

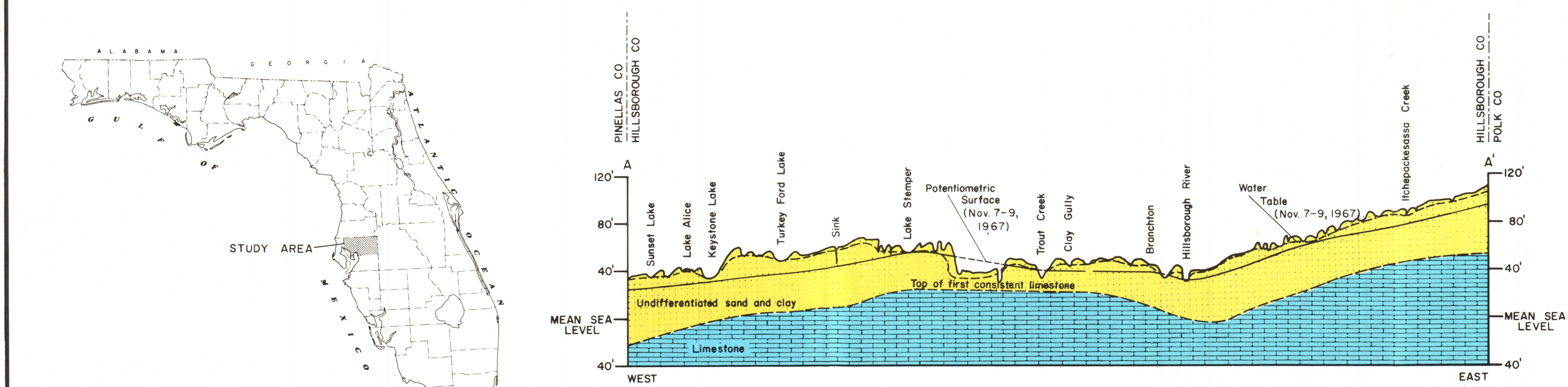


Figure 1.—Location of northern Hillsborough County, Florida.

HYDROLOGIC FACTORS AFFECTING THE UTILIZATION OF LAND FOR SANITARY LANDFILLS IN NORTHERN HILLSBOROUGH COUNTY, FLORIDA

By
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INTRODUCTION

The disposal of solid wastes into pits or depressions was practiced in Hillsborough County before 1950. Sites suitable for this method of refuse disposal posed no serious problem as late as 1950. Rapid urbanization since 1950 has decreased the land readily available for economical refuse disposal, has generated refuse in increasing volume, and has increased the demand for domestic and public water supplies in the area. Thus, the selection of sites suitable for solid waste disposal is becoming more difficult as the county's population grows and as readily available land diminishes. At the end of 1969, three landfills were in operation in the northern half of the county. These included the Plant City landfill in the eastern part of the area, and two county-operated landfills in the central and western parts.

PURPOSE AND SCOPE

At the request of Hillsborough County and the City of Tampa, the U. S. Geological Survey began an investigation of the northern half of the county in July 1967. The purpose of the investigation was to establish generalized geologic and hydrologic guidelines that could be used by county and city officials, sanitary engineers, and others in selecting prospective landfill sites that have a low potential hazard to the water resources of the area. Landfills in Hillsborough County are constructed by burying solid wastes in trenches in surficial sand, silt, and clay overlying a limestone aquifer. This aquifer supplies nearly all of the water for domestic, public, and industrial supplies in western Florida. Contaminated water leaking from the landfills into the limestone would move rapidly through fissures, cavities, and joints in the limestone, possibly to nearby wells and streams. Streams could also be contaminated by lateral movement of leachate from landfills. The geologic factors affecting the contamination potential of landfill sites are those that control the rate and the vertical and horizontal directions of ground-water movement.

This report describes and discusses the geology and hydrology of northern Hillsborough County as related to the location and the possible effects of landfills on the water resources of the area. The selection of landfill sites based on knowledge of geologic factors will decrease operating problems and will minimize danger of surface and ground water pollution.

