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Feasibility and Design Studies: Camplain Valley Sanitary Landfill

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FEASIBILITY AND DESIGN STUDIES: CHAMPLAIN VALLEY SANITARY LANDFILL

by

W. Philip Wagner and Steven L. Dean*

INTRODUCTION

In theory, solid waste disposal in Vermont has progressed from dumps to sanitary landfills, but in practice the differences between the two often are obscure. According to a recent review, "Over 90% of the small towns in Vermont dispose of their refuse in open dumps or substandard landfills"(Report of the Governor's Task Force, 1970). There is growing evidence that some of the better sanitary landfills are polluting (Thompson and Costello, 1972; Wagner et al., 1971; Wagner and Thompson, 1971). Although recycling eventually may solve the solid waste problems, sanitary landfilling is the only practical method presently available for Vermont.

This report is intended to illustrate that:

- knowledgeable landfill location and site evaluation can greatly reduce the chance of environmental degradation...

- sanitary landfills are not merely covered dumps, but in fact represent specially designed systems...

- short of recycling, there can be such a thing as a "good landfill", even in Vermont.

This is not a comprehensive account of all aspects of landfills. Emphasis is focused on pertinent, but commonly ignored geological and hydrogeological factors. The bibliography includes all publications reviewed in this project.

LANDFILL LOCATION

Much of the work presented here stemmed directly from a request from Paul Casey, Hinesburg Sand and Gravel Co., Inc., for help in designing a landfill that absolutely would not degrade the environment. Thus, the problem began, at least in a general way, with a given location near Burlington. For a private operator, a public official, or a planner faced with the initial problem of locating a suitable landfill site, the procedure to be followed would be much the same as used here. The Appendix includes a check list for evaluation of different sites. The following discussion deals with environmental guidelines for landfills.

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Sanitary landfills can be located in almost any place, but if financial costs for protecting the environment are to be minimized, it is desirable to recognize and take advantage of certain natural characteristics of the land. The problem, simply stated, is to identify criteria for locating landfills in Vermont. If meaningful, such criteria will aid rather than hinder landfill development. Sound guidelines for locating landfills will make good economic as well as environmental sense.

The logical way to develop criteria is to consider previous studies on the subject. Literature dealing with sanitary landfills is extensive. In some places certain criteria have been developed, but most publications relate studies of individual landfills. Some aspects of studies elsewhere may not be directly applicable to Vermont due to differences in topography, climate, soils, or rocks. On the other hand, similarities in reports from diverse places indicate that there are some universal "truths" that cut across political boundaries. By combining information from various studies it is possible to develop criteria for locating landfills according to substrate and cover materials. Depending on whether the substrate is relatively permeable or impermeable, the following criteria can be identified:

1. Permeable substrate, generally sand and gravel, with:
   a) minimum 1000 feet to nearest perennial stream
   b) minimum 30 feet of <u>dry</u> substrate below landfill base
   c) maximum 10% slope

2. Impermeable substrate, generally certain glacial tills and some lake or marine bottom sediments, with:
   a) minimum 200 feet to nearest perennial stream
   b) minimum thickness of 5 feet of substrate below landfill base
   c) maximum 10% slope
   d) minimum 6 feet of <u>dry</u>, permeable material overlying impermeable substrate
   e) leachate control and treatment

The current trend nationally is toward sites with impermeable substrata. In such sites leachate is either prevented from leaving the landfill, or moves at such low velocities that it undergoes optimum purification by chemical and biochemical reactions, filtering, and dilution. Landfills with permeable substrate may be suitable for certain kinds of waste material not likely to cause environmental degradation.

As for cover materials, both impermeable and permeable soil covers have been used elsewhere. The former has the advantage of repelling surface water, thereby minimizing leachate generation, but retarding gas release. The latter promotes upward escape of gas but also allows for surface water infiltration leading to increased leachate production. A formula of 80% well-graded gravel, 10-15% sand, and 5-10% fines provides a relatively impermeable cover that, with specially designed gas vents, offers optimum conditions for controlling leachate production, gas diffusion, rodents, flies, and frost heaving. In addition, such material can be compacted and can support heavy vehicle traffic. Thus, site location considerations should include, in addition to substrata conditions, the availability of sufficient volumes of cover materials which will offer the benefits outlined above. In Vermont, the natural deposits most closely resembling the ideal cover material are certain glacial tills and glacial gravels. In most cases, however, cover material probably will have to be specially prepared by mixing materials of different grain size.

