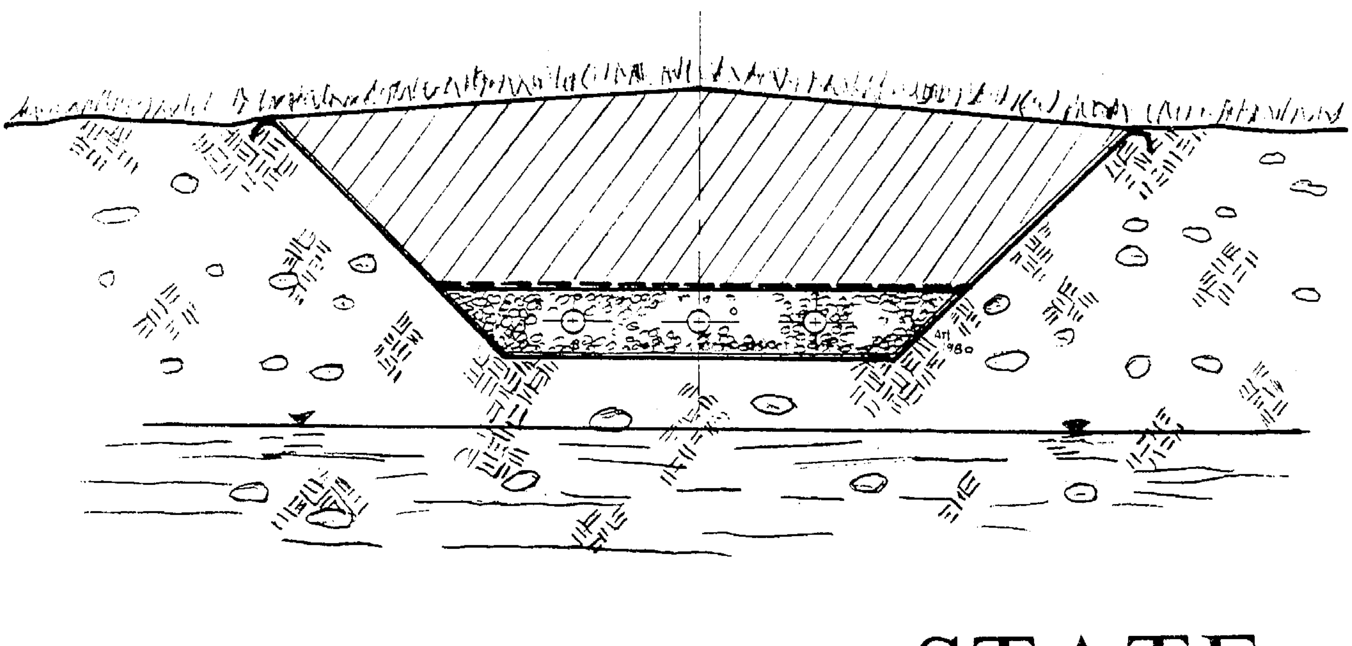
GUIDELINES FOR EVAPOTRANSPIRATION SYSTEMS



STATE WATER RESOURCES CONTROL BOARD

January 1980

GUIDELINES

FOR

EVAPOTRANSPIRATION SYSTEMS

STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

Alan T. Ingham

January 1980

Reprinted

April 1982

November 1983

April 1984

January 1987

January 1990

ACKNOWLEDGEMENTS

The author wishes to thank the California Regional Water Quality Control Boards, the California State Water Resources Control Board staff, the U.S. Environmental Protection Agency's Municipal and Environmental Research Laboratory, California local health agencies and the Alternative Systems Technical Advisory Committee for their review, critique and/or provision of technical material instrumental to the preparation of this document. Gratitude is expressed to Cathy Reimel and Frances Jones of the California State Water Resources Control Board, and the State Board's Word Processing Center staff for their typing, editorial review and reproduction services.

TABLE OF CONTENTS

TABLE OF CONTENTS

(Cont'd)

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

GUIDELINES

FOR

EVAPOTRANSPIRATION SYSTEMS

I. INTRODUCTION

The State Water Resources Control Board (SWRCB) has prepared these guidelines for voluntary use by the Regional Water Quality Control Boards, local health agencies and technical persons associated with the planning, design, construction or regulation of wastewater disposal systems relying on evapotranspiration (ET) or evapotranspiration/infiltration (ETI) for residential wastewater disposal. All local agencies and technical persons are cautioned to consult the appropriate Regional Board prior to planning, designing or constructing any ET/ETI system. Regional Board approval of any such system may be required. These criteria are offered for voluntary use in an attempt to provide a rational planning, design, construction and operation basis for ET/ETI systems so that benefits typical of these systems may be fully realized without jeopardizing water quality and public health. The use of ET/ETI systems should be considered only after determining that the site is unacceptable for subsurface soil percolation alone. The site, regulatory and cost feasibility of a mound versus the ET/ETI systems, should be made (see SWRCB mound guidelines) prior to selecting an ET or ETI system. Once the decision has been made to use an evapotranspiration system, the ETI system should, because of generally lower costs, be the first choice unless subsurface site conditions are unsuited to receiving effluent. These restrictions will be noted by the Regional Board and/or local health agency. The guidelines cover all essential aspects needed to understand ET/ETI systems. Included are discussions on design, effluent storage, drip irrigation systems, construction techniques, O&M of the treatment unit and the disposal bed, and monitoring recommendations. An example design calculation is also included in Appendix A.

Although the use of ET systems for wastewater disposal is not new, expanding development into areas not suited to the conventional septic system has caused a dramatic increase in the requests to regulatory agencies for approval for these devices. Response to this demand has indicated a definite lack of information for planning, design, construction and operation of these systems. At this time, all systems utilizing evaporation or evapotranspiration in California should be considered experimental and should be monitored by local and/or state regulatory agencies during initial operation until the appropriate regulatory agencies are convinced that the system designs are reliable. Since these systems require careful monitoring, the number of systems approved must not exceed the resources available for monitoring. Failure to provide adequate review of design, construction and monitoring during use has resulted in a number of system failures.

Approval may necessitate the satisfaction of specific regulatory requirements of the Regional Board such as:

o Notification of the Regional Board of the proposed project

- Use of approved design criteria
- Identification of public or private entity, acceptable to the appropriate regulatory agencies, to accept responsibility for system inspection, monitoring and maintenance.

The guidelines presented are based on a review of literature as noted and the experiences of the State Board and Regional Water Quality Control Board's staffs. Two sources were particularly beneficial in the preparation of these guidelines: Draft criteria for these systems by the County of San Diego (1) and research conducted at the University of Colorado by Bennett and Linstedt (2). Both of these documents illustrate the care which must be taken with planning, design, construction and operation of ET and ETI systems.

Although these guidelines are voluntary, they are worded in such a way that the essential elements may be easily converted to regulations for these systems if a local agency desires.

Although some criteria may seem stringent, they are intended to assure that the critical design aspects of ET/ETI systems are covered. Local experience may dictate more stringent criteria. These guidelines provide minimum standards unless noted otherwise. Local designers are encouraged to suggest alternate design approaches if equal performance can be demonstrated. Local regulatory agencies can, through a careful documented monitoring program, verify whether local design modifications meet (or exceed) original expectations.

II. DEFINITIONS

Evapotranspiration - The combined effect of water removal from soil by direct evaporation and by transpiration of vegetation.

Infiltration - The effect of water removal from a soil area by the downward migration of moisture into the soil depths.

Evapotranspiration (ET) System - A subsurface system designed to dispose of effluent exclusively by evapotranspiration; therefore, effluent cannot encounter either ground or surface water. ET beds are enclosed by a water-tight liner or are constructed in impervious soils.

Evapotranspiration/Infiltration (ETI) System - A subsurface system designed to dispose of effluent jointly by the effects of evapotranspiration and infiltration into the soil. Such systems differ from mounds or filled systems in that the primary effluent disposal method is designed to be evapotranspiration.

III. DESIGN GUIDELINES

Engineered Design -

ET and ETI systems shall be designed by a civil engineer, engineering geologist or sanitarian well versed concerning small wastewater flow technology and who is licensed to practice in the State of California. All plans, design computations, layout sheets, reports and other engineering documents shall be signed by the designer (1).

Siting -

Exposure of the system to sun and wind is desirable. Therefore, the general site location on a parcel shall be selected in an area as open as possible to maximize exposure (3). This will enhance the transfer of moisture from the system to the atmosphere.

