Alternative Septic & Irrigation System for Vineyard on Oak Creek

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Figure 1: Project Site, taken by Will Richardson

Project Background

Location:

- Located at 1955 North Echo Canyon Rd. Page Springs, AZ
- Yavapai County
- Largely located within the 100-year floodplain

Scope of Services:

- Alternative septic system design selection
- Irrigation design for vineyard
- Water quality analysis of well water
- 1-ft topographic map of property

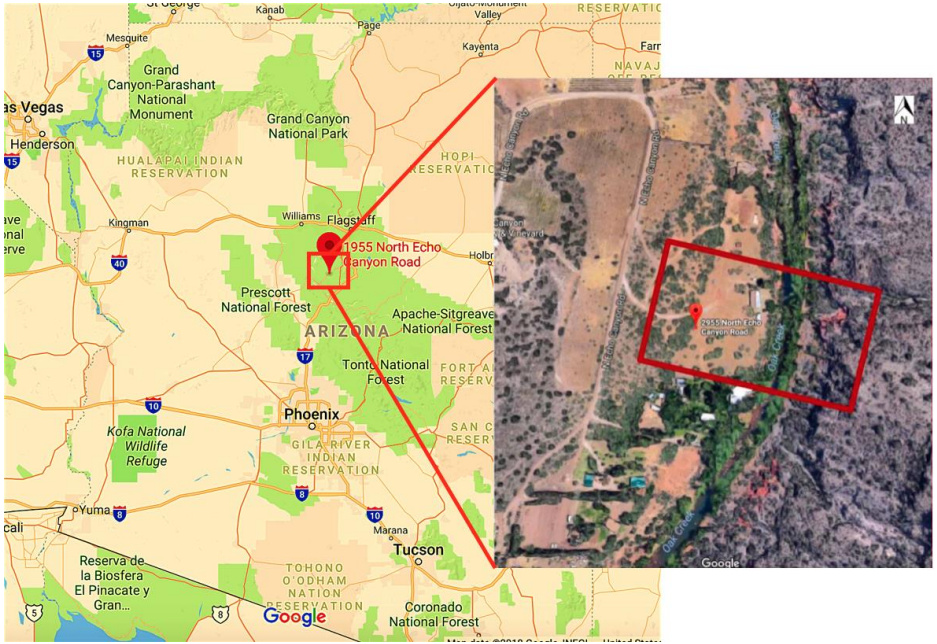

Figure 2: Site Location, provided by Google Maps [1]

Water Quality Analysis For Drinking Water Well

- Analysis was performed to determine any impacts of the septic system on the well.
- Three samples tested from each source location.
- Samples were tested against two independently prepared blanks.
- Secondary Maximum Contaminant level (SMCL)

Table 1: Average Water Quality Analysis and EPA Standards

	Average Tap	Average Well	EPA Standards [2]	Methods Used
Total Nitrogen (mg/L)	0.675	0.325	N/A	HACH 10071
Nitrate (mg/L)	0.1	0.3	10	HACH 8039
Fecal Coliform (number of colonies)	0	0	0	HACH 8074
pH	7.14	N/A	6.5 - 8.5 (SMCL)	Hanna Meter

Compliant Alternative Systems

Wisconsin Mound [3]

- 3 components : septic tank, dosing chamber, and mound
- Elevated soil absorption system, located above the existing soil
- Fill material required
- Mound acts as filter for effluent before the water is recharged into the ground
- Cannot be located within the floodplain

