

GEOLOGICAL SURVEY CIRCULAR 230



## AIRBORNE RADIOACTIVITY SURVEYS FOR PHOSPHATE IN FLORIDA

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UNITED STATES DEPARTMENT OF THE INTERIOR  
Douglas McKay, Secretary

GEOLOGICAL SURVEY  
W. E. Wrather, Director

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By R. M. Moxham

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Washington, D. C., 1954

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Free on application to the Geological Survey, Washington 25, D. C.

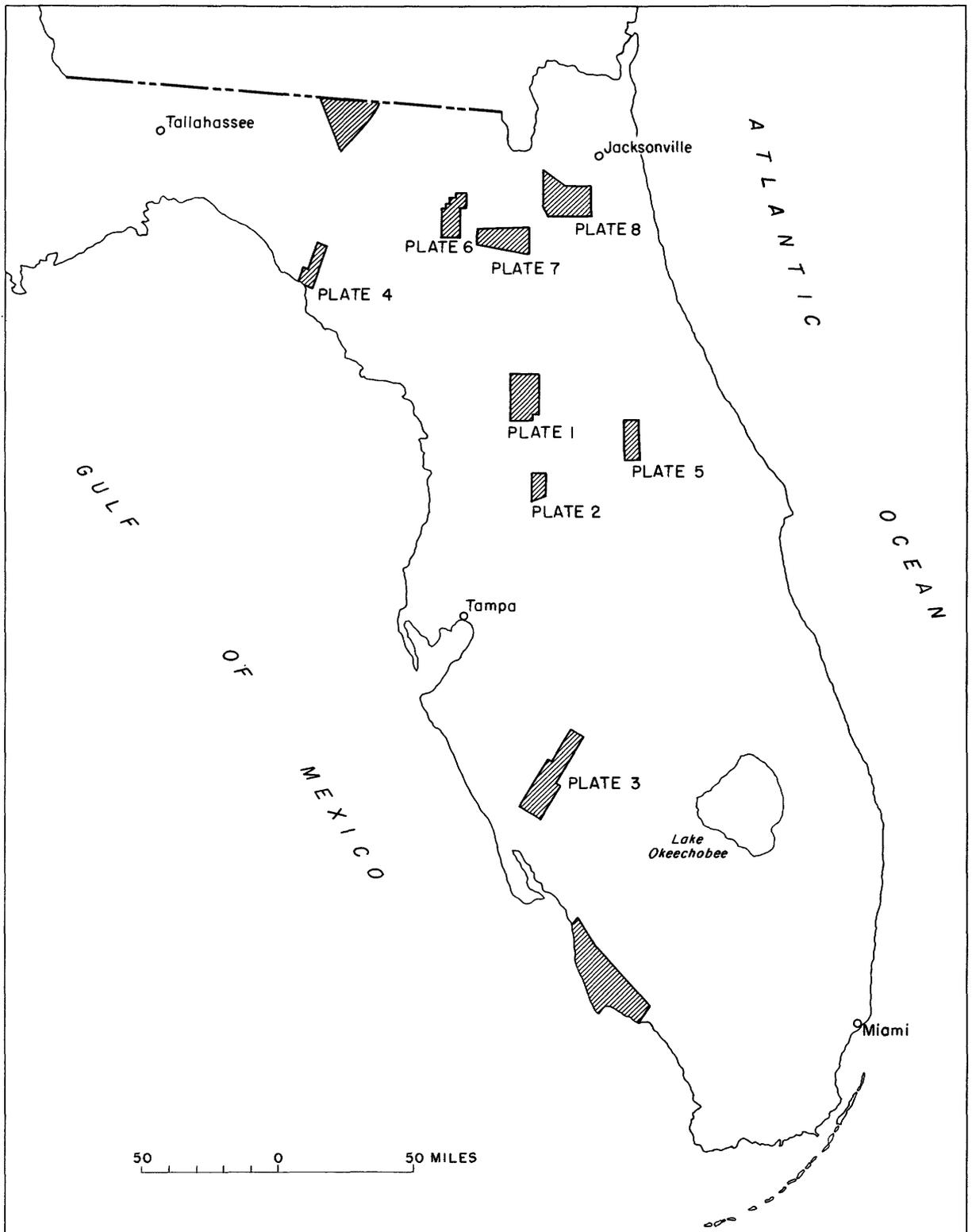


Figure 1.—Index map of Florida showing the location of areas surveyed.

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## ABSTRACT

Airborne radioactivity surveys totaling 5,600 traverse miles were made in 10 areas in Florida, which were thought to be geologically favorable for deposits of uraniferous phosphate. Abnormal radioactivity was recorded in 8 of the 10 areas surveyed. The anomalies are located in Bradford, Clay, Columbia, DeSoto, Dixie, Lake, Marion, Orange, Sumter, Taylor, and Union Counties.

Two of the anomalies were investigated briefly on the ground. One resulted from a deposit of river-  
pebble phosphate in the Peace River valley; the river-  
pebble samples contain an average of 0.013 percent  
equivalent uranium. The other anomaly resulted from  
outcrops of leached phosphatic rock containing as much  
as 0.016 percent equivalent uranium. Several anomalies  
in other areas were recorded at or near localities  
where phosphate deposits have been reported.

## INTRODUCTION

Deposits of phosphate in Florida, beyond the limits of present production areas, have been reported by prospectors and mining companies. Much of the information has been based upon prospecting and exploration which was undertaken many years ago. As a result the published data relating to the occurrence of these

deposits are fragmentary, and few details relating to specific locations and extent are available.

Because of the present interest in uranium as a byproduct of phosphate production, a reconnaissance of some of those areas which appeared geologically most favorable for the phosphate deposits seems desirable. Airborne radioactivity surveys, a means of undertaking rapid low-cost reconnaissance of large areas, is particularly suited to this work. At the outset, however, one serious limitation was recognized—a variable thickness of overburden covering much of the potential phosphate areas. This absorbing layer would reduce the radiation intensity from underlying source rocks and where sufficiently thick, could reduce the radiation intensity to an undetectable level. As the overburden is generally thinnest in stream valleys, most of the areas surveyed were chosen to take advantage of this feature.

Our knowledge of phosphate distribution in Florida, beyond the present production areas, is summarized in a report by Mansfield (1942) which served as one of the guides in selecting the areas to be surveyed.

