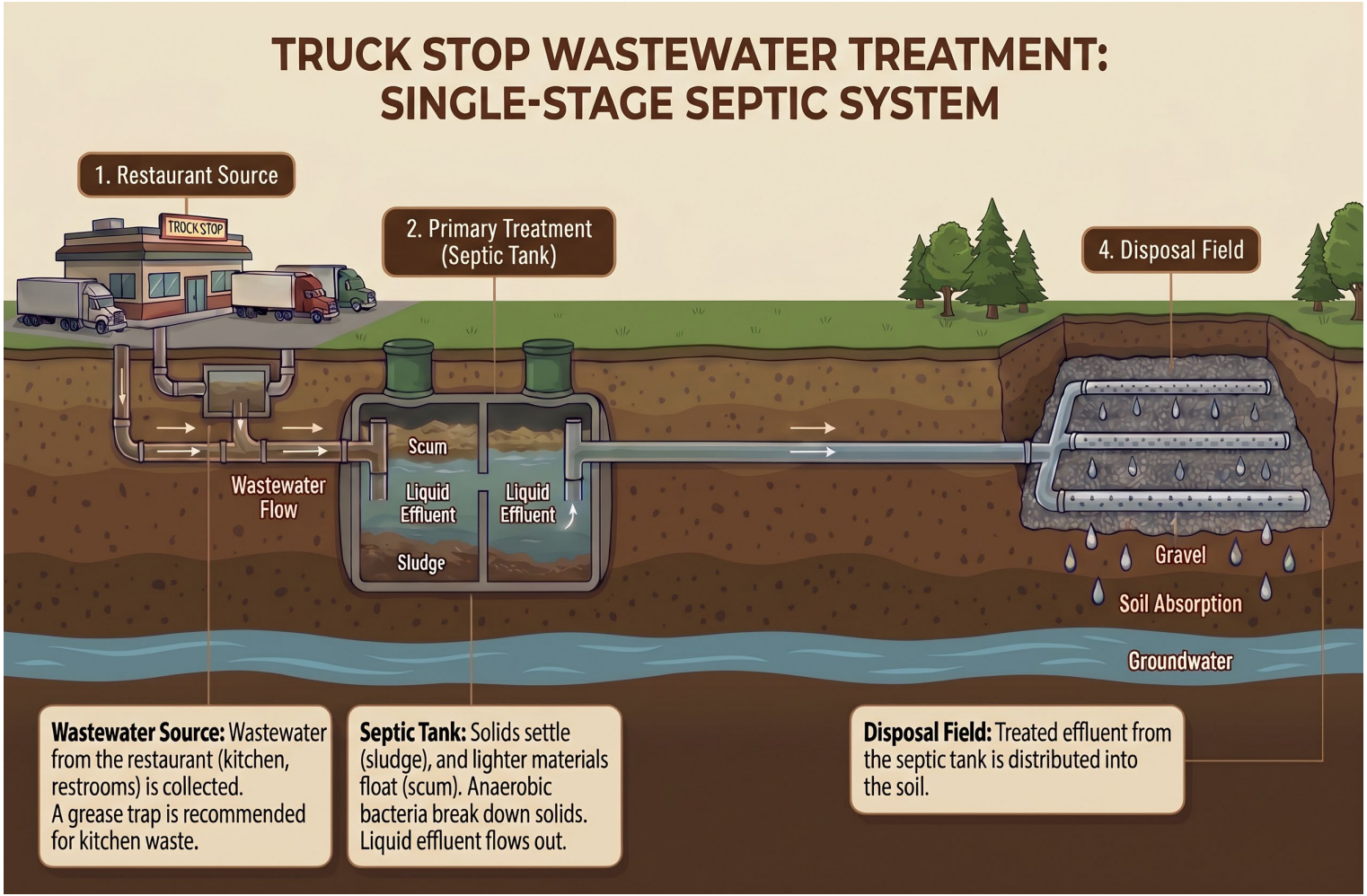
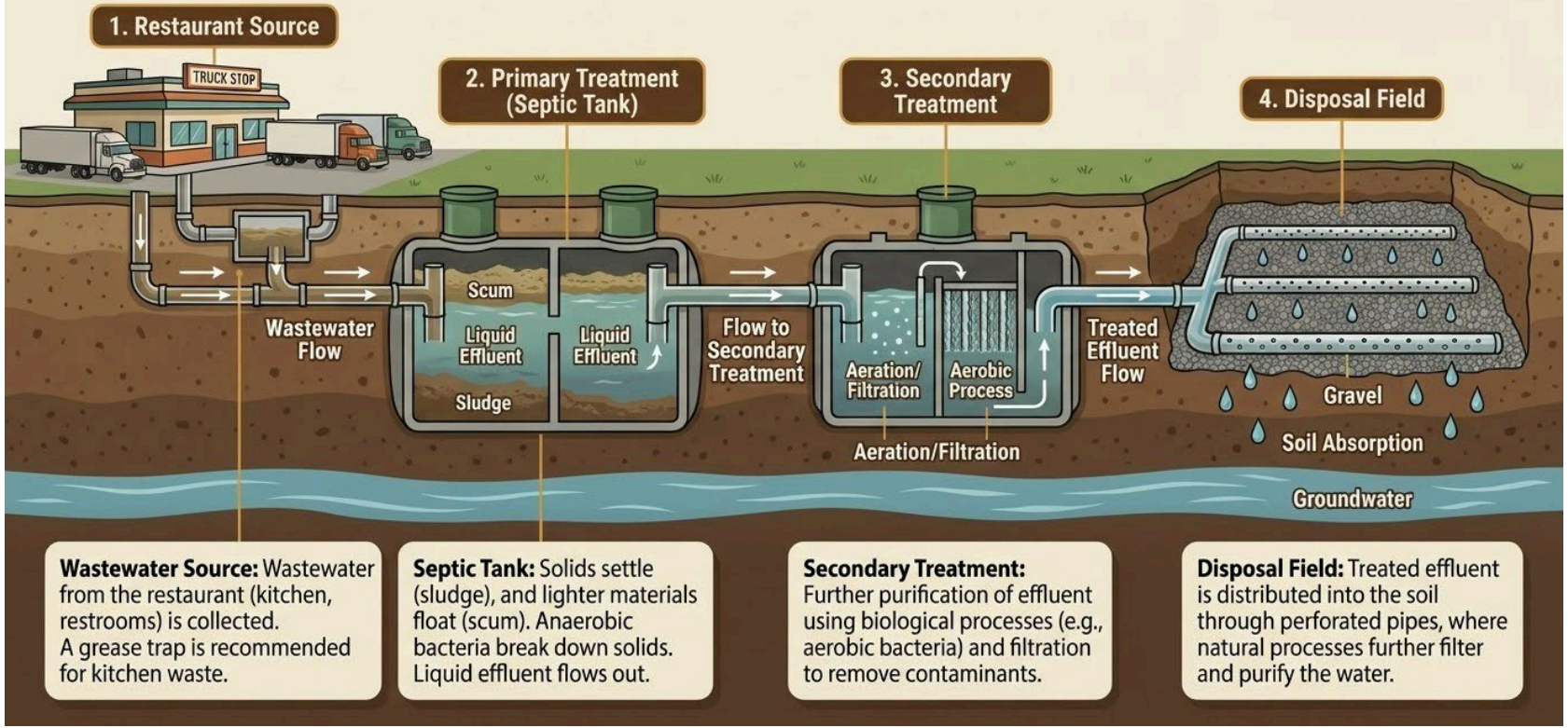
Delegated Agency Training:
How to Design & Review an Onsite Wastewater Treatment Facility for a Truck Stop with a Restaurant (Part Three)