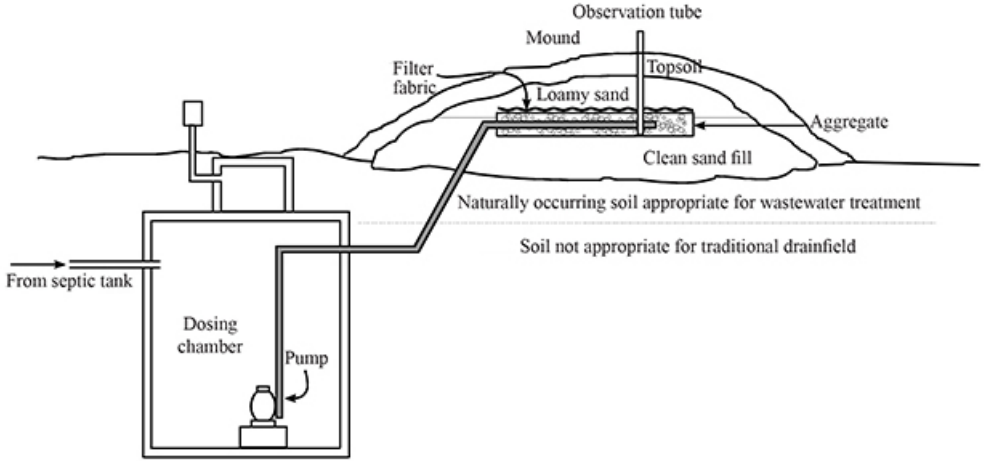

Figure 3: Wisconsin Mound Schematic [3]

Compliant Alternative Systems

Sequencing Batch Reactor [4]

- Aerobic treatment process confined to one tank
- Less space required
- Eliminates need for additional clarifying tanks
- Works the best with intermittent flows

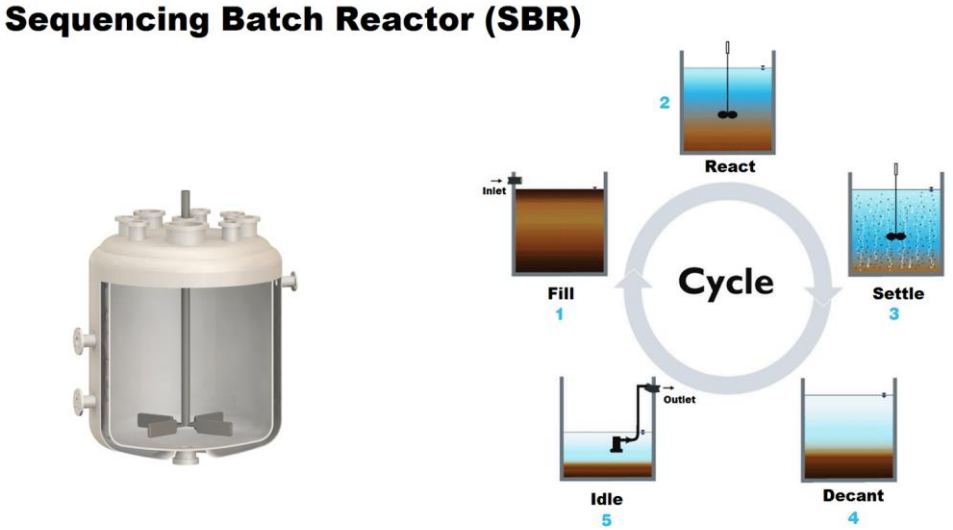

Figure 4: Sequencing Batch Reactor Treatment System [4]

Compliant Alternative Systems

Aerobic System [5]

- Utilizes Aerobic bacteria to treat wastewater
- Permitted within the 100-year floodplain, given the effluent is treated to code requirements
- Multiple chambers or tanks
- Works best with consistent flows
- Some systems use UV or chlorination for disinfection at end of treatment

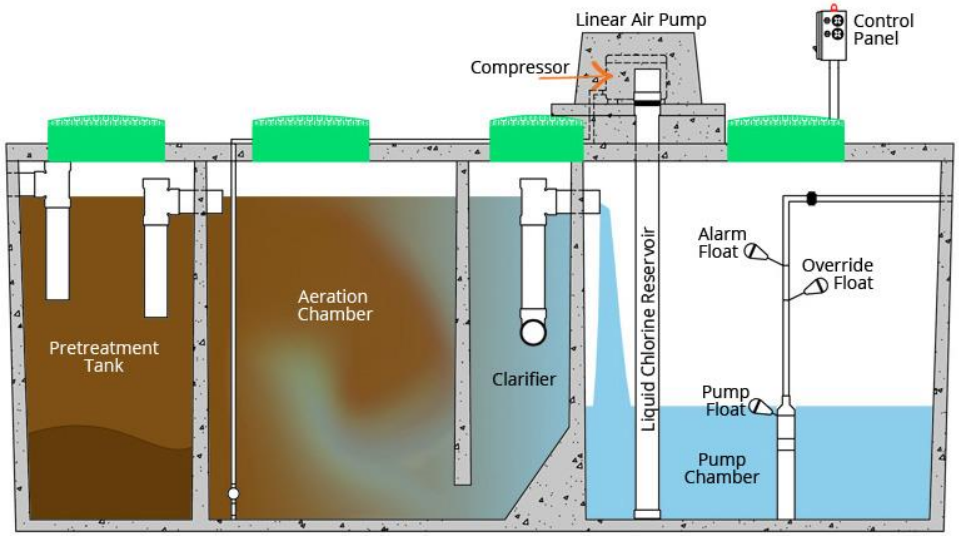

Figure 5: Aerobic septic system components [5]