Disposal areas must be used exclusively for disposal of wastewaters and not used for corrals, playfields, parking lots, building sites or any other such use that would impair the system (3 & 4). In locations accessible to children, a fence shall be provided to prevent their access to the disposal site.

Site Drainage -

The site shall be graded such that rainfall runoff from adjacent areas is directed around and away from the system (1).

Incident Rainfall -

The design shall assume that 100 percent of all rain falling on the ET/ETI bed enters the system (2). The ET/ETI bed surface is sandy and most incident rainfall will soak into it.

Design Flow Rate -

System design shall be based on a flow rate of 75 gallons per capita per day or 150 gallons per bedroom--whichever is greater. The use of water-conservation fixtures is permitted, however the local regulatory agency shall require that it be noted on the deed. Should the sytem fail, the replacement/repair system shall be based on design criteria not employing water-conserving fixtures. The designer shall certify the flow reduction allowance for all water-conservation fixtures employed (4 & 5).

Note: reserve areas for replacement systems shall be determined by designs based on full-house flow without water-conservation fixtures (see Reserve Areas).

Evapotranspiration Rate -

The design evapotranspiration rate shall be equivalent to the minimum monthly winter Class A pan evaporation rate. The design rate shall be the minimum winter pan rate taken from the previous ten years of record (2). The minimum winter pan rate is selected because it has been observed (2) that summer evapotranspiration rates are generally about 70-80 percent of the summer pan rate; as winter approaches, the two rates become closer. During the winter, the minimum annual evapotranspiration rate is approximately equal to the minimum Class A pan rate.

The designer shall provide adequate justification for any rate different from the minimum winter evapotranspiration rate.

Infiltration Rate -

For ETI Systems, the infiltration rate shall be based on a typical wastewater infiltration rate for a leachfield having a developed organic mat (0.20 gal/ft^2/day) (4, 6, & 7)1/. This assumes that at critical times of the year, water will pond over the bottom of the bed in the gravel layer (see Appendix B-Recommendations for Refined Percolation Test).

Soil and Groundwater Depth -

A minimum depth of three feet of soil is required under the ETI bed with a minimum depth of three feet to high groundwater. Regulatory agencies may impose more stringent depths based on local experience.

Note: An ETI bed is used only in fine textured soils and not in coarse material. Therefore, soil treatment of the effluent should be adequate.

No minimun depths to groundwater are specified for ET systems; however, the liner hydraulic continuity and protection from rodents shall be demonstrated to the satisfaction of the appropriate regulatory agencies (see section on Liners).

1/ This rate shall be used whenever it is permissible to discharge effluent into the subsoil and the percolation test detects noticeable percolation. The limit for observed percolation shall be set at 500 minutes per inch. If slower rates are observed, the bed shall not consider infiltration and the design disposal shall be by evapotranspiration alone. The percolation test shall be taken at a depth 6 inches below the bottom of the proposed ETI bed gravel layer (see Appendix B Recommendations for a Refined Percolation Test).

Note: If the native soil does not percolate or has a slow percolation with no possibility for groundwater contamination, a liner may not be required for an ET system.

Horizontal Setbacks -

Minimum horizontal separation between treatment/disposal facilities and other features shall be as specified below (1, 4, & 5). Local regulatory agencies may specify more stringent requirements based on local conditions.

Setbacks	Tank feet	ET bed feet	ETI bed feet
Structures	10	10	20
Property lines	5	5	10
Water supply wells[1/]	50	50	100
Streams, drainage ways and reservoirs	50	50	100
Private waterlines	5	5	10
Driveways and roads	5	5	5
Cuts or embankments	15	15	4H[2/]
Swimming Pools	10	10	15

1/ Sewerage facilities should be located as far as possible from wells but under no condition less than the dimensions shown. This criteria shall also be applied to future well locations.

2/ H is height of the cut or embankment. Therefore the setback from the embankment is four times the height of the embankment.

Treatment Tank -

The designer shall specify a two-compartment septic tank having a minimum capacity of 1200 gallons with the addition of 250 gallons for every bedroom over four. The first compartment shall contain two-thirds the total volume of the tank. The tank shall be of water-tight construction and be fabricated from concrete, fiberglass or other material approved by the designer and shall be fitted with approved inlet and outlet baffles. The tank shall be fitted with covered access ports flush with the ground. These covers shall be removable to provide access to the tank covers located over the inlet and outlet baffles. The provision of these entry ways enables ease of tank inspection and pumping as required. A local onsite waste-water management district or, if not available, the homeowner should inspect the tank once every two years and should have the tank pumped when the sludge or scum layer is a foot or more in thickness. The use of an aerobic treatment system must meet the requirements of the local agency or Regional Board. No literature has been able to demonstrate that this system functions for soil or ET disposal superior to the septic tank in terms of overall system performance in spite of the higher capital and operation and maintenance costs (2, 4, 5, 6 & 8).

Mechanical Components -

Any mechanical equipment associated with either the treatment or disposal processes shall be fitted with visual (light) and audible (horn) warning devices to alert the homeowners of malfunction (1).

Systems employing mechanical devices shall be functional for a minimum of 48 hours following malfunction of key mechanical components. The appropriate regulatory agencies shall require a signed maintenance agreement to ensure 48-hour replacement or repair in the event of mechanical failure. The requirement for this maintenance agreement shall be recorded on the property deed.

Reserve Areas -

Reserve areas shall be provided to expand ET and ETI systems should the original system fail to accommodate its design loading. System augmentation may be required in advance of failure if observations indicate bed surcharging during the dry months which can predict an overflow during the rainy season.

Replacement areas for ET and ETI systems shall be provided to accommodate as a minimum a flow based on 100 percent of the hydraulic loading without water-conservation allowances. The replacement bed shall be operated as the final bed in series with the original. Construction of a replacement disposal system will be required when the original system fails (4).

The specification for ET and ETI beds in series will require that the first bed (the failed bed) of the two-bed series reach its maximum liquid level prior to overflow to the second bed (the new bed). The maintenance of a maximum level in the first bed encourages a higher ET rate than when the effluent must be drawn from a greater depth for evapotranspiration.

Design for replacement ETI systems shall utilize the series arrangement as discussed above. Literature indicates that a resting period for a subsurface disposal system can restore some infiltration rate lost due to organic mat build up. However, since evapotranspiration is the primary method of effluent disposal for an ETI system, and evapotranspiration is benefited by the series arrangement as discussed above, and the infiltration design rate is taken at 0.2 gallons/square foot/day which is approximately the infiltration rate with a developed organic mat, the resting will not benefit the failed ETI bed as much as the maintenance of higher liquid levels to promote evapotranspiration (1, 4 & 9).

The reserve area for ET and ETI systems shall not be built upon nor accommodate roads or other construction which would impair the use of the area for a future disposal system. The local agency shall require the reserve area to be noted on the deed to inform future owners of the restrictions on reserve disposal areas.

Evapotranspiration Sand -

Sand used as bed fill shall be as follows: ET and ETI bed sand shall be clean, uniform sand having a D_{50} size in the range of 0.10-0.15 mm (50 percent by weight smaller than 0.10-0.15 mm). The sand fill shall be placed to a depth of not less than 20 nor more than 30 inches (2). Sand of this size has an effective hydraulic rise of about 30 inches yet has a grain size sufficiently large to ensure adequate hydraulic conductivity to prevent the surface from drying out on a hot day.

Sand different from above will be approved if the designer supplies capillary rise height and hydraulic conductivity information which shows such material is compatible with the configuration of the ET or ETI bed. The ET or ETI bed surface shall be crowned with a 2-3 percent slope away from the bed center (2).

Gravel Base Layer -

Gravel is placed over the bottom of the bed. The distribution pipes are placed within this gravel fill. The gravel shall be 1.25 - 1.75 inch size and be placed to a depth not to exceed 8 inches (2).

The gravel layer serves the exclusive purpose of providing distribution to result in a uniform pond volume for wicking up by the overlying capillary sandfill. The gravel layer cannot be used as storage volume since it lacks the necessary capillary rise to transport contained (stored) water to the capillary sand which then transports the moisture to the surface. For this reason, gravel depth is restricted to 8 inches. Alternate designs may be approved if the designer can provide assurance of hydraulic conduction from the gravel storage to the capillary sands.