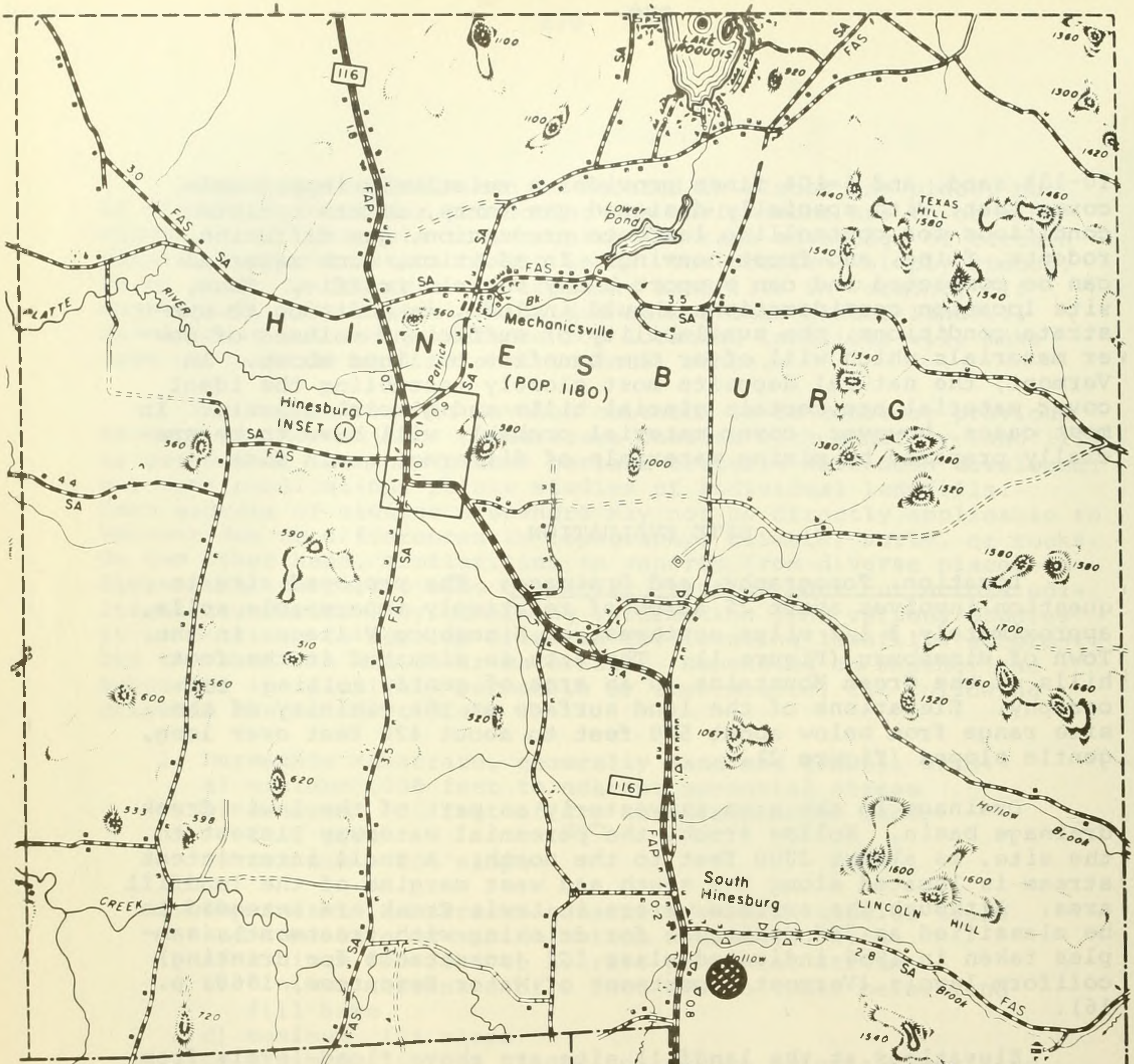
SITE EVALUATION

Location, Topography, and Drainage: The proposed site in question involves about 25 acres of relatively impermeable soils, approximately 3 1/2 miles southeast of Hinesburg Village, in the Town of Hinesburg (Figure 1). The site is situated in the foothills of the Green Mountains in an area of gently rolling topography. Elevations of the land surface at the vicinity of the site range from below about 500 feet to about 420 feet over long, gentle slopes (Figure 2).

Drainage in the area is westerly as part of the Lewis Creek drainage basin. Hollow Brook, the perennial waterway closest to the site, is almost 2000 feet to the north. A small intermittent stream is located along the south and west margins of the landfill area. Although the surface waters in Lewis Creek are intended to be classified as "B" (suitable for drinking with treatment), samples taken in 1956 indicated class "C" (unsuitable for drinking) coliform levels (Vermont Department of Water Resources, 1968, p. 16).

