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LEACHATE MIGRATION INVESTIGATION

Prepared for:
Village of Wellsville

Prepared by:
Recra Research, Inc./
Wehran Engineering, P.C.

RECRA RESEARCH, INC.
TOTAL CHEMICAL WASTE MANAGEMENT
THROUGH APPLIED RESEARCH

P.O. Box 448 / Tonawanda, New York 14150

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INVESTIGATION

Prepared for:

Village of Wellsville
Department of Public Works
Wellsville, New York 14895

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February 27, 1980

RECRA RESEARCH, INC. P.O. Box 448 / Tonawanda, New York 14150 / (716) 838-6200
TOTAL CHEMICAL WASTE MANAGEMENT THROUGH APPLIED RESEARCH

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HYDROGEOLOGIC INVESTIGATION

A hydrogeologic field investigation of the subject landfill was conducted during the week of October 15, 1979. The specific objectives of the investigation were to:

(1) Define the general geologic and ground-water conditions around the existing landfill and the relationship of the landfill to the local hydrogeology.

(2) Investigate the potential for leachate migration to Duffy Hollow Creek via subterranean pathways and estimate its contribution to the problem existing in the creek.

(3) Preliminarily evaluate the hydrogeologic constraints or advantages to certain leachate control programs at the site.

In order to meet the above objectives, without undertaking an additional boring program, the following tasks were performed:

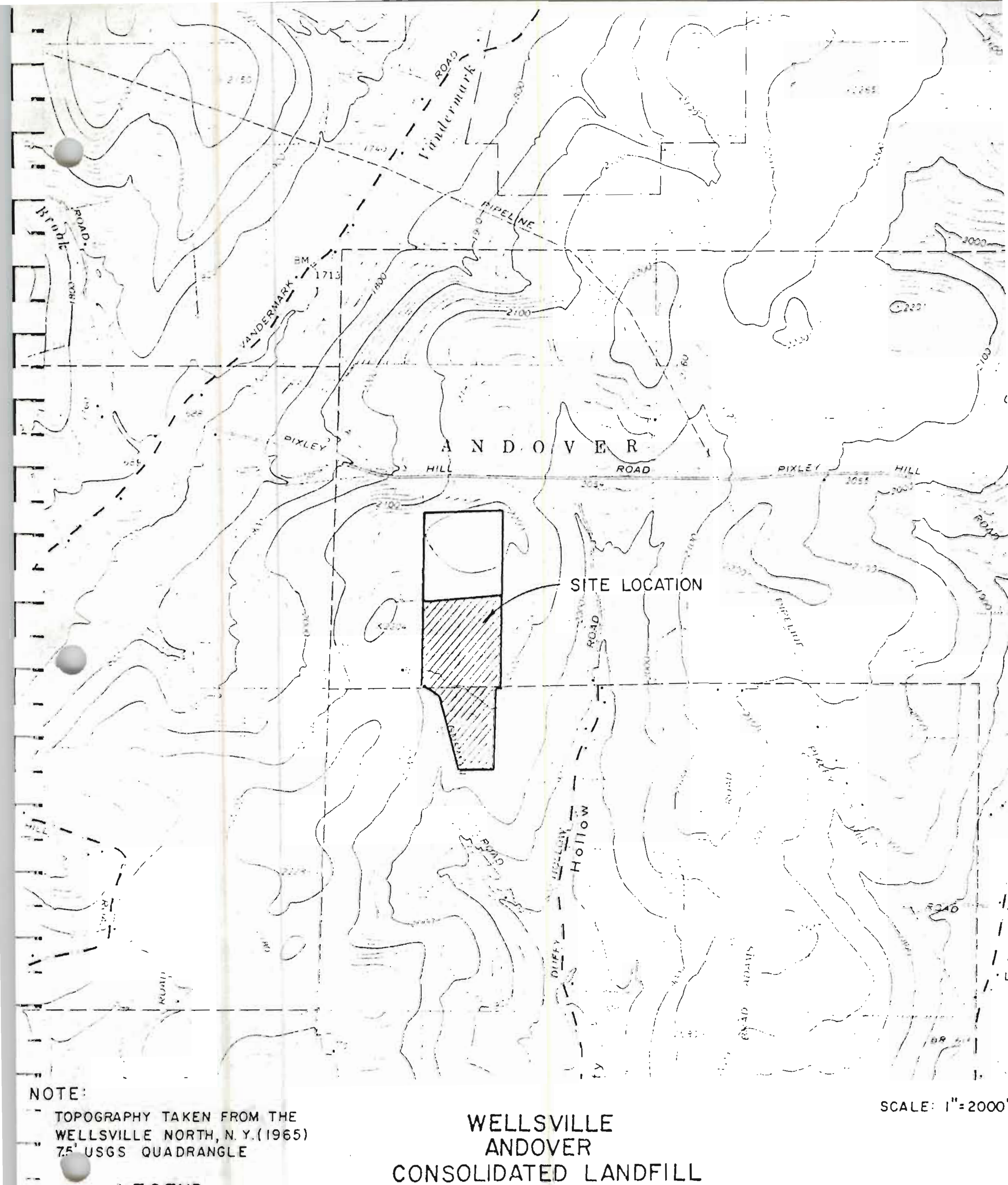
(1) Test pit excavations at six locations around the landfill.

(2) In-situ permeability tests at three locations within and around the landfill.

(3) Earth resistivity investigations on downgradient portions of the site.

(4) Specific conductivity survey of springs and streams in and around the landfill site.

The above tasks were performed jointly by Recra Research, Inc. and Wehran Engineering, P.C. in conjunction with Wellsville Department of Public Works personnel. Existing site specific data was used, where possible, to augment the previously described tasks. Existing data included boring logs, soils reports, seismic survey data, existing



NOTE:

TOPOGRAPHY TAKEN FROM THE
WELLSVILLE NORTH, N. Y. (1965)
7.5' USGS QUADRANGLE

SCALE: 1"=2000'

WELLSVILLE ANDOVER CONSOLIDATED LANDFILL

TOWNS OF ANDOVER
AND WELLSVILLE
ALLEGANY COUNTY, NEW YORK

FIGURE 1
LOCATION MAP

LEGEND

☐ APPROXIMATE PROPERTY BOUNDARY

▨ FILL SITES CONSIDERED

ground-water wells, permeability test results and landfill plans.

Test Pit Investigation

Six test pits were excavated around the Wellsville Sanitary Landfill to characterize the unconsolidated soil conditions and permit the installation of monitoring points in each pit. A P&H Track mounted backhoe was employed to extend the test pits as deep as possible. Test pits ranged from 11 to 18 feet in depth. Soil samples were collected at intervals of several feet in each pit. Jarred samples are available for inspection at the offices of Wehran Engineering in Middletown, New York. Logs of all test pits are included in the Appendix of this report. Following excavation, the test pits were outfitted with Vyon tipped well points on one-inch PVC risers. All pits were backfilled with excavated soils. The test pit locations are shown on Map 1 in the rear pocket of this report. The test pits permitted detailed observation of the character of the surficial materials and enabled the construction of additional monitoring points in the upper portions of the zone of saturation around the perimeter of the landfill. Test pits were terminated where either saturated conditions limited further excavation or pit excavation became extremely difficult due to the dense nature of the unconsolidated soils. Test pits typically encountered brown to gray Silty CLAY to CLAY and SILT, some medium to fine Gravel, little coarse to fine Sand with frequent angular to subangular Siltstone and Sandstone rock fragments.

In Situ Permeability Testing

During the course of the field work, three in situ permeability tests were conducted to evaluate the soils at various depths around the site. Test locations are illustrated on Map 1. Location K-1 was set up below the old landfill in Test Pit TP-2 approximately 3.5 feet below land surface Test K-2 was conducted about ten feet below original land surface in the east, central end of a trench excavation prepared for fill. Test K-3 was conducted six inches below original land surface south of the K-2 location. (Map 1).

The procedure for testing soil permeability followed guidelines established by Cedergren (1977) and involved the implacement of Shelby Tubes (2.85 to 3.00 inches in diameter) firmly into the scoured, level surfaces to be tested. The disturbed zone around the outside of each tube was recompacted with three or four "lifts" of native soil to prevent short-circuiting around the base of the tube. Two inches of pea gravel was placed in each tube or permeameter to prevent soil scour during filling operations. Once the permeameter was set in place, it was filled with clear water and the infiltration rate was monitored through time. When the rate of head decline per unit time became constant, the requirements for accurately determining the soil permeability were met.

Two permeability tests were conducted at the K-1 location. Both tests failed at maintaining a constant rate of head decline per unit time. This is illustrated on a plot of K-1 in the Appendix of this report. The poor test results at K-1 were attributable to "short circuiting" of water around the base of the permeameter. This could be observed during the test. Subsequent efforts to prevent loss of head by short circuiting could not be prevented and testing at this location was abandoned.

Much better results were obtained at the K-2 and K-3 locations. At K-2 an adequate seal was attained and the test procedure continued for two days with no head drop recorded. As no head drop occurred over a two day period, no actual permeabilities could be computed. However, it is reasonable to predict permeabilities on the order of less than 10^{-6} cm/sec based on a two day observation period. The K-2 test was located in the base of a landfill trench and the soils which were tested had undergone compaction. Water was ponded adjacent to the permeameter suggesting compact, saturated soil conditions in this area.

A plot of the K-3 test results in shown on Figure 2. The K-3 results indicated a steady drop per unit period of time following initial saturation of the soil. The data plot suggested that the permeability of the soil could be computed from the data collected. The following formula from Cedergren (1967) was used to compute permeability:

$$K_m = \frac{\pi \cdot D}{11(t_2 - t_1)} \ln \frac{h_1}{h_2}$$

Where: D=Diameter of Permeameter (cm)

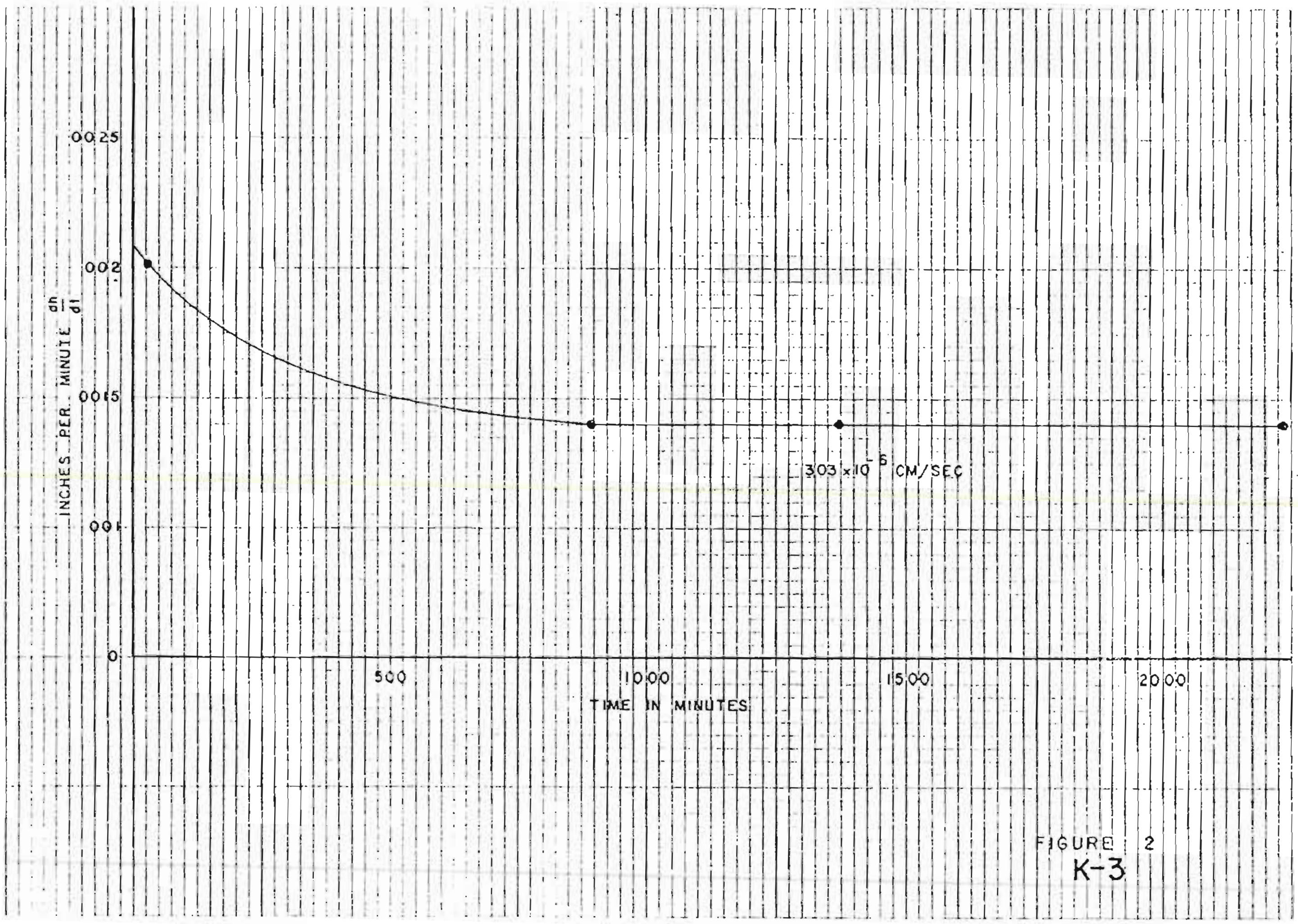

INCHES PER MINUTE $\frac{dh}{dt}$
0025
002
0015
001
0
500
1000
1500
2000
TIME IN MINUTES
3.03×10^{-6} CM/SEC

FIGURE 2
K-3

h_1=Piezometric Head at Time t_1 (cm)

h_2=Piezometric Head at Time t_2(cm)

t=Time (seconds)

ln=LOG_E base 2.31

and Km=Mean Coefficient of Permeability (cm/sec)

The computations for K-3 indicate a permeability of approximately 3 x 10^{-6} cm/sec. A discussion of these findings is included in the Ground Water Section of this report.

Earth Resistivity Assessment

An earth resistivity survey was conducted during the week of October 15, 1979 to help define the extent, if any, of leachate migration in areas south and southeast of the Wellsville Andover Consolidated Sanitary Landfill. The study employed the services of a two man field crew composed of a Wehran Engineering hydrogeologist and either Recra Research or Wellsville DPW technical personnel. All work was performed with a Bison Model 2350 earth resistivity meter. Resistivity investigations were conducted around and within the landfill complex with rather extensive investigations to the south and southwest of the landfill topographically and hydraulically downgradient from the subject site.

