RESEARCH SUMMARY
WASTEWATER SURGE VOLUME AND STORAGE REQUIREMENT DESIGN CONSIDERATIONS

Authors: A. R. Rubin, Ph.D., and William S. Janna, Ph.D.

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Adequate storage is needed to accommodate surge or peak flows and to buffer excessive liquid loadings into the soil system.

INTRODUCTION
Onsite wastewater treatment systems have been used extensively to provide safe and effective wastewater treatment in rural and suburban areas for over 100 years. The ability to design onsite or cluster soil-based wastewater systems has improved dramatically during this time. Nonetheless, several sizing, design, and management issues remain unresolved.

One of the issues mentioned frequently concerns requirements for providing storage in a system. In conventional septic tank/drainfield systems, this design issue is frequently resolved through a provision for wastewater storage in field lines or trenches.

The design, specification, operation, and maintenance of an onsite wastewater treatment and dispersal system require an accurate assessment of the quality and quantity of liquid to be treated in a specified soil receiving environment.

The U.S. Census Bureau estimates that the typical home houses 2.7 individuals. Most health department and water quality agencies assign two people per bedroom and 50 to 75 gallons per resident per day. The typical three-bedroom home is designed to accommodate a flow between 300 and 450 gallons per day (gpd). These flow rate figures fail to consider the patterns of flow generated in a day or the use patterns during periods of system stress. The U.S. EPA estimates that during various times, peak flow rates may approach 15 to 20 gallons per minute. Environmental health specialists claim/report that increased trench volume provides a higher level of security and safety in the operation of a subsurface wastewater treatment system. Onsite wastewater professionals require the following:
- safety factors in design;
- safety in product (i.e., that it will perform as designed),
- safety in opration (i.e., without undue involvement of the homeowner).

SURGE VOLUME CAPACITY
The estimated storage volume requirement is dependent on a balance of the inflow rate to the trench or daily loading rate, and on the wastewater dispersal rate or discharge rate from the trench to the soil.

The surge volume capacity requirement can be defined as the maximum discharge rate for any given day minus the average daily flow rate.

The soil system can be designed:
- to receive this liquid volume as generated, with a slight delay and attenuation as naturallly occurs, or
- the system can be designed to receive liquid in discrete doses through a specific protocol or rate.

These discharge scenarios lead to two general conditions in the soil:
- the first produces continuous ponding, and
- the second produces intermittent ponding through dosing and resting.

DESIGN BOUNDARY CONDITIONS
The influence of system design must be explored as an element of the volume/surge discusstion.

TABLE 1 -- Design Conditions		
Condition 1:	Continuous Ponding	infiltration equilibrium through ponded sidewall
Condition 2:	Continuous Ponding	surge capacity handled through effluent level rising and falling along the sidewall
Condition 3:	Dose/Rest Cycles:	infiltration equilibrium through umponded bottom and limited sidewall infiltration
Condition 4:	Dose/Rest Cycles:	equilibrium through bottom and sidewall with surge capacity accepted through extended dose cycle
Condition 5:	Dose/Rest Cycles:	equilibrium through bottom and side and surge capacity through extended sidewall infiltraiton

DEFINITIONS
Figure 1 is a sketch of a subsurface drainage system consisting of a trench that may contain a product that will disperse wastewater into the trench and ultimately into the surrounding soil.

With the trench as our control volume, we consider wastewater flow per day that is generated from the dwelling and that moves into the trench per day (*Qin*). The wastewater then leaves the trench, infiltrating the soil and moving under influence of the soil's matric potential (soil capillarity) and gravity (*Qout* also per day). When fluid moves into soil, the term *infiltration* is commonly used. Some researchers use *i*, which is an infiltration rate having the same dimensions/units as *Q*.

