United States Department of Agriculture
Soil Conservation Service

Northeast NTC
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DEC 1 . 90

Subject: ENG - Trip Summary, EM Survey at the Gervais Farm near North Enosburg, VT

Date: December 7, 1990

To: John C. Titchner
State Conservationist
Soil Conservation Service
Winooski, VT

File Code: 210

Purpose:

To evaluate the holding performance of the Gervais Farm animal waste storage facility by electromagnetic (EM) induction survey in response to your requests (11 Oct 1990 and 19 Oct 1990) for our technical assistance.

Participants:

John S. Moore, Engineering Geologist, SCS, NNTC, Chester, PA
James A. Doolittle, Soil Specialist, SCS, Chester, PA
Richard J. Croft, State Conservation Engineer, SCS, Winooski, VT
Richard A. Fisher, State Design Engineer, SCS, Winooski, VT
David G. Van Houton, State Soil Scientist, SCS, Winooski, VT
James W. Monahan, District Conservationist, SCS, St. Albans, VT
Katherine Hakey, Civil Engr. Technician, SCS, St. Albans, VT
Michel LaPointe, Civil Engineer, SCS, St. Albans, VT
Penny Battison, Soil Conservation Technician, SCS, St. Albans, VT

Activities:

James Doolittle and John Moore arrived in Winooski on Monday, November 5, 1990. On November 6 and 7, we used electromagnetic induction (EM) techniques to evaluate variations in terrain conductivity in a 28-acre area surrounding the animal waste (dairy manure) storage facility at the Gervais Farm, North Enosburg, Vermont.

The St. Albans Field Office and the State Office staffs provided elevation and survey control of the measurement points and developed the site base map on a scale of one inch equals 40 feet with one-foot contour intervals. A reduced version of this map is given on Figure 1 at a scale of one inch equals 200 feet with a 2-foot contour interval. The elevations shown on Figure 1 are based on an assumed datum plane and are not adjusted to standard mean sea level.

David Van Houton conducted a detailed soil survey of the site. The soil map, Figure 4, is superimposed on the topography as given in Figure 1.

John Moore conducted a reconnaissance geologic investigation of lineaments in the vicinity on Thursday, November 8, 1990.

SUPPORTING BACKGROUND INFORMATION

Animal Waste Storage Facility

Prior to the construction of the animal waste storage facility, the manure handling method was stacking with spring/fall spreading (Field Office Baseline Data Sheet, Jan. 1986). The manure stacking site was located at the site of the present holding facility. According to SCS file reports, the new structure maintains its level and shows no obvious signs of loss to seepage during the storage period. John Moore inspected the pit with Richard Croft in early October 1990 and again during this EM survey (Nov 1990) and saw no signs of seepage through the embankment or anywhere along the downstream toe.

The facility overflowed in the Spring of 1989; the amount of discharge is undetermined.

Soils

The animal waste storage facility is located in an area of Peru stony fine sandy loam, 8 to 15 percent slopes (PeC). Adjoining areas are mapped as Westbury stony fine sandy loam, 8 to 15 percent slopes (WrC), and Cabot extremely stony fine sandy loam (Cb). The Peru (coarse-loamy, mixed, frigid Aquic Haplorthods), Westbury (coarse-loamy, mixed, frigid Typic Fragiaquods), and Cabot (coarse-loamy, mixed, nonacid, frigid, Typic Humaquepts) soils are all very deep and have formed in till on backslope positions of glaciated uplands. Peru soils are moderately well drained. Westbury soils are somewhat poorly drained and Cabot soils are somewhat poorly drained to poorly drained; both have a dense, very firm substratum. Included with these soils are small areas having bedrock within depths of 60 inches.

Within the survey area on lower backslope and footslope positions are areas of Munson silt loam, 3 to 8 percent slopes. The very deep, somewhat poorly drained Munson (coarse-silty over clayey, mixed, nonacid, mesic Aeric Haplaquepts) soils formed in glaciolacustrine sediments comprised of coarse silts over clay.

Surficial Geology

During deglaciation of this region in late Pleistocene time, the margin of the continental ice sheet retreated both northward and away from the Green Mountain front. Large, proglacial lakes formed at the margin of the ice sheet in the Champlain Valley with arms of the lakes extending well up into major valleys, including the Missisquoi River Valley and its tributaries. According to Parrott and Stone (1972), there were two principle stages of Glacial Lake Vermont in the Missisquoi Valley: an upper phase at approximately 740 feet in elevation and a lower phase at 600 feet. The Gervais Farm headquarters, barn, and manure holding facility are located at approximately 600 to 620 feet in elevation in what would have been the near-shore, high-energy environment of the lower stage of Glacial Lake Vermont. The field downslope from the farmyard area (approximately 500 linear feet north) is underlain by a zone of wave-washed till, corresponding to the Peru and Westbury soils described above. The general lack of fines in these soils and the abundance of prominent, subrounded stones and cobbles reflect the winnowing and rounding effects of wave-action on materials in the near-shore environment. Above elevation 740 feet (the highest stage of Lake Vermont in the Missisquoi Valley), the stone and cobble fraction exhibits the more characteristic angularity of upland till. Near the east-west stone wall located 500 feet north of the holding facility the finer textured Munson soils reflect quiet water deposition in deeper water of Glacial Lake Vermont. The increase in clay content is reflected in the EM data discussed below (illustrated in Figures 2 and 3) and has been field-verified by David Van Houton, State Soil Scientist.

Bedrock Geology

According to Dennis (1964), the bedrock underlying the Gervais farm is the Underhill facies of the Pinnacle Formation which is comprised of a quartz-chlorite-sericite phyllite of Cambrian age. The site is located on the eastern flank of the Enosburg Anticlinorium in the Western Schist Belt tectonic zone of New England. Local bedrock structure is oriented N25°E, dipping steeply to the southeast.

Lineaments

John Moore analyzed the following aerial photographs and slides (year of flight in parentheses) at the St. Albans Field Office using stereographic viewing techniques on available pairs: (1) infrared (1986); (2) ASCS Acreage Compliance Slides (1986); (3) ASCS (1980 and 1986); and (4) SCS - USDA no. 4050019 (1980).

From this analysis it was determined that the alleged east-west lineament extending from the Longe Spring to 100 feet into the lower Gervais field (as drawn by the Johnson Report, 1989) coincides exactly with a low stone wall (this may have been an old property line). There is no surficial geologic evidence to support the contention for a geologic fracture or lineament in the bedrock at this location. In fact, the bedrock in this area is concealed by a mantle of glaciolacustrine deposits over till with a combined thickness of up to 22 feet. It is the nature of till to vary in both thickness and surface expression. Furthermore, there are no patterns in the EM data to suggest a fracture type (or any type) of lineament in or near the study area.