To prevent migration of sand into the gravel layer, an acceptable barrier shall be provided between these two media which shall have a minimum life expectancy of 20 years (1). An example would be a 3-6 inch layer of 1/4-inch gravel or synthetic materials available for preventing the migration of soil into the gravel fill of a typical leachfield trench, such as DuPont Typar (4-6 oz per yd) polypropylene filter fabric or equal.

Distribution System -

In an ET or ETI system, an engineered distribution system is unimportant since the influent will pond in the gravel layer. The influent must be effectively directed to the gravel layer and from here it will move through the voids in the gravel over the level bed bottom forming a uniform pond depth. In cases where a pressure distribution system is used, care must be taken to prevent the influent from mounding in local areas of the bed into the capillary sand fill. Pressure distribution systems are not recommended for ET/ETI applications.

A screen shall be provided to remove solids in treatment tank effluent prior to entering the distribution system[1/]. The effluent screen is recommended for use following aerobic or anaerobic treatment tanks and should have openings sufficiently small to remove

---

1/ Preliminary results from the Manila pressure sewer septic tank effluent pumping project indicate that some soilds having a specific gravity close to that of water find their way into the disposal system. These solids (mostly cigarette filters and lint) if not strained out of the treatment tank effluent can contribute to a premature clogging of the holes in a pressure distribution system or gravity tile system.

1/8-inch spheres. The solids removal is improved by specifying a two-compartment tank with adequate baffles (see section on Treatment Tanks).

Interconnection Lines -

For beds in series, connection lines shall be of water-tight construction. The soil separating the beds shall be undisturbed and all backfill of connection lines shall be carefully compacted to prevent wastewater from migrating through the berm or connection trench (1). This is especially important for either lined or unlined systems.

Liners -

ET systems specifying a liner shall select a liner having an adequate durability over a 20-year service life (1). The designer shall provide a special design to protect the integrity of the bed lining from rodents over its service life in areas having the possibility of rodents penetrating the liner (1)[1/]. Liner specification and testing shall meet the requirements of the appropriate regulatory agencies.

1/ Ten or 15 mil. PVC liners may be considered as meeting the 20-year service life requirement if adequately protected against construction puncture. If rodents are present, a possible consideration would be 3/4-1 inch of blown concrete overlain with 2 inches of sand and the PVC liner. An alternative would be to replace the sand and PVC liner with a 1 inch bentonite layer over the concrete. The bentonite is able to seal small leaks or cracking in the concrete without the need for excavation and repair.

Grading of Bed Base -

All ET and ETI beds must be constructed with level bottoms. The grading tolerance shall be within 0.1 foot over the bottom of the bed (1).

Construction on Filled Material -

ET systems may be constructed on well compacted fill material certified by the designer that adequate construction techniques were employed to ensure settlement of the bed will be within the grading tolerance previously specified. ETI systems shall not be constructed on fill material due to the possibility of slip or settlement failure of the fill terrace due to percolated water. A variance may be granted if the design includes an adequate examination of the soil stability under these conditions. Site drainage is particularly important for ET systems constructed on fill (2, 6 & 10).

Evapotranspiration Plants -

The designer shall specify the planting of the bare surface of the ET and ETI bed with the juniper shrub, pfitzer. Other plantings or the maintenance of a bare bed shall be allowed with justification by the designer. The plantings must be established prior to the occupancy of the dwelling (2). The local Agricultural Commissioner or Resource Conservation District may be a good source for obtaining recommendations for ET plants tolerant to wide ranges in salinity and soil moisture.

Observation Wells -

The designer shall provide a minimum of two observation wells 6 inches in diameter having slots in the lower two feet. These wells shall be placed to the bottom of the gravel layer and shall rise 6 inches above the surface[1/]. As a minimum, they shall be fitted with a snug-fitting cap over their openings to prevent odors and insect access routes. One well shall be placed near the center of the bed and another at the corner. If an ET bed is constructed on fill, the corner well shall be placed at a corner nearest the fill embankment. Such inspection wells shall also serve as pumping accesses when the bed requires flushing due to salt accumulation (2 & 3).

Additional wells 3-4 inches in diameter, of plastic (or equivalent) pipe may be required by the local regulatory agencies for ETI systems and shall be placed midway along the outside perimeter of each side of the bed and extend to a depth of 10 feet. These wells shall be perforated within 18 inches of the ground surface and adequately sealed at the surface to prevent the entry of rain water.

Note: Wells will only monitor saturated soil conditions. If it is desired to monitor unsaturated soil moisture, it will be necessary to construct an impervious PVC

1/ In systems sealed with a liner the designer shall provide protection of the liner from puncture by any wells extending to the base of the gravel layer. An adequate provisions would be to specify a 12-inch square concrete pad 2 inches thick under each well extending to the base of the gravel layer.

film horizontal stop at the proper depth to intercept and direct downward migrating water to a collection and sampling sump.

As a minimum, the bed and perimeter monitoring wells shall be measured for depth to groundwater one day following storms in excess of one inch of rainfall or once every two weeks in areas where snow melt may affect the bed's water level (usually March through May). The ground surface at the well shall be taken as measurement datum.

The perimeter wells, when required, shall be monitored alternately once every two months for total and fecal coliform.

Monitoring shall be conducted by the homeowner and/or the local agency and/or Regional Board and only that number of systems should be allowed for which monitoring resources are available. The groundwater quality monitoring program, when required, should be developed specifically for each installation according to local conditions.

Salt Accumulation -

Over a period of time, all ET systems and some ETI systems will reach a salt buildup able to damage or kill vegetation on the bed. In a completely closed system, one can expect salt concentrations to increase at 1250 mg/l/year (0.025 mg/yr/gm of sand fill) with the salt migrating to the surface. (This assumes a wastewater loading of 0.04 gal. per square foot per day.) One typical bed was noted to have a surface salt concentration of 11.5 mg/gm of soil after five years of use. As part of the design of an ET system the designer shall specify a flushing schedule based on the salt content of the domestic supply, wastewater loading and the salt tolerance of the plantings used. The disposal of brine pumpings shall be made to a wastewater treatment facility in the same manner as with septage, if permitted. Otherwise disposal shall be in a manner prescribed by the Regional Water Quality Control Board. This same analysis shall be provided for ETI systems if the designer's computations indicate insufficient infiltration to keep the bed purged of salt concentrations exceeding those levels tolerable for the recommended vegetation (1, 2, & 3).

Minimum Freeboard -

A minimum 10-inch depth to the peak effluent level in the bed shall be maintained in the critical year design to prevent a soggy bed surface (11). The ET bed liner shall extend to within 2 inches of the bed surface. In practice this will provide emergency storage should the 10 inch design freeboard be exceeded. In this way, surcharged effluent will not flow into adjacent subsoil.

IV. PROVISION OF STORAGE

Typical Systems -

It has been suggested (2) that ET systems be restricted to locations where the minimum winter pan rate (annual design evapotranspiration rate) exceeds rainfall for every month for the previous ten years of record. This requirement greatly restricts the acceptable site locations. The provision of storage will enlarge the geographic area acceptable for such systems. Some storage capacity may be feasible if the bed sand depth required to provide storage volume does not exceed the capillary rise of the evapotranspiration bed fill sand. For ET sand which maximizes capillary rise while maintaining adequate hydraulic conductivity, this is generally limited to a maximum of 25-30 inches (D_{50} = 0.10-0.15 mm) (2). If the sand fill depth exceeds the sand's capillary rise, the sand will be unable to wick up water stored below the capillary rise height. It is therefore necessary that the designer evaluate local site conditions, available sands and climatological data prior to the specific design effort. This will avoid the problem of designing a storage depth exceeding the sand's capillary rise. Once this effort is completed for a local area, other systems may readily incorporate this information into their designs for the same region.

Another consideration could be the provision of a transparent or translucent canopy or precipitation shield over the ET bed. This structure would allow air with the exclusion of precipitation and would enable a design based on the minimum 10 years winter class A pan evaporation rate alone without consideration of precipitation. In some situations this would be an effective way of minimizing or eliminating storage requirements. The use of a design employing a canopy shall necessitate the specification of the canopy as permanent part of the onsite wastewater management systems on the deed by the local regulatory agency.

Should the designer determine that the initial bed area is inadequate for storing the desired volume within a depth limited by the 10-inch freeboard and the maximum capillary depth of the sand, the engineer may recompute a larger bed area or provide separate wet weather storage facilities isolated from rainfall. The cost will dictate the selected design. If the design employs storage within the sand fill, the porosity of the fill sand shall be employed to compute the volume available for storage.

