ALTERNATIVE SEPTIC SYSTEM

Page Springs, AZ

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CENE 476

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1.0 Introduction

The following literature review contains the background research from Team SepTank. Various septic systems, regulations, irrigation methods, and standard methods were researched.

2.0 Technical Aspects

2.1 Septic Tanks

2.1.1 Aerobic Septic Systems

Aerobic systems using conventional tanks utilize air injection to stimulate and agitate the tank [1]. This method increases efficiency in breaking down solids. Many of these tanks have a separator wall, where water flows over the top to a separator and clarifier.

2.1.2 Anaerobic Up Flow Septic Tank

This septic system's main purpose is the removal of BOD, COD, and TSS in residential up-flow septic tanks through hydraulic retention times. This system has shown removal efficiencies of 86% for BOD, COD, and TSS with a twenty-four-hour hydraulic retention time [2].

2.1.3 Up-Flow Anaerobic Sludge Blanket (UASB) Tanks

Up-flow Anaerobic Sludge Blanket reactors are single tank processes that remove high levels of organic pollutants [3]. Bacteria is used to break down solids in the wastewater through degradation, which settle at the bottom of the tank, and clarified water collects at the top to be removed. The sludge remains at the bottom and assists the filtering process as it accumulates.

2.1.4 Wastewater Treatment for Residential Septic Systems

This system uses small residential septic tanks. Mixing is used for the wastewater present and a chlorine canister connected to a Venturi chamber [4]. After using, the chlorine must be sent to a disposal area. The remaining effluent from the original wastewater is then used on a spray field to allow absorption into the soil.

2.1.5 Effect of temperature on anaerobic treatment of black water in UASB-septic tank systems

Fluctuating temperatures during the year may have an effect on UASB septic tanks. If the outside temperature decreases, the removal of suspended solids and COD will become less efficient. Until the sludge in the system has enough time to adapt to the change in temperature [5].

2.2 Regulations & Codes

2.2.1 Arizona Revised Statutes

49 A.R.S. § 201(25)
"'On-site wastewater treatment system' means a conventional septic tank system or alternative system that is installed at a site to treat and dispose of wastewater of predominantly human origin that is generated at that site."
This is important to define when reviewing codes and permit requirements as a wastewater treatment facility is considered different and permit requirements are distinct between the two.

49 A.R.S. § 241(B)(9)
This section addresses discharge permits regarding aquifers. It states that unless exempted under section 49-250, or is determined by the director that the facility is designed, constructed, and operated under that no pollutants will migrate to the vadose zone or aquifer, a sewage treatment facility, including on-site wastewater treatment, will require a discharge permit.

49 A.R.S. § 250
The section named above, does not mention on-site wastewater treatment or sewage treatment as being exempt. However, it does exempt facilities that require a permit for direct reuse of reclaimed water. This further clarifies the above section that a discharge permit will be required for a septic system.

49 A.R.S. § 701(14)
This section states that "household waste" includes sanitary waste from septic tanks.

49 A.R.S. § 1001(21)
This section clarifies that septic tanks are not considered underground storage tanks. This exempts the installation of a septic tank from requiring addition permits for underground storage tanks.

2.2.2 Arizona Administrative Codes

18 A.A.C. 9 – Environmental Quality – Water Pollution Control
This chapter defines codes, rules, and permits required as it relates to water pollution control. Matters of interest within this chapter include the Aquifer Protection Permit, biosolids, and reclaimed water direct reuse and conveyances. This chapter of Title 18 – Environmental Quality is expected to be the primary source of information regarding permits, permitting process, regulatory compliance, and any further quality conditions regarding septic systems and irrigation systems.

18 A.A.C. 9, Article 1

Aquifer Protection Permits – General Provisions

R18-9-103
Land Applications of biosolids do not require an Aquifer Protection Permit (APP).

18 A.A.C. 9, Article 3

Aquifer Protection Permits – General Permits

R18-9-A309 to R18-9-A317
These rules define the general provisions, site investigations, facility selection, design, installation, operation, maintenance, and other applicable rules for on-site wastewater treatment facilities. These rules apply to the various levels of permits, from type 1 to 4.

R18-9-E301 to R18-9-E323
This part (E) defines all requirements for varying type 4 general permits. The type 4 general permit is for on-site wastewater treatment, and each rule addresses a single type of on-site treatment. Each rule addresses the design, performance, constraints, and discharge requirements. This part will be impactful as the team investigates potential alternative systems.

