FIELD WASTEWATER MANAGEMENT IN DESERT ENVIRONMENTS

TECHNICAL INFORMATION PAPER #32-001-0904

PURPOSE

The purpose of this technical information paper (TIP) is to provide guidance regarding human waste and wastewater management to unit field sanitation personnel and preventive medicine detachments. This TIP specifically identifies wastewater management techniques and disposal devices for use in desert environments. Existing Army field sanitation manuals do not specifically address desert environments. This TIP identifies available technical guidance documents, extracts from lessons learned, and focuses on issues that may arise in the desert.

BACKGROUND

Preventive medicine surveillance and field sanitation protect combat effectiveness of friendly forces and the ability of a military unit to execute its mission successfully. "The [Department of the Army] objective is to dispose of Army waterborne wastes in a manner that protects water resources from contamination and preserves the public health." (AR 40-5). To accomplish this goal, Soldiers must be isolated from contact with human waste, especially from contaminated food and water. Vectors also must be denied access to human waste and to standing water that would allow them to feed and breed.

Despite dry conditions, wastewater disposal is an issue in the desert. Unit field sanitation teams and preventive medicine units deployed to desert environments face unique conditions and challenges related to field waste disposal. These include: extreme temperatures, particularly heat; winds; dust; desert soils and terrain; lower than expected evapo-transpiration rates at some locations; desert insects/vectors; water availability; and limited infrastructure and support services.

This TIP summarizes field waste treatment, disposal, and sanitation practices experienced in desert environments and arid areas to include past contingency operations in Iraq, Qatar, Afghanistan, Pakistan, Uzbekistan, Kyrgyzstan, Kosovo, Somalia, and Kuwait; and training activities at White Sands Missile Range, New Mexico/Fort Bliss, Texas. This document also tries to incorporate some lessons learned (unclassified) from past practices.

Use this document in conjunction with Army field manuals FM 21-10 Field Hygiene and Sanitation , FM 4-25.12 Unit Field Sanitation Team, FM 3-34.471 Plumbing, Pipe Fitting, and Sewage, and Contingency and Long Term Base Camp Facilities and Standards ("The Sand Book") as well as other technical guidance referenced here to facilitate field wastewater management in desert environments.

CURRENT GUIDANCE ON FIELD WASTEWATER MANAGEMENT IN THE DESERT (see Appendix A)

FM 90-3 / FMFM 7-27, Desert Operations makes the following brief points regarding field latrines and wastewater management:

- Trench-type latrines should be used where the desert soil is suitable, but they must be dug deeply, as shallow latrines become exposed in areas of shifting sand.
- In a sandy dune desert, digging and keeping a trench open is difficult or impossible.
- In deserts near the ocean, the ground may be marshy and the air humid which hinders evaporation.

FIELD WASTEWATER TECHNIQUES SUITABLE FOR DESERT ENVIRONMENTS

Standard Practice

The policies and standard practices delineated in FM 21-10, FM 4-25.12, and especially FM 3-34.471, can be adapted to desert environments by applying the desert-specific limitations and considerations contained herein. FM 21-10 and FM 4-25.12 are the primary preventive medicine field manuals for improvised wastewater disposal devices. FM 3-34.471 contains specific guidance for designing both improvised and more advanced wastewater disposal devices listed in this TIP. It also describes the percolation test and its use in calculating the size of various improvised field devices as well as several longer-term options. The wastewater disposal devices and time lines set forth in the development matrix in Contingency and Long Term Base Camp Facilities Standards, Annex 3 are intended for base camp operations in the desert. The table below summarizes the standard practice for contingency base camp development. For long-term base camp development, the standard practice is an improvement over the 24-month contingency base camp. See Contingency and Long Term Base Camp Facilities Standards for more details.

Contingency Base Camp Development as Prescribed in Contingency and Long Term Base Camp Facilities Standards, ("The Sand Book")			
Type of Facility	Duration of Encampment		
	< 3 Months	< 6 Months	< 24 Months
Latrine	Burnout	Chemical	AB Units (Ablution) / SEAhut
Shower	Shower Unit Tent	Shower Unit Tent	AB Units (Ablution) / SEAhut
Sewage Disposal	Leach Field / Lagoon	Leach Field / Lagoon	Lagoon/ Sewage Treatment Plant

Hindrances to Percolation and Evaporation by Soil and Climate

In most areas, water either percolates into sand or marl or evaporates sufficiently. However, on several occasions the Army has experienced conditions where water did not percolate well or evaporation was hindered.

