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REMOTE SENSING OVER NORTH MERRITT ISLAND

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ABSTRACT

In an effort to apply remote sensing techniques to the problem of monitoring the surface environment of North Merritt Island, two methods are being studied, namely, Color Infra-Red Photography and machine processing of LANDSAT Multispectral Scanner data. C.I.R. photos made at a height of about 12000' have been found to define the borders of ground features around the Space Shuttle Runway with a non-significant mean error of 0.138 meters but a wide range, which can perhaps be reduced with photos taken at about 6000'. LANDSAT Multispectral Scanner Data transformed by use of the function $f(g) = g1+g2-g3-g4$ where g1, g2, g3, g4 represent reflectance or grey levels of multispectral channels 1, 2, 3, 4, give values which are classifiable into a relatively small number of categories which will be refined by Discriminant Analysis into a number of natural categories representing corresponding ground features.

INTRODUCTION

The principal aims of the Research Project of Bethune-Cookman College in the Area of the John F. Kennedy Space Center are to study artificial reefs for improving the estuarine environment and to compare various remote sensing techniques for monitoring the terrestrial environment of North Merritt Island.

At the final 1974 meeting of the Study Committee headed by Mr. Fred Schoenberger, it was decided that remote sensing studies be intensified and the estuarine effort be correspondingly reduced. Accordingly, sampling in the estuary has been severely curtailed and attention is being directed largely to the study of biomasses around the reefs. The final permit for establishing the second reef whose site is shown as B in Figure 1, became effective on 18th May and the reef was laid down on 24th May, 1975. The biomass studies around the two reefs will continue.

Remote sensing studies over North Merritt Island received considerable attention during the first six months of the present project period. This report will be devoted entirely to the results of those studies.

Two methods of remote sensing were employed, namely Color Infra-Red Photography by low-flying aircraft and Multispectral Scanning by LANDSAT I formerly known as ERTS A Satellite.

AIMS

The principal purpose of the remote sensing studies is to observe environmental changes which may occur on North Merritt Island as a result of the Space Port Operations.

The specific purpose of the study of Color Infra-Red (C.I.R.) photos at the present time is to measure quantitatively any changes which may occur in ground features in the immediate neighborhood of the Space Shuttle Runway.

The specific purpose at the present time, of the study of Multispectral Data acquired by the LANDSAT Satellite, is to devise more efficient and generalized methods of processing the data for location of ground features.

MATERIALS AND METHODS

Environmental monitoring by use of C.I.R. photos

The materials which were used so far in the study of the environment by Color Infra-Red photos were C.I.R. transparencies and prints of North Merritt

Island, a transparency projector, a "roll-a-tape" for field measurements and a manual electronic calculator.

The experimental area over which the studies were carried out consists of North Merritt Island and is shown in Figure 1.

In the Color Infra-Red study, features selected on the C.I.R. transparencies on the borders of the Space Shuttle Runway were compared with the corresponding ground features. The comparison consisted of a study of differences between measurements taken across 31 selected ground features and their images on C.I.R. photos. The sites of the measurements are shown in Figures 2 and 3 and the actual measurements and derived values are given in Table 1.

The derived values (4) which were computed from the data are the Mean Difference $\bar{d}$, the Standard Error of the Mean Difference

$$S.E.\ \bar{d} = \frac{\sigma_d}{\sqrt{n - 1}}$$

where

d =	a field measurement - its estimated measurement
$\bar{d}$ =	arithmetic mean of the 31 d values
n =	number of field measurements
σ_d =	standard deviation of d
$S.E.\bar{d}$ =	standard error of $\bar{d}$

and lastly, the maximum value of $\bar{d}$ which would not be significantly different from zero on a probability of .05, obtained as follows: -

$S.E.\bar{d}$ X t (for $P = .05$ and $n - 1 = 30$)

where

t is read from a table of t for $P = .05$ and $(n - 1) = 30$.

$S.E.\bar{d}$ is computed as above.

Because of the smallness of the scale of the C.I.R. transparencies which were used in the study, the exact positions of all lines which were measured are not shown in Figures 2 and 3. Larger Scale Photos are now being employed in this aspect of the study.

