United States Department of Agriculture

Soil Conservation Service

Northeast NTC
160 East 7th Street
Chester, PA 19013-6092
215-499-3960

Subject: EM Survey of Indian Mounds Date: April 19, 1990

To: Richard A. Rogers
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693 Federal Building
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Des Moines, Iowa 50309

Please forgive my oversight. Enclosed find graphs depicting relative ground elevations and EM (vertical) measurements at the four sites along Three Mile Creek in Union County.

Each of the enclosed figures contains graphs of relative ground elevations and EM measurements in the upper and the lower parts, respectively. Elevations have not been tied to a datum and merely provide relative values along each transect lines. In the upper part of each figure, the elevation scale ranges from 0 to 20 feet. Apparent electrical soil conductivities were measured using the EM38 in the vertical profiling mode. This provided a theoretical profiling depth of 1.5 meters. In the lower part of most figures, the conductivity scale ranges from 20 to 80 mS/m (transect 4C is the exception with a range of 10 to 80 mS/m).

Discussion:

General

Electromagnetic methods measure the apparent electrical conductivity of earthen materials. Factors influencing the conductivity of earthen materials include (i) volumetric water content, (ii) amount and type of salts in solution, (iii) amount and type of clays in the soil matrix, and (iv) soil temperature. Measurements are expressed in millisiemens/meter (mS/m).

The soils along Three Mile Creek were slightly to moderately conductive with EM (v) readings ranging from 19 to 76 mS/m. Sites were in areas of Colo (fine-silty, mixed, mesic Cumulic Haplaquolls), Vesser (fine-silty, mixed, mesic Argiaquic Argialbolls), and Nodaway (fine-silty, mixed, nonacid, mesic Mollic Udifluvents) soils. It was assumed that moist soil conditions and the medium clay contents of these soils were responsible for the relative magnitudes of the EM measurements.

Along Three Mile Creek, burial mounds are micro features in the landscape. These features are often barely perceptible. These micro-highs have convex surfaces and are slightly better drained than surrounding soils. Although the influence of terrain on soil moisture was considered slight, this factor can not be ruled out as affecting the EM measurements.

At burial sites, artifacts have displaced the natural soil materials. Artifacts were commonly buried in layers of sands carried from areas adjacent to the stream channel. The artifacts are presumed to be and the layers of sand are more resistive than the surrounding soil materials which have higher clay contents. Burial mounds. containing more resistive materials, were presumed to have lower electrical conductivities than adjoining areas of non-disturbed soils.

Site 1

Site 1 consisted of three transects (A, B, and C). Observation markers A-10 and C-0 are identical as transects A and C crossed at this location.

Figure 1: Transect A has a 10 foot spacing between each observation marker. Along this transect, the land surface rises from the stream channel (left to right). Relief is 8.7 feet. Along transect A, EM values averaged 51 mS/m with a range of 40 to 58 mS/m.

A convex surface believed to be an Indian mound, is apparent in the upper graph at observation marker 30. At this marker, the EM value was 44 mS/m. This value was 20 % lower than surrounding values and 15 % lower than the averaged value (51mS/m) for this transect. The low values at observation marker 0 was attributed to coarse-textured, more resistive alluvium. No explanation can be offered for the low EM value at marker 80.

Figure 2: Transect B has a 10 foot spacing between each marker. This transect parallels the stream channel and local relief is slight (2.7 feet). Along transect B, EM values averaged 57 mS/m with a range of 48 to 76 mS/m.

EM values decrease from left to right reflecting differences in soil type or clay content, or possible burials. A burial site was suspected between observation markers 40 and 60. However, the spacing in Figure 2 is too coarse and the variability in EM measurements to slight to confirm this inference.

Figure 3: A portion of transect B was re-surveyed with the EM38. Additional observation markers were inserted at a one foot interval between observation markers 40 and 60 (see Figure 2). Relief is 1.0 foot. Along this transect, EM values averaged 50 mS/m with a range of 43 to 58 mS/m.

Two micro-highs having convex surfaces are evident in Figure 3 between observation markers 41 to 50 and 54 and 59. Burial mounds were believed to be centered about observation markers 46 and 56. EM values were reduced across these surfaces. The averaged EM value for the mounds was 45 mS/m. This value of soil conductivity was 15 % lower than the value for the surrounding soils.

Figure 4: Transect C has a 10 foot spacing between each observation marker. Between observation markers 0 and 20, the surface rises from the stream channel to a higher-lying stream terrace. Relief

is 6.2 feet. Along transect C, EM values averaged 54 mS/m with a range of 45 to 59 mS/m.

The convex surface at observation marker 20 was near the center of the second mound identified in Figure 3. At this marker, the EM value was 45 mS/m. This value was 19 % lower than surrounding values and 17 % lower than the averaged value (54 mS/m).

Site 2

Site 2 consisted of three transects (A, B, and C). Transect A was on an intermediate terrace and paralleled the stream channel. Transects B and C were perpendicular to the stream channel. Transects B and C were too short and lacked sufficient observation markers to be analyze.

Figure 5: Transect A had a 10 foot spacing between each observation marker. Relief is 2.5 feet. Along transect A, EM values averaged 46 mS/m with a range of 43 to 56 mS/m.

Two burial mounds were identified in this figure (between observation markers 0 to 20 and 40 to 60). The suspected mound had convex surfaces of low relief and lower conductivities than the surrounding soils. However the data was too limited and widely space to be analyzed further.

Figure 6: Two portions of transect A were re-surveyed with the EM38. Additional observation markers were inserted at a one foot interval between observation markers 10 and 20 (see Figure 5). Along this portion of transect A, relief was 1.5 feet. Along this transect, EM values averaged 45 mS/m with a range of 38 to 55 mS/m.

A slight convex surface is evident in the upper graph between observation markers 14 to 17. This area corresponded with a zone of lower electrical conductivities and was suspected of being "artificially manipulated or disturbed." The averaged conductivity on adjoining plane or slightly concave surfaces (observation markers 10 to 13, 18 to 20) was 47 mS/m. The suspected burial mound had an average conductivity of 40 mS/m. The site of the suspected burial mound (observation markers 14 to 17) had an averaged conductivity which was 15 % lower than the surrounding surfaces.

Figure 7: This is a graph of the second portion of transect A which was re-surveyed with the EM38. Additional observation markers were inserted at a one foot interval between observation markers 46 and 54 (see Figure 5). Relief was 1.2 feet. Along this transect, EM values averaged 46 mS/m with a range of 42 to 52 mS/m.

Although the surface was slightly convex between observation markers 49 and 53, EM measurements did not support the presence of a burial mound.

Site 3

Site 3 consisted of three transects (A, B, and C). Observation markers A-54 and B-10 are identical as transects A and B crossed at this location.

Figure 8: Transect A has a 10 foot spacing between each observation marker. Relief is 8.3 feet. Along this transect, EM values were relatively high and averaged 62 mS/m with a range of 51 to 70 mS/m.

A convex surface believed to be a burial mound, is apparent in the upper graph at observation marker 50. At this marker, the EM value was 51 mS/m. This value, though higher than on other mounds was 20 % lower than surrounding values and 18 % lower than the averaged value (62mS/m). The EM measurements, though limited and widely spaced, support the presence of a burial at observation marker 50.

Figure 9: A portion of transect A were re-surveyed with the EM38. Additional observation markers were inserted at a one foot interval between observation markers 50 and 70 (see Figure 8). Relief was 2.4 feet. Along this portion of transect A, EM values averaged 55 mS/m with a range of 46 to 64 mS/m.

A slight convex surface is evident in the upper graph between observation markers 50 to 56. This area corresponded with a zone of lower electrical conductivities. The slightly convex surface had an average conductivity of 49 mS/m; a value 17 % lower than the conductivity on surrounding surfaces (59 mS/m).

Figure 10: Transect B has a 10 foot spacing between each observation marker. The surface slopes toward the stream channel (to the left). Relief is 5.1 feet. Along this transect, EM values averaged 60 mS/m with a range of 48 to 75 mS/m.

The burial mound discussed above under Figures 8 and 9 was located at observation marker 10 in this figure.

Figure 11: The portion of transect B which contained the suspected burial mound was re-surveyed with a spacing of one foot between observation markers. Relief along this portion of the transect was 1.6 feet. Along this portion of transect B, EM values averaged 55 mS/m with a range of 48 to 62 mS/m.

The suspected burial mound appears as a convex surface in the upper graph and as an area of lower electrical conductivities in the lower profile. Along this transect, the lowest conductivity value (48 mS/m) was obtained on the mound. However, along this transect, the mound had an average conductivity of only 9 % less than the surrounding areas. In this direction and with this number and spacing of observations, a burial mound would not have been inferred from the EM measurements alone.

Figure 12: Transect C has a 10 foot spacing between each observation marker. Relief is 4.9 feet. Along transect C, EM values averaged 63 mS/m with a range of 58 to 70 mS/m.

No surface convexity is evident in the upper graph, nor is there any pattern in the distribution of soil conductivities in the lower graph to suggest the occurrence of a burial mound.

Site 4

Site 4 consisted of four transects (A1, A, B, and C). Transect A1 is not described in this report. In addition, only a portion of transect A is discussed.

Figure 13: Transect A has a 10 foot spacing between each observation marker. This transect crossed a small drainageway (between observation markers 30 and 60). Measured relief was 6.4 feet. Along this transect, EM values averaged 47 mS/m with a range of 32 to 62 mS/m.

The large range in EM measurements reflect variations in soils, management (observation markers 60 to 90 were in an area which was disturbed by pigs), and terrain. Generally, EM values decrease across this figure from left to right. Within the drainageway EM measurements decrease with decreasing elevations. A reduction in clay content of the soil materials with decreasing elevation within the drainageway is believed to be responsible for these lower EM measurements. Observation markers 70 to 90 were located in an area disturbed and influenced by pigs. The lower EM values in this portion of the transect is believed to be a manifestation of management practices. No pattern is evident in this profile which suggest a burial mound (a mound did occur at 66 feet).

Figure 14: A portion of transect A which contained a suspected burial mound was re-surveyed with a spacing of one foot between each observation marker. Relief along this portion of the transect was 1.5 feet. Along this portion of transect A, EM values averaged 43 mS/m with a range of 30 to 52 mS/m.

The suspected burial mound is centered at observation marker 66. While there is little surface manifestations of this mound, EM values dip between observation markers 62 and 67. The low EM values at observation markers 68 to 70, is a manifestation of management practices (see Figure 13).

Figure 15: Transect B has a one foot spacing between each observation marker. This transect crossed transect A near the center of a suspected burial mound (observation markers 28 to 31). A second suspected burial mound is located between observation markers 18 and 21). Relief was 5.0 feet. Along this transect, EM values averaged 37 mS/m with a range of 32 to 48 mS/m.

In this figure, EM measurements are highly variable over short horizontal distances. While the EM values dip at each of the suspected burial sites, these variations are masked by the general level of variability in EM measurements along this transect. The disturbance of this site by pigs and related management practices has affected the interpretiblity of the EM measurements.

Figure 16: This figure is a representation of a portion of transect C. This portion of transect C has a one foot spacing between each observation marker. This transect crossed the center of a known

burial mound (observation markers 47 to 57). Relief along this portion of the transect was 6.0 feet. In this figure, EM values averaged 27 mS/m with a range of 19 to 44 mS/m.

The convex surface of the burial mound is evident in the upper part of this figure. Within the burial mound (observation markers 47 to 50), EM measurements averaged 21.8 mS/m. This averaged value was 37 % lower than the averaged soil conductivity value for the surrounding soils. Although the EM values obtained along this portion of the transect were exceptionally low, the presence of a burial mound was confirmed with the EM38 meter.

Conclusions:

Electromagnetic techniques can be used to nondestructively to investigate burial mounds.

When investigated (September 1989) burial mounds along Three Mile Creek had averaged EM values which were 15 to 37 % lower than values obtained from adjoining non-disturbed areas. Inferences can be strengthen by multiple transects with more closely spaced observations. However, confirmation of burial mounds requires excavation.

Convex mounds occur naturally within the study areas. These micro-features do not contrast with adjoining areas as great as do the burial mound.

Large and irregular variations in EM measurements can be anticipated in areas of intense surface disturbance. These variations complicate EM interpretations. Electromagnetic Induction surveys in these areas should be avoided.

Hope that this material will be of assistance to you. Let me know if more can be done. With kind regards.