Percolation

Desert soils are clayey rather than sandy in parts of Iraq, Saudi Arabia, and Somalia. When wet, the fine dust expands and becomes impermeable which prevents gray water (water from showers and laundry) in lagoons as well as urine and shower water in seepage pits from percolating into the sand.

Caliche, also called calcrete, prevents water from percolating from lagoons that have been constructed over this impermeable hardpan at White Sands Missile Range, New Mexico / Fort Bliss, Texas. A mixture of gray water and black water (from the latrines) does not penetrate this calcium carbonate ($CaCO_3$)-rich, crusty, concrete-like layer. Caliche is widely dispersed in desert soils and, therefore, would be expected to be present in other deserts of the world. The caliche can be more than 1 meter thick and be nearly impenetrable.*

Percolation tests are used by preventive medicine units during the operations' coordinating and planning phase to determine the proper wastewater devices to be built by the local engineer unit. Ground that is too clayey or includes caliche will preclude particular wastewater devices (see Appendix B for percolation tests).

Evaporation

Humid conditions coupled with cloudy weather hinders the evaporation of water from gray water lagoons or evaporation beds on the Qatar Peninsula. However, when the weather turns sunny, evaporation is sufficient.

Wastewater Disposal Devices

This section describes various wastewater disposal devices, their technical suitability for desert use, and any caveats pertaining to the desert.

* Caliche is formed when rainwater or ground water with high amounts of dissolved materials, particularly calcium carbonate, percolates through the sand. When the water evaporates, the dissolved materials are left behind in the pores between the grains of sand or coarse pebbles to form a solid, carbonate cement that binds with the sand grains. It forms in stratigraphic accretions where the tops are typically less than ½ to 1 meter below the soil surface in the nearby Sonoran Desert, though outcroppings can be found at the surface.

DEVICE: Straddle Trench Latrines (Slit Trenches)
(FM 4-25.12, FM 21-10, FM 8-250, and FM 3-34.471)

DEVICE DESCRIPTION:

- Uncovered trenches without a seat above.
- Boards may be placed on the ground along both sides of trench to provide better footing and prevent crumbling / cave-in of sides.
- Two trenches. Each trench is 1 foot wide x 2.5 feet deep x 4 feet long and can accommodate 2 soldiers at one time.)
- Excreta must be covered with soil after each use since the trenches are open to filth flies, thereby reducing the serviceable volume.
- Design capacity – 2 trenches (capacity for 4) per 100 male soldiers, 3 trenches (capacity for 6) per 100 female soldiers.
- An interim measure, only expected to last 1 to 3 days while final facilities are being constructed or installed.

PROS	CONS
• Can be dug quickly	• Don't last long (1 to 3 days) • Trenches open to filth flies – must cover excreta after each use. • Covering excreta partially fills trench. • Difficult to use – no seats or support. • Sides may collapse in some sandy desert soils.

TECHNICAL SUITABILITY FOR DESERT USE: Good.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Side wall strength may be insufficient in some sandy desert soils.

DEVICE: Soakage Pits and Trenches
(FM 4-25.12, FM 21-10, FM 8-250, and FM 3-34.471)

DEVICE DESCRIPTION:

- Designed for liquids only.
- Pit 4 feet x 4 feet x 4 feet filled with gravel; rubble; or shredded metal, e.g., aluminum cans.
- Constructed as dedicated, stand-alone urine soakage pits with urine tubes or pipes.
- Should be constructed in conjunction with standard in-ground latrines, chemical toilets or burn-out latrines for solid human waste.
- Soakage pits or trenches for shower and kitchen are built separately from urine soakage pits. Four trenches radiating from a central 1 foot deep pit are 6-feet long, 2 feet wide and increase in depth from 1 to 1½ feet. Kitchen soakage pits or trenches also need grease traps to prevent percolation from being blocked.
- No estimate of length of service for soakage pits and trenches is made in any field manuals, except the instruction to build a new one when the existing one stops working (standing water is observed).

PROS	CONS
• Reduces traffic in latrines intended for solid human waste. • Reduces liquid in burn-out latrines, which reduces the amount of fuel required for burning out semi-solids. • Can last indefinitely if soil is permeable.	• Must compete for gravel that can be in high demand for other uses. • Rubble or gravel may not be plentiful at the beginning of deployment when needed to build soakage pit. • May need to build new one on short notice, especially if soil is not permeable.