LOCATION AND EXTENT OF AREA

The study area is the northern half of Hillsborough County as shown on figure 1. It extends northward from about 3½ miles south of State Road 60 to the Pasco County line, and from Polk County on the east to Pinellas County on the west. The total area encompasses about 600 sq mi (square miles).

ACKNOWLEDGMENTS

The cooperation of John Dobkins, Hillsborough County Engineer; Ivan Dory, Engineer of Utilities, Hillsborough County; Dan Gorman, Director, Hillsborough County Mosquito Control; and Sam Lockwood, Superintendent, Tampa Water Works, is gratefully acknowledged. Special thanks are extended to other officials of Hillsborough County who aided in obtaining data for this report. The helpful cooperation of property owners who permitted access to both their land and wells in order to collect hydrologic data is appreciated.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The western half of Hillsborough County is generally flat with land-surface altitudes ranging from sea level at Tampa Bay to 60 feet above and (mean sea level) near Keystone Lake. The eastern half of the county is gently rolling with altitudes ranging from 20 feet above and along the Hillsborough River to 100 feet at Plant City. About 60 square miles, or 10 percent of the area, is occupied by lakes, marshes, and swamps. Most of the lakes are north of U. S. Highway 92 and west of U. S. Highway 41. Most marshes and swamps are in the north-central part of the county north of State Road 582 and east of U. S. Highway 41. Most surface drainage is to the south and west from the high ridges in the eastern part of the county and from the low ridges in the western and southern parts into Hillsborough Bay. The southeastern part of the report area is drained by the Alafia River and its tributaries. Because of the potential hazard of contaminating streams by leachate draining from a landfill, the selection of sites is influenced to a large extent by surface drainage. The principal stream, the Hillsborough River, drains about 320 sq mi of the north-central part of the county. The river's course is apparently controlled by the fracture pattern in the underlying limestone, and generally flows in the direction of dip of the buried limestone strata. Major tributaries of the Hillsborough River are Pemberton, Baker, and Blackwater Creeks which drain northern Hillsborough County, and Trout Creek and Clay Gully which drain the north-central part of the county.

GEOLOGY

The sedimentary strata underlying the northern half of Hillsborough County at an altitude of about 80 feet below mid (depths from 0 to 220 feet below land surface) consist, from oldest to youngest, of the Suwannee Limestone, the Tampa Limestone, and the Hawthorn Formation. The limestone formations comprise the Floridan aquifer, the principal source of water in the area. In the northern half of Hillsborough County, the top of the first consistent limestone ranges in depth from about 80 feet below land surface in the eastern part to about 40 feet below land surface in the western part. The first consistent limestone east of the Hillsborough River is within the Hawthorn Formation, whereas the first consistent limestone west of the Hillsborough River is the Tampa Limestone. The relationship of geologic units, water table, and the potentiometric surface along the lines A-A' and B-B' are shown by the sections on figure 2. Sand, clay, and silt of Holocene to Miocene age overlie limestone of Miocene to Oligocene age. The sand and clay is thickest in the eastern part of the county, ranging from about 140 feet near Baker Creek to about 5 feet near Hillsborough River. The average thickness of the sand and clay is about 50 feet, and the average saturated thickness is about 40 feet. The thickness of the sand and clay is shown on figure 3.

SOILS

The upper 48 inches of the material underlying the area has been grouped into two categories, permeable and semipermeable, as adapted from U.S. Department of Agriculture Soil Survey, Hillsborough County (1958). Soil permeability influences the rate of infiltration of water into the ground and subsequent movement of water into the zone of saturation. Well-drained areas are underlain by fine to medium sandy soil overlying the limestone and swampy or marshy areas are underlain by semipermeable silt or clayey sandy soil. The generalized soil permeability of the area is shown on figure 4. Samples from wet holes throughout the area show that the permeable material is generally very fine to medium light-colored sand; the semipermeable material is generally very fine to medium dark sand that contains large amounts of peat, organic material, clay, and silt. About 350 sq mi of the area is classified as poorly drained semipermeable soils, about 150 sq mi as classified as well-drained permeable soils. The remaining 100 sq mi includes urban areas (40 sq mi), coastal areas (15 sq mi), mining areas (15 sq mi), and lakes and streams (10 sq mi).