Environmental monitoring by use of Multispectral Data

The materials which were used so far for the study of the environment by the use of Multispectral Data were LANDSAT (ERTS) (1) tapes for North Merritt Island produced in Spring, 1974, a G.E. 635 Computer, a Wang 2200 S Minicomputer and a G.E. IMAGE 100 System (2).

The experimental area over which the study was carried out was North Merritt Island.

LANDSAT Multispectral Scanner receives reflectance or grey level values for each picture element in 4 spectral bands or channels. It was shown in a study carried out on Merritt Island in 1974 (3) that the value "Channel 1 - Channel 4" was strongly correlated with types of plant associations occurring at different levels above the water table.

In the present study the concept of the above correlation was further developed and used as a basis for classification of multispectral data into the natural groups which they represent, that is to say, into groups of data which correspond with specific ground features. The theory of the method was derived by examining the density traces of the four spectral bands across a single line as shown in Figure 4.

It is seen there that the general slope of the left halves of the four traces increases from Channel 1 to Channel 4. Also the troughs of the right halves of Channels 3 and 4 are relatively deeper while their peaks are relatively higher. This suggests that any point along the line of the density traces may be defined uniquely by a difference between Channels 1 and 2 on the one hand and Channels 3 and 4 on the other hand. One natural function which can define the points along the line is

$$f(g) = g1 + g2 - g3 - g4$$

where g1, g2, g3 and g4 represent the grey levels in the four spectral bands.

It will be shown later that if the values of f(g) may, at a first approximation, be taken to represent the various natural categories of ground features, then a very large amount of multispectral data can thus be classified into relatively few categories.

Moreover the classes can be further refined by Discriminant Analysis, which will be applied to the data during the second half of the current project year. It may be mentioned here that this method of automatic or machine processing of multispectral data has the capability of producing very meaningful outputs in regard to surface environmental features, both on a Multispectral Image Analysis System and on an Electronic Digital Computer. The method therefore possesses a promising potential as an environmental tool on a large scale.

RESULTS

Data were analyzed to investigate the degree of effectiveness of two methods of remote sensing for distinguishing the vegetation types and other ground features of North Merritt Island shown in Figure 1. In each case, the analysis has been carried only through a first stage, with at least two further stages remaining. The results are nevertheless interesting and valuable.

Results obtained with color infra-red photos

Color infra-red transparencies and photos were used to study the numbered sites shown in Figures 2 and 3 which are situations where small areas of mechanical disturbances were unavoidable. Field measurements taken in a N - S or an E - W direction over the sites were compared with measurements made on C.I.R. transparencies with a view to testing C.I.R. photography as an environmental tool.

The mean difference $\bar{d}$ of the 31 pairs of values is 0.452' or 0.138 m. The standard deviation of the differences is 7.936 m or 26.037 feet. By use of the standard deviation, the standard error of the mean was calculated to be 1.425 m. or 4.676 feet.

Since the product of the standard error of the mean and the value of t for $P = .05$ and $n = 30$ is more than 0.452 feet or 0.138 meters, the mean of the errors of measurement, it may be concluded that the mean error is not significant. However, because the errors ranged from -16.76 m to +25.91 m, it has been decided that for the rest of the project period C.I.R. photos taken from a height of only 6000' will be used and measurements on the photos will be carried out with a planimeter.

Results obtained with machine processing of multispectral data

The multispectral data processed so far, represent the pixels or picture elements acquired by LANDSAT I Multispectral Scanner about the line shown as Line 378 in Figure 4, being a part of North Merritt Island. The scanner receives reflectance grey levels in 4 spectral bands numbered 1, 2, 3, 4 respectively. The multispectral data were transformed by the function

$$f(g) = (g1 + g2 - g3 - g4)$$

which was previously mentioned under Materials and Methods and in which the values g1, g2, g3, g4 represent reflectance or grey levels of the four channels for each picture element.

The quantity f(g) was found to vary from -21 to +27. The total number of such values was 44. Thus 44 categories were created with numbers lying between -21 and +27 and all pixels giving the same value for f(g) was placed in the category bearing that number. It was found that of the 44 categories which resulted, 25 could be considered to be major and 19 to be minor categories.

An example of the results obtained by this method so far in regard to the classification of 11,909 picture elements into their natural classes, is given in Table 2. The categories shown in the Table are numbered -17 and +21. Thus all pixels in Category -17 for example, give a value of -17 for the function f(g).