Alternative Septic System Requirements

System Requirements [A.A.C. R18-9-A314]:

- 1000 gallon system
- Hydraulic loading = 300 gpd
- Effluent TSS = 30 mg/L
- Effluent BOD = 30 mg/L
- Effluent Total N = 53 mg/L
- Effluent Coliform = 300,000 colonies/100 mL

Figure 6: Seal of Arizona [A.A.C.]

Recommended System

- MicroFAST 0.5 Aerobic treatment unit made by Biomicrobics
- Meets Arizona Effluent standards
- 1000 gallon tank, and can handle the 300 gallon per day flow rate required
- Approximate $12,000 cost for purchase of the aerobic unit, tank, UV chamber, and transportation
- Uses one singular tank
- 1 - Influent
- 2 - Settling
- 3 - Aeration pump
- 4 - Fixed bacteria media
- 5 - Effluent to leach field

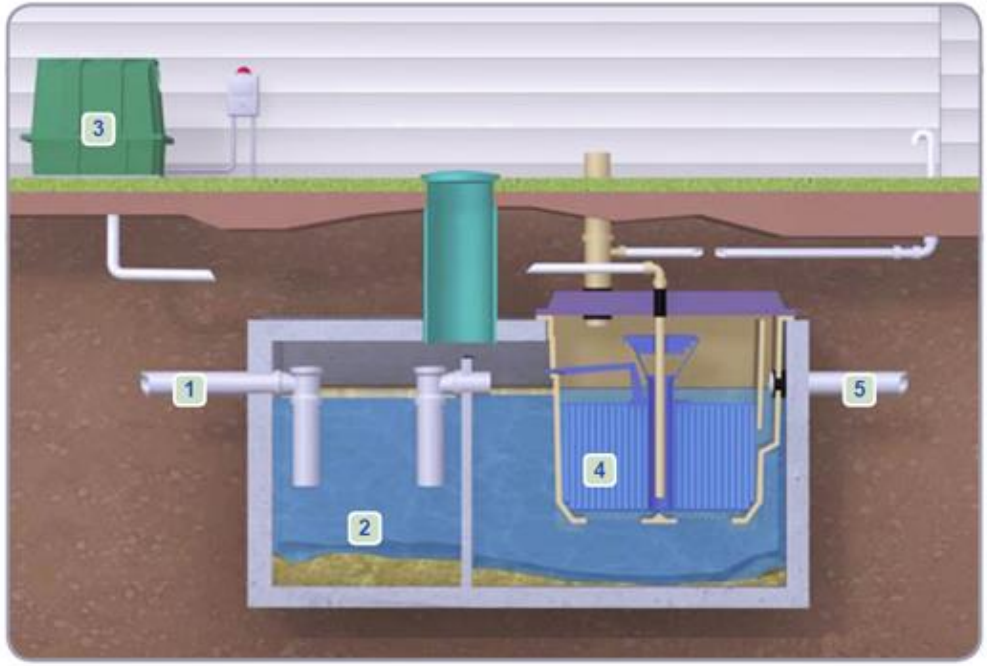

Figure 7: MicroFAST 0.5 wastewater treatment system [6]

Disposal Works Design

Key:
- Well
- Proposed Leach Field

- Static Water Level in Well = 25 ft
- Percolation Rate = 1.58 min/in
- Soil Absorption Rate = 0.93 gpd/ft^2
- Adjusted Soil Absorption Rate (SAR_a) used for alt. septic systems [A.A.C. R18-9-A312]

$$SAR_a = \left[\left(\frac{11.39}{\sqrt[3]{TSS + BOD_5}} - 1.87\right) SAR^{1.13} + 1\right] SAR$$