Earth resistivity study is a technique for measuring the variations of subsurface geologic strata by passing successive electrical currents through the earth's surface in the area of interest and measuring resultant voltage drops between input and measuring electrodes. Earth resistivity readings vary, depending on the lithology, density, degree of saturation and nature of saturation of the geologic strata tested.

Where ground-water quality varies significantly with respect to total dissolved solids, and hence electrical conductivity, contrasts in ground-water quality can be discerned electrically. However, natural and artificial conditions affecting the conductivity/resistance of subsurface materials will often mask the existence of ground-water pollution. Therefore, its application is limited to those areas where significant variations in ground-water quality occur which can be differentiated from other changes in resistivity due to factors other than water quality. According to Stollar & Roux (1975) the following criteria are pertinent to the success of evaluating pollution migration by resistivity methods:

(1) Contrast between the conductivities of contaminated and natural ground water.

(2) Depth below land surface to the top of the contaminated ground water body.

(3) Thickness of the contaminated ground-water body.

(4) Lateral variations in surficial geology.

Preliminary investigations suggested that the Wellsville Landfill might be a suitable setting for the use of resistivity to define pollution migration. A discussion of Earth Resistivity describing the basis for the work performed at the landfill is contained in the

Appendix of this report. A discussion of this study's findings is contained in the Earth Resistivity Study Section of this report.

Specific Conductivity Field Survey

As part of the overall Hydrogeologic Investigation, a specific conductivity survey was performed in the field on October 18, 1979 as a joint effort by Recra Research and Wehran Engineering. The purpose of the survey was to monitor, on an instantaneous basis, the condition of springs and streams in and around the landfill with specific emphasis on observing changes in conductivity in the downstream reaches of the unnamed tributary to Duffy Hollow Creek. The locations of the conductivity survey are shown on Map 1 in the rear pocket of this report.

Conductivity is an indirect measure of the total dissolved solids in a water sample since dissolved solids increase the electrical conductant properties of water. Specific conductance is the reciprocal of resistance, the units of measure being umhos/cm rather than ohms. Conductivity readings were taken using a YSI Portable Conductivity Meter with automatic temperature compensation. Conductivity readings were taken in pools of spring or stream water or, where flow was too low or too turbulent, in a sample taken from the spring or stream and measured at the time of collection.

Conductivity and temperature readings are included in the Appendix of this report. As can be seen from a comparison of the data results and the sampling locations, conductivity readings from upgradient spring and stream sources are in the range of 40 to 60 umhos/cm, whereas, the unnamed tributary to Duffy Hollow Creek, below the point of major leachate discharges from the landfill, exceeds 1000 umhos/cm. The source of sample C-13 is a leachate discharge from the site and measures over 4000 umhos/cm.

The conductivity readings are indicative of the actual total dissolved solids content and, according to Davis and DeWiest (1965), follow a proportional relationship depending on the type of dissolved solid present. Generally, most total dissolved solids fall within 0.6 to 0.75 of the conductivity reading taken. A conductivity of 4000 mhos/cm would suggest a total dissolved solids content likely to fall into a range of 2400 to 3000 mg/l. The background water quality readings of 40 umhos/cm indicates that natural ground and surface water in this area is very soft and has a very low total dissolved solids content. The very low buffering capacity of this water plays a significant role in the overall condition of the unnamed tributary and Duffy Hollow Creek.

Figure 3 illustrates, in profile, the effects of leachate discharges from the landfill on the unnamed tributary to Duffy Hollow Creek. Sharp rises in the conductivity are evident at points of leachate discharge to the stream. At station C-21, conductivity results are still highly elevated above the background reading at station C-8.

Table 1 contains results of conductivity readings from three test pit monitoring points installed in October, 1979 and sampled on October 19, 1979.

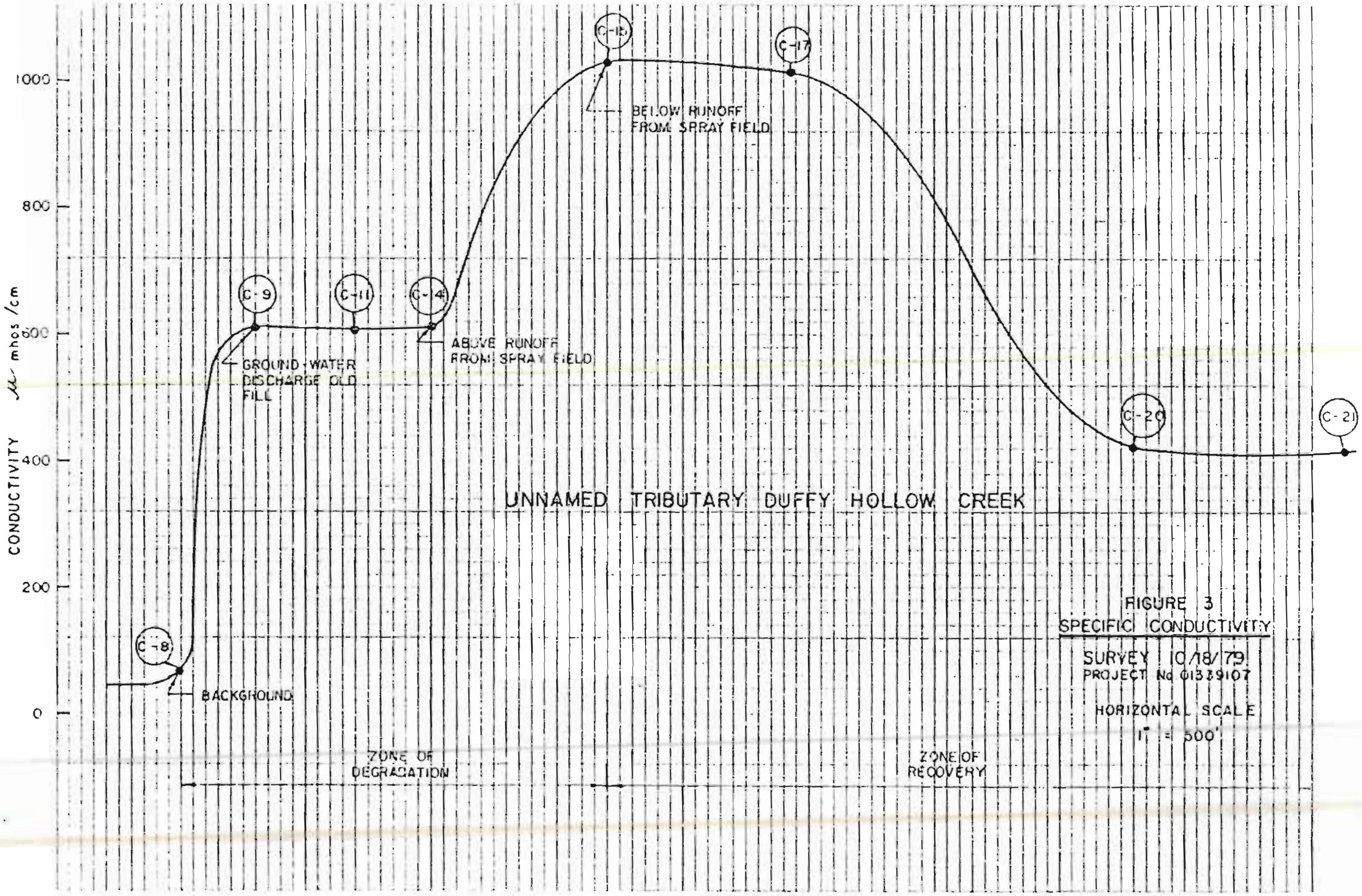


FIGURE 3
SPECIFIC CONDUCTIVITY

SURVEY 10/18/79
PROJECT No 01339107

HORIZONTAL SCALE
1" = 500'

TABLE 1

SPECIFIC CONDUCTIVITY RESULTS-Samples Collected 10/19/79

Test Pit 1	25° C	519 mhos/cm
Test Pit 2	25° C	564 mhos/cm
Test Pit 5	25° C	130 mhos/cm

Results suggest a four-fold increase in conductivity in ground water in the unconsolidated soils below the site. Such changes are indicative of possible contamination increasing the total dissolved solids concentration in ground water. Specific donductance laboratory results are included in the Appendix.

GEOLOGY

The geology of the site consists of three principal units:

(1) Unconsolidated glacial debris that forms a thin veneer on the upland slopes and is, according to Woodruff (1942), never more than a few inches to a few feet thick.

(2) Unconsolidated colluvial material that has formed on the upland slopes from the mass wasting of the Paleozoic hills and is largely indistinguishable from glacial debris of local origin.

(3) Bedrock consisting of Upper Devonian shales, siltstones and sandstones of the Conneaut Group which form the consolidated rock beneath the site.

Colluvium & Glacial Debris

Unconsolidated glacial debris was not differentiated from colluvium in the field investigation although numerous cobbles of granite and grannodiorite from the Canadian Shield were scattered over the site. Test pits 1-5 did not encounter erratics beneath the upper few inches. Rock fragments in the colluvium were typically brown to gray siltstones & sandstones, angular to sub-rounded, and representative of the underlying bedrock. As reported previously, the logs for Test Pits 1-5 are included in the Appendix of this report. As can be seen from the test pits, very little lithologic or textural changes occur at depth. Gradation analyses were performed on three samples. These are also included in the Appendix of this report. Analyses show the gravel, sand, clay & silt compositions for each sample were within several percent variations of each other. The colluvium generally became very dense beyond eight feet and contained higher proportions of flaggy sandstone, siltstones and ferruginous shale rock fragments.

Many of the rock fragments, obviously beyond the direct influence of the landfill, were iron stained and iron staining was frequently observed on the sub-angular structural partings of the soil peds. The source of this natural iron is probably derived from the iron-bearing minerals associated with the bedrock which subsequently weathered to the present colluvial debris. The high iron concentrations inherently part of the natural geologic setting may be a significant factor in the overall iron concentrations in the leachate discharges from the site.

The total depth of each test pit was limited by the excavation capability of the backhoe and, in the case of TP-5, by ground water entering the pit to the extent that continued excavation was not feasible. In no case was bedrock encountered in the test pits constructed in October, 1979 although excavation up to approximately 18 feet was completed in TP-1, TP-3 and TP-4.

Depth to bedrock is variable across the site. Previous test pits by the SCS and seismic survey work by the New York State DOT generally agree. The previous test pit investigation appears to have encountered zones of shallow bedrock not revealed by the seismic work. One area of shallow bedrock (less than four feet) on the north side of the present work area was uncovered during the trench-fill operation and present filling of refuse is occurring around that zone. Neither the seismic nor previous test pit exploration encountered this rock zone. Additional test pit exploration around the critical zones of shallow bedrock defined by the seismic survey could improve future landfill design and operational plans.

Bedrock

Bedrock underlying the site is composed of medium to fine-grained flaggy sandstones and shales of the Whitesville formation. The Whitesville formation is underlain by the Wellsville formation and has similar lithic character. According to mapping by Woodruff (1942) the site is located on the north limb of a syncline with bedding dipping gently south several tens of feet per mile. According to Woodruff (1942), most of the Whitesville formation resulted from marine deposition. However, some beds are unquestionably of non-marine origin. The field investigation of October, 1979 did not involve a detailed evaluation of the bedrock. Most of the bedrock exposures observed in the vicinity of the site were brown to olive-gray arenaceous shales and fine-grained sandstones of probable marine origin. Some of the beds contain calcareous cement. The surface of the bedrock was typically highly fractured with iron staining. According to Woodruff (1942, p. 120):

> "Traces of iron are present in all of the rocks and there are a few beds that can be considered as low grade iron ores. The rocks along some of the streams are sometimes stained by the hydrated iron oxides."

Ferruginous bedding in Duffy Hollow has been observed by Woodruff (1942) and ferruginous rock fragments were observed in the colluvium during the test pit investigation in October of 1979. Although the iron staining in Duffy Hollow Creek and its tributary near the landfill should not and cannot be attributed to natural conditions, the possible "synergistic" effects of leachate in contact with iron-rich native materials could accentuate the visual degradation of these local streams. This is discussed further in the Ground Water section of this report.

GROUND WATER

An evaluation of ground-water occurrence and flow was based on the following:

(1) Test boring and water level data from Parratt Wolff Inc.

(2) Field observations and work performed October, 1979 as previously described.

(3) Water level data collected September 26, 1979 by Recra Research at the six Parratt Wolff test wells

Much of the information on ground-water occurrence and flow is conjectural. The construction techniques of the six test wells may have been insufficient to prevent surface water infiltration and abnormally high water level readings may be resulting in several of the test wells. All of the test wells were constructed within the unconsolidated colluvium above bedrock. No cluster wells or nesting piezometers were installed to monitor vertical components to the ground-water flow system. The following comments, in our opinion, define the probable ground-water conditions in and around the landfill site based on the above sources of information:

(1) A localized ground-water table occurs in the unconsolidated colluvium. The water table under the site varies between zero and 35 feet below land surface. Average annual water-table fluctuations are unknown but, based on a comparison between a July, 1977 and September, 1979 reading, suggest fluctuations up to ten feet.

(2) Springs on the upland slopes are indicative of both perched

water zones that discharge when precipitation exceeds infiltration and seasonal ground-water discharges from the localized ground-water table.

(3) The ground-water table in the colluvium probably recharges a deeper regional aquifer system in the Whitesville and Wellsville formations. The bedrock aquifer occurs under semi-confined conditions. Ground-water is encountered in the joint, fractures and bedding plane partings in the bedrock. Characteristics such as flow and potential ground-water yield of the bedrock aquifer are largely dependent on the number, extent, orientation and degree of interconnection of these fractures. The regional semi-confined aquifer occurs at an elevation below the localized ground-water table. This is based on a static water level measurement of greater than 50 feet from a bedrock well at a summer home 500 feet south of the site. Further substantiation of this is necessary.

(4) Ground-water flow directions in the ground-water table and the semi-confined aquifer are generally to the south. Ground-water flow contours in these types of geologic materials almost always follow the local topography although gradients are somewhat more subdued. Gradients of the ground-water table in the colluvium based on Recra Research's September, 1979 water level measurements average between two and three percent. Gradients in the bedrock aquifer are not known at

present.

