# NEW JERSEY WETLANDS MAPPING PILOT PROJECT FINAL REPORT

PREPARED FOR
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
DIVISION OF MARINE SERVICES

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AND

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This aerial color infrared photograph was taken in the Tuckerton area. It shows (in the upper left corner) a "Venice" type development encroaching on the wetlands; the upper wetlands boundary (lower left corner) and the extensive misquito ditching common to the New Jersey wetlands. Tonal and textural variations on the original color infrared transparency were used by EarthSat biologists, to map the upper wetlands boundary, major species associations, and the biological high water line.


1:12 000
CJF-

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# 1.0 INTRODUCTION

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## 1.1 STATEMENT OF THE PROBLEM

The New Jersey Wetlands Act of 1970 (A-505) defines wetlands as:

> "....any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the State of New Jersey along the Delaware Bay and Delaware River, Raritan Bay, Barnegat Bay, Sandy Hook Bay, Shrewsbury River including Navesink River, Shark River, and the coastal inland waterways extending southerly from Manasquan Inlet to Cape May Harbor, or at any inlet, estuary or tributary, waterway, or any thereof, including those areas now or formerly connected to tidal waters whose surface is at or below an elevation of 1 foot above local extreme high water, and upon which may grow or is capable of growing some, but not necessarily all, of the following: Salt meadow grass (Spartina patens), spike grass (Distichlis spicata), black grass (Juncus gerardi), saltmarsh grass (Spartina alterniflora), saltworts (Salicornia europaea, and Salicornia bigelovii), Sea Lavender (Limonium carolinianum), saltmarsh bulrushes (Scirpus robustus and Scirpus paludosus var. atlanticus), sand spurrey (Sperqualaria marina), switch grass (Panicum virgatum), tall cordgrass (Spartina pectinata), hightide bush (Iva frutescens var. oraria), cattails (Typha angustifolia, and Typha latifolia), spike rush (Eleocharis rostellata), charimaker's rush (Scirpus americana), bent grass (Agrostis palustris), and sweet grass (Hierochloe adorata)."

The Wetlands Mapping Pilot Project was initiated to develop, test, and apply a methodology for mapping and inventorying state wetlands preliminary to the production of a state-wide wetland map series. Earth Satellite Corporation, Washington, D.C. performed the work under contract from the Department of Environmental Protection.

It is essential that map products have validity which can withstand the challenge of litigation. In addition to the legal basis for protecting the state's private wetlands, as provided by the Act, state riparian rights can provide a basis for protecting these areas. Put simply, lands seaward of the mean high water line (riparian lands) are owned by the state unless the state sells them.

Mapping a mean high water line within densely vegetated welands is a difficult problem. Ground survey methods are inaccurate and too costly and time consuming; aerial survey methods, used along open shorelines require complex ground-to-air logistics, and the mean high water boundary is difficult to discriminate when it occurs in wetlands vegetation.

Tidal wetlands are distinguishable by characteristic botanical associations. These associations, when identified on aerial photographs and further substantiated by selected field observations, can be used to determine the upper wetland boundary and biological high water lines. Analysis of aerial photographs permits the inventory of plant species (delineation of major species associations) present in wetland areas as a measure of the general aesthetic, nutrient, and recreational value of specific wetlands areas.

The pilot project was conducted under severe time constraints; it required the close integration of aerial photography, advanced biological remote sensing, and map production. The photointerpretative techniques adopted are innovative. The pilot project was used not only to test procedures and solve problems, but also to produce legally viable final products. The procedure is summarized in Figure 1.

Methodoligies established for the pilot project are documented in this report. Additional modifications will be required and integrated into the system for future wetlands mapping in order to improve the efficiency and quality of map products.

Individuals involved in the successful completion of the pilot projects are listed in Appendix I.

## 1.2 PURPOSE OF THE STUDY

Pilot program objectives follow:

1. To develop, test and apply a practical methodology to determine the upper (inland) boundary of New Jersey's coastal wetlands
2. To delineate major associations of wetlands vegetation (major species associations)
3. To develop, test and apply a practical biologically based methodology which may be used to determine the physical mean high water line
4. To provide the state with a variety of map products at 1:2400 and 1:6000 scales

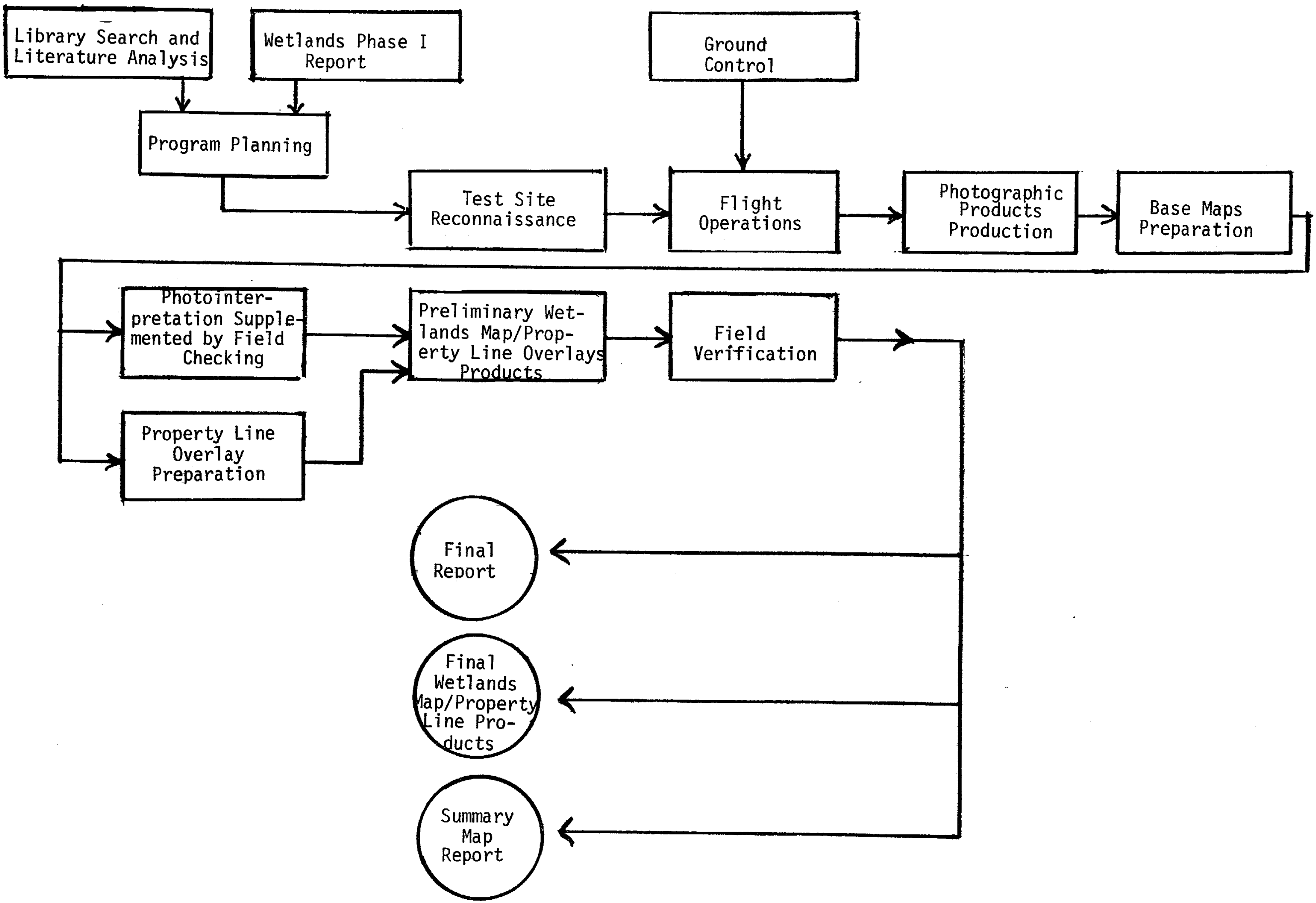



Figure 1: Summary of Overall Project Procedure

For clarity and consistency, the following definitions shall apply:

| | |
|---|---|
| "Act" | shall refer to the New Jersey Wetlands Act of 1970. |
| "NJDEP" | shall refer to the New Jersey Department of Environmental Protection. |
| "State" | shall refer to the State of New Jersey. |
| "Wetlands" | shall refer to coastal wetlands as cited in the New Jersey Wetlands Act of 1970. |
| "Map delineation" | shall be defined as that mapping which is the direct result of imagery interpretation and associated field checking. |
| "Upper Wetlands boundary" | shall be defined as the boundary between wetland and dryland as usually characterized by either a rapid rise in elevation with forested or agricultural ground as the wetlands border or ground rise in elevation producing a succession of plant communities from wetland to dryland. Plant species typical of N.J. wetlands as defined in the Wetlands Act of 1970, U.S. Fish and Wildlife Service inventory of N.J. wetlands, 1954, and this final report were used to identify the boundary. |
| "Major species associations" | shall be defined as one or more species for delineation having an areal extent of five (5) or more acres on the ground. Major species associations shall be named by species present, but limited to species which are 25% or more of the total area delineated. |
| "Biological criteria" | shall refer principally to the use of wetland plant species (but including animal indicators) as sensitive indices of environmental variables, (e.g. moisture and salinity) which are useful for delineating the biological highwater and upper wetlands boundary lines. |
| "Physical criteria" | shall refer to the use of techniques which may at times supplement or replace biological criteria; these shall include, but are not necessarily limited to, geomorphological and sedimentary criteria. |

"Map report" shall refer to a technical record describing the principal participants, observations, and problems which shall be an integral part of each map sheet.

The term "biological high water" is used in this report. Studies are underway to establish the exact relationship(s) between the physical and and biological high water lines. Establishing exact physical - biological relationships will require tidal studies based on mean high water (tide gauge) statistics from one year's observations. The National Ocean Survey and the U.S. Geological Survey are currently establishing this data base.

## 1.3 TEST SITES

### 1.3.1 General

Aerial mapping and biological discrimination procedures were applied in Salem County (Mannington Meadows) and Ocean County (Tuckerton), New Jersey. The latter area is a true salt marsh (Figures 2 and 3); the former may be classified as a fresh to brackish marshland (Figures 4 and 5).

These test areas were chosen by NJDEP because neither site (a) crosses county lines nor (b) contains large tracts owned by the State, the Federal government, or private conservation groups. Each site is, in addition, complex (a) both contain wetlands and riparian lands; (b) each has a broad vegetative spectrum; (c) both have some fresh water inflow; and (d) both are in the vicinity of established bench-marks and tidal gauging stations.

An examination of photography collected during the pilot study, and field observations at each site, affirms EarthSat's technical judgment that statewide mapping will not introduce problems significantly different from those met and resolved in the pilot project.

### 1.3.2 Tuckerton Area

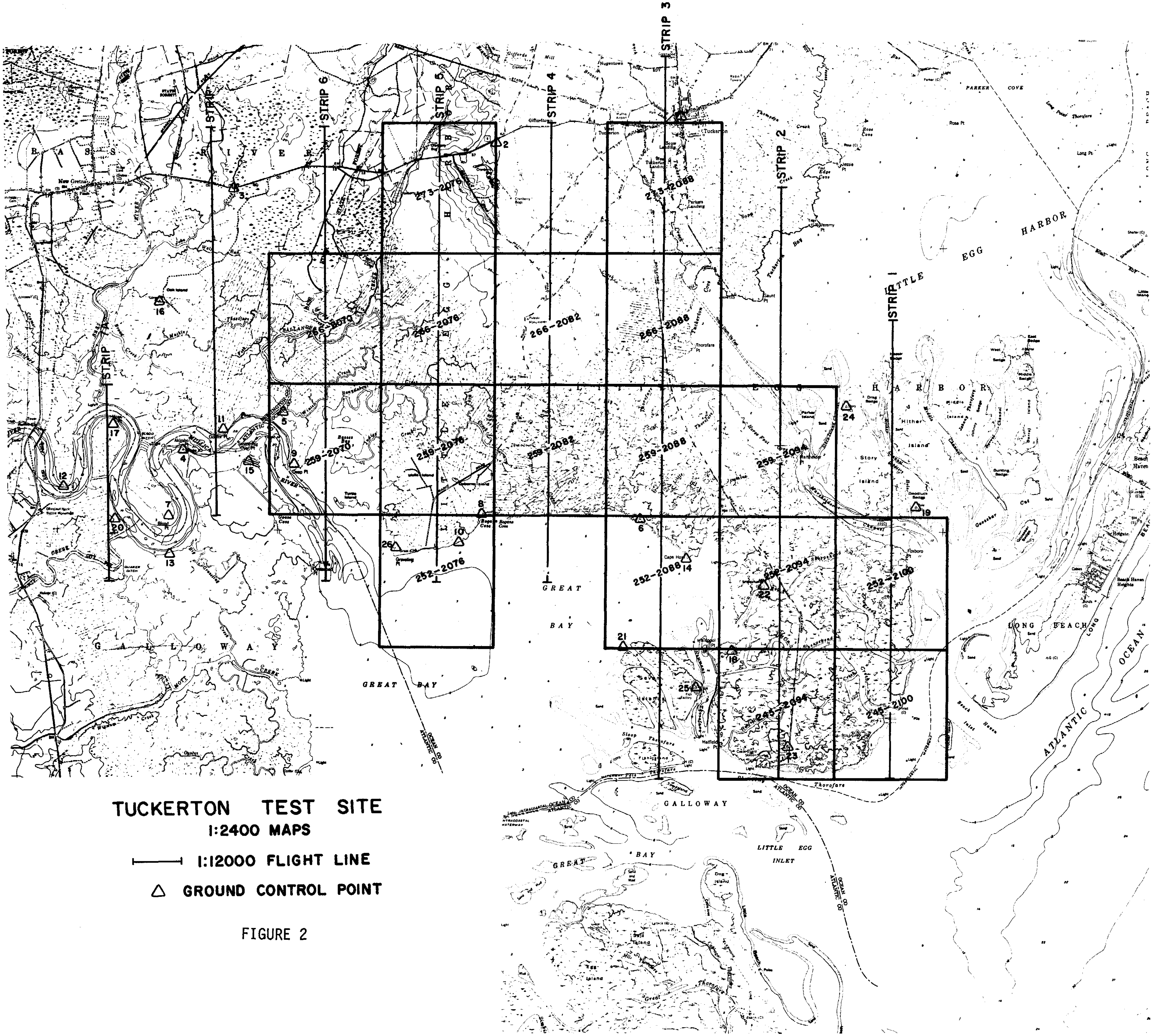
This saline wetland (Figure 6A and 6B) contains shore housing and some light (fish processing) industry. A high incidence of mosquito ditching has already changed the natural ecosystem of the area. Ditching has caused the wetlands to become partially dried in some places and natural succession (the orderly process of change in plant species) is being upset. Tidal plant communities are being replaced by other aquatic plants.

Areas which are partially covered by fill material apparently once supported a lush growth of *Spartina alterniflora*. Portions of the dredged and covered wetlands once were tidal lands which probably belonged to the State. Observations of dredging operations in the Mystic Islands area indicated extensive wetlands damage.

A locally stabilized narrow berm of mixed sand, and shell debris standing a few feet above the low marsh fronts Little Egg Harbor and parts of Great Bay. Although this berm is cut by guts and creeks, water is "ponded" and "perched" landward of the berm ridge. This feature -- which has utility as a "buffer" against marsh erosion -- is sufficiently extensive and well-developed to be mapped and protected.

### 1.3.3 Mannington Meadows Area

This is a fresh to brackish water wetland. Diking occurs locally throughout the area. (Figure 7)