Drip Irrigation Systems -

The detailed design of effluent drip irrigation systems are outside of the scope of these guidelines. Key aspects requiring extra literature search include the following:

- o effectiveness of drip line placement methods (e.g., depth, trench profile, backfill material, etc.)
- o impacts of moisture content and soil type at the time of constructions.

- the tendency of emitter openings to clog.

- the effects of soil temperature, permeability, slope and rainfall.

- optimum emitter and distribution line spacings.

- the general impacts on groundwater quality.

The following summary is possible due to the literature search on ET and ETI systems. While not intended to be comprehensive, it can provide some guidance.

In soils having small pore sizes (unlike the sands used in ET/ETI systems) drip irrigation systems must be loaded at a rate lower than those used in ET/ETI beds due to the small pore sizes and hence lower hydraulic conductivity for evaporation. The presence of plants should not be used in the design to increase ET because there is no guarantee they will remain for the life of the system, possibly due to salt buildup. There is no way to flush these systems.

Drip irrigation systems cannot provide storage from month to month and therefore must dispose of all of their hydraulic loading by evapotranspiration or percolation the same month as loaded. Unless the evapotranspiration (winter pan evaporation rate) exceeds rainfall for <u>all</u> months during the previous ten years of climatologic data, the system design must be based exclusively on percolation since it is by this method alone that the system must dispose of all of its hydraulic loading during this critical month.

V. CONSTRUCTION

The designer shall inspect ET and ETI systems at critical construction points and submit a written certification that the system was installed in exact accordance with design. The written certification shall be signed by the designer (1).

For ET systems, great care must be taken to protect the lining. In addition to the rodent barrier, when required, PVC or other liners of equivalent strength shall be protected by a minimum of two inches of sand when placed on rocky soil which could puncture the liner. Once placed, the liner is covered with a minimum of three inches of sand prior to placing the gravel and distribution system. At this point, all lined beds regardless of lining type shall be filled with water and tested for a period of at least 24 hours for water-tight integrity (1). The beds shall be filled to within one inch of the top of the liner (three inches under the future surface of the bed).

VI. OPERATION AND MAINTENANCE

The homeowner of a mechanized system shall have a signed maintenance or replacement agreement stipulating procedures to ensure maintenance, repair, or replacement of critical items within the 48-hour period following failure.

The following tips and suggestions are reproduced with modifications for ET and ETI systems from the Homeowners and Users Guide for Onsite Wastewater Disposal Systems prepared by the Stinson Beach County Water

District (12). They are intended to increase the useful life of the treatment system. Their applicability and effectiveness will vary with each home.

Minimize the Liquid Load

The less wastewater you produce, the less wastewater there will be to dispose. The following suggestions will help to reduce the liquid load.

- Repair leaky fixtures. Check your toilet by dropping food dye in the tank and see if it shows up in the bowl without flushing.
- Wash clothes only when you have a full load. Avoid doing several loads in one day.
- Take short showers instead of baths. Don't turn the shower on all the way and turn off the water while lathering.
- Use a water-saving device in your toilet tank and don't flush unnecessarily.
- Don't let water run while washing teeth, hands, vegetables, dishes, etc. Use a stoppered basin.
- Don't let rain water drain onto the ET or ETI bed area from higher ground.
- Many other ways of conserving water exist. Be alert for other water-saving ideas.

Minimize the Solids Load

A good rule is: don't use your septic system for anything that can be disposed of some other way. The less material you put into your septic tank, the less often it will need pumping.

- o Avoid using a garbage disposal unit. Compost scraps or throw them out with the trash.

- o Collect grease in a container near the sink rather than pouring it down the drain.

- o Minimize the discharge of paper products. Nondegradable items, such as disposable diapers, sanitary napkins, kleenex, and paper towels are especially harmful. Don't throw cigarette butts down the toilet.

- o Only three things should go into the septic tank: human wastes, toilet paper, and water from toilets, bathing fixtures, laundry and kitchen sinks.

Ordinary use of household chemicals won't hurt the bacteria in your system but don't use excessive amounts. Also don't use your tank to get rid of oils, paint thinner, or other poisonous liquids.

Septic Tank Additives

Chemicals, bacteria, enzymes, etc., do not help solids break down in the tank and will not reduce the need for pumping.

Keep Heavy Vehicles Off Your System

Underground pipes and soil porosity can be damaged by driving over them repeatedly. Never drive over the disposal area. This area should be walked on only to attend the planted vegetation. This vegetation should never be irrigated.

If Your System Fails

If your ET or ETI system has failed, provisions should have been made for supplementing the original bed with a new one of equal or greater size. A qualified person shall design all failed system repairs. ET/ETI systems shall be repaired with a new system placed in series with the original.

Operation and Inspection of ET or ETI Beds

Check your system inspection pipes regularly. Water standing higher than 10 inches under the soil surface may be an indication of trouble. These inspections must be made during the rainy season and periodically as required during the dry season of the year. Your septic tank should be inspected at least once every two years. If it is not routinely inspected by a wastewater agency, you should inspect your own tank. To inspect, remove the manhole cover at the inlet end. The best practice is to check both scum and sludge levels, but the following simplified procedure works well in most cases. Use a shovel to push the scum layer away from the side of the tank so that you can estimate its thickness. If the thickness of the scum layer is a foot or more, arrange to have your tank pumped immediately. Replace the manhole cover and wash off the shovel and your hands as a sanitary precaution. If the tank is not pumped, solids can carry over to the disposal bed and affect proper bed operation.

Aerobic Systems

The same basic tips are applicable to aerobic systems. The solids accumulation rate in these units may be more rapid than a septic tank and therefore they need to be inspected more frequently. The designer or manufacturer should provide a required inspection and pumping schedule. Due to increased capital and operation and maintenance costs of these systems over the septic tank, coupled with a lack of information indicating the superiority of the overall treatment and disposal process, aerobic treatment systems are not considered to have any overall advantage over septic tanks for use with ET/ETI beds. They have a definite disadvantage in that they are more vulnerable to homeowner neglect.

VII. MONITORING REQUIREMENTS

ET and ETI beds are experimental systems in California. Implementation approval should not be granted for these systems until a monitoring program is developed which is acceptable to both the local health agency and the Regional Board. A primary need is the monitoring of accumulated effluent in the bed. Since the relationship of storage depth and capillary rise potential of the bed fill sand is so critical to proper bed operation, these values should be confirmed for each local sand type used in the bed. Likewise, vegetation, salt buildup, and different storage configurations are dependent upon local conditions and will prove valuable for future designs.

With ETI systems the quality or quantity of percolated water may be of concern.

Each bed installation should be monitored until the local agency and the Regional Board are satisfied that each design will result in an acceptable system.

Most important, the number of experimental installations authorized should not exceed the resources available for adequate monitoring of each system.

REFERENCES

1. San Diego, County of, Experimental Alternative Systems - Minimum Criteria for Design and Construction of Evapotranspiration (ET) and Evapotranspiration/ Infiltration (ETI) Areas (Beds). Department of Environmental Health, 1979

2. Bennett, E. R. et al, Sewage Disposal by Evaporation-Transpiration, Report to U. S. Environmental Protection Agency, Grant No. R 803871-01-1, 1978

3. Washington, State of, Guidelines Governing Total Evapotranspiration Systems, Department of Social Health Services, 1977

4. California Regional Water Quality Control Board, San Francisco Bay Region, Minimum Guidelines for the Control of Individual Wastewater Treatment and Disposal Systems, 1979

5. Storm Engineering, Stinson Beach County Water District, Wastewater Facilities Plan, 1979

6. Otis, Richard, Seminar. Individual Wastewater Management: The Mound System Design and Installation, Davis, CA, Feb. 1979

7. University of Wisconsin Extension, Management of Small Waste Flows, Report to EPA, Grant No. R-802874, 1978

8. Washington State, Report and Departmental Policy Concerning the Use of Aerobic Treatment Devices, Department of Social and Health Services Technical Review Committee, 1975

9. McGauhey, P. H. and R. B. Krone, Soil Mantel as a Wastewater Treatment System, SERL Report No. 67-11, 1967

10. Wisconsin, State of, Alternate Sewage Manual, Prepared by the University of Wisconsin Small Scale Waste Management Project, 1976

11. Raba and Associates, Evapotranspiration A Method of Disposing of Septic Tank Effluent, Report No. 75-185, for Edwards Underground Water District, 1977

12. Stinson Beach County Water District, Homeowners and Users Guide for Onsite Wastewater Disposal Systems, 1979

APPENDICES

APPENDIX A
Design Example:
Computations for an Evapotranspiration System

Assumptions:

1. All rainfall enters bed.

2. Any water disposed by plants is not accounted in design (safety factor).

3. Permanent residence: wastewater flow is constant throughout the year.

4. No disposal due to soil infiltration

Criteria:

1. Select the most conservative net Class A pan evaporation rate in ten years of record preceding design. Evaporation must exceed precipitation for every month of record.[1/]

2. The house flow is 75 gallons per capita per day or 150 gallons per bedroom per day.

3. All water contained in the ET bed lies no deeper than the capillary rise height of the sand used for the ET system (excludes gravel bed).