The east-west lineament identified by Dennis (1964) was also field checked by John Moore. Although a fence line follows the lineament for the most part, its most noteworthy aspect is that it closely correlates with a strandline (between approx. elevation 420 and 440 ft) of the Champlain Sea identified by Parrott and Stone (1972). The strandline marks part of a former shoreline of the Champlain Sea which extended up the Missisquoi Valley following the Lake Vermont stages. The strandline is characterized by the contact between marine sedimentary deposits and till on the south side of the Missisquoi River valley. The lineament has no structural bedrock fracture implications, being entirely a surficial geologic phenomenon.

Ground Water

The underlying bedrock has essentially zero primary porosity owing to its tight, crystalline metamorphic characteristics. Secondary porosity associated with fractures and joints is also very limited. Examination of rock outcrops reveals only widely spaced, tight to hairline-wide fractures and joints. The joint face rock material exhibits no chemical or physical weathering that is normally associated with the movement of ground water through a bedrock fracture system. Because the fracture system in the rock mass is so tight and poorly integrated, perched water table conditions are thus induced by rejected recharge which creates seasonal wetness in the overlying, poorly drained Westbury and Peru soils.

Water wells drilled in the Pinnacle formation in glaciated uplands are typically low-yielding and must be drilled deep in order to intercept a sufficient number of widely separated, thin fractures that may contain small amounts of water.

A detailed topographic survey (mapped on a scale of one inch equals 40 feet with a one-foot contour interval) shows three topographic divides within the 28-acre study area on the Gervais property; the county road acts as another divide, and the Johnson Report (1989) topographic survey delimits yet a fifth divide on the Longe field itself. Surface runoff from the Gervais farmyard is therefore not part of the watershed of the Longe Spring. Since the shape of a water table is generally a subdued reflection of surface topography, it is concluded that five water table divides separate the Longe groundwater drainage area from the Gervais groundwater drainage area. Therefore, there are no data to support a hydraulic connection, either surface or subsurface, between the Longe Spring and the Gervais animal waste storage facility or the lower field.

THE ELECTROMAGNETIC INDUCTION SURVEY

Background Information on EM Techniques

A GEONICS Limited EM-31 ground conductivity meter was used in this survey and consists of a 4.0 meter boom and a console weighing 11.0 kg. The operating frequency of the meter is 9.8 kHz. With the EM-31 placed on the ground surface, measurements of the terrain conductivity were made to depths of 5.50 meters (with the meter in the vertical dipole position) and 2.75 meters (with the meter in a horizontal dipole position). Values of terrain conductivity obtained by these measurements represent the average over the total depth of the measured profile (i.e., 2.75 meters for the horizontal position and 5.50 meters for the vertical position). Values are expressed in millisiemens per meter (mS/m). The operation of the EM-31 meter is described in detail by McNeill (1989).

Electromagnetic induction methods involve the measurement of apparent electrical conductivity of earthen materials. Factors influencing the conductivity of earthen materials include: (1) volumetric water content, (2) amount and type of salts in solution, (3) amount and type of clays in the soil matrix, and (4) soil temperature.

As discussed by Benson and others (1984), the absolute EM measurements are not necessarily diagnostic in themselves, but lateral and vertical variations in conductivity are significant. Interpretation of the EM data is based on the identification of spatial patterns in the data set.

At each grid point, induced electromagnetic conductivity was measured in both the vertical and horizontal dipole positions, and the elevation determined by conventional topographic survey.

The data obtained with the EM-31 meter were plotted on two-dimensional contour plots using the SURFER software program. These plots were constructed using a kriging interpolation and octant search methods.

The Survey Area

A 1500-foot by 750 to 800-foot grid was established across the survey area (see Figure 1). The grid interval was 50 feet. The survey area covered about 28 acres and consisted of 486 equally spaced observation points. The survey site extended 350 feet upslope and 1050 feet downslope from the animal waste storage facility (A). The blanked area in Figure 1 represents the general location of major cultural features and the limits of the survey. The blanked area along the upper right margin of Figure 1 represents a roadway. Buildings and features associated with the Gervais farm constitute the blanked area in the upper part of this figure (B). The blanked area in the lower left hand corner of Figure 1 represents the limits of the survey.

Ground conditions at the time of the survey were saturated due to the perched water table and recent, hard rains, including rain on the first day of the survey. The EM meter readings were therefore not exhibiting variations in moisture content, since essentially all points were saturated.

Survey Results

Figure 1 is a topographic base map of the survey area using an assumed datum plane (not adjusted to standard mean sea level). Figures 2 and 3 are two-dimensional contour plots illustrating the spatial distribution of EM measurements within the survey area. Figure 2 represents values obtained with the EM-31 meter in the vertical dipole position (5.50 meters); Figure 3 represents values obtained with the EM-31 meter in the horizontal dipole position (2.75 meters).

Interpretations

Two major spatial patterns are evident in Figures 2 and 3: one produced by variations in electromagnetic properties associated with changes in soil parent material (till versus glacio-lacustrine deposits); the other produced by variations in electromagnetic properties associated with the Gervais's farming activities.

Variations in the electromagnetic properties occur between the predominantly coarse-loamy till and the finer glaciolacustrine deposits. Soils formed in till occupy higher-lying slope positions (Figure 1, south of coordinate 550 along y-axis). A value of 0.1 mS/m was selected as the average terrain conductivity (natural background) for this area of Peru and Westbury soils. The lower clay content and cation exchange capacities of these soils are reflected in the very low terrain conductivity values obtained in areas of till (see Figures 2 and 3).

Within the survey area, soils formed in glaciolacustrine sediments occupy the lower-lying slope positions (Figure 1, north of coordinate 550 along y-axis). These soils have higher clay contents, higher cation exchange capacities, and higher terrain conductivity values (see Figures 2 and 3). In areas of Munson soils, values of 4.3 mS/m and 4.0 mS/m were selected as the average terrain conductivity (natural background) for the 5.50 and 2.75 meter profiles, respectively. The slightly higher vertical dipole measurements (5.50 meters) reflect the increasing clay content of Munson soils with depth. In areas of Munson soils, terrain conductivity values reflect variations in the thickness, depth to clays, and amount of clays in the profile.

The other major spatial pattern evident in Figures 2 and 3 is the result of variations in electromagnetic properties associated with the Gervais's farming activities. The blanked area in the upper part of Figures 2 and 3 represents the Gervais Farm. This area represents the general location of the farm house, access road, farm buildings, silage pits, animal holding areas, and animal waste holding pond.

In Figures 2 and 3, the blanked area representing the Gervais Farm is surrounded by high values of terrain conductivities. In areas immediately adjoining the animal waste holding pond, EM values were noticeably higher than the selected background value of 0.1 mS/m for Peru and Westbury soils. In the vertical dipole position (5.50 meters), EM values ranged from 1.0 to 18.0 mS/m (10 to 180 times higher than the selected background value). In the horizontal dipole position (2.75 meters), values ranged from 1.0 to 13.0 mS/m (10 to 130 times higher than the background value). The highest terrain conductivity values (greater than 3.0 mS/m) and the steepest gradient of the contours illustrate that dissolved salts (such as chlorides and nitrates) are confined within the footprint of the embankment materials of the storage facility (Figure 2).