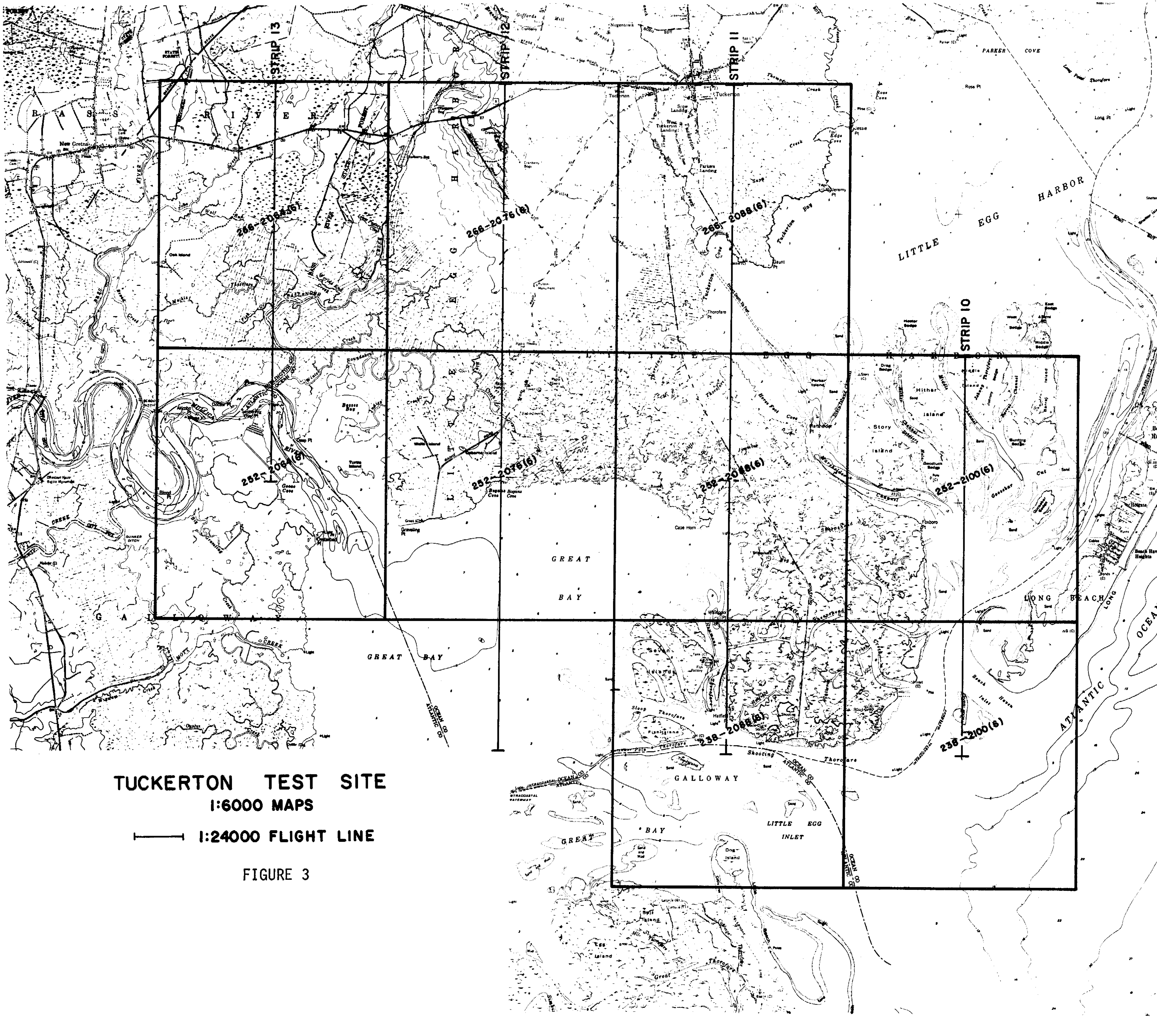



TUCKERTON TEST SITE
1:2400 MAPS

1:12000 FLIGHT LINE

△ GROUND CONTROL POINT

FIGURE 2

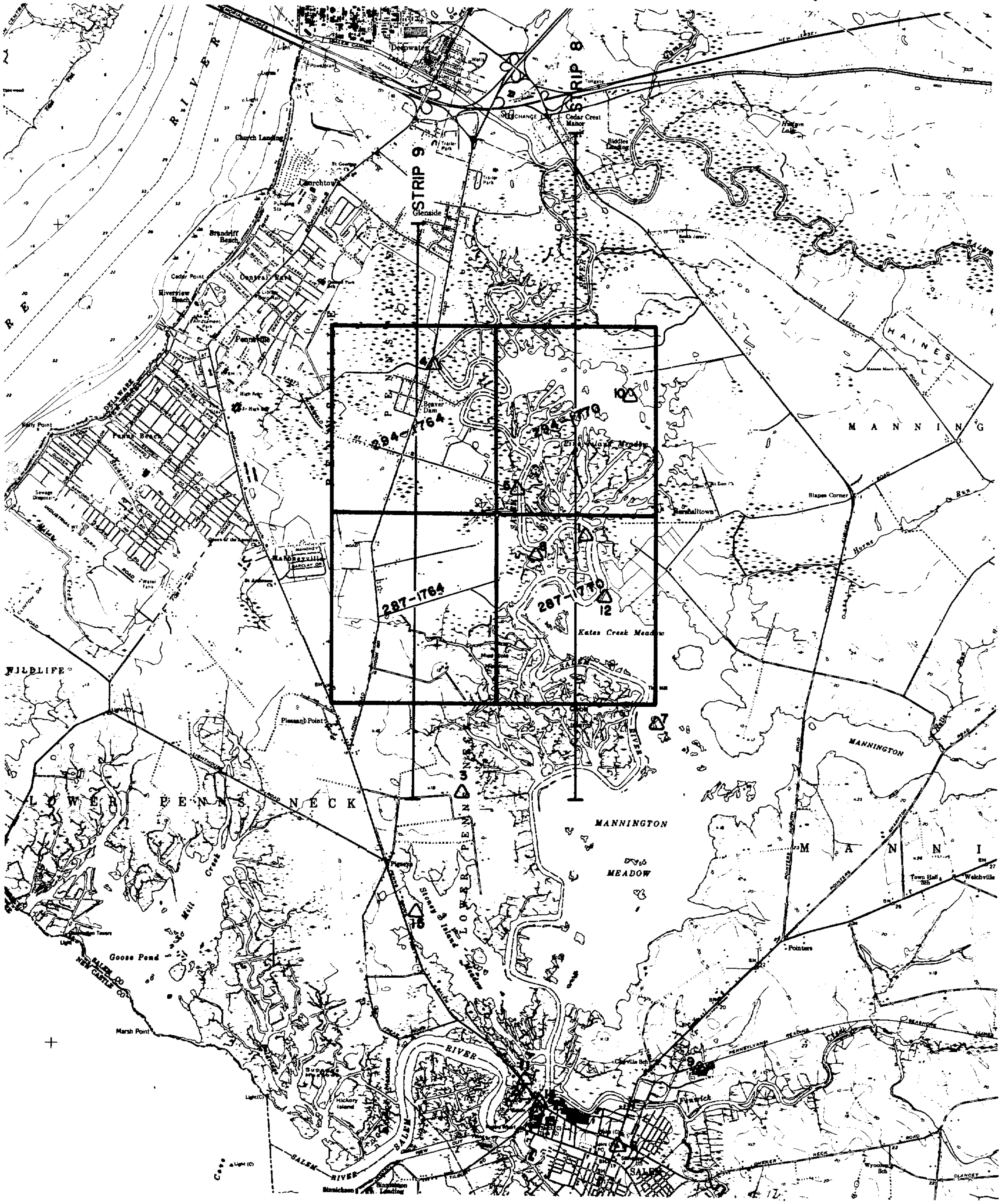



## TUCKERTON TEST SITE

**1:6000 MAPS**

**⊢——⊣ 1:24000 FLIGHT LINE**

FIGURE 3



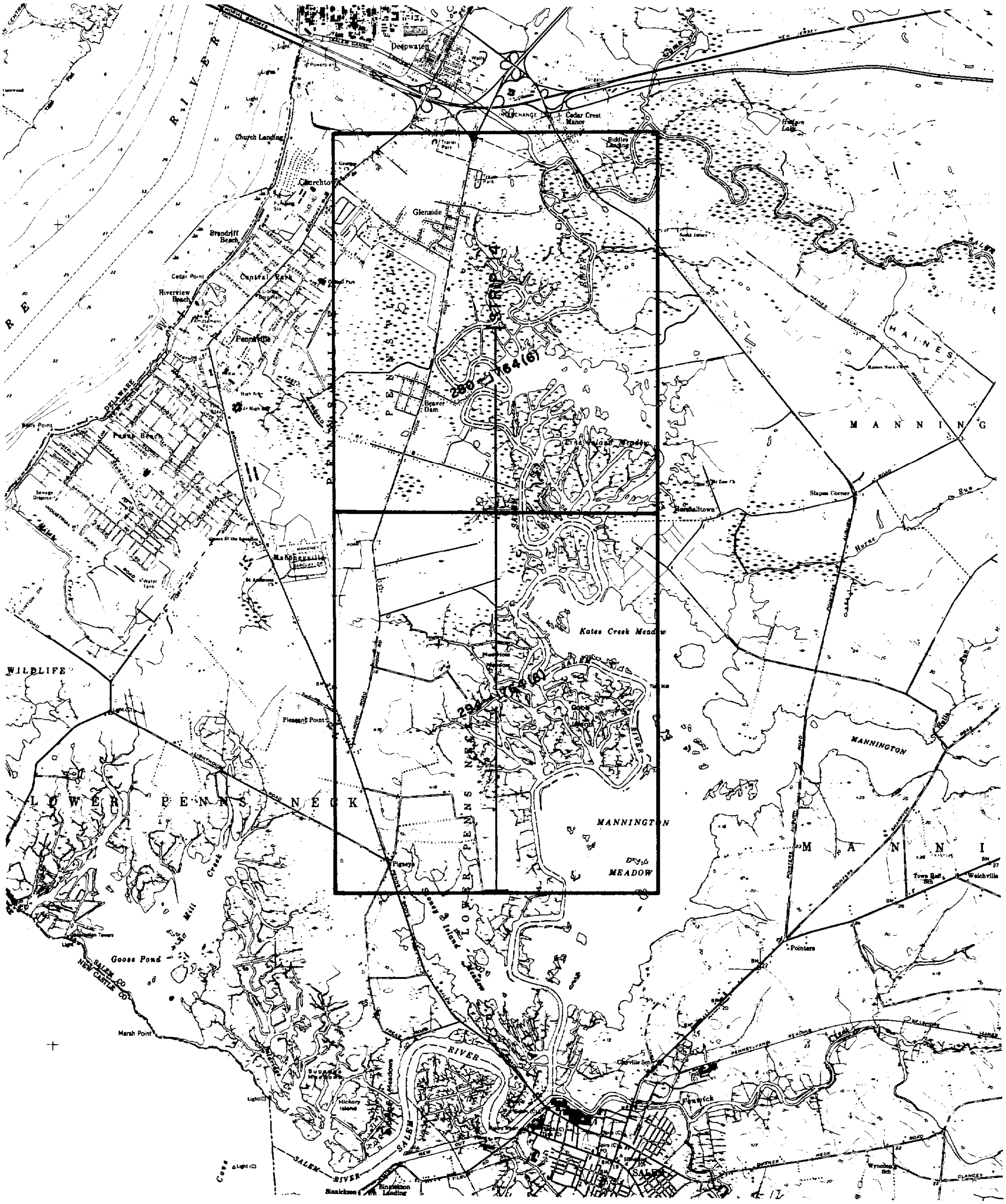

# MANNINGTON MEADOW TEST SITE

**1:2400 MAPS**

**├──┤ 1:12000 FLIGHT LINE**

**△ GROUND CONTROL POINT**

FIGURE 4




# MANNINGTON MEADOW TEST SITE

1: 6000 MAPS

├──┤ 1:24000 FLIGHT LINE

FIGURE 5

Figure 6A. Well defined boundary between (high vigor) *Spartina alterniflora* (light tone on water's edge) and *Spartina alterniflora* (low vigor) in the vicinity of Graveling Point. High vigor *Spartina alterniflora* is washed by tidal waters twice daily; the low vigor forms receive periodic tidal inundation, in part, indirectly through the peat soil.

Figure 6B. Trash line (right) in the Tuckerton area lies well above the Spartina alterniflora boundary. The trash line is indicative of the high tide but not the mean high water boundary.

Figure 7. Previously forested area exposed during low tide at the northern edge of Mannington Meadows.

# 2.0 TECHNICAL PROCEDURES

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## 2.1 GROUND CONTROL

### 2.1.1 General

National Map Accuracy Standards apply to those portions of each map sheet falling within the delineated wetlands area. These Standards require that 90% of well defined map features be positioned on the 1:2400 scale maps within 1/30 inch (6.67') of their correct location when refered to basic ground control. Basic control refers to government surveys previously established by such agencies as the National Ocean Survey (U. S. Coast and Geodetic Survey), U. S. Geological Survey, New Jersey Geodetic Survey, State of New Jersey, Bureau of Geology and Topography, and the U. S. Army Corps of Engineers. These Standards do not apply necessarily to biological high water lines, upper (inland) wetlands boundaries or to lines enclosing major species associations.

To meet National Map Accuracy Standards, networks of ground control points were established at Tuckerton (Table 1) and Mannington Meadows (Table 2). The Tuckerton site contained sufficient existing basic control; in Mannington, additional surveys were required because (a) there were apparent gaps in control and (b) not all existing control was recoverable.

High altitude photography was used to establish supplemental control. This technique is especially important for establishing control on isolated islands where it is practically impossible to perform aerial triangulation

| Point | Agency | New Jersey State Plane Coordinates X | Y | Remarks |
|---|---|---|---|---|
| 1. 2259 | NJGS | 2091866.00 | 280587.16 | -- |
| 2. 2261 | NJGS | 2081996.85 | 279027.99 | -- |
| 3. 7871 | NJGS | 2070205.40 | 277037.31 | Not used - incompatible |
| 4. AKimbo | C&GS | 2065438.83 | 262366.90 | -- |
| 5. Ballin | BFM | 2070632.76 | 264315.97 | -- |
| 6. Bay | C&GS | 2089811.83 | 258865.67 | -- |
| 7. Blood | BFM | 2064697.47 | 258724.62 | -- |
| 8. Bogan | BFM | 2081690.11 | 259310.81 | Not used - incompatible |
| 9. Deep | BFM | 2071222.20 | 261581.37 | -- |
| 10. Division | BFM | 2080486.44 | 257750.79 | Not used - incompatible |
| 11. Doc | BFM | 2067709.20 | 263449.20 | -- |
| 12. French | BFM | 2059021.78 | 260532.38 | Not used - outside area |
| 13. Gravel | BFM | 2065603.70 | 256917.05 | Not used - outside area |
| 14. Horn | BFM | 2092483.48 | 256969.47 | -- |
| 15. Leh | BFM | 2068570.56 | 261418.26 | -- |
| 16. Long | C&GS | 2064134.88 | 270271.34 | -- |
| 17. Moss | BFM | 2061447.65 | 263875.04 | Not used - outside area |
| 18. Pool | BFM | 2094623.11 | 252103.87 | -- |
| 19. Pole | C&GS | 2104336.73 | 259536.40 | -- |
| 20. Seth | BFM | 2061842.50 | 257973.90 | Not used - outside area |
| 21. Seven | BFM | 2089971.66 | 251961.39 | -- |
| 22. Sheepshead | C&GS | 2096303.68 | 255285.31 | -- |
| 23. Shooting | C&GS | 2097610.86 | 246706.09 | -- |
| 24. Story | C&GS | 2100595.72 | 264917.96 | -- |
| 25. Tank | C&GS | 2092844.09 | 249859.45 | -- |
| 26. Wash | BFM | 2076763.75 | 256876.55 | -- |

Legend:

NJGS New Jersey Geodetic Survey
C&GS U. S. Coast and Geodetic Survey
(recently changed to National Ocean Survey)
BFM New Jersey Bureau of Fisheries Management
PI Photo-identified

Table 1. Ground Control Points (Tuckerton Site)
See Figure 2 for location.

| | | New Jersey State Plane Coordinates | | |
|---|---|---|---|---|
| Point | Agency | X | Y | Remarks |
| 1. Bank | Hurd | 1773165.69 | 293418.66 | -- |
| 2. Bridge | Hurd | 1771393.60 | 272308.44 | Intermediate Traverse Station Only |
| 3. Chestnut | Hurd | 1768316.37 | 283560.86 | -- |
| 4. Dike | Hurd | 1767620.07 | 300334.66 | -- |
| 5. Dock | Hurd | 1770815.03 | 294918.29 | -- |
| 6. First Presbyterian Church spire | C&GS | | | Azimuth mark only |
| 7. Island | Hurd | 1775941.20 | 286422.14 | -- |
| 8. Levee | Hurd | 1771597.97 | 292617.23 | -- |
| 9. Mannington Mill Water Tank | C&GS | 1777513.92 | 273350.80 | Azimuth mark only |
| 10. Point | Hurd | 1774985.65 | 298547.19 | -- |
| 11. Rambler | Hurd | 1770915.70 | 273010.68 | Intermediate Traverse Station Only |
| 12. Reed | Hurd | 1774026.97 | 291038.27 | -- |
| 13. Salem RM2 | C&GS | 1771516.14 | 271697.64 | Traverse origin |
| 14. Salem U.S.E. | CE | 1771557.09 | 272169.49 | Traverse origin |
| 15. Sheen | Hurd | 1766836.59 | 279295.91 | Intermediate Traverse Station Only |

Legend:

C&GS U.S. Coast and Geodetic Survey (recently changed to National Ocean Survey)
Hurd Mark Hurd Aerial Surveys, Inc.
CE U.S. Army Corps of Engineers

Table 2. Ground Control Points (Mannington Meadow Site)
See Figure 4 for location.

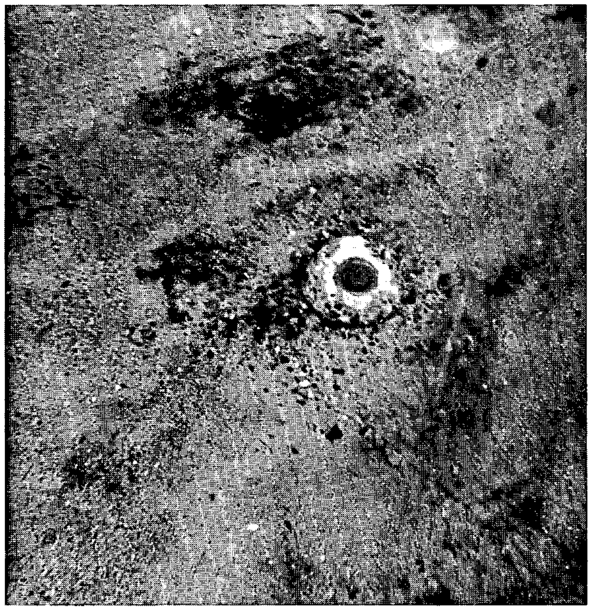
using only low altitude photography; it also reduces field control costs which in some areas would have been prohibitive.

### 2.1.2 Control Point Paneling

Ground control points (Figure 8) are used to control aerial photography in photogrammetric mapping. Control points can be marked by a ground panel prior to flying (to be imaged during photographic overflights) or the control points may be related to photographic images by field survey subsequent to flying. If scheduling permits, the first method is more efficient and more accurate than the second.

For the pilot program, survey parties were dispatched prior to acquisition of aerial photography to recover and panel all locatable points. Panels generally consisted of two strips of cheesecloth 15 feet long by three (3) feet wide placed at right angles to one another. They were centered on the control points, and fastened to the ground with spikes. T or L shapes were used when obstructions limited full targeting; in some cases paneling was not practical, and sketches were made to permit photo-identification directly on aerial photographs.

The traverse lines required for the new surveys at Mannington Meadows area were laid out, and the new control points were paneled before flying. Additional control points were established in the Mannington Meadow area between 12 and 21 June by electronic traversing procedures. The origins for the traverse were stations SALEM RM 2, and SALEM USE. The stations were used for position and azimuth. A closed traverse was run through paneled control points and additional azimuth checks were made by reading the direction of



TYPICAL CONTROL POINT MONUMENT

TYPICAL PANEL

Figure 8. Ground Control Points

Mannington Mill Water Tank and the First Presbyterian Church Spire. The traverse closed within one part in 52,000.

#### 2.1.3 Accuracy of Control Points

All existing control points were reported by the government agencies involved to have an accuracy of Third Order (as defined by the National Ocean Survey) or better. As indicated above, the new survey traverse closed with an accuracy for better than Second Order (one part in 52,000). For further discussion of control point accuracy refer to Section 2.5.7.

#### 2.1.4 Problems and Solutions

Some key ground control points could not be recovered. Markers were either destroyed or insufficient descriptive matter was available to permit the field crews to pinpoint locations. More "second choice" points were used, and this required aerial photography beyond the project limits.

New surveys at Mannington were difficult to perform; government monuments along Highway No. 45 east of Salem, were no longer in existance; field crews were forced to use inconvenient points, and heavy trees, tall grass, flat ground, saturated soils, and high water conditions made area traverses difficult.

### 2.2 AERIAL PHOTOGRAPHY

#### 2.2.1 Flight Plan

The flight plan provided NJDEP consisted of two parts, one for 1:12,000 and one for 1:24,000 scale photography. The flight lines for these two plans are shown in Figures 2,3,4, and 5. The basic flight plan is included as Appendix VI. Flights were made at altitudes of 6,000 and 12,000 feet. Flight maps, showing each flight line and pre-determined exposure station, were submitted to the NJDEP for approval. Flight crews utilized existing aerial photography annotated with exposure stations to accurately spot individual exposures. Flight lines were planned in a north-south direction. Pre-determined photo-centers were plotted on the flight maps at 3500-foot intervals and 7000-foot intervals to provide a gain of two exposures for the 1:2400 and 1:6000 scale sheets. This represents an average forward lap of approximately 61%.

Flights were made down the center of each tier of 1:2400 and 1:6000 scale sheets. Based upon the planned 6000-foot and 12,000-foot east-west dimension for each scale sheet, average sidelap between flights was approximately 33%.

2.2.2 Equipment

The aircraft used for aerial photographic data acquisition was Mark Hurd's Beechcraft Model AT-11, license number N508MH. This aircraft (Figure 9) is equipped to carry at least three metric mapping cameras on which shutters can be tripped simultaneously. The cameras will physically synchronize within ± one degree in the vertical and ± five degrees in azimuth. The aircraft carried adequate personnel and navigation equipment to accomplish the task of spotting each photograph over pre-determined points.

The cameras (with the specified film type) used for the project are listed in Table 3. Calibration certificates (see Appendix VII) for the three cameras were furnished NJDEP as part of the flight plan. The Zeiss RMK 15/23 camera (#21214) and Wild RC-8 camera (#577) were mounted in a single gymbol-mount in the center of the aircraft fuselage. Zeiss camera RMK 15/23 (#21129) was mounted in a separate gymbol in the nose compartment alongside the photo-navigator station.