SINKHOLES

Sinkholes occur throughout most of the area, except within the areas of artesian flow. Sinkholes are generally unfavorable sites for sanitary landfills because water in most sinks is hydraulically connected with the Floridan aquifer. Therefore, sinks are areas by which surface water may move rapidly into the Floridan aquifer. The rapid movement of water from a sinkhole into the Floridan aquifer was demonstrated in January 1958 when fluorescent dye, introduced into a sink about 2 miles north of Sulphur Springs, was detected in Sulphur Springs in about 25 hours (City of Tampa Water Department, 1958). Most of the sinkholes in the report area occur in a southeast trending band, 5 to 8 miles wide, that extends from the western to the northern part of the county to the Alafia River in the southeastern part. The sand and clay in the areas of sinkhole occurrence is predominantly well drained and permeable. Generally, this sand and clay is about 35 to 35 feet thick on the west side of the Hillsborough River, and about 25 to 85 feet thick on the east side of the river.

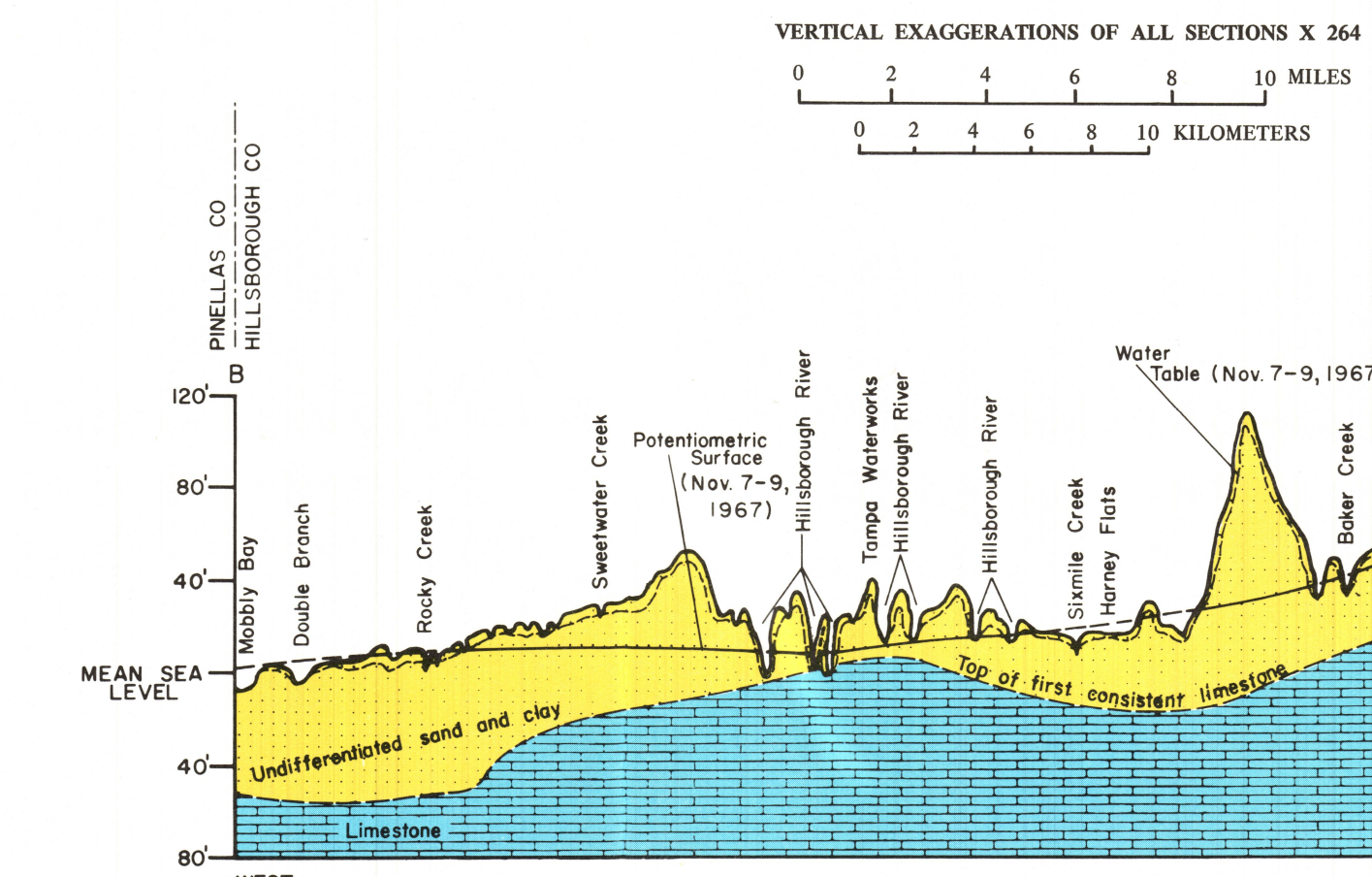


Figure 2.—Generalized sections showing geology. (Trace of sections shown on figure 4).

WATER-LEVEL FLUCTUATIONS

WATER TABLE

The water table ranges from less than 5 feet below land surface throughout most of the southern half of the area to as much as 15 feet below land surface in most of the northern half of the area, as shown on figure 5. The water table is generally more than 10 feet below land surface in areas of large pumping withdrawals from the Floridan aquifer in the northern part of the county. Where the surficial sediments are highly permeable, and the limestone is near land surface, the water table may be within the top of the limestone. In much of the area the shallow water-table aquifer is hydraulically connected with the underlying limestone and the potential hazard of contaminating the water in the Floridan aquifer with leachate from sanitary landfills is great. Water levels in wells that tap the semipermeable sands have smaller ranges of fluctuations than do water levels in wells that tap permeable sands. The annual range in water-level fluctuations in 1967 was less than 3 feet in the semipermeable sands and 5 to 6 feet in the permeable sands. Near Plant City, where the water table is less than 5 feet below land surface, the altitude of