<u>Letter of Transmittal</u>

Ruff Engineering, Inc.

NAU Civil & Environmental Engineering Department - Pets Return Home - Abigail Autieri, Ryann DuBose, Allyson Fedor, Crockett Saline

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05/05/2019

Mark Happe
Pets Return Home
4555 N Peyton Place
Clarkdale, AZ 86324

Dear Mr. Happe,

Attached is our final report titled Pets Return Home Site Design. The purpose of the final report is to demonstrate the work completed and the design decided to be best for the site by the team. The project was completed on May 4, 2020. This is submitted as the final copy of the report. Please let us know if you have any concerns.

Best,

Ruff Engineering, Inc.
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Pets Return Home Site Design

Ruff Engineering

Abigail Autieri, Allyson Fedor,
Ryann DuBose, Crockett Saline

Final Report

May 5, 2020

Table of Contents

List of Figures

List of Tables

List of Equations

List of Abbreviations

PRH: Pets Return Home
ADEQ: Arizona Department of Environmental Quality
USDA: United States Department of Agriculture
ASTM: American Society for Testing and Materials
pt: Point
USGS: United States Geological Survey
LID: Low Impact Design

Acknowledgments

The team received a tremendous amount of help when completing this project and would like to recognize those key contributors. Thank you to our grading instructor Dr. Bridget Bero for her knowledge, expertise, and countless draft revisions. Thank you to our technical advisor, Stephen Irwin, for the knowledge and guidance he provided during the course of the project. Thank you to Western Technologies - Flagstaff for letting us complete testing in their lab. Thank you to Mark Lamer, Adam Bringhurst, and Kai Kaoni, for equipment and advice for surveying the site. Lastly, thank you to our client Mark Happe for trusting us with this project.

1.0 Project Introduction

Pets Return Home is a dog rehabilitation, sanctuary, and adoption center. The purpose of the project was to evaluate the feasibility of modifying the kennel space at the rescue. The project was needed to improve the aesthetic appeal and the functionality of the kennel space. The increase in functionality included improvements in maintenance, sanitation, drainage, and quality of life for those living in the kennel space.

1.1 Project Location

The site was located at 4555 N. Peyton Place in Clarkdale, Arizona. Clarkdale, Arizona has been considered to be within the county boundaries of Yavapai County. Figures 1-1, 1-2, and 1-3 below depict the location of Yavapai County, the location of Clarkdale, Arizona, and an aerial view of the project site.

Figure 1-1: Location Map of Yavapai County and the Town of Clarkdale, Arizona. [1]

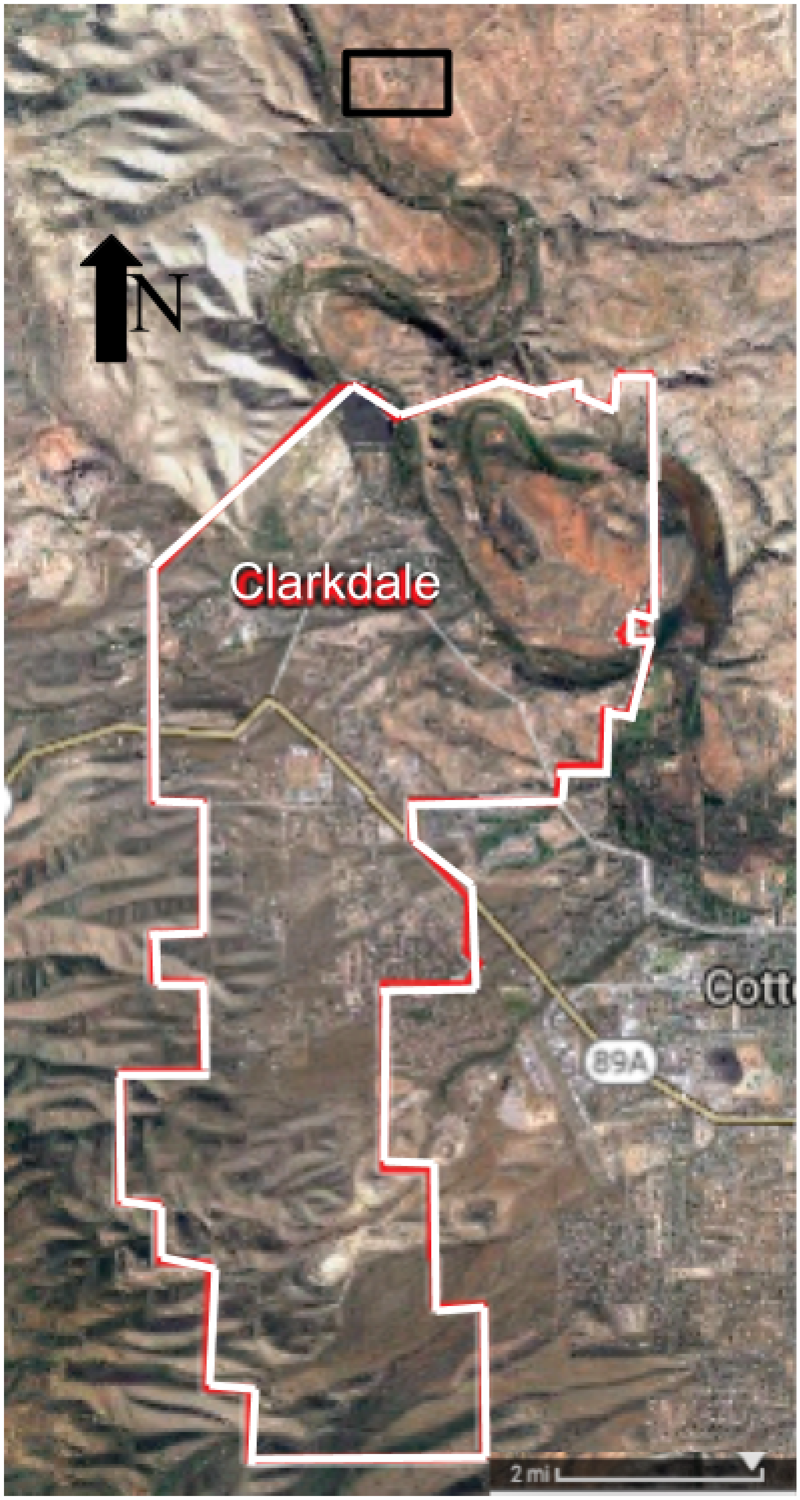


Figure 1-2: Location of the Town of Clarkdale in relation to Cottonwood, AZ Black box depicts where the site is located on the map.

Figure 1-3: Aerial view of the project site. The outlined area highlights the site.

1.2 Current Conditions

The site was a 4.01 acre developed residential lot on the east side of a dirt cul-de-sac on Peyton Place. This lot is surrounded by developed and undeveloped residential lots. The site shown in the map consists of multiple structures; including a residential structure with barns and kennels along the north and eastern property borders. The kennel space consists of 10 kennels with 10 feet by 10 feet spaces for the dogs seen below in Figure 1-4. The residential structure has the north and east sides of the structure underground with the deepest on the north east corner approximately five feet deep, having walkout entrances/exits on those sides.


Figure 1-4 : South Kennels Facing SE.

The natural surface drains in a south southwestern direction. The surface in the center of the lot has been graded and large gravel (passing a 3 inch sieve but retained on ¾ of an inch sieve) has been put in place for the driveway and walking areas. Ditches and retention ponds have been constructed to drain water away from the residential structure. The site has exhibited poor surface drainage by sheet flow and shallow channel flow to the south southwest. During our field investigation, pooled water was present in some of the drainage ditches. Vegetation consists of sparse growth of native grasses, weeds, bushes, and both planted and native trees.

2.0 Zoning Due Diligence

Figure 2-1 identifies the parcel number and boundaries of the site. The property has been classified as part of the RCU District of Yavapai County with a density designation of 2A. The designation of RCU was given to all unincorporated properties of Yavapai county and was meant to represent rural, single-family, residences. According to Section 413 of the Planning and Zoning Ordinance for the Unincorporated Areas of Yavapai County [2], properties classified as RCU are allowed all uses of the R1L, RMM, and R1 Districts. A designation of R1L was given to single family residences limited to site built structures only. Additionally, designations of RMM are given to single family, residential properties with site built, factory built and Multi-Sectional Manufactured Homes, no single-wide manufactured homes. Similarly, designated R1 properties were single family, residential properties with site built, multi-sectional and manufactured structures.

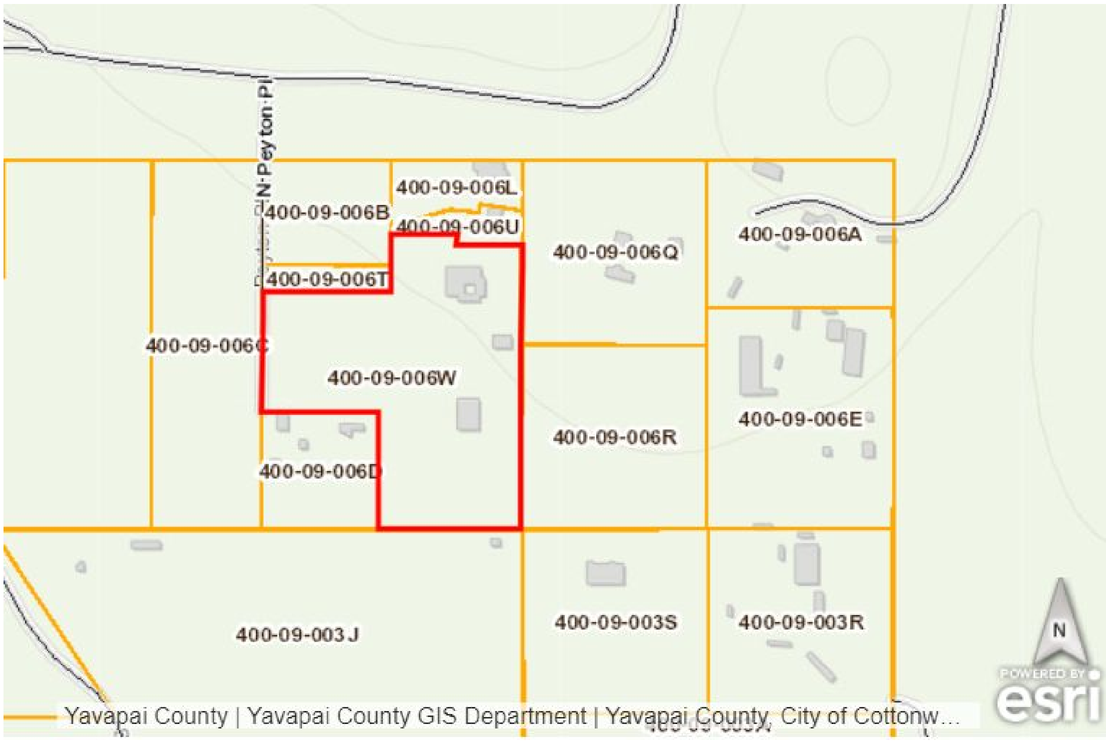


Figure 2-1 : Parcel number and location map provided by
the Yavapai County Interactive Map [1].

Zoning ordinances considered applicable in relation to the project are as follows:

- Section 410 R1L District - G - Allowed "Accessory uses and structures (concurrent with and located on the same lot with the principal uses and structures and including the following)" [2]:
  - 7 - "Household pets"
  - 8 - "Fences and free-standing walls"

Therefore, there are no zoning ordinances applicable that prevent the implementation or client use of the proposed slab expansion for the project site. The client may fence or use shade structures in conjunction with the provided slab.

3.0 Field Work

3.1 Geotechnical Sampling

The geotechnical investigation was performed on January 31 and February 1, 2020. Prior to the investigation, four test pit locations were designated and Arizona 811 was called to ensure that no public utilities were within the vicinity of the locations. The test pits were excavated in accordance with the Sampling and Analysis Plan (see Appendix A). Four locations were excavated, one hand excavated and the other three were excavated with a backhoe (Case 580 with 18-inch bucket). The excavations ranged from about 2 feet to 4 feet below existing site grades at the approximate location shown in Figure 3-1 and the typical test pit characteristics can be seen in Figure 3-2. Logs of the test pits are presented in Appendix B. Subsoils encountered during excavation were examined visually and sampled at selected depth intervals. In addition, three field infiltration tests were performed in proposed sanitary leach fields and stormwater retention basin. Ring samples and large grab samples were taken at each location. Samples were labeled according to the job, test pit location, and depth that the sample was obtained. For example of a sample label, PRH 1(0-2), PRH would have indicated the job (Pets Return Home), location 1, and the depths of 0 to 2 foot depth.

Figure 3-1: Test Pit Diagram

Figure 3-2: Typical test pit after excavation (right) and a test pit with ongoing infiltration test (left).

Ring samples were taken by a hand operated device that drives a sampler that consists of multiple rings. Figure 3-3 shows the device and typical ring. The rings were constructed out of brass and with dimensions of 1-inch high and an inner diameter of 2.42 inches. After the sampler had been driven into native soil, the bottom six rings were collected as a single cylinder, placed in a plastic bag, and then placed in a protective plastic sleeve with lid and labeled. This protected this type of sample so that in-site characteristics of the soil can be determined in the lab. These ring samples determined the moisture, density, and consolidation/compaction of the existing soils in place.

Figure 3-3: Collected sample in hand operated device (right) and sample in rings at lab (left).

Bulk or grab samples consisted of placing excavated soil in a bag that has a volume of approximately a 5-gallon-bucket. A bulk sample was collected when soil composition was noticeably different. There was a grab sample of the initial soil from the first excavation depth (approximately 2 feet) and if the field engineer deemed that the soil changed, additional samples were collected and labeled accordingly. Grab samples were collected to determine the soil classification, unit weight, and other soil properties for the design of kennel addition.

A field log was prepared for each test pit by the field engineer during the excavations. These logs contained visual classification of the materials encountered during the excavation as well as interpolation of the subsurface conditions between samples. Final logs, included in Appendix B, represented our interpretation of the field logs and included modifications based on laboratory observations and laboratory tests of the field samples. These logs, with the results of the infiltration tests, can be found in Appendix B. Infiltration tests were performed at Locations 2, 3, and 4, at the base of excavation with the presoak on January 31st, and the final test on February 1st.

The ASTM soil classification or Unified Soil Classification System was used to classify soils for the test pit logs. The Soil classification symbols appeared on the boring logs and are briefly described in Appendix B.

3.1.1 - Location 1

Test pit of Location 1 was chosen due to its close proximity to the proposed expansion of the concrete slab that was planned to be used for kennel space and was hand excavated. It was located along the center of the south side of the existing kennelspace. Duing the hand excavation, the existing concrete slab was observed (see Figure 3-4) and consisted of a simple 4 to 5 inch thick slab-on-grade (no foundation). The samples taken at this location consisted of two ring samples (one after another) at the base of existing concrete slab, and a grab sample.

Figure 3-4: Measurement of the existing slab.

Test pit logs indicated the observed soil classification and characteristic was Clay Sand; trace to some gravel; brown, loose, moist to wet, and might be a subbase fill. Due to the kennels being washed daily, these soils generally stay moist to wet. Excavation stopped at 2 feet.

3.1.2 - Locations 2 and 3

Test pits at Location 2 and 3 were selected based on ease of access for the backhoe in close proximity to the kennels. A geotechnical investigation at these locations were necessary to determine a solution for the sanitary runoff from the kennels. The test pits were excavated through use of a backhoe to the depth of 4 feet. At the bottom of excavation, infiltration tests were performed according to Arizona Department of Environmental (ADEQ) “Title 18. Environmental Quality Chapter 9. Water pollution Control - R18-9-A310 - Part F” [3]. Ring samples were taken at a depth of 2 feet and bottom of excavation. These samples were used to determine in place moisture and density of existing soils. A total of four grab samples were collected at these locations; two samples were collected at each location at the same depths. First, grab samples were collected of the initial soils from 0 to 4 feet deep, and the second set were taken from the depth of 4 to 5 feet. The second grab samples consisted of the tailorings of the hand excavated soils from the 12 inch cubic pit for the infiltration test.

Test pit log of location 2 indicated visual soil classification and characteristic was Clay Sand; gravel; brown, loose to medium dense, and damp to moist. The amount of fines increased and no gravel was seen with increasing depth. Infiltration test results at location 2 was 68 minutes per inch.

Test pit log of location 3 indicated observed soil classification and characteristic at 0 to 4 feet depth of Sandy Lean Clay; trace of gravel, brown, loose, and moist. Test pit log indicated a soil change at a depth of 4 feet to Clayey Sand; some gravel, white, medium dense, moist (limestone residue soil). Infiltration test results at location 3 was 56 minutes per inch. The excavation was stopped at 4 feet depth at both locations.

3.1.3 - Location 4

The test pit at Location 4 was selected based on observed topography and route of flow from rainfall events. This location provided the client with additional information about the soil characteristics that may be used for future projects that were not within the current scope of work. Geotechnical investigation at this location was needed to determine a solution to long-term ponding at the site. It was excavated by a backhoe to the depth of 4 feet. At the bottom of excavation, infiltration tests were performed according to ADEQ standards [3]. Ring samples were taken at the depth of 2 feet and due to the limestone at the base of excavation no ring sample was attempted. The samples will be used to determine in place moisture and density of existing soils. Grab samples were collected of the initial soils from a depth of 0 to 3 feet, from 3 to 4 feet due to an observed soil change, and of the soils that infiltration tests were performed.

Test pit log of location 4 indicated visual soil classification and characteristic of the initial soil was Clay Sand; trace of gravel, red/brown, medium dense to dense, and moist. The soil change at 3 feet consisted of a soil of the underlying limestone residue, and this was the same for the grab sample of the infiltration test location. Infiltration test results at location 4 was 16 minutes per inch. The excavation was stopped at 4 feet deep at this location.

3.2 Surveying

The survey was performed on February 8, 2020. The starting point of the survey was decided prior to heading into the field and an assumed northing, easting, and elevation for that point was determined. All other point elevations were based on the assumed point. The location of the total station setup can be seen in Figure 3-5. The total-station set-up point was marked using rebar with painted white top.

Figure 3-5 : Total Station Set Up Location

Using the data collected during the survey, a topographic map was made of the site. The topographic map with a reference photo of the site behind it can be seen in Figure 3-6. The topographic map can be seen in Figure 3-7. There were 94 points taken in the field in the form of point, northing, easting, elevation, and description. There were 16 points added to the surface using Google Earth for a total of 110 points. These points were deemed sufficient due to the dogs being under duress during surveying. The csv point file contains 94 points and was used to create the surface and can be seen in Appendix C.