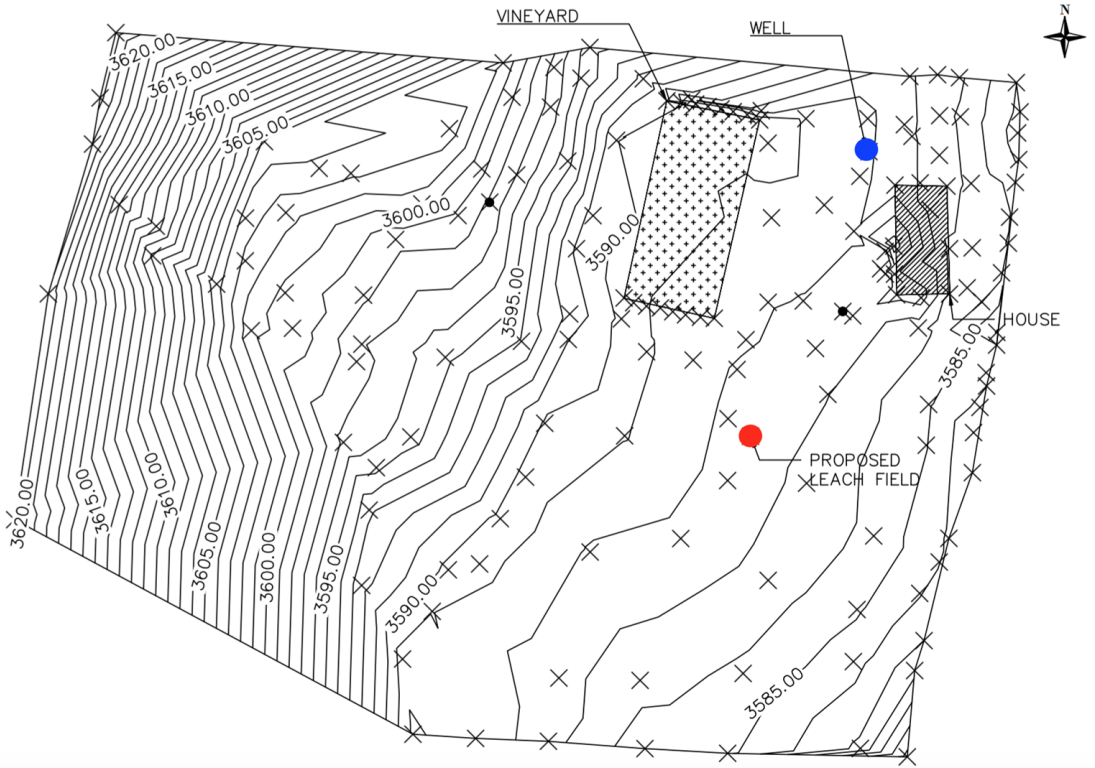

Figure 8: Site Topographic Map

Disposal Works Design

Table 2: Trench Specifications [A.A.C. R18-9-E302]

Adjusted SAR [A.A.C. R18-9-A312]	1.82 gpd/ft^2
Min. Surface Area of Leach Field	165 ft^2
Trench Length	19 ft
Bottom Width of Trench	3 ft
Effective Trench Depth	4 ft
Trench Separation	8 ft
Total Area of Leach Field	25 x 19 ft

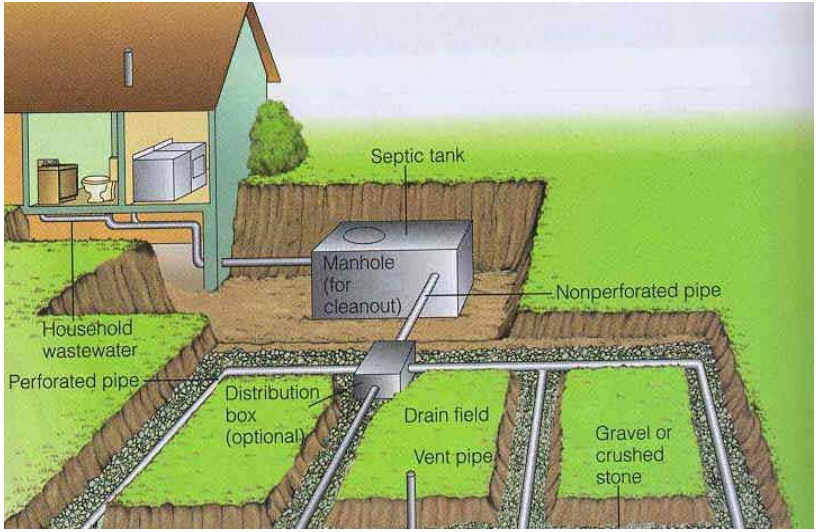

Figure 9: Trench system leach fields [7]

