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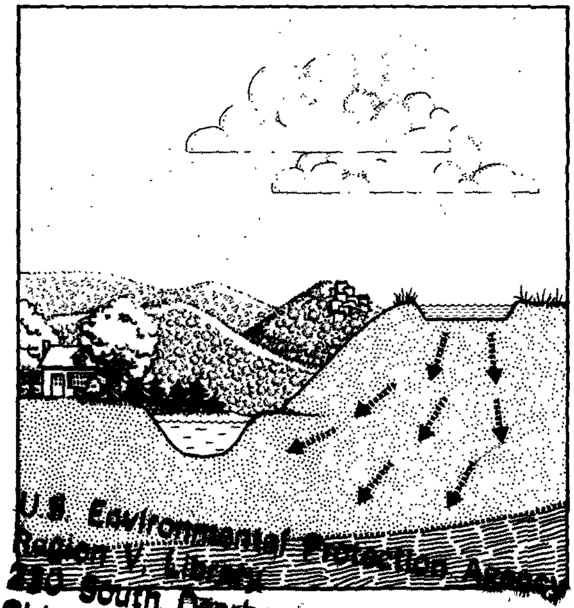
Land Treatment:

Rapid Infiltration

Plan, Design, and Construct for Success



The Cautions

It is not possible in a limited space to deal in detail with all of the potential problems listed in Table 1. Many might not occur at all if the design team had previous practical experience using and interpreting the procedures described in the Process Design Manual for Land Treatment of Municipal Wastewater (EPA 625/1-81-013). It is relatively easy in a hindsight analysis to conclude that a problem could have been avoided if common sense had been applied. For example, it seems obvious that field tests should always be at the actual location and elevation of the proposed system. However, in the real world it might be that a number of proper and expensive tests were run to characterize a general area. Then, during development of the final design, constraints arose so that a slightly different location or depth was selected for the basins. It would then be a great temptation to assume that the original investigation still applied since the available time and funds remaining are limited. In some cases, yielding to such temptations may result in premature system failure.

Other, Specific Cautions

Basin construction in filled areas should be avoided if possible. If construction in fill is absolutely necessary, soils should be coarse-textured with a fine fraction (passing #200 sieve) of 5% or less. Pilot scale infiltration tests in a constructed fill are necessary, along with rigorous analysis of test results and on-site control of construction.

Clayey sands with fines exceeding 10% (by weight) have not been successful for infiltration surfaces in filled areas.

Typical earthwork construction strives for the maximum practical density and structural stability of the soil. In contrast, construction of the infiltration surface in a RI basin requires a different attitude and approach, since maintenance and/or development of the maximum possible hydraulic capacity is the goal.

When a clay fraction is present, placement of fill or final construction activities in a cut are typically limited to periods when the soil moisture is on the "dry" side of optimum. This precaution is taken to avoid reduction of soil permeability by compaction.

Land Treatment: Rapid Infil

The Concept
Rapid infiltration (RI) land treatment can be the simplest and least costly wastewater treatment system available for a community, where site conditions are suitable. Often all that is required is a means for applying partially treated wastewater, typically less than full secondary, to a set of basins excavated in sandy soils.

There are two basic types of RI systems. In the majority of the systems, the applied wastewater seeps downward through the earth, joins the ground water and eventually emerges in adjacent surface waters. Most of the treatment occurs at shallow depth during and after intermittent wastewater applications. A long travel path and travel time in the soil allow for further treatment so the liquid that emerges in the surface water is of better quality than could be obtained with most advanced wastewater treatment techniques.

In the second type, where more direct control is desired or where recovery of the treated water for unrestricted agricultural irrigation is economical, underdrains or recovery wells are sometimes used, as shown in Figure 1.

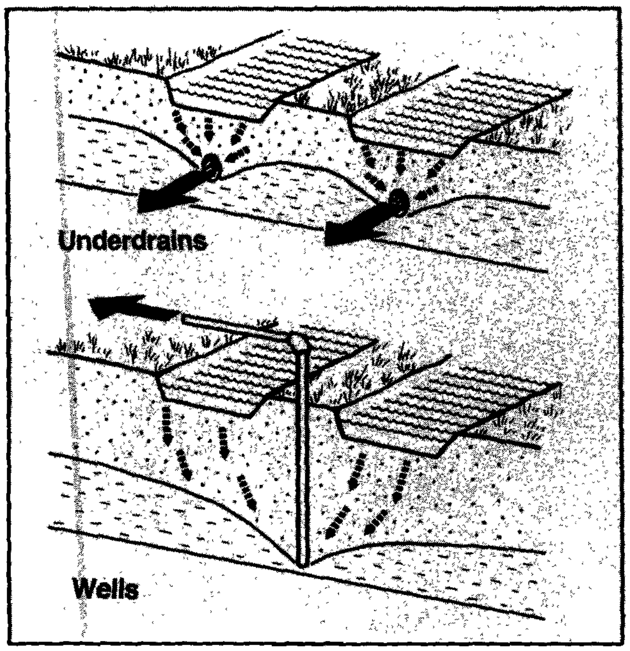


Figure 1. Recovery of Treated Water

In some large-scale systems in arid climates, such as in Israel and Arizona, the treated wastewater is recovered through wells and used to irrigate a variety of crops. However, treated wastewater is not recovered and used in the majority of systems. Rather, the RI concept is used because of its simplicity and low treatment costs.

