County Quality Assurance Case Studies
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Monitoring of Liquid Levels in Selected Dispersal System Trenches and Adjacent Soil over Time

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Options for dispersal of liquid in soils vary dramatically. Trench characteristics have been identified as one of several factors in the performance of land based wastewater systems. Previous work (Converse, Keys, Tyler, 1998; Loudon, 1994) suggests that the trench options typically accumulate liquid gradually until liquid ponding begins and that further migration of liquid from the trench into the adjacent soil occurs through the trench bottom and the trench sidewall – particularly that at the uppermost fringe of the wetted volume. This assessment of performance of various trench configurations was accomplished at a single site in North Carolina. The site where the testing occurred was a construction office employing 8 persons.

Both liquid levels in a variety of approved trench designs and the soil moisture levels in natural soil material adjacent to test trenches were measured; liquid levels with Stevens Level Recorders and moisture levels with Irrometer Moisture Blocks. The system utilized a pressure manifold to distribute septic tank effluent to a series of trenches. Each trench received the same volume of liquid at each dosing event. Dosing events were demand based as determined by a simple float switch in the pump tank.

Design – 200 GPD
Soil: Wagram, deep sand, measured permeability of 2.2 to 2.4 inches per hour. NRCS reports 2 inch per hour in subsoil at depth of 24 to 30 inches. These are the depths where systems placed.
Design load: 0.5 gal/ft sq/day
Area: 200/0.5 = 400 ft sq
Pressure manifold utilized to lift liquid from facility to treatment site. System consists of 1200 gal septic tank and 1200 gallon pump tank.
Configuration; 6 trench configurations and 2 experimental systems developed by Crumpler Plastic Pipe.

Trench configurations or characteristics are:

1. Control: 30 in x 30 in x 20 ft gravel trench designed for 25 gpd or 50 square feet (20 feet of 2.5 ft trench)
2. Chamber developed to allow the 25% reduced length permitted in NC laws and rules (15 feet)
3. EPS (1003H) (15 feet)
4. EPS (1003 T) (25 feet)
5. 10 in fiber wrap pipe (25 feet)
6. 12 inch EPS (1201) (25 feet)

7. Two experimental dispersal technologies

A 1200 gallon septic tank with a Zabel 1800 Screen provided primary treatment. Flow was directed from the septic tank to a 1200 gallon pump tank and from there through a 0.4 HP Little Giant Effluent Pump to the treatment site. Wastewater was pumped twice a day to a pressure manifold and from the pressure manifold, liquid was directed simultaneously to each of the test trenches.

Liquid was dispersed along a gravity gradient from the manifold to the trenches. A pump was required because the treatment site was up-gradient of the office. The trenches were established with liquid level monitoring ports extending from the trench bottom to the soil surface. The monitoring ports were covered when not in use. Liquid levels were monitored monthly to determine the level of ponding in each of the trenches with time. The study was conducted for three (3) years. Liquid levels are thought to represent an indicator of the acceptance of liquid into the soil through the initial trench/soil interface or barrier. The liquid level monitoring port was located approximately at a point representing 60% of trench length. In a 20 foot trench, the port was at 12 feet from the inlet. In a 15 foot trench, the port was at 10 feet from the inlet. In a 25 foot trench, the port was at 15 feet from the inlet. Liquid levels were monitored monthly (generally the first Sunday in each month) for 4 hours or until the liquid level returned to the equilibrium level measured initially following a forced dispersal event. This sampling regimen limits the reliability of the data since system use was generally limited over weekends and the liquid discharged on Friday had some time for assimilation between the Friday dosing and the Sunday dosing (There was a small apartment located over the office and there was intermittent occupancy during the study).

Results:

Liquid levels: All trenches received nearly the same volume of liquid. No meters were utilized on each of the lines, but the manifold was developed to supply near identical volumes to each of the trenches with each dose. Each of the trenches was developed utilizing design criteria established in NC Laws and Rules.

Liquid levels in the gravel trench achieved an apparent equilibrium at approximately 9 months from beginning the project. The chamber and the horizontal EPS achieved an apparent equilibrium at approximately 15 to 18 months and the remaining trenches at approximately 18 to 20 months. This equilibrium was defined as the beginning of observed ponding between dosing events.