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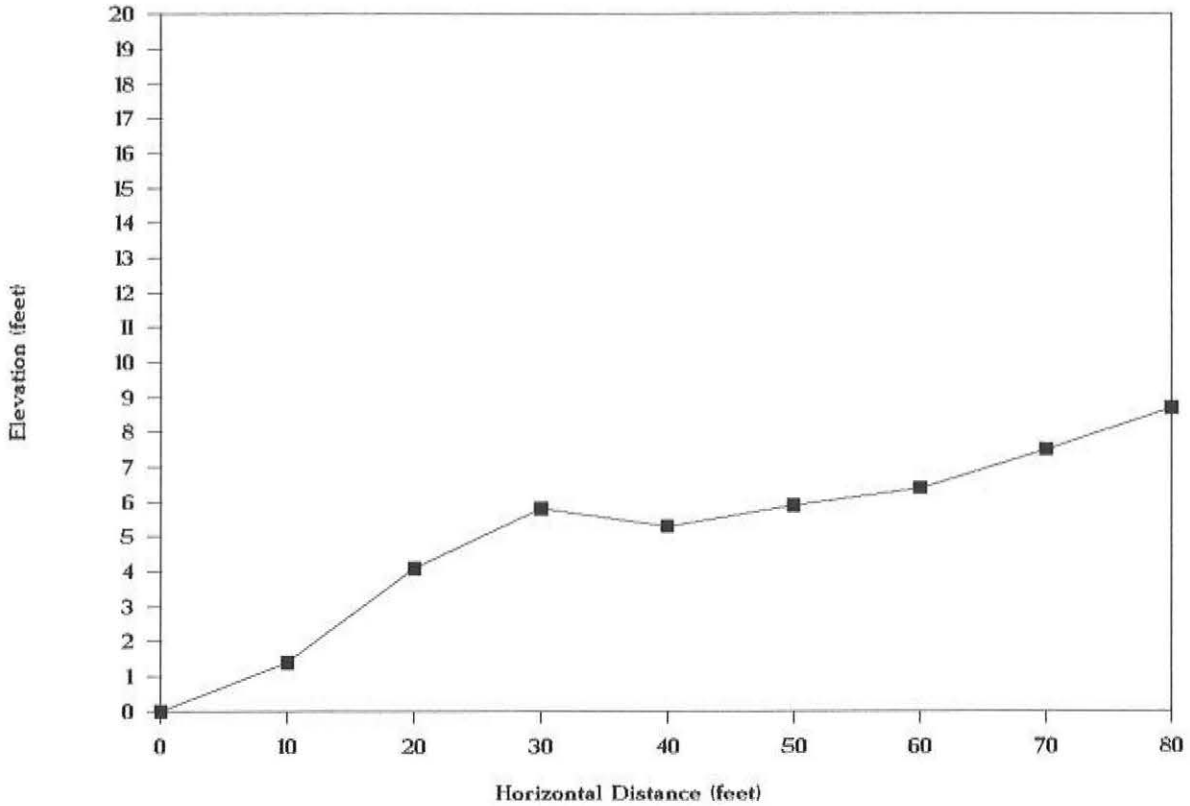
1A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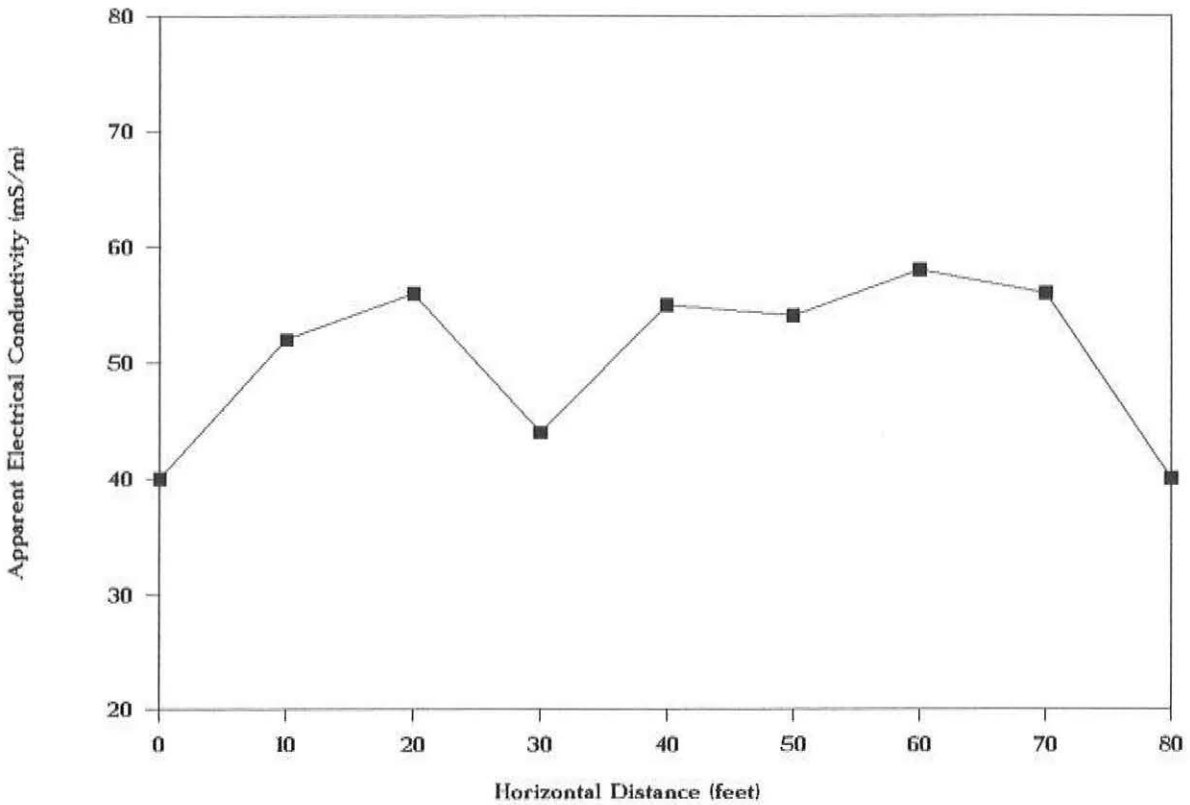
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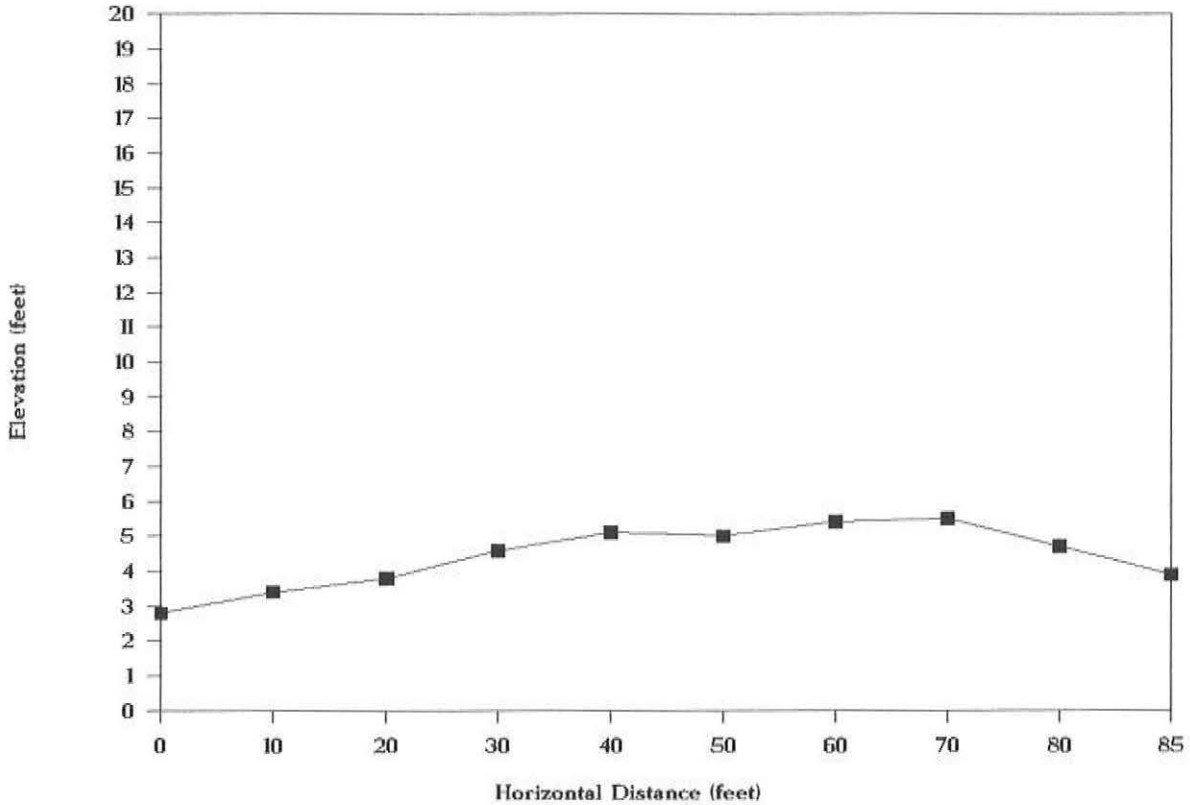
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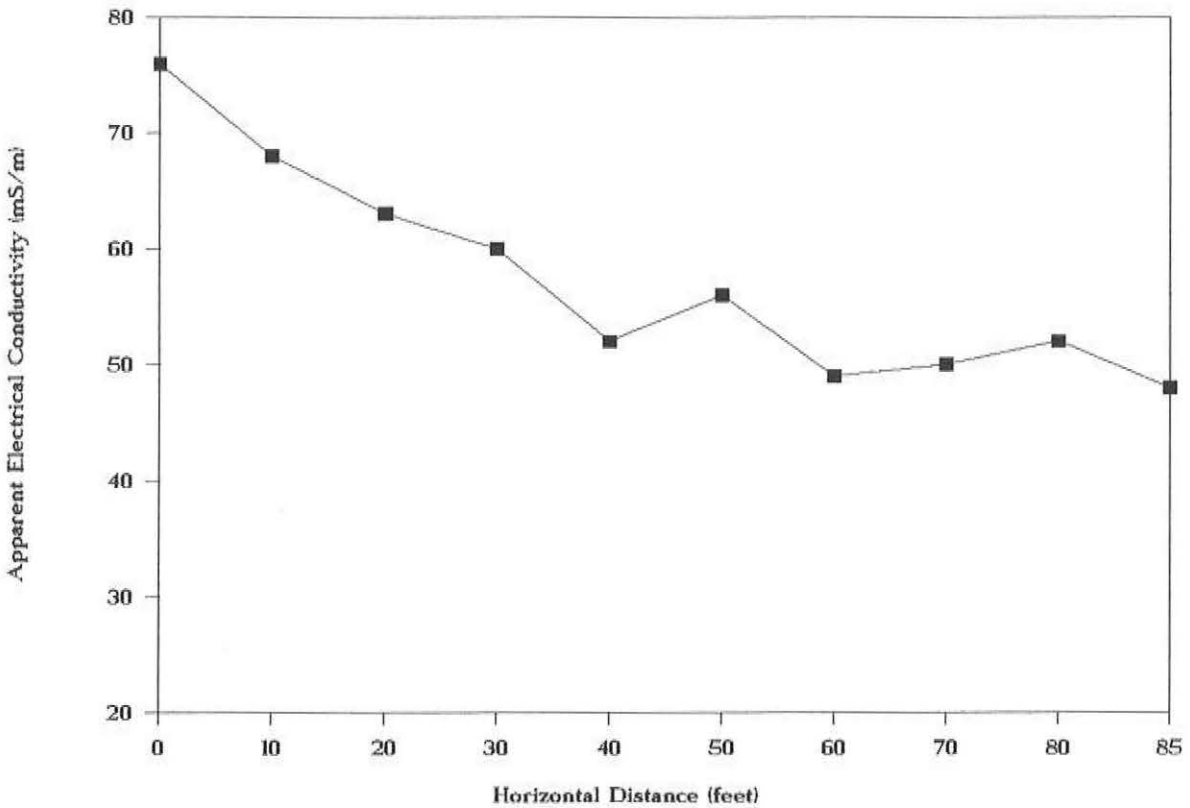
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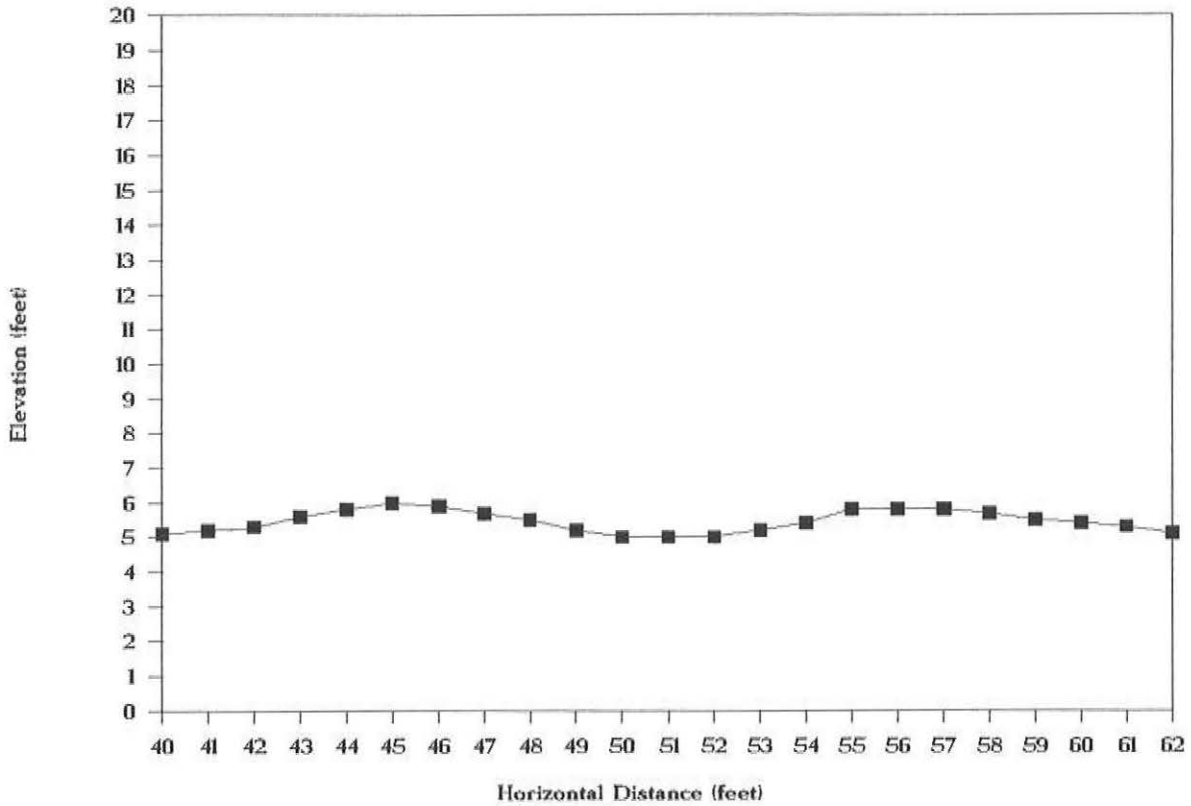
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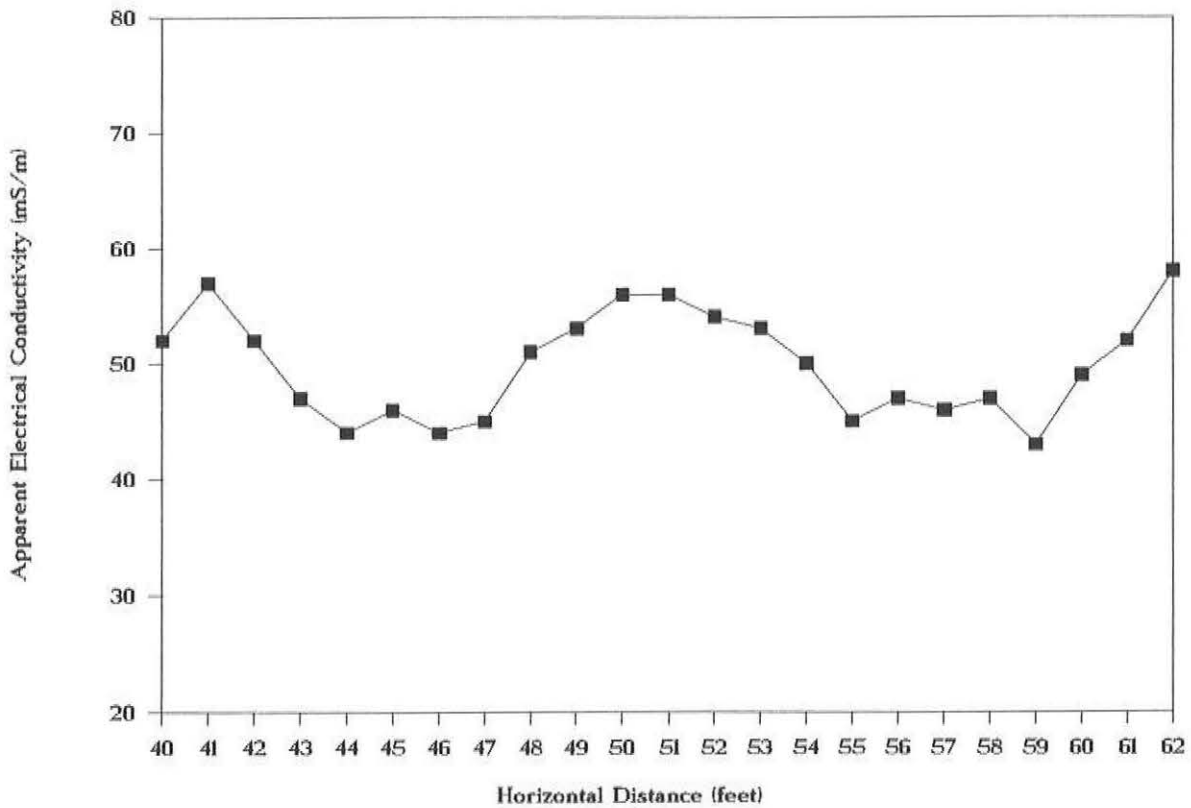
