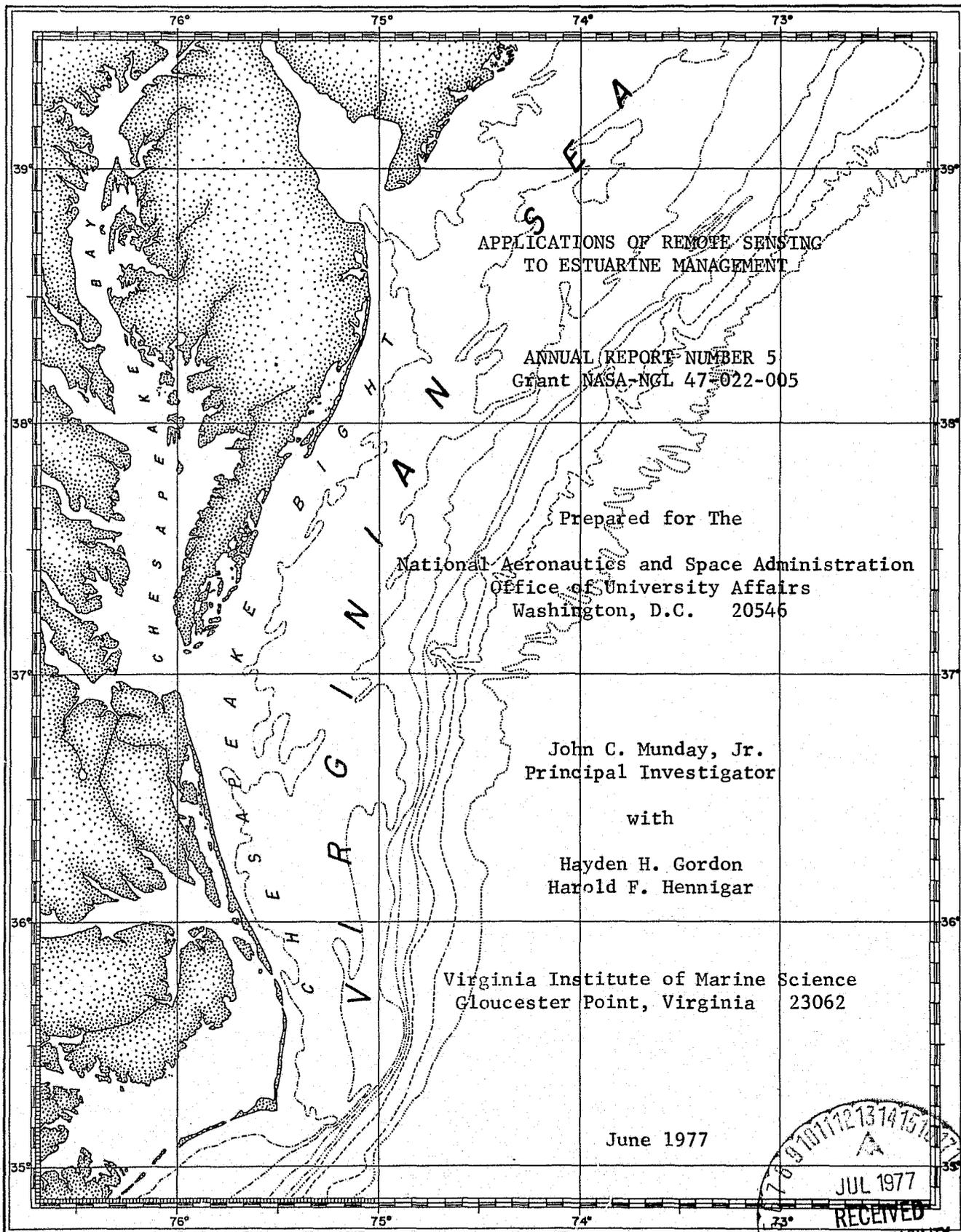


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APPLICATIONS OF REMOTE SENSING  
TO ESTUARINE MANAGEMENT

ANNUAL REPORT NUMBER 5

Grant NASA-NGL 47-022-005

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Washington, D.C. 20546

John C. Munday, Jr.  
Principal Investigator

with

Hayden H. Gordon  
Harold F. Hennigar

Virginia Institute of Marine Science  
Gloucester Point, Virginia 23062

June, 1977

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## ABSTRACT

Remote sensing was used in the resolution of estuarine problems facing federal and Virginia governmental agencies. A prototype Elizabeth River Surface Circulation Atlas was produced from photogrammetry of Lagrangian drifters for the U.S. Coast Guard to aid in oil spill cleanup and source identification. Aerial photo analysis twice led to selection of alternative plans for dredging and spoil disposal which minimized marsh damage. Marsh loss due to a mud wave from a highway dyke was measured on sequential aerial photographs. An historical aerial photographic sequence gave basis to a potential Commonwealth of Virginia legal claim to accreting and migrating coastal islands.

#### ACKNOWLEDGMENTS

We thank the National Aeronautics and Space Administration, Office of University Affairs, Washington, D.C., for support of this project. We also thank various governmental agencies involved in the applications, including the U.S. Army Corps of Engineers, the U.S. Coast Guard, the U.S. Federal Highway Administration, the U.S. Fish and Wildlife Service, and the Canada Centre for Remote Sensing, Ottawa, Canada.

Many VIMS personnel made major contributions to the applications, and many contributed to field operations, data reduction, photo and art work, and secretarial assistance. We wish to especially thank Mr. Charles Alston, Ms. Gaynor Williams, and Mrs. Beth Marshall.