Moisture levels: The distribution of moisture appeared consistent around the various open top systems examined and appeared slightly more semi-radial in the closed top system. Zones of saturation are present at the base of all systems monitored and soil moisture levels decrease dramatically with increasing distance from the various dispersal systems examined.

Moisture levels were measured using an Irrometer water Mark Indicator. These devices provide a reading of resistance levels in soil materials and the resistance can be converted to soil moisture levels. A low reading (0 to 10) on an Irrometer Watermark Indicator indicates a saturated or very wet soil. Levels of 20 to 50 indicate a friable soil, and levels over 50 indicate very dry soil conditions and these are considered a danger to plants. These devices were developed to support agriculture. The watermark indicator is a simple, reliable indicator of moisture level. It does not provide an exact value for soil moisture.

Discussion:

Liquid levels: These relationships are presented graphically in the figures attached. The monitoring demonstrates the importance of the uppermost level of the liquid fringe in the long term acceptance of liquid into soil systems. This zone is exposed to ponding and aeration and the 0.25 to 1.0 or more inch fringe developed (see chart) facilitates the acceptance of liquid dosed into the soil absorption trench. Systems were dosed 2 times per day. Each dose designed to deliver 12.5 gallons to each of the trenches. The area through which this liquid moved can be calculated based on system geometry and the height of the fringe. Rough calculations for each of the trench configurations are presented below with length and end dimension, width and fringe available.

1. 25 foot(L) with 12 inch trench (W) and 1 inch fringe: ((25ft x 2)+2) x 0.08 ft = 4.33 sq ft
2. 20 foot (L) with 24 inch trench and 0.5 inch fringe: ((20ft x 2)+4) x 0.04 ft = 1.76 sq ft
3. 15 foot trench with 36 inch trench and 0.4 inch fringe: ((15ft x 2)+6) x 0.03ft = 1.1 sq ft

The 12.5 gallons must move through the fringe area and the trench bottom. The capacity of these sandy soils to transmit liquid is high. The soil survey of Sampson County indicated values of between 0.6 and 2 inches per hour and measured permeability at the bottom of the trenches ranged from 2.2 to slightly over 2.4 inches per hour. The capacity of these sandy soils to transmit liquid is estimated as much as several feet per day and the potential to move 12.5 gallons through a 1 square foot area in 12 hours is not unrealistic.

12.5 gallons of water represents 12.5 gallons/7.48 gallons per cubic foot = approximately 1.5 cubic feet of water. The 1.5 cubic feet through a 1 square foot window in 12 hours requires the soil transmit 3 feet of water per day. The potential to move liquid increases as the square footage of fringe area increases. Consequently, the potential to move liquid through the larger area associated with the longer trenches is not unrealistic.

Moisture levels: In addition to the liquid level monitoring, a series of moisture sensors (Irrometer watermark indicators) were placed at specified locations adjacent to each of the trenches to monitor moisture levels in the soil. Moisture levels are thought to represent a model for movement of liquid into and through the soil. Moisture follows gradients from low tension to higher tension and the indicators selected reportedly measure moisture tension. These devices proved to be difficult to utilize because of inadequate contact between soil and device. Recent modifications to the indicators reported by Irrometer should allow improved capability to monitor moisture tension. Moisture monitoring data was sporadic because of poor contact with the dry soil located in sandy topsoil above and between trenches, but is reported in this presentation nonetheless.

The Irrometer moisture measuring devices provide a unitless indication of moisture level. A level of 100 indicates a very dry soil while a unit of 1 indicates a very wet, saturated soil. Moisture levels ranged typically between 1 and 4 immediately adjacent to the dispersal trench and fell radially the open top systems and semi-radially with the closed top system. As distance from the trench/soil interface increased moisture levels fell consistently. This indicates that the increasingly large volume of soil containing increasingly large void volumes is available into which liquid migrates according to moisture gradients from wet to dry.

The limited data from this demonstration suggests that moisture levels fell as distance radiated away from the trenches except in the closed, impermeable top systems (chambers). However, these data are too limited to provide any definitive statement of radial flow and no statement is offered.