the water table is about 140 feet above mid, or about 65 feet above the potentiometric surface of the principal limestone aquifer in the area. The potentiometric surface is an imaginary surface representing the pressure head of water confined in an artesian aquifer. It is defined by the height to which water will rise in tightly cased wells that penetrate the aquifer. Where the potentiometric surface is higher than the land surface, wells tapping the artesian aquifer will flow. Near Citrus Park, the water table is about 5 feet below land surface, or about 30 feet above mid and about 5 feet above the potentiometric surface.

The location of sanitary landfills in areas where the bottom of the trench is below the level of the water table is undesirable because the refuse is continuously saturated and leachates can percolate into the ground-water system. Because the water table is less than 5 feet below land surface in most of the county, disposal trenches constructed in such areas will require pumping to lower the water table below the bottom of the trenches. In some areas it may be advisable to line the trenches with poorly permeable clay and cover the refuse by clay or other material to prevent rapid movement of leachate from the trenches.

POTENTIOMETRIC SURFACE

The potentiometric surface ranges from about 90 feet above mid in the northeastern part of the county to less than 5 feet above mid in the southwestern part of the county as shown on figure 5. The configuration of the potentiometric surface in the northern part of the county, where ground-water withdrawals from the Floridan aquifer are minimal, corresponds generally to the configuration of the top of the first consistent limestone, although the potentiometric surface ranges from about 20 to 40 feet above the top of the limestone (See section A-A', fig. 2). The potentiometric surface generally coincides with the top of the limestone near Plant City, and ranges from a few feet above the top of the limestone near Temple Terrace to as much as 50 feet above the top of the limestone near Citrus Park. However, in the southeastern part of the county, water levels were lowered as much as 30 to 40 feet from September 1958 to October 1967 by extensive ground-water pumping in western Polk County, and the potentiometric surface does not follow the configuration of the top of the limestone (See section B-B', fig. 2).