A zone of moderately high conductivities (1.0 to 3.0 mS/m) extends up to 200 feet from the downstream toe of the waste storage facility with EM values decreasing away and downslope from the holding facility. This area is the former location of the manure stacking area prior to construction of the new holding facility; it also marks the location of a previous spillage (overflow) event.

In Figure 3, a narrow zone of moderately high values for the shallow (2.75 meters) EM readings, ranging from 0.2 to 2.7 mS/m, extends 500 feet downslope from the northwest side of the manure facility to the county road ditch. This zone is believed to reflect the deposition of dissolved salts (such as chloride and nitrate ions) from the waste-laden surface runoff from livestock holding areas adjacent to the farm buildings. It is important to note that over most of the area below the waste facility, EM values decrease with depth, that is, the horizontal EM values are consistently higher than the vertical EM values which is an indication that salts have accumulated only to the upper part of the soil profile. In addition, after comparing Figures 2 and 3, and considering the variations in soil type and clay content, the occurrence of road salts near the road ditch is suspected to be influencing terrain conductivity values in that area.

References Cited

1. Benson, R.C., Glaccum, R.A., and Noel, M.R., 1984, Geophysical techniques for sensing buried wastes and waste migration: an application review, in: D. M. Nielsen and M. Curls (Eds.) Surface and Borehole Geophysical Methods in Ground Water Investigations. NWWA/EPA Conference, San Antonio, Texas, pp. 533-566.

2. Dennis, J.G., 1964, Geology of the Enosburg Area, Vermont: Vermont Geological Survey Bulletin No. 23, 56 pp.

3. Flynn, D. J., and Joslin, R.V., 1979, Soil survey of Franklin County, Vermont: U.S. Dept. Agriculture, Soil Conservation Service, Washington, D.C.

4. McNeill, J. D. 1989, EM-31 Operating Manual: GEONICS Ltd. Mississauga, Canada, 35 pp.

5. Parrott, W.R., and Stone, B.D., 1972, Strandline features and late Pleistocene chronology of northwestern Vermont: in, Doolan, B.L., and Stanley, R.S. (Eds.), 64th Annual Meeting of the New England Intercollegiate Geological Conference Guidebook, pp. 359-376.

6. Johnson Company, Inc., Nov. 1989, Longe Farm, Enosburg Falls, Vermont, spring contamination study: unpublished report, 5 State Street, Montpelier, VT, 14 pp.

Summary

1. The highest terrain conductivity for the deep (5.50-meter) profile values (3.0 to 18.0 mS/m) and the steepest gradient of the contoured data imply that dissolved salts (such as chlorides and nitrates) are confined within the footprint of the embankment materials of the storage facility.

2. The shallow (2.75-meter) profile data around the lower north side of the facility delimits an area that was "burned" by the old manure stacking handling method, spillage, and surface and near-surface accumulation of dissolved salts, such as nitrates, from waste-laden surface runoff from the livestock holding area adjacent to the farm buildings.

3. The holding facility is entirely surrounded by a 200-foot wide band having extremely low background values at both the 2.75 and 5.50 meter survey depths. It is inferred from this pattern that dissolved salts are not migrating beyond the footprint of the embankment of the facility.

4. In areas immediately surrounding the storage facility, deep EM values are consistently lower than surface EM values and provide evidence that dissolved salts are not migrating into the lower profile.

5. The higher background EM values in the lower north end of the field are attributed to an increase in clay content of the soils in that area based on detailed field checking and the published Franklin County Soil Survey Report.

6. There is no evidence from: (1) the EM survey data, (2) five flights of aerial photography (including infrared), and (3) on-site surficial geologic and soil investigations to support the contention of bedrock fracture traces on the farm or adjoining lands. A low, old stone wall occurs along the alleged trace in the Johnson report.

Conclusions

1. A detailed electromagnetic induction survey conducted on a 50-foot grid over a 28-acre area using 942 readings taken at 486 points indicates that the Gervais animal waste storage facility is not leaching dissolved salts into ground water and is performing according to current engineering design standards.

2. There is no geophysical or geologic evidence to support a hydraulic connection by surface or subsurface waters between the Jervais animal waste storage facility and the Longe Spring.

Follow up/Recommendations:

1. In the event of litigation between the Gervais and Longe parties, we recommend that an electromagnetic induction survey (EM) be conducted within the drainage area above (to the south) and adjacent to (east and west) the Longe Spring to include the area directly below the three residences and in the field around the spring. The EM survey will identify where patterns of concentrations of dissolved salts (chloride and nitrate ions) occur within the watershed of the spring itself. This survey will require the cooperation of Mr. Longe and can be conducted by the SCS at government expense, not his. We understand Mr. Longe is a cooperator with the local District. The field survey can be monitored by his technical advisors, if he so desires.

2. Although surface runoff is not contaminating the Longe Spring itself, we recommend that a resource management system be

developed to improve the control of surface runoff in the Gervais farmyard area.

This report has been technically reviewed by Howard W. Hall, Soil Engineer, and Frank Geter, Environmental Engineer, at the NNTC, Chester, PA. We appreciate this opportunity to work with you and your staff on this matter. Please let us know if there are any questions.