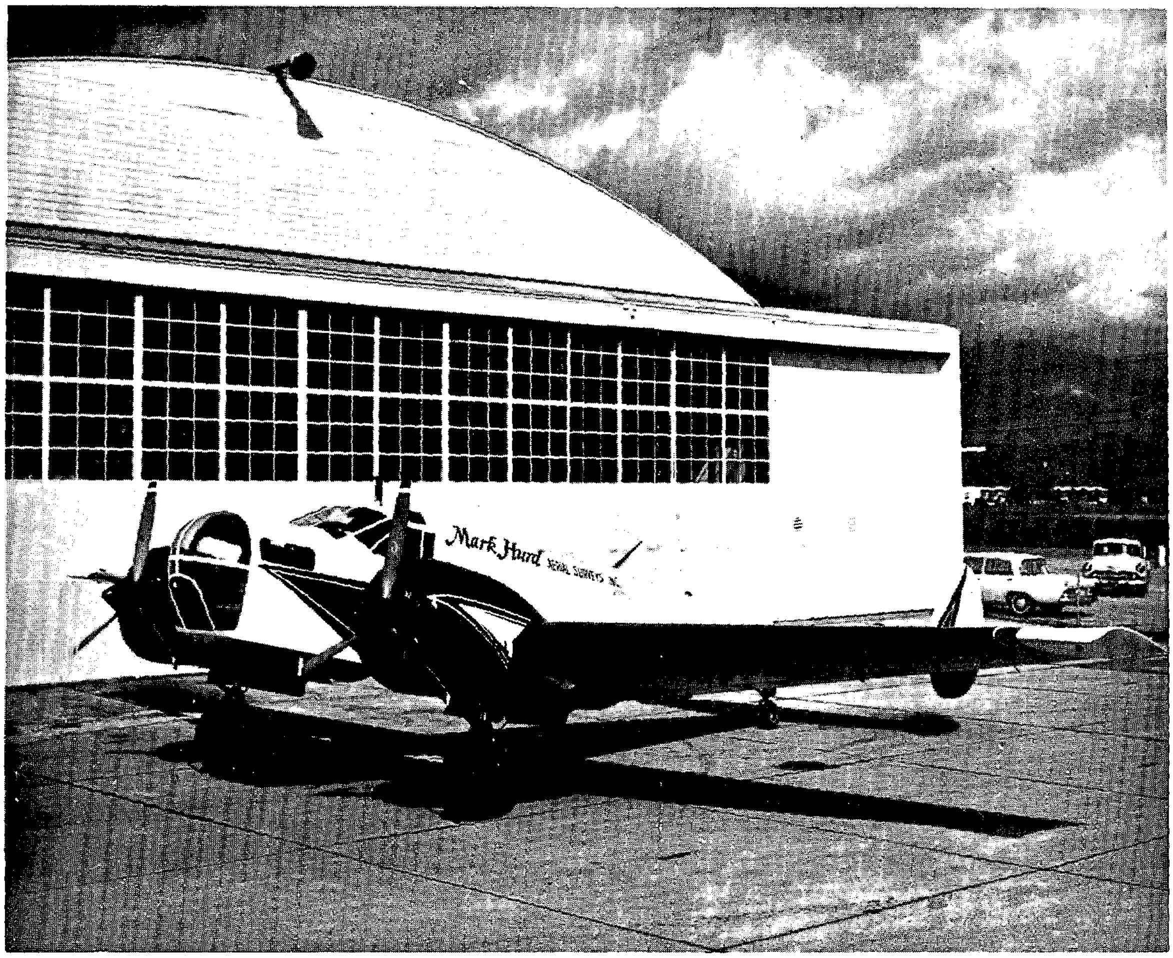
### 2.2.3 Film

To obtain maximum benefits from the three films used, they were exposed simultaneously under identical conditions of lighting, tide level and surface wind conditions. The films chosen are manufactured by Eastman Kodak specifically for aerial mapping. All three films are coated on polyester (ESTAR) stable base plastic, and the emulsions are designed for developing in high speed continuous processing machines of the "Versomat" type. The film types used are as follows:

- Eastman Kodak #2443 Aerochrome Infrared Film. This is a color, positive reversal film. When exposed through a 520 micrometer (Zeiss C) filter its spectral response results in subtle false color hues, which serve as a base for biological interpretations.

- Eastman Kodak #2448 Ektachrome MS Aerographic Film. This is a natural color reversal film, which most nearly records scenes as they appear to the normal eye. This film record serves as supporting data when exposed simultaneously with color infrared (Type 2443) film.

- Eastman Kodak #2405 Double- X Aerographic Film. This is a black and white panchromatic negative film that has high sensitivity, high acutance, good contrast and wide exposing latitude. Its extended red sensitivity permits greater shutter speed through haze-cutting filters. It served as a backup for map production.




PHOTOGRAPHIC AIRCRAFT

Figure 9

To insure maximum uniformity for interpretation flights were made using color films from the same production run. The identifying batch numbers were (a) Kodak #2443 (2443-19-1); and, (b) Kodak #2448 (2448-133-31/32). To further insure satisfactory photography, exposure tests were made at various camera settings enroute to the project. This film was processed and evaluated prior to project flying. Settings used are shown in the tabulation of photography (Table 3).

#### 2.2.4 Filters

Generally, filtration was as follows:

- Kodak #2443 was exposed using the Ziess KLF36 antivignetting filter with a Zeiss C 520 micrometer glass insert.
- Kodak #2448 was exposed using a Wild 2.2 AV clear filter.
- Kodak #2405 was exposed with a Zeiss D filter.

#### 2.2.5 Flight Procedure

The color film was stored in a frozen state until the flight crew departed for the project site. While the flight crew was waiting for suitable flying weather, all film was kept refrigerated. After exposure, the film was shipped directly to Data Corporation in Dayton, Ohio, for processing and returned to the flight crew for inspection. Upon completion of all photography, the film was hand carried to Washington, D.C. and examined by personnel from NJDEP, EarthSat and NOS. Upon acceptance, the film was transferred to Mark Hurd's Minneapolis laboratory for film titling and preparation of indices.

The time periods which were judged suitable[1/] for wetlands mapping between June 15 and July 1 and occurred between the hours of 7:30 and 9:00 AM and 3:00 and 5:30PM. The sun is less than 50° above the horizon at these times. Specular reflection from water surfaces and/or the sun spot which can occur in the imagery when the sun is above 50° would be detrimental for wetlands mapping, because they would "wash out" vegetation detail.[2/]

A visibility of 10 miles from the airplane to a point on the ground was chosen as a minimum for exposure of the #2448 (color) film without haze filtration. While less visibility would have been satisfactory for the #2443 (color infrared) film it was decided not to risk reducing the color contrast of the #2448 (color) photography required for wetlands vegetation documentation.

### 2.2.6 Photograph Titling

Aerial photographs were titled in such a manner that simultaneous exposures carried the same number with a special letter-symbol designation to indicate the type of film. For example: CJF-PAN-1 refers to panchromatic film; CJF-COL-1 refers to natural color film; and, CJF-IRC-1 refers to infrared color film.

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1/ Consideration was given flying in late August to further enhance tonal (and textural) signatures for *Spartina alterniflora*. The NJDEP-dictated mapping deadline precluded late summer flying; furthermore, it was judged satisfactory signatures could be obtained from photography flown in June or July.

2/ Angular restrictions provide for optimum illumination while minimizing specular reflection from water surfaces. These reflections would be further minimized by flying only on calm days; however, the combination of calm and clear weather imposes too great a restriction on the flying operation. "Hot" spot images appear only when the shadow point of the aircraft enters the image field. By photographing at a sun angle of less than 45 degrees, "hot" spot images are avoided.

### 2.2.7 Photo-Indices

Standard photo-indices were prepared for 1:2400 and 1:6000 scale photography by photographically reducing a stapled assembly of contact prints. Indicies for the 1:12,000 scale flights, were made from photographically reduced panchromatic contact prints; other photography was referenced to this index.

A tabulation of all exposures made is shown on Table 3 with pertinent information including exposure numbers, dates flown, f-stops, shutter speed, filter information, and film used. All color film was cut into individual exposures and placed into protective plastic sleeves preliminary to EarthSat analysis. Panchromatic film was left in rolls and delivered directly to NJDEP.

### 2.2.8 Problems and Solutions

The problems encountered in acquiring aerial photography were anticipated. Historical records indicated that the incidence of good flying weather in New Jersey during the month of June is at an annual low. Ten days elapsed with the flight crew on-station before satisfactory flying conditions occurred.

## AERIAL PHOTOGRAPHY

### Kodak #2443 Film

Scale 1:12,000
Camera Zeiss RMK 15/23 #21214
Lens #98177
F-stop 6.3
Shutter speed 1/100
Filter KLF 36 and Zeiss C

| Strip | Exposures | | Date Flown |
|---|---|---|---|
| 1 | 1-6 | | 6/16/71 |
| 2 | 7-16 | | 6/16/71 |
| 3 | 25-36 | | 6/16/71 |
| 4 | 17-24 | | 6/16/71 |
| 5 | 37-44 | | 6/16/71 |
| 6 | 45-52 | | 6/16/61 |
| 1 | 167-174 | | 6/17/71 |
| 2 | 157-166 | | 6/17/71 |
| 3 | 132-144, | 145-156 | 6/17/71 |
| 4 | 124-131, | 175-182 | 6/17/71 |
| 5 | 116-123, | 183-190 | 6/17/71 |
| 6 | 108-115 | | 6/17/71 |
| 7 | 101-107 | | 6/17/71 |
| 7A | 97-100 | | 6/17/71 |
| 8 | 69-76, | 77-84 | 6/17/71 |
| 9 | 53-60, | 61-68 | 6/17/71 |
| 9 | 85-92 | | 6/17/71 |
| 8 | 211-218 | | 6/18/71 |
| 9 | 219-225 | | 6/18/71 |

### Kodak #2448 Film

Scale 1:12,000
Camera Wild RC-8 #577
Lens #245
F-stop 5.6
Shutter speed 1/200
Filter 2.2 AV Clear

| Strip | Exposures | | Date Flown |
|---|---|---|---|
| 1 | 1-6 | | 6/16/71 |
| 2 | 7-16 | | 6/16/71 |
| 3 | 25-36 | | 6/16/71 |
| 4 | 17-24 | | 6/16/71 |
| 5 | 37-44 | | 6/16/71 |
| 6 | 45-52 | | 6/16/71 |
| 1 | 167-174 | | 6/17/71 |
| 2 | 157-166 | | 6/17/71 |
| 3 | 132-144, | 145-156 | 6/17/71 |
| 4 | 124-131, | 175-182 | 6/17/71 |
| 5 | 116-123, | 183-190 | 6/17/71 |
| 6 | 108-115 | | 6/17/71 |
| 7 | 101-107 | | 6/17/71 |
| 7A | 97-100 | | 6/17/71 |
| 8 | 69-76, | 77-84 | 6/17/71 |
| 9 | 53-60, | 61-68 | 6/17/71 |
| 9 | 85-92 | | 6/17/71 |
| 8 | 211-218 | | 6/18/71 |
| 9 | 219-225 | | 6/18/71 |

### Kodak #2405 Film

Scale 1:24,000
Camera Zeiss 15/23 #21129
Lens #98129
F-stop 8
Shutter speed 1/500
Filter Zeiss D

| Strip | Exposures | Date Flown |
|---|---|---|
| 10 | 191-194 | 6/17/71 |
| 11 | 195-200 | 6/17/71 |
| 12 | 201-206 | 6/17/71 |
| 13 | 207-210 | 6/17/71 |
| 14 | 93-96 | 6/17/71 |

### Kodak #2405 Film

Scale 1:12,000
Camera Zeiss 15/23 #21129
Lens #98129
F-stop 8
Shutter speed 1/500
Filter Zeiss D

| Strip | Exposures | | Date Flown |
|---|---|---|---|
| 1 | 167-174 | | 6/17/71 |
| 2 | 157-166 | | 6/17/71 |
| 3 | 132-144, | 145-156 | 6/17/71 |
| 4 | 124,131, | 175-182 | 6/17/71 |
| 5 | 116-123, | 183-190 | 6/17/71 |
| 6 | 108-115 | | 6/17/71 |
| 7 | 101-107 | | 6/17/71 |
| 7A | 97-100 | | 6/17/71 |
| 8 | 69-76, | 77-84 | 6/17/71 |
| 8 | 211-218 | | 6/18/71 |
| 9 | 53-60, | 61-68 | 6/17/71 |
| 9 | 85-92 | | 6/17/71 |
| 9 | 219-225 | | 6/18/71 |

Table 3. Details of Aerial Photography

## 2.3 IMAGE INTERPRETATION PROCEDURES

### 2.3.1 General

Many of the procedures by which photo interpreters analyze aerial photography are difficult to document step-by-step. Experience, knowledge of complex biological interrelationships, and, at times, a necessity for subjective interpretative decisions provide the photo analyst with keys by which wetlands phenomena are defined. These techniques are difficult to transfer from analyst to analyst; they are not adaptable to a convenient listing of procedures by which uninitiated individuals can duplicate interpretations made by trained biologists.

### 2.3.2 Manual Techniques

Interpretive experience with both color and infrared color aerial photography to date indicates that manual procedures will probably not, in the near future, be completely supplanted by automated techniques. This is particularly true in mapping and inventoring coastal wetlands. For this reason, formal guidelines to facilitate manual image interpretation were developed during the pilot project. These guidelines aided experienced interpreters in maintaining high quality and generally low error delineations; they were also used to train individuals who came into the project with little prior experience in wetlands mapping from aerial photography.

The following guidelines and manual techniques relate both to color and color IR photography:

1. Preliminary scan of imagery. This is done to determine tonal structure and range of tones; for example, variations in sun angle from one flight line to the next will affect tonal quality.

2. Relate tonal structure to species composition. Intensity of tones may vary within a frame, or from frame-to-frame, although the range of tonal signatures relative to species composition will remain constant under near-constant conditions of illumination. This procedure must therefore be repeated (and checked) from frame-to-frame.

3. Conform tone codes. Tonal indications for various wetland plant species and communities which are indicators of tidal influence and the biological high water lines are determined. Careful attention is given the environment in which the tone occurs (between mosquito ditches or along open shorelines) as a key to proper species identification.

4. Delineate tidally-influenced wetlands. Based on indicator plant species, upper wetlands boundaries (landward extent of the marsh), and tidally-influenced wetlands including biological high water lines, are delineated.

5. Spot field checks. Field checking is conducted in selected wetland areas to verify interpretation and delineation of plant species composition from tone on the film. Biological environments are also checked.

Other EarthSat special techniques and analysis procedures would require extensive documentation and are used only in rare or special cases. They are well beyond the scope of this report; some of the problems associated with the general procedures cited above are incorporated in summary map reports, submitted to NJDEP (Appendix IV).

### 2.3.3 Enchancement Techniques

A variety of enhancement techniques are currently available for facilitating rapid and accurate image interpretation. These vary from varying the light intensity of light tables to density slicing where false colors displayed on a screen relate to differences in density on the film. The latter more sophisticated techniques were not used during Phase II. These are still in the experimental-developmental stage and cannot, at the present time, be relied upon for accurate delineation of wetlands environmental phenomena. The following enhancement techniques were used with varying degrees of success during Phase II.

1. Varying intensity of light on light table to dampen or enhance certain tonal features.

2. Various degrees of magnification using hand lenses and a binocular microscope.

3. Placement of filters over transparency or light table to change the tonal structure on the film. This was used sparingly to better contrast what otherwise were nearly identical tonal signatures.

### 2.3.3 Delineation Procedure

Mapping annotation procedures which were used to complete 1:2400 amd 1:6000 scale final products are summarized below. For delineation, a line weight of 0.013 inches represents approximately 2.5 feet on the ground; a line weight of 0.025 inches is 5.0 feet on the ground.

1) The upper wetland boundary, shall be delineated by a solid (0.025" weight) black line.

2) Major species associations shall be delineated (where species stands are five (5) acres or more in area) by a solid (0.013" weight) black line.

3) The line of biological high water shall be delineated by a line equal in weight to the species delineation line, but with superimposed black dots.

4) Where the upper wetlands boundary line and biological high water line are coincident, e.g. in built up or diked areas, a line equal in weight to the upper wetlands boundary line (0.025" weight) with conspicuous dots shall be used.

5) Where the species delineation line coincides with the biological high water line, the biological high water line will be used.

6) Where lines of species delineation abut the upper wetlands boundary line, it shall be understood that the upper wetlands boundary line serves to close species delineation lines.

7) Both natural (e.g. evaporation pans) and manmade (e.g. dredge spoil) bare ground areas of five acres or more within wetlands areas, shall be delineated by a line equal in weight to that used to delineate major species associations. Such bare ground within wetlands shall be so delineated regardless of the elevation above mean sea level.

8) Bare areas which are building sites or occupied home sites shall be enclosed with upper wetlands boundary lines.

9) Where natural bare ground or manmade spoil crosses the upper wetlands boundary, its wetland edge shall be mapped as the upper wetland boundary.

10) When and if biological criteria are unsatisfactory for delineating the biological high water or upper wetlands boundary lines, physical criteria may be used for mean high water and upper wetlands boundary delineations. No specific symbol shall be used to differentiate a line drawn by biological and/or physical criteria although the areas involved shall be referenced in the map report to NJDEP.

A sample map legend is illustrated in Figure 10. Alphabetical and numerical designators (A, B, B/1, 1/3) have been used to reference major species associations. In no instance do designators relate to the biological (e.g. nutrient) value of a plant species, value of a property for development, nor priority of a particular area for state preservation or control. Alphabetical designators are given to species which occur in saline marshlands; numerical designators are given to species which occur in saline marshlands; numerical designators are limited to freshwater marsh species. Where alphanumerical combinations occur, brackish wetlands are indicated.

Biological stands of less than five (5) acres in size were generally not mapped. This five acre limitation was specified by contract with the understanding that lesser areas might be mapped when such was in the interest of wetlands magagement. For example, scattered one acre stands of wild rice might be mapped because wild rice has value as a food for waterfowl. When it appeared that mapping units less than five acres would provide reference points in complex biological areas, one acre stands were mapped.

## LEGEND

| | |
|---|---|
| △ | MONUMENTED CONTROL POINT |
| ● | PHOTOGRAMMETRIC CONTROL POINT |
| ——— | SPECIES LINE |
| ━━━ | UPPER (INLAND) WETLANDS BOUNDARY |
| -o——o- | BIOLOGICAL HIGH WATER LINE |
| -o━━o- | UPPER (INLAND) WETLANDS BOUNDARY AND BIOLOGICAL HIGH WATER LINE IN JUXTAPOSITION |
| A | SPARTINA ALTERNIFLORA (HIGH VIGOR)– SALT MARSH CORD GRASS |
| B | SPARTINA ALTERNIFLORA (LOW VIGOR)– SALT MARSH CORD GRASS |
| C | SPARTINA PATENS– SALT MEADOW GRASS |
| D | DISTICHLIS SPICATA– SPIKE GRASS |
| E | IVA FRUTESCENS– HIGHTIDE BUSH |
| F | JUNCUS GERARDI– BLACK GRASS |
| J | BARE GROUND |

SPECIES COMBINATIONS ARE INDICATED
BY MULTIPLE LETTERS FOR EXAMPLE: B/C

FIGURE 10. MAP LEGEND

This might seem inconsistent; however, it does ease the task of biologists who may use the maps for field investigations. NJDEP (in close consultation with EarthSat) judged that it was not cost effective to map all species associations within the wetlands in fine detail. Local (but critical) wetlands protection decisions can be based on 1:2400 scale wetlands maps supplemented by selective (and low cost) sampling and mapping.

### 2.4 FIELD CHECKING

Although interpretation of color infrared aerial photography provided 85-90% of the required wetlands biological data, supplementary (and selective) field checking was absolutely necessary. The most efficient procedure required the use of 36" X 48" black and white photographic enlargements made from original color infrared transparencies. All field annotations were added to these enlargements. Original color infrared photography (Figure 11) and polaroid prints were used for field checking vegetative detail. Once field work was completed, field data was transferred to 36" X 48" Cronaflex office copies from which final (master) maps were prepared.

