DESIGN MANUAL

SUBSURFACE SEWAGE DISPOSAL SYSTEMS

FOR HOUSEHOLDS AND

SMALL COMMERCIAL BUILDINGS

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

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PART I

1. DOMESTIC SEWAGE

Subsurface sewage disposal systems designed in accordance with the requirements of Section 19-13-B103 of the Public Health Code, the Technical Standards and the engineering practices described in this manual are intended for the treatment and disposal of domestic sewage only. Domestic sewage consists of wastes incidental to the occupancy of a residence or small commercial building. It contains toilet wastes, laundry wastes, wash water, kitchen wastes and possibly wastes from garbage grinders. It may also contain small amounts of potentially dangerous chemicals such as paints and solvents which may be used in the home and which cannot practically be excluded from the disposal system. Wastes from small restaurants and commercial laundries are also considered as domestic sewage, although the composition is not typical, and therefore special design may be required for a subsurface sewage disposal system which receives them.

Table 2-1 lists the pollutants of concern in domestic sewage, the per capita contribution and the concentration range.

Table 2-1 - Pollutants in Domestic Sewage

Pollutant	Per Capita Contribution (grams/day)	Concentration in Domestic Sewage (mg/l)
Suspended Solids	35-50	200-290
Bio-chemical Oxygen Demand (BOD_5)	35-50	200-290
Total Nitrogen	6-17	35-100
Total Phosphorus	1-4	6-24
Grease & Oils	4-25	25-150
Coliform Bacteria	-	10^6-10^8 /100ml

A sewage containing chemical or biological pollutants and concentrations significantly outside this range, or which may contain non-biodegradable synthetic organics, carcinogens or biotoxins should not be considered domestic sewage, since it may not be properly treated or disposed of by subsurface sewage disposal systems designed to receive domestic sewage. These wastes must be disposed of in accordance with standards established by the State Department of Environmental Protection under permits issued by that agency. Following is a partial list of such wastes.

- Industrial process wastes
- Liquid agricultural manure
- Food processing wastes
- Car wash wastes
- Dry cleaning wastes
- Photographic wastes
- Slaughter house wastes
- Waste oils
- Waste from furniture stripping
- Milk Wastes

In designing and constructing a subsurface sewage disposal system, even one intended only for domestic sewage, it is necessary to know the various pollutants of concern in order to have an understanding of the possible effects on ground and surface waters. Following is a brief discussion of the various pollutants.

BIO-CHEMICAL OXYGEN DEMAND (BOD)

Bio-chemical oxygen demand, commonly referred to as BOD, is a measure of the amount of bio-degradable organic chemicals in the wastes. Sewage effluent contains a vast array of organic chemicals which are biodegradable to varying degrees under various conditions. It is not practical to measure them directly. Organic compounds are bio-degradable when common soil or water bacteria can utilize them as a source of energy or "food". When these chemicals are discharged into ground or surface water, the bacteria will bio-chemically combine them with oxygen dissolved in the water to produce bacterial cells. This reduces the amount of dissolved oxygen in the water. The amount of dissolved oxygen removed from the water is in direct proportion to the amount of biodegradable organic chemicals present, and this is the way they are measured. The BOD_5 test is a measurement of how much dissolved oxygen is removed from aerated water inoculated with bacteria, mixed with a sample of the sewage and held under standard conditions for a period of five days. This measure is of great environmental significance because of the undesirable effects which it can cause.

Ground water is said to be polluted when it contains potentially harmfully bacteria or bacteria producing undesirable physical characteristics such as taste or odor. Removal or depletion of the dissolved oxygen in the ground water also can produce undesirable chemical changes. Certain minerals normally present in soils, such as iron and manganese, are chemically reduced to more soluble forms and readily dissolved by oxygen deficient ground water. Rust colored deposits occasionally are found in streams draining built-up areas containing many subsurface sewage disposal systems crowded together in a small area. These deposits do not result directly from bio-degradable organic chemicals in the water itself, but rather are due to the leaching of inorganic iron caused by oxygen deficient ground water. The soluble iron in the water is oxidized upon contact with the air producing the undesirable deposits.

A properly functioning septic tank will reduce the BOD in the effluent by about 25 to 30 percent. Greater reductions occur when the septic tank is compartmentalized. Further reduction occurs as the effluent comes in contact with bacterial growth in the leaching system and the aerated soil zone above the ground water table. The amount of reduction depends on the volume of bacterial growth in the leaching system, the manner in which the effluent is distributed throughout the system, the availability of oxygen and the contact time. A large leaching system constructed in moderately permeable soils and effectively dosed is quite efficient in reducing BOD, and is unlikely to cause any significant ground water pollution. On the other hand, leaching systems constructed in highly permeable soils, particularly where the ground water is shallow, may have an adverse affect on ground water, since in this case the amount of bacterial growth in the leaching system would be relatively small, distribution through the system might be quite irregular and movement of the effluent through the soil would be rapid.

NITROGEN

Nitrogen in domestic sewage and sewage effluent exists in different chemical forms depending on the degree of oxidation. Fresh sewage is high in organic nitrogen. This will first break down into ammonia nitrogen. In the presence of oxygen, ammonia nitrogen is quite rapidly oxidized, first into nitrite nitrogen (NO_2) and subsequently into nitrate nitrogen (NO_3). This oxidation process primarily takes place near the infiltrative surface of the leaching system. Nitrate nitrogen is an essential nutrient for the growth of plants and algae, and is an end product of any properly functioning leaching system. Nitrates are not readily removed by filtration through soil, so that ground water underlying a leaching system would receive a certain amount of nitrate "fertilization". Typically, septic systems remove approximately 30% of total nitrogen with the remaining 70% being discharged to the ground water.

There are many other nitrogen sources in the environment which also will contribute nitrates to the ground water, such as fertilizers, rotting vegetation and the atmosphere itself. For this reason, it is usually not practical or necessary to try to design small subsurface sewage disposal systems for nitrate removal. An exception to this might be in heavy developed lakeside property where nitrates from subsurface sewage disposal systems could be a significant source of nitrate fertilization of the lake water, which would cause undesirable algae blooms. Excessive nitrate levels in drinking water wells could be a hazard to the health of infant children who consume the water regularly. However, it is extremely unlikely that domestic subsurface sewage disposal systems could ever produce hazardous nitrate levels in wells as long as the separating distances required by the Public Health Code are provided.

PHOSPHATE

Phosphate in another nutrient which is essential for plant growth, but unlike nitrate, only a small amount may be required to stimulate a considerable algae growth in surface water. Domestic sewage contains small, but significant amounts of phosphates. Fortunately, research has shown that phosphates in sewage combine readily with certain minerals normally present in soils, such as iron and aluminum, to form insoluble deposits which are readily removed by filtration through only a foot or two of soil. Since these minerals are generally abundant in Connecticut soils, it is unlikely that properly designed subsurface sewage disposal systems would be a significant source of phosphate pollution.

COLIFORM BACTERIA

Coliform bacteria are a type of bacteria which are indigenous to the intestinal tract of humans and warm-blooded animals. Therefore, they are always present in sewage. While they are not necessarily harmful themselves, the presence of coliform bacteria indicates that disease causing pathogenic organisms might also be present. High concentrations of coliforms are found in the septic tank effluent and throughout the leaching system. They are removed by filtration through the soil and are rarely found to pass through more than three to five feet of unsaturated soil, or ten to fifteen feet of saturated, naturally occurring soil. It has also been shown that the survival of this bacteria seldom exceeds 10 days if confined to unsaturated soils. The principle factor determining the survival of bacteria in soil is moisture. In view of this, the minimum separating distances required by the Public Health Code between sewage disposal systems and wells or surface waters may seem to be very conservative. However, these separating distances are mainly based on the possibility of disease transmission by viruses in contaminated ground water.

Viruses are smaller than bacteria and are not as readily removed by filtration. Also, viruses are better able to survive in harsh environments than coliform bacteria, and therefore require a much longer time for natural die-off in ground water. Presently a 21 day minimum travel time is desired for proper viral renovation.

The presence of even one coliform organism in ground water may be taken as an indicator of possible sewage pollution. However, coliforms in surface waters do not necessarily indicate sewage pollution, since sewage is not the only source of coliforms in the environment. A more detailed discussion of coliform levels in surface waters may be found in Chapter 27 of this manual.

HAZARDOUS CHEMICALS

Domestic sewage must be considered to possibly contain some of the more hazardous chemicals such as paints, solvents and chlorinated hydrocarbons. These chemicals are considered to be hazardous because they will readily pass through a subsurface sewage disposal system and enter the ground water. Many of them are known to be cancer producing agents, and even small amounts of such chemicals in a water supply well could present a health hazard. Presumably, the amount of such chemicals in domestic sewage would be extremely small on the average, but some home activities as photographic development, furniture refinishing, metal working, arts and crafts could result in significant amounts of hazardous chemicals being discharged carelessly into the subsurface sewage disposal system. It is probably neither practical nor necessary to attempt to exclude such chemicals from all sewage disposal systems. However, special consideration should be given where domestic sewage systems are located within the drawdown area of a public water supply well. It may be necessary to limit the number of subsurface sewage disposal systems in such a location, in order to be assured that there will be sufficient dilution of these hazardous chemicals before they enter the water supply. Homeowners within public water supply aquifer areas should be educated about careless dumping of paints, solvents, etc., on the ground or into the subsurface sewage disposal system, and commercial or home businesses which generate such wastes may have to be restricted in these areas.

NON-TYPICAL DOMESTIC SEWAGE

Most domestic subsurface sewage disposal systems receive wastes from kitchens and laundries. The kitchen waste may sometimes include garbage grinders. However, there are occasions when a separate subsurface sewage disposal system is provided for this waste, or where the amount of such wastes received is disproportionate to the overall sewage volume. An understanding of the particular characteristics of each waste is necessary in order to properly design a modified subsurface sewage disposal system.

Kitchen wastes are relatively high in grease, containing approximately five times the concentration of domestic sewage. The wastes may also be quite warm due to the amount of hot water used in machine dishwashing. This, together with the high detergent level in the waste, tends to keep the grease in an emulsified condition so that it is not easily removed by floatation or settlement in the septic tank. Grease removal is enhanced by mixing the kitchen wastes with cooler sewage such as toilet wastes. For this reason, it is not advisable to construct separate systems for kitchen wastes.

Wastes from garbage grinders are extremely high in settleable solids, as would be expected. However, they are also very high in grease, due to ground-up foods, and BOD resulting from organic decomposition in the septic tank. Garbage grinders are not recommended for residential systems served by subsurface sewage disposal systems. Increasing the size of the septic tank will provide more storage volume for settleable solids, but it will not necessarily reduce the BOD of the effluent unless the tank is pumped frequently. Experience has shown that pumping the septic tank more frequently is more effective in preventing problems resulting from garbage grinders than by increasing the tanks size itself.

Laundry wastes are normally low in nitrogen and high in phosphates. This has a tendency to retard bacterial action in a septic tank which receives only this type of waste, but should have no adverse affect when discharged to a septic tank which also receives toilet wastes. Laundry wastes also contain cloth fibers called lint which bio-degrade very slowly. It also contains a surprisingly high amounts of oils and coliform bacteria, presumably shed from the body on soiled clothes. Laundry wastes can cause excessive clogging of soil by the formation of a mat formed from strained lint and emulsified oils, and by inorganic phosphates. Some type of filtration system for lint removal ahead of the septic tank is beneficial for commercial laundry systems**.** Outlet filters can also be utilized to prevent lint and other fibrous material from entering the leaching field.

The backwash from swimming pool filters is quite high in settleable solids, but the solids themselves are relatively stable. Pool filter backwash shall be directed to a dedicated leaching system or on to the surface of the ground as provided by DEP's General Permit for this type of discharge. It is not advisable to discharge the backwash into the septic tank serving the building since the hydraulic load created would have a tendency to wash solids from the tank into the leaching fields..

2. DETERMINING DESIGN SEWAGE FLOW

The Public Health Code specifies design requirements for subsurface sewage disposal systems serving residential buildings which are different from those serving non-residential buildings. There are two practical reasons for this. Firstly, it is logical to relate the size of the sewage disposal system to architectural features of the building served, wherever possible, since the system is a permanent attachment to the building. This can conveniently be done by basing the size of the sewage disposal system of a residential building on the number of bedrooms it contains. Secondly, subsurface sewage disposal systems serving owner-occupied dwellings must be designed on a much more conservative basis than those serving other buildings since it is almost impossible to condemn such a dwelling because of a failing sewage disposal system which cannot be corrected. The economic and social hardships presented by putting a family out of a home in which they have invested their life savings are such that regulatory officials usually must resort to less satisfactory abatement methods, such as holding tanks and reduced water use, which are objectionable to the residents and difficult to enforce. Non-residential buildings present a different situation, of course. A restaurant or other high water use facility may be converted to a retail store or low water use facility, without any undue economic hardship. Also, there is more latitude for the use of water reducing fixtures and water conservation. It probably also would be possible to condemn a non-residential building within the legal and political structure if abatement is impossible by any other means.

RESIDENTIAL BUILDINGS

The size of the septic tank and leaching system serving a residential building is related to the number of bedrooms, without consideration of the number of occupants or the water consumption. The requirements in the Technical Standards may appear to be extremely conservative, considering that the size of the average family has been decreasing and now consists of less than three persons, and considering that studies have shown per capita water consumption to average approximately 50 gallons per day. On the other hand, it must be realized that sewage disposal requirements cannot be based on average figures, since if this were done, one-half of all the systems would be substandard and in danger of failing. A factor of safety of 1.5 is required to bring the confidence level to over 90 percent, for the reasons previously described. Therefore, in water usage terms, the design flow for each bedroom has been set at 150 gallons per day. This is based on two occupants. each averaging 50 gallons per day, with a 1.5 safety factor applied. The 150 GPD per bedroom usage factor would be utilized whenever performing hydraulic analysis calculations for residential buildings. The leaching system sizing tables in the Technical Standards utilized this flow rate to determine the effective leaching area per bedroom. No new residential building should be constructed except on this basis of design.

REVIEWING THE HOUSE PLANS: The design of sewage disposal systems in repair situations is relatively simple due to the fact that the number of bedrooms in an existing house can be provided by the licensed installer, the design engineer or the property owner during the application phase of the repair process. If there is a question, the sanitarian could request the property owner to allow access to the dwelling in order to confirm the basis of design. This process becomes much more complex with respect to proposed new home construction, particularly when permits are requested and approved prior to the final determination of what the house may look like. For that reason, it is essential that the basis of design be based on very detailed house plans and those plans be incorporated as part of the sewage disposal review process. In order to reduce the risk of any miscommunication, a copy of the house plans should be signed off by the health department and forwarded to the town building official prior to issuance of a building permit.

DEFINITION OF A BEDROOM: Within today's custom homes it is not uncommon to see exercise rooms , sewing rooms, studies, offices, dens, family rooms and other similarly labeled non-bedroom spaces shown on residential house plans. However, these same rooms can and are used as bedrooms when a family grows or the house is sold to another family which has different needs. To make sure the home is served by a sewage disposal system which is sized properly, the system must be based on the potential number of bedrooms in the house.

There are certain standards by which a room can be deemed a potential bedroom. They provide:

1. A defined habitable space per Building Code requirements. The exception to this statement would pertain to obvious future habitable space (such as the unfinished second floor in a "cape" style home) which has the appropriate structural shell but has not been "finished" to meet Building Code standards for habitable space.
2. Privacy to the occupants.
3. Full bathroom facilities (containing either a bathtub or shower) which are conveniently located to the bedroom served.
4. Entry from a common area, not through a room already deemed a bedroom.

Consideration should be given to the number of rooms in a new dwelling which may be used as bedrooms, even though the builder may not intend to use them as such. This is particularly true for homes built on speculation, since the builder has no control over who purchases the dwelling. Generally, all rooms on the second floor of a two story house, except for the bathroom and hallway, are considered bedrooms. Two bedrooms houses are allowed by the Public Health Code. However, such buildings would be expected to be relatively small in total floor area.

A significant number of homes are being constructed with habitable space above a two or three car garage. This space may be accessible from either the first or second floors or both. They are typically labeled as second floor playrooms or bonus rooms, may be quite large in area and have the potential to be a bedroom. Using the above criteria, this space should be deemed a bedroom when access is from the second floor and a full bathroom is readily available. The same designation would apply if access were provided from both the second and first floor. It would not be designated a bedroom if the only way to gain access to this area above the garage were perhaps from a first floor stairway when the first floor does not have a full bathroom facility, or access is from the garage.

Some latitude can be applied to the above when dealing with large homes, consisting of more than 5 bedrooms. It would not be unusual for this type of home to have a truly functional library, an exercise room, or a home office. However, before a bedroom designation can be made there should be some architectural feature which would typically exclude it from being used as a bedroom (such as, bookshelves around perimeter of library, sauna built into exercise room, etc.).

Rooms on the first floor of two story homes are generally easier to deal with. If rooms do not have access to full bathroom facilities on the first floor or are constructed with large archways, or, where entrance is through another room, they would not be deemed bedrooms.

Basement areas can be utilized for bedrooms in certain circumstances. Walk-out basements with large windows, sliding glass or conventional doors could allow the area to be converted to a bedroom in the future. The key to this situation is the availability of plumbing fixtures on this level of the house. Plumbing plans should be examined at the time of initial construction to determine if plumbing will be “roughed in” which would provide access for future bathroom facilities. If a full bathroom (with a tub or shower) is shown on the plans then all rooms in the basement area shall be considered bedrooms when they meet the aforementioned “potential bedroom” standards.

It is also a phenomenon of the 90’s that large homes are being built for “small” families. The two person occupancy per bedroom used for design purposes is not realistic for many single family homes that exceed four (4) bedrooms (there are just not a lot of families which consist of 10 or more people). It is for that reason that a reduction in the sizing tables for leaching systems serving single family homes is being considered for homes which exceed four (4) bedrooms.

WASTE DISTRIBUTION: There may be a situation where a residence will be served by more than one subsurface sewage disposal system and the total sewage flow divided between the two systems, in accordance with the sanitary fixtures which they serve. This is not very desirable from the design standpoint since the characteristics of the wastes and the functioning of the sewage disposal systems may be altered. The Public Health Code requires that the subsurface sewage disposal system receiving the toilet wastes be large enough to meet the requirements for the entire house, and the other system to be at least one-half the size required for the full house. This requirement is based on the following normal distribution of sewage flow from a residence, with a factor of safety.

Usage	Per Cent of Total Flow
Toilets	40
Bath and Shower	30
Laundry	20
Kitchen	10

In most split systems, the toilet and bath water goes to one system and the kitchen and laundry to the other, although occasionally only the laundry system is separated.

The volume of sewage flow from a residence will fluctuate considerably during the course of a day, and from day to day. However, the peak discharge rate is not a critical factor in the design of a residential sewage disposal system. Peak flows are unlikely to exceed 100 gallons per hour or 20 gallons a minute, and these should not interfere with the functioning of a properly designed septic tank.

NON-RESIDENTIAL BUILDINGS

Non-residential buildings are designed on the basis of the estimated 24 hour sewage flow. A list of estimated flows for certain non-residential buildings is included in the Technical Standards. These figures include a factor of safety. Non-residential buildings also may be designed on specific flow figures obtained for the particular type of facility to be constructed. However, the design engineer must include a factor of safety in this figure. For instance, water consumption figures may be available for a chain of fast food restaurants or supermarkets which would be acceptable as a design basis for similar facilities in Connecticut. In such a situation, an average flow figure for 3 to 5 such establishments maybe used with a factor of safety of 1.5 to 2.0. Lacking any specific information, the flow figures in the Technical Standards should be used.

Unlike residential buildings, the peak flow for certain non-residential buildings may be a critical design consideration. Buildings such as churches and athletic stadiums have extremely high one day flows, but relatively low weekly average flows. In such a situation, the septic tank is normally designed for the peak day flow, but the leaching system could be designed for an average flow over a few days to a week providing there is sufficient storage volume in the leaching system to hold the peak flows. Sewage would fill up the leaching system during the peak day and leach away into the soil before the next peak. Leaching galleries or pits are usually used in order to provide sufficient storage of peak flows. Some facilities such as parks and recreational camp grounds have very high three day flow on certain week-ends, but lower flows during other times. The subsurface sewage disposal system should be designed for these peak flow periods.

SEWAGE FLOW REDUCTION BY USE OF SPECIAL SANITARY FIXTURES

Subsurface sewage disposal systems serving new buildings normally should not be based on a low design flow due to the use of sanitary fixtures which reduce the amount of water used. Such sanitary fixtures do not always prove to be acceptable to the users, and they may subsequently be replaced by conventional fixtures. This is difficult to prevent, particularly in residential buildings. However, there are situations where the use of low flow sanitary fixtures is desirable in order to abate an existing sewage overflow. The only reliable way to produce a significant volume reduction is by the use of special toilets or toilet appurtenances. Tank inserts may be used which reduce the volume of flushing water in the tank. Some toilets have adjustable flush controls which allow either a large volume or a limited volume flush. Other types have a specially designed bowl for a reduced flush volume. Connecticut has passed legislation which requires that all new toilets discharge a maximum 1.6 gallons per flush. In general, these types of low water flush toilets will reduce the volume of toilet wastes by 25 to 50 per cent and reduce the total sewage flow by 5 to 15 per cent produced from fixtures used in older homes. There are also available special toilets which provide only a minimum bowl rinse, or which use vacuum or compressed air assisted flushing water. In general, these toilets will use only about one gallon per flush and will reduce total sewage volume by 20 to 30 per cent. There are also non discharging toilets which would reduce the volume of sewage generated in a household by about 40 per cent. A more detailed discussion of the various types of low water use toilets may be found in Part II of the manual.

Pressure reducing attachments on shower heads and sink faucets also will tend to reduce water consumption. However, it is doubtful that it will produce much over 5 to 10 per cent reduction in total sewage volume. The amount of water used for sanitary fixtures other than toilets is controlled mainly by the habits of the users, not by the sanitary fixture itself. When the desire is strong enough, it is possible to make extreme reductions in water consumption. This has occurred in some cases, such as where a holding tank is used which must be pumped periodically at a considerable expense. However, it is not advisable to rely on reducing sewage volume in this manner.

3. SITE INVESTIGATION

The importance of the site investigation cannot be over-emphasized. A careless or incomplete site investigation which fails to identify soil limitations, such as seasonal high ground water or underlying ledge, is the cause of a high percentage of sewage disposal system failures. Certain planning must be done even before going to the site, and the investigation itself must be sufficiently thorough as to identify all the soil conditions which could affect sewage disposal. Reinvestigation is expensive and time consuming, and therefore is unlikely to be done simply to obtain information which was overlooked initially. If the investigation is done properly, immediately afterwards it should be possible to make a general conclusion as to the suitability of the site for sewage disposal purposes and specific recommendations for the design of the sewage disposal system. In certain cases, additional investigation for maximum ground water levels may be necessary, but it should be possible to develop a procedure and schedule for obtaining this information on the basis of the original site investigation.

PREPARING FOR THE SITE INVESTIGATION

There is a considerable amount of information relative to land use and development which sanitarians and engineers should review and be familiar with before making any site investigation. First of all, the investigator should know the type and size of the building which is proposed for the site. Obviously, large commercial buildings or apartments would require larger sewer disposal systems than single family homes, and therefore the area of the site to be tested must be larger. The investigator should also be familiar with local planning and zoning requirements. For instance, if 100 foot setbacks are required from watercourses, it would be foolish to test any area located within 100 feet of a stream. If the property to be tested is located within an approved subdivision, it is probable that the site has been tested previously. These tests results should be reviewed, if available, prior to the investigation, since they might be helpful in indicating the type of soil conditions to look for. The availability of public water supply mains and public sewers should also be checked prior to the investigation because these would have considerable bearing on determining the suitability of the site and the location of the sewage disposal system. A water supply well would not be necessary if the public water supply were available, and more of the lot area could be used for sewage disposal purposes. If public water supply is not available, it would mean that there may be wells on adjacent lots which must be located, either from review of health department records prior to the investigation, or from inquiries made during the investigation. Reserve area for enlargement of the leaching system will not be required if public sewers were scheduled within five years, so that the area to be tested could be reduced. Also, it would be likely that the sewage disposal system would be located between the proposed building and the street to facilitate the future sewer connection. It also may be necessary to check information regarding the location of high volume public water supply wells and public water supply reservoirs and watersheds. Special design considerations may apply in these locations, and the investigator should be aware of it before he goes on to the site.

Certain types of soil and geological information may be available on maps published by the U.S. Government. Review of these maps will be helpful in indicating the type of soil conditions to expect, but should not be used in place of a site investigation. The U.S. Geological Survey publishes a series of topographic maps on a scale of 1:24,000 showing ground contours, hydrographic features, such as streams, swamps, etc., streets and buildings. An effort should be made to locate the site to be tested on these maps before making the investigation. If this is not possible, the appropriate map should be taken along and the site located on the map in the field. An experienced investigator can tell much about a site from its location in the general topography of the area. The U.S.G.S. also publishes surficial geology maps which classify the soils overlying bedrock on the basis of their geological formation. The classification is not detailed, but can be helpful in identifying such features as flood plains, alluvial terraces and drumlins, which exhibit certain characteristic soil conditions. The National Cooperative Soil Survey published by the Soil Conservation Service, uses a more detailed soil mapping system. Soils are classified on the basis of certain characteristics, such as texture, structure, color consistency and drainage. The maps reflect soil profiles to a depth of about 5 feet. Therefore, they may be generally useful for evaluating soils for subsurface sewage disposal purposes. However, they are not sufficiently accurate to be used in place of a site investigation. Their main value is in indicating wetlands or soils with a seasonally high ground water table, which must be carefully evaluated before any sewage disposal system is designed. See the Chapter on “Soil Identification” for a more detailed discussion of the use of the soil survey maps.

Certain arrangements should be made by the applicant or his representative for the scheduled time of the investigation. Normally, a back hoe and operator, another person with a hand shovel and about 40 gallons of water are required. It also would be desirable to have on hand several 10 foot lengths of rigid plastic pipe which could be placed in the deep pits as monitoring wells for ground water before backfilling. A plot plan must be provided. As a minimum, the plan must show property lines accurately and indicate some landmarks which can be located easily in the field, such as stone walls, fences, survey markers or numbered utility poles. Property lines should be flagged or staked where suitable landmarks are lacking or are difficult to find, such as in proposed subdivision lots located away from existing roads. It may be necessary to do some clearing of trees and brush on the site to make it accessible to digging equipment. The owner, builder or engineer must be available on the site at the time of the investigation, in order to answer any questions which the investigator may have.

Engineers and developers should carefully consider testing needs prior to hiring a backhoe for site testing. If deep leaching structures are contemplated, such as galleries or pits, conventional rubber tired backhoes may have great difficulty in digging a deep enough test hole for evaluation. In such cases, it may be economical to rent a large, track-mounted backhoe for rapid, definitive exploration. Terrain and weather conditions may also dictate tracked equipment for efficient testing.

DETERMINING WHEN TO MAKE THE SITE INVESTIGATION

In general, site investigations may be made at any time of the year. However, on some sites it may not be possible to determine the maximum ground water level accurately unless the investigation is made during the season when the ground water is high. The Public Health Code gives the director of health the authority to require that the maximum ground water levels in areas of special concern be determined by investigation made between February 1 and May 31, or at such other times as the ground water is determined to be near its maximum level by the State Department of Public Health. This does not mean that all testing for ground water must be done at this time, even for areas of special concern. This frequently is unnecessary, and can present a hardship, both for the property owner and for the local health department. There are many sites where the maximum ground water level can be determined quite accurately by other methods, such as soil mottling. If there is general agreement between the engineer and the sanitarian as to the maximum ground water level and the design of the sewage disposal system, additional ground water investigation during the wet season may not be required. This is more fully discussed in the chapter on "Determining the Maximum Ground Water Level".

While the maximum ground water level almost always occurs sometime between February 1 and May 31, there may be other times when the level is sufficiently high to allow a reasonably accurate determination to be made of the maximum level. The State Department of Public Health utilizes monitoring information supplied by the U.S. Geological Survey which documents monthly ground water levels in various locations throughout the state. When levels are found to be at or above mean springtime elevations, the allowable testing period may be extended by the State Department of Public Health. Variations in water levels in the U.S.G.S. wells are used as an indicator of the general ground water levels within a town or region. The range of such variations may be quite different from well to well, however, depending on the construction of the well and its geological and topographic location. Water level readings in observation wells cannot be used to adjust ground water level readings taken at other locations. For instance, the water level in an observation well which seasonally rises and falls about three feet may be observed to be one foot below its normal maximum. This does not mean that the maximum ground water level at another location can be determined by adding one foot to the observed level at that location, since the ground water level at that particular location may rise and fall seven feet during the year.

The real danger in making site investigations during a dry season is not the inability to determine the maximum ground water level accurately, since this also can be done by additional investigation or monitoring during a wetter season. Rather, it is the possibility that a seasonal ground water condition may be completely overlooked. This probably is more likely to occur where the soils are fairly well drained, than where the soils are poor and evidence of seasonal ground water is obvious. For this reason, some town health departments do not allow site investigations to be made during certain months of the year. Fortunately, experience has shown that 80 to 90 percent of the time that an investigator had failed to identify a seasonal ground water condition was when the investigation was made during the months of July, August or September. Therefore, there probably is some basis for restricting site investigations during those months. However, there is little justification for requiring all site investigation to be made only during the wet season, since a trained and careful investigator should be able to make a valid assessment of ground water conditions at most times of the year. A technique sometimes used in dry soil conditions in order to enhance coloration and improve identification of mottles is to moisten the side of the test hole with water from a spray bottle.

MAKING THE SITE INVESTIGATION

Before any test holes are dug, the investigator must determine the location of the property lines, the probable building location and the location of existing wells on adjacent property. It should be kept in mind that the sewage disposal system normally is located down slope from the building served, in order to allow gravity flow without placing the leaching system too deep in the ground. Some investigators make the mistake of testing the highest part of the property because it appears to have the best soil. In fact, this would be the least likely area to be used for sewage disposal purposes. The well, if required, should be located on the higher portion of the lot, uphill from the sewage disposal system. However, the location of both well and sewage disposal system may depend on the location of wells and sewage disposal systems on adjacent lots.

Once a likely location has been selected, the probable depth of the leaching system must be decided. Leaching systems on a level lots are usually somewhat deeper than on sloping lots, and if it is necessary to locate the sewage disposal system upgrade from the building, it could be quite deep. If leaching pits or deep leaching galleries are used, the bottom of the leaching system could be up to eight or ten feet deep. It also should be determined from the builder whether or not basement fixtures will be used. Split level houses and raised ranch houses usually require deeper sewers, since sanitary fixtures are on the lower floor. The builder should be questioned about this. It should also be determined whether or not there will be any regrading done in the area of the building and sewage disposal system, since this will affect the depth to which the soil must be tested.

MINIMUM NUMBER OF DEEP TEST AND PERCOLATION HOLES

A minimum of two or three deep test holes should be dug in the area of the proposed leaching system to a depth of four feet below the probable bottom of the deepest leaching unit. Such holes are normally at least seven feet deep and may be considerably deeper. At least one percolation test should be conducted at the probable depth of the bottom of the primary and reserve leaching system areas. A much greater number of deep pits and percolation tests should be made if there are any significant variations in the soil characteristics, either in depth or from location to location, or if shallow ledge rock is found. An effort should be made to lay out a series of test holes in a grid arrangement where the sewage disposal system is large and will cover a considerable area, since this would provide more meaningful information than randomly located holes. At each test hole, the soil should be identified and the depth to ledge and ground water noted. When determining the percolation rate for sizing purposes, the Technical Standards require that it be based on representative test results. The number of percolation tests performed should be a function of the consistency of the results. If the soil conditions throughout the primary system area (and the reserve area if located directly downgrade of the proposed primary area) are consistent and the two initial percolation tests resulted in rates that are within the same sizing category than there would not be a need for further testing. However if the initial test results are not consistent then multiple percolation tests would be required. Tests would be concluded when 3 out of 4 percolation tests (75% or greater) resulted in rates which are within one sizing category.

The location of each deep test and percolation hole must be measured from a landmark and recorded on the plot plan or in the field notes. To avoid confusion, a north orientation should be determined or assumed in the field, and marked on the plot plan. The U.S.G.S. maps are helpful for this purpose. This should be the responsibility of the engineer or surveyor, if one is involved in the investigation. If the test holes indicate a probable seasonal high ground water condition, an. effort should be made to obtain as much information as possible relative to existing and proposed drainage improvements. Existing and proposed storm drains in the street should be noted because they may be necessary if foundation or curtain drains are required. Note also should be made of potential surface water drainage problems which might be caused by building or regrading, both on the property being investigated and on the adjacent property. These should be addressed on the sewage disposal plan before it is approved.

4. SOIL IDENTIFICATION

There are many ways that soils can be identified or classified. Geologists generally classify soils according to how they were formed, using such terms as "alluvium" or "terrace deposits". Soil scientists from the U.S. Conservation Service classify soils on the basis of the profile of the upper few feet of soil. Soils that have profiles nearly the same are given series names, such as "Paxton" or "Woodbridge". Civil engineers identify soils by describing their physical appearance, such as "light brown medium sand with a trace of silt". It may be difficult to understand how the same soil can be identified in three different ways. The fact is that soils do not exist in a limited number of distinct, uniform and consistent types. Rather, the variability of soils is infinite. They have been identified and classified by scientists or engineers in different ways for different purposes. Geological maps are used mainly to identify soil deposits for mining, aquifer development or large scale construction. The SCS soil survey maps were developed for agricultural or land use planning purposes, and the soil designations used by civil engineers are related to their use for construction purposes.

The civil engineering method of describing soils is the most useful one for subsurface sewage disposal purposes, since this is basically a construction activity. However, leaching systems normally are constructed in naturally occurring soils, and therefore information obtained from other sources, such as the soil survey maps, may also be quite pertinent. Satisfactory identification of a soil depends mostly on the experience and thoroughness of the investigator. The system of identification serves to record and transmit soil information in a clear and consistent manner so that it may be used for certain purposes, in this case the design of subsurface sewage disposal systems.

EXAMINING SOILS

Soils in a test pit must be examined at close range and felt with the hand. Examining the soil after it has been excavated can be misleading. For instance, hardpan often will have the appearance of a sandy or silty loam when broken up. The degree of compaction of a soil layer is difficult to determine unless the investigator enters the test pit and probes the sides of the pit with a stick or shovel. This also is necessary in order to determine the exact level at which changes in soil characteristics occur. These must be measured from a fixed reference point, normally the ground surface, so that the elevation of the various soil layers can be calculated and the leaching system elevation set properly relative to these layers. This cannot be over-emphasized, since a mistake of six or twelve inches in the elevation of a leaching system relative to hardpan or groundwater could cause the system to fail.

Coarse grained soils, such as sand and gravel, are readily identified by rubbing the soil between the fingers. However, some care should be taken to note the size and shape of the grains. Flat grained soils will compact easily and may cause trouble with leaching systems, particularly when used as fill material. Sand and gravels to be used as fill should be examined as to the uniformity of the particle sizes. If all of the particles are approximately the same size, it would be good for leaching purposes, but if there is wide range of particle sizes, it would be poor for this purpose. It should be noted that the term "well graded" is used to refer to a soil which has a wide range of particle sizes. The term originated because this type of fill material was best suited to road construction. It certainly would not be "well graded" for the purposes of sewage disposal.

Fine grained soils, such as silt, clay and even very fine sand, are difficult to differentiate either by sight or feel. Almost all Connecticut soils contain silt, and determination of the approximate amount of the silt in the soil is a critical consideration, since even small percentages of silt will greatly reduce the ability of a soil to transmit water. The amount of silt in a sand or gravel may be determined by placing a spoonful of the soil in a glass of water. The sand and gravel grains will settle almost immediately, while the silt particles will still be in suspension after five or ten minutes. Determination of the amount of silt in a loamy soil is more difficult. One way this can be done is by observing how easily the soil surface is smeared by digging equipment or in the hand, when moist. Soils with high silt content can be formed into a clod which can be handled without breaking, and when dried and pulverized on the hand, will have a feeling like flour or talcum powder. Some purer silts, lacking binders such as clay, will become elastic when saturated, and water may be squeezed from them. Soils with high clay content are rare in Connecticut and there normally is no need to differentiate them from silty soils. Where clays do occur, they usually are prevalent throughout a general area. Experienced investigators normally are aware of this and may take special care to identify and avoid these soils. A more detailed description of methods for field identification of soils is included in Section II.

The soil color should be noted, since it is a good indicator of how well drained it is. Light brownish, yellowish or reddish colors indicate that the soil is well drained and aerated. Bands or mottles of brighter color should be noted, particularly if they are interspersed or underlain by layers of grayish soil. This may indicate a seasonal or perched water table. Grayish or dark colors indicate poorly drained soils.

The firmness of each soil layers should be noted. Some generally firm soil layers may have narrow bands of looser, sandy soils which should not be overlooked. Similarly, some coarse grained soils are extremely stratified, with thin layers of silt which may not be readily apparent. Ground water seepage and soil dampness must also noted, and the level measured. Such seepage does not always occur immediately, so that the test pits should be left open and reinspected after an hour or so. The observed ground water table is normally recorded as the highest level at which seepage is noted. The depth to the bottom of the pit must also be measured so that it is understood that there is no information available on soil characteristics below that level. The presence of ledge rock or refusal should be noted. Occasionally, it is difficult to determine whether refusal is caused by ledge or by a large bolder. In such a case, another pit should be dug about ten to fifteen feet away. If refusal is found in this pit also, it can be assumed that ledge is present. The ground will vibrate when a boulder is struck or scraped by a backhoe. An experienced investigator or backhoe operator is unlikely to mistake a boulder for ledge.

DESCRIBING SOILS

Each layer of soil with different physical characteristics, such as particle size, color or compactness, should be described separately, and its boundary levels noted. Soils usually are described as gravel, sands, silts or clays, depending on their dominant particle size, in accordance with the following table:

Soil Type	Particle Size		Example#	Sieve Size
	(inches)	(mm)		
Gravel	3.0 - 0.19	76 - 4.75	Lemons to peas	3” - #4
Coarse Sand	0.19 -0.08	4.75 - 2.0	rock salt	#4 - #10
Medium Sand	0.08 - 0.02	2.0 - 0.425	sugar	#10 - #40
Fine Sand	0.02 - 0.003	0.425 - 0.075	powdered sugar	#40 -#200
Silt	.less than 0.003	0.075-0.002	talcum powder	pass #200
Clay		Smaller than 0.002	-	pass #200

Most soils are a mixture of particle sizes, and therefore are described as a mixture of soil types, such as "silty sand" or "fine sandy clay". A "silty sand" has the predominant characteristics of sand, but contains a significant amount of silt. A "fine sandy clay" is essentially a clay, but contains an identifiable amount of fine sand. A more sophisticated system for describing mixed soils sometimes is used, as follows, although the accuracy of such a description must be suspect unless a sieve analysis is made.

Descriptive Term	Percentage Range
"And"	More than 40%
"With"	30 to 40%
"Some"	20 to 30%
"Little"	10 to 20%
"Trace"	Less than 10%

There are other terms used to describe soil which are more general but which can be useful if properly used. "Loam" is frequently used to describe a mixture of loose sand, silt and clay. This term is usually modified by describing the predominant soil type in the mixture, such as a "sandy loam" or "silt loam". Another descriptive term commonly used is "hardpan". This refers to a soil layer which is significantly more compact than the overlying soils layers. While the physical characteristics of "hardpan" may vary somewhat, the term is useful in describing a silty, compact soil layer commonly formed in glacial till soil. The term "top soil" needs no explanation, and is meaningful when used in connection of leaching systems.

A soil identification may be as follows:

0 - 6	inches - top soil
6 - 30	inches - light brown medium sandy loam, some stones
30 - 48	inches - clean, medium sand. Mottling at 36 inches to 48 inches.
48 - 86+	inches - firm, silty sand. Groundwater at 54 inches.

USING THE SOIL SURVEY MAPS

Some mention should be made of the S.C.S. soil survey maps and their use in identifying soils for subsurface sewage disposal purposes. These maps are useful, but are not sufficiently detailed to eliminate the need to dig test pits. The soil maps indicate the predominant soil type within a particular area, but that does not necessarily mean that all of the soil within that area is of the designated type. There generally are small areas of other related soil types within any delineated area. The amount varies, depending on the complexity of the soil pattern on the landscape and the skill of the soil scientist who mapped the area. Soil scientists know this, and usually are willing to gather more detailed information on a particular piece of property, if it would be helpful. Information shown on soil maps generally is not precise enough for design purposes since it is necessary to have a range of physical characteristics within each soil type. Soil maps are most reliable in identifying seasonal ground water conditions, and find their greatest use for this purpose. They are also quite reliable in identifying the existence of underlying layers of compact soil. However, the depth to these layers and the degree of compaction may show some variation within the same soil type. This could be critical in the design of a leaching system. It is generally acknowledged that the maps are less reliable in identifying underlying ledge rock because of the wide topographic variations of this material.

5. PERCOLATION TESTING

The percolation rate is not a measure of any one physical property of a soil, but is generally related to the rate at which a soil will disperse liquid by capillary uptake. When properly performed, the percolation test provides a valid basis for determining the necessary amount of leaching area in a subsurface sewage disposal system. Although there is a general relationship between the percolation rate and the soil permeability, this relationship is not sufficient to indicate possible hydraulic restraints in the surrounding soil layers. This can only be done by considering site-related conditions, such as soil permeability, ground slope, size and configuration of the leaching system, and depth to ground water, ledge or hardpan.

PERFORMING THE TEST

The Technical Standards state that when calculating the required leaching area, only representative tests results in the area and at the depth of the proposed system be used. Care must be taken to insure that only one soil layer is being tested at a time. Since the test is made in only the bottom 12 inches of the hole, frequently the top 1« to 2 feet of soil is stripped away by a back hoe to make the test hole easier to observe and measure. The hole itself is hand dug with a shovel or post hole digger. There should be no large stones or boulders on the bottom or side of the hole which could give misleading results. A fixed reference point is established, usually consisting of a stick or nail on the side of the hole or across the top. From this point, the depth to the top of the water in the hole is measured at regular intervals and recorded. The time that the reading was made is also recorded. The depth of the bottom of the test hole below ground surface must be recorded in order to relate the percolation rate to the various layers of soil. Table 5-1 shows the way that the data is tabulated from a typical percolation test.

TABLE 5-1 Calculation of Minimum Percolation Rate

Field Data		Calculations		
Time	Reading (Inches)	Elapsed Time (Minutes)	Drop (Inches)	Percolation Rate (Minutes/Inch)
9:45 AM	7			
9:50 AM	10 1/2	5	3 1/2 = 3.5	5/3.5 = 1.4
9:55 AM	13 1/4	5	2 3/4 = 2.75	5/2.75 = 1.8
10:00 AM	15 1/4	5	2	5/2 = 2.5
10:05 AM	16 1/4	5	1	5/1 = 5.0
10:10 AM	16 3/4	5	1/2 = 0.5	5/0.5 = 10.0
10:15 AM	17 1/8	5	3/8 = 0.375	5/0.375 = 13.3
10:25 AM	17 3/4	10	5/8 = 0.63	10/0.63 = 15.7
10:35 AM	18 1/4	10	1/2 = 0.5	10/0.5 = <u>20.0</u>
10:50 AM	19	15	3/4 = 0.75	15/0.75 = <u>20.0</u>

The data to the left two columns must be recorded in the field, while the remainder of the data may be calculated later. However, it is desirable to calculate the percolation rate while the tests are being done in order to determine how long the readings should be made and whether additional tests should be made at different locations or depths. The percolation rate is calculated as follows:

1. The drop in water level is found by subtracting the previous readings of the depth to water from the current reading.

2. The elapsed time is found by subtracting the previous time reading from the current reading.

3. The percolation rate is found by dividing the elapsed time by the drop in water level.

Figure 5-1 shows graphically how the percolation rate in a typical test hole will decline as the test proceeds, reaching a relatively uniform rate after 30 to 60 minutes. This relatively uniform rate is taken to represent the minimum percolation rate referred to in the Public Health Code.

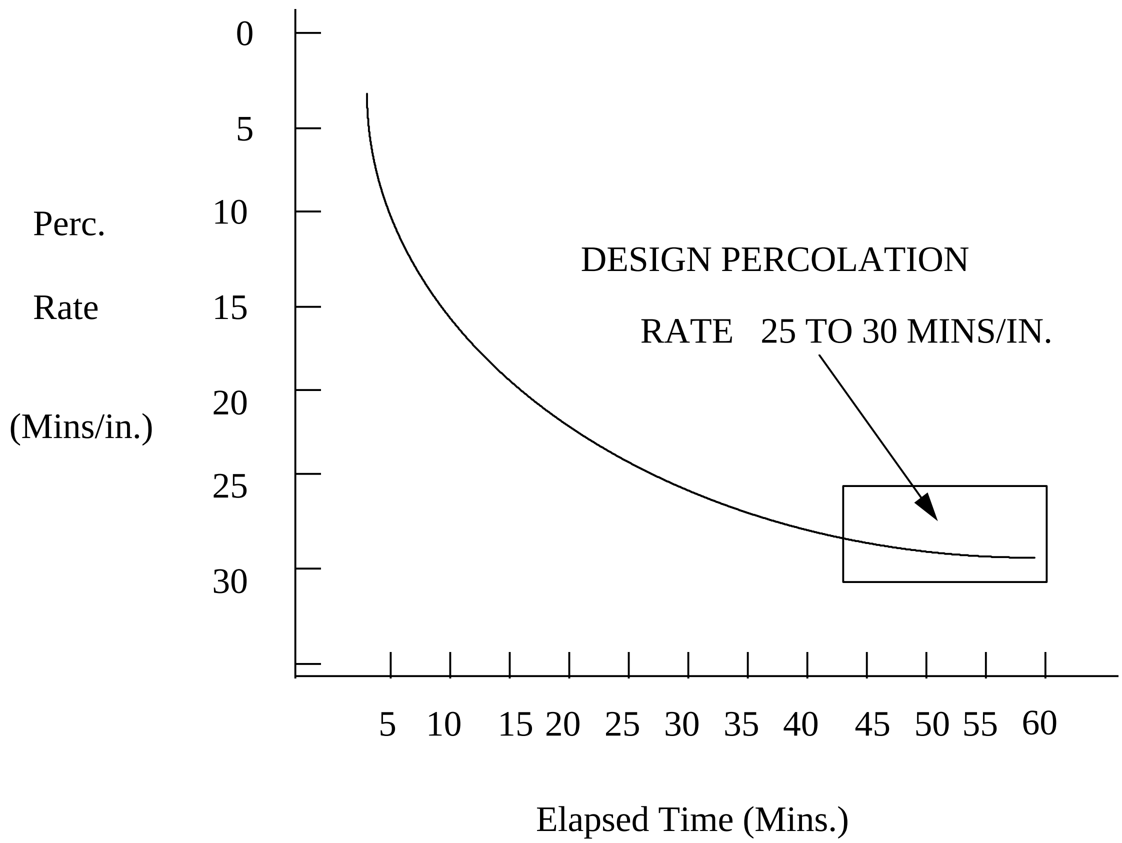


Figure 5-1 - Percolation Test

TESTING INTERVALS: Due to the nature of the testing procedure, erratic fluctuations sometimes occur when calculating percolation rates between timing intervals. This is mainly due to errors in reading a ruler when the drop in water in the hole is relatively small because of the combined effect of slow soils and a short time frame between readings. To reduce this effect it is recommended that the time intervals between readings increase in proportion with the slowness of the percolation rate. It is suggested the following table be utilized when performing a percolation test:

TABLE 9-2 SUGGESTED TIME INTERVALS BETWEEN READINGS

INTERVAL PERCOLATION RATE	SUGGESTED TIME INTERVAL

Faster than 1.0 minute/inch	Less than every 2 minutes
1.0 to 5.0 minutes/inch	Every 2 to 5 minutes
5.1 to 10.0 minutes/inch	Every 5 to 10 minutes
10.1 to 20.0 minutes/inch	Every 10 to 15 minutes
20.1 to 30.0 minutes/inch	Every 15 to 20 minutes
30.1 to 45.1 minutes/inch	Every 20 to 30 minutes*
45.1 to 60.0 minutes /inch	Every 30 minutes**

* Test expanded to approximately 1.5 hours   ** Test expanded to approximately 2.0 hours

EFFECT OF FIELD CONDITIONS ON TEST RESULTS

As with most tests which are performed in place, the results of the percolation tests may be affected by certain field conditions prevailing at the time of testing. The sanitarian or engineer must be careful to look for conditions which might affect test results, and use judgment in performing the test and evaluating the results. Of principal concern is the ground water level relative to the test hole and the soil moisture content at the time of testing.

The percolation test must be done in unsaturated soil above the ground water table, since it is greatly affected by capillary dispersal into the soil. Furthermore, when the bottom of the test hole is close to the ground water table, the capillary water zone above the ground water table may interfere with capillary dispersal from the test hole. Percolation tests may be misleadingly slow if the test hole is located only a few inches above the water table, and it may show no percolation if located partly below the ground water table. It is surprising how many times investigators fail to look for ground water before making a percolation test, particularly in relatively tight soils or during the spring of the year. Wherever possible, the bottom of the percolation test hole should be located at least 18 inches above the observed ground water table. Where this is not practical, the ground water level should be noted with the test results so that a proper evaluation of the test results can be made when designing the leaching system.

Seasonal variations in soil moisture also will affect percolation test results. Percolation tests made during the early spring, when soil moisture is high, will be somewhat slower than those made during the late spring or fall, when the soil moisture is lower. However, the requirements for leaching area in the Public Health Code are based on percolation tests made when the soil is only slightly moist, and therefore there is no need to require that all percolation tests be done during the early spring. Such a requirement could present a hardship to both builders and sanitarians. Percolation tests made during the months of July, August and September, when the soils may be very dry, can give erratic results. In some soils, the percolation rate results are somewhat faster than normal, while in other soils the results are somewhat slower than would be expected. The faster than normal results probably are due to silt shrinkage and cracking, and the relatively short presoaking period specified in the Code. The slower than normal results may be due to entrapment of air bubbles in dusty soils, which are not adequately purged by a short presoak period. The elimination of percolation testing during the driest time would eliminate misleading results, but this may create some hardship and additional expense. Most investigators have found it more practical, and just as safe, to oversize leaching systems which are designed on the basis of percolation tests made during the dry months of July, August and September. Experience has shown that the variation in percolation test results obtained in dry and moist soils will not exceed one category in the range of percolation rates shown in the tables for required leaching system capacity in the

Technical Standards. Therefore, most investigators and health departments have adopted the policy of using a leaching system that is one category larger than required when the percolation tests were done during an unusually dry period. For instance, if a minimum percolation rate of 1 inch in 7 minutes were obtained in August, the designer would use 675 square feet of leaching area for a three bedroom house, rather than 495 square feet, to compensate for possible variation in percolation test results due to soil dryness.

OTHER FACTORS AFFECTING TEST RESULTS

The condition of the soil interface in the percolation test hole can affect the results. Washing silt into the hole when pouring the water or smearing the soil surface during digging may cause artificially slow percolation test results. On the other hand, lining the hole with burlap or filling it with stone may give an artificially fast percolation rate. In general, the percolation test holes should be tested no differently than the excavation for a leaching system would be treated. The depth of water in the test hole can have some effect on the readings. This effect is not significant, however, as long as the water depth during the test is not over 12 inches or less than 4 inches. The width of the test hole also has an effect, and it is important to follow the Code requirement that the percolation test be made in a 6 to 12 inch diameter hole. Placing 100 gallons of water in the bottom of a pit excavated by a back hoe and observing how quickly it seeps into the soil, is not a meaningful test of any kind.

Percolation tests should be conducted at least 18” above actual groundwater levels. However, there are circumstances whereby this may not be possible (water table is less than 30” below the surface of the ground on the day the test is conducted). Under these conditions a percolation test can be run knowing full well that the results will be somewhat slower than if the water table was the proper distance below the percolation hole. The intent of the code is to prevent deeming a soil impervious based on a percolation test which has been performed too close to the water table. In such a case the area would have to be dewatered by installing a curtain drain or the test would have to be postponed to a drier time of the year.

6. DETERMINING THE MAXIMUM GROUND WATER LEVEL

"Maximum ground water level" as used in the Public Health Code refers to a relatively static ground water table which exists for one month or more during the wettest season of the year. It does not refer to a short term "perched" water table, a capillary water zone, or a temporary subsurface flooding condition which may occur following a heavy rainfall or snow melt. All of these ground water conditions are significant, however, and must be recorded and taken into account in designing the leaching system.

There are several reasons why it is not necessary to attempt to determine the absolute maximum ground water level. Experience has shown that short periods of moderately high ground water are unlikely to cause a leaching system to fail, as long as the system itself does not fill with water. Furthermore, high ground water levels of short duration are difficult to detect, since they do not last long enough to leave indications of high ground water, such as soil mottling or wetland vegetation. Most importantly, a high ground water table which lasts for a month or more is very likely to be caused by hydraulic limitations of the soil or topography, not by temporary conditions of rainfall or flooding. Logically, leaching systems should be designed on these hydraulic limitations rather than on something as unreliable as weather conditions prior to the time of the site investigation.