The selection of areas was made by J. B. Cathcart of the U. S. Geological Survey; J. L. Meuschke was in charge of flight operations. The surveys were made from April 22 to May 19, 1953. The work was undertaken on behalf of the Division of Raw Materials of the Atomic Energy Commission.

The surveys were made with scintillation-detection equipment mounted in a Douglas DC-3 aircraft. Parallel traverse lines, spaced at quarter-mile intervals, were flown about 500 feet above the ground. Aerial photographs were used for pilot guidance, and the flight path of the aircraft was recorded by a gyro-stabilized, continuous-strip film camera. The distance of the aircraft from the ground was measured with a continuously recording radio altimeter.

#### EXTENT OF COVERAGE

At 500 feet above the ground, the width of the zone on the ground from which anomalous radioactivity is measured differs with the tenor and areal extent of the source and with the spatial relationship of the aircraft to the source. For strong sources, the width of the zone measured is as much as 1,400 feet, so that quarter-mile spacing of the flight paths of the aircraft should be adequate for complete coverage of areas surveyed. However, small areas of considerable radioactivity midway between flight paths may not be noted.

Ten areas requiring about 5,600 useful traverse miles were surveyed. These locations are shown on figure 1. Abnormal radioactivity was recorded in 8 of the 10 areas.

#### RADIOACTIVITY MEASUREMENTS

The anomalies, or areas of greater-than-average radioactivity, are shown on plates 1 through 8. For some anomalies the radiation intensity is of the same general amplitude throughout, that is, there are no localities of markedly greater intensity within the anomalous area. The ratio between the maximum and background radiation intensities shown at each anomaly therefore applies to the entire anomalous area. For other anomalies distinct peak intensities were recorded within the limits of the anomalous areas, and in nearly all such instances these peak intensities tend to be grouped. The general limits of the areas of peak or maximum intensities within the overall anomaly have been indicated in an arbitrary fashion. The ratio of maximum radiation intensity to background radiation intensity, thus affords a rough qualitative measure of the relative merits of anomalies.

The background radiation intensity mentioned in this report in connection with the airborne measurements refers to gamma radiation from the ground minus the cosmic and contamination components.

#### Marion County

The area surveyed in the central part of Marion County (pl. 1) is underlain by the Ocala limestone of Eocene age and outliers of sandy phosphatic limestone of the Hawthorn formation of Miocene age (Cooke, 1945). No phosphate deposits have previously been reported in this area. The eastern limit of the hardrock phosphate area, as delineated by Mansfield (1942), lies a few miles west of the surveyed area.

Several radioactivity anomalies were recorded by the airborne equipment within a belt about 5 miles in width which extends for a distance of about 13 miles southward from Ocala. The orientation of the belt parallels the axial trend of the Ocala uplift. The airborne radioactivity

anomalies apparently conform in a general way, to the Hawthorn outcrop area.

Background radioactivity at the 500-foot flight level over the Ocala limestone areas averaged about 0.25  $\mu$ r per hour. The peak intensities of the anomalies recorded over the Hawthorn(?) outcrop reached a maximum of 2.75  $\mu$ r per hour.

One of the anomalies recorded in south-central Marion County is in secs. 13 and 24, T. 17 S., R. 22 E. A brief ground investigation was made on the Hatcher farm, in sec. 24, about  $1\frac{1}{2}$  miles southwest from Summerfield. Leached phosphatic rock crops out at several localities near the crest of a low north-trending ridge. The exposures are relatively small—about a few square feet. At two such localities, the maximum radioactivity recorded at the surface was 0.11 mr per hour; background radioactivity, measured several hundred feet from the outcrop, was 0.01 mr per hour. Float of leached phosphatic rock was found over a soil-covered area of several acres, contiguous to the outcrops. The radiation intensity in the soil-covered area generally was relatively low—about 0.03 mr per hour.

One hand specimen of leached phosphatic rock, collected from an outcrop of maximum radiation intensity (0.11 mr per hour), contains 0.016 percent equivalent uranium (by beta-gamma counting).

#### Sumter County

The area surveyed in Sumter County (pl. 2) is underlain chiefly by the Suwannee limestone (Oligocene) and is near the crest of the Ocala uplift. The north-south axis of the area is aligned roughly with that of the area surveyed to the north in Marion County.

No previous record of phosphate deposits in this area has been published.

Two small anomalies were recorded by the airborne equipment, one 2 miles south from Center Hill, the other 4 miles southeast from Webster. Background radioactivity at the 500-foot flight level was about 0.25  $\mu$ r per hour, and the peak intensities of the anomalies were 3 and 4 times this value.

Both anomalies occur over slight topographic highs, which may have resulted from outliers of the Hawthorn formation.

#### Charlotte, DeSoto, and Sarasota Counties

The survey in Charlotte, DeSoto, and Sarasota Counties was confined to the Peace River valley and immediately adjacent areas (pl. 3). The areas adjacent to the Peace River valley are occupied by the Caloosahatchee formation comprising marine and shell marl, and by marine and estuarine phosphatic sand, clay, and gravel of the Bone Valley formation of Pliocene age. The river valley is underlain by Quaternary alluvium.

Deposits of river-pebble phosphate were mined at a number of localities in the early 1900's, chiefly in the Arcadia and Fort Ogden areas, but little detailed information relating to the location of these deposits has been published (Mansfield, 1942, p. 24-27).

Background radiation at the 500-foot flight level in areas adjacent to the alluvial deposits in the Peace River valley was about  $1.25 \mu\text{r}$  per hour. The alluvium along Peace River was in general slightly more radioactive than the contiguous formations, and two obvious anomalies were recorded. The peak intensities ranged from 2.1 to  $2.5 \mu\text{r}$  per hour.

The radioactivity anomaly located north of Arcadia, DeSoto County, was investigated briefly on the ground. The investigation showed that the anomaly at this locality is due to river-pebble phosphate contained in the alluvium of the Peace River. The phosphatic nodules were found over an area of several acres on the southeast shore of the river and were concentrated in topographic lows apparently by the removal of sand by wind.

The radiation intensity in the area of the anomaly averaged about  $0.03 \text{ mr per hour}$ ; background radiation was about  $0.01 \text{ mr per hour}$ . Local concentrations of phosphatic nodules showed intensities that ranged from about  $0.05$  to  $0.10 \text{ mr per hour}$ . Grab samples were collected at three such concentrations having an areal extent of as much as a few tens of square feet each. The average equivalent uranium content of the samples is  $0.013$  percent by beta-gamma counting.