(5) According to Woodruff (1942) the bedrock aquifers of the Wellsville quadrangle (15 minute) yields large supplies of good quality water although many of the sandstones contain a calcareous cement which results in moderate hardness. Iron and perhaps hydrogen sulfide concentrations could be natural sources of problems in wells in the area based on literature review and on-site observations.

Ground Water & Leachate Generation

The relationship of the landfill to the bedrock aquifer is unknown at present. The low permeabilities in the colluvium discussed previously may inhibit direct migration of leachate into the bedrock. Also, when cell construction for landfilling progresses, the base of the trench becomes compacted. This is probably the reason that no drop of water was noted in the K-2 permeability test. What, in effect, appears to be happening is that the trenches, when completely filled, act as collection sumps for leachate. When the trenches fill, they overflow to the leachate collection system. This "bathtub" effect within the landfill trenches may provide an effective collection system for leachate. This would have to be evaluated further. The present system air-locks continually and leachate by-passes are common. Modification of the present collection system is necessary for a number of reasons. These include:

(1) The collection system is basically non-operative during the winter months.

(2) The system air-locks continually.

(3) The spray irrigation system is overloaded and run-off from the spray field is contributing to stream quality problems.

(4) The system doesn't totally isolate clean run-off from leachate.

(5) All leachate discharges are not being intercepted.

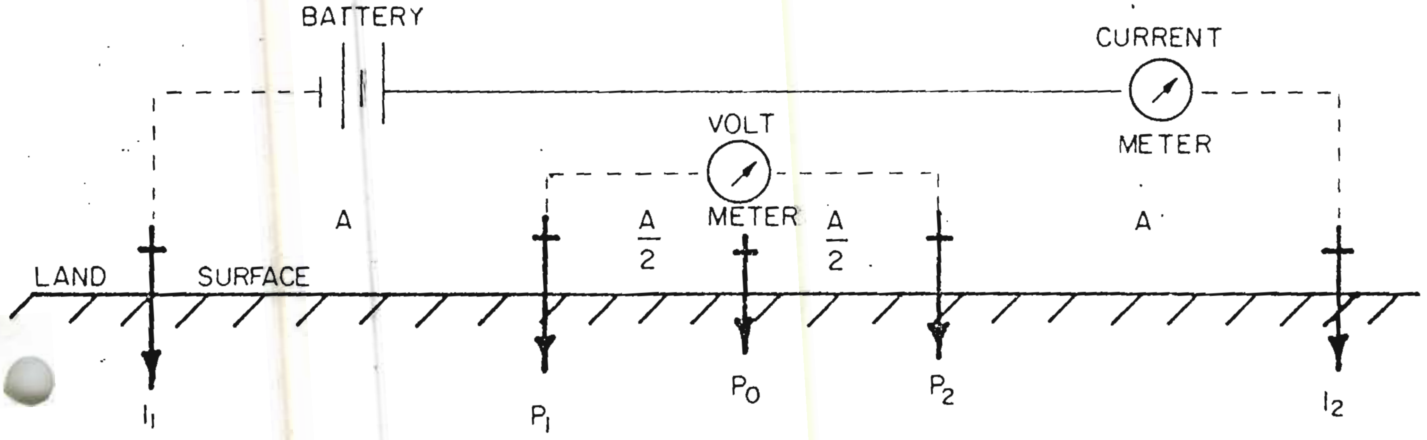
The two natural considerations in the analysis of the effects the landfill may be having on the stream are:

(1) The low buffering capacity in the stream and

(2) The geochemical effects that anaerobic leachate has on increasing the solubility of naturally occurring iron bearing minerals in the colluvium and bedrock may be pronounced.

Both of these natural conditions could be exacerbating the visual problems (iron staining) of the unnamed tributary and Duffy Hollow Creek. If these effects could be counteracted, overall reductions in the extent of the stream degradation could probably be reduced.

Water-table readings from measurements in test wells by Recra Research and levels from the test pit monitoring points are given in the Appendix.



A — A-SPACING BETWEEN ELECTRODES

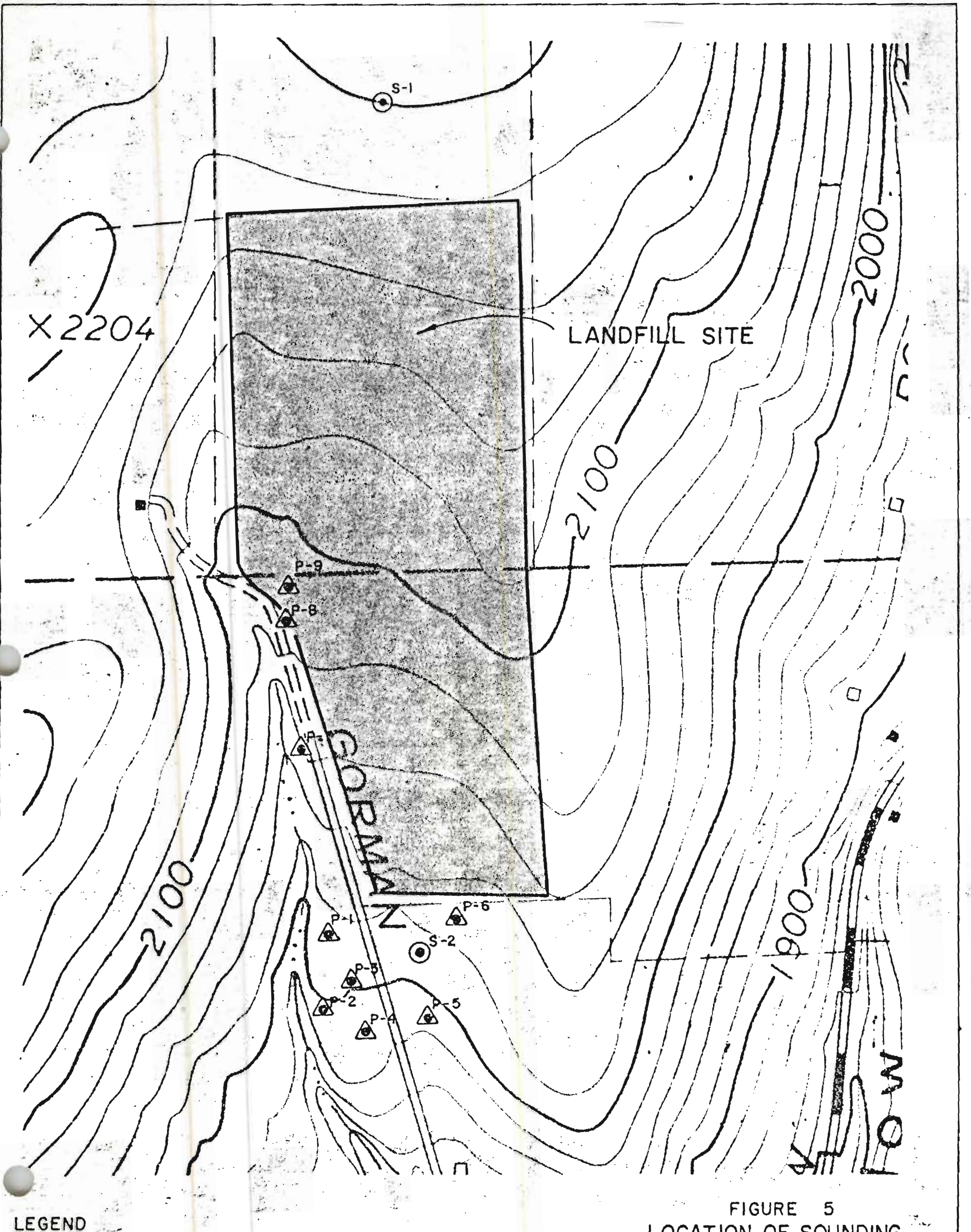
$I_{1,2}$ - CURRENT OR INPUT ELECTRODES

$P_{1,2}$ - POTENTIAL ELECTRODES

P_0 - LEE POTENTIAL ELECTRODE

FIGURE 4

WENNER
ARRANGEMENT
LEE
MODIFICATION



LEGEND

▲ PROFILE LOCATION & NUMBER

◉ SOUND STATION & NUMBER

FIGURE 5

LOCATION OF SOUNDING AND PROFILE STATIONS

EARTH RESISTIVITY SURVEY

Two resistivity procedures were used to evaluate leachate occurrence and migration at the Wellsville Andover Consolidated Sanitary Landfill. A "sounding survey" provided background information on variations in subsurface conditions with depth. Based upon the results of the soundings, an electrical "profile survey" was conducted at various depths or A-spacings to attempt a delineation of the extent of leachate contamination. For each procedure the Lee Modification of the Wenner Arrangement of Electrode Spacings was employed.

The electrode configuration or "array" is illustrated in Figure 4. The outer electrodes are the current (I) electrodes while the inner electrodes ($P_{1,2}$) are the potential, or receiving, electrodes. The Lee electrode (P_O) is placed at the center of the spread and allows successive readings on the right and left portions of the line (P_1P_O and P_OP_2). The Lee Modification was utilized to account for possible lateral changes in resistivity which could be misinterpreted as variation with depth since lateral changes in resistivity as the electrode spread increases is possible. For the sounding surveys, readings were taken along a line with the electrode spacing, or A-spacing, normally expanding at three (3) foot increments up to sixty (60) feet. Resistivity readings were taken at each incremental change in the A-spacing. Locations of sounding and profile stations are illustrated on Figure 5. Sounding S-1 on the north side of the site was run to establish background data hydraulically upgradient from the landfill. Sounding S-2 was run on the south side of the landfill, essentially downgradient from the fill areas. Soundings were not conducted on the refuse mass due to the extremely low resistive material short circuiting the input charges in the upper zones of rubbish. Resistivity readings on refuse are commonly less than 100 ohm-feet where A-Spacings are less than 100 feet.

Soundings S-1 and S-2 were selected to identify the variations of geologic conditions with depth up and downgradient of the site. Previous boring logs and seismic work on the site suggested the anticipated conditions north and south of the site with respect to depth to bedrock, water-table information and anticipated overburden quality.

Following the collection and field interpretation of the sounding data a profile survey was conducted over the western and southern periphery of the landfill site. The nine profile stations and two sounding stations illustrated on Figure 5 provide the data base for interpretation.

Sounding Data Results

Data results from the sounding survey were plotted up in two ways in order to assess changes in resistivity and identify the depths at which geologic boundaries might occur. Plots of the data are included in the Appendix. The simplest method involved the plotting of apparent resistivity in ohm-feet (X-axis) versus electrode or A-spacing (Y-axis). Interpretation requires noting where breaks occur in the shape of the curve and then relating them to the A-spacing or depth in feet. The Lee Right and Lee Left electrode readings indicated no great lateral variations in resistivity occurred between the right and left sides of the electrode array at A-spacings up to sixty feet. If the readings had diverged, lateral variations might have been a problem and the results, as interpreted on a depth basis, would have been considered less reliable. This was not the case as both the S-1 and S-2 soundings showed very good correlation between the Lee Left and Lee Right readings. This indicated that the observed changes in resistivity readings were attributable to changes with depth rather than horizontal discontinuities as the A-spacing of the electrode array was expanded.

A second graphical method for analyzing the sounding data is also presented in the Appendix. This method, known as the Moore Cumulative Method, requires that readings be taken at equally spaced intervals. For each electrode interval the apparent resistivity reading is added cumulatively to the sum of all preceding readings. Cumulative readings are plotted against the A-spacing. Aligned points are connected by straight lines. The intersection of the straight lines are considered to be equal to the depths of the various geologic boundaries. Moore cumulative plots cannot be graphed where the A-spacing is interrupted due to physical features limiting readings at regular intervals.

On the Moore Cumulative Plot of S-1, two points derived from the intersections of three lines can be discerned from the data. These points correspond to A-spacings or depths of approximately nine and 30 feet respectively. In the case of S-2, no break is discernible in the apparent resistivity plot and only a "shallow" break at about ten feet and again at 27 feet is suggested by the Moore Cumulative Plot.

A comparison of the S-1 Moore Cumulative "plot breaks" with subsurface data suggests that the break at the ten foot A-spacing likely represents the ground-water table in the unconsolidated colluvium on site. During the test pit investigation in October 1979, Test Pit 5 was constructed on the northeast side of the landfill approximately 450 feet from S-1. Saturated conditions were encountered in TP-5 between seven and eleven feet. The break at the 30 foot A-spacing probably indicates the bedrock surface. This conclusion is supported by earlier test boring logs by Parratt Wolff Inc. (1977) which report bedrock occurs up to 38 feet below land surface around the future portions of the site. It is also supported by a seismic survey conducted in 1977 by the New York State Department of Transportation.

Sounding S-2, set up and run south of and hydraulically downgradient from the landfill, presented somewhat different findings than Sounding S-1. After approximately nine feet, the plot of resistivity versus A-spacing flattens out to a slow decline in resistivity with increasing A-spacing. A break occurs at about eight feet presumably as the result of the ground-water table.

Static water levels from TP-1 and TP-2 near S-2 on October 19, 1979 measured approximately 7.3 feet and 4.7 feet respectively. The Moore Cumulative plot for S-2 showed a very slight break at about 27 feet which probably represents the top of rock. The two most outstanding features to note in the sounding curves are that:

(1) The S-2 readings are generally lower than the S-1 readings and;

(2) The S-2 readings do not vary appreciably with an increase in A-spacing.

