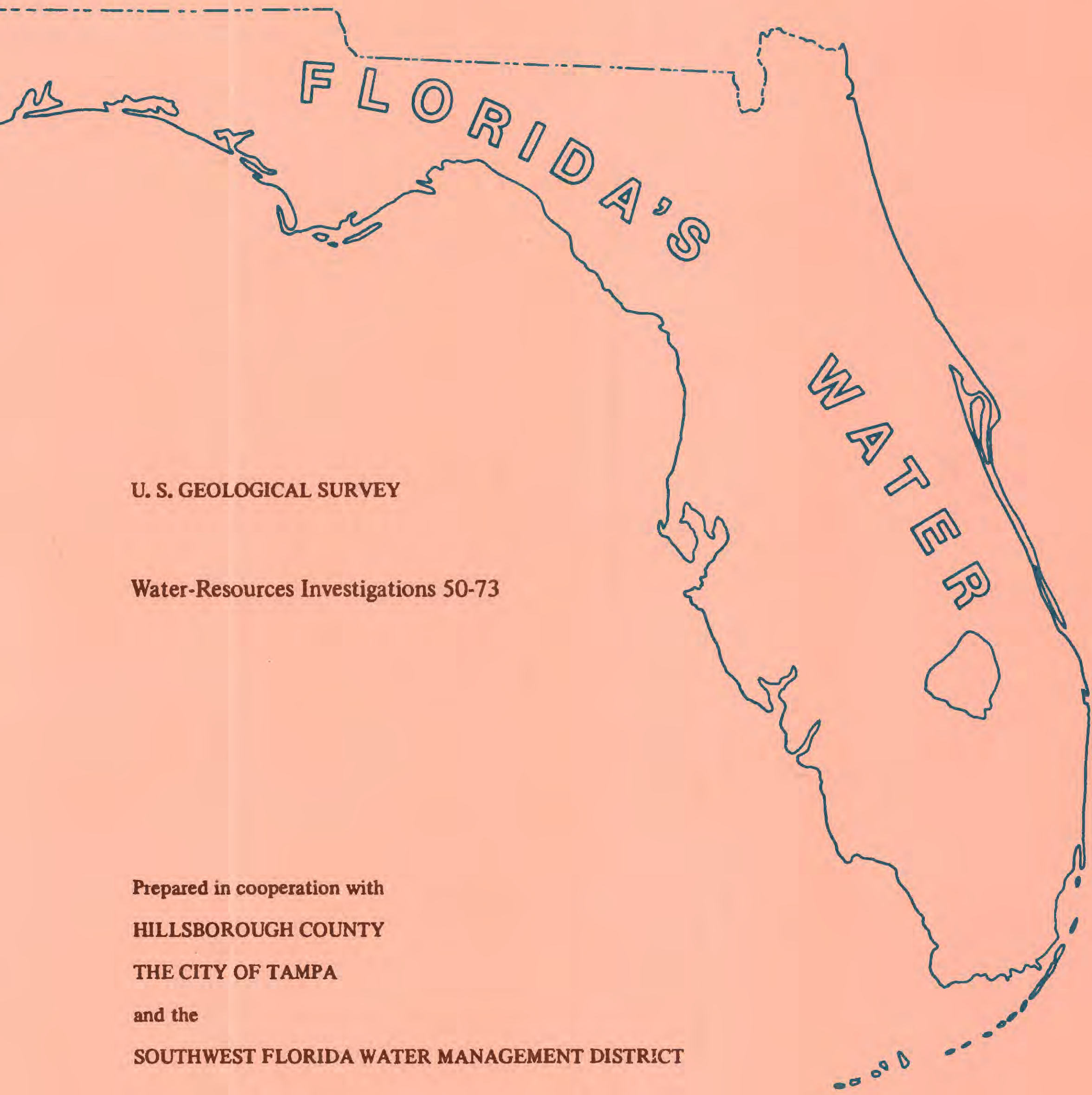
HYDROLOGIC AND GEOLOGIC CONSIDERATIONS FOR SOLID-WASTE DISPOSAL IN WEST-CENTRAL FLORIDA



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Hydrogeologic studies are a prerequisite to selecting landfill sites karst topography of west-central Florida to minimize water pollution problems. the area is low, poorly drained, and water table is near land surface. Prepara selected sites usually will require the construction of trenches with dikes to tate dewatering, extra pumps for dewatering during high intensity rainfall, and struction of oxidation ponds for retaining water pumped directly from active tr prior to discharging water out of the area. A water-quality network is also es to monitor the effects of solid wastes on the water resources of an area. The contains 73 photographs that illustrate the various operations of solid-waste c beginning from the initial investigation of a site to final burial of solid was trench.

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October 1973

UNITED STATES DEPARTMENT OF THE INTERIOR

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October 1973

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INTRODUCTION

Solid waste, which most of us call garbage and trash, has become a major disposal problem in this country, particularly during the past two decades. Expenditure of public funds for disposal of solid waste now ranks third in the nation, exceeded only by expenditures on education and highways.[1/] The tremendous increase in the volume of waste generated, which averages more than 5 pounds per person per day, is attributed largely to three factors: (1) an increasing population which generates increasing amounts of solid waste; (2) an increase in the use of prepackaged goods utilizing throw-away cartons -- paper, plastics, and glass and (3) our standard of living which places a great demand on service and convenience.

Of the several methods of disposing of solid waste used in this country, the most common are: (a) uncontrolled open dumping; (b) planned burial on land (sanitary landfill); and (c) controlled burning in incinerators. The once common but ill-planned, smoldering, open dump is still widely used, but fortunately it is slowing disappearing from the American scene. In Florida, a regulation beginning in 1971 prohibits open burning. Today the open-dump method of waste disposal is gradually being replaced by landfilling methods using modern earth-moving equipment needed to handle the large volumes of solid waste generated daily in this country. The antiquated methods of a generation ago are no longer adequate to dispose of the ever-increasing solid waste in a manner that is efficient and that provides for protection of the environment. Only within the past decade has much consideration been given to the effect of land disposal of solid waste on the water resources of an area.