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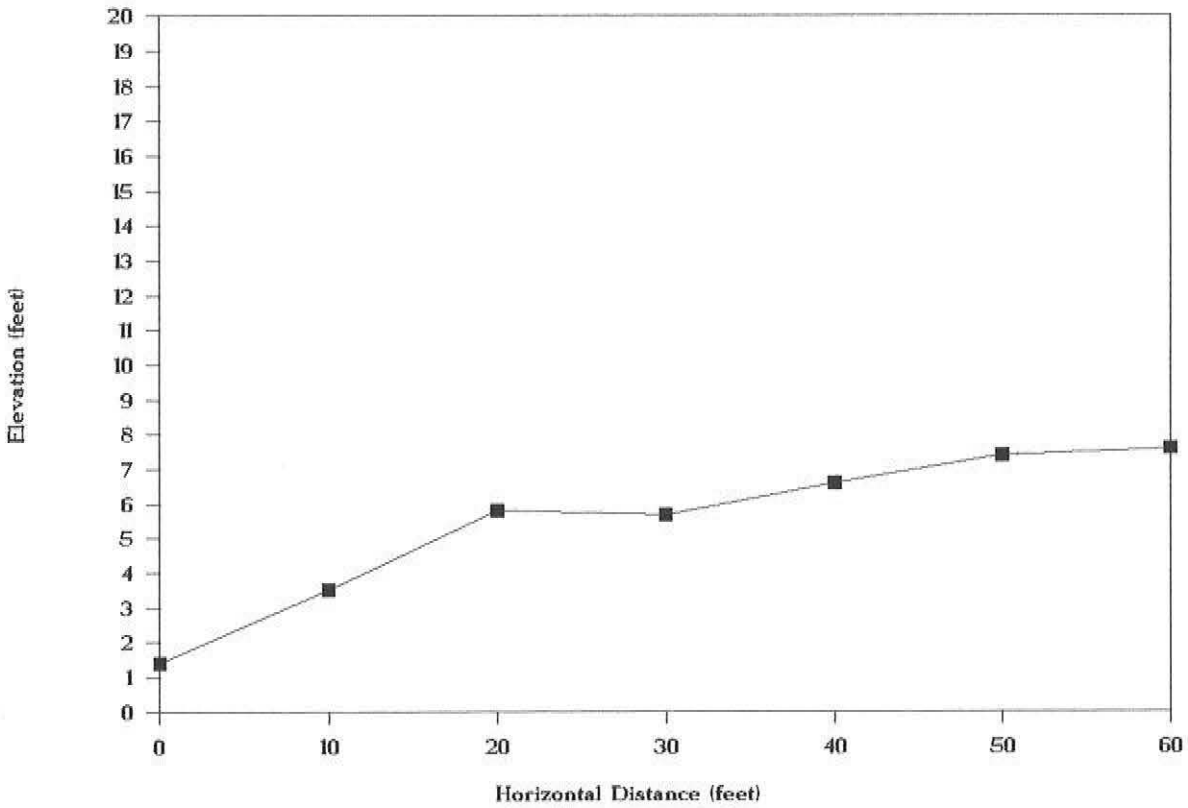
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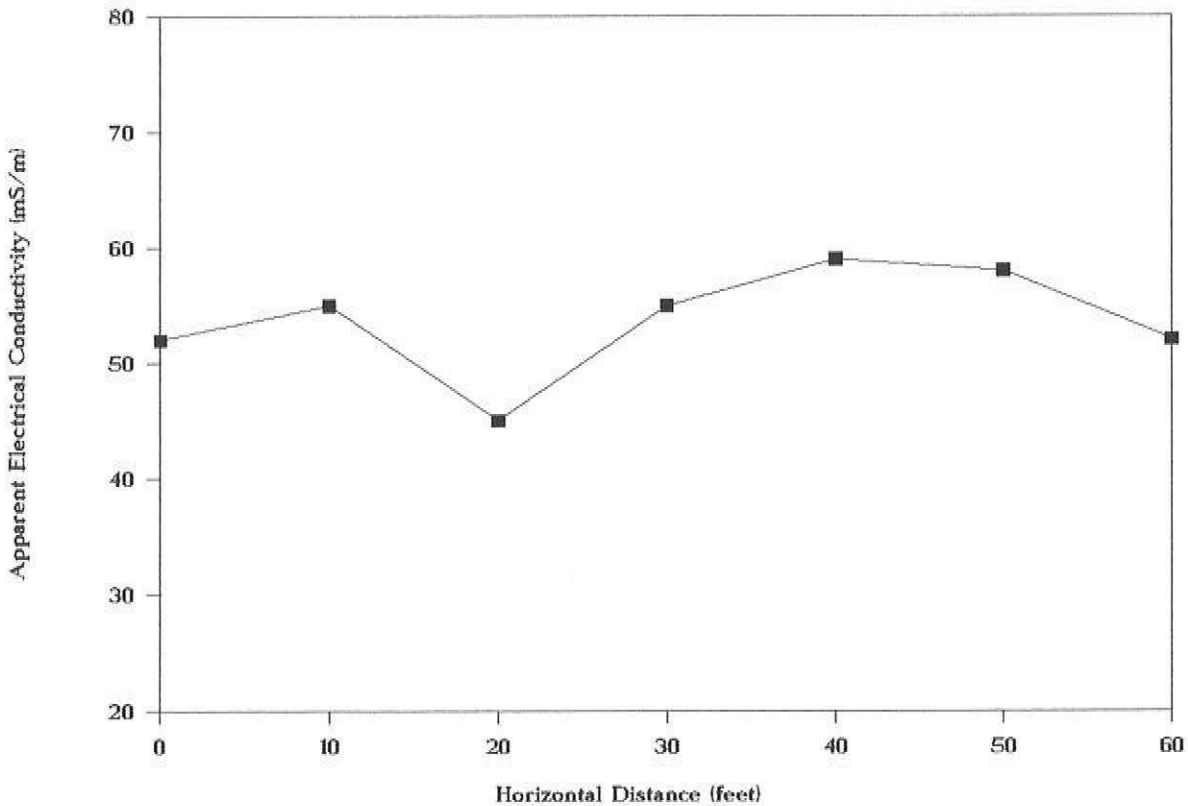
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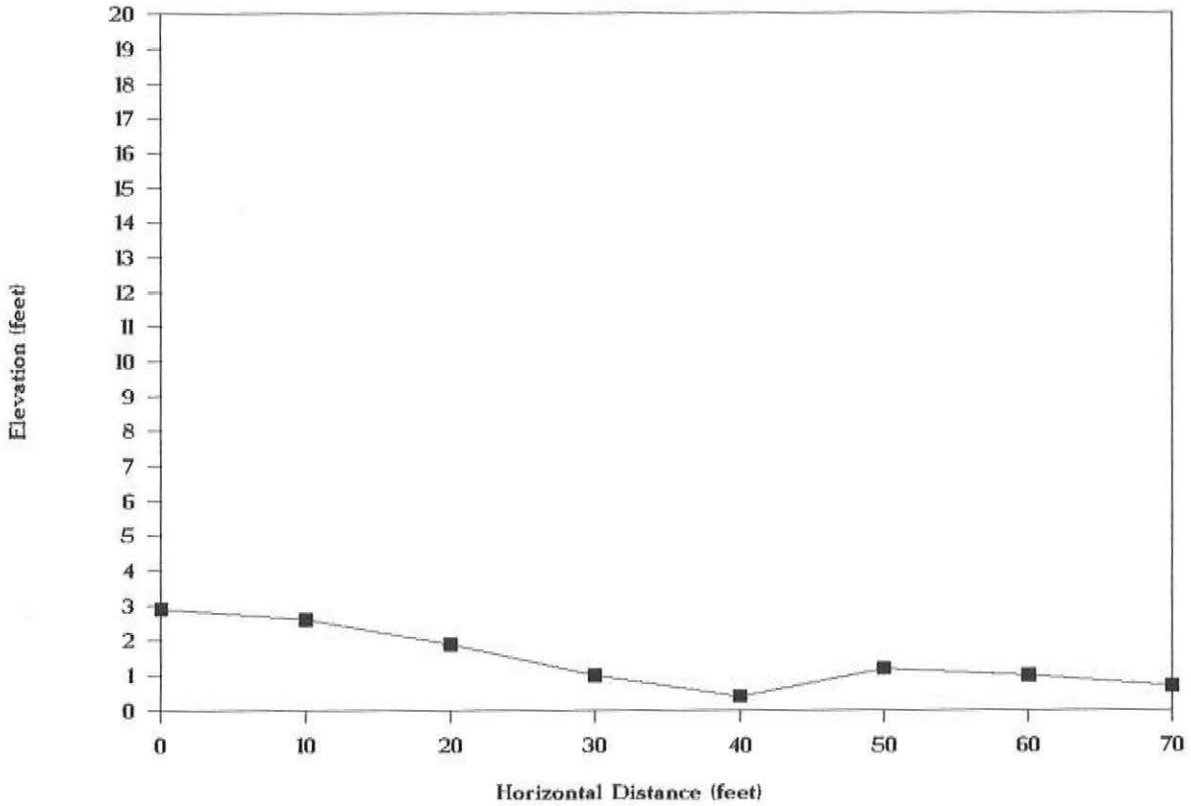
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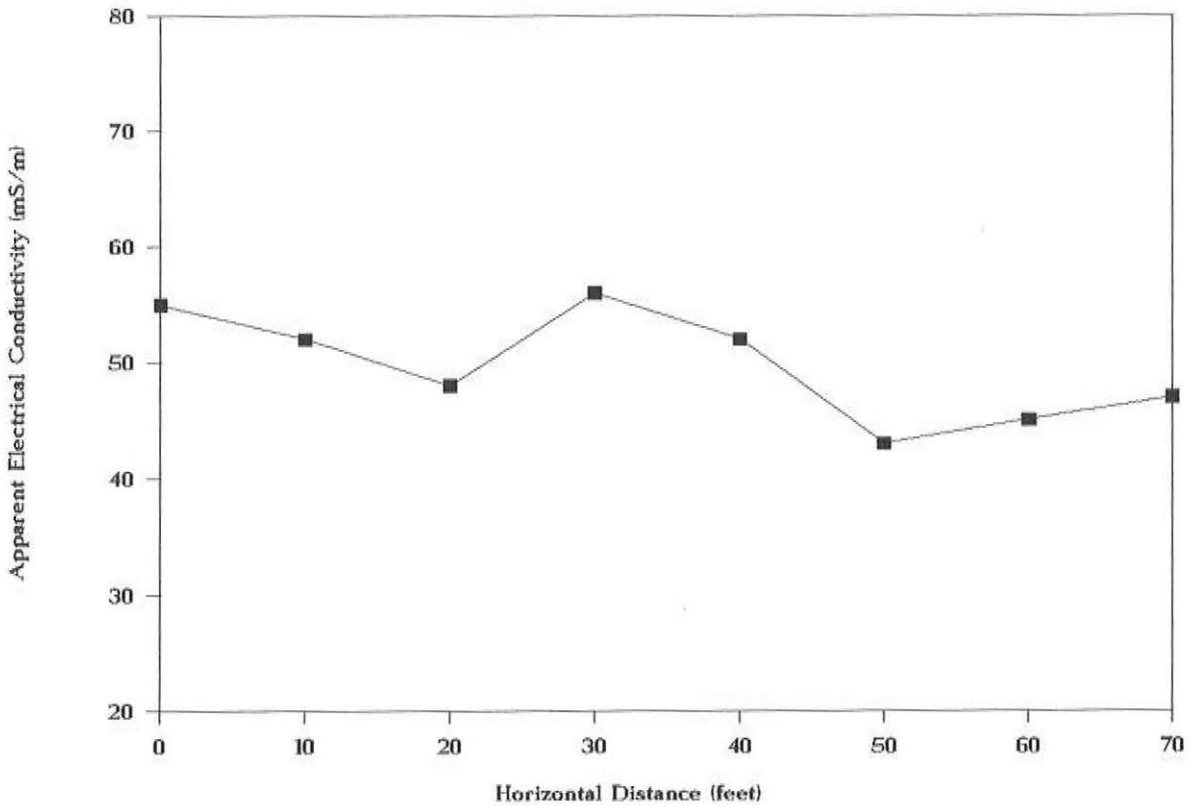
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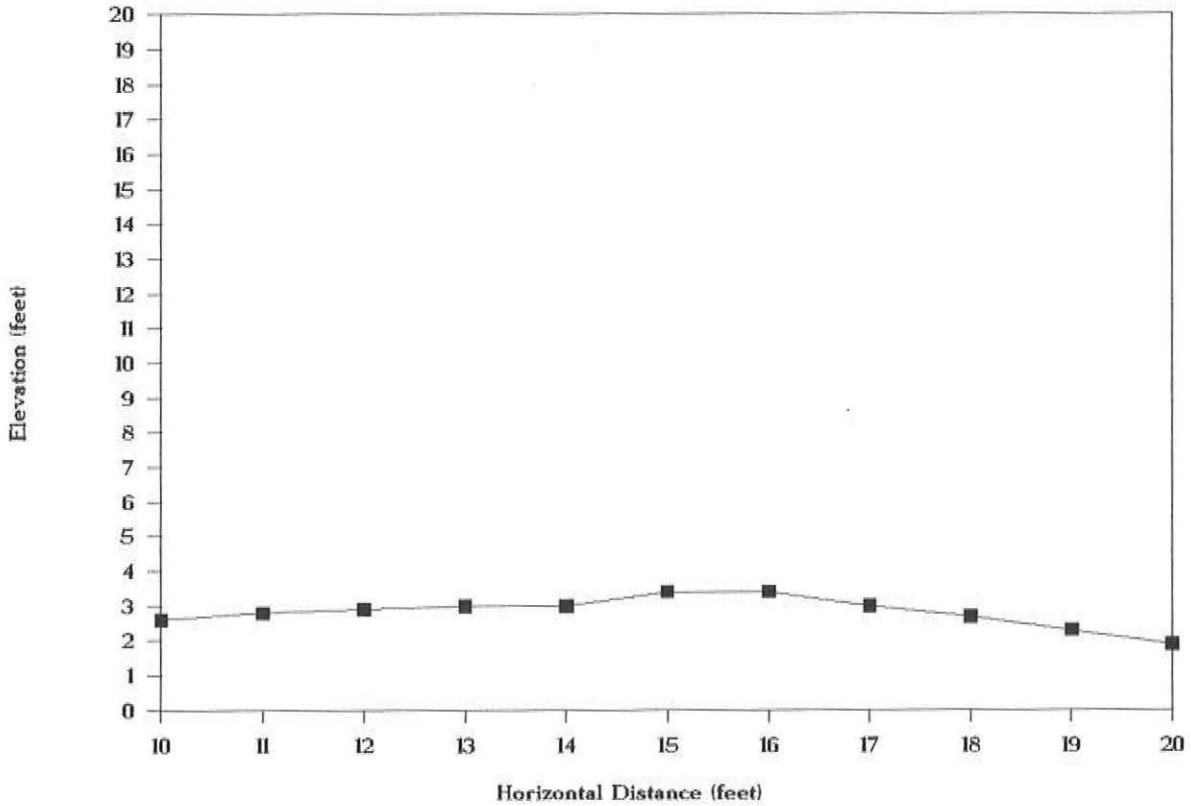
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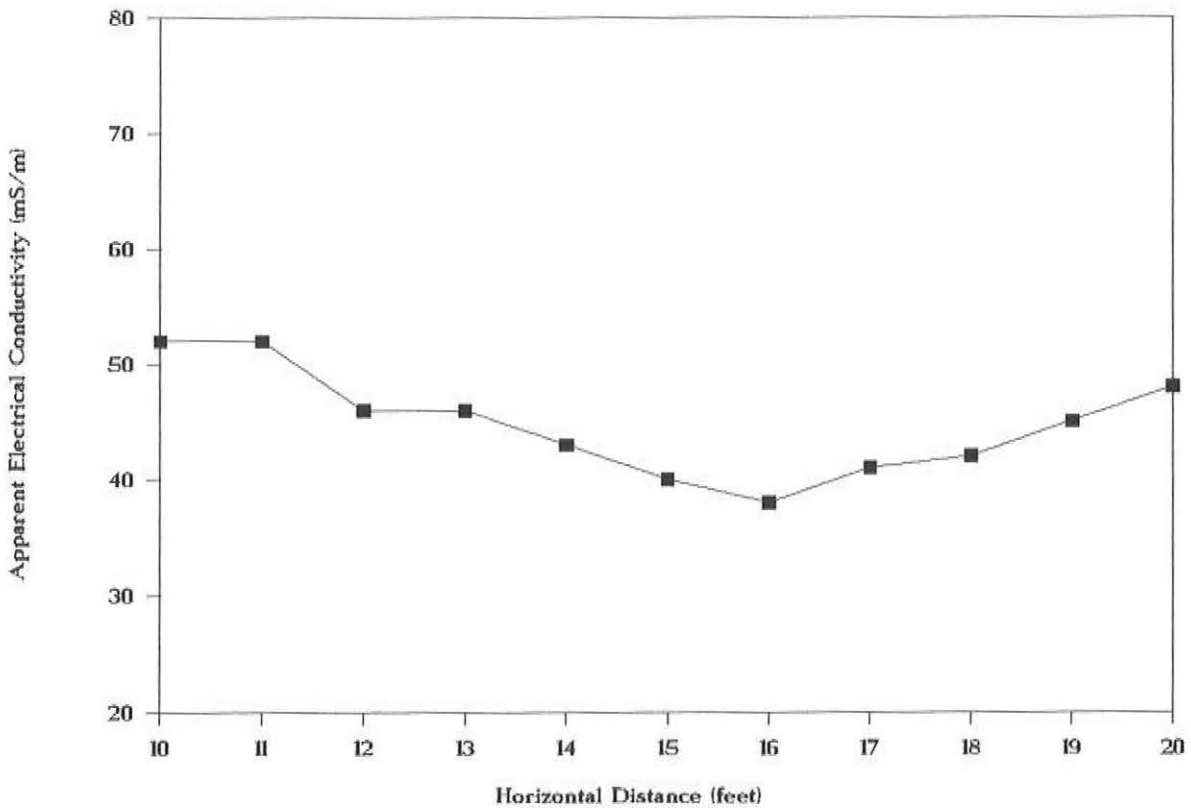
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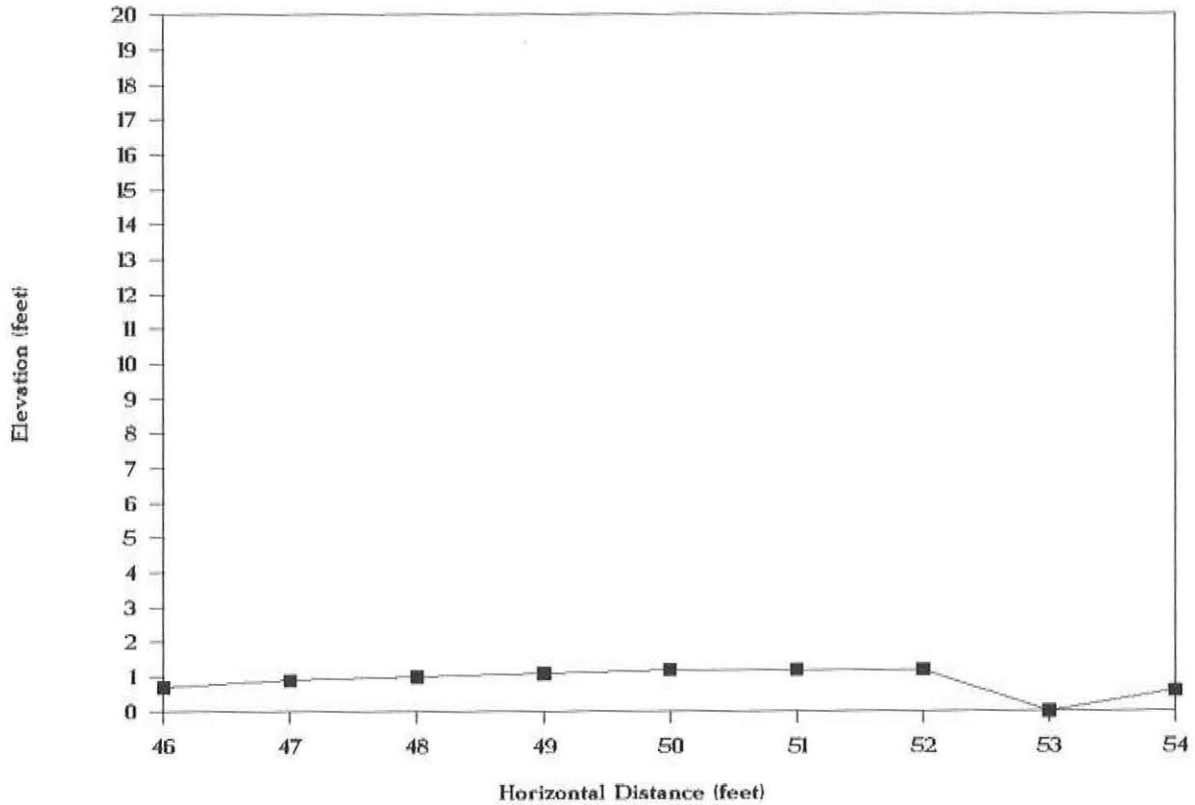