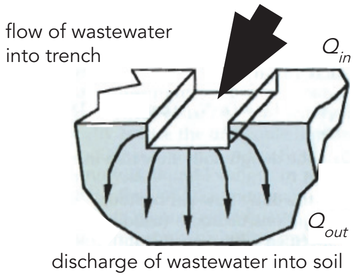

Figure 1 -- Schematic of Flows in a Subsurface Drainage System

The input flows to the soil include the equilibrium infiltration rate and the surge infiltration rate. We define an instantaneous infiltration rate i with dimensions of volume per unit time (e.g., per day). We define cumulative infiltration as the total infiltration, or volume, over a certain time interval, such as an hour. The instantaneous infiltration integrated over a time interval will yield cumulative infiltration:

$$I = \int_0^t i\, dt$$

where 0 to *t* is the time interval. It is desirable in a well-designed system that the output flows from the trench will not exceed input infiltration rate to the soil.

We can design a drainage system according to the sketch of **Figure 1**, but our interest is in the long-term performance. **Figure 2** contains profile views of two trenches -- one is new and the other is mature. A mature trench has settled fines as well as a biomat The lines labeled a through f in **Figure 2b** are the surfaces that the wastewater must pass through. The bottom surface, c-d, is one that may contain fines and the thickest biomat growth, which provides an additional resistance to the flow of wastewater from the trench into the soil. The surfaces labeled b-c and d-e may also have fines and biomat growth, but because these are along the lower sides of the trench, these surfaces may have a resistance to flow that is lower than that along the bottom. The surfaces labeled a-b and e-f represent the upper sides of the trench, and they too may have a lower resistance to flow compared to the other surfaces. The presence of these two things -- fines and biomat -- affect the flow rate of effluent through the sides and bottom of the mature trench.

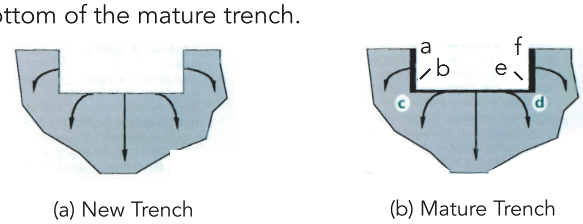

Figure 2 -- Sketch of a New Trench and a Trench That Has Fines/Biomat Formation

With regard to the sketches and associated description for **Figure 2**, we define various flows associated with the system as follows:

Q_d = design daily flow rate, the volume of liquid per unit time (i.e., per day) generated from a treatment unit to soil when low-volume fixtures are discharging from facility.

Q_s = surge flow rate, the discharge per unit time (i.e., per day) of high-volume flow rate fixtures, excessive use, unusual flow patterns, and other use factors that influence the surge or peak flow into the soil system.

i_d = equilibrium infiltration, the flow rate the soil can attenuate, with dimension of volume per unit time.

I = cumulative infiltration, with dimensions of volume of fluid (e.g., gallons).

i_s = surge infiltration, the infiltration rate the soil must attenuate to accommodate both the equilibrium and surge requirements, with dimensions of volume per unit time.

N = Number of bedrooms.

Sizing Procedure: Summary

1 Calculate the design daily flow rate $Q_{in} = Q_b * N$.

2 Apply safety factor (unless a safety factor is implicitly included in Q_a to determine the modified design daily flow rate into the trench Q_d.

3 Determine outflow; i.e., wastewater to be infiltrated by the soil.

4 Solve for the soil interface area $A_d = Q_{out}/H_e$, where *H* is the hydraulic loading rate for the soil.

5 Express soil surface area in terms of the trench length *L*.

6 Solve for trench length. This result is for a new trench.

7 For a mature trench, divide the cross-sectional area into two regions; one is for an area that has a fines/biomat layer and the other is for a soil surface.

8 Determine surge volume flow.

9 Express the total flow rate as the sum of the flow that pass through the fines/biomat surface and the flow that passes through the soil surface.

10 Express the area for both of these regions in terms of trench length.

11 Solve for the trench length required. This result is for a mature trench.

12 If necessary repeat calculations to include precipitation and/or evaporation using:

13 $Q_{out} = Q_{in} + Q_{precip} - Q_{evap}$

This calculation procedure should provide a useable estimate of the volume and length required of a trench that will satisfy surge volume capacity sizing for a given application.