It is not yet known what ground features correspond with the various categories but it can be seen from a comparison of the four sets of means of the two categories shown in Table 2 that the categories are distinctly different from each other. The standard deviations indicate that the variation within each category is very small.

It is of course possible that some of the 44 categories which resulted from the transformed values can be further refined and that some may be merged with each other by the methods of Discriminant Analysis.

The ground features which the final classes represent will then be plotted by a Digital Computer or the IMAGE 100 System. Thus it is quite probable that in the next stage of the analysis, patterns will be produced which will accurately represent the ground features of the surface of Merritt Island.

FIGURE 1. Locating of North Merritt Island, the site of the Remote Sensing Experiments.

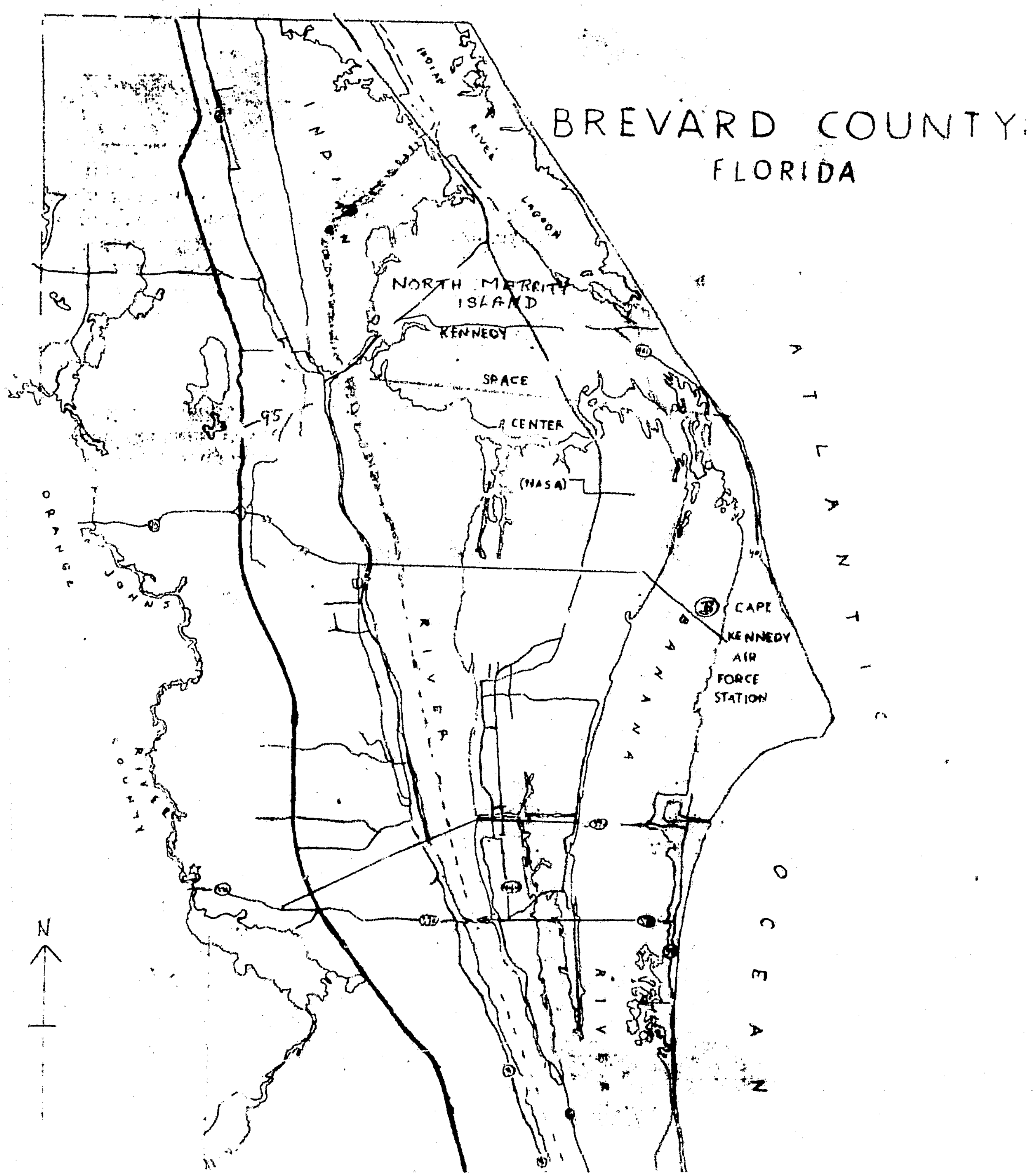


FIGURE 2. Showing sites on which field measurements were taken for the analysis shown in Table 1.