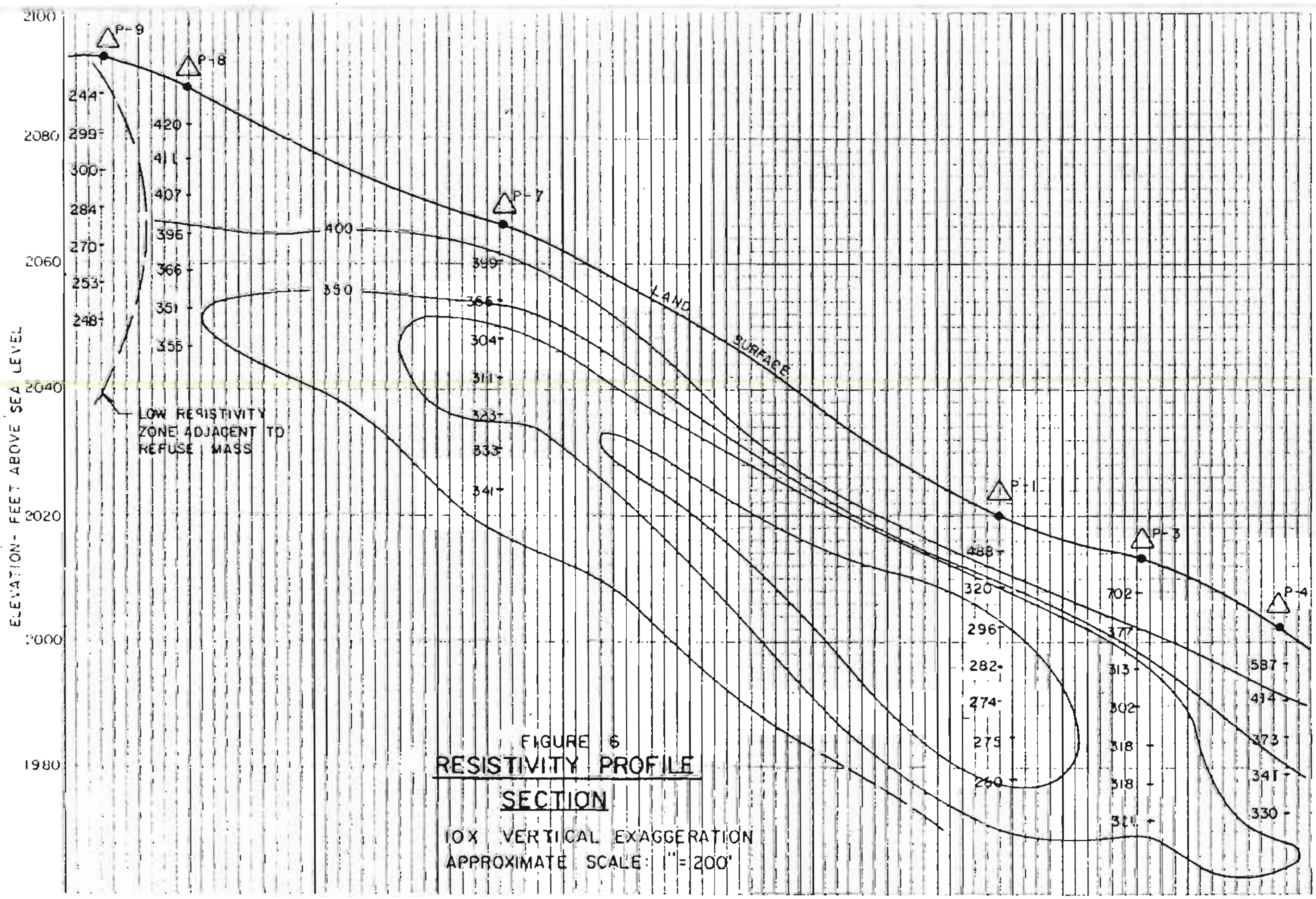


FIGURE 6

RESISTIVITY PROFILE

SECTION

10X VERTICAL EXAGGERATION
APPROXIMATE SCALE: 1" = 200'

Both of the above observations could be interpreted as a response to localized ground-water degradation recharging a deeper bedrock aquifer that is highly fractured. The observations might also simply indicate that finer-grained colluvium overlies fractured bedrock in the S-2 location as compared to the S-1 location. Interpretation of the observations are discussed in the following sections.

Because the sounding data did not vary appreciably with an increase in the A-spacing, a specific A-spacing was not selected for the profile survey. Rather, a number of "mini-soundings" were run at nine locations, P-1 through P-9, in an attempt to profile the south and west portions of the site. A-spacings were selected at six foot intervals up to a 42 foot A-spacing to provide information within the ground-water table in the colluvium overlying bedrock.

The location of the profile stations and the depth of the "mini-soundings" were aimed at determining the following:

(1) Locating zones of degradation resulting from leachate contamination of the ground-water table.

(2) Determining whether that contamination was migrating vertically into ground water in the underlying bedrock.

(3) Examining, if possible, the relationship between ground water in the colluvium and ground water in bedrock.

Profile Data Results

Results of the profile survey have been illustrated graphically in several ways. Figure 6 depicts resistivity results versus approximate

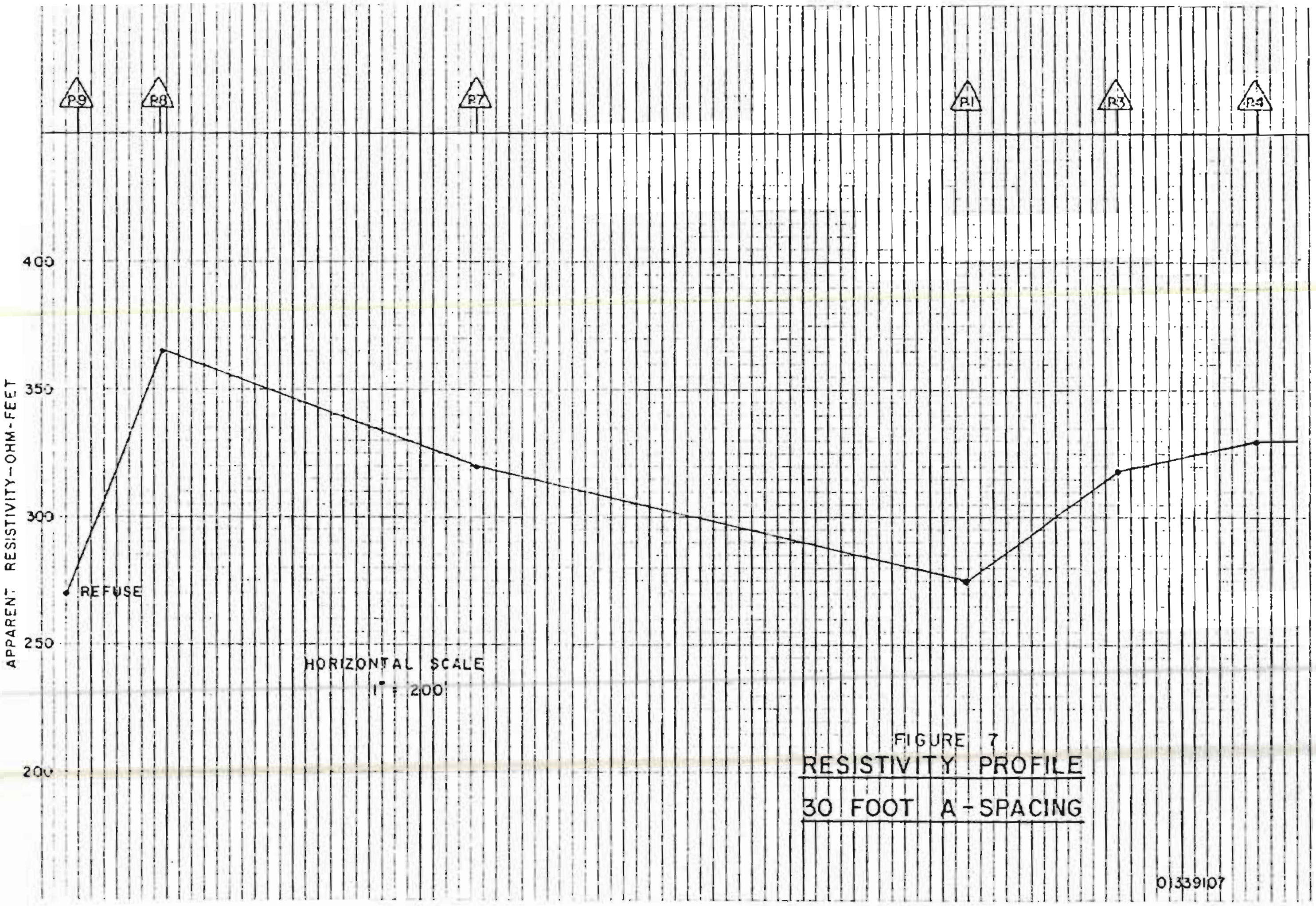


FIGURE 7
RESISTIVITY PROFILE
30 FOOT A-SPACING

01339107

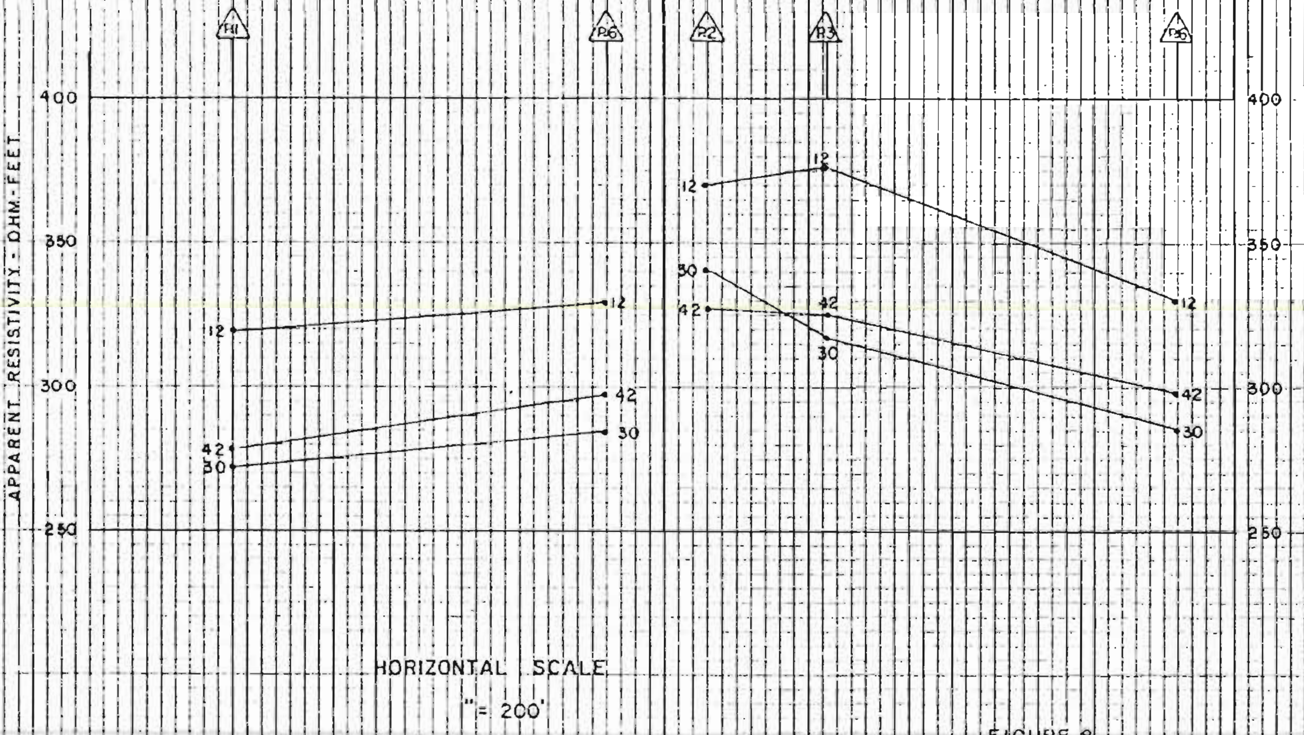


FIGURE 8
RESISTIVITY PROFILES
AT INDICATED A-SPACINGS

elevation above mean sea level along a north-south traverse between P-9 and P-4. A-spacings are inferred to correspond to the depth below land surface. The P-9 station near refuse exhibits moderately low readings, as expected for its location. This profile section illustrates a "bulb" of low resistivity material increasing in thickness and total depth in a downgradient direction. Downgradient from P-1, the "bulb" appears to dissipate rapidly with higher resistivity readings for equivalent A-spacings at the P-3 and P-4 locations. Figure 7 also illustrates the same sectional profile, using a 30 foot A-spacing as typical of the zone of saturation in the colluvium. The X-axis is the apparent resistivity; the Y-axis is the horizontal section independent of actual elevations above mean sea level. This figure illustrates a distinct "sag zone", indicating more electrically conductive materials at a 30 foot depth between stations P-8 and P-1. It should also be noted that resistivity readings increase beyond P-1 indicating less conductive materials at the 30 foot A-spacing further downgradient from the site.

Figure 8 illustrates two plots of apparent resistivity at various A-spacings, along two profile sections: P-1 to P-6 and P-6, P-3, to P-2. Several points can be discerned from these plots:

(1) Section P-1, P-6 which is closer to the landfill than Section P-2, P-3, P-6 exhibits lower apparent resistivities for each given A-spacing of 12, 30 and 42 feet respectively indicating more highly conductive materials closer to the fill.

(2) P-1, P-6 exhibits a lower "gradient" to the apparent resistivities than Section P-2, P-3, P-6.

(3) Section P-2, P-3, P-6 indicates that higher resistivities result, for equal A-spacings, the further the station reading is from the landfill.

Resistivity Interpretations

Results of the data collected to date suggest that leachate generated from the landfill may be affecting the localized ground-water table in the immediate vicinity of the landfill. This is suggested in Figures 6 and 7. These profiles illustrate a potential pollution plume adjacent to the landfill possibly recharging deeper water bearing zones such as the semi-confined aquifer in the underlying bedrock. Figure 7 illustrates a depressed or "sag" zone at the 30 foot A-spacing adjacent and downgradient from the landfill. The resistivity profile is apparently recovering at P-1 below the site. This type of profile is typical of a section through a zone containing higher salt concentrations than background. It illustrates the effects a contaminating source has on ground water and the eventual recovery zone downgradient. Recovery of ground water from salt contamination is primarily by the mechanisms of dilution and dispersion.

The movement of ground water from this site has not been well defined. If, as conjectured, the ground-water table in the unconsolidated colluvium at the landfill is recharging a deeper flow system, that flow zone should also be monitored.

Figure 8 shows two interesting sections at and below the landfill. The salient points of each section have been described. Section P-6, P-1 depicts higher conductivity (lower resistivity) approaching P-1, near the unnamed tributary of Duffy Hollow Creek, from P-6. If the lower resistivities are a result of leachate contamination, then the unnamed tributary is still being degraded by contaminated ground water recharging it at that location.

The P-6, P-3, P-2 section shows higher resistivities downgradient and the zone at P-2, near the stream, has distinctively higher resistivity (lower conductivity) than the area around P-6. This suggests that the stream or downgradient water resources in the vicinity of P-2 are not affected by leachate contamination. This may be the result of ground-water discharge of uncontaminated ground water from the semi-confined aquifer into the contamination plume or the result of simple admixing and dilution in the localized ground-water table in the colluvium. The latter is thought, at present, to be the most probable explanation for the recovery zone noted in Figure 7, and profile section P-6, P-3, P-2.