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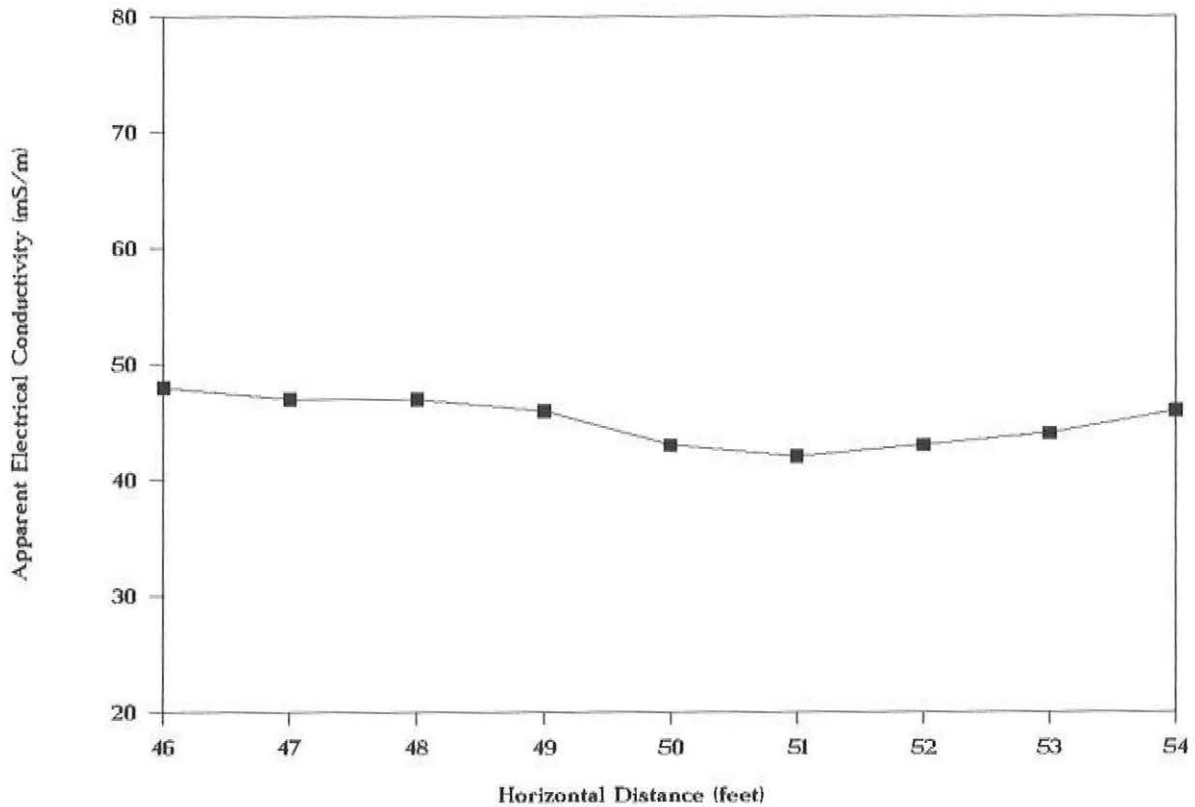
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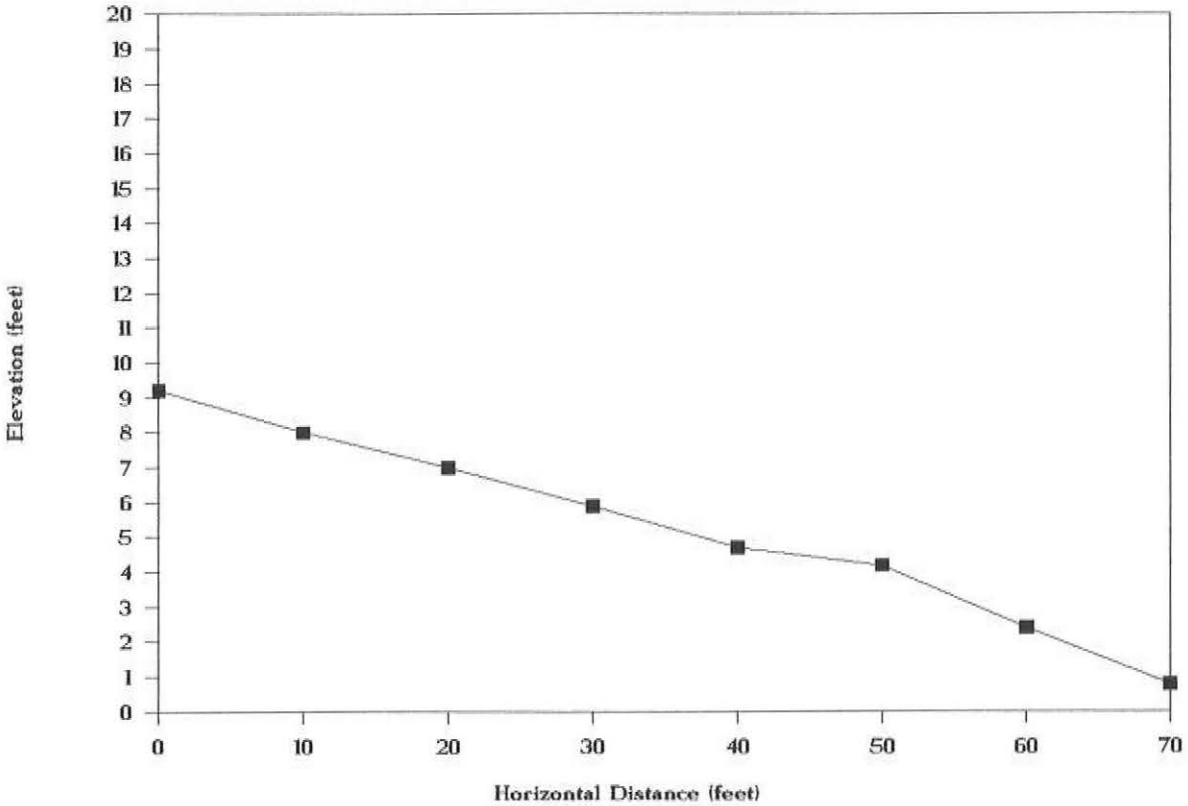
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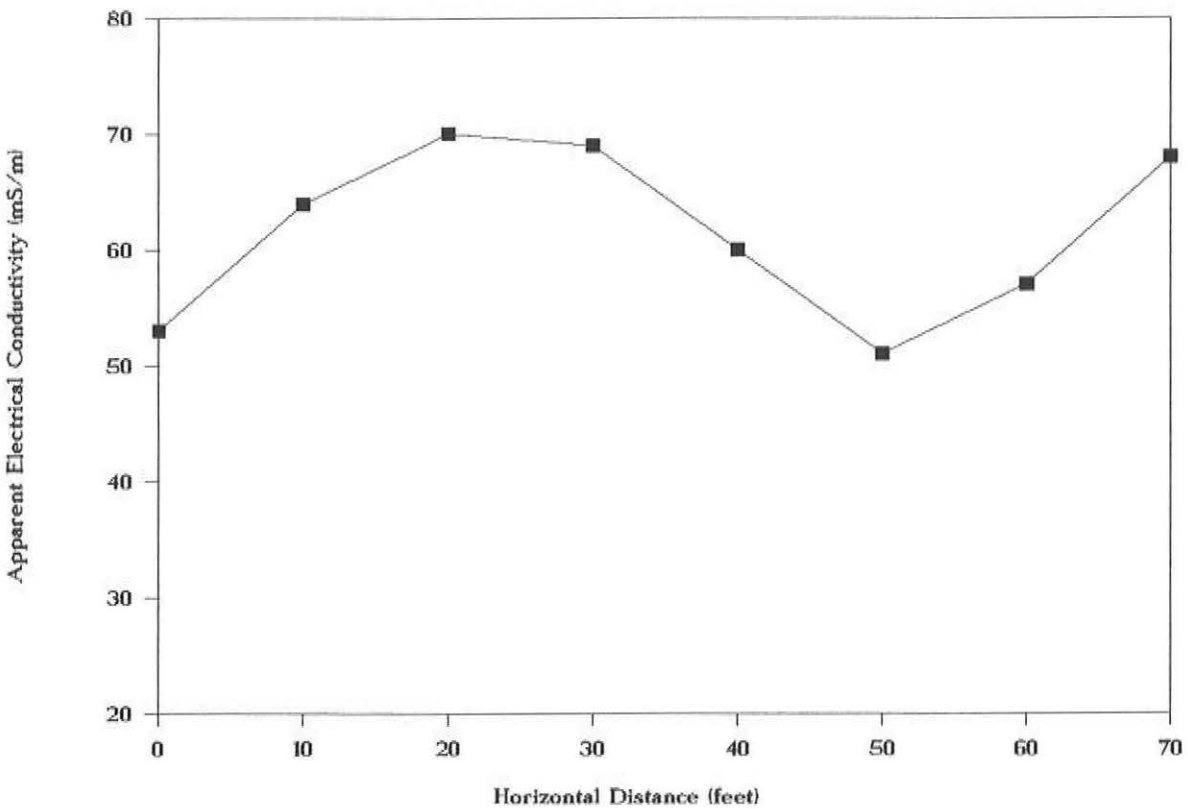
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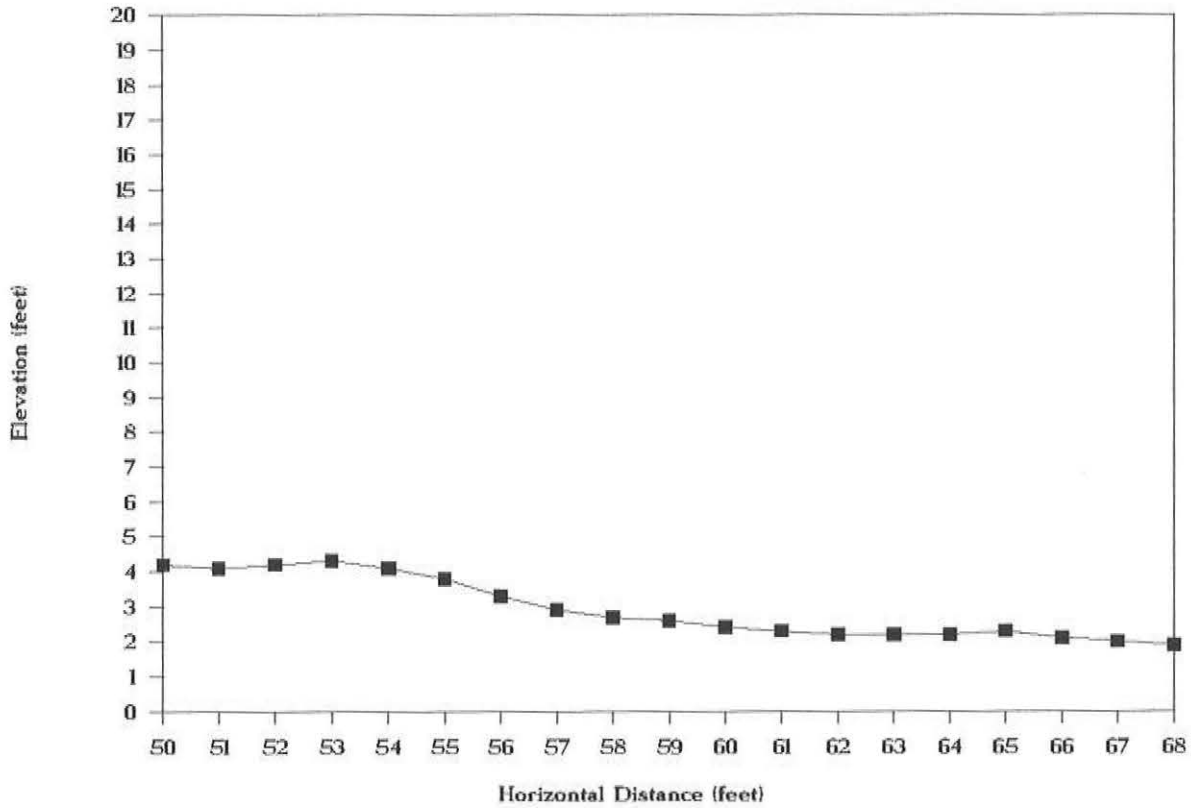
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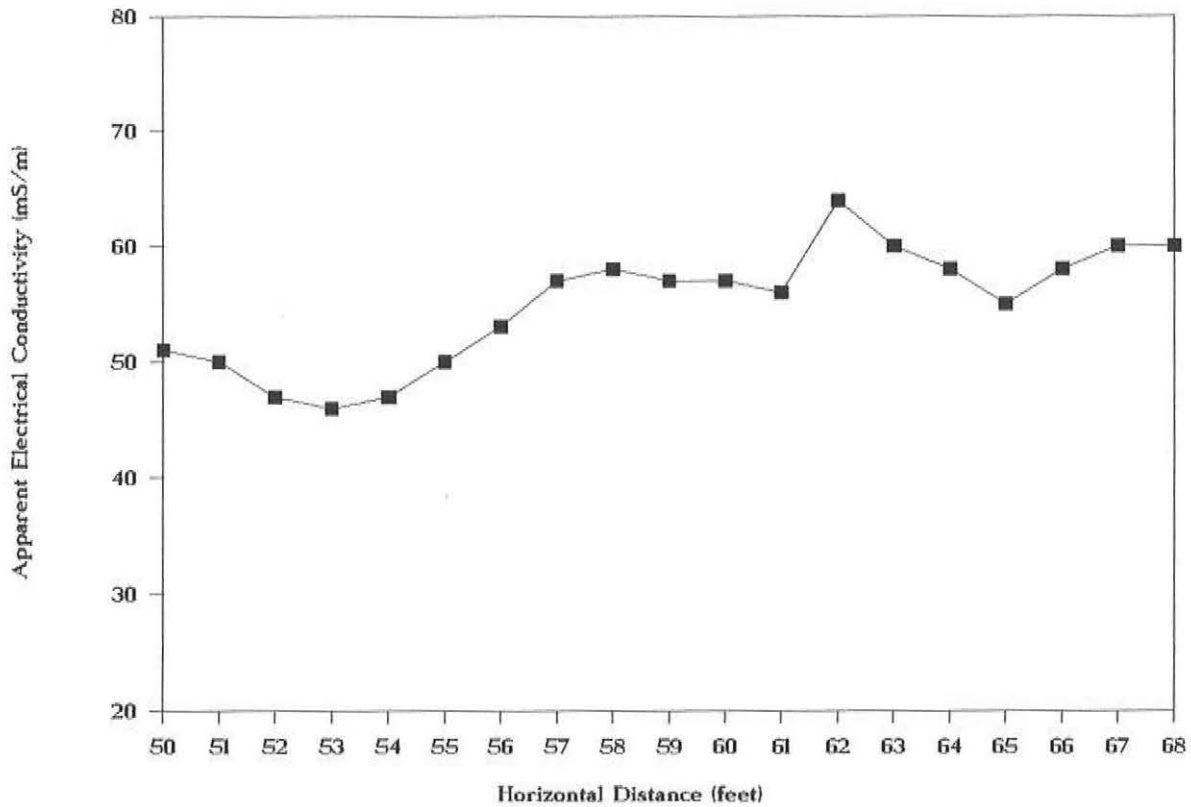
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Horizontal Distance (feet)