SPRINGS AND AREAS OF FLOW

Four large areas of artesian flow (fig. 3) occur in the coastal areas south and west of Tampa, and the inland areas east and north of Tampa. During May 1968, 13 springs were observed in the west-central part of the county and several springs were reported to discharge into the Hillsborough River between Temple Terrace and the Pasco County line. Crystal Springs, about half a mile north of the Hillsborough-Pasco County line (not shown on map), provides most of the base flow of the Hillsborough River. The well-known Boiling Spring, in the southeastern corner of the report area, was not flowing when visited in May and October 1968. This spring reportedly flowed 2,000 gpm (gallons per minute) in October 1958 (McKenzie and others, 1961). Depending on certain hydrologic and geologic conditions, areas of artesian flow may be either favorable or unfavorable for locating sanitary landfills. Possible areas are: (1) unsaturated areas; (2) areas of artesian flow; (3) areas of artesian flow during wet periods; (4) large declines in artesian water levels caused by large ground-water withdrawal or by extended dry periods, making possible movement of dissolved contaminants from a landfill into underlying aquifers; and (5) improperly constructed existing wells that flow uncontrolled at the surface and flood low-lying areas, or create a potential interaquifer leakage pollution problem. Favorable conditions include: (1) adequate drainage in areas not subject to flooding; (2) sufficiently high artesian pressures to prevent movement of contaminants into the Floridan aquifer; and (3) a confining layer, and earth materials of low permeability which will retard movement of contaminants from the disposal site.

GROUND-WATER MOVEMENT

The greatest head differences between the shallow water table (which is generally higher) and the potentiometric surface occur in the high ridges in the eastern part of the county and in areas of large pumping withdrawals from the Floridan aquifer in the southwestern part of the county. Movement of water in both the water table and artesian aquifers is from the eastern and northern parts of the county to the south and west as shown by the potentiometric contours on figure 5. This direction of movement is toward centers of present and proposed ground-water use in the county. The direction of movement is significant because large pumping withdrawals in localized areas cause an increase in head differential between the water table and the potentiometric surface. This increased head differential can induce vertical movement of water from the sediments to the underlying limestone, thereby increasing the potential hazard of contamination of the limestone aquifer by a sanitary landfill.

The rate of ground-water movement through the sediments underlying the northwestern part of the county ranges from about 3 to 36 feet per year (Stewart, 1968). Based on the fluorescent dye test completed near Sulphur Springs in 1958 by the City of Tampa, the rate of ground-water movement in the Floridan aquifer ranged from about 400 to 1,500 feet per hour. This high rate of movement indicates that the water flows through a cavernous limestone and approaches the rate of flow in an open channel. However, except for limestone that have well developed joints, fractures, and other openings, the rate of movement would normally be on the order of a few feet per year. The direction and rate of movement of ground water determines the most water may be expected to move from landfills leachates will take, and the rate of contaminant movement from a landfill site.

The city of St. Petersburg, in adjacent Pinellas County, has two well fields in northern Hillsborough County (fig. 3). The fields were pumped at an average rate of 27.5 mgd (million gallons per day) in 1967 and about 25.8 mgd in 1968. The Pinellas County well field, in the northeast corner of Pinellas County near the Hillsborough County line, was pumped an average of about 20.7 mgd in 1967 and about 21.2 mgd in 1968. In 1966, the Pinellas County field was extended into the extreme northwest corner of Hillsborough County by the addition of 10 wells. However, these wells were not used in 1969. The city of Tampa has the largest public supply in Hillsborough County. The city used an estimated 39.2 mgd in 1967 and 40.4 mgd in 1968 from the Hillsborough River. Tampa pumps a supplemental supply of 20 mgd from Sulphur Springs during dry periods when the Hillsborough River is low. The city has proposed construction of a well field about 14 miles east of the city and about 6 miles west of Plant City. Other municipal supplies using ground water in the area include those of Brandon, Plant City, and Temple Terrace. Eleven privately owned public utilities in the area also pump ground water. Both the water table and potentiometric surface are depressed in areas of large ground-water withdrawals, and water in the shallow aquifer may be induced into the artesian aquifer, and subsequently be withdrawn through a well. Therefore, the location of sanitary landfills near or upgradient from these well fields is undesirable because of possible contamination of the Floridan aquifer by leachates from landfills.