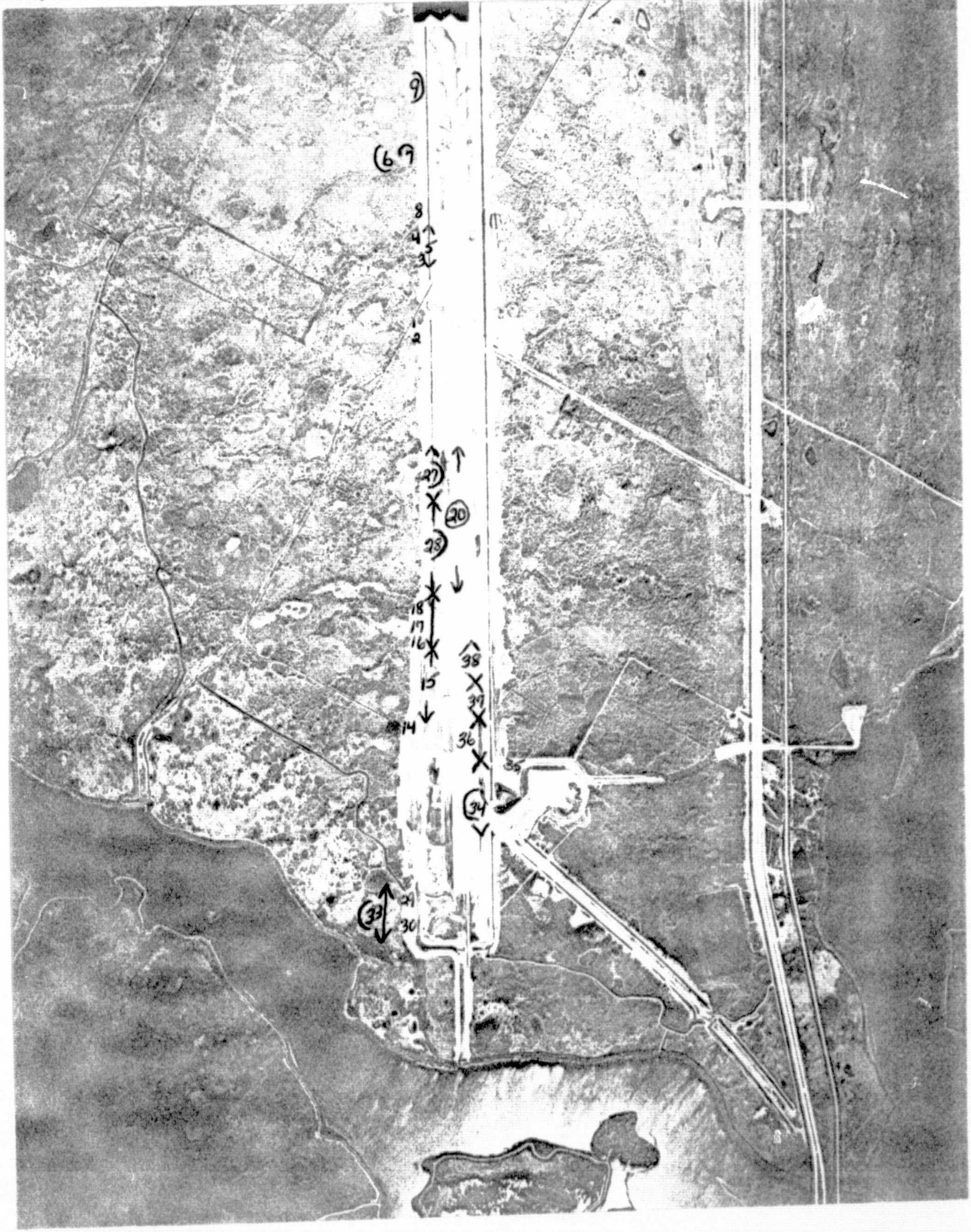


FIGURE 3. Showing sites on which field measurements were taken for the analysis shown in Table 1.