Elevations at the landfill site are above flood levels from any streams. However, Hollow Brook to the north is actually at a higher level than the site. Surface flooding of the site from Hollow Brook is prevented by extensive, high deposits of gravel between the landfill site and Hollow Brook. These deposits should be partially preserved from commercial gravel excavations to prevent southward diversion of Hollow Brook through the landfill site.

Soils: From the point of view of soils and topography throughout Chittenden County, the South Hinesburg area is considered as having good potential for sanitary landfills (Sargent and Watson, 1970). However, the detailed soils map of the area by the Soil Conservation Service (Figure 3) shows some limitations for landfills. A summary of the pertinent aspects is presented in Table 1.



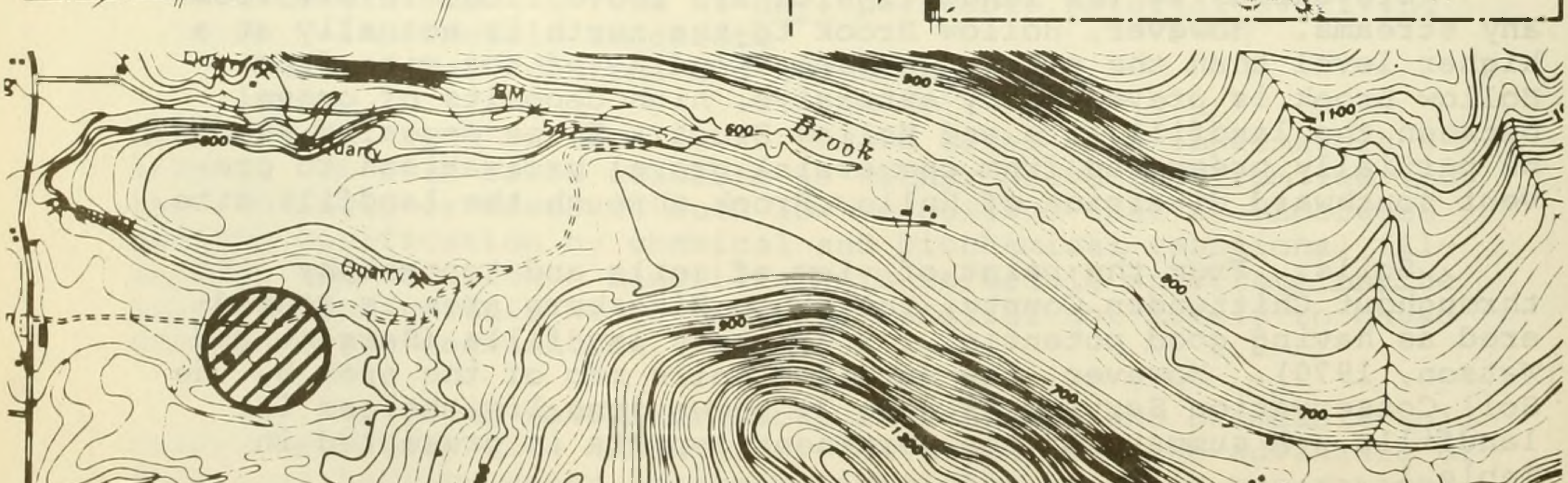


Figure 1: (top) Location of site on County Highway Map(diagonally-ruled circle.

Figure 2: (bottom) Topography at site and vicinity (diagonally-ruled circle).