The ground water table is the upper boundary of a continuous zone of saturated soil. The water level in a pit or observation well will rise to the level of the ground water table over a period of time. The ground water generally rises and falls with the ground surface, but normally is deepest near the top of the slopes and shallowest near the bottom. Ground water flows from higher elevation to lower elevation. Therefore, the direction of ground water flow can be determined by the relative elevation of the ground water table at various locations. This can be important in determining the location of water supply wells and ground water drains in relation to leaching systems, particularly on relatively flat lots where the slope of the ground surface may not indicate the direction of ground water flow. Changes in ground water depths at various locations or over a period of time can also be used in calculating the soil permeability and the capability of the site to disperse sewage effluent. Therefore, it is always advisable to record water levels at several locations.

VARIATIONS IN GROUND WATER LEVELS

The level of the ground water table fluctuates seasonally, with the greatest fluctuation occurring in the less permeable soils. Silts, clays and hardpan with minimum percolation rates poorer than 1 inch in 60 minutes will show no evidence of a ground water table during the driest months, but will be completely saturated for a month of more during the wet season. For this reason, such soils are considered unsuitable for leaching purposes. Year to year variations in rainfall will affect the duration of the maximum ground water level, but appears to have little effect on the maximum level, itself. In an extremely dry spring, the ground water may be at its maximum level for only a week or two, while it may be at its maximum level for three months or more during an extremely wet year.

In addition to seasonal fluctuations in the ground water table, heavy rainfall or snow melt can cause short term subsurface flooding conditions which will raise the ground water table above its normal maximum level. Such short term flooding should not last more than a few days to a week, and will not adversely affect the functioning of a properly designed leaching system. Of course, the ability of the leaching system to disperse liquid into the surrounding soil is reduced as the ground water level in the soil rises. When the dispersal rate is less than the rate at which sewage is discharged, effluent will accumulate in the leaching system. However, leaching systems designed in accordance with Code requirements contain a relatively large volume of hollow spaces, either in the stone or the hollow leaching structure, which normally would be sufficient to store any excess volume of sewage accumulated during a period of high ground water not exceeding one month in duration.

Flooding conditions become more serious when the ground water level rises above the level of the bottom of the leaching system, since not only is the dispersal rate severely restricted, but the storage capacity of the leaching system also is reduced. Sewer backup will occur when the ground water level rises to the level of the distribution pipe in the leaching system. For this reason, the

Public Health Code requires that all leaching systems must be protected from flooding. Leaching systems located in low areas are more subject to flooding by both ground and surface water than those located on slopes. Such systems routinely should be kept higher above the probable maximum ground water level. Leaching systems on flood plains must be elevated above normal spring flooding levels. It is neither practical or necessary from the public health standpoint to elevate such systems above any flood level occurring less frequently than every five or ten years. Flooded leaching systems do not pollute ground or surface waters, since they are not functional when flooded. They are an inconvenience to the property owner who cannot flush his toilet during this time, but there is a question as to how much importance regulatory officials should assign such a condition when it may occur for only a day or two, every five to ten years.

PERCHED GROUND WATER

Ground water is said to be "perched" when there is an underlying layer of slowly permeable soil which restricts its downward movement. Water will accumulate on top of this layer and move laterally in a downhill direction. Perched water tables are seasonal in nature, developing when the rainfall exceeds the ability of the underlying soil to disperse it. The duration and severity of the condition is quite variable, depending on the tributary drainage area, the ground slope, and the relative permeability's of the upper and underlying soil layers. Most hardpan soils in Connecticut would be expected to develop a perched water table under certain conditions. This may last only a few hours following a heavy rainfall, or it could last for three months or more during the wet season. With proper design, most perched ground water conditions can be controlled, and it may not be necessary to keep leaching systems 18 inches above a perched water level. See the chapters on "Ground Water Control Drains" and "Leaching Systems in Hardpan Soils". Perched ground water, as indicated by high level seepage from the side of an observation pit, must not be disregarded or overlooked during the site investigation. Unless controlled, perched water flowing down from higher elevations usually will flood leaching systems constructed below the perched water level, causing them to fail.

Soil dampness occasionally is noted above the static water table. This results from capillary action, and is most apparent where the soil consists of a fairly uniform fine sand or silt. It is not necessary to keep the bottom of the leaching system 18 inches above this capillary water zone. However, leaching systems constructed close to or within the capillary zone will disperse liquid more slowly than those constructed in dry soil. This can be compensated for if the design of the leaching system is based on percolation tests made completely within the capillary zone, not in the dry soil above it.

INDICATORS OF SEASONAL HIGH GROUND WATER

The best way to determine the maximum ground water level is to make the site investigation during the spring of the year when ground water is high. This is not always practical, and it may be unreasonable to require that all soils be tested during this time period. Whenever the site investigation is made, the investigator must look for certain characteristics of soil and topography which may indicate a seasonal high ground water level, or give an indication of the maximum level to which ground water may rise during the wet season. On some sites, these indicators might be conclusive enough to serve as a basis for designing the leaching system, while on other sites they may be inconclusive, but would serve to indicate the need for reinvestigation or monitoring ground water levels during the spring.

Soil mottling is one of the best indicators of seasonal ground water. Mottling consists of contrasting patches of color in the soil, and may be either gray, orange or reddish. The variations in color is caused by a chemical oxidation of certain minerals containing iron. Orange or reddish mottles indicate oxidized iron and a relatively well aerated zone of soil. Gray mottling indicates that poor soil aeration has kept the iron minerals in a chemically reduced state. Orange and reddish mottling frequently is found in the capillary water zone just above the seasonal high ground water level. Much of the ground water evaporation takes place in this zone, and it is probable that over a period of years a certain amount of soluble iron is deposited at this point as the ground water evaporates. A layers of relatively bright orange or reddish mottles separating an upper layer of tan or brownish soil from an underlying grayish soil is a reliable indicator of the seasonal maximum ground water level. However, investigators should not rely too heavily on indistinct or non-typical soil mottling, or on the absence of soil mottling. Such indications are best interpreted by an experienced soil scientist.

There are several situations where soil mottling or its absence can be misleading. Frequently, stratified deposits of sand and gravel will show distinct orange or reddish mottling well above the maximum ground water table. This appears to be caused by capillary retention and evaporation of rainfall runoff in layers of fine grained soil, causing deposition of iron in these layers. Perched water tables may also cause some mottling above the normal maximum ground water level. A careful examination usually will reveal both reddish and grayish mottles where seasonal perching is significant. Certain deposits of light colored silica or "beach" sand do not contain enough iron bearing minerals to cause mottles. The absence of mottling in these deposits does not indicate that there is no seasonal high ground water. Some Connecticut soils, particularly in the Central Valley, are highly colored throughout, and mottles are extremely difficult to detect. Examination of these soils for mottling is best left to experts.

Surface slopes and elevations, soil type, underlying ledge rock or hardpan, and general topography also are indicators of possible high seasonal ground water. Wetland vegetation and shallow tree roots indicate seasonally wet soil and a need to monitor ground water levels during the wet season. Publications on wetland plants may be obtained from the State Department of Environmental Protection.

MONITORING GROUND WATER LEVELS

Where the site investigation indicates a seasonal high ground water, but the probable maximum level cannot be determined, an observation well should be constructed so that the ground water level can be measured periodically during the wet season. Such monitoring should reveal the normal maximum ground water level referred to in the Public Health Code, as well as any short term subsurface flooding condition which may occur. Care should be taken to record the date as well as the ground water level at each reading so that the duration of the high ground water level and its relationship to season and rainfall can be established. This is extremely valuable information when designing a leaching system in an area where seasonal ground water is severe. Monitoring wells are also used in questionable areas to establish the effectiveness of ground water intercepting drains.

DURATION OF MONITORING: Section 19-13-B103d.(e)(2) of the Public Health Code states that the investigation for maximum ground water levels be made between February 1 and May 31 (designated wet season), or such other times when ground water is determined by the Commissioner of Public Health to be near its maximum level. The interval was set over that long a time frame because in Connecticut each year the median maximum peak for ground water is usually reached within that particular period of time. Since no one can predict when ground water will reach peak conditions within any one year, monitoring should be conducted throughout the designated wet season interval. If while monitoring maximum peak ground water levels are observed (documented by the U.S. Geological Survey for the region of the state being observed) monitoring may be discontinued prior to the end of the defined wet season. However if monitoring commences following the start of the designated wet season (February 1) it will be at the applicants risk. Monitoring during a partial wet season will only be valid if a median peak ground water level is reached in the region during the actual monitoring period.

MONITORING WELL CONSTRUCTION: Monitoring wells are easily constructed by placing a length of 4 inch diameter plastic sewer pipe upright in the deep observation pit before it is backfilled. Solid pipe should be used rather than perforated pipe to prevent loose soil and silt from collecting in the pipe. In particularly silty soils, it may also be necessary to place some stone or filter fabric around the open end of the pipe before it is buried. It is not necessary to place stone or gravel completely around the pipe, since the back fill is loosely compacted and readily transmits water. However this technique may lead to erroneous results since the entire pit serves as the groundwater collector, so that both perched and static groundwater are measured. Surface water may also collect around the well, giving misleading results. The ground should be mounded up in this area so that surface water does not puddle around the pipe.

A preferred method of installation would consist of digging a relatively small diameter hole (8-12 inches) down to a depth which would be at least two (2) feet below the proposed leaching system. Place stone or sharp sand on the bottom 3” of the hole; then place a solid or slotted 4” PVC pipe upright in the hole. Once placed, the pipe should be surrounded by stone or sharp sand to within 6” of the surface of the ground. Soil should then be packed around the pipe making sure that it is “mounded” above grade level to prevent surface water from entering the monitoring well. The extension of the pipe above grade should not be such that it will hinder the actual monitoring procedure (See Figure 6.1)

ANALYSIS OF THE RESULTS: In many cases it is not necessary to determine the exact maximum ground water level in order to make a conclusion as to the suitability of the site for building purposes. For instance, there are many sites which may have a moderately high seasonal ground water table, but which are not severely limited by ground water conditions. In such a case, the builder or engineer may agree to keep the elevation of the proposed building and sewer high so that it would be possible to construct a shallow leaching system, using some fill if necessary, which would be sufficiently above any likely maximum ground water level. The sewage disposal system itself would not be installed until an accurate determination has been made of the maximum ground water level by subsequent observations during the wet season. In the meantime, it might be possible to approve preliminary plans for the sewage disposal system and issue the building permit so that construction can start on the foundation or building. There also may be situations where there is an underlying hardpan layer which could cause a seasonal perched water table. It may not be possible to make an assessment of the severity of the perched water condition or the necessity of a curtain drain to control it until additional investigation can be made during the wet season. However, if the engineer or builder agrees to design the sewage disposal system with a curtain drain, it may be possible to issue the necessary approvals and permits so that construction can start. A final decision on whether or not to install the curtain drain could be delayed until further investigation can be made during the wet season, as long as the building will not be occupied in the meantime.

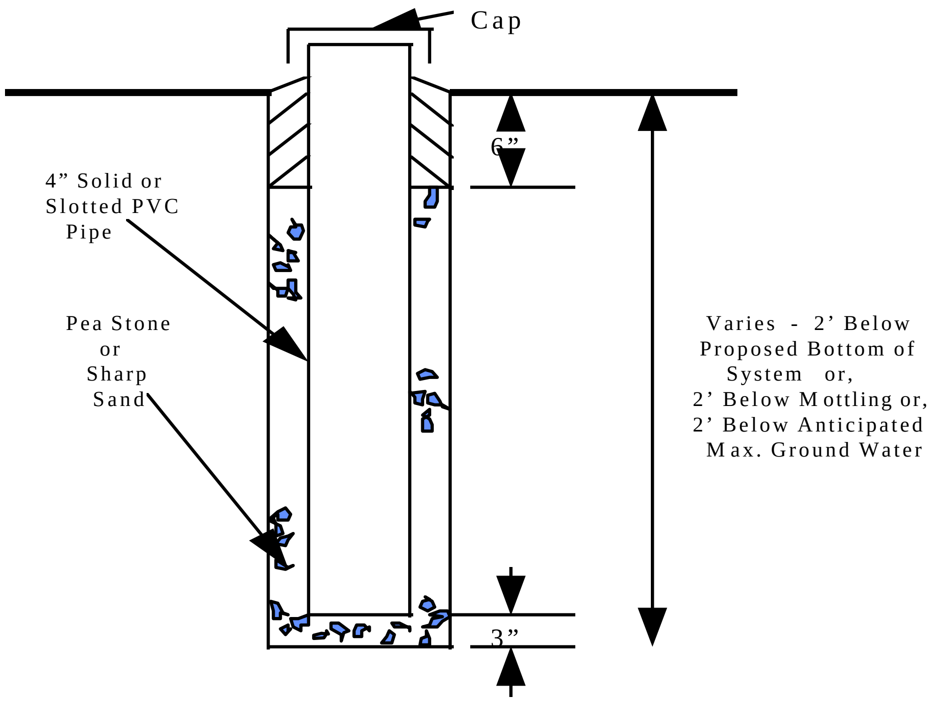


Figure 6.1 Ground Water Monitoring Well

7. GROUND WATER CONTROL DRAINS

In certain situations, ground water drains can be used to control a seasonal high ground water condition. However, in other situations such drains may not be effective, and cannot be relied upon. Therefore, when ground water is found, it is essential that a careful evaluation is made of the soil and site conditions in an effort to determine the nature or cause of the ground water, the type of control drain to use, and it s probable effectiveness, before designing any sewage disposal system.

GROUND WATER INTERCEPTING DRAINS

Intercepting or "curtain" drains are reliable only for the control of perched water tables which seasonally develop where there is a layer of relatively permeable soil underlain by a layer of relatively impermeable soil or ledge. During wet periods, the ground water will be retained upon the relatively impermeable layer, saturating the looser soil above it. This is particularly severe on hillsides or low areas where there will be an accumulation of ground water flowing down from higher elevations. Where there is sufficient slope, the perched ground water can be intercepted by drains on the uphill side of the leaching system. In order to be effective, the drain must be constructed deep enough to penetrate into the relatively impermeable underlying layer of soil and completely intercept the ground water moving on top of it. Generally, the bottom of the intercepting drain should penetrate a minimum 24 inches into this underlying soil layer to assure that the perched ground water condition will be encountered. The stone or gravel in the drain should extend at least 18 to 24 inches above the top of the relatively impermeable soil layer to effectively collect the water moving on top of that layer. Figure 7-1 shows how a typical intercepting drain functions.

GROUND WATER DRAINS IN PERMEABLE SOILS

Ground water control drains constructed in permeable soils function differently from intercepting drains, and are far less reliable. In this situation, the ground water table is continuous since ground water easily can move under the drain. The construction of the drain produces a drawdown in the level of the ground water table at the drain location, as shown in Figure 7-2. In permeable soil, the drain must be quite deep in order to draw the ground water table down sufficiently over a wide enough area to allow the construction of a conventional leaching system. This is even more of a problem on slopes because the distance of the drawdown area in the downslope direction is relatively small. For this reason, intercepting drains on slopes are generally ineffective when the underlying soil is permeable. See Figure 7-3.

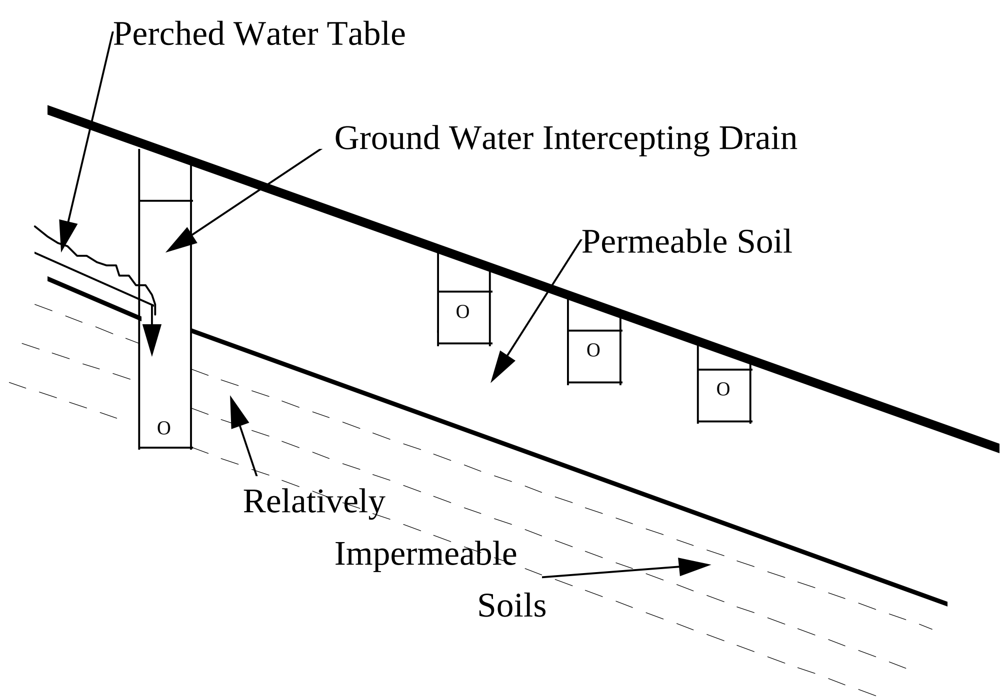


Figure 7-1 - **Ground Water Intercepting Drain**

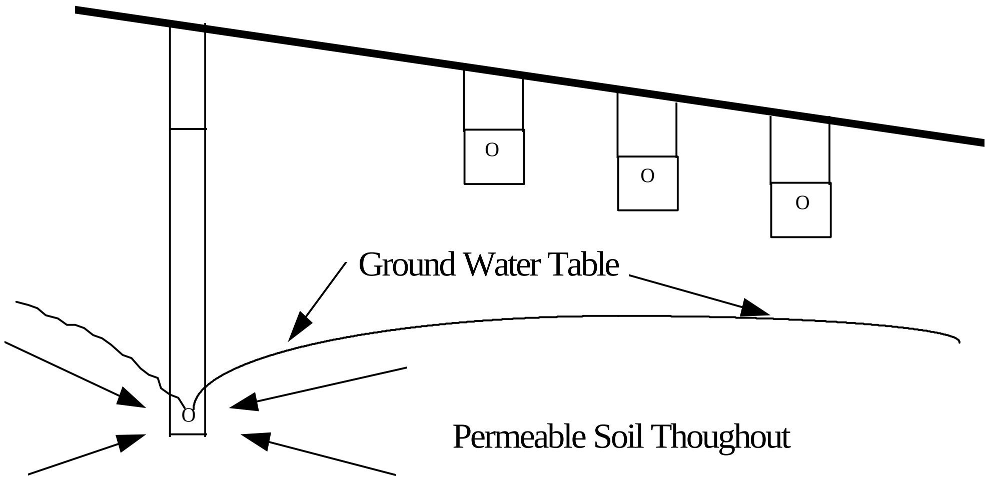


Figure 7-2 - **Ground Water Drain In Permeable Soil**

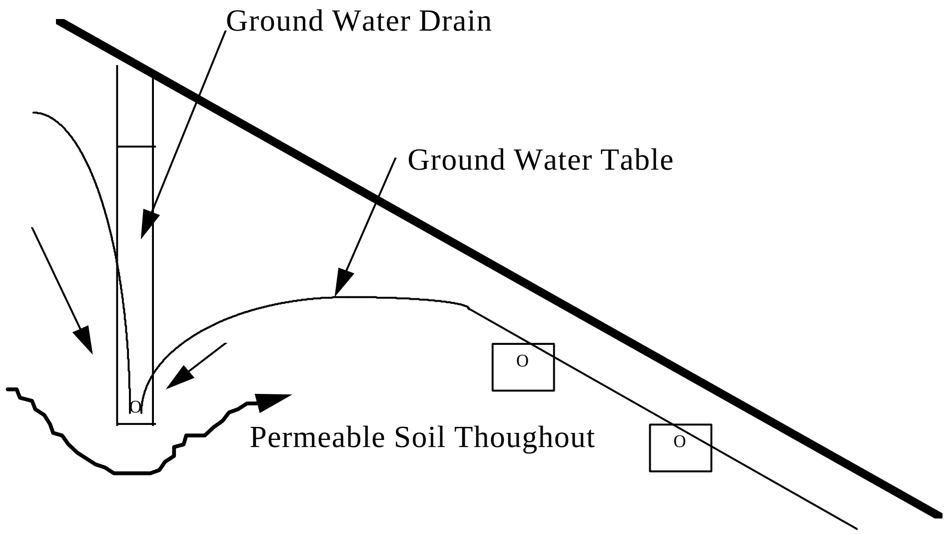
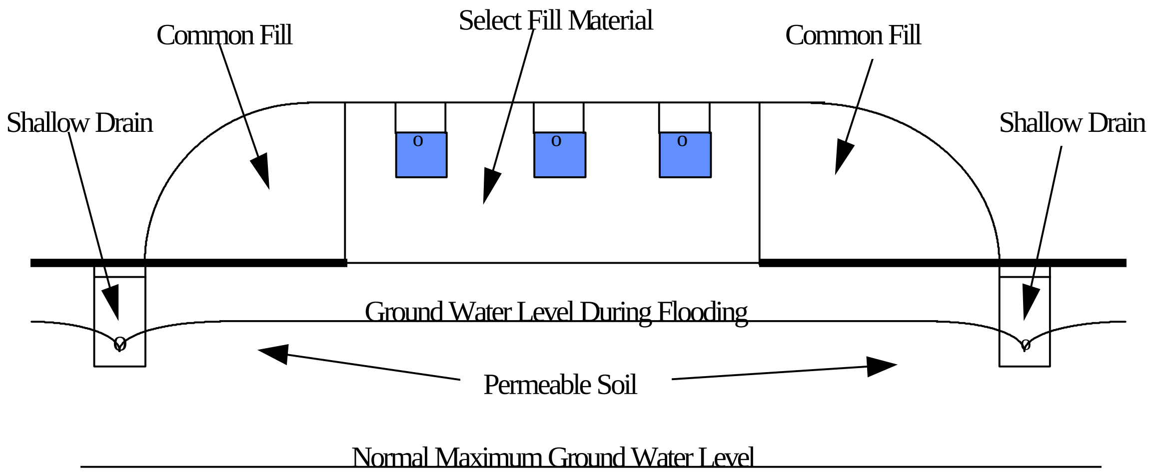


Figure 7-3 - **Ground Water Drain on Permeable Slope**

Ground water control drains usually are effective where the ground is relatively level and the soil is highly permeable, because the area of the drawdown is quite large. However, there is a danger of collecting insufficiently treated sewage effluent, since the ground water movement is from the area of the leaching system toward the drain, and sewage may not be adequately filtered by the highly permeable soil. In this situation, leaching systems usually are elevated in fill above the observed ground water level, but occasionally shallow ground water drains also are installed for the purpose of controlling subsurface flooding conditions. Figure 7-4 shows an elevated leaching system protected from flooding by shallow ground water drains.



<u>Figure 7-4</u> - Shallow Drains To Control Flooding

<u>LOCATION OF GROUND WATER DRAINS</u>

The Public Health Code requires a minimum separating distance of 25 feet between a subsurface sewage disposal system and a ground water drain located up-gradient of the system, and a minimum separating distance of 50 feet when the drain is located down-gradient. The term "gradient" refers to the hydraulic movement of the ground water table <u>before</u> the drain and leaching system are installed. In most cases, the ground water gradient may be assumed to be consistent with the slope of the ground surface, but in questionable cases the ground water gradient should be determined by observation pits. Evidently, the ground water gradient may change after installation of the drain and leaching system. Experience has shown that ground water intercepting drains which are properly designed for controlling perched ground water are unlikely to collect sewage effluent as long as they are located 25 feet from the leaching system. However, ground water drains in relatively level areas of permeable soil may act as collection drains for sewage effluent, and should be carefully evaluated. In such cases, a hydraulic analysis should be made of the direction and rate of ground water movement after construction of the drain and leaching system, or the separating distance should be increased to 50 feet. Ground water intercepting drains should be located no farther than 25 feet away from leaching systems wherever possible, since experience has shown that such drains often are unreliable in controlling severe seasonal ground water or short term ground water flooding if located much greater than 25 feet from the leaching system. Any part of a ground water drain which must pass within 25 feet of a leaching system, or within 50 feet in a down gradient direction, must be constructed of tight pipe with no stone or gravel backfill.

<u>DRAIN CONSTRUCTION</u>

The construction detail of the drain itself may vary depending on soil and ground water conditions. Collection pipe must be surrounded by carefully specified stone or gravel in order to effectively collect water without becoming clogged with silt. A fairly uniform « inch stone or screen gravel has been found effective. Larger stones may become clogged. Stone clogging can be eliminated by wrapping the stone with filter fabric of an appropriate mesh size. Unspecified bank run sand and gravel should not be used, since this often will not have the required permeability. Stone or gravel graded to engineer's specifications for drainage purposes would be satisfactory. Slotted or porous wall collection pipe with washed sand or gravel backfill have been used successfully where the flow of intercepting groundwater is not great. In any case, the collection pipe should be raised 6 to 12 inches above the bottom of the trench to prevent silt from settling in the pipe. The collection pipe should be set with perforations downward, so that any silt settling in the pipe will be washed out.

In areas where separation distances are critical, an “egg crate” plastic fin and corrugated plastic pipe enveloped in a non-woven filter fabric (Eljen Drainage System) can be used to produce a ground water collection system which is relatively narrow in cross-section. However, this type of system should not be installed without a technical analysis of filter fabric pore sizes relative to the grain sizes of the soils the drain is being installed into, the iron content of the ground water and bacteriological slime which may buildup on the fabric’s surface.

Where there is relatively little difference in elevation between the ground water intercepting drain and the leaching system, it may be advisable to line the downslope face of the intercepting drain trench with an impervious polyethylene plastic sheet, such as is used for agricultural purposes. This reduces the possibility of sewage effluent flowing toward the drain and increases the drains effectiveness. Such impervious barriers also are used when a footing, foundation or other collection drain is located somewhat less than 25 feet from a leaching system, or less than 50 feet in a downhill direction.

The depth of stone or gravel in a ground water drain should be sufficient to intercept all of the layers of soil which carry ground water, and in some cases should extend to near ground surface. The top of the stone should be covered with a filter fabric to prevent silt or mud from entering. No impervious soil should be used for backfill purposes.

MONITORING GROUND WATER CONTROL DRAINS

Normally, it can be assumed that a properly designed and constructed intercepting drain will correct a seasonal perched ground water condition, and it would not be necessary to evaluate the effectiveness of the drain before installing the leaching system. However, there are some situations where the underlying soil layer is somewhat permeable, and the seasonal ground water is due to both perched ground water and the rising ground water table itself. There may be other situations where the seasonal ground water is extremely severe due to topographic location, or where it is necessary to install a leaching system below the seasonal ground water table. In all of these situations, a properly designed ground water drain probably will lower the seasonal ground water level, but it is difficult to know exactly how much. There are methods of calculating how much a ground water drain will lower the water table, but such methods are frequently unreliable since they depend on limited testing and certain assumptions. Unlike similar calculations made relative to leaching systems, there is no margin of safety in most of these methods of analysis. A more reliable and practical method of evaluating the effectiveness of a ground water drain is to construct a drain at the proper location and depth, and monitor the ground water level in the area of the leaching system through the wet season (See Chapter 6 on Determining Maximum Ground Water Levels). Although this may cause some delay in construction schedules, it is a relatively simple procedure, and gives extremely reliable results. Normally it is not necessary to complete the ground water drain, since an open ditch will function just as effectively. Monitoring wells are usually placed in a grid 25 and 50 feet below the drain (at least to a distance which will be at the lowest extension of the proposed leaching system) and approximately 25 feet above the drain. The results from monitoring a grid arrangement of wells in the above configuration will determine the effectiveness of the installed drain. The wells above the drain will monitor preconditions, while the lower wells will establish how much the water table rebounds as the distance increases from the drain.

PROTECTING THE SEWAGE DISPOSAL SYSTEM FROM GROUND WATER INFILTRATION

Excessive amounts of ground water can be collected in house sewers, manholes, septic tanks and sewage pumping chambers which are installed in areas where the maximum ground water table is high. This collected water can hydraulically overload the leaching system and cause it to fail, even when the leaching system itself is located in an area where the ground water table is not high. This potential is frequently overlooked, particularly in the design of large systems where the leaching system is located some distance from the septic tank and collection system. Pumping chambers usually are located in low areas or are quite deep in the ground, and frequently are below the water table. Leakage of ground water into these chambers is likely to occur in this situation because the liquid level inside the pumping chamber is frequently low. Leakage into septic tanks is less likely because it will occur only when the ground water level is higher than the tank outlet. Both septic tanks and pumping chambers are generally precast units which are made up of several sections assembled in the field. It is important that the joints between the sections are made water tight with bituminous seal. Knock-out holes where sewers enter must be tightly sealed. Many precast tanks are constructed with small drain holes located in the bottom so that rain water will not collect in them while they are stored outside. These holes must be sealed when the tanks are installed. All such units must be sealed and tested for leakage after installation according to engineers and manufacturers specifications if they are to be located in high ground water areas. Sewers should be air tested for leakage when they are constructed in high ground water areas, or if the total sewer length exceeds 200 or 300 feet. Manholes on sewers, septic tanks and pumping chambers should be raised to prevent surface water from entering. If they are located under a road or parking lot and cannot be raised, bolted manhole covers with rubber gaskets should be used.

It should be noted that sealing tanks against ground water infiltration is done differently than sealing tanks against leakage of sewage from the tank. Generally, the tanks must be sealed from the outside, rather than the inside, so that this must be done before the tanks are backfilled. It is not easily accomplished, and sometimes a clay backfill is used to reduce the water pressure on the tank. As a last resort in repair situations, a curtain drain can be used to lower the water table around the tank.

8. HOUSE SEWERS

The term “house sewer” refers to sewers located between the building served and the septic tank.. These sewers carry raw sewage and require special design to prevent settling of solids and clogging of the pipe. These sewers must be particularly tight and strong to assure that there will be no leakage of sewage which could enter the basement of the dwelling or the foundation drain and present a health hazard. The section of sewer extending from the foundation wall to the septic tank may be subjected to greater stresses than a public sewer buried in the street, and for this reason must be constructed of extra heavy cast iron pipe or a pipe with equal structural strength. This sewer is rigidly supported at the foundation wall and at the septic tank, but frequently is laid in poorly compacted backfill between these points. Excavations around the building foundation and septic tank frequently become a disposal pit for scrap lumber, stone and other construction debris. Little care and no inspection generally is given to the backfilling of these excavations, so that subsequent settlement may be great, causing the sewer to bend and separate. Even if the pipe does not leak, a low point in the line can allow sewage to collect and freeze in the winter, or cause blocking and sewage backups.

Table 2 in the Technical Standards lists types of sewer pipe which have adequate structural strength and tightness to be accepted for house sewers within 25 feet of the building served. All of these pipes are relatively expensive, but since only 15 to 25 feet of pipe would be required, the savings which would result from using a lighter weight pipe would not be worth the risk involved. The State Building Code does allow lighter weight pipe to be used in the building, however, some difficulty can be encountered where it is necessary to make a transition from one type of pipe to another immediately outside the foundation wall. Special transition fittings with rubber compression gaskets should be used in these instances. However, in some cases it may be necessary to use rubber sleeves with steel straps to make the transition joint. If a tight joint (see Table 2 in the Technical Standards) is not provided, additional sleeving with heavy duty pipe should be provided whenever such a joint is encountered. In some older homes, the house sewer may pass through the foundation wall within 25 feet of the well. Special construction is required when it is necessary to replace such a line. Generally, all pipe joints within 25 feet of the well should also be sleeved in heavy duty pipe to provide extra protection, or the pipe should be laid in a vault which is accessible for inspection, so that any leakage can be detected and the sewer repaired before the well becomes polluted.

House sewers are designed for open channel flow, both to assure adequate velocity for carrying settleable solids and to allow positive venting of gases. It should be noted that in an properly installed subsurface sewage disposal system, gases are vented from the leaching system and septic tank through the house sewer and out the roof vent on the uppermost end of the waste line. All sanitary fixtures attached to the line must be trapped to prevent gases and odors from escaping within the building. Such an arrangement increases air circulation in the soil around the leaching system and promotes BOD reduction. However, occasionally there are odor problems resulting from a poorly located roof vent, usually connected to a large disposal system which receives a strong waste. In such a case, the odor problem usually can be eliminated relatively easily by placing an elbow on the inlet to the septic tank or by capping the top of the inlet “T”, so as to trap the gases before they go out the roof vent. In these cases a separate vent pipe should be installed at the tank or from the leaching system. The vent piping then could be directed up a tree or similar structure which is located away from the building served.

House sewers should be kept as high as possible in order to allow a shallow leaching system to be constructed, if necessary. The house sewer drains dry in use, so that there is no need to provide a minimum cover of soil over the pipe to prevent freezing. Sanitary fixtures located in the basement should be avoided, particularly on relatively level lots. Some towns have gone as far as prohibiting the construction of split level houses or raised ranch houses in certain subdivisions where the ground water is high, because these type of houses generally have the sanitary fixtures located on the lower level. Washing machines have discharges capable of lifting wastes about 5 to 7 feet above the washer level, so that it is not necessary to keep the sewer low to serve such equipment. However, the connection to the sewer should have a check valve or manual shut-off on the washer discharge line where the machine is located below sewer level. Toilet systems are available which will grind and lift waste discharges, and these should be considered for basement usage.

House sewers carry raw sewage containing solids which will readily settle and may cause blockages at changes in direction and slope. Changes in direction exceeding 45° particularly should be avoided since sewer routing equipment may not go around such sharp bends. It is also recommended that whenever there are more than one change of direction on a house sewer line that cleanouts extending to grade be provided at every second bend. Occasionally, distribution boxes are installed on the house sewer for the purposes of dividing sewage between two sewage disposal systems, or to reduce flow velocity ahead of the septic tank. Invariably, these cause settling of solids and clogging. Special non-clogging design is required for all structures or manholes on the sewer ahead of the septic tank. In general, a continuous pipe or channel must be provided with smooth changes of direction and no corners or projections. The best way to divide raw sewage is by means of a “T” with a relatively high approach velocity or slope. “Y’s” or “D-boxes” will clog or partly clog, creating an unequal division of flow. Reduction of flow velocity is best accomplished by flattening the slope of the sewer ahead of the septic tank, rather than by constructing a special structure or manhole.

9. SEPTIC TANKS AND GREASE TRAPS

A properly functioning septic tank serves three main purposes.

1. It removes most of the settleable solids.

2. It produces an effluent of relatively uniform physical, chemical and biological quality from a raw sewage with widely fluctuating characteristics.

3. It produces some reduction in pollutant levels in the effluent.

The removal of settleable solids is important in protecting the leaching system from excessive sludge and slime build-up and possible clogging. A relatively uniform effluent promotes the development of a stable biological slime in the leaching system which is important in protecting against groundwater pollution. The septic tank will reduce influent BOD levels by about 25 to 30 percent. Most of this reduction is due to the venting of certain gases, such as methane. Solid organic particles are removed by settlement, and a certain amount of soluble organic chemicals are removed by the formation of bacterial cells within the tank. However, no significant BOD reduction results from this without regular removal of the accumulated sludge. A relatively stable biological system soon is established in a septic tank in which most of the organic solids are converted to soluble organic chemicals and gases. This chemical decomposition results in a relatively slow build-up of sludge in the tank, most of which is biologically stable in the absence of oxygen. The septic tank will produce about 10 percent reduction in nitrogen and 30 percent reduction of phosphate in the effluent, mostly by combining these chemicals in the relatively stable biological sludge. The proper venting of gases is very important in the efficient functioning of a septic tank. An excessive buildup of scum or grease may interfere with this, and it is important that large volumes of grease not be discharged into the septic tank. There must always be space between the scum layer and the top of the tank. The inlet baffle should be open at the top to allow venting. Where a two compartment tank is used, the baffle wall between the first and second compartments must be open at the top, for the same reason.

The efficiency of the septic tank as a settling unit is reduced when the velocity of the liquid moving through the tank is increased. This may be caused by a tank which is too small or too shallow due to an excessive depth of sludge in the bottom. The lack of a proper inlet baffle will tend to allow liquid entering the tank to short-circuit across the surface of the tank, particularly if the liquid is warm and consequently less dense than the liquid in the tank. The settling efficiency of a septic tank can be greatly improved by constructing the tank with two compartments. This results from both further reduction of velocity currents within the tank and from reduction in gas information in the second compartment. Gas bubbles formed within decomposing sludge layer will cause solids to float and possibly go out the outlet. In a two compartment tank, practically all of the sludge digestion and gas formation takes place in the first compartment.

SEPTIC TANK CONSTRUCTION

All concrete septic tanks utilized in the State of Connecticut shall conform to ASTM C-1227-95 standards by July 1, 2000.

Presently**,** most septic tanks are constructed of precast concrete sections which are assembled in the field. Such precast tanks come in sizes up to 30,000 gallons. Larger capacities also may be obtained by installing two tanks in series. The outlet of the first tank is joined to the inlet of the second tank. Normally this is done with pipe baffles extending to approximately mid-depth of each tank. In this way, the tanks may be considered equivalent to one large two compartment tank. The first tank in series should be twice the capacity of the second tank in order to be consistent with the requirement that 2/3 of the total volume of a two compartment tank be in the first compartment. It should be noted that many precast tanks with a capacity of 2,000 gallons or greater are not fabricated as two compartment tanks. In this case, it will be necessary to specify that a baffle wall be constructed in the field. This is relatively easy to do with concrete block. The normal precast concrete tank is not designed to withstand heavy loads on top of it. For this reason, it should be specified that the tank be reinforced for H-20 wheel loading if located under a driveway or parking lot.

Metal, fiberglass or polyethylene plastic septic tanks are also acceptable, providing they are equivalent to a two compartment concrete tank in size, dimensional requirements and strength. Such tanks are relatively expensive. They normally are used in locations which are inaccessible to the heavy truck which is necessary to carry the concrete tank. Plastic tanks can be hand-carried to inaccessible locations. However, such tanks should not be used in areas of high ground water because they are light weight and tend to float, particularly when the liquid level is low during cleaning.

Septic tanks are constructed with the inlet three inches higher than the outlet in order to assure that the liquid level will not rise up into the house sewer. If this occurs, solids could be deposited in the sewer, causing clogging. Installers must take care that precast tanks are not reversed during installation, and that all tanks are set as level as possible.

SEPTIC TANK MAINTENANCE

Septic tanks should be inspected at intervals of no more than every two years to determine the rate of scum and sludge accumulation. If inspection programs are not carried out, a pumpout frequently of once every three to five years is reasonable. Once the characteristic sludge accumulation rate is known, inspection frequently can be adjusted accordingly. The tank should be cleaned whenever the thickness of the scum layer is two inches or more, or the sludge level is within 12 inches of the bottom of the outlet baffle.

Scum can be measured with a stick to which a weighted flap has been hinged or with any device that can be used to feel the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until the resistance from the bottom of the scum is felt. A long stick rapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid level of the tank. After several minutes, the sludge layer can be distinguished by sludge particles clinging to the toweling.

Following is a list of considerations pertaining to septic tank operation and maintenance.

1. Climbing into septic tanks can be dangerous, as the tanks are full of toxic gases, such as, hydrogen sulfide. Do not enter a septic tank without a proper air supply or safety rope tied around the chest or waist.

2. The manhole, not the inspection opening, should be used for pumping so as to minimize the risk of harm to the inlet and outlet baffles. Inlet and outlet baffles should be inspected for damage or clogging whenever the septic tank is cleaned. It is particularly important that missing or damaged outlet baffles are replaced promptly, since floating solids can be carried into the leaching system, clogging it and requiring expensive repairs.

3. It is not necessary to leave solids in the septic tank as an aid in starting digestion.

4. When pumped, the septic tank need not be disinfected, washed or scrubbed.

5. Chemical or biological additives should not be added to a septic tank. They are unnecessary and probably ineffective. Furthermore, certain chemical additives such as chlorinated hydrocarbons may be carcinogenic and cause groundwater or well pollution if added to the septic tank. Ordinary amounts of bleaches, lye, caustics, soaps, detergents and approved drain cleaners will not harm the operation of the septic tank.

6. Materials not readily decomposed, such as sanitary napkins, coffee grounds, cooking fats, bones, wet-strength towels, disposable diapers, facial tissues, cigarette butts, etc., should not be flushed into a septic tank. They will not degrade in the tank and can clog the inlet or outlet.

GREASE TRAPS

Grease traps, although similar in appearance to septic tanks, are intended as pretreatment units for kitchen wastes only, before discharge to conventional septic tanks. In a large restaurant or cafeteria, the sewer serving the dishwasher, pot sink, floor drains and food preparation sinks and equipment should be separated from the toilet wastes inside the building and connected to a grease trap located outside the building. The grease trap is deeply baffled and is sized to allow food particles to settle and floating grease to rise to the top of the unit. Some studies suggest that grease traps are capable of removing up to 60% of oil and grease and 50-80% of the BOD and TSS. Grease traps are not intended for decomposition of the accumulated solids, and should therefore be cleaned frequently, about every one or two months. To facilitate this, cleanout manholes on grease traps should be extended to grade. Grease traps will not remove emulsified grease from the kitchen wastes. Kitchen waste may contain considerable amounts of emulsified grease where dishwashers are connected to the system discharging large amounts of hot water and detergent. Some removal of emulsified grease may be produced in the septic tank where the kitchen waste is cooled by mixing with toilet waste and comes in contact with solid particles and gas bubbles produced by biological decomposition.

It may not be practical to use outside grease traps in large office buildings or schools where the cafeteria is connected into the main sewer system. Also, it may not be feasible to install an outside grease trap on an existing restaurant. In such cases, small, inside grease traps located in the kitchen may be used. These units should be cleaned once or twice a week. This frequently is not done, since the traps would have to be cleaned by kitchen workers, who find the job objectionable.

10. DOSING THE LEACHING SYSTEM

Incomplete utilization of the leaching system is an important but often overlooked factor in subsurface sewage disposal system failure. The most common example is sloping leaching trenches constructed on a hillside, where all the sewage effluent collects at the lowest point in the system and breaks out on the ground surface, while the higher portions of the system receive little or no effluent and are still completely functional. The primary objective in laying out the dosing arrangement of any leaching system is to assure that all portions of the leaching system are utilized before failure can occur. An equal or uniform application of sewage effluent throughout the leaching system is also considered to be desirable, but it is questionable how important the distribution arrangement is in achieving this. The growth of slime layers on the infiltrative surfaces appear to be the most important factor in producing a relatively uniform usage of the leaching area. Perforated distribution pipe in trenches, and hollow chambers in pits and galleries mainly serve to assure that excessive slime growth will not clog portions of the leaching system and prevent effluent from reaching other portions.

There are three techniques which can be used to assure that all portions of the leaching area are utilized before failure can occur. These are:

1. Intermittent dosing or flooding of the leaching system,
2. Keeping the leaching units level and interconnecting them, and
3. Serial distribution with high level overflow connections from higher leaching units to lower leaching units.

These techniques may be used separately or in combination. The decision as to which type of dosing arrangement to use depends on the type of leaching unit, the size of the leaching system and the slope of the ground surface in the area where the system is located.

INTERMITTENT DOSING

Intermittent dosing is necessary where there is a system of leaching trenches containing a large amount of perforated or open-joint distribution pipe. Intermittent dosing causes sewage effluent to be carried farther along the perforated pipe, preventing excessive loading on the inlet ends of the leaching system which could cause heavy slime growth and premature soil clogging. It allows an increase in the length of leaching trench which can be effectively used. There is also some advantage in using intermittent dosing where it is necessary to divide effluent equally to a number of separate leaching units, either trenches, pits, or galleries. Intermittent dosing will flood, or at least raise the liquid level in the distribution box sufficiently to assure that the volume of effluent discharged through each outlet in the box will be more or less equal. If intermittent dosing is not used, the liquid level in the distribution box in a small sewage disposal system will rarely rise more than 1/4 inches above the outlet inverts, and there could be extreme variations in the volume of effluent discharged through the various outlets if the inverts are not set exactly at the same elevation (see Table 10-1).

Table 10-1 Discharge Rate and Theoretical Head Developed in Distribution Box for Various Household Plumbing Fixtures.

Fixture	Discharge Rate (gpm)	Head Developed in Dist. Box (inches): 3-Outlet D-box	Head Developed in Dist. Box (inches): Single Outlet Serial D-box
Wash basin-water running	0.75	1/8	1/4
Kitchen sink-dishwasher rinse	1.50	3/16	3/8
Shower	3.50	1/4	1/2
Washing Machine	10.0	1/2	7/8
Bathtub Draining	15.0	5/8	1 1/8

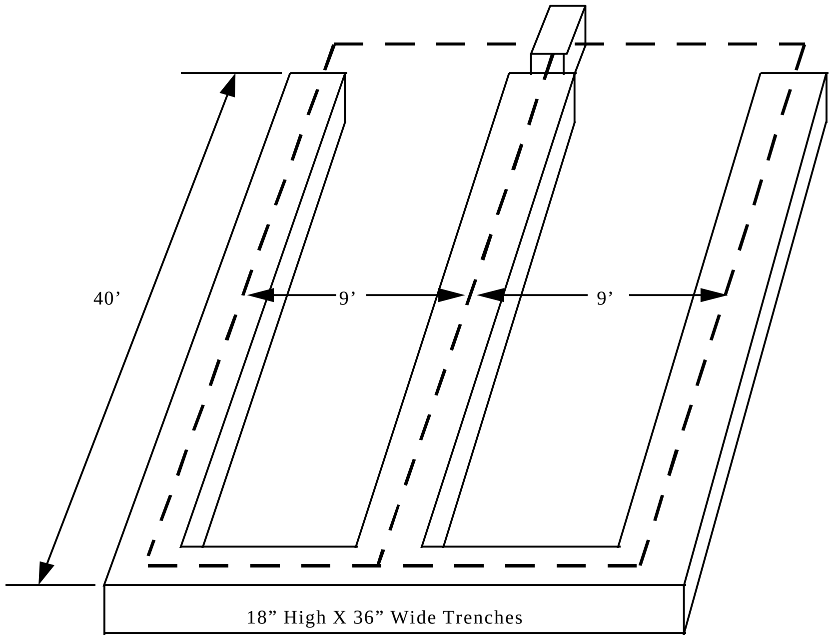
In deciding whether or not to use intermittent dosing, some consideration also must be given to the difference in elevation which could be prudently provided between the septic tank and the leaching system. The most inexpensive and reliable method of dosing is by means of a siphon chamber or the Rissy Floating Outlet Distribution Chamber. However, these devices require a hydraulic head in order to function, so that a minimum elevation difference of 21 to 24 inches must be provided between the chamber inlet and outlet, depending on the diameter of the siphon. Where the ground is relatively flat, this might result in the leaching system being constructed too deep. Problems which could result from high ground water and underlying ledge or hardpan may outweigh any advantages produced by intermittent dosing in this situation. Sewage pumps can be used for intermittent dosing where siphons are not feasible. However, they are relatively expensive to install and operate, and some provision must be made to eliminate inconvenience and possible health hazards which could result from pump or power failure. For these reasons, intermittent dosing of smaller leaching systems normally is considered only where siphons can be used.

Another perceived advantage of intermittent dosing is the "rest period" which a leaching system receives between doses. There may be some marginal benefit where the period between doses is long enough for the leaching system to drain completely and allow air to reach the slime layers. But in most cases, this is of questionable value, since variation in water usage throughout the day and night provides a substantial rest period for a properly designed leaching system to drain completely. Past design practice occasionally had called for separate leaching systems dosed by alternating siphons, in order to provide a longer rest period between doses. This is no longer an acceptable design practice since it reduced the assurance that all portions of the leaching system would be utilized before failure occurred. When one siphon became inoperative due to clogging or leakage, all of the effluent was directed to the leaching system served by the functional siphon, resulting in overload and premature failure. The design of siphons and sewage pumping systems is more fully discussed in Section II of this manual.

LEVEL LEACHING SYSTEMS

The type of leaching system which provides the greatest assurance that all portions of the system will be utilized before failure occurs is a system in which all of the leaching units are of the same type, are constructed at the same elevation, and are interconnected as fully as possible. The leaching units in such systems may consist of trenches, pits or galleries. All level leaching systems have two features in common. (1) Each leaching unit has appropriately the same effective leaching area and is dosed with approximately the same volume of effluent from a central distribution box. (2) The leaching units also are connected to one another by a separate pipe or trench with acts as a relief line, allowing effluent from overloaded leaching units to flow to underloaded ones before failure occurs.

In trench and gallery systems, the relief line is normally located at the end of the trench or gallery farthest from the inlet. Trench systems are usually connected by an equalizing trench consisting of perforated pipe laid in a stone filled trench, rather than a solid pipe relief line (Figure 10-1). The equalizing trench is counted as part of the required leaching area. An equalizing trench is much more effective in preventing overloading than a solid pipe, since effluent can flow through the stone to other trenches before severe overloading occurs.



EFFECTIVE LEACHING AREA

40 FT X 3 X 3 = 360 SF
6 FT X 3 X 2 = 36 SF
396 SF

Figure 10-1 Level Leaching Trenches

Leaching pits are normally interconnected to one or more other pits on the same elevation by solid pipe connections at mid-depth (Figure 10-2). Connections near the pit bottom are difficult to construct and may become clogged with sludge or dirt. High level connections are not desirable for pits on the same elevation because a pit must be full and near the point of failure before relief occurs. In level leaching systems, it is also desirable that the central distribution box be located near the leaching units and sufficiently deep so that it is below the elevation of the ground surface over the leaching unit. This would allow the distribution box itself to act as a relief line, since effluent would backup into the box and be redistributed between the functioning leaching units before breaking out on the ground surface.

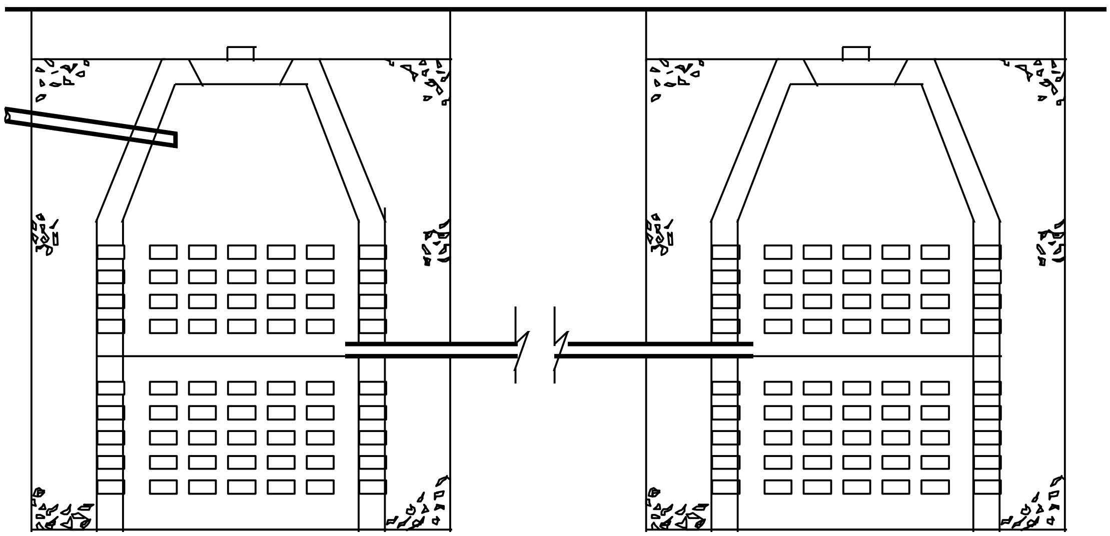


Figure 10 -2 - Pits at Same Elevation - Connection at Mid-Depth
Effective Area = Pit Depth **Utilized** X Pit Diameter X π

Level leaching systems should be used where the ground surface in the area of the leaching system is generally flat. They may also be used on sloping areas where there is a sufficiently deep strata of good soil to allow the bottom of the deepest leaching unit to be kept the required elevation above underlying ledge, hardpan and groundwater. As a rule of thumb, level leaching systems should be considered wherever the slope of the ground surface across the area of the leaching system is less than two feet. If leaching trenches were used in such a situation, the deepest trench on the upslope side could be three to four feet below grade, which would not be excessive. The shallowest trench on the downslope side would then be one to three feet deep, and could be constructed partially in fill, if necessary.

SERIAL LEACHING SYSTEMS

In a serial leaching system, the individual leaching units are set on different elevations, and each unit is connected by a high level overflow pipe to the next lower unit. Effluent is directed to the highest leaching unit. When this unit becomes filled and is functioning at its maximum capacity, any additional effluent will overflow to the next lower unit, and subsequently to others in series. No failure will occur until all leaching units are fully utilized (Figure 10-3). This is the only practical design for small leaching systems constructed on sloping ground where it is necessary to have the leaching units on different elevations. Experience has shown that many leaching systems installed on slopes fail because sewage effluent is not equally divided between the various leaching units. Some units receive an excessive amount which causes overload and failure. This is usually due to a carelessly installed distribution box, in which the outlets are not level. Serial systems are not likely to fail even if installed in somewhat careless fashion since effluent will overflow to lower leaching units before breaking out on the ground surface.