At least a part of the deposit north of Arcadia was dredged for river pebble sometime before 1910. The anomaly southwest of Arcadia is also situated in an area of Peace River alluvium from which river pebble has been recovered. Probably conditions similar to the Arcadia deposit prevail.

#### Dixie, Lafayette, and Taylor Counties

The survey in Dixie, Lafayette, and Taylor Counties includes the lower part of the Steinhatchee River valley and immediately contiguous areas (pl. 4). The greater part of the area adjacent to the valley is underlain by the Ocala limestone (Eocene); the extreme northeastern limit includes outcrops of the Alachua formation (Pliocene) comprising largely unconsolidated sand and clay. The floor of the Steinhatchee River valley is covered by Quaternary alluvial deposits.

Nearly all the area surveyed is within the Steinhatchee phosphate district as described by Mansfield (1942, p. 48-49), but only fragmentary information is available on deposits reported in this district.

Only one anomaly was detected by the airborne survey. It is for the most part within the limits of the Steinhatchee valley, extending along the course of the stream, from Jena, northward for about  $5\frac{1}{2}$  miles. The radiation intensity is relatively low; the maximum intensity was about 3 times the background level at the 500-foot altitude.

#### Lake and Orange Counties

The survey in Lake and Orange Counties (pl. 5) covers a part of the Wekiva River and Blackwater Creek drainage basins. The lowland areas along these drainages are underlain by late Pleistocene marine and estuarine deposits. Higher elevations adjacent to the river valleys are occupied by the marine sand and shell marl of the Caloosahatchee formation (Pliocene).

Pebble phosphate deposits have been reported (Mansfield, 1942, p. 6) along Blackwater Creek in the vicinity of Cassia and "north and east" of Rock Springs Run. They are said to be covered by "light overburden." No details as to the location of the deposits are given.

Anomalous radioactivity was recorded during the airborne surveys in three areas near Blackwater Creek and in one at Rock Springs. In all four areas the surficial deposits are late Pleistocene sands and clay. Mansfield states that the phosphate deposits are "under light overburden" presumably Pleistocene deposits. The maximum radiation intensity, about  $0.8 \mu\text{r}$  per hour at 500 feet, was recorded over the Rodriguez Grant, northwest of Cassia Station.

#### Alachua, Columbia, and Union Counties

The survey in Alachua, Columbia, and Union Counties (pl. 6) includes part of the Olustee Creek valley and contiguous areas. The southern half of the region is underlain by sand and phosphatic sandy limestone of the Hawthorn formation (Miocene); the northern part of the region is occupied by early Pleistocene marine terrace deposits.

According to reports quoted by Mansfield (1942, p. 34) rock containing an abundance of light- and dark-colored phosphatic pebbles is found on Olustee Creek near Lulu. Deposits of river pebble are also said to occur along Olustee Creek but the locations of these deposits are not given.

Two anomalies were recorded during the airborne survey. One is in the Olustee Creek valley, 2 miles south from Lulu, where the surficial material is early Pleistocene sand. The other anomaly is  $4\frac{1}{2}$  miles south from Lulu, in the Hawthorn outcrop area. Background radiation during the airborne survey was about  $0.25 \mu\text{r}$  per hour; the anomalies reached a peak intensity of about  $0.75 \mu\text{r}$  per hour.

Both anomalies described above are located approximately at the level of the Wicomico shoreline (MacNeil, 1949). In addition to phosphate as a possible source of the activity, the beach concentrations of heavy minerals along the shoreline must be considered as potential source materials.

#### Alachua, Bradford, and Union Counties

The survey includes most of the southern half of Bradford County and very small parts of Alachua and Union Counties (pl. 7). The Hawthorn formation (Miocene) occupies most of the western part of the region and also crops out along the southern limit of the area surveyed. The remainder of the region is mantled by early Pleistocene sands.

A report by Sellards (1915, p. 39) states that in a deep sink about 3 miles southeast from Brooker, 39 feet of "matrix" lies beneath 37 feet of shell marl and covered slopes. Mansfield (1942, p. 6) reports an area of 16,000 acres of pebble phosphate north of the Santa Fe River between the towns of Brooker, Hampton, and Sampson.

Two airborne radioactivity anomalies were recorded in the vicinity of Brooker. Background radiation in the area at the 500-foot flight altitude was about 0.6  $\mu$ r per hour. The maximum anomalous radioactivity was 1.2  $\mu$ r per hour recorded at Brooker.

#### Clay and Duval Counties

The area surveyed in Clay and Duval Counties (pl. 8) is underlain by unconsolidated deposits of Miocene and Pleistocene age. The Duplin marl (Miocene) comprising argillaceous and arenaceous shell marl occupies portions of the valley of Black Creek and its south fork, in the western part of the surveyed area. Most of the eastern portion is underlain by late Pleistocene marine and estuarine deposits. A report cited by Mansfield (1942, p. 6) states that pebble phosphate under "light" overburden occurs in an area 15 miles long by 10 miles wide, with Black Creek about centrally located.

One large area of slightly anomalous radioactivity was recorded by the airborne survey. The radiation intensity is low, about twice the background level throughout the anomalous area; no localities of peak intensity above the general anomalous level were detected. The western portion of the anomaly is over the Duplin marl but abnormal radioactivity extends eastward into the area of Pleistocene deposits. The northern limit of the anomalous area conforms roughly to the Pamlico shoreline (MacNeil, 1949), so that the possibility exists that the anomaly may be due at least in part to beach concentrations of heavy minerals.

#### Madison, Hamilton, and Collier Counties

The areas surveyed in Madison and Hamilton Counties, and in Collier County are shown on figure 1.

Pebble phosphate has been found at several localities between the Withlacoochee and Allapaha Rivers in western Hamilton County, but no radioactivity anomalies were recorded during the airborne survey in this area.

Phosphate has been reported near Naples, on the Gulf Coast in western Collier County,

but no anomalous radioactivity was detected in this vicinity.