TECHNICAL SUITABILITY FOR DESERT USE: Good.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Clayey soils may expand, become impermeable, and prevent sufficient percolation. Impermeable caliche may prevent sufficient percolation.

DEVICE: Evaporation Beds
(FM 4-25.12, FM 21-10, and FM 3-34.471)

DEVICE DESCRIPTION:

- Intended for kitchen, wash, and bath wastewater.
- Each bed is 8 feet x 10 feet x 6 inches with rows or in 3 tiers where one pond flows into the next if space is limited.
- 3 square feet / person / day for kitchen waste plus 2 square feet / person / day for wash and bath waste.
- Beds are flooded to an average depth of 3 inches on successive days. Beds are rotated and water must evaporate and percolate within 4 days. Underlying soil is spaded and bed is reused.

PROS	CONS
• Simple to build.	• Labor intensive. • Time consuming to maintain. • Small capacity. • Space consuming.

TECHNICAL SUITABILITY FOR DESERT USE: Good. Suitable for company-sized or smaller elements.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Clayey soils may expand, become impermeable, and prevent sufficient percolation. Impermeable caliche may prevent sufficient percolation.

DEVICE: Pail Latrines
(FM 4-25.12, FM 21-10, FM 8-250, and FM 3-34.471)

DEVICE DESCRIPTION:

- Buckets are placed under box latrine seats.
- Double trash bags or similar liner is recommended for ease of disposal and cleaning.
- 4 seats with pails (e.g., 5-gallon).

PROS	CONS
• Can be constructed quickly. • Can last indefinitely. • Can be constructed in areas where conditions prevent digging (e.g., populated areas, rocky plateau desert). • Can be constructed in areas where trenches cave in (e.g., sandy dune desert). • Can be constructed in areas with high water table (e.g., desert marsh such as those near Basra, Iraq).	• Labor intensive. Pails must be emptied and cleaned daily. • Must find proper disposal area immediately.

TECHNICAL SUITABILITY FOR DESERT USE: Good.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: None.

DEVICE: Deep-Pit Latrines (Box Latrines) (FM 4-25.12, FM 21-10, FM 8-250, and FM 3-34.471)	
DEVICE DESCRIPTION: • A 6-foot (general maximum, per guidance above) deep trench with a 2-seat or 4-seat box on top. • The edges around the box and hole are sealed with soil, and seat lids seal when closed to keep filth flies out.	
PROS	CONS
• The standard configurations would be expected to last roughly 33 to 35 days.	• Deserts too rocky or too sandy may preclude its use. • Desert soil must be soft enough to dig and firm enough to hold the walls and edges without caving in.
TECHNICAL SUITABILITY FOR DESERT USE: Good	
DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Side wall strength may be insufficient in some sandy desert soils. In other locations, clayey soils thwarted percolation but were strong enough to support trenches that were deeper than the usual 6 foot maximum. These 20- to 25-foot deep trenches were dug with engineer support. Pit life can be extended by burning the contents of the deep-pit latrine weekly.	

DEVICE: Bored-hole Latrine (FM 4-25.12, FM 8-250, and FM 3-34.471)	
DEVICE DESCRIPTION: • Made by boring a cylindrical hole 6 to 20 feet in the ground. • Half a drum (e.g., 55-gallon) with a hole cut in it and a seat on top of the half-drum is placed over the hole.	
PROS	CONS
• Can be constructed quickly with drill rig and cutting torch. • The standard configuration would be expected to last roughly 16 to 63 days.	• Deserts that are too rocky or too sandy may preclude its use. • Desert soil must be soft enough to bore and firm enough to hold the walls and edges without caving in. • Bored-hole latrines may need side wall support, (e.g., from cylindrical drums) in sandy desert soils, or must be more shallow. • Requires engineering support to bore hole and maintenance support to cut drum.
TECHNICAL SUITABILITY FOR DESERT USE: Ranges from very good to poor, depending upon side wall strength and cave in.	
DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Side wall strength may be insufficient in some sandy desert soils.	