The purpose of this report is to show how hydrology and geology are applied in evaluating landfill sites in west-central Florida, and to illustrate a land disposal method of handling solid waste. The method utilizes engineering techniques in conjunction with a knowledge of the hydrologic and geologic characteristics of an area to provide for protection of the environment. The report was prepared primarily for public officials who are responsible for final program decisions, and for planners and operational personnel who are directly involved in solid waste disposal. The report is also intended for the layman who is interested in learning about the problems of disposing solid waste in the State.

Most of the information presented in this report was obtained by the U. S. Geological Survey in cooperation with Hillsborough County and the city of Tampa from 1969-71, as part of a cooperative program to investigate the geology and hydrology of sanitary landfill sites in the north

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M. DeVon Bogue[1/]. Paper presented at the 22nd meeting of the Southeast Basins Inter-agency Committee, Callaway Gardens, Georgia, January 21-22, 1970.

half of the county. Field data relevant to areas outside Hillsborough County were collected cooperatively with the Southwest Florida Water Management District as part of the District's comprehensive water resources study of west-central Florida.

ACKNOWLEDGMENTS

The cooperation of John Dobbins, Executive Director, Hillsborough County; Sam Lockwood, Superintendent, Tampa Water Works; Dan Gorman, Director, Hillsborough County Mosquito Control; and Julio Pelaez, Director, Sanitation and Landfill Department, Hillsborough County, is gratefully acknowledged.

The authors thank Mr. J. B. Druse, Supervisor, and Messrs. M. D. Harley and L. P. Tuttle, Solid Waste Planning, Florida Division of Health, and G. G. Parker, Senior Scientist and Chief Hydrologist, Southwest Florida Water Management District, for their critical review and suggestions which helped to improve the report.

HOW MUCH SOLID WASTE DO WE PRODUCE?

The term "solid waste," is used in this report to mean garbage and other discarded solid waste materials resulting from community activities, and from commercial and industrial operations, but does not include solids or dissolved materials in waste-water effluents. The daily per capita production of waste materials that fall in this category, as reported by the Florida Division of Health (1971) include, for the State: (1) residential, 2.2 pounds; (2) commercial, 1.1 pounds; (3) demolition and industrial, 1.3 pounds; and (4) brush, leaves and grass, 0.4 pound. Thus, in 1970, 5 pounds of solid waste each day were generated for each Floridian, more than 1,800 pounds for the year. For a family of four the year's output approached 8,000 pounds. By 1980 the daily per capita output of waste is expected to reach 8 pounds, and by 1990, 12 pounds (Florida Division of Health, 1971).

Based on a daily residential use of 2.2 pounds of solid waste per person and an average weight of 300 pounds per cubic yard, a Florida family of four produced about 3,300 pounds of solid waste in 1970. By 1980 this figure is estimated to be 5,100 pounds; and by 1990 it could increase to about 7,800 pounds, or more than double the 1970 figure if the life style of the populace doesn't change.

In 1970 the population of Florida was 6.8 million (U. S. Bureau of Census, 1970). In 1980 the population will be about 8.0 million (Florida Division of Health, 1971). In 1970 an estimated 12.4 billion pounds of solid waste were generated, and in 1980 an estimated 23.4 billion pounds of waste is expected to be generated. Based on a weight of 800 pounds per cubic yard of solid waste (which includes residential, commercial, and industrial solid waste), about 15.5 million cubic yards were produced in 1970 and about 23.4 million cubic yards are expected to be produced in 1980. To portray the vast quantity of waste being produced in the State, figure 1 has been constructed which shows the length of a train of railroad boxcars that would be required to haul away the waste produced in 1970 and also in 1980. The boxcars are average sized, having a capacity of 183 cubic yards. In 1970, the quantity of solid waste generated in the State would have been sufficient to fill a line of boxcars 920 miles long as shown on the map of Florida. In 1980, more than 1,735 miles of boxcars would be needed to hold all the solid waste produced during that year. Such a train would extend from Tampa to the southeast corner of Montana (fig. 1).

SOLID WASTE AND THE OPEN DUMP

During the early growth and development of this country, settlers discarded their solid waste wherever and whenever they saw fit to do so. Such a practice presented a minimum threat to the environment because of the vastness of undeveloped land, and because their numbers were so few that very little waste was generated. However, as the population multiplied, it became obvious that people could no longer discard their waste in the haphazard manner of their forefathers and still expect to keep their surroundings clean.

Today we have acceptable methods of disposing of solid waste that provide for protection of the environment. Nontheless, many people continue the practice of dumping waste in the most convenient places available.

Many cities, towns, and villages continue to use outmoded open dumps. These dumps generally are unplanned--solid waste is deposited without regard to pollution of the environment or to the future use of the land. Most of these dumps become burning, smoldering blights on the landscape and pollute the land, water and air.

Some examples of undesirable dumping of solid waste on our land and water are shown in figures 2, 3, and 4.

WHAT IS A SANITARY LANDFILL?

The term "sanitary landfill" is used quite frequently when referring to solid waste. What is a sanitary landfill and how does it differ from a dump?

The Committee on Sanitary Landfill Practice of the Sanitary Engineering Division of the American Society of Civil Engineers (1959, p. 1), defines a sanitary landfill as follows:

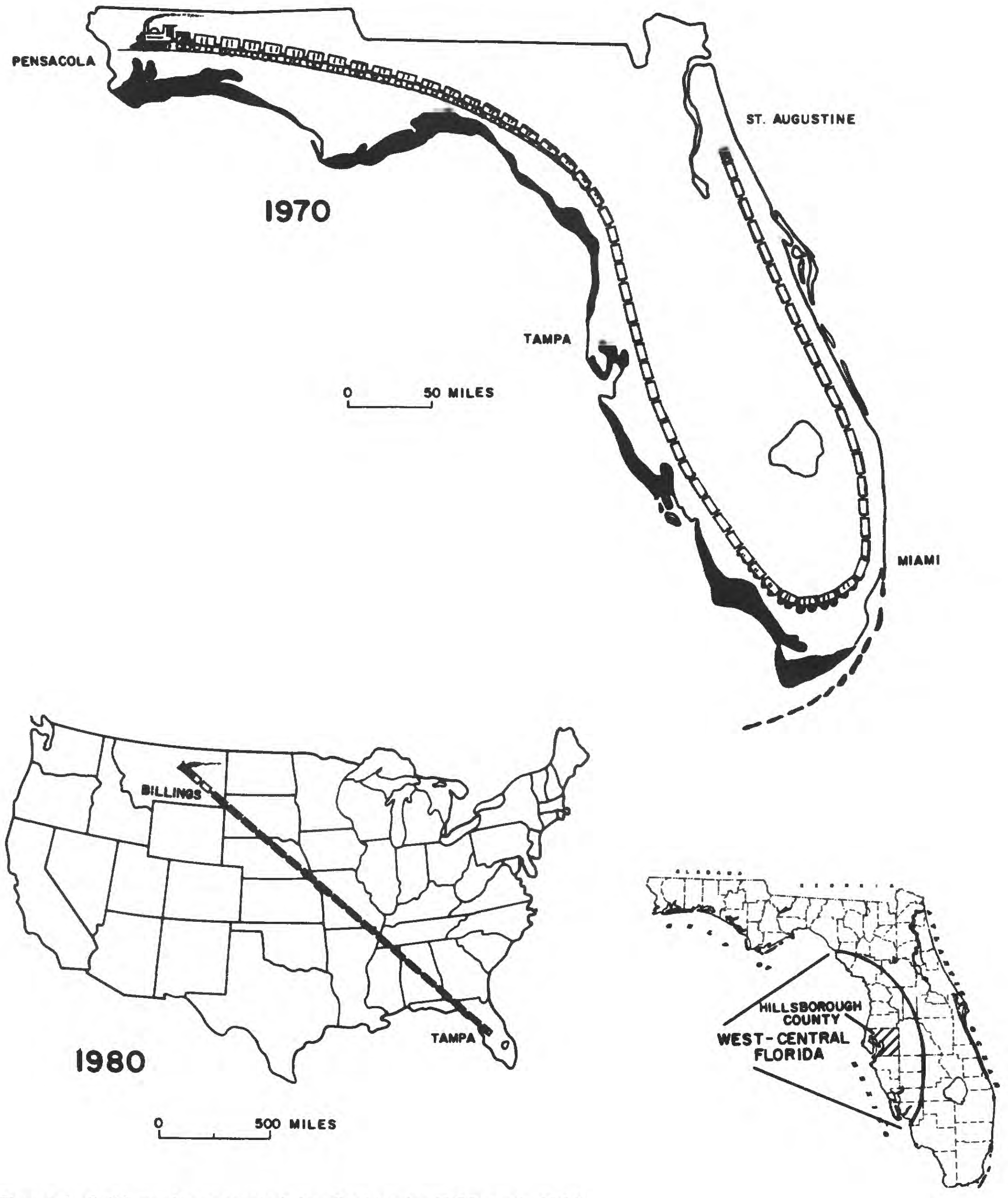


Figure I. Solid waste generated in Florida in 1970 and 1980

A. Oil and chemical drums strewn on the land. Oil destroys vegetation and wildlife, and contaminates soil and water.

B. Automobiles discarded into a former quarry which is now used as an open dump. Most of the flammable material in the quarry has been burned off by earlier fires.

C. Piles of used lumber are unsightly, present a fire hazard, and provide homes for rats and snakes. Such areas are also fertile breeding grounds for mosquitoes.

D. The number of appliances junked continues to increase yearly, and the future outlook is for more discards, adding to solid waste problems.

Figure 2. Solid waste polluting the land.

A. Solid waste dumped into open water. Such practices create health problems by polluting surface and ground water.

B. The decomposition of solid waste is shown by gas escaping from ponded water overlying the wastes. Such disposal practices are potential threats to the water supply of an area.

Figure 3. Solid waste polluting the water.

A. Windblown paper everywhere--on the road, in the woods, and in the trees. Much of this paper finds its way into lakes and streams where it contributes to water pollution problems.

B. A burning, smoking dump not only pollutes the air and causes odor problems, but also contaminates potable water in the area.

Figure 4. Solid waste polluting the air.

"Sanitary landfill is a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary."

The word "refuse" as used in this definition includes all solid waste. The Committee states "that...the selection of a location is based on engineering consideration, economic factors, and public acceptance." Some of the factors considered in selecting a suitable landfill location are: (a) drainage; (b) soil types; (c) effect on water supplies; (d) topography; (e) length of haul; and (f) reclamation value of site.

Two general methods of sanitary landfilling are practiced in the United States: the area method and the trench method (Sorg and Hickman, 1970). In the area method, solid waste is placed on the land, then spread and compacted with a bulldozer or other equipment. A 6-inch layer of dirt is spread and compacted over the waste at the end of each day's operation and a final 2-foot layer of dirt is added after the site is completed. Schneider (1970) indicated that normally about 1 foot of soil cover is used for each 4 feet of compacted solid waste. The area method of disposal is not used in west-central Florida because cover material would need to be hauled into the site from outside the area. In the trench method, solid waste is spread and compacted into trenches dug specifically for this purpose. Cover material for daily and final covers is obtained from the spoil of the trench. This report is concerned with the trench method.

SELECTING A SANITARY LANDFILL SITE

What are Some of the Features that are Considered?

Florida probably ranks near the lowest of the 50 states in the number of sites suitable for landfill operation. The difficulty in selecting sites that will insure protection of the water resources arises because west-central Florida has numerous natural features that make much of it hydrologically undesirable for disposing of solid waste on land.

For example, west-central Florida has:

(1) A humid, subtropical climate with an annual precipitation of about 53 inches. The area is also in the hurricane belt and is subject to high-intensity rainfalls.

(2) A high water table that fluctuates about 3 to 8 feet seasonally.

(3) Low, poorly-drained flat lands, much of which are at or near sea level; such areas are flood prone.

(4) A variety of soil types that have a wide range of engineering, agricultural, and hydraulic properties.

(5) Highly permeable limestones that underlie a thin mantle of sand and clay in which the landfill trenches are constructed. The limestones comprise the Floridan aquifer, the major source of fresh water in west-central Florida.