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cc August J. Dornbusch, Jr., Director, SCS, MNTC, Lincoln, NE
D. Bruce Champeon, State Geologist, SCS, Orono, ME
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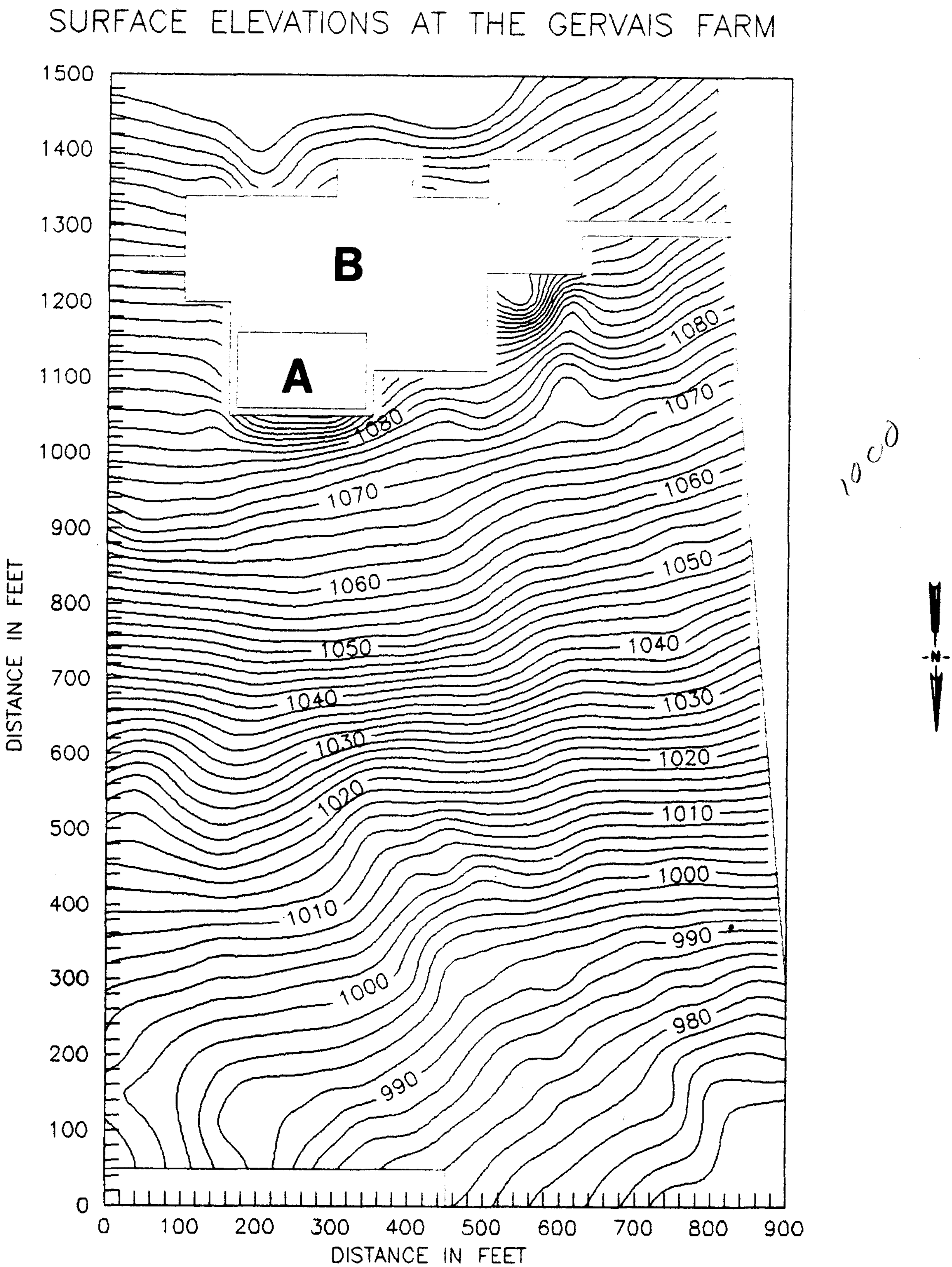
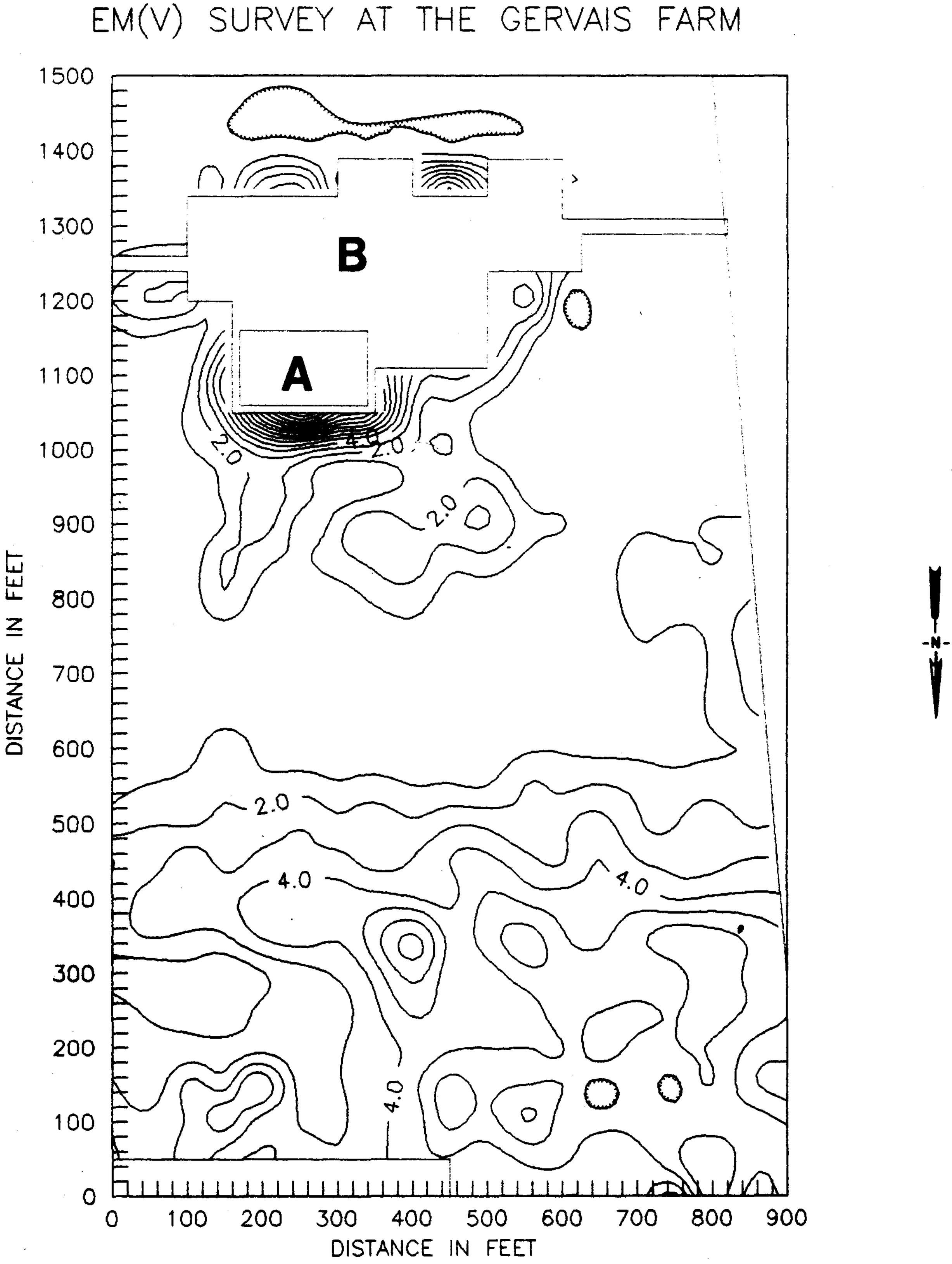
Figure 1