DEVICE: Mound Latrine (FM 4-25.12, FM 8-250, and FM 3-34.471)	
DEVICE DESCRIPTION: • A mound above grade with a trench in it and a 4-seat box over the pit. • Either a mound is constructed and a trench is dug in the mound, or soil is piled up in stages around supporting walls that will become the trench. • Trench must be located 1 foot above ground water or rock. • Depth of trench is variable.	
PROS	CONS
• Mound latrines may be suitable in rocky desert soil or mountainous deserts where the ground is too rocky to dig. • The standard configuration of a 4-seat mound latrine with a 6-foot deep pit would be expected to last roughly 35 days.	• Requires engineering support to construct mound and trench. • Liquid wastes may escape through the side of the mound if the soil is too permeable.
TECHNICAL SUITABILITY FOR DESERT USE: Very Good in absorbing soils. Poor where liquid waste could break through the mound.	
DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: Leakage from side of mound is possible with sandy desert soils.	

DEVICE: Burn-out Latrines (FM 4-25.12, FM 21-10, FM 8-250, and FM 3-34.471)	
DEVICE DESCRIPTION: • 55-gallon metal drum is cut in half and placed under a seat. Handles are welded onto the drum. • Plywood shelter to support toilet seat and provide privacy.	
PROS	CONS
• Can be constructed quickly with right equipment. • Can last indefinitely, requiring only the remaining ash to be buried.	• Host nation and Final Governing Standards regarding open burning or air emissions may prohibit. PM personnel must check. • Requires engineering support to cut drums and weld handles. • Labor and fuel intensive. • Smoke announces presence and is not beneficial to soldiers' health.
TECHNICAL SUITABILITY FOR DESERT USE: Very Good.	
DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: None.	

DEVICE: Chemical toilets (and other portable toilets or self-contained vault toilets) (FM 4-25.12, FM 21-10, and FM 3-34.471)

DEVICE DESCRIPTION:

- Self-contained, portable or nonportable outbuildings with holding tank under seat.
- Primary or preferred field device (FM 4-25.12, and FM 21-10, Task 9, Step 1). The required human waste disposal device for use during field exercises or missions (FM 21-10, Task 9, Note).
- May contain chemical additives (not recommended) that aid in the decomposition of the waste and odor control.
- "The number of [chemical toilets] required is established by the surgeon or other medical authority in the AO [Area of Operations]" (FM 4-25.12 section 2-23.b(1)). The surgeon or other medical authority can adjust the number of chemical toilets that are required from the standard one commode or urinal per 25 male Soldiers and one commode per 17 female Soldiers, depending upon the demand and frequency of emptying.

PROS	CONS
• Have been used successfully when serviced adequately and wastes disposed of properly. • Can be adapted for use as burn-out latrines if wastewater treatment facility or waste disposal support (e.g., sewage vacuum trucks) are unavailable.	• Must be pumped out at least weekly to break the filth fly reproductive cycle, or as frequently as daily depending upon usage. • PM inspection may be required to ensure that all solids are suctioned out, especially when the vacuum on pump truck is weak. • Pumped out material must be disposed of properly. • A proper waste disposal area must be prepared within 1 week. • Length of use is limited by the disposal area.

TECHNICAL SUITABILITY FOR DESERT USE: Very Good.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: None.

DEVICE: Force Provider containerized latrines.
(FM 42-424)

DEVICE DESCRIPTION:

- Containerized or palletized latrines that are part of the larger system, Force Provider. Similar to US Air Force Harvest Eagle and Harvest Falcon.
- Wastewater from latrines (black water) is collected in 380-gal holding tanks beneath the latrines.
- Latrines must be pumped out periodically with a sewage vacuum truck.
- Wastewater from showers and laundry (gray water) is collected through plumbing into large (10,000 gal) holding tanks or balloons.
- Gray water must be pumped out periodically also.

PROS	CONS
• Can be connected to plumbing lines for wastewater disposal thus eliminating the need for the sewage vacuum truck.	• PM inspection may be required to ensure that all solids are suctioned out, especially when vacuum on pump truck is weak. • A proper waste disposal area must be prepared within 1 week for pumped out material. • Length of use is limited by the disposal area.

TECHNICAL SUITABILITY FOR DESERT USE: Very Good.

DESERT-SPECIFIC LIMITATIONS / CONSIDERATIONS: None.

DEVICE: Leach Field
(FM 3-34.471)

DEVICE DESCRIPTION

- A gravity-fed subsurface drainage bed system, such as a tile or plastic pipe drain field consisting of narrow, shallow trenches through which effluent is discharged.
- The effluent infiltrates the soil primarily through the sides of the trenches.
- Provides physical, biological, and chemical treatment.
- Settling system, such as septic tank or Imhoff tank, to remove sewage solids, at a minimum, is implied as pretreatment.