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## SUMMARY OF APPLICATIONS

### 1. Elizabeth River Surface Circulation Atlas.

A prototype Atlas of Surface Circulation in the Elizabeth River, Hampton Roads, Virginia was prepared from data collected by sequential aerial photography of dye-emitting Lagrangian drifters. The Atlas leaves show trajectory maps for a variety of wind and tidal conditions. The U.S. Coast Guard, Fifth Coast Guard District, Portsmouth, Environmental Protection Branch is evaluating the use of the Atlas in oil spill cleanup on a day-to-day basis.

### 2. Quantico Creek/Town of Dumfries Flood Control Dredging.

The town of Dumfries, Virginia, sought a permit to dredge a flood control channel through the Quantico Creek marsh and creek system (0.7 km<sup>2</sup>). The U.S. Fish and Wildlife Service at first advised the U.S. Army Corps of Engineers against the permit. After an appeal from Dumfries, aerial photography was obtained by VIMS, and by engineering proposals transferred to a mosaic of the aerial photos using a Bausch & Lomb Zoom Transfer Scope. Acceptable engineering recommendations based on the mosaic were prepared jointly by FWS and VIMS, and incorporated into a revised permit application. The Army Corps approved the revised permit application and Dumfries is now opening bids for the dredging.

3. Marsh Changes from Papermill Creek Highway Construction Dyke.

A new highway constructed near Williamsburg, Virginia was routed over Papermill Creek and its associated marsh by means of a dyke and culvert system. In cooperation with the U.S. Federal Highway Administration and the U.S. Fish and Wildlife Service, VIMS has monitored the construction effects by aerial photography and field studies. A mud wave has developed which has caused the loss of 3000 m<sup>2</sup> of marsh. Reduced tidal fluctuations are causing a change in the marsh species composition. The FHA will use results from this and another study to formulate guidelines for future highway construction over marshes.

4. Disposal of Spoil from Tangier Island Channel Dredging.

The population of Tangier Island, Virginia in the Chesapeake Bay is dependent on boat deliveries of fuel and supplies. Continuing siltation of channels, which blocks routes to the supply docks, necessitates periodic dredging by the U.S. Army Corps of Engineers. The Army Corps asked VIMS to make recommendations on acceptable locations for spoil disposal from urgently needed dredging. VIMS obtained color and panchromatic infrared photography of the island at high and low tide, and used the imagery to discriminate tidal from non-tidal lands and to classify land use. A detailed report was submitted to the Army Corps containing alternatives and recommendations for disposal sites. The Army Corps has selected one of the alternatives and is proceeding with the dredging.

5. Ownership of the Fisherman Island Complex.

The Commonwealth of Virginia Senate, by a joint Resolution, directed that VIMS perform a study of the ownership of an evolving

island complex at the Chesapeake Bay mouth, to determine if Virginia has a claim to ownership of part of the complex. An earlier VIMS study had mapped old island changes using historical photography. New photography was obtained to bring maps up-to-date. Interpretation of the sequence of changes as revealed in the photography has resulted in the conclusion that Virginia has basis for a legal claim to ownership of several parcels of land. Other claims from the Federal Government and private citizens are already pending in the courts. The Attorney General of the Commonwealth of Virginia will, in all likelihood, enter a claim for ownership of parcels of land identified in the course of the remote sensing analysis.

## ELIZABETH RIVER SURFACE CIRCULATION ATLAS

### Surface Circulation

The concept of a Circulation Atlas is mentioned in Annual Report Number 4 (Munday et al., 1976) as it pertains to surface circulation in the Elizabeth River basin. As discussed by Munday and Gordon (1977) circulation studies are needed with respect to siting of outfalls, water supply intakes, oil tanker and pipeline routes, oil transfer and processing facilities, power generating stations, and harbor construction or modification. A knowledge of surface circulation particularly is necessary to predict the trajectory of floating and near-surface pollutants in estuaries. Surface circulation in a relatively shallow, confined tidal estuary is complex, highly dependent on wind as well as tide, and marked at certain phases of the tide by zones of shear and convergence. Study techniques must be suited to examination of the full range of possible wind and tide conditions, and must be able to elucidate fronts and convergence zones. This requires that the techniques be synoptic and inexpensive, and provide data of high spatial density over the region of interest.

### General Methods of Circulation Study for Siting Problems and Pollution Control

Historically, for siting problems, physical and numerical models based on hydrographic studies have been used to study basin-wide

circulation. Dye-diffusion studies have been performed at specific sites to permit calculation of pollutant dispersion. As discussed by Munday, Welch and Gordon (1977), the basin-wide models are excellent as a consistent basis for uniform evaluation of general circulation, and diffusion studies give good dispersion data. Both models and diffusion studies, however, fail to provide information on fine structure of circulation involving fronts and convergence zones. Also, wind effects are rarely taken into account. These deficiencies will limit the usefulness of such methods for determining the ultimate destination of released materials such as pollutants and sediment. Finally, due to the constraints of expense and technique, simultaneous study of circulation at alternate sites is precluded, with the result that an environmental impact statement may be prepared which fails to comparatively evaluate various alternate sites in terms of the effects of circulation. These deficiencies can be overcome by supplementary studies with Lagrangian drifters.

Some estuarine pollution control activities such as oil spill clean-up and evaluation of suspended solids movement require the knowledge of water parcel trajectories (Lagrangian data). Eulerian (point velocity) data provided by current meters (in hydrographic surveys) can be transformed into pseudo-Lagrangian trajectories, but the results may fail to be reliable, especially if the spatial density of current meters is low, and/or tidal fronts and convergence zones are found in the region. In such cases, Lagrangian drifter data are preferred as direct evidence of the water motion.

Thus there is a distinct need for study of circulation by Lagrangian methods.