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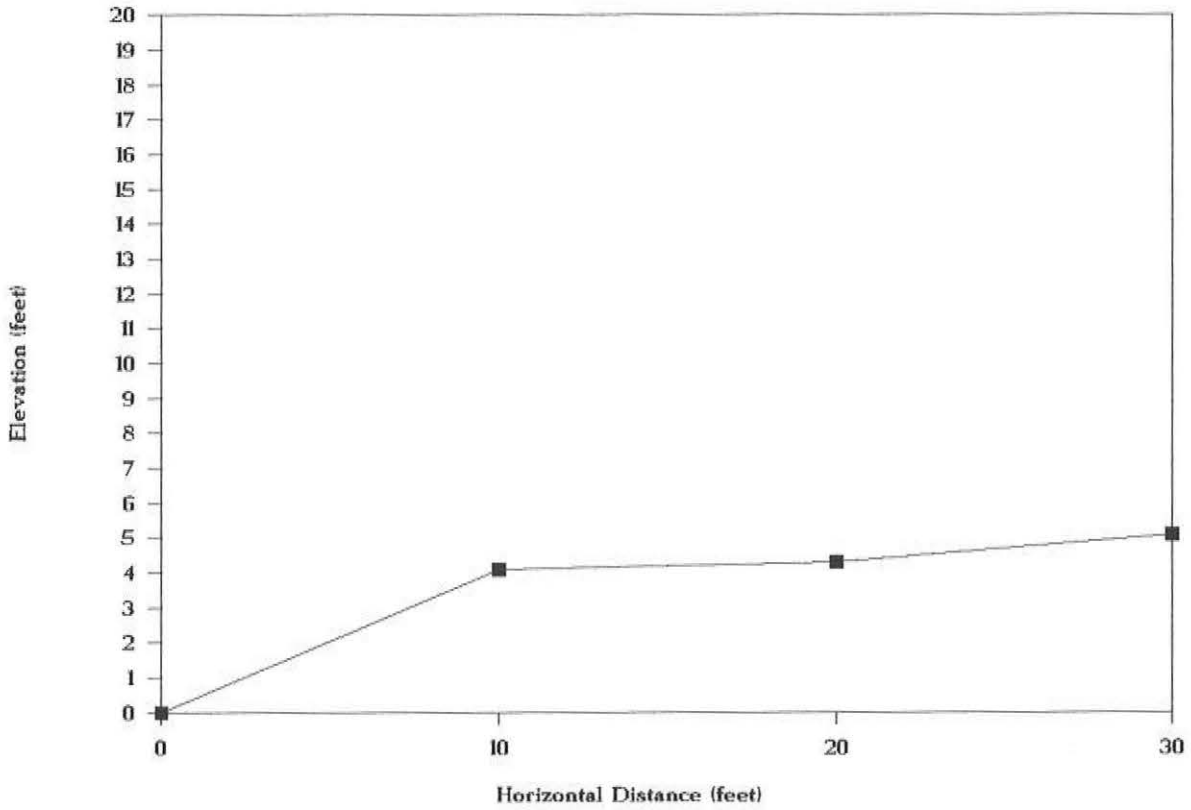
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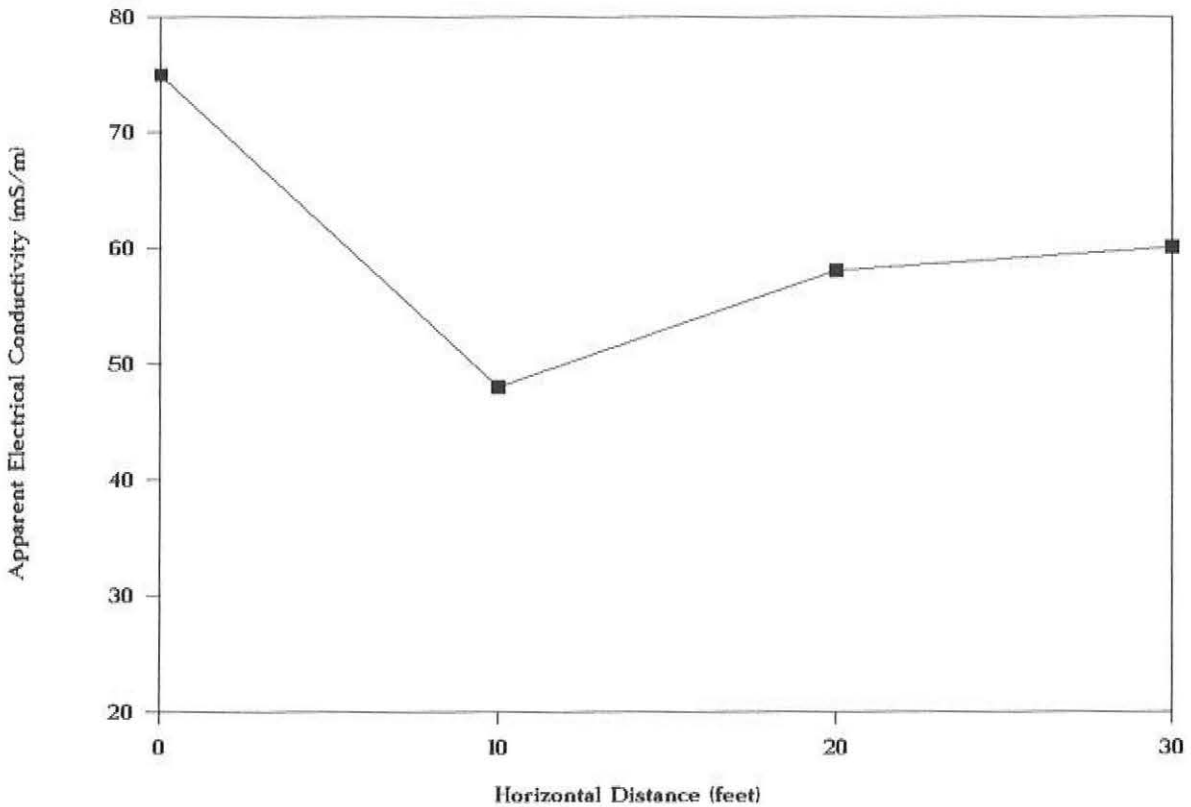
Apparent Electrical Conductivity (mS/m)
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Horizontal Distance (feet)