Vineyard Irrigation Design Overview

Vineyard Specs:

- 1500 Vines/acre & 1-2 acres
- Vine spacing of 6-ft by 8-ft
- Maximum water demand: 10,200 gpd/acre [8,9,10,11]
- Average water demand: 4,095 gpd/acre [8,9,10,11]

Components:

- Submersible Pump
- Storage Tank & Pump
- Pressure Tank
- Drip Irrigation

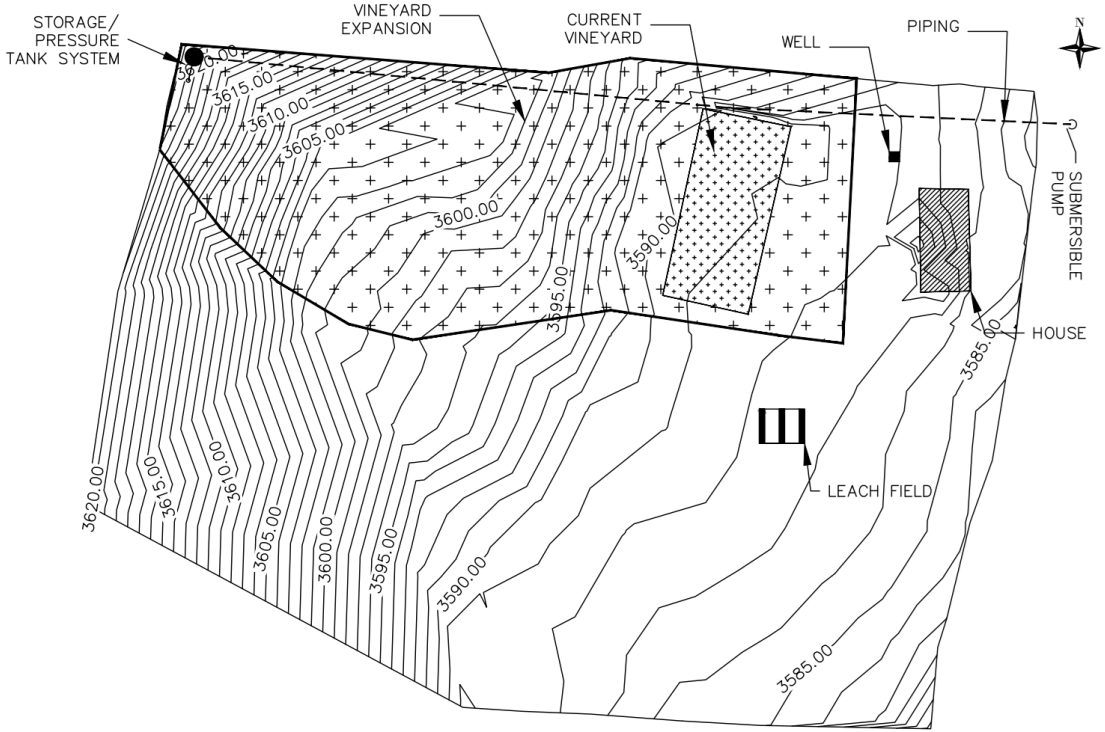

Figure 10: Vineyard & Irrigation Layout

Irrigation System Design
Drip Irrigation

Table 3: Dripline Specs

Dripline	
1/2 ” Polyethylene Dripline Tubing [12]	Rated up to 60 PSI
Emitter Flow Rate [12]	0.5 gph
Typical Operating Pressure [13]	8-50 PSI
Row Length	< 350 ft
No. of Emitters	1500
Irrigation Demand	~ 12.5 gpm/acre

Pressure Tank [15]:

- 62 gallons total volume
- 19.9 gal drawdown at 30/50 PSI
- Recharged in 2 min with 10 gpm pump

Additional Components:

- Backflow Prevention
- Thread Filter
- Pressure Regulator
- Pump switch

Figure 11: Pressure Tank [15]

Irrigation System Design
Storage Tank & Irrigation Pump

Requirements:

- 5000 gallon storage tank
- 7 gpm minimum flow rate

Selected System:

- 5000 gallon tank, 119” diameter & 112” height [16]
- 3/4 HP well jet pump [17]
- 12.5-30 gpm [17]