Field checking of vegetation required the use of a cabin cruiser or small outboard provided by the New Jersey Department of Environmental Protection. These boats were used to traverse numerous tidal streams within otherwise inaccessible wetlands areas. Where roads bordered or led into the wetland regions, field checking was completed by automobile and on foot; in one instance, a light helicopter was used to check the upper wetlands boundary at Tuckerton.1/

Principal wetlands species were collected and provided as a herbarium to NJDEP (Appendix II). A set of 35mm slides showing wetlands ecology was also submitted to NJDEP; these slides were collected during field checking. Biological field checking was supplemented using a variety of field (ground) criteria as described in Appendix III; in no instance did these criteria

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1/ Helicopters promise to be the most efficient method of field checking. They increase both the speed and the accuracy of field checking and provide access to otherwise inaccessible areas.

Figure 11. Boundary between *Spartina alterniflora* (high vigor) and *Spartina patens* (light tone, foreground). The color infrared aerial photograph was used for field checking and shows the area in the vicinity of Basses Bay.

supplant biological data. In all cases, field checking was conducted by two persons because of possible danger from deep water, saturated soils, and deep, mud-filled ditches.

Spot field observations were made several times in the "hook" area of Tuckerton to establish a preliminary relationship between biological and physical mean high water. While this relationship was not tested over a wide area, the tidal flooding observed fell within the zone of high vigor Spartina alterniflora. Small berms sometimes retarded the spread of tidal waters and the relief apparently changes with each coastal storm.

Several problems in field checking were experienced: One involved the delineation between two growth forms of Spartina alterniflora which grow under different tidal conditions (designated high and low vigor forms). Extensive mosquito ditches created a second problem by shifting natural ecological successions. Difficulty was also encountered in crossing these ditches; even at low tide when little or no water was present, a deep, soft layer of mud remained. In other areas Phragmites communis was so dense that field checking was slow and tedious. In fresh water wetlands, the upper wetlands boundary was often so densely vegetated that access on foot was limited.

Ditching, in some areas, has affected the normal flooding pattern of incoming tidal water. Pressure at the head of some ditches causes flooding around small islands of Spartina patens which are normally above mean high water. It was difficult to separate these areas from those that were high water due to the complexity of vegetational distribution.

## 2.5 MAP PRODUCTION

### 2.5.1 Map Scales

The pilot mapping project involved the preparation of maps at 1:2400 and 1:6000 scales; however, principal attention was given 1:2400 scale maps. Maps at 1:6000 scale were prepared from the 1:2400 scale products.

### 2.5.2 Map Sheet Indexing System

The map sheet indexing system is based on the New Jersey State Plane Coordinate System. Each 1:2400 scale map sheet has a neat area of 6000 feet in the east-west direction and 7000 feet in the north-south direction. Each 1:6000 scale sheet covers 12,000 feet in the east-west direction and 14,000 feet in the north-south direction. The sheet limits are grid lines and exact multiples of 6,000, 7,000, 12,000, and 14,000 feet.

Map sheet dimensions are such that each 1:2400 scale map can be covered completely with a single 1:12,000 scale photograph and each 1:6000 scale map sheet by a single 1:24,000 scale photograph.

As a basis for a sheet numbering system (Figure 12), the grid value of the lower left (southwest) corner of each sheet -- for example, north 280,000 and east 1,776,000 -- was used. The cardinal direction and last three digits are omitted with a resulting sheet number of 280-1776. This system is especially appropriate because the grid values provide a means of referencing the areas to general maps such as U.S.G.S. quandrangles, the 1:250,000 scale topographic map series, and the official highway map and guide prepared by the New Jersey Department of Transportation.

EarthSat

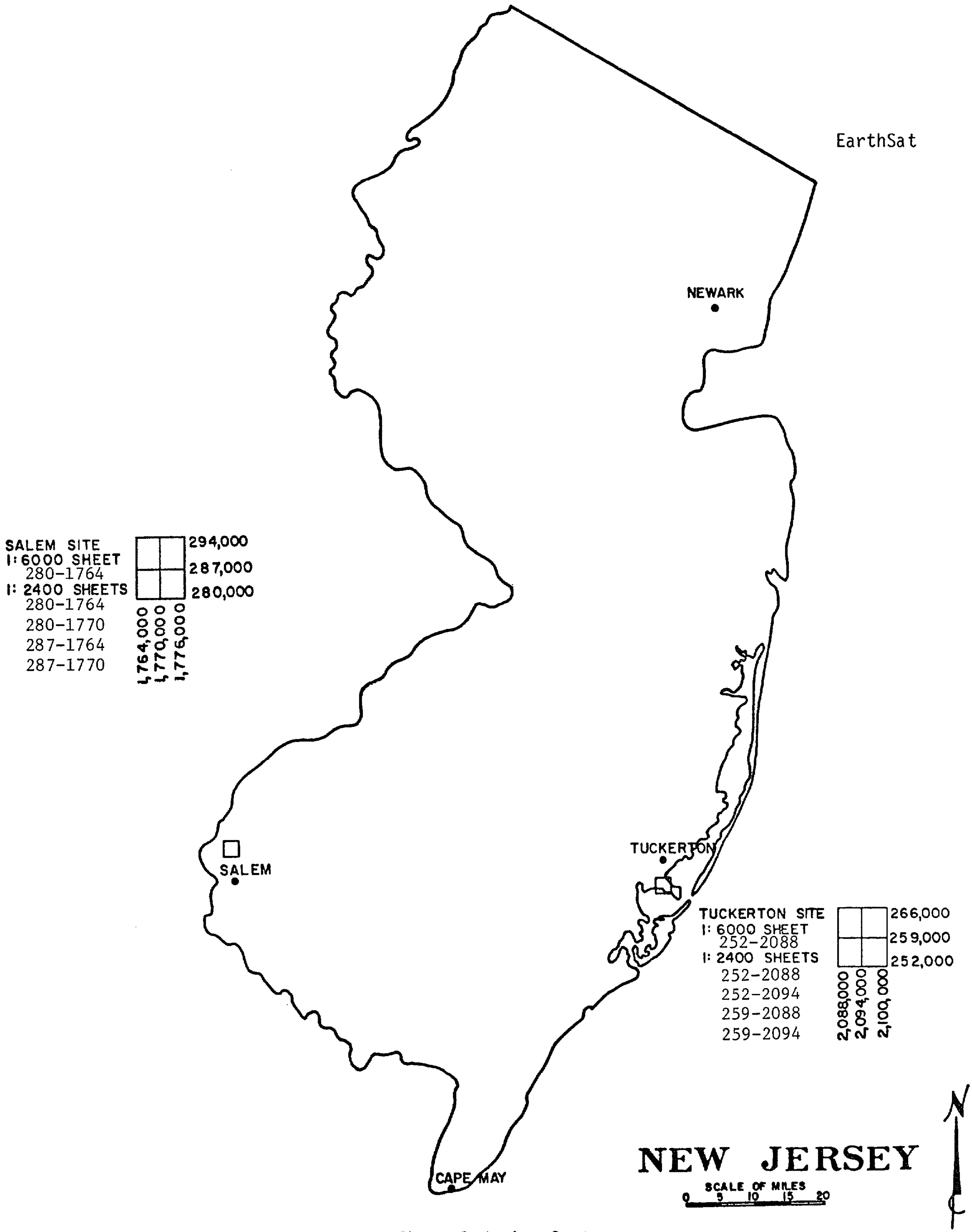


Figure 12. Map Sheet Indexing System

#### 2.5.3 Map Sheet Nomenclature

As an integral part of map indexing procedures, map sheets were named by NJDEP using the following procedure:

(1) The primary basis for wetlands map nomenclature is the United States Geological Survey (USGS) 7-1/2 minute quadrangle. In the absence of 7-1/2 minute quadrangles, a 15 minute quadrangle (subdivided into 7-1/2 minute sections) will be used.

(2) Names were selected from the water body (and preferably marsh area) nearest the center of the wetlands map area as determined from applicable 7-1/2 minute quadrangle. The center of the wetlands area is defined as the intersection of diagonal lines drawn from the northwest to souteast and from the northeast to southwest corners of the wetlands map.

(3) A geographic place name which does not conflict with the USGS 7-1/2 quadrangle sheet was used in the absence of a water body. The geographic place name selected will be that of a permanent feature.

(4) In the absence of a suitable water body or geographic location near the center of the wetlands map, the wetlands sheet carries the name of the adjacent wetlands sheet, with north, south, east or west designator, e.g. Sheepshead Creek West.

The U. S. Geological Survey (USGS) 7-1/2 minute quadrangle name follows the primary map name determined by the above procedure.

#### 2.5.4 Black and White Internegatives of Infrared Color Film

Tests were conducted to determine (1) if suitable photographic enlargements could be made from infrared color film for map production and (2) whether such an enlargement would more faithfully represent subtle color variations (as shades of grey) than enlargements prepared from panchromatic film. Analysis (and finally field testing) by EarthSat biologists proved conclusively that enlargements made from the infrared color film were superior to those made from panchromatic film for biological delineation purposes. For all practical purposes the quality of images was comparable to the panchromatic enlargement, and furthermore the enlargement from infrared color film depicted a much greater variety of tones representing different variations in vegetation species.

Black and white internegatives were prepared for the twenty-one (21) 1:2400 sheets from which enlargements (paper prints) were made for field use. Cronaflex prints for office (biological delineation) use and enlargements for final map production were made from these internegatives.

#### 2.5.5 Black and White Film Positives of Infrared Color Film

Panchromatic photography was to be used in the photogrammetric purposes, but, because of the success in reproducing the infrared color film, a set of duplicate film positives was made. Infrared color film was utilized as a medium for performing the aerial triangulation necessary to establish supplemental control for base maps. Problems were experienced in transferring control points to the internegatives used to prepare rectified enlargements. Future wetlands mapping work will be accomplished on negatives to increase efficiency and accuracy.

#### 2.5.6 Photographic Enlargements

Black and white internegatives were used to produce two sets of ratioed photographic paper enlargements (1:2400 scale). EarthSat used these enlargements to delineate biological information including major species associations and the upper wetlands boundary.

This approach was unsatisfactory; biological detail could not be easily transferred to final map products, because the enlargements were only approximate in scale, which meant that the enlargements had to be shifted during the drafting process. Stable base film positive copies of rectified enlargements were used to facilitate drafting. These film positives were unsuitable for field use, therefore, a procedure utilizing both mediums was adopted. Rectified positives were used exclusively for office delineation, and prints (enlargements) were used for field notation and largely in place of field notebooks.

### 2.5.7 Aerial Triangulation

Aerial triangulation utilizes aerial photography and ground control information to establish supplemental control preliminary to map production. "Pass points" are selected and marked on the aerial film so that points are common to overlapping photographs in line of flight and from flight-to-flight. Ground control points (which are visible on the photography) are included in this scheme and these points have a fixed position, and may be defined by the rectangular coordinates of the State Plane Coordinates System. The relative positions of the fixed points and the selected pass points are determined to within a few micrometers using precision measuring instruments. Using computer programs, these measurements are used to compute ground coordinates of the pass points. The program includes a least squares adjustment with the capability of rejecting any ground control points for which the given position or pass point are not reasonably correct. The amount that is reasonable is programmed into the system; this resulting in a tabulation of coordinates for all points, and residual values indicative of how well the adjustments fit each control point.

2.5.8 Grids and Projections

The basic grid system adopted for the project is the New Jersey State Plane Coordinate System; the Universal Transverse Mercater (UTM) grid, and the latitude-longitude systems are shown on the map sheets. Computations were made to determine the exact relationship of the other two systems to the State Plane grid. A layout for each map sheet using the State Plane Coordinates System lines as a base was prepared. Positions of the other two systems were plotted on this base; all ground control points and pass points were also plotted.

2.5.9 Rectified Enlargements

Using a Zeiss SEG-V enlarging rectifier, black and white internegatives were projected and rectified to fit the control points plotted on the layout sheet. The enlargements were printed in the form of halftone film positives.

2.5.10 Border Format

Standard border information (legend, north arrow and bar scale), was developed and furnished to NJDEP for approval. The border information was printed on Cronaflex to provide a (drafting) base for each sheet. The border layout includes grid lines at 5-inch intervals representing the State Plane Coordinates System at 1000-foot ground intervals.

2.5.11 Base Map Composite

The border format was registered to the sheet layout using grid lines.

to transfer control points, the UTM grid system, and latitude and longitude ticks. The border format was then registered to the halftone enlargement using control points to form a "sandwich." This sandwich was overlayed and registered to the photographic enlargements prepared by EarthSat containing the required biological data. The biological information was transferred using base map detail. This combination was photographically reproduced as a single reproducible film positive, which became the master copy of the base map.

### 2.5.12 Quality Control

After drafting, all maps were inspected by Mark Hurd Aerial Surveys, Inc. Black and white diazo prints were furnished simultaneously to NJDEP and EarthSat biologists for inspection. After their review, necessary changes were made on the original "sandwich" and a new master film positive was prepared when necessary.

Photographic images of control points on the photographic enlargements consistently matched the plotted coordinates for these points within accuracy standards. The accuracy of the 1:2400 maps was verified during preparation of the rectified enlargements and the base map composite.

### 2.5.13 Delivered Products: Base Maps at 1:2400 Scale

The master film positive was used to print a contact film negative from which chronapaque prints and black and white diazo prints were generated. The master film positive, chronapaque print, and the diazo prints were delivered to NJDEP. The film negative was filed with Mark Hurd.

The original "sandwich" was revised to include the biological high water line. A series of dots were added to the species line between Spartina alterniflora (high vigor) or Spartina alterniflora (low vigor) and other species, appropriate symbols were added to the legend and another negative and chronapaque print were made and delivered to NJDEP. Figure 13 depicts a portion of a 1:2400 base map.

2.5.14 Delivered Products: Base Maps at 1:6000 Scale

The 1:6000 scale map series is a by-product of the 1:2400 base maps (reduced photographically without the biological high water line). First, four (and sometimes fewer) 1:2400 sheets were combined to form one sheet. This material was used for control in preparing rectified halftone positives of the composite area. The enlargements were prepared from panchromatic 1:24,000 scale photography.

A standard border and grid layout was prepared (similar to the 1:2400 scale sheets) and biological information was re-drafted. Delivery consisted of a master reproducible positive, one chronapaque print, and ten diazo prints.

## 2.6 PROPERTY LINE OVERLAY PREPARATION

### 2.6.1 Purpose

Property line overlays (Figure 14) were prepared to provide NJDEP with a convenient source of ownership information. The 1:2400 scale base map served as a base for preparing this overlay and each overlay was keyed to the base.

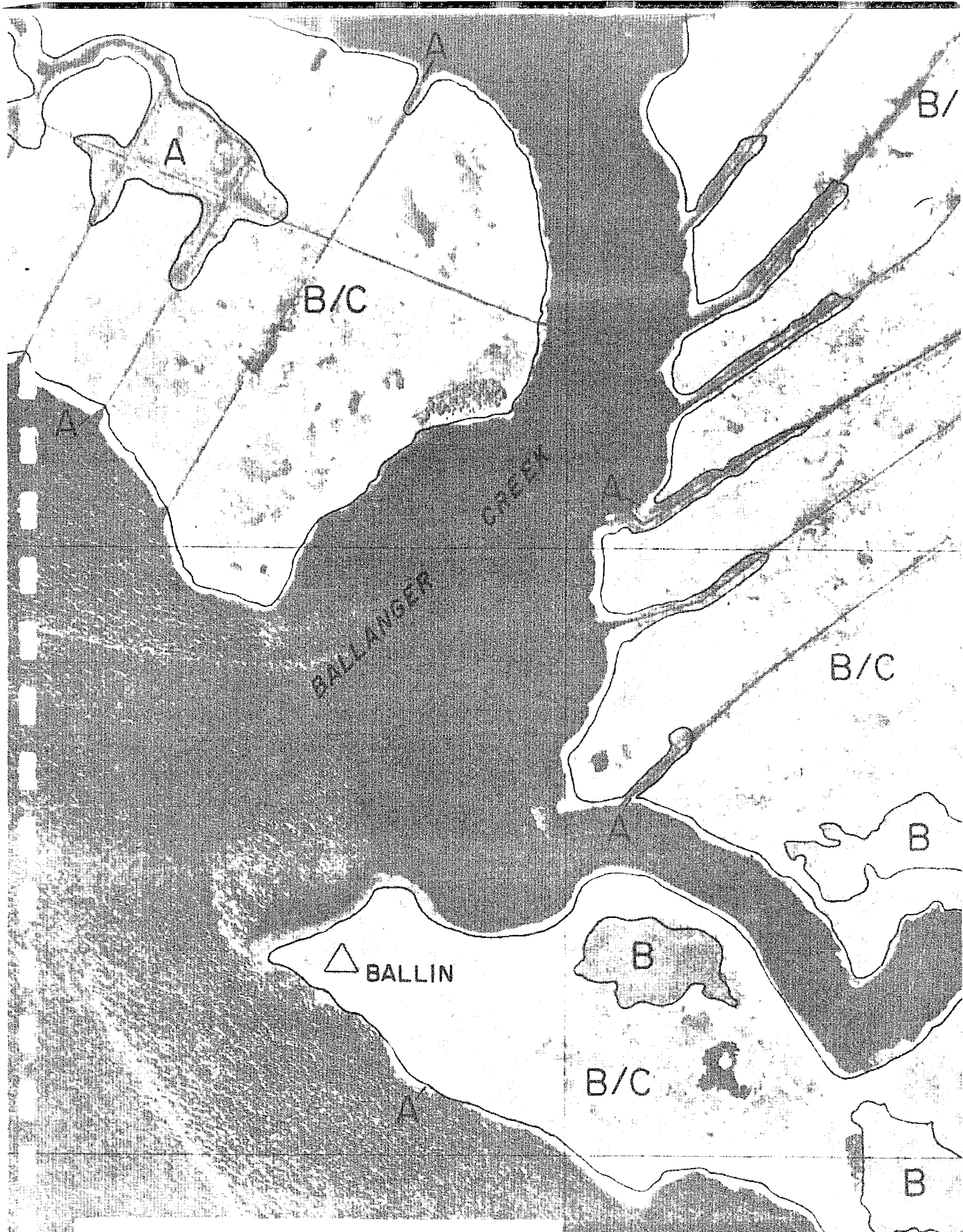


Figure 13. Portion of 1:2400 Base Map

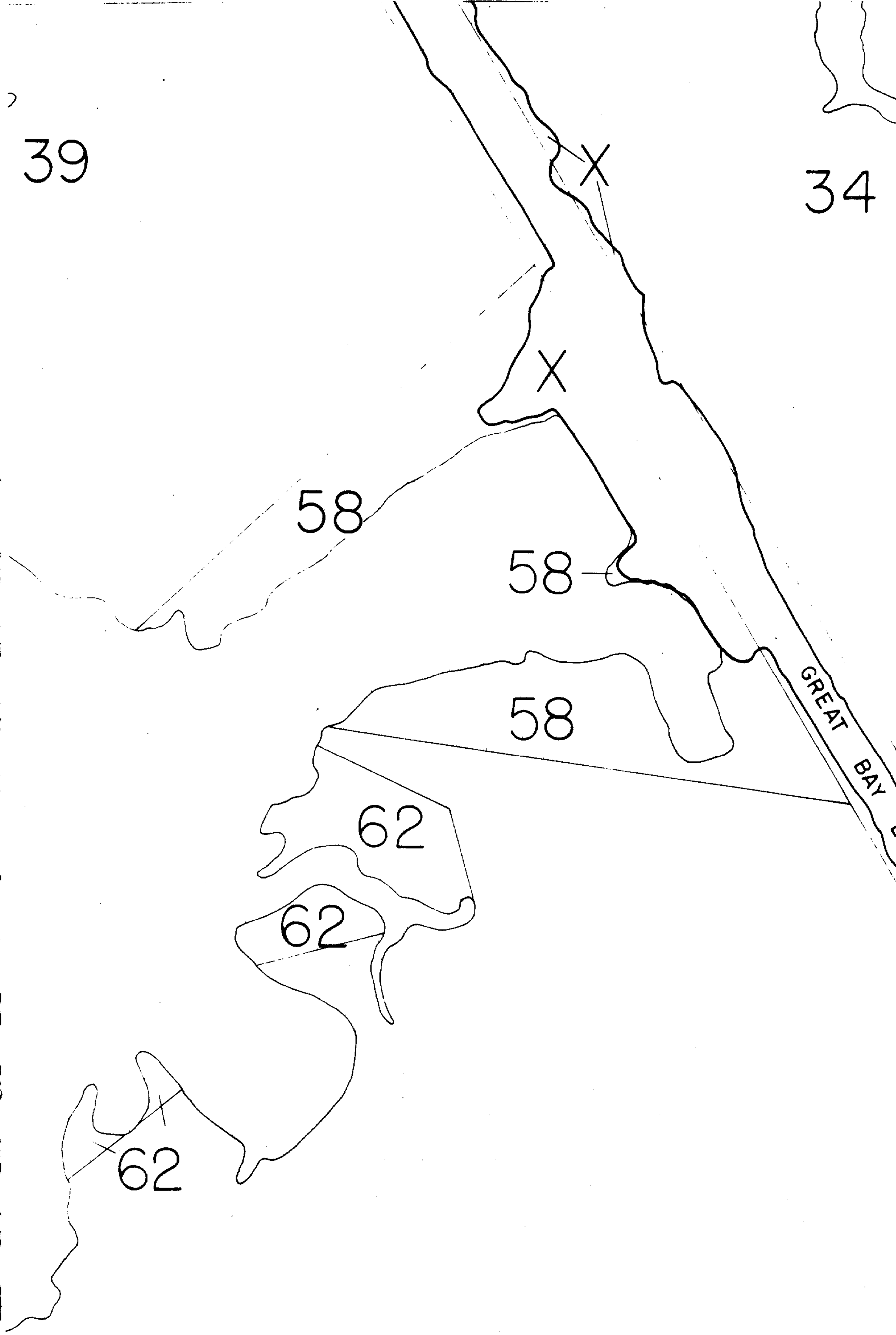


Figure 14. Portion of Property Line Overlay

2.6.2 Source of Information

NJDEP developed the required tax maps and ownership information ir Municipal tax offices; These basic data were forwarded to Mark Hurd.