4. A 10-inch (0.83 feet) freeboard shall be maintained to prevent a soggy ET/ETI bed surface.

1/ This assumes no storage in the sand fill of the bed. An exemption may be granted if the designer can demonstrate sufficient storage exists to accommodate the climatological data used.

5. The design evapotranspiration rate shall be equal to the minimum winter evaporation rate from the previous ten years of record.

   Example:

   Given a residence: 3 bedrooms, 4 persons.

   One water-conserving toilet is used 75 percent of the time.

   Toilet uses: 5 per capita per day.

6. All incident rainfall enters the bed.

I. Minimum Surface area

A. Annual effluent volume (V) in cubic feet

1. Basic flow calculation

   a. 150 gallons per bedroom per day x 3 bedrooms = 450 gallons per day

   b. 75 gallons per person per day x 4 persons = 300 gallons per day

Since 450 is greater than 300, base the design on 150 gallons per bedroom per day.

2. Allowance for water-conserving fixtures

   Standard toilet 5 gallons/use

   Assume, for example, a water-conserving toilet 2 gallons/use

   Total flushes: 4 persons x 5 uses per person per day = 20 uses.

   Due to specific house configuration, assume 75 percent of uses are with water-conserving unit 15 uses x (3 gallons saved per use) = 45 gallons per day saved

3. Design flow

a. Daily flow (gallons per day)

(450 gallons per day basic flow) - (45 gallons saved due to water-conserving appliance) = 405

Say: <u>400 gallons per day design flow</u>

b. Annual flow (cubic feet)

400 gal/day x 365 days/year = 146,000 gallons

Volume V = 146,000 gallons/(7.48 gallons/cubic foot) =

19,520 cubic feet

B. Annual Class A Pan Evaporation from local climatological data (assumed for example, 0.40 ft/month minimum winter pan rate) x 12 months = 4.80 ft.(ET)

C. Annual precipitation (P) from local climatological data (assumed for example) = 2.38 feet

D. Area A = V/(ET-P)

=19,520 cubic feet/(4.80 feet-2.38 feet) = 8,066 square feet

Say: <u>8,100 square feet</u>

II. Bed Depth (See Table A-1)

A. From local data, place monthly precipitation data in Column A and monthly design ET values (minimum winter evaporation) in Column B.

TABLE A-1

EVAPOTRANSPIRATION BED DESIGN SHEET
(for example)
VALUES IN FEET

Column Ident.		A	B	C	D	E	F	G
Month/Days		P	ET[1/]	P-ET	Cumulative P-ET	Effluent Depth	Cumulative Effluent Depth	Bed Depth
Jan	31	0.35	0.40	-0.05	-0.05	0.20	0.20	1.26
Feb	28	0.32	0.40	-0.08	-0.13	0.18	0.38	1.54
Mar	31	0.28	0.40	-0.12	-0.25	0.20	0.58	1.77
Apr	30	0.21	0.40	-0.19	-0.44	0.20	0.78	1.80 (Design Value)
May	31	0.19	0.40	-0.21	-0.65	0.20	0.98	1.77
June	30	0.10	0.40	-0.30	-0.95	0.20	1.18	1.48
July	31	0.0	0.40	-0.40	-1.35	0.20	1.38	0.92
Aug	31	0.0	0.40	-0.40	-1.75	0.20	1.58	0.34
Sep	30	0.10	0.40	-0.30	-2.05	0.20	1.78	0.06
Oct	31	0.20	0.40	-0.20	-2.25	0.20	1.98	0.06
Nov	30	0.25	0.40	-0.15	-2.40	0.20	1.18	--
Dec	31	0.38	0.40	-0.02	-2.42	0.20	1.38	--
Totals		2.38	4.8					

1/ For ET this is minimum monthly class A pan evaporation for design year.
For ETI Col. B include sum of design evaporation and infiltration rates.

B. For each month, compute the difference between precipitation and evapotranspiration (Columns A-B = C).

Note: In an ETI bed the percolation quantity is added to evapotranspiration quantity to derive Column B.

C. For each month, compute the cumulative difference. Add the present month's difference to the previous month's cumulative difference.

D. Assume that each month's effluent volume is spread uniformly over the bed area computed in I.D. above. Then determine the depth of each month's effluent:

(Column E) Depth =

Month's effluent volume (cu. ft.)/Minimum surface area (sq. ft.)

Depth (for any month) =

(No. of days in month x 53 cu.ft./day)/8,100 sq. ft.

E. For each month, determine the cumulative effluent depth (due to wastewater loading). Add the present month's depth to the previous month's cumulative depth

Feb. Col. F = January Column F + Feb. Column E

Mar. Col. F = February Col. F + March Column E, etc.

F. The final bed depth may be computed by adding the depth due to precipitation and ET to the depth due to wastewater loading.

This total depth is then divided by the sand porosity (assumed here to be 35 percent) and a 0.83 foot freeboard is added. Total depth (Col. G) = (Col. D + Col. F + 0.83)/0.35

The maximum depth month becomes the actual point for which the system is designed. This depth shall not exceed the capillary rise height of the ET sand. If it is exceeded, then the bed area must be enlarged until it is not, or separate storage facilities must be provided to isolate stored wastewater from precipitation.

For an ETI bed, the monthly hydraulic loss is added to evapotranspiration for the month (Column B value) and subsequent computations are identical.

By adjusting the bed area, one can obtain an acceptable maximum bed depth commensurate with the ET sand capillary rise height.

The example results in a sand fill bed depth of 1.80 ft. (21.6 inches). This is within the acceptable capillary rise range of 20-30 inches, therefore no adjustment in bed area is necessary. Loading rates will typically vary between 0.03-0.08 gallons/square foot/day (2). In the example, the resultant loading was

(400 gallons/day) 8100 square feet = 0.05 gallons/square foot/day.

APPENDIX B

Recommendations for a Refined Percolation Test

Introduction

The percolation test procedure was originally developed in 1926 by Mr. Henry Ryon, an engineer with the New York State Engineer's Office. The results of his work remain essentially unchanged in the general percolation test procedure used as the basis of subsoil disposal system designs today. The standard for percolation tests is contained in the U.S. Public Health Services Manual of Septic Tank Practices (USPHS Manual)[1/]. The soil percolation test can give variable results due to changes in site conditions, innate variation in the reproducibility of the test, and differences in the test specifications and procedures.

A promising alternative to the percolation test procedure involves an analysis of soil type and texture. This procedure will continue to be refined as the practice continues to be advanced. A soil examination should take place even when a percolation test is used for system designs. As the percolation test pit is excavated, the soil type should be identified, taking care to note texture, the presence of any soil mottling due to previous high groundwater levels, and the existence of any impervious layers. This investigation is an important part of any site investigation for a subsoil disposal system. This appendix, while acknowledging the innate shortcomings of the percolation test,

---

1/ U. S. Department of Health, Education, and Welfare, Public Health Service, Manual of Septic Tank Practice, U. S. Government Printing Office, 1967 edition. The USPHS Manual has undergone one revision and four reprintings since its first printing in 1957.

will establish a rationale and make a recommendation for a refined percolation test to eliminate the differences resulting from the varying test specifications and procedures.

Research (1, 2, 3, 4, & 5) has shown that percolation test results can be affected by the following variables:

- The method used in digging the test hole,
- The diameter, or size, of the test hole,
- Silting of the hole during the test,
- The height of water during the test
- The equipment and methods used to obtain readings.