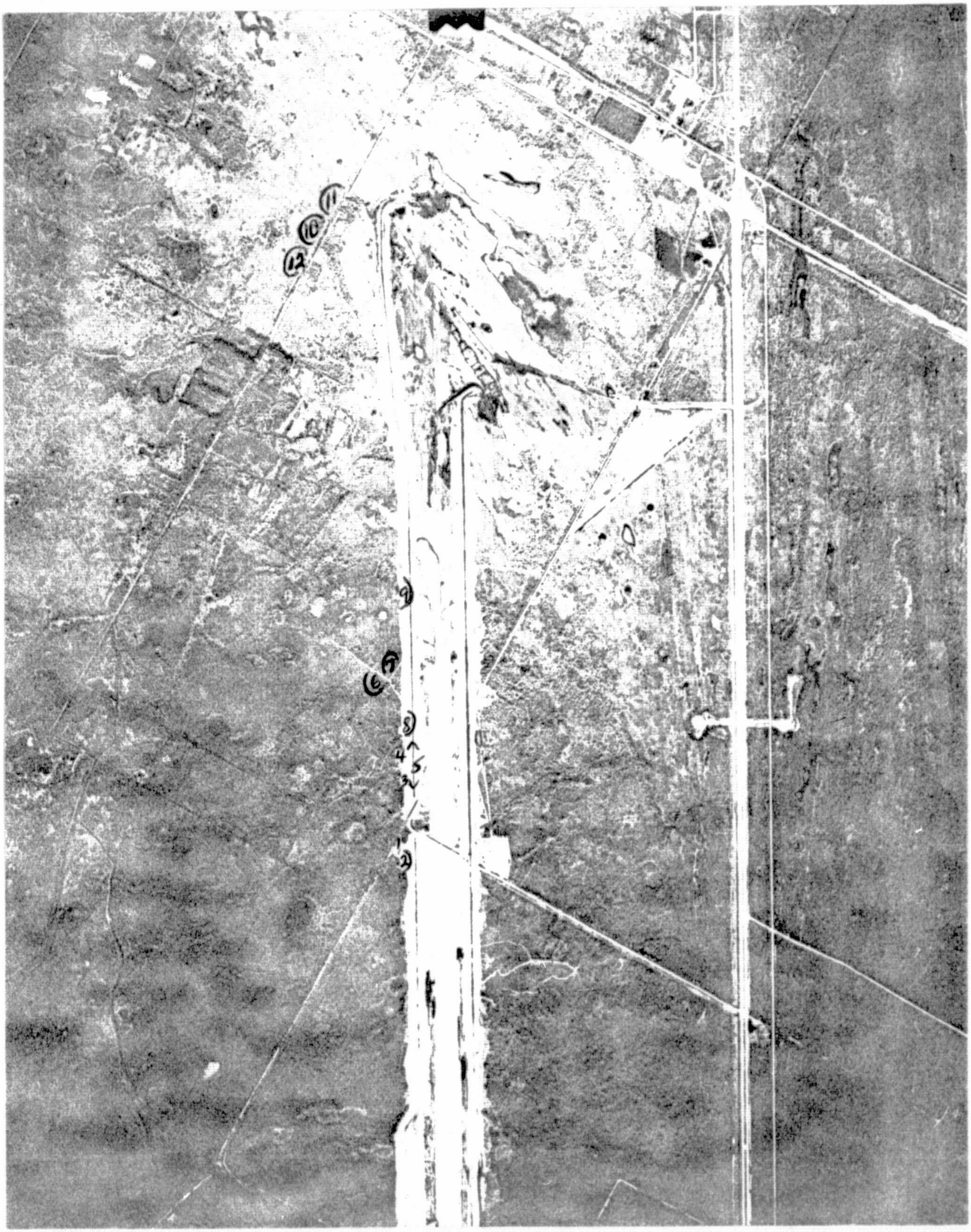
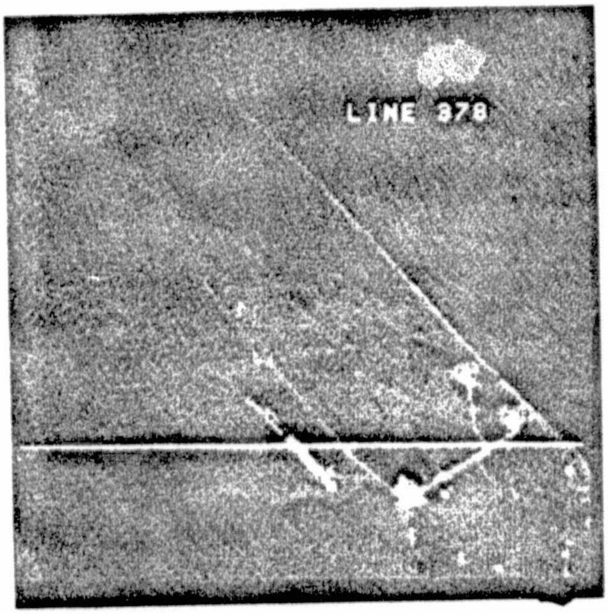


