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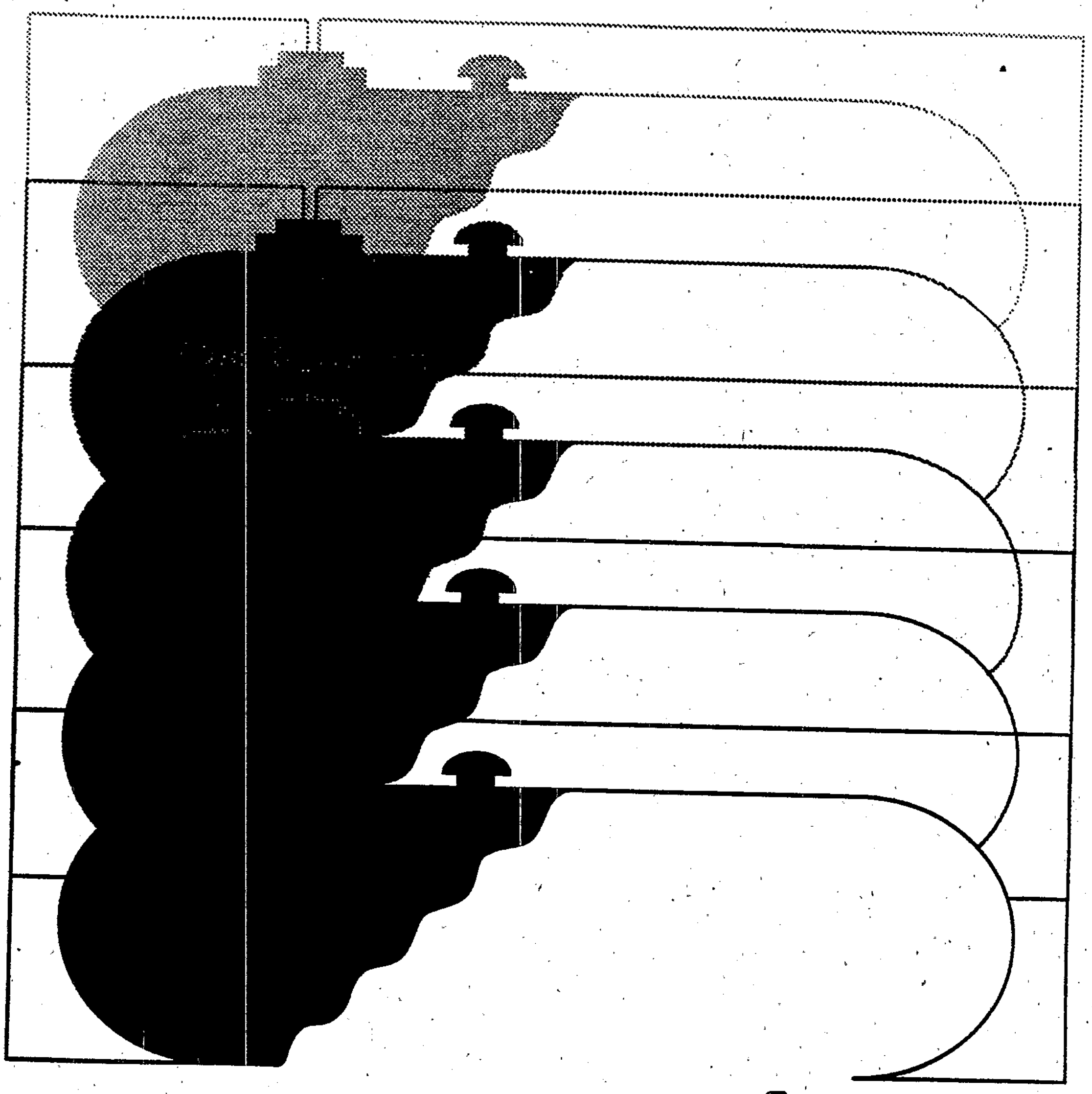
Underground Storage Tanks

EPA

Tank Issues

Site Characterization for External Leak Monitoring



A series of informative articles of interest to tank owners and consultants concerned with management of underground tanks for storage of fuel.