Refining and standardization of the percolation test methods, while not necessarily resulting in more conservative results, will result in more constant results indicative of improved practice. The USPHS Manual allows for hole size variations from 4-12 inches, having either a square or circular cross section. Measurements are taken with a batter board and measuring stick, and percolation rates are measured during varying liquid levels in the hole. The USPHS Manual does not address specific methods for excavating the test hole, or the effects of sidewall siltation, during the test. Much of the procedural wording is casual in the USPHS Manual. To obtain more reproducible results in the same soil, the test procedure needs to be standardized beyond the procedures identified in the USPHS Manual.

Field Practices which Introduce Variation in Percolation Test Results

The following discussion addresses various field practices which have resulted in percolation test variations.

Power augers can compact the sidewalls of a test hole. Studies with power augers have shown approximately 85 percent of the soil is removed from percolation test holes, with 15 percent being compacted into the walls (2 & 4). Test results indicate the percolation rates may decrease 10-100 fold due to sidewall compaction. Sidewall compaction, even with the proper surface scraping to remove soil smearing due to the digging equipment can significantly effect test results (1 & 2).

The test hole diameter can cause percolation test results to vary widely (1, 2, & 3). This is due to the varying ratio of hole percolation area to volume of water (small diameter holes yield faster percolation rates). This is especially true of holes dug with shovels. Frequently, unless great care is exercised, the lower walls of these excavations can taper in toward the center of the hole.

Experience has indicated that the siltation of test hole due to unstable sidewall caving during the test can cause a decrease in the percolation rate observed in some soils. Another effect of this problem is the filling of the hole which destroys the bottom of the hole as a water depth measurement datum, while elevating the general test depth (1, 2, & 3).

Winneberger (1) found that variations in hydraulic head caused changes in the percolation rate with deep water test depths yielding the faster percolation rates. This will result in a varying percolation rate depending upon the elevation of the test water at the time the reading is taken.

The use of a batter board and measuring tape, or stick, can likewise introduce errors (1). These may be due to depressing the batter board when taking a reading (the batter board may be laying on dry grass or other unstable surface), mistaking when the measuring stick, or tape, touches the water surface due to ripples in the water surface caused by falling soil particles not the measuring stick, or holding the measuring stick out of plumb. All of these results can amount to errors with a variation of 1/8 of an inch or more. This seemingly small amount of error can become significant when measuring tight soils with percolation rates in the vicinity of 60 minutes per inch.

Rationale for the Components of a Refined Standard Percolation Test Procedure

Below is the rationale to support selection of specific refinements in percolation test procedures. The refinements are discussed under the major topics of test hole excavation, hole diameter, sidwall and bottom protection, water height, and water height measurement.

Digging the percolation test hole:

> The test section (bottom 8-12 inches) of the test hole should be dug by a manual auger. Power augers may be used to reach the test section depth, but must not be allowed to continue beyond this depth. An auger will maintain a uniform hole cross-section geometry throughout the test section. The use of a hand auger will enable a careful examination of soil characteristics, especially in the test section. Sidewall soil compaction caused by power augers will be avoided.

Diameter or size of test hole:

Literature varies on the recommended size of the test hole. Ryon's original test hole was one foot square. Winneberger and the San Francisco Regional Board Guidelines recommend a hole 12 inches square or 14 inches in diameter (1 & 3). The USPHS Manual of Septic Tank Practice allows a hole 4-12 inches in diameter, or one foot square. The draft EPA Manual for On-Site Wastewater Treatment and Disposal Systems (5) recommends a hole 6-9 inches in diameter. Caltrans recommends a 6-inch diameter hole (2). A review of local and regional; regulatyory agencies indicates that practices vary.

Ryon's original hole was 12 inches square and had a 6-inch test depth (6). The various procedures for converting percolation test results to soil absorption system size trace their origins to Ryon's original percolation test procedures. Since this work forms the cornerstone of today's design procedures, it is important that any recommended percolation test provide results commensurate with Ryon's test procedure.

An additional consideration for standardization is to select a geometry minmizing excavation energy while providing a sufficient cross-section for effective side wall sacrification, final side wall inspection and the placement of a side wall gravel pack when required.

The excavation of a 12-inch square hole require great care to maintain a uniform cross-section over the bottom 6 inches of depth and requires the excavation of a considerable quantity of soil especially at a 3 or 4-foot test depth.

A 6-inch diameter hole can effectively meet the uniformity requirements with test depths to 4 feet while minimizing excavation energy and providing effective side wall access. The 6-inch diameter hole is used by several counties and regional regulatory agencies, Caltrans (2), and falls within the range of the USPHS Manual and the EPA draft manual (5). Six inches is also a standard hand auger diameter.

The use of the 6-inch diameter hole requires adjustment of resultant percolation values to those representative of Ryon's 12-inch square test hole.

The following routine derives a correction factor, F, based on surface area to volume ratios which is multiplied by the results (minutes/inch) of the 6-inch diameter test to result in a value (minutes/ inch) representative of Ryon's 12-inch square standard hole:

Percolation surface areas (6-inches deep)

6 inch diameter hole = 141 square inches

12 inch square hole = 432 square inches

Volume of hole (6-inches deep)

6 inch diameter hole = 170 cubic inches

12 inch square hole = 864 cubic inches

Surface area to volume ratio

6 inch diameter hole	0.83
12 inch square hole	0.50

Factor (F) to adjust the results of the 6-inch diameter hole to the 12-inch square hole: 0.83/0.50 = 1.66

F = 1.66

When multiplied by the resultant time for the 6 inch diameter hole test depth to drop 1 inch, the result will be adjusted to the result from Ryon's standard 12 inch square hole. Results are reported in minutes/inch.

Sidewall and bottom protection:

While not mentioned in the USPHS Manual, other literature recommends the protection of sidewalls for those soils whose sidewalls cave in during testing (1, 2, 3, & 5). The most common form of protection is use of a perforated pipe with an external gravel pack (1, 2, & 3). All references use 2 inches of pea gravel at the base of the hole to prevent bottom scouring when adding water. An excellent method for retaining the side wall gravel pack is the use of 1/8 inch mesh galvanized hardware cloth rolled into a 4 inch diameter cylinder having sufficient length for the test. This simplifies the adjustment computations of the test hole liquid volume by not requiring the consideration of the gravel retainer displacement in addition to the gravel. The use of pipe requires consideration of its volume in deriving the test volume adjustment. Hardware cloth is economical and is readily available. It requires no shop work to apply it to this use.

The use, when required, of gravel side wall protection necessitates the use of a correction factor, C, to allow the volume reduction of the test water due to the gravel volume. The factor is based on the gravel percent voids (volume of gravel voids/total volume of gravel) and many be derived as follows:

Volume of unobstructed 6 inch diameter hole (6 inch deep):

$$\pi r^2 h = 3.14\ (3)^2\ (6) = 170 \text{ cubic inches}$$

Liquid volume of 6-inch hole (6 inch deep) with 1 inch wide pea gravel annular fill:

Volume of 4-inch diameter hole (6 inch deep) +

Liquid volume of the 1 inch wide annular pea gravel wall =

$3.14(2)^2(6)$ + (percent voids/100) x $[3.14(3)^2(6) = 3.14(2)^2(6)]$ =

75 + (percent voids/100) x (170 - 75) =

75 + 95 (percent voids/100) = 75 + 0.95 (percent voids)

The correction Factor C is therefore the unobstructed volume/the liquid volume of the hole with the pea gravel side wall protection.

Hence:

C = 170/[75 + 0.95 (percent voids)]

This factor is multiplied by the resultant time for the test water to drop 1 inch. The result is equivalent to the result obtained with the 6-inch diameter hole without the pea gravel sidewall protection.

Height of water during the test:

The test procedure should minimize the water fluctuation enabling a more consistent percolation rate. The USPHS Manual and several local and regional procedures allow the test depth to vary over 4 to 6 inches or more during the test. Several procedures recommend minimizing percolation variation (1, 3, 5, & 6).

Ryon's original work measured the time required for 6 inch deep water surface to drop 1 inch. From this practice, the percolation test units of minutes per inch were derived. This procedure has two advantages.

1. The variation in head is restricted to 1 inch prior to readjusting the hole test depth.

2. The test procedure remains unchanged for rapid or slow percolating soils.

The test continues until three consecutive times for a 1 inch drop vary by less than 10 percent (1,3 & 6). This method has been selected for the refined percolation test procedure and will minimize the impact of test water depth variations on resultant percolation rate values. Since the water depth is 6 inches in both the refined percolation test procedure and Ryon's original procedure, the variations from Ryon's work due to head variation are eliminated.