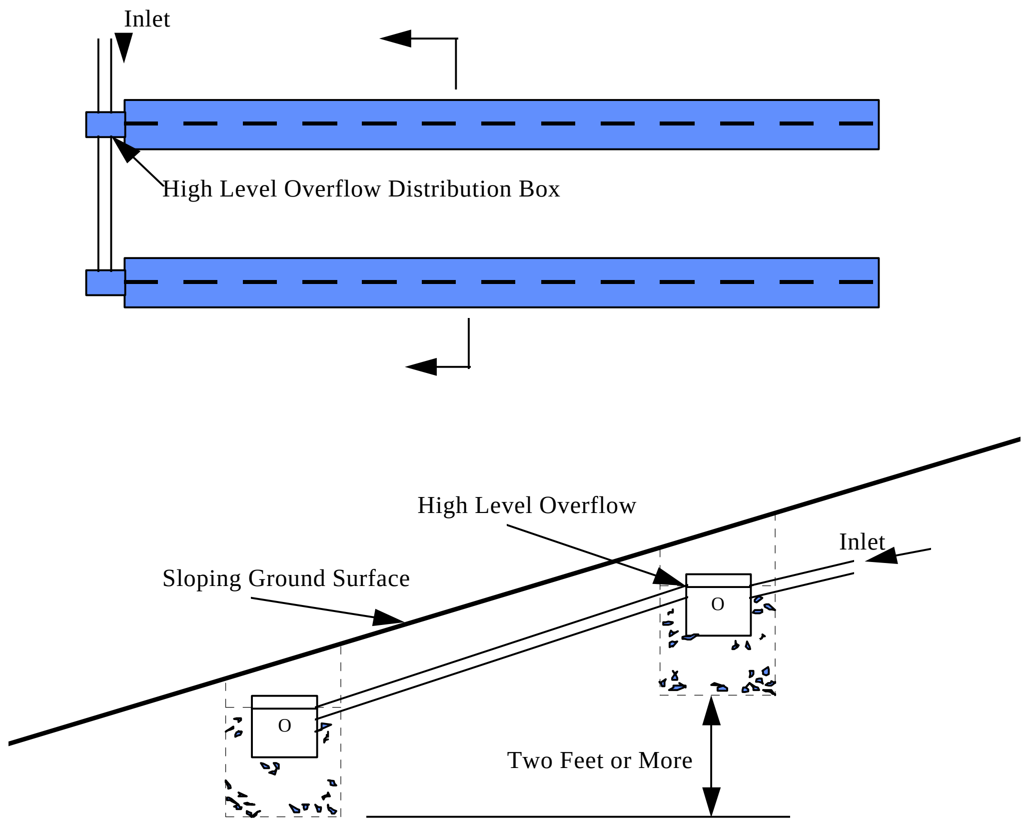
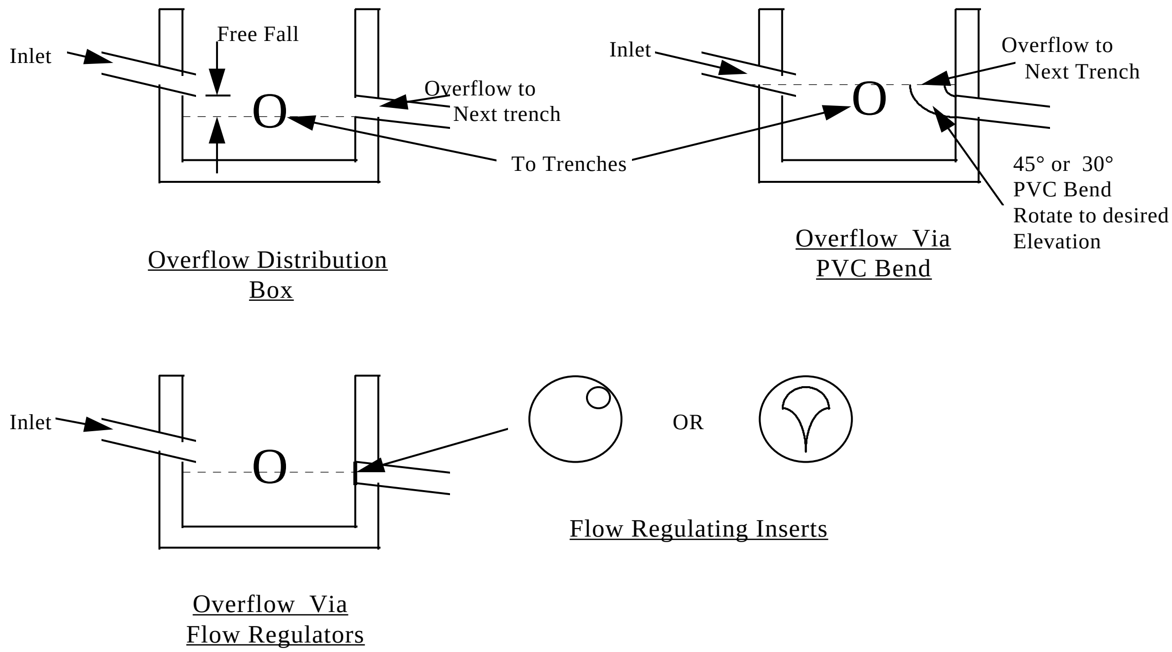


Figure 10-3 - Serial Leaching Trenches

In serial leaching trenches, the upper trenches are flooded above the flow line of their distribution pipes. This is commonly done by means of a distribution box which has been configured so that the outlet opening of the overflow pipe is set one to two inches above the trench piping. Another method is the use a normal distribution box where all the outlets are set at the same elevation, but the overflow outlet is raised by means of a weir which is constructed and set in the field at the desired overflow level. Often, an elbow or perforated plastic cap is used for the overflow weir because the overflow level can be easily adjusted by rotating it on the outlet pipe. Figure 10-4 shows typical overflows for serial distribution trenches. The higher the overflow level is set above the trench distribution pipe, the more fully the trench is utilized before overflow occurs. However, care must be taken that the trench is not filled so high that break-out occurs at a low point on the ground surface over the trench. Normally, serial distribution trenches are constructed with at least twelve inches of cover to guard against this possibility. The overflow can be located at any point in the trench, since the trench is constructed level. It is usually at one end or the other so that it can be more easily located. There is no particular limit on the length of serial trenches, since there is no attempt to equalize trench loading. Excessively long trenches become more difficult to construct level, and overflows should be provided at least every seventy-five feet in order to prevent possible effluent break-out at low points along the trench. Intermittent dosing normally is not used with serial trenches because the upper trenches are usually filled with effluent, and a sudden surge of additional effluent could cause break-out. The excavation between trenches containing the overflow pipes must be backfilled with compacted soil, not stone, so that effluent does not pass through the stone to the lower trenches before the upper ones are full.



HIGH LEVEL OVERFLOW DISTRIBUTION BOXES

Figure 10-4

Leaching pits and galleries also may be arranged for serial distribution, as shown in Figure 10-5. In such systems, the overflow is through an outlet pipe placed near the top of the hollow structure. Overflow of effluent from the upper pits or galleries occurs less frequently than in trenches because of the relatively large storage volume in these units. For this reason, no more than two such units normally are arranged in series.

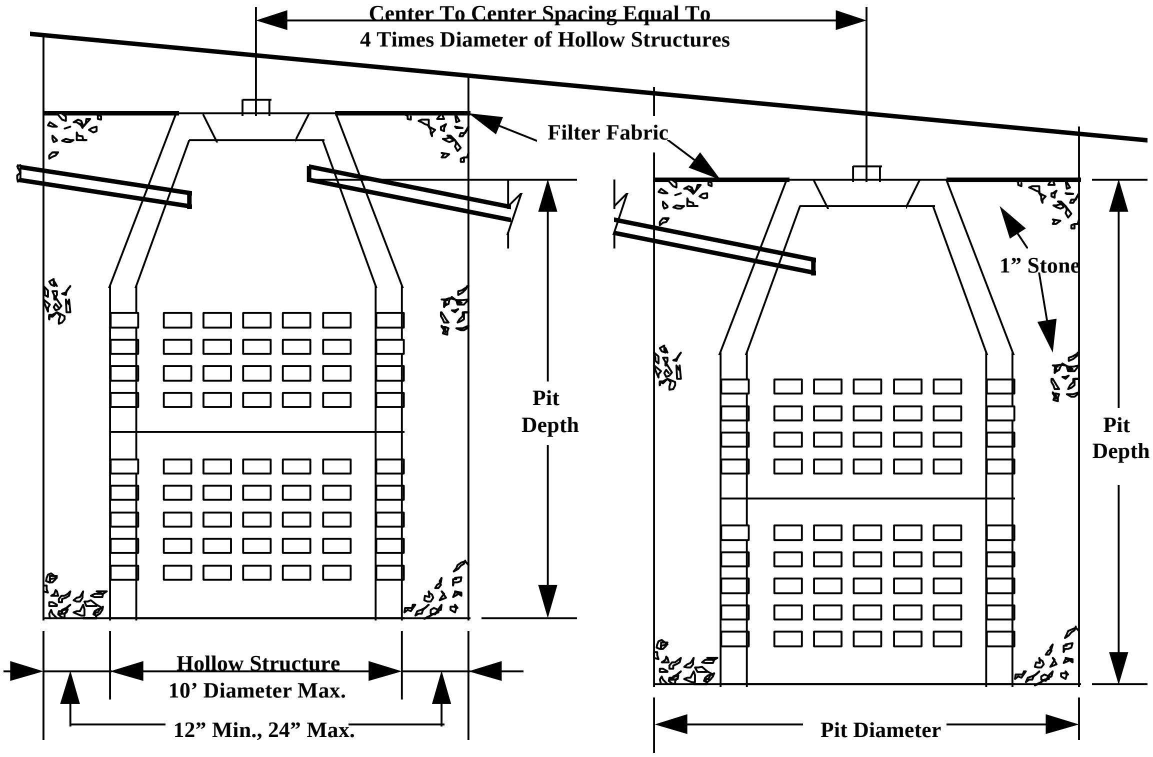


Figure 10-5 Pits at Different Elevations - High Level Overflow
No More Than Two Pits in Series

COMBINATIONS OF LEVEL AND SERIAL LEACHING SYSTEMS

The difference in the loading rate on the various leaching units in a serial leaching system is quite large, the higher units receiving much more effluent than the lower ones in series. This has caused some concern about the functional life expectancy of such systems. For this reason, most serial leaching systems are arranged in such a manner as to avoid placing more than three or four leaching units in series. As long as this design practice is followed, there appears to be no detectable reduction in the functional life expectancy of a serial leaching system. Of course, there are many leaching systems which require more than three leaching units in order to provide the necessary leaching area. In such a case, it will still be possible to avoid having more than three units in series if several leaching units can be constructed on the same elevation and can be interconnected as a single level leaching system. One way of doing this is to spread out a number of leaching units on the same elevation along the slope. Figure 10-6 shows how this may be done using trenches or pits. Other arrangements can be used where it is not possible to spread along the hillside due to space limitations.

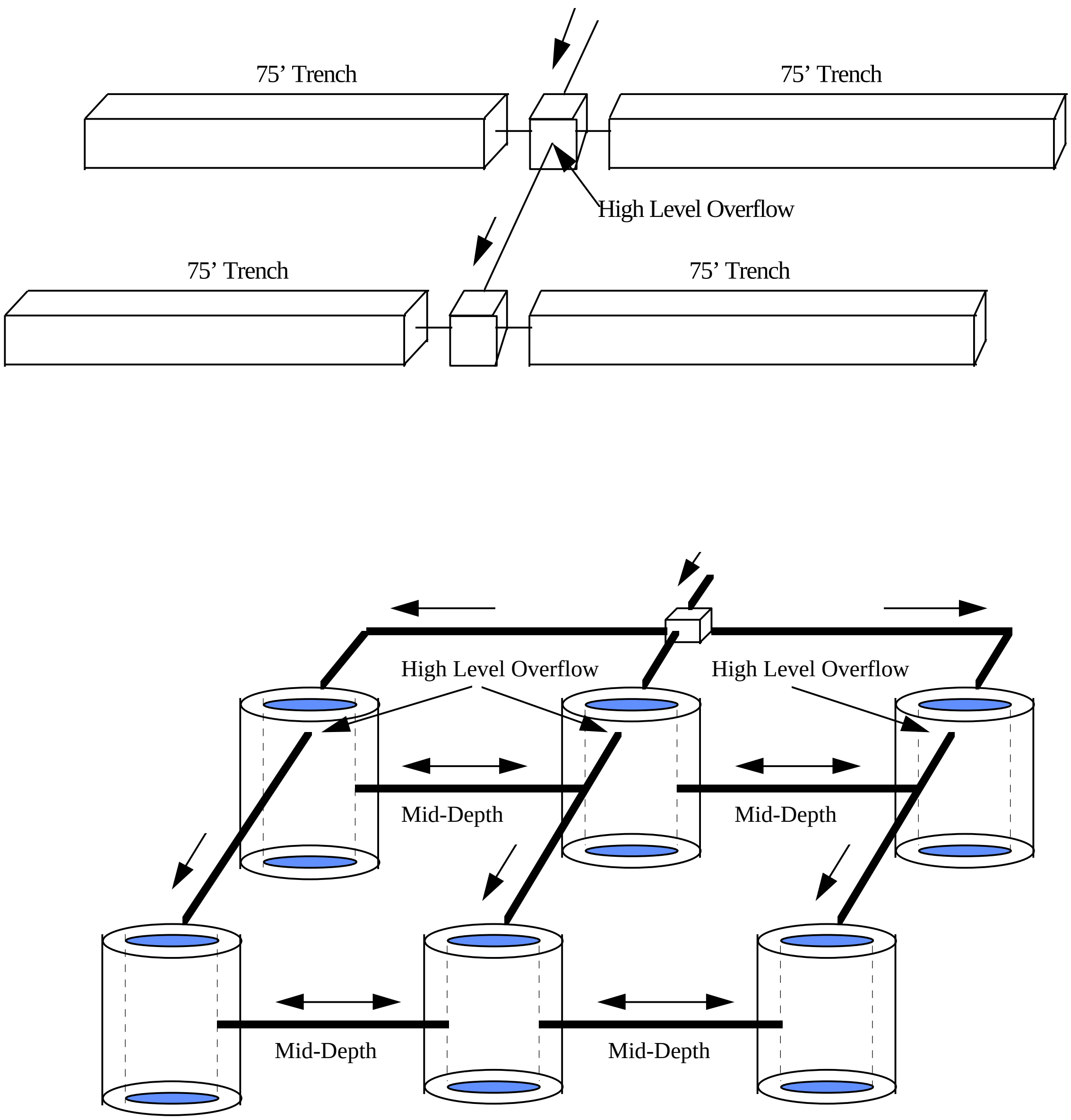


Figure 10-6 - Combination Level and Serial Distribution

If the slope is moderate, and there is no shallow underlying ledge, hardpan or ground water, it may be possible to keep one or more rows of leaching units on the same elevation, even though they may be located in a downhill direction from one another. Figure 10-7 shows such an arrangement of trenches. Note that trenches on the same elevation are connected with equalizing trenches. Such an arrangement has only one high level overflow, and constitutes an arrangement of two level leaching systems in series. Where the slope is relatively steep, or where it is underlying shallow ledge, hardpan or ground water which prevents a leaching system from being constructed too deeply below grade, an opposite arrangement may be used. That is, two separate serial distribution systems may be constructed down hill from one another, each feed from a dosing distribution box which splits the effluent volume approximately equally among the two systems. In such an arrangement, the dosing distribution box is able to perform that function by storing sewage in a tray which flips over when approximately 1.5 gallons of sewage is collected.. Once empty, the tray's counterweight returns it to the horizontal position for the next cycle. The box should be set on a firm base but it is not critical that each outlet pipe be set at the exact elevation of the other since the rush of the sewage leaving the storage tray will negate any small difference in outlet elevations. See Section II for a discussion on D-box design and construction.

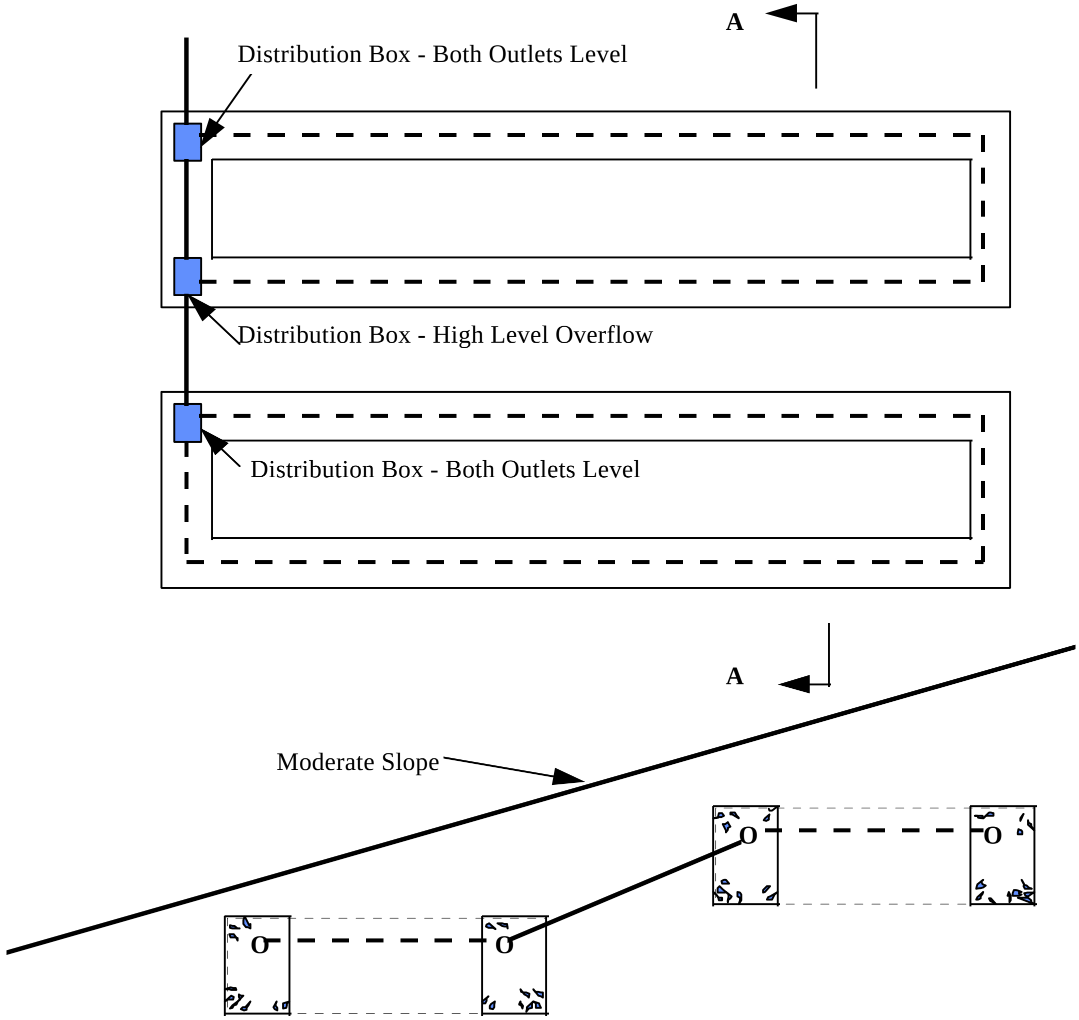


Figure 10-7 - Two Level Trench Systems in Series

11. HOW LEACHING SYSTEMS FUNCTION

A properly functioning leaching system should disperse sewage effluent into the surrounding naturally occurring soil without breaking out on the ground surface or backing up during periods of heavy use or under adverse weather conditions. Such a system also should not cause an unacceptable level of ground water pollution. In order to accomplish these objectives, a leaching system must be designed with three separate functions in mind.

1. The system must provide sufficient infiltrative surface to prevent excessive clogging by the biological slime which forms on the soil interface.

2. The system must be surrounded by an area of soil with sufficient hydraulic capacity to disperse the liquid volume without becoming saturated.

3. The system must contain sufficient hollow spaces within the stone or leaching structure to allow sewage to be stored during periods of heavy use, or when rainfall or subsurface flooding reduces the ability of the system to disperse liquid.

Enlarging a leaching system will enhance all of these functions, assuming it is not constructed in saturated or impermeable soil. However, it is more proper to consider the effect of the soil, site conditions and system design on each of these functions separately when designing the leaching system.

PREVENTING CLOGGING OF THE SOIL INFILTRATIVE SURFACE

A layer of biological slime is formed on the interface between the soil and the leaching surface of the particular type of leaching unit being utilized (such as the stone in a leaching trench or gallery; filter fabric used in products like the Contactor, etc.; or the soil itself utilized in stoneless plastic leaching trenches). This soil infiltrative surface results from bacterial and biological particles being collected on the soil surface, and from the growth of certain organisms within the slime layer itself. The thickness of the slime layer mainly is related to the sewage application rate, being thicker for more heavily loaded systems. The growth of the slime layer reduces the rate at which sewage passes into the soil. In so doing, it causes sewage effluent to be distributed over more infiltrative surface, thereby equalizing the distribution of sewage effluent throughout the leaching system. This, together with the reduction of BOD which occurs when the sewage effluent is filtered through the slime layer, is extremely important in preventing ground water pollution. Eventually, most of the active infiltrative surface will be covered by a slime layer of more or less uniform thickness, and the rate of which the sewage effluent passes through the layer will stabilize. This stabilized infiltration rate is sometimes called the “long term acceptance rate” of the soil.

The minimum leaching area requirements of the Public Health Code are related to the expected long term acceptance rate of the infiltrative surface within the leaching system, as indicated by percolation testing. The relationship between the percolation test results and the expected long term acceptance rate has been established empirically through observation and experience by many agencies over a long period of years. The effective leaching credits assigned to each type of leaching product in the Technical Standards of the Code have taken this relationship into account (a more detailed discussion of effective leaching credits is presented in Chapter 12). Therefore, in theory, no matter what type of leaching product is utilized, in order to provide the minimum square footage of effective leaching area required for any system, the daily discharge volume should be the same. The only exception to the above statement pertains to leaching pits, where only the side area is counted as effective, not the bottom. This discrepancy is due more to the variability of pit construction and an attempt to ease the mathematical calculation process then to any scientific reason. In fact, both the bottom and sides of leaching pits constitute active infiltrative surfaces the same as all other leaching products. The decision as to what type of product to use should be based on the soil conditions present in and around the proposed leaching area (deep pits should not be used in areas of high ground water, etc.) and economic factors. In general, the adequacy of the Code requirements for leaching area are well proven. Engineers, Sanitarians and Installers can be assured that leaching systems for household and small commercial subsurface sewage disposal systems based on the Public Health Code requirements will not fail due to excessive clogging of the leaching systems.

Periodically, the slime layer on the infiltrative surface will become unstable and a "breakthrough" of sewage effluent will occur. Such breakthroughs are more frequent in the more permeable soils where the biological particles are more easily detached and washed into the larger voids in the soil. Fluctuating liquid levels and loading rates accelerate slime deterioration and breakthrough. In fact, many leaching systems in highly permeable sand and gravel have functioned satisfactory for many years at loading rates well in excess of the theoretical long term acceptance rate. This is probably because instability of the slime layer allows frequent breakthroughs of sewage effluent. Engineers sometimes take advantage of this by using deep leaching systems in permeable fill where the area available for leaching purposes is severely limited.

DISPERSING LIQUID INTO THE SURROUNDING SOIL

After sewage effluent passes through the slime-covered soil infiltrative surface, it must be dispersed into the surrounding soil. In a properly functioning leaching system, this is accomplished in two ways: (a) by hydraulic flow through the voids in the soil, and (b) by capillary dispersal and evaporation. Hydraulic flow is the predominant mechanism of dispersal in the coarser grained soils, while capillary dispersal is important for the finer grained soils. Most leaching systems are constructed in moderately permeable, well graded soils where hydraulic flow and capillary dispersal occur simultaneously. An understanding of the mechanisms of dispersal can help engineers, sanitarians and installers in designing and constructing leaching systems for maximum dispersal into the surrounding soil.

In a properly functioning sewage disposal system, liquid flowing from the leaching system to the ground water table will not saturate the soil under the system because the liquid will pass through the slime-covered soil infiltrative surface at a slower rate than it will pass through the soil behind it. However, it will cause a slight elevation of the ground water table under the system as the liquid is added to the ground water in this area, or will cause a "mounding" of liquid on underlying impermeable layers of ledge or hardpan. (See Figure 11-1) In the worst case, the mound of saturated soil could rise to the level of the leaching system, causing it to fail. Therefore, a conservative estimate of a hydraulic capacity of this soil surrounding a leaching system can be obtained by assuming a certain saturated flow pattern from the leaching system, and calculating the rate at which liquid would flow through the saturated soil. This sometimes is called the "hydraulic conductivity" of the surrounding soil. It depends on the soil permeability, the cross-sectional area of saturated flow, and the slope of the hydraulic gradient. Increasing any one of these factors will increase the hydraulic conductivity. On the other hand, if any one of these factors is severely limited, the hydraulic conductivity is also severely limited. Therefore, leaching systems can fail because of hydraulic limitations of the surrounding soil, such as flat slope or shallow underlying hardpan or ledge. This type of failure has nothing to do with clogging of the leaching area, and enlargement of the leaching system may not prevent such failure. This subject will be discussed in more detail in Chapter 13 - Hydraulic Capacity of Underlying Soils and Minimum Leaching System Spread.

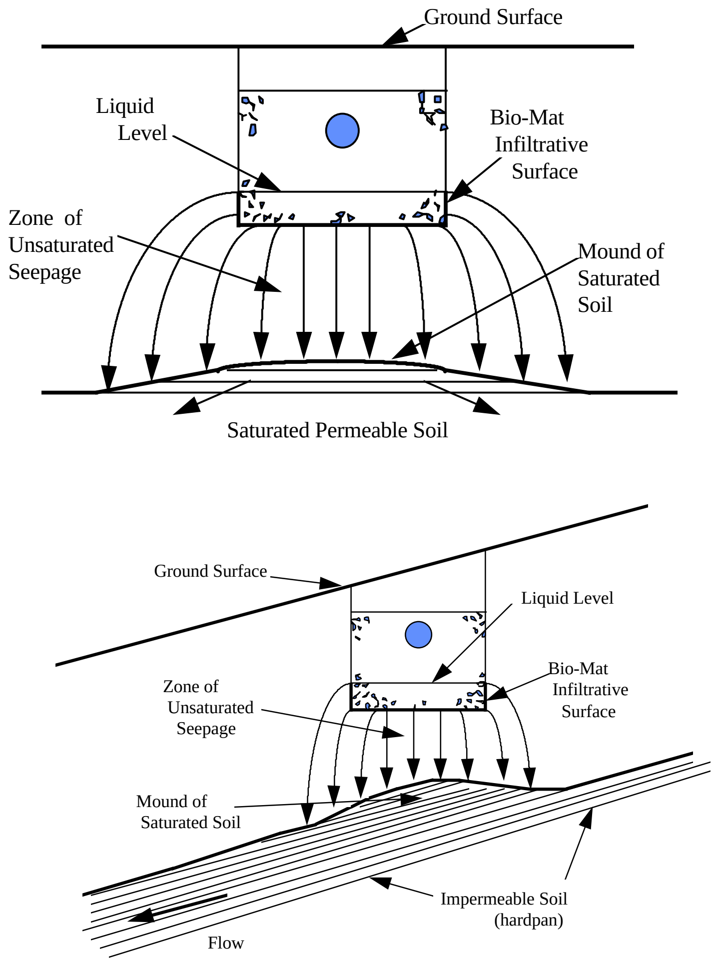


Figure 11-1 - Effluent Mounding

Where site conditions are particularly severe, the Public Health Code states that a study may be required of the capacity of the surrounding natural soil to absorb or disperse the expected volume of sewage effluent without overflow or breakout. The method of making such hydraulic analyses are discussed in Part II. The key to proper analysis depends on a correct determination of the type of flow pattern by which the sewage effluent is dispersed into the surrounding soil. This depends on whether or not there are impermeable “boundaries” which restrict downward flow. Where there is an underlying boundary layer of hardpan or ledge, the cross-sectional area of saturated flow can be increased by spreading the leaching system as much as possible along the hillside, perpendicular to the slope of the hydraulic grade. Figure 11-2 shows how this can be done. The slope of the hydraulic grade can be increased by elevating the leaching system as shown in Figure 11-3. Engineers, sanitarians and installers should take this into account when repairing systems which are located in areas where there may be hydraulic limitations.

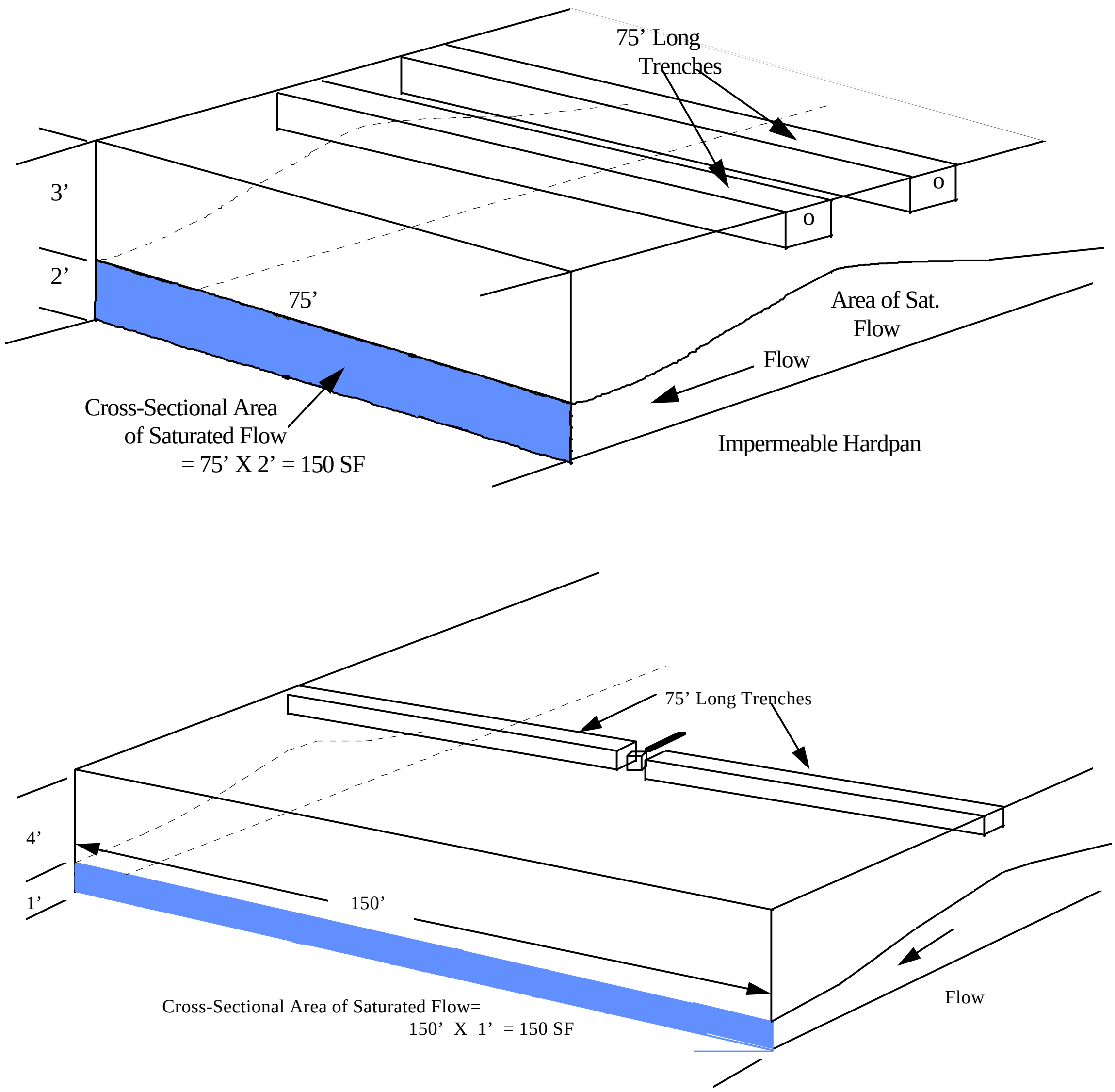


Figure 11-2 Spreading Trenches to Reduce Effluent Mounding

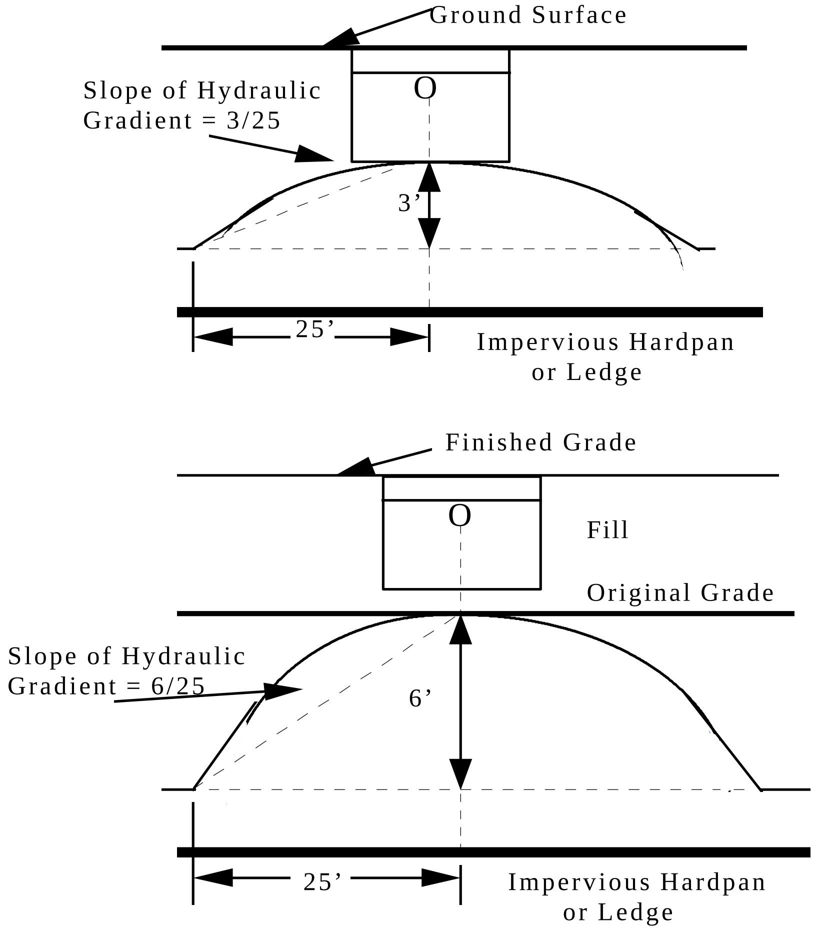


Figure 11-3- Elevating Trenches to Increase Hydraulic Gradient

Water readily adheres to the surface of most naturally occurring minerals. In moderately permeable soils, capillary attraction tends to hold water in the smaller void spaces, preventing them from draining. This creates a zone of moist, unsaturated soil around a leaching system in which air circulating through the larger voids will evaporate water from the smaller voids and disperse it to the atmosphere as water vapor. See Figure 11-4. This process is continuous as long as the soil is unsaturated, and results in a significant dispersal of liquid from leaching systems constructed in moderately permeable soils. The amount of liquid dispersed depends primarily on the size and uniformity of the soil particles, their mineral composition, and the atmospheric evaporation rate. Most leaching systems constructed in fine grained soils function primarily by capillary dispersal and evaporation during the drier months. Capillary dispersal will slow or stop when rainfall, frost or snow cover prevents atmospheric evaporation. However, such periods rarely exceed a few weeks or a month in Connecticut, even during the winter and spring seasons. Capillary dispersal and evaporation becomes less important as soils become saturated because the capillary area under and around the leaching system is reduced and air circulation is impeded. While some evaporation occurs when capillary dispersal moves liquid upward toward the more permeable shallow soil layers, this is relatively minor compared to the hydraulic flow under saturated conditions. For this reason, it is inadvisable to depend on capillary dispersal and evaporation in slowly permeable soils which tend to become seasonally saturated. Capillary dispersal and evaporation is maximized in leaching systems consisting of shallow, narrow leaching trenches. Leaching systems constructed in a relatively uniform very fine sand or silt loam have the greatest capillary dispersal and evaporation. Engineers sometimes specify this material for covering leaching systems in marginal locations.

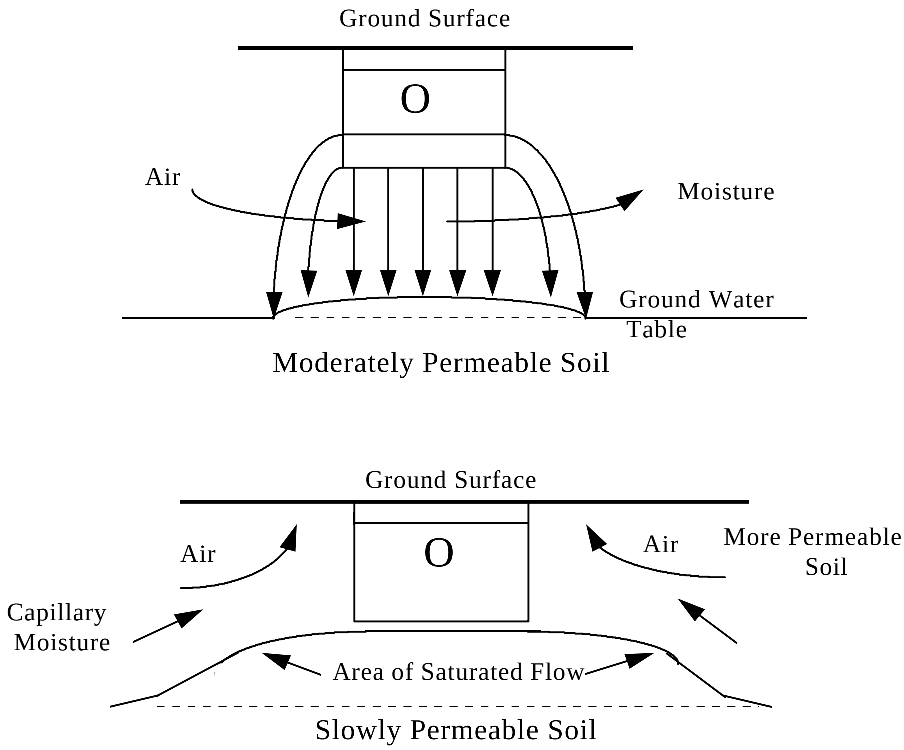


Figure 11-4 - Capillary Dispersal and Evaporation

STORING LIQUID WITHIN THE LEACHING SYSTEM

There are times when rainfall or poor soil evaporation will reduce capillary dispersal into the surrounding soil. Seasonally high ground water levels reduce the hydraulic gradient and the hydraulic conductivity of the surrounding soil. Excess sewage effluent will accumulate in the leaching system when the rate of dispersal is reduced below the rate at which sewage is discharged to the system. Accumulation can also result from unusually high sewage discharge from the building served. All leaching systems must have sufficient void space within the stone or leaching structure to store excess sewage effluent during this time, until it can be satisfactorily dispersed into the surrounding soil. Leaching systems designed in accordance with the Public Health Code requirements should have sufficient storage within the system to provide for all normally occurring variations in soil dispersal rate or sewage flow. Hollow structured plastic leaching products, leaching galleries or pits provide considerable storage under the above adverse conditions, but are normally only suitable for relatively permeable soils.

12. HOW PRODUCTS ARE ASSIGNED AN EFFECTIVE LEACHING FACTOR

For many years the only types of leaching systems installed in Connecticut consisted of trenches, galleries, pits and beds (beds are now prohibited by Code). Over the past few years many new products have been introduced utilizing different materials and configurations in order to apply sewage into the soil. In order to provide a fair and consistent means of assigning effective leaching credits to these various products an empirical formula was developed by the State Department of Public Health (in conjunction with their Code Advisory Committee).

DEVELOPING THE FORMULA

In developing the formula, basic assumptions were made based on the performance characteristics of the most widely used leaching system in Connecticut at the time, the three (3) foot wide leaching trench. Over the years this type of system has been installed using "sizing tables" which have been modified (upward) as experience and data accumulated. To a point were today a leaching trench system, installed per Code requirements, will perform satisfactorily for a substantial period of time. Due to the vast amount of historical information available, it was decided that the three (3) foot leaching trench would be the standard by which all other leaching products would be judged.

As stated in the previous chapter, a leaching system must provide sufficient infiltrative surface to prevent excessive clogging by the biological slime which forms on the soil interface. Studies have been performed which actually determined the long-term acceptance rates (LTAR) of sewage passing through this biological mat. Typically, they range from 0.3 to 0.8 gallons per square foot per day. The rate is at the low end of the scale when the permeability of the soil is slow and at the high end when the permeability of the soil is fast.

An analysis of the present sizing tables in the Technical Standards will illustrate that the typical stone/soil leaching trench corresponds to the following LTAR values:

STONE/SOIL INTERFACE				LTAR RATE
Percolation Rate	0-10.0	Min./Inch	=	0.55 GAL/SF/DAY
	10.1-20		=	0.40
	20.1-30		=	0.36
	30.1-45		=	0.30
	45.1-60		=	0.27

The basis of the above Table is predicated on the leaching system being fully utilized at the design rate for the system (150 gallons/bedroom/day) and sized per the representative percolation rate of the soils in which it will be installed. It therefore can be concluded that if the water usage from the building does not exceed its daily design rate and the LTAR is not slower than the above levels (caused by slower than anticipated percolation rates or a stronger quality septage inadvertently leaves the septic tank), the leaching system should be able to release the daily discharge indefinitely.

Also working in the system's favor is the fact that water usage on average should be lower than these "peak" design rates and that the LTARs being utilized are somewhat slower than typically found in the above cited studies (if the actual LTARs are faster then the system would be able to discharge a greater volume than the design rate).

All of the above analysis is based on standard stone/soil interfaces. However the “new technology” products are made of different materials and are configured in numerous ways in order to “maximize” infiltrative surfaces. In discussing these variables with the Code Advisory Committee, it was decided that each type of infiltrative surface would be assigned its own Interface Factor (IF). These factors would be based on our judgment on how the LTAR would be affected by the different means of sewage application. The highest rating was assigned to “direct soil” application (open bottom area beneath galleries and plastic leaching products); a reduced rating was given to “filter fabric/direct soil” application: followed by the standard “stone/soil” application; ending with the lowest rating given to systems which are backfilled with “native material” or when “stone is wrapped with filter fabric”.

In developing a formula to determine an Effective Leaching Unit (ELU) credit for each indivual product approved for leaching system use, the three (3) foot wide leaching trench, at 3.0 SF/LF, was used as the standard, knowing full well that the actual “wetted area” of sewage application was five (5) SF/LF (three SF/LF of bottom and one SF/LF for each side of the trench). To assign ELUs to any other type of product the total wetted area provided by the product for each type of interface would have to be determined. This is due to the fact that some leaching products consist of more than one type of interface (example: galleries consist of both “direct soil” and “stone/soil” interfaces). Once each interface’s wetted area (per linear foot) is determined it is a straight mathematical procedure to apply the interface factor to each and then multiply the total by a constant to determine the product’s ELU**.**

ADVANTAGES AND CONCERNS

The advantages of utilizing the ELU method for crediting new products are as follows:

1. The speed in which a new product can be assigned an ELU factor.

2. The consistency in which each product is reviewed and credited. This eliminates all appearance of unfairness relative to crediting different leaching products.

3. The product manufacturers, knowing the basis of the formula, can design products which maximize their products infiltrative surfaces and hence increase their product’s ELU factor.

4. If in the future it is determined that a “Interface Factor ” is not representative of its actual LTAR, the factor can be adjusted and the ELUs of all of the products utilizing that type of infiltrative surface can be recalculated.

It is important to keep in mind that the ELU of any particular product was and is based on the configuration of the product at the time of review by the Department of Public Health. Any physical change to the product must be reviewed by the Department and reassigned a new ELU. At that time a new name or model number would have to be designated by the manufacturer to distinguish the new product from the old. Any misuse of product ELUs could lead to premature failure of the leaching system.

13. LEACHING SYSTEMS IN SOILS WITH SLOW SEEPAGE

Leaching systems in soils with a minimum percolation rate slower than 1 inch in 30 minutes require special design in order to avoid possible problems. Both the investigation and the detailed plan of the system must be made by a qualified professional engineer. Experience has shown that with proper design and construction, subsurface sewage disposal is possible in soils with minimum percolation rates of 1 inch in 30 to 60 minutes, assuming that there is no ground or surface water draining into the area from a higher elevation. Such drainage must be excluded from the area of the leaching system by ground water intercepting drains and surface swales. Soils with minimum percolation rates slower than 1 inch in 60 minutes are considered impervious and unsuitable for leaching purposes because they are likely to become saturated for a month or longer during the wettest season of the year.

NARROW LEACHING TRENCH SYSTEMS

Shallow leaching trenches, 18 to 24 inches wide, are the preferred type of leaching system in soils with slow seepage. Such systems take maximum advantage of lateral seepage into the more permeable layers in the upper few feet of soil, and promote capillary dispersal and evaporation. Four (4) foot wide trenches should not be used since the majority of their effective leaching is through the bottom. When systems are located in slow soils, it is important that the loamy subsoil not be stripped from the area of the leaching system because this usually is more permeable than the underlying soil. Care should be taken to only remove the vegetative growth on the top surface and not compact the loamy subsoil with heavy equipment during construction in order to maintain the larger soil voids through which air may circulate and evaporate moisture. Rainfall will tend to saturate soils with slow seepage. Therefore, it is important that the ground surface over the leaching system is sloped to drain rapidly.

ALTERNATELY USED LEACHING SYSTEMS

In some cases on existing lots it is necessary to repair leaching systems in soils which will become saturated by a continuous application of sewage effluent during the wet season. Where space is available, this may be done successfully by constructing two separate leaching systems, each large enough to dispose of the entire sewage flow under favorable seasonal conditions. During the wet season, the leaching systems are alternated in use, with one system “resting” while the other receives the entire effluent flow. The systems are watched closely and switched over manually by means of a gate or valve in a diversion box when the system in use appears to be almost saturated. Alternation intervals are usually 1 to 3 weeks during the wetter season and 3 to 4 months during the drier season. The relatively frequent alternation during the wetter season makes maximum use of the storage capacity in both the leaching system and in the surrounding soil. The relatively longer rest periods during the drier season allow the slime layer in the leaching system to dry and shrink, partially restoring the infiltrative capacity which had been reduced by clogging while the system was saturated. Figure 13-1 shows a typical alternately used leaching system.

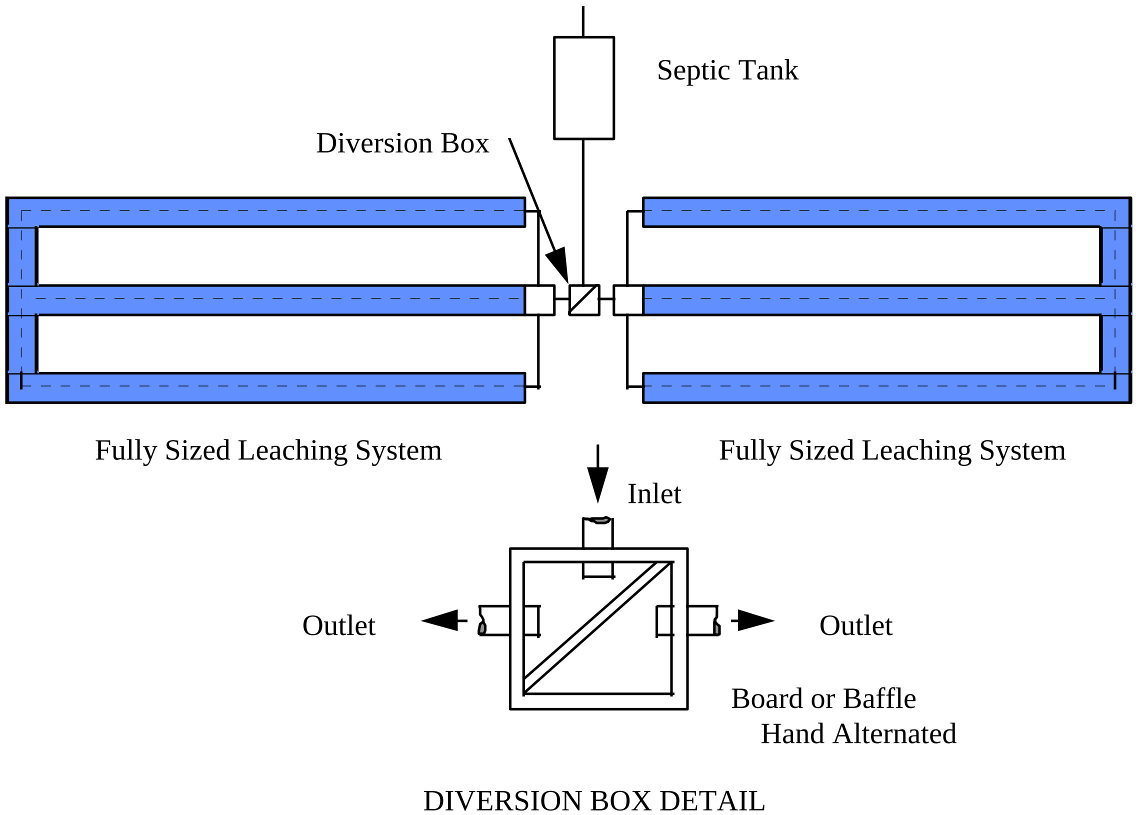


Figure 13-1 - Alternating Leaching System

SUBSURFACE IRRIGATION SYSTEMS

Subsurface irrigation systems are systems of distribution pipe buried just below ground surface for the disposal of partially stabilized sewage effluent. Such systems are not included in the Technical Standards of the Public Health Code, and require special approval of state and local health departments. Trench construction details vary, but they are normally very shallow and narrow, frequently only 12 inches wide and 12 to 18 inches deep. A relatively long length of distribution pipe is necessary to produce maximum liquid dispersal and to provide the storage volume which is lacking in the trench. Application rates are normally less than 1.0 gallons per lineal foot per day. Slotted or filter fabric wrapped plastic pipe laid in a washed sand or gravel backfill may be used, or perforated plastic pipe laid in pea stone. In any case, the sewage effluent must be partially stabilized before being applied to the leaching system in order to reduce clogging around the distribution pipe. Normally a subsurface sand filter is used for this purpose. Subsurface irrigation systems generally are constructed in high, well-drained areas which are not subject to seasonally high ground water, or are surrounded by shallow swales or ditches which prevent ground and surface water from saturating the upper soil layer. Figure 13-2 shows a typical subsurface irrigation system.

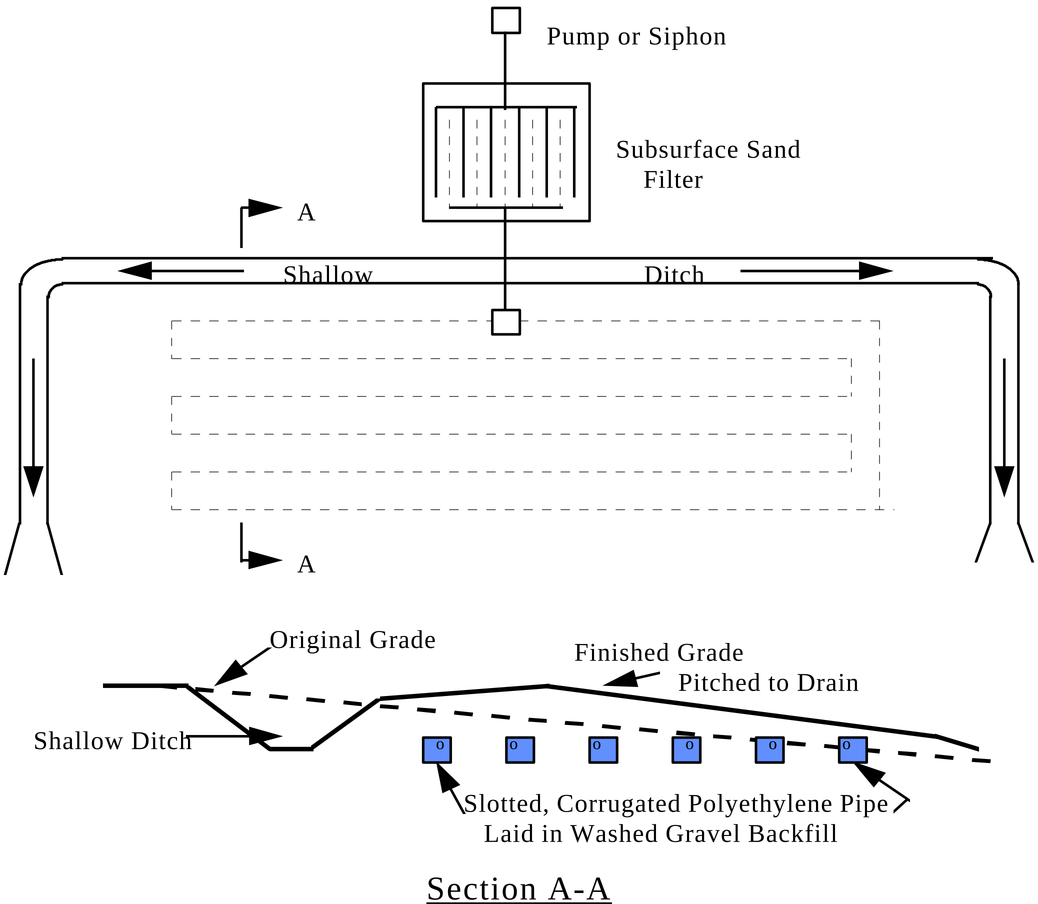


Figure 13-2 - Subsurface Irrigation System

SUPPLEMENTING OR REPLACING IMPERVIOUS SOIL

Occasionally it is necessary to repair or enlarge a leaching system in a location where the available area is limited and the existing soil has a minimum percolation rate slower than 1 inch in 60 minutes. In such a case, it is not advisable to attempt to construct a leaching system directly in the existing impervious soil. Instead, the leaching system should be constructed in an area of fill placed on top of or within the existing soil in such a manner as to allow liquid to pass through the fill into the surrounding soil with a minimum of seepage to ground surface. The most important considerations in the design of such systems is to provide the greatest possible interface area between the fill and the surrounding impervious soil, and to distribute the sewage effluent throughout the fill in such a manner as to prevent it from collecting at one point and breaking out to the surface. The amount of interface area between the stone in the leaching system and the fill is less critical because failure is unlikely to occur due to clogging at that point. Where grades permit, the leaching system should be constructed in a low mound of fill over a generally level area of existing soil. The base of the mound should be as large as possible to provide for extremely slow seepage of sewage effluent into the underlying soil, and to allow development of a mound of saturation within the fill. Generally a minimum lateral separating distance of 25 feet is provided between the leaching system and the toe of the fill to reduce the possibility of breakout. In critical cases, the basal area of the mound may be designed on the results of hydraulic analysis of the underlying soil. See the section on "Leaching Systems In Fill" for further discussion.