PROS	CONS
• Underground system eliminates surface discharge and subsequent human contact or filth fly / mosquito breeding. • Can be close to human habitation. • Treatment and disposal work well where soil porosity is moderate. • Low maintenance. • Can last for many years.	• Requires a significant amount of space. • Slope should be less than 25%. • Can clog permanently if solids enter the leach field. • Requires moderately porous soil so that sewage will neither backup or pond on the surface nor percolate too rapidly to contaminate the ground water.

TECHNICAL SUITABILITY FOR DESERT USE: Excellent to Good.

DESERT-SPECIFIC RESTRICTION / CONSIDERATIONS: None.

DEVICE: Lagoon or Oxidation Pond (FM 3-34.471)	
DEVICE DESCRIPTION • Shallow lagoon or pond dug into ground. Excavated material is sometimes formed into earthen walls. Walls and bottom may require waterproof skin. • Wastewater is pumped from camp to lagoon.	
PROS	CONS
• Lagoon proper can be constructed easily with mechanized equipment. • One option for sewage disposal prescribed in "The Sand Book."	• Must be located at least ½ mile from population center because of odors and filth fly / mosquito breeding. • Requires sewer collection system piping and possibly automatic lift stations. • Earthen walls can leak. • Not a recommended theater practice per FM 3-34.471.
TECHNICAL SUITABILITY FOR DESERT USE: Satisfactory to Poor.	
DESERT-SPECIFIC RESTRICTION / CONSIDERATIONS: Clayey soils may hold water. May act similar to an evaporation bed, except that the pest reproduction cycle is not broken by a drying period.	

DEVICE: Sewage Treatment Plant	
DEVICE DESCRIPTION • A broad class of facilities intended to handle human waste. • It usually employs secondary biological treatment by microorganisms naturally found in the waste. • Can be a package or pre-engineered system.	
PROS	CONS
• Provides high level of treatment (secondary) and effluent. • Prefabricated treatment plants can be shipped. • Small crew can control plant once it is operational. • Possible re-use of treated water for flushing toilets reduces use of potable water.	• May require a flow equalization pond to handle large variations in flow during staging. • Requires minimum flow. • Requires trained operators.
TECHNICAL SUITABILITY FOR DESERT USE: Excellent to Good.	
DESERT-SPECIFIC RESTRICTION / CONSIDERATIONS: Biological treatment by microorganisms is not affected adversely by high desert temperatures in existing sewage treatment plants.	

RECOMMENDATIONS

Use the desert-specific limitations and considerations contained in this TIP to manage field wastewater in the desert. Adapt the general policy and guidance in FM 21-10, FM 4-25.12, FM 3-34.471, and Contingency and Long Term Base Camp Facilities Standards ("The Sand Book") to take advantage of recent field experience.

Perform percolation tests in the planning stages to determine whether clayey desert soils or caliche are present. Use the percolation test to determine the best wastewater disposal devices to use and to design them to work properly. Ensure that the proper devices are constructed by coordinating with local engineer units early in the desert operations planning phase.

For base camps, transition to more advanced devices as the camp matures in accordance with the Contingency and Long Term Base Camp Facilities Standards.

APPPENDIX A
DESERT-SPECIFIC GUIDANCE DOCUMENTS AND GENERAL WASTEWATER REFERENCES

Desert-Specific Guidance Documents

Guidance Document	Brief Description of Applicable Aspects
FM 90-3 / FMFM 7-27, Desert Operations, 24 August 1993 (Joint US Army Field Manual and US Marine Corps Fleet Marine Force Manual (FMFM)). (http://www.adtdl.army.mil/cgi-bin/atdl.dll/fm/90-3/toc.htm) (http://155.217.58.58/cgi-bin/atdl.dll/fm/90-3/toc.htm) https://www.doctrine.usmc.mil/signpubs/fm903.pdf	• Recognizes the importance of sanitation in desert operations. • Provides a brief, practical primer on the desert environment as it applies to operations, including a brief discussion on latrines. • Discusses and illustrates types of desert terrain (mountainous, rocky plateau, and sandy dune), which determines the types of latrines that can be employed and the effectiveness of wastewater disposal. • Describes desert-specific problems and some solutions.
Contingency and Long Term Base Camp Facilities Standards, "The Sand Book," United States Central Command, MacDill AFB, FL 33621, 24 September 2002 (Unclassified/ For Official Use Only)	• Specifies standards for facilities at contingency and base camps. • Specifies types of latrines, showers, and sewage disposal for various lengths of deployment.