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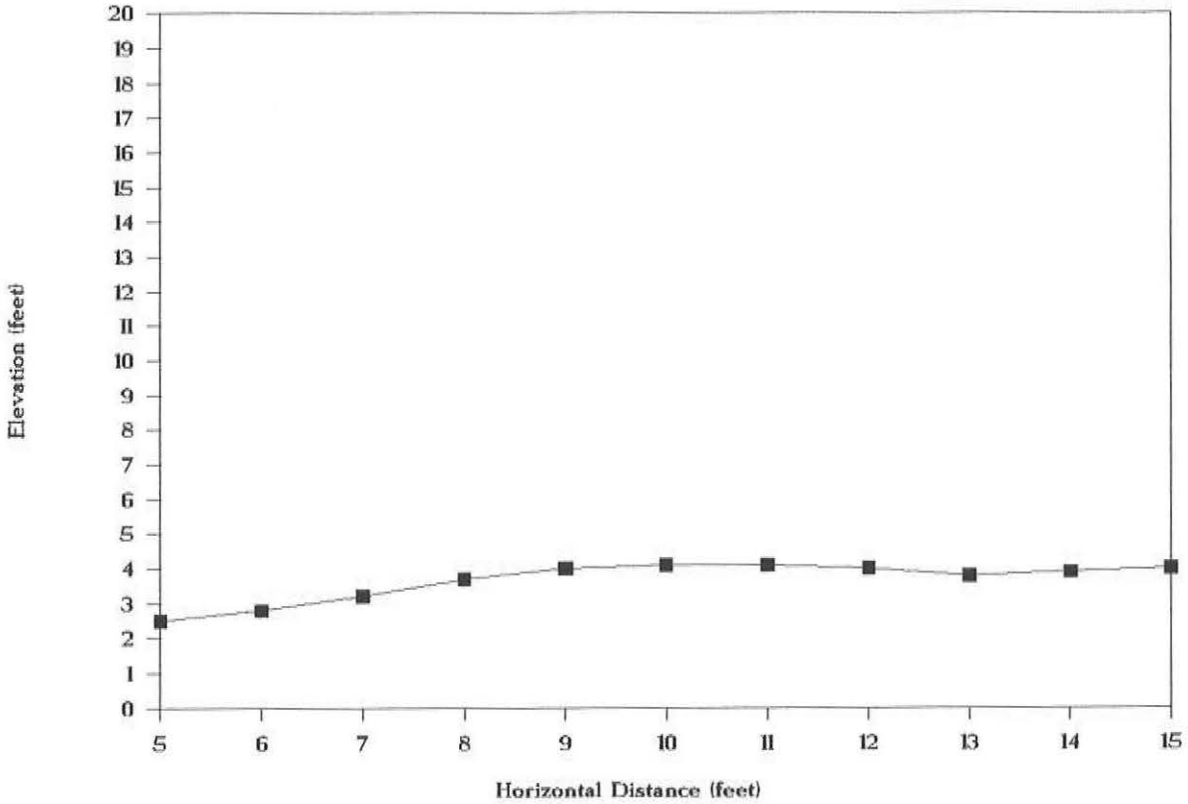
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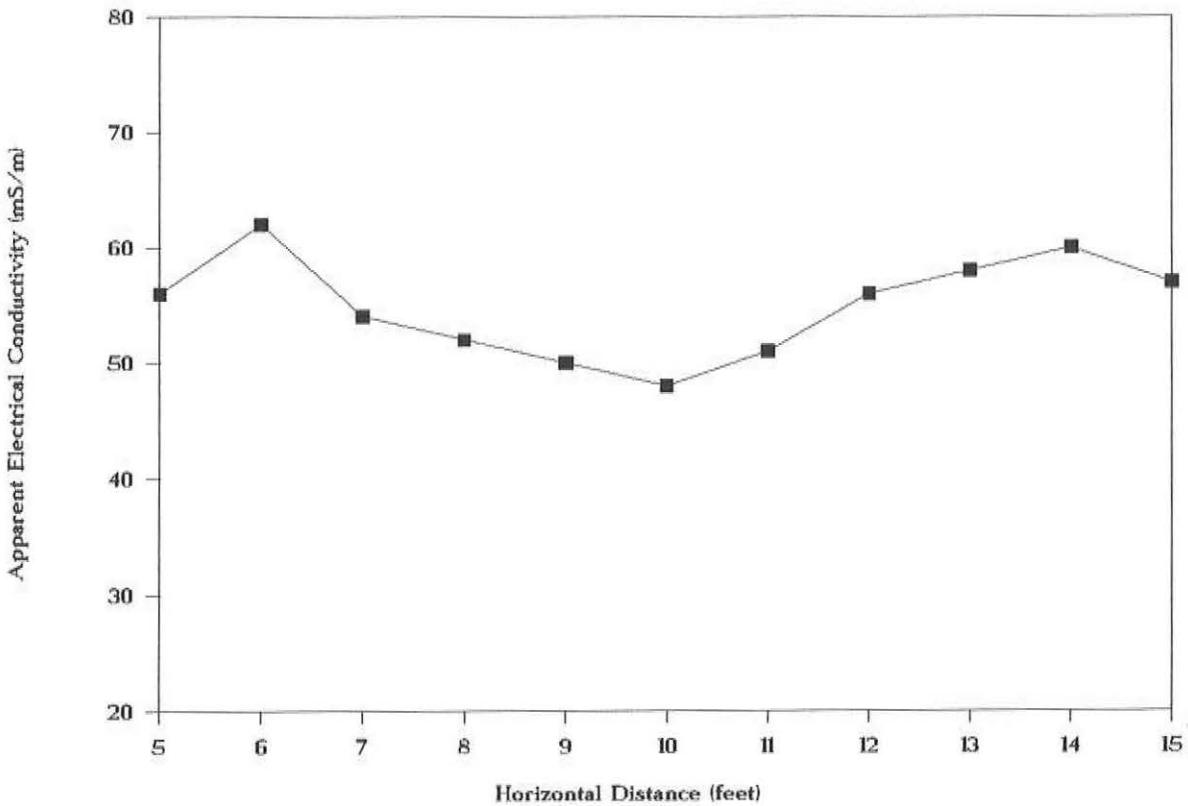
Apparent Electrical Conductivity (mS/m)
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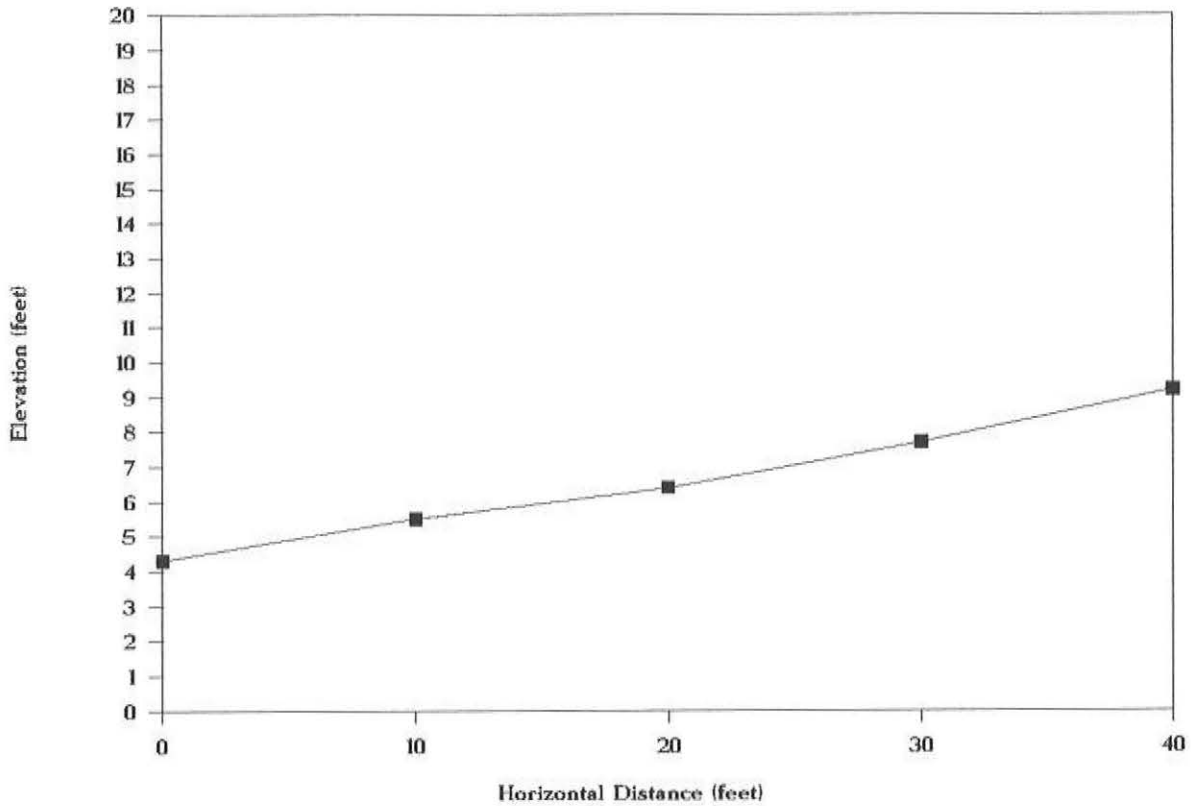
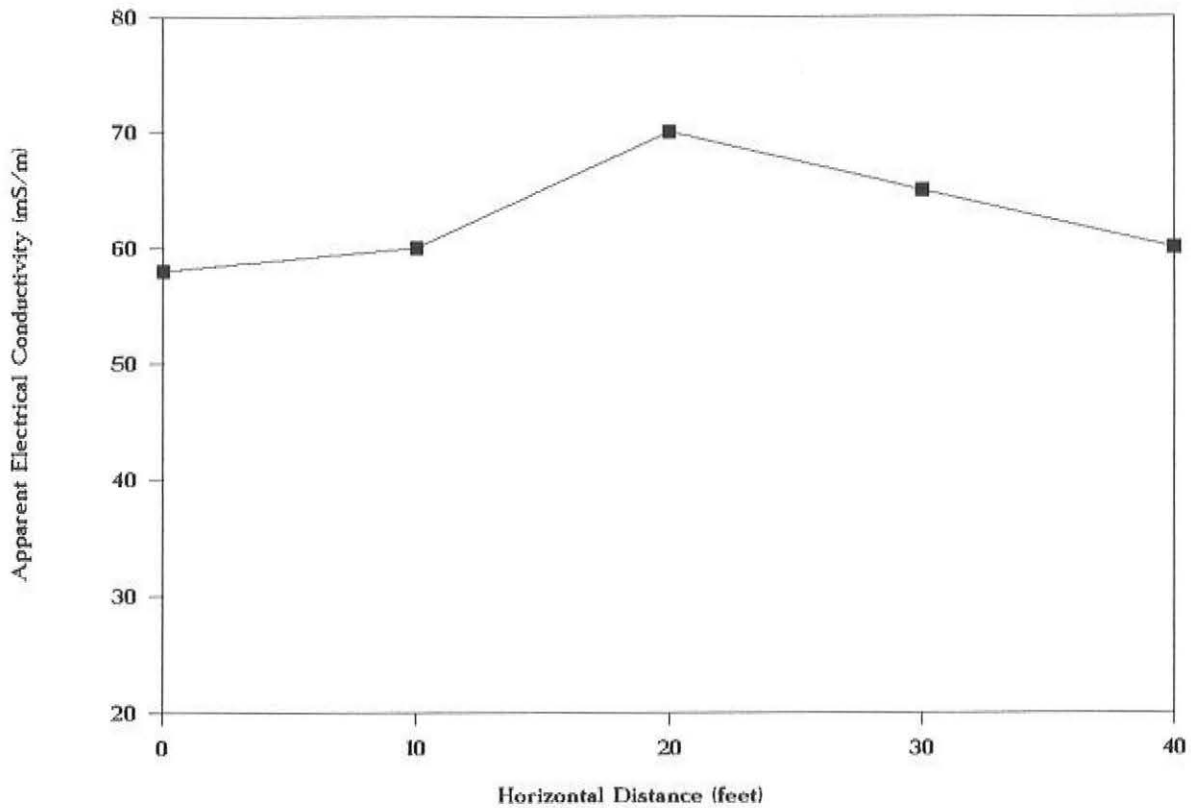
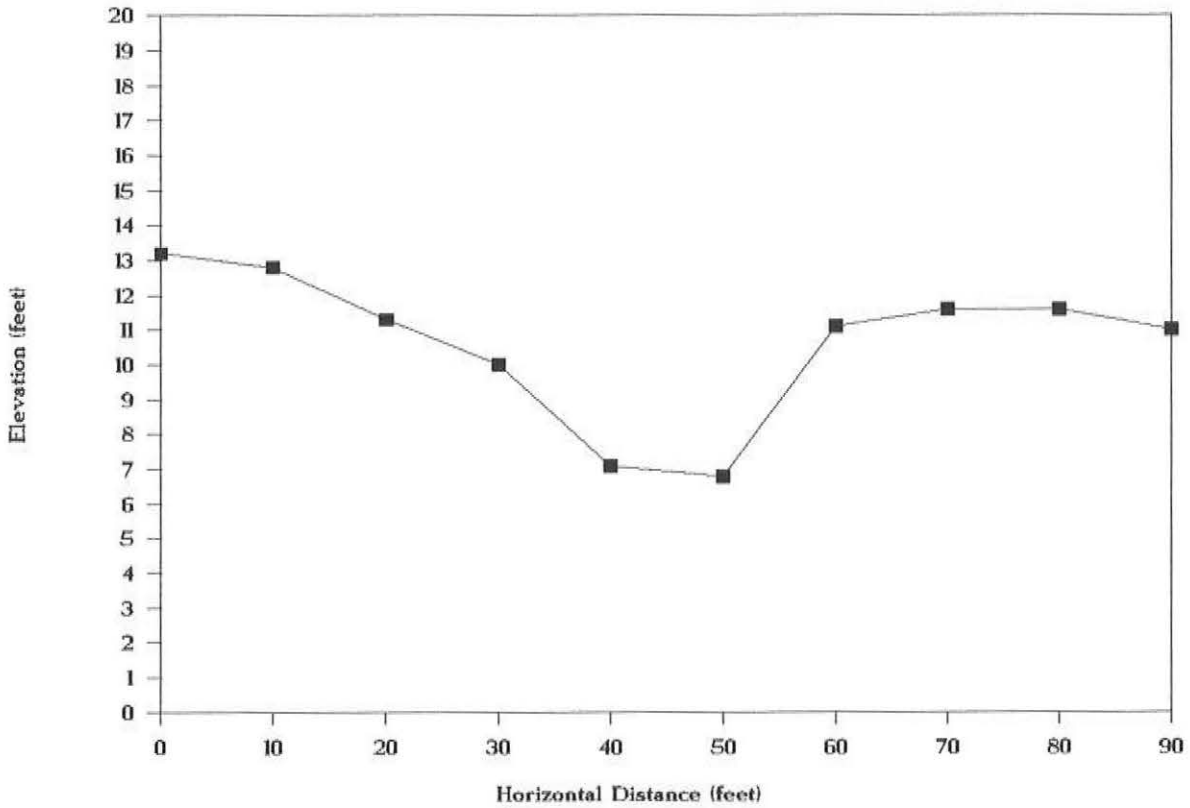
Horizontal Distance (feet)