2.6.3 Overlay Compilation Procedures

Tax maps were photographically reproduced as clear base film posit at 1:2400 scale. These film positives were overlaid on base maps using recognizable features to the best possible fit. A standard border layou was prepared and submitted to NJDEP for approval. An ownership list (Fi 15) was prepared and keyed to each overlay indicating the parcel, name a address of owner, date and tax map from which the information was obtair With the approval of NJDEP, the following procedure for preparing the ov was developed:

(1) Outline and account for all land area on each sheet.

(2) Use a standard property line symbol to indicate the actual property lines taken from tax maps.

(3) Use a heavy line symbol to indicate the upper wetlands boundary and include this in the legend of the property line overlay. This line indicates that no attempt has been made to define properties above this line.

(4) Label all properties below the upper wetlands boundary by number and key them to the ownership list.

(5) Label all areas above the upper wetlands boundary by the letter (X) and reference this symbol in the legend as "Area Above the Upper Wetlands Boundary--Property Information Not Shown".

(6) Where the tax maps indicate that the water's edge is the property limit, the water limits as portrayed by the base map will be traced rather than the exact line as shown on the tax maps.

(7) Where the water line forms an inlet and eventually becomes a body of water too narrow to show by two lines, a single line will be shown if such is the case on the tax map.

PROPERTY OWNERS OF RECORD

STATE OF NEW JERSEY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

BIG SHEEPSHEAD CREEK WEST/TUCKERTON MAP # 252-2094

OCEAN COUNTY 18 JUNE 1971

| OWNER | TAX MAP | BLOCK | LOT |
|---|---|---|---|
| J. Lawrence Entwistle<br>S. Green St.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 327 | 35 |
| Cape Horn Marina<br>c/o W. R. Scott, Sr.<br>Box 206<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 37 |
| Unknown<br>(c/o Carlton Corliss<br>Bay Ave.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 38 |
| Dr. Edward & Sylvia White<br>746 Queen Anne Rd.<br>Teaneck, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 39 |
| J. Lawrence Entwistle<br>S. Green St.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 40 |
| Dr. Edward & Sylvia White<br>746 Queen Anne Rd.<br>Teaneck, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 41 |
| J. Howard Smith Inc.<br>Shore Rd.<br>Port Monmouth, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 42 |

Figure 15. Typical Ownership List

The property line information and identifying numbers were drafted on a Cronaflex overlay keyed to the base map to form a reproducible master.

### 2.6.4 Delivered Products: Tax Map Overlays

Overlays were reproduced as five clear base film positives and de ered to NJDEP along with the master and ownership list.

Property line overlays keyed to the 1:6000 scale base maps were p pared by photographically reducing the 1:2400 scale overlays and combin them into appropriate composites to make master overlays. The informat was reproduced in the form of five clear base film overlays and deliver to NJDEP, along with the master. This completed delivery of 1:6000 sca tax maps.

### 2.6.5 Problems and Solutions

Assembling tax information turned out to be difficult for NJDEP i absence of a suitable map base for determining wetlands limits. For fu work, no attempt will be made to assemble tax map information until the maps for the 1:2400 sheets are completed and submitted to NJDEP.

## 2.7 SUMMARY MAP REPORT

The summary map report is a permanent record which includes names individuals involved in map delineation and production, significant eco cal observations, problems experienced, and procedural notes.

The standardized format of summary map reports is shown in Append

## 2.8 INTERIM AND FINAL REPORTING

Interim reports were prepared twice monthly. These interim repor provided NJDEP with a summary of the status of the program, previewed f activities, and pointed up problems. Extensive letter documentation wa intentionally used to facilitate record-keeping. Numerous meetings to detailed technical and legal mapping issues were held between NJDEP and Sat. This final report was prepared to document the program approach procedures.

# 3.0 INTERPRETATION TECHNIQUES DESCRIPTION

# 3.0 INTERPRETATION TECHNIQUES DESCRIPTION

## 3.1 GENERAL

Vegetation types (species associations) are sensitive indicators (Figure 16A) of wetland conditions. Vegetation integrates many environm parameters; vegetation responds sharply to slight changes in moisture or salinity; and vegetation is stationary and easily observable. Although or no significance can be assigned to the occurrence of an isolated indi or small stands of a single species, large stands of characteristic spec are reliable indicators of such variables as wetland habitats, salinity, tions of sedimentation, and topography.

It is an accepted ecological fact that plant (and faunal) species to various environmental conditions. Zonation of plant species is chara tic of most plant communities. Each zone will contain a single or many depending on the environment. Tidal wetlands are no exception to this r

There are at least[1/] two environmental factors which are most impor determining the species composition of each community (zone) within the lands. They are salinity (soil and water) and elevation. Within a give land, elevation above mean low water plays the major role in determining composition of plant communities. Elevation determines the extent to wh each community will be inundated with each high tide. Certain plant spe saline and brackish marshes are extremely sensitive to the degree to whi tidal inundation occurs, the amount of salt which is deposited in the so

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1/ EarthSat's field studies revealed ecological effects on biological comm ties due to dredging. These factors do not affect the mapping process thoroughly understood.

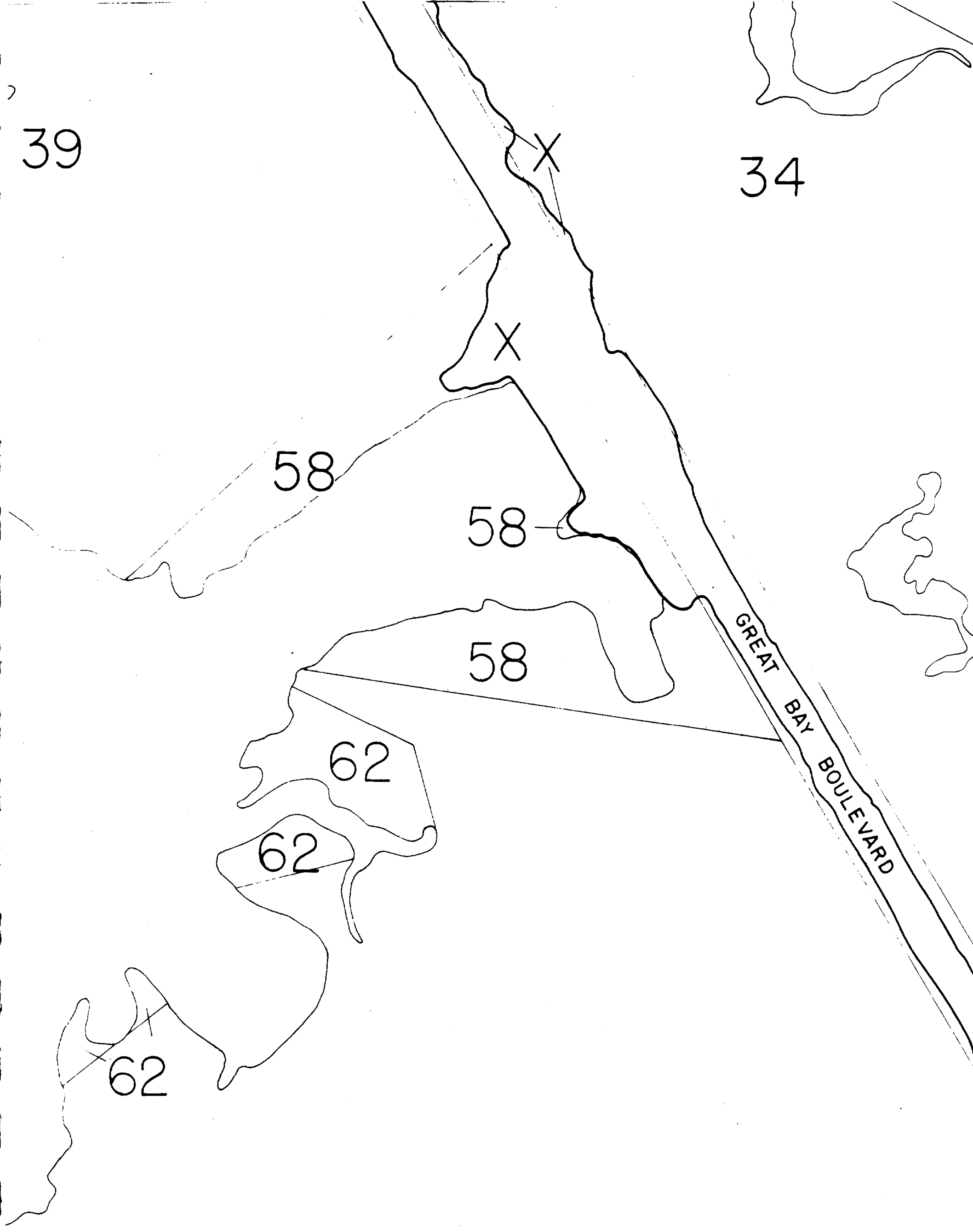


Figure 14. Portion of Property Line Overlay

### 2.6.2 Source of Information

NJDEP developed the required tax maps and ownership information in the Municipal tax offices; These basic data were forwarded to Mark Hurd.

### 2.6.3 Overlay Compilation Procedures

Tax maps were photographically reproduced as clear base film positives at 1:2400 scale. These film positives were overlaid on base maps using recognizable features to the best possible fit. A standard border layout was prepared and submitted to NJDEP for approval. An ownership list (Figure 15) was prepared and keyed to each overlay indicating the parcel, name and address of owner, date and tax map from which the information was obtained. With the approval of NJDEP, the following procedure for preparing the overlays was developed:

(1) Outline and account for all land area on each sheet.

(2) Use a standard property line symbol to indicate the actual property lines taken from tax maps.

(3) Use a heavy line symbol to indicate the upper wetlands boundary and include this in the legend of the property line overlay. This line indicates that no attempt has been made to define properties above this line.

(4) Label all properties below the upper wetlands boundary by number and key them to the ownership list.

(5) Label all areas above the upper wetlands boundary by the letter (X) and reference this symbol in the legend as "Area Above the Upper Wetlands Boundary--Property Information Not Shown".

(6) Where the tax maps indicate that the water's edge is the property limit, the water limits as portrayed by the base map will be traced rather than the exact line as shown on the tax maps.

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|---|---|---|---|
| J. Lawrence Entwistle<br>S. Green St.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 327 | 35 |
| Cape Horn Marina<br>c/o W. R. Scott, Sr.<br>Box 206<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 37 |
| Unknown<br>(c/o Carlton Corliss<br>Bay Ave.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 38 |
| Dr. Edward & Sylvia White<br>746 Queen Anne Rd.<br>Teaneck, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 39 |
| J. Lawrence Entwistle<br>S. Green St.<br>Tuckerton, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 40 |
| Dr. Edward & Sylvia White<br>746 Queen Anne Rd.<br>Teaneck, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 41 |
| J. Howard Smith Inc.<br>Shore Rd.<br>Port Monmouth, N. J. | Little Egg Harbor Twp.<br>Sheet No. 30-Sept. 1959,<br>Revised 1968 | 326 | 42 |

Figure 15. Typical Ownership List

The property line information and identifying numbers were drafted on a Cronaflex overlay keyed to the base map to form a reproducible master.

### 2.6.4 Delivered Products: Tax Map Overlays

Overlays were reproduced as five clear base film positives and delivered to NJDEP along with the master and ownership list.

Property line overlays keyed to the 1:6000 scale base maps were prepared by photographically reducing the 1:2400 scale overlays and combining them into appropriate composites to make master overlays. The information was reproduced in the form of five clear base film overlays and delivered to NJDEP, along with the master. This completed delivery of 1:6000 scale tax maps.

### 2.6.5 Problems and Solutions

Assembling tax information turned out to be difficult for NJDEP in the absence of a suitable map base for determining wetlands limits. For future work, no attempt will be made to assemble tax map information until the base maps for the 1:2400 sheets are completed and submitted to NJDEP.

## 2.7 SUMMARY MAP REPORT

The summary map report is a permanent record which includes names of individuals involved in map delineation and production, significant ecological observations, problems experienced, and procedural notes.

The standardized format of summary map reports is shown in Appendix IV.

## 2.8 INTERIM AND FINAL REPORTING

Interim reports were prepared twice monthly. These interim reports provided NJDEP with a summary of the status of the program, previewed future activities, and pointed up problems. Extensive letter documentation was intentionally used to facilitate record-keeping. Numerous meetings to resolve detailed technical and legal mapping issues were held between NJDEP and Earth-Sat. This final report was prepared to document the program approach and procedures.

# 3.0 INTERPRETATION TECHNIQUES DESCRIPTION

## 3.0 INTERPRETATION TECHNIQUES DESCRIPTION

### 3.1 GENERAL

Vegetation types (species associations) are sensitive indicators (Figure 16A) of wetland conditions. Vegetation integrates many environmental parameters; vegetation responds sharply to slight changes in moisture or salinity; and vegetation is stationary and easily observable. Although little or no significance can be assigned to the occurrence of an isolated individual or small stands of a single species, large stands of characteristic species are reliable indicators of such variables as wetland habitats, salinity, conditions of sedimentation, and topography.

It is an accepted ecological fact that plant (and faunal) species respond to various environmental conditions. Zonation of plant species is characteristic of most plant communities. Each zone will contain a single or many species depending on the environment. Tidal wetlands are no exception to this rule.

There are at least[1/] two environmental factors which are most important in determining the species composition of each community (zone) within the wetlands. They are salinity (soil and water) and elevation. Within a given wetland, elevation above mean low water plays the major role in determining the composition of plant communities. Elevation determines the extent to which each community will be inundated with each high tide. Certain plant species in saline and brackish marshes are extremely sensitive to the degree to which tidal inundation occurs, the amount of salt which is deposited in the soil, and

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[1/] EarthSat's field studies revealed ecological effects on biological communities due to dredging. These factors do not affect the mapping process if thoroughly understood.

Figure 16A. Boundary between Spartina alterniflora (high vigor) and Spartina patens (light tone, foreground). Spartina patens is highly reflective in the infrared and can be identified using aerial color infrared transparencies. Spartina patens lives above the zone of regular tidal inundation and contrasts sharply with Spartina alterniflora.

the degree to which the soil is saturated with water. Because these species are sensitive to this type of environmental condition, they are good indicators of the biological high water line.

Wetlands vary in species composition and depend mainly upon the amount of salt in the tidal water. There are three general types of wetlands in New Jersey: saline marshes; brackish marshes; and slightly brackish and freshwater marshes. Saline wetlands, such as those along the ocean shores of New Jersey, are characterized by very low species diversity. Many zones contain only a singles species and occur over large areas. The most abundant plant species occurring between mean low and mean high water is the Smooth Cordgrass (*Spartina alterniflora*). It grows virtually without competition in this region of the saline wetland and therefore is an excellent indicator of the extent to which a given marsh is inundated.

Above the level of high tide one may find isolated, low vigor, stands of Smooth Cordgrass but the dominant species (in this geographic region) is Salt Meadow Grass (*Spartina patens*). Marsh Spike Grass (*Distichlis spicata*) also may be a constituent of some high marsh communities. Results of research with color infrared photography (R. R. Anderson) have shown that the low marsh *Spartina* is easily distinguished from high marsh *Spartina* and that biological high tide line can be determined in saline wetlands.

Brackish water wetlands vary in species composition from being quite similar to saline marshes to having some plant species which are characteristics of freshwater marshes. These wetlands are common along estuaries and tributaries where the incoming tidal water is still saline.

Brackish wetlands have plant species similar to saline wetlands. Spartina alterniflora is common in areas with tidal inundation and Spartina patens is common in the marsh above the high tide line. Biological high water is determined as in saline wetlands.

In brackish marshes with lower amounts of salt in the soil, plant species composition changes and becomes more diverse. Salinity is often too low to support Spartina alterniflora and Spartina patens. Species such as Giant Cordgrass (Spartina cynosuroides), bulrush (Scirpus species) and Cattail. Giant Cordgrass, typically grows in the high marsh; however, this plant may at times be found growing in the lower marsh so field checking becomes more important in these wetlands. Cattail is almost always found in the lower marsh which is inundated by each tide; therefore, it is a good indicator of lower marsh areas.

In low salinity and fresh water tidal marshes, species diversity increases considerably. Common plant species are Cattail, Arrow Arum, Pickerel Weed, Yellow Waterlily, and Wild Rice. Because all of these species may grow either below or above the high water line, biological indicators of high tide line are more difficult to determine. Black and White IR photography if flown near or at high tide, during the winter months would supplement biological tidal determinations. Operational problems are, however, very numerous, and data acquisition is quite costly.

Many useful indicator-species are listed in Appendix V. For example, salt meadow grass (Spartina patens) and spike grass (Distichlis spicata) thrive in an environment which is normally flooded during spring tides. Saltmarsh grass (Spartina alterniflora) is an inter-tidal species which must be flooded daily to thrive and reproduce (Figure 16B). Depauperate (low vigor)

Figure 16B. <u>Spartina alterniflora</u> (high vigor) along a tributary of Big-Little Thorofare, Tuckerton.