The major reason for the low cost is the use of high wastewater hydraulic loading rates relative to other land treatment systems. A rapid infiltration system on a typical sandy soil might easily accept 100 acre-feet (748 gal/ft^2) per year, while irrigation of beans or corn on the same soil might only need 3 acre-feet of water per year. Therefore a much smaller land area is needed for rapid infiltration. A simpler distribution system also contributes to cost savings.

Present design criteria for rapid infiltration are conservative to ensure long-term successful operation. The 100 acre-feet per year, for example, translates to a daily average of about 2 gal/ft^2/day, which is no greater than the application rate on household leachfield systems in similar soils. Many of the existing RI systems in the U.S. have been successfully operating for 40 years or more. In 1981 there were about 320 rapid infiltration systems in the United States either operating or under construction.

The Concerns

Most of the operating systems in the U.S. are successfully meeting all RI performance standards. However, a very small number of systems that have been recently constructed do not satisfy all design expectations. These system designs did not adequately account for the volume of wastewater that can be applied and infiltrated within the time allowed. Therefore, sites with limitations that are difficult to discern may require additional construction or process modifications before the system is capable of performing as designed. Such problems can be avoided in future designs. An analysis indicates that the problems can be grouped, as shown in Table 1, into four major categories related to: soil conditions, ground water conditions, design assumptions, and construction control.

The simplicity of the concept tends to mislead individuals to assume that all that is needed is a hole in the ground with simple piping, and that nature will take care of the rest. In fact, from a construction engineering point of view, the simplicity of the concept hides the variable and complex interrelationships of soil, water, and geohydrology. Understanding these relationships at sites with atypical limitations is essential for a successful design. However, the special skills and expertise that are required may not be present in the background of the wastewater system designer, so outside assistance may be needed. The criteria for rapid infiltration designs are conservative, but the hydraulic loading rates are usually an order of magnitude greater than those used for irrigation type systems. As a result, the margin of safety is reduced somewhat and the system is less forgiving of errors and omissions in its design and construction.

Stabilization of the soil "fines" in the surface layer of basins constructed in cut sections may be needed when the fines exceed about 10% (by weight). Vegetation (water tolerant grasses) is the only effective stabilization method known to date.

A surface layer of gravel or coarse sand to filter algae or excess suspended solids is not recommended. This may cause a continuously wet interface between the gravel and in-situ soil that may result in system failure.

Site investigations which do not identify seasonally high ground water levels may lead to biological clogging and slow water movement.

A sufficient number of drill holes and test wells must be installed to define the ground water position and flow direction.

A reliable estimate of horizontal hydraulic conductivity at the site is essential and special tests for this purpose may be needed.

Long narrow basins, with the long axis parallel to the ground water contours, will have the least problem with ground water mounding. Clusters of basins will require detailed mounding calculations and careful *operational scheduling.*

At northern sites, where significant long-term ice formation is possible, any vegetation in the basin should be cut close to the ground or burned in late fall to prevent ice adherence at the infiltration surface. Construction of a ridge and furrow configuration on the basin surface and promoting development of a floating ice sheet will allow continuous winter operation.

The Conclusions

Rapid infiltration is a reliable and cost effective technique for wastewater treatment. The use of routine planning, design and construction procedures insures successful systems for favorable site conditions. The design becomes increasingly complex as key site conditions become less favorable. These factors include (1) increasing percentage of fines (passing #200 sieve) above 5%, (2) a soil profile with fine-textured lenses, (3) a seasonably high water table, and (4) an undulating topography requiring major cut and fill.

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Soils	Ground Water
Layers or zones of less permeable soils not revealed during site investigation may impede water movement.	Unexpected high seasonal ground water table interferes with subsurface water movement.
Design may be based on inappropriate data from field testing conducted at a different location or at different depth than the final system.	Inadequate capacity to move water away from the site, laterally or vertically in the time allowed by design.
Final surface layer in infiltration basin may contain significant clay or silt. These "fines" may segregate during flooding, resettle on the surface and impede future water movement.	Subsurface flow from one basin may influence the capacity of an adjacent basin.
Design Assumptions	**Construction Control**
Less than design capacity for water movement because backfill operations have reduced soil permeability (see related note under Construction).	Excess traffic and inadvertent compaction of final basin surfaces.
Actual wastewater characteristics (algae, suspended solids) different than assumed.	Failure to remove all of the fine soils in surface layers or specified zones of unacceptable soils.
Design based on improper use of criteria.	Construction activity in the basin infiltration area when soil moisture content is too high.
Design ignores potential for freezing during winter operations in cold climates.	Rainfall sorting of fines into layers of low permeability during fill operations.

Table 1. Rapid Infiltration - Potential Problems