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

TRUCK STOP WASTEWATER TREATMENT: SINGLE-STAGE SEPTIC SYSTEM



TRUCK STOP WASTEWATER TREATMENT: INTEGRATED SEPTIC & SECONDARY SYSTEM



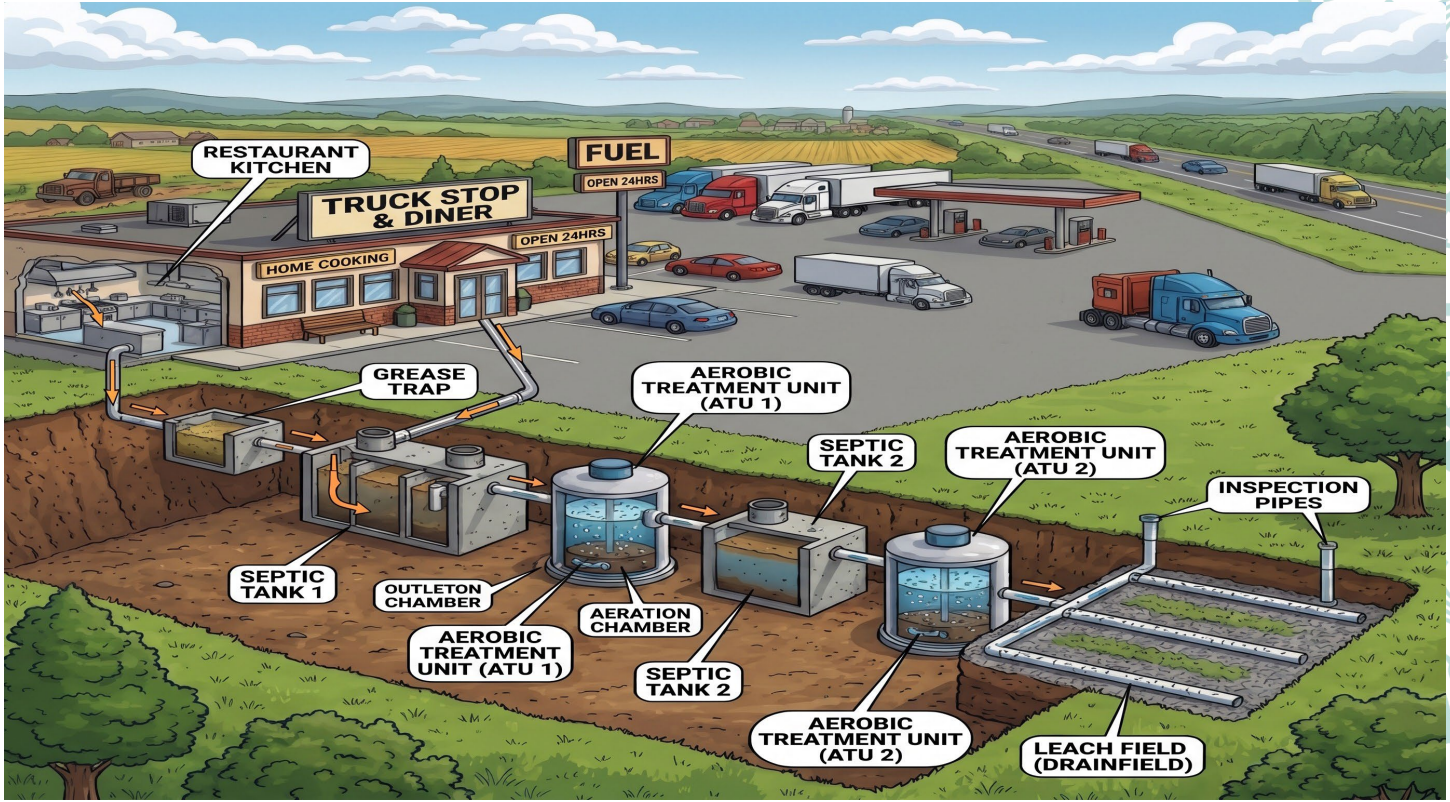
Wastewater Source: Wastewater from the restaurant (kitchen, restrooms) is collected. A grease trap is recommended for kitchen waste.