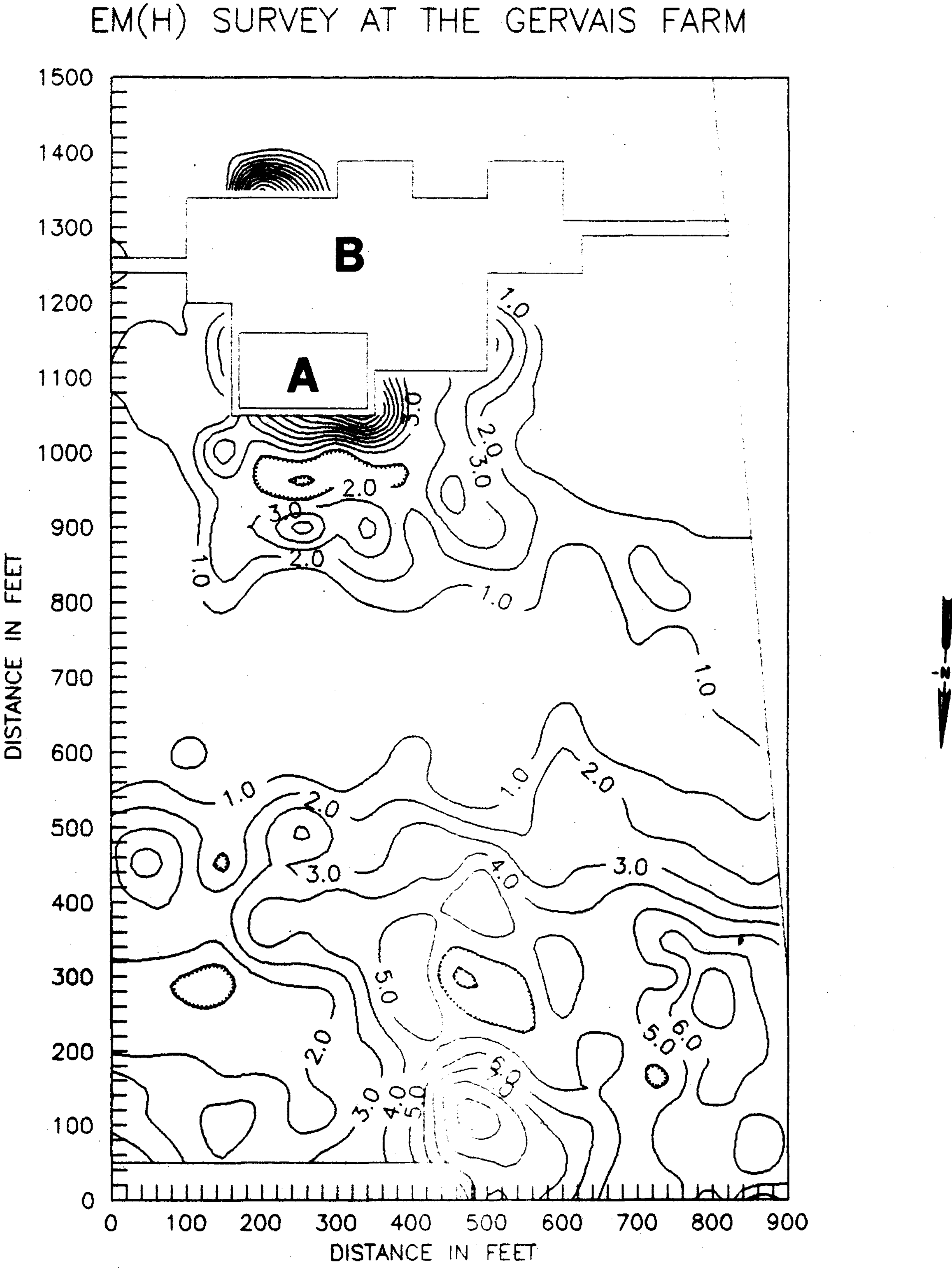


NOTE: Datum plane is assumed; elevations are not adjusted to mean sea level.

Figure 2

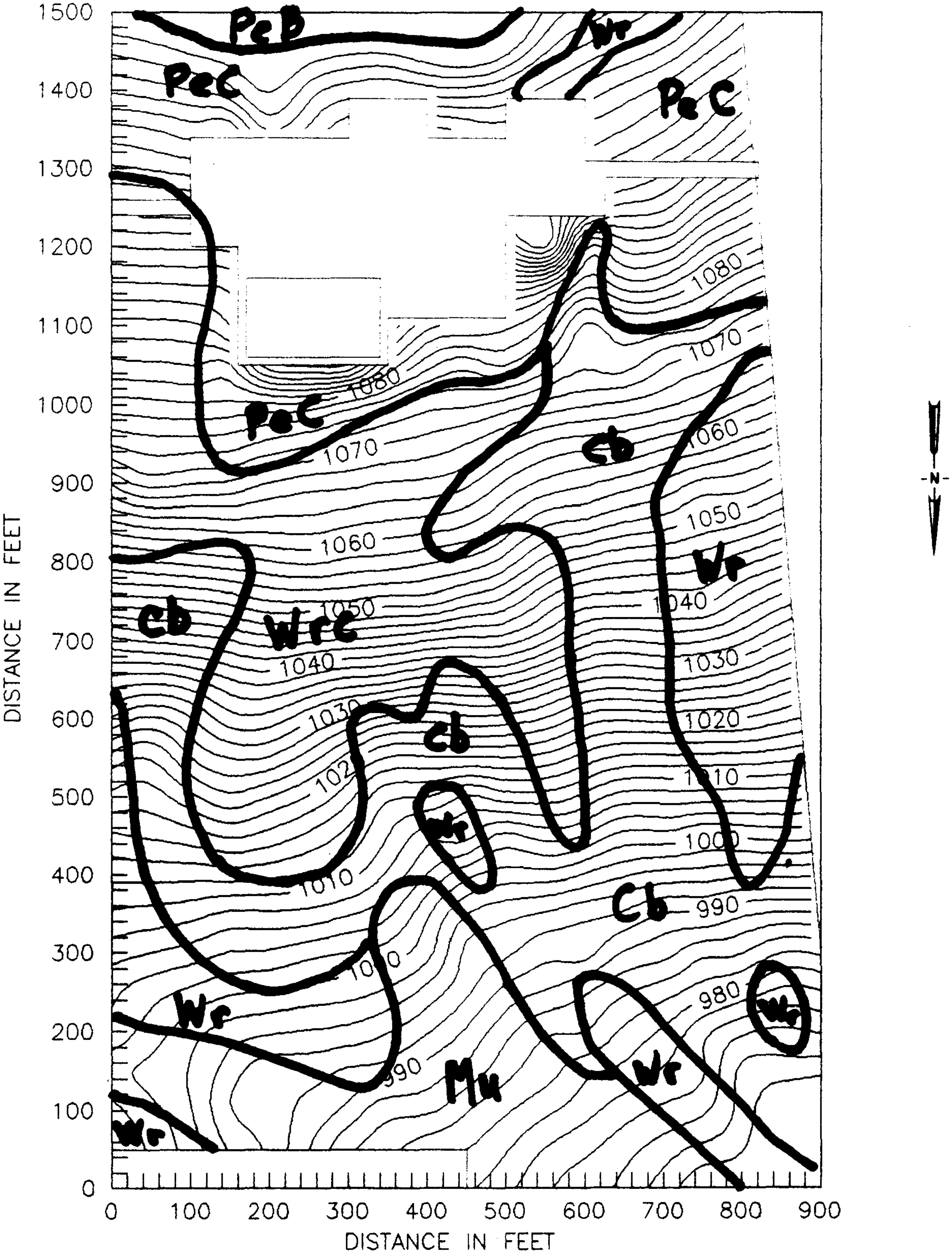


Note: values are expressed in millisiemens per meter (mS/m).



Note: values are expressed in millisiemens per meter (mS/m).