*Spartina alterniflora* thrives in the zone which requires less frequency of flooding than high vigor *Spartina alterniflora*. In addition to biological criteria, sedimentary criteria which have narrow vertical and lateral limits can be used to supplement aerial photographic and field (mappable) indicators of wetlands and boundary and tidal conditions.

### 3.2 Aerial Photographic Products Analyzed

Prior to aerial data acquisition, available USGS and NOS aerial photography was reviewed for applicability, and analyzed. This photography proved of little direct value to the mapping program, however, it did provide useful information concerning the biological and sedimentary environments which occurred within the Salem and Ocean County test areas.

The color and color infrared aerial photography at 1:12,000 scale acquired for the pilot project was the only source of photographic information used for map delineation and production. Color infrared photography was the principal tool used for species and boundary delineation.

The upper wetlands boundary can be mapped using aerial color photography although the patterns (and tones) of those specific species of vegetation growing at the wetlands-drylands interface are generally indistinct compared to infrared color photography. Color photographs are, however, simple and understandable and they are valuable to those whose knowledge of color infrared is limited or non-existent.

EarthSat concludes that aerial color infrared photography should be used to delineate the upper wetland boundaries; this technique permits the most accurate differentiation for mapping of the critical wetland species.

## 3.3 BIOLOGICAL MAPPING TECHNIQUES

### 3.3.1 Upper Wetlands Boundary Determination

The upper boundary of wetlands (Figures 17 and 18) occurs as three separate, definable types. These are: (a) abruptly changing topography where both stereoscopic techniques and image tone may be used, (b) gradual changes in topography where subtle vegetational changes must be interpreted, and (c) along man-made disturbances such as ditches, spoil piles, dikes and roads.

All three types were present in the Mannington and Tuckerton test sites. They are discussed in detail below:

- Abruptly Changing Topography: This type of upper wetland boundary was very common at both test sites. The change in relief varied from 1.5 to 9.0 feet. In all cases, vegetational changes were striking and contrasted well with the wetland vegetation. Only in areas obscured by shadows was the line difficult to interpret. Common dryland species bordering the wetland were Arrowwood, Cedar, Pine, and various hardwood trees such as Oak. Tulip, Poplar and Hickory.

  Wetland species occuring at the upper boundary varied considerably at each test site. The following are examples:

  1. Spartina patens growing up to a sharp rise in local relief.
  2. Spartina patens in association with Iva frutescens.

Figure 17. Upper reaches of a tidal stream in the vicinity Ballanger Creek, Tuckerton showing a transitional upper wetlands boundary. _Spartina alterniflora_ (high vigor) occurs as light toned patches along streams.

Figure 18. Aerial view of upper wetlands boundary in the Tuckerton area. Development pressure can be identified in the upper left; circular light toned areas contain dredge spoil.

3. Baccharis halimofolia in association with Panicum virgatum.

4. Typha species along the upland border.

5. Phragmites on the upland border, occasionally growing across the border into well defined dry land and onto roads.

• Gradual Change in Topography: In localities where the transition from wetland to dryland was gradual, delineation of the boundary on aerial photography was particularly difficult. Extensive field checking was required to draw the boundary to NJDEP specifications in these areas.

The following are some of the typical intermixed plant species encountered along a transition from a wetland to dryland habitat:

1. Spartina patens -- Juncus gerardi -- Iva frutescens -- Baccharis halimofolia -- Panicum virgatum -- cedar -- hardwood trees.

2. Spartina patens -- Scirpus olneyi -- Typha species -- Red maple -- Willow -- Alder -- Hardwood trees.

Shadows cast by surrounding tree species also obscured what otherwise might have been good tonal signatures for key species.

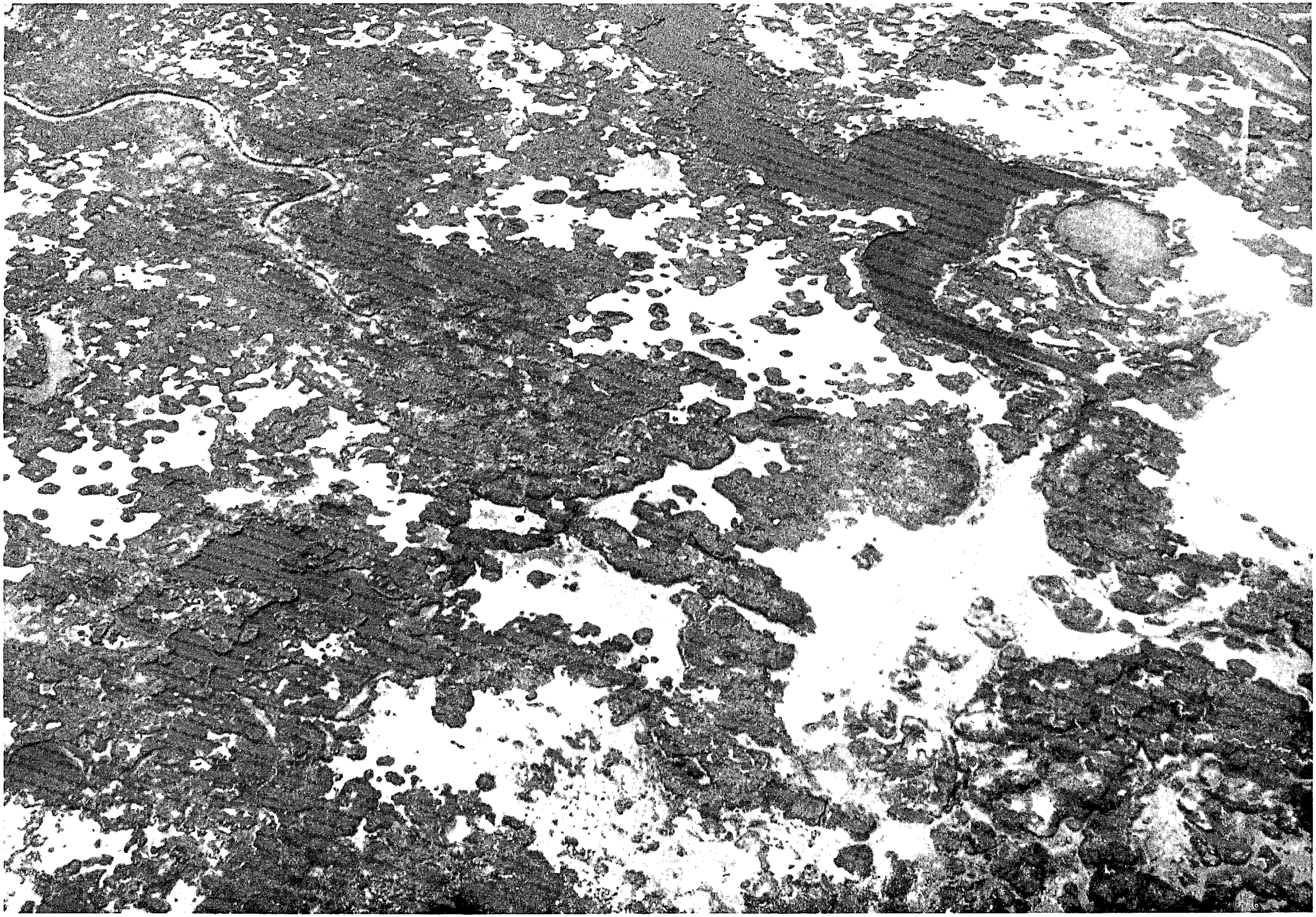
• Coincident with Ditches, Dikes, and Spoil Disposal: Because both test sites (and particularly Tuckerton) were chosen in areas of heavy wetland development pressure, this type of upper wetland boundary was quite common. In many cases (Mystic Islands) the boundary was coincident with the high water line along spoil piles on wetlands. The spoil was considerably above the one foot contour and no longer supported wetland vegetation; with NJDEP concurrence, this was interpreted as dry land. There were few if any vegetational features which could be used to define the boundary along these man-made structures. Occasionally species such as Iva and Baccharis which colonized the lower portions of spoil and diked areas could be used as indicator species.

### 3.3.2 Major Species Associations

#### General

For operational wetlands mapping, major species associations were interpreted as those natural groups of species occurring as mappable units and having unique tones on aerial photographic film. Species associations were differentiated according to unique tones or combinations of tones on the aerial photography. An understanding of dynamic regional biological and sedimentary features (Figures 18 and 19) also was essential.

Figure 19. Salt pans and exposed sandy areas at the edge of Great Bay. Some sand is washed onto wetlands during storms. This results in dynamic and complex ecological (vegetative) successions. Understanding of these environments is essential to sound interpretation and mapping.



The minimum-size mappable unit was approximately five (5) acres. This minimum mappable unit rule was violated where necessary; areas of less than five acres were mapped when points of reference (possibly for future field studies) were required in otherwise large areas of the same species association, or if significant ecological benefit might be realized for NJDEP by mapping smaller and contiguous units.

By delineating up to four (4) species within each mixed species association, units of approximately one acre were sometimes identified (species must be present in amounts up to 25% of the five (5) acre area to be mapped). Associations varied from a single species (Spartina patens) to several species, Typha, Zizania aquatica, Peltandra virginica, Spartina alterniflora. Efforts were made to keep the number of species within an association to a minimum by mapping as small a unit as possible. There were instances where species mix was so complex and uniform over a large area that it was impossible to designate separate small units. In some parts of Mannington Meadows, species association lines were drawn around distinct portions of the wetland and enclosed sparsely vegetated areas. In these cases, the species association line does not appear to fall along any distinct vegetative line. (Such lines were drawn to encompass all vegetated areas to include considerable open water interspersed with portions of wetlands.)

Ecologically-significant associations include many species which provide plant detritus important for supporting wildlife. For example, Typha species and Scirpus species are important for the maintenance of muskrat populations and might be mapped in small stands. Associations containing major quantities of _Phragmites_ as are not particularly valuable for preservation of wildlife and were not mapped in one-acre units. Inconsistencies introduced by the occasional variation in the size of mappable units do not degrade maps; such variations can make them more useful to those determining on the general value of a wetland area. Minor species such as _Salicornia_ are ecologically-insignificant and undeterminable using aerial photographs. Intensive ground studies would have been required to discriminate and map these as a single (or as part of a mixed species) unit. Furthermore, minor species change rapidly in abundance from season to season and often within a growing season; mapping to finer detail would have, in such instances; (a) increased mapping costs to the state; (b) added dynamic biological data of marginal value; and (c) marginally enhanced the position of the State in routine wetlands protection.

Based on the above data, the five (5) acre minimum mapping unit could, in the best judgment of the contractor and NJDEP, be somewhat fluid; units less than five acres were mapped primarily to facilitate future state management decisions. In addition to meeting basic wetlands management and protection objectives, maps which stringently meet the five acre mappable unit requirement will:

1) Permit field investigators to conveniently locate themselves on the ground; one-acre species units were added to assist investigators as well.
2) Contribute to identifying habitat - types (ponds, pans and tidal streams)
3) Prove useful for _general_ productivity estimates. The maps will not (and were never intended to)

provide a base for precise productivity estimates; intensive local field investigations or low altitude aircraft surveys will be required.

4) Permit the development of a considerable amount of ecological information. For example, low vigor Spartina alterniflora - Spartina patens associations in ditched areas indicates a successional trend from Spartina alterniflora to the less desirable Spartina patens. Ditching and disposition of spoil on wetlands (Figures 20 and 21) accelerates the "drying out" process in wetlands. Such information can be taken directly from maps by trained NJDEP personnel.

Figure 20. Fill area containing dredged materials, which has apparently been pumped onto wetlands sediments, spread out and destroy natural vegetation, raise the marsh, and generally result in a net loss of wetland area.

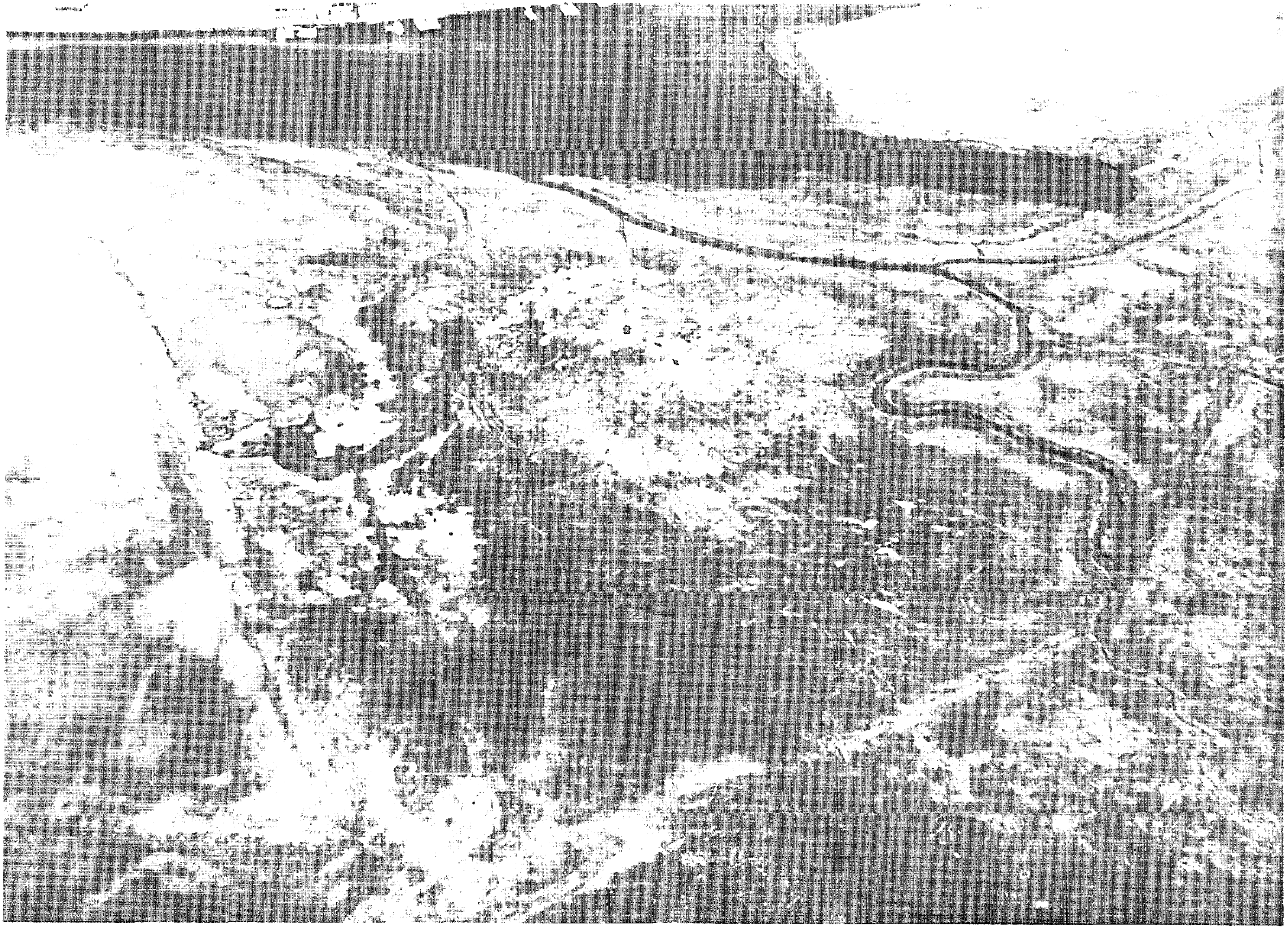


Figure 21. Ditched wetlands in Southern New Jersey. An irregular pattern of nearby parallel mosquito ditches can be identified.

### 3.3.3. Tidal Boundary Determination: Saline Wetlands

Results of several research investigations in wetlands (including leveling experiments) have shown that certain species are accurate indicators of environmental parameters. The presence of Spartina alterniflora zones have been used as an indicator of areas inundated by tidal waters. More recent work has cited the occurrence of three growth forms of Spartina alterniflora based on the height of the plant -- tall, medium and short. Leveling experiments have indicated that the mean high water line fell somewhat below the upper boundary of medium height.

#### Spartina alterniflora

Infrared color photography obtained during the mapping project showed many areas having a Spartina alterniflora community low in vigor. Subsequent field studies at selected points, during periods of mean high water, indicated that tidal inundation did not occur in these areas at all times. It was concluded the low vigor Spartina alterniflora represented portions of the population which did not receive sufficient tidal flooding (were above mean high water) to provide all the nutrients required for vigorous growth. Because the high vigor and low vigor forms of Spartina alterniflora were, in most cases, easily distinguished on infrared color film, the line of demarcation between the two forms was used to establish a line of biological high water.

It must be emphasized that vigor of species does not always correspond to plant height. In some cases, relatively short plants imaged as high vigor and some taller stands imaged as low vigor. Infrared color photography provides a more sensitive indicator of vigor than the human eye. Unless an interpreter who is field checking the area has infrared color photography to reference, the rationale for drawing a high water line may not always be evident on the ground.[1/]

A more easily interpretable key for drawing the biological high water lines was differentiating between Spartina alterniflora (high vigor) and Spartina patens. The latter species is known to grow almost exclusively above areas where frequent (daily) tidal inundation occurs. Tonal contrast between these two species was particularly sharp using infrared color photography. In such cases the biological high water line is interpreted as the boundary between Spartina alterniflora and Spartina patens.

### 3.3.4. Tidal Boundary Determination: Freshwater-Brackish Wetlands

Wetlands which occur in the upper tidal reaches of rivers (Mannington Meadows location) are characterized by a wide variety of plant species. Many of these species occur below the high water line and can be used as indicators of daily tidal inundation. Species such as Typha, Peltandra, Spartina alterniflora and Zizania are almost unique to tidally-influenced fresh water wetlands. In some cases, however, these species (with the exception of Spartina alterniflora) may occur in non-tidal areas along rivers where soil moisture is high. The delineation of a biological high water line may, therefore, be subject to slight error. Phragmites will grow both below and well above the biological high water line; this species obscures useful (mappable)

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[1/] This is also true with respect to field checking (on the ground) of association-delineations developed from synoptic aerial photography. Half-acre stands may appear significant depending on point of observation and result in less accurate estimates of percent of species composition than those obtained using aerial photography.

vegetative indicators and makes definition of a biological high water line especially difficult.

Specifically, however, interpretation and definition of the biological high water line at the Mannington site did not cause serious problems. This water line was in many cases coincident with the upper wetland boundary and is to be expected in wetlands of this type. The greatest problems were encountered where Phragmites was a major constituent and where diked wetlands had sluices which permitted infrequent tidal flooding.

### 3.3.5 Accuracy

Vegetational, tonal and textual indicators were sufficiently well defined on infrared color photography to draw the biological high water and upper wetland boundary lines within accuracy limits set forth by NJDEP, ("Placement of the upper wetlands boundary and biological high water lines shall not exceed a horizontal accuracy of either ± 10 feet of the true line position as measured on the ground.") Where ecological or physical conditions (flooding) existed so that the error in the upper wetlands boundary would not meet specifications, NJDEP and EarthSat jointly resolved the issue. Boundary placement and species associations boundary problems were, in general, resolved jointly by using a single criteria -- the effect of boundary problems on state-defined management objectives.

# 4.0 SUMMARY AND CONCLUSIONS

# 4.0 SUMMARY AND CONCLUSIONS

## 4.1 GENERAL

Twenty-one maps at 1:2400 scale were produced for the Tuckerton and Mannington Meadows sites in a 105-day period. These maps were prepared using color infrared and color aerial photography. Biological field checking supplemented photo interpretive techniques. The maps will be used to implement the "Welands Act of 1970" and they are sufficiently accurate and detailed to serve as useful wetlands management decision tools.