The following conclusions are inferred from the resistivity study to date:

(1) Ground-water contamination may be resulting in the localized ground-water table immediately around the landfill.

(2) Contamination may extend into the semi-confined bedrock aquifer.

(3) The degree of contamination is unknown.

(4) Borings or wells should be constructed to support or refute the earth resistivity study results and monitor ground-water quality downgradient from the site.

(5) The earth resistivity study suggests that a measurable contamination plume in the unconcolidated colluvial materials extends only a short distance beyond the limits of the landfill and that stream degradation does not increase from approximately the P-2 profile stations.

(6) The resistivity survey results (Figures 6, 7 and 8) complement the Specific Conductivity Survey results of the unnamed tributary to Duffy Hollow Creek (Figure 3).

CONCLUSIONS

(1) The earth resistivity data indicates probable leachate plume migration into the bedrock aquifer in the immediate vicinity of the site.

(2) Leachate in the colluvium and the bedrock is probably being rapidly dispersed and diluted to the extent that resistivity methods for detecting low level contaminants in the flow systems are ineffective at distance from the site.

(3) Leachate discharges to the unnamed tributary to Duffy Hollow Creek are apparently through the following pathways: (a) surface run-off from by-passes of the collection system; (b) surface run-off from the sprayfield and; (c) ground-water discharge from the shallow water table in the colluvium and glacial till on site.

(4) Resistivity investigations coupled with the conductivity survey tend to support the conclusion that stream degradation from leachate discharges beyond the immediate boundaries of the site is not occurring and improvement in stream quality can be attained by intercepting the leachate flows to the stream from the previously described pathways.

(5) Permeameter test results tend to support previous evaluations of the permeability of the unconsolidated deposits on site. Compaction of the base of the trench cells probably creates a "bathtub" effect in which leachate builds up in each trench and discharges under head to the present collection systems.

(6) The present collection and treatment system cannot effectively operate to handle all of the leachate generated from the site.

(7) The present ground-water monitoring system cannot monitor the environmental impact the site may be having on the local ground-water resources.

(8) The October, 1979 field investigation results suggested that the naturally low buffering capacity of the stream and the presence of ferruginous deposits in soil and bedrock might be exacerbating the leachate problem.

(9) A water-table map was not constructed for the overall site because a wider monitoring system and up-to-date survey elevations are needed.

RECOMMENDATIONS

(1) Nesting piezometers should be constructed to support or refute the conclusions expressed in Conclusions 1-4. These monitoring points should be constructed in accordance with NYS DEC monitoring well requirements so they can serve a permanent ground-water monitoring wells for a permitted site. A water table and piezometric map should be developed from this additional hydrogeologic work.

(2) A water balance should be run as part of the final report to assure that all contaminated flows are being intercepted.

(3) Additional test pits to determine the areas where landfilling is not practical or where ground water interception is needed should be undertaken.

(4) Consideration, in the conceptual engineering report, should be given to reducing the synergistic effects natural site conditions may be having on the leachate problem.

(5) Land application of treated wastes should be considered in the analysis of control options.

(6) The hydraulic relationship of leachate in the trenches to the ground-water table should be evaluated further.

(7) An up-to-date survey of existing facilities is warranted. Elevations of all wells and piezometers should be precisely measured.

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APPENDIX

EN-F-090775

WEHRAN ENGINEERING TEST PIT LOG

Project No. 9107 Client RECRA RESEARCH - WELLSVILLE DPW Test Pit No. 1

Project HYDROGEOLOGIC INVESTIGATION

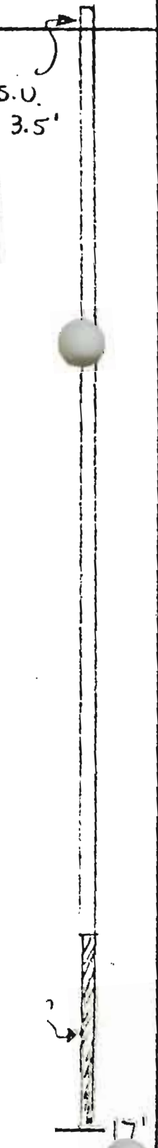
Location TOWNS OF WELLSVILLE & ANDOVER Date 10/15/79

Contractor DPW Equipment P&H Track Inspector RLK

Location of Pit SOUTH WEST SIDE OLD FILL

Ground Elev. ______ Ground Water Depth 10'10" TOC 10/19/79 Elev. ______

Remarks ______

ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
 S.U. 3.5'				DARK BROWN TOP SOIL
	1 2		S-1 S-2	RED BROWN to YELLOW Brown Clayey SILT, some fine Gravel, little c-f Sand - DAMP
	3 4 5	WATER enter hole AT 4.5'		Mottled brown & gray Clayey SILT, Some+ m-f Gravel, little+ c-f Sand DAMP-wet OCCASIONAL ROCK FRAGMENTS
	6 7 8 9 10 11 12 13 14		S-3 S-4	Brown Clayey SILT, some± c-f Gravel, some c-f SAND damp - wet - STABLE OCCASIONAL - FREQUENT ROCK FRAGMENTS & BOULDER - SUB ANGULAR TO SUB ROUNDED SST. & Ferruginous shale
17'	15 16 17	END OF PIT	S-5	Brown-Gray Clayey SILT & C-f GRAVEL, some+ m-f SAND MOIST - wet FREQUENT ROCK FRAGMENTS

KEY TO VISUAL DESCRIPTIONS

e = 0-10%, little = 10-20%, some = 20-35%, and = 35-50%, (+) or (-) after denotes extremes of range i.e. 19% is written as little (+)

WEHRAN ENGINEERING

TEST PIT LOG

Project No. 9107 Client RECRA RESEARCH-Wellsville DPW Test Pit No. 2

Project HYDROGEOLOGIC INVESTIGATION

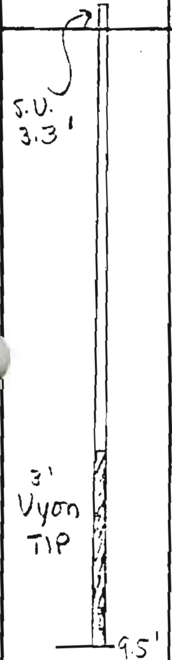
Location TOWNS OF WELLSVILLE & ANDOVER Date 10/15/79

Contractor DPW Equipment P&H Track Inspector RLK

Location of Pit SOUTHCenter SIDE OLD FILL - 100 yds east TP-1

Ground Elev. Ground Water Depth 8.0' TOC 10/19/79 Elev.

Remarks



ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
				DARK BROWN TOPSOIL w/ ROOTS WET
	1		S-1	Reddish Brown SILT, little m-f SAND, occasional rock FRAGMENTS
	2			
	3		S-2	Mottled Red & Grey Clayey SILT, little^{-} c-f Gravel, little^{-} c-f SAND Prominent mottles wet - SATURATED Wavey boundary
	4			
	5			
	6			
	7			Brown - Grayish brown Clayey SILT & m-f SAND, some^{+} c-f Gravel
	8			
	9			
	10			Frequent Rock FRAGMENTS (SS+) SUBANGULAR TO SUBROUNDED MOIST
	11			END OF PIT
	12			
	13			
	14			
	15			
	16			
	17			

KEY TO VISUAL DESCRIPTIONS

trace = 0–10%, little = 10–20%, some = 20–35%, and = 35–50%, (+)or(–) after denotes extremes of range i.e. 19% is written as little (+)

EN-F-090775

WEHRAN ENGINEERING **TEST PIT LOG**

Project No. 9107 Client RECRA RESEARCH - WELLSVILLE DPW Test Pit No. 3
Project HYDROGEOLOGIC INVESTIGATION
Location TOWNS OF WELLSVILLE & ANDOVER Date 10/17/79

Contractor DPW Equipment P&H Track Inspector RLC
Location of Pit WEST SIDE OLD FILL ADJACENT to GARAGE
Ground Elev. ______ Ground Water Depth DRY Elev. ______
Remarks ______

ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
				DARK BROWN TOPSOIL - ROOTS & Organics
				Red-Brown SILT & F. SAND, Some m-f Gravel)
3.8' S.U.	1			Mottled Red-Brown Clayey SILT, some c-f Gravel, some c-f SAND
	2			Frequent Cobbles & Rock FRAGMENTS MOIST
	3		S-1	
	4			Brownish gray to reddish brown clayey SILT, some m-f Gravel, little c-f SAND
	5			
	6			
	7		S-2	FREQUENT ROCK FRAGMENTS of SST. & Ferruginous Shale
	8			
	9		S-3	
	10			becoming
	11			very to extremely
	12		S-4	dense with clay SILT,
	13			some^{+} c-f Gravel &
	14			some c-f SAND
3' Vyon Tip	15			
	16			
	17			
17.8'				END OF PIT 17.8'

KEY TO VISUAL DESCRIPTIONS

trace = 0−10%, little = 10−20%, some = 20−35%, and = 35−50%, (+)or(−) after denotes extremes of range i.e. 19% is written as little (+)

EN-F-090775

WEHRAN ENGINEERING **TEST PIT LOG**

Project No. 9107 Client RECRA RESEARCH - Wellsville DPW Test Pit No. 4

Project HYDROGEOLOGIC INVESTIGATION

Location TOWNS OF WELLSVILLE & ANDOVER Date 10/17/79

Contractor DPW Equipment P&H Track Inspector RLK

Location of Pit WEST SIDE OLD FILL AT ENTRANCE ROAD

Ground Elev. Ground Water Depth DRY Elev.

Remarks

ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
3.25' S.U.	1			FILL CONSISTING OF TOPSOIL MIXED w/ WOOD & DEMO DEBRIS DAMP
	2		S-1	MOTTLED RED & GRAY CLAYEY SILT, Some+ c-f SAND, some c-f Gravel
	3			
	4		S-2	Brown to gray clayey SILT, some m-f Gravel, little c-f SAND
	5			
	6			FREQUENT ROCK FRAGMENTS of Sst. & shale w/ iron STAINING ON SOIL
	7			
	8			Very DENSE
	9		S-3	Dry to Damp
	10			
	11			
	12			
	13			
	14		S-4	
	15			
	16			
?	17			Seepage in hole AT bottom END OF PIT 17.9'

KEY TO VISUAL DESCRIPTIONS

:e = 0–10%, little = 10–20%, some = 20–35%, and = 35–50%, (+)or(–) after denotes extremes of range i.e. 19% is written as little (+)

EN-F-090775

WEHRAN ENGINEERING TEST PIT LOG

Project No. 9107 Client RECRA RESEARCH - WELLSVILLE DPW Test Pit No. 5

Project HYDROGEOLOGIC INVESTIGATION

Location TOWNS OF WELLSVILLE & ANDOVER Date 10/17/79

Contractor DPW Equipment P&H Track Inspector RLK

Location of Pit Northeast SIDE OF landfill near springs

Ground Elev. ______ Ground Water Depth 3.6' TOC 10/19/79 Elev. ______

Remarks ______

ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
				DARK BROWN TOPSOIL wavy BOUNDARY WET-SAT.
	1 2 3		S-1	Gray Clay & SILT, some m-f SAND, little m-f Gravel wet, unstable
	4 5 6 7 8 9 10 11			Brownish gray Clayey SILT & FINE SAND, some c-f Gravel, frequent cobbles boulders & Rock fragments unstable, SATURATED END OF PIT 11'
	12 13 14 15 16 17			

KEY TO VISUAL DESCRIPTIONS

ace = 0-10%, little = 10-20%, some = 20-35%, and = 35-50%, (+)or(-) after denotes extremes of range i.e. 19% is written as little(+)

EN-F-090775

WEHRAN ENGINEERING

TEST PIT LOG

Project No. 9107 Client RECRA RESEARCH - WELLSVILLE DPW Test Pit No. 6

Project HYDROGEOLOGIC INVESTIGATION

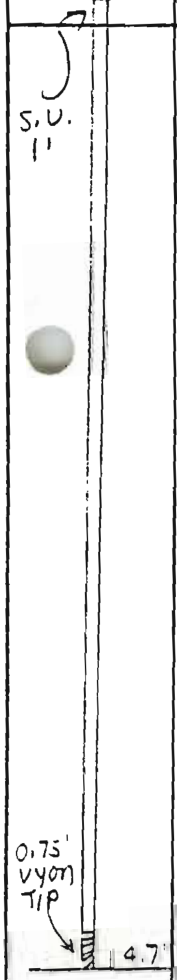
Location TOWNS OF WELLSVILLE & ANDOVER Date 10/17/79

Contractor DPW Equipment P&H TRUCK Inspector RLK

Location of Pit Center of LANDFILL Along ACCESS ROAD

Ground Elev. ________ Ground Water Depth DRY 10/19/79 Elev. ________

Remarks ________



ELEVATION	DEPTH (Feet)	LOG	SAMP NO	DESCRIPTION
				BROWN TOPSOIL & ORGANIC MATTER
	1			MOTTLED BROWN & Gray Clayey SILT,
	2			some c-f Gravel, little c-f SAND WET
	3			
	4			
	5			Brown to grayish brown Clayey SILT, some c-f Gravel, some c-f SAND frequent SST. & shale rock fragments ferruginous shale Angular to subrounded DRY - MOIST
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			END OF PIT 14.7'
	15			
	16			
	17			

KEY TO VISUAL DESCRIPTIONS

trace = 0–10%, little = 10–20%, some = 20–35%, and = 35–50%, (+)or(–) after denotes extremes of range i.e. 19% is written as little (+)

CONSULTING ENGINEERS

AGGREGATE ANALYSIS

Date Sample Received: 10/22/79

S[illegible]ple No.: 1 Project No.: 01339107

ent: RECRA RESEARCH, INC. Project: Wellsville, N. Y.

ple Received from: R.L.K.

ation: South side of entire landfill

t Pit: 1 Field Sample No.: 2 Depth: 15" - 18" Elev.:

er Source:

ple Description: Mottled brown & gray clayey SILT, some (+) med-fine Gravel, little (+) c-f Sand

ted By: WSP Checked By: Date Finished:

LE SAMPLE

Wet Soil & Tare	gms	
Dry Soil & Tare	273.7 gms	
Water	gms	31.1 % Gravel
Ta[illegible]	17.9 gms	17.4 % Sand
D[illegible] Soil	255.8 gms	51.5 % Clayey SILT
sture Content	gms	
Wt. Test Sample	255.8 gms	
Wt. + #200 Washed Sample	124.9 gms	
of Silts & Clays lost	130.9 gms	