Septic Tank: Solids settle (sludge), and lighter materials float (scum). Anaerobic bacteria break down solids. Liquid effluent flows out.

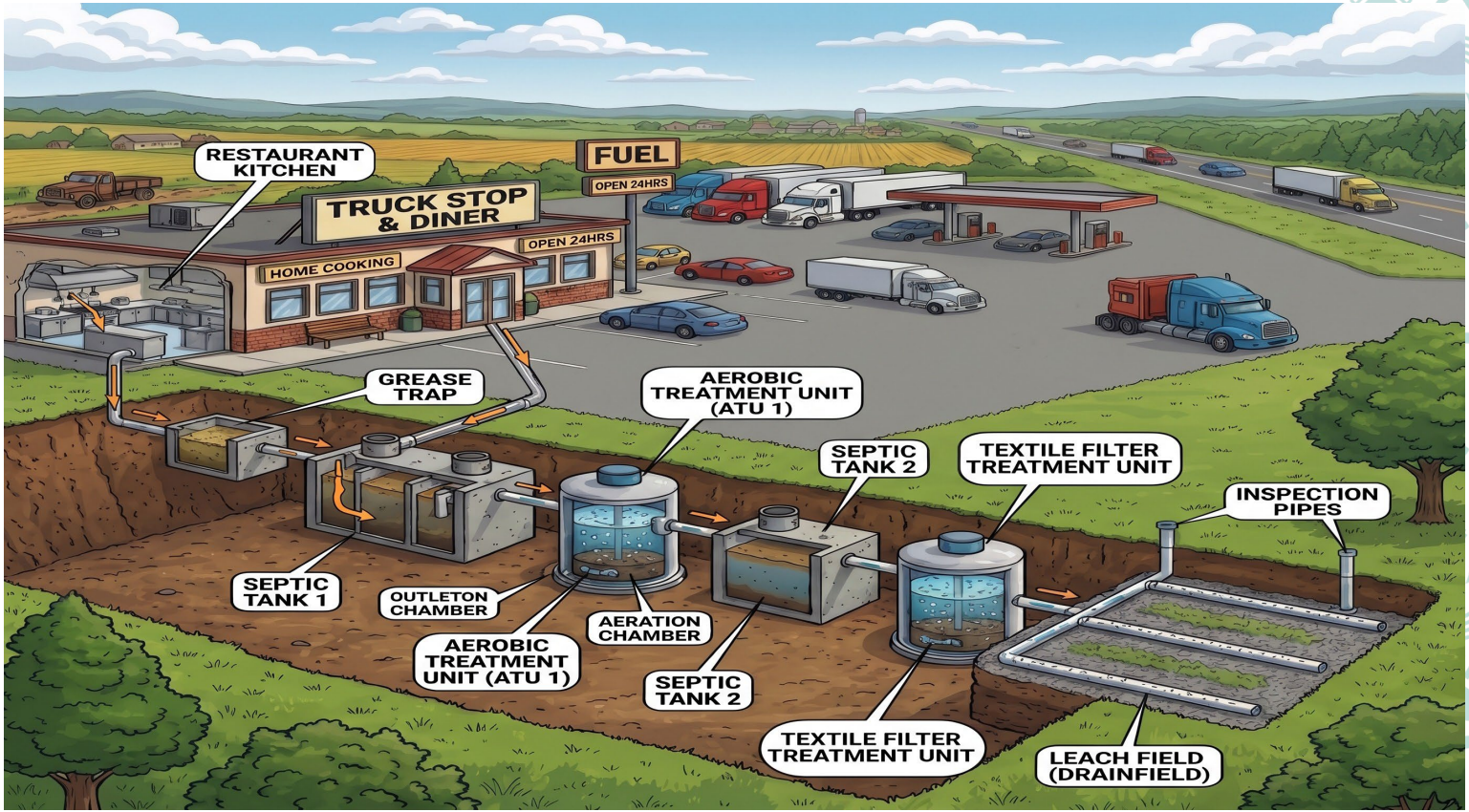
Secondary Treatment: Further purification of effluent using biological processes (e.g., aerobic bacteria) and filtration to remove contaminants.