General Wastewater References

AR 40-5 Preventive Medicine, 15 October 1990.
(http://www.usapa.army.mil/pdffiles/r40_5.pdf)
(http://www.army.mil/usapa/epubs/pdf/r40_5.pdf)
(http://www.army.mil/usapa/epubs/xml_pubs/r40_5/head.xml)
(http://www.army.mil/usapa/epubs/40_Series_Collection_1.html)

FM 4-02.17 Preventive Medicine Services, 28 August 2000.
(http://155.217.58.58/cgi-bin/atdl.dll/fm/4-02.17/fm4-02_17.htm)

FM 21-10 / MCRP 4-11.1D, Field Hygiene and Sanitation, 21 June 2000, (Joint US Army Field Manual (FM) and Marine Corps Reference Publication (MCRP)), (supercedes FM 21-10, 22 November 1988).
(http://chppm-www.apgea.army.mil/deployment/fm21-10.pdf)
(http://atiam.train.army.mil/portal/atia/adlsc/view/public/296878-1/fm/21-10/fm21-10.htm)
(http://www.vnh.org/FM21-10/toc.html)
(https://www.doctrine.quantico.usmc.mil/signpubs/r4111d.pdf)

FM 4-25.12 Unit Field Sanitation Team, 25 January 2002, (supercedes FM 21-10-1 Unit Field Sanitation Team, October 1989).
(http://155.217.58.58/cgi-bin/atdl.dll/fm/4-25.12/fm4-25.12.htm)
(http://www.army.mil/usapa/doctrine/8_Series_Collection_1.html)

FM 3-34.471 Plumbing, Pipe Fitting, and Sewerage, 31 August 2001 (supercedes FM 4-520, 7 May 1983, and FM 5-163, 15 October 1973).
(https://atiam.train.army.mil/portal/atia/adlsc/view/restricted/297109-1/fm/3-34.471/toc.htm)
(http://155.217.58.58/cgi-bin/atdl.dll/fm/3-34.471/toc.htm)

FM 8-250, Preventive Medicine Specialist, Change 1, 12 September 1986 (Hard copy only. Contains specifications for urinoil.).

FM 42-424 Quartermaster Force Provider Company, 6 Aug 1999.
(http://155.217.58.58/cgi-bin/atdl.dll/fm/42-424/toc.htm)

DoD 4715.5-G Overseas Environmental Baseline Guidance Document, 15 March 2000.
(https://www.denix.osd.mil/denix/Public/Library/Intl/OEBGD/toc.html)

Virtual Naval Hospital, Chapter 9, Preventive Medicine for Ground Forces, Section IV, Waste Disposal Methods in the Field. Revised June 1991. Manual of Naval Preventive Medicine, NAVMED P-5010, 010-LP-207-1300, Department of the Navy, Bureau of Medicine and Surgery, Washington, D.C. 20372-5120
(http://www.vnh.org/PreventiveMedicine/Chapter9/Chapter9.html) [1]

[1] Virtual Naval Hospital(TM)
URL: http://www.vnh.org

APPPENDIX B
PERCOLATION TESTS[2]

PERCOLATION TEST FOR SURFACE DRAINAGE - EVAPORATION BEDS, SEEPAGE PITS, AND SOAKAGE TRENCHES

Step 1. Dig one or more holes 1 foot square by 1 foot deep.

Step 2. Fill the test hole(s) with water and allow it to seep into the surrounding soil.

Step 3. Refill the hole(s) to a depth of at least 6 inches while the bottom of the hole is still wet.

Step 4. Measure the depth of the water and record the time it takes for all of it to be absorbed into the soil.

Step 5. Calculate the time required for the water level to drop 1 inch.

Step 6. Use the time from Step 5 to determine the application rate from Table B-1 or Table B-2. For surface evaporation beds, use Table B-1. For seepage pits or soakage trenches, use Table B-2. The rates in the table include allowances for resting, recovery, maintenance, and rainfall.

NOTE: If the percolation rate exceeds 60 minutes, the soil is not suited for a seepage pit. A percolation rate over 30 minutes indicates borderline suitability for soil absorption, and other methods of wastewater disposal should be considered.