Another method minimizing test depth fluctuations (5) takes measurements over 30 minutes or 10 minutes (depending upon soil infiltration capacity) and requires refilling the hole to a 6 inch depth (over the bottom gravel layer) prior to taking the next reading the same period (30 or 10 minutes) later. The test continues until the extremes of three measurements vary by less than 10 percent.

Measurement equipment and methods:

There are numerous simi-automatic techniques that can be used to monitor hole water level more accurately than the common batter board and tape measure method. One low-cost example from the literature (1) is presented below. Refer to Figure B 1 for a sketch. This method minimizes equipment complexities, and eliminates the errors discussed above.

The entire apparatus is mounted on a 1/2-inch diameter steel stake, 18 inches long, fitted with a sharpened end, which is driven into the soil adjacent to the test hole. A laboratory clamp is fastened to the steel rod and may be adjusted vertically, as required. The other end of the clamp has a thumb screw for extending another gripping clamp over the center of the test hole. This clamp can be procured from any laboratory supply house.

A 1/2-inch diameter acrylic tube 18 inches long is fastened in vertical position in the gripping clamp over the hole center. A 2-inch diameter spherical or cylindrical float (a float can be fashioned from a 300 ml polyethylene bottle) is used to monitor the water level. The float is weighted with sufficient sand to ballast it for floating half submerged with the weight of a rigid 1/8-inch diameter wire above it. The 1/8-inch diameter stiff steel or brass wire is fastened at the top of the float. The bottle's cap and all construction joints are sealed. The depth (draft) from the bottom of the float to its water line when floating in vertical position with the wire above, shall be carefully noted and recorded. The rod should be about 48 inches long and fitted with an index girdle every 12 inches along its length.

Each index should be a different color to easily distinguish them apart. Colored tape can work well for this application. The index wire extends through the center hole of the 1/2-inch acrylic tube. The acrylic tube is fitted with a permanently attached plastic index tape with the scale starting in the upper 1/4-inch of the tube's length and continuing to its bottom. The scale should be calibrated in inches and tenths. (SCALAFIX is one brand sold through laboratory supply houses). If this cannot be procurred, an appropriate scale may be etched on the acrylic tube and blackened with shoe polish. The laboratory clamp is then rased up and down along the steel stake with the float at the bottom of the hole on the gravel. The scale tube is adjusted until a convenient index on the wire corresponds to a point 6 inches minus the draft of the float lower than the zero index on the scale fastened to the plastic tube. The hole is filled gently with water for presoak until the wire index indicates approximately 6 inches above the zero point on the acrylic tube scale (water in hole: 12 inches above gravel). Presoak continues for four hours. The water level is maintained at 12 inches for this period. The next day, water is added or bailed from the hole thereby adjusting the scale to its zero point (6 inches of water over the gravel layer). A stopwatch is used to monitor time during the test. The hole is refilled with water to the zero point after every reading detecting a 1 inch drop in water level.

Refined Percolation Test Procedure

The following is a recommended refined standard test procedure employing the methods discussed above. If followed carefully, it will reduce the variability of results common to the percolation test procedure described in the USPHS Manual.

1. Dig a test hole 6 inches in diameter to the desired depth, depending upon site conditions, using a hand auger[1/]. Examine and record the soil type and texture every 6 inches over the depth of the hole. Special note shall be made of abrupt changes in soil type or the existence of any impermeable layers. The presence of soil mottling shall be noted thereby identifying a previously high groundwater condition. The test hole side walls shall be scraped with a garden fork or a exposed nail point to remove any smearing effects of the digging equipment to a depth 12 inches above the base of the hole. Remove all loose earth.

1/ Power machinery may dig to within 12 inches of the hole bottom with the final 12 inches completed with a hand auger.

2. Prepare a cylindrical silt barrier form 4 inches in diameter and at least 24 inches long from 1/8-inch gird hardware cloth. Procure sufficient pea gravel to cover the bottom of the hole to a depth of 2 inches and fill the 1-inch annular space between the hardware cloth cylinder and hole sidewall to a minimum depth of 12 inches. Prior to placing pea gravel, determine the percent voids by placing the gravel in a vessel of known volume. Add water until the water level coincides with the level of gravel in the vessel. Pour off the water and determine its volume. The percent void is simply: (volume of water/volume of gravel) x 100. This value is used to adjust the percolation results to compensate for the volume displaced by the gravel in the annular space. Place the gravel over the hole bottom; place the pea gravel uniformly in the annular space between the hardware cloth and walls of the hole.

   The use of the hardware cloth and pea gravel annular silt barrier may be eliminated in soils having stable side walls. In these cases, one may eliminate the use of the gravel void correction factor as discussed below. The 2-inch thick gravel base shall be placed in the bottom of all test holes. Special care shall be taken to prevent erosion of the unprotected hole side walls when applying water for the tests not using the gravel packed side walls.

3. Install the float guage (See Measurement Equipment and Methods in the previous section for a discussion on the float guage and its use). Presoak the test hole one day before the test for 4 hours by maintaining the water level at a depth of 12 inches above the base of the hole. An

automatic valve is acceptable for regulating the 12-inch depth for the required 4-hour period(2). This will cause swelling of the clay minerals enabling a more realistic test result.

In sandy soils having a low clay content (the water drains from the hole in less than 10 minutes) the 4-hour presoak may be eliminated.

4. Perform the test the next day following the presoak. There are two cases:

   a. Water remains in the hole following presoak:

      If water remains in the hole, adjust it to 6 inches above the pea gravel bottom (8 inches above the soil bottom of the hole) by bailing any excess water over this level or adding if under 6 inches(5).

   b. The hole contains no water following presoak:

      If the hole contains no water, fill it to the 6 inch level.

5. Using a stopwatch, determine the time for the water to drop 1 inch using the float guage used during presoaking. Depth changes may be precisely determined with this guage. Similar arrangements such as hook guages and various calibrated floats are also acceptable. These methods provide resolution to the nearest 1/16 inch. Following each timed 1 inch drop in water level, the hole is readjusted to the original depth 6 inches above the gravel bottom with water. The process is repeated until each time varies by no more than 10 percent.

6. Percolation Value Standarization

The percolation rate is adjusted by two factors: C and F. The factor C adjusts for the presence of pea gravel side wall protection and the factor F adjusts the rate to Ryon's standard 12-inch square hole size.

If the side wall protection was used, the rate is adjusted as follows:

Standard percolation value (minutes/inch) =

Test percolation value (minutes/inch) x C x F

where:

C = 170/[75 + 0.95 (percent voids in gravel)]

F = 1.66

If the side wall protection is not used, the rate may be adjusted as follows:

Standard percolation value (minutes/inch) =

Test percolation value (minutes/inch) x F

where:

F = 1.66

The following example illustrates the adjustment of a test percolation value to a standard percolation value.

Example:

Assume final fime for a 1 inch drop was 25 minutes after getting less than 10 percent variation in the final three time readings (test percolation value).

The gravel percentage of voids is obtained by filling a 500 ml container with gravel. Water is added until its surface corresponds with the surface of the gravel at the 500 ml mark. All of the water is decanted into a graduate cylinder. The volume is 225 ml. Hence, the percentage of voids is simply

(225 ml/500 ml) x 100 = 45

The test percolation value is adjusted to allow for the gravel packed side walls (C) and the adjustment to Ryon's original test role size results (F). Therefore:

C = 170/[75 + 0.95 (percent voids)] =

170/[75 + 0.95 (45)] = 1.44

F = 1.66 for a 6-inch diameter percolation hole

Standard percolation value =

25 minutes/inch (C)(F) = 25 (1.44) (1.66) = <u>60 minutes per inch</u>

This value is then used in the design.

APPENDIX B REFERENCES

1. Winneberger, J. T. and J. W. Klock, Current and Recommended Practices for Subsurface Wastewater Systems in Arizona, Engineering Research Center, Arizona State University, 1973.

2. California Department of Transportation (Caltrans), Unpublished percolation studies at their Materials and Research Laboratory, Sacramento, California; 1979.

3. California Regional Water Quality Control Board, San Francisco Bay, Minimum Guidelines for the Control of Individual Wastewater Treatment and Disposal Systems, 1979.