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Introduction

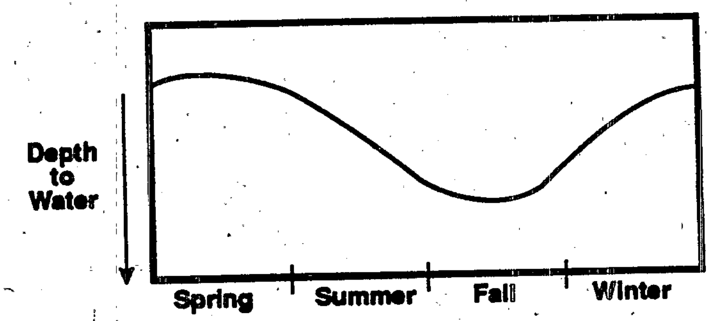
Before designing an external monitoring system, information is needed about the natural and man-made characteristics of the site. Site characteristics are important in selecting the appropriate monitoring method. This paper discusses site characteristics with respect to external monitoring by liquid product monitoring and vapor monitoring.

Hydrologic Site Characteristics

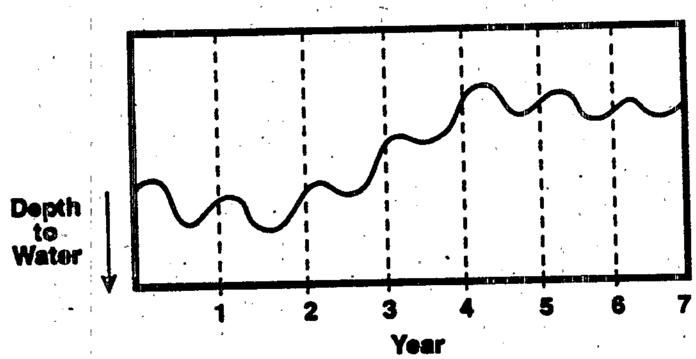
DEPTH TO THE WATER TABLE—The water table, also called the free surface, is the level at which the liquid is at atmospheric pressure. Liquids can enter wells that are perforated below the free surface. The depth to the water table at a given time is thus relatively simple to determine by measuring the water level in a well. The position of the water table and fluctuations of the water table are the major factors in selection of the monitoring method. The position of the water table is important in selecting a liquid product monitor or a vapor monitor, in design and construction of monitoring wells, and in placement of hydrocarbon monitors. Although the depth to the water table is relatively easy to determine at any specific time, the range of fluctuations of the water table that will occur during the time that the monitoring network is to be in operation is not so readily determined nor is it easily predicted. Natural fluctuations of the water table occur in response to seasonal cycles of recharge such as by infiltration of rainfall and by changes in water stage of nearby lakes and streams. Fluctuations of water level may also be caused by withdrawal of water by nearby wells.

Water Table fluctuates in response to:

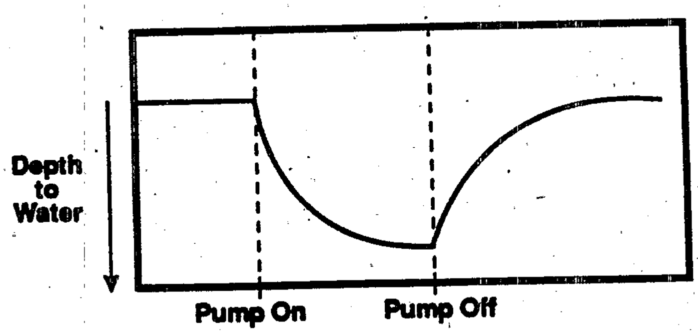
1) seasonal variations in recharge and discharge



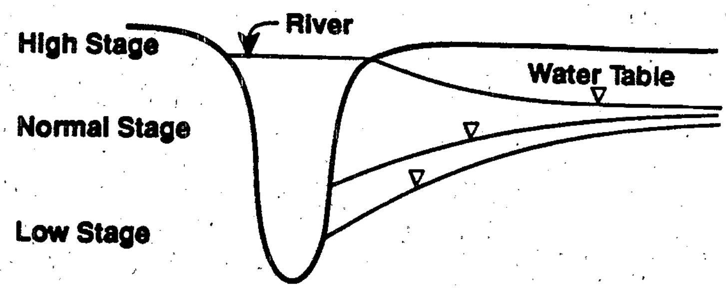
2) long term variations in recharge and discharge