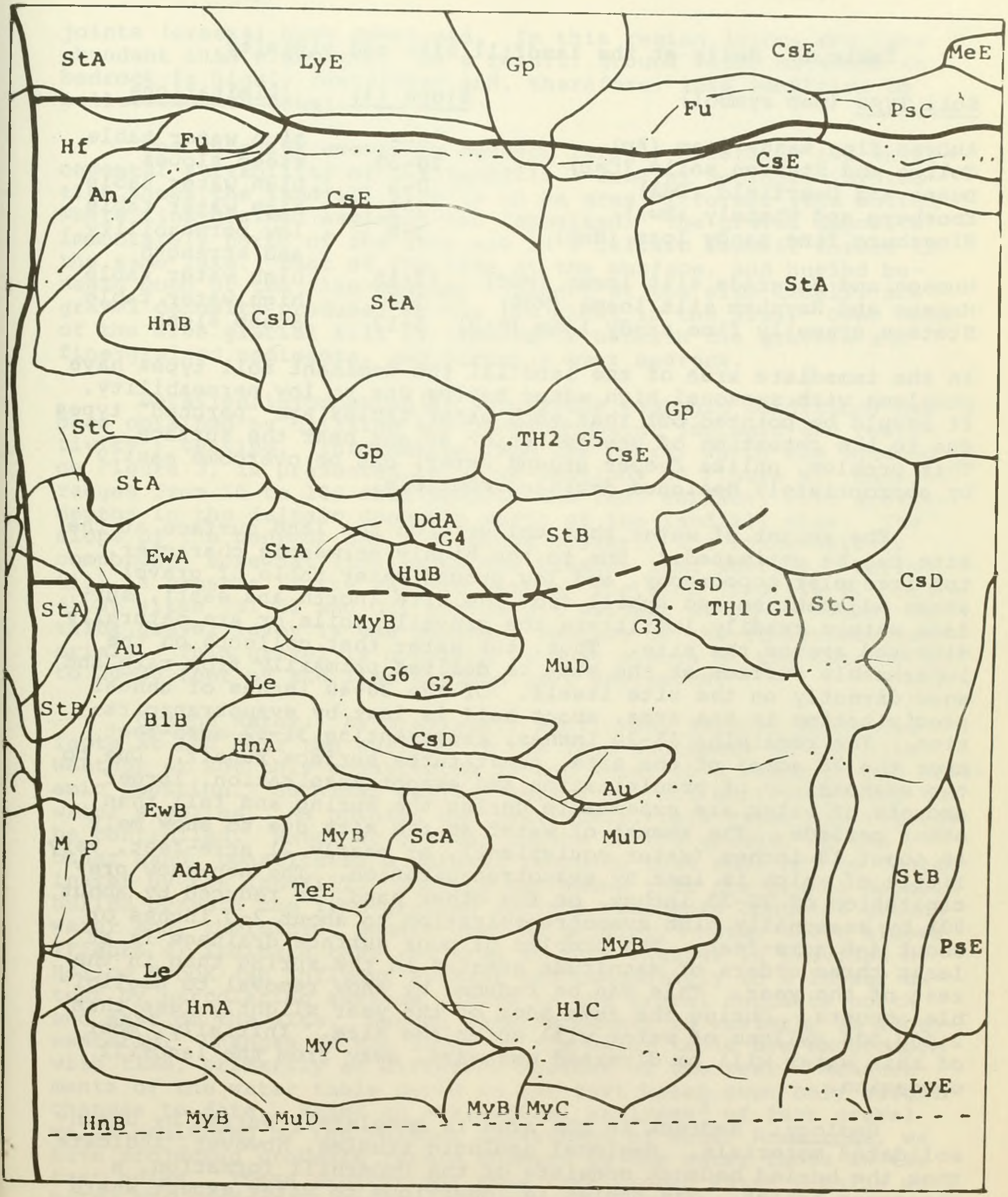


Figure 3: Detailed soils map of the landfill area by Soil Conservation Service. Units are explained in Table 1. TH = test hole; G = geophysical test.

Table 1: Soils at the landfill site and vicinity.

Soil Type (map symbol)	Slope (%)	Limitations
AuGres fine sandy loam (Au)	---	high water table
Colton and Stetson soils (CsD)	20-30	steep slopes
Duane and Deerfield (DdA)	0-5	high water table
Enosburg and Whately (EwA)	0-3	high water table
Hinesburg fine sandy loam (HnB)	3-8	low permeability and strength
Munson and Belgrade silt loams (Mud)	12-15	high water table
Munson and Raynham silt loams (MgB)	2-6	high water table
Stetson gravelly fine sandy loam (StB)	5-12	steep slope

In the immediate area of the landfill the dominant soil types have problems with seasonal high water tables due to low permeability. It should be pointed out that such water tables are "perched" types due to the retention of precipitation at and near the surface. This problem, unlike deeper ground water, can be overcome easily by appropriately designed drainage controls.

The amount of water that collects on the land surface at the site can be estimated.[1] Due to the highly permeable character, the irregular topography, and low ground water table of gravel areas adjacent to and uphill from the site (north and east), surface waters readily infiltrate the gravelly soils or are naturally diverted around the site. Thus, the water that collects on the impermeable surface at the site is derived primarily from rain and snow directly on the site itself. Of the 30-40 inches of annual precipitation in the area, about half is lost by evapotranspiration. The remaining 15-20 inches, representing 31-42 acre-feet over the 25 acres of the site, constitutes surface runoff. Due to the seasonality of precipitation and evapotranspiration, larger amounts of water are expectable during the spring and fall than other periods. The amount of water at the site due to snow melt is about 10 inches (water equivalent), or nearly 21 acre-feet, very little of which is lost by evapotranspiration. The non-snow precipitation of 20-30 inches, on the other hand, is reduced by about 90% by seasonally high evapotranspiration to about 2-3 inches or about 4-6 acre-feet. The problem of poor surface drainage is at least three orders of magnitude greater in the spring than in the rest of the year. This can be reduced by snow removal to negligible amounts. During the remainder of the year slightly less than 2,000,000 gallons of water will enter the site. Initially, most of this water will be diverted westward, away from the landfill operation.