EVALUATION OF A SANITARY LANDFILL SITE

An investigation of a proposed sanitary landfill site should obtain the following types of hydrologic information: (1) thickness and character of overburden; (2) character of bedrock; (3) depth of water table and potentiometric surface; (4) depth to water-table aquifer and artesian aquifer; (5) local and regional ground-water flow systems; (6) chemical quality of surface and ground waters; (7) frequency and extent of flooding of the area; and (8) nature and volume of the waste materials to be buried. Ideally, a sanitary landfill should be located in an area where the geologic materials are relatively impermeable and where the refuse and its leachate is contained or its movement from the site is retarded. Sites underlain by highly permeable sand are generally unfavorable. Moreover, areas directly underlain by fractured and cavernous limestone should be avoided because of the unpredictability of the direction and rate of ground-water movement in such materials. Other areas that should be avoided include swamps and marshes (hazardous to streams and areas that contain sinkholes). Throughout west-central Florida surficial materials are permeable, limestone of the Floridan aquifer is generally permeable, and the water table, so that natural geologic and hydrologic conditions are generally not adequate to protect the water resources from leachates from landfills. The procedures that may be required to minimize or to prevent pollution of ground and surface water in west-central Florida where geologic conditions for sanitary landfills are less than ideal include: (1) lining trenches with plastic sheeting, clay or other material to contain the leachate; (2) constructing a perimeter canal around all or part of landfill to lower the water table within the working area and to stabilize the impermeable lining; (3) providing drainages to intercept and divert runoff from the landfills and to minimize erosion and gully development; (4) constructing an oxidation pond or holding lagoon to provide temporary retention and treatment of water to be discharged from the landfill site; (5) providing adequate equipment to dewater operating trenches and perimeter canal during excessively wet periods; and (6) utilizing poorly permeable materials for the final cover of filled trenches to retard evaporation of rain water through the waste materials.

West-central Florida, the following hydrologic characteristics should be considered when evaluating a proposed sanitary landfill site:

1. Type of unconsolidated material.
Favorable: clay, silt, clay, clayey silt, and silt.
Unfavorable: sand.
2. Thickness of unconsolidated materials.
Favorable: at least 25 feet.
Unfavorable: less than 15 feet.
3. Site topography.
Favorable: adequate drainage and not subject to flooding.
Unfavorable: low swampy areas; areas subject to flooding; sinkholes and areas near sinkholes; along stream channels hydraulically connected with Floridan aquifer.
4. Ground-water levels.
Nonartesian aquifer:
Favorable: greater than 15 feet below land surface.
Unfavorable: less than 5 feet below land surface.
Artesian aquifer:
Favorable: potentiometric surface at least 5 feet above water table.
Unfavorable: potentiometric surface near or below the water table.
5. Character of limestone aquifer.
Favorable: dense, unfractured.
Unfavorable: fractured and cavernous.