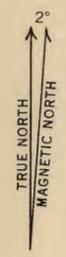
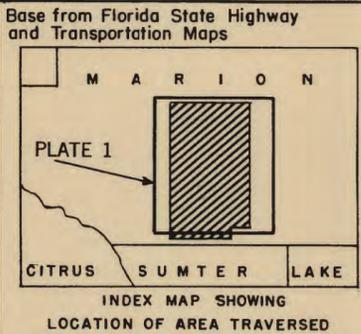
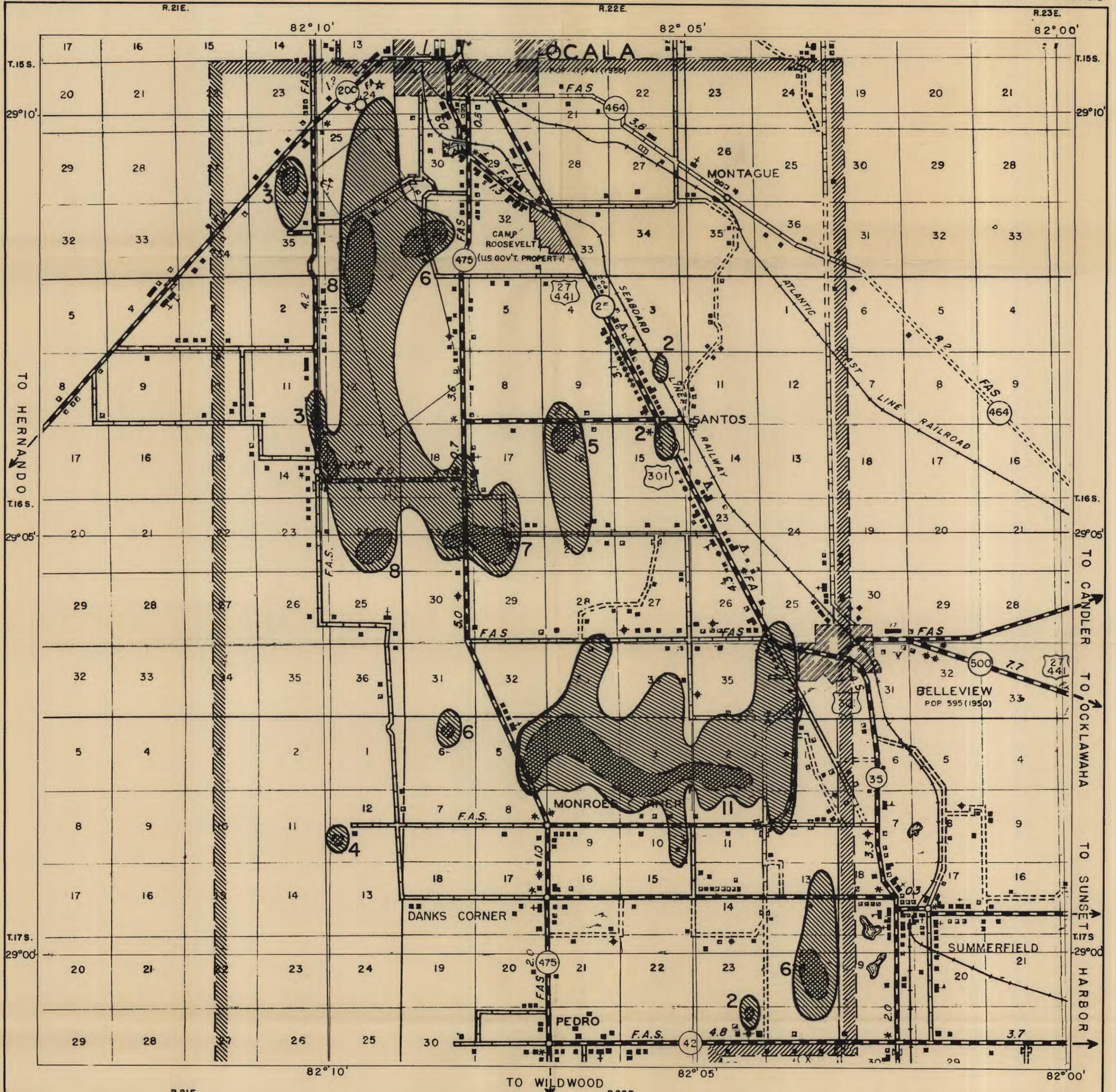
#### CONCLUSION

At least two of the airborne radioactivity anomalies described above have been caused by deposits of uraniferous phosphatic materials. Most of the other anomalies were detected in areas in or near which phosphate has been reported, so it would appear that the anomalies are in some manner related to uranium associated with phosphatic materials. However, it should be pointed out that, at nearly every locality at which phosphate has been reported, the material is said to be covered by as much as 50 feet of overburden. If radioactive source rocks of the tenor with which we are dealing are covered by more than 1 foot of inert overburden, the radiation intensity should be reduced to an undetectable level at the 500-foot flight level. So, if the anomalies described above are to be attributed to phosphatic materials, we must assume that (1) the deposits are at or near the surface of the ground or (2) radioactive materials are being transported to surface from buried deposits.

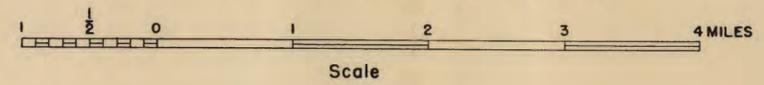
The results of the surveys indicate that the phosphate deposits of Florida contain sufficient uranium to be detected by airborne radioactivity detection equipment provided there is some surface expression of the deposits. The significance of the radioactivity anomalies in the areas of buried phosphate deposits cannot be ascertained until adequate exploration work is undertaken.

#### LITERATURE CITED

- Cooke, C. W., 1945, Geology of Florida: Florida Geol. Survey Bull. 29.  
MacNeil, F. S., 1949, Pleistocene shorelines in Florida and Georgia: U. S. Geol. Survey Prof. Paper 221-F, p. 95-107.  
Mansfield, G. R., 1942, Phosphate resources of Florida: U. S. Geol. Survey Bull. 934.  
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AIRBORNE RADIOACTIVITY SURVEY OF PART OF MARION COUNTY, FLORIDA