Based on experience gained during the pilot program, statewide wetlands mapping in New Jersey can proceed using the methodologies developed in the period of June - August 1971.

# APPENDICES

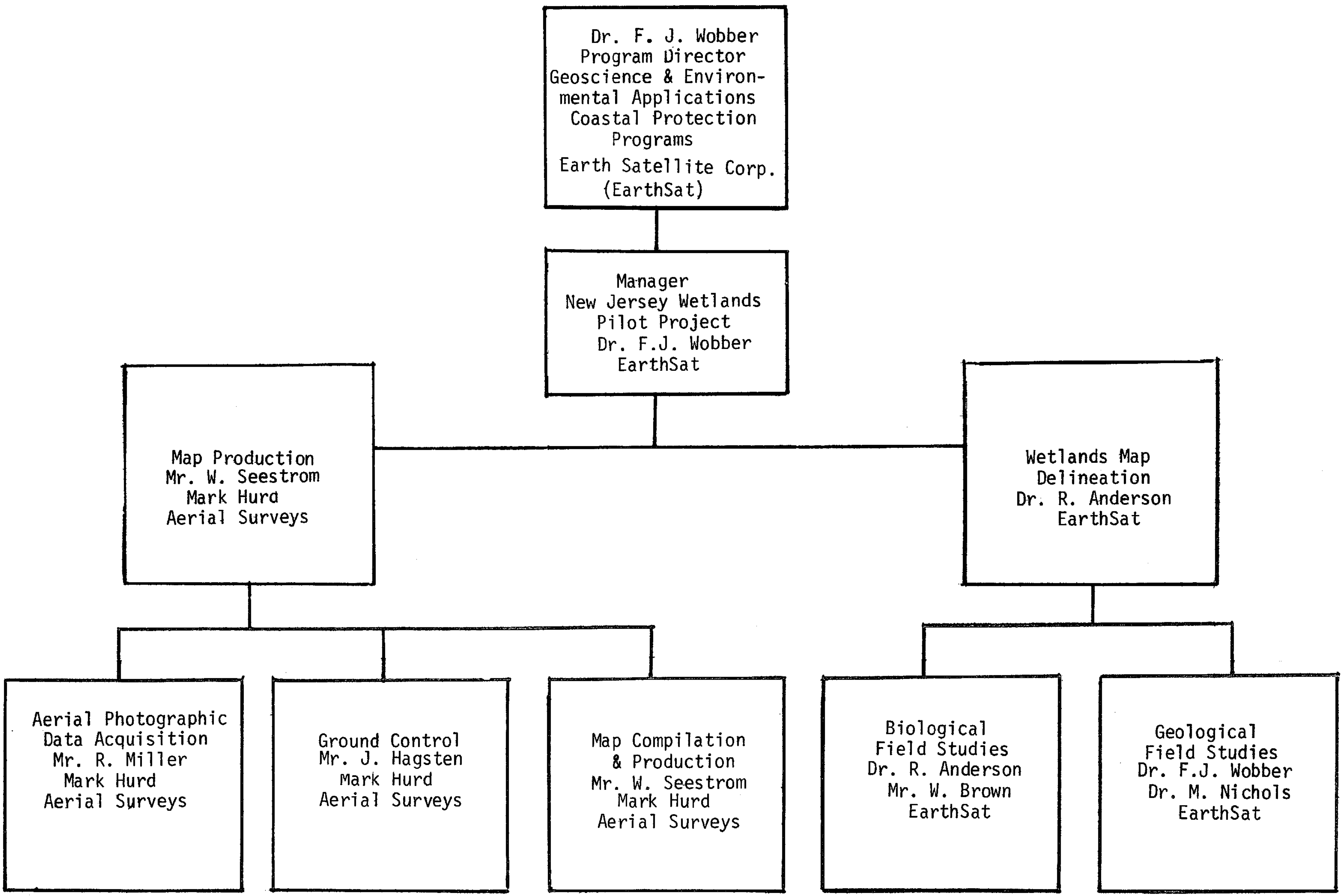
# APPENDIX I

## STUDY ORGANIZATION

Principal project participants are shown on the organization chart (overleaf). Total program management was the responsibility of Dr. F. J. Wobber, Director of Geosciences and Environmental Applications, Earth Satellite Corporation. Dr. Wobber participated in all aspects of the work and was primarily responsible for supplementary sedimentary field investigations. Dr. Richard Anderson, EarthSat Principal Associate and Chairman, Department of Biology, American University, was responsible for all biological discrimination using color and color infrared aerial photography; he was assisted in field checking and mapping by Mr. Walley Brown, EarthSat biologist. Dr. M. Nichols, Virginia Institute of Marine Sciences, assisted early in the project by defining sedimentary field criteria.

Mr. William Seestrom, Mark Hurd Aerial Surveys, Inc. was responsible for map production. Mr. Raymond H. Miller, pilot, was responsible for the acquisition of all photography, and Mr. Jack N. Ward served as photographer.

Pre-photo mission field work was under the general supervision of photogrammetric surveyor Mr. John Hagsten; he was supported by Mr. George Channel, Division of Marine Services; NJDEP. Traverses were conducted by a local survey crew from Michael Baker, Jr., Inc. under the general supervision of Mr. Earl Holderbaum, who is registered as a surveyor in Pennsylvania under license number 6659-E.


Dr. F. J. Wobber
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Mr. R. Miller
Mark Hurd
Aerial Surveys
Ground Control
Mr. J. Hagsten
Mark Hurd
Aerial Surveys
Map Compilation & Production
Mr. W. Seestrom
Mark Hurd
Aerial Surveys
Biological Field Studies
Dr. R. Anderson
Mr. W. Brown
EarthSat
Geological Field Studies
Dr. F.J. Wobber
Dr. M. Nichols
EarthSat

## APPENDIX II

## WETLANDS SPECIES HERBARIUM

Botanical specimens from fresh, brackish and saline wetlands were submitted to NJDEP to supplement the final report. The herbarium is representative of the most ecologically-significant and common wetlands species; it is not all encompassing nor was it intended to be.

Specimens listed were collected in New Jersey's wetlands by Dr. R. Anderson, Dr. F. J. Wobber and Mr. W. Brown, Earth Satellite Corporation, from June through September, 1971.

# APPENDIX II

## NJDEP HERBARIUM

| Technical Name | Common Name | Family | Locality [1/] | Habitat |
|---|---|---|---|---|
| Scirpus americanus Pers, | Bulrush | Sedge | S | Brackish wetlands, below MHW |
| Scirpus olneyi Gray | Bulrush | Sedge | T | Brackish wetlands, mainly below MHW |
| Sabatia campanulata (L.) Torr. | Marsh Pink | Gentian | T | Brackish wetlands, above MHW |
| Bidens laevis (L.) BSP. | Bur-marigold | Composite | S | Fresh water - brackish wetlands, below MHW |
| Typha angustifolia L. | Narrow-leaved cattail | Cattail | S | Fresh to brackish wetlands, below MHW |
| Polygonum Punctatum Ell. | Water smartweed | Buckwheat | S | Frest water wetlands, below MHW |
| Hibiscus palustris L. | Marsh-mallow | Mallow | S | Fresh water wetlands above or below MHW |
| Pontederia cordata L. | Pickerelweed | Pickerelweed | S | Fresh water wetlands, below MHW |
| Zizania aquatica L. | Wild rice | Grass | S | Fresh water wetlands, below MHW |
| Juncus gerardi | Blackgrass | Rush | T | Saline wetland, above MHW and along upper wetland boundary |
| Peltandra viginica | Arrow Arum | Arum | S | Fresh to brackish wetlands |

| Technical Name | Common Name | Family | Locality[1/] | Habitat |
|---|---|---|---|---|
| Phragmites communis | None | Grass | S | Saline fresh and brackish wetlands |
| Echinochloa walteri (Pursh) Nash | None | Grass | S | Fresh water wetlands, below MHW |
| Solidago sempervirens L. | Seaside goldenrod | Composite | T | Saline wetlands, Above MHW |
| Spartina alterniflora Loisel (low growing form) | Salt Marsh Cord grass | Grass | T | Saline wetlands, above MHW |
| Salicornia europaea L. | Glasswort | Goosefoot | T | Saline wetlands, at or above MHW |
| Iva frutescens L. | Highwater-Bush | Composite | T | Saline wetlands, above MHW |
| Spartina patens (Ait.) Muhl. | Salt-meadow Grass | Grass | T | Saline wetlands, above MHW |
| Limonium carolinianum (Walt.) Britt | Sea Lavender | Leadwort | T | Saline wetlands, above MHW |
| Distichlis spicata (L.) Green | Spike-grass | Grass | T | Saline wetlands, transition zone at MHW line |
| Panicum virgatum L. | Switchgrass | Grass | T | Saline wetlands, upper wetlands boundary |

1/ S = Salem; T = Tuckerton

## APPENDIX III

## FIELD (GROUND) CRITERIA

Field teams used variety of field guidelines to confirm upper wetlands boundary areas and zones (and degrees) of tidal influence. Such features as the pattern (and density) of water courses, salt ponds, and mudflats provided useful evidence of wetlands locations to supplement the aerial photographic analysis of photo-identifiable biological indicators.

| FEATURE | USE | DESCRIPTION |
|---|---|---|
| Drainage density | Upper Wetlands Boundary | Drainage density is far greater below than above mean high water by virtue of the fact that, being covered twice daily by the tides, this terrain has more water to drain and responds by developing a denser drainage system. |
| Drainage pattern | Upper Wetlands Boundary | Within the wetlands, drainage is dendritic or meandering; this is not necessarily true in uplands areas. Pattern is therefore an approximate indicator. Drainage patterns within wetlands also provide evidence of high and low marsh. Use of drainage patterns in the New Jersey wetlands is limited by the extensive ditching which obscures natural patterns. |
| Silt lines | Tidal | The extent to which plants in fresh or brackish wetlands are covered by the tide can be determined by silt lines on plant stems and leaves. Tidal water, when heavily laden with clay and silt, deposits a thin sediment-covering on plants during periods when the vegetation is inundated. Within many wetlands areas, "clean" vegetation contrasts with that "dusted" with wilt and clay. This provides an indicator of tidal reach. |

| FEATURE | USE | DESCRIPTION |
|---|---|---|
| Soil type | Upper Wetlands Boundary | There is good correlation between soil type and the upper boundary of the wetlands as defined by vegetation. Peaty (high organic) wetlands soils can be identified from borings and discriminated from upland soils. |
| Stain lines | Tidal | Iron stains which develop on walls and bridge abutments prove useful criteria for determining tidal influence. Where artificial fills (e.g., dikes along roads) extend above the high tide line, the embankment will be marked by visible soil variations and changes in soil chemistry. |
| Topographic profile | Upper Wetlands Boundary | Local topography is an excellent physical indicator of boundaries between wetlands and inland or upper boundary. The boundary between wetland and upland lies at the break in slope. Upland areas are generally dry compared to saturated wetlands areas. |
| Trash lines | Tidal | These are debris lines made up of decomposing plant materials, plastic bottles, aluminum cans, and other floating materials. These are useful anthropomorphic indicators of the last high tide line. |
| Zoological observations | Tidal | Mosquito eggs are a general indicator of frequency of tidal flooding because these eggs must remain above flood level for a certain number of days before larvae develop. Fiddler crabs are also a useful indicator of areas of tidal inundation. In addition to gills, Fiddler crabs have (unlike other crabs) evolved primitive lungs under the edge of their shells which must be kept moist for breathing. During periods of tidal inundation, they can survive without oxygen, and they are able to withstand rapid changes in water salinity which makes them well suited to the coastal wetlands. |

# APPENDIX IV

FOR THE INTERNAL USE OF THE NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION ONLY

## NEW JERSEY WETLANDS MAPPING PROGRAM
## NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

**REFERENCE DATA**

| MAP SHEET NAME | MAP SHEET INDEX NO. |
|---|---|
| Tuckerton Creek - Tuckerton | 273-2088 |

| PHOTO INDEX NUMBER | DATE OF PHOTOGRAPHY |
|---|---|
| CJF-IRC-154 | June, 1971 |

**BASE MAP PREPARATION**

| NAME(S) | DATE(S) |
|---|---|
| Mr. W. Seestrom | |
| Mr. D. McCurdy | |
| | 7/16/71 |

**FIELD CHECKING**

| FIELD INVESTIGATOR(S) | DATE(S) |
|---|---|
| Dr. Richard Anderson | |
| Mr. Walley W. Brown | |
| | 8/22/71 |

**MAP AREA DESCRIPTION**

Extensive building is present throughout the area, and the wetlands are heavily ditched. Active dredging of some areas is in progress. A tidal stream is dammed to make a lake. Large patches of *Juncus gerardi* occur in *Spartina patens* meadows. High tide lines are coincident with built-up areas where they occur along Tuckerton Creek. The sheet illustrates the ultimate end of ditched wetlands, i.e. succession to *Spartina patens* meadows.

DELINEATION PROBLEMS AND PROBLEM RESOLUTION(S)

Incoming tidal water floods into areas that have large stands of *Spartina patens*. The water appears to flood around islands of *Spartina patens* creating the illusion that *Spartina patens* is growing in tidal water. Delineation is rather difficult. The lines of high tide are being drawn with small islands of *Spartina patens* below the mean high water line where it is practical to make the line less complicated for NJDEP management use. Several small patches of wetland (e.g. N 273,000'-E 2,091,000') have been mapped above the upper wetlands boundary because of current (and rapid) dredging, and because they are now largely value-less for preservation. NJDEP concurred with this interpretation judgement.

FOR ADMINISTRATIVE USE ONLY

| | | |
|---|---|---|
| 4/30/71 | 8/2/71 | |
| BASE MAP MAILED | BASE MAP RECEIVED | |
| 8/23/71 | 9/3/71 | |
| MAP SHEET REVIEWED | MAP SHEET TRANSMITTED | NOTES |

REPORT REVIEW

| | |
|---|---|
| Frank J Wobber | |
| FOR EARTH SATELLITE CORPORATION<br>DR. FRANK J. WOBBER | ACCEPTED BY NEW JERSEY DEPARTMENT<br>OF ENVIRONMENTAL PROTECTION |

# APPENDIX V

## WETLANDS SPECIES LIST

| Family | Common Name | Genus Species | Common Name |
|---|---|---|---|
| Amaranthaceae | Amaranth | Acnida cannabina | Hemp, water |
| Araceae | Arum | Peltandra virginica | Arrow arum |
| Balsaminaceae | Buckthorn | Impatiens biflora | Jewelweed, common |
| Caryophyllaceae | Pink | Spergularia marina | Saltmarsh sand spurrey |
| Chenopodiaceae | Goosefoot | Atriplex patula | Marsh orach |
| | | Salicornia Europaea | Glasswort |
| | | Suaeda maritima | Sea blite |
| Compositae | Composite | Baccharis halimifolia | Groudsel - bush |
| | | Bidens laevis | Marigold bur |
| | | Iva frutescens | High-tide bush |
| | | Pluchea camphorata | Fleabane, saltmarsh |
| | | Solidago sempervirens | Goldenrod, seaside |
| Cyperaceae | Sedge | Eleocharis olivacea | Rush, bright green spike |
| | | Eleocharis rostellata | Spike rush |
| | | Scirpus americanus | Three-square bulrush |
| | | Scirpus cyperinus | Common wood grass |
| | | Scirpus Olneyi | Olney's bulrush |
| | | Scirpus robustus | Saltmarsh bulrush |
| Graminae | Grass | Distichlis spicata | Marsh spike grass |

| Family | Common Name | Genus Species | Common Name |
|---|---|---|---|
| Graminae (cont.) | | Echinochloa Walteri | Millet, Walter's |
| | | Leersia oryzoides | Rice, cutgrass |
| | | Panicum virgatum | Switch grass |
| | | Phragmites communis | Phragmites |
| | | Spartina alterniflora | Tall cord grass |
| | | Spartina cynosuroides | Salt reed grass |
| | | Spartina patens | Salt meadow grass |
| | | Zizania aquatica | Rice, wild |
| Iridaceae | Iris | Iris versicolor | Wild iris |
| Juncaceae | Rush | Juncus effusus | Rush, soft |
| | | Juncus Gerardi | Black grass |
| Malvaceae | Mallow | Hibiscus palustris | Mallow, swamp rose |
| Myricaceae | Bayberry | Myrica pensylvanica | |
| Najadaceae | Pondweed | Ruppia maritima | Grass, widgeon |
| Plumbaginaceae | Leadwort | Limonium carolinianum | Sea-lavender |
| Polygonaceae | Smartweed | Polygonum pensylvanicum | Smartweed, large seeded |
| | | Polygonum punctatum | Smartweed, dotted |
| | | Rumex verticillatus | Water dock |
| Pontederiaceae | Pickerel-weed | Pontederia cordata | Pickerelweed |
| Sparganiacea | Burreed | Sparganium americanum | Nuttall's burreed |
| Typhaceae | Cattail | Typha angustifolia | Narrow-leaved cattail |
| | | Typha latifolia | Common cattail |

# APPENDIX VI

## NEW JERSEY WETLANDS PILOT PROJECT FLIGHT PLAN

This flight plan is submitted in accordance with Section 1.8 of the Scope of Work. The following sections correspond with the sub-sections listed under Section 1.8.

1.8.1 Maps showing flight lines are attached as follows:

Mannington Meadow -- Salem site:

Salem
Penns Grove

Little Egg Harbor Bay -- Mullica site:

Tuckerton
New Gretna

1.8.2 The flight direction for all flights will be north-south. As explained later, there is a direct relationship between the aerial photograph format and the final 1:2400 scale map format and indexing system. Therefore this flight direction is planned for the entire wetlands.

1.8.3 The design altitude is 6000 feet above mean ground. Because of the small amount of relief, the altitude above mean sea level, for all practical purposes, is also 6000 feet.

1.8.4 Pre-determined photo centers are plotted on the flight maps at 3500-foot intervals in order to provide a gain of two exposures for each 1:2400 scale sheet. This represents an average forward overlap of approximately 61%.

1.8.5 The flight plan is designed with a flight flown down the center of each tier of 1:2400 scale sheets. Based on the planned 6000-foot east-west dimension for each sheet, the average sidelap between flights will be approximately 33%.

1.8.6 The aircraft will be Mark Hurd's Beechcraft Model T-11, license number N508MH. This aircraft is equipped to carry at least three mapping cameras which can be tripped simultaneously and which will physically synchronize within ± 1 degree in vertical and ± 5 degrees in azimuth. The aircraft is capable of carrying adequate personnel and navigation equipment to accomplish the task of spotting each photograph over a predetermined ground point.

1.8.7 The cameras will be mounted in the fuselage of the twin-engine aircraft to prevent engine heat and smoke from occurring in the field of view of either of the cameras. They will be paired in a single mount located in the center of the aircraft.

1.8.8 The project limits and 1:2400 map sheet lines are shown on the attached map. Photographic coverage will extend beyond the boundary as indicated by the photo centers. Stereo coverage would be obtained up to a point including the last exposure station. Physical coverage will be extended approximately 3500 feet beyond this exposure station.

1.8.9 The flight crew will consist of the following personnel:

Pilot: Raymond H. Miller

Mr. Miller has been in the aerial photographic field since 1942 with a number of responsible positions. He has accrued approximately 8000 hours of survey flying.

Photographer: Jack N. Ward

Mr. Ward started his career in aerial photography in 1943. Since then he has logged approximately 10,000 hours of survey hours.

1.8.10 The film will be exposed on a cloudless day with a surface visibility of at least 10 miles and when the sun is less than 50° above the horizon. Reflection from water and/or the sun spot which can occur in the imagery when the sun is above 50° may be detrimental for wetland mapping purposes.