Figure 3-6 : Surface with Photo Reference

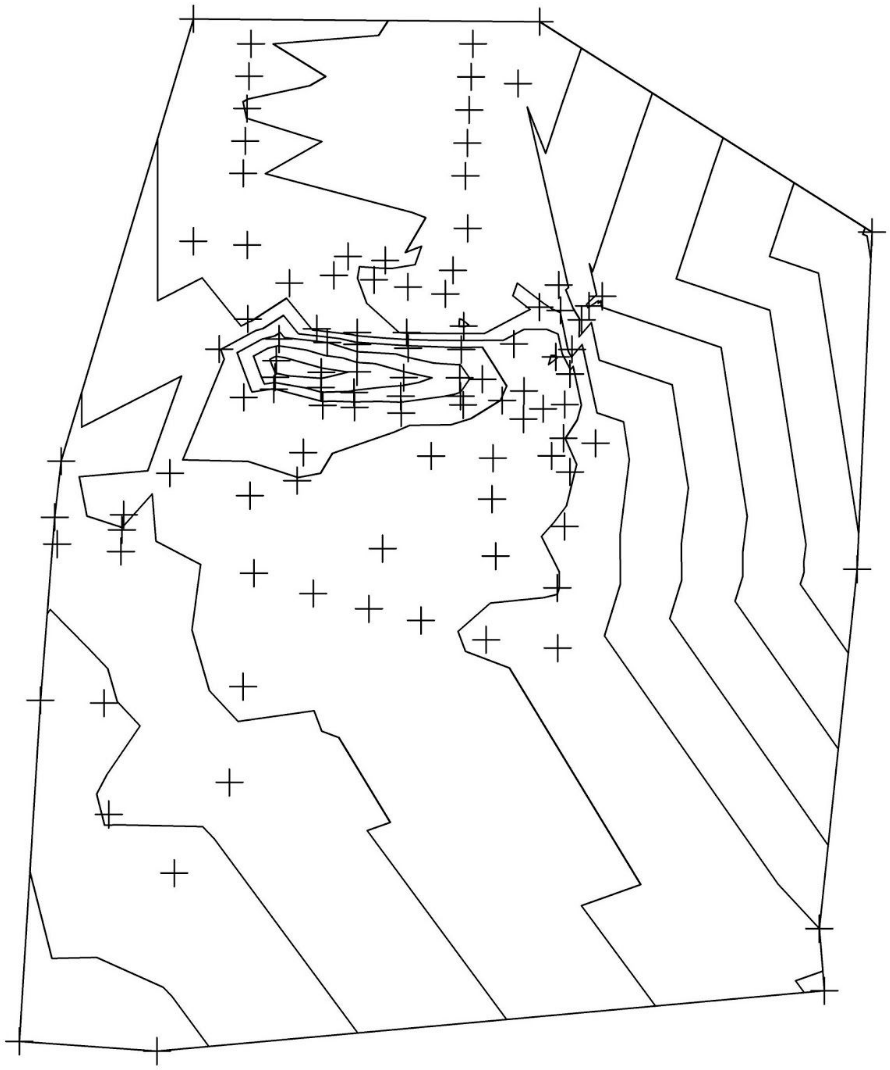


Figure 3-7 : Surface Points

The surface seen above will be used to identify alternative designs for the drainage of the kennels.

4.0 Testing/Analysis

Laboratory analyses were performed on representative soil samples to aid in material classification and to estimate pertinent engineering properties of the on-site soils for the site design. Testing was performed in accordance with applicable ASTM and Arizona Methods. The following laboratory tests were performed on the collected field samples:

- Soil Classification (ASTM D2487) [4]
- Field moisture contents (ASTM D2216) [5]

- In-situ soil density (ASTM D2937) [6]
- Remolded expansion potential (ARIZ 249) [7]
- Consolidation/Compression (modified ASTM D2435) [8]
- Liquid limit and plasticity index (ASTM D4318-17e1) [9]
- Compaction proctor (ASTM D698-12e2) [10]
- Hydrometer (ASTM D7928-17) [11]

4.1 Results

Results of the laboratory tests are displayed in tables/figures below. Sample labels are synonymous with the labeling system for sample collection. Test pit #(depth of sample). Depth of samples labeled "PERK" are samples collected from the infiltration tests. Tests with multiple replicates are differentiated by the number of replicates taken.

4.1.1 Soil Classification

4.1.1.1 ASTM

The soil classification standard ASTM D2487 (soil classification, unified soil classification system) was used to determine the soil classification at all testing locations [4]. Results are shown in Table 4-1. Three replicates were completed for each sample.

From the results in Table 4-1, it was observed that coarse grained soils (SC) were most commonly present throughout the project site.

Table 4-1: Soil classification results from samples taken at Locations 1, 2, 3, and 4.

Sample	**1(0-2)**	**2(0-4)**	**2(PERK)**	**3(0-2)**	**3(PERK)**	**4(0-3)**	**4(3-4)**	**4(PERK)**
	Soil Classification							
Replicate 1	SC-SM	SC	SC	SC	SC	CL	SC	SC-SM
Replicate 2	SC-SM	SC	SC	SC	SC	CL		SC-SM
Replicate 3	SC	SC	CL	SC	SC	CL		SC-SM
Average	**SC-SM**	**SC**	**SC**	**SC**	**SC**	**CL**	**SC**	**SC-SM**

Please note, that test pit four at the depth of 3 to 4 feet was only tested once. The reason is that the excavation tailoring was not enough and was contaminated with upper strata soil layer. The soil that was tested from the infiltration test is a more appropriate sampling of same weather limestone soil strata with lower levels of contamination. Test pit four soil classification from the infiltration test results showed that the soil was of a dule classification of Silty, Clayey SAND (SC-SM).

4.1.1.2 USDA

The hydrometer test was done in accordance with ASTM D7928-17 [5]. Results of the hydrometer tests performed at Test Pits 2, 3, and 4 are depicted graphically below in Figures 4-1, 4-2, and 4-3. The results of the hydrometer tests were used to determine the USDA soil classifications of the three test pits.

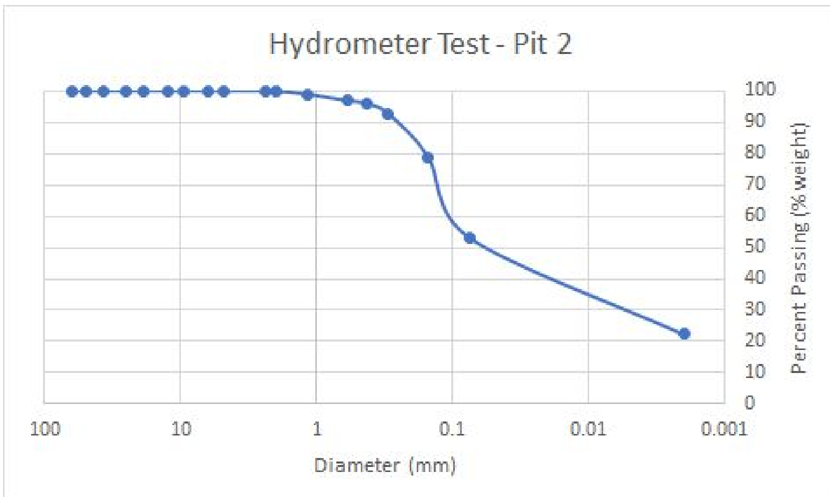


Figure 4-1: Results of hydrometer test at Test Pit 2.

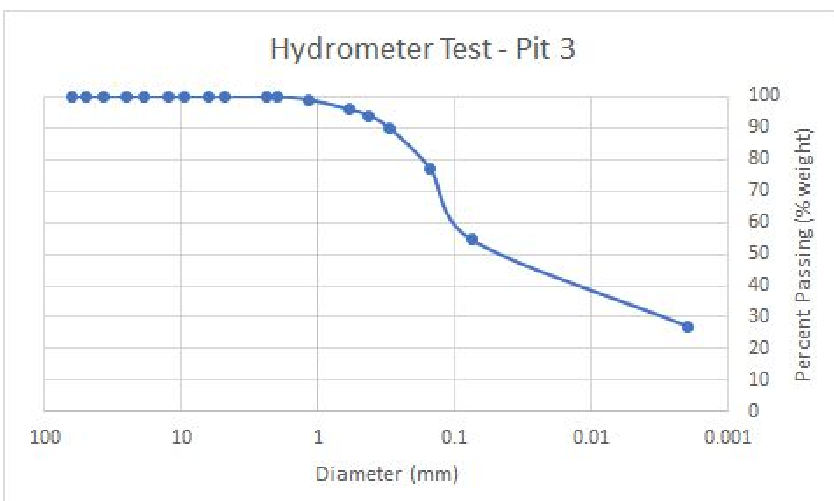


Figure 4-2: Results of hydrometer test at Test Pit 3.

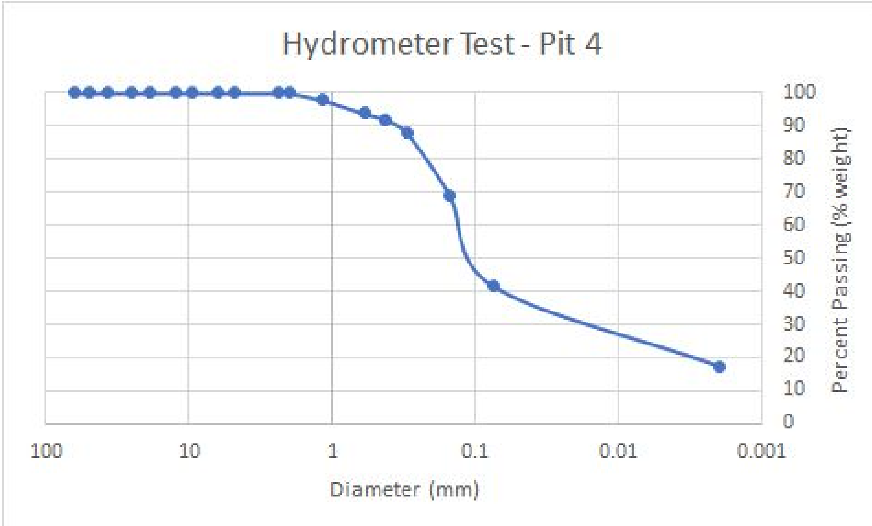


Figure 4-3: Results of hydrometer test at Test Pit 4.

Table 4-2 below shows the percentages of sand, silt, and clay for each of the test pits. These percentages were used for the USDA triangles to determine soil classification.

Table 4-2: Percentage of soil particles

Test Pit	% Sand	% Silt	% Clay
2	55	25	20
3	55	15	30
4	65	15	20

Figures 4-4, 4-5, and 4-6 depict the USDA soil texture chart at the depth of 4 to 5 feet in Test Pits 2, 3, and 4. The USDA soil texture chart results show that the soil at Test Pits 2, 3, and 4 is Sandy Clay Loam.

Test Pit 2, Depth 4 to 5 Feet

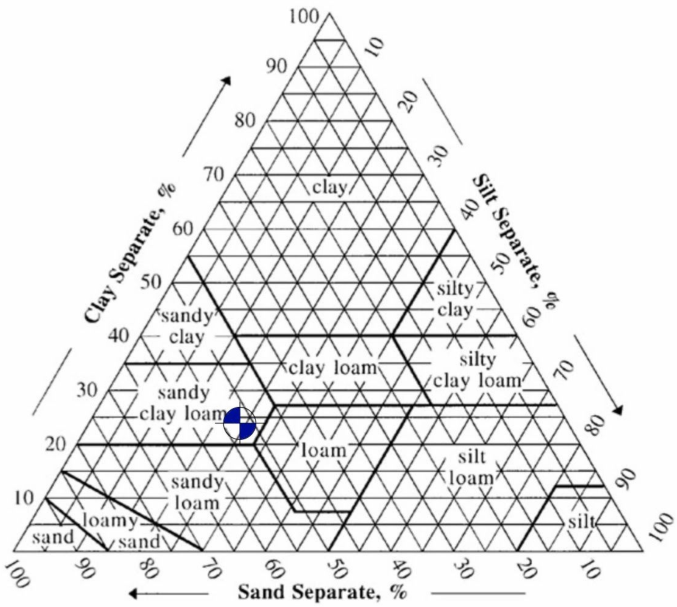


Figure 4-4: USDA soil texture chart for Test Pit 2 at a depth of 4 to 5 feet.

Test Pit 3, Depth 4 to 5 Feet

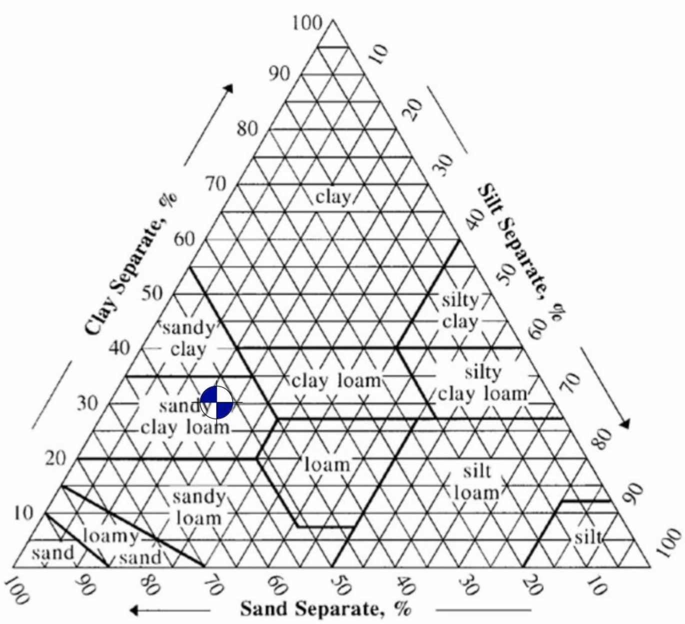


Figure 4-5: USDA soil texture chart for Test Pit 3 at a depth of 4 to 5 feet.

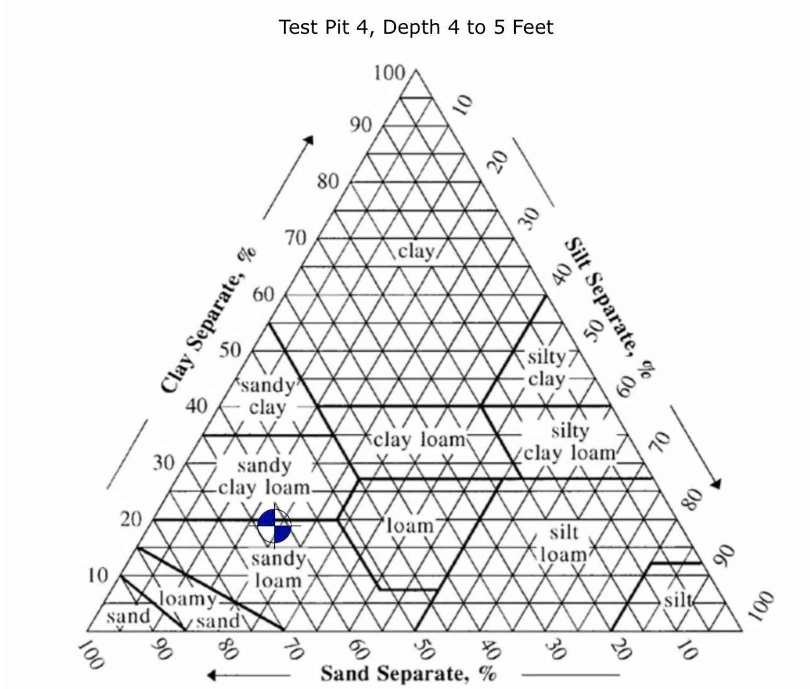


Figure 4-6: USDA soil texture chart for Test Pit 4 at a depth of 4 to 5 feet.

4.1.2 Field Moisture Contents

Table 4-3 shows the field moisture content (ASTM D2216 (in-place moisture content)) [6].

Table 4-3: Field moisture content results from samples taken at Locations 1, 2, 3, and 4.

Sample	1(0-1)	1(1-2)	2(2-3)	2(4-5)	3(2-3)	3(4-5)	4(2-3)
Field Moisture Content (%)	17.8	14.1	10.3	4.7	14.7	16.2	2.9

4.1.3 In-situ Soil Density

Table 4-4 shows the in-situ soil density (ASTM D2937 (in-place density)) [7].

Table 4-4: In-situ soil density results from samples taken at Locations 1, 2, 3, and 4.

Sample	1(0-1)	1(1-2)	2(2-3)	2(4-5)	3(2-3)	3(4-5)	4(2-3)
Inplace Density (lb/cu.ft)	105.6	104.5	104.6	108.4	102.3	113.4	98.2

The density observed from the lab results can be considered normal for uncompacted soil near or at surface. Often native soil is found at 85 percent of a common compaction proctor, and the inplace density depicts that. This gives an indication that the onsite soil is relatively consistent and that it is consistent with the type of soil that is encountered on site.

4.1.4 Remolded Expansion Potential

Remolded expansion potential tests were performed on all testing locations according to the standard ARIZ 249 [8]. Figure 4-7 shows the results of the test. The expansion percentages that are seen in Figure 4-4 are in the zero swell potential, 0% to 1.5%, and moderate swell potential, 1.5% to 3%. These swell potential results would be considered normal to expected from the sandy clay loam soils classifications. The standard is normal within the state of Arizona, but there are other means of determining swell potential such as a test called “expansion index”.