Disposal Field: Treated effluent is distributed into the soil through perforated pipes, where natural processes further filter and purify the water.

Truck Stop with Pretreatment & Aerobic Treatment



Truck Stop with Pretreatment & Textile Filter Treatment



Design Summary

- Average Daily Wastewater Flow (ADWF) – 19,496 gallons per day (gpd)
- Peak Daily Wastewater Flow (PDWF) - 24,370 gpd
- Design Flow = PDWF = ADWF X 1.25 peaking factor.
  - Five-Day Biochemical Oxygen Demand (BOD5) – 876 milligrams per liter (mg/l) (178 pounds (#) @ 24,370 gpd)
  - Total Nitrogen (TN) – 74 mg/l (15# @ 24,370 gpd)
  - Soil – Loam; Moderate Structure
  - Soil Absorption Ratio (SAR) – 0.60 gpd/square foot (sf)
  - Soil Absorption Ratio adjusted (SARa) – 1.29 gpd/sf

Nitrogen Cycle Involving Humans

- Nitrogen is a component of protein
- As protein is degraded during digestion, nitrogen is released in the form of ammonia/ammonium
- The ammonia/ammonium (NH_3/NH_4^+) is then released from the body primarily as a component of urine.
- The process of ammonification then takes place outside of the human body in the treatment process to reduce any ammonia to ammonium.

Nitrogen Cycle Involving Humans

- Ammonification is carried out by a variety of **microorganisms** such as bacteria and fungi that occur in **aerobic** and **anaerobic** conditions. The process begins when these microorganisms break down organic nitrogen compounds such as proteins and urea. During degradation, the organically bound nitrogen is converted into **ammonia** or **ammonium** by enzymes, depending on the environmental conditions, especially **pH** and **temperature** .
- Ammonia (NH_3) and ammonium (NH_4^+) are in an **equilibrium** that is strongly dependent on the **pH value.**
- The combination of ammonia/ammonium can also be referred to as "free ammonia".

Biological Nitrification

- Ammonia/ammonium is then converted to nitrite and nitrate after ammonification occurs. To accomplish this conversion to nitrite and nitrate, the following needs to occur:
  - Nitrification
  - Adequate oxygen is supplied to support nitrification
- Nitrification is a two-step autotrophic process
  - Autotrophs are organisms that can produce their own food, using materials from inorganic sources.
  - The conversion from ammonium to nitrate takes place.