3) nearby ground-water withdrawal



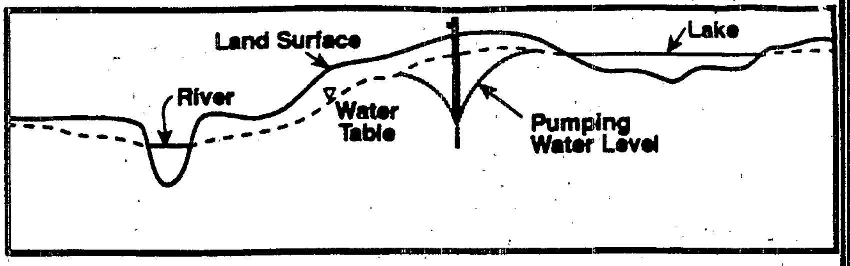
4) changes in water level in nearby streams and lakes

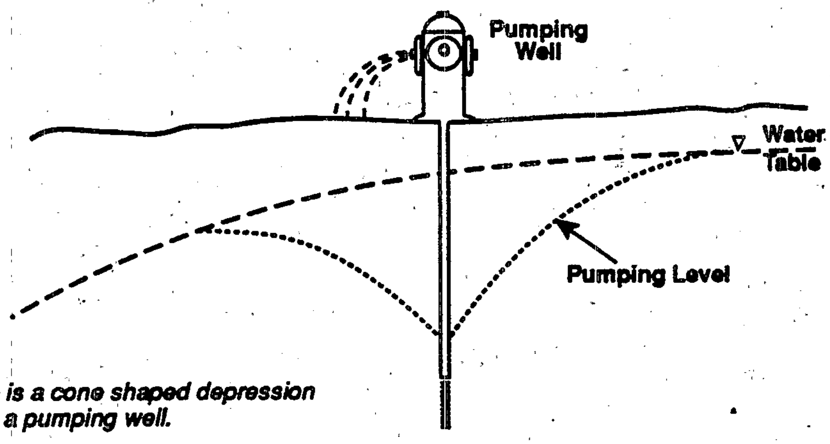


The range of fluctuations at an underground storage tank site may be estimated from the water-level measurements taken periodically over a long period of time. In response to natural factors that cause water table fluctuations, there is an annual cycle of fluctuations. Water levels generally reach their highest levels in the year during the late spring following or near the end of the annual period of recharge. The period of recharge is when there is an excess of water for infiltration from the surface to the water table and when the stream and lake levels are high. Water levels decline as the potential for evaporation and transpiration increases. In the late fall or early winter, when evaporation and transpiration are low and precipitation increases, water levels begin to rise. The annual cycle is similar in many parts of the country, but the seasonal timing of climatic factors affects regional differences in timing of the annual cycle. Water levels also respond to long term periods of drought and above normal precipitation and below-normal temperature. Thus the seasonal cycles are superimposed on long term water level changes. In urban areas, water level fluctuations may be influenced by activities such as recharge from storm runoff and lawn watering.

Water levels measured monthly or recorded continuously over a period of several years may provide a basis for an estimate of the range of water-level fluctuations. Such a long record of water levels before establishing a tank monitoring system would be practicable in few, if any cases. In addition to measurement of water levels at the site, the files of State and Federal water agencies may provide water-level records in nearby wells in the shallow water-table aquifer, or in shallow wells in similar hydrogeologic and climatic settings. A hydrogeologist could estimate the probable range of water table fluctuations on the basis of such records and site information including water levels at the site and nearby production wells that may cause drawdown at the storage tank installation, local hydrogeologic conditions, such as the potential for recharge and discharge from the aquifer, and the interconnection between the aquifer and nearby streams and lakes.

DIRECTION OF GROUND-WATER FLOW—The natural water table gradient generally slopes from high to low topographic surfaces — commonly toward streams and lakes. During flood stages the gradient may be reversed. Changes in direction of ground-water flow may also be caused by nearby pumping wells.





There is a cone shaped depression about a pumping well.

The site characterization study should include determination of the direction and grad of the water table in the vicinity of the site. Liquid monitors should generally be placed the downgradient side of the tank excavation. Liquid monitoring sensors upgradient fr the tanks beyond the range of detection of the tanks of primary interest would be use establishing background hydrocarbon concentrations in the area and detecting off site sources of hydrocarbon contamination.