EFFLUENT DISTRIBUTION IN SOILS WITH SLOW SEEPAGE

Leaching systems in soils with slow seepage have a tendency to become seasonally saturated, so that special care must be taken in design and construction to assure that no part of the leaching system is overloaded to the extent that effluent comes to ground surface during the wet season. In level areas, all leaching units should be level and interconnected as much as possible. Serial distribution or a combination of serial and level leaching systems should be used on slopes. Leaching systems of narrow trenches require proportionately greater trench length, and intermittent dosing may be necessary even for household and small commercial systems under 2000 gallons per day in size. The discharge volume usually is limited by the available storage within the leaching system during adverse seasonal conditions, and frequently it must be adjusted after installation. Pumps are often used for dosing because the discharge volume can be easily adjusted by changing the pump control level switches. Pressure dosing through small diameter pipe is sometimes used because effective distribution can be produced with a relatively small discharge volume.

14. LEACHING SYSTEMS IN HIGHLY PERMEABLE SOILS

Soils with a minimum percolation rate faster than 1 inch a minute are considered to be highly permeable. Leaching systems in such soils require special design consideration in order to assure that they will not pollute wells, and ground and surface waters. In general, a determination should be made of the direction and rate of ground water movement, and a review should be made of the adequacy of the lateral separating distances between the leaching system and down-gradient wells or watercourses. If necessary, separating distances should be increased, or the design of the leaching system modified to reduce possible pollution. It is not advisable to attempt to alter the permeability of the soil by excavating and replacing it with less permeable fill or by mixing silt or loam with the existing soil. Attempts to do this in the past have been consistently unsuccessful due to poor construction techniques and lack of proper control.

PREVENTING WELL POLLUTION

The Public Health Code requires that the minimum separating distance between a subsurface sewage disposal system and a water supply well be doubled where the soil percolation rate is faster than 1 inch per minute and ledge is located less than eight (8) feet from the bottom of the proposed leaching system. Most wells serving households and small commercial buildings have a withdrawal rate of less than 10 gallons per minute, therefore a minimum separating distance of 150 feet would be required only where the soil is highly permeable and ledge is less than eight feet from the bottom of the leaching system.. The intent is to discourage the use of individual wells and sewage disposal systems in areas of highly permeable soil and shallow ledge rock. If such areas are to be developed, the public water supply or a community well should be used. See the section on “Leaching Systems In Areas of Shallow Ledge Rock” for further discussion on this subject. Wells in highly permeable soils have rapid recharge rates which result in relatively shallow drawdown and quick recovery. For this reason, movement toward such wells is not as rapid as might be expected. Time of travel from the leaching system to the well is related mainly to the amount of water withdrawn from the well over a period of time, rather than to the pumping rate. As long as the well does not receive heavy use, there is ample time for bacterial die-off. The rate of movement increases where the aquifer is shallow and underlain by impervious soil or bedrock. Fortunately, shallow, high yield wells are rare in Connecticut, and are usually only used for public water supplies which are regulated by the State Department of Health Services. The Public Health Code classifies the drawdown area of a public water supply well with a withdrawal rate in excess of 50 gallons per minute as an area of special concern. A special study of possible detrimental affect of the sewage disposal system on ground water quality may be required in such areas. The Code also requires that all wells drilled into rock be cased and sealed where overlying soil is less than 20 feet deep.

Both experience and hydraulic calculations have shown that leaching systems serving household and small commercial buildings with a sewage flow of 5000 gallons per day or less will not cause well pollution even in the most permeable soil as long as three precautions are observed.

1. The volume of water removed from the adjacent well should not exceed 5000 gallons per day.

2. The adjacent well should be properly cased and sealed into consolidated rock where ledge rock is less than 20 feet below ground surface.

3. The domestic sewage should contain no unusual amount of hazardous chemicals.

Improperly cased and sealed wells located in areas of shallow ledge rock can become polluted even by small sewage disposal systems, however. The potential for pollution is greater if the overlying soil is highly permeable, of course, although the basic problem is poor well construction.

PREVENTING GROUND WATER POLLUTION

Ground water may become polluted by biodegradable organic chemicals where the soil is highly permeable, the ground water is relatively high, and the volume of sewage discharged is large. However, experience has shown that an unacceptable level of pollution is unlikely to occur unless the volume of sewage discharged exceeds 2000 gallons per acre over an area of about 5 acres or more. Where this situation does occur, design engineers should consider pretreatment of the sewage by aeration systems or subsurface sand filters before discharge to the ground by conventional or modified leaching systems. Elevating leaching systems as much as possible above the ground water will reduce the potential for pollution where the soil is highly permeable. Deep leaching pits or galleries should not be used in such soils unless the ground water is very deep. Providing larger leaching systems is of questionable value, since distribution of sewage effluent throughout the leaching system is extremely difficult where the soil is highly permeable. Intermittent dosing would be beneficial, however, to distribute effluent more evenly through the leaching system. Pressure distribution leaching systems built up in fill have been effective in preventing pollution in areas of highly permeable soil and high ground water

PREVENTING SURFACE WATER POLLUTION

Pollution of surface waters by bacteria, oxygen-depleting organic chemicals or phosphates from household or small commercial subsurface sewage disposal systems is extremely unlikely even in the most permeable soils, as long as the minimum separating distances in the Public Health Code are observed. However, nitrate enrichment of surface waters from such leaching systems could be a problem since the nitrate level in the sewage effluent would not be reduced significantly by percolation though highly permeable soil. Generally, nitrate levels in surface waters must be controlled by limiting the volume of sewage effluent discharged into a given area of soil, thereby assuring adequate dilution by rainfall and mixing with groundwater. The nitrate level in sewage effluent discharged to the groundwater from a single family home located on a 1 acre building lot in Connecticut should be about 3 milligrams per liter when diluted by the average annual rainfall infiltrating into the soil on the lot. This is well below the drinking water standard of 10 milligrams per liter. Therefore, no adverse affect would be anticipated on surface water quality from housing developments with 1 acre or even ½ acre building lot requirements.

A possible exception might be lake front developments, where even low levels of nitrates could contribute to accelerated eutrophication. Such situations must be studied on a watershed basis, and is clearly beyond the control of an engineer designing a single subsurface sewage disposal system. There are certain things that a design engineer can do in such a situation, however. Leaching systems on lakefront lots could be located as far from the lake as possible, even if pumping is required. The increased distance from the lake would assure adequate mixing of sewage effluent with the groundwater before entering the lake. The ground surface could be graded or terraced to promote infiltration of rainfall rather than runoff, thereby enhancing dilution. In particularly critical situations, non-discharging toilet systems could be used. These could reduce the nitrate contribution from a dwelling by as much as 80%. Garbage grinders should not be used since they significantly increase nitrate levels in the sewage effluent. Where necessary, special subsurface sewage disposal systems can be designed for nitrogen removal. These are described in Section II of the manual, “Denitrification Systems”.

RECOMMENDED SIZING WHEN SYSTEM IS PLACED IN UNIFORM VERY FINE SANDS

Across the country, there have been a disturbing number of leaching systems which have experienced overloading, where the only common link as to the cause was the type of soil the systems were installed. All of the systems were installed in a highly permeable uniform very fine sand (a soil where the majority by percentage of the particle size is smaller than 0.15 mm - passing the #100 sieve). The theory is that the bio-mat which develops on the soil interface is thicker and less permeable than coarser soils. Therefore more wetted surface should be provided by a leaching system when installed in this type of soil condition (whether as a fill material or naturally occurring). Hence, it is recommended that a percolation rate no faster than 10.1-20 minutes/inch be utilized for sizing purposes.

15. LEACHING SYSTEMS IN AREAS OF SHALLOW LEDGE ROCK

As commonly used, “ledge rock” refers to the continuous bedrock underlying the soil layers. In Connecticut, ledge rock is quite variable in elevation and slope, and it generally forms an impervious barrier to the movement of ground water and sewage effluent. The upper surface of the ledge rock frequently is deeply contoured, forming hollows and ravines which collect percolating ground water and direct it into a channeled flow over the surface of the ledge rock. This can cause a rapid rise in the ground water level following a heavy rainfall which will interfere with the functioning of a leaching system. Sewage overflow can occur if the leaching system is not sufficiently above the underlying ledge rock.

Drainage channels on the ledge rock surface often contain granular soil or broken rock fragments which are considerably more permeable than the overlying soil. Sewage effluent “streamlining” through these drainage channels on top of ledge can move for a considerable distance before being adequately treated by filtration or dilution. This can cause well pollution where wells are not properly cased and sealed into the rock, or where the rock is fissured, allowing pollutants to enter the aquifer.

DETERMINING LEDGE ROCK ELEVATIONS

The design of the leaching system in an area of shallow ledge rock depends on the contour and slope of the underlying ledge, the size of the upslope drainage area, and the depth of the soil overlying the ledge, both under the leaching system and in a downslope direction. For this reason, it is extremely important that a sufficient number of observation pits or probes for ledge rock be made where ledge rock is found at a depth of 7 feet or less. For a household system, the depth to ledge rock should be determined at three or four locations within the area of the proposed leaching system, and at one or more locations downslope from the system. A greater number of pits would be required for larger systems or where ledge outcroppings are noted adjacent to the proposed system. It may also be advisable to dig an observation pit at the proposed location of the septic tank, in order to avoid possible installation problems. The location of ledge outcroppings should be noted.

Ledge rock depth normally is measured from ground surface. Such depth readings are often quite variable, however, since both the ground surface and the underlying ledge rock usually slope. In order to avoid confusion in designing the leaching system, the ground surface elevation should be determined at each test pit location by measuring from a bench mark. The ledge rock elevation and slope can then be calculated, and the location and elevation of the leaching system determined. Using this approach, it will frequently be found that ledge rock shows a relatively consistent profile, even when the depth readings are erratic.

REQUIRED DEPTH OF SOIL ABOVE LEDGE ROCK

Technical Standard VIII requires that the bottoms of leaching systems be kept a minimum of 4 feet above ledge rock, but some judgment is necessary in using this standard. The basic consideration should be the likelihood of the underlying ledge rock interfering with dispersal of ground water and sewage effluent. Experience has shown that underlying ledge rock is unlikely to interfere with the functioning of a leaching system as long as the bottom of the leaching system is elevated 4 feet above the ledge rock surface. However, a small projection of ledge rock under a leaching system is unlikely to cause failure if it rises closer than 4 feet from the bottom of the system, particularly if the ledge is sloped so that ground water and sewage effluent will move out of the area. On the other hand, an elevation greater than 4 feet may be required if the ledge forms a basin or ravine which causes a buildup of ground or surface water during wet periods.

Where there is less than 6 to 7 feet of existing soil over ledge rock, the placement of fill would be necessary in order to construct a leaching trench system with the trench bottoms 4 feet above ledge. Such a method of construction would present no unusual difficulty as long as there is at least 4 to 5 feet of soil above ledge rock, since the bottom of the leaching trenches essentially would be constructed in existing soil. However, construction becomes more critical if there is less than 4 feet of existing soil above underlying ledge. In this situation, the entire leaching system must be constructed in fill, and the nature and compaction of the fill must be carefully evaluated before the leaching system can be designed. For this reason, Section 19-13-B103e(a) of the Public Health Code prohibits the issuance of sewage disposal approvals or permits where there is less than 4 feet of existing soil over ledge rock. It should be understood, however, that this does not mean that no sewage disposal system could ever be built at this location. It only means that the necessary fill must be placed, compacted and tested before the final sewage disposal plan is approved and a building permit issued. This puts the responsibility for making the site improvements entirely on the property owner or builder, and tends to discourage the installation of sewage disposal systems in areas with less than 4 feet of naturally occurring soil over ledge rock. It also encourages owners and builders to test their properties more thoroughly in order to find a location for the sewage disposal system where ledge rock is sufficiently deep to avoid the need for filling before a permit can be obtained. Many planning and zoning commissions use the requirement of 4 feet of existing soil over ledge rock as a standard for approving building lots. All of this is beneficial in avoiding potential sewage disposal problems in shallow ledge rock areas.

The depth of soil overlying the ledge rock <u>downslope</u> from the leaching system also must be considered. In general, a more or less continuous layer of at least 2 feet of soil would be necessary on top of the ledge rock to assure adequate dispersal of sewage effluent. A greater depth of soil would be necessary if significant amounts of ground or surface water drain through the area, or if the ledge rock is relatively level. Where there is less than 2 feet of soil over ledge down grade of a proposed leaching area, it may be necessary to make a hydraulic analysis to determine whether or not sewage effluent will break out prematurely. See Section II for further information on hydraulic analysis. There should be no ledge outcroppings within 50 feet downslope of the leaching system, and no springs within 75 feet downslope.

PREVENTING WELL POLLUTION

Well pollution is frequently a problem in areas of shallow ledge rock, particularly where there are a number of building lots involved, each served by an on-site sewage disposal system and water supply well. In larger subdivisions, some lots normally are located downhill from others, and the wells on these lots may be downhill from the sewage disposal systems. Sewage effluent moving through permeable channels on top of ledge may travel quite a distance and enter wells which have been improperly cased or sealed into consolidated rock. Some ledge rock is fissured, and sealing of the wells may be difficult. Proper well construction should prevent pollution, but unfortunately experience has shown that where there are large number of wells involved, some are always likely to be improperly sealed and subject to pollution. The surest way to prevent well pollution in areas of shallow ledge rock is to extend public water supply mains to the area, or to construct a community well to serve the subdivision. Such a well could be kept at a high elevation and remote from on-site sewage disposal systems. In general, all subdivisions containing 25 or more lots located in an area with underlying ledge rock less than 7 feet deep should be served by a public or community water supply.

Well pollution also has occurred when shallow ledge rock is excavated by blasting to construct roads, sewer lines or subsurface sewage disposal systems. Blasting can open fissures in the ledge and rupture the well casing or seal. Public water supply systems are essential if any rock blasting is to be done in an area of shallow ledge rock and on-site sewage disposal systems.

OTHER DESIGN CONSIDERATIONS

The construction of ground water intercepting drains in areas of shallow ledge rock is difficult and in many cases they are not effective in controlling subsurface flooding. On top of ledge rock, ground water tends to "streamline" through depressions or channels in the rock surface, or through fissures in the ledge rock itself. It is extremely difficult to intercept this flow of water effectively without excavating into the rock. Even if the ground water were intercepted, it may not be possible to discharge the drain by gravity without rock excavation (see Figure 15-1). For these reasons, ground water intercepting drains must be considered unreliable on shallow ledge rock, and generally should not be used. Ground water flow usually is found only in certain locations on top of ledge, and it is better to avoid using those areas for leaching systems.

In some shallow ledge rock areas there may be only limited areas, or "pockets", where the overlying soil is sufficiently deep to be considered for leaching purposes. In such a situation, it may be advisable to divide the leaching system into two or more separate systems, rather than to attempt to put all of the sewage effluent into an area of soil with a limited dispersal capacity. This is particularly important for larger leaching systems, which generally should not be constructed over shallow ledge rock unless the leaching system can be spread over a large area.

NON-TYPICAL LEDGE ROCK

Occasionally a soft, partly decomposed rock layer will be found which easily can be excavated by a backhoe, but which appears to be part of the continuous bedrock. This material is considered to be non-typical ledge rock, inasmuch as it does not present a barrier to the movement of water. In fact, a percolation test made in this material would probably show a moderately good percolation rate. However, in this case, the water moves through small, continuous pores in a solid matrix, rather than through larger, non-continuous voids, as in a soil. While water moves rapidly, sewage effluent will tend to clog the small pores. Because of this, leaching systems should not be constructed directly in decomposed rock. Recommended design practice calls for the bottoms of leaching systems to be constructed at least 2 feet above such non-typical rock, or if necessary, a portion of the decomposed rock may be removed and replaced with 2 feet of sand for filtration purposes. The decomposed rock is usually underlain with consolidated rock, and the leaching system must be at least 4 feet above this layer.

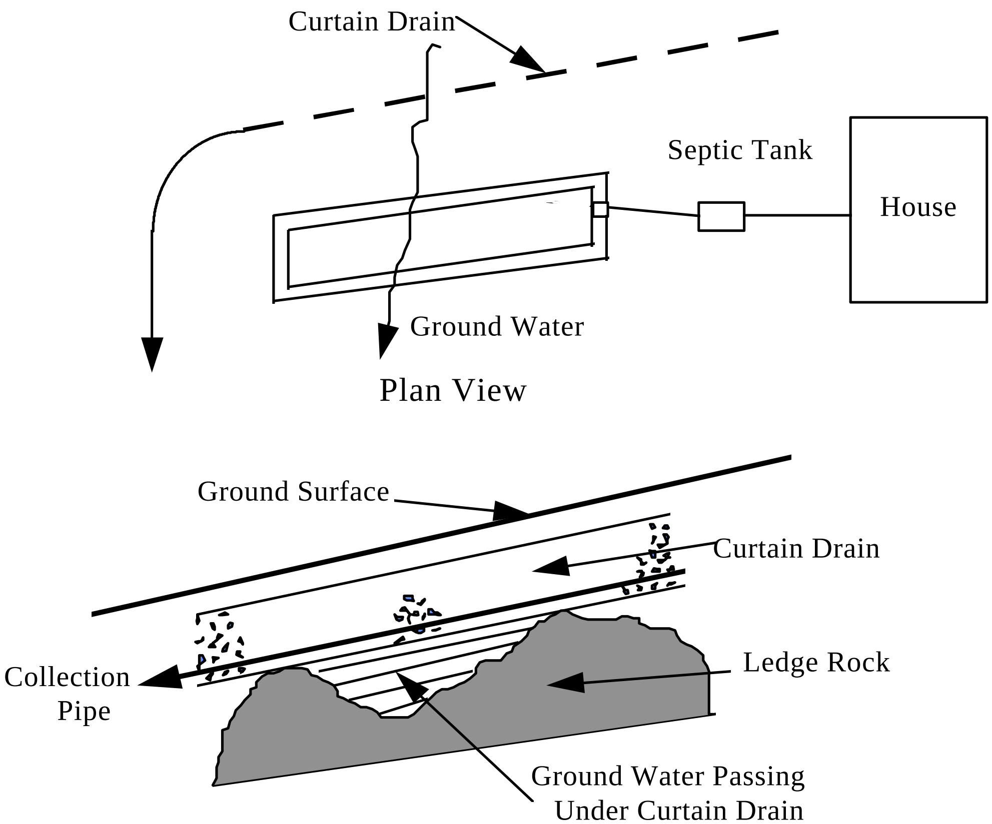


Figure 15-1 - Profile Through Curtain Drain

Sometimes, layers of loose, fractured rock will be found on top of consolidated ledge. Unlike the decomposed rock, the fissures are large and do not provide filtration of sewage effluent. Leaching system normally should be kept 4 feet above the top of the fractured layers, and no attempt should be made to remove the loose rock. This is particularly important when there are water supply wells in the area which would be difficult to seal into fractured rock.

16. LEACHING SYSTEMS IN HARDPAN SOILS

"Hardpan", as commonly used, refers to any naturally occurring layer of hard, densely compacted soil. In Connecticut, such hardpans generally are formed on glacial tills and are located on upland areas where they frequently are found at a depth of 4 feet or less. Hardpans vary in composition, but they always have relatively little void space, low permeability, and slow percolation rates. The minimum percolation rate will vary from 20 minutes per inch to virtual imperviousness, depending on the particle gradation and the degree of compaction. Hardpan in Connecticut normally contains a high percentage of silt which tends to fill the voids between the larger soil particles. This is why even a hardpan with a large amount of sand or gravel will be quite compact and have relatively low permeability.

Sewage system failures are common in hardpan soil areas. In most cases, these are related to failure to properly evaluate the minimum percolation rate, the restrictive effect of underlying hardpan, or seasonal perched water. Often the percolation test hole penetrates only a few inches into the hardpan layer. When tested with a 12 inch depth of water, a fairly good percolation rate may be obtained due to lateral seepage into layers of good soil on top of the hardpan. The leaching system subsequently may be constructed deeper into the underlying hardpan and may fail due to poor seepage or groundwater flowing on top of the hardpan layer.

Failure also can occur because of the inability of the leaching system to adequately disperse sewage effluent into the surrounding soil due to the restriction presented by the underlying hardpan layer. This can occur even with proper testing and construction and effective control of perched groundwater. Possible dispersal limitations in hardpan soils can be evaluated by permeability testing and hydraulic analysis. However, it probably is not practical or necessary to require this procedure for all sewage disposal systems in such soils. The design guidelines in this section have been developed through many years of experience with small residential sewage disposal systems installed in hardpan soils. It is based on selective percolation testing of both the underlying hardpan and the looser upper soil layers, and on careful placement of the leaching system relative to the restrictive hardpan layer. It should be cautioned that while these design principles are well proven for small sewage disposal systems, they may not be adequate for effluent discharges exceeding 1,000 gallons per day, or for areas where the soil layers overlying the hardpan has a minimum percolation rate poorer than 20 minutes per inch. In these situations, permeability testing and hydraulic analysis is advisable. It also should be noted that hardpan layers at depths greater than **5** feet below ground surface normally need not be considered for small sewage disposal systems, since experience has shown that they are unlikely to significantly restrict dispersal of small volumes of effluent.

TESTING HARDPAN SOILS

The key to proper design of small leaching systems in hardpan soils is making a proper evaluation of the minimum percolation rate of the underlying hardpan layer and the overlying looser soil, and accurately measuring the depth to the top of the hardpan layer. It is important that the percolation tests be made entirely within the hardpan layer wherever hardpan is found at a depth of less than 5 feet, in order to determine the characteristics of the hardpan only. This would mean that the bottom of the test hole must penetrate at least 12 inches into hardpan, so that the water will contact only the hardpan soil itself. If the hardpan layer is found to have a minimum percolation rate slower than 30 minutes per inch, another percolation test should be made in the looser soil layers above the hardpan.

Extended presoaking normally is not necessary in order to obtain the minimum percolation rate of a hardpan, since most hardpans in Connecticut contain very little swelling clay.

MODERATELY RESTRICTIVE HARDPAN

Hardpan with a minimum percolation rate of 20 to 30 minutes per inch is considered to be moderately restrictive. A leaching system constructed with all or part of the stone-soil interface within the hardpan layer itself should function properly provided:

a) The size of the leaching system is based on percolation tests made completely within the hardpan layer, not partially in the looser upper soils, and

b) A ground water control drain is provided which will control both perched water on top of the hardpan layer and the seasonal high groundwater table in the hardpan layer itself.

Figure 16-1 shows the cross section of a typical leaching trench system constructed partly in moderately restrictive hardpan. Note that the percolation test was made at a sufficient depth to properly measure the minimum percolation rate in the hardpan, and this was used to determine the required amount of leaching area. Also note that the ground water control drain penetrates deeply into the hardpan layer in order to draw down the seasonal high ground water table in that layers, and that the stone in the drain is extended to near ground surface to intercept ground water perched on top of the hardpan.

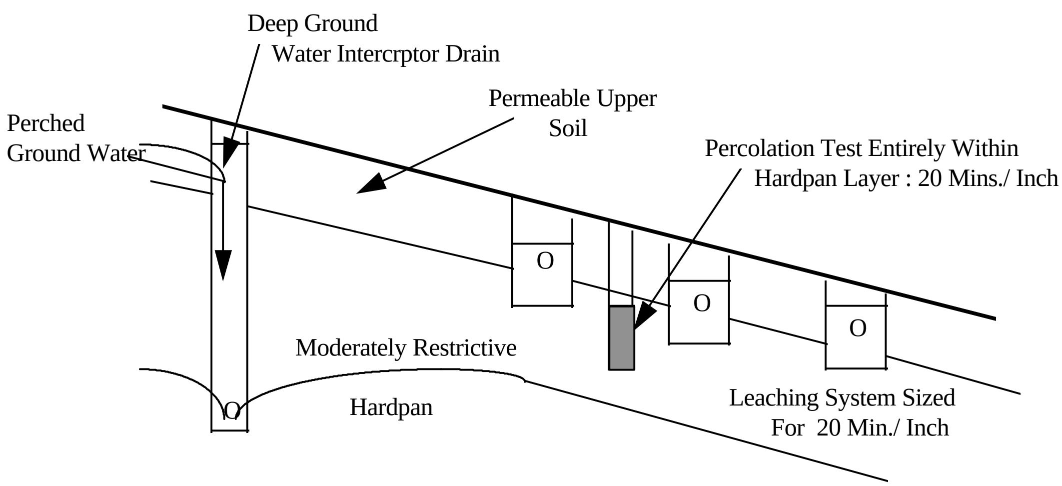


Figure 16-1 - Moderately Restrictive Hardpan

SEVERELY RESTRICTIVE HARDPAN

Hardpan with a minimum percolation rate of 30 to 60 minutes per inch is considered to be severely restrictive. Because of its low capacity to transmit water, the hardpan probably will become saturated during the wet season, even though a ground water control drain is used. For this reason, no part of the stone-soil interface in a leaching system should be constructed directly in the hardpan layer. Instead, the bottom of the leaching system should be raised above the top of the hardpan. It may not be necessary to keep the leaching system 18 inches above the hardpan layer (as long as a curtain drain is provided) because the hardpan would be saturated only for short periods of time, and it is unlikely that there would be significant effluent mounding on top it. Normally, the bottoms of leaching systems should be kept 12 inches above the top surface of severely restrictive hardpan, with a greater elevations being used where the hardpan surface is more level. Of course, an intercepting drain would be necessary to control perched ground water which would collect on top of the hardpan layer, but in this case, the drain would not have to penetrate deeply into the hardpan because no attempt is made to lower the ground water level in the hardpan itself.

Determining the required size and configuration of the leaching system in this case shall be based on the percolation rate of the upper permeable subsoil above the hardpan and the minimum spread of the system determined by MLSS criteria.

Figure 16-2 shows the cross section of a typical leaching trench system constructed above severely restrictive hardpan. Note that separate percolation test were made in both the hardpan and in the more permeable upper soil layer. The size of the leaching system is based on a minimum percolation rate of 10 minutes per inch. In order to keep the underlying soils from becoming saturated due to the daily discharge from the leaching system, the system must be spread to meet MLSS criteria. Also note that the placement of some fill is necessary in order to construct a leaching system sufficiently above the hardpan layer. Refer to the section on "Leaching System In Fill" for information on how this should be done.

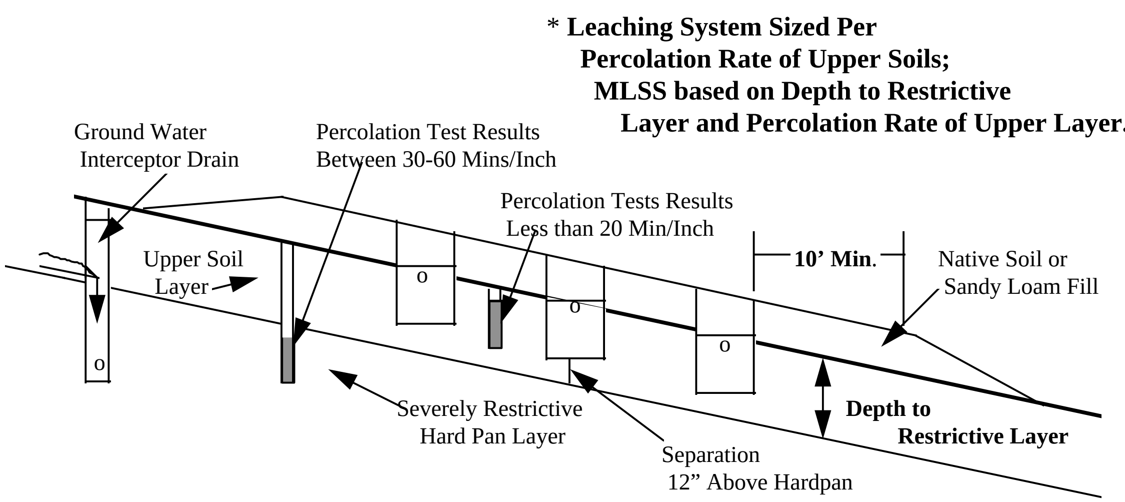


Figure 16-2 - Severely Restrictive Hardpan

IMPERVIOUS HARDPAN

Hardpan with a minimum percolation rate poorer than 60 minutes per inch is considered to be impervious. Leaching systems must be raised well above such an impervious layer since it is likely that a mound of saturated soil will develop on top of this barrier when sewage effluent is applied. Where possible, the bottom of the leaching system should be kept 18 inches above impervious hardpan to allow a zone of unsaturated soil between the leaching system and the effluent mound for effluent renovation. While the leaching system can be constructed in fill, if necessary, to keep it sufficiently above the impervious hardpan, the depth and permeability of the surrounding soil overlying the hardpan is critical since all of the effluent must be dispersed laterally through these soil layers. If the depth or permeability of the overlying soil is insufficient, or if the hardpan is too flat to allow adequate hydraulic gradient, sewage effluent may surface. It may be necessary to make a hydraulic analysis of the capacity of the surrounding soil to disperse the expected volume of sewage effluent in marginal situations or where the volume of effluent is large. (See section II for information on hydraulic analysis.) However, experience has shown that small leaching systems, such as for single family residences, can be installed successfully over imperious hardpan as long as there is at least a 24 inch depth of overlying surrounding soil with a minimum percolation rate of 20 minutes per inch or better. Perched ground water on top of the hardpan must be controlled, of course, and this may be difficult in extremely level areas.

In general, the leaching system shall be sized, as with Severely Restrictive Hardpan mentioned above, based on the percolation rate of the upper permeable soils. Hydraulic concerns shall be addressed by applying MLSS criteria and spreading the system out enough to avoid saturating the underlying soils from the system’s daily discharge.

Figure 16-3 shows the cross section of a typical leaching trench system constructed above impervious hardpan. It is evident that construction becomes critical when the hardpan layer is less

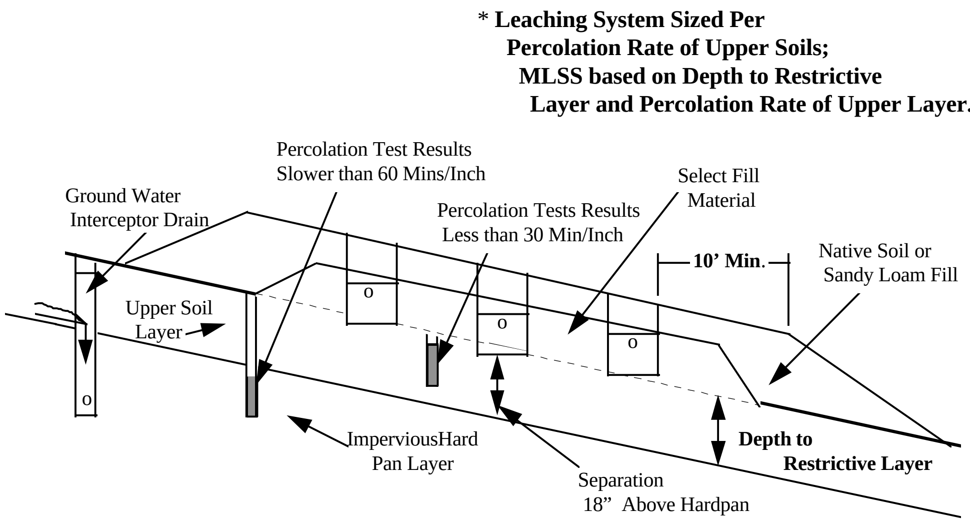


Figure 16-3 - Impervious Hardpan

than 30 inches below ground surface because part of the leaching system must be constructed in fill. Special care must be taken to follow the recommended design and construction practice in this manual to avoid possible problems.

A question frequently asked as to why leaching system must be kept 4 feet above ledge rock, but only 18 inches above impervious hardpan. The reason for this is that channeled flow seldom occurs on top of hardpan layers. The surface of the hardpan normally is smooth, without depressions to collect and transmit effluent. Also, there rarely are layers of highly permeable soil on top of the hardpan, as there frequently are on top of ledge, so that movement over the hardpan in relatively slow, allowing effluent renovation.

CONTROL OF PERCHED GROUND WATER

There is almost always perched ground water flowing on top of hardpan during the wet season or after periods of heavy rainfalls. This ground water will collect in leaching systems which penetrate into the hardpan layer, particularly on hillsides where the ground water will flow down from higher elevations. Particularly severe ground water conditions can be expected on top of hardpan with a minimum percolation rate slower than 30 minutes per inch, or where there is an extensive uphill drainage area. Uphill curtain drains should be used wherever possible to alleviate this condition. Such drains normally are effective when they are constructed deep enough to penetrate 24 inches into the hardpan layer and are backfilled with stone extending 18 to 24 inches above the top of the hardpan layer to intercept perched ground water.

17. LEACHING SYSTEMS IN SELECT FILL MATERIAL

The Public Health Code allows the approval of leaching systems in fill providing two conditions are met:

1. The soil conditions in the area of the proposed leaching system are not unsuitable for sewage disposal purposes as described in Section 19-13-B103e(a)(3) at the time that the system is approved.

2. The surrounding naturally occurring soil can adequately absorb or disperse the expected volume of sewage effluent without overflow, breakout, or detrimental effect on ground or surface water.

There is nothing in the Code to prohibit the placement of fill over any soil, suitable or unsuitable, although in many cases approvals for filling must be obtained from the local planning and zoning or wetland agencies. Certain sites with soil conditions which are unsuitable for sewage disposal may be made suitable by filling. However, other sites, such as those consisting of exposed ledge rock, cannot be made suitable by filling because sewage effluent eventually would pass through the fill and seep to ground surface. Therefore, any filling done where soil conditions are unsuitable is done entirely at the risk of the owner or builder. Ultimately, the acceptability of the site will depend on the results of tests made after the fill has been placed and compacted. In some cases, a special study will be required of the capacity of the surrounding naturally occurring soil to absorb or disperse sewage effluent before any approval is given. Because of these uncertainties, owners and builders are strongly urged to have a qualified professional engineer study the feasibility and cost of the necessary site improvements before placing any fill where soil conditions are classified as unsuitable for sewage disposal.

There are several situations where the placement of fill in the area of the leaching system is necessary or desirable to assure that it will function properly. One such situation is where the soil is permeable, but has a high ground water table which cannot be lowered by an intercepting drain because the area is low or flat. Filling allows the system to be raised sufficiently above the observed maximum ground water level. In other cases, there may be a layer of suitable soil underlain by shallow hardpan or ledge rock. Placement of fill would allow the leaching system to be constructed sufficiently above this material so that it will not interfere with the proper functioning of the system.

TYPE OF FILL MATERIAL, PLACEMENT AND INSPECTION

A clean, granular sand and gravel fill should be used in the area of leaching systems. The fill should contain no more than 5% fines, and preferably no more than 2%. Fines are clay and silt sized particles which pass the #200 sieve. Even a small amount of these particles will severely reduce the ability of the fill to transmit water, particularly when compacted. It has been determined that a significant number of leaching systems installed in select fill fail because the material brought to the site did not meet the above standard. In order to reduce the risk of fill related failures it is recommended that the following guidelines be adhered to:

1. “Select fill” shall be comprised of clean sand and gravel, free from organic matter and deleterious substances. Mixtures and layers of different classes of soil

should not be used. The fill material should not contain any material larger than three (3) inches. A sieve analysis should be performed on a representative sample of the fill. Up to 45% by weight of the fill sample may be retained on the #4 sieve. The material that passes the #4 sieve is then dried and reweighed and the sieve analysis started. The sieve analysis must demonstrate that the material meets each of the following specifications:

	SIEVE SIZE	EFFECTIVE PARTICLE SIZE	% THAT MUST PASS SIEVE	
Coarse Sands	#4 - #10	± 4.75 mm - 2.0 mm	#4	100%
Medium Sands	#10-# 40	± 2.0 mm - 0.425 mm	#10	0% - 100%
Fine Sands	#40-100	± 0.425 mm - 0.15 mm	#40	0% - 50%
Very Fine Sands	#100-#200	± 0.15 mm - 0.075 mm	#100	0% - 20%
Silts and Clays	#200	< 0.075 mm	#200	0% - 5%

2. The contractor should meet with the engineer and sanitarian on the site to review procedures, and to agree on the fill material to be used. Inspection and testing of the fill material may be necessary unless an approved commercial sand or gravel bank is to be used which can supply material which will meet the above criteria. The location of the area to be filled should be marked by the engineer at this time and approved by the sanitarian.

3. The area should be cleared and rough graded. All stumps and large boulders should be removed. If necessary, top soil should be stripped and the area plowed or scarified. Prior to placement of the fill, the bottom surface of the excavation shall be scarified. Fill material should be stockpiled at the edge of the excavation until a suitable base of select material has been spread over the entire exposed area. Fill should not be placed during periods of heavy rains, snow storms or freezing temperatures. If water is present at the bottom of the excavation following a period of rain, the excavation shall be dewatered as necessary and rescarified. The excavation for and placement of "select fill" shall extend a minimum of five (5) feet laterally in all directions beyond the outer perimeter of the leaching system and to a depth to make contact with naturally occurring pervious material.

4. The engineer should inspect the prepared site and set grade stakes before "select fill" is placed. The sanitarian also should be notified, in case he wishes to make an inspection.

5. "Select fill" should be placed on the edge of the site and spread over the prepared area with a bulldozer. No trucks should run over the fill until 12 inches of fill has been placed. The remainder of the fill should be placed in layers 8 to 12 inches deep and compacted by normal bulldozing or other construction equipment. Filling and compaction should be discontinued during rain storms and for 24 hours thereafter. All fill should be placed and compacted before any of the leaching system is installed.

6. If there is any question as to the characteristics of the fill material being placed, a minimum of one representative sample (made up of a composite taken from numerous locations in the fill section) may be taken from the in-place fill for a system serving a single family residence. The sample should be tested for compliance with the grain size distribution noted in Item 1, above. For larger systems, one sample may be taken for each day the filling operation is conducted.

7. The sanitarian should be informed when filling is complete and before the construction of the leaching system has started. The sanitarian should inspect any fill over 30 inches in depth. Observation pits should be dug when there is any question as to the nature or depth of the fill, and percolation tests shall be conducted whenever the entire leaching structure (bottom and sides) will be situated within the fill package or when it appears that the fill may not be suitable. If it appears that the fill may not be sufficiently compacted, an engineering compaction test may be required. Inspection of the upper surface of fill can be misleading, particularly if the fill is clean and has not recently been compacted. The top few inches of a clean and or gravel fill, lacking binding material, may appear loose and insufficiently compacted. However, digging a few inches into the fill will usually show adequate density in the underlying material.

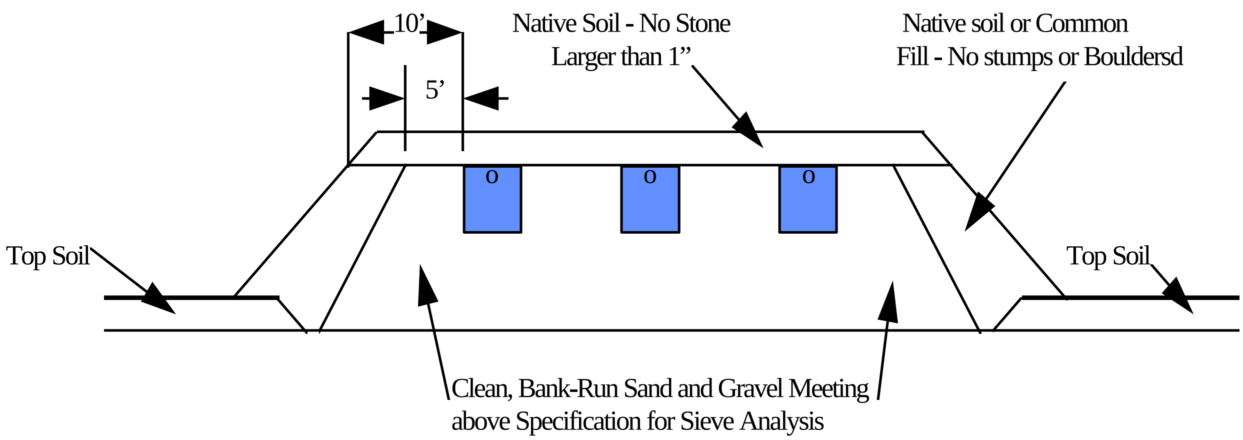


Figure 17-1 Filling on Flat Lots

The reason clean bank-run sand or gravel makes the best fill for leaching systems is because its permeability is not greatly reduced by compaction. This is not true for most soils. Loamy soils, containing a well graded mixture of sand, silt and clay, may have a permeability in the desired range when found in their naturally compacted state. However, they can be easily compacted by standard construction equipment, and their permeability can be reduced to an unacceptable level. On the other hand, it is relatively difficult to compact a clean mixture of sand and gravel by more than 5% to 10%, and even when compacted to over 90% of optimum density, it has a sufficient permeability for leaching purposes. Native soil normally should not be used for fill in the area of the leaching system itself. However, a reasonably workable native soil could be used for cover over a leaching system or for forming the fill embankment outside the leaching area, as shown in Figure 17-1.

SIZE OF THE LEACHING SYSTEM

The required size of a leaching system constructed totally in fill in the past was determined by the percolation rate of the underlying soil, not that of the fill. In most cases, select fill is more permeable than the underlying soil, even when adequately compacted. Therefore basing the size of the leaching system on percolation tests conducted in the fill would theoretically be adequate to disperse the expected sewage from the leaching system. However, predicting the quality and resulting percolation rates of select fill prior to its placement is very difficult due to the number of variables associated with the filling operation. Therefore sanitarians are very skeptical of basing the size of a proposed leaching system on fill material that has not been placed and tested. It is for that reason that the Technical Standards allows a maximum size reduction based on a percolation rate of 30 minutes per inch when the underlying naturally occurring soils are slower than 30 minutes per inch. For example, a four bedroom house is proposed on a lot which has percolation rates in the naturally occurring soils which are slower than 30 minutes per inch. If the design engineer proposes a leaching system which will be installed totally in “select fill”, he may size the system utilizing a 21-30 minute percolation rate. This would result in a minimum 200 sq. ft. reduction (1,200 sq.ft. requirement down to 1,000 sq. ft.) in system size.

It should be noted, however, that the use of select fill and the ability to downsize the leaching system does not change the hydraulic conditions below the system and the need for adequate dispersal of the sewage discharge. Minimum Leaching System Spread shall be applied using the percolation rate of the underlying slow naturally occurring soil when determining the Percolation Factor (PF) when calculating the required spread of the system.

It should be realized that compacted fill may not always be as permeable as expected, and in some cases it may be less permeable than the underlying soil. Therefore, a percolation test may be required in the fill wherever the active infiltration surface of the leaching system is entirely within the fill. Occasionally, on existing lots under repair conditions, it is found that the minimum percolation rate in the fill does not meet design requirements, and there is insufficient area of fill to enlarge the leaching system. It may be too costly or impractical to replace the entire fill section. In such a situation, deep leaching trenches penetrating into the better underlying soil could be used. If necessary, select sand fill could be placed in the bottom of the deep trenches so that the stone in the leaching system would be sufficiently above ground water. The additional storage and infiltrative surface provided by the side area of the deep trenches should adequately compensate for the poor percolation of the fill. See Figure 17-2.

Another possible way of circumventing the poor fill situation would be to provide “Tee-Wicks” of select fill material in which to place new leaching units. This configuration has the dual advantage of providing access to the more permeable suitable soils below the leaching system and a sidewall interface with absorptive capabilities. See Figure 17-3 for an illustration of a “Tee-Wick” installation. NOTE: Access should be into soil conditions where groundwater will not interfere with the downward movement of effluent into the natural soils.

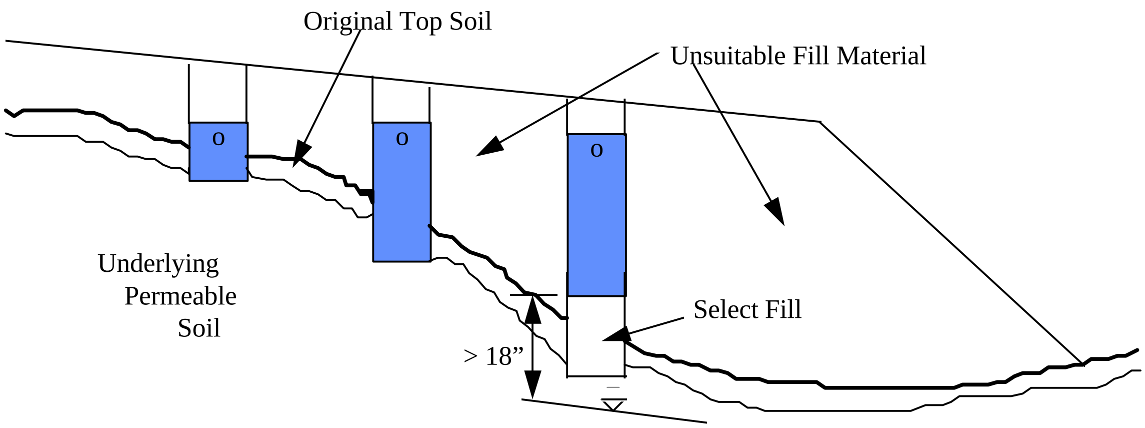


Figure 17-2 - Leaching System In Unsuitable Fill

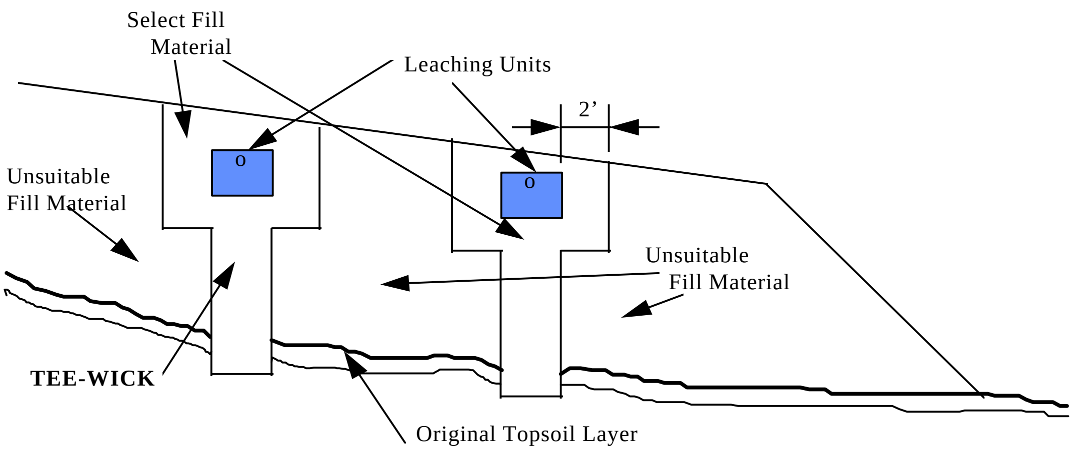


Figure 17-3 - Tee-Wick Installation

FILLING ON HILLSIDES

There are many situations where placement of a shallow depth of fill on a hillside can be used to raise the area of the leaching system so as to utilize a layer of good soil overlying relatively poor hardpan or shallow ledge rock. In such a case, the bottom of the leaching system should be located in the original soil wherever possible, not in the fill, otherwise sewage effluent may flow through poorly compacted fill on top of the original soil, and break out below the filled area.

The selection of fill to be used on hillsides also is important. Extremely permeable materials should be avoided, since this would facilitate downhill seepage, and is unnecessary as long as the size of the leaching system is based on tests made in the underlying soil. Native soil, taken from the site, frequently is used where the depth of fill is 18 inches or less, since the active part of the leaching system is mostly in the underlying, original soil, and the leaching characteristics of the fill is less important. A clean bank-run sand and gravel fill also may be used on slopes providing it is carefully compacted before the trenches are dug. The fill should extend 15 to 20 feet downhill beyond the lowest trench and should be smoothly sloped to the original grade.

Special precautions are required where a leaching system on a slope must be constructed entirely in fill due to unusual soil conditions, such as very shallow ledge rock or hardpan. Clean, bank-run sand and gravel must be used to allow thorough compaction and to assure proper permeability. The fill should be mechanically compacted and carefully inspected. The original soil should be contour plowed or scarified to form a rough interface between the fill and underlying soil, which will retard downhill movement of effluent. A denser soil usually is used for the fill embankment downhill from the leaching system. Clay or hardpan are difficult to work with, however, and should not be used for this purpose. A loamy, easily compacted native soil is recommended. It is extremely important that the downslope fill be free of large boulders, stumps and other debris which could create channels through which sewage effluent might surface. Refer back to Figures 16-1, 16-2 and 16-3 for typical leaching systems in fill on slopes.

The construction of level leaching trenches on terraces made by cutting and filling on slopes should be avoided. Cuts on slopes frequently intercept ground water which will flood leaching systems constructed in these areas. Even if a ground water intercepting drain is used, the soil in cut areas may be dense hardpan, unsuitable for leaching purposes. Figure 17-4 shows an unsatisfactory construction practice which often leads to sewage problems.

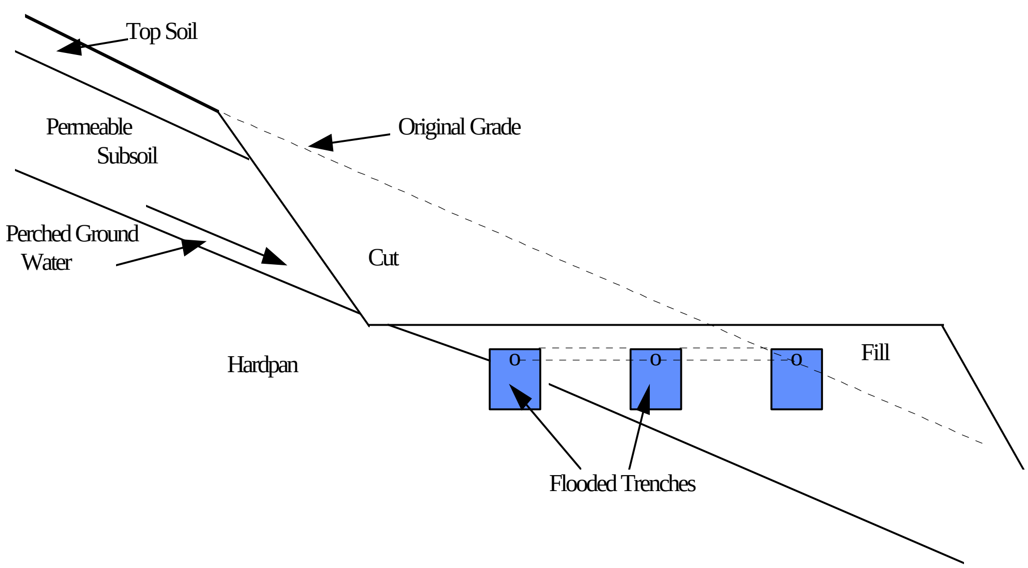


Figure 17-4 - Cut and Fill on Slope

FILL SYSTEMS IN LEVEL AREAS

Frequently low, level areas having a high ground water level are underlain with permeable soil. Generally, it is not possible to lower the ground water level by ground water control drains. In such a situation, leaching systems may be installed in fill raised sufficiently above the anticipated maximum water level. In some areas, leaching systems in permeable, alluvial soil may be subject to seasonal flooding if they are not raised in fill.