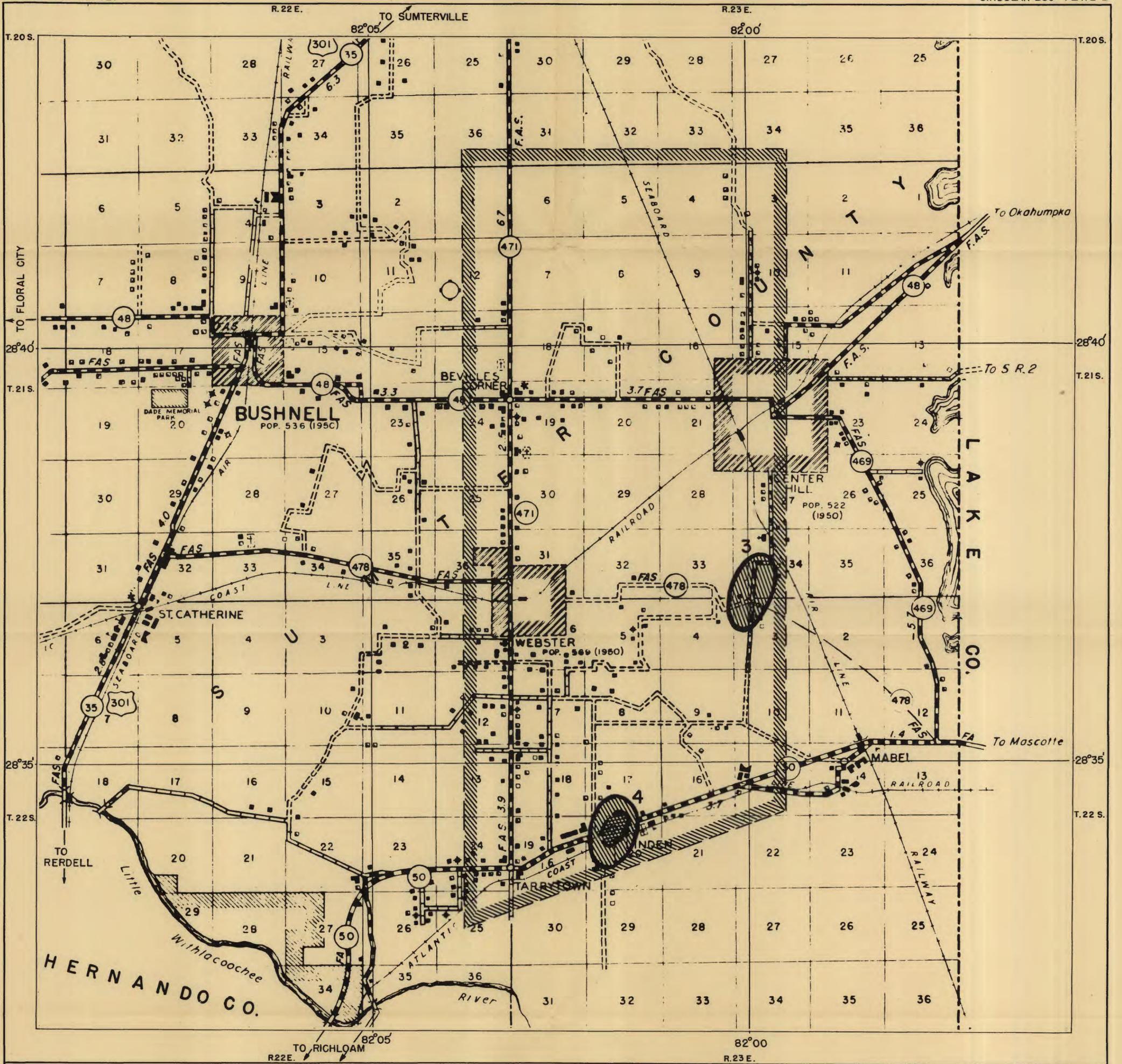


August 1953

Airborne radioactivity measurements by R. M. Moxham and J. L. Meuschke

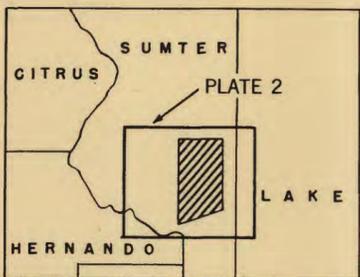
EXPLANATION

- Area of greater-than-average radioactivity
- Area of maximum radiation intensity
- Ratio of maximum radiation intensity to background radiation intensity
- Boundary of area traversed