Biological Nitrification

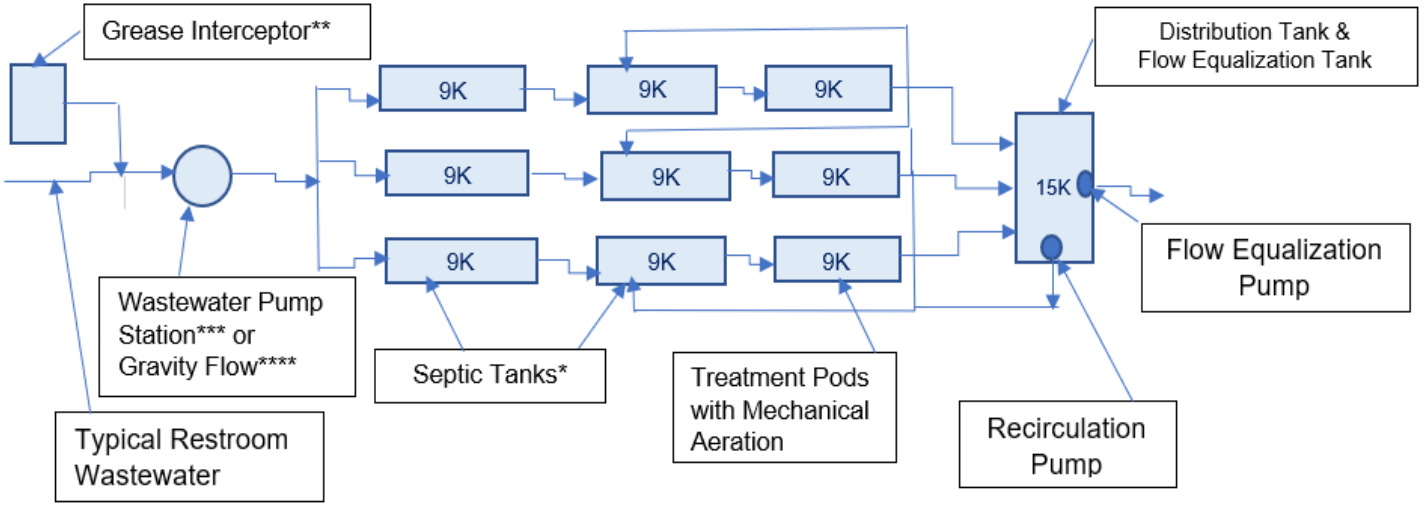
- Step 1: $NH_4^+ + 3/2O_2 + \text{Nitrosomonas} \rightarrow NO_2^{2-} + 2H^+ + H_2O$

- Step 2: $NO^{2-} + 1/2O_2 + \text{Nitrobacter} \rightarrow NO^{3-}$

Biological Denitrification

- NO_3^- can be reduced,
  - Under anoxic conditions, to N_2 gas through heterotrophic biological denitrification
  - You need two conditions for this to take place
    - Anoxic conditions
    - Heterotrophic bacteria
      - A heterotroph is an organism that cannot make its own food but gets its nutrition from other sources of organic carbon, such as plants or animals.
      - The heterotrophs get their oxygen from nitrate during dentification and produce N_2 gas as a result.

Design Summary – Preliminary Treatment Flow



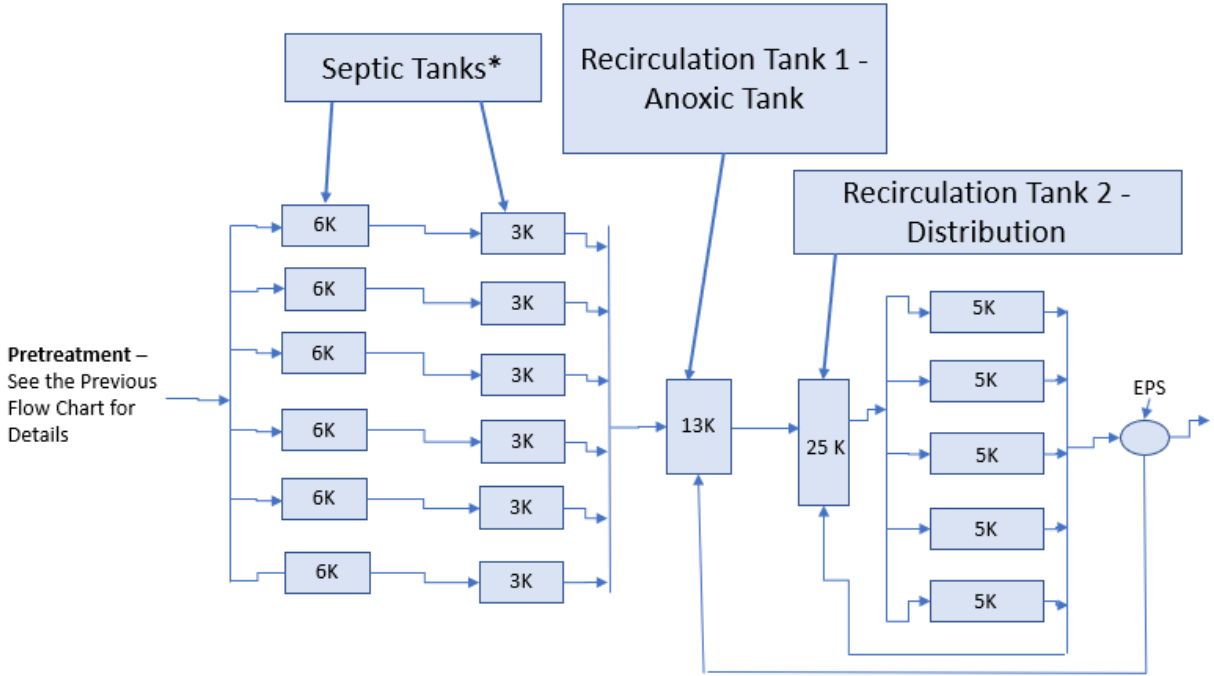
*Septic Tanks with a baffle and a septic tank filter. A water spigot located next to each septic tank is preferred to make it easier to periodically clean the septic tank filter.