When a leaching system is constructed in fill placed over a level area of permeable soil, there is little tendency for sewage effluent to move laterally. Therefore, there is no particular limitation on the depth of fill, and leaching systems have been installed successfully in mounds of fill up to 5 feet deep. However, whenever the bottom of the leaching area will not be in original soil, clean, bank-run sand or gravel fill should be used. Methods of placement and compaction also are critical for fill over 3 feet deep. Relatively impermeable sites or organic layers may be found overlying permeable alluvial soils. These must be stripped before filling. However, stripping of silt layers over 4 feet deep to reach permeable underlying soil may not be practical because of construction difficulty. Such excavations often fill with water and washed-in silt which clogs the soil. The excavations must be pumped continuously while digging to remove silt before it can settle. The water level may rise when the silt layer is removed. Therefore, it is very important to make an accurate determination of the maximum ground water level by the use of monitoring pipes where there is permeable soil overlain with a thick layer of silt.

Often it is difficult to determine whether or not a saturated soil layer is suitable for leaching purposes. It is not possible to make a percolation test in this situation, but other tests may be used. The soil permeability may be determined by a bailing test or a tube sample. A sieve analysis also may be used to obtain a rough idea of soil suitability in a questionable case. No leaching system should be constructed in fill unless it can be determined by some method that the underlying soil is suitable.

The top of the fill embankment should have a slight slope to shed surface water. When the bottom of the leaching system is above the surrounding ground surface, the fill should be extended 10 feet beyond any part of the leaching system. Beyond that point, the fill may be sloped on a one on two slope to existing grade. Figure 17-5 shows a typical leaching system in fill over level, permeable soil. Note that topsoil and silt have been removed to expose the permeable underlying soil before filling. The fill is pitched to shed water, and surface runoff from uphill areas has been diverted around the fill by a berm or swale.

FILL COMPACTION

Generally, all sand or gravel fill should be mechanically compacted at the time that it is placed. Clean sand and gravel is readily compacted by the methods described above, and is unlikely to become over-compacted. Compaction tests seldom are necessary as long as this material is spread in layers during placement. Where there is a question, a modified optimum density test (ASTM D1557, Method C) may be required. A compaction of 90 to 95% of optimum usually is used as a standard for clean sand and gravel since it can be readily obtained and such material still is sufficiently permeable for leaching purposes at this density. Another important reason for mechanically compacting sand and gravel fill when it is placed is to prevent the possibility of silt migration, which can occur when this material is loosely placed and subjected to rainfall during or after placement. In its natural state, silt particles have been retained in the smaller void spaces in the sand and gravel and do not move. However, they become loosened when the soil is disturbed during excavation and handling. If the fill is loosely placed, rainfall will cause the small silt particles to migrate, possibly forming layers within the fill or clogging the leaching system itself.

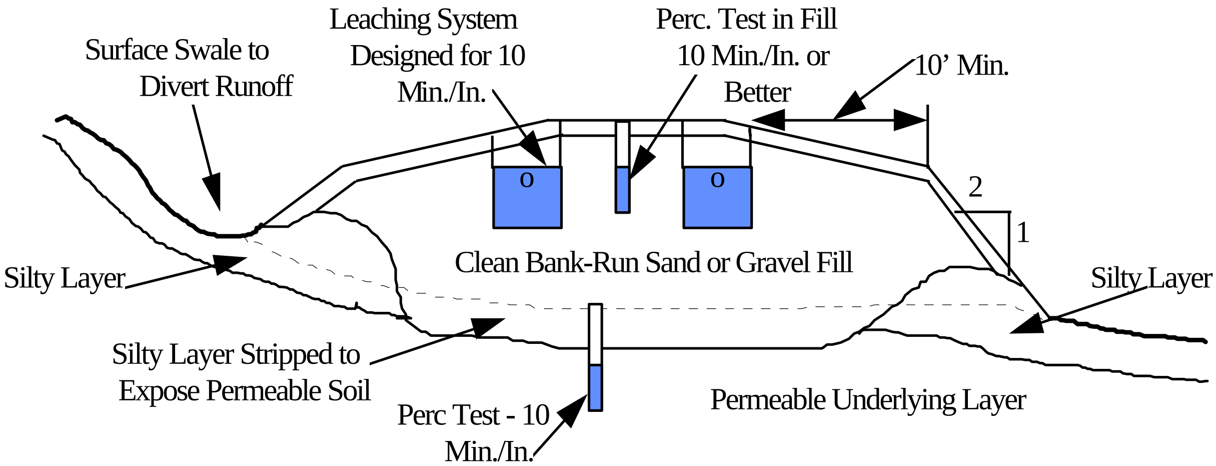


Figure 17-5 - Soil Replacement Filling

Uneven mechanical compaction and subsequent settling can be a problem in deep fills. This frequently occurs when trucks or earth moving equipment heavily compact the embankment slope on a deep fill, but neglect the center portion of the fill. When sewage is applied to the leaching system, the center of the filled area may settle forming a "dish" or basin which retains rainfall. This can flood the leaching system and cause failure. The problem can be prevented by over filling the center portion, forming a crown which compensates for possible settlement.

Loamy soils may not have sufficient permeability if mechanically compacted to 90% of optimum density. Therefore, native soils or loamy fill should not be compacted in the same manner as sand and gravel, unless they are to be used only for covering the leaching system. Instead, they should be allowed to compact naturally over a period of 3 to 6 months, preferably during a wet season. Rainfall and settlement will compact these soils to about 85% of optimum density, which is about the same as the density of the root zone in most naturally occurring soils. Depending on the composition of the fill, the permeability should remain within the acceptable range.

OTHER DESIGN CONSIDERATIONS

Freshly placed fill is easily eroded. Therefore, erosion control measures should be taken as soon as final grading is completed. Uphill drainage should be intercepted and diverted by means of a berm or swale. The fill should be protected with mulch or tobacco netting if it is too late in the season to establish a grass cover before winter.

Placement and compaction of clean sand and gravel fill on steep slopes is difficult because of the looseness of this material. In such a situation, some contractors will first form an embankment on the downhill side, either by cutting into the existing soil or by placing large boulders, top soil and stumps in the area. This is said to hold the fill in place. Such practices are extremely dangerous, since a channel of loosely compacted or permeable material can be formed which allows sewage effluent to break out at the lower end of the fill. See Figure 17-6. Sanitarians and engineers should make sure that this is not done.

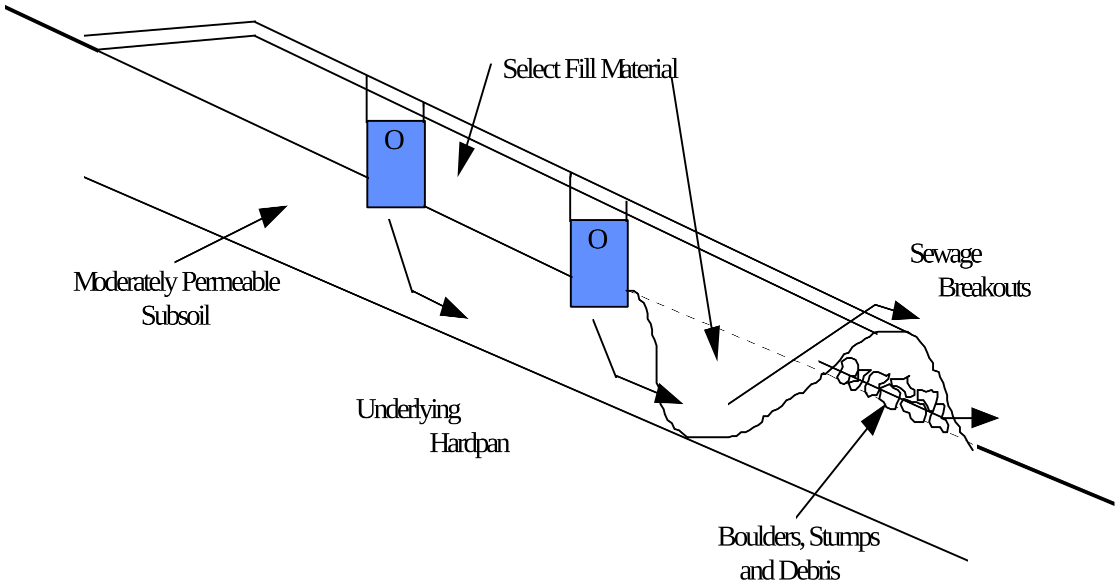


Figure 17-6 - "Keyed-In" Cut In Downslope Subsoil

Sometimes a leaching system is constructed in a filled area at the base of a hillside because the fill is less obtrusive is such a location. Unfortunately, such areas are the location of seasonal springs. Ground water may rise into the fill and cause the leaching system to fail. Ground water levels should be carefully monitored during the wet season before any fill is placed at the base of a hillside. If ground water is found at ground surface during this time, there is the possibility that it may rise up into any fill placed at this location and the area should be avoided.

18 . SUBMISSION 0F ENGINEERING PLANS

Section 19-13-B103 of the Public Health Code requires preparation and submission of detailed engineering designed plans for sewage disposal systems proposed in areas of special concern and for all large sewage disposal systems with design flows of 2000 gallons per day or greater. Areas of special concern are defined in Section 19-13-B103d(e) of the Code. Plans for the design of sewage disposal systems in these areas or for large sewage disposal systems must be prepared by a professional engineer registered in the State of Connecticut. Engineers typically become involved in the design process prior to or shortly after soil testing on the subject property revealed a limiting condition. A property owner may employ a professional engineer on his own, but no property owner should be encouraged by a director of health or sanitarian to engage the services of such an engineer, if in his opinion, the property is unsuitable for sewage disposal purposes. It should be realized that subsurface sewage disposal may not be feasible on properties where impervious soil, seasonally high ground water, or extremely shallow soil coverage over bed rock exists.

It is essential the design engineer or staff engineers working under his direction personally inspect the property, observe and review soil test data with the sanitarian prior to designing a sewage disposal system. Basic design concepts agreed upon by the engineer and sanitarian avoid unnecessary delays in the review and approval process and limit the number of revisions required. The engineer should consider comments and recommendations listed on backside of the soil test data form which has been prepared or confirmed by the director of health or sanitarian. The engineer’s submission must include a report of the findings of his investigation, design calculation, a general statement as to the suitability of the site for sewage disposal purposes, the particular advantages of the design proposed, and a detailed plan for construction of the sewage disposal system. The Public Health Code lists major items such as existing and proposed contours and elevations, property lines, building locations, water courses, ground and surface water drains and other essential information which must be shown on the plan. Some engineers have developed informational checklists which cover the broad range of essential information typically shown on plans. Included at the end of this section is a checklist of standard items which should be considered as part of a well prepared engineering plan. The purpose for preparation of the engineering report and detail plan is to identify site limitations and clearly demonstrate how the engineer proposed to overcome the limiting conditions. With design of sewage disposal systems serving individual residences, it is possible to include the engineering report in the cover letter by briefly defining site limitations and explaining proposed solutions.

Upon completion of the report and design plan, the engineer must sign and seal each of the copies submitted to the local and state health departments for review. The Public Health Code requires plans be submitted to the local health departments for their review. Design plans for small sewage disposal systems and residential properties in areas of special concern may be reviewed and approved by local sanitarians authorized to provide this service by the Commissioner of Public Health. Local health department staff may forward design plans together with comments to the Commissioner of Public Health for review by his/her staff. No plan should be submitted directly by the applicant or engineer to the Commissioner unless specifically requested by the local director of health.

In order to assure a satisfactory installation in accordance with Code requirements, it is essential the design plan be complete and cover all items of concern to the sanitarian and installer. Construction notes, sequence of construction and site preparation, mechanical and electrical specifications for small pump lift stations and erosion and sedimentation controls are often included on plan. Detached pages of soil test data, construction notes or instructions to installers are often misplaced and are not as effective as the same information described on plans.

Before the engineer begins actual layout of the proposed building and sewage disposal facilities, he must have an accurate plot plan of the property with existing contours. Use of existing topographic maps available from various town and federal agencies may be acceptable if field observations confirm the contour data. For sewage disposal purposes, it is most important that accurate contours be developed only within the proposed building and sewage disposal areas. Field contours of an entire two (2) acre building lot would represent an unnecessary expense when only a small percentage of the property is being developed. Significant changes in slopes or other irregularities in remote areas of the lot may be identified by note on plans.

19. CHECK LIST - DESIGN PLANS

1. Original signature and seal of design engineer on each copy of plans (Blue print of seal and signature is unacceptable)

2. Plan drawn to scale; 1" = 20' or 30' for residential lots; 1" = 40' or 50' for large projects such as schools, shopping centers. "Key" or location maps may be inserted on large residential, industrial or commercial properties with proper scale addressing building and sewage disposal areas only

3. Mailing address of engineer

4. Lot size with dimensions of property lines

5. Lot numbers or assessors map block and lot identification

6. Legend to identify various indicators of stone walls, test pits, wells, hay bales etc.

7 Existing contours in building and leaching areas (including 25-50’ downgrade)

8. Proposed contours showing fill extensions, cuts, walls

9. Cross sections through leaching area indicating elevations of system, ledge, curtain drain, ground water etc.

10. Building sewer line to septic tank

11. Septic tank location

12. Pump chamber location, chamber cross section showing manhole, float controls, discharge volume

13. Effluent distribution piping, “D” boxes

14. Leaching system layout (trenches, pits, or galleries) with dimensions on center

15. Invert elevations at foundation wall, inlet and outlet of septic tank, inlets and outlets at distribution boxes and at all leaching systems (including bottom elevations of galleries)

16. Stable bench mark adjacent to proposed building and sewage disposal system. Installer should not be required to transfer bench marks when considerable differences (more than 10' to 15') exist between the bench mark and leaching area. If the bench mark is disturbed prior to construction, the engineer should set another one for construction purposes.

17 North arrow (may be true, magnetic or assumed, note on plan)

18. Number of bedrooms or basis of design including proposed use of building. Example: light manufacturing, 30 employees @ 25 GPD = 750 GPD

19. Required leaching area by Code. Example: 4 bedroom home, 15 min/inch perc = 900 sq.ft. Required Minimum Leaching System Spread, including criteria.

20. Written description of leaching system proposed indicating effective area provided. Example: 3 rows of leaching trench, 75' long, 3.0’ wide = 675 sq.ft.

21. Soil test data shown on plan including deep test hole soil descriptions and all time and measurement readings of the percolation test

22. Test hole locations, including perc test holes. Show all tests

23. Dimension leaching system lengths, distances from tank to building, system to building, system to walls, embankments, drains etc. Do not rely on installer to accurately scale critical dimensions off the plan.

24. Well location with protective radius. Recommend increasing minimum 75' distance for private residential well where possible to provide increased protection. Locate well to avoid condemnation of suitable leaching areas on adjacent properties.

25. Locate wells, septic systems and other potential sources of pollution on adjacent properties. If none exist, note on plan.

26. Show building footing drain discharges (90% of homes have foundation/footing drains), storm drains in roads, streams, brooks, drainage swales, swamps, ponds or other watercourses

27. Identify ledge rock outcrops, wet surface areas, old bury holes, filled-in foundations, etc.

28. Show existing structures on same lot

29. Locate public water lines in road and show water service line to building

30. Locate human habitations on adjacent lots

31. Show detail of leaching system proposed

32. Show detail of curtain drain

33. Indicate driveway location

34. Provide detail specifications for materials to be used such as fill, force main piping, pump model and manufacturer, H-20 wheel loading for pits or galleries under pavement, curtain drain backfill, manhole frames and covers and other non-typical items required for design

35. Identify reserve leaching area by layout of a leaching system of acceptable size

36. Revision dates

37. Indicate location of buried oil tanks (must be 75' from private wells)

20. REPAIR PROCEDURES

The Public Health Code requires that all repairs to existing sewage disposal systems must be made in accordance with the requirements in the Technical Standards, unless a special exception is granted. This does not mean that every part of an existing sewage disposal system must be brought up to present standards whenever a repair is made. Rather, it means that all new construction must meet the minimum standards. However, it is the policy of the State Department of Public Health and most local health departments that whenever a repair is made, the deficient part of the system which appears to have caused the failure should be enlarged or replaced in accordance with minimum Code standards. For instance, if it is determined that the probable cause of failure is insufficient leaching area, the leaching system should be enlarged to the minimum size required by the Code, but a somewhat undersized septic tank need not be replaced.

RESPONSIBILITIES OF LOCAL HEALTH DEPARTMENTS

The sanitarian or local regulatory official must assume the primary technical responsibility for repairs to existing sewage disposal systems, for several reasons.

1. The local health department probably was involved in installing the original system, and may have information regarding soils and system design.

2. The local health department is responsible for protecting public health and for causing abatement of potential health hazards as soon as possible.

3. The local director of health may be required to grant certain exceptions to the Code requirements in order to correct the sewage problem.

4. Local regulatory officials are in the best position to weigh possible economic hardships or legal complications which might impede or delay abatement.

For the above reasons, the Public Health Code does not require an engineer's plan for repair of existing subsurface sewage disposal systems in areas of special concern. Generally, engineers are reluctant to design any repair other than installation of a complete new sewage disposal system meeting all Code requirements. This may mean additional and perhaps unnecessary costs, which may make abatement more difficult to achieve. However, the Code does allow the director of health to require an engineer 's plan wherever he feels that the technical complexities of the repair are beyond the capabilities of the local health department or installer.

Orders, if issued, should require the owner to "abate the sewage overflow", rather than make some specific repair, such as "install 150 feet of leaching trenches". The method of repair should be proposed by the owner or his representative, such as an installer or engineer. The local director of health must approve the proposal, but he is not responsible for originating it. The local health department also may accept a program for repair where there is uncertainty or disagreement as to how much must be done to effectively abate a sewage problem, or where economic hardship is involved. For instance, a system failure may appear to be due to a combination of high seasonal ground water and poor soil. In this case, the owner may be allowed to install a ground water control drain first, to see if this will correct the failure. If the problem continues, the leaching system would then have to be expanded or replaced.

INVESTIGATING SEWAGE PROBLEMS

Whenever a sewage problem is reported, the local health department should investigate. First, a preliminary, fact-finding investigation should be made, and the occupants of the premises interviewed. An effort should be made to determine the nature of the problem, if one exists, the probable cause, the apparent deficiencies of the sewage disposal system, and what might be done to correct the problem. The following questions might be asked.

1. When did the problem occur? When was the system installed? - (A system which functioned properly for ten to fifteen years usually indicates that the soil in the area is satisfactory)

2. Does the problem primarily occur during the spring? - (Seasonal high ground water is likely)

3 How many occupants or users of the system are there? Are roof leaders, cellar drains, water softeners or swimming pool filters connected to the system? - (System may be loaded beyond its design capacity)

4. When was the septic tank pumped? - (There may be solids clogging the leaching system)

5. Is effluent breaking out at one point only? - (This may be due to broken pipe, poor distribution or insufficient cover)

6. Does the curtain drain discharge during the wet season? - If not, it may be clogged with silt)

7. Does the overflow or backup only occur after heavy rainfall? - (System may be subject to flooding)

8. Does the overflow or backup only occur during heavy use? - (System may have insufficient storage capacity)

As much information as possible should be obtained on the system size, location and depth. If this is not available from health department records, it might be obtained from the owner or installer. The sewer inside the basement might give an indication of system location and depth. The location of nearby wells, drains, property lines, etc. should be obtained at the time of the initial investigation. All information should be recorded and sketched with dimensions, where possible. The investigator should go to the property with a hand shovel and an auger or crowbar, so that a cursory exploration could be made for system location, depth and soil conditions.

Depending on the findings of the preliminary investigation, more extensive investigation and soil testing may be required. This usually will involve digging deep observation pits, and possibly digging up and examining part of the existing system. Percolation tests normally should be required whenever the leaching system will be replaced or enlarged (This requirement can be waived if prior testing has been performed in the area of the proposed repair and its accuracy can be verified). This investigation should be made with the owner and his representative, either an installer or engineer, so that an agreement may be reached at that time as to how to proceed with repair of the system. The investigation should be thorough enough to settle any questions as to what portions of the existing system may be utilized, and what must be replaced. Any possible exceptions to Code requirements should be discussed at this time, before proceeding with the repair.

CODE EXCEPTIONS

The Public Health Code allows the director of health to make exceptions to most of the requirements of the Code and Technical Standards for repairs of existing sewage disposal systems. However, there are certain exceptions which the local health department cannot make. Instead, a special exception must be obtained from the State Department of Public Health for the following.

1. Reduction in the minimum separating distance between a water supply well and a sewage disposal system.
2. Construction of a sewage disposal system serving more than one building.
3. Construction of a sewage disposal system not located on the same lot as the building served.

In order to obtain an exception from any Code requirement, either from the local director of health or the State Department of Public Health, an exact description of the requested exception must be submitted. This may be in the form of a plan or sketch, or a verbal description, depending on the situation. No exception can be allowed unless it has been determined that the repair cannot be made in compliance with the Code requirements, and that it is unlikely that a nuisance or public health hazard will occur if the exception is granted. All exceptions must be noted on the repair permit and ultimately on the "Permit to Discharge".

PERMIT TO DISCHARGE FOR REPAIRS

In some cases, repairs can be made only by allowing major exceptions to the Code requirements. In a case where the exceptions are sufficiently great to raise a question as to the suitability of the system for certain uses, it would be advisable to state this on the "Permit to Discharge". For instance, it might be stated that the system is adequate for seasonal use only or is not sized for laundry wastes, etc.. Or it might be stated that the system was approved for use by the present occupants, and may not be adequate for more than four persons. In critical cases, it might be advisable to make note in the town land records of properties where use is limited due to shortcomings of the sewage disposal system. Since the status of a particular system can change depending on the occupancy of the building, the actions taken to correct the deficiencies and/or the availability of sanitary sewers, it is not advisable to actually state the system's shortcomings. It is recommended that a generic statement be made which will provide a warning to prospective buyers regarding the condition of the septic system on the property.

AN EXAMPLE OF A LAND RECORD NOTATION:

> All interested parties should contact the Town's Health Department for information regarding the current status of the subsurface sewage disposal system serving this

property.

By agreement with the local building official, structural or plumbing modifications may be required which will reduce the amount of sewage generated. These can be useful in repairing sewage disposal systems on small lots where previous attempts to repair the system have been unsuccessful. Limitations may be imposed on occupancy of a residence by restricting the number of bedrooms. However, where this is done, it generally is necessary to make architectural modifications, such as removing walls and reducing the number of rooms., to provide some reasonable assurance that the actual occupancy will conform to that permitted. Water use may be limited by requiring low water volume sanitary fixtures. These are described in the Section on "Determining Design Sewage Flows". As with repair permits carrying major exceptions, it may be advisable to make note of properties with occupancy or use limitations in the town land records by use of the aforementioned notation.

RENOVATING CLOGGED LEACHING SYSTEMS

In certain situations, it may be cost effective to attempt to restore some of the infiltration capacity of an existing leaching system which has failed due to clogging of the distribution pipe, stone or surrounding soil. This may be practical where it has been determined that the existing leaching system has failed due to overloading or where faulty septic tank construction or maintenance has allowed sewage solids and grease to accumulate within the leaching system. On the other hand, it may be useless to renovate a leaching system which has failed due to high ground water or unsuitable soil. Typically, renovation is done in conjunction with enlargement or replacement of the failed leaching system since it usually is inadequate. In general, no renovation can be expected to restore the full infiltrative capacity of the original leaching system. However, even partial restoration may be desirable in order to obtain additional leaching capacity, particularly where area for expansion is limited.

REMOVAL OF CLOGGED STONE AND SOIL

Slime-clogged stone from leaching systems must be removed and replaced with clean stone. It cannot be cleaned and reused. For this reason, it probably is not practical to attempt to renovate clogged leaching trenches, pits or beds in this manner. However, it may be cost effective for systems consisting of precast leaching gallery units. Before any construction is started, the septic tank and galleries must be pumped dry. Incoming sewage must be pumped from the septic tank during construction so as to maintain dry conditions. Deep galleries (4 ft. deep) can be renovated fairly easily in place by removing the stone and clogged soil with a backhoe. The excavation thus formed around the gallery is refilled with clean stone and the system is put back into service. Shallow galleries normally are removed, cleaned and replaced back in the enlarged excavation after the clogged stone and soil has been removed. Sometimes a small bulldozer is used for this trench cleaning. The leaching capacity of shallow gallery systems can be restored almost completely in this manner, since both bottom and side infiltrative surfaces are cleaned.

TREATMENT WITH OTHER CHEMICALS

Chemicals other than hydrogen peroxide should not be used for treating clogged leaching systems since their potentially harmful effects would more than cancel out any temporary beneficial effect that may be produced.

Strong acid or alkali drain cleaners are available. These may effectively open clogged house sewers but can be harmful when used ahead of a septic tank and leaching system. Acid has an extremely corrosive effect on concrete and may damage septic tanks, sewers and distribution boxes. Alkali is less damaging to concrete and most household drain cleaners contain such caustic chemicals. However, both acids and alkalis will liquefy the grease which comprises the scum layer in a septic tank and coats the inside of house sewers. This liquefied grease can be carried into the leaching system where it will further clog the soil. Strong acids and alkalis also will disrupt sludge digestion. Alkali may produce excessive gas formation which will carry accumulated sludge from the septic tank into the leaching system. High concentrations of acids or caustic chemicals may even adversely affect the permeability of the soil itself by destroying its structural characteristics.

Some drain cleaners contain hazardous chemicals which can pollute ground waters. Chlorobenzene is one such chemical which was widely used in sewage treatment because of its ability to prevent grease clogging. This has been found to be a cancer causing agent which constitutes a very serious threat to ground water when applied to a leaching system. Almost all such organic grease solvents are in the same category.

Certain soil conditioning chemicals are available which are said to increase the soil percolation rate and therefore restore the capacity of clogged leaching systems. This is highly unlikely. Such chemicals may have some marginal benefit when applied to clean or dry soils in such a manner as to coat the individual soil particles. However, they are of no value when applied to clogged, flooded or saturated soils surrounding failing leaching systems.

One chemical, copper sulfate has been used to destroy tree roots which are growing into sewers or leaching systems. Copper sulfate has recently been designated by DEP to be a groundwater contaminate and therefore it should not be utilized without DEP approval.

SELF-RENOVATION BY "RESTING"

The infiltrative capacity of most clogged leaching systems can be partially restored by taking them out of service for a year or more. This lets the system dry and allows some aerobic decomposition of the accumulated organic solids to take place. The degree of self-renovation is closely related to the soil characteristics and the period of resting. Clogged leaching systems in sands and gravels will regain their original infiltrative capacity almost completely if allowed to rest for about one year. Systems in clays or silts may never recover more than 25% of their original infiltrative capacity no matter how long they are rested. This probably is because of chemical changes which have occurred in the soil structure itself. Self-renovation is greatly hastened if the system is dewatered by pumping when taken out of service. Leaching systems which have been clogged by grease are extremely slow to recover and in many such cases self-renovation may not be a practical consideration. In all cases, self-renovation of clogged leaching systems by resting should be looked upon as a way of providing future system capacity rather than a method of abating an existing problem because of the long resting period which is required.

CLOGGED DISTRIBUTION PIPE

Surprisingly, leaching system clogging does not always occur at the soil infiltrative surface. In some cases, clogging may occur in the perforated distribution pipe or in the stone surrounding the pipe. This usually is associated with high strength laundry or kitchen wastes containing lint or grease which forms filamentous accumulations on pipe and stone surfaces. Sometimes clogging occurs as a result of backwash from water softeners. Such a clogged leaching system may be renovated by removing the clogged perforated pipe and stone, and relaying new pipe with open joints and a few inches of clean, coarse stone (1 1/2 to 2 inches) placed over the existing stone. The addition of intermittent dosing facilities may also be helpful.

AIR PENETRATION SYSTEMS

A process, presently marketed by the Terra-Lift Company, which utilizes a long, narrow probe and pneumatic hammer to penetrate soils to depths of three to six feet (depending on the depth of the leaching system). Very small polystyrene pellets are forced into the soil by compressed air at a controllable rate, fracturing the soil, and creating a network of fissures and cracks. The operation is repeated every four feet (depending on the soil conditions) around each of the leaching field trenches. This process, relatively new to on-site sewage disposal systems, has been used since 1992 as a means of rejuvenating leaching systems. Because of this relatively short time frame, there is no data on the long-term effectiveness of this process. The process should only be utilized where the soil conditions surrounding the existing system are deemed suitable per the Technical Standards.

21. MODEL GUIDELINE FOR LIMITED SYSTEM REPAIRS

The Public Health Code requires that all repairs to existing sewage disposal systems be pursuant to the requirements of Section 19-13-B103 and Technical Standards of the code. It is, therefore, standard practice that whenever an old (exceeding 20 years) existing leaching system fails, a new leaching system is installed which meets all code requirements, including size. Exceptions to the code are only granted when necessary. This policy should be the basis of enforcement at the local health department level. However, sanitarians are sometimes asked to allow the installation of "undersized" systems if the property owner anticipates that sanitary sewers will be available in the near future or, there is a determination that the existing system is located in suitable soil conditions and still possesses the ability to disperse a significant amount of the building's daily sewage discharge. How to handle these requests in a fair and consistent manner is not specifically addressed in the code. When a failure occurs and a health hazard exists, abatement of that health hazard is the prime objective of the repair. Therefore before any decision can be made as to the exceptions which can be granted, it is imperative that the cause of the failure be determined. Once the investigation is completed (many times soil and percolation testing will be required) conclusions can be reached as to what corrective action is necessary. In some cases, a "full" repair may not be deemed necessary.

SUGGESTED GENERAL GUIDELINES

1. The code requires the repair of subsurface sewage disposal systems be pursuant to code requirements.

2. Unless code exceptions are necessary due to existing site conditions, all portions of the repair installation shall be installed per code requirements.

3. Elements of the existing system not affected by the repair installation can remain, even if not up to current code requirements (example: old single compartment septic tanks do not have to be replaced [unless defective in some way] at the time of repair).

4. To be consistent, all repairs shall be treated in the same manner. Issues, such as indefinite sewer availability or, financial hardship of the property owner, should not be the factors that determine the extent of repairs for a failing system.

5. The minimum repair parameters shall be based on technical data established during the repair investigation process. If an existing "failed" leaching system is situated within soil conditions which are deemed to be unfavorable for continued operation, or the system can not be salvaged, then that system shall be abandoned and the replacement system "sized" per code requirements. If the soil conditions are acceptable, the leaching system is the proper distance above maximum ground water and ledge and the failure is attributed to leaching field clogging then a limited enlargement to the original system can be allowed. In that case, the enlargement does not necessarily have to constitute an entirely new system, even though the majority of such repairs are total system replacements. If a limited enlargement is requested by the property owner the procedures listed in the next section of this chapter should be followed.

6. Limited or partial repairs can be allowed as long as the conditions of such an approval are documented and recorded in health department files and the property owner places a notation on the town land records (see Note 6 under Procedures).

PROCEDURES

1. All property owners needing septic repairs should be given information relative to the availability of sanitary sewers in their area. When sewer connections will be available to the property owner (construction contracts have been signed and a definite schedule has been established by the town's Water Pollution Control Authority) within twelve (12) months, a "partial" system repair could be approved by the local health department. Availability further out than twelve (12) months shall require the repair of the septic system be per standard procedures. In cases where a "partial" repair was installed the health department approval shall expire twelve (12) months after issuance. If sewers are available, the property owner should be required to connect within a reasonable length of time. If for some reason sewers are not available within the allotted twelve (12) months then the health department will reevaluate the approval for an additional specified time.

2. If the existing system has to be abandoned then the repair shall be sized per code (if site conditions permit). Sewer availability (unless less than twelve [12] months as noted above) and financial hardship should not be considered.

3. If after thorough analysis, the existing system is determined to be functional but inadequate (accurate documentation, such as, soil test information and "as-built" drawings, should be available to establish suitability for continued use) then a limited enlargement to repair that system can be approved. The size of the enlargement shall be determined on a case by case basis. The minimum size of the limited system enlargement should be based on adding enough leaching area to bring the existing system up to current code requirements or, on adding enough leaching area to satisfy present water usage needs of the home. The amount added shall be at least the larger of the above two calculations.

4. Systems approved for a limited enlargement should be analyzed to determine if they provide adequate extra storage capacity to lower the risk of overloading due to peak usages.

5. Any property owner requesting a limited enlargement to their system should be required to document the request in writing, indicating actual water usage data or occupancy levels of the home, that they are aware the repair does not provide for an entirely new code complying leaching system and that if this repair does not handle their needs, a fully sized system will be installed. This letter should be notarized.

6. Prior to final approval of the limited enlargement, the health department should require the property owner to place a Land Record Notation as suggested in Chapter 20.

7. After approval and installation of a limited enlargement, a Permit to Discharge should be forwarded to the property owner which sets a limit on the amount of sewage which can be introduced into the new portion of the leaching system. The water usage limit shall be in proportion relative to the actual enlargement versus a "full" system installation.

8. A copy of the Permit to Discharge should be filed with the Department of Public Health.

22. HOME BUYERS GUIDE

What a Purchaser Should Know Before Buying

A Home Served by a Septic System

I. PURPOSE

Frequently prospective buyers of a single family home have many questions regarding the septic system serving the dwelling: What does the existing septic system consist of? Is it working properly? How long will it last? If it fails, how much will a replacement system cost?

In order to help buyers obtain information which address these concerns, we have put together this Fact Sheet to guide them in making informed decisions regarding the potential problems and costs associated with a property's septic system.

II. OVERVIEW

The purpose of a home's subsurface sewage disposal system (septic system) is to dispose of the waste water generated by the occupants in such a manner that the soils on the property can disperse it without causing an adverse effect on groundwater and in turn on public health and the environment. To accomplish this a system consists of the following elements: (1) A sewer line, which connects the home's plumbing to the septic tank; (2) A septic tank, which allows for the settling of solids and provides the initial treatment of the sewage. This is where waste material is broken down by bacterial action. A properly functioning septic tank will reduce pollutant levels and produce an effluent of fairly uniform quality. This is accomplished by providing inlet and outlet baffles to reduce the velocity of liquid moving through the tank. New tanks (installed since January, 1991) consist of two compartments in order to do an even more effective job of obtaining the above objective; (3) A distribution system which directs the flow of effluent from the septic tank to the drainage system in such a manner to insure full utilization of the system. Most systems are "gravity" systems, meaning the flow runs through piping and distribution boxes without the assistance of any mechanical device, such as a pump or siphon; (4) A drainage (leaching) system, which disperses the sewage effluent into the surrounding natural soils. There are many types of drainage systems. The specific type utilized on a particular property is usually dependent on the soil conditions which exist on the site. Most residential installations utilize stone-filled leaching trenches, but galleries, pits and beds have historically been used.

For a drainage system to function properly it must:

1. Provide enough application area. The application area is the amount of surface area of soil provided by the particular drainage system (sides and bottom area of leaching units) where sewage effluent is applied (referred to as "wetted" area). The amount of application area needed for a given house depends on the characteristics of the soils on the property and the daily flows (in gallons) generated from the house. The anticipated flow from a house is usual predicated on the number of bedrooms in the dwelling.

2. Be surrounded by natural soil conditions which will be able to dissipate and disperse the septic tank effluent discharge without becoming over saturated.

3. Provide enough capacity to store effluent during periods of unusually heavy use or when rainfall or subsurface flooding reduces the ability of the system to disperse the liquid. Note: Curtain drains/groundwater interceptor drains are sometimes installed upgrade of the drainage system to minimize high groundwater conditions.

It is important to realize that, once a system has been installed, only one of the above factors can be controlled by the homeowner. The homeowner can control how much water is actually being discharged to the system. Since each system has a set maximum capacity, it behooves the homeowner not to exceed that amount.

If a system starts to experience difficulties, what are some of the common symptoms?

1. Plumbing fixtures may exhibit difficulty in releasing its contents (slow draining, bubbling, backups, etc.). This condition may be system related but it could also indicate just a clog in the interior piping or sewer line. You should have the interior piping checked before proceeding with an investigation of the sewage disposal system.

2. Large volume discharges (such as, washing machines, dishwashers and bathtubs) cause either a backup, as noted above, or, an overflow of sewage above the septic tank or leaching field. This condition is usually at its worst during and/or directly following a heavy rain event.

3. Foul septic odors in storm drainage piping, catch basins, footing drain piping or curtain drain discharges may indicate that sewage from your or an adjacent property is entering these groundwater systems.

III - SOURCES OF INFORMATION

What can a prospective purchaser of a home do to gather as much information as possible relative to the present condition and possible future expenses associated with the existing septic system? Here are a few suggestions:

1. Obtain Information from the Present Property Owner

    a. Ask for any drawings regarding the actual location (an "as-built" drawing) of the existing septic system. Another source would be the town's health department (see Paragraph 3, below).

    b. Ask for the records regarding maintenance of the system; Has the septic tank been pumped at a frequency of at least 3 to 5 years?; What pumping contractor was used?; If the system contains a pump, how often has it been maintained?; If major repairs have been made, when and to what extent?

    c. Ask about the past performance of the system. Have any of the symptoms described in Section II manifested during the life of the system?

2. Do a Site Inspection of the Property

a. Once the location of the septic tank and drainage fields are known, walk over the entire area and observe whether there is evidence of a sewage overflow condition. Greener grass in the drainage area may not necessarily indicate a system problem. If, however, the area is completely saturated and odorous you should be very concerned. It most likely indicates an active failure.

b. Try to get a sense of how natural conditions are effecting the capacity of the property to disperse water. Is the sewage disposal area located in a depression which would have a tendency to collect run-off of rain water? Is the lot flat? Is there a watercourse or wetland (swamp) near the drainage system and is the system virtually at the same elevation? Are there steep slopes and/or ledge outcrops which reduce the available area for leaching purposes? All of the above factors could indicate that the existing system will experience difficulty or, that there may not be much additional area suitable for sewage disposal on the lot if needed in the future.

3. <u>Go to Town Health Department to Review Property's File</u>

a. Ask the town sanitarian to review the file with you. Is there enough information in it for him/her to give you an opinion on how the existing system and/or lot meets present health code requirements?

b. Your goal is to confirm and supplement information received from the property owner.

c. Obtain guidelines concerning the proper maintenance of a subsurface sewage disposal system.

d. If you are contemplating an addition to the home or plan on renovating an unfinished basement, discuss the possibilities with the sanitarian and determine the procedures you would have to follow to accomplish your plans. In some cases, it will not be possible to "enlarge" an existing home.

e. Ask about the general neighborhood, the frequency of repairs, ability to install proper size repair systems, average life of systems in the areas, etc.

4. <u>Obtain Additional Information from Outside Sources</u>

a. Presently, many home sales are contingent upon a <u>home inspection</u>. Depending on whether or not the present owner of the property will permit it, <u>opening up and examining key elements of an existing sewage disposal system is the most reliable means to determine the present condition of the system.</u> Examining the inside of the septic tank(s) and distribution boxes <u>may</u> indicate that the system is experiencing difficulties in dispersing the volume of sewage generated by the home. If access to the existing system is not available, home inspectors sometimes use other methods in which to ascertain the status of an existing system. Unfortunately some of the people performing these tests do not have a complete understanding of how a system functions. Therefore, the conclusions reached from these tests can be misleading. For example, testing a system in the summer months may indicate a functioning system, when in fact that same system may be under groundwater in the Spring and unable to function properly.

Three common tests performed during home inspections are as follows:

1) The Dye-Test is used to trace the movement of septic tank effluent into the leaching system. The theory is that if the dye "surfaces" to the ground or appears in a brook or catch basin the system is in trouble. Although this is indeed true, the opposite result does not necessarily mean the system is functioning or will function properly in the future. In order for the dye to appear it must flow through the septic tank and leaching fields prior to arriving at the breakout point. This usually would take a large amount of water and sufficient time to occur, and most home inspections do not last long enough to fulfill this requirement. This type of test would only detect grossly failed systems (ones which have a direct discharge of sewage to the environment).

2) The Probe-Test is a procedure whereby the inspector attempts to locate the "key" elements of the system (septic tank and drainage fields) and determine if they are experiencing overflow conditions (meaning the septic tank and fields are flooded). This test is basically inaccurate since it only takes a single "snapshot" of the condition of the system. It may be a "good" day for the system (very little water was used by the homeowner that day; the house may have been empty for some time; it may be the middle of the summer when soil conditions are at their best) and a judgment is being made with very little long-term information.

3) The Flooding Test (sometimes referred to as a "push test") is actually the process of discharging a substantial quantity of water into the existing septic system to simulate a typical "peak" usage of water by a family. The purpose of the test is to expose those systems which no longer have the capability to disperse "peak" flows and, therefore, may not be adequate to satisfy the needs of the prospective buyers. After a certain amount of water is "flushed" down sinks, tubs and toilets, the inspector examines the leaching area to observe any signs of an "overflow" condition. If an "overflow" is noted, the conclusion reached by the inspector is that the system is not functioning properly. It should be noted, however, that "passing" the test does not necessarily mean that the system is working properly. This type of test is conducted by many inspectors, who feel it would be a disservice to their clients not to obtain information on the present status of an existing system. We, however, have concerns that unless this test is performed in a responsible, site specific manner, it could cause harm to the existing system or lead to erroneous conclusions. If this test is conducted, we suggest the following items be considered before conclusions are reached:

1. The present occupancy of the home.

2. The possible water usage of the occupants within the last 24 hours prior to conducting the tests.

3. Soil conditions in the leaching area, such as, the degree of saturation due to groundwater levels, rain fall events or time of year.

4. That the application of water to the system (by running water through the plumbing fixtures) be performed in a slow, uniform manner to prevent a "slug" of water from entering the septic tank and disturbing the contents.

5. That the procedure limit the amount of water utilized for the test based on the information listed above, but should not exceed 50 gallons per bedroom in a fully occupied (two people per bedroom) home.

To repeat, the above testing is meant to discover obvious malfunctioning septic systems. None of the above tests can lead to a guarantee that the existing sewage disposal system for a home will continue to work properly in the future.

b. Use the Soil Conservation Service County Maps (through the town sanitarian) to try to identify the type of soil most likely present on the site in order to predict the feasibility of future repairs to the existing leaching system.

c. Talk to neighbors about the general performance of septic systems in the area and specifically the system on the property you're interested in. However, this is suggested only for those "comfortable" in approaching this subject with "strangers" and with the realization that the information gathered may not be totally factorial for various reasons (devaluation of their own property; not wanting to "spoil" the sale of a friendly neighbor, etc.).

d. Hire your own consultant, either a professional engineer, who specializes in septic system designs or, a licensed septic system installer, who performs a great deal of work in the particular town. They can give you advise as to the conditions of the soils and septic systems in the area and what might be expected (especially pertaining to costs) if you did have problems with the existing system.

e. Obtain water meter readings (if the home is serviced by a municipal water supply) to determine what the present occupants of the home are utilizing. Then compare those results with what your family is presently using. If your family is using significantly more water than the former occupants you may be asking for trouble if the sewage system is "undersized" to today's standards.

IV. FINAL OBJECTIVE

It is our opinion that when buying an existing home, especially one which is old and does not have a sewage disposal system which meets today's standards, the fundamental question which should be answered is: If the existing system fails, how will we repair it and how much will those repairs cost? If accurate soil test data is not available through the local health department, the only sure way of answering this question is to actually perform all the deep hole testing and percolation tests required by code. As you can understand, most sellers would take a dim view of prospective buyers wanting to tear up their property to perform these tests. Therefore, the more information a buyer can obtain, the better able he or she will be to judge the adequacy of the existing system and what will most likely be required to repair the system, when needed. In that way, the buyer will not be caught unaware when that day arrives, since it was part of the financial assessment establishing the value of the property at the time of purchase.

PART II

23. HYDRAULIC ANALYSIS - GENERAL PRINCIPLES

Hydraulic analysis simply consists of applying basic hydraulic laws to the flow of sewage effluent through soil. However, there are certain differences between the way that leaching systems are assumed to function by hydraulic analysis and the way that they actually do function. For instance, hydraulic analysis assumes a constant and continuous flow of sewage effluent through saturated soil. It is known that, under normal conditions, sewage effluent is dispersed into the soil surrounding leaching systems in an unsaturated and discontinuous flow. Depending on seasonal conditions, effluent may be dispersed by atmospheric evaporation or may accumulate within the leaching system or surrounding soil. However, the continuous, saturated flow conditions assumed for hydraulic analysis probably will occur before a leaching system fails. A mound of saturated soil will form under the leaching system where the hydraulic capacity of the surrounding soil is limited. This will rise to surround the leaching system as failure approaches. In this situation, the leaching system itself will be continuously filled with sewage effluent causing fluctuating sewage discharges from the building served to be equalized into a steady flow into the soil. Where the soil surrounding a leaching system is poor or where there is high ground water, flat slopes or underlying ledge or hardpan, hydraulic analysis is a useful tool for estimating the maximum capacity of the leaching system to disperse effluent into the surrounding soil without breakout.

Using Hydraulic Analysis For Small Leaching Systems - In general, hydraulic analysis should not be used for the design or regulation of household or other small sewage disposal systems with a capacity of 1,000 gallons or less where the site is generally favorable for leaching purposes. Conformance to the requirements of the Public Health Code and the general design principles outlined in Part I of this manual should assure a satisfactory system. Hydraulic analysis becomes important where the capacity of the surrounding soil is limited. Reference should be made to the section on “Hydraulic Analysis - Examples” before requiring any hydraulic analysis beyond what is called for under Minimum Leaching System Spread (MLSS) criteria.

Hydraulic analysis may be required for either of two separate purposes. The most common purpose is to indicate the nature and probable magnitude of the hydraulic limitations on a particular site so that the leaching system can be designed to overcome those limitations. When hydraulic analysis is used for design purposes, the accepted practice is to make an analysis based on existing site conditions, maximum ground water levels and conservative sewage flow estimates. This results in a conservative leaching system design, which is what is desired.

Hydraulic analysis also may be used as a regulatory basis for rejection of proposed subsurface sewage disposal systems in extremely limited or unfavorable locations. Hydraulic analysis may depend heavily on certain specific assumptions or approximations which must be made for each particular site. Therefore, the reliability of the analysis depends on the validity and accuracy of the assumptions and, ultimately, on the experience and judgment of the investigator. As might be expected, disagreements are common when hydraulic analysis is used for regulatory purposes. For this reason, a formal hydraulic analysis, other than the MLSS calculation, should rarely be necessary if all other requirements of the Public Health Code are met.

In general, no leaching system should be approved on the basis of favorable hydraulic analysis unless it also meets Code requirements.

When hydraulic analysis is used for regulatory purposes, certain adjustments normally are made to allow for site improvements such as ground water intercepting drains, filling and grading to promote rainfall runoff. The beneficial effects these improvements have on the hydraulic conditions in the area of the proposed leaching system may be applied to the analysis and approval process.

Darcy's Law - The flow of sewage effluent and ground water through soils may be analyzed by using a basic hydraulic formula referred to as "Darcy's Law". This formula assumes a constant and continuous gravity flow through unconfined "channels" or areas of saturated soil. In its simplest form, Darcy's Law states that the velocity of a liquid moving through an unconfined channel under gravity conditions is proportional to the loss of hydraulic head per unit length of flow path, or:

$$V = K \ X \ (H_1 - H_2 / L)$$

Where:

V = Velocity of flow

K = Coefficient of permeability

H_1-H_2= Loss of hydraulic head

L = Length of flow channel

Darcy's Law generally is used in a modified form for hydraulic analysis of sewage and shallow ground water flow. In this analysis, the main concern is the volume of water which will flow through an area of saturated soil in a given period of time. This sometimes is called the hydraulic conductivity of the soil. The equation is usually written:

$$Q = K \, i \, A$$

Where:

Q = The hydraulic conductivity or saturated flow rate, usually expressed in cubic feet per day.

K = The coefficient of permeability of the soil through which the saturated flow takes place. This is usually expressed in feet per day.

i = The slope of the hydraulic grade. When used in hydraulic analysis of sewage or shallow ground water flow, only the horizontal length of the flow channel normally is considered since the flow channel usually follows the ground surface and is relatively flat. Therefore, i normally is expressed as a dimensionless fraction or decimal representing a vertical drop divided by a horizontal distance.

A = The cross sectional area of saturated flow, usually expressed in square feet.

It is evident from the form of this equation that if either the permeability, the slope of the hydraulic grade or the cross sectional area of saturated flow is limited, the hydraulic conductivity of the soil is likewise limited.

Determining Soil Permeability - The coefficient of permeability, or simply the permeability of the soil, is a measure of how easily liquid passes through a particular soil. This depends on such things as the distribution of the particle sizes in the soil and their shape and geometrical arrangement. The permeability of naturally occurring soils can be quite variable due to stratification of different particle sizes, varying degrees of compaction and the existence of naturally occurring drainage channels formed by percolating ground water. It is not unusual for the permeability to vary by a factor of 1,000 in small samples taken from various soil layers at different locations or depths on the same site. There also may be considerable difference between the horizontal and vertical permeability in the same soil at the same location and depth. Horizontal permeabilities usually are much greater than vertical permeabilities due to the effect of layering, particle orientation and natural drainage channels. Because of this variability, considerable judgment must be used in determining the permeability of naturally occurring soils.

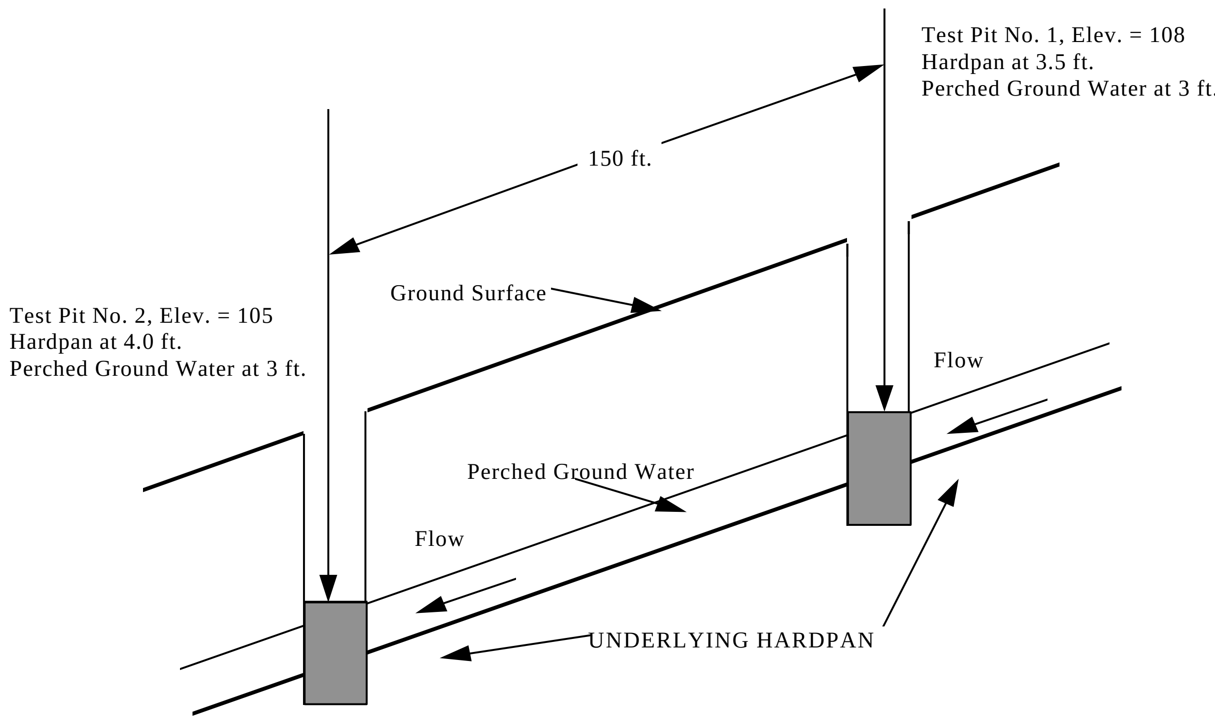
While the permeability is a definite physical property of a soil, it should be understood that the overall permeability of any site or any portion of the naturally occurring soil on the site can only be estimated. It cannot be measured directly. Estimates of site permeability can be based on four general types of measurements or observations.

1. Estimates based on ground water observations made on the site.
2. Estimates based on in-place testing on the site.
3. Estimates based on testing of soil samples.
4. Estimates based on soil identification and reference to available data.

The most appropriate method for estimating the permeability depends mainly on the soil and site conditions. The season or time of year also is an important consideration since most field tests or observations depend on ground water being present. In many cases, the most reliable method of estimating the overall site permeability for sewage disposal purposes is by observations of ground water levels on the site. This is particularly true where shallow or stratified soil layers are involved. In-place pit bailing tests are quite reliable and may be used for estimating the permeability of deep soil layers. Estimating overall site permeability on the basis of sample testing or soil identification requires considerable experience and judgment on the part of the investigator. However, this may be done in the absence of seasonal ground water and the field procedures are quite simple.