18 A.A.C. 9, Article 6

Reclaimed Water Conveyances
This article defines two types of conveyances – pipeline and open water. Three rules address applicability of conveyances, regulatory requirements, and requirements while constructing. If the proposed system includes reclaimed water this article will provide the information needed.

18 A.A.C. 9, Article 7

This article states the regulations regarding the direct Reuse of Reclaimed Water.

R18-9-701
This article applies to reclaimed water that meets standards A+, A, B+, B, and C. These standards are established in 18 A.A.C. 11, Article 3. This article does not exempt disposal under AAP requirement.

R18-9-703(C)(2)
Defines the requirements for the Department to amend an individual APP.

R18-9-704
In section A, this rule states that a sewage treatment facility shall provide reclaimed water only under an individual APP amended under R18-9-703(C)(2). In section F, this rule outlines the general requirements for irrigating with reclaimed water.

R18-9-705 to R18-9-719
These rules state the requirements and process for obtaining and operating under select reclaimed water permits. These rules address the requirements of maintaining records and

reporting results. These rules will be referred to once a determination of the possibility of reclaimed water use is determined.

18 A.A.C. 9, Article 10

This article defines and addresses applicability and requirements for use of biosolids for land application. These biosolids are prepared from a sewage sludge unit and if in compliance, may be applied for land applications without requiring an APP. This article will provide guidance on the applicability of use of the biosolids as it relates to the project.

18 A.A.C. 11, Article 3

This article outlines the minimal quality needed for various uses. For home irrigation, type A is needed. For vineyard irrigation, type B is required.

18 A.A.C. 11, Article 4

R18-11-406
This article specifically defines the numerical values associated with water quality in an aquifer. As well, Narrative standards are explicitly defined.

2.3 Irrigation Techniques

The following section contains potential irrigation techniques that will be used for the completion of this project.

2.3.1 Flood (furrow) Irrigation

This method consists of flooding small trenches through the crops [6]. This method is typically used in less-developed areas of the world where technology is not as advanced [6]. This is not the most cost-effective or sustainable method, as a large volume of water is lost to evaporation [6]. Refer to Figure 1 for reference [6]. This method has been proven to increase the salinity content of the soil and water table over an extended period and must be monitored [7].

To become more efficient, the following techniques may be used:

2.3.1.1 Leveling of fields:

This ensures that the ground the crops are planted on is void of any slope [6]. Water will flow with gravity; any slope will decrease the effectiveness of the flood irrigation [6].

2.3.1.2 Surge Flooding:

Surge flooding is a variation of flood irrigation. The flooding occurs at predetermined intervals to reduce unwanted runoff [6].

2.3.1.3 Capture and reuse of runoff:

As a large volume of water is wasted during flood irrigation, this method captures the runoff water into a retention basin and pumps it back to reuse for irrigation [6].

2.3.2 Drip Irrigation (micro irrigation)

Water runs through pipes slightly above the ground and drips almost directly onto the crops and roots. This method allows for less water to be lost to evaporation and transpiration, which cuts costs down [7]. This method decreases the amount of wetted area, which also decreases the amount of water lost to evaporation [8]. Refer to Figure 2 for reference.

This requires very little pressure and can increase the yield of crops [8]. This method is also not labor intensive and can irrigate on sloped or irregularly-shaped land, which flood irrigation would fail to do [8].

A study was also conducted that tested subsurface drip irrigation systems in which the pipe that delivered the water to the crops was underground. This study concluded that subsurface irrigation systems were as efficient as the traditional drip irrigation system located above the ground [9]. It was determined that the lifetime of the subsurface drip irrigation systems is long, assuming the system is properly designed, maintained, and installed [9].

2.3.3 Spray Irrigation

Spray irrigation is widely used, though slightly inefficient [9]. The most commonly used spray irrigation applicator is the "center-pivot" system, which utilize electric motors to move a large frame in a circle to squirt water over the crops [9]. This requires high pressure to operate and loses approximately 35% of the water due to evaporation [9]. Refer to Figure 3 for reference.

2.3.3.1 Low Energy Precision Application (LEPA)

This alternative spray irrigation system does not launch water through the air to deliver it to the crops [10]. Outwardly, it appears to be very like the traditional spray irrigation system, but it also has pipes that hang very close to the ground and essentially sprays water directly on the crops [10]. This method allows for approximately 90% of the water to be used [10]. Refer to Figure 4 for reference.