FIG. 4 — SOIL MAP ON TOPOGRAPHY



Key to Soils Map

Cb	Cabot extremely stony fine sandy loam
Mu	Munson silt loam
Pe	Peru stony fine sandy loam
Wr	Westbury stony fine sandy loam

Note: Datum plane is assumed; elevations are not adjusted to mean sea level.

11 12 13 14 15 16 17

V/H

Row	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
15[illegible] A	0.5/0.4	0.2/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	•	0.1/0.1	0.1/0.1	•		
[illegible] B	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	•	•	0.1/0.1	0.1/0.1	0.2/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	•		
14[illegible] C	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.2/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	•		
1350 D	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	4.0/15.0	5.0/7.0	0.1/0.1	•	4.6/0.1	8.9/0.1	• Pond	•	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	•		
13[illegible] E	0.5/0.6	0.1/0.1	0.1/0.1	•	SILAGE •	•	•	•	•	•	•	•	•	•	ROAD	•	•		
[illegible] F	1.0/2.0	•	2.0/0.1	CONCRETE •	BARN •	•	•	•	•	•	•	•	HOUSE •		0.1/0.1	0.1/0.1	•		
1200 G	2.0/0.1	3.5/0.2	3.1/1.1	0.1/1.5	•	•	•	•	•		1.5/2.0	5.4/0.2	0.1/0.1	0.1/0.1	1.2/0.1	0.2/0.1	•		
1150 H	0.4/0.3	0.8/2.1	0.1/0.6	2.2/3.8	WASTE POND •	•	•	•	CONCRETE FEEDLOT •		5.0/5.4	1.3/2.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1		
1100 I	0.9/1.4	0.9/1.5	0.2/0.8	6.0/2.8	•	•	•	•	3.2/2.1	3.3/3.0	2.5/3.5	0.4/1.3	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1		
1050 J	0.3/0.2	0.2/1.5	1.1/1.0	4.2/1.5	12.0/5.6	18.0/9.0	12.0/10.0	11.0/13.0	2.1/2.5	1.7/3.8	0.4/1.4	0.3/1.3	•	0.5/0.1	0.1/0.1	0.1/0.1	0.1/0.1		
[illegible] K	1.1/0.2	0.5/0.8	1.0/1.3	1.5/5.6	3.0/1.2	2.0/3.2	1.8/0.2	1.5/2.4	1.8/1.6	2.5/3.3	0.2/3.0	0.4/0.2	0.1/0.5	0.1/0.2	0.1/0.1	0.1/0.1	0.1/0.1		
[illegible] L	0.1/0.1	0.1/0.2	0.5/0.4	1.1/2.3	2.8/1.9	2.0/0.1	0.1/2.6	0.4/2.3	1.1/2.1	1.2/5.0	2.8/2.4	0.1/2.0	0.2/1.1	0.1/0.4	0.1/0.1	0.1/0.1	0.1/0.8		
900 M	0.6/0.3	0.1/0.9	0.2/0.1	1.0/2.8	3.0/3.2	0.1/6.7	1.5/3.2	3.2/4.8	1.7/0.9	2.6/3.1	3.4/3.4	1.6/2.2	1.1/1.7	0.1/1.6	0.8/1.4	0.5/1.1	1.3/0.7		
850 N	0.1/0.6	0.1/0.2	0.1/0.1	2.4/3.0	1.1/1.3	0.9/0.7	1.8/1.4	2.2/2.9	2.8/2.0	1.1/1.7	1.7/2.3	0.6/2.0	0.1/0.1	0.4/0.6	1.7/2.7	1.6/1.4	0.7/1.7		
800 O	0.1/0.1	0.1/0.1	0.2/0.5	2.3/1.5	0.2/0.1	0.2/0.1	0.1/0.6	1.2/1.1	1.7/1.4	0.3/0.5	0.4/0.1	0.1/1.6	0.1/0.1	0.1/0.1	1.8/1.7	1.8/2.5	1.4/1.5		
750 P	0.1/0.1	0.1/0.1	0.1/0.1	0.2/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.6/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	1.1/1.2	0.7/0.1	1.1/1.8	2.9/0.9	
[illegible]00 Q	0.1/0.1	0.1/0.1	0.1/0.1	0.4/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.3	0.1/1.0	0.8/0.5	0.6/0.2	1.0/1.3	2.3/1.5	
[illegible]0 R	0.1/0.1	0.1/0.1	0.1/0.2	0.4/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.1/0.1	0.4/0.2	0.1/0.1	0.1/0.1	0.2/0.1	0.1/1.6	0.4/0.2	0.5/0.5	0.3/0.4	1.3/1.0	2.1/1.4	
[illegible]00 S	0.2/0.3	0.6/0.1	0.4/1.8	1.9/0.5	0.7/1.1	0.1/0.1	0.2/0.1	0.1/0.1	0.2/2.0	0.4/0.1	0.1/0.1	0.8/0.4	0.9/2.1	0.7/0.9	0.6/0.1	0.5/0.3	0.8/0.1	0.9/0.8	
[illegible] T	0.5/0.7	1.1/1.4	1.2/0.3	2.1/0.7	1.1/0.8	1.8/1.7	1.1/0.7	1.6/1.6	0.9/1.5	1.1/0.1	0.7/0.1	2.5/1.7	1.7/3.0	2.1/2.5	1.9/1.9	1.5/1.0	1.8/1.0	1.5/0.7	
[illegible]0 U	1.5/2.6	2.1/3.0	1.7/2.6	2.2/1.5	2.4/2.7	3.2/5.0	2.1/2.7	2.9/2.1	2.0/3.6	3.0/3.0	2.9/1.9	1.8/1.7	2.7/2.9	3.8/2.2	1.8/1.8	1.9/1.7	2.7/1.8	1.7/1.0	
[illegible] V	3.1/2.5	2.0/3.0	4.1/2.6	2.6/0.8	3.3/2.8	3.1/2.5	3.4/2.8	2.5/2.6	3.1/3.8	4.0/3.4	4.5/5.2	3.3/2.2	2.9/2.8	4.2/3.0	3.0/3.0	2.8/2.7	2.6/2.0	3.2/1.9	
[illegible] W	2.2/2.5	3.5/2.8	3.8/2.7	3.8/2.4	4.5/4.4	4.8/4.0	4.6/4.8	4.4/4.1	3.6/4.4	3.4/5.2	5.4/6.0	4.4/4.0	4.4/3.4	4.3/4.1	4.5/5.0	3.6/4.1	4.0/3.4	4.2/2.2	
X	2.5/2.7	3.4/3.0	2.8/2.7	2.8/2.0	4.5/5.0	4.7/3.5	4.0/4.9	5.6/4.6	8.4/6.3	4.3/4.0	5.7/5.1	7.0/5.0	5.0/5.4	4.6/4.0	6.0/5.1	7.0/6.8	6.7/4.8	5.9/5.8	
Y	1.6/1.4	1.1/1.2	1.7/0.7	1.2/0.7	1.6/1.9	2.5/2.5	3.1/2.7	4.2/4.5	6.6/6.1	4.4/3.1	4.2/3.0	5.8/4.0	5.7/5.8	5.5/4.3	5.0/4.6	5.5/4.8	7.0/7.8	5.5/5.8	5.5/5.4
Z	2.5/2.0	2.0/1.7	1.9/1.2	1.8/1.2	2.3/1.6	2.9/0.8	2.7/1.9	3.5/3.9	5.6/6.4	4.2/4.7	4.4/3.4	4.2/3.4	5.8/5.6	5.8/3.3	6.5/5.4	5.8/6.3	6.5/6.9	6.0/6.1	5.1/5.7
AA	2.1/1.7	2.1/1.7	2.2/2.0	2.0/1.3	2.3/0.9	2.1/1.6	3.0/3.5	3.5/2.7	4.0/4.2	4.9/5.0	5.0/6.2	5.0/4.4	4.6/3.8	7.2/6.9	5.4/4.0	6.0/4.7	6.0/6.0	4.6/6.8	4.5/5.0
BB	3.2/4.0	2.0/3.0	4.6/3.0	3.6/2.4	7.0/2.8	2.2/1.8	2.9/2.4	3.4/2.7	4.8/4.8	6.4/8.2	5.6/8.0	6.0/5.8	6.0/4.9	4.4/4.8	5.4/4.0	4.8/4.4	6.4/7.0	4.0/5.3	3.5/5.6
CC	4.0/3.7	3.1/2.8	4.0/2.7	5.9/3.6	3.2/3.0	2.9/1.5	2.6/2.0	4.1/4.0	4.0/4.6	6.8/8.6	5.4/10.0	7.9/8.0	5.3/6.4	5.2/6.1	5.3/4.2	5.4/6.4	5.0/5.0	5.8/6.3	4.8/5.8
DD	4.3/5.2	3.2/4.4	4.7/2.7	3.1/3.0	2.6/2.0	3.7/2.9	3.1/4.0	3.6/3.6	4.8/5.0	4.8/7.5	3.9/7.4	5.0/7.8	5.3/7.4	4.4/5.3	4.6/4.6	6.0/5.3	7.5/4.4	5.0/7.5	6.0/5.5
EE	•	•	•	•	•	•	•	•	•	4.6/3.2	5.0/8.8	5.0/7.3	4.0/6.3	4.2/4.8	4.4/4.4	2.7/4.4	7.1/7.4	4.1/2.8	5.5/4.6
	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900