4. Winneberger, J. T., Practical Uses of New Septic-Tank Technology, Journal of Environmental Health, Vol. 30, No. 3, Nov.-Dec. 1967.

5. Environmental Protection Agency and SCS Engineers, Manual for On-site Wastewater Treatment and Disposal Systems, Unpublished draft edition, 1979.

6. Winneberger, J. T., Ryon's Septic Tank Practices Corrected, National Home Sewage Disposal Symposium, Published by American Society of Agricultural Engineers, December, 1974.

FIGURES

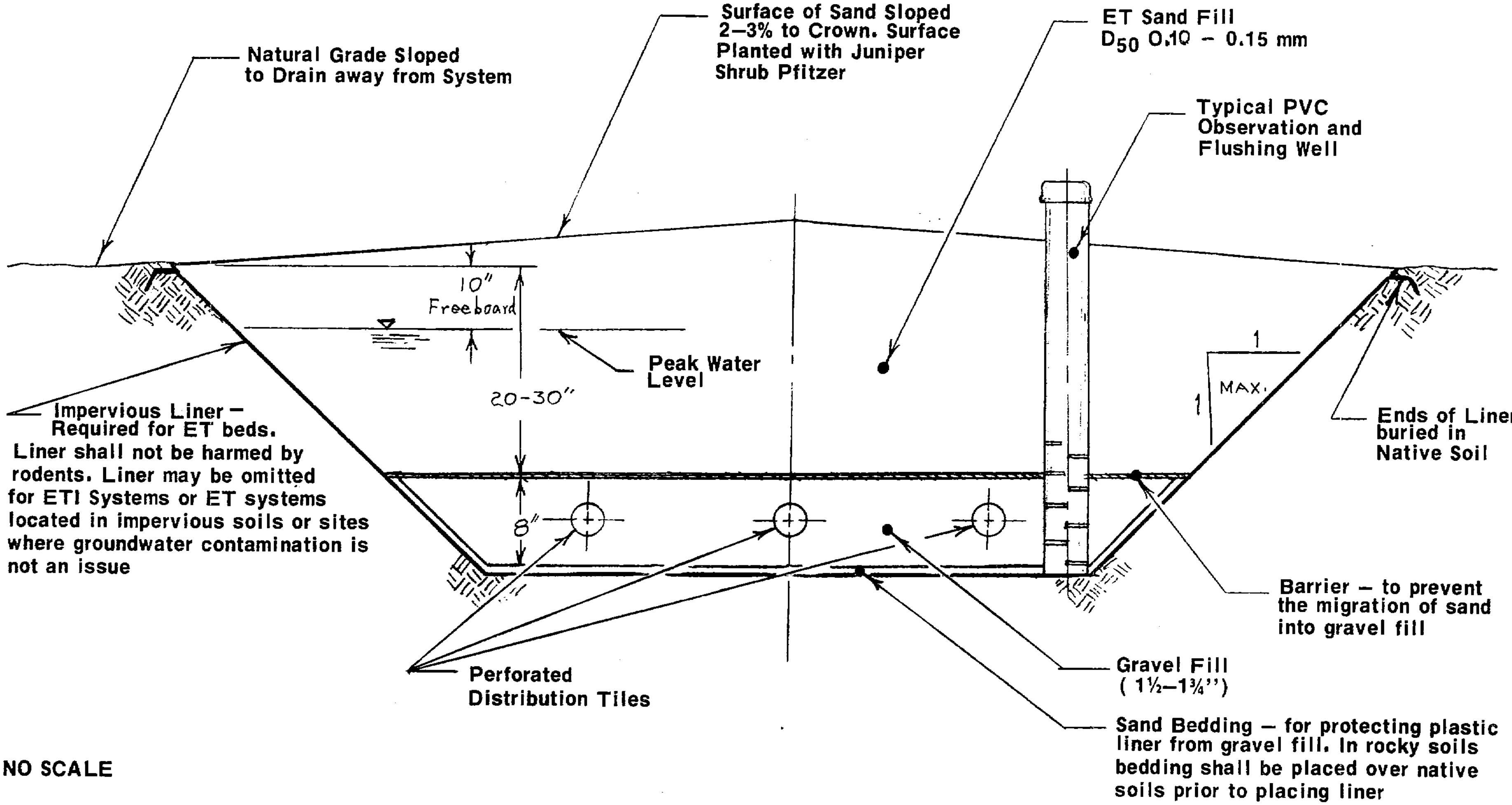


FIGURE 1. TYPICAL ET/ETI CROSS SECTION

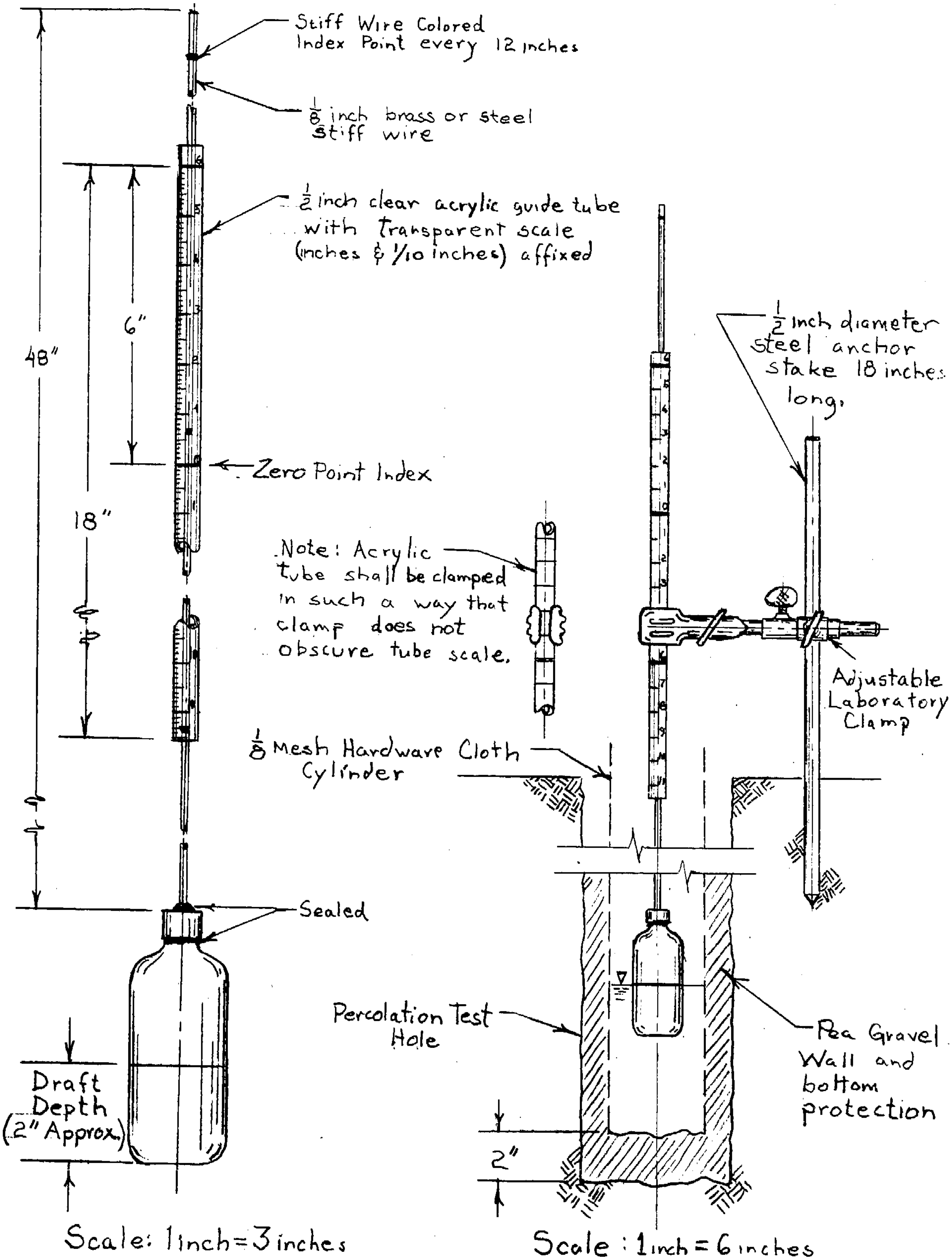


FIGURE B1. FLOAT GAGE AND PERCOLATION TEST ASSEMBLY

Reference: 1