2.4 Standard methods Water Quality Analysis

2.4.1 Turbidity and Solids

Turbidity is the white-cloudiness color which is caused in the water. Turbidity can be measured by determining the Total Solids, Total Suspended Solids, Total Dissolved Solids, Total Volatile Solids, Volatile Dissolved Solids, Volatile Suspended Solids, Total Fixed Solids, Fixed Dissolved Solids, and Fixed Suspended Solids.

Standard Method # 2130 B: Nephelometric Method [11]

Standard Method # 2540: Total Solids [11]

Standard Method # 2540 C & D: Suspended Solids & Dissolved Solids [11]

2.4.2 PH, Alkalinity, and Hardness

Solutions with PH below 7 considered to be acidic and above is basic, natural water ranges in between 6-9. Alkalinity can be used to neutralize acidic. When adding bases or acids, the buffering capacity of the water will resist changes in the level of the ph. Common water hardness are Calcium and Magnesium.

Standard Methods: 2320 B. EDTA Titration Method [11]

HACH Water Analysis Handbook: Alkalinity Method 8221 [12]

Standard Methods: Method C Titration Method [11]

HACH Water Analysis Handbook: Total Hardness Method 8226 [12]

HACH Water Analysis Handbook: Calcium Hardness Method 8222 [12]

2.4.3 Oxygen

The amount of oxygen will vary depend on the temperature of the water.

Standard Method #2710B: Oxygen Uptake Rate and Specific Oxygen Uptake Rate [11]

2.4.4 Nutrients

Nutrients include Nitrogen, Phosphorus, and Sulfur. Nutrients are treated in municipal wastewater treatment.

(Ammonia NH_3) Test N' Tube Salicylate Method HACH Method #10031 [13]

(Nitrate) Cadmium Reduction Method HACH Method #8171 [13]

(Total Nitrogen) Test N' Tube Persulfate Method HACH Method #10071 [13]

2.4.5 Coliforms

Coliform bacteria can be found in the intestines. The presence of coliforms indicates that the water has fecal bacteria contamination.

Standard Method 9215 C Spread Plate Method [14]

Standard Method 9215 Heterotrophic plate count [14]

2.5 Watershed in Oak Creek

2.5.1 Pollutant of Concern

Oak Creek has failed to meet the water quality standards for E. coli bacteria, as it has exceeded the state standards of 235 colony cfu per 100mL. Human waste, pets, livestock and other animals accounted for 33% of E. coli. Testing for E. coli is low in cost and is a practical way of monitoring potential fecal pollution [15].

2.5.2 Watershed Description

Oak Creek watershed is a sub-watershed of the Verde River Watershed between north central Arizona and the Colorado Plateau. It is located in Coconino and Yavapai counties. The land use consists of forestry, grazing, recreation, agriculture, residential, and commercial [15].

2.5.3 Water Quality Concerns

The repetition of the exceedance of E. coli standards led the Arizona Department of Environmental Quality (ADEQ) to list Oak Creek as an impaired water. Also, it should develop a Total Maximum Daily Load (TMDL). Water quality is impaired during of peak recreational use, which led the concentration of E. coli to exceed the standards by contact (swimming). This result is due to recreational as a source of fecal bacteria entering the Oak Creek, and to the disturbance of stream sediment by swimmers and waders [14].

The water quality violations in Oak Creek happens only when sediments were found to have high fecal coliform counts. When the sediment is disturbed by recreation or turbulent and high velocity storm flows, the sediment is lifted into the water column where increased contact between sediment particles and water causes entrainment of E. coli. The remainder of E. coli are from wildlife animals [15].

Oak Creek fecal pollution comes from multiple sources based on the high temporal and spatial variability of E. coli in water and sediment. The fecal pollution is not a regrowth phenomenon. E. coli concentration in water demonstrates that pollution is a sum of material transported from upstream. In order to reduce E. coli pollution, implement locally approved grazing modifications that decrease the inflow of sediment carrying fecal material and to continue monitor the water quality [15].

2.5.4 Water Quality Standards

(A.A.C. R18-11 Article 1) are state regulations that protect lakes and other surface bodies from pollution. These regulations contain important designations, water quality criteria that are protective of the use designation, and procedure for applying the water quality criteria to wastewater discharge and other sources of pollution [16].