REMOLDED SWELLS							
TEST PIT NO.	DEPTH (FEET)	SOIL CLASSIFICATION	SOIL PROPERTY		EXPANSION		REMARKS
			INITIAL DRY DENSITY (PCF)	INITIAL WATER CONTENT (%)	SURCHARGE (KSF)	EXPANSION (%)	
1	0-2	SC-SM	112.2	10	0.1	2.3	1,2
2	0-4	SC	113.3	12.7	0.1	0	1,2
2	4-5	SC	113.3	12.7	0.1	0.6	1,2
3	0-2	SC	113.3	12.7	0.1	0.2	1,2
3	4-5	SC	111.3	13.5	0.1	0.2	1,2
4	0-3	CL	113.3	12.7	0.1	1.8	1,2
4	3-4	SC	111.3	13.5	0.1	0.7	1,2
4	4-5	SC-SM	113.3	12.7	0.1	0.1	1,2

Remarks:
1. Compacted Density (approximately 95% of ASTM D698 maximum density and -3% below optimum moisture content
2. Submerged to approximate saturation

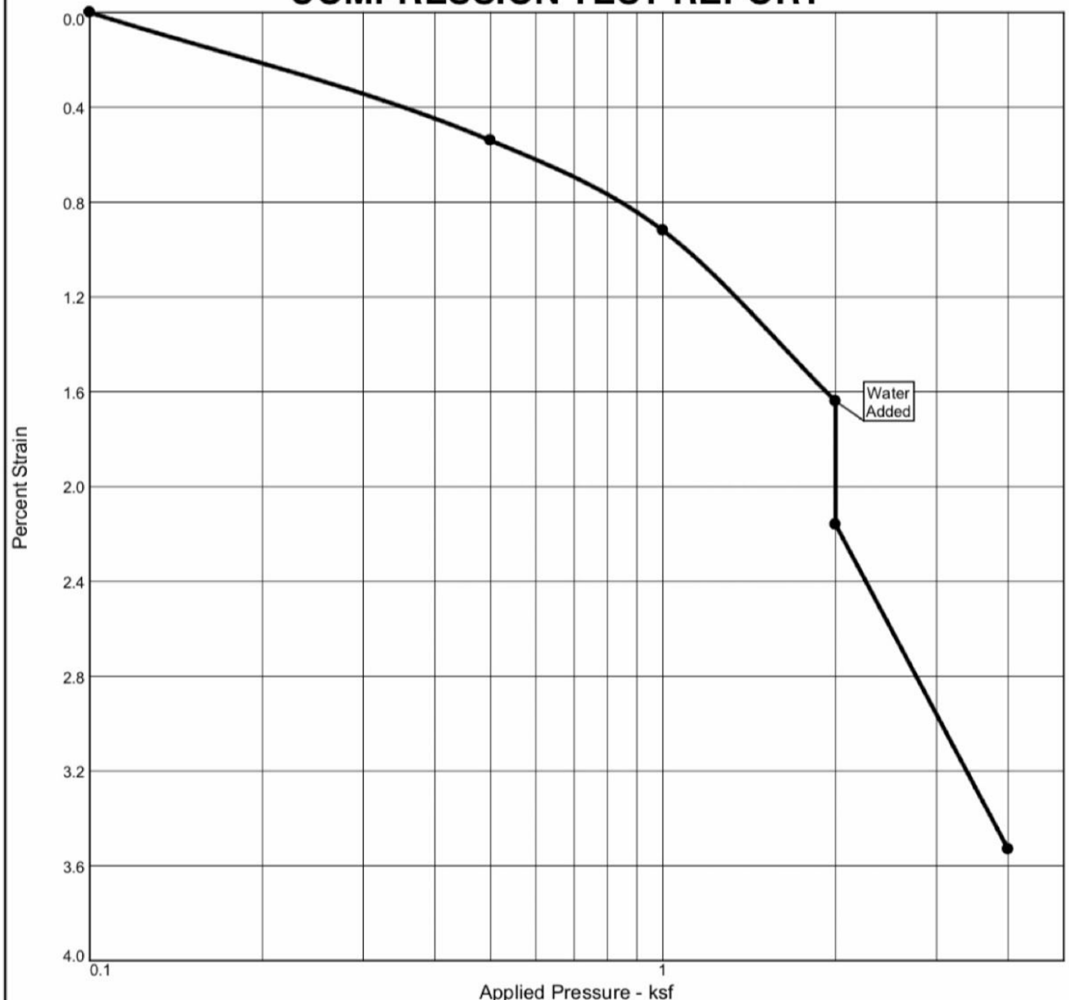
Figure 4-7: Remolded Swells

4.1.5 Modified Consolidation/Compression

The modified consolidation/compression test was done in accordance with modified ASTM D2435 [9] to determine how an in place soil will cope with different loads. Figures 4-8 and 4-9 show how the in-situ soil from the ring samples would handle different loads. The lads were added after the soil had stabilized from the previous load. The initial load is called the seating load and is 0.1 kpsf., and the following loads are 0.5 kpsf, 1.0 kpsf, 2.0 kpsf, saturation, and 4.0 kpsf.

The reason why this is considered a modification from a consolidation test is because the sample is not saturated from start to finish, but is saturated subsequent to loading of 2.0 kips per sq. ft. Due to the environment of Arizona soil conditions are not normally saturated but in a few cases, and to better understand how an in-situ soil supports loads with different conditions, hence the reason for the modification. This modification occurs after what would be considered the load required the soil to support a normal structure. Saturating the soil at the point sees what would happen if the footing were inundated with water and observing the hydro collapse for any potential issues.

COMPRESSION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	e_o	Swell Press. (ksf)	Clpse. %	C_r
Sat.	Moist.									
88.3 %	17.8 %	107.9			2.65		0.534		0.5	

MATERIAL DESCRIPTION	USCS	AASHTO
SILTY, CLAYEY SAND	SC-SM	

Project No. 2520L6000 **Client:** C. SALINE

Project: PRH

Source: RING SAMPLE **Depth:** 0-1 FOOT **Sample No.:** TEST PIT 1

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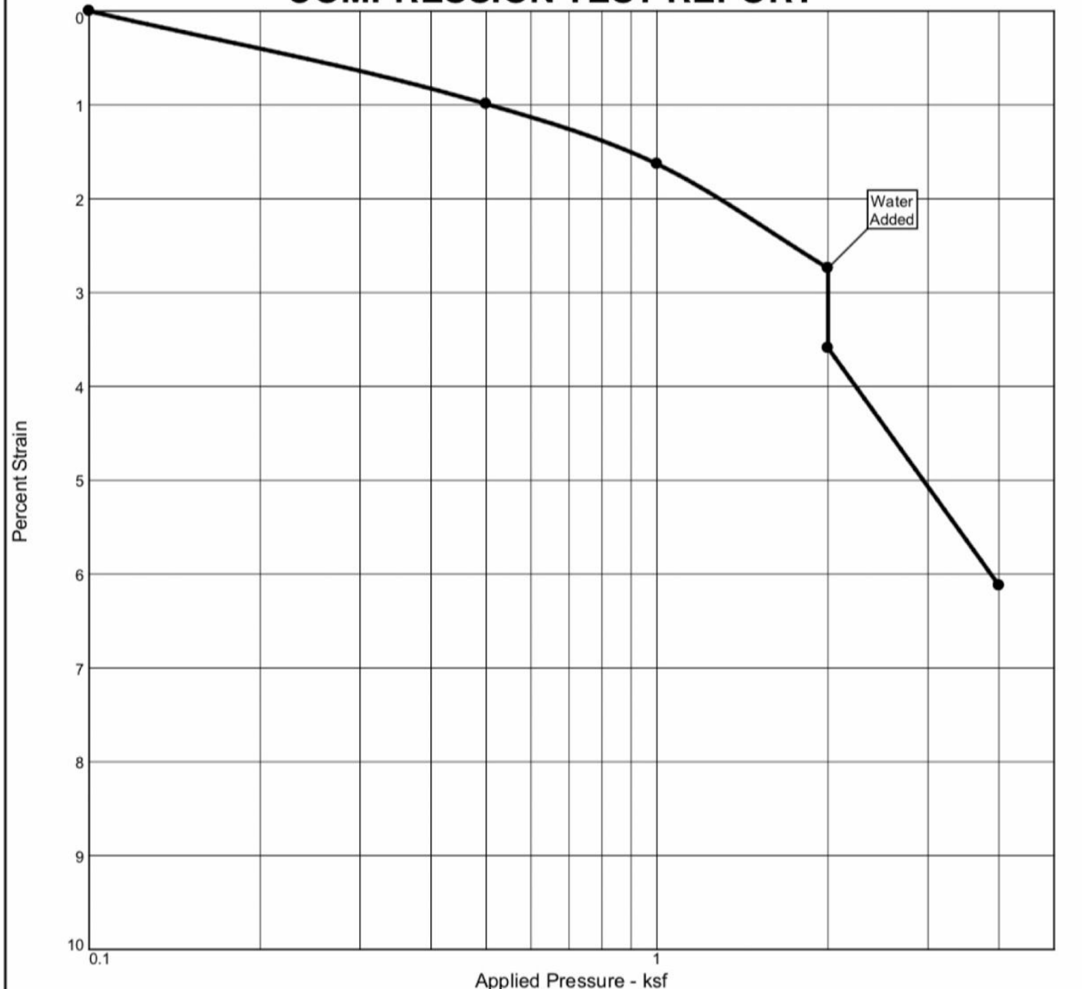
Remarks:

Figure 4-8: Location 1, 0-1 foot depth

COMPRESSION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	e_o	Swell Press. (ksf)	Clpse. %	C_r
63.4 %	14.1 %	104.0			2.65		0.591		0.8	

MATERIAL DESCRIPTION	USCS	AASHTO
SILTY, CLAYEY SAND	SC-SM	

Project No. 2520L6000 **Client:** C. SALINE

Project: PRH

Source: RING SAMPLE **Depth:** 1-2 FEET **Sample No.:** TEST PIT 1

Remarks:

RUFF ENGINEERING

Figure 4-9: Location 1, 1-2 foot depth

The compaction of the surface soil can be compared to the Compaction Proctor results (see Section 4.1.7 below) and the upper sample had a compaction of 91.4 percent and the lower sample with 88.1 percent. These soils have been disturbed due to the freeze and thaw cycle, and the moisture content exacerbates this freeze and thaw condition. This condition produces gaps between the particles in the soil causing the soil to collapse when loads are placed on them. This is why it is required to scarify and recompact the top 8” of soil under and extending 5 feet beyond the footprint of the proposed kennel. It is recommended that a large vibrating steel drum roller performs the compaction.

4.1.6 Liquid limit and plasticity index

Tables 4-5 and 4-6 show the liquid limit and plasticity index (ASTM D4318-17el.) [10].

Table 4-5: Liquid limit results from samples taken at Locations 1, 2, 3, and 4.

Sample	1(0-2)	2(0-4)	2(PERK)	3(0-2)	3(PERK)	4(0-3)	4(PERK)
	Average Liquid Limit (%)						
Replicate 1	24.00	25.00	26.00	25.00	26.00	28.00	23.00
Replicate 2	24.00	24.00	22.00	24.00	25.00	31.00	21.00
Replicate 3	24.00	24.00	24.00	25.00	25.00	28.00	23.00
Average	**24.00**	**24.33**	**24.00**	**24.67**	**25.33**	**29.00**	**22.33**
Standard Deviation	0.00	0.58	2.00	0.58	0.58	1.73	1.15

Table 4-6: Plasticity index results from samples taken at Locations 1, 2, 3, and 4.

Sample	1(0-2)	2(0-4)	2(PERK)	3(0-2)	3(PERK)	4(0-3)	4(PERK)
	Plasticity Index (%)						
Replicate 1	17.00	15.00	15.00	16.00	14.00	14.00	17.00
Replicate 2	17.00	15.00	14.00	15.00	14.00	14.00	16.00
Replicate 3	16.00	15.00	14.00	16.00	14.00	12.00	17.00
Average	**16.67**	**15.00**	**14.33**	**15.67**	**14.00**	**13.33**	**16.67**
Standard Deviation	0.58	0.00	0.58	0.58	0.00	1.15	0.58

Both liquid and plastic limits are the percentage of moisture content when the soil meets a particular characteristic. The liquid limit is where the moisture that is contained in the soil is causing the soil to be unstable and liquefied. While the plastic limit is when a soil has enough moisture to be considered plastic. The difference between the liquid limit and the plastic limit is the plasticity index. Despite that two different soil classifications were used they have some similarities. The plastic index results are consistent with soils of sandy clay loam.

4.1.7 Compaction Proctor

Compaction proctor tests were performed on the bulk sample collected from Location 1 and performed in accordance with ASTM D698-12e2 [11]. Samples from Location 1 were the only ones used because Location 1 is where the concrete pad will be. The soil compaction is only needed for a structurally sound concrete pad. Results of the test can be seen in Figure 4-10. A maximum density of 118.1 lbs/ft^3 and optimum moisture content of 13.0% was determined. If no additional soil is used to produce grade under proposed kennel this data can be used to compare field density to determine rate of compaction and moisture content compliance.

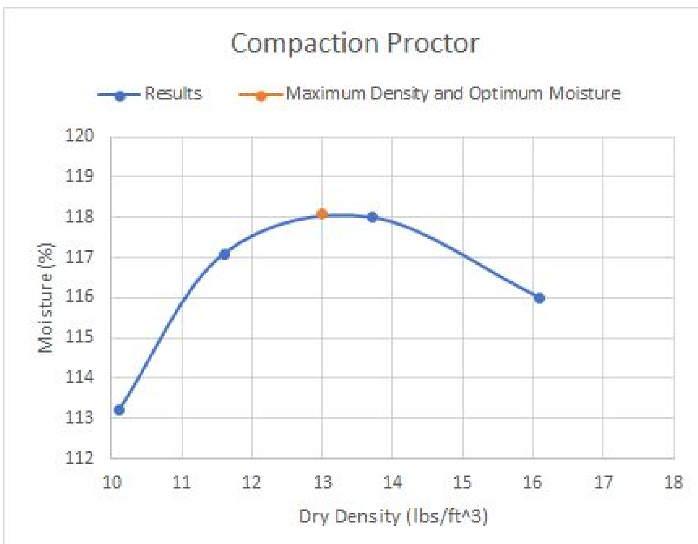


Figure 4-10: Results of the compaction proctor test.

4.1.8 Summary of Infiltration Test

Infiltration testing was performed in the field during the site visit and soil investigation according to ADEQ standards [3]. The records of the results can be found in Appendix B. Table 4-7 contains the final results of the tests. Based on the results of the testing it is assumed that infiltration rates improve the further south the location is from the slab location.

Table 4-7: Infiltration Test Results

Infiltration Rates			
Test Pit Location	2	3	4
Percolation (mins./inch)	68	56	16

4.2 Geotechnical Evaluation

This geotechnical evaluation includes a discussion of the subsurface conditions found from the field work and laboratory testing performed (see Sections 3.1 and 4.1) and design recommendations required to satisfy the purpose of the project.

This report is for the exclusive purpose of providing geotechnical engineering and/or testing information and recommendations. The scope of services of this project does not include, either specifically or by implication, identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

4.2.1 General

Recommendations contained in this report are based on the understanding of the project criteria described in Section 1.0, Project Introduction, and the assumption that the soil and subsurface conditions are those disclosed by the ring samples and lab testing. Others may change the plans, final elevations, number and type of structures, foundation loads, and floor levels during design or construction. Substantially different subsurface conditions from those described herein may be encountered or become known. Any changes in the project criteria or subsurface conditions shall be brought to our attention in writing.

4.2.2 Slab-on-Grade Support

Meyrerhof's shallow foundation equation (Equation 4-1) was used to determine the bearing capacity of the existing surface.

Equation 4-1: Meyerhof Shallow Foundation Bearing Capacity

$$q_u = c'N_c F_{cs} F_{cd} F_{ci} + qN_q F_{qs} F_{qd} F_{qi} + \frac{1}{2}\gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i}$$

q_u = Net ultimate bearing capacity (lb/ft^2)

C' = Cohesion (lb/ft^2)

q = effective stress at the level of the bottom of the foundation (lb/ft^2)

γ = unit weight of soil (lbs/ft^3)

B = width of foundation (ft)

$F_{cs},\ F_{qd},\ F_{\gamma s}$ = shape factors

F_{cd}, F_{qd}, $F_{\gamma d}$ = depth factors
F_{ci}, F_{qi}, $F_{\gamma i}$ = load inclination factors
N_c, N_q, N_γ = bearing capacity factors

Equation 4-2: The Gross Allowable Load

$$q_{all} = q_u/FS$$

q_{all} = Net stress increase on soil (lb/ft^2)
q_u = Net ultimate bearing capacity (lb/ft^2)
FS = Factor of safety

Due to the project consisting of a slab-on-grade, the soil is required to support the concrete pad when the soils are in their moist or wet condition. This is not considered normal for Arizona, but is necessary due to the daily washing of the kennels. Variables of the Meyerhof's equations are determined by the soil properties determined experimentally and the structure of the slab. Due to the fact that the slab is not underground, a term of "$qN_qF_{qs}F_{qd}F_{qi}$" is zero. The other two-thirds of the equation determined that the net ultimate bearing capacity is 21,000 psf and applying a factor of three, the net stress is 7,000 psf. A safety factor of three is customary for bearing capacity of shallow foundations. The bearing capacity accounts for how the soil will react at near saturated conditions, and soils in drier conditions are able to support more weight than when they are near their liquid form.

4.2.3 Drainage

The major cause of soil-related foundation and slab-on-ground problems is moisture increase in soils below structures. Properly functioning conventional slabs-on-ground require appropriately constructed and maintained site drainage conditions. Therefore, it is extremely important that positive drainage be provided during construction and maintained throughout the life of the concrete slab. It is also important that proper planning and control of landscape and irrigation practices be performed.

Scuppers and drain pipes should be designed to provide drainage away from the area for a minimum distance of 10 feet. Planters or other surface features that could retain water adjacent to a concrete pad should be avoided if at all possible. If planters and/or landscaping are adjacent to or near the slab, there will be a greater potential for moisture infiltration, soil movement and structure distress.

As a minimum, we recommend the following:

- Grades should slope away from the slab

- Planters should slope away from the house and should not pond water. Drains should be installed in enclosed planters to facilitate flow out of the planters.
- Only shallow rooted landscaping should be used.
- Watering should be kept to a minimum. Irrigation systems should be situated on the far side of any planting and away from the slab to minimize infiltration beneath foundations from possible leaks.
- Trees should be planted no closer than a distance equal to three-quarters of their mature height or 15 feet, whichever is greater.
- It should be understood that these recommendations will help minimize the potential for soil movement and resulting distress, but will not eliminate this potential.

4.2.4 Additional Infiltration Testing

The infiltration tests performed at Testing Sites 2, 3, and 4 show that infiltration increases with distance is from the proposed slab-on-grade location. To prevent moisture increase beneath the slab and improve infiltration, it is recommended that the proposed drainage design be placed further away from the slab than initially observed during the initial site visit. Additional testing in the proposed location is recommended to support this assumption.

5.0 Hydrology

A hydrological analysis was conducted to determine the water flow through the kennel space. It was determined the best way to conduct the analysis was to determine the drainage area for the flow through the kennels. Previous studies were found to obtain precipitation data for the area [12]. Flow routing, weighted curve number, and time of concentration were determined; these values were then used to find the storm event runoff.

5.1 Basin Delineation

Basin delineation was done to determine the area of rainfall that contributes to the flow going through the kennel space.

5.1.1 Major Basin

The major basin the site is within was determined using USGS StreamStats [13]. Figure 5-1 below shows the major basin determined for the site. The site is marked with a blue pin.