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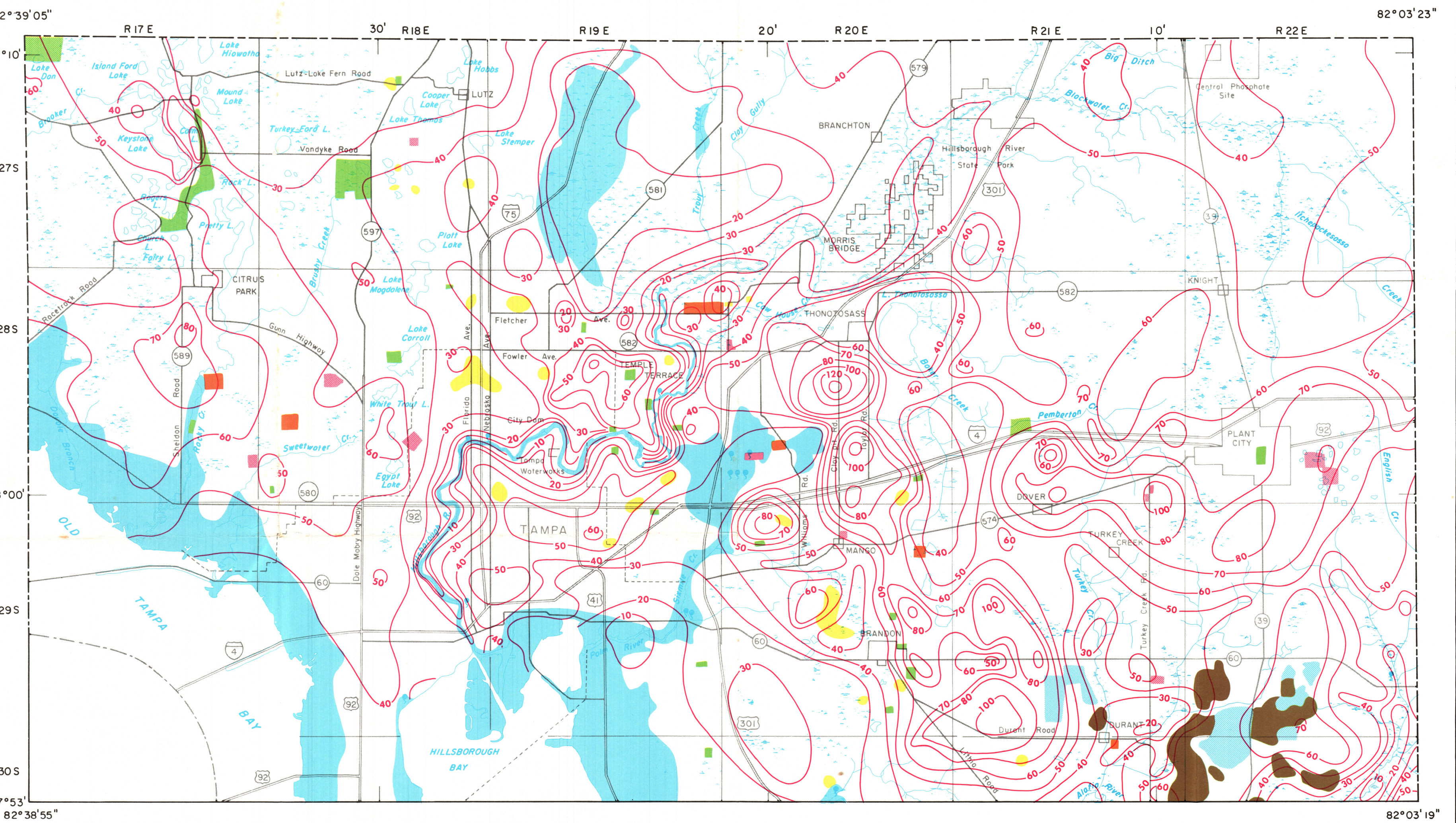


Figure 3.—Hydrologic map showing drainage, thickness of undifferentiated sand and clay in feet. Interval 10 feet changing on 80-foot line to 20 feet.