E	U.S. BUREAU OF STANDARDS		WT. OF SIEVE & SOIL	WT. OF SIEVE	WEIGHT RETAINED	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
	SIEVE SIZE (INCHES)	SIEVE SIZE (M.M.)						
	2.00	50.8						
	1.00	25.4						
	.750	19.1			0	0		100.0
	.500	12.7						
	.375	9.52			30.2	11.8		88.2
	.187	4.76			23.7	9.3		78.9
	.0787	2.00			25.6	10.0		68.9
	.0331	0.84						
	.0232	0.59			22.3	8.7		60.2
	.0165	0.42						
	.0098	0.25			10.0	3.9		56.3
	.0070	0.177			2.9	1.1		55.2
	.0041	0.105			4.5	1.8		53.4
	.0029	.07			4.9	1.9		51.5
	0	0			0.8			
	TOTAL WT. RETAINED IN SIEVES				124.9	TOTAL WT. RETAINED IN SIEVES		

CONSULTING ENGINEERS

AGGREGATE ANALYSIS

Date Sample Received: 10/22/79

S[illegible]le No.: 2 Project No.: 01339107

ent: RECRA RESEARCH, INC. Project: Wellsville, N. Y.

ple Received from: R.L.K.

ation: South and West of Old Landfill

Pit: 3 Field Sample No.: 2 Depth: 84" Elev.:

er Source:

ple Description: Brown Clayey SILT to SILT and CLAY, some med-fine Gravel, little c-f Sand

ted By: WSP Checked By: Date Finished:

LE SAMPLE

Wet Soil & Tare	gms
Dry Soil & Tare	374.1 gms
Water	gms
Ta[illegible]	17.0 gms
Dr[illegible]Soil	357.1 gms
sture Content	gms
Wt. Test Sample	357.1 gms
Wt. + #200 Washed Sample	160.4 gms
of Silts & Clays lost	196.7 gms

29.0 % m-f Gravel
15.1 % c-f Sand
55.9 % SAND & CLAY

U.S. BUREAU OF STANDARDS		WT. OF SIEVE & SOIL	WT. OF SIEVE	WEIGHT RETAINED	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
SIEVE SIZE (INCHES)	SIEVE SIZE (M.M.)						
2.00	50.8						
1.00	25.4			0			100.0
.750	19.1			19.0	5.3		94.7
.500	12.7						
.375	9.52			34.0	9.5		85.2
.187	4.76			25.5	7.1		78.1
.0787	2.00			25.3	7.1		71.0
.0331	0.84						
.0232	0.59			21.4	6.0		65.0
.0165	0.42						
.0098	0.25			11.7	3.3		61.7
.0070	0.177			4.3	1.2		60.5
.0041	0.105			8.1	2.3		58.2
.0029	.07			8.3	2.3		55.9
0	0			2.8			
TOTAL WT RETAINED IN SIEVES				160.4	TOTAL WT. RETAINED IN SIEVES		

WEHRAN ENGINEERING
CONSULTING ENGINEERS

AGGREGATE ANALYSIS

Date Sample Received: ______________

Sample No.: 3 Project No.: 01339107

ient: ______________ Project: Wellsville, N. Y.

mple Received from: ______________

cation: ______________

st Pit: 4 Field Sample No.: 4 Depth: 14' Elev.: ______________

her Source: ______________

mple Description: Variegated red-brown, brown & gray, SILT and CLAY to CLAY and SILT,
me (-) fine Gravel, little c-f Sand

sted By: ______________ Checked By: ______________ Date Finished: ______________

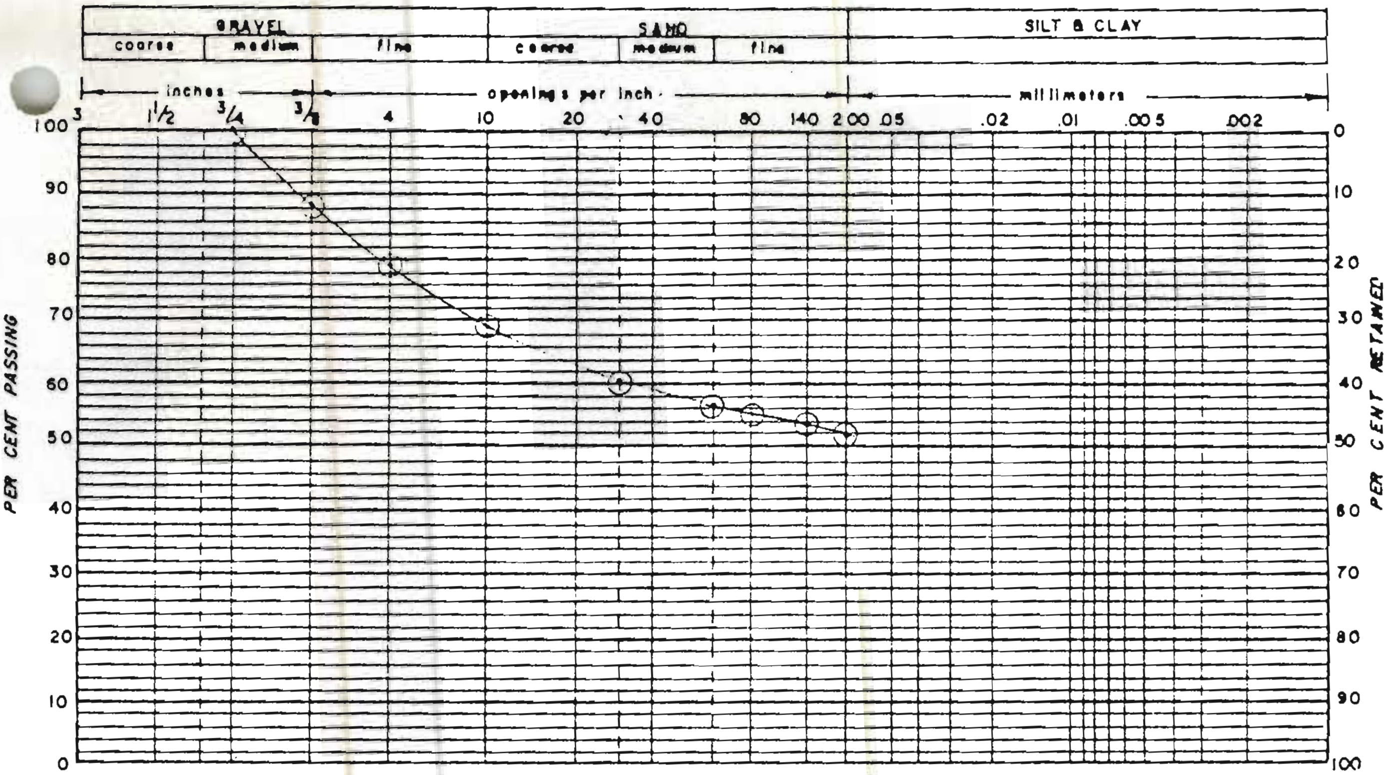
OLE SAMPLE

23.4 % Gravel
16.6 % Sand
60.0 % SILT & CLAY

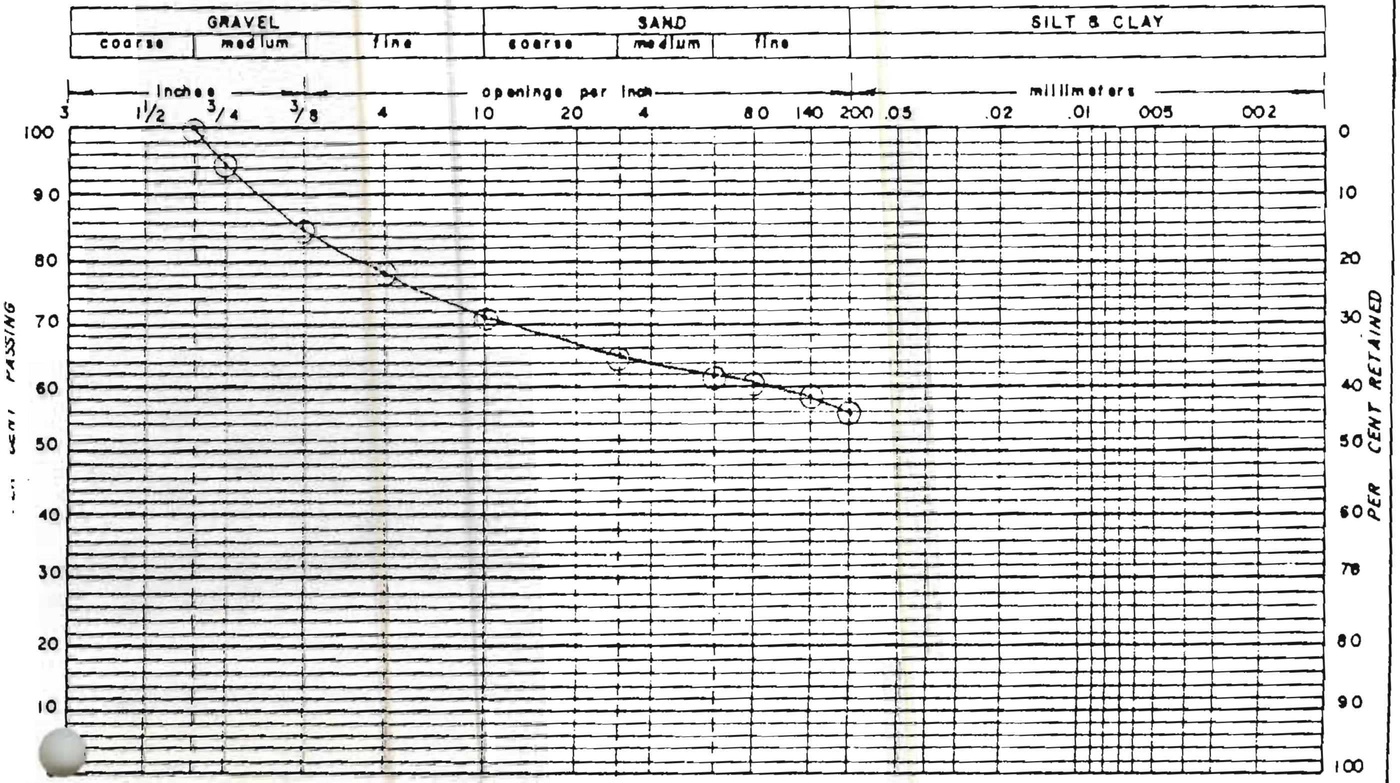
. Wet Soil & Tare ______ gms
. Dry Soil & Tare 366.8 gms
. Water ______ gms
. Tare 17.3 gms
. Dry Soil 349.5 gms
isture Content ______ gms
Wt. Test Sample 349.5 gms
Wt. + #200 Washed Sample 141.1 gms
of Silts & Clays lost 208.4 gms

E :	U.S. BUREAU OF STANDARDS		WT. OF SIEVE & SOIL	WT. OF SIEVE	WEIGHT RETAINED	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
	SIEVE SIZE (INCHES)	SIEVE SIZE (M.M.)						
	2.00	50.8						
	1.00	25.4						
	.750	19.1			0			100.0
	.500	12.7						
	.375	9.52			19.6	5.6		94.4
	.187	4.76			33.7	9.6		84.8
	.0787	2.00			28.5	8.2		76.6
	.0331	0.84						
	.0232	0.59			26.1	7.5		69.1
	.0165	0.42						
	.0098	0.25			13.6	3.9		65.2
	.0070	0.177			4.3	1.2		64.0
	.0041	0.105			7.5	2.1		61.9
	.0029	.07			6.8	1.9		60.0
	0	0			1.0			
TOTAL WT RETAINED IN SIEVES					141.1	TOTAL WT RET		

GRAIN-SIZE DISTRIBUTION



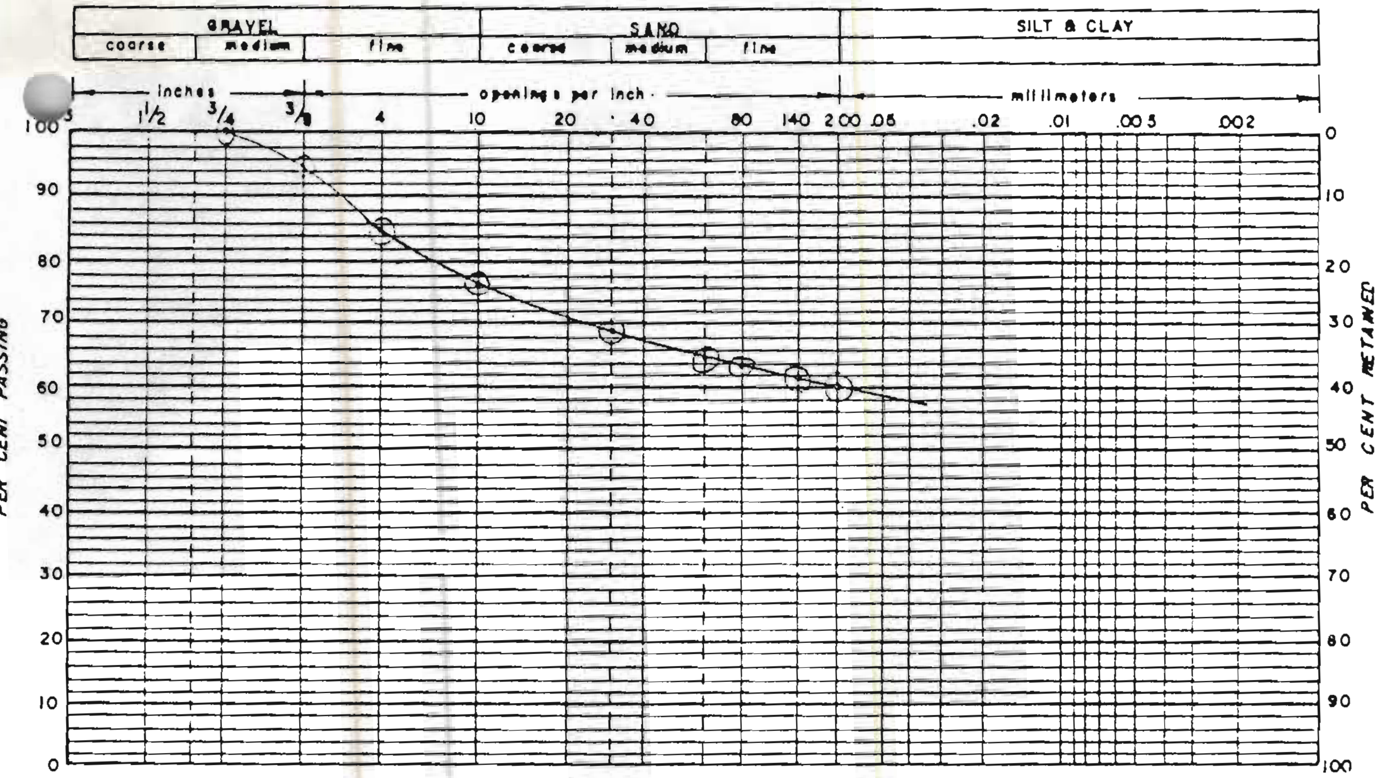
T.Pit	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
1	2	15" - 18"	⊙	Mottled brown and gray Clayey SILT, some (+) mf Gravel, little (+) cf Sand			