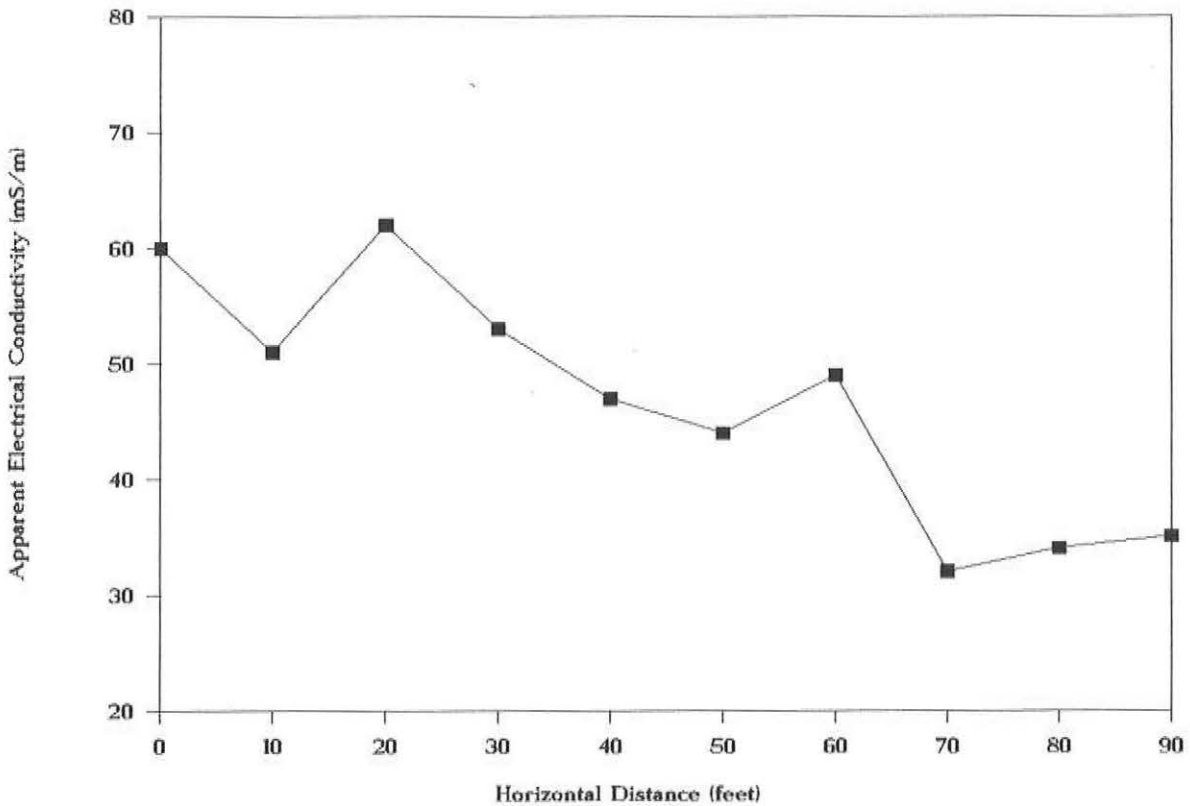
3C


Elevation (feet)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
Horizontal Distance (feet)

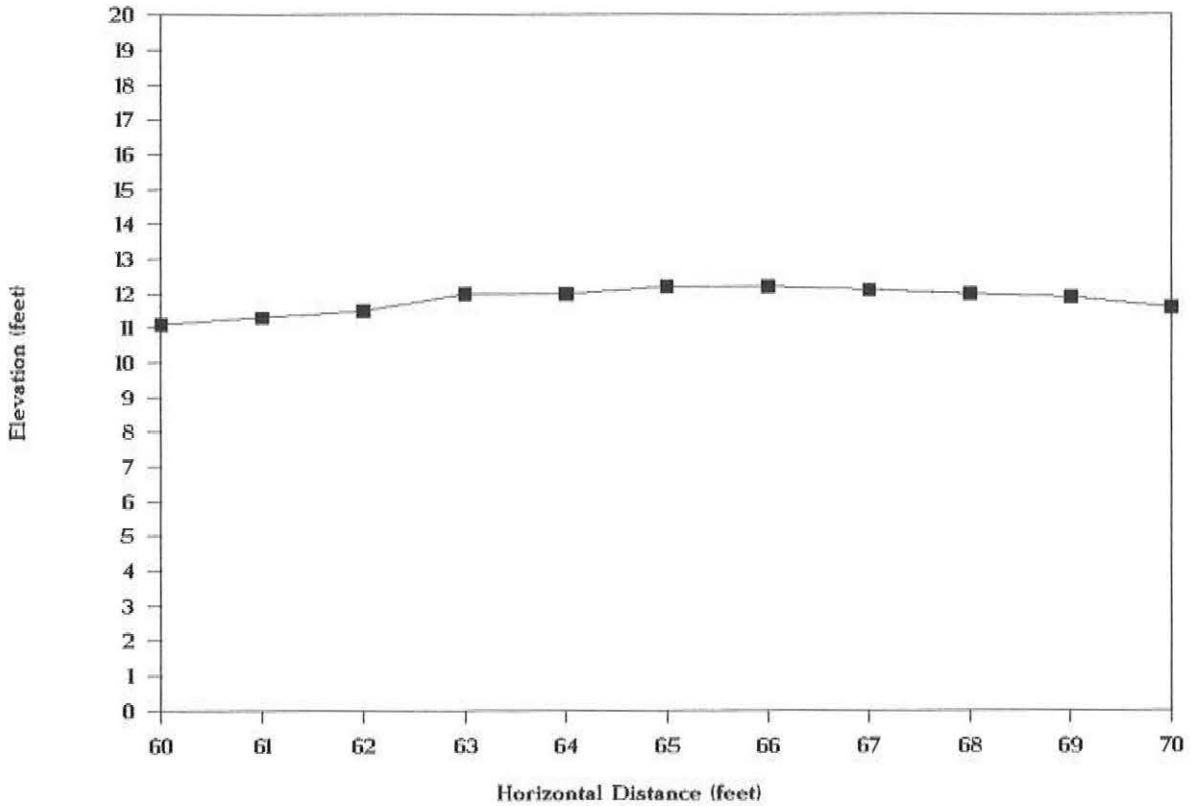

Apparent Electrical Conductivity (mS/m)
80
70
60
50
40
30
20
0
10
20
30
40
Horizontal Distance (feet)

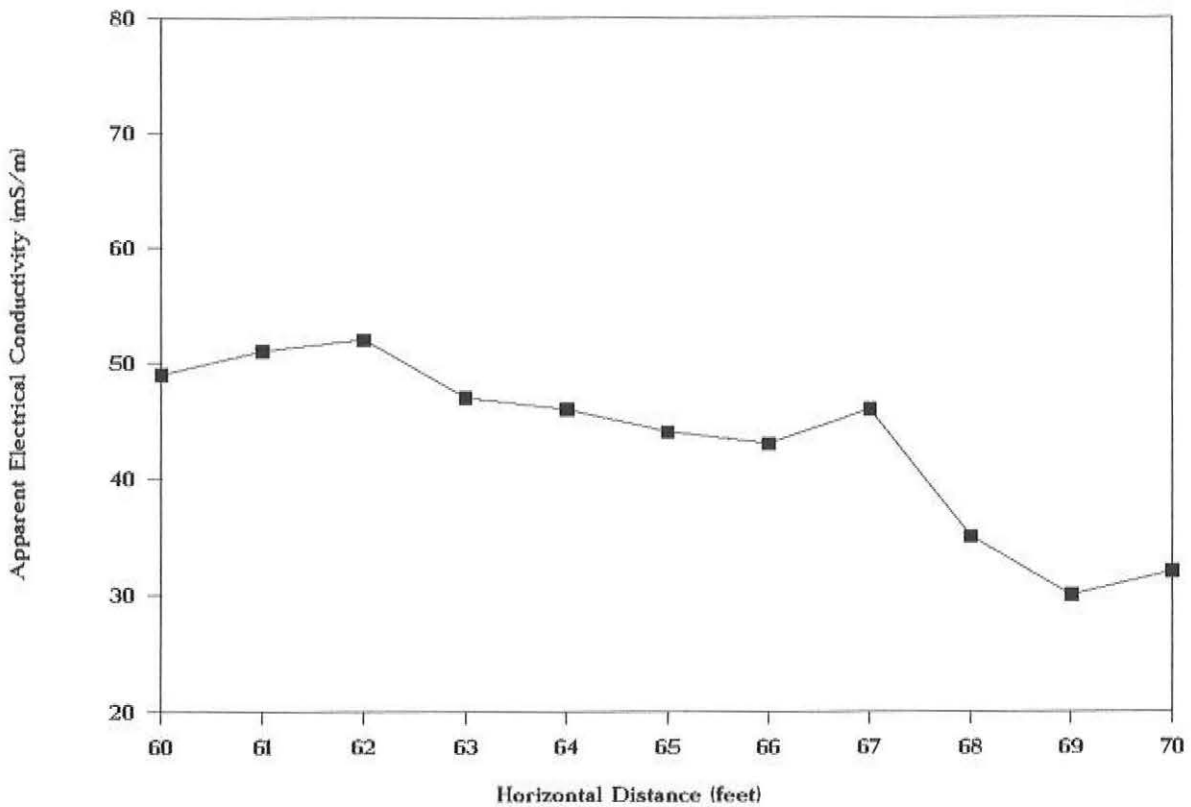
4A


Elevation (feet)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
Horizontal Distance (feet)