Wherever possible, the permeability should be estimated by more than one method. If the estimates are fairly close, it can be assumed that no errors of judgment have been made in selecting or performing the test and that the estimated permeability is valid for hydraulic analysis. Refer to the Section 25 titled “Methods of Estimating Soil Permeability” for a detailed discussion of the various procedures for estimating soil permeability. Only those procedures which are recommended for the particular conditions existing on the site should be used. Particular attention should be given to the special precautions which should be taken when using each method.

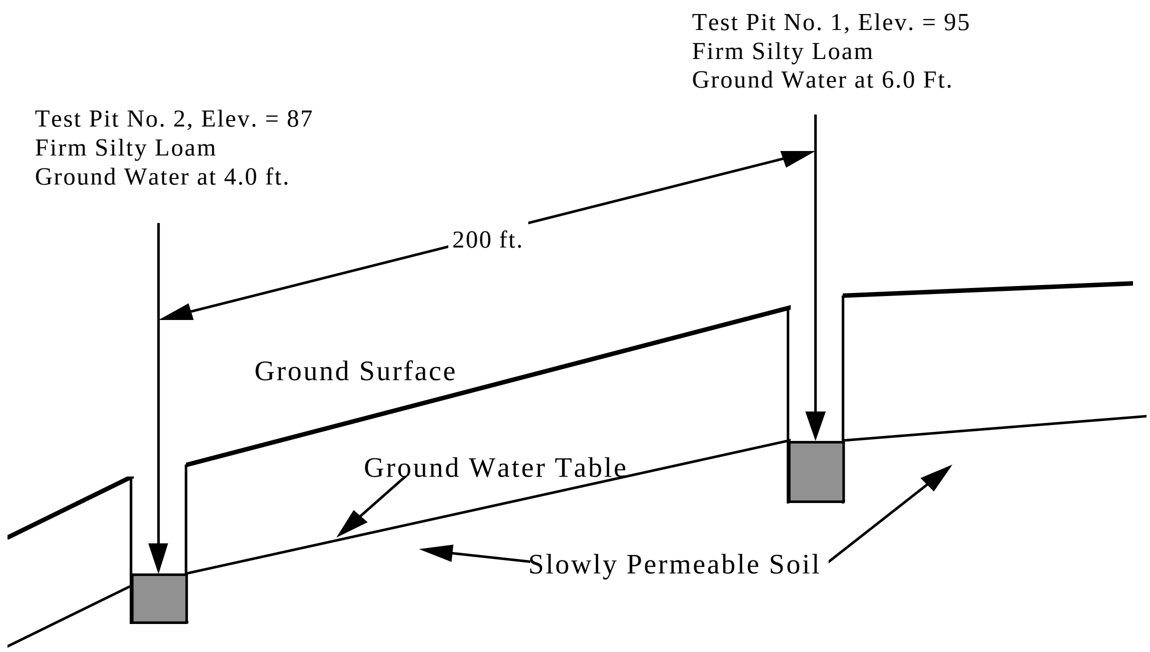
Determining The Hydraulic Grade - The slope of the hydraulic grade depends on the direction and slope of the flow channel. Where layers of compact hardpan or ledge underlie a leaching system, sewage effluent flows in a generally horizontal direction following the ground surface. In this case, the slope of the hydraulic grade is equal to the difference in elevation of the underlying impervious layer at two observation pits, divided by the distance between the pits. If only horizontal distances are considered and minor variations in depth of underlying impervious layer are disregarded, the slope of the hydraulic grade may be taken to be equal to the slope of the ground surface (refer to Figure 23-1).



$$i = \text{Slope of Ground Surface} = \frac{108 - 105}{150} = 0.02$$

Figure 23-1

Horizontal flow also may be assumed to exist in slowly permeable soils even though underlying impervious boundary layers are not apparent. In this case, the slope of the hydraulic grade may be taken to be equal to the difference in the ground water elevation at two observation pits divided by the distance between the pits (refer to Figure 23-2). If variations in depth to the ground water table are minor, the slope of the hydraulic grade also may be taken to be equal to the slope of the ground's surface.



$$i = \frac{(95-6) - (87-4)}{200} = 0.03$$

Figure 23-2

A mound of saturated soil will form under the leaching system where there are hydraulic constraints in the surrounding soil. This mound of saturated soil constitutes part of the effluent flow channel and its formation increases the slope of the hydraulic grade of the flow channel. Therefore, it is evident that constructing a leaching system in fill above the surrounding ground surface will increase the slope of the hydraulic grade and enhance the ability of the system to disperse effluent into the surrounding soil. Increasing the slope of the hydraulic grade in this manner normally is not considered when using hydraulic analysis to design a leaching system because such systems should be designed on conservative assumptions. However, when hydraulic analysis is used for regulatory purposes, it is reasonable to allow certain minor adjustments to be made in the hydraulic grade of the leaching system by elevating it in fill. Where leaching systems are located over underlying impervious layers, it may be assumed that the upper end of the hydraulic grade is at the bottom of the proposed leaching system but not higher than the original grade. The lower end can be assumed to be the elevation of the impervious layer at a distance 50 feet downslope. The 50 foot distance represents the normal maximum horizontal extent of the saturation mound, as indicated by field experience (refer to Figure 23-3)*. Similarly, where there is no underlying boundary layer, the lower end of the hydraulic grade may be assumed to be at the elevation of the ground water table 50 feet downslope from the leaching system.

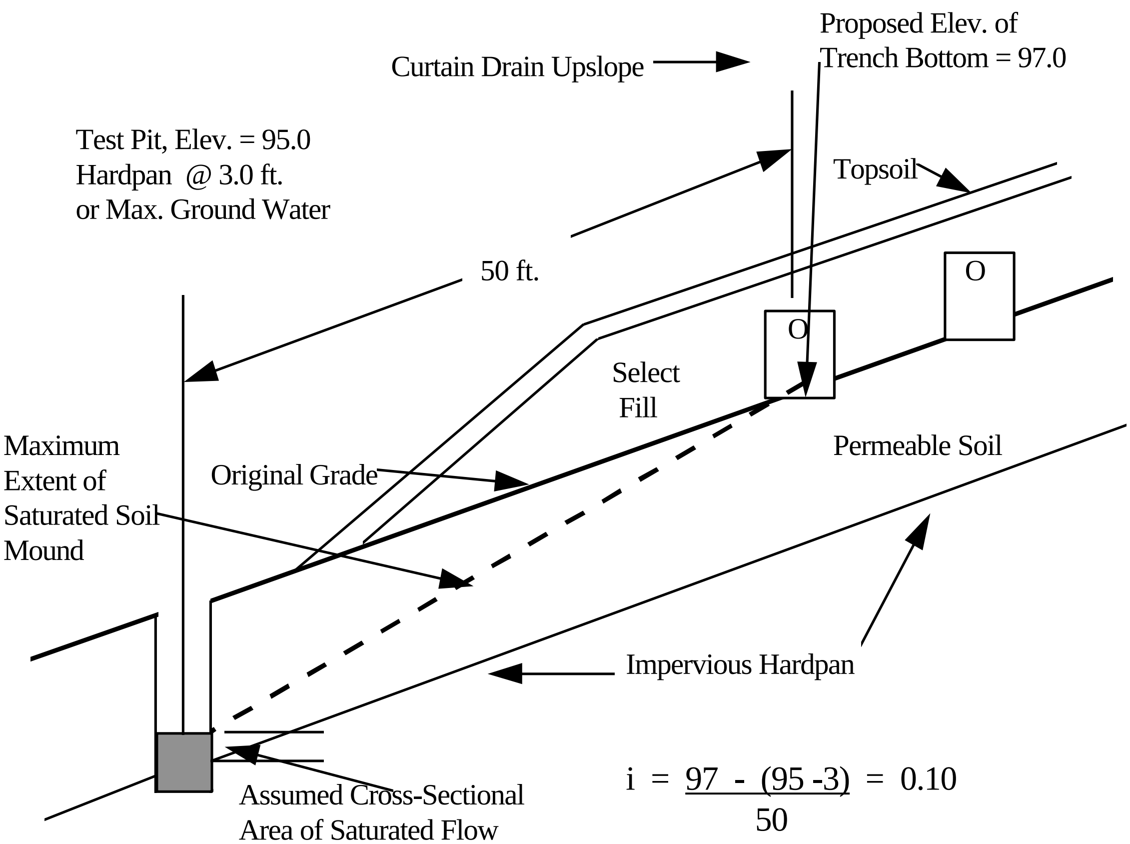
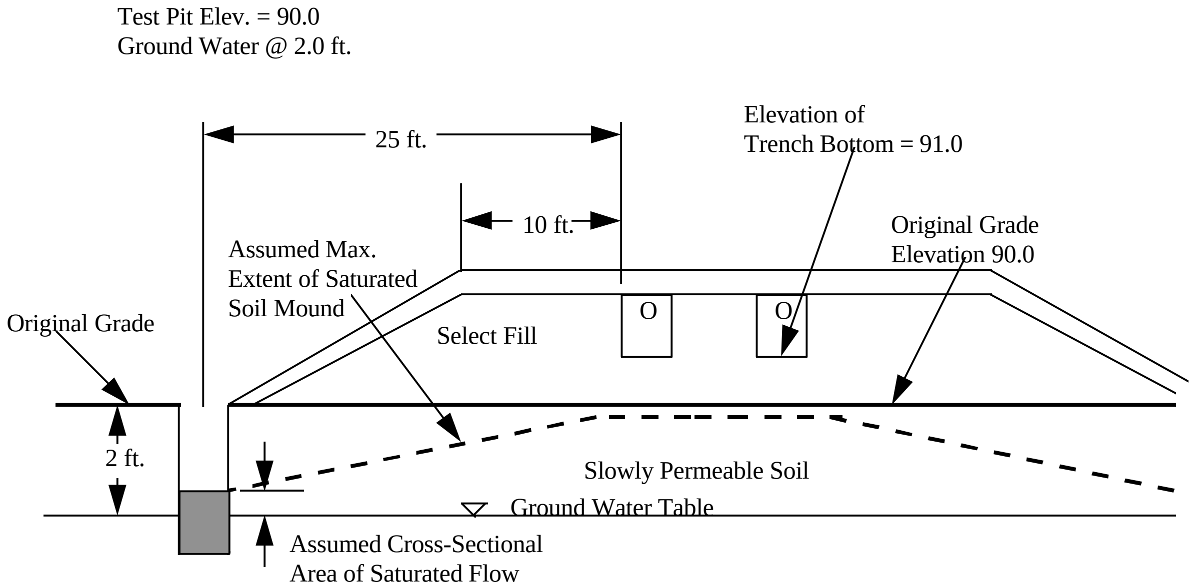


Figure 23-3

*The exact horizontal extent of the saturation mound depends on the rate at which potential energy (system elevation) is converted into kinetic energy (flow velocity). This in turn depends on the soil permeability, with the more permeable soils having less extensive mounding.

In level areas, the saturation mound extends out in all directions from the leaching system and the lower end of the hydraulic grade may be assumed to be at the elevation of the ground water table 25 feet from the leaching system (refer to Figure 23-4).

Determining The Cross-Sectional Area Of Saturated Flow - Where flow is in a generally horizontal direction due to underlying impervious layers, slowly permeable soil or high ground water, the cross-sectional area of saturated flow is measured in a vertical direction. The maximum cross-sectional area available to disperse sewage effluent on a hillside is equal to the depth of unsaturated soil downslope from the leaching system. Saturated flow will occur in all directions where the ground is level.



$$i = \frac{90.0 - (90.0-2.0)}{25} = 0.08$$

Figure 23-4

The cross-sectional area of unsaturated soil downslope from a leaching system can be increased by spreading the system perpendicular to the direction of the slope. Assuming that the volume of effluent to be dispersed remains constant, the depth of the area of saturated flow is reduced. (Refer back to Figure 11-2)

It is evident that where horizontal flow occurs, the depth of unsaturated soil available for effluent dispersal may be increased by spreading fill over the naturally occurring soil surrounding the leaching system. This would enhance effluent dispersal and prevent breakout within the filled area. This concept is routinely employed in the repair of sewage disposal systems which failed due to hydraulic overloading. However, breakout still may occur from the naturally occurring soil at the toe of the fill, particularly when located on a slope For this reason, leaching systems normally should not be designed in this manner. Even though it is possible to calculate the combined permeability of both original soils and fill placed on the lot, it is extremely important to realize that wherever the fill material ends, the underlying original soil has to have sufficient capacity to absorb and disperse projected flows. Bleed out of partially treated effluent is unacceptable. Sewage disposal systems which depend upon filtration and detention in fill material prior to discharging at the surface of the ground, water course or subsurface drain cannot be approved by local health departments (refer to Figure 23-5).

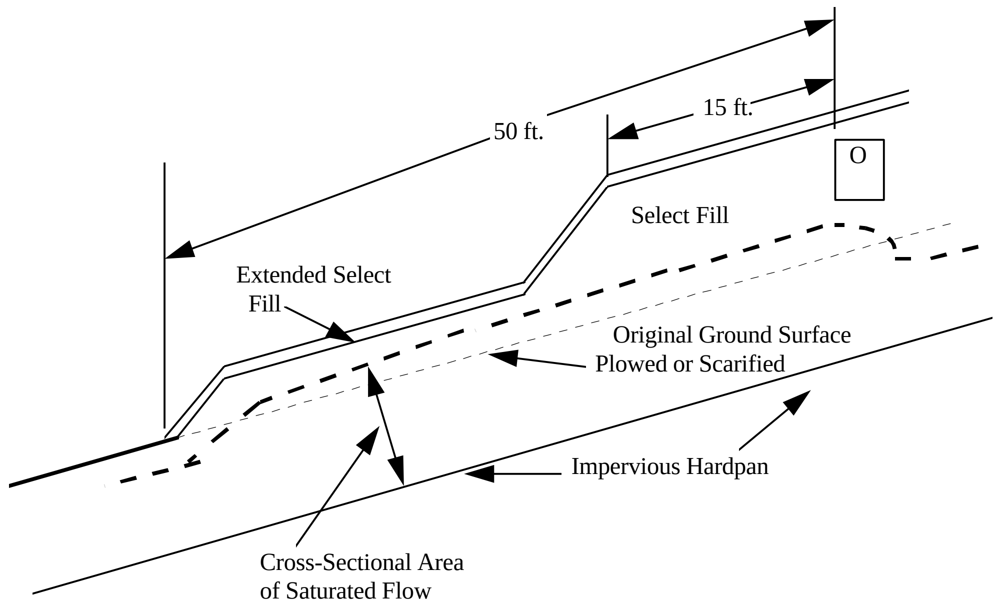
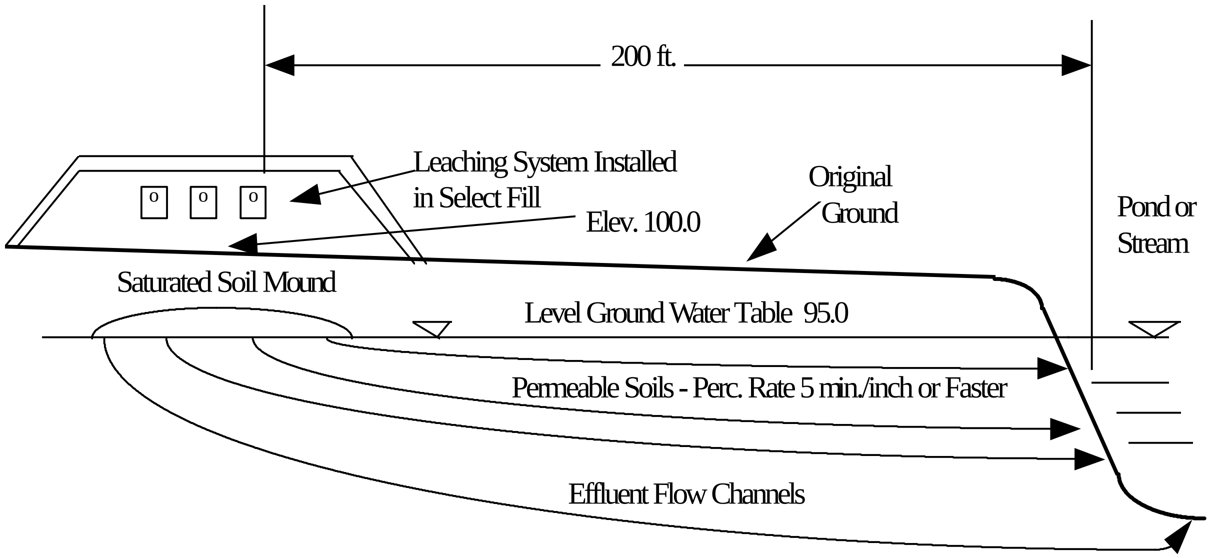


Figure 23-5

Where there is a deep layer of permeable soil underlying a leaching system, sewage effluent will flow downward. Such downward flow is impeded where the underlying permeable soil is saturated and horizontal flow may be assumed where the saturated underlying soil is only moderately permeable. However, where the underlying soil is quite permeable (percolation rate of 5 minutes per inch or faster), downward flow still will occur. This is particularly true for small sewage disposal systems where the effluent flow volume is small relative to the storage volume of the permeable soil underlying the system. Such soils may be considered to be unconfined aquifers and downward flow into the aquifer may be assumed. It would be a mistake to assume that no flow occurs simply because the ground water table is level. Hydraulic limitations are slight where these soil conditions exist and hydraulic analysis normally is not necessary (refer to Figure 23-6).

Determining The Required Hydraulic Conductivity - The naturally occurring soil surrounding leaching systems should be capable of hydraulically dispersing the entire volume of sewage effluent discharged into it on a continuous basis. Ideally, it also should be capable of dispersing any ground water flowing into the area of the leaching system from higher elevation, as well as any rain falling in the immediate area of the system. In theory, any hydraulic analysis of the surrounding soil should take into count all of these sources of flow. However, for small leaching systems, it has been found to be much more realistic to design the systems with such site improvements as ground water intercepting drains or fill which will eliminate or mitigate the effects of seasonal ground water or rainfall accumulations. The justification for this is more fully explained in Section 25.



$$\text{Maximum } i = \frac{100.0 - 95.0}{200} = 0.025$$

Figure 23-6

In practice, hydraulic analyses made for the design of small leaching systems consider only the hydraulic conductivity in the surrounding soil necessary to disperse the expected daily volume of sewage effluent discharged to the system. For single family dwellings, a figure of 150 gallons per bedroom per day should be used. Other daily usages from non-residential type buildings should be based on figures contained in Table No. 4 in the Technical Standards Section of the Public Health Code or on more detailed flow estimates provided by the design engineer.

Designing For Seasonal Rainfall Accumulation And Ground Water Movement - In Connecticut, rainfall accumulates at an average rate of about 0.01 cubic feet per day for each square foot of ground surface during the months of November through April. This is primarily because atmospheric evaporation is very low during this period. The primary goal is designing the system so that it will not be adversely affected by temporary or seasonal rainfall accumulation. This can be assured for small leaching systems by following the design recommendations in Part I of this manual. The bottom of the leaching system should be kept at least 18 inches above the maximum ground water level and at least 18 inches above any impervious soil layer. This assures a depth of at least 30 inches of unsaturated soil surrounding the leaching system (not counting the topsoil layer). Typically, a substantial portion of this soil consists of fill. Assuming a drainable porosity of 0.2, this surrounding soil would contain about 0.5 cubic feet of available storage per square foot of ground surface. This would be sufficient to store all rainfall received for a period of about 50 days during the wet season, even if all of it infiltrates into the soil. Actually, the percentage of rainfall runoff during this season can be quite substantial, particularly during the winter months when the ground is frozen. Runoff can be further enhanced by proper leaching system design. Normally, the finished ground surface over the system is sloped 5 to 10% and is loamed, grassed and kept mowed to promote runoff. The width of small leaching systems usually does not exceed 25 feet, allowing surface runoff to be effectively diverted from the area of the system. Because of these considerations, seasonal accumulation of rainfall may be disregarded in hydraulic analysis of a small leaching systems on sloped lots where curtain drains can be installed up gradient from the system.

Ground water movement from higher elevation into the area of the leaching system can hydraulically overload the surrounding soil causing the system to fail. However, experience has shown that this is unlikely to be a significant problem for a small leaching system except where there is a shallow underlying layer of impervious soil or ledge. In this situation, most of the seasonal rainfall accumulation moves from higher elevation on top of the impervious layer. Such perched ground water can be effectively intercepted by a properly designed and constructed curtain drain and diverted from the area of the leaching system. Ground water movement through the underlying impervious layer is minimal. In most such cases, the intercepting drain can be assumed to be 100% effective and perched ground water moving into the area from higher elevation can be disregarded in the hydraulic analysis.

Where there is no underlying impervious layer or where the slope of the ground surface is relatively flat, curtain drains may be ineffective. Leaching systems usually are constructed in fill in such situations and curtain drains may not be used or may be used only as an extra safeguard. In these situations, the maximum ground water in the area of the leaching system must be carefully determined by field observation during the wet season. Once the maximum ground water level has been determined, an analysis may be made to determine the hydraulic conductivity of the unsaturated soil layers above this maximum level since only this soil would be available for dispersal of sewage effluent. If such design procedures are followed, it should not be necessary to provide for dispersal of seasonal ground water in most hydraulic analyses made for small leaching systems.

24. METHODS OF ESTIMATING SOIL PERMEABILITY

The following methods of estimating soil permeability are recommended for use in connection with hydraulic analysis of small subsurface sewage disposal systems receiving less than 2,000 gallons of sewage per day. Other methods are not recommended for this particular use, for various reasons. For instance, disturbed, recompacted tube samples are widely used for permeability tests in connection with construction of dams, etc. However, they could produce questionable results for naturally occurring soil other than clean sand or gravel because the permeability in naturally occurring soils depends to a large extent on particle orientation and arrangement and on naturally formed drainage channels which are disturbed by recompaction. Block samples are of little value since normally they can only be collected from layers of compact soil which should be avoided for sewage disposal purposes Observations of falling ground water levels following rainfall can be used to estimate the permeability of saturated soil layers. However, this is practical only where the soil is quite permeable. Hydraulic analysis should not be necessary for the design of small sewage disposal systems in such soils. Wherever possible, soil permeability should be estimated by two or more methods for confirmation purposes. Site conditions should be considered when selecting the methods to be used.

NOTE: In all of the following methods of determining the soil permeability (K), it is assumed that we are evaluating a one foot slice of soil to determine the area of saturated flow (A), therefore, A = 1 ft. x d

Method A - Observation of Perched Ground Water During The Spring

Site Conditions - This method is most reliable for estimating the permeability of a sloping layer of relatively loose, well draining soil (minimum percolation rate of 10 minutes per inch or better) underlain by compact hardpan or ledge. In this situation there is a relatively large seasonal flow of ground water through a relatively small flow channel formed by the looser upper soil layer. The cross-sectional area of the flow channel is proportional to the depth of the perched watertable above the underlying impervious boundary layer and the slope of the hydraulic grade is approximately the same as the ground slope. Therefore, if the volume of ground water flowing through the upper soil layer can be estimated, the permeability of the layer can be calculated using Darcy's Law.

Procedure - Field procedures are extremely quick and simple, but judgment must be used in deciding when and where to make ground water observations. Observations should only be made during the early spring after all frost is out of the ground. April probably is the most favorable month since, at this time of the year, the upper soil layers are damp, atmospheric evaporation is at a minimum and rainfall runoff is usually low. The observation pits should be dug in an area where the slope is smoothly contoured. Swales, gullies or depressions should be avoided since these will cause a concentration of ground water flow which will result in inaccurate permeability calculations.

Several observation pits should be dug in the area and, at each location, the depth of the perched water on top of the underlying impervious layer should be carefully measured. The average slope of the ground surface in the area also should be measured using a tripod or hand-held level. The drainage area must be determined either by measurements in the field or from a USGS topographic map. If the observation pits have been properly located on a smoothly contoured slope, the drainage area may be measured in profile from the pits upslope to the high point of land perpendicular to the ground contours.

Permeability Calculation - During this time of year in Connecticut, the amount of perched ground water flowing through the looser upper soil layers is roughly equal to the average rate at which rainfall is collected on the upslope drainage area minus a factor of 50% to account for surface runoff. Therefore, a rate of 0.005 cubic feet per day for each square foot of upslope drainage area will be utilized.

$$K = \frac{Q}{iA} = \frac{0.005 \times w}{S \times d}$$

Where:

K = Soil permeability, in feet per day.
w = Upslope drainage area, in square feet. (Length x 1 foot wide slice)
S = Average ground slope (drop, in feet/horizontal distance, in feet)
d = Depth of perched water table, in feet.

Example: (refer to Figure 24-1) - It is found that during April, a perched water table averaging about 2 feet in depth exists in the loose soil on top of an underlying layer of impervious hardpan (percolation rate poorer than 60 minutes per inch). The ground in this area slopes about 5 feet in 100 feet, and the drainage area extends about 500 feet upslope from the location of the observation pits. Therefore:

$$K = \frac{0.005 \times 500}{0.05 \times 2} = 25 \text{ ft./day}$$

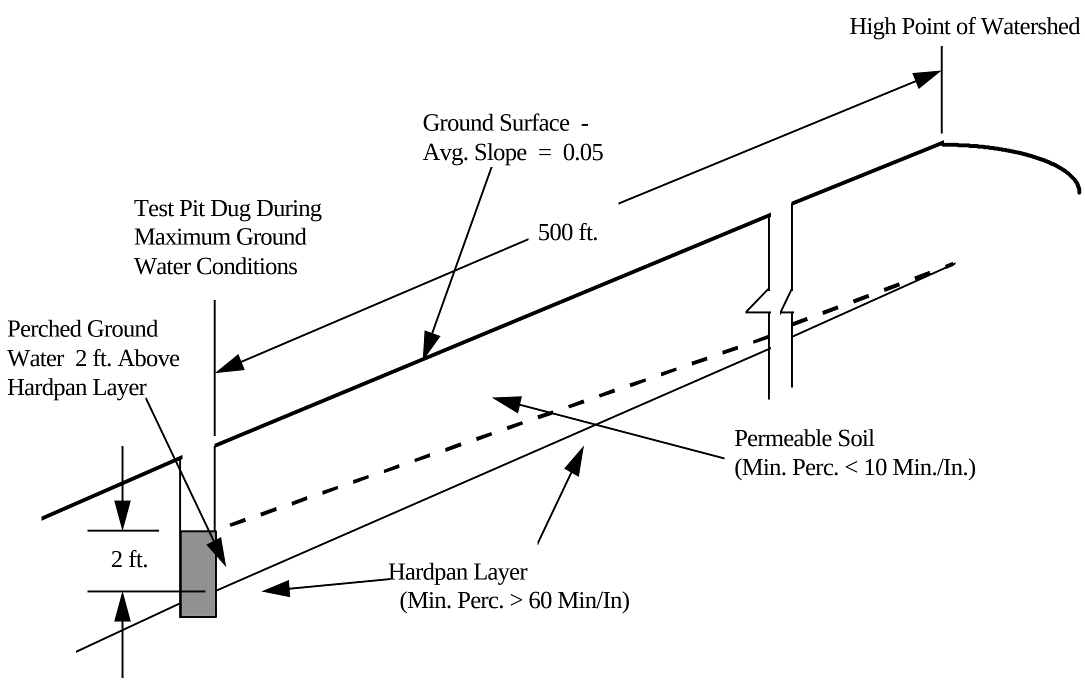


Figure 24-1

Special Precautions - This method of estimating the permeability should not be used for soils with percolation rates poorer than 20 minutes per inch. Such soils drain slowly and the ground water level will be more closely related to rainfall occurrences than to perched ground water flow. In any case, observations should not be made for 3 to 5 days following a rainfall. The effect of rainfall can be eliminated by making a series of ground water observations over a period of time in an observation well or standpipe and determining the normal minimum perched ground water depth during this period.

This method should not be used in level areas or where the upslope drainage area cannot be defined. It should not be used in deep, uniform soil where perched water tables do not occur.

Method B - Observation Of Differences In Ground Water Level

Site Conditions - This method is most reliable for moderate to slowly permeable soils (minimum percolation rate of 10 to 60 minutes per inch) on sloping areas underlain by impervious ledge or hardpan. This method also may be used where no underlying impervious layer is apparent, as long as the soil is slowly permeable (percolation rate slower than 20 min./inch) to the bottom of the observation pit. In these situations, the movement of ground water through the upper soil is slow and during the wet season, accumulating rainfall will cause a measurable rise in the water table in the downslope direction. The rise in the water table and the slope of the hydraulic grade can be determined by making ground water observations at two locations, one downslope from the other. The accumulation of rainfall during the spring of the year is proportional to the increased drainage area between the observation pits. Therefore, the soil permeability may be calculated from Darcy's Law:

Procedure - Ground water observations should be made during the spring when atmospheric evaporation is minimal. Rainfall during this period will greatly affect the ground water level but both observation pits will be affected equally. The permeability calculation results should be unchanged.

Two observation pits should be dug on a smoothly contoured slope, one about 100 to 200 feet directly downslope from the other. The depth to ground water and any underlying impervious layer should be carefully measured. The difference in ground water elevation between the observation pits should be determined, preferably by use of a tripod level. The distance between the pits should be measured.

Permeability Calculations - During this time of year in Connecticut, rainfall accumulates in slowly draining soil at a rate roughly equal to 0.005 cubic feet for every square foot of upslope drainage area. Therefore, from Darcy's Law:

$$K = \frac{Q}{iA} = \frac{0.005 \text{ X } D}{i \text{ X } d}$$

Where:

D = Distance between observation pits, in feet.
i = Slope of hydraulic grade (difference in elevation/D)
d = Difference in depth of saturated flow, in feet.

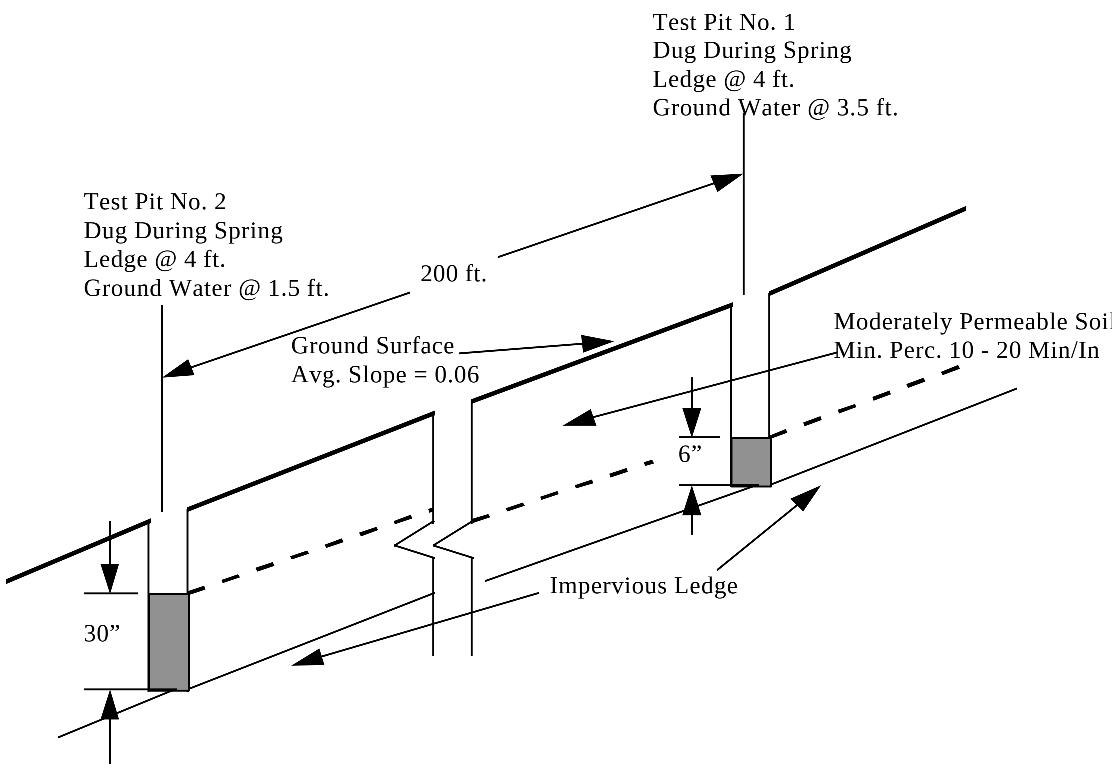


Figure 24-2

Example 1: (refer to Figure 24-2) - An observation pit is dug 100 feet upslope from a proposed leaching system, and another is dug 100 feet downslope from the system. At both locations, ledge is noted at a depth of 4 feet During the spring, a 6 inch depth of ground water is noted on top of ledge in the upper pit, and a 30 inch depth of ground water is noted on top of ledge in the lower pit. The slope of the ground and ledge surface averages about 6%. Therefore:

$$K = \frac{0.005 \text{ X } D}{i \text{ X } d} = \frac{0.005 \text{ X } 200}{0.06 \text{ X } 2} = 8.33 \text{ ft./day}$$

Special Precautions: This method of estimating soil permeability should not be used in level areas or where the depth to the impervious layer is inconsistent.

Example 2: (refer to Figure 24-3) - A slope is underlain with firm, silty loam having a minimum percolation rate of about 30 minutes per inch. During the spring of the year, ground water was found at a depth of 6 feet below ground surface in an observation pit near the top of the slope and at a depth of 2 feet below ground surface at another pit located 150 feet downslope. The difference in ground elevation between the pits was 15 feet.

In this case, the increase in the depth of ground water may be assumed to be equal to the decrease in the depth to the ground water surface. Therefore:

$$K = \frac{0.005 \text{ X } D}{i \text{ X } d} = \frac{0.005 \text{ X } 150}{(15\text{-}4/150) \text{ X } 4} = 2.6 \text{ ft./day}$$

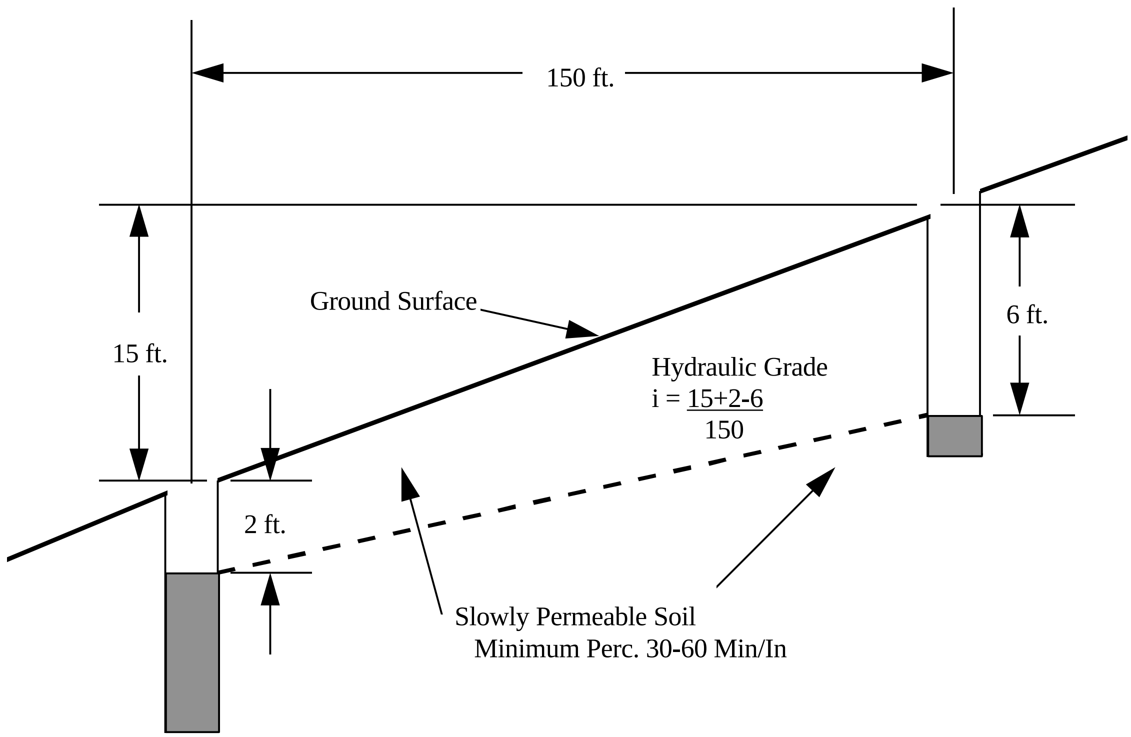


Figure 24-3

Special Precautions: - This method of estimating soil permeability should not be used in level areas or where the direction of ground water flow is not apparent.

Method C - Pit Bailing Tests

Site Conditions - This method is reliable for estimating the permeability of relatively level layers of loose to firm soil (percolation rates of 60 minutes per inch or better) underlain with compact hardpan or ledge. This method also may be used where no underlying impervious layer is apparent as long as the soil is slowly permeable (percolation rate slower than 20 minutes per inch) to the bottom of the observation pit and basically uniform throughout. This in-place test is the most reliable method for estimating soil permeability where the ground water table is level and the direction of ground water flow is not apparent.

Procedure - The test can be performed at any time of the year. However, the ground water table must be within 8 to 10 feet of ground surface. A deep observation pit should be dug and the depth to any impervious underlying layer measured. Where the soil is slowly permeable and no impervious layer is noted, a boundary layer may be assumed at the bottom of the pit. The permeability will be slightly overestimated by this procedure. There are two ways to perform the test. The first involves measuring the rate of water level rise in the pit when it is first dug. This is best suited to relatively firm soil which allows the pit to fill slowly without collapsing. Where the soil is loose, the pit may be dug and allowed to fill. When the water level in the pit has stabilized, normally after 24 hours, it is lowered by pumping and the rate at which it refills is measured. In either case, the static ground water level in the surrounding soil must be measured before or after performing the test.

The rate at which the water rises in the pit should be recorded in a manner similar to that used in recording percolation test results, except that in this case water is entering the pit rather than leaving. Unlike percolation test holes, the sides of the pit may slope. Therefore, the volume of water entering during any interval may not be directly proportional to the difference in liquid level. For this reason, the area of the water surface in the pit also should be measured at the same time that its depth from a reference point is measured so that the change in volume can be calculated.

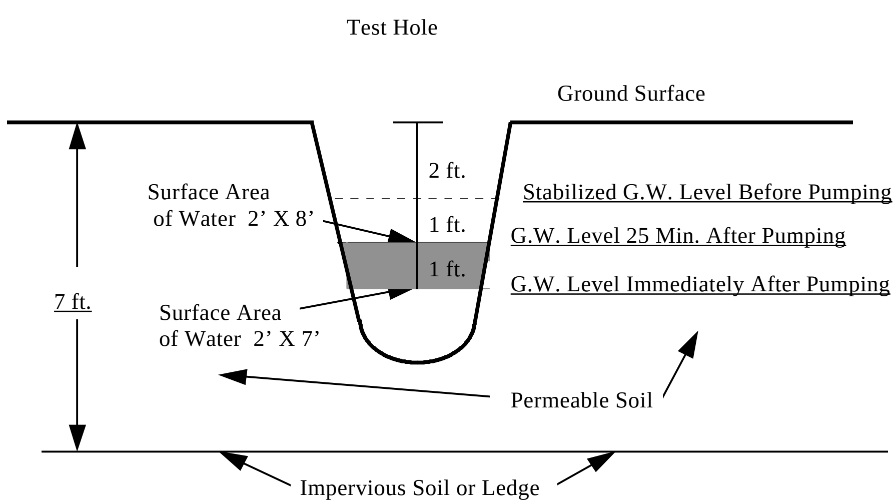
<u>Permeability Calculation -</u> The permeability of the saturated soil layer may be computed from the following equation which is derived from Darcy's Law:

$$K = \frac{\ln R / r \, Q}{H^2 - h^2} = \frac{642 \, Q}{H^2 - h^2}$$

Where:

K = Soil permeability, in feet per day.
Q = Rate of water in flow, in cubic feet per minute.
H = Static depth of water in the surrounding soil above the underlying impervious layer, in feet. Where there is no impervious layer, H may be taken as equal to the static depth of water in the pit before or after testing.
h = Average depth of water in the test pit above the underlying impervious layer during the bailing test, in feet, or above the bottom of the pit if there is no impervious layer.

$$642 = \ln R/r \times 1440 \frac{\text{Min}}{\text{Day}} = \frac{1.4}{3.14} \times 1440 = 642\text{, an assumed constant}$$



<u>Figure 24-4</u>

Example 1: (refer to Figure 24-4) - A 5 foot deep bailing test pit is dug in a level layer of moderately loose soil underlain with ledge at a depth of 7 feet. The static water table in the surrounding soil is observed to be at a depth of 2 feet. The test pit is allowed to fill with ground water. The next day, the water level in the pit is lowered 2 feet by pumping, and the water surface in the pit is measured. The water surface rises 1 foot in 25 minutes. The water surface area is measured again, and the following data recorded.

Time (mins.)	Depth to Water Surface (ft.)	Area of Water Surface (sq.ft.)	Volume (cu.ft)	Q (cu.ft./min.)
0	4	2 X 7 = 14	-	-
25	3	2 X 8 = 16	(14+16)/2 = 15	15/25 = 0.6

$$H = 7 - 2 = 5 \text{ ft.}$$

$$h = 7 - \frac{4+3}{2} = 3.5 \text{ ft.}$$

$$K = \frac{642\,Q}{H^2 - h^2} = \frac{642 \times 0.6}{(5)^2 - (3.5)^2} = 30 \text{ ft./day}$$

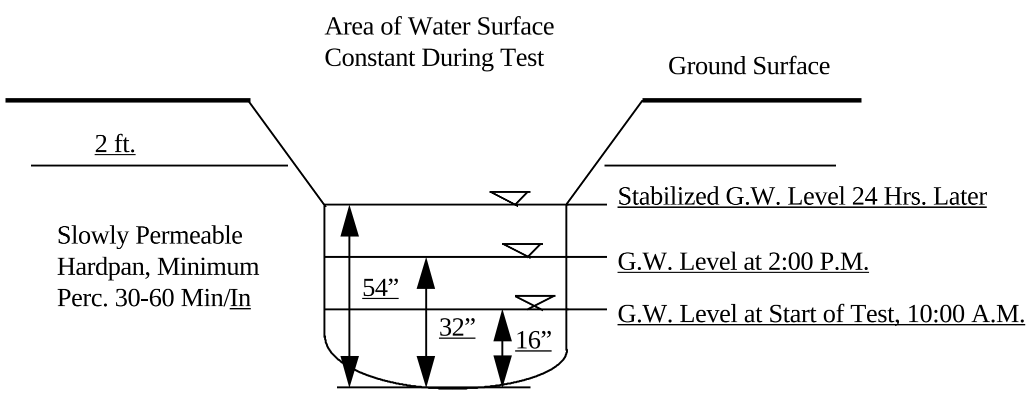


Figure 24-5

Example 2: (refer to Figure 24-5) - An 8 foot deep observation pit is dug in a level area. The soil is observed to consist of hardpan below a depth of 2 feet. Ground water starts to seep into the bottom of the pit. The sides of the pit are then made vertical above the water surface by the backhoe. The water surface is measured to be 2 feet wide and 10 feet long.

At 10:00 am, the pit is measured to contain a 16-inch depth of water. At 2:00 pm, the depth of water in the pit is 32 inches. The following day, the water level in the pit stabilizes at a depth of 54 inches. Therefore:

$$\text{Volume} = \frac{32-16}{12} \times (10 \times 2) = 26.7 \text{ cu. ft.}$$

$$Q = \frac{26.7}{4 \times 60} = 0.1 \text{ cu. ft./min.}$$

$$H = 54/12 = 4.5 \text{ ft.}$$

$$h = 16 + 32 \times 1/2 = 2 \text{ ft.}$$

$$K = \frac{642\,Q}{H^2-h^2} = \frac{642 \times 0.1}{(4.5)^2 - (2)^2} = 3.9 \text{ ft./day}$$

Special Precautions - Pit bailing tests may give misleading results where there are several layers of soil carrying ground water, particularly if the permeabilities are quite different. Often, there is perched ground water moving through relatively permeable soil on top of firm underlying soil. The intercepted perched water fills the test pit relatively quickly and the overall permeability as calculated from the test will be relatively high. A careless investigator may attribute this permeability to the firm underlying soil layer. Any hydraulic analysis based on this assumption would be very misleading. The permeability of soil layers carrying perched ground water should be evaluated separately by shallower pit bailing tests. The permeability of the firm underlying soil should be determined by a pit bailing test made at a time when there is no perched water.

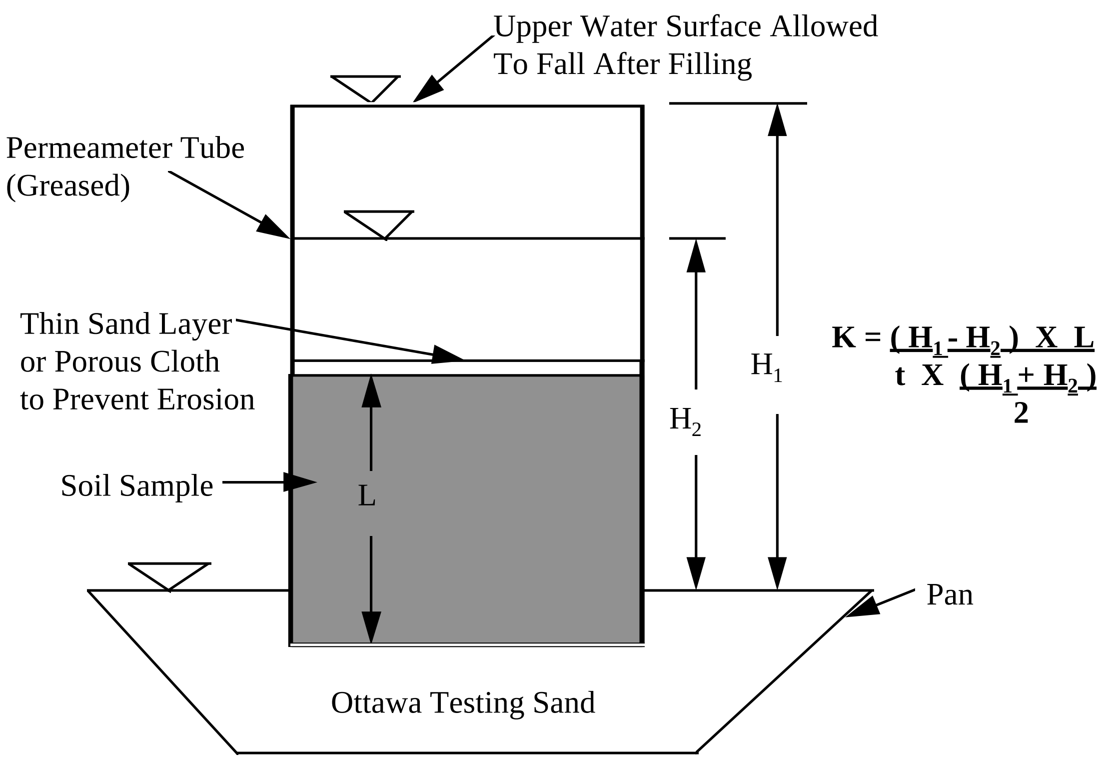
Method D - Undisturbed Tube Samples

Site Conditions - This method is most reliable for estimating the permeability of uncemented loamy soils containing little gravel. Such soils generally are relatively soft and cohesive, and undisturbed soil samples may be collected by forcing a sharpedged, thin-walled tube into the soil. However, such a sampling technique is not suitable for loose sands or gravels which will not stay in the tube or for most hardpan soils which will crack or crumble from the excessive force required to insert the tube. The permeability of undisturbed tube samples may be determined quite accurately by measuring the amount of water which will pass through the sample in a measured period of time under known hydraulic conditions.

Procedure - Field procedures are quite simple. Sharp-edged, thin-walled tubes about 6 to 12 inches long and 1 to 3 inches in diameter should be used. In practice, 1 and 1/4 to 1 and 1/5 inch diameter, plated sink drain tubes usually are used. The inside of the tube should be greased to assure that the soil sample will be sealed to the sampling tube. The tube should be pushed smoothly into the soil . It should not be driven, since this is likely to cause cracking. A 3 to 6 inch long sample should be taken. The depth and orientation (horizontal or vertical) of the sample should be carefully recorded. This could greatly affect the permeability because such samples are so small. The samples could be tested in the field if appropriate apparatus is available. However, in most cases, they are taken to an office or shop for testing. The tubes containing the soil sample should be placed upright on a bed of sand for transporting.

Undisturbed soil samples must be tested in the same tube in which they are collected. They are placed upright in a shallow pan on a bed of clean, uniform sand. A standardized material, called Ottawa Testing Sand, is available for this purpose. A 1/2 inch depth of testing sand also should be placed on the surface of the sample. The sample and testing sand should be saturated with water until the shallow pan overflows and the water level remains above the surface of the sample. De-aerated water must be used. This is water which has been heated and then cooled to remove dissolved air. Water should continue to be applied until it appears that all entrapped air bubbles have been removed and there is a constant flow rate through the tube.

Permeability Calculation - The permeability may be calculated by either of two methods.



Falling Head Permeability Test

Figure 24-6

In the failing-head method, the permeability is calculated by measuring the rate at which the water level above the sample surface falls (refer to Figure 24-6). The following equation is used:

$$K = \frac{(H_1 - H_2)}{t \times \frac{H_1 + H_2}{2}}$$

Where:

H_1 = Hydraulic head at start of test, in inches.
H_2 = Hydraulic head at end of test, in inches.
L = Length of sample, in inches.
t = Elapsed time, in minutes.
K = Sample permeability, in inches/min. This can be converted to feet per day by multiplying the result by 120.

conversion: $\frac{\text{inches}}{\text{minute}} \times \frac{1\text{ ft.}}{12\text{ inches}} \times \frac{1440\text{ minutes}}{\text{day}} = 120$

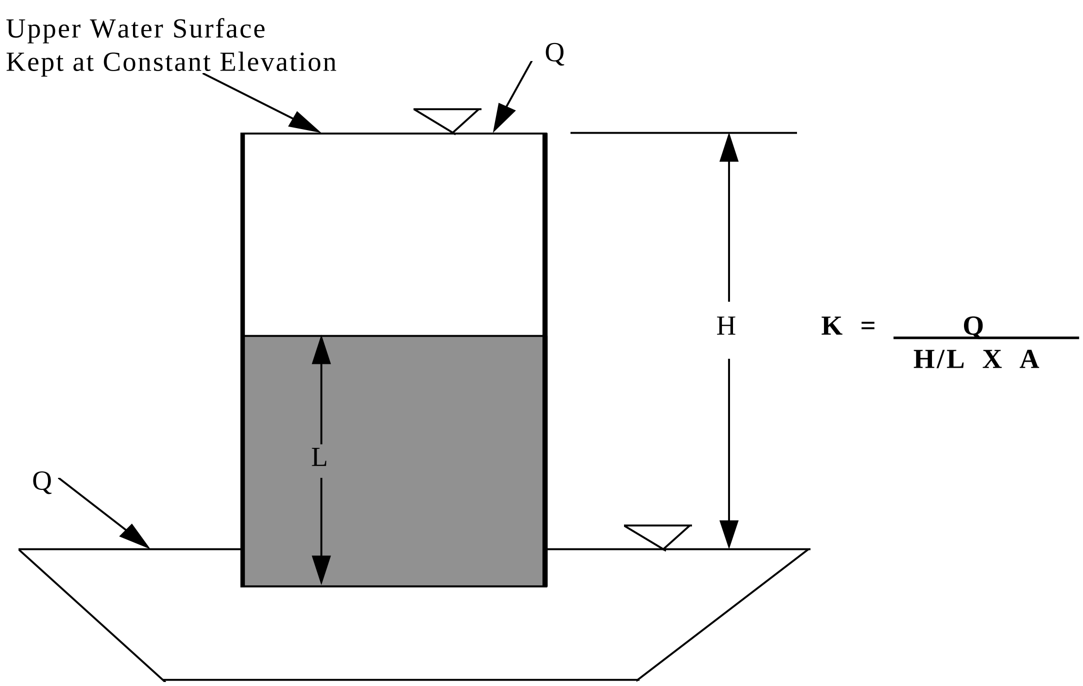
Example 1: A 6 inch long undisturbed soil sample is collected in a 11/2 inch diameter tube. After thorough saturation, the water level above the surface of the sample is measured to fall 3 inches in 12 minutes. Therefore:

H_1 = 11 inches L = 6 inches

H_2 = 8 inches t = 12 minutes

$$K = \frac{(H_1 - H_2)\,L}{t \times \frac{H_1 + H_2}{2}} = \frac{(11-8) \times 6}{12 \times \frac{11+8}{2}} = 0.16 \text{ inches/minute}$$

$$K = 120 \times 0.16 = 19 \text{ ft./day}$$



Constant Head Permeability Test
Figure 24-7

In the constant head method, the water surface is kept constant by adding water from a reservoir with an adjustable discharge. The permeability is calculated by measuring the amount of water which overflows from the receiving pan during a given time (refer to Figure 24-7). The following equation is used:

$$K = \frac{Q}{\frac{H}{L} \times A}$$

Where:

Q = Rate of flow, in cubic inches/min.
H = Hydraulic head, in inches.
L = Length of sample, in inches.
A = Cross section area of sample in square inches.
K = Sample permeability, in inches/min. This can be converted to feet per day by multiplying by 120.