(6) Active sinkholes and drainsinks that occur throughout most of the area. Many of these sinks are directly connected with cavernous zones of the underlying Floridan aquifer.

The disposal of solid waste in west-central Florida is an involved process: Selecting sites for landfills only on the basis of hydrologic and geologic criteria will insure minimal pollution of the water resources, particularly because of the limestone terrane. Undoubtedly, any site selected will have some undesirable features. However, modifying one or more of these features might make the site acceptable insofar as protection of the water resources is concerned.

Factors in landfill site selection are divided into two broad groups, visible and hidden. The visible factors are those that are familiar to many people, particularly planners, designers, and operational personnel who are directly involved in the solid waste field. These factors include: (a) land development; (b) surface drainage and topography; (c) soil types; (d) swamps, streams, and lakes, including their drainage areas; (e) sinkholes; and (f) nearby individual and public-supply wells.

The hidden factors are those that cannot be observed directly, and require personnel experienced in hydrology and geology to obtain the specialized types of information needed to make a site evaluation for a landfill operation. The hidden factors include: (a) type, thickness and permeability of surficial sand, silt, and clay; (b) depth to top of limestone; (c) depth to and thickness of relatively impermeable clay zones; (d) depth to water table and direction of shallow ground-water flow; (e) depth to water level in artesian aquifer and direction of ground-water flow; (f) filtering capacity of clays; and (g) sinkholes connected either directly or indirectly with the underlying limestone aquifer.

<u>Prospective landfill sites</u>.--Two areas were found to have hydrologic and geologic conditions less objectionable for landfills than most sites in the area. These are shown on figure 5. Both areas were well-drained, had deep water tables, relatively thick and extensive basal clay layers, and were remote from urban development and areas of large ground-water withdrawals.

A. This site is on a well-drained, wooded ridge area having a thick sand cover and a deep water table. The area is undeveloped and water drains naturally toward a small stream.

B. At this site some overburden has been removed for road beds but the area has a thick cover of sand and clay, a deep water table, nearby highways, is in a rural area outside a large city, and surface drainage does not discharge into a potable body of water.

Figure 5. Examples of sites that are least objectionable for landfill operations.

Unfavorable landfill sites.--Several hydrologic and geologic factors in the limestone topography of west-central Florida are considered to be unfavorable for land disposal of solid waste. Numerous examples of the more important factors are used in the report to illustrate the specific problems they create. These unfavorable areas include:

1. Poorly-drained, swampy sites.

2. Sites containing sinkholes and drainsinks.

3. Sites near lakes and springs.

4. Sites near streams.

5. Low-lying, flood-prone land.

6. Sand pits, limestone quarries, and phosphate pits.

7. Sites near public water-supply well fields.

Figures 6 to 10 show several sites that have one or more of the undesirable features. For each, specific geologic and hydrologic information, and political, economic and esthetic factors would be evaluated to decide whether to develop the site or to reject it.

TEST DRILLING FOR SUBSURFACE INFORMATION

Once a prospective landfill site is ranked as the best available on the basis of the visible factors that are considered for site selection, a study is made to determine if the risks engendered by its hidden factors, its geologic and hydrologic characteristics, are acceptable. Although Florida does not require test drilling at proposed landfill sites, evaluation of the hydrogeology requires that several test holes be drilled near each site so that the subsurface material can be sampled. These test holes provide information about the thickness of the sand and clay, and about the depth and direction of movement of shallow ground water, information that will be used to determine its influence on a landfill operation. Test holes drilled to different depths provide data about the horizontal and vertical movement of water within landfill sites. Information obtained from drilling enables a hydrologist or hydrogeologist to determine what will be the effects of using the site for a landfill operation so that managers can decide if the site is acceptable.

Power augers are used often in west-central Florida to drill test holes in a sand and clay material (fig. 11). Data on subsurface conditions are collected at each test site and examined in the field (fig. 12).

A. Most swamps contain water throughout the year. Generally this water represents the shallow water table. These swamps are unsuitable for solid waste sites because contaminating both the surface and ground water is almost certain.

B. Some swamps dry up during normal dry weather periods. These dry swamps are poor sites for landfills because they flood periodically, are difficult to drain, and buried waste can easily pollute the water.

Figure 6. Landfill sites near swampy areas pollute the shallow ground water.

A. Circular depressions such as the one shown at the left, are surface indications of collapsed sinkholes. These are common in the State, and should be examined thoroughly if a landfill site is planned near one. However, locating landfills in areas where such depressions exist is best avoided.

B. Scuba divers reached a depth of 200 feet in this small drainsink (less than 100 ft. in diameter) and the bottom was nowhere in sight. The drainsink forms a direct connection from land surface to the Floridan aquifer. The sink extends more than 150 feet into the limestone aquifer. The upper 50 feet is an overburden of sand, silt, and clay.

C. This drainsink is filled with mud and debris. It is about 25 feet in diameter and less than 5 feet deep, yet it drains the northern half of a large lake in west-central Florida. A water-stage recorder is in the rectangular box on top of the corrugated pipe. This instrument provides a continuous record of lake-level fluctuations. The instrument is about 20 feet above the lake bottom to protect it from flood waters.

Figure 7. Landfill sites near or in drainsinks pollute the ground water moving through the Floridan aquifer.

A. Many springs are found throughout Florida where the water in the limestone is under pressure sufficient to force it above land surface through natural openings in the soil and rock. Landfills near springs are undesirable because of the potential danger of contaminating the water.

B. Lakes provide some of the most scenic beauty in the State. Because of the flat topography and low relief throughout much of west-central Florida, landfill sites should not be near lakes or near intermittently dry streams that drain into lakes.

C. Streams in shallow channels occasionally flood surrounding low-lying areas. Some streams also provide recreation and some are sources of public water supplies.

Figure 8. Landfill sites near springs, lakes, and streams pollute the surface water.

Low-lying areas flood easily. Flooding may also force shut-down of a landfill because the site becomes too wet or access roads become flooded.

Figure 9. Landfill sites in flood-prone areas pollute surface water and cause operational problems.