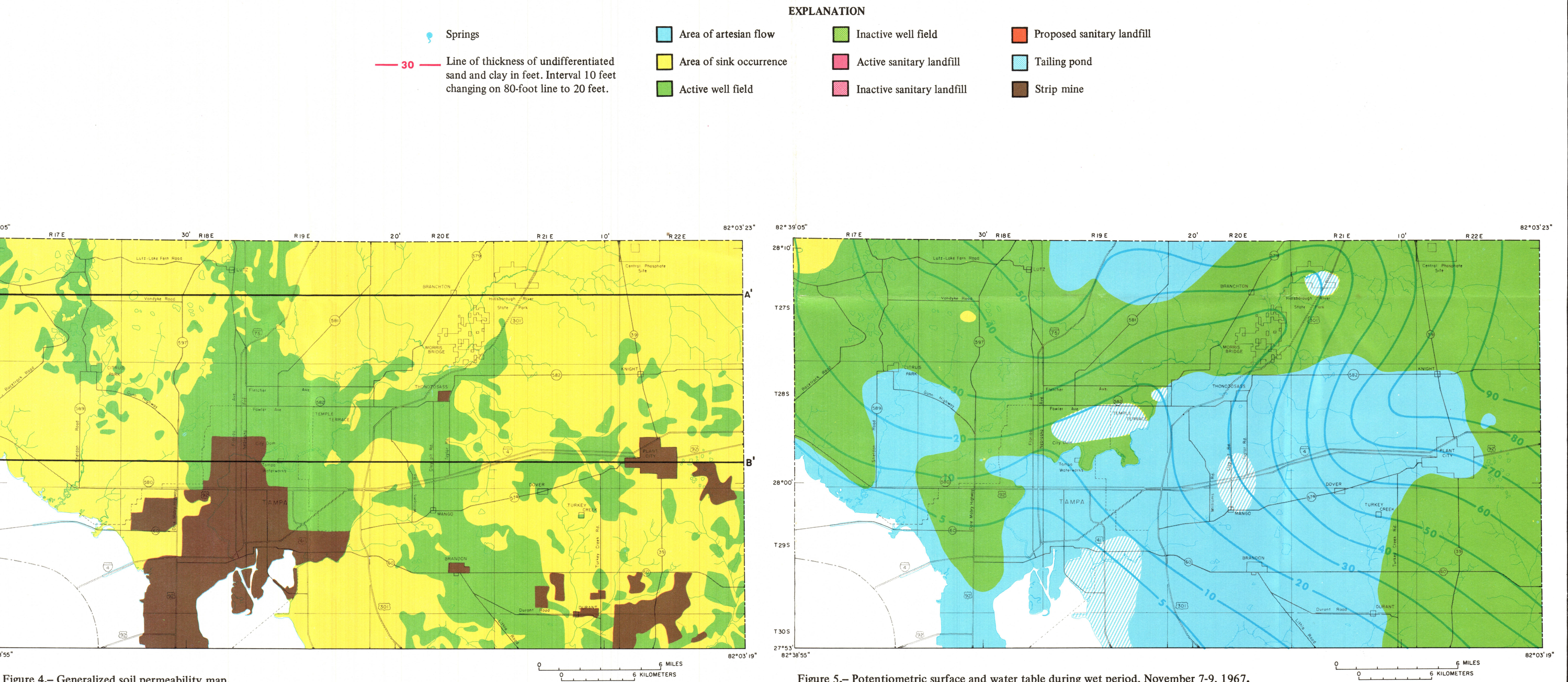


Figure 4.—Generalized soil permeability map.

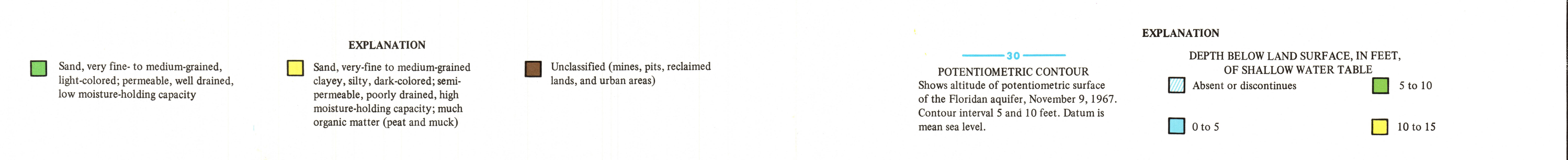


Figure 5.—Potentiometric surface and water table during wet period, November 7-9, 1967.