Geology: Bedrock in the area is completely buried by unconsolidated materials. Regional geologic studies, however, indicate that the buried bedrock consists of the Underhill formation, a micaceous schist. The schist is impervious to water except where

[1] Robert Hendricks, U.S.D.A., provided meteorological data and helped with estimations.

joints (cracks) have developed. In this region joints are less abundant than elsewhere. As a result, ground water movement in bedrock is highly restricted and, therefore, less sensitive to pollution than usual.

The deposits overlying bedrock largely determine the environmental suitability of the landfill. General geologic information shows the landfill site is in an area of former lake bottom where fine-grained sediment was deposited. The gravel deposits immediately north of the site are in a deltaic deposit formed in the same lake. East of the site at the surface, and buried beneath much of the fine-grained sediment at the site itself, are gravel deposits produced by the ice sheet in the area. Over much of the area glacial till is expectable beneath the gravels and fine-grained sediments, and directly over bedrock.

Detailed information on subsurface geologic conditions has been obtained by drilling and by geophysical (seismic and resistivity[2]) testing. Information from the tests, which are located on Figure 3, is presented in cross-sections in Figure 4. Bedrock ranges from 50 to 100 feet beneath the land surface, with greater depths in the deltaic deposits north of the landfill site. The slope of the bedrock has a distinct westerly and southwesterly component, somewhat similar to the present land surface. Buried till is present in the eastern part of the area (profile A, Figure 4) at sites TH1-G1 and G3, but is not evident at other sites. A thick gravel layer is the dominant feature of the subsurface materials. This gravel is overlain in most places at the site by up to 20-30 feet of the fine-grained lake sediments.

Ground Water: As previously mentioned, perched water collects at and near the surface of the lake sediments at the site. Whether or not this constitutes ground water is a semantic and academic question. Such near-surface waters are not generally used for water supplies. As pointed out previously, this water can readily be controlled. Water at greater depths in the ground, on the other hand, constitutes a natural resource that must not be contaminated by the landfill. Testing has shown that the gravel deposit buried beneath the fine-grained surface sediments contains ground water and, therefore, constitutes an aquifer. Water table slopes (Figure 4) indicate that recharge to this aquifer is provided by Hollow Brook (an influent stream) and undoubtedly to a lesser extent by percolating surface waters in the gravel deposits north and east of the site. Ground water movement is westerly to southwesterly. Changes of the level of the water table are expectable with time, primarily at different seasons of the year. Measurements of the water table depth in the test holes show only slight changes to date. Based on statistical analyses[3] of four gravel wells monitored by the Vermont Department of Water Resources, we have projected probable future changes in the water table in the test holes. These projections show that ground water remains well below the surface at all times, with seasonal fluctuations no more

[2] Resistivity data provided by Arthur Huse.

[3] Statistical work by Steven Pendo.

than about 10 feet.

From the viewpoint of ground water contamination it is important to note that the landfill site is not a recharge area for the gravel aquifer. Significant downward movement of leachate through the fine-grained sediment is not expectable. Percolation tests in such materials have shown exceedingly low rates of movement (Mullen, 1972; Waite, 1971). Thus, with special precautions to control and monitor leachate movement, ground water contamination can be prevented.

Miscellaneous: A variety of aspects deserve brief mention.
1. Biota: The immediate area of most of the landfill site has been actively farmed until the present time, so that no natural plant species are endangered. Along the periphery of the landfill on all but the north and northwest sides are common species of mixed hardwood and softwood trees, grasses and sedges. Animals in the area are likewise common species. No damage to ecologically fragile or otherwise unique biota is likely to occur.

2. Forest reserves: The landfill site mostly lacks timber except along the eastern fringe. The site is on the margin of the productive forest area of the Green Mountains, with soils rated fair at best for potential forest productivity (Gilbert, 1970).

3. Agricultural reserves: According to Carlson et al. (1970, p. 3), the landfill area is in a classification noted as "..the least suitable of all land now being used for agriculture in the county." Moreover, the area's present agricultural land use is considered by the same authors to be marginal to poor.

4. Natural areas: The site has no known value as a natural area deserving protection for biologic, geologic, archaeological, or other natural characteristics.