A. Sand pits generally are undesirable sites for landfills because of their poor drainage and because material needed for covering the solid wastes has been removed. Excavated areas such as this are also difficult to plan for efficient operations because of the inconsistent manner in which the pits were mined for scattered lenses of clean sand.

B. Areas near public-supply well fields should never be used for landfill sites because pumping water from the limestone may affect the shallow water table and the level of nearby lakes. Under such conditions leachate from a landfill could move into the underlying aquifer and contaminate the water supply. The pumphouse was removed to show the pump and electric controls.

Figure 10. Sand pits require special studies, and heavily pumped areas should be avoided.

A. A power auger is used to drill test holes to determine where water occurs in the ground and what type of materials underlie the test site.

B. Test drilling along a county road near a proposed landfill site. Road rights-of-way generally are good places to drill because they are easily accessible.

C. Sometimes it is necessary to drill in awkward and dangerous places. Here the auger is drilling near the intersection of a county and state road and a railroad. Such sites are hazardous to the workmen because of the high voltage lines and the heavy traffic in the area.

Figure 11. Test holes are drilled to obtain hydrologic and geologic information at a prospective landfill site.

A. Geologist examining a core sample from a test hole. The sample is in a brass cylinder which will be sealed at both ends and sent to a laboratory for analysis.

B. Geologist recording description of the type of material found in a test hole.

Figure 12. The collection of geologic information at test-drilling sites provides data about subsurface conditions.

SPECIAL TYPES OF HYDROLOGIC AND GEOLOGIC DATA

Some of the various types of geologic and hydrologic work which should be done at a landfill site are shown in figure 13. An understanding of the geology is needed to know how fast water infiltrates both the natural soil cover and trench cover and the rate and direction the water is most likely to move.

WATER QUALITY NETWORK

A properly placed network of test wells will allow monitoring the quality of water in and around landfill sites. Such a sampling network makes it possible to determine whether ground water near a landfill operation is being contaminated. In those areas where the sands are relatively thick, multiple wells are installed at different depths to insure an adequate number of sampling points within the sand aquifer. Figure 14 shows three wells that were completed at different depths in a sand aquifer and a test well being pumped to collect a water sample.

Several chemical constituents and properties of water are determined in the field with a portable laboratory. However, most samples collected in the field are shipped to chemical and biological laboratories for analysis (fig. 15).

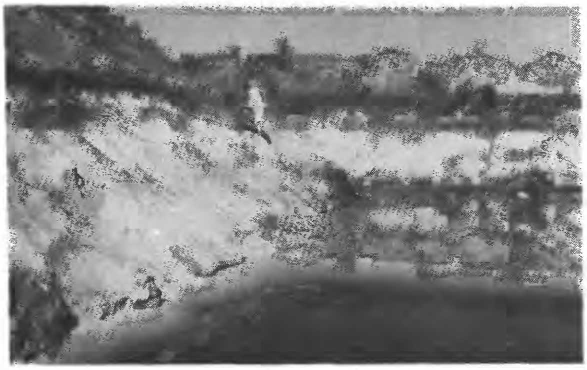
Water quality data collected at test-well sites often include specific conductance, pH, coliform, biologic oxygen demand, organic carbon, trace elements, nutrients, color, temperature, calcium, sodium, and chloride.

INSTRUMENTATION

Automatic-recording instruments are useful at landfill sites to provide continuous records of several parameters that are essential in evaluating the effects of a landfill operation on the water resources of an area. The instrument shown in figure 16 is a battery-operated electronic device which records six parameters on a tape. They are: rainfall; elevation, temperature, and conductivity of the water in an oxidation pond; and conductivity and temperature of the water in a nearby perimeter canal.

PREPARING A SANITARY LANDFILL SITE

The purpose of this report is not to include a step-by-step method of planning and preparing a landfill site, but rather to present those hydrologic and geologic factors that should be considered when selecting landfill sites in west-central Florida. Many excellent publications are



A. Collecting soil samples along the sides of a trench to determine the type of material within the trench and the soil horizons through which most of the water will move.

B. Geologic samples are collected from the trench bottom to determine the vertical movement of water in the trench.

C. Making a test to determine the rate at which water infiltrates a soil. Similar tests should also be made on selected trench covers to determine how effective they are in repelling rain and overland flow.

Figure 13. Many different types of geologic and hydrologic information are collected at landfill sites.

A. Test wells are installed at different depths to monitor the chemical quality of the water from several horizons in sand and clay. This site shows three wells which were completed at different depths in sand, sandy clay, and limestone.

B. Pumping a test well with a pitcher pump to obtain a water sample. The posts protect the wells from vehicle traffic.

Figure 14. Water samples for chemical and biological analyses are collected from test wells installed at a landfill site.

A. Some constituents in the water are determined in the field using portable equipment.

B. Other constituents are determined in water quality laboratories. Here a water sample is being filtered and prepared prior to its shipment to a laboratory.

Figure 15. Monitoring water quality is a part of a well-planned sanitary landfill operation.

A. Instrument installed on an oxidation pond. Such instruments record data continuously on what is happening to the water at a specific location.

B. This instrument records six different parameters by punching a tape. These include rainfall (cylinder at left); the elevation, temperature, and conductivity of the water in the oxidation pond; and the temperature and conductivity of the water in a nearby perimeter canal.

Figure 16. Instrumentation provides for continuous monitoring of landfill sites.

available for those who wish detailed and specific information on preparing and operating a landfill. Several of these publications are listed in the section, "Additional information on solid waste."

Before receiving the first load of waste the site must be prepared for the landfill operation. Where the water table is at or near the land surface, provisions must be made to dewater the site to avoid dumping waste into water. Perimeter canals serve to dewater the area, prevent surface drainage from entering the site, and after operations begin, intercept surface and ground water that may drain from the site. Good access roads must be constructed to withstand the weight of heavy trucks under all weather conditions. Litter fences are necessary to prevent windblown paper from escaping the landfill site. Scales are installed to weigh the incoming waste to determine the site life for future planning and to determine the fee for dumping.

Figure 17 shows a clean, well-prepared entrance to a landfill site and an easily read sign listing the operating hours and the fees charged for disposing of solid waste at the site.