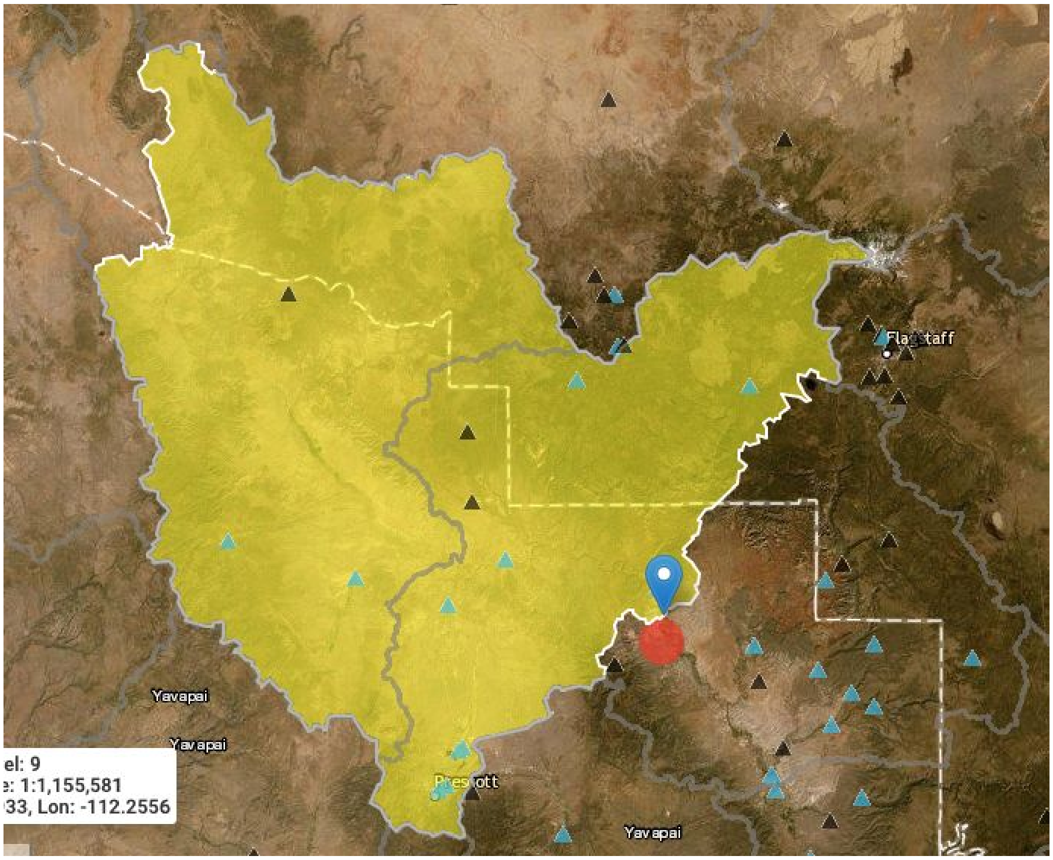


Figure 5-1: Major Basin [13]

The major basin was much too large to analyze for the size of the site. The size of the major basin also made it difficult to determine a sub-basin to analyze. For this reason, the team used the topography of the area surrounding the site to determine a drainage area for the site.

5.1.2 Sub-Basin

The "sub-basin" used to analyze the hydrology of the site was the drainage area determined using the topography of the area. Figure 5-2 below shows the drainage area used to analyze the hydrology of the site. The drainage area is outlined in red and the kennel space is marked by a green star.

Figure 5-2: Drainage Area

5.2 Sub-Basin Variables

5.2.1 Flow Routing

Flow routing was done using the contours of the drainage area. Figure 5-3 below shows the flow of the water through the site. The dark blue line shows runoff that flows through the kennels. The light blue lines show runoff that is near the kennel but does not flow through them. The light blue line east of the kennel flow does go through the clients property and may cause flooding, but since it is not a part of this project, it will not be analyzed. The flow route is also known as the time of concentration flow path.

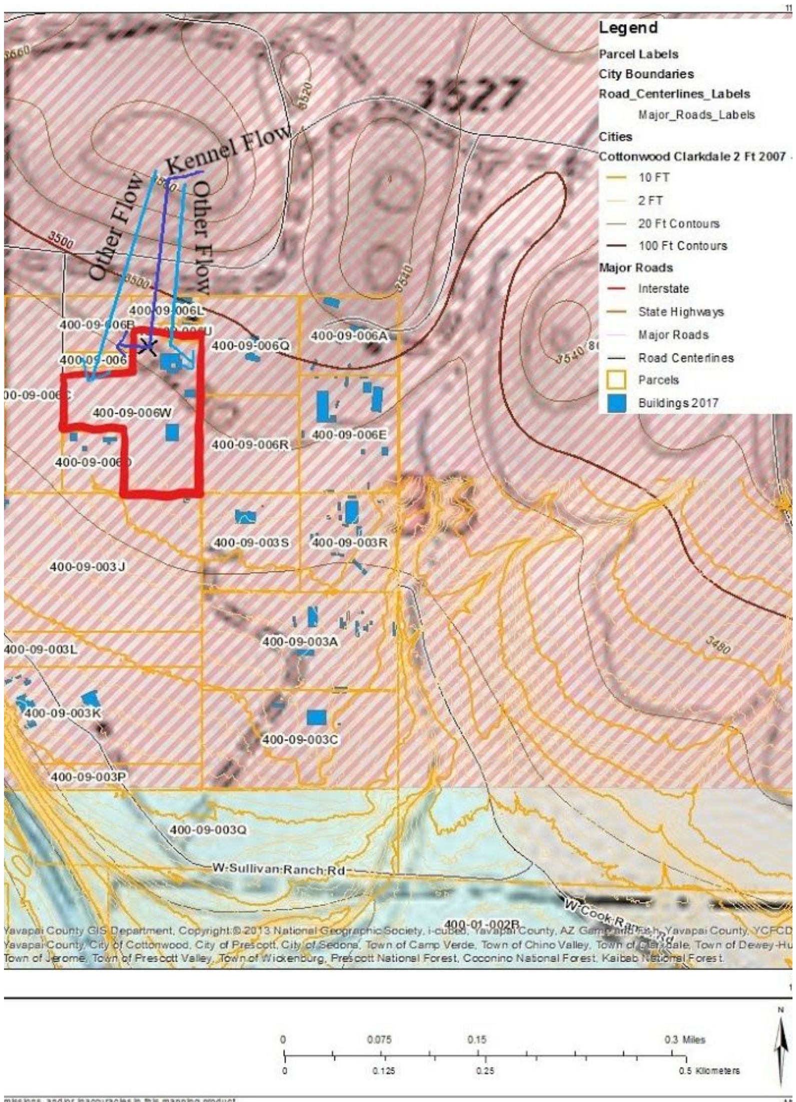


Figure 5-3: Flow Routing [14]

5.2.2 Weighted Curve Number

The weighted curve number was calculated using Table 7.6 in the Yavapai County Drainage Design Manual [15]. The curve number was found by determining the types of landscape, curve number for each landscape, and percentage of drainage area for landscape type. The table below shows the weighted curve number for the area that flows through the kennel space.

Equation 5-1: Weighted Curve Number

$$WC = \sum(C * \%A)$$

WC: Weighted Runoff Coefficient
C: Runoff Coefficient
%A: Percent of Total Area

Table 5-1: Weighted Curve Number

Percentage of Surface Type within Sub-Basin (%)				Weighted C
Natural Desert Rangeland	Hillslopes	Gravel Road	Roof	
66%	16%	16%	2%	0.58
0.48	0.67	0.84	0.95	
Runoff Coefficient				

The weighted runoff coefficient was determined to be 0.58. The references used to determine the weighted curve number can be found in Appendix D.

5.2.3 Time of Concentration

The time of concentration (T_c) was calculated for the drainage area following Equation 7.2 in the Yavapai County Drainage Design Manual [15]. Based on Equation 5-2 the time of concentration was determined to be 30 minutes for the site. Since rainfall intensity is based on time of concentration, the theoretical time of concentration was used to determine the different rainfall intensities for each T_c for each storm. These were then used in the equation to determine the calculated time of concentration. The calculated time of concentrations that matched the theoretical time of concentrations were those used for further calculations. For every storm event, the time of concentrations that matched were for a 30 minute T_c. The rainfall intensities used to solve for time of concentration were found using NOAA Atlas 14 [16]. The length and slope of flow were determined through measurements found using Google Earth and contours provided by USGS. The equation and references used to calculate T_c can be found in Appendix D.

Equation 5-2: Time of Concentration

$$Tc = 11.4L^{0.5}{K_b}^{0.52}S^{-0.31}i^{-.038}$$

T_c: Time of Concentration (hr)
L: Length of Hydraulic Path (ft)
K_b: Watershed Resistance Coefficient
S: Slope of Hydraulic Path (ft/mi)
i: Average Rainfall Intensity (in/hr)

Table 5-2 below shows the calculation for time of concentration for the site for various storm events. The complete table can be found in Appendix D.

Table 5-2: Time of Concentration

Knowns	
Length of Flow Path - L (mi)	0.370
Watershed Resistance Coefficient - Kb	0.250
Slope - S (ft/mi)	378.4

Theoretical Time of Concentration (min)	Storm (yr)	Rainfall Intensity (in/hr)	Calculated Tc (hr)	Calculated Tc (min)
30	1	0.546	0.674	40
30	2	0.705	0.612	37
30	5	0.957	0.545	33
30	10	1.16	0.506	30
30	25	1.46	0.464	28
30	50	1.71	0.437	26
30	100	1.98	0.413	25

5.3 Storm Event Runoff

To determine the storm event runoff for the site, the Rational Method was used following Yavapai County Drainage Design Manual Equation 7.1 [15].

Equation 5-3: Storm Event Runoff

$$Q = CiA$$

Q: Runoff (cfs)
C: Weighted Runoff Coefficient
i: Rainfall Intensity (in/hr)
A: Drainage Area (acre)

The area used to calculate the flow was determined using Google Earth. The rainfall intensity values used are the 30 min duration intensities from NOAA Atlas 14 [16]. The storm event runoff was only calculated once because there is no change in the impervious area. At the location of the concrete pad the soil is already compacted which makes it impervious, so the addition of the concrete pad does not change the impervious area. Table 5-3 below shows the storm runoff for different storm events. The table is for both existing and proposed runoff. The impervious area does not change with the addition of the concrete pad because the ground is already compacted at the location the concrete pad will be placed. It was determined that the best storm to design for is the one correlating with a monsoon season storm. Research was done to determine which storm correlates with a monsoon level storm. The Cottonwood area gets approximately 5.37 inches of rain during monsoon season [17]. Out of 55 days of the monsoon season, Cottonwood only gets rain 10 of those days [18]. With this, it was determined that every day it rains during monsoon season, approximately 0.5 inches of rain falls. Monsoon storms last approximately one to two hours, which means the rainfall intensity in inches per hour most closely matches a 1 year storm event.

Table 5-3: Storm Event Runoff

Flow Through Kennels	
Storm (yr)	**Q (cfs)**
1	**0.58**
2	0.74
5	1.01
10	1.22
25	1.54
50	1.80
100	2.09

6.0 Hydraulics

Bernoulli's Equation (see Equation 6-1) was utilized to determine the volume of flow utilized to sanitize the kennel space. The client uses a well pump system north-east of the existing slab (see Figure 6-1) to supply water to his hose to wash the kennel space. The client informed us that the pump supplying pressure was of 60 psi.

Figure 6-1: Existing well location in respect to the site location and pipe system. Star represents the general location of the project location. Figure is not to scale.

Equation 6-1: Bernoulli's Equation

$$\frac{P_1}{\gamma} + \frac{V_1^{\,2}}{2g} + h_1 + h_P = \frac{P_2}{\gamma} + \frac{V_2^{\,2}}{2g} + h_2 + h_L$$

P = Pressure (psi)

V = Velocity (ft/s^2)

g = Acceleration due to gravity (32.2 ft/s)

h = Height (ft)

h_L= Head loss (ft)

h_P= Pump head (ft)

γ = Specific weight of water (62.4 lbs/ft^3)

Educated assumptions regarding the length and type of material for the pipe and hose were made to estimate flows according to what the team experienced during the site visits to the project location. Table 6-1 shows values for the assumptions made. The process of determining the velocity due to the pipe and hose material was iterative. Hand-written calculations can be seen in Appendix E. Results of the hydraulic analysis show that a total of 3.4 gpm are supplied to the hose used to wash the kennel space.

Table 6-1: Assumptions made for flow rate determination of hose at existing kennel space.

Hydraulic Assumptions	
Δ Elevation	0 ft
Δ Pressure	0 psi
Pipe Material	PVC
Pipe Diameter	0.75 in
Length of Pipe	200 ft
Hose Material	Rubber
Hose Diameter	0.75 inch
Length of Hose	100 ft

7.0 Site Design Alternatives

7.1 Methodology

In order to propose a solution for the sanitary sewer runoff from the kennel space, a decision matrix was utilized for the design alternatives. The decision criteria and designs were evaluated through the use of a weighted decision matrix (see Figure 6-1). Each criteria was given a weight based on the criteria's ability to affect the clients feasibility to implement the design. Then each design was ranked one, two, or three with "one" being the design that best met the criteria and "three" being the design that least met the criteria. The weight of each decision criteria and the rank that the design was given were multiplied and summed together to give a weighted score for each design. The design that scored the least is the design that best met the decision criteria. The goal was to develop at least three design alternatives and decision criterias each to use in the weighted decision matrix.

7.2 Description of Criteria

Using engineering judgement, the designs were evaluated based on their ability to meet the criteria identified as critical to meeting project objectives. The decision criteria selected are as follows: Sanitation, Space Required, Construction Cost, and Maintenance Cost.

The Sanatitation criteria evaluates each design's ability to infiltrate/remove the sanitary sewer waste, minimize the waste smell, and keep the dogs from drinking/wading in the waste which has been a problem for the client in the past. The Space Required criteria evaluates the surface area each design would need to meet the project objective. The client expressed that maximizing the available surface area on the property was important due to the dogs and vehicles on the property needing space to move freely.

Since the Client would likely be paying for the design utilizing donations, the Construction and Maintenance Cost of each design was evaluated to determine what design would best suit the client's budget. It was assumed that lower cost designs would be more feasible to implement. It was also assumed that the cost of the construction should be weighted more than the other criteria because the cost would affect the client's ability to implement. This is due to the construction cost needing to be feasible to collect from donors over a period of time. All other criteria were weighted the same value because the feasibility of the design wouldn't be affected by the design's ability to meet the criteria.

7.3 Description of Alternatives

In order to investigate solutions to the sanitary sewer drainage, as per client request, three different designs were selected: a leach field and septic tank, a lagoon, and a LID retention pond. These designs were selected because they are designs meant to collect and infiltrate water.

These alternatives were developed because they are the most commonly used when dealing with wastewater that can not go to a treatment plant. A septic tank and leach field is the most common way to deal with wastewater when there is no access to a treatment plant. Septic tanks help settle out solids and through anaerobic process reduce solids and organics. After the water sits in a septic tank for the allotted time it is discharged into the ground, which slowly filtrates the discharge through infiltration. This makes the water clean enough by the time it reaches the ground water. Septic tanks and leach fields are also underground which benefits sanitation and aesthetics.

A lagoon is an aerated pond that uses microbial activity and oxygen to break down pollutants in water. The discharge of lagoons is controlled and only happens a few times every couple of years. This alternative does not promote sanitation and would take a large amount of surface area to hold the amount of water for the required amount of time.

An LID retention pond is similar to a lagoon. It employs the same processes of a lagoon to clean the wastewater, however an LID retention pond slowly discharges the water into the ground. The discharge from the pond infiltrates through the ground cleaning it further before it enters the groundwater.

7.4 Selection of Final Design

In order to evaluate how each design meets the decision criteria, research into each of the three designs in relation to the decision criteria were completed. Regarding the Sanitation of each design, the lagoon and retention pond allows water to infiltrate above ground; thus there is concern for smell and accessibility by the dogs on the property. The septic tank and leach field design is underground; thus preventing the smell and accessibility to the dogs. Space required for the lagoon and LID retention pond were assumed to be equal due to the similarity in function. The septic tank and leach field design has nearly a zero surface area footprint as it is an underground system, but it does require limitations on use of the surface above the leach field.

After speaking with other professionals and reviewing previous bids, the following construction costs for each design was approximated [19]. Septic Tank and Leach Field - $4,000 - $5,000, Lagoon - $2,000, LID retention pond - $2,000 [20, 21]. Maintenance for the lagoon and LID retention pond are similar, needing regular removal of debris and weeding yearly. It was assumed that the owner would take care of maintenance, therefore cost of maintenance is zero. Cost of maintenance for a septic tank and leach field is approximately $173 every 4.6 years [21].

Table 7-1 displays the weighted decision matrix used to determine the design that best met the criteria outlined in section 7.1. The design that best met the decision criteria is the leach field and septic tank.

Table 7-1: Decision Matrix

Decision Criteria			
Sanitation	Area Required	Construction Cost	Maintenance Cost

Weight	0.23	0.23	0.31	0.23	Total
Septic Tank and Leach Field	1	1	2	2	**1.54**
Lagoon	3	2	1	1	**1.69**
LID Retention Pond	2	2	3	1	**2.08**

8.0 Proposed Design Recommendations

8.1 Existing Slab Expansion Design

The final design recommendation for the concrete pad expansion is to add 10 feet in width to the south side and tie in to the pad and the 1,471.1404 cubic feet of existing kennel surface (see Figure 8-1). The pad will be on the native soil at the site and have a compaction of 95%. The top 8 inches of soil under the footprint of pad and five feet beyond the pad is required to meet a compaction level of 95% per ASTM D698 standards with a plus or minus 3% of optimum moisture, which is 13%. The 95% compaction requirement can be achieved by the advised sheepsfoot or dule steel drum roller. The pad concrete thickness will be a minimum of 5 inches to match the existing pad thickness.

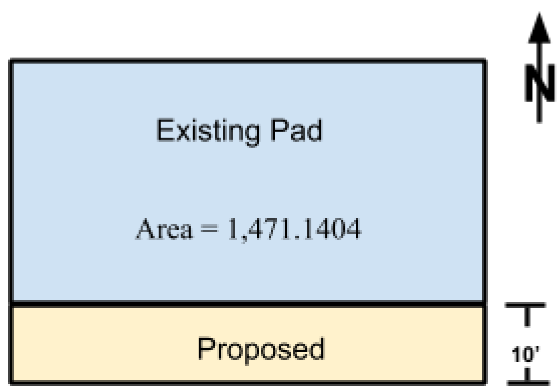


Figure 8-1: Plan view schematic of existing pad versus proposed.

Since the pad will be exposed to high moisture soil conditions, it is recommended that a moisture barrier is implemented underneath the pad to prevent water from inundating under the concrete pad and creating unwanted conditions. The drawing for the expansion in plan view can be seen in the construction plan set, along with a cross-section of the concrete pad extension. The construction plan set was created in accordance with Yavapai County Development Services' "Plot Plan Checklist" (see Appendix G).