List of Figures

Figure1: Flood Irrigation [6]

Figure2: Drip Irrigation [7]

Figure3: Spray Irrigation [8]

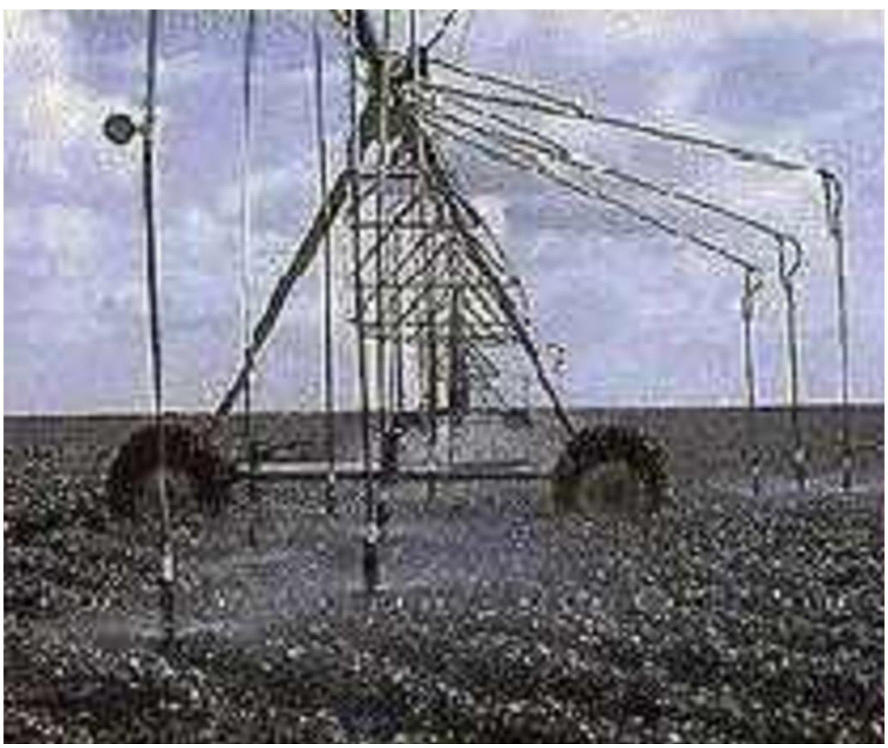

Figure 4: Low Energy Spray Irrigation [9]