2 10 10 30 30 40 4[illegible] 50 50 60 60 80 80 6[illegible] 6[illegible]

50' Interval

STA.	ELEV.	STA.	ELEV.	STA.	ELEV.	STA.	ELEV.
T-3	1026.4	W-6	1011.7	Z-8	997.6	CC-8	986.1
T-4	1028.0	W-7	1010.9	Z-9	995.3	CC-9	987.0
T-5	1028.1	W-8	1007.8	Z-10	992.5	CC-10	984.4
T-6	1025.0	W-9	1004.1	Z-11	989.3	CC-11	982.2
T-7	1021.2	W-10	1000.8	Z-12	988.0	CC-12	980.7
T-8	1017.4	W-11	999.0	Z-13	986.2	CC-13	978.8
T-9	1018.0	W-12	999.7	Z-14	984.0	CC-14	976.9
T-10	1018.0	W-13	997.8	Z-15	983.1	CC-15	975.5
T-11	1017.9	W-14	996.3	Z-16	980.9	CC-16	974.8
T-12	1017.4	W-15	995.3	Z-17	979.8	CC-17	971.3
T-13	1015.1	W-16	995.2	Z-18	977.2	CC-18	967.3
T-14	1013.5	W-17	994.4	Z-19	978.0	CC-19	966.1
T-15	1013.4	W-18	994.7	AA-1	1003.7	DD-1	1004.1
T-16	1013.3	X-1	1009.7	AA-2	1001.3	DD-2	1001.7
T-17	1013.1	X-2	1009.3	AA-3	998.7	DD-3	999.2
T-18	1012.8	X-3	1008.8	AA-4	997.0	DD-4	995.9
U-1	1019.5	X-4	1007.3	AA-5	996.4	DD-5	993.9
U-2	1019.0	X-5	1007.6	AA-6	995.9	DD-6	989.9
U-3	1021.4	X-6	1007.5	AA-7	995.4	DD-7	986.0
U-4	1023.8	X-7	1006.1	AA-8	994.1	DD-8	984.8
U-5	1021.7	X-8	1004.6	AA-9	992.2	DD-9	982.4
U-6	1019.8	X-9	1000.2	AA-10	989.7	DD-10	982.1
U-7	1016.8	X-10	995.6	AA-11	986.5	DD-11	980.3
U-8	1011.7	X-11	994.6	AA-12	983.9	DD-12	977.6
U-9	1012.5	X-12	993.4	AA-13	984.4	DD-14	974.7
U-10	1009.0	X-13	992.4	AA-14	981.6	DD-15	973.0
U-11	1011.3	X-14	991.9	AA-15	979.6	DD-16	971.3
U-12	1011.3	X-15	989.4	AA-16	976.4	DD-17	970.8
U-13	1009.6	X-16	990.1	AA-17	974.1	DD-18	967.0
U-14	1006.8	X-17	988.2	AA-18	973.5	DD-19	964.6
U-15	1007.2	X-18	987.5	AA-19	974.3	EE-1	1003.0
U-16	1007.1	Y-1	1006.9	BB-1	1000.5	EE-2	1001.5
U-17	1006.7	Y-2	1006.1	BB-2	999.2	EE-3	999.6
U-18	1006.7	Y-3	1005.2	BB-3	998.0	EE-4	997.0
V-1	1015.7	Y-4	1003.9	BB-4	995.0	EE-5	993.3
V-2	1016.4	Y-5	1003.9	BB-5	992.5	EE-6	990.1
V-3	1017.0	Y-5	1003.3	BB-6	992.7	EE-7	987.8
V-4	1018.2	Y-6	1002.5	BB-7	991.7	EE-8	984.9
V-5	1017.3	Y-7	1002.0	BB-8	991.3	EE-9	980.1
V-6	1015.5	Y-8	1001.1	BB-9	989.1	EE-10	980.3
V-7	1013.3	Y-9	999.1	BB-10	987.4	EE-11	978.6
V-8	1010.1	Y-10	993.5	BB-11	984.7	EE-12	976.3
V-9	1006.6	Y-11	992.6	BB-12	982.9	EE-14	973.6
V-10	1006.6	Y-12	990.6	BB-13	980.6	EE-15	971.0
V-11	1002.9	Y-13	990.8	BB-14	979.5	EE-16	968.4
V-12	1005.0	Y-14	987.8	BB-15	977.9	EE-17	967.4
V-13	1003.9	Y-15	986.9	BB-16	976.2	EE-18	966.3
V-14	1001.0	Y-16	984.6	BB-17	971.1	EE-19	964.8
V-15	1001.5	Y-17	984.4	BB-18	971.4		
V-16	1000.1	Y-18	981.8	BB-19	970.6		
V-17	1000.2	Z-1	1004.3	CC-1	1002.7		
V-18	1001.0	Z-2	1002.5	CC-2	1000.6		
W-1	1012.5	Z-3	1001.6	CC-3	998.3		
W-2	1012.9	Z-4	1000.2	CC-4	993.7		
W-3	1012.6	Z-5	999.9	CC-5	992.7		
W-4	1013.1	Z-6	999.1	CC-6	991.7		
W-5	1012.6	Z-7	998.9	CC-7	989.6		