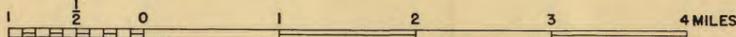


Base from Florida State Highway and Transportation Maps

Airborne radioactivity measurements by R. M. Moxham and J. L. Meuschke

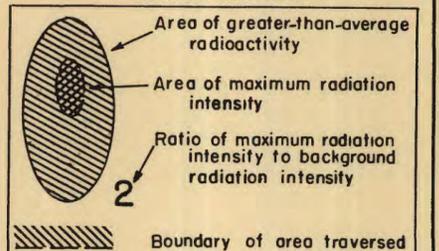


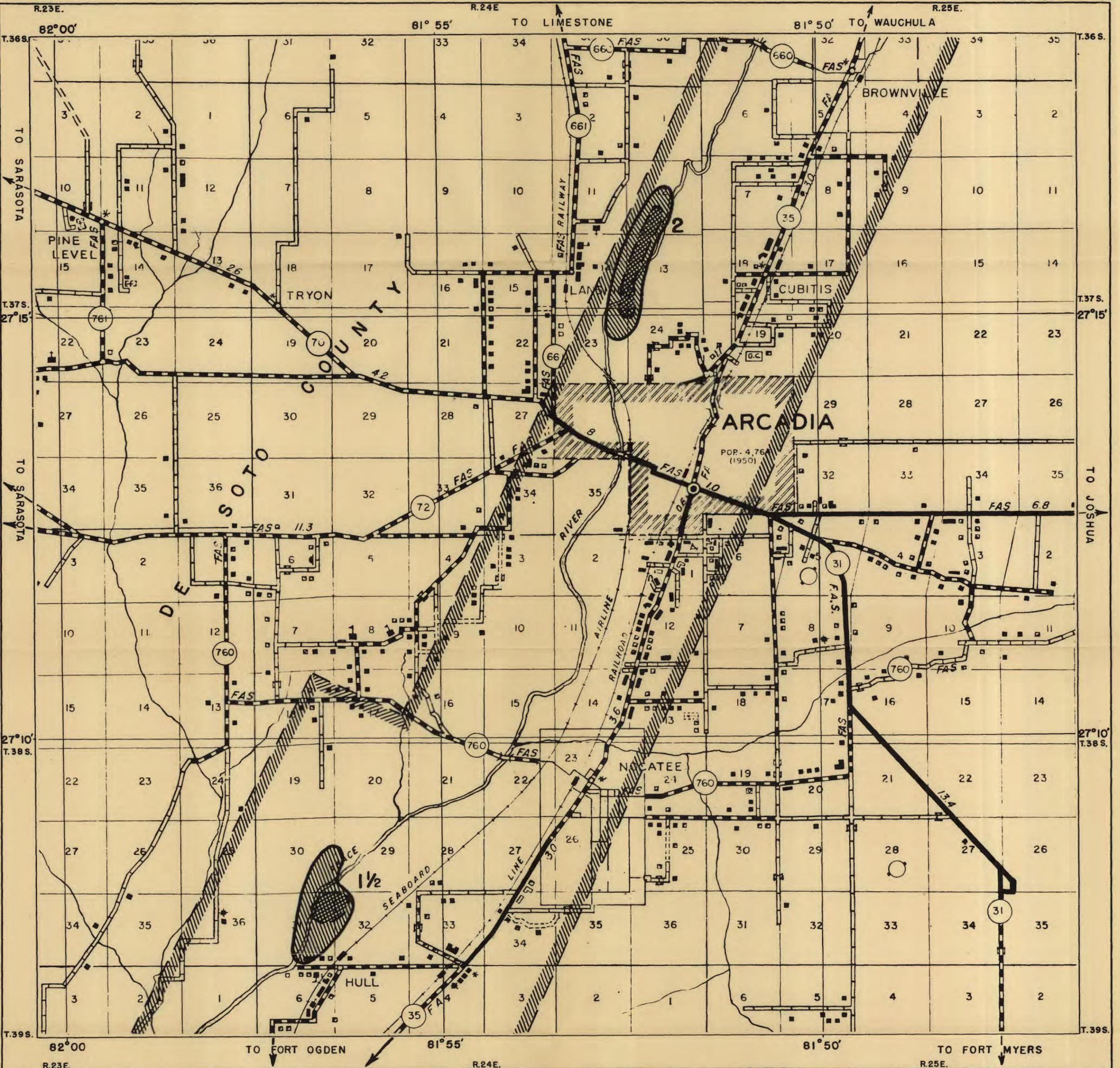
### AIRBORNE RADIOACTIVITY SURVEY OF PART OF SUMTER COUNTY, FLORIDA



Scale  
August 1953

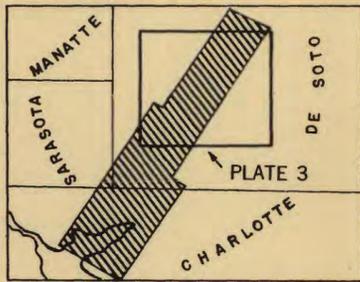
#### EXPLANATION





Base from Florida State Highway and Transportation Maps

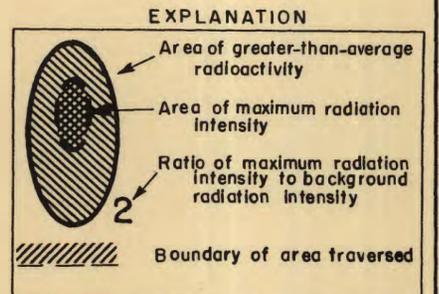
Airborne radioactivity measurements by R. M. Moxham and J. L. Meuschke