FIGURE 4. Density traces of multispectral data received from a single line across North Merritt Island.



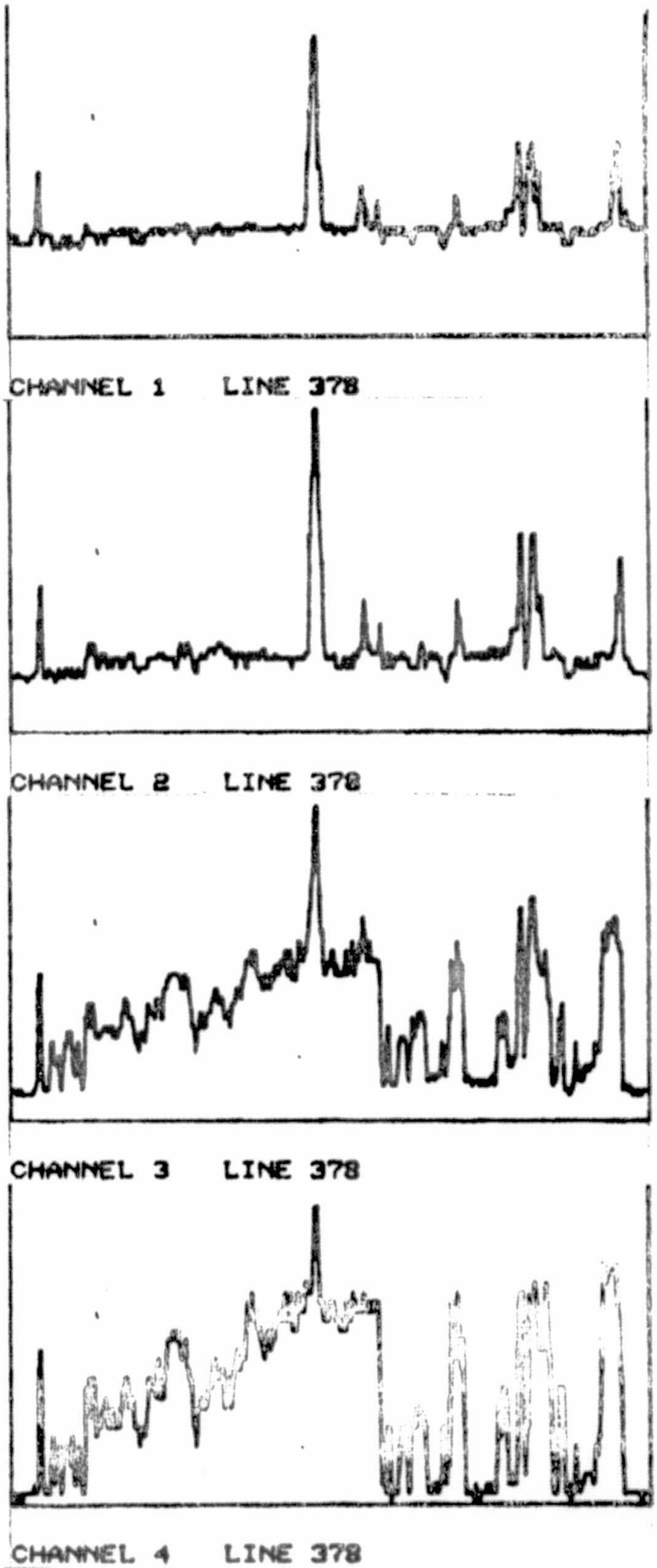


TABLE I

Comparison of field distances and distances estimated on Color Infra Red Photo Maps