5. Aesthetics: View of the landfill site is blocked by high banks of gravel to the north, by the Green Mountains and tree cover to the east, and by a fringe of trees along the south and southwest margins. The only open view of the site is from the northwest and west. This will be remedied by tree plantings. Thus, complete privacy for the operation will be provided from all public vantage points.

6. Erosion: Erosion is not a problem in the area of fine-grained soils due to the soil cohesion and particle size. In gravel soil areas, only artificial slopes greater than about 65% show evidence of instability and erosion.

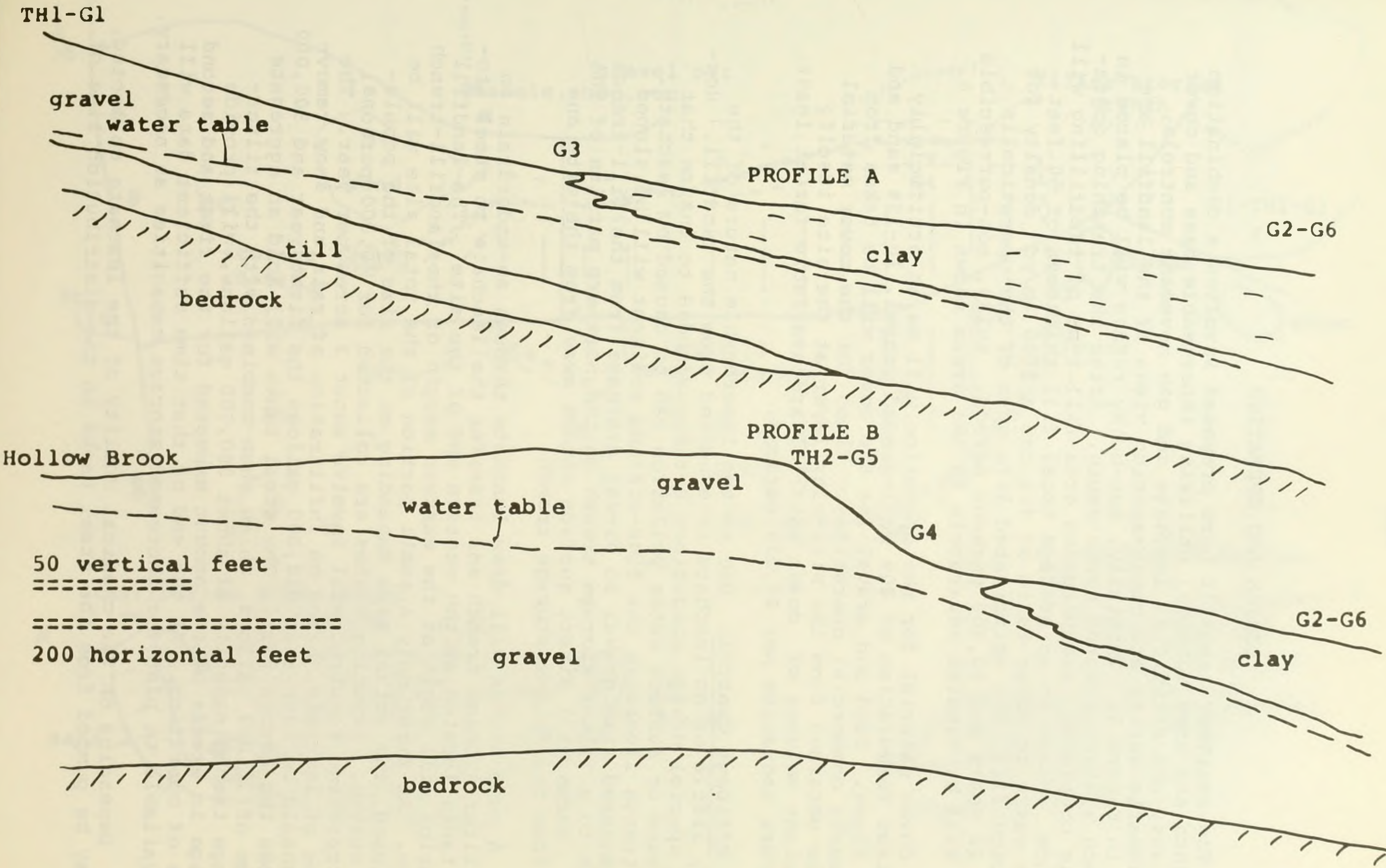


Figure 4: Approximate east-west (upper) and north-south (lower) cross-sections of landfill area. See Figures 3 and 5 for locations of tests.