Example 2: (refer to Figure 24-7) - A 4 inch long undisturbed soil sample is collected in a 1 1/2 inch diameter tube. After saturation in a permeameter with a constant head of 12 inches, water is found to flow through the sample at a rate of 0.75 cubic inches in 10 minutes. Therefore:

H = 12 inches Q = 0.75/10 = 0.075 cu. inches/min.

$$A = \pi r^2 = (3.14)(1.5/2)^2 = 1.77 \text{ sq. inches}$$

$$K = \frac{Q}{\frac{H}{L} \times A} = \frac{0.075}{\frac{12}{4}(1.77)} = 0.014 \text{ inches/min.}$$

$$K = 0.014 \times 120 = 1.7 \text{ ft./day}$$

Method E - Soil Identification

Site Conditions - This method should only be used for confirming estimates of soil permeability which have been made using other methods. A thorough knowledge of soils and the techniques of examining them is required. This method is best applied to soil layers which are relatively uniform and typical.

Procedure - An effort should be made to identify the particle sizes, their distribution and the degree of compaction. This may be done subjectively since available references for permeability values are not sufficiently exact to justify a more sophisticated examination. The soil should be examined closely at several depths and locations to obtain a true identification.

Permeability Determination - Once the soil has been identified, a number of technical references may be used to select an approximate permeability value. However, the most valid reference should be ones own experience in obtaining permeability values in similar soils by pit bailing tests or tests on undisturbed tube samples. A careful and experienced investigator should be able to estimate soil permeability within an order of magnitude (factor of 10).

The following tables may be used for relating identified soil types to their permeability values. It should be clearly understood that these relationships are approximate and may be subject to identification error.

Other references, such as the US Soil Conservation Service soil surveys, also may be used. The permeability ranges have been determined by testing typical block samples of each identified soil type at various depths. While not exact, these permeabilities must be considered quite reliable. It would be advisable to identify the soil type by field examination rather than by map reference.

TABLE 24-1 - Uniform Soils

SOIL IDENTIFICATION	HORIZONTAL PERMEABILITY FEET PER DAY
Coarse Sand	100 - 1,000+
Medium Sand	50 - 500
Fine Sand	20 -100
Very Fine Sand	0.1 - 10
Silt	0.0001 - 0.1

TABLE 24-2 - Mixed Soils

SOIL IDENTIFICATION	HORIZONTAL PERMEABILITY FEET PER DAY		
	LOOSE		FIRM
Mixed Sand and Gravel	100 - 1,000+		10 - 100
Silty Sand and Gravel	10 - 1,000		0.1 - 10
Mixed (medium) Loam	1 - 10		0.1 - 1
Sandy Loam	10 - 100		1 - 10
Silty Loam	1 - 10		0.01 - 1
Weathered Clay Loam	0.1	-	10
Mixtures of Sand and Silt	0.1	-	100
Sandy or Gravelly Clay	0.001	-	0.1
Hardpan	0.01	-	5
Weathered or Sandy Hardpan	1	-	20
Swamp Muck (Organic Loam and Silt)	0.1	-	10

25. HYDRAULIC ANALYSIS - MINIMUM LEACHING SYSTEM SPREAD

Minimum Leaching System Spread (MLSS) criteria should be applied to all leaching system designs in order to address the hydraulic concerns associated with the particular site. A more in-depth analysis would be required if MLSS is not satisfied. MLSS calculations are applied where site limitations will likely impact the ability of the surrounding naturally occurring soils from absorbing and dispersing the expected daily discharge from a septic system. Leaching systems shall be configured in such a manner that the total expected daily discharge will be applied fairly uniformly over the entire length of the system so that overloading does not occur in “multi-stacked” areas. Whenever a leaching system contains more than one trench or row on a sloping lot it is recom-mended that each such trench or row be the required length per MLSS criteria. However when unequal length “stacking” is necessary due to site limitations, there are ways to analyze the impact of such “stacking”.

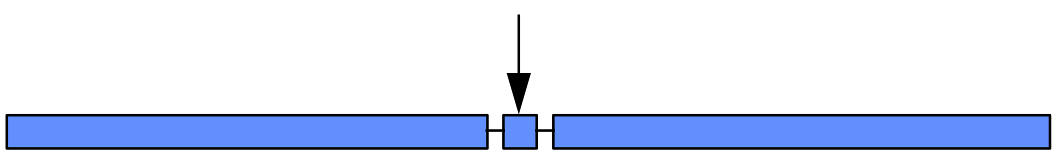
<u>MLSS ANALYSIS OF UNIFORMLY STACKED SYSTEMS</u>

As an example, if a four bedroom house is being built on a site with maximum ground water at 24 inches, a slope of 5 percent and a percolation rate of 25 minutes per inch, the required minimums would be: (see Appendix A of Technical Standards for MLSS criteria):

Size of Leaching System per Code: 1,000 sq. ft.
MLSS = (HF - 34 X FF -2.0 X PF -2.0) = 136 feet

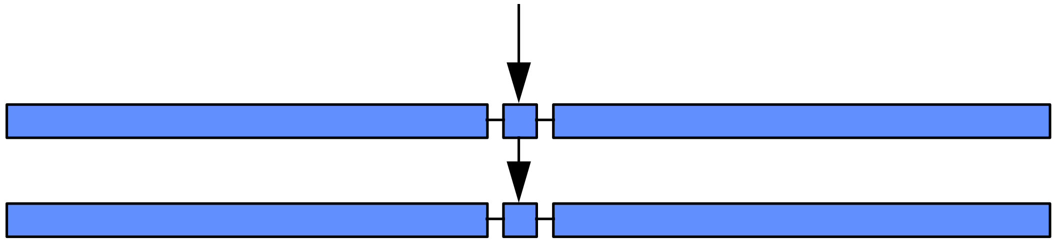
DESIGN OPTIONS

<u>Single Row</u>: In order to provide 1,000 sq. ft. of leaching area and 136 feet of system spread a leaching product would have to provide a minimum 7.35 sq.ft. (1,000/136) of effective area per lineal foot. Utilizing a 30 inch high gallery at 7.4 sf/lf would result in the following system configuration:



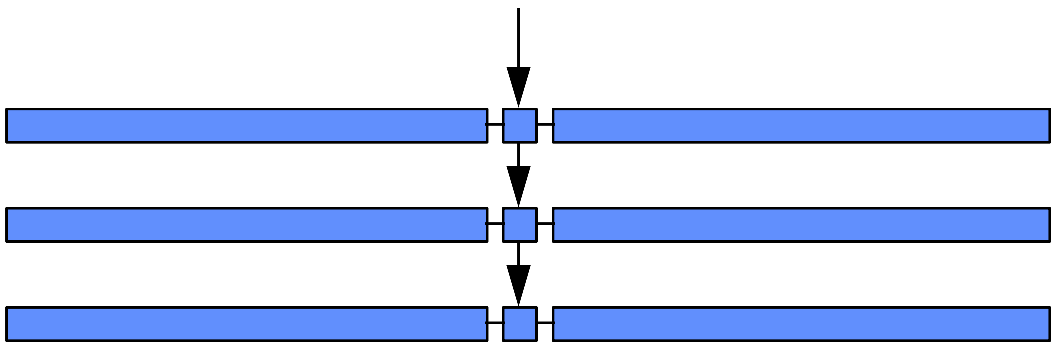
2 trenches X 68’ long X 7.4 SF/LF = 1,006 SF
(NOTE: one trench would be 72’ and the other 64’ due to concrete gallies being 8’ long)

<u>Two Rows</u>: If two rows are utilized a product would have to provide a minimum 3.68 sq. ft. (1,000 sq. ft. / 2 rows / 136 ft.) of effective area per lineal foot. Fourteen (14) inch Bio-Diffusers or twelve (12) inch Standard Sidewinders provide 3.7 sf/lf of effective area. Utilizing these products would result in the following system configuration:



4 trenches X 68’ long X 3.7 SF/LF = 1,006 SF

Three Rows: A three row system would require a product which would provide a minimum of 2.45 sq. ft. (1,000 sq. ft. / 3 rows / 136 ft.) of effective area per lineal foot. Standard 30 inch wide trenches providing 2.7 sf/lf or 12 inch Contactor 75’s providing 2.6 sf/lf could be used. The system configuration would be as follows:

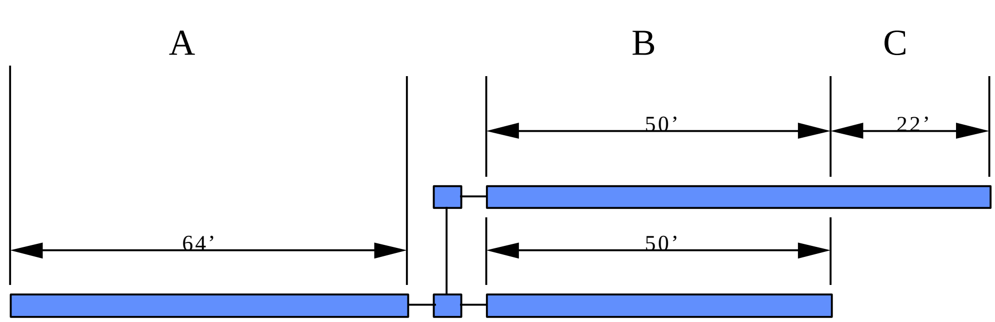


6 trenches X 68’ long X 2.6 SF/LF = 1,060 SF

MLSS ANALYSIS OF NON-UNIFORMLY STACKED SYSTEMS

Occasionally, site conditions make it necessary for engineers to configure systems which are not all the same length meeting MLSS criteria. Whenever unequal “stacking” occurs an analysis of the impact such a configuration will have on the underlying naturally occurring soils will be necessary to assure that hydraulic overloading does not occur. An example of how to perform such an analysis follows:

Unequal Stacked Rows: From the previous example, a plan is designed/submitted utilizing 12” high leaching galleries (5.9 sf/lf) in the following configuration:



It should be obvious that hydraulic overloading is not critical in Sections “A” and “C” of this design. Section “B” has stacking of two segments each 50 feet long. A simple mathematical analysis can be performed to determine if the percentage of leaching system which is stacked exceeds the required hydraulic window for that section. In other words, will the underlying soils beneath that section of the system be able to accept the percentage of daily flow which will be generated by the amount of leaching system within the section?

To determine if hydraulic overloading will occur in a particular hydraulic window the following analysis should be performed:

1. Draw section line (perpendicular to natural contour lines) at the end of the leaching rows wherever the number of rows change within a hydraulic window (see example at bottom of page 127).

2. Determine the minimum spread required for the design using MLSS criteria.

   In this case <u>MLSS = 34 X 2.0 X 2.0 = 136 ft.</u>

3. Divide the cumulative length of system within the section which has the <u>most</u> “stacked” elements (Section B: 50 + 50 = 100 ft.) by the total length of system provided (Total: 64 + 50 + 50 + 22 = 186 ft.)

   <u>Section Utilization = 100/186 = 54% Utilization</u>

   This indicates that 54% of the anticipated sewage flow will be within Section “B”’s hydraulic window when the discharge from the home is at daily design rates (full utilization).

4. Divide the length of spread provided in the hydraulic section of concern (Section “B” = 50 ft) by the minimum spread required for the entire system using MLSS criteria (Item #2, above - MLSS = 136 ft).

   <u>Hydraulic Capacity = 50/136 = 37% Capacity</u>

   Note: Only use MLSS criteria, not actual length of system if length provided exceeds MLSS criteria.

5. If the percentage of Section Utilization exceeds the percentage of Hydraulic Capacity then hydraulic overloading will likely occur within this section of the system and, therefore, the design does not meet code requirements for hydraulic reasons.

   <u>Section Utilization = 54% Hydraulic Capacity = 37%</u>
   <u>Design should be rejected</u>

This type of analysis should be performed whenever a “stacked” system configuration is of concern. The risk of hydraulic overloading will be greatest where unequal “stacking” occurs, therefore, it is important to understand the benefit of <u>uniform application</u>.

OTHER MLSS ISSUES

PIGGY-BACK SYSTEMS

The relative placement of adjacent leaching systems is important since hydraulic overloading can occur when too much effluent from multiple systems discharge into the same hydraulic window. This is especially relevant when subdivisions are being created. Before individual lot line are established an analysis of the impact a proposed leaching system would have on an adjacent property's leaching area most be conducted. To determine the impact of the two systems, MLSS criteria should be utilized based on the total number of bedrooms for both houses. Where soil characteristics or percolation rates differ system to system, the down gradient system's conditions should take precedence.

There comes a point when the distance between "piggy-back" systems are far enough that the upper system will not adversely affect the performance of the downslope system. Although there is no definitive way of calculating this distance in exact terms, a separation distance of fifty (50) feet has been recommended by the Department of Public Health. Due to the natural tendency for sewage to dissipate once it leaves a leaching system, the impact on a downgrade leaching system located at least 50 feet from an upgrade system will be minimal. Under these conditions each system can be analyzed independently.

HYDRAULIC RESERVE

The Technical Standards to the code clearly requires MLSS to be applied to the primary leaching area only. It is desirable to provide additional hydraulic relief to facilitate future expansion of a residence, commercial or industrial building. If additional hydraulic capacity is provided either by installing the primary system wider than the required MLSS spread or if this capacity is clearly shown in the reserve area on design plans, approval of future building use changes or enlargements are more likely. If no additional hydraulic reserve is provided, property owners may not be allowed an addition which includes increasing the total number of bedrooms to the house, unless site specific hydraulic analysis is performed by a professional engineer to demonstrate suitability.

HYDRAULIC GRADIENT

When calculating MLSS, the determination of the hydraulic gradient can be influenced by the boundary conditions the reviewer uses when establishing the percentage of grade in the leaching area. In order to establish a more uniform standard for determining the hydraulic gradient, the measurements should begin near the upper most primary leaching trench and extend a distance of 25 to 50 feet below the lowest proposed leaching trench.

DEPTH TO RESTRICTIVE LAYER

The soil conditions near the lowest leaching trench are most critical when analyzing hydraulic capacity. Therefore, in most cases use the depths to restrictive layer in this area when calculating MLSS. Even though soil depths within the leaching area may be somewhat different, the down gradient receiving soil layer actually governs the total quantity of sewage that will be absorbed and dispersed.

HYDRAULIC ANALYSIS - IN-DEPTH METHODS

Whenever conditions are unusually severe or where the volume of sewage effluent to be dispersed is large and MLSS criteria is exceeded a more formal investigation of hydraulic capacities would be required. The methods used for hydraulic analysis depend on the nature of the site limitations and the intended purpose of the analysis. The effects of site modifications (placement of fill material) normally are not considered when designing new subsurface sewage disposal systems.

Special notice should be made of the recommended applications for each particular method of hydraulic analysis outlined in the following sections. Hydraulic analysis should not be required for subsurface sewage disposal systems with a design flow of 1000 gallons per day or less except in the specific situations described.

APPLICATION I - DETERMINING LENGTH OF LEACHING SYSTEM APPLICATION ON SLOPES UNDERLAIN BY SHALLOW LAYERS OF IMPERVIOUS SOIL OR LEDGE.

In this situation, the cross-sectional area of the surrounding soil is severely restricted by the shallow, underlying boundary layer. The object of the hydraulic analysis is to determine to what extent the leaching system must be spread out parallel with the contours in order to provide sufficient cross-sectional area of soil downslope for effluent dispersal.

Recommended Application This method of hydraulic analysis is recommended for the design of leaching systems located on slopes where:

1. The surrounding naturally occurring soil is underlain by an impervious layer at a depth of less than 2 feet or

2. The area has been filled and the underlying naturally occurring soils have less than 18" of unsaturated peameable conditions.

3. The capacity of the leaching system is over 1000 gallons per day and the surrounding naturally occurring soil is underlain by impervious soil or ledge at a depth of 4 feet or less.

Procedure

1. Estimate the permeability of the upper naturally occurring soil by two or more of the methods described in Section 24.

2. Determine the average depth of the underlying impervious layer by digging observation pits at several locations in the area of the proposed leaching system and in an downslope direction.

3. Determine the slope of the underlying impervious layer. If the depth to the impervious layer varies by no more than a foot, the slope of the impervious layer may be taken to be equal to the ground slope.

4. Calculate the distance that the leaching system must be spread out perpendicular to the direction of the slope in order to provide sufficient cross-sectional area of soil downslope for effluent dispersal. Use Darcy's Law, as follows:

$Q = KiA$ Where A is the cross sectional area of the original soil down gradient from the system. A (area) = depth (d) X Length

$Q = Ki (d \times L)$

$$L = \frac{Q}{Kid}$$

Where:

L = Length that the leaching system must be spread out perpendicular to the slope, in feet.
Q = Volume of sewage effluent to be dispersed, in cubic feet per day.
K = Soil permeability, in feet per day.
i = Slope of the ground surface or underlying impervious layer.
d = Average depth of subsoil above the impervious layer, in feet.

Note that after the permeability of the soil, the slope of ground surface (or hydraulic gradient) and the depth of permeable soil available has been determined, the only variables left are the length of system spread and the volume of sewage to be discharged. Examples 1-3 address typical situations which can be used to determine minimum length (L) of system applications on critical properties.

Examples 4-6 cover situations which help us determine the total amount of water (Q) a particular parcel can safely handle and the limited options available.

Example 1 The leaching system for a two-bedroom single family house is to be located on a large lot underlain with hardpan at a depth of 18 to 22 inches. A 20-inch deep percolation test produced a rate of 15 minutes per inch. The hardpan has a minimum percolation rate poorer than 60 minutes per inch. The permeability of the upper soil layer is estimated to be about 4 feet per day, and the slope of the ground surface is about 5%. Therefore: System design based upon 15 min/inch perc rate, **500 sq.ft**. effective area required;

Q = 150 gal/bedroom X 2 bedrooms = 300 G.P.D.; convert to cubic feet $\frac{300}{7.5} = 40\ ft^3/day$

Q = 40 cu. ft./day K = 4 ft./day i = 0.05

$$d = \frac{(18 + 22)}{2} = 20 \text{ in.} = 1.67 \text{ ft.}$$

$$L = \frac{40}{4 \times 0.05 \times 1.67} = 120 \text{ feet}$$

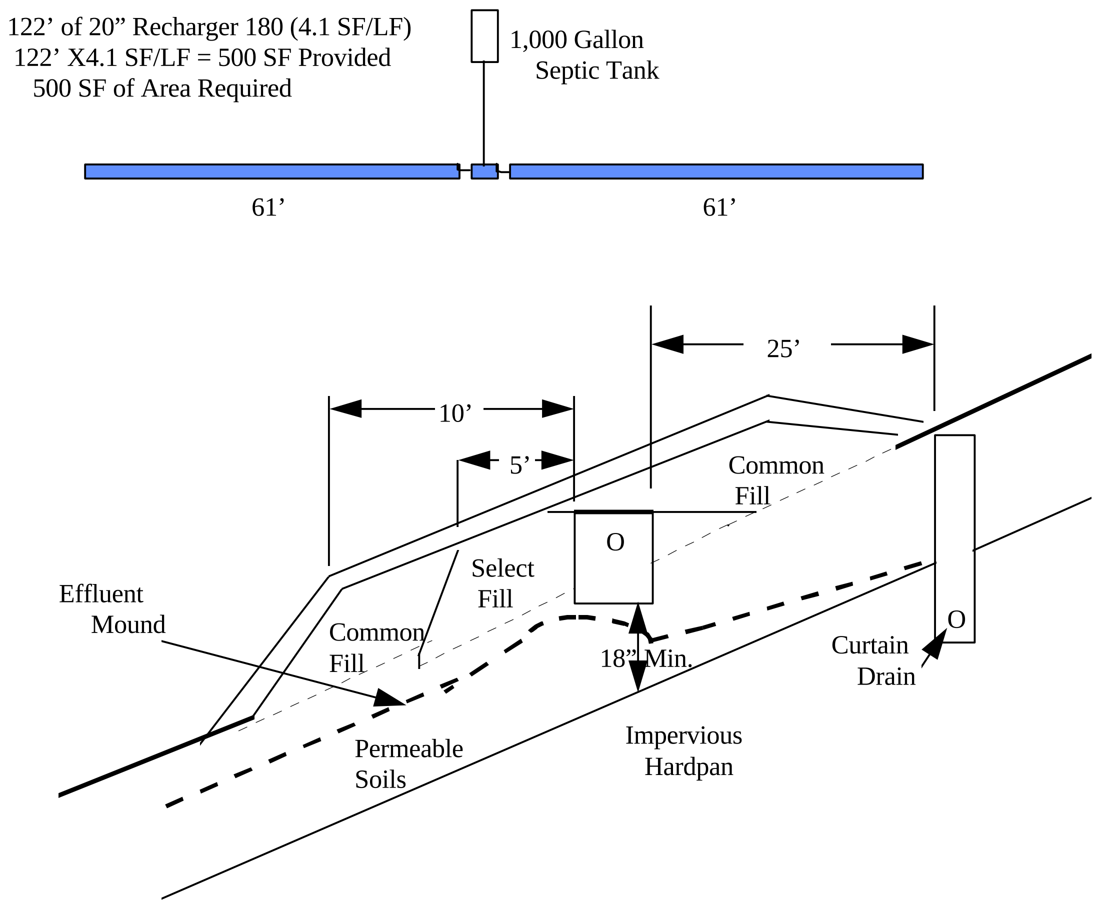


Figure 25-1 - Trenches Spread On Slope Over Impervious Hardpan

See Figure 25-1 for an acceptable leaching system design for this location. Note that the leaching trenches will be constructed in fill so that the trench bottoms will be at least 18 inches above the hardpan layer. 504 square feet of leaching area will be provided, with a curtain drain to intercept perched ground water will be installed.

Example 2 The leaching system for a two-bedroom single-family home will be constructed on a large, sloping lot underlain with impervious hardpan at a depth of 3 feet. The overlying soil consists of silty loam with a minimum percolation rate of 30 minutes per inch. The permeability of the overlying soil is estimated to be about 2 foot per day, and the ground slope is about 8%. Therefore:

$$L = \frac{Q}{Kid} = \frac{40}{1 \text{ X } 0.08 \text{ X } 3.0} = 167 \text{ feet}$$

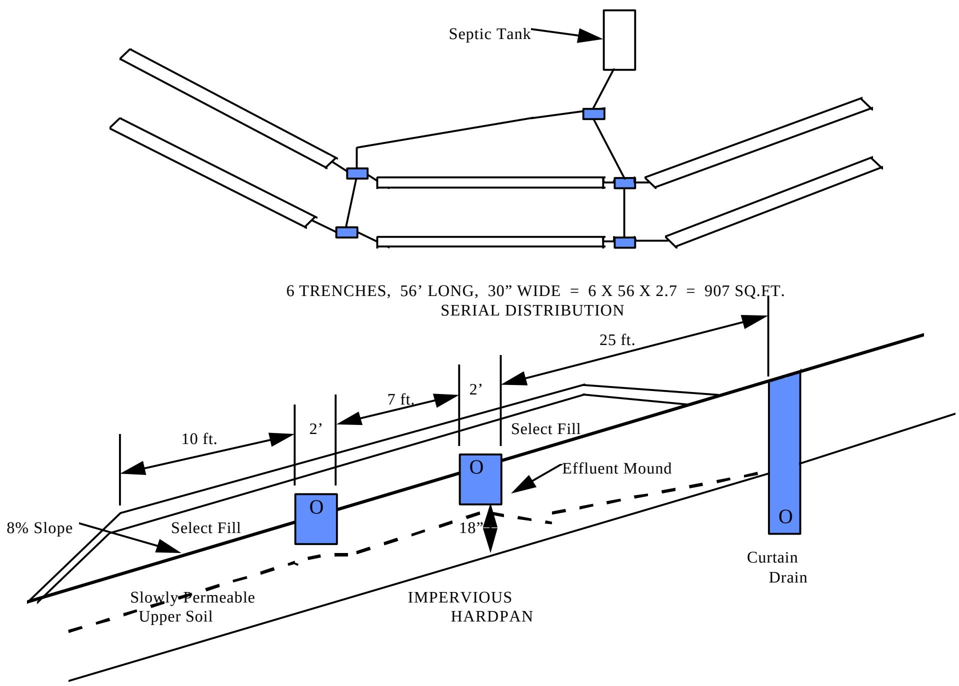


Figure 25-2 - Trenches In Slowly Permeable Soil Spread On Slope

See Figure 25-2 for an acceptable leaching system design for this situation. Note that **565 square feet** of leaching trenches will be used, constructed with the invert elevations approximately at original ground surface. A curtain drain will be installed.

Example 3 The leaching system for a small restaurant with a design flow of 1,500 gallons per day will be installed in a sloping area underlain by ledge at a depth of 4 to 5 feet. The soil on top of the ledge consists of sandy loam with a minimum percolation rate of 5 minutes per inch, and an estimated permeability of about 10 feet per day The ledge drops about 4 feet in a distance of 100 feet. No ground water was noted on top of the ledge even during the wet season. Therefore:

$$Q = 1{,}500/7.5 = 200 \text{ cu. ft./day}$$

$$L = \frac{Q}{Kid} = \frac{200}{10 \times 0.04 \times 4} = 125 \text{ feet}$$

$$\text{Code requires } \frac{1{,}500 \text{ GPD}}{0.8 \text{ (application rate)}} = 1{,}875 \text{ sq. ft. of area}$$

Design Proposal: 4 rows of 30 inch galleries, each row is 64 feet long. Total effective leaching area provided: 4 rows X 64' long X 7.4 sf/lf = 1,894 sq.ft. which exceeds the 1,875 sq. ft. required.

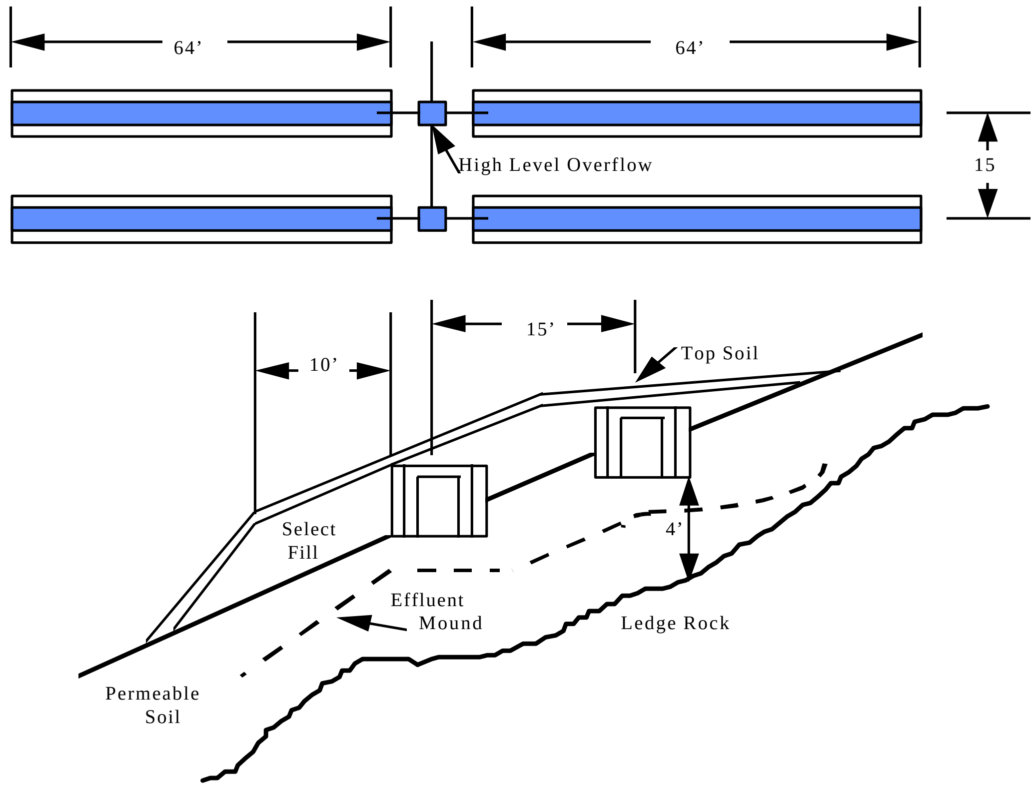


Figure 25-3 - Galleries Spread On Slope Over Ledge Rock

See Figure 25-3 for an acceptable design for this location. Note that leaching galleries are used, constructed in fill over the original soil. The size of the leaching system is based on the requirements of the Public Health Code. No curtain drain is installed. However, the relatively substantial depth of surrounding soil and fill should be sufficient to store and disperse any seasonal rainfall accumulation.

APPLICATION II - DETERMINING THE MAXIMUM HYDRAULIC CAPACITY SOILS

Quite frequently, engineers and health department staff must be able to calculate or estimate the hydraulic capacity of any given site to determine if proposed development is feasible for particular soil conditions. This is particularly important for construction of large sewage disposal system or on sites where the soils are marginal for leaching purposes. Central sewage disposal systems which concentrate discharges in one or more limited areas may also warrant close evaluation. Proper use of Darcy's Law can be a useful tool in determining whether proposed development exceeds the soils ability to disperse projected sewage flows or whether the scope of development should be scaled down within a safe range to assure health and environmental protection.

The following is a few examples of situations which local health departments have typically had to analyze:

Example 4 - Feasibility of Proposed Subdivision

A local developer wishes to subdivide a 10.5-acre parcel into 7 lots in accordance with existing zoning requirements. The property has 1,300 foot frontage along an existing town road and slopes gently away from the road toward a wetland near the rear property line. The developer would like approval for 6 lots, each approximately 180 ft. in width by 340 ft. in depth. Considering minimum zoning setback of 50 ft., average house width of 30 feet and the required 25 feet set back from building footing drains, a series of deep test pits were excavated approximately 125 feet from the front property lines to evaluate soil, water and ledge conditions.

Evaluation of the soils confirms the presence of Paxton soils, S.C.S. classification of PbB with approximately 8% slope. Subdivision plans submitted to the health department for review and comment show a series of 4-bedroom homes, all with wells located in the front yards and rear yard leaching areas spread out 100 feet parallel to the contours. Due to the compact till observed 32 inches below grade, it is reasonable to assume each system will be placed in select fill (once top soil is removed) and a curtain drain installed upgrade to intercept ground water. Percolation rates were found to be between 31 to 45 minutes per inch. The Planning and Zoning Commission wants to know if this subdivision should be approved. Without requiring extensive permeability testing or ground water monitoring, how can Darcy's Law and available sources of information be used to assist you in preparing a response?

First, MLSS calculations can be very useful in the initial configuration of the subdivision lots. The spread required by MLSS can be “blocked” out on each lot to indicate the necessary size and spread of a typical leaching system. In this example the spread required for the system would equal:

MLSS = HF X FF X PF = 26 X 2.0 X 3.0 = 156 feet

Therefore, if each of the proposed lots provided the required amount of primary and reserve leaching areas and were spread a minimum of 156 feet along ground contours the lots could be approved.

A further analysis to confirm the above results would employee direct use of Darcy’s Law:

GIVEN:
(1) 4 bedroom houses x 150 gal/room = 600 GPD/7.5 = 80 cubic feet/day
(2) Paxton soils in SCS book have permeability’s which range as follows
0-8” 0.6-2.0 inches/hr = 1.2-4.0 ft/day
8"-32" 0.6-2.0 inches/hr = 1.2-4.0 ft/day
32"-60" 0.06-0.2 inches/hr = .12-0.4 ft/day
(3) Width of system application 180’ lot - 10' each property line - +160 ft
(4) Gradient = 8% or .08
(6) Depth of permeable soil = 32"

ASSUME:
(1) K = average of SCS range 1.2 + 4.0 = 5.2/2 = 2.6 ft/day
(2) Curtain drain will cut off all inflow from up slope watershed
(3) L = 160’ parallel to contours

Solve for Q, the quantity of water each lot can handle:

$$Q = KiA = Ki(L \times d)$$
$$Q = 2.6 \ X \ 0.08 \ X \ (160 \times 32/12)$$
$$Q = 88.8 \text{ cubic feet}$$

With the potential for generation of 80 cubic feet of sewage and capacity to handle over 88 cubic feet, it is evident that the lot can support a system for a 4 bedroom home, both in terms of MLSS criteria and Darcy's Law.

However, if the developer wanted to increase the number of lots on the subdivision by reducing the width of the property (relative to the contours), hydraulic constraints would quickly become evident. If the width of the lots were reduced to 150 feet across (meaning the maximum amount of system spread would be reduced to 130 feet) then the required spread of 156 feet determined by MLSS would not be available. The developer would than have to reduce the number of bedrooms allowed for each home to three (3) in order to meet MLSS requirements:

MLSS = HF X FF PF = 26 X 1.5 X 3.0 = 117 feet

Under Darcy's Law:

A three (3) bedroom home will generate:

Q = 150 GPD X 3 Bedrooms / 7.5 gallons per cu.ft. = 60 cu.ft.

The proposed lot will support:

Q = KiA = Ki (L X d) = 2.6 X 0.08 X (130 X 2.66) = 71.9 cu ft.

Therefore, a three (3) bedroom home would be acceptable.

It is reasonable to recommend that development of the proposed subdivision of 3 or 4 bedroom homes will be dependent on the proposed width of the lots. If the above MLSS type analysis indicates that a lot can not meet requirements of Public Health Code Section 19-13-B103e.(a)(4.), which specifically prohibits the issuance of permits on any property where the surrounding naturally occurring soil cannot adequately absorb or disperse the expected volume of sewage effluent without overflow, breakout or detrimental effect on ground or surface water , approval of that subdivision lot should not be granted. It would be advisable to discuss your comments with the design engineer prior to preparing a response to local commissions to determine if additional tests should be made to confirm soil permeability's and method of analysis which may alter the status of the lot..

<u>Example 5</u> - The Motel/Restaurant Proposal

A local business man owns a 1.8 acre parcel at the intersection of two busy state highways. He would like to construct a two story 30 room motel and a 50 seat restaurant on this parcel which is 280' wide by 280 feet in depth. The view from the highway shows the land sloping from the left to the right at approximately 12% grade. In order to meet all zoning requirements, preliminary site plans designate a leaching area in the rear right corner approximately 190 feet wide (parallel with contours) by 70 feet in depth. Soil tests reveal the presence of Charlton soils, SCS classification CfC with a restrictive compact soil noted 4.5 feet below existing grade. Can this site handle the proposed development?

GIVEN: (1) 30 room motel @ 100 gal/room = 3000 GPD
50 seat restaurant x 3 turnovers x 10 gal = 1500 GPD
Total 4500 GPD/7.5 = 600 cubic ft.

(2) Charlton soils in SCS book have permeabilities which range as follows:

0-6"	-	0.6-6.0 inches/hr = 1.2-12 ft/day
6-26"	-	0.6-6.0 inches/hr = 1.2-12 ft/day
26-60"	-	0.6-6.0 inches/hr = 1.2-12 ft/day

(3) Percolation Rate = 4 minutes/inch
(4) Width of application area 190 feet
(5) Gradient s 12% = .12
(6) Depth of permeable soil = 4.5 ft. to restrictive layer, no groundwater observed or anticipated
(7) Tube samples (minimum of 6 tubes) confirm average K values of 6.2 ft/day.

Determine whether this site can handle projected flows:

Utilizing MLSS Criteria:

MLSS = HF X FF X PF = 14 X 4500/300 X 1.0 = 210 feet of spread required.

Utilizing Darcy's Law:

This analysis will be based on the actual permeabilities from the tube samples and the actual length of application (190') available on this site.

Q = KiA = Ki (LXd)
Q = 6.2 x .12 x 190 x 4.5
Q = 636 cubic feet/day
Q = 636 cu.ft./day X 7.48 gal./cu.ft. = 4,757 gallons per day can be discharged into the naturally occurring soils without becoming completely saturated.

As this example illustrates, the MLSS calculations may be more restrictive in some cases, especially when dealing with fast soils, than Darcy's Law. MLSS indicated that 210 feet of spread would be required in order to adequately disperse the 4,500 gallons of daily discharge. Since the site can provide only 190 feet of spread, MLSS would deem it unacceptable for the proposed usage. However, when a more in-depth hydraulic analysis was performed, utilizing actual permeabilities and Darcy's Law, it was found that the 190 feet of actual spread available would be sufficient for the proposed usage.

Special Note: The placement of the system in terms of elevation should be of concern in the above example, since the hydraulic mound created beneath a fully utilized system will likely saturate almost all of the underlying naturally occurring soils. Therefore it would be detrimental to the performance of the system if the system was placed into the natural soils and become flooded whenever the system is used at peak flow. Therefore, designing a leaching system 18" above maximum ground water (the minimum separation required by code) may not be appropriate when the system does not have extra hydraulic relief built in (significantly more spread than what is required by MLSS or Darcy's Law).

Consideration for "reserve hydraulic capacity" must also be considered when designing a leaching system. For the primary system adding "spread" to a system increases the safety factor for proper performance of the system by providing additional hydraulic window (access to additional unsaturated soils beneath the system) to accept those "above peak" discharges which may occur from time to time (during house parties or temporary increases in house occupancy). Another reason for providing extra hydraulic capacity, especially for the reserve area, is to allow the owners of the home or building to increase usages in the future. Under present health codes, house additions can be approved when the lot the building is located on can support a septic system, based on the ultimate configuration of the building, which will meet all health code requirements (including MLSS). If the total number of bedrooms or design flow increases, no approval may be given for a building addition, unless hydraulic capacity (MLSS/Darcy's Law) is established.

<u>Example 6</u> - The Flat Wet Lot

A local developer wishes to build a 4 bedroom home on the last remaining lot in an old residential subdivision. Soil testing during the wet spring months confirms the presence of ground water 18 inches below grade during the wet season monitoring. The lot is essentially level and the soil profile agrees with local mapping as described in the SCS soil survey as Ludlow silt loam. There is no slope available to allow curtain drain installation and, even if possible, there is the concern for back flow of ground water from the system area to the drain. The builder's engineer is recommending installation of a large trench system constructed in fill with trench bottoms set at existing grade. The percolation rate determined during testing in July produced a rate of 35 min/inch in a hole that was 18 inches deep. Can this lot handle the projected sewage flows?

GIVEN:

(1) 4-bedroom house x 150-gal/bedroom = 600 GPD = 80 cubic feet

(2) Ludlow soils in SCS book have permeabilities which range as follows

0-8" 0.6-2.0 inches/hr = 1.2-4.0 ft/day
8-30" 0.6-2.0 inches/hr = 1.2-4.0 ft/day
30-60" 0.2 inches/hr = 0.4 ft/day

(3) System design is a level mound, 2.0 ft of select sand and gravel fill with 4 rows, 75' long, 3' wide standard trench, 6 end connecting trenches. The fill extends 15 feet beyond the entire trench system prior to sloping 2 ft vertical/1 ft horizontal back to original grade. Plans specify placement of select sandy fill only 5 feet beyond the proposed leaching trenches. Dimensions of the select fill mound are 85' long x 40' wide.

,:

(4) The gradient is assumed to be the difference between the trench bottom set at grade and the ground water level (18") divided by 25 feet (assumed extension of saturated mound) i = 1.5/25 = .06

(5) Depth of permeable naturally occurring soil at base of select fill = 1.5 ft

ASSUME:

(1) K = average of SCS range 1.2 + 4.0/2 = 2.6 ft/day

(2) A (application area) = length of application to both sides of system plus connected ends = (75' + 75' + 30' + 30') X 1.5' depth = 315 sq.ft.

Utilizing MLSS Criteria

MLSS = HF X FF X PF = 42 X 2.0 X 3.0 = 252 feet required

Provided = 75’ + 75’ + 30’ + 30’ = 210 feet provided

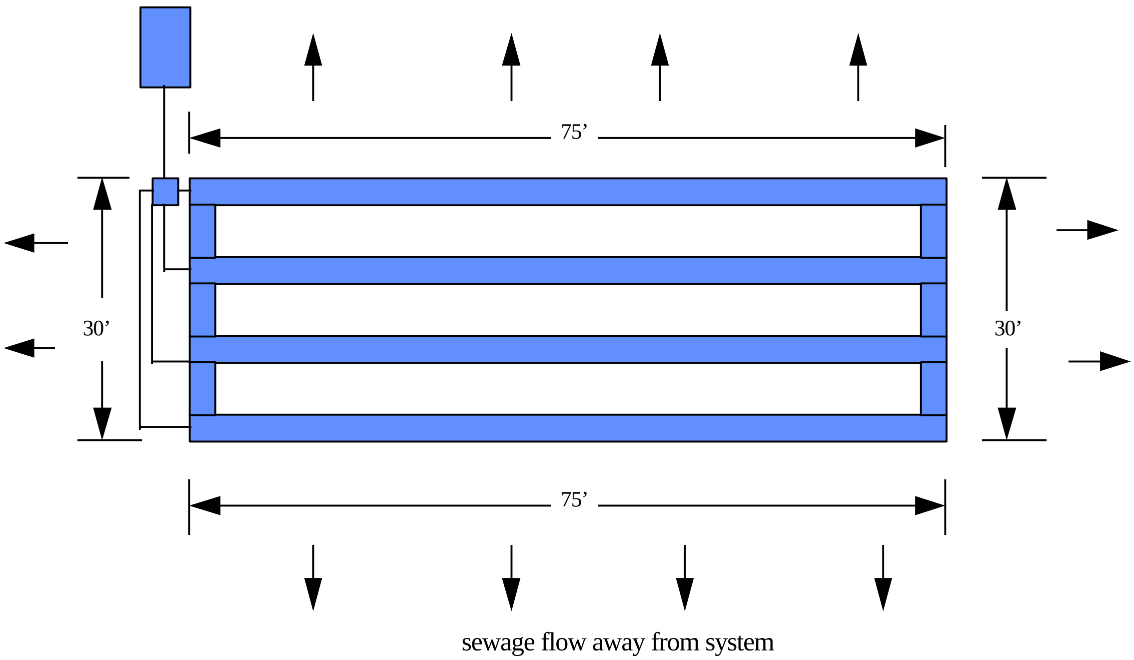


Figure 25-4 - Flat Lot System with Radial Flow

Utilizing Darcy’s Law

Q = KiA
Q = 2.6 x .06 x 315
Q = 49.1 cubic ft/day

As you can see, the calculations indicate a 4 bedroom home could not be approved if the assumptions made above were shown to be correct. Field testing to accurately determine permeability would be warranted if the builder wanted to pursue the 4 bedroom home approval. Further analysis of the above example brings out a key element of MLSS versus Darcy’s Law, namely there are going to be situations where MLSS criteria will be met when a Darcy’s Law analysis fails. If the above builder

decides to reduce the number of bedrooms in the proposed house to three (3) the MLSS equation will change to:

MLSS = 42 X 1.5 X 3.0 = 189 feet required < 210 feet provided

(This assumes the size of the system will not be reduced to a 3 bedroom)

Therefore, approved by MLSS

However, Darcy's Law indicates only 49.1 cu. ft. (368 gallons) of flow can be absorbed daily, which is below the design rate for a three (3) bedroom home of 60 cu. ft. (450 gallons).

Under the current Technical Standards the three (3) bedroom home would be approved for the above example even though Darcy's Law did not confirm result. The factor tables used for MLSS have this anomaly built in since the empirical data of years of existing leaching systems performing adequately does not warrant spreading the systems out any further.

It should be noted that if the ends of the above level leaching system where not tied in then the 60 feet of "side" lengths (30 feet to each side) could not be granted.

26. FIELD EXAMINATION OF SOILS

Soil Class	Feeling and Appearance: Dry Soil	Feeling and Appearance: Moist Soil
Sand	Loose, single grains which feel gritty. Squeezed in the hand, the soil mass falls	Squeezed in the hand, it forms a cast which crumbles when touched. Does not form a rib-

	apart when the pressure is released.	bon between thumb and fore-finger.
Sandy Loam	Aggregates easily crushed; very faint velvety feeling initially but with continued rubbing the gritty feeling of sand soon dominates.	Forms a cast which bears careful handling without breaking. Does not form a ribbon between thumb and forefinger.
Loam	Aggregates are crushed under moderate pressure; clods can be quite firm. When pulverized, loam has velvety feel that be-comes gritty with continued rubbing. Casts bear careful handling.	Cast can be handled quite freely without breaking. Very slight tendency to ribbon between thumb and forefinger. Rubbed surface is rough. is rough.
Silt Loam	Aggregates are firm but may be crushed under moderate pressure. Clods are firm to hard. Smooth, hard. Smooth, flour-like feel dom-inates when soil is pulverized.	Cast can be freely handled with-out breaking. Slight tendency to ribbon between thumb and forefinger. Rubbed surface has a broken or rippled appearance.
Clay Loam	Very firm aggregates and hard clods that strongly resist crush-ing by hand. When pulverized, the soil takes on a somewhat gritty feeling due to the harsh-ness of the very small aggre-gates which persist.	Cast can bear much handling without breaking. Pinched bet-ween the thumb and forefinger, it forms a ribbon whose surface tends to feel slightly gritty when dampened and ribbed. Soil is plastic, sticky and puddles easily.
Clay	Aggregates are hard; clods are extremely hard and strongly resist crushing by hand. When pulverized, it has a grit-like texture due to the harshness of numerous very small aggregates which persist.	Casts can bear considerable handling without breaking. Forms a flexible ribbon between thumb and forefinger and retains its plasticity when elongated. Rubbed surface has a very smooth, satin feeling. Sticky when wet and easily puddled.

27. IDENTIFYING SEWAGE POLLUTION IN GROUND AND SURFACE WATERS

Local health departments frequently receive complaints of alleged ground or surface water pollution by subsurface sewage disposal systems. Investigation often will reveal direct sewage discharges or overflowing sewage disposal systems in the area. But in some cases, no sources of pollution are evident and the occurrence of pollution is questionable. Such cases are difficult to resolve to the satisfaction of the complainant and may require laboratory testing of water samples or dye testing of suspected pollution sources. In general, however, sampling of ground and surface water should be avoided in the absence of some indication of possible sewage pollution and no sample should be collected until as much information as possible is obtained relative to potential sources of pollution. If samples are collected, care must be used not to request laboratory tests which are costly and unnecessary. Judgment is necessary in interpreting the laboratory results and in general, no tests should be required unless the results can be properly interpreted by the collector. It also is necessary to have an understanding of the techniques on limitations of dye testing before any such program is undertaken.

IDENTIFYING SEWAGE POLLUTION IN WELLS

The sanitary quality of ground water is of concern mainly in connection of possible pollution of wells or springs. Sewage pollution in wells can be identified fairly conclusively by laboratory analysis, since ground water should contain little or no bacteria or organic chemicals. Wells may be suspected of being polluted if the water shows objectionable taste, odor or physical appearance, or if there is a history of illness which may be water related. In such a situation a water sample should be collected for complete physical, chemical and bacterial analysis. There also may be wells where the sanitary quality of the water is suspect because the separating distance from a nearby sewage disposal system does not meet Code requirements. As long as there is no physical indication of pollution or history of illness, samples should be collected for bacterial examination only. Wells polluted by sewage would be expected to contain coliform bacteria well in excess of 2 per 100 ml as measured by the membrane filter test. Nitrogen constituents also are likely to be high. Nitrate nitrogen would probably exceed 1.0 mg/1, although this in itself may not indicate sewage since there are other sources of nitrates in ground water such as fertilizers. Any significant amount of nitrite nitrogen (0.01 mg/1 or greater) may indicate more direct sewage pollution because nitrites are rapidly oxidized to nitrates by percolation through soil. Organic (albuminoid) nitrogen and ammonia nitrogen are constituents of fresh sewage and should only be found in highly polluted wells. However, they may also be due to the presence of other organic matter such as leaves, insects, dirt or debris which has somehow entered the well. Except for coastal areas, ground waters in Connecticut are generally low in chloride content. Therefore, chloride levels exceeding about 15 mg/1 may also indicate sewage pollution. It should be noted that wells and springs producing water of good overall sanitary quality may occasionally contain low levels of coliform bacteria. This probably results from chance contamination by surface water draining into the well aquifer, or by contamination in the storage or piping system. Disinfection and resampling should produce good bacterial results. Repeated bacterial contamination without confirming chemical pollution or nearby sources of sewage pollution probably indicates that the well is poorly sealed or protected.

IDENTIFYING GROUND WATER POLLUTION

Other than where wells are concerned, the effect of subsurface sewage disposal systems on ground water is rarely a public health concern. It can be assumed that the ground water table in the immediate area of such a system is polluted to some extent. Such a level of pollution is acceptable from the standpoint of public health and this is the reason for the separating distances required by the Public Health Code. Unacceptable ground water pollution occurs when the dissolved oxygen which is normally present in ground water is depleted by high levels of organic pollutants. When this occurs, the physical and chemical characteristics of the ground water can change significantly. The ground water can become odorous if sulfates, which may be present in the waste or in the soil, are chemically reduced to hydrogen sulfite. Iron, which is common in Connecticut soils, probably will be dissolved by the oxygen deficient ground water and may be deposited as an orange sludge where polluted ground water leaches to the surface. Blackish sludge deposits may also occur in some areas due to manganese leaching. Ground water pollution can be greatly aggravated by the action of certain bacteria which can thrive in ground water which is rich in iron or manganese and organic nutrients, and is deficient in dissolved oxygen.

Subsurface sewage disposal systems which have been properly designed and installed in accordance with the Code requirements should not cause an unacceptable level of ground water pollution. Most cases of ground water pollution are caused by the burial of large volumes of organic material, such as municipal refuse, demolition material, agricultural waste or swamp muck. However, an unusually large subsurface sewage disposal system installed in an area of highly permeable soil may cause ground water pollution, particularly if the ground water table is high. The same may occur from smaller systems if Code requirements are not followed. It should be noted that ground water pollution from sewage is more likely to occur in permeable soils than in poor soils and sewage disposal system failure or overflow is rare in such situations.

Often there is little that can be done to correct an existing ground water pollution problem since it is not possible to change soil conditions or to reduce the volume of sewage discharged to the ground water. The main thing that the investigator should do is to determine whether observed nuisance conditions result from ground water pollution or from direct sewage discharge from unknown sources. This can only be determined by sanitary survey, including dye testing if necessary. Other potential sources of ground water pollution, such as sanitary land fills, etc., should not be over looked when making the survey. Depending on the findings, conclusions can be made as to the public health significance and possible long range solutions. This may include such things as extension of public sewers or public water supply mains, rezoning, or ground or surface water drainage projects which would alleviate the nuisance conditions.

IDENTIFYING SEWAGE POLLUTION IN SURFACE WATERS

It is difficult to identify sewage pollution in surface waters by laboratory analysis because of the great variations in naturally occurring levels of both bacteria and organic chemicals in such waters. In some cases, there may be relatively high levels of the type of bacterial or chemical pollutants which are normally found in sewage, without any sewage actually being present. In other cases, sewage may be entering surface waters without producing unusually high pollutant levels because of high dilution. For these reasons, a program of sanitary survey, supplemented by dye testing if necessary, should be used where surface water pollution is suspected. Water samples should only be used to confirm or supplement sanitary survey information, although samples are frequently collected to satisfy public demand for information about the sanitary quality of a particular body of surface water.

If samples are collected from a surface water, only bacterial analysis should be requested. Information should be provided as to the expected bacterial quality of the water since this will determine the testing methods and sample dilution’s used in the laboratory. Chemical testing is not recommended because there is little if any relationship between chemical constituents and sanitary quality in most surface waters.

The standard test for bacterial quality of surface water is the total coliform determination. The test is based on determination of the quantity of a particular type of bacteria in a given volume of water samples. Since this type of bacteria is naturally found in the intestinal tract of humans and warm blooded animals, its presence in water is taken as being indicative of the presence of sewage in the water and the quantity of the organism present is taken as being indicative of the degree of sewage pollution. Unfortunately this is not entirely true because naturally occurring coliform organisms are also found to be present in varying amounts in all surface waters. Coliform organisms are found in soils, muds and decaying vegetation. Large numbers of such organisms are discharged by animals and surface runoff from pastures normally is high in coliforms. There are other bacterial tests which are possibly more valid indicators of sanitary quality. The most important of these is the fecal coliform test which is a modified total coliform test. In this modified test, a new medium is utilized and an elevated incubation temperature is used to distinguish the fecal coliforms from the total coliforms. While this technique may offer some advantages, it is subject to the same general criticism as the total coliform test. A disadvantage of this test is that the uninformed public has a tendency to conclude that the presence of any fecal coliforms indicates human sewage pollution which may not be the case. In general, fecal coliform tests are not recommended except in certain situations where the total coliform test appears to be giving misleading high results. In such situations, both tests are run on the samples and if the fecal coliform content is much lower than the total coliform content, it is assumed that the bacteria are not due to sewage.