Determine the Number or Size (Acreage) of Evaporation Beds

Step 1. Perform a percolation test for surface drainage (above). The test should be performed in at least 3 or 4 locations over the area of the proposed bed.

Step 2. Divide the total daily effluent by the appropriate application rate in Table B-1 to determine the required acreage.

Table B-1. Application Rate for Evaporation Beds.

Soil Percolation Rate (1 inch)	Application Rate (Gallons per Day (GPD) / Acre)
1 minute	57,700
2 minutes	46,800
5 minutes	34,800
10 minutes	25,000
30 minutes	12,000
60 minutes	8,700

[2] FM 3-34.471, Plumbing, Pipe Fitting, and Sewerage, Sections III and VIII.

Step 3. Construct enough evaporation beds or evaporation beds of sufficient size to equal the acreage calculated in Step 2.

Determine the Size of Seepage Pits

Step 1. Perform a percolation test for surface drainage (above) twice – initially and again at the full estimated depth (6 feet deep or less).

Step 2. Determine the application rate using Table B-2.

Table B-2. Application Rate for Seepage Pits and Soakage Trenches.

Soil Percolation Rate (1 inch)	Application Rate (GPD / sq ft of wall)
1 minute	5.3
2 minutes	4.3
5 minutes	3.2
10 minutes	2.3
15 minutes	1.8
20 minutes	1.5
30 minutes	1.1
45 minutes	0.8
60 minutes	0.5

Step 3. Find the required absorption area by dividing the total estimated effluent from the facility by the application rate. The effective absorption area is the total area of the walls in the pit; the bottom of the pit is not considered.

Step 4. Divide the required absorption area (Step 3) by 4 (the number of walls).

Step 5. Divide the required absorption area per wall (Step 4) by the depth of the pit (normally 6 feet). This will be the length of each wall. Remember, the bottom of the pit must be 2 feet above the ground-water table and 5 feet above any type of impermeable soil conditions.

Step 6. Construct a pit or pits by the wall length determined in Step 5. Using several small pits rather than one large pit reduces the excavation effort required. The distance between seepage pits should be at least twice the size of the pits.

Determine the Length of Soakage Trenches

Step 1. Perform a percolation test for surface drainage (above).

Step 2. Determine the application rate using Table B-2.

Step 3. Determine the required absorption area by dividing the total estimated flow from the facility by the application rate.

Step 4. Divide the absorption area (Step 3) by 8 (four radiating trenches; each trench has two walls).

Step 5. Divide the wall area from Step 4 by the average depth of 1.25 feet, since each trench is 1 foot deep at the central end and 1.5 feet at the far end.

Step 6. Construct the soakage trench with four trenches of the determined length (Step 5), each radiating from the central pit.

PERCOLATION TEST FOR SUBSURFACE DRAINAGE BEDS

Step 1. Dig at least six test holes, 1 foot square, to a depth equal of that of the planned drainage bed.

Step 2. Place a 2-inch layer of gravel in the bottom of the holes and fill the holes with water.

Step 3. Let the test holes stand overnight if the soil is tight or has a heavy clay content. If the soil is sandy and the water disappears rapidly, no soaking period is needed. Pour water into the holes to a depth of 6 inches above the gravel. The batter board acts as a reference line, and a ruler should be used to record the level of water in the hole below the batter board.

Step 4. Measure the water every 10 minutes over a 30-minute period. The drop in water level during the final 10 minutes is used to find the percolation rate of the soil.

- Soil that takes 30 minutes to absorb 1 inch of water needs 4 feet of drainage for each gallon of liquid.
- If a test hole needs more than 30 minutes to absorb 1 inch of water, the soil is not suitable for subsurface-drainage system.

Determine the Length of Piping for Subsurface Drainage Beds

Step 1. Determine the soil absorption rate using Table B-3.

Table B-3. Soil Absorption Rates of Drainage Lines.

Time Required for Water Level to Fall 1 Inch (in minutes)	Absorption (GPD/ sq ft of Trench Bottom in the Field)
1 minute	4.0
2 minutes	3.2
5 minutes	2.4
10 minutes	1.7
30 minutes	0.8
60 minutes	0.6

Step 2. Calculate the area of trench bottom required for absorption by dividing the total estimated effluent by the absorption rate of the soil. Round up to the nearest 10 square feet.

Step 3. Calculate the length of trench and pipe needed by dividing the area of trench bottom required (Step 2) by the width of the trench in feet. Round up to the nearest 10 feet.