - 100	9/1	11/1
Chinese Chestnut	*Castanea mollissima*	40 - 60	40 - 60	9/15	10/20

American Chestnut	*Castanea dentata*	40 - 60	60 - 100	10/15	11/15
All-in-one Almond	*Amygdalus communis L. var. dulcis "All-in-One"*	15	15		
American Hazelnut	*Corylus americana*	10 - 15	8 - 12		
Nitrogen Fixing Support Trees & Shrubs					
		Spread (ft)	**Height (ft)**	**Bloom Start**	**Bloom End**
Black Locust	*Robinia pseudoacacia*	20 - 35	35 - 80	5/15	6/20
Honey Mesquite	*Prosopis glandulosa*	30 - 40	25 - 35		
Mimosa	*Albizia julibrissin*	20 - 40	30	5/20	9/10
Chilean Mesquite	*Prosopis chilensis*	30	30		
Velvet Mesquite	*Prosopis velutina*	12 - 35	12 - 35		
White Mesquite	*Prosopis alba*		24 - 30		
Leucaena	*Leucaena leucocephala*	6 - 10	6 - 10	5/15	9/15
Thornless Honey Locust	*Gleditsia triacanthos*	35 - 50	75 - 135		
False Indigo Bush	*Amorpha fruticosa*	6	6 - 10	6/1	8/25
Silver Bush Lupine	*Lupinus albifrons*	3 - 5	3 - 5		
Goumi	*Elaeagnus multiflora*	6 - 10	6		
Understory Plantings					
Lemon Balm	*Melissa officinalis*	1 - 3	1 - 3		
Rugosa Rose	*Rosa rugosa*				
Dwarf Yaupon	*Ilex vomitoria 'Stoke's Dwarf'*	4	3		
Yaupon	*Ilex vomitoria*				
Goji Berry	*Lycium barbarum*	4	4	7/15	9/1
Cape Honeysuckle	*Tecomaria capensis*	6 - 8	8 - 20		
Lemon Verbena	*Aloysida citrodora*	1 - 4	2 - 6		
Comfrey	*Symphytum officinale*	2 - 6	1 - 5	4/10	7/20
Borage	*Borago oficianalis*				

Hot Lips Salvia	*Salvia spp.*				
Tansy	*Tanacetum vulgare*	1.5	2 - 4	7/1	9/30
Salad Burnett	*Sanguisorba minor*	1.5	1		
Chives	*Allium schoenoprasum*	1	1		
Lab Lab Purpurea	*Dolichos lab lab*		5 - 8		
French Sorrel	*Rumex acetosa*	1	1		
Morrocan Mint	*Mentha spicata*				
Naked Lady	*Amaryllis belladonna*		1.5 - 2	8/15	10/1
Daffodil	*Narcissus pseudonarcissus*	1	1.5		
Baby Sun Rose	*Aptenia cordifolia*	3	0.8	5/1	7/30
San Diego Dudleya	*Dudleya edulis*	1	1	4/20	7/20
Woolly Yarrow	*Achillea tomentosa*		0.16	5/10	6/20
Thyme - Creeping	*Thymus vulgaris*	2 - 3	.3		

Appendix D - Solar Data

Solar Azimuths



Sun Angles Chart