Figures 18 to 20 show several features such as access roads, perimeter canals, oxidation ponds, and pumping equipment needed to improve operating efficiency in an area at a disposal site where the water table is high. Figure 21 shows an aerial view of landfilling at a trench in west-central Florida shortly after the site became operational. The perimeter canals intercept ground water and lower the water table within the working area, particularly during rainy seasons when the water table is near the land surface. A discharge line transports water from active trenches to an oxidation pond where the water is retained and eventually pumped away from the site. The oxidation pond temporarily holds any water that may have come into contact with solid wastes. Water in the pond may require treatment before being discharged out of the site if chemical or bacteriological analyses indicate that it is contaminated.

In west-central Florida most of the high, well-drained land is occupied by citrus groves, homesites and other buildings. Because in the aggregate only a small amount of land is suitable for landfill sites, in many areas it is necessary to obtain land occupied by groves or buildings, then to strip the site so that it can be used (fig. 22).

EQUIPMENT IS NEEDED FOR TODAY'S OPERATIONS

A well-planned sanitary landfill operation utilizes the proper equipment to operate efficiently and uninterruptedly during all types of weather. For example, an efficient operation includes facilities for proper maintenance of equipment and pumps which may be required for emergencies such as underground fires or flooding during hurricanes or other unusually heavy rains. Several of the most important types of equipment used are shown in figures 23 to 26.

A. Access road into a landfill site and weighing station (at right). The main highway to the site is in the foreground. The wood fence is neat and makes the entrance attractive.

B. Signs at landfill sites should inform the public of the hours of operation, cost of disposal, and rules and regulations.

Figure 17. A landfill entrance should be attractive, and the rules should be displayed prominently.

A. Graded roads provide access to the site in all types of weather. This road leads from a main highway to a landfill site.

B. This view within a landfill site shows an access road at left and a perimeter canal for dewatering the area at the right.

Figure 18. Good access roads into landfill sites are necessary.

A. View showing a dairy pasture at left, perimeter canal in the center, and access road and completed trenches at right.

B. This view shows piles of cover dirt from excavated trenches at left, pipe leading from a trench to oxidation pond in the center, and one leg of a perimeter canal at right.

Figure 19. View of a landfill site shows perimeter canals and completed trenches.

A. Oxidation ponds retain water pumped from active trenches to avoid discharging contaminated water out of a site. Note instruments on pond in left background.

B. Dewatering a site where the water table is high. Sea gulls were at the site when this photograph was made.

Figure 20. Oxidation ponds and pumping equipment regulate water at landfill sites.

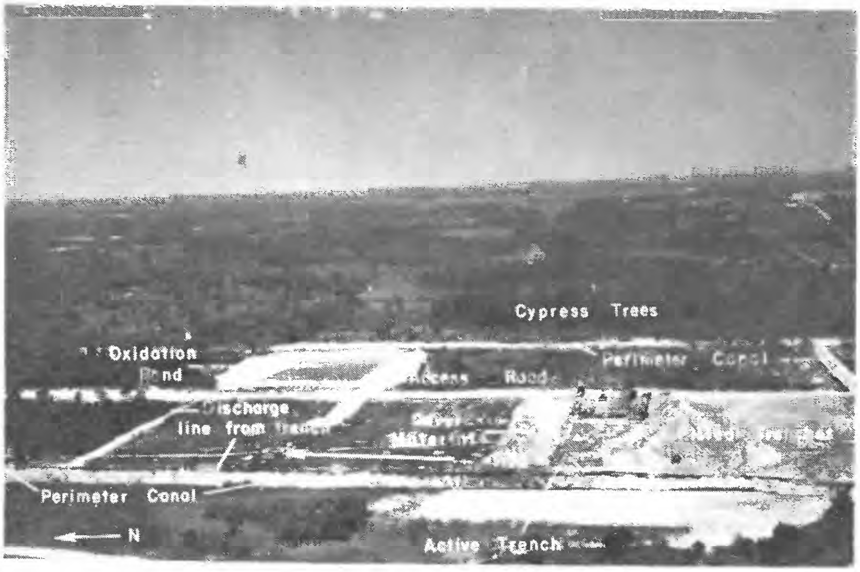


Figure 21. Aerial view of a sanitary landfill in west-central Florida. This site is in an area having a high water table in a sandy soil that overlies a limestone aquifer. The direction of future trench excavations is indicated by the long horizontal arrow immediately north of the active trench and cover material.

Photography by J. D Gorman, Hillsborough County Mosquito Control Department; April 1970

The house on this site had to be removed before construction of the landfill site could begin. Purchase of improved property may be costly but is often necessary because only a small amount of suitable unimproved land is available for landfill operations.

Figure 22. Selection of landfill sites may require removal of houses and other buildings.

Figure 23. A dragline is used to excavate a trench in sand. Special types of trenches may be required in some areas to facilitate de-watering and to insure proper spreading and compaction of the solid waste.

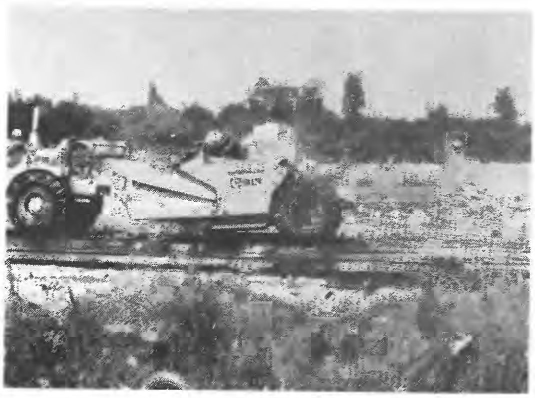
A. Weighing solid waste to record the quantity deposited at a landfill. This type of information is needed in order to plan for future land requirements.

B. Front-end loaders insure rapid loading and unloading of solid waste.

C. Trees and shrubbery are a large part of solid waste generated in Florida, and special trucks are used for pick-up and delivery to a landfill.

Figure 24. Specialized equipment is used to collect and transport solid waste.

A. A compactor is used to spread and compact solid waste.



B. A scraper is needed to bring in dirt for cover material.

Figure 25. Landfill operations require the right type of equipment to handle the job.