EFFECT OF RUNOFF ON BACTERIAL QUALITY OF SURFACE WATERS

The Connecticut Department of Health Services, in cooperation with various local health departments, has done extensive monitoring of surface waters. This monitoring has shown a very distinct relationship between the bacterial quality as indicated by the total coliform content and the amount of surface water runoff at the time of sample collection. Experience has shown naturally high coliform contents in streams, ponds and even small lakes after a rainfall, even where there is no known source of sewage pollution on the watershed. Such elevated counts are concluded to be due to naturally occurring coliforms and are not a true indication of pollution. Water washing over the surface of the ground after a rainfall will pick up naturally occurring coliforms and carry them into streams, rivers and lakes. For this reason, the total coliform content of a surface water will reflect the amount of surface runoff in it as well as the degree of sewage pollution. Therefore, the total coliform content of a running stream or river will always be higher than that of a large pond or lake since the percentage of surface wash is higher, particularly after a rain when the runoff is high. Coliform organisms will naturally tie out with time in clear water with low organic content. This characteristic also contributes to the lower coliform levels in large ponds and lakes where the storage time of the surface water runoff is great.

Experience in Connecticut has shown that inland lakes with relatively clean watersheds should show coliform counts under 200 per 100 ml. On the other hand, the coliform content in a running stream is rarely under this figure and a coliform content of 1000 per 100 ml or less is considered an indication of good sanitary quality, suitable for bathing purposes. The same streams may show counts of up to 10,000 coliforms per 100 ml following a heavy rain due to coliforms from natural sources without indicating sewage pollution. Counts of over 10,000 per 100 ml indicate probable sewage pollution. It is evident, therefore, that considerable judgment must be used when interpreting the results of bacterial samples collected from surface waters. Water samples should not be collected after a heavy rain- or when the water is noted to be turbid due to heavy runoff. Sanitary quality judgment should be made only after review of the results of the number of samples taken over a period of time under various conditions, together with a sanitary survey of the watershed for possible sources of pollution. when a number of tests results are available, the median figure should be used as the determining value rather than the average, which may be distorted by a few high sample results. Samples should be collected by dipping under the water surface where the water is sufficiently deep so that no mud or silt will be stirred up and collected in the sample bottle.

DYE TESTING

Dye testing of sewage collection and disposal systems may be done for any of the following purposes.

1. To find the source of an obvious sewage discharge when it is not apparent.

2. To establish evidence of sewage overflow or discharge in preparation for legal action.

3. To locate illegal sewage connections to storm sewers.

4. To determine if a subsurface sewage disposal system periodically overflows to ground surface or leaks into a ground or surface water drain.

5. To determine if a water discharge contains sewage.

The water soluble dyes used for these purposes are detectable in very dilute solution. Therefore, the dye is relatively easy to see in water discharges, catch basins, streams and pools of standing water. Most of these dyes are adsorbed to some degree by various minerals in the soil. For this reason, dye may be removed by percolation through even a few feet of soil and is reliable only as an indicator of more or less direct pollution. Failure to recover dye in a well or ground water does not necessarily indicate that there is no sewage pollution.

Fluorescein dye is normally used for testing subsurface sewage disposal systems since it is less readily absorbed by soils than most other dyes. It is usually used in the form of a sodium salt called uranine, a reddish powder rapidly soluble in water. Normally, a tablespoon of this powder is placed in the toilet bowl and flushed into the sewage disposal system in question. The dye will not stain sanitary fixtures but must be handled carefully to avoid spilling since even a few crystals will stain clothes, floors and furniture. When diluted, fluorescein has a greenish-yellow color which is fluorescent under ultraviolet light. Fluorescein can be detected in dilute concentrations invisible to the naked eye by means of a laboratory fluorometer. It also can be measured in dilute concentrations in the laboratory by acid extraction techniques.

Rhodamine dyes also may be used as sewage tracers. These come in liquid solution, are also fluorescent, and are available in several colors. The more widely used dyes of this type are Rhodamine B which is red, and Sulpho Rhodamine Pink B which has a brilliant pink color. Rhodamine dyes are generally more stable in sunlight than fluorescent and, for this reason, they are frequently used for streamflow measurement. They are more readily absorbed by soil than fluorescent and therefore are less suitable for testing subsurface sewage disposal systems. The variety of available colors allows several such systems to be tested at the same time, thereby expediting dye testing programs involving a large number of systems.

When dye testing a subsurface sewage disposal system, it should be understood that the dye may not immediately show up at the suspected point of discharge. The sewage may first pass through a septic tank or leaching system which will delay the appearance of the dye for one or two days. Therefore it is necessary to periodically reinspect such systems over several days after using the dye before it can be concluded that the system is functioning properly. Dyes are generally unaffected by chemicals normally found in domestic sewage with the possible exception of chlorine bleach. Before using dye, a brief inspection should be made of the plumbing system. It may be found that there is more than one waste line leaving the building. In such a case, each system should be tested separately with dye   Frequently basement washing machines are discharged into cellar trains and can easily be overlooked when dye testing for pollution sources.

28. NON-CONVENTIONAL TOILET SYSTEMS

From time to time, local or state officials are requested to review various proposals for the installation of non-conventional toilet systems. Technical Standard IX describes several types of non-discharging toilet systems which are acceptable for certain uses. Public Health Code regulation 19-13-B103f describes the conditions under which these systems may be approved. In all cases, approval must be granted by the local director of health before such systems can be used and in some cases approval also is necessary from the State Department of Public Health. This section of the Public Health Code also allows the State Department of Public Health to grant an exception to allow one of these toilet systems or another type not specifically included in the Technical Standards to be used in a particular instance upon a determination that the system will provide for proper disposal and treatment of toilet wastes or gray water.

Non-conventional toilet systems are most commonly used in the repair of failing subsurface sewage disposal systems on marginal lots where it is necessary to reduce the volume of sewage discharge to the leaching system in order to allow it to function properly. Most regulatory officials are reluctant to approve non-conventional toilet systems for other purposes because acceptance of such toilets by the public is generally poor. High operating costs, increased maintenance and objectionable aesthetic conditions are common with most non-conventional toilet systems. Many users will desire to convert to conventional water carriage flush toilets after a period of time. For this reason, application for approval of nonconventional toilet systems should come from the property owner and individual who will use the system, not from the builder or developer. Application for installation of a non-conventional toilet system in no way eliminates the need to test the lot as to its suitability for subsurface sewage disposal since a gray water disposal system will be necessary in almost all cases. Property owners should seek the advice of an experienced engineer or installer, as well as the local Sanitarian, before making any final decision on using a non-conventional toilet system. If a non-conventional toilet system is approved on a lot which is unsuitable for sewage disposal from conventional flush toilets, this fact should be noted on the permit. It would also be desirable to record this on town land records to alert prospective buyers as to limitations on toilet and sewage disposal systems.

Table 28-1 provides a brief description and summary of pertinent information concerning many of the toilet and treatment systems discussed. Selection of a nonconventional toilet system depends on the desires reduction in sewage volume, the availability of utilities such as water and electricity and the expected usage. It should be kept in mint that all residential buildings and most non-residential buildings will generate liquid wastes from sinks, tubs, showers etc. which will require a conventional subsurface sewage disposal system.

LOW VOLUME FLUSH TOILETS

Specially designed or modified toilet fixtures which use a reduced volume of water for flushing purposes are the type of non-conventional toilet systems which are most acceptable to the user and are the most widely used. Devices are available which can be used to modify conventional water closets and reduce flush volume. Such devices generally are inexpensive and can be installed by the homeowner. In general, no approvals are required from health or building officials for making such modifications. Tank inserts reduce the volume of flush water stores in the tank while utilizing the same flush valve. New valves can be installed in most existing tanks which will allow the flush to be regulated for larger or smaller volume, depending on what is required. Such modifications of existing toilets may reduce the volume of toilet wastes by up to 50%. Specially designed gravity operated toilets also are available which will reduce waste volume even more. Most of these use a high velocity discharge from an elevated storage tank to clear wastes from a hydraulically modified toilet bowl with a relatively small volume of water. Such special toilets use 1 to 2 gallons per flush and are similar in appearance and operation to conventional toilets. However, more frequent cleaning of the bowl may be required. Installation may be made by a plumber and little modification to the existing house plumbing is required.

COMPRESSED AIR/VACUUM TOILETS

Toilet systems which utilize compressed air or vacuum provide greater reduction in effluent flows generated. Some systems use as little as 1 pint per flush and provide acceptable bowl evacuation. Because of the high initial cost involved with installation of air pressure or vacuum systems, their use is usually restricted to commercial or manufacturing facilities which can incorporate the cost of installation and maintenance as part of their operational budget. Portable toilet facilities which utilize compressed air or vacuum have been leased by the State Department of Environmental Protection for use in state parks. Their function was deemed adequate for the required short period of service and they may be well suited for mass gatherings or public events. However, electrical service must be available.

COMPOSTING TOILETS

Composting toilets have no liquid discharge of any kind. There is a small volume of composted solid material which must be periodically removed. This waste is likely to contain pathogenic organisms and should be disposed of by burial or land filling. Large volume composting units allow a relatively long time period for the composting action. There is little regulation of moisture or temperature within the unit and composting action may be slow or irregular. They may be used where water or electricity is not available, but an electrical ventilation fan is desirable to control odors and reduce moisture buildup within the unit. Installation of a large composting toilet within an existing house may require removal of exterior or interior walls in order to accommodate the large chamber. Excessive liquid accumulation has been a problem where large composting chambers are located outside or in an unheated basement or enclosure. Heat assisted composting toilets are equipped with electrical heating units and ventilation fans which may be regulated to provide optimum conditions for composting action. The relatively small size of the units allows them to be placed within existing rooms. However, experience has shown that most users are unable to properly regulate the composting action. Compost dehydration and odor is common in such small composting units. Most manufacturers recommend that heat assisted compost toilets not be used for more than 2 or 3 persons on a continuous basis.

Successful operation of both large capacity and heat assisted composting toilets is closely related to the habits of the users and their care and understanding of the composting process. Moisture must be controlled by adding solid material or regulating ventilation or temperature. Changes in these conditions or in patterns of use may cause problems. Insect breeding or mold growth can create nuisances. Composting toilets are allowed in Connecticut only for abatement purposes, for replacing existing privies, or for new buildings on lots which have been tested and found to be satisfactory for a conventional subsurface sewage disposal system.

INCINERATION TOILETS

Incineration toilets also have no liquid discharge. They are rarely used in residential buildings but may be installed to provide toilet facilities in lightly used non-residential buildings such as warehouses or electric substations, where no water supply is available. Incineration toilets require electrical power to operate a blower, and electricity, gas or oil to generate the temperature required for combustion. Installation and operating costs are relatively high and their use has been declining in recent years. Odors may be a problem in built-up locations, particularly with the electric burning units which require a longer period of time to reach proper combustion temperatures. It also may be difficult to keep the toilet bowl clean since there is no rinse action. Incineration toilets are not suitable for public toilets or for any kind of heavy use because of the burning time required between uses.

CHEMICAL FLUSH TOILETS

Chemical flush toilets do not discharge to a subsurface sewage disposal system. Instead, the chemical solution used for flushing purposes is recycled. Most such toilets use a water solution containing deodorizing chemicals which may be hazardous if discharged to the ground waters. This liquid must be periodically removed and disposed of off-site. Chemical flush toilets cannot be located within residential buildings or human habitations, except with special approval by the State Department of Public Health. This is mainly to assure adequate venting of chemical odors and to facilitate periodic removal of the chemical solution. Chemical flush toilets normally are located in freestanding toilet buildings or vehicles. The chemical flushing solution is stored in a holding tank within the toilet building or vehicle. Spent solution may be periodically discharged to a larger holding tank located nearby. It should not be discharged into a leaching system.

An oil recycling flush toilet system is somewhat different, inasmuch as the chemical used for flushing purposes does not have to be periodically removed. An odorless mineral oil is used for flushing and transporting waste to a sealed separation tank. The mineral oil floats to the top of the tank, is separated and recycled. The solid and liquid wastes remain in the bottom of the separation tank and must be periodically removed. This waste is biodegradable, but it is extremely concentrated and may be contaminated with oil. It should be taken to a septage disposal area rather than discharged to a subsurface sewage disposal system. This type of chemical flush toilet can be located within a human habitation with approval by the State Department of Public Health. However, installation and operation costs are extremely high since a completely separate plumbing system is required. All recycling toilets probably are practical only for commercial buildings or separate toilet buildings.

TREATMENT AND RECYCLING TOILET SYSTEMS

Some technologically advanced systems are available which can treat and recycle water-flushed toilet wastes without the addition of chemicals. Toilet wastes are pumped to a series of packaged treatment modules which aerate, filter and disinfect the waste prior to recycling. No toxic chemicals are added since treatment is largely by a biological means. Solids are broken up, digested and recirculated. Only a small volume of liquid is periodically withdrawn from the close system and replaced with water. Such complete treatment and recycling toilet systems are very expensive to install and operate and probably only suitable for commercial buildings where operating costs can be included as part of the normal cost of doing business. Treatment facilities should be placed in a separate room if they are located within a human habitation. Special approval may be granted by the State Department of Public Health for treatment and recycling toilet systems. However, site conditions would have to be unusual for such a system to be considered. Engineers' plans would be required.

TABLE 28-1 - NON-CONVENTIONAL TOILET SYSTEMS

Generic Type	Description	Considerations	Operation and Maintenance	Total Flow Reduction %
Toilet with Tank Inserts	Displacement devices placed into storage tank of conventional toilets to reduce	Device must be compatible with existing toilet and not interfere	Post-installation and periodic inspections to insure proper	4-8

	volume but not height of stored water. Varieties: Plastic bottles, flexible panels, drums or plastic bags.	with flush mechanism. Installation by owner.	positioning.	
Dual Flush Toilets	Devices made for use with conventional flush toilets; enable user to select from two or more flush volumes based on solid or liquid waste materials. Varieties: Many	Device must be compatible with existing toilet and not interfere with flush mechanism. Installation by owner.	Post-installation and periodic inspections to insure proper positioning and functioning.	6-15
Water-Saving Toilets	Variation of conventional flush toilet fixtures; similar in appearance and operation. Redesgned flushing rim and priming jet to initiate siphon flush in smaller trapway with less water. Varieties: Many manufacturers but units similar.	Interchangeable with conventional fixture. Requires presurized water supply.	Essentially the same as for a conventional unit.	6-10
Washdown-Flush	Flushing uses only water, but substantially less due to washdown flush. Varieties: Few	Rough-in for unit may be non-standard. Drain line slope and lateral run restrictions. Requires pressurized water supply.	Similar to conventional toilet, but more frequent cleaning possible.	21-27

Generic Type	Description	Considerations	Operation and Maintenance	Total Flow Reduction %
Pressurized Tank	Specially designed toilet tank to pressurize air contained in toilet tank. Upon flushing, the compressed air propels water into bowl at increased velocity.	Compatible with most any conventional toilet unit. Increased noise level. Water supply pressure of 35 to 120 psi.	Similar to conventional toilet fixture.	14-18

	Varieties: Few			
Compressed Air-Assisted Flush Toilets	Similar in appearance and user operation to conventional toilet; specially designed to utilize compressed air to aid in flushing. Varieties: Few	Interchangeable with rough-in for conventional fixture. Requires source of compressed air; bottled or air compressor., need power source.	Periodic maintenance of compressed air source. Power use - 0.002KwH per use.	30
Vacuum-Assisted Flush	Similar in appearance and user operation to conventional toilet; specially designed fixture is connected to vacuum system which assists a small volume of water in flushing. Varieties: Several	Application largely for multi-unit toilet installations. Above floor, rear discharge. Drain pipe may be horizontal or inclined. Requires vacuum pump. Requires power source.	Periodic maintenance of vacuum pump. Power use - 0.002KwH per use.	30
Black Water Treatment & Recycling	Similar in appearance and user operation to conventional toilet; waste water aerated, filtered, disinfected and returned for use in flushing. Varieties: Few	Application largely for multi-unit toilet installations. Requires separate closed loop plumbing, room for treatment components. Uses air compressor, pumps, filter and disinfection units. Requires power source.	Periodic maintenance of all treatment units including pumps and compressor by skilled technicians.	40

Generic Type	Description	Considerations	Operation and Maintenance	Total Flow Reduction %
Gray Water Treatment & Recycling	Similar in appearance and user operation to conventional toilet; wastes from sinks, showers and tubs are filtered, disinfected and returned for use in flushing.	Application for single family residential. Requires separate closed loop plumbing. Requires use of filter, pump and disinfection units.	Periodic maintenance of filter, pump and disinfection units.	40

Requires power source.

29 HOLDING TANKS

A holding tank is a large, watertight tank which receives and stores liquid wastes from a building. The tank is pumped periodically and the waste removed for disposal off the site by a licensed septage hauler. Pumping such a tank can be quite expensive and for this reason, holding tanks normally should be considered only as an interim measure until a permanent method of disposal is available. This is particularly true for residential buildings where per capita water consumption and related pumping costs are high. Holding tanks may be used as an interim measure while public sewers are under construction or where a building is scheduled to be abandoned in the near future. Interim holding tanks for residential buildings probably are not cost effective if the period of use exceeds twelve months, although non residential holding tanks may be used for longer periods.

There are also situations where the long term use of a holding tank may be considered. A holding tank may be used to abate an existing sewage problem at a private residence where there is no other alternative. However, it is extremely important that water usage be reduced as much as possible by the installation of non-discharging toilet systems, removal of laundry facilities and use of water saving sanitary fixtures. Failure to do this will result in high pumping costs and may cause the owner to install an illegal overflow or discharge. Water usage is more easily reduced at a seasonal cottage and holding tanks are more practical for abatement situations. There are certain commercial and industrial buildings such as warehouses, garages and equipment buildings for which installation and operation of a holding tank would represent a relatively small part of the overall operational cost of such a facility and therefore may be a feasible alternative. Holding tanks are not normally approved for new construction projects.

The holding tank should have sufficient liquid storage capacity to hold the volume of sewage expected to be discharged from the building over the period of a week or more. Holding tanks should never be designed to be pumped when full. Instead, the schedule of pumping should be such that the tanks are pumped when about half full. For instance, if a holding tank is large enough to store one weeks sewage flow, the tank should be pumped about every three days on a regular schedule. Such an arrangement anticipates that there will be occasions when the scheduled pumping will be delayed due to reasons beyond the control of the pumper such as equipment breakdown, illness or adverse weather. There should be a liquid level indicator or alarm which would readily indicate when the holding tank has reached the level at which it should be pumped. This would tell the owner of the building that there is a potential for overflow and allow him to contact the pumper before this occurs. Sometimes two holding tanks are used in series with a high level alarm sounding when the first tank is full.

Holding tanks should be located in secure areas which are not available to the general public. Holding tanks must have easily removal manholes extended to grade, which could represent a safety hazard. Holding tanks should be considered potential sources of pollution and should be located so as to provide the minimum required separating distances for subsurface sewage disposal systems in the Public Health Code. In some situations it may be necessary to reduce the required minimum separating distance in order to abate a sewage problem. If this is allowed, particular care must be given to sealing and testing the holding tank for leakage and the ground surface around the tank should be paved and graded to carry possible overflow away from wells, watercourses and residences.

No holding tank should be installed without approval of both the State Department of Public Health and the local director of health. The owner of the facility must agree to enter into a contract with a licensed subsurface sewage disposal system cleaner for the regular pumping of the tank. The owner of the facility may be required to furnish the health department a copy of a written contract with such a cleaner. The cleaner must specify the final disposal area for the waste removed from the holding tank. If the volume of waste is large, a letter of acceptance may be required from the operator of the disposal area. The pumping of the holding tank and disposal of the waste should be periodically inspected by the local health department.

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30. SEWAGE PUMPING STATIONS

Sewage pump stations are sometimes necessary to make use of leaching areas located at higher elevations than the building served or for dosing large leaching systems when use of a siphon is not feasible. The sewage pump station consists of a concrete or polyethylene pump chamber, electrical controls, high level alarms and associated piping. For most installations, liquid discharged from the septic tank enters into the pump chamber and is stored until the liquid reaches the pump activation level. The pumps then activate and force sewage through a small diameter pressure pipe to the leaching system.

Section Vl of the Technical Standards specifically requires intermittent dosing through use of siphons or pumps for large leaching systems with a design flow of 2,000 gallons per day and greater where the total length of distribution pipe is 600 feet or more. If the property is relatively level or the building sewer exits the foundation wall at depths which prevent use of a dosing siphon, a pump lift station may be required. For large sewage disposal systems, dual alternating pumps must be provided. For small sewage disposal systems with design flows less than 2,000 gallons per day, either duplicate alternating pumps or a single pump with emergency storage volume in the pump chamber must be provided. Household pump chambers are usually 1,000 gallon septic tanks which are converted for use as a pump station. High level indicators or alarms and extension of access manholes to grade are required for all pump lift stations.

When used as dosing mechanisms, pump controls should be set to discharge at least 50% of the volume of distribution pipes, or 3 to 5 discharges per day for large leaching gallery systems. When designing systems with flows 2,000 GPD or greater and more than 600 linear feet of distribution pipe, each discharge should be directed to a large distribution box with multiple outlets at the same elevation to assure equal dosing of all parts of the leaching system. Small residential or commercial pump lift stations may be set to discharge 2 or 3 times per day. It is essential that the chambers and pumps be properly sized to achieve the intended goal of dosing or elevating the effluent in such a manner to promote long effective life of the pump station. The specification of a pump capable of discharging 150 gallons per minute at the desired head would not be satisfactory for a small chamber sized to discharge 100 gallons per cycle. The pump would start and stop within less than 1 minute, shortening pump life and using energy inefficiently. Use of a pump capable of discharging 30 gallons per minute also would be unacceptable if placed in a pump chamber with a design dose rate of 2,100 gallons per cycle. Such a small pump would run for periods in excess of 70 minutes and not provide the rapid discharge of effluent required to effectively dose a large leaching system.

A common error in the design of sewage disposal systems utilizing pump lift stations is to overlook the importance of pump station location with respect to existing grade. Ground water infiltration into pump chambers placed below seasonal high ground water level may cause failure of the leaching system. Every effort must be made to locate the septic tank and pump chamber in areas not subject to seasonally high ground water or at elevations above the ground water table. It may be necessary to locate the septic tank and pump chamber farther from the building on the downhill side even though the length of force main is increased.

Most pump chambers are constructed of precast concrete or polyethylene. Installation of the lightweight plastic tanks may be critical where ground water problems exist. All pump chambers must be constructed watertight (this requires that the tank's bottom weep hole be properly sealed during installation) and designed to prevent floatation during high ground water periods. Submersible pumps are used for a large majority of pump stations. These pumps are activated by mercury float switches or diaphragm pressure switches attached to the pump. See Figure 30-1 for a cross sectional view of a typical pump station. Pumps should be located under the access manhole to facilitate inspection and repair. Installation of a union or other means to permit pump removal is essential. A check valve and gate value are typically installed after the union to prevent back flow. These elements should also be situated beneath the access manhole for ease of maintenance. The force main usually remains full of liquid and must be placed in a trench at least to 4 feet below grade to prevent freezing. Draining of the force main back to the pump chamber through a small diameter hole located after the check valve may be necessary to prevent freezing for shallow installations. If a "weep hole" is provided for the force main then it is important to raise the distribution box feeding the highest component of the leaching system to prevent a backflow from the system. Because of the corrosive nature of effluent discharged from the septic tank, use of PVC or polyethylene piping, valuing and fixtures is recommended whenever possible. Where dual alternating pumps discharge through a single force main, separate check or gate valves must be provided on each pump discharge line to facilitate removal of one pump while keeping the second pump operational. Sharp bends in the force main should be avoided whenever possible. Use of thrust blocks may be required when directional changes in the force main are necessary. Wiring leads and float control wires are normally attached to a vertical pump rail with plastic connectors rather than free hanging. Enough extra wiring will be needed to allow the pump and piping assembly to be freely lifted out of the chamber and riser for servicing. The lift chain should be made of a non-corrosive material, such as, plastic or nylon. The electrical connections and assembly shall be installed by a licensed electrician under proper permits.

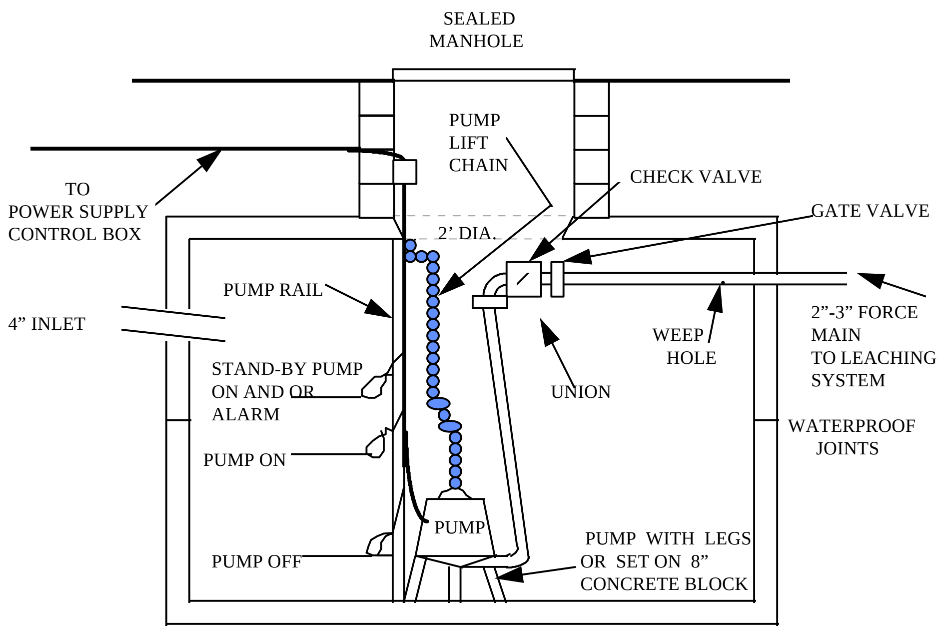


Figure 30-1 - Effluent Pump Chamber

In some repair situations or for new buildings containing a single basement fixture, use of an internal grinder sewage pump may be acceptable. These small self-contained pump lift stations are enclosed in a 30 to 50 gallon container and are installed inside the foundation below the cellar floor. Raw sewage entering the pump chamber is ground up and discharged to the septic tank in relatively small doses. Use of these units may be acceptable where first and second story plumbing fixtures can be directed to the septic tank by gravity and flow from basement fixtures is limited. The pumped discharge of a large volume of sewage to the septic tank is undesirable because it may cause sludge to be washed out of the tank into the leaching system.

Large sewage pump lift stations usually are controlled by a series of 3 or 4 mercury float switches which activate the pumps depending upon flow conditions. The lowest float turns the pump off when the discharge cycle is completed. The second float activates the lead pump and in the case of duplicate alternating pumps, cycles the electrical control to switch the standby pump to lead position. A third float is installed to activate the standby pump during periods of peak flows. In that case, discharge piping must be sized to handle flows from both pumps. The fourth float is a high level alarm which activates audible or visible alarms located at the station or maintenance facility. The alarm should also be set to be activated if the pumps fail to alternate. Small residential pump lift stations usually contain 2 or 3 float control switches to regulate the off, on and high level alarm functions. Electrical connections should not be made within the pump chamber in order to prevent problems associated with corrosion. The connections may be placed in a waterproof electrical box located above ground or inside the building. The alarms and pump power supply must be connected to different electrical circuits. All electrical work associated with pump station installation must be done in accordance with the State Building Codes and requires a separate electrical permit.

31. DISTRIBUTION BOXES

The use of distribution boxes has many advantages in assuring proper utilization of leaching systems of all sizes and design. Foremost of these is the precision with which effluent flow volume can be regulated to the various leaching units. Experience has shown that "T's" or 'Y's" are difficult to set and adjust to proper elevation during construction, and cannot be relied upon to regulate the flow of sewage throughout the network of effluent distribution pipe in the leaching system. On the other hand, distribution boxes can be set easily and firmly to exact elevation and provide central locations from which the effluent flow to several separate leaching units can be controlled. Furthermore, distribution boxes are readily accessible and relatively easy to find with accurate as-built plans. If a sewage problem arises, it is possible to inspect the boxes and determine which of the various leaching units are functioning properly and which are not. Effluent flow can then be redirected to the functional units by adjusting the elevations of the box outlets or by plugging the outlets to the failing units. This is easily done without damage to any part of the leaching system itself.

In practice, distribution boxes should be used at all distribution system junctions where effluent is directed to any leaching unit on a different elevation, or to more than two units on the same elevation. "T's" or 'Y's" should only be used for splitting effluent to no more than two trenches on the same elevation with ends connected.

TYPES OF DISTRIBUTION BOXES

There are three separate types of distribution boxes; splitter boxes (both equal or proportional), high level overflow boxes, and adjustable outlet boxes, which can serve both purposes.

Splitter boxes normally have a single, high level opening which serves as an inlet, and several openings on a lower level which serve as outlets. Preferably, the outlets should be set somewhat above the bottom of the box to provide a "sump" which will prevent entering sewage from flowing directly above the bottom of the box towards the nearest outlet. When a splitter box is set level, approximately the same portion of the incoming flow should flow out of each outlet and subsequently to each leaching unit connected to it. Small splitter boxes normally are used only for leaching systems where all of the leaching units are on the same elevation, or where it is desired to split flow equally between separate leaching systems. Large splitter boxes normally are used in conjunction with intermittent dosing of a large number of leaching units by pumps or siphons. Sewage effluent enters the boxes at a high rate and raises the liquid level in the box well above the outlets, assuring equal distribution. The inlet to such boxes should be baffled or the flow directed downward to prevent short-circuiting through the box.

Splitter boxes also may be used to divide effluent proportionately to leaching systems of different capacity by connecting a various number of outlets to the different leaching systems. For instance, two outlets of a three outlet splitter box could be connected to a larger leaching system and one outlet to a smaller leaching system in approximate proportion to their respective capacities. The difficulties with this division of flow are centered around the extremely critical task of setting all outlets at the exact same elevation and the prevention of box movement by frost action or construction activities.

High level overflow boxes are used for serial distribution to leaching units constructed on different elevations. The simplest form of high level overflow box consists of a standard distribution box which has been reversed so that the high opening serves as the overflow to the next lower leaching unit. One of the lower openings is used as an inlet and the other low openings are outlets to the higher leaching units. One undesirable feature of using a reversed distribution box is that the inlet and trench distribution piping are always submerged when operating at the overflow level thus making system analysis and investigation more difficult. Some boxes, specifically designed for serial distribution, have openings on three levels; a high level inlet, a mid-level overflow to the next lower leaching unit and low level outlets to the leaching units. Serial distribution boxes also may be made in the field by constructing a mid-level overflow on the outlet from a standard box which is connected to the next lower leaching unit. In this process, the outlet level is raised by installing an elbow or by capping the outlet with a flow regulating insert. Refer to Figure 10-4, page 43.

Adjustable outlet boxes are constructed by extending the outlet pipes into the box and placing elbows on the pipes. The elbows can be rotated to conveniently set each outlet to the desired level. Caps with holes cut on one side can be used where the box is too small for elbows. Adjustable outlet boxes frequently are used as splitter boxes to divide effluent equally among leaching systems at different levels because of the fine adjustment which is possible after installation and during use. They also may be used as high level overflows for serial trenches because it allows adjustment of the liquid level in the trenches for maximum utilization of the surrounding soil without breakout.

Another type of distribution box which provides 1.5 gallon doses to four outlets set at the same elevation has been in use throughout the state. It is referred to as a dosing distribution box and can be used for both level and serial leaching systems.

INSTALLING DISTRIBUTION BOXES

Distribution boxes should be set as level as possible, particularly splitter boxes which must have all outlets on the exact same elevation. In general, all splitter boxes should be set on 12 to 18 inches of broken stone. The stone allows the box to be adjusted easily during installation. It also assures that there will be no wet soil in contact with the bottom of the box which could freeze, expand and tilt the box. It generally is unnecessary to place splitter boxes on slabs or poured footings. Such construction could cause more problems than it would solve. High level overflow boxes normally are set right into the stone filled leaching trenches.

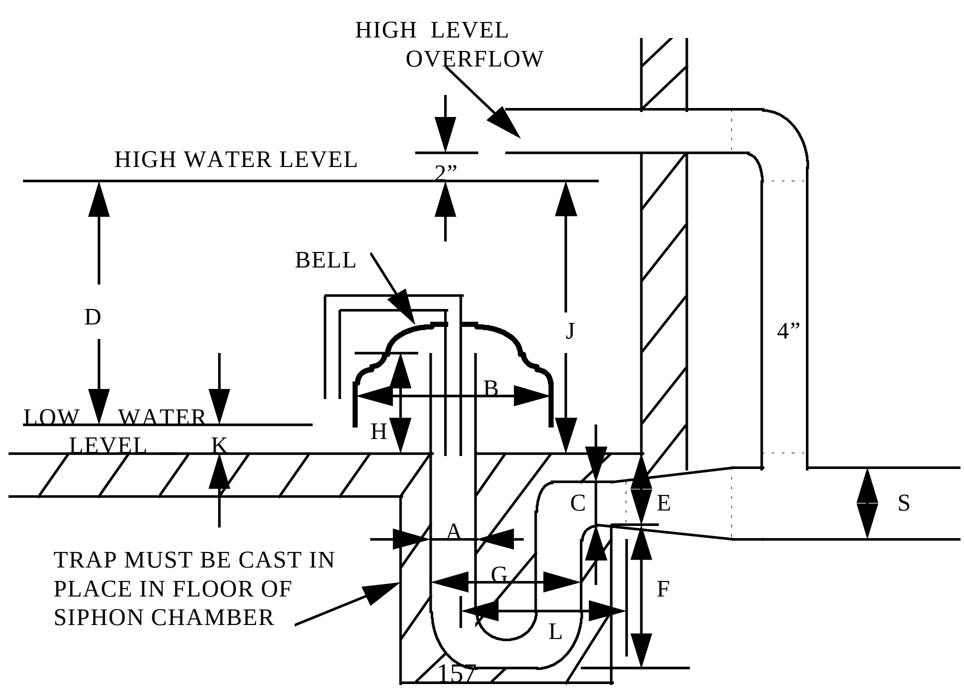
All splitter box outlets should be checked for level after installation. This usually is done by means of a tripod level or by filling the box with water to the outlet level. Larger distribution boxes, containing six or more outlets, should be provided with a manhole or opening to grade which would facilitate inspection and cleaning. It is important that all distribution box knockout holes be sealed with concrete around the entering pipes so that effluent will not escape.

32. SIPHONS AND DOSING CHAMBERS

Dosing siphons, installed in specially constructed siphon chambers, are one means for providing intermittent dosing where sufficient elevation (3 to 4 feet) between the septic tank and leaching system exists. The siphon unit is a nonmechanical plumbing arrangement consisting of inverted 'U" piping, bell dome and dome vent piping. The siphon, when properly installed in its chamber, provides for the storage of liquid effluent from the septic tank and automatic discharge of a preset quantity depending upon the size of siphon chamber and construction of the siphon. Discharge of large quantities of liquid effluent to a leaching system, referred to as intermittent dosing, is required in Section VI of the Technical Standards for all large subsurface sewage disposal systems with design flows of 2000 gallons per day or greater where the total length of distribution pipe is 600 feet or greater. The primary function of the dosing chamber is to fully distribute liquid throughout leaching systems containing significant lengths of distribution pipe. Typically, effluent is directed to a large distribution box with multiple outlets which may then discharge to smaller distribution boxes at various locations and elevations throughout the large leaching system. Failure to use some form of dosing mechanism with large leaching systems could easily result in disproportionate division of effluent and premature failure caused by overloading.

Figure 32-1 illustrates a cross sectional view of a dosing siphon. In order to begin operation of the siphon, the inverted 'U" piping (trap) must be filled with water. Effluent entering the chamber flows around and under the siphon dome until the water level in the chamber rises to the elevation of dome vent piping, trapping the air under the dome. Additional liquid entering the chamber begins to compress the trapped air. When the water level in the chamber reaches the prescribed height, air pressure under the dome becomes greater than the liquid head in the trap and the air forces the liquid out of the trap. With this air-lock broken, the liquid in the chamber flows by gravity through the trap until the water level is lowered to the bottom of the dome. At this time, air entering the dome vent piping breaks the siphon effect but retains sufficient liquid in the trap to create a seal. As can be seen from the diagram, liquid entering the siphon chamber is generally 2 to 3 feet below the outlet piping. For this reason, siphon chambers are only used where sufficient elevation difference between the septic tank and leaching system exist. A high level overflow pipe within the siphon chamber is required to provide emergency gravity flow.

Dosing siphons must be routinely inspected and maintained in order to assure proper function. The chamber should be inspected on an annual basis and routine pumping of the chamber is necessary to eliminate a sludge build-up, since the domes are placed only 3 inches above the floor of the precast concrete chamber. Corrosion of the dome or vent piping will cause the siphon to malfunction and revert to trickle gravity flow. Inspection of the siphon should indicate a fluctuating water level which rises above the vent piping. Access manholes extended to grade are required for all siphon chambers with design flows of 2000 gallons per day or greater. For leaching trench systems, Technical Standard VI requires chambers to be sized to discharge at least 50% of the volume of distribution pipes. For large leaching gallery systems, the siphon should be sized to discharge approximately 1/5 to 1/3 of the design flow each discharge cycle. The siphon units are typically manufactured of PVC or cast iron and steel piping and must be installed plumb in the siphon chamber. Design plans which indicate use of a dosing chamber utilizing a siphon should include the size and manufacturers identification number of the siphon unit and the detail of the siphon chamber. The internal length and width of the siphon chamber multiplied by the effective
drawdown of the siphon will determine cubic feet of discharge per cycle. Conversion to gallons per cycle may be achieved by multiplying the cubic feet quantity by 7.5.



3”, 4”, 5”, 6”, 8” Standard Design Single Sewage Siphons

Figure 32-1 - Siphon Chamber

Approximate Dimensions in Inches and Average Weights in Pounds

Diameter of Siphon	A	3	3	4	4	5	6	8
Drawing Depth	D	13	15	14	17	23	30	35
Diameter of Discharge Head	C	4	4	4	4	6	8	10
Diameter of Bell	B	10	10	12	12	15	19	24
Invert Below Floor	E	4.25	4.25	5.5	5.5	7.5	10	12
Depth of Trap	F	13	13	14.25	14.25	23	30.25	36.5
Width of Trap	G	10	10	12	12	14	16	22.5
Height Above Floor	H	7.25	9.25	8.75	11.75	9.5	11	13.5
Invert to Discharge = D+E+K	J	20.25	22.25	22.25	25.5	33.5	44	52
Bottom of BeLl to Floor	K	3	3	3	3	3	4	5
Center of Trap to End of Discharge EU	L	8.65	8.65	11.75	11.75	15.5	17.5	23.5
Diameter of Carrier	S	4	4	4-6	4-6	6-8	8-10	12-15
Average Discharge Rate G.P.M.	-	72	76	157	165	328	474	950
Maximum Discharge Rate G.P.M.	-	96	104	213	227	422	604	1210
Minimum Discharge Rate G.P.M.	-	48	48	102	102	234	340	690
Shipping Weight in Pounds	--	60	70	110	120	190	300	500

The use of dosing siphons is not restricted to large sewage disposal systems and, on occasions, are included in designs *of* residential sewage disposal systems. On lots where slow seeping soil requires installation *of* narrow trenches which may exceed over 500 lineal foot in length, a siphon may be helpful in distributing effluent uniformly. The inlet piping to the siphon chamber must be located a minimum of 3 inches above the high level overflow.

FLOUTING OUTLET (FLOUT) DOSING CHAMBER

The FLOUT dosing chamber has been approved by the Department of Public Health as a substitute for a conventional siphon chamber. The FLOUT consists of a waterproof PVC weighted box with one or more discharge hoses connected to discharge pipes set low in a large concrete distribution box. The flexible hose connecting the discharge pipes to the PVC box act as a tether which allows the box to pivot at the outlet pipes. As effluent enters the chamber, the plastic box begins to float and rises to a predetermined height until the liquid level reaches a large diameter hole at the top of the PVC box. As the box begins to fill with effluent and subsequently sinks, the total volume accumulated in the chamber quickly discharges to the leaching system. The flexible hoses connecting the discharge pipes to the water proof box are the only moving parts.

33. SUBSURFACE SAND FILTERS

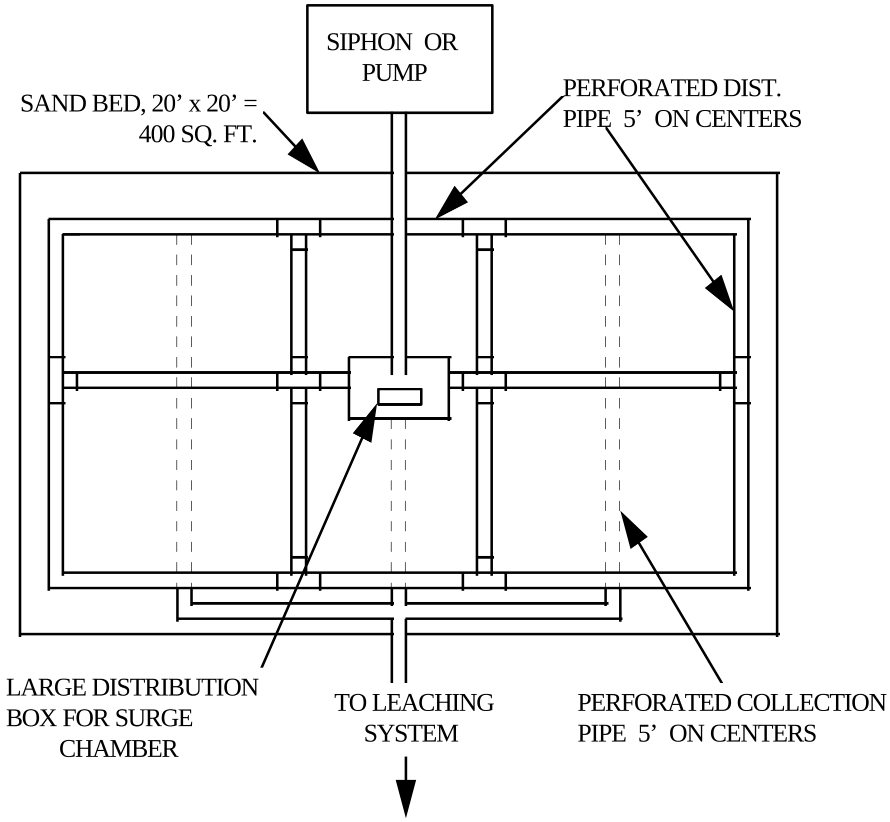
In the design of small subsurface sewage disposal systems, buried sand filters may be used to produce a partially stabilized effluent for application to subsurface irrigation systems or evaporation-transpiration mounds. They also may be used for oxidizing septic tank effluent before it is applied to denitrification contact beds. In a conventional subsurface sand filter, septic tank effluent is distributed through a system of perforated pipe and stone over the surface of a buried sand bed. The septic sewage is filtered and oxidized as it passes through the sand bed. Effluent is collected below the sand bed and is discharged to a conventional or modified leaching system. In most subsurface sand filters, effluent is applied intermittently by pumps or siphons to produce a relatively uniform biological growth in the filter and a better stabilized effluent. Modified subsurface sand filters may be designed for higher filtration rates, sometimes with provisions for effluent recirculation. Occasionally such filters are used for final filtration of aerated sewage effluent. High rate subsurface sand filters usually are placed in buried concrete tanks or structures with access openings to the sand surface which allow cleaning if excessive clogging occurs.

CONVENTIONAL SUBSURFACE SAND FILTERS

Figure 33-1 shows the construction of a conventional subsurface sand filter, as typically designed for use with small subsurface sewage disposal systems. Septic tank effluent is discharged to the filter intermittently by means of a siphon or dosing chamber. The chamber usually is sufficiently large so that it does not discharge more than once or twice daily. The surge produced when the siphon discharges tends to surcharge the distribution pipe of small subsurface sand filters. For this reason, small filters frequently are designed with 6 inch diameter distribution pipe which will accommodate a larger liquid volume. Locating distribution boxes in the center of the filter and connecting the ends of the distribution pipe also are helpful in preventing siphon discharging. Perforated distribution pipe are laid 4 to 6 feet on centers in a continuous, 10 to 16 inch deep layer of 1/2 to 1 inch broken stone. The top of the stone layer is protected with filter fabric to prevent dirt and silt from being washed down onto the sand surface.

The filter bed itself consists of 24 to 30 inches of carefully selected sand. The sand must be relatively coarse and extremely uniform so that it will not become clogged by the buildup of fine inorganic particles which are the end product of biological decomposition. The sand should have an effective size of between 0.4 and 0.6 millimeters and a uniformity coefficient of 3.5 or less. The effective size is the sieve size which allows 10% of the grains to pass. The uniformity coefficient is the ratio of the sieve size which passes 60% of the sand to that which passes 10% of the sand. It is highly unlikely that any bankrun sand will meet this specification, no matter how good it may appear. Filter sands normally are screened and washed to meet gradation requirements. Subsurface sand filters receiving septic tank effluent usually are designed for a loading rate of about 1 gallon of effluent per day for each square foot of bed surface. Such a loading rate will allow aerobic conditions to be maintained throughout most of the filter, particularly when effluent is intermittently applied. This promotes the growth of nitrifying organisms and higher forms of protozoan which are able to reduce the BOD in the filter effluent to less than 5 milligrams per liter, and to oxidize over 80% of the nitrogen to the nitrate form. The suspended solid content of subsurface sand filter effluent normally is less than 5 milligrams per liter and the dissolved oxygen exceeds 50% of saturation.

Filter effluent is collected in a layer of 1/2 to 1-inch stone underlying the sand bed and is carried away by perforated collection type. It is important that the top of the stone layer is covered with



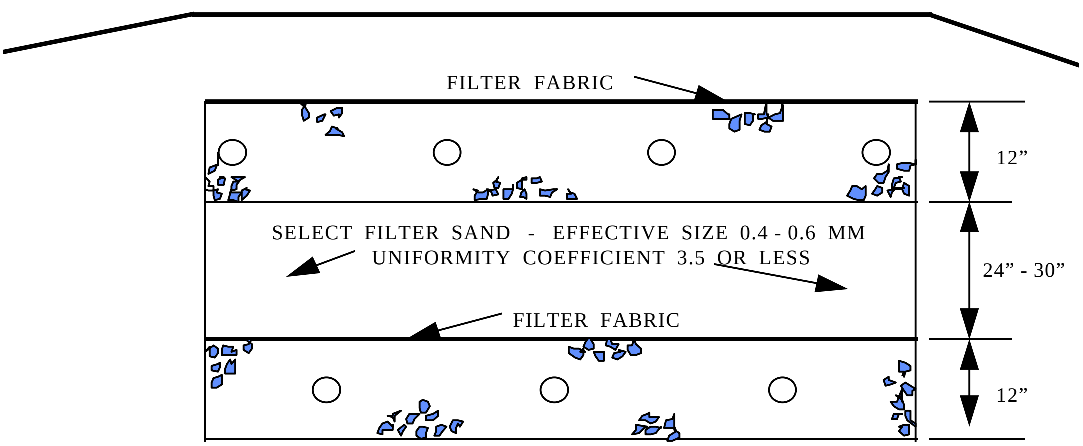


Figure 33-1 Subsurface Sand Filter

filter fabric to prevent the filter sand from being washed away. Normally, the collection pipe is vented to ground surface to promote air circulation and help maintain aerobic conditions in the sand bed.

MODIFIED SUBSURFACE SAND FILTERS

Figure 33-2 shows a modified subsurface sand filter as might be used with a small subsurface sewage disposal system. The entire sand bed is placed within a concrete structure. No system of distribution pipe is used to apply sewage to the filter. Instead, sewage is applied freely to the uncovered surface of the sand. Higher loading rates are possible because the sand surface can be cleaned through access openings in the concrete cover. This structure is vented to the atmosphere and aerobic conditions are maintained either by recirculating filter effluent or by applying aerated sewage effluent from a small packaged aeration unit.

The gradation and depth of the sand bed is comparable to that of a conventional subsurface sand filter, but the loading rate usually is considerably higher. Loadings of 2 to 10 gallons per day per square foot of filter surface may be used. This may produce a clogging mat on the sand surface which must be periodically removed. High hydraulic loadings may produce saturated flow conditions through the filter and consequently lowered rates of BOD removal and effluent nitrification. This can be overcome by recirculating the filter effluent by means of a pump. Recirculation rates are adjusted as required, with a recirculation ratio of about 4 volumes of recirculated filter effluent for each volume of applied sewage being about average.

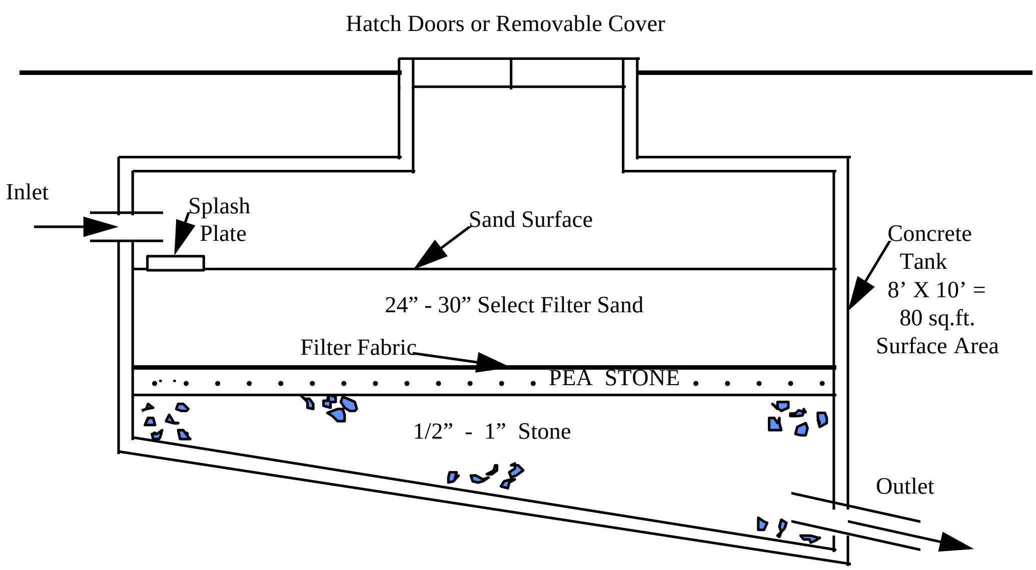
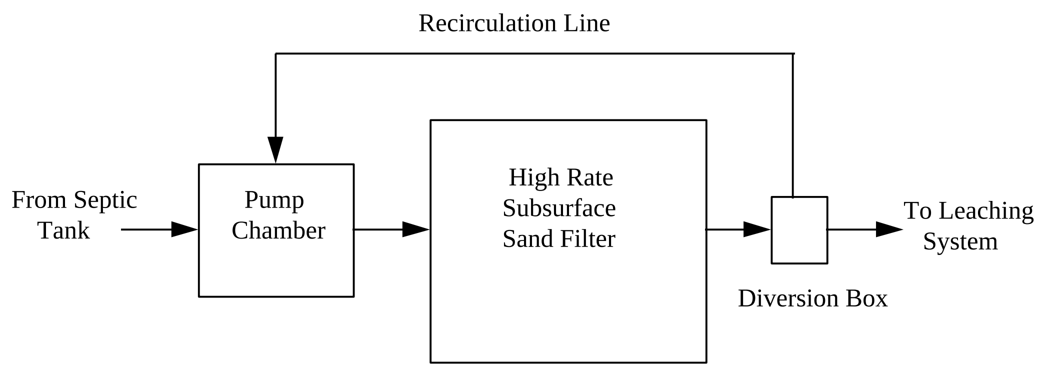


Figure 33-2 High Rate Subsurface Sand Filter

The effluent collection system in high rate sand filters must be carefully designed to handle the high flow rate without losing sand. Generally, several layers of graded stone are used, ranging from 1-inch stone to 1/4-inch pea stone. Figure 33-3 shows a recirculating subsurface sand filter. Such a system is designed with a collection and recirculation tank containing a float controlled pump. This tank receives both incoming unfiltered sewage and recirculated filter effluent which is mixed and intermittently pumped to the filter. An adjustable diversion box is located on the filter effluent return line. From this box, a portion of the flow is returned for recirculation and a portion is discharged to the leaching system. Recirculating subsurface sand filters are generally unsuitable for household or small subsurface sewage disposal systems because of high installation and operating costs and maintenance requirements.



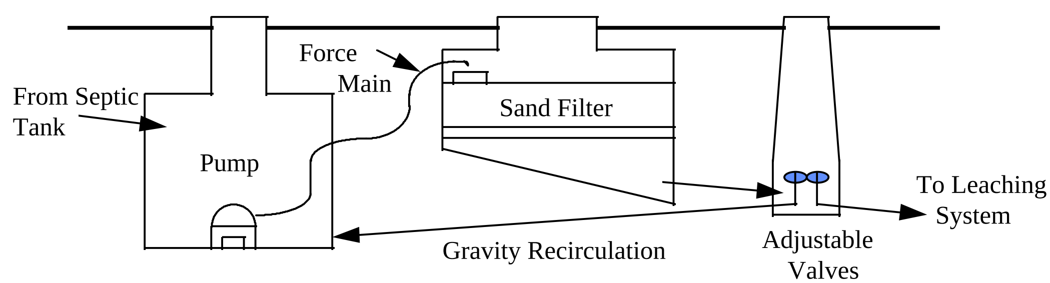


Figure 33-3 Recirculating Sand Filter