**Grease Interceptor with a grease trap filter

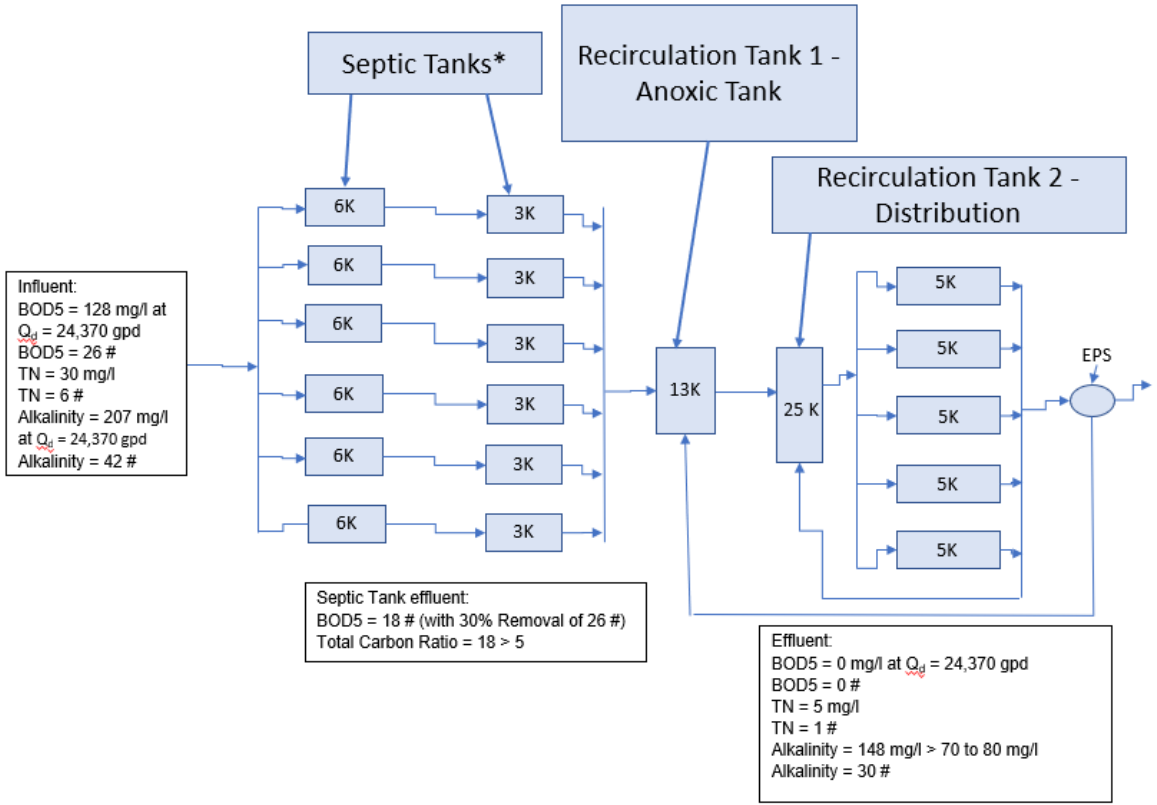
***If a Wastewater Pumping Station is used, a grinder pump should be avoided, if possible, to improve the treatment performance of the downstream septic tanks.