A. A crawler tractor equipped with a landfill blade is used to spread solid wastes and cover material. Here it is spreading dirt over a filled trench.

B. In west-central Florida rainfalls of several inches per hour are common, and pumps are used to keep the working areas dry.

Figure 26. Cover dirt and dry working areas are essential to good landfill practices.

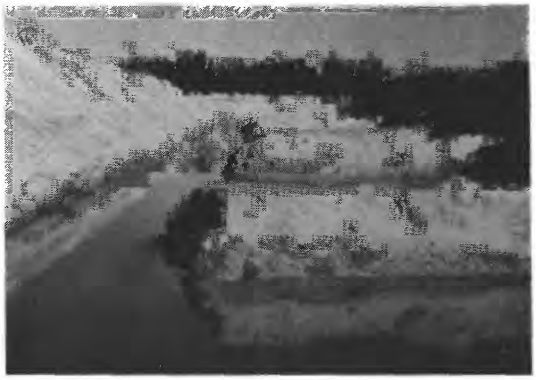
PREPARING, FILLING, AND COVERING A TRENCH

Upon completion of access roads, perimeter canals, oxidation pond and other facilities, the landfill site is ready to receive solid waste. Figure 27 shows a trench constructed in an area having a high water table. The photographs in figure 27 show the water level in a trench before and after dewatering a site. The surface of the water in the trench is about at the same height as the water table in the adjacent shallow aquifer. After dewatering, the trench is ready to receive solid waste. The solid waste is hauled to the site and dumped in a trench (figs. 28-30). Crawler tractors spread and deposit the waste and compactors repeatedly crush and compact the waste into a dense layer over which a 6-inch cover of soil is spread at the end of each day's operation (fig. 31). After the trench is filled with compacted waste a 1-foot intermediate soil cover is placed over the trench if a second layer or lift of solid waste is planned. This second lift generally is built up to a level of 5 to 8 feet above land surface. After the second lift is deposited a minimum compacted final soil cover, 2 feet thick, is placed over the trench (figs. 32 and 33). A final cover is needed to prevent direct infiltration of rain into the trench, to fill in voids caused by decomposition of solid waste, to minimize rodent and insect problems, and to provide a support for vegetation.

MAINTENANCE OF A LANDFILL SITE

After the trenches are covered, maintenance of the site is continued for whatever period of time is needed to insure that the site is kept clean and that the trenches remain adequately covered. Figures 34 and 35 show completed trenches at landfill sites that are about two years old. In some areas (fig. 35) additional cover material has been placed on the trenches to replace soil cover that either was washed away by heavy rainfalls or has sifted down to fill the voids caused by decomposition of the waste.

During the maintenance period a water-monitoring network is maintained for mapping the movement of water and for determining changes in water quality. The network is continued until it is determined that the effects of decomposing solid waste at a landfill site is not contaminating the water resources of the area.



A. Completed trench filled with water. Special dikes divide the trench into cells that can be isolated for dewatering. The water in this trench represents the level of the shallow water table in the area. This trench is 400 feet long, 100 feet wide, and 8 feet deep.

B. This is the same trench shown above after it has been dewatered.

Figure 27. Special types of trenches are constructed in soils having a high water table.

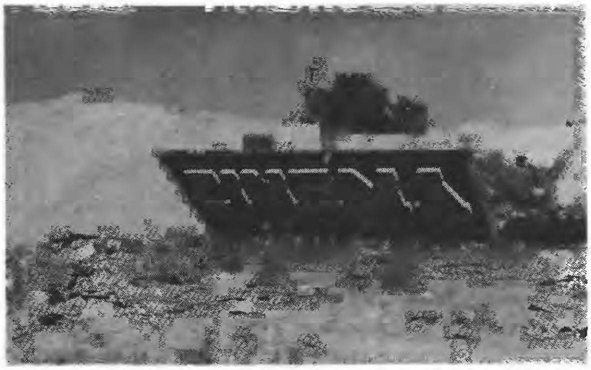
Rapid unloading of solid waste in a trench.

Figure 28. After construction a trench is ready to receive solid waste.

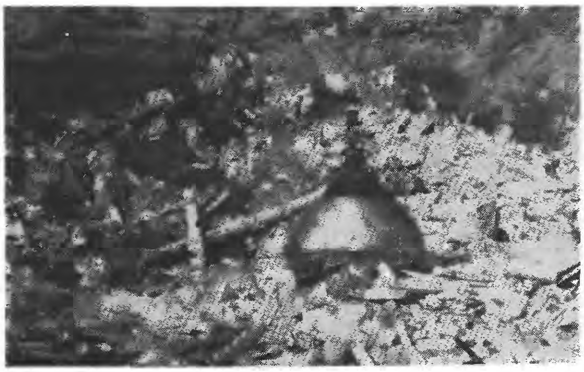
A. Tires are a common item at most landfills. Generally they come by the truckload.

B. Tires are placed on or near the bottom of a trench to insure proper earth coverage. If placed too close to the surface, tires tend to become exposed after a short period of time.

Figure 29. Some solid waste present special problems in filling a trench.



A. Even an old theater marquee that has served its purpose ends up in a landfill.



B. A little of everything--a T. V. tube, bricks, wood, paper, and roofing material.

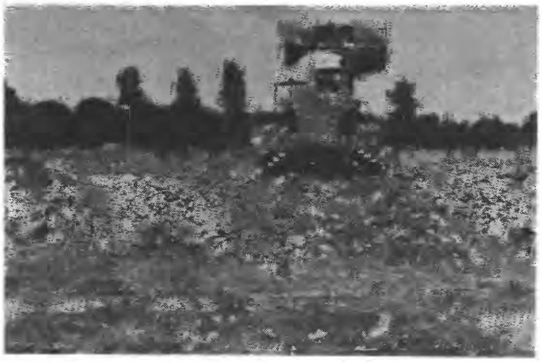
Figure 30. A trench receives many things that man discards.