8.2 Septic Tank and Leach Field Design

The final design recommendations for the drainage of the pad is to add two catch basins, 18 inches by 18 inches, at the natural drainage points seen in the field. These drainage points were observed to be on the west side of the existing pad and at the north and south ends (see drainage plan for location call out). The water from the catch basins will be conveyed by 4 inch PVC pipe for 185 feet to a septic tank on site. A 8 foot by 5 foot 8 inch by 5 foot 2 inch septic tank will discharge into a 4 inch perforated pipe that disperse the water into a 1,500 ft^2 leach field [22]. The leach field will allow the water to infiltrate into the ground while being filtered before it reaches the ground water table [22]. Capacity of the septic tank allows for additional flow retained from any monsoon storm event (a 1 year storm event) for the location.

The drainage plan set shows a plan and profile view of the drainage system and a details of the catch basins, the recommended septic tank, and the leach field. The drainage plan set was created in accordance with Yavapai County Development Services' "Conventional Septic Systems: Plot Plan Checklist" (see Appendix H). As required by the checklist, a 50 foot setback from the property line was provided. Figure 8-2 shows a plan view of the leach field and septic tank.

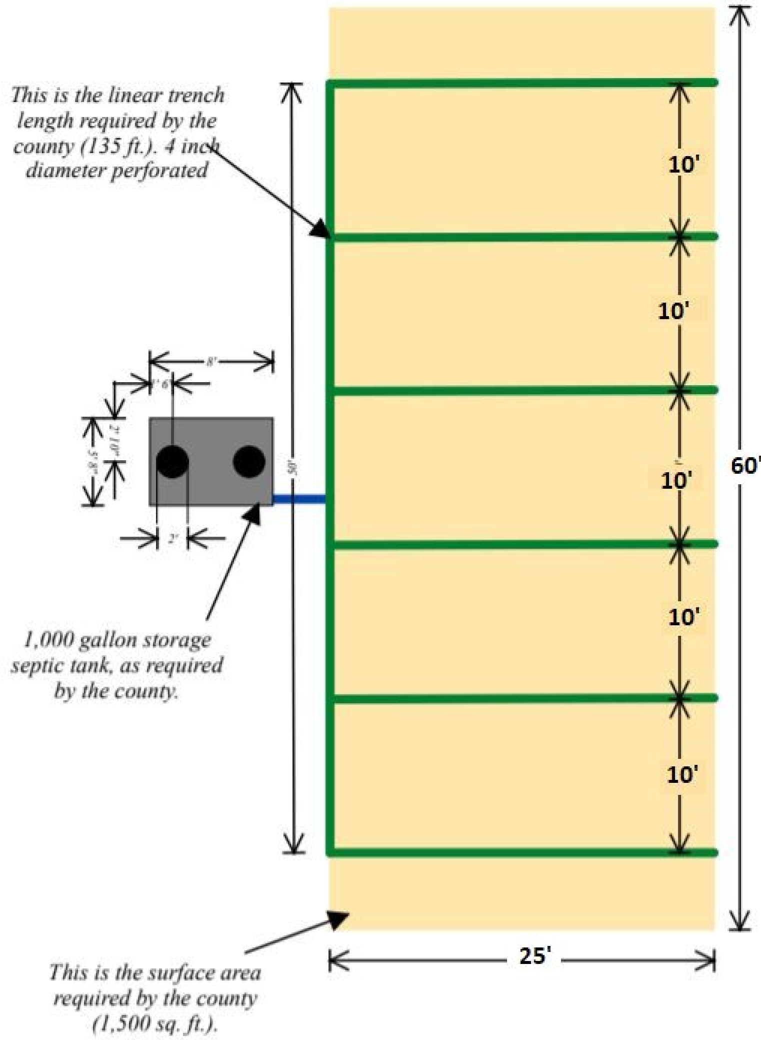


Figure 8-2: Plan view of septic tank and leach field.

8.3 Impacts of Design

8.3.1 Social

Social impacts of increasing the kennel slab size and improving the drainage condition on site will create positive and negative impacts on the dogs and the people living on the site. The increase in slab area is intended to provide a run space, increasing their activity. This increase in activity should improve the health and the happiness of the dogs, possibly allowing them to be rehabilitated sooner than normal. Allowing the dogs to be rehabilitated faster will allow for more dogs to be helped than before but may result in additional need for volunteers or increase working hours.

Preventing the accumulation of wastewater around the kennel space will improve the aesthetics of the facility. An improvement in aesthetics may increase the willingness of volunteers and adopters to visit the facility and stay longer hours. Thus, this likely would improve the facility and care of the dogs as well as increase adoption rates. Additionally, the organization may be able to relieve stress of other local facilities more often since the canine occupants may be adopted out more quickly.

8.3.2 Environmental

Increasing the kennel slab and addressing the drainage of the site can cause both positive and negative impacts. Addressing the drainage allows for the cesspool at the end of the kennel space to be eliminated creating a healthier and safer environment for the dogs that live in the kennels. The drainage addressed in the drainage plans include storm water which could have a positive impact of reducing the water flowing into the Verde River, eliminating the contaminated runoff to surface waters to reduce the chance of eutrophication, and mitigating the flooding. A negative impact of catching too much of the water flow which could inadvertently affect plant growth.

8.3.3 Economic

Since the kennel space is used for quarantining dogs, the dogs should improve more rapidly after the living conditions are improved; therefore, decreasing the time each dog spends in quarantine. This means the dogs may become adoptable more quickly and more dogs can enter quarantine. With the rate of dogs being exchanged increasing, it can be assumed more dogs will get adopted faster and increase revenue for the non-profit. Additionally, decreasing the risk of infection/illness from standing water cesspools for the dogs will decrease the expense of infections/illness treated by a vet.

The cost of construction and maintenance of the design, in addition to the expenses already being covered, requires additional revenue. Since Pets Return Home is a non-profit, additional time spent fundraising will be needed. The client has made use of adoption events in order to increase revenue. Therefore, more frequent attendance to adoption events may increase expenses due to additional gas and time spent at these events.

8.4 Cost to Implement the Design

The cost of implementing the design can be seen below in Table 8-1. The materials for the construction plans include the cost of the cement and the vapor barrier. The materials included for the drainage plan are the septic tank, the 4 inch PVC pipe and associated fitting, and the catch basins. The physical labor of both designs is assumed to be completed by the client, so there will be no cost of labor. Installation of the septic tank is based on previous installation costs [21,23].

Table 8-1: Cost of Design

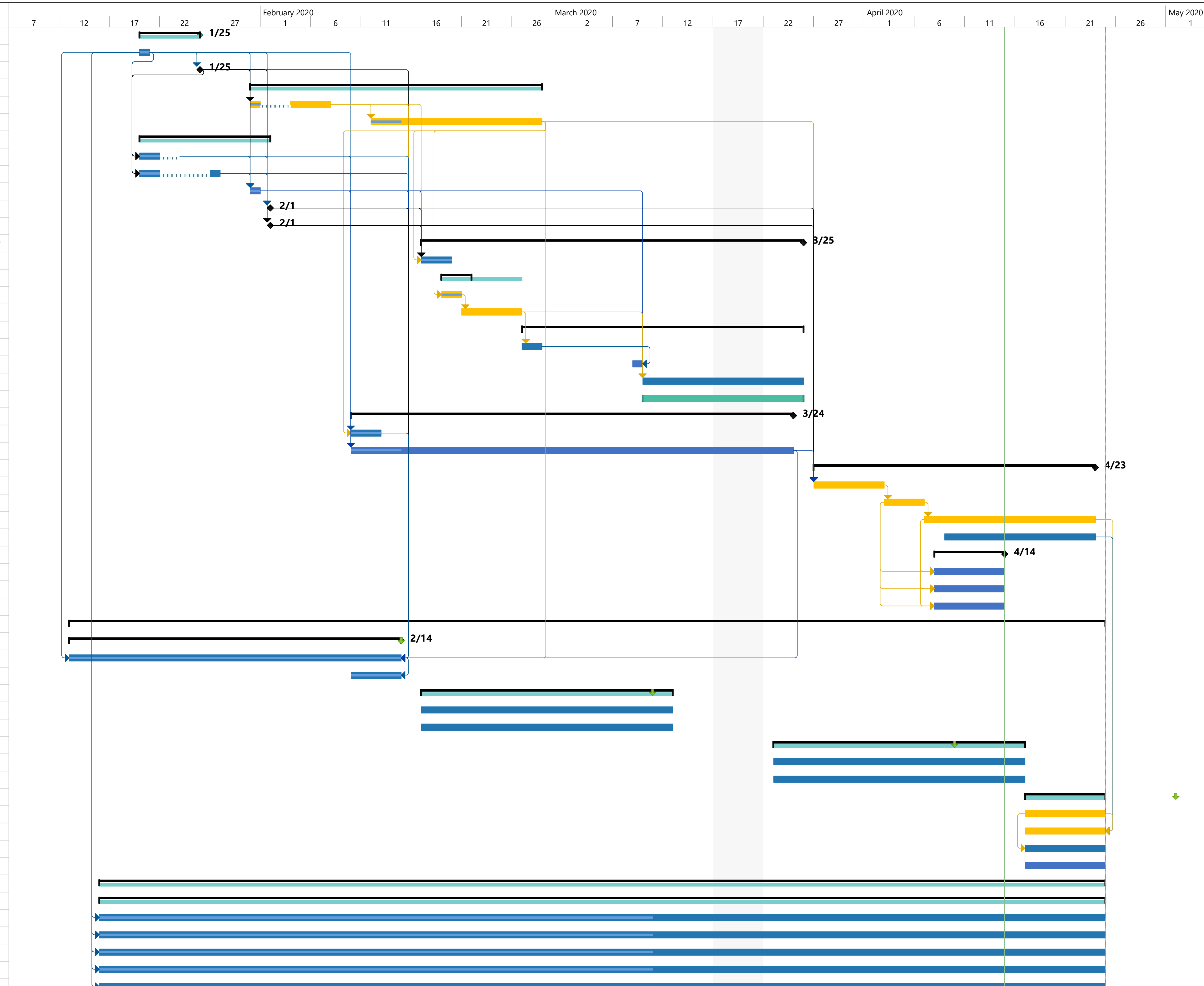
Materials	Unit price	Units	Total
Vapor Barrier [24]	$60.00	1	$60.00
Cement ($/per bag) [25]	$4.55	312.5	$1,421.88
1000 gal Septic Tank ($/per tank) [26]	$1,000.00	1	$1,000.00
4 inch PVC pipe ($/per 10 feet length) [27]	$20.00	104.5	$2,090.00
Steel frame for catch basin ($/per unit) [28]	$240.00	2	$480.00
Septic Tank Installation [21,23]	$5,000.00	1	$5,000.00
			$10,051.88

9.0 Summary of Engineering Work

The Gantt chart in Figure 9-1 below shows the task completion timeline for the project. It differs from the projected timeline due to multiple setbacks. The beginning of schedule was pushed back due to availability for access to the site. It was necessary to coordinate site visits with the client so that the client may remove the dogs from the project area for our safety and to prevent interference with testing and data collection. Multiple site visits were necessary due to survey equipment errors and additional time needed to complete data collection. Additionally, not all the survey data collected was used in the creation of the topographic map due to human error and resulted in missing the originally intended deadline for the task. In order to meet the final deadline, geotechnical lab tasks expected to be completed for the 60% deliverables were shifted to be started and completed earlier; which helped the project get back on track by the 60% deliverables deadline.

Four tasks were removed from the schedule because the team realized they would not be needed to complete the design. The three tasks removed were Task 4.3.4, sub-basin storage, Task 4.4, hydrograph development, and Task 7.3.2, cut and fill. It was decided that Task 4.3.4 and Task 4.4 could be removed because they were not needed to create the final design. Task 7.3.2 was removed because it was determined in the design that there would be no significant amount of soil brought onto the site or removed from the site.

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Task 1: Due Diligence**	**6 days**	**Mon 1/20/20**	**Sat 1/25/20**
2		Task 1.1: Zoning Due Diligence	1 day	Mon 1/20/20	Mon 1/20/20
3		Task 1.2: Arizona 811	0 days	Sat 1/25/20	Sat 1/25/20
4		**Task 2: Surveying**	**21 days**	**Fri 1/31/20**	**Fri 2/28/20**
5		Task 2.1: Survey	5 days	Fri 1/31/20	Fri 2/7/20
6		Task 2.2: Topographic Map	13 days	Wed 2/12/20	Fri 2/28/20
7		**Task 3 Field Investigation**	**11 days**	**Mon 1/20/20**	**Sat 2/1/20**
8		Task 3.1: Sampling Plan	2 days	Mon 1/20/20	Thu 1/23/20
9		Task 3.2: Safety Plan	3 days	Mon 1/20/20	Mon 1/27/20
10		Task 3.3: Geotechnical Sampling	1 day	Fri 1/31/20	Fri 1/31/20
11		Task 3.4: Infiltration Testing	0 days	Sat 2/1/20	Sat 2/1/20
12		Task 3.5: Existing Slab Analysis	0 days	Sat 2/1/20	Sat 2/1/20
13		**Task 4: Hydrology**	**23 days**	**Mon 2/17/20**	**Wed 3/25/20**
14		Task 4.1: Previous Studies	3 days	Mon 2/17/20	Wed 2/19/20
15		Task 4.2: Basin Delineation	3 days	Wed 2/19/20	Fri 2/21/20
16		Task 4.2.1: Major Basin Delineation	2 days	Wed 2/19/20	Thu 2/20/20
17		Task 4.2.2: Sub-Basin Delineation	4 days	Fri 2/21/20	Wed 2/26/20
18		Task 4.3: Sub-Basin Variables	15 days	Thu 2/27/20	Wed 3/25/20
19		Task 4.3.1: Flow Routing	2 days	Thu 2/27/20	Fri 2/28/20
20		Task 4.3.2: Time of Concentration	1 day	Mon 3/9/20	Mon 3/9/20
21		Task 4.3.3: Weighted Curve Number	7 days	Tue 3/10/20	Wed 3/25/20
22		Task 4.5: Storm Event Runoff Deter.	7 days	Tue 3/10/20	Wed 3/25/20
23		**Task 6: Geotechnical Analysis**	**27 days**	**Mon 2/10/20**	**Tue 3/24/20**
24		Task 6.1: Previous Studies	3 days	Mon 2/10/20	Wed 2/12/20
25		Task 6.2: Laboratory Testing	27 days	Mon 2/10/20	Tue 3/24/20
26		**Task 7: Site Design**	**20 days**	**Fri 3/27/20**	**Thu 4/23/20**
27		Task 7.1: Develop Alternatives	5 days	Fri 3/27/20	Thu 4/2/20
28		Task 7.2: Decision Matrix	2 days	Fri 4/3/20	Mon 4/6/20
29		Task 7.4 Construction Drawings	13 days	Tue 4/7/20	Thu 4/23/20
30		Task 7.5 Cost Estimate	11 days	Thu 4/9/20	Thu 4/23/20
31		**Task 8: Impacts**	**5 days**	**Wed 4/8/20**	**Tue 4/14/20**
32		Task 8.1: Environmental	5 days	Wed 4/8/20	Tue 4/14/20
33		Task 8.2: Economic Impacts	5 days	Wed 4/8/20	Tue 4/14/20
34		Task 8.3: Social Impacts	5 days	Wed 4/8/20	Tue 4/14/20
35		**Task 9: Deliverables**	**72 days**	**Mon 1/13/20**	**Fri 4/24/20**
36		Task 9.1: 30% Submittal	27 days	Mon 1/13/20	Fri 2/14/20
37		Task 9.1.1: 30% Report	27 days	Mon 1/13/20	Fri 2/14/20
38		Task 9.1.2: 30% Presentation	5 days	Mon 2/10/20	Fri 2/14/20
39		Task 9.2: 60% Submittal	19 days	Mon 2/17/20	Thu 3/12/20
40		Task 9.2.1: 60% Report	19 days	Mon 2/17/20	Thu 3/12/20
41		Task 9.2.2: 60% Presentation	19 days	Mon 2/17/20	Thu 3/12/20
42		Task 9.3: 90% Submittal	19 days	Mon 3/23/20	Thu 4/16/20
43		Task 9.3.1: 90% Report	19 days	Mon 3/23/20	Thu 4/16/20
44		Task 9.3.3: 90% Website	19 days	Mon 3/23/20	Thu 4/16/20
45		Task 9.4: Final Submittal	6 days	Fri 4/17/20	Fri 4/24/20
46		Task 9.4.1: Final Report	6 days	Fri 4/17/20	Fri 4/24/20
47		Task 9.4.2: Final Construction Doc.	6 days	Fri 4/17/20	Fri 4/24/20
48		Task 9.4.3: Final Presentation	6 days	Fri 4/17/20	Fri 4/24/20
49		Task 9.4.4: Final Website	6 days	Fri 4/17/20	Fri 4/24/20
50		**Task 10: Project Management**	**69 days?**	**Thu 1/16/20**	**Fri 4/24/20**
51		Task 10.1: Meetings	69 days?	Thu 1/16/20	Fri 4/24/20
52		Task 10.1.1: Client Meetings	69 days?	Thu 1/16/20	Fri 4/24/20
53		Task 10.1.2: Grading Instructor	69 days?	Thu 1/16/20	Fri 4/24/20
54		Task 10.1.3: Technical Advisor	69 days?	Thu 1/16/20	Fri 4/24/20
55		Task 10.1.4: Team	69 days?	Thu 1/16/20	Fri 4/24/20
56		Task 10.2: Schedule/Resource Management	69 days?	Thu 1/16/20	Fri 4/24/20



Project: Capstone Schedule
Date: Wed 4/15/20

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

10.0 Summary of Engineering Costs

Tables 10-1 and 10-2 show a breakdown of original staffing plan and overall staffing hours completed according to the tasks performed. It can be seen that Task 5: Hydraulics hours were decreased significantly from proposed due to a decrease in scope of work. Additionally, the sub-basin storage and hydrograph development tasks were excluded from the project as they were not needed to complete the hydrologic analysis. There was a scope of work creep in the proposal, which was to address the drainage of the whole site with the addition of the kennel pad as well. The scope of work creep was addressed and the original scope of work, addressing the drainage of the kennels and extending the kennel 10 feet, was reinstated.

Table 10-1 below shows the original staffing plan for the project.