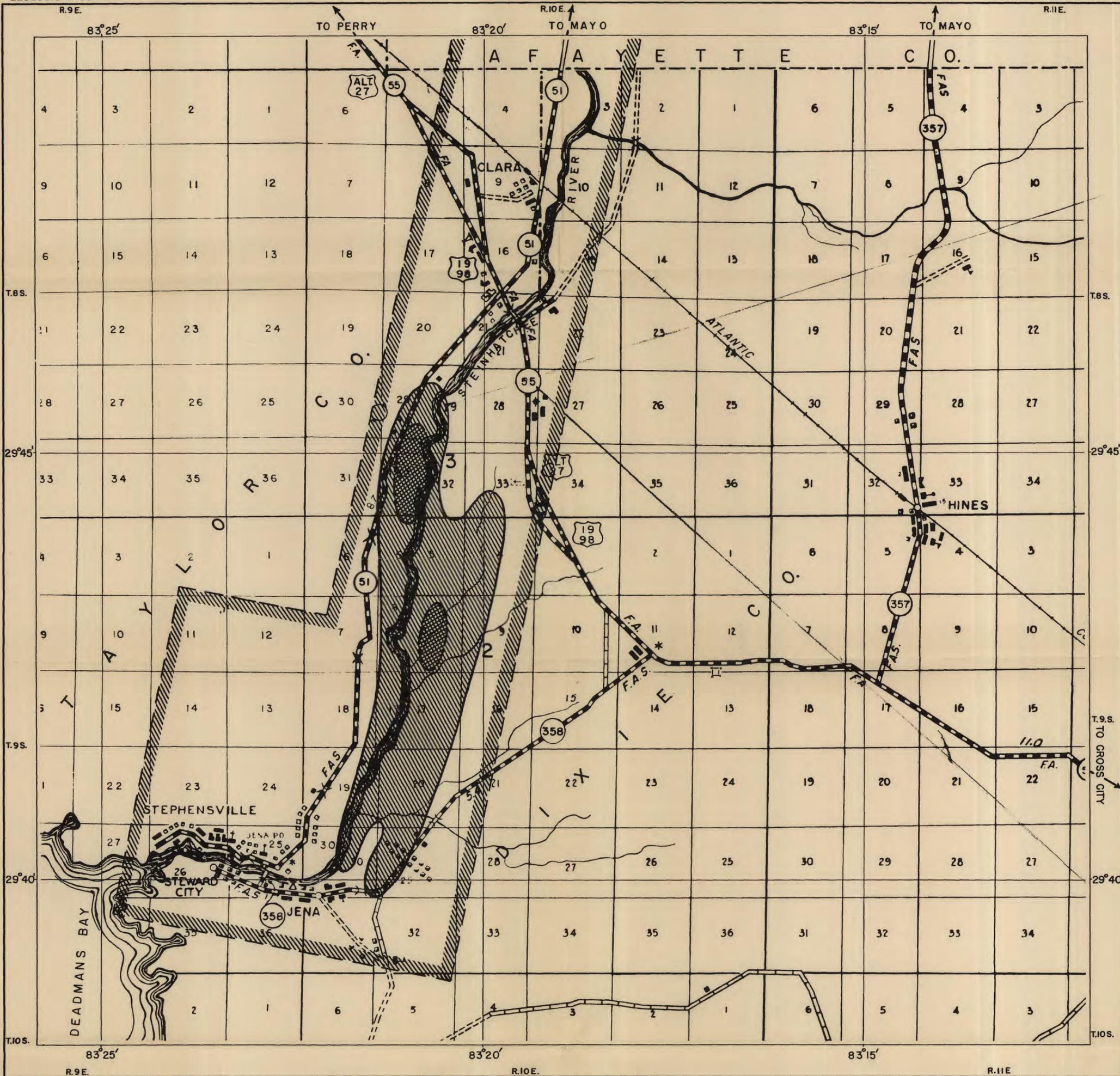


### AIRBORNE RADIOACTIVITY SURVEY OF PARTS OF CHARLOTTE, DE SOTO, AND SARASOTA COUNTIES, FLORIDA



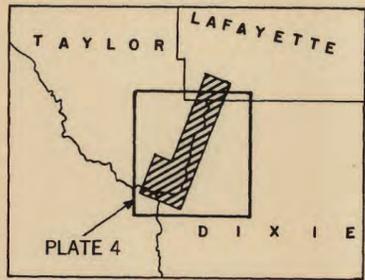
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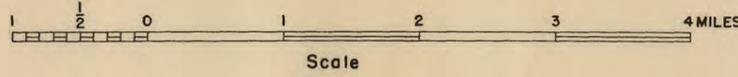
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Airborne radioactivity measurements by R. M. Moxham and J. L. Meuschke



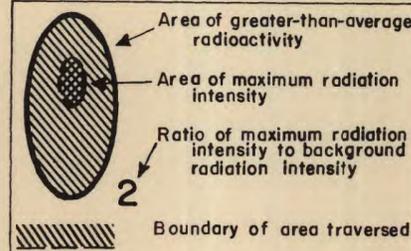
TRUE NORTH  
MAGNETIC NORTH

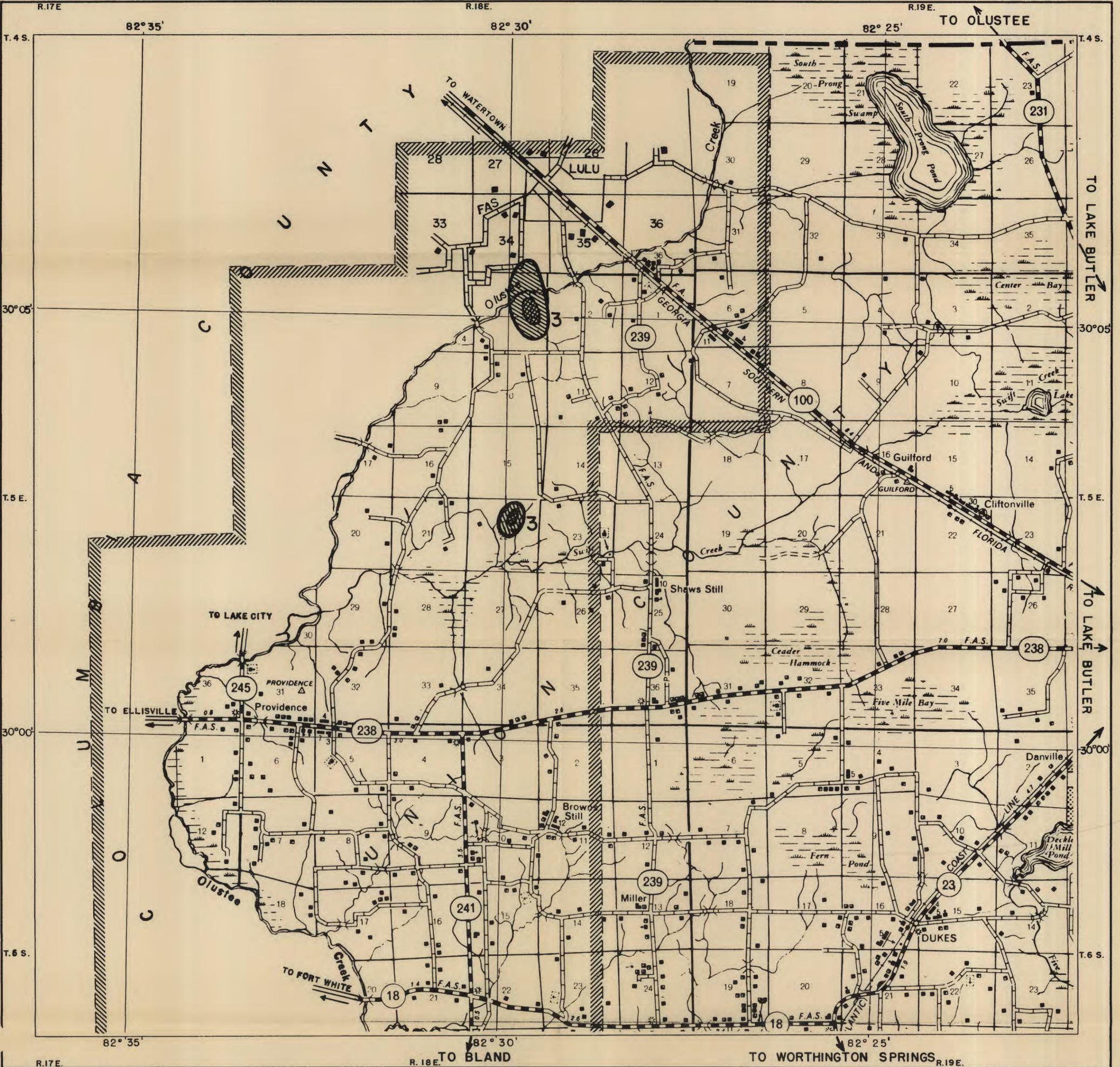
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August 1953

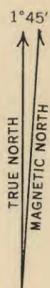
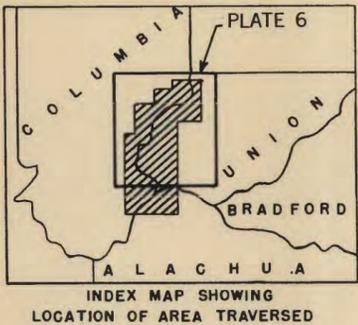
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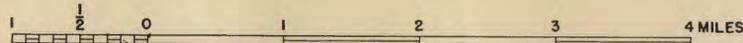