Line Nos	Field Distances (feet)	Field Distances (meters)	Estimated Distances (feet)	Estimated Distances (meters)	Differences d (feet)	Differences d (meters)
	(1)	(1)	(2)	(2)	(1)-(2)	(1)-(2)
1	372	113.39	374	114.00	-2	-0.61
2	400	121.92	415	126.49	-15	-4.57
3	65	19.81	75	22.86	-10	-3.05
4	114	34.75	124	37.80	-10	-3.05
5	678	206.65	656	199.95	+22	+6.71
6	15	4.57	17	5.18	-2	-0.61
7	12	3.66	8	2.44	+4	+1.22
8L	135	41.15	125	38.10	+10	+3.05
8W	64	19.51	83	25.30	-19	-5.79
9L	89	27.13	91	27.74	-2	+0.61
9W	113	34.44	108	32.92	+5	+1.52
10	325	99.06	332	101.19	-7	-2.13
11	450	137.16	415	126.49	+35	+10.67
12	340	103.63	332	101.19	+8	+2.44
14	165	50.29	166	50.60	-1	-0.30
15	1035	315.47	1079	328.88	-44	-13.41
16	793	241.71	830	252.98	-37	-11.28
19	182	55.47	174	53.04	+8	+2.44
20	2140	652.27	2166	660.20	-26	-7.92
21	1081	329.49	996	303.58	+85	+25.91
24	687	209.40	672	204.83	+15	+4.57
27	631	192.33	647	197.21	-16	-4.88
28	1522	463.91	1577	480.67	-55	-16.76
29	186	56.69	154	46.94	+32	+9.75
30	268	81.69	257	78.33	+11	+3.35
33	771	235.00	789	240.49	-18	-5.49
34	1055	321.56	1038	316.38	+17	+5.18
35	64	19.51	58	17.68	+6	+1.83
36	517	157.58	498	151.79	+19	+5.79
37	602	183.49	622	189.59	-20	-6.10
38	561	170.99	540	164.59	+21	+6.40
Total	15,432	4703.67	15,418	4,699.41	+14	4.27
Mean	497.81	151.73	497.35	151.59	0.452	0.138

A significant difference between means must exceed 4.676t feet or 1.425t meters. Thus the mean difference of 0.452' or 0.138 meters, is not significant.

<u>Note</u>. 1' = 0.3048 m

t = 1.697

TABLE 2

Showing an example of similarities of spectral signatures within categories* and differences between categories*.

Category in which f(g) = 21

Frequency	Channel 1	Channel 2	Channel 3	Channel 4
58	18	11	7	1
31	18	10	6	1
19	18	10	7	0
18	18	9	5	1
16	18	12	7	2
15	18	9	6	0
14	19	11	8	1
11	18	11	6	2
11	17	11	6	1
9	18	10	5	2
8	18	12	8	1
7	18	11	8	0
6	17	11	7	0
Mean	17.987	10.547	6.583	0.951
Std. Dev.	0.373	0.871	0.863	0.608

Category in which f(g) = ¯17

Frequency	Channel 1	Channel 2	Channel 3	Channel 4
14	22	15	34	20
9	22	15	35	19
9	22	13	33	19
9	22	13	32	20
8	22	15	33	21
8	22	16	35	20
7	22	13	34	18
7	23	15	35	20
7	22	14	34	19
6	23	14	35	19
6	21	14	34	18
5	25	15	37	20
5	22	16	34	21
5	24	15	35	21
Mean	22.305	14.467	34.143	19.629
Std. Dev.	0.841	0.986	1.116	0.908

*All members of the same category have identical f(g) values.

$f(g) = g_1 + g_2 - g_3 - g_4$

g signifies grey levels

1, 2, 3, 4 represent channels