Table 10-1: Original Staffing Plan

STAFF HOURS					
Task	**SENG**	**PE**	**Technician**	**EIT**	**Task Total**
Task 1: Due Diligence					18
Task 1.1: Zoning Due Diligence	1	6	0	4	
Task 1.2: Arizona 811	1	4	0	2	
Task 2: Surveying					42
Task 2.1: Survey	2	6	16	0	
Task 2.2: Topographic Map	1	3	6	8	
Task 3: Field Investigation					80
Task 3.1: Sampling Plan	2	5	5	3	
Task 3.2: Safety Plan	1	2	0	1	
Task 3.3: Geotechnical Sampling	0	10	6	8	
Task 3.4: Infiltration Testing	3	10	6	8	
Task 3.4: Existing Slab Analysis	2	8	0	0	
Task 4: Hydrology					222
Task 4.1: Previous Studies	1	8	0	8	
Task 4.2: Basin Delineation					
Task 4.2.1: Major Basin Delineation	1	20	0	10	
Task 4.2.2: Sub-Basin Delineation	1	30	0	10	
Task 4.3: Sub-Basin Variables					
Task 4.3.1: Flow Routing	1	8	0	8	
Task 4.3.2: Time of Concentration	1	8	0	6	
Task 4.3.3: Weighted Curve Number	1	10	0	6	
Task 4.3.4: Sub-basin Storage:	1	12	0	10	
Task 4.4: Hydrograph Develoment	1	10	0	8	
Task 4.5: Storm Event Runoff Deter.					
Task 4.5.1: Existing	2	10	0	9	
Task 4.5.2: Proposed	2	10	0	9	
Task 5: Hydraulics					49
Task 5.1: Previous Studies	1	6	0	8	
Task 5.2 Proposed Channel Hydraulics	2	20	0	12	
Task 6: Geotechnical Analysis					30
Task 6.1: Previous Studies	1	3	0	4	
Task 6.2: Laboratory Testing	2	0	20	0	

Task 7: Site Design					93
Task 7.1: Develop Alternatives	1	9	5	6	
Task 7.2: Decision Matrix	2	6	0	2	
Task 7.3: Drainage Plan					
Task 7.3.1: Grading	1	6	8	5	
Task 7.3.2: Cut/fill	1	3	4	8	
Task 7.4 Construction Drawings	2	9	6	5	
Task 7.5 Cost Esitmate	0	2	0	2	
Task 8: Impacts					72
Task 8.1: Environmental	2	12	0	10	
Task 8.2: Economic Impacts	2	12	0	10	
Task 8.3: Social Impacts	2	12	0	10	
Task 9: Deliverables					98
Task 9.1: 30% Submittal					
Task 9.1.1: 30% Report	2	4	2	4	
Task 9.1.2: 30% Presentation	1	1	0	1	
Task 9.2: 60% Submittal					
Task 9.2.1: 60% Report	2	4	2	4	
Task 9.2.2: 60% Presentation	1	2	0	2	
Task 9.3: 90% Submittal					
Task 9.3.1: 90% Report	2	4	2	4	
Task 9.3.2: 90% Presentation	1	1	0	1	
Task 9.3.3: 90% Website	1	6	0	6	
Task 9.4: Final Submittal					
Task 9.4.1: Final Report	2	4	2	4	
Task 9.4.2: Final Construction Docs	2	6	0	6	
Task 9.4.3: Final Presentation	1	2	0	2	
Task 9.4.4: Final Website	1	3	0	3	
Task 10: Project Management					81
Task 10.1: Meetings					
Task 10.1.1: Grading Instructor	3	3	0	3	
Task 10.1.2: Technical Advisor	3	3	0	3	
Task 10.1.3: Client	3	3	0	3	
Task 10.1.4: Team	8	8	8	8	
Task 10.2: Schedule/Resource Management	2	10	0	10	
TOTAL	71	309	81	244	**705**

Table 10-2 below shows the actual hours worked on the project.

Table 10-2: Actual hours worked by staff.

Task	SENG	PE	Technician	EIT
Task 1: Due Diligence				
Task 1.1: Zoning Due Diligence	0	0	0	2
Task 1.2: Arizona 811	0	0	3	0
Task 2: Surveying				
Task 2.1: Survey	0	0	46	6
Task 2.2: Topographic Map	0	4	0	4
Task 3: Field Investigation				
Task 3.1: Sampling Plan	0	3	2	6
Task 3.2: Safety Plan	0	0	1	3
Task 3.3: Geotechnical Sampling	0	2	16	8
Task 3.4: Infiltration Testing	0	0	15	10
Task 3.4: Existing Slab Analysis	0	0	2	1
Task 4: Hydrology				
Task 4.1: Previous Studies	0	0	0	2
Task 4.2: Basin Delineation				
Task 4.2.1: Major Basin Delineation	0	0	0	2
Task 4.2.2: Sub-Basin Delineation	0	0	0	1
Task 4.3: Sub-Basin Variables				
Task 4.3.1: Flow Routing	0	0	0	2
Task 4.3.2: Time of Concentration	0.5	1	0	2.5
Task 4.3.3: Weighted Curve Number	0.5	0	0	3
Task 4.3.4: Sub-basin Storage:				
Task 4.4: Hydrograph Develoment				
Task 4.5: Storm Event Runoff Deter.				
Task 4.5.1: Existing	0	0	0	1
Task 4.5.2: Proposed	0	0	0	1.5
Task 5: Hydraulics				
Task 5.1: Previous Studies	0	0	0	1
Task 5.2 Proposed Channel Hydraulics	0	5	0	2
Task 6: Geotechnical Analysis				
Task 6.1: Previous Studies	0	0	0	1
Task 6.2: Laboratory Testing	0	0	51.5	7

Task 7: Site Design				
Task 7.1: Develop Alternatives	0	1	2	1
Task 7.2: Decision Matrix	1	3	1	1
Task 7.3: Drainage Plan	0	0	0	17
Task 7.3.1: Grading	0	0	0	0.5
Task 7.3.2: Cut/fill				
Task 7.4 Construction Drawings	0.5	1	0	7.5
Task 7.5 Cost Esitmate	0	0	3	3
Task 8: Impacts				
Task 8.1: Environmental	0	0	0	2
Task 8.2: Economic Impacts	0	3	0	0
Task 8.3: Social Impacts	0	0	0	0
Task 9: Deliverables				
Task 9.1: 30% Submittal				
Task 9.1.1: 30% Report	0	6	5	8
Task 9.1.2: 30% Presentation	0	4	0	4
Task 9.2: 60% Submittal				
Task 9.2.1: 60% Report	2.5	18	1	8
Task 9.2.2: 60% Presentation	1	3.5	3	6
Task 9.3: 90% Submittal				
Task 9.3.1: 90% Report	4	8	2	9
Task 9.3.2: 90% Presentation	0.5	1	0.5	6
Task 9.3.3: 90% Website	0	0	0	3
Task 9.4: Final Submittal				
Task 9.4.1: Final Report	1	7	4	8
Task 9.4.2: Final Construction Docs	1	6	0	6
Task 9.4.3: Final Presentation	1	5	0	2
Task 9.4.4: Final Website	0	5	0	1
Task 10: Project Management				
Task 10.1: Meetings				
Task 10.1.1: Grading Instructor	7	7	7	7
Task 10.1.2: Technical Advisor	2	2	2	2
Task 10.1.3: Client				
Task 10.1.4: Team	7	6	7	6.5
Task 10.2: Schedule/Resource Management	2.5	19	0	12.5
TOTAL	32	120.5	174	187
	513.5			

Additionally, due to the efficiency of the firm, a decrease in personnel hours logged is present. Senior Engineer (SENG) hours came below expected by 39 hours. The senior engineer involvement was kept minimal, focusing on project management and project status meetings. This allowed for costs to be kept low, as the senior engineer is the highest paid member of Ruff Engineering. The Professional Engineer (PE) involvement was utilized for every aspect of the project and cme below the expected hours by 188.5 hours. Lab technician came above expected hours by 93 hours. The majority of lab technician hours were during the field investigation and laboratory testing which took longer than expected. Additionally, the technician was present during all status meetings so that the team could be updated frequently on the progress and results of the surveying and geotechnical analysis. The engineer in training (EIT) hours came below expected by 37 hours. The EIT was involved with nearly every aspect of the project in order to gain experience and assist others when necessary.

Table 10-1 shows a breakdown of the final actual costs for engineering work performed. Since Western Tech provided facilities and equipment for the geotechnical tests, laboratory rental was excluded from costs and instead individual testing costs, provided by Western Technologies, was utilized for a more accurate representation of costs. Originally, laboratory facilities were to be provided by Northern Arizona University. Additionally, personnel vehicles were used for transport to and from the project site. Therefore, vehicle rental has been excluded from costs. Total final cost of the engineering work comes to $64,707 and the proposed cost of the project was estimated to be $105,906. The project came in under budget by $41,199.

Table 10-3: Itemized cost of engineering work completed

1.0 Personnel	Classification	Hours	Rate, $/hr	Cost
	SENG	32	$219	$7,008
	PE	120.5	$175	$21,088
	EIT	174	$110	$19,140
	Technician	184	$65	$12,023
	Total Personnel			**$59,258**
2.0 Travel	**Classification**	**Item Total**	**Unit Cost**	**Cost**
	3 meetings @ 140 mi (roundtrip)	1350	$0.12	$159
	Vehicle Rental (per day/trip)	0	$125.00	$0
	Total Travel			**$159**
3.0 Supplies	**Classification**	**Days**	**Unit Cost ($/day)**	**Cost**
	Total Station Rental	3	$275	$825
	Geotech Equipment Rental	2	$200	$400
	Total Supplies			**$1,225**
4.0 Testing	**Category**	**Totals**	**Unit Rate**	**Extension**
	Proctors	1	$150.00	$150.00
	Atterberg Limits	21	$60.00	$1,260.00
	Sieve Analysis	8	$75.00	$600.00
	Consolidation	2	$150.00	$300.00
	Moisture/Density	7	$15.00	$105.00
	Remolded Swell	8	$150.00	$1,200.00
	Hydrometer	3	$150.00	$450.00
	Total Testing			**$4,065**
5.0 Total				**$64,707**

11.0 Conclusion

The objective of this project was to extend the concrete pad of the kennel space and improve the drainage of the wastewater from the kennel space. Prior to designing for the site, soil analysis was needed to determine the properties of the soil to determine drainage capability and ability to hold the concrete pad. Three alternatives were developed for the drainage of the site. The three alternatives were evaluated in a decision matrix and the best was chosen based on the criteria. This final recommendation was determined to be a catch basin that leads the water into a septic tank. No alternatives were needed for the concrete pad as the design will match the existing pad and will simply be extended to the fence line. The project was completed on time and met the objectives of the project.

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Appendices

Appendix A - Sampling Plan

Sampling and Analysis Plan

Pets Return Home Project

4555 N. Peyton Place Clarkdale, AZ

Ruff Engineering
Ryann DuBose, Abigail Autieri, Allyson Fedor, Crockett Saline
Flagstaff, Arizona

Northern Arizona University
Flagstaff, Arizona

January 26, 2020

1.0 Purpose

The plan details tools, safety equipment, test locations (location and depth), sample volume, storage of samples, type of lab tests to be performed, and where the lab testing will occur for the Pets Return Home (PRH) project.

2.0 Tools and Safety Equipment

The following personal protective equipment will be used:

- Hardhat
- Closed-toe shoes (i.e. boots or tennis shoes)
- Leather gloves
- Hearing protection (ear plugs/ear muffs)
- Eye protection (i.e. construction glasses/goggles)

Additionally, a safety officer will be assigned to monitor and correct personnel when a safety violation is observed. This responsibility will rotate throughout the time in both the field and the laboratory. The safety officer will be Crockett.

The following hand tools will be used:

- Shovel
- Ring driving (with appropriate tools)
- Tape measure
- Digging bar
- Infiltration monitors
- Buckets

3.0 Samples

Samples will consist of bulk, ring samples, and if needed a few cobbles or boulders. Bulk samples will be contained in either a 5-gallon bucket or a bag. Ring samples are extracted from the native ground using brass rings. Ring samples are placed in small plastic bags and then placed in a hardened plastic cylinder to ensure that the sample stays in the conditions that it was extracted.

A different bulk sample will be taken for each different soil type that is encountered during the excavation. These samples will be labeled according to the job indicator then followed by locations and depth on the side of the bucket or bag. For example, PRH 1(0-4), this indicates that this sample was collected at the job that correlates to that number of PRH and location 1 at the depths of 0 through 4 feet. The sample size will consist of a full 5-gallon-bucket or bag (approximately 5 gallons) to ensure that a sufficient amount of sample is obtained.

Ring samples consist of six 1-inch thick rings with an inner diameter of 2.42 inches. These samples are forced into undisturbed native soils to a depth of 8 to 12 inches. By forcing the rings into place or virgin soil, the six rings will be filled with samples that consist of soil in close native or onsite conditions. At locations one (adjacent to existing kennels), ring samples will be taken at the base of slab or footing. In location two through four, ring samples are to be taken at depths of 2 feet and at the base of excavation (approximated depth of three to four feet). Ring sample labels will consist of masking tape on the top of the outer ring sample casings lid. The masking tape serves two purposes, showing the orientation of the sample, and a removable surface to act as a label. The rings will be labeled in the same format as the bulk samples with the job indicator first then following location and then depth. For example, PRH 1(2-3) These samples are to indicate the conditions of the existing soils.

During the investigation, if the soil conditions are not suitable to obtain ring samples because the soil is rocky, a cobble or boulder sample will be collected. These samples will be used to perform compressive strength tests in the laboratory.

These samples will be stored at Western Technologies (WT) Flagstaff facilities and will be held until the project is completed. The disposal of soil samples will be through the local trash dump. The disposal of testing materials containing chemical contaminants, such as hydrometers, will be done by WT in a 55-gallon drum that is picked up every 1 to 2 years by a third party.

4.0 Test Locations

There are four proposed test locations. These test locations can move as needed by the client's needs or request, location of utilities, and the discretion of the field engineer. For proposed test locations see in Figure 4.1 below, marked by the circles with crosses.

Figure 1: Test Locations

Location 1: Adjacent To Existing Kennels

This location is to investigate the existing kennel pad. The investigation is needed to see the details of the previous construction of the slab/foundation, and to collect samples of existing fill and its condition. The test pit will be dug excavated by hand and should be no deeper than the depth of slab or footing of foundation. A bulk sample will be taken of every soil type and a ring sample will be taken at the base of slab or footing.

Locations 2, 3, and 4: Additional Development Requiring Infiltration Testing

These locations are to be excavated with a backhoe to the approximate depth of a potential leach field (generally 3 to 4 feet deep) or base of any proposed basins. Bulk Samples will be collected of any soil change during the excavations. These locations will be excavated to a depth of approxiamly 2 feet to attempt to extract a ring sample. After the 2 foot attempt of the ring sample, excavation will resume to the depth of 3 to 4 feet to again attempt another ring sample. At the base of excavation a 12-inch cube is to be hand excavated to perform an infiltration test according to the Arizona Department of Environmental Quality (ADEQ). Hand excavations of the 12-inch cube space are to be collected as a bulk sample of its own. Additional bulk samples are to be taken of the trench tailoring each soil type excavated with ring samples taken at approximately 2 feet deep and at the base of the excavation. Infiltration tests are generally performed the following day. This means test pits will remain open overnight and will require backfill after the test is completed.

Other information that will be collected on site Boring/Test logs and Site Checklist will be utilized to record the finding of the field investigations. These logs will document the sample types with their locations and depth, blow counts of ring samples, water table (if encountered), and description of soil encountered (described by field engineer). For an example of a Boring/Test Log form refer to the Appendices, Plate A-1. Site Checklist will be filled out on site, and this form documents relevant information about the site's conditions. For an example of a Checklist form refer to the Appendices, Plate A-2 and A-3.

5.0 Laboratory Test

Following the field investigation a Sample of Receiving Order and Schedule of Tests Sheet will be filled with the inventory of the field samples taken from the field. For an example of a Sample of Receiving Order and Schedule of Tests Sheet form refer to Appendices, Plate B-1

The following laboratory may be tests may be performed on the collected field samples:

- Field moisture contents (ASTM D2216) [3]
- In-situ soil density (ASTM D2937) [4]
- Remolded expansion potential (ARIZ 249) [5]
- Compression (modified ASTM D2435) [6]
- Liquid limit and plasticity index (ASTM D4318-17e1) [7]
- Compressive strength test of rock sample (ASTM C39/C39M) [29]
- Compaction proctor (ASTM D698-12e2) [8]
- Hydrometer (ASTM D7928-17) [9]

The samples collected will be classified by ASTM D2487-17 [4] standards, but the bulk samples from the infiltration test will be classified by United State Department of Agriculture (USDA) [30] standards given the regulations put forth by ADEQ [3].

Tests will be conducted three times to ensure precision of results. Tests such as ASTM soil classifications, remodeled expansion potential, and compressive strength test of rock cores (if samples were obtained in field) will each be performed in triplicates.

6.0 Experimental Matrix

The experimental matrix below will be used for data collection.

ASTM #:

Test Location	Result 1	Result 2	Result 3	Average	Standard Deviation
1					
2					
3					
4					

7.0 Quality Control and Quality Assurance

To ensure that quality control and assurance will be maintained through the sample collection and soil testing (in field and lab) a QC/QA officer, for this case Abigail, will be assigned to observe and manage one of the members of the team. Quality assurance in the field will be managed by ensuring the samples collected are collected without bias, the mass collected is approximately 5-gallons, and labeled clearly and correctly. In the laboratory, quality assurance will be managed through the review of the ASTM standard testing procedures before, during, and after each test. The responsibility of QC/QA officer will be Abigail throughout both field and laboratory.

Quality control will be maintained through the sample collection and soil testing by completing calculation checks and recording multiple results of the same test for the same sample. Using engineering judgement, a standard deviation of significant value will be used to determine if more replicate tests need to be completed for the sample.

Appendix B - Boring Logs

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test Pit
LOG OF ~~BORING~~ NO. 1

Project PRH — Job No. PRH

Elevation Top of Hole ____ Datum 34°48'44.27" 112° ~~3.11~~ 3' 11.46" — Prepared By C. Saline — Date 1/31

Type / Size of Boring 18" Bucket — Rig Type SBO — Driller CASE — Reviewed By ____ — Date ____

DEPTH, FEET	PENETRATION RESISTANCE BLOW / FOOT: C	N/R	SAMPLE TYPE	DRY DENSITY, PCF	WATER CONTENT, %	SOIL CLASSIFICATION	SOIL TYPE DESCRIPTION (Modifier, Color, Density, Moisture, etc.)	MAXIMUM SIZE	PARTICLE SIZE DISTRIBUTION, %: BOULDERS / COBBLES	GRAVEL	SAND	SILT & CLAY	GRADATION (WELL, MEDIUM, POOR)	GRAIN SHAPE (ANGULAR, SUBANGLAR, SUBROUNDED, ROUNDED)	RELATIVE DENSITY (LOOSE, MED. DENSE, DENSE, VERY DENSE)	PLASTICITY (NONE, LOW, MEDIUM, HIGH)	CONSISTENCY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	CEMENTATION (NONE, LIGHT, MODERATE, HEAVY)
1	8		R				Bottom of footing Clayey Sand w/ gravel brown, loose											
2	12		R				Moist to wet.											
3																		
4							Excavation Stopped @ 2'											
5																		
6															RELATIVE DENSITY			
7																		
8																		
9																		
0														GRAIN SHAPE			CONSISTENCY	CEMENTATION
1													GRADATION			PLASTICITY		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		

GROUNDWATER CONDITIONS: Date ____ No Groundwater Encountered ____
Date ____ Time ____ Depth ____
Date ____ Time ____ Depth ____

Western Technologies Inc.