Figure 12: Straight Centrifugal Pump [17]

Figure 13: 5000 Plastic Storage Tank [16]

Irrigation System Design
Submersible Pump

Pump Specifications

- Static Head = 63 ft
- Liquid Depth = 8 ft
- Discharge Length = 500 ft
- 3” schedule 40 PVC piping
- Flow of 53 GPM
- Calculated Total Head = 65.4 ft
- *Total head is calculated using PumpFlo Application*

Selected Pump [18]

- Gorman-Rupp Model S2A1
- 2” Inlet/Outlet
- 4.25” diameter
- 115 V

Figure 14: Gorman-Rupp Model S2A1 [18]

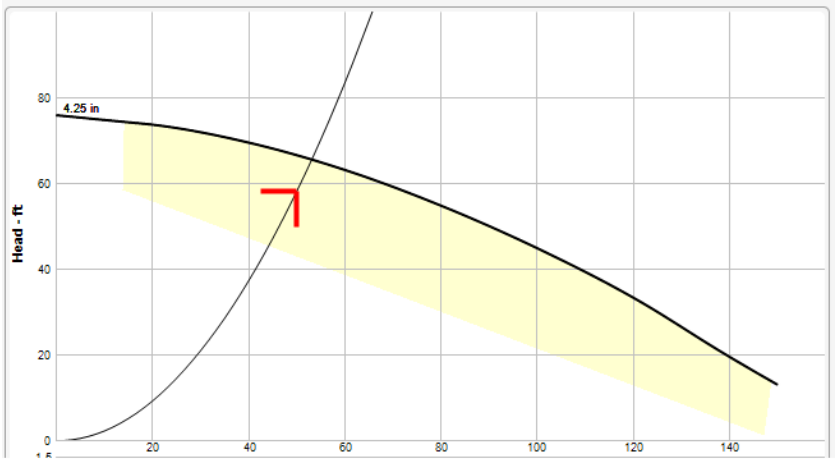

Figure 15: Pump Performance Curve [19]

Schedule

Key:

Orange - Completed Late

Table 4: Team Schedule

Task No.	Task	Start Date	Original Predicted End Date	Actual End Date
1.0	**Site Investigation**	2/3/18	1/28/18	2/3/18
2.0	**Off-site Technical Analysis**	1/29/18	2/4/18	4/16/18
3.0	Alternative Septic System Design Evaluation	2/5/18	3/25/18	3/25/18
4.0	Irrigation System Design Evaluation	2/5/18	3/25/18	3/25/18
5.0	**Alternative Septic System & Irrigation System Design**	3/26/18	4/19/18	4/22/18

Cost of Staffing

Table 5: Cost of Staffing and Engineering Services [20]

1.0 Personnel	Classification	Hours	Rate ($/hr)	Cost
	PE	15	$195.00	$2,925.00
	EIT	450	$67.00	$30,150.00
	TECH	5	$48.00	$240.00
	AA	200	$56.00	$11,200.00
	Total Personnel Cost			$44,515.00
2.0 Travel	3 Site Visits @ 110 mi		$0.40/mi	$132.00
3.0 Subcontract	Site Survey			$1,000
4.0 Total		**670**		**$45,647.00**

Cost of Systems

Table 6: Estimated Quotes

Component	Estimated Quote
Septic System [21]	$ 12,000
Septic Installation [21]	$ 10,000
Submersible Pump (Creek) [22]	$ 6,000
Irrigation System (1 acre) [23]	$ 1,075
5,000 Gal Storage Tank [16]	$ 2,000
Irrigation Pump (Tank) [17]	$ 450
Estimated Total :	**$ 31,525**

References

[1] Google Maps. [Online]. Available: https://www.google.com/maps/search/1955 N Echo Canyon Rd. Page springs AZ/@34.7765732,-111.9062815,13.87z. [Accessed: 22-Apr-2018].

[2] “National Primary Drinking Water Regulations,” *EPA*, 11-Jul-2017. [Online]. Available: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. [Accessed: 22-Apr-2018].

[3] W. Woldt and S. Skipton, “Residential Onsite Wastewater Treatment: Mound Systems,” *Nebraska Extension*, 2002. [Online]. Available: http://extensionpublications.unl.edu/assets/html/g1475/build/g1475.htm. [Accessed: 24-Apr-2018].