1.8.11 The two cameras to be used are listed below with the film type to be exposed in each. The mating of film type to individual lenses is based on practical experience with these combinations.

Kodak #2448 (natural color) in Wild RC-8 #577 with lens #245

Kodak #2443 (color I.R.) in Zeiss RMK 15/23 #21214 with lens #98177

Calibration certificates for these two cameras are attached.

1.8.12 The aerial film is currently stored in a frozen state and will be kept frozen until the flight crew departs for the project site. Until such time as the film can be exposed, it will be kept refrigerated. After exposure all film will be shipped directly to Rapid Color, Inc. at Glendale, California. All processing will be carried out within the shortest possible time.

1.8.13 Calibration of photography will be accomplished by duplication of overflights using various F-stops and shutter speeds and filters to determine the most desirable exposure for the intended purpose. These overflights will all be made using film from the same production run. The identifying batch numbers are as follows:

Kodak #2443: 2443-19-1

Kodak #2448: 2448 133 31/32

1.8.14 The designed negative scale is 1:12,000. As indicated in Section 1.7 of the Scope of Work, the departure from the flight height above mean ground to produce this scale will not exceed approximately 5% deviation from the specified height.

The above details cover the flight plan required to obtain the aerial photography covered by the Scope of Work. It is our plan to operate a third camera on an experimental and back-up basis using alternately panchromatic and black and white I.R. film. The purpose will be to obtain alternate materials for preparing the base map products and/or for interpretation depending upon the results obtained. Tentative details for these have been worked out but are subject to modifications in the field depending upon developments.

It is also our plan to obtain aerial photography at a negative scale of 1:24,000 for use in aerial triangulation, if necessary, and/or preparing 1:6000 map products. Again, tentative details are planned but may change as work progresses.

# APPENDIX VII

FORM NBS-443
(REV. 11-68)

NBS Test No. 232.05/204600

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

WASHINGTON, D.C. 20234

RECEIVED
JUL 22 1971
MARK HURD
SURVEYS, INC.

July 20, 1971

# REPORT OF CALIBRATION

of Aerial Mapping Camera

Camera Type: Zeiss RMK A 15/23
Lens Type: Zeiss Pleogon A
Nominal Focal Length: 153 mm

Camera Serial No.: 21129
Lens Serial No.: 98129
Maximum Aperture: f/5.6
Test Aperture: f/8

Submitted by
Mark Hurd Aerial Surveys, Inc.
Minneapolis, Minnesota 55426

Reference: Mark Hurd Purchase Order No. 4809, dated July 9, 1971.

These measurements were made using Kodak Micro Flat Glass Plates, 0.25 inch thick with Spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68°F for three minutes, with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using K-3 filters and an incandescent tungsten light source.

I. Calibrated Focal Length: 152.36 mm

This measurement is considered accurate within 0.02 mm.

II. Radial Distortion:

| Field Angle | $\bar{D}_c$ | $D_c$ for azimuth angle: 0° A-C | 90° A-D | 180° B-D | 270° B-C |
|---|---|---|---|---|---|
| Degrees | µm | µm | µm | µm | µm |
| 7.5 | -2 | 0 | -2 | -2 | -2 |
| 15 | -4 | -4 | -1 | -6 | -4 |
| 22.5 | -1 | 0 | 1 | -8 | 0 |
| 30 | 4 | 9 | 6 | -3 | 5 |
| 37.5 | 4 | 11 | 9 | -11 | 9 |
| 45 | 23 | 46 | 19 | 0 | 26 |

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, the calibrated focal length is derived to equalize the absolute values of the maximum positive and maximum negative distortions. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion $D_c$ based on the calibrated focal length are listed for azimuth angles 0, 90, 180, and 270 degrees. The radial distortion is given in micrometers and indicates the radial displacement of the image from its ideal position for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 µm.

III. Tangential Distortion

| Field Angle | 22.5° | 30° | 37.5° | 45° |
|---|---|---|---|---|
| Displacement in μm | 1 | 2 | 4 | 5 |

The values reported are displacements from the center image point of a straight line connecting corresponding image points at equal field angles along opposite radii of the focal plane. The method of measurement is considered accurate within 5 μm.

IV. Resolving Power, in cycles/mm : Area Weighted Average Resolution 52.2

| Field Angle: | 0° | 7.5° | 15° | 22.5° | 30° | 37.5° | 45° |
|---|---|---|---|---|---|---|---|
| Tangential lines | 63 | 63 | 53 | 46 | 46 | 46 | 27 |
| Radial lines | 63 | 76 | 63 | 63 | 63 | 53 | 32 |

The resolving power is obtained by photographing a series of test bars and examining the resulting image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable assurance. The series of patterns has spatial frequencies in a geometric series having a ratio of the fourth root of two. Tangential lines are those perpendicular to the radius from the center of the field. Radial lines are those lying parallel to the radius.

V. Principal Point of Autocollimation

The lines joining opposite pairs of collimation index markers intersect at an angle within 1 minute of 90° and their intersection indicates the location of the principal point of autocollimation within 0.03 mm.

VI. Collimation Marker Separation

A-B 226.01 mm

C-D 226.02 mm

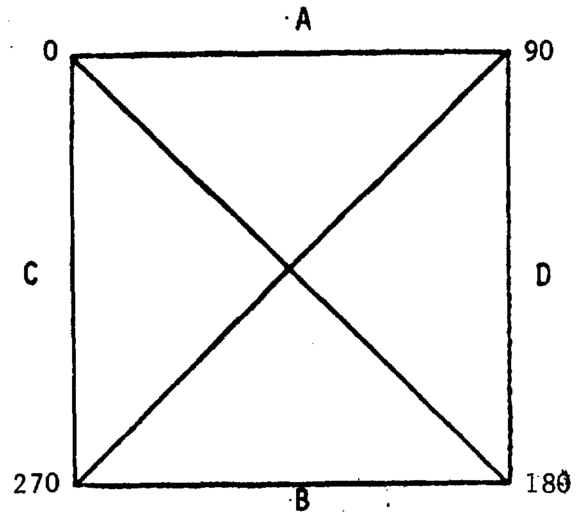
Markers A and B lie in the line of flight. The method of measuring these separations is considered accurate within 0.01 mm.

VII. Filter Parallelism

The two surfaces of the B No. 15240, D No. 15282, and KL No. 14323 filters accompanying this camera are withing ten seconds of being parallel. The B filter was used for the calibration.

VIII. Magazine Platen

The platen mounted in FK 24/120 film magazine, No. 36252 does not depart from a true plane by more than 13 micrometers (0.0005 inch).




**The diagram indicates the orientation of the reference points when the camera is viewed from the back. The direction of flight fiducial marker or data strip is at the top.**

IX. Shutter Calibration

| Indicated Shutter Settings | Effective Shutter Speeds | Efficiency |
|---|---|---|
| 1/200 | 4.2 ms = 1/235 s | 85% |
| 1/400 | 2.2 ms = 1/444 s | 85% |
| 1/600 | 1.6 ms = 1/625 s | 84% |
| 1/800 | 1.2 ms = 1/840 s | 82% |
| 1/1000 | 0.9 ms = 1/1100 s | 82% |

The effective shutter speeds were determined with the lens at aperture f/8. The method is considered accurate within 3%. The technique used was a modification of the method described in American Standard PH3-4-1959.

In mechanical and optical characteristics this camera and magazine comply with the U.S. Department of Agriculture Specifications No. ASCS-AP-201, Revision 4 (Amendment 1), for a precision aerial mapping camera, dated January 26, 1971, and Forest Service Specifications dated January 31, 1969.

This report supersedes the previous calibration of this camera contained in NBS Report No. 195624 dated May 28, 1968.

For the Director,

K. D. Mielenz
for Chris E. Kuyatt, Chief
Electron & Optical Physics Section
Optical Physics Division, IBS

FORM NBS-443
(REV. 12-65)

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

NBS Test No. 201263

April 9, 1970

# REPORT OF CALIBRATION

of Aerial Mapping Camera

| | | | |
|---|---|---|---|
| Camera Type | Zeiss RMK A 15/23 | Camera Serial No. | 21214 |
| Lens Type | Zeiss Pleogon A | Lens Serial No. | 98177 |
| Nominal Focal Length | 153 mm | Maximum Aperture | f/5.6 |
| | | Test Aperture | f/8 |

Submitted by
Mark Hurd Aerial Surveys, Inc.
Goleta, California 93017

Reference: Mark Hurd Aerial Surveys, Inc. Purchase Order No. 4374 dated April 1, 1970.

These measurements were made using Kodak Micro Flat Glass Plates, 0.25 inch thick with Spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68°F for three minutes, with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using K-3 filters and an incandescent tungsten light source.

I. Calibrated Focal Length: 152.34 mm

This measurement is considered accurate within 0.02 mm.

II. Radial Distortion

| Field Angle | $\bar{D}_c$ | $D_c$ for azimuth angle 0° A-C | 90° A-D | 180° B-D | 270° B-C |
|---|---|---|---|---|---|
| Degrees | µm | µm | µm | µm | µm |
| 7.5 | -1 | -1 | -2 | 0 | -1 |
| 15 | -3 | -5 | -3 | -7 | 1 |
| 22.5 | -1 | -1 | -3 | 0 | 0 |
| 30 | 2 | 1 | -3 | 0 | 10 |
| 37.5 | -3 | -3 | -12 | -8 | 12 |
| 45 | * | * | * | * | * |

*Fiducial marks in the corners prevented measurements at 45°.

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. The calibrated focal length is derived to minimize the average radial distortion over the field. $\bar{D}_c$ is the average distortion for a given field angle. Values of distoriton $D_c$ based on the calibrated focal length are listed for azimuth angles 0, 90, 180, and 270 degrees. The radial distortion is given in micrometers and indicates the radial displacement of the image from its idealposition for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 µm.

III. Tangential Distortion

| Field Angle | 22.5° | 30° | 37.5° |
|---|---|---|---|
| Displacement in μm | 1 | 2 | 4 |

The values reported are displacements from the center image point of a straight line connecting corresponding image points at equal field angles along opposite radii of the focal plane. The method of measurement is considered accurate within 5 μm.

IV. Resolving Power, in cycles/mm    Area Weighted Average Resolution 56.7

| Field Angle: | 0° | 7.5° | 15° | 22.5° | 30° | 37.5° | 45° |
|---|---|---|---|---|---|---|---|
| Tangential lines | 76 | 76 | 63 | 63 | 53 | 46 | * |
| Radial lines | 76 | 76 | 63 | 76 | 63 | 53 | * |

The resolving power is obtained by photographing a series of test bars and examining the resulting image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable assurance. The series of patterns has spatial frequencies in a geometric series having a ratio of the fourth root of two. Tangential lines are those perpendicular to the radius from the center of the field. Radial lines are those lying parallel to the radius.

V. Principal Point of Autocollimation

A. Side Fiducial Marks

The lines joining opposite pairs of side fiducial marks intersect at an angle within 1 minute of 90° and their intersection indicates the location of the principal point of autocollimation within 0.03 mm.

B. Corner Fiducial Marks

The lines joining opposite pairs of corner fiducial marks intersect at an angle of 90.027°. The principal point of autocollimation lies at a distance of 216 μm from the point of intersection as shown in the diagram. The measurements are considered accurate within 5 μm, and 0.001°.

VI. Collimation Marker Separation

| | | | |
|---|---|---|---|
| A - B | 226.03 mm | AC - BD | 295.22 mm |
| C - D | 226.05 mm | AD - BC | 295.22 mm |

Markers A and B lie in the line of flight. The method of measuring these separations is considered accurate within 0.01 mm.

VII. Filter Parallelism

The two surfaces of the B No. 14457, D No. 15481, and Clear No. 15407 filters accompanying this camera are within ten seconds of being parallel. The B filter was used for the calibration.

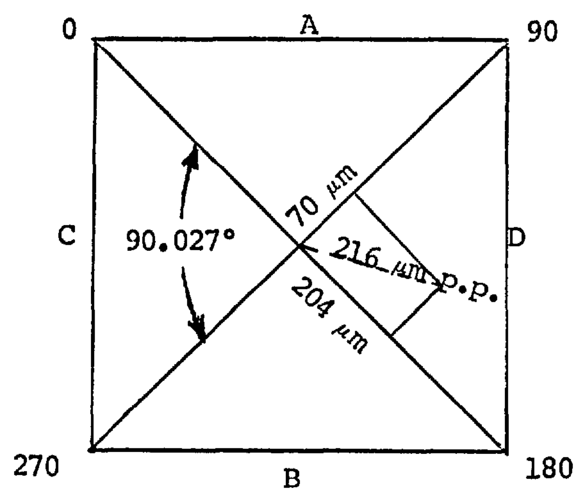
VIII. Magazine Platen

The platen mounted in Type T-11 film magazine, No. 51-007, does not depart from a true plane by more than 13 micrometers (0.0005 inch).

IX. Shutter Calibration

| Indicated Shutter Settings | Effective Shutter Speed | Efficiency |
|---|---|---|
| 1/200 | 4.2 ms = 1/235 s | 85% |
| 1/300 | 2.9 ms = 1/348 s | 85% |
| 1/400 | 2.4 ms = 1/420 s | 85% |
| 1/600 | 1.7 ms ≐ 1/588 s | 85% |

The effective shutter speeds were determined with the lens at aperture f/8 and are correct within ± 3%. The technique used was a modification of the method described in American Standard PH3.4-1959.




The diagram indicates the orientation of the reference points when the camera is viewed from the back. The direction of flight fiducial marker or data strip is at the top.

For the Director,

C. S. McCamy, Chief
Image Optics & Photography Section
Metrology Division, IBS

FORM NBS-443
(REV. 12-65)

NBS Test No. 232.05/203121

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

RECEIVED
FEB 22 1971
MARK HURD

February 17, 1971

# REPORT OF CALIBRATION

of Aerial Mapping Camera

Camera Type Wild Heerburg RC8
Lens Type Wild Universal Aviogon
Nominal Focal Length 6 inches

Camera Serial No. 577
Lens Serial No. UAg245
Maximum Aperture f/5.6
Test Aperture f/8

Submitted by
Mark Hurd Aerial Surveys, Inc.
Minneapolis, Minnesota 55426

Reference: Mark Hurd Purchase Order dated December 9, 1970.

These measurements were made using Kodak Micro Flat Glass Plates, 0.25 inch thick with Spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68°F for three minutes, with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using K-3 filters and an incandescent tungsten light source.

## I. Calibrated Focal Length: 152.21 mm

This measurement is considered accurate within 0.02 mm.

## II. Radial Distortion:

| Field Angle | $\bar{D}_c$ | $D_c$ for azimuth angle 1 B-C | 2 A-C | 3 A-D | 4 B-D |
|---|---|---|---|---|---|
| Degrees | μm | μm | μm | μm | μm |
| 7.5 | 3 | 3 | 3 | 3 | 3 |
| 15 | 4 | 4 | 4 | 4 | 4 |
| 22.5 | 4 | 4 | 3 | 4 | 6 |
| 30 | 0 | 0 | 0 | -2 | 2 |
| 37.5 | -5 | -4 | -5 | -5 | -6 |
| 45 | * | * | * | * | * |

*Fiducial marks in the corners prevented measurements at 45°.

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, the calibrated focal length is derived to equalize the absolute values of the maximum positive and maximum negative distortions. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion $D_c$ based on the calibrated focal length are listed for azimuth angles 0, 90, 180, and 270 degrees. The radial distortion is given in micrometers and indicates the radial displacement of the image from its ideal position for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 μm.

III. Tangential Distortion

| Field Angle | 22.5° | 30° | 37.5° |
|---|---|---|---|
| Displacement in μm | 1 | 2 | 2 |

The values reported are displacements from the center image point of a straight line connecting corresponding image points at equal field angles along opposite radii of the focal plane. The method of measurement is considered accurate within 5 μm.

IV. Resolving Power, in cycles/mm : Area Weighted Average Resolution 49.8

| Field Angle: | 0° | 7.5° | 15° | 22.5° | 30° | 37.5° | 45° |
|---|---|---|---|---|---|---|---|
| Tangential lines | 76 | 76 | 53 | 46 | 46 | 39 | * |
| Radial lines | 76 | 76 | 63 | 63 | 63 | 46 | * |

The resolving power is obtained by photographing a series of test bars and examining the resulting image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable assurance. The series of patterns has spatial frequencies in a geometric series having a ratio of the fourth root of two. Tangential lines are those perpendicular to the radius from the center of the field. Radial lines are those lying parallel to the radius.

V. Principal Point of Autocollimation

The lines joining opposite pairs of collimation index markers intersect at an angle within 1 minute of 90° and their intersection indicates the location of the principal point of autocollimation within 0.03 mm. This condition is true for both the corner and mid-side fiducials.

VI. Collimation Marker Separation

| | | | | | |
|---|---|---|---|---|---|
| 1-2 | 211.99 mm | 4-1 | 211.99 mm | A-B | 220.00 mm |
| 2-3 | 211.99 mm | 1-3 | 299.80 mm | C-D | 220.01 mm |
| 3-4 | 212.01 mm | 2-4 | 299.81 mm | | |

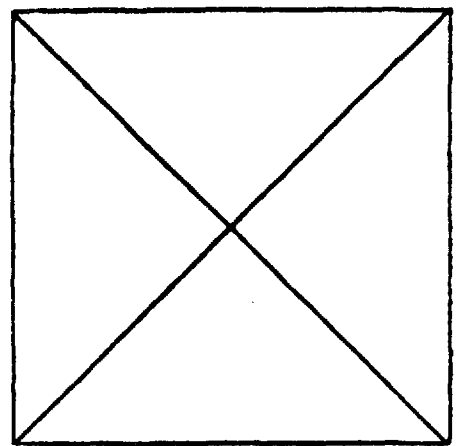
Markers A and B lie in the line of flight. The method of measuring these separations is considered accurate within 0.01 mm.

VII. Filter Parallelism

The two surfaces of the Wild 450 Pan No. 245, 500 Pan No. 1741, 700 Pan No. 1946, and Clear No. 1820 filters accompanying this camera are within ten seconds of being parallel. The 450 Pan filter was used for the calibration.

VIII. Magazine Platen

The platen mounted in Wild RC8 film magazine, No. 501 and 502 does not depart from a true plane by more than 13 micrometers (0.0005 inch).




The diagram indicates the orientation of the reference points when the camera is viewed from the back. The direction of flight fiducial marker or data strip is at the top.

## IX. Shutter Calibration

| Indicated Shutter Speed | Effective Shutter Speed | Efficiency |
|---|---|---|
| 1-s | 4.2 ms = 1/235 s | 88% |
| 1-f | 3.0 ms = 1/330 s | 87% |
| 2-s | 2.7 ms = 1/364 s | 87% |
| 2-f | 1.7 ms = 1/570 s | 86% |
| 3-f | 1.2 ms = 1/797 s | 85% |

The effective shutter speeds were determined with the lens at aperture f/8. The method is considered accurate within 3%. The technique used was a modification of the method described in American Standard PH3.4-1959.

In mechanical and optical characteristics this camera and magazine comply with the U. S. Department of Agriculture Specifications No. ASCS-AP-201, Revision 4, (Amendment 1), for a precision aerial mapping camera, dated January 26, 1971, and Forest Service Specifications, dated January 31, 1969.

This report supersedes the previous calibration of this camera contained in NBS Report No. 196210-1 dated July 25, 1968.

For the Director,

Chris E. Kuyatt

CHRIS E. KUYATT, Chief
Electron & Optical Physics Section
Optical Physics Division, IBS