A. Unloading solid waste on second lift. The intermediate cover in foreground is 1 foot thick.

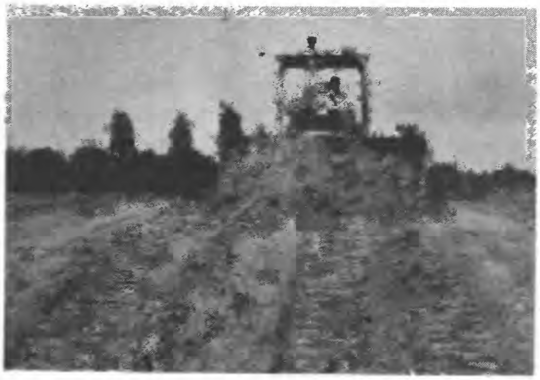
B. A tractor spreading solid waste into an excavated trench. Solid waste is spread and compacted into a dense layer to reduce the volume of the waste and the space required in a trench.

C. Compacting solid waste before applying 6-inch soil cover. Area at left of compactor has been covered with soil.

Figure 31. Solid waste is unloaded, spread, and compacted at a landfill site.



A. Compacting solid waste to prepare trench for a final 2-foot soil cover.



B. Spreading of final earth cover using a crawler tractor equipped with a landfill blade.

C. Compacting final cover on a completed trench.

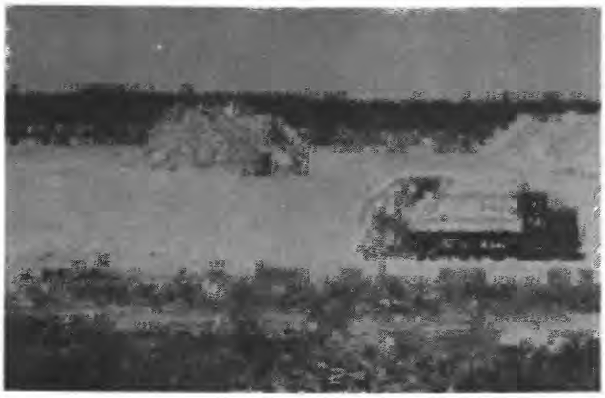
Figure 32. Solid waste is compacted and a soil cover is completed over a trench.

A. Trench in final stage of completion. Compactor at left moves forward and backward over the material to form a solid, dense final cover.

B. View of completed trench one year later. Grass has begun to grow on the soil cover.

Figure 33. A final earth cover is completed over a trench, and a view of the same trench a year later.

A. A clean, well-kept landfill. Filled trenches are to the left of the access road.



B. Filled trenches between piles of extra cover material. The material will be placed on the trenches to provide a 2-foot final cover.

Figure 34. A landfill operation leaves the land neat and clean and provides for daily upkeep of the site.

Periodically, additional earth material is needed to maintain a 2-foot final cover over completed trenches. This site needed additional cover material 2 years after the trenches were initially covered. The pipeline carries water from an active trench to an oxidation pond.

Figure 35. Completed trenches require periodic inspection and maintenance.

MONITORING BURIED SOLID WASTE

After solid waste is deposited in a trench and buried, it is important to know how fast the waste decomposes and what effect this decompositon has on the surface and ground water of the area. In order to find these answers, test holes are constructed in filled trenches to provide monitoring sites from which water samples can be collected and analyzed for various chemical constituents.

Figure 36 shows the drilling and construction of test holes in filled trenches at a landfill site. An automatic recording instrument will be installed on the large-diameter test hole shown in figure 36B to obtain a continuous record of selected quality-of-water parameters for the trench. These data will assist in evaluating the effects of the solid waste on the water resources of the area.

SUMMARY

Disposing of solid waste on land while still preserving the environment is a major problem in Florida as well as in the rest of the country. Disposal problems are acute in the heavily congested urban areas of the State, particularly near the coast and elsewhere where the land is low and flat and the water table is at or near land surface. The need to consider in detail the hydrologic and geologic conditions at solid waste disposal sites is not yet fully recognized by most residents and some public officials. Failure to recognize this need in water-rich and water-dependent Florida could result in contamination of its water resources.

The most common and least desireable method of disposal, and perhaps the most harmful to the environment, is open dumping. Open dumping probably constitutes the largest and most widely used means of disposing of solid wastes in the State. Various state and federal agencies, and particularly some cities and counties in Florida, have made much progress within the last few years in upgrading waste-disposal methods and eliminating open dumps.

The sanitary landfill method of solid-waste disposal is practiced in parts of west-central Florida. This method of land disposal has been used for many years in other parts of the county, and today is widely approved and accepted where properly operated.

A sanitary landfill should be a well-planned, carefully designed, and properly located operation that is based on engineering methods and techniques, applied knowledge of the hydrology and geology of the area, and is operated in a manner that protects and maintains the quality of our environment. A landfill operation utilizing these factors provides one approach to the disposal of the ever-increasing volumes of solid waste generated in this country without destroying or permanently harming the ecological balance of an area.

A. Drilling into a filled trench to determine what is happening to the solid waste.

B. Installing a 4-inch plastic casing in a test hole augered in solid waste. These large diameter test holes will be equipped with instruments to monitor the water in the trenches.

Figure 36. Drilling and constructing test wells in filled trenches. These test wells provide data about both the rate of decomposition of solid waste and the level of water in the trenches.

Some pollution of the water resources will occur in the immediate vicinity of a solid-waste disposal site regardless of the method used. Therefore, it is not meant to imply that sanitary landfills are the answer to all solid-waste disposal problems. Unless the site is well planned and operated and its location selected with due regard for geologic and hydrologic conditions, it could become just as great a polluter of the environment as an open dump. However, until more acceptable and easily implemented methods become available, the sanitary landfill still remains one of the best and most efficient means of disposing of solid waste.

ADDITIONAL INFORMATION ON SOLID WASTE

For those who wish to know more about solid waste, many excellent reports are available from industry, various publishing firms, and state and national agencies. These publications range from those prepared for the layman to the more highly technical and scientific reports resulting from special research projects and investigations. Several nontechnical reports are included in the list that follows.

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Stewart, J. W. and Hanan, R. V., 1970, Hydrologic factors affecting the utilization of land for sanitary landfills in northern Hillsborough County, Florida: Florida Bur. of Geology Map Series 39.

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