MOISTURE CONTENT OF SOIL AND BACKFILL—Studies by Schreiber and others (1988) show a great reduction in rate of gaseous diffusion in moist and wet materials. Coarse-grained materials used as backfill drain readily, and in the absence of a wate or an impeding layer, will normally retard diffusion of vapors temporarily during perioc following infiltration of water. Fine-grained materials such as silt and clay tend to hold larger amounts of water for sustained periods by capillarity, and thus their natural low permeability is further reduced by moisture.

Man-Made Site Characteristics

BACKFILL—Hydraulic permeability, grain size and moisture content of the backfill me and the natural soil or host material in which the tank excavation is made are importa determining if a liquid or vapor monitor can be used to monitor a leaking tank and in h to choose between a vapor or liquid hydrocarbon monitor. The general requirement is the backfill media be permeable to saturated flow of water and hydrocarbons and also provide high diffusion rates to hydrocarbon vapors in the vadose or unsaturated zone. uniformly coarse-grained medium, such as pea gravel, will meet these requirements. Backfilling of tank excavations with coarse-grained media such as pea gravel is a com practice.

Sites that are contaminated by previous leaks or large surface spills may not be amenable to liquid product monitoring because of high background content of hydrocarbon and the difficulty of discriminating between product of new leaks and the product of old leaks or surface spills. The backfill material in which the monitors are located must be relatively permeable to allow the hydrocarbons to spread rapidly on top of the water table. Old tank installations may be difficult to monitor because of the low permeability of the backfill or the presence of high content of residual hydrocarbons from previous spills or leaks.

Fine-grained backfill such as fine-grained sand, silt, and clay may be of such low permeability that the migration of hydrocarbons to the water table is greatly impeded. Above the zone of saturation, fine-grained material may hold much of the fuel in the capillary fringe above the water table (Johnson and others, 1989). Fuel released in the saturated zone migrates very slowly toward the water table in fine-grained material or may be trapped below the water table.

Vapor Monitoring

- *Most suitable in soils with low moisture content, highly permeable backfill, and where background hydrocarbon content is low or negligible*
- *Must be located above water table*
- *Commonly not used where the water table is within the tank excavation zone*

Vapor monitoring of sites contaminated by previous leaks or surface spills may be hampered by similar problems that occur in liquid product monitoring, that is, the discrimination between the hydrocarbon vapor from new leaks and vapor from product of surface spills or old leaks. The backfill material in which the vapor monitors are located must be relatively permeable to allow the hydrocarbon vapors to migrate rapidly by diffusion. Old tank installations may be difficult to monitor because of the low gas permeability of the backfill or the presence of high content of residual hydrocarbons from previous spills or leaks.

Fine-grained backfill such as silt and clay may be of such low gas permeability that the diffusion of hydrocarbon vapors is impeded or confined. Under such conditions vapors migrate very slowly to vapor detectors. High moisture content of soils reduces the gas permeability and the rate of diffusion of hydrocarbon vapors. Vapor monitors must, of course, be located above the water table. Beneath the water table all the soil pores are saturated with water. Vapor monitors are most effective with regard to the time delay between a leak and its detection. Where a leak occurs in the zone of saturation, the product would have to migrate to the water table and into a well or possibly into the capillary fringe before it could volatilize.

If the water table is within the zone of excavation, the more suitable method of external monitoring is commonly considered to be liquid monitoring of the floating product. However, if the water table is within the zone of excavation and vapor detector is used, the vapor detector must be placed in the well above the highest fluctuation of the water table. If the vapor detection mechanism withdraws, or pumps vapor from the well, the point of vapor withdrawal must be above the water table.

*U.S. Government Printing Office: 1993 — 750-071/80204

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Schreiber, Robert, Levy, Benjamin, Rosenberg, Myron, 1988, Modeling vapor phase movement in relation to UST leak detection - Phase 1: Final Report, Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Las Vegas, Nevada, 81 p.

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"Tank Issues" are short articles of information on the current state-of-the-art on management of underground fuel tanks. These articles provide recommendations but are not regulations; neither the U.S. Environmental Protection Agency nor the Environmental Research Center, University of Nevada, Las Vegas may be held responsible for consequences of following recommendations in these articles. All appropriate state, local, and federal regulations should be followed in installation and operation of leak detection devices and in management of underground storage tanks.

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