DESIGN AND OPERATION

The sanitary landfill here proposed involves a combination of trench and area methods, utilizing impermeable base and cover materials, and artificial leachate and gas movement controls. Diagrammatic aerial and cross-section views of the landfill are given in Figure 5. Initially, non-bulky refuse will be placed in a trench system oriented north-south. After the trenching operation is completed, a superposed area-fill type of landfilling will commence. Based on an average total fill thickness of 50 feet with a waste to cover ratio of 4:1 and a 1000 lb/yd^3 density for compacted fill, the anticipated life span of the operation is about 22 years per 40,000 persons served. Bulky, non-putrescible items will be handled separately in the areas shown in Figure 6.

Cover material for the operation will be an artificially pre-mixed formulation of 80% well-graded gravel, 10-15% sand and 5-10% fines. Sand and gravel for the cover will be taken from the nearby commercial operations. Fines for the cover material will be obtained from the silt-clay layer at the site itself. Sufficient volumes of cover material are available for at least 100 years operation per 40,000 persons.

Effluent Control: Due to the impermeable nature of the cover, little or no leachate is expected from the landfill. However, special design conditions are recommended to insure that no ground or surface water pollution can be caused by leachate. Fill-trench floors in the fine-grained sediment will be sloped and veneered with gravel to direct drainage from the fill-trench system to a filter-storage trench on the northern margins of the fill. Berms will divert surface waters away from the site and away from the filter-storage trench.

A pump system will draw leachate through an underdrain in the filter-storage trench and transfer the leachate to steel storage tanks located at the western end of the site. The landfill operation will begin at the eastern margin of the landfill-trench system. At first only a small portion of the total site will be developed, the actual size depending on the size of the population served. Assuming wastes are collected for 40,000 persons, the trenching required will involve about 3 acres per year. The volume of leachate, based on infiltration of rain and snow removal, should be less than 250,000 gallons the first year and 500,000 gallons the second year. The steel tanks will hold an aggregate volume of 30,000 gallons, which when combined with the filter-storage trench capacity of about 500,000 gallons, will provide storage in excess of the amount expected for the first and second years of operation. At the end of that time sufficient data will be available to plan for increased storage capacities as necessary.

Depending on the chemical quality of the leachate collected, it may be pumped from the steel tanks to the distribution line of