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·LOG ~~OF BORING~~ test pit NO. 2

Project PRI-1 Job No. PRH

Elevation Top of Hole ______ Datum 34°48'44.01" 112° 3' 11.76" Prepared By ~~BC~~ C. Sclone Date 1/31

Type/Size of Boring ~~18~~ 18" Bucket Rig Type ~~Cat~~ 580 Driller CASE Reviewed By ______ Date ______

DEPTH, FEET	PENETRATION RESISTANCE BLOW/FOOT C	N/R	SAMPLE TYPE	DRY DENSITY, PCF	WATER CONTENT, %	SOIL CLASSIFICATION	SOIL TYPE DESCRIPTION (Modifier, Color, Density, Moisture, etc.)	MAXIMUM SIZE	PARTICLE SIZE DISTRIBUTION, % BOULDERS/COBBLES	GRAVEL	SAND	SILT & CLAY	GRADATION (WELL / MEDIUM / POOR)	GRAIN SHAPE (ANGULAR / SUBANGULAR / SUBROUNDED / ROUNDED)	RELATIVE DENSITY (LOOSE / MED. DENSE / DENSE / VERY DENSE)	PLASTICITY (NONE / LOW / MEDIUM / HIGH)	CONSISTENCY (SOFT / FIRM / STIFF / VERY STIFF / HARD)	CEMENTATION (NONE / LIGHT / MODERATE / HEAVY)
1						SC	Clayey SAND: w/ gravel, Brown/tan,						X MEDIUM, X POOR	X SUBANGULAR, X SUBROUNDED	X LOOSE, X MED. DENSE	X LOW, X MEDIUM	X FIRM	X NONE
2			G				~~Moist~~ Damp to moist											
3	25		R				increase of Clay w/ depth No gravel w/											
4							depth											
5	35		R															
6							Excavation ~~Rep~~ Stopped @ 6'								R			
7															E			
8															L			
9														G			C	C
0														R	A	P	O	E
1													G		T	L		
2													R	A	I	A	N	M
3													A	I	V	S	S	E
4													D	N			I	N
5													A		E	T	S	T
6													T			I	T	A
7														S	D	C		
8													I	H	E	I	E	T
9													O	A			N	I
0													N	P	N	T	C	O
1															S	Y		
2														E	I		Y	N
3															T			
4															Y			
5																		
6																		
7																		
8																		
9																		
0																		

GROUNDWATER CONDITIONS: Date ______ No Groundwater Encountered ______

Date ______ Time ______ Depth ______

Date ______ Time ______ Depth ______

Results of Infiltration Test at Site 2

PreSoak 1/31

2:57 PM

4½ Test

2/1

1.)	8:35	9:35	1"	Hour/in
2.)	9:41	9:58	1/4	68 Min/in
3.)	9:59	10:16	1/4	68 Min/in
4.)	10:19	10:36	1/4	68 Min/in

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LOG ~~OF BORING~~ test Pit NO. 3

Project: PRH   Job No.: PRH

Elevation Top of Hole: ______   Datum: 34°48'43.75" 112°3'11.75"   Prepared By: C. Salme   Date: 1/31

Type/Size of Boring: 18" Bucket   Rig Type: 580   Driller: CASE   Reviewed By: ______   Date: ______

DEPTH, FEET	PENETRATION RESISTANCE BLOW/FOOT C	N/R	SAMPLE TYPE	DRY DENSITY, PCF	WATER CONTENT, %	SOIL CLASSIFICATION	SOIL TYPE DESCRIPTION (Modifier, Color, Density, Moisture, etc.)	MAXIMUM SIZE	BOULDERS/COBBLES	GRAVEL	SAND	SILT & CLAY	GRADATION (WELL / MEDIUM / POOR)	GRAIN SHAPE (ANGULAR / SUBANGULAR / SUBROUNDED / ROUNDED)	RELATIVE DENSITY (LOOSE / MED. DENSE / DENSE / VERY DENSE)	PLASTICITY (NONE / LOW / MEDIUM / HIGH)	CONSISTENCY (SOFT / FIRM / STIFF / VERY STIFF / HARD)	CEMENTATION (NONE / LIGHT / MODERATE / HEAVY)
1			S			CL	Sandy Lean Clay: trace gravel: darkbrown,											
2	25	1	R				, Moist						X POOR	X ROUNDED		X LOW X MEDIUM	X FIRM	X NONE
3			C															
4							/ ~~No increase clay No gravel @ depth~~											
5	35	1	R				Less Clay More Sand turning yellow											
6						SC	Residual Lime Stone Clayey/Silt SAND						X POOR		X MED. DENSE X DENSE	X LOW		X NONE X LIGHT
7							Some gravel, white Mdense to dense Moist											
8																		
9							Excavation Stopped @ 4 Feet											
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		

GRADATION / GRAIN SHAPE / RELATIVE DENSITY / PLASTICITY / CONSISTENCY / CEMENTATION

GROUNDWATER CONDITIONS: Date ______ No Groundwater Encountered ______
Date ______ Time ______ Depth ______
Date ______ Time ______ Depth ______

Results of Infiltration Test at Site 3

test 2/1

Preasoak 1/31
2:15 PM

				Per inch
1.)	8:30	9:20	1"	50 Mm
2.)	9:23	9:43	3/8"	53.3m
3)	9:45	10:06	3/8	56.0m
4	10:00	1021	3/8	56.0

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test Pit LOG ~~OF BORING~~ NO. 4

Project PRH Job No. PRH

Elevation Top of Hole ______ Datum 34°48'39.61" 112°3'11.88" Prepared By C. Saline Date 1/31

Type / Size of Boring 18" Bucket Rig Type 580 Driller Cave Reviewed By ______ Date ______

DEPTH, FEET	PENETRATION RESISTANCE BLOW/FOOT C	N/R	SAMPLE TYPE	DRY DENSITY, PCF	WATER CONTENT, %	SOIL CLASSIFICATION	SOIL TYPE DESCRIPTION (Modifier, Color, Density, Moisture, etc.)	MAXIMUM SIZE	PARTICLE SIZE DISTRIBUTION, % BOULDERS / COBBLES	GRAVEL	SAND	SILT & CLAY	GRADATION (WELL / MEDIUM / POOR)	GRAIN SHAPE (ANGULAR / SUBANGULAR / SUBROUNDED / ROUNDED)	RELATIVE DENSITY (LOOSE / MED. DENSE / DENSE / VERY DENSE)	PLASTICITY (NONE / LOW / MEDIUM / HIGH)	CONSISTENCY (SOFT / FIRM / STIFF / VERY STIFF / HARD)	CEMENTATION (NONE / LIGHT / MODERATE / HEAVY)
1						SC	Clayey SAND: w/gravel: Red brown, M. dense to dense						X (POOR)	X (ROUNDED)	X (MED. DENSE) X (DENSE)	X (LOW) X (MEDIUM)		X (NONE)
2			6				Moist.											
3	30	0.5	R															
4			6				Lime Stone Hard digging 3(e 4')											
5																		
6							Excavation Stopped @ 4'											
7																		
8																		
9																		
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
0																		

GROUNDWATER CONDITIONS: Date ______ No Groundwater Encountered ______
Date ______ Time ______ Depth ______
Date ______ Time ______ Depth ______

Results of Infiltration Test at Site 4

9" test 2/1

Pre-Soak 1/31
3:45

10:32	10:51	1.75	~~10~~ 11
10:52	~~0~~ 10:56	1/4	~~24~~ 16
10:57	11:01	1/4	34 16
11:01	11:05	1/4	16

Appendix C - CSV Point File

Point	Northing	Easting	Elevation	Description
1	5000	5000	1000.497	Start
2	5069.117	4957.348	1001.471	fence
3	5016.957	4952.07	1000.069	fence
4	5068.267	4969.488	1001.934	fence/stake 2
5	5019.659	4927.584	999.73	fence
6	5059.691	4978.993	1001.874	test loc 2
7	5007.068	4926.139	999.416	fence
8	5061.448	4989.011	1001.401	tree
9	5007.614	4941.673	1000.667	tree
10	5065.722	4992.184	1001.676	fence
11	5004.216	4941.276	999.881	fence
12	5060.419	4998.061	1002.415	tree
13	4999.349	4941.051	999.49	fence
14	5064.833	5000.567	1001.723	fence
15	5021.602	4982.118	999.863	tree
16	5058.84	5005.692	1002.64	tree
17	5034.018	4968.705	999.675	test loc 3
18	5062.585	5015.846	1002.349	fence
19	5020.826	5010.94	1000.462	tree
20	5057.281	5014.117	1002.715	tree

21	5032.308	5018.138	999.709	pt
22	5030.498	5004.184	999.816	pt
23	5034.282	5004.06	998.542	pt
24	5034.276	5017.562	999.16	pt
25	5038.414	5017.345	998.402	pt
26	5038.449	5004.757	997.592	pt
27	5045.06	5005.733	999.612	pt
28	5044.784	5017.711	999.708	pt
29	5050.042	5018.249	1003.082	pt
30	5048.577	5005.394	1002.091	pt
31	5048.565	4994.27	1001.476	pt
32	5049.427	4985.163	1001.297	pt
33	5045.899	4994.256	999.684	pt
34	5051.63	4969.635	1001.282	pt
35	5045.967	4994.298	999.702	pt
36	5039.738	4994.233	997.11	pt
37	5044.856	4963.188	1000.085	pt
38	5035.131	4993.563	998.108	pt
39	5047.14	4976.654	998.619	pt
40	5031.778	4993.666	999.517	pt
41	5042.267	4976.045	996.599	pt
42	5032.214	4986.483	999.418	pt
43	5038.545	4975.764	997.133	pt

44	5036.22	4986.099	997.514	pt
45	5035.858	4975.48	999.059	pt
46	5039.638	4986.181	996.675	pt
47	5046.351	4987.52	998.993	pt
48	4994.472	4971.013	1000.342	tree
49	5011.92	4970.098	1000.174	tree
50	4989.908	4984.362	1000.494	pt
51	5015.282	4980.741	1000.017	pt
52	4986.459	4996.905	1000.926	pt
53	4972.265	4991.151	1000.617	tree
54	4983.848	5008.623	1000.811	pt
55	4971.364	5000.651	1001.403	tree
56	4979.503	5023.305	1001.143	pt
57	4964.114	5013.387	1001.444	tree
58	4977.618	5039.442	1001.283	res
59	4957.428	5025.214	1001.305	tree
60	4991.148	5039.335	1000.967	res
61	4950.168	5038.297	1001.456	tree
62	4998.315	5025.465	1000.817	pt
63	5011.133	5024.639	1000.473	pt
64	5004.989	5040.975	1001.092	res
65	5020.335	5024.839	1000.842	pt
66	5017.253	5042.19	1000.847	res

67	5035.431	5031.836	1000.191	pt
68	5020.846	5038.038	1000.731	EOS
69	5043.112	5039.007	999.944	EOS
70	5029.136	5031.723	1000.4	EOS
71	5032.4	5041.028	1000.717	tree
72	5039.266	5042.195	1000.655	EOS
73	5023.698	5047.958	1001.425	EOS
74	5031.44	5036.132	1000.622	EOS
75	5024.826	5040.729	1000.974	EOS
76	5044.803	5042.667	1002.627	wall
77	5053.592	5040.071	1002.098	pt
78	5051.46	5044.818	1003.112	pt
79	5054.588	5046.503	1004.122	pt
80	5056.75	5049.479	1004.209	tree
81	5059.296	5039.654	1002.655	pt
82	5054.316	5035.312	1001.846	pt
83	5046.002	5029.578	1000.442	pt
84	5038.106	5022.461	999.734	pt
85	5033.301	5026.937	1000.017	pt
86	5001.01	4926.68	999.269	fence
87	4965.886	4922.906	998.626	fence
88	4889.215	4918.151	997.378	fence
89	4965.265	4937.238	998.856	pt

90	4901.924	4933.646	997.787	pt
91	4940.23	4938.304	999.081	pt
92	4902.663	4955.855	998.051	pt
93	4927.024	4953.042	998.623	pt
94	4887.01	4949.177	997.652	fence

Appendix D - Hydrology Results

Table 7.6 Rational Method General Runoff Coefficients for Yavapai County Derived from ADOT (1993) and Maricopa County (2008)									
Land Use Code	Land Use Category	Runoff Coefficients by Storm Frequency							
		2-10 Year		25-year		50-year		100-year	
		min	max	min	max	min	max	min	max
VLDR	Very Low Density Residential[1]	0.33	0.45	0.36	0.50	0.40	0.60	0.45	0.65
LDR	Low Density Residential[1]	0.42	0.48	0.46	0.55	0.50	0.64	0.53	0.70
MDR	Medium Density Residential[1]	0.48	0.65	0.53	0.72	0.58	0.78	0.60	0.80
MFR	Multiple Family Residential	0.65	0.75	0.72	0.83	0.78	0.90	0.82	0.94
C1	Commercial 1	0.55	0.65	0.61	0.72	0.66	0.78	0.69	0.81
C2	Commercial 2	0.75	0.85	0.83	0.94	0.90	0.95	0.94	0.95
I1	Industrial 1	0.60	0.70	0.66	0.77	0.72	0.84	0.75	0.88
I2	Industrial 2	0.70	0.80	0.77	0.88	0.84	0.95	0.88	0.95
P	Pavement and Rooftops	0.75	0.85	0.83	0.94	0.90	0.95	0.94	0.95
GR	Gravel Roadways & Shoulders	0.60	0.70	0.66	0.77	0.72	0.84	0.75	0.88
AG	Agricultural	0.10	0.20	0.11	0.22	0.12	0.24	0.13	0.25
LP1	Landscaped Park 1	0.30	0.45	0.35	0.48	0.36	0.50	0.38	0.55
LP2	Landscaped Park 2	0.20	0.35	0.25	0.40	0.30	0.45	0.35	0.50
LP3	Landscaped Park 3	0.10	0.25	0.11	0.28	0.12	0.30	0.15	0.35
L1	Desert Landscaping 1	0.55	0.85	0.61	0.94	0.66	0.95	0.69	0.95
L2	Desert Landscaping 2	0.30	0.40	0.35	0.45	0.36	0.48	0.38	0.50
NDR	Undeveloped Desert Rangeland	0.30	0.40	0.35	0.45	0.36	0.48	0.38	0.50
NHS	Hillslopes, Sonoran Desert	0.40	0.55	0.45	0.60	0.48	0.66	0.50	0.70
NMT	Mountain Terrain	0.50	0.70	0.65	0.80	0.70	0.90	0.75	0.90
1	Based on NDR (undeveloped desert rangeland) terrain class. Values should be increased for NHS and NMT terrain classes by the difference between NHS or NMT and the NDR C values, up to a maximum of 0.95. Engineering judgment should be used.								

Time of concentration (T_c) is to be calculated by Equation 7.2:

$$T_c = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38} \quad (7.2)$$

Note: Reference Papadakis and Kazan, 1987

where:

T_c = the time of concentration, in hours,

L = the length of the longest hydraulic flow path, in miles,

K_b = watershed resistance coefficient,

S = the slope of the longest hydraulic flow path, in ft/mile, and

i = the average rainfall intensity, in inches/hr, for a duration of rainfall equal to T_c (the same (i) as Equation 7.1) unless T_c is less than 10-minutes, in which case the (i) of Equation 7.1 is for a 10-minute duration).

Table 7.4 Resistance Coefficient (K_b) for use in the Rational Method T_c Equation

Derived from: ADOT, 1993

Description of Landform	K_b	
	Defined Drainage Network	**Shallow Overland Flow Only**
Mountain, with forest and dense ground cover (overland slopes – 50% or greater)	0.15	0.30
Mountain, with rough rock and boulder cover, and sparse vegetation (overland slopes – 50% or greater)	0.12	0.25
Foothills (overland slopes – 10% to 50%)	0.10	0.20
Alluvial fans, Pediments and Rangeland (overland slopes – 10% or less)	0.05	0.10
Irrigated Pasture [a]	---	0.20
Tilled Agricultural Fields [a]	---	0.08
Urban		
Residential/ Commercial/Industrial, L < 1,000 ft [b]	0.04	---
Residential/ Commercial/Industrial, L > 1,000 ft [b]	0.025	---
Grass; parks, cemeteries, etc. [a]	---	0.20
Bare Ground; playgrounds, etc. [a]	---	0.08
Paved; parking lots, etc. [a]	---	0.02

Notes:

a – No defined drainage network.

b – L is the length in the T_c equation (Equation 7.2). Roadways serve as drainage network.

PDS-based precipitation frequency estimates with 90% confidence interv							
Duration	Average recurrence interval (years)						
	1	2	5	10	25	50	100
5-min	**0.215** (0.183-0.253)	**0.278** (0.236-0.327)	**0.377** (0.319-0.442)	**0.459** (0.385-0.536)	**0.576** (0.479-0.671)	**0.673** (0.555-0.784)	**0.779** (0.634-0.908)
10-min	**0.327** (0.278-0.386)	**0.423** (0.358-0.498)	**0.574** (0.485-0.673)	**0.697** (0.587-0.817)	**0.876** (0.729-1.02)	**1.02** (0.845-1.19)	**1.18** (0.965-1.38)
15-min	**0.406** (0.345-0.478)	**0.524** (0.444-0.617)	**0.711** (0.601-0.834)	**0.864** (0.727-1.01)	**1.09** (0.903-1.27)	**1.27** (1.05-1.48)	**1.47** (1.20-1.71)
30-min	**0.546** (0.465-0.644)	**0.705** (0.598-0.830)	**0.957** (0.809-1.12)	**1.16** (0.979-1.36)	**1.46** (1.22-1.71)	**1.71** (1.41-1.99)	**1.98** (1.61-2.31)
60-min	**0.676** (0.575-0.797)	**0.873** (0.740-1.03)	**1.18** (1.00-1.39)	**1.44** (1.21-1.69)	**1.81** (1.51-2.11)	**2.12** (1.75-2.46)	**2.45** (1.99-2.85)
	0.791	**1.00**	**1.33**	**1.60**	**2.00**	**2.33**	**2.69**

Knowns	
Length of Flow Path - L (mi)	0.370
Watershed Resistance Coefficient - Kb	0.250
Slope - S (ft/mi)	378.4

Time of Concentration	***30 min***

Theoretical Tc (min)	Storm (yr)	Rainfall Intensity (in/hr)	Calculated Tc (hr)	Calculated Tc (min)
10	1	0.327	0.819	49
15	1	0.406	0.754	45
30	**1**	**0.546**	**0.674**	**40**
60	1	0.676	0.621	37
10	2	0.423	0.743	45
15	2	0.524	0.685	41
30	**2**	**0.705**	**0.612**	**37**
60	2	0.873	0.564	34
10	5	0.574	0.661	40
15	5	0.711	0.610	37
30	**5**	**0.957**	**0.545**	**33**
60	5	1.18	0.503	30
10	10	0.697	0.614	37
15	10	0.864	0.566	34

30	**10**	**1.16**	**0.506**	**30**
60	10	1.44	0.466	28
10	25	0.876	0.563	34
15	25	1.09	0.518	31
30	**25**	**1.46**	**0.464**	**28**
60	25	1.81	0.427	26
10	50	1.02	0.531	32
15	50	1.27	0.489	29
30	**50**	**1.71**	**0.437**	**26**
60	50	2.12	0.402	24
10	100	1.18	0.503	30
15	100	1.47	0.463	28
30	**100**	**1.98**	**0.413**	**25**
60	100	2.45	0.381	23

$$Q = CiA \qquad (7.1)$$

where:

Q = the peak discharge, in cfs, of the selected return period,

C = the runoff coefficient,

i = the average rainfall intensity, in inches/hr, of calculated rainfall duration for the selected rainfall return period, and

A = the contributing drainage area, in acres.