T.Pit	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
3	2	84"	⊙	Brown Clayey SILT to SILT and CLAY, some mf Gravel, little cf Sand			

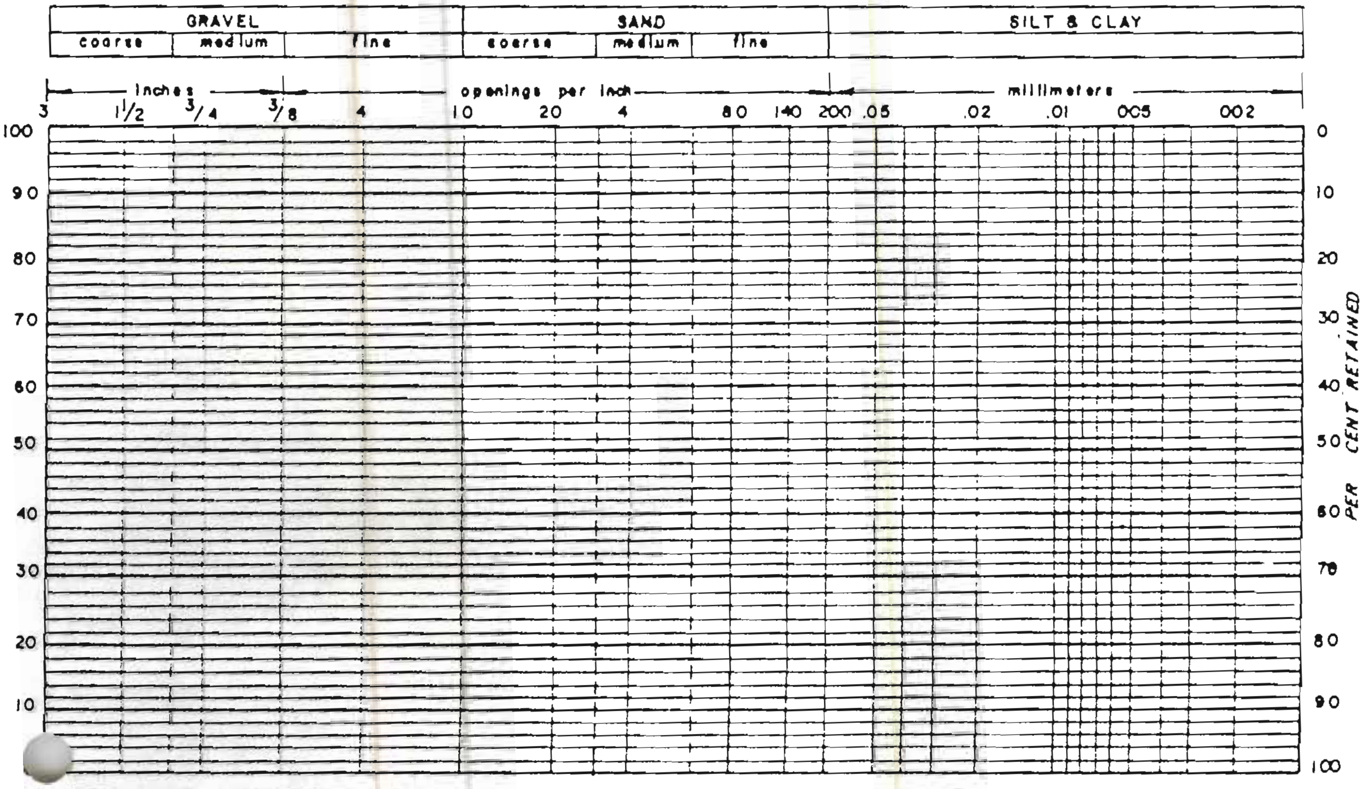
FIGURE

GRAIN-SIZE DISTRIBUTION

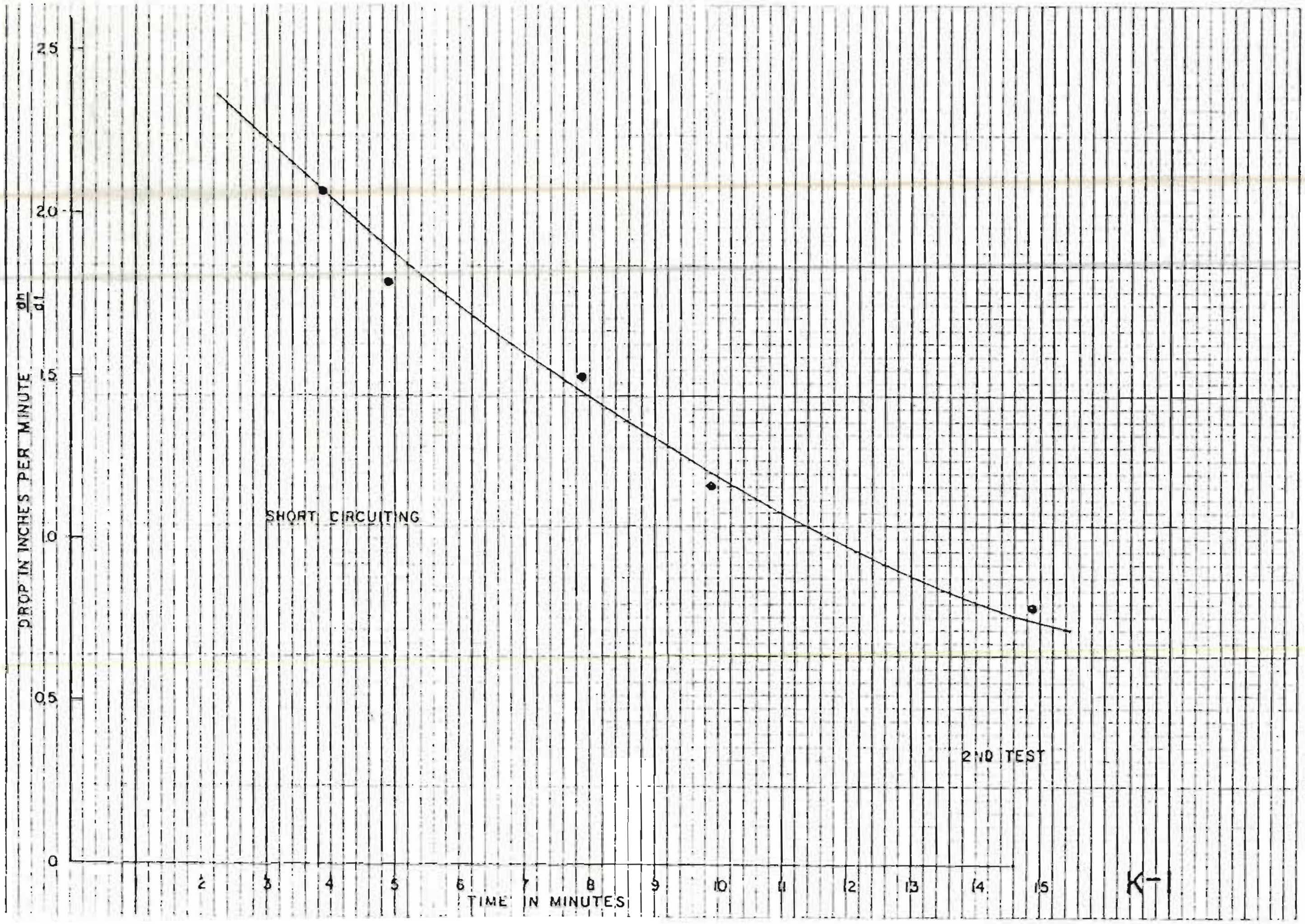


T.Pit	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL
4	4	14'	⊙	Variegated re-brown, brown & gray SILT & CLAY to CLAY & SILT, some (-) fine Gravel			

FIGURE



BORING	SAMPLE	DEPTH	SYMBOL	CLASSIFICATION	MC	LL	PL


2.5
2.0
1.5
1.0
0.5
0
DROP IN INCHES PER MINUTE $\frac{dh}{dt}$
2
3
4
5
6
7
8
9
10
11
12
13
14
15
TIME IN MINUTES
SHORT CIRCUITING
2ND TEST
K-1

RESISTIVITY THEORY & BASIS OF USE IN FIELD

The following discussion is derived largely from the "Earth Resistivity Manual" by Soil Test, Inc.

All materials have the property of resistivity. Resistivity varies depending on physical factors such as material composition and saturation. Instruments capable of introducing electrical currents into the ground can measure the resistivity of earthen materials at various depths. Resistivity is related to resistance by the following equation:

$p = RA/L$ where

p = Resistivity

A = Cross Sectional area (L^2) of the block of conductive material being measured

L = length of block of material being measured

Resistance is measured in ohms; resistivity is commonly measured in ohm-feet or ohm-centimeters as indicated by the above equation. Resistivity can be thought of as the reciprocal of conductivity. Resistivity is commonly measured by delivering an electric current (I) into the ground and then measuring the potential gradient (V) of the electrically resistant material between the input electrodes (I) and two measuring electrodes attached to a voltmeter. The resistivity instrument measures V/I which is the resistance of the material.

The volume of material through which the current passes is proportional to the distance between the four electrodes and, therefore, the depth of the survey is proportional to the space between electrodes. Intuitively, the spacing between electrodes equals the depth measured although this should be confirmed by boring or other field verification.

For this study the basic formula for resistivity is given as:

$$p = 2\ A(V/I)$$

where A = the spacing between adjacent electrodes (referred to as the A-spacing)

Perfectly homogeneous earth materials are genuinely rare. Field applications of resistivity refer to "apparent resistivity" as the resistivity measured in the preceding equation. Variations in apparent resistivity readings permit one to distinguish one type of subsurface material from another. Apparent resistivity is essentially a weighted average of all the different true resistivities in the volume of earth measured.

For most earth material, the resistivity decreases with increasing water content or increasing salinity; that is, they become more conductive. Dense bedrock or other non-porous materials ordinarily exhibit high resistivity values. Some porous but unsaturated materials, such as a dry sand, will exhibit moderately high resistivity values. Even saturated clean sands and gravel containing low dissolved solids (salts) can exhibit moderately high resistivity, hence, low conductivity. Conversely, dirty gravels containing intermixed clays will exhibit lower resistivities due to the free ion content (salinity) of the charged clay particles.

Because clays and silts are capable of holding more water (above the water table) then clean sands and gravels they, predictably, exhibit lower resistivity. Soils in valleys where fine-grained sediments can accumulate in moist environments characteristically exhibit lower resistivity. Equal resistivity readings do not always signify similar materials if the survey is conducted where moisture contents vary appreciably. Therefore, periods of extended rainfall can create problems in the interpretation of data results.

Resistivity can be correlated with various materials. For dense rocks, expected values may range from several thousand to several tens of thousands of ohm-feet. Clean gravels range from several hundred to several thousand ohm-feet. Most soils, since they are moist, and contain clays with net ionic charges, have lower resistivities in the range of 20 to 200 ohm-feet.

Electrolyte concentration in ground water increases conductivities within the zone of saturation resulting in lower resistivity. In order to utilize resistivity equipment in the detection of ground-water contamination from leachate salts, there must be rather significant contrasts in the conductance/resistance of uncontaminated zones surrounding the contaminated area. It can be seen from the preceding discussion that earthen materials exhibit wide ranges in resistivity values. It is, therefore, essential to determine the resistive properties of the background materials prior to interpreting the results as they relate to contamination of ground water.

SPECIFIC CONDUCTIVITY SURVEY
FIELD RESULTS

STATION NUMBER	TEMP. °C	READING umhos/cm
C-1	12	40
C-2	12	40
C-3	12	40
C-4	11	500
C-5	10	260
C-6	14	6000
C-7	12	900
C-8	11	53
C-9	11	600
C-10	13	4600
C-11	11	600
C-12	9	40
C-13	12	4150
C-14	11	600
C-15	12	1020
C-16	15	280
C-17	12	1000
C-18	11	60
C-19	12	68
C-20	11	410
C-21	12	410
C-22	12	400
C-23	13	230
C-24	13	35

**WEHRAN
ENVIRONMENTAL
LABORATORY**
Middletown, New York

LABORATORY REPORT

Client Wellsville Village (RECRA RESEARCH)
Sample No. 79668 Date, Time Sampled / Job No. 01339107
Sample Type / Quantity GROUND WATER / 500 ml
Sample Source TEST PIT /
Analysis Requested SPECIFIC CONDUCTANCE
Sampler D. Kraybill
Analyst T. CLARK

ANALYTICAL DATA

PHYSICAL AND CHEMICAL

Acidity	
Alkalinity	
Appearance	
B.O.D.5	
Bromide	
Carbon Dioxide	
Chloride	
Chlorine, Free	
Chlorine, Tot. Res.	
C.O.D.	
Color	
✓ Cond. Sp. (25°C)	519
Cyanide	
Fluoride	
Hardness, Total	

Nitrogen, Ammonia	
Nitrogen, Kjeldahl	
Nitrogen, Organic	
Nitrogen, Nitrate	
Nitrogen, Nitrite	
Odor	
Oil & Grease	
Oxygen, Dissolved	
pH	
Phenols	
Phosphate, Ortho	
Phosphate, Total	

Silica	
Sulfate	
Sulfite	
Surfactants (MBAS)	
Tannin & Lignin	
Temperature	
Total Organic Carbon	
Turbidity	
Volatile Acids	

SOLIDS

Total	
Volatile Total	
Fixed Total	
Total Suspended	
Fixed Suspended	
Total Dissolved	
Volatile Dissolved	
Fixed Dissolved	
Settleable	

BACTERIOLOGICAL

Total Coliform		Per 100 ML.
Fecal Coliform		Per 100 ML.
Fecal Streptococci		Per 100 ML.
Standard Plate Count (35°C)		Per ML.