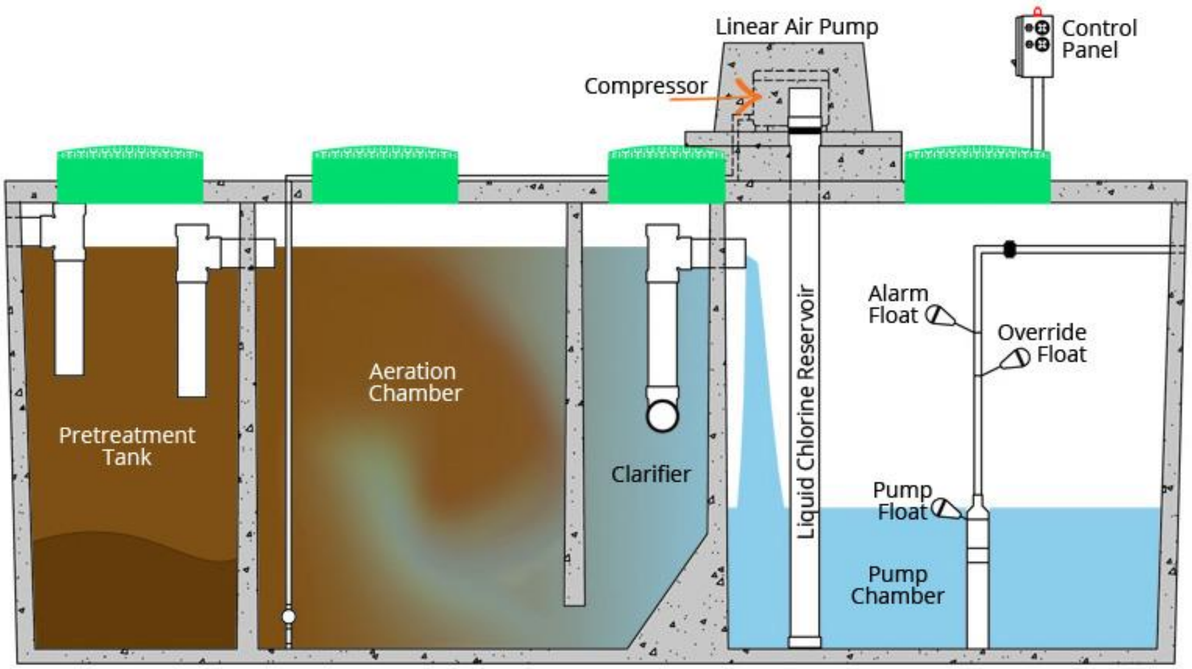

Figure 5 Aerobic Septic Tank [18]

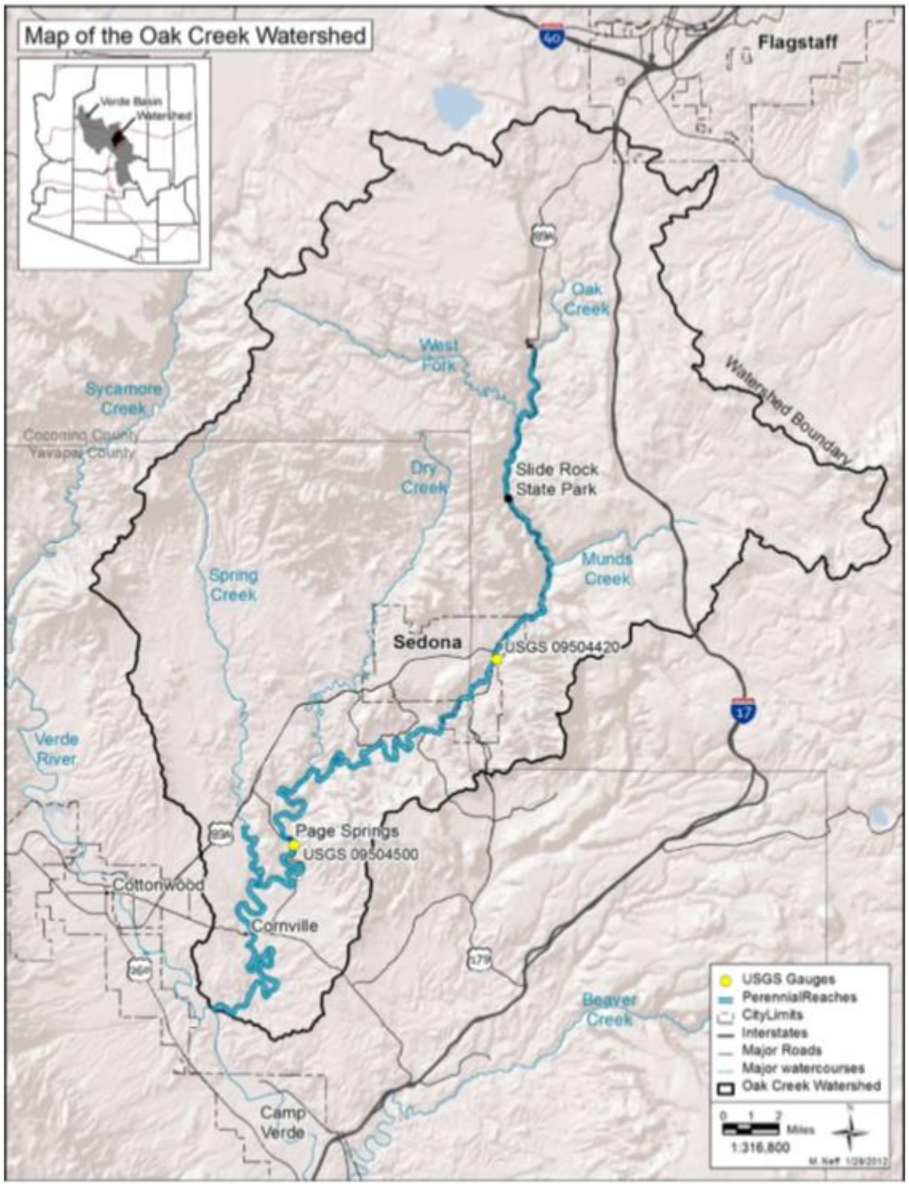

Figure 6 Map of Reference [15]

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