Appendix E: Hydraulic Hand Calculations

found on Well's SS that the site shares a well with the property just north

I is Assumed that this property has a 3/4" pvc p feeding the Home and the pipe is 90 feet long if the water traveled another distance of 110 feet through 1" pipe and fixtures And then through a 3/4 rubber Hose to Clean existing kennels

we Assume that ELEVation from well to End of Hose is the Same

FE HAnd Book 106

$$\frac{P_1}{\gamma} + z_1 \frac{V_1^2}{2g} + \text{Pump} = \frac{P_2}{\gamma} + z_2 + \frac{V^2}{2g} + h_f \longrightarrow h_f = f\frac{L}{D}\frac{V^2}{2g}$$

$$\frac{144\ \text{in}^2}{\text{ft}^2}\ \frac{\text{ft}^3}{62.3\ \text{lb}} = \underline{2.311\ \text{ft}}$$

$$138.7 = \frac{V^2}{2g} + \underbrace{f\frac{L}{D}\frac{V^2}{2g}}_{\text{PVC}} + \underbrace{f\frac{L}{D}\frac{V^2}{2g}}_{\text{Hose}}$$

f of pvc
f of Rubber Hose

2.311 feet of water 1 PSI

No pressure due to tank
No ELEVation Change
No V_1 No Change A Base of well
Pump = 138.7 feet

Pump 60 psi need Head
$60\ \text{psi} \cdot \frac{2.311\ \text{feet}}{1\ \text{psi}} = 138.7\ \text{feet}$

P_2 No pressure At end of Hose
Z_2 no ELEV. Change
Have V_2

need to find h_f So we Start to Assume

And run through needing Reynolds Number with A Assumed Velocity

So try 16 gallons per min $\quad \frac{5\ gall}{Min} \cdot \frac{ft^3}{7.48\ gall} = \frac{0.668\ ft^3}{Min}$

3/4" pipe = Area in ft^2

Kinematic Viscosity @ 60°F 0.000012 ft^2/s $\quad \frac{(3/4/12)^2 \cdot \pi}{4} = 0.00307\ ft^2 \quad \phi = 0.0625\ ft$

18888 - for Both = $Re = \frac{VD}{\nu} = \frac{3.63\ ft}{s} \cdot 0.0625\ ft^2 \left(\frac{s}{0.000012\ ft^3}\right) \quad \frac{0.668\ ft^3}{Min} \cdot \frac{}{0.00307\ ft^2} = \frac{217.6\ ft}{M}$

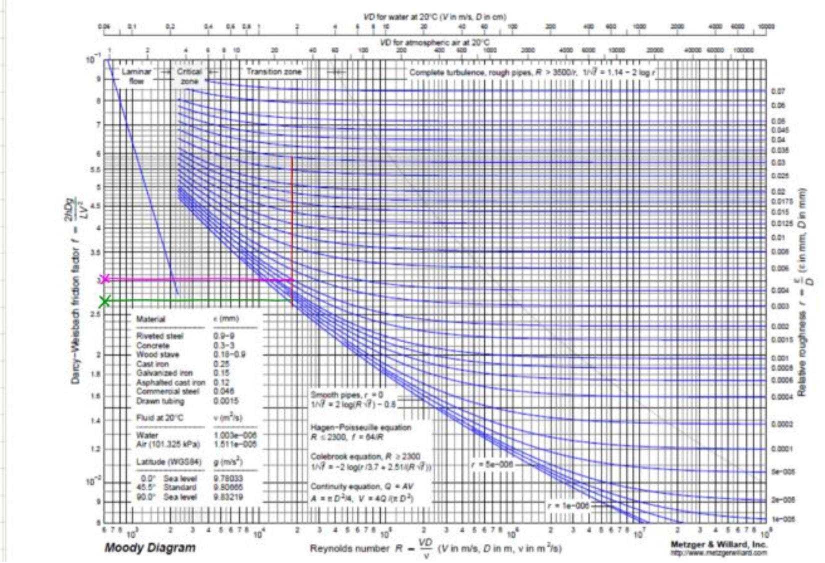
1.9 x10^4

	Roughness (mm)	in	RR
PVC	0.00575	0.000226	0.000301
Flexible Rub tubing	0.038	0.00150	0.00200

$\frac{217.6\ ft}{M} \cdot \frac{M}{60s} = \frac{3.63\ ft}{s}$

PVC $f = 2.7 \times 10^{-2}$ 0.027

FRT $f = 3.0 \times 10^{-2} = 0.031$



$$138.7\,ft = \frac{V^2}{2g} + f\frac{L}{D}\frac{V^2}{2g} + f\frac{L}{D}\frac{V^2}{2g}$$

PVC $\qquad$ Hose

PVC $f = 2.7\times10^{-2}$ 0.027 $\qquad \frac{3.63\,ft}{s}$

FRT $f = 3.1\times10^{-2} = 0.031$

$g = 32.17\,ft/s$

$$138.7 = \frac{V^2}{64.34} + \frac{0.27\cdot 200}{0.0625\cdot 64.34}V^2 + \frac{0.30\cdot 100}{0.0625\cdot 64.34}V^2$$

$2g = 64.34\,ft/s$

$\phi = 3/4'' = 0.0625'$

$$138.7 = 0.02\,V^2 + 13.43V^2 + 7.46\,V^2 = \frac{\cancel{21.16}\,V^2}{20.91} = \frac{2.58\,ft}{s}$$

And our Assstutday speed was $\frac{3.63\,ft}{s}$

with this we try Again But $\frac{2.56 + 3.63}{2} = 3.10\,ft/s$ new Assumed Velocity

$$Re = \frac{VD}{\nu} = \frac{3.63\,ft}{s}\cdot 0.0625\,ft^2\left(\frac{s}{0.000012\,ft^3}\right)$$

But using $3.10\,ft/s$

$$\frac{3.10\,ft}{s}\cdot 0.0625\,ft\,\frac{s}{0.000012\,ft^2} = 16146 = 1.6\times10^4$$

PVC - δ of 0.28

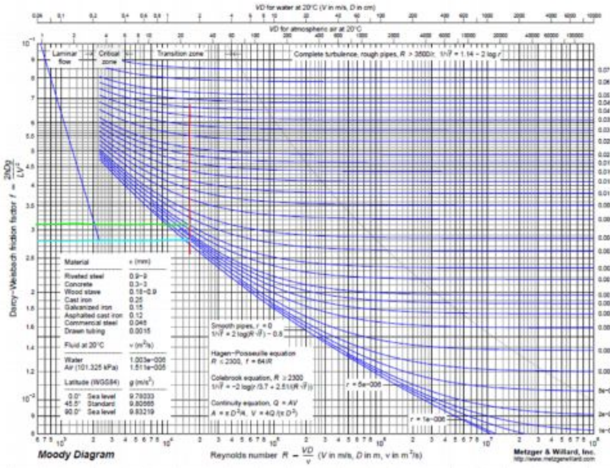
tubing - δ of 0.31

$$138.7 = \frac{V^2}{64.34} + \frac{0.28 \cdot 200}{0.0625 \cdot 64.34} V^2 + \frac{0.31 \cdot 100}{0.0625 \cdot 64.34} V^2$$

$$138.7 = 0.02V^2 + 13.93V^2 + 7.71V^2$$

$$\sqrt{\frac{138.7}{21.66}} = V = 2.53 \frac{ft}{s}$$ with $3.10 \frac{ft}{s}$

next Assumption of $2.45 \frac{ft}{s}$



$$Re \quad \frac{2.45\ ft}{s} \cdot 0.0625\ ft \quad \frac{s}{0.000012\ ft^2} = 1.2760 \quad 1.3 \times 10^4$$

PVC - δ - 0.295

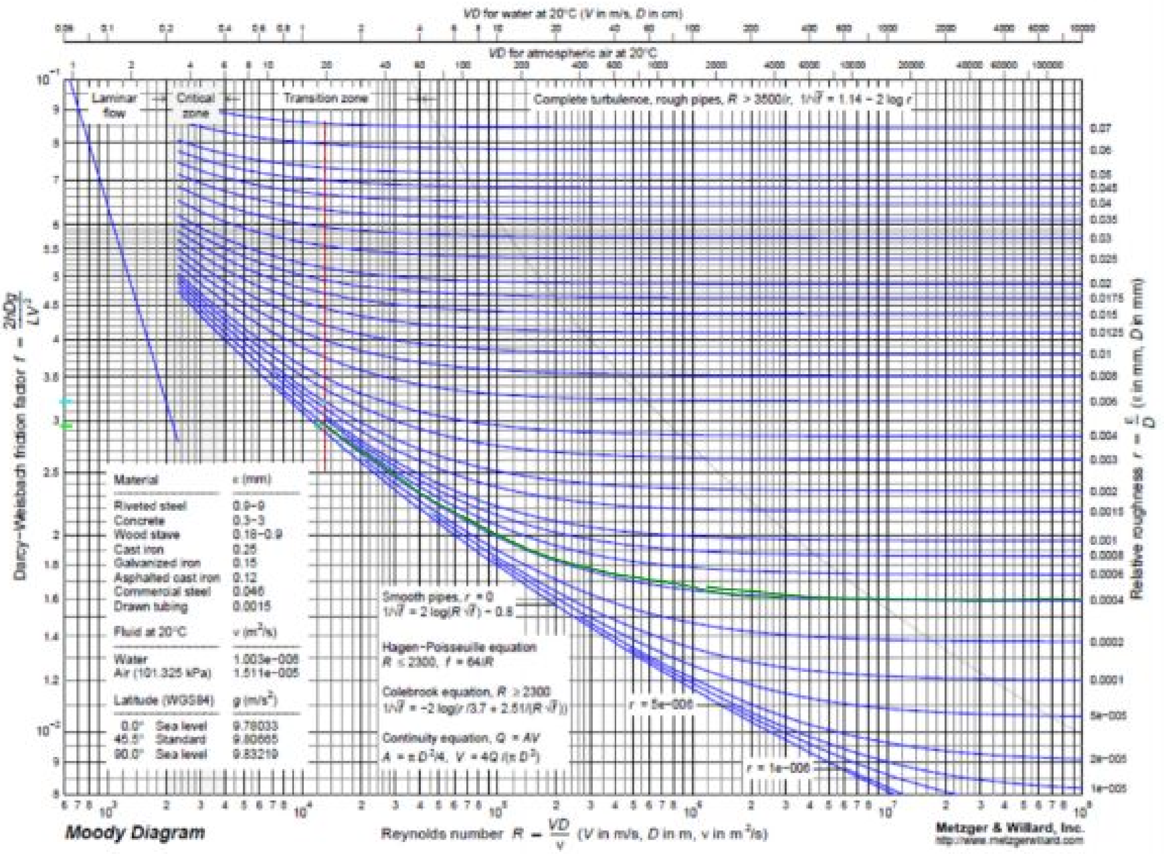
Tube - δ - 0.32

$$138.7 = 0.02V^2 + \frac{0.295 \cdot 200}{0.0625 \cdot 64.34} V^2 + \frac{0.32 \cdot 100}{0.0625 \cdot 64.34} \cdot V^2$$

$$138.7 = 0.02V^2 + 14.67V^2 + 7.96V^2$$

$$\sqrt{\frac{138.7}{22.65}} = V = 2.47$$ with start of 2.45

$$V = 2.47 \frac{ft}{s}$$



$$\frac{3''}{4}\cdot\frac{ft}{12''} = 0.0625\ ft$$

$$V = \frac{2.47\ ft}{s}\ 0.00307\ ft^2 \qquad \frac{(0.0625\ ft)^2}{4}\pi = 0.00307\ ft^2$$

$$\frac{2.47\ ft}{s}\ 0.00307\ ft^2 = \frac{0.00757\ ft^3}{s}$$

$$\frac{0.00757\ ft^3}{s}\ \frac{60\ s}{M} = \frac{0.455\ ft^3}{M}\cdot\frac{7.48\ gall}{M} = \frac{3.4\ gall}{Min}$$

$$\frac{3.4\ gall}{Min}$$

Appendix F: Yavapai County Development Services Plot Plan Checklist

PLOT PLAN CHECKLIST

NOTE: PLOT PLAN MUST BE DRAWN TO SCALE IN BLACK INK ON THE FORM PROVIDED THAT INCLUDES ALL OF THE FOLLOWING INFORMATION.

( ) Property dimensions
( ) Indicate scale used (Engineer's Scale-1"=20'; 30'; 40'; 50'; 60')
( ) Indicate North with directional arrow
( ) Proposed structures with all dimensions, including pools, fences, walls, etc.
( ) Existing structures with all dimensions, including pools, fences, walls, etc.
( ) Distances between structures
( ) Distance from all structures to property lines
( ) Description of each structures use
( ) Adjacent streets/roads
( ) Driveway (s) and material used (i.e. gravel, concrete...)
( ) Location, Size, Dimensions of Septic System with Leach Area
___ Perc test holes
___ 100% Expansion Area (minimum distance from septic and leach)
___ Length and slope of outlet lines (5 foot min.)
___ Distribution Box/Diversion Valve
___ Inspection Pipe (s)
___ Length, width and number of leach lines; distance between trenches
___ Degree of slope in leaching area
___ Length and slope of building sewer line (max 100 feet)
___ Cleanout pipe in building sewer lines
___ Setbacks from property lines, buildings, wells, dry washes, other sewage systems, water lines.
(NOTE: If individual wells provide water, maintain minimum septic setbacks of 50' from property lines and 100' from all wells including neighboring wells)
( ) Location of all utilities, poles, meters and lines
( ) All easements, regardless of purpose (i.e. roads, utilities)
( ) Slope Information
___ Indicate High and Low points
___ Indicate by arrows direction of slope
___ Indicate difference in elevation between high and low points
( ) Distance from the closest structure to the top of bank of any watercourse (s) (i.e. washes, streams, creeks, arroyos, rivers, drainage ways, drainage easements and slews)
( ) Indicate elevation difference of proposed building site to the lowest wash elevation adjacent to the building site.
( ) Location of existing roadside ditches and road culverts with size
( ) Layout of parking spaces, including handicapped, per use requirements (pertains to all except single family dwelling permits)
( ) Signage must be identified but requires a separate permit (non-residential permits)
( ) Location and type of exterior lighting (non-residential permits)
( ) Location where orange will be posted

Appendix H: Yavapai County Development Services Septic Systems: Plot Plan Checklist

Yavapai County – Development Services Department

Conventional Septic Systems: Plot Plan Checklist

Note: **A plot plan must be drawn to engineering scale (e.g. 1"-20', 1"-40', 1"=60') on 8 ½ by 11" paper in black ink.** The following information is required. If any of this information is missing or does not conform to the Arizona Administrative Code, your application will be considered incomplete and may be returned to you causing a delay in processing.

Parcel Number:____

	The engineering scale used and "North" must both be clearly indicated.
	Property dimensions including easements must be clearly shown. If you have large acreage, the grid inset in the upper right hand corner of the plot form may be used to show the lot boundaries and the detail of the disposal location is to be shown on the plot layout. AAC R18-9-A309(B)(2)
	Slope must be clearly indicated. AAC R18-9-A309(B)(2)
	The location of the soil profile ("test") holes and perc holes must be shown for both the primary disposal area and the 100% reserve area. The entire disposal area must fit inside a 30' radius of the test holes. AAC R18-9-A310(F)(3).
	The length and slope of the building sewer line (from house to tank) must be shown. Avoid right angle bends in sewer line. AAC R 18-9-A312(C), AAC R18-9-A312(A)(2)
	The septic tank must be shown. It must meet ADEQ requirements. AAC R18-9-A309(B)(2)
	The length of the outlet line (from tank to disposal area) must be shown. There should be a minimum separation of 5 feet from the tank to the disposal area. AAC R18-9-A309(B)(2)
	The location and length of the leach lines (or other disposal) must be shown. AAC R18-9-A309(B)(2)
	A distribution box is required if there are two or more disposal lines. Multiple lines shall be of equal length where possible. Serially loaded trenches are an acceptable method of splitting lines. AAC R18-9-A309(B)(2), AAC R18-9-E302(C)
	The distance between multiple disposal lines must be 5' or twice the effective depth, *whichever is greater.* AAC R18-9-A309(B)(2), AAC R 18-9-E302(C)
	A 100% replacement area for disposal area must be shown in detail. AAC R18-9-A310 (F)(1) and (3)

The location of these features must be shown, if present, AND the minimum setbacks must be met and clearly indicated: AAC R18-9-A309(B)(2), AAC R18-9-A312 (C)		water mains (10 feet)		driveways (5 feet)
		water service lines (5 feet)		other paved areas (5 feet)
		other utilities (not to cross over septic tank or disposal area)		structures (10 feet)
		road cuts, ditches and culverts (15 feet)		washes and drainage easements greater than 20 acres (50 feet)
		Easements (5 feet)		Swimming pools (5 feet)
		wells (including those on adjoining properties) (100 feet)		waterways (100 – 200 feet)
		property lines with well (50 feet)		property lines with community water (5 feet)

	Inspection pipes must be shown at the ends of the leach lines. AAC R 18-9-A301(D)(2)
	The plot plan must have a signature. Yavapai County Planning and Zoning Ordinance Section 205 (F)(3)(K)

Revised 6/2014