METALS

Aluminum	
Antimony	
Arsenic	
Barium	
Beryllium	
Bismuth	
Boron	
Cadmium	
Calcium	
Chromium, Hex.	

Chromium, Total	
Cobalt	
Copper	
Iron	
Lead	
Lithium	
Magnesium	
Manganese	
Mercury	
Molybdenum	

Nickel	
Potassium	
Selenium	
Silicon	
Silver	
Sodium	
Tin	
Titanium	
Vanadium	
Zinc	

Additional Data / Remarks:

NOTES: 1. All Results in Milligrams/Liter Unless Otherwise Noted.
2. Sample Stored at 0° to 4°C. and Chemically Preserved as

Eugene P. Cocozza, Laboratory Director
10/22/79

**WEHRAN
ENVIRONMENTAL
LABORATORY**
Middletown, New York

LABORATORY REPORT

Client Wellsville Village (RECRA RESEARCH)

Sample No. 79669 Date, Time Sampled ____ Job No. 01337107

Sample Type / Quantity GROUND WATER / 500 ml

Sample Source Test pit 2

Analysis Requested SPEC. COND.

Sampler D. KRAYBILL

Analyst T. CLARK

ANALYTICAL DATA

PHYSICAL AND CHEMICAL

Acidity	
Alkalinity	
Appearance	
B.O.D.$_5$	
Bromide	
Carbon Dioxide	
Chloride	
Chlorine, Free	
Chlorine, Tot. Res.	
C.O.D.	
Color	
Cond. Sp. (25°C)	56.4
Cyanide	
Fluoride	
Hardness, Total	

Nitrogen, Ammonia	
Nitrogen, Kjeldahl	
Nitrogen, Organic	
Nitrogen, Nitrate	
Nitrogen, Nitrite	
Odor	
Oil & Grease	
Oxygen, Dissolved	
pH	
Phenols	
Phosphate, Ortho	
Phosphate, Total	

Silica	
Sulfate	
Sulfite	
Surfactants (MBAS)	
Tannin & Lignin	
Temperature	
Total Organic Carbon	
Turbidity	
Volatile Acids	

SOLIDS

Total	
Volatile Total	
Fixed Total	
Total Suspended	
Fixed Suspended	
Total Dissolved	
Volatile Dissolved	
Fixed Dissolved	
Settleable	

BACTERIOLOGICAL

Total Coliform		Per 100 ML.
Fecal Coliform		Per 100 ML.
Fecal Streptococci		Per 100 ML.
Standard Plate Count (35°C)		Per ML.

METALS

Aluminum	
Antimony	
Arsenic	
Barium	
Beryllium	
Bismuth	
Boron	
Cadmium	
Calcium	
Chromium, Hex.	

Chromium, Total	
Cobalt	
Copper	
Iron	
Lead	
Lithium	
Magnesium	
Manganese	
Mercury	
Molybdenum	

Nickel	
Potassium	
Selenium	
Silicon	
Silver	
Sodium	
Tin	
Titanium	
Vanadium	
Zinc	

Additional Data / Remarks: ____

NOTES: 1. All Results in Milligrams/Liter Unless Otherwise Noted.
2. Sample Stored at 0° to 4°C. and Chemically Preserved as

Eugene P. Cocozza, Laboratory Director
12/22/79

ENVIRONMENTAL LABORATORY
Middletown, New York

LABORATORY REPORT

Client Wellsville Village (RECRA RESEARCH)

Sample No. 29670 Date, Time Sampled ______ Job No. 01339107

Sample Type / Quantity GROUND WATER / 500 ml

Sample Source Test Pit 5

Analysis Requested SPEC. COND.

Sampler D KRAYBILL

Analyst T. CLARK

ANALYTICAL DATA

PHYSICAL AND CHEMICAL

Acidity		Nitrogen, Ammonia		Silica	
Alkalinity		Nitrogen, Kjeldahl		Sulfate	
Appearance		Nitrogen, Organic		Sulfite	
B.O.D.$_5$		Nitrogen, Nitrate		Surfactants (MBAS)	
Bromide		Nitrogen, Nitrite		Tannin & Lignin	
Carbon Dioxide		Odor		Temperature	
Chloride		Oil & Grease		Total Organic Carbon	
Chlorine, Free		Oxygen, Dissolved		Turbidity	
Chlorine, Tot. Res.		pH		Volatile Acids	
C.O.D.		Phenols			
Color		Phosphate, Ortho			
✓ Cond. Sp. (25° C)	130	Phosphate, Total			
Cyanide					
Fluoride					
Hardness, Total					

SOLIDS

Total	
Volatile Total	
Fixed Total	
Total Suspended	
Fixed Suspended	
Total Dissolved	
Volatile Dissolved	
Fixed Dissolved	
Settleable	

BACTERIOLOGICAL

Total Coliform		Per 100 ML.
Fecal Coliform		Per 100 ML.
Fecal Streptococci		Per 100 ML.
Standard Plate Count (35° C)		Per ML.

METALS

Aluminum		Chromium, Total		Nickel	
Antimony		Cobalt		Potassium	
Arsenic		Copper		Selenium	
Barium		Iron		Silicon	
Beryllium		Lead		Silver	
Bismuth		Lithium		Sodium	
Boron		Magnesium		Tin	
Cadmium		Manganese		Titanium	
Calcium		Mercury		Vanadium	
Chromium, Hex.		Molybdenum		Zinc	

Additional Data / Remarks: ______

NOTES: 1. All Results in Milligrams/Liter Unless Otherwise Noted.
2. Sample Stored at 0° to 4° C. and Chemically Preserved as

Eugene P. Cocozza, Laboratory Director
12/21/79

RECRA RESEARCH/WEHRAN ENGINEERING
WATER LEVEL READINGS

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LOCATION	DEPTH BELOW TOP OF CASING IN FEET
TW-1	30.08
TW-2	7.75
TW-3	20.42
TW-4	30.17
TW-5	12.83
TW-6	19.08

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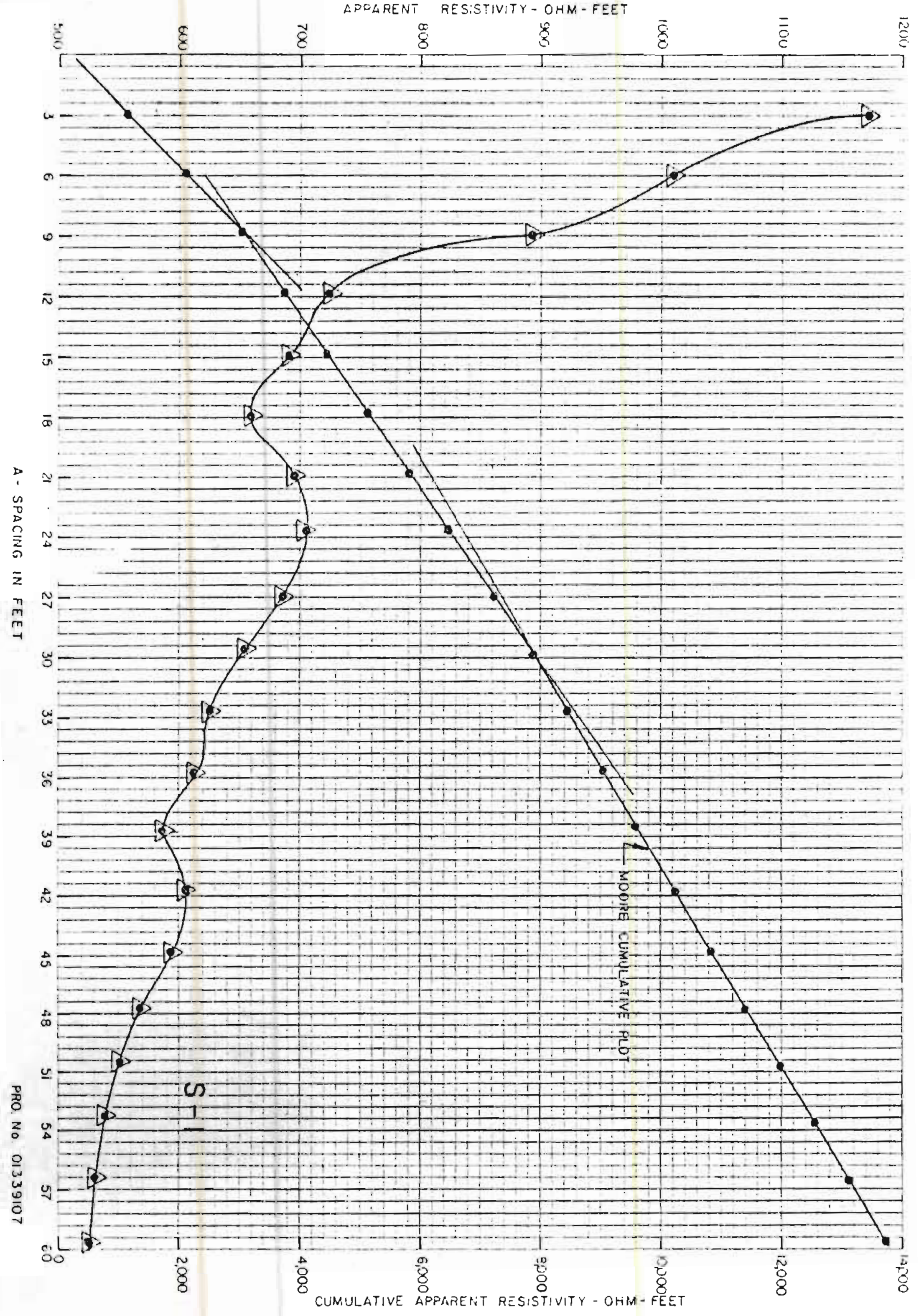
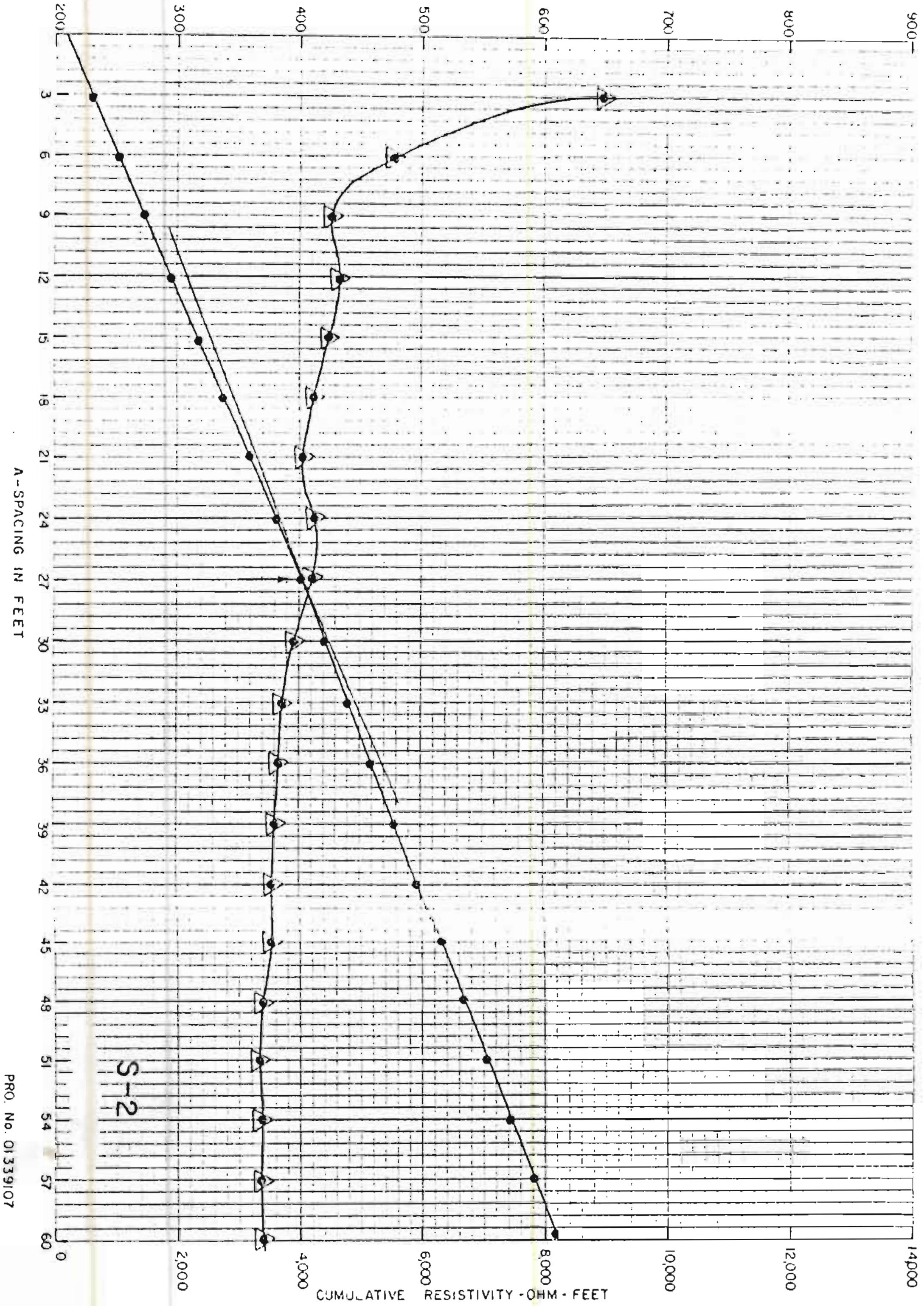
TP-1	10.83
TP-2	8.00
TP-3	DRY TO 21.67
TP-4	DRY TO 20.42
TP-5	3.58
TP-6	DRY TO 15.58


APPARENT RESISTIVITY - OHM-FEET
500
600
700
800
900
1000
1100
1200
A - SPACING IN FEET
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
CUMULATIVE APPARENT RESISTIVITY - OHM-FEET
MOORE CUMULATIVE PLOT
S-1
PRO. No. 0133107



PRO. No. 01339107

SITE PLAN
HYDROGEOLOGIC
SITE EVALUATION

SHEET	OF
1	1

PROJECT NO. 01339107