****For Gravity Flow to work, the downstream tanks will probably have to be buried deeper.

Design Summary – Final Treatment Flow Chart



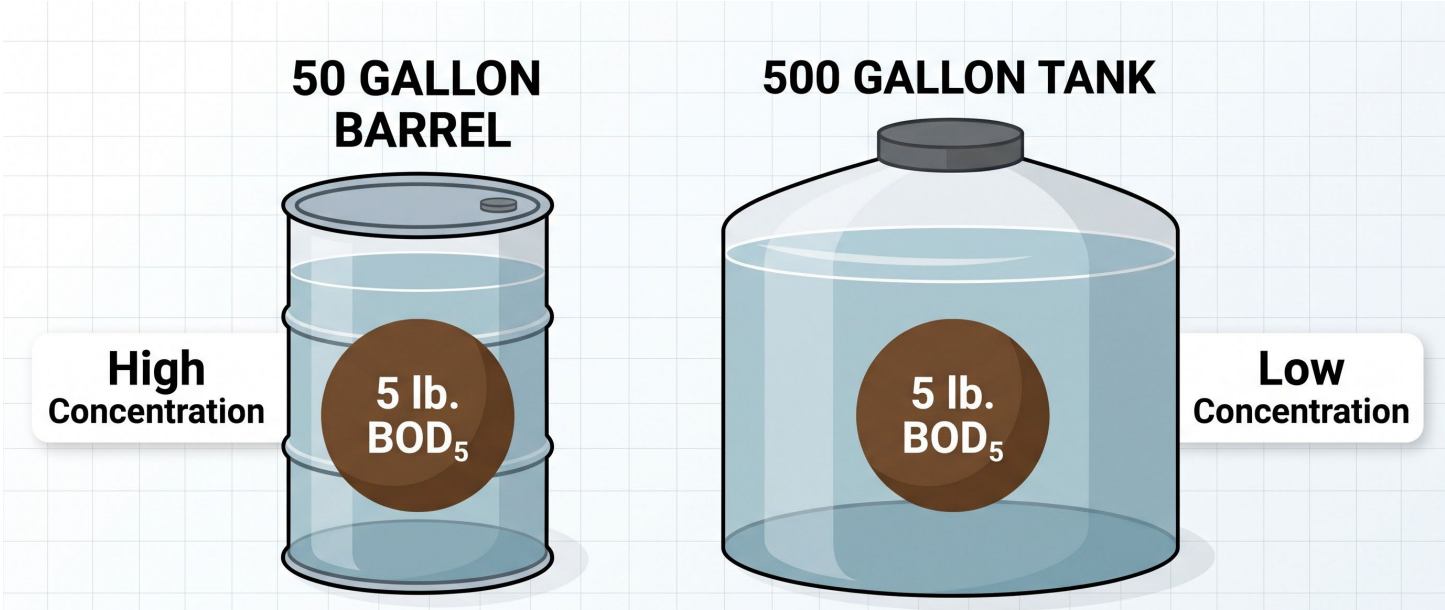
Treatment Flow Chart – Key Wastewater Values



Final Treatment Equipment Summary

- Primary & Secondary Treatment Equipment
  - Size of treatment modules – 5000 gpd
  - Size of Septic Tanks – 6,000 gal. (1 st tank in series) & 3,000 gal. (2 nd tank in series) (2.1 days of detention time as per the PPL Approval Certificate)
  - Recirculation Tank(s) (as per the PPL Approval Certificate) – 25,000 gallons
  - BOD_5 Removal – 41 # at 25,000 gpd
  - Total Nitrogen Removal – 5 # at 25,000 gpd

Final Treatment Calculations for BOD5



The same number of pounds of BOD_5 is found in both containers.

However, the concentration of the BOD_5 is greater in the 50 gallon barrel than in the 500 gallon tank.

Weight of BOD_5 (lbs.) = Concentration (weight/volume) **x Peak Design Flow** (volume/day) **x Conversion Factors**

Final Treatment Calculations for BOD5

- Primary & Secondary Treatment Process – Final Treated Effluent BOD_5
  - Final Treated Effluent BOD_5 (#) = [(Influent Wastewater BOD_5 from Pretreatment Equipment (mg/l) x Peak Design Flow (mgd) x 8.34] – [Final Treatment Facility BOD_5 removal in #]
  - Final Treated Effluent BOD_5 (#) = [128 mg/l x .02437 mgd x 8.34] – [41#]
  - Final Treated Effluent BOD_5 (#) = 26 #- 41 # = 0 #
  - Final Treated Effluent BOD_5 = 0 mg/l

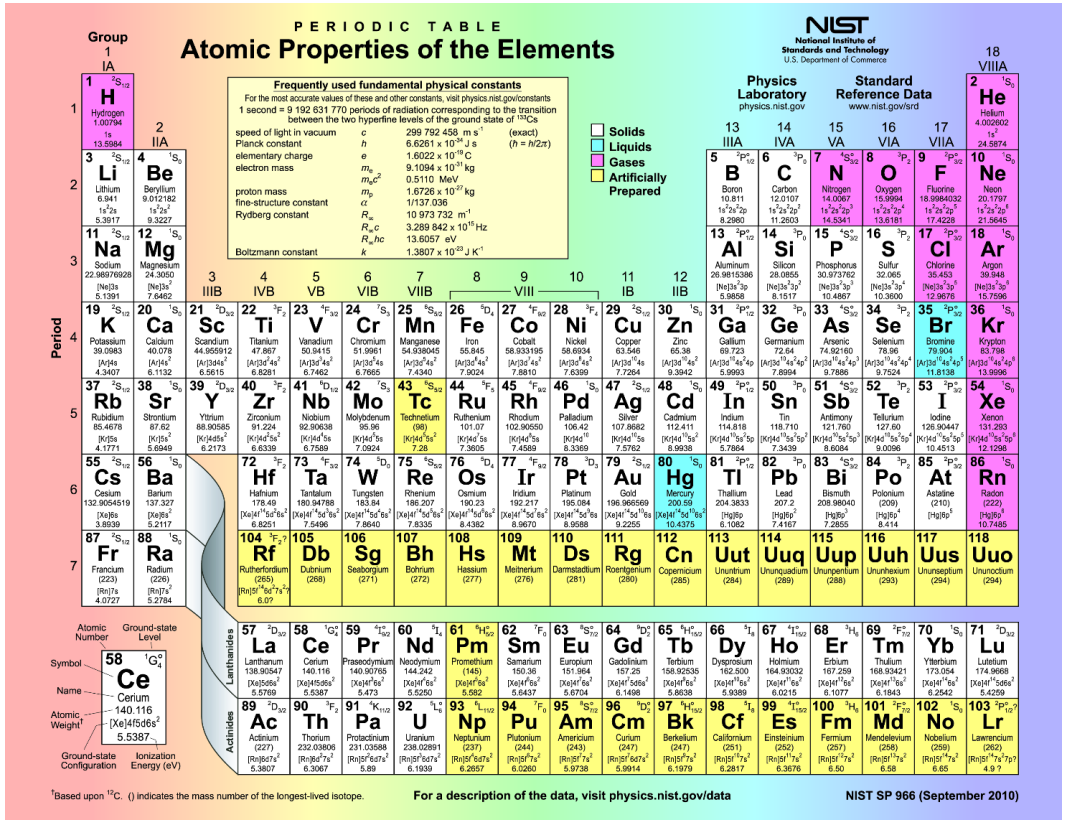
Final Treatment Calculations for Nitrogen 1