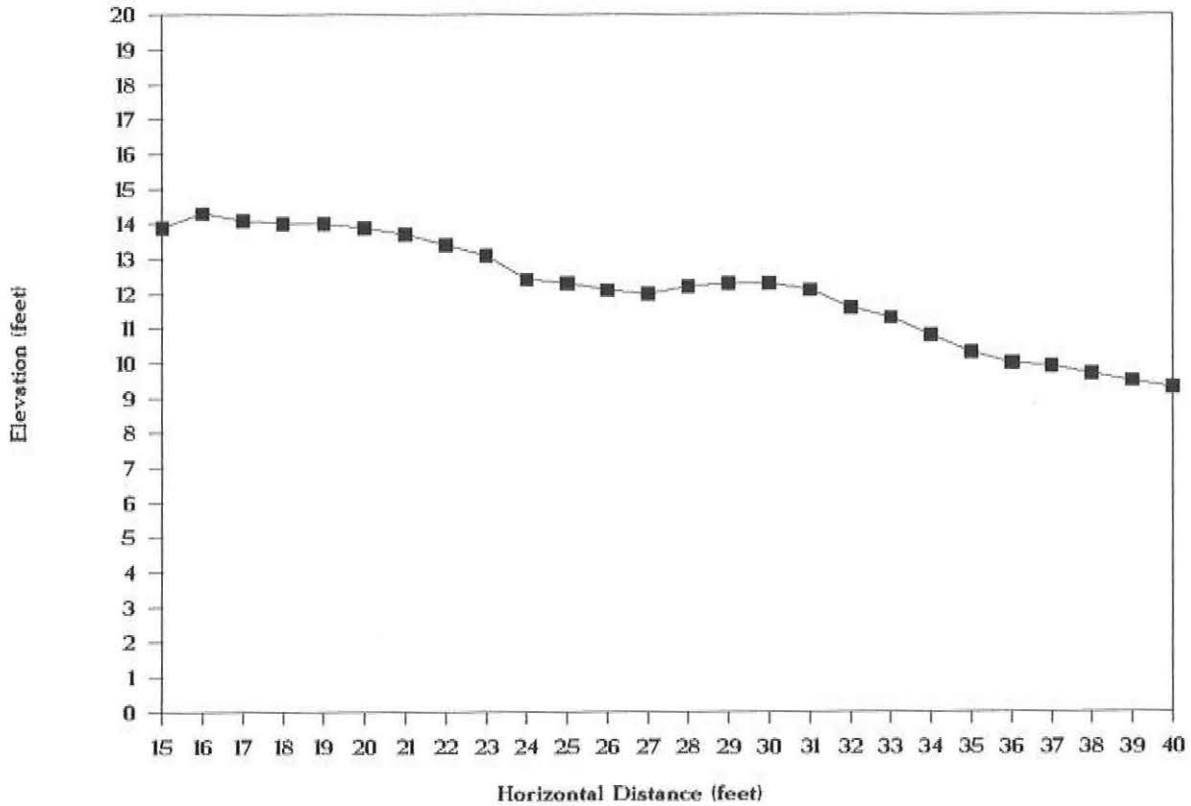

Apparent Electrical Conductivity (mS/m)
80
70
60
50
40
30
20
0
10
20
30
40
50
60
70
80
90
Horizontal Distance (feet)

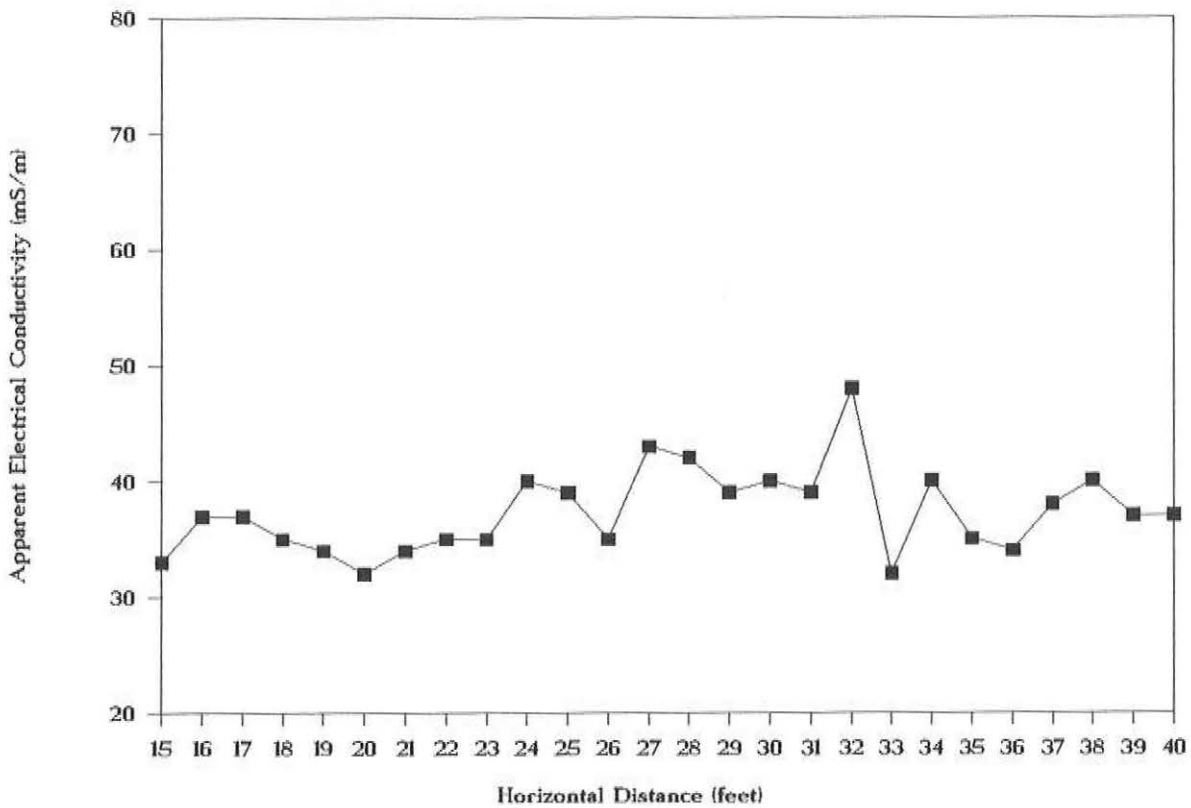
4A


Elevation (feet)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
60
61
62
63
64
65
66
67
68
69
70
Horizontal Distance (feet)

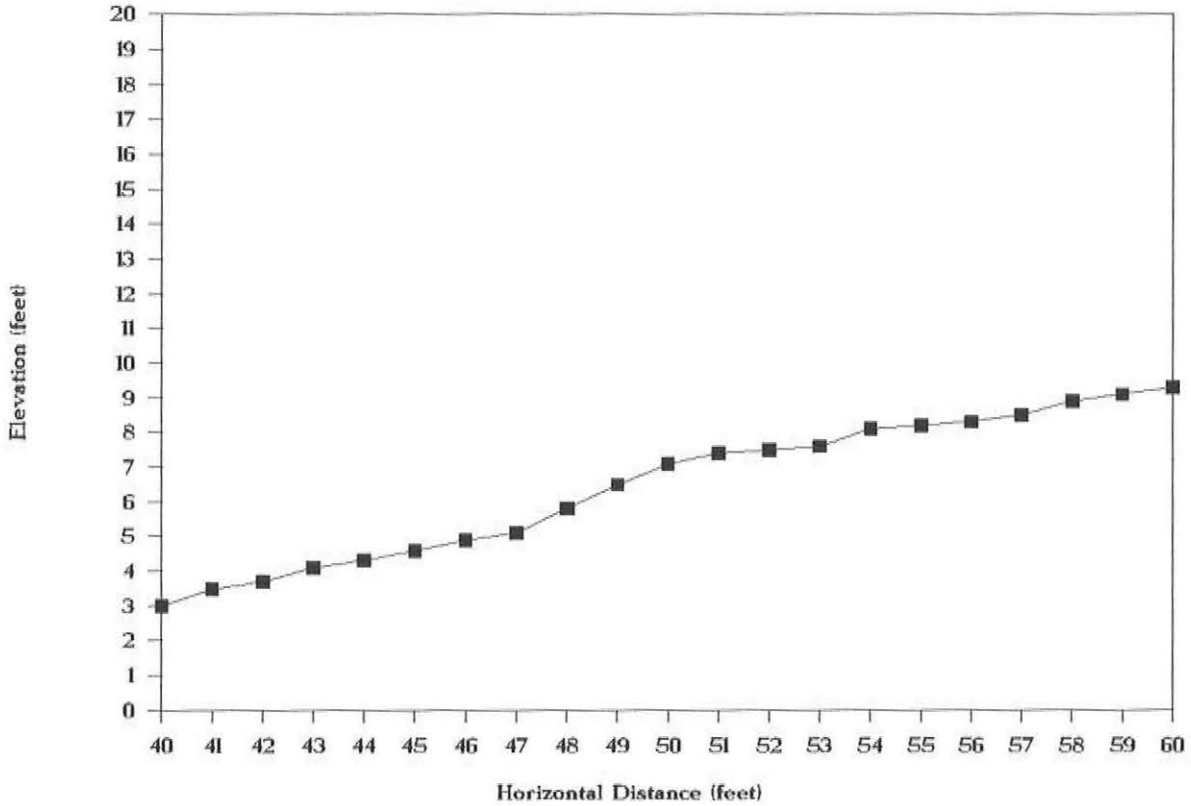

Apparent Electrical Conductivity (mS/m)
80
70
60
50
40
30
20
60
61
62
63
64
65
66
67
68
69
70
Horizontal Distance (feet)

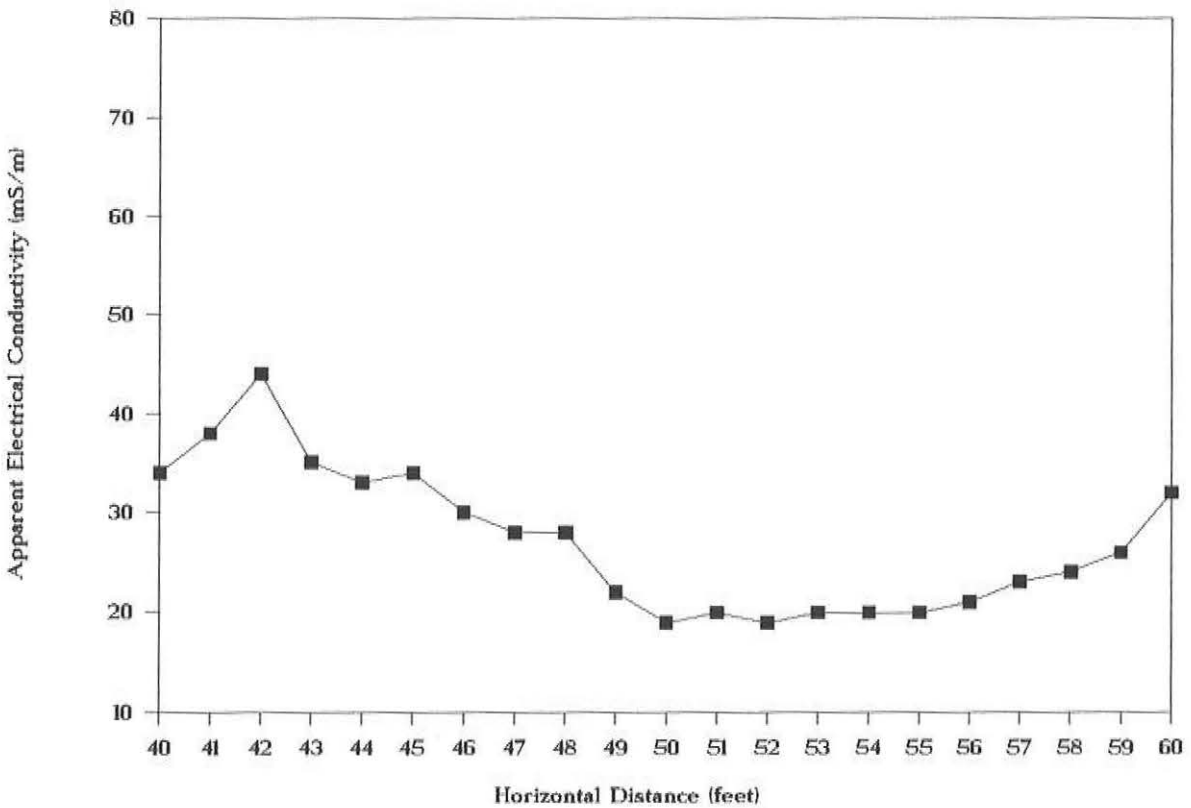
4B


Elevation (feet)
Horizontal Distance (feet)


Apparent Electrical Conductivity (mS/m)
Horizontal Distance (feet)

4C


Elevation (feet)
Horizontal Distance (feet)


Apparent Electrical Conductivity (mS/m)
Horizontal Distance (feet)