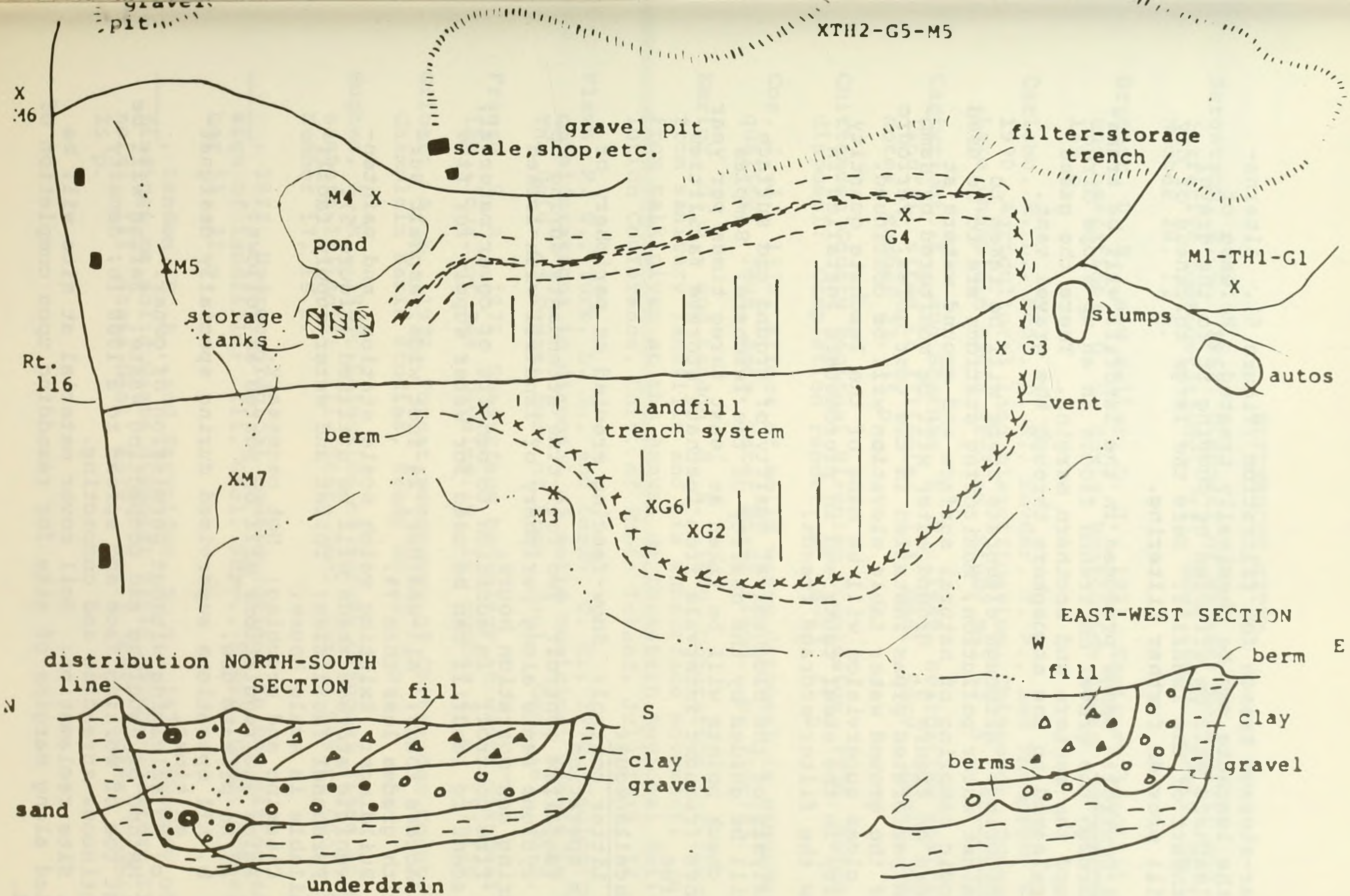


Figure 5: Schematic plan and section views of landfill area. M = monitoring stations; G = geophysical tests; Th = test hole.

the filter-storage trench for filtration (Figure 5). Alternatively, the leachate may be chemically treated. Release of treated leachate will be effected by pumping it to the gravel area northeast of the landfill. Here the large thickness of dry gravel will provide further filtering.

Gas Control: Gases produced in the landfill will be transmitted through the gravel on trench floors in an up-slope direction toward the eastern and southern margins. There the gases will be released to the atmosphere through the gravel vent.

Monitoring: Although elaborate steps will be taken to guard against water pollution, monitoring stations are to be used for periodic sampling of natural surface and ground waters at sites shown on Figure 5. Ground water will be monitored by sampling from perforated pipes installed in the test holes. Periodic checks of the ground water table elevation will be continued. Finally, close supervision will be made of the leachate quantity and quality in the steel tanks and in piezometers installed in and below the filter-storage trench.

Analysis of the biochemical quality of ground and surface waters will be guided by the quality of the leachate. Samples from all check points will be taken at least three times per year and at more frequent intervals from leachate storage facilities as required.

Miscellaneous:

1. Litter control: Snow-fencing erected on periphery of trench in operation.
2. Vandalism control: Two full-time attendants during operation; cyclone fence along periphery of landfill with locked gates during non-operation hours.
3. Fire control: In addition to benefit of cover material, pond adjacent to landfill can be used for water supply for fire fighting.
4. Access roads: All-weather, 24 foot wide, asphalt surfacing with grades less than 7%.
5. Buildings: Existing weigh scale station, and maintenance and vehicle storage sheds will be utilized (Figure 5).
6. Personnel facilities: Toilet and water supply facilities available in scale house.
7. Clearing and grubbing: Not necessary.
8. Rules and regulations will be posted as follows:
   a. No private use.
   b. All operations supervised during specially designated times.
   c. No salvaging without permission of owner.
9. Method of handling and compacting waste: Refuse will be dumped at toe of working face and spread to a 1000 lb. density with continuous spreading and compacting.
10. Site reclamation: Soil cover material at site will be stockpiled along margins of site for resodding upon completion of landfill.

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APPENDIX: Site Evaluation Considerations for Landfill Location

Economic Factors:

Initial-

- acreage
- estimated cost per acre
- estimated access road cost
- estimated site clearing cost
- estimated site modification cost
- estimated building cost
- estimated engineering costs
- estimated equipment costs
- estimated fencing costs

Annual-

- salaries and benefits
- equipment operation
- maintenance and repair
- snow removal
- depreciation
- amortization of initial costs
- administrative overhead
- cost per capita

Other-

- reclamation
- recycling-distance from population centroid

Social Factors:

- prevailing winds (incineration; dust; odors; noise)
- aesthetics
- present landuse on site
- present landuse adjacent to site
- landuse plans and zoning
- fire protection
- traffic flow congestion and safety
- road conditions leading to site

Environmental:

- site volume
- site longevity
- substrate character and thickness
- cover material character and volume
- bulky item space
- distances to perennial streams, and floodplains
- slope
- groundwater depth and flow direction

Environmental: (continued)

gas control
surface water control
distance to nearby wells
monitoring
near present or future sewage treatment plant