- Primary & Secondary Treatment Process – Final Treated Effluent Total Nitrogen (TN)
  - Final Treated Effluent TN (#) = [Influent Wastewater TN from Pretreatment (mg/l) x Peak Design Flow (mgd) x 8.34] – [Final Treatment Facility TN removal in #]

Final Treatment Calculations for Nitrogen 2

- Final Treated Effluent TN (#) = [30 mg/l mg/l x .02437 mgd x 8.34] – [5 #]
- Final Treated Effluent TN (#) = 6 # - 5 # = 1 #
- TNc = (TN # /Design Flow mgd) * 1/8.34
- Final Treated Effluent TN = 5 mg/l

Total Carbon Calculations



The Total Carbon Ratio Concept

1. The anaerobic bacteria in the septic tank need carbon for food. They already have their oxygen in the nitrate molecules. The metabolic process of consuming the carbon and oxygen will result in nitrogen being freed from the nitrate molecule and released to the atmosphere. De-nitrification will take place during this process.
2. In order to make sure that enough carbon is available for this process, the ratio of total carbon (TC) to total nitrogen (TN) is calculated. This ratio should as a minimum be 4 but can be higher. NSF uses a ratio of 5. A normal range is a ratio from 4 to 6. In the Truck Stop design, it is higher than this range which is okay.

Total Carbon Ratio Calculations

1. Total Carbon Ratio (TCR) = Total Carbon (#) / Total Nitrogen (#)
2. Pretreatment
    a. TCR = 125# / 6# = 20.8 > 5 OK
3. Treatment
    a. TCR = 18# /1# = 18 > 5 OK

Total Alkalinity Calculations



The Total Alkalinity Concept

1. During the nitrification process the alkalinity in the wastewater will act as a buffering solution to the pH being lowered from its ideal level of between 7.0 to 7.4 to some lower value. In summary, the alkalinity is consumed during this buffering process and if the alkalinity is not high enough at the beginning of the treatment process, additional alkalinity may need to be added.
2. Nitrification converts ammonia to nitrate.
3. Alkalinity is consumed at the rate of 7.14 # per # of ammonia. However, we need to remember that 3.57 # of alkalinity are restored during the denitrification process. So, there is a net loss of 3.57 # of alkalinity per # of ammonia converted to nitrate during the treatment process.

Total Alkalinity Calculations

4. Pretreatment
   a. Total Alkalinity Needed (TAN) (#) = (3.57 # of alkalinity needed per # of ammonia) x Ammonia (#)
   b. Ammonia (#) = 0.55 x Total Nitrogen (#)
   c. TAN = 3.57 # x (0.55 x 74 mg/l x 8.34 x .02487 MGD)
   d. TAN = 3.57 # x 8 # = 29 # < 71 #
   e. Total Alkalinity Available (TAA) (#) = 350 mg/l x 8.34 x .02437 = 71 #
5. Treatment
   a. Total Alkalinity Needed (TAN) (#) = (3.57 # of alkalinity needed per # of ammonia) x Ammonia (#)
   b. Ammonia (#) = 0.55 x Total Nitrogen (#)
   c. TAN = 3.57 # x (0.55 x 30 mg/l x 8.34 x .02487 MGD)
   d. TAN = 3.57 # x 3 # = 11 # < 42 #
   e. Total Alkalinity Available (TAA) (#) = 207 mg/l x 8.34 x .02437 = 42 #
   f. Total Alkalinity Remaining (TAR) = 153 mg/l (31 #) > 50 to 80 mg/l OK

Thank you. Questions?

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