[4] “Sequencing Batch Reactor (SBR),” *ABSUN PALAYESH ENG Co.*[Online]. Available: http://absunpalayesh.com/en/2015/12/30/sequencing-batch-reactor-sbr/. [Accessed: 24-Apr-2018].

[5] C. H.- clickharder.com, “Parts of the Tank,” *Lonestar Aerobic Services*. [Online]. Available: https://www.lonestaras.com/system-orientation/parts-tank/. [Accessed: 24-Apr-2018].

[6] “MicroFast,” *Florida Onsite Systems & Design*. [Online]. Available: http://floridaonsitesystemsanddesign.com/microfast/. [Accessed: 23-Apr-2018].

[7] “How It Works,” *The Drainfield*. [Online]. Available: http://www.co.thurston.wa.us/health/ehoss/drainfield.html. [Accessed: 23-Apr-2018].

[8] “Climate Arizona,” U.S. climate data, [Online]. Available: http://www.usclimatedata.com/climate/arizona/united-states/3172. [Accessed 24 March 2018]

[9] P. Brown, “Standardized Reference Evapotranspiration: A New Procedure for Estimating Reference Evapotranspiration in Arizona,” College of Agriculture and Life Sciences, University of Arizona, Tuscon, 2005.

[10] D.C. Slack and E.C. Martin, “Irrigation Water Requirements of Wine Grapes in the Sonoita Wine Growing Region of Arizona,” Department of Agricultural and Biosystems Engineering, University of Arizona, Tuscon 1999.

[11] M. Moyer, R.T. Peters and R. Hamman, “Irrigation Basics for Eastern Washington Vineyards,” Washington State University Extension, Pullman, 2013.

[12] “Standard Drip Irrigation Kit for Vineyard,” DripDepot, [Online]. Available: http://www.dripdepot/com/product/standard-drip-irrigation-kit-for-vineyard. [Accessed 23 April 2018].

[13] D.F. Zoldoske, “Selecting a Drip Irrigation System for Vineyards,” Center for Irrigation Technology, 1998.

[14] “Pressure Loss Calculator,” DripDepot, [Online]. Available: http://www.dripdepot.com/irrigation-calculators/pressure-loss-calculator. [Accessed 15 April 2018].

[15] "Amtrol Well-X-Trol WX-251D, 62 Gallon, Water Pressure Tank with Composite Tank Stand," Aqua Science, [Online]. Available: http://www.aquascience.net/amtrol-well-x-trol-62-gallon-water-system-pressure-tank-with-composite-base-wx-251d. [Accessed 24 April 2018].

[16] 5000 Gallon Plastic Water Storage Tank,” *5000 Gallon Plastic Water Storage Tank (N-42044)*. [Online]. Available: http://www.tank-depot.com/productdetails.aspx?part=N-42044&gclid=Cj0KCQjwh7zWBRCiARIsAId9b4r7cRVZMoFemeVuZRY3g9_64btgyUXtGIGaF3cPV6_YNb_xxKKxuk8aAjHEEALw_wcB. [Accessed: 24-Apr-2018].

[17] "Goulds J7S, 3/4HP, Single Nose Shallow Well Jet Pump," Aquascience.com, [Online]. Available: http://www.aquascience.net/goulds-j7s-single-nose-shallow-well-jet-pump-3-4hp. [Accessed 7 May 2018].

[18] “S Series (Widebase Submersible),” Gorman-Rupp, [Online]. Available: http://www.grpumps.com/product/S-Series-Widebase-Submersible. [Accessed 15 April 2018].

[19] “Gorman Rupp Application Selection Program,” Gorman-Rupp, [Online]. Available: http://gorman-rupp.pump-flo.com/app/pump.aspx?sid=gorman-rupp&CATID=622&SELID=2987936&PSID=38089064. [Accessed 15 April 2018].

[20] “Cost of Staffing,” Dr. Bero. Available: http://www.bblearn.nau.edu. [Accessed: March-2017].

[21] Aim Environmental Industries, “Quote Estimation,” *D. Norfleet*, 16-Apr-2018.

[22] Phoenix Pumps Inc., “Quote Estimation,” *W. Richardson*, 16-Apr-2018.

[23] “Standard Drip Irrigation Kit for Vineyard,” DripDepot, [Online]. Available:http://www.dripdepot.com/product/standard-drip-irrigation-kit-for-vineyard. [Accessed 23 April 2018].

Questions?