Facilities are designed routinely with a reduction in the area required for assimilation of a specified design flow. The use of a slight reduction in “footprint” did not adversely impact the performance of the systems developed in Sampson County. The flows are small. Extrapolation of the reduction from a single lot treating between 200 GPD and 500 or 600 GPD to a site receiving thousands of gallons per day can not be established. Criteria for larger flows must be established on a site by site basis.

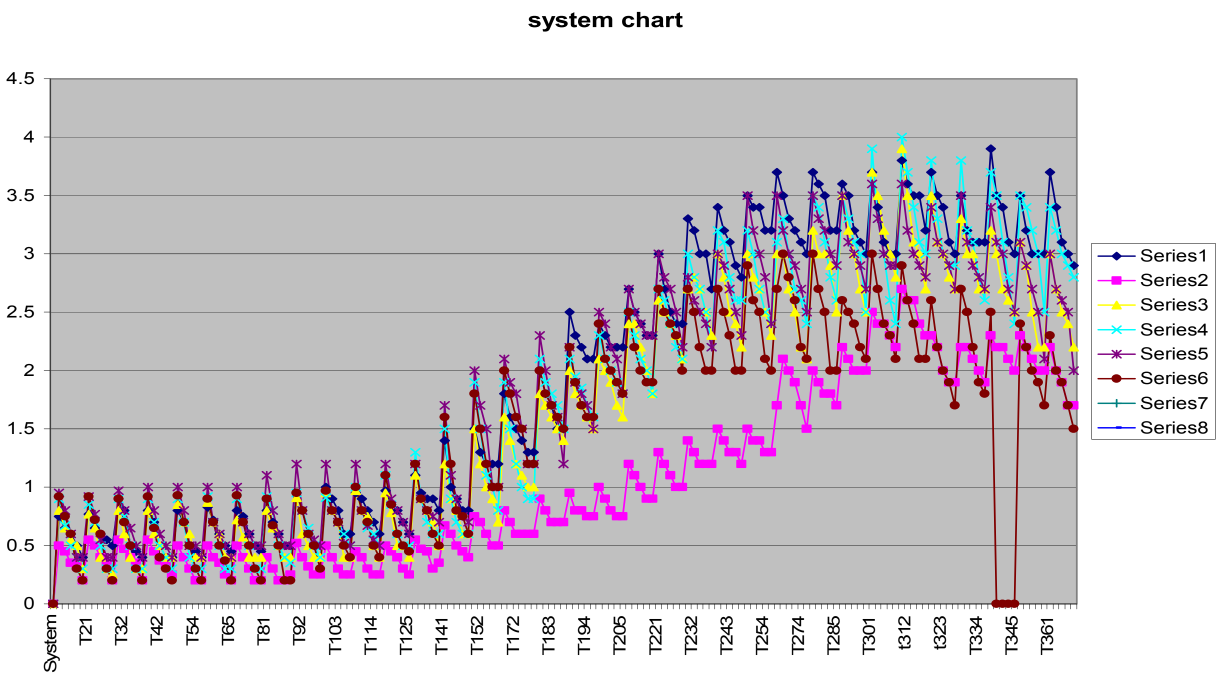
The data collected from this single demonstration can not be extrapolated to justify any greater reductions in area associated with soil systems. Data collected in this demonstration represent no attempt at replication. The wastewater flow from the facility limited the potential for replication on this site. Since the site was developed, several additional sites have been identified and the study will be replicated.

Of the data collected, the liquid level in the trench appears most indicative of potential system performance. The moisture levels in soil fall with near uniformity with distance from a dosed trench system. This confirms a major tenet of soil physics, that moisture levels migrate from wet to dry.

Conclusions:

Liquid levels in soil absorption systems accumulate through time. The goal of our wastewater management efforts should be one of developing sustainable solutions to wastewater management. Dosing and resting does appear to limit ponding in trench systems and to facilitate long term successful system performance.

No attempt to measure treatment levels was undertaken in this demonstration. The soil system is assumed to provide reliable treatment provided systems are designed appropriately. There was no evidence of trench volume increasing to a maximum level potentially stored in any of the trenches. Storage was not an issue in this study since the goal was to facilitate discharge from the trench system into the adjoining soil. There was no evidence of plumbing that failed to discharge from the facility served. Each of the systems examined performed satisfactorily through the duration of this demonstration.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System
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T54
T65
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