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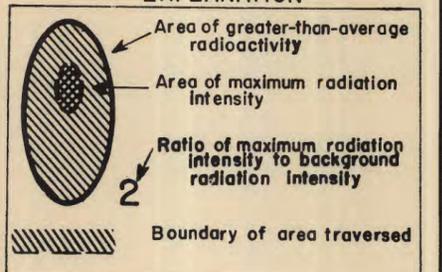


### AIRBORNE RADIOACTIVITY SURVEY OF PARTS OF ALACHUA, COLUMBIA, AND UNION COUNTIES, FLORIDA



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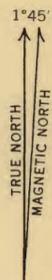
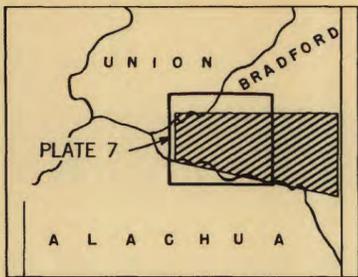
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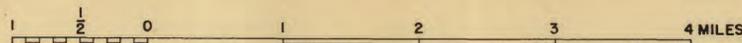


Base from Florida State Highway and Transportation Maps

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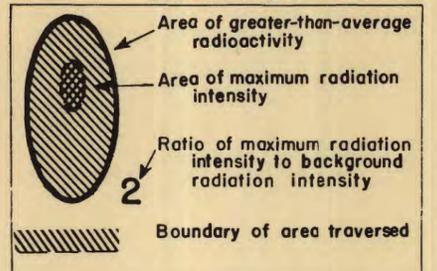


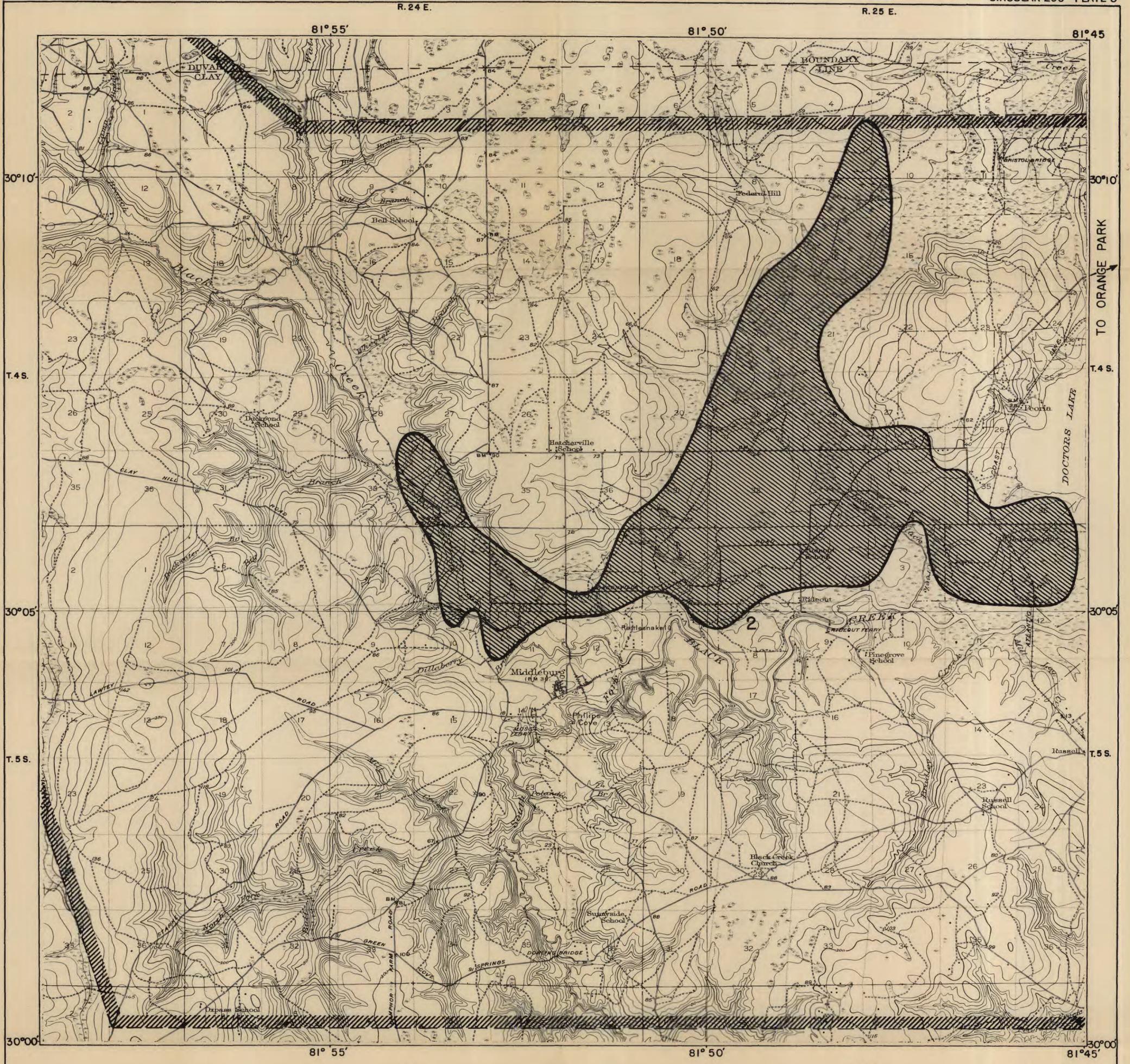
### AIRBORNE RADIOACTIVITY SURVEY OF PARTS OF ALACHUA, BRADFORD, AND UNION COUNTIES, FLORIDA



Scale August 1953

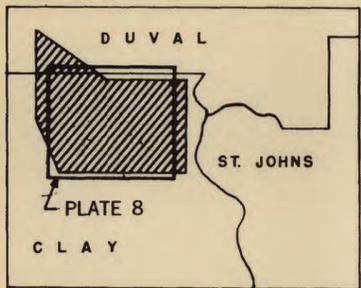
#### EXPLANATION





Base from U.S. Geological Survey topographic quadrangle

Airborne radioactivity measurements by R. M. Moxham and J. L. Meuschke



1°30'  
TRUE NORTH  
MAGNETIC NORTH

### AIRBORNE RADIOACTIVITY SURVEY OF PARTS OF CLAY AND DUVAL COUNTIES, FLORIDA



Scale  
CONTOUR INTERVAL 10 FEET  
August 1953 A

#### EXPLANATION