VEREC.GRD

TBM = 100.00 + 1000 = 1100 FT (ASSUMED)

VEREL.GRD

STA.	ELEV.	STA.	ELEV.	STA.	ELEV.	STA.	ELEV.	STA.	ELEV.
A-1	1122.2	D-10	1108.6	J-12		M-12	1059.6	P-18	1034.8
A-2	1122.8	D-11		J-13	1072.7	M-13	1058.4	Q-1	1041.0
A-3	1123.9	D-12	1107.6	J-14	1073.5	M-14	1057.1	Q-2	1042.5
A-4	1125.6	D-13	1105.6	J-15	1069.7	M-15	1055.6	Q-3	1042.9
A-5	1125.7	D-14	1104.0	J-16	1068.7	M-16	1053.5	Q-4	1043.7
A-6	1125.1	D-15	1102.2	J-17	1066.9	M-17	1053.1	Q-5	1045.2
A-7	1125.1	D-16	1099.7	K-1	1079.3	N-1	1061.6	Q-6	1044.0
A-8	1125.8	E-1	1105.8	K-1	1079.2	N-2	1062.8	Q-7	1043.7
A-9	1126.1	E-2	1106.3	K-2	1080.1	N-3	1062.7	Q-8	1042.8
A-10	1127.5	E-3	1107.3	K-3	1080.1	N-4	1063.5	Q-9	1041.8
A-11	1125.3	F-1	1101.0	K-4	1079.3	N-5	1063.2	Q-10	1041.0
A-12	1119.1	F-2		K-5	1078.9	N-6	1063.5	Q-11	1041.1
A-13	1117.4	F-3	1101.5	K-5	1078.5	N-7	1075.3	Q-12	1038.8
A-14	1115.2	F-15	1094.9	K-6	1078.4	N-8	1061.7	Q-13	1034.7
A-15	1113.4	F-16	1089.9	K-7	1076.5	N-9	1061.3	Q-14	1033.7
A-16	1110.3	G-1	1096.0	K-8	1074.4	N-10	1060.4	Q-15	1034.5
B-1	1118.3	G-2	1095.8	K-9	1072.5	N-11	1057.7	Q-16	1034.2
B-2	1119.0	G-3		K-10	1072.4	N-12	1054.2	Q-17	1032.5
B-3	1120.3	G-4	1096.7	K-11	1071.1	N-13	1053.8	Q-18	1029.6
B-4	1121.3	G-15	1088.8	K-11	1070.7	N-14	1052.0	R-1	1035.5
B-5	1121.3	G-16	1084.3	K-12	1069.4	N-15	1051.3	R-2	1034.8
B-6	1121.1	G-17	1081.1	K-13	1068.4	N-16	1049.1	R-3	1035.5
B-7	1120.5	H-1	1091.6	K-13	1068.3	N-17	-1048.6	R-4	1037.8
B-8	1120.1	H-2	1092.0	K-14	1067.5	O-1	1055.3	R-5	1038.8
B-9	1121.8	H-3	1092.1	K-15	1067.0	O-2	1056.0	R-6	1036.9
B-10	1123.2	H-4	1092.0	K-15	1066.7	O-3	1056.7	R-7	1035.4
B-11	1120.9	H-11	1087.6	K-16	1065.1	O-4	1057.1	R-8	1035.2
B-12	1116.1	H-12	1087.1	K-17	1062.7	O-5	1057.8	R-9	1033.0
B-13	1113.1	H-13	1086.5	K-17	1062.6	O-6	1058.5	R-10	1033.3
B-14	1111.5	H-14	1084.2	L-1	1074.2	O-7	1057.4	R-11	1033.2
B-15	1109.8	H-15	1082.3	L-2	1075.1	O-8	1057.2	R-12	1030.4
B-16	1106.4	H-16		L-3	1074.9	O-9	1056.1	R-13	1028.1
C-1	1114.5	[redacted]	1075.7	L-4	1075.1	O-10	1055.4	R-14	1027.6
C-2	1115.0	I-1	1087.2	L-5	1073.6	O-11	1053.4	R-15	1028.3
C-3	1116.1	I-2	1087.6	L-6	1072.8	O-12	1049.1	R-16	1027.4
C-4	1117.0	I-3	1087.5	L-7	1071.2	O-13	1047.2	R-17	1026.5
C-5	1117.0	I-4	1089.9	L-8	1070.1	O-14	1045.8	R-18	1024.1
C-6	1116.3	I-9	1084.2	L-9	1069.4	O-15	1045.5	S-1	1029.8
C-7	1114.9	I-10	1083.8	L-10	1068.1	O-16	1044.9	S-2	1027.3
C-8	1113.8	I-11	1082.7	L-11	1065.9	O-17	1042.5	S-3	1029.7
C-9	1115.3	I-12	1080.2	L-12	1063.6	P-1	1049.0	S-4	1033.1
C-10	1115.1	I-13	1079.0	L-13	1062.8	P-2	1049.2	S-5	1033.3
C-11	1113.8	I-14	1075.8	L-14	1062.6	P-3	1049.5	S-6	1030.3
C-12	1111.0	I-15	1075.0	L-15	1060.6	P-4	1050.5	S-7	1027.9
C-13	1109.2	I-16	1074.6	L-16	1059.4	P-5	1052.0	S-8	1024.9
C-14	1107.0	I-17	1070.7	L-17	1057.2	P-6	1052.0	S-9	1024.4
C-15	1105.0	J-1	1083.4	M-1	1068.3	P-7	1051.9	S-10	1025.4
C-16	1102.3	J-2	1083.7	M-2	1071.5	P-8	1050.9	S-11	1025.1
D-1	1109.4	J-3	1084.0	M-3	1070.2	P-9	1051.3	S-12	1024.0
D-2	1109.8	J-4	1083.8	M-4	1069.7	P-10	1048.9	S-13	1021.1
D-3	1111.1	J-5	1092.4	M-5	1067.8	P-11	1047.4	S-14	1020.2
D-4	1110.8	J-6	1093.2	M-6	1066.7	P-12	1043.5	S-15	1020.8
D-5	1113.8	J-7	1091.9	M-7	1066.7	P-13	1041.1	S-16	1020.4
D-6	1113.6	J-8	1084.2	M-8	1065.8	P-14	1041.0	S-17	1020.2
D-7	1110.7	J-9	1078.6	M-9	1065.7	P-15	1040.5	S-18	1018.6
D-8	1105.9	J-10	1076.7	M-10	1064.5	P-16	1040.5	T-1	1023.2
D-9	1107.0	J-11	1078.6	M-11	1061.7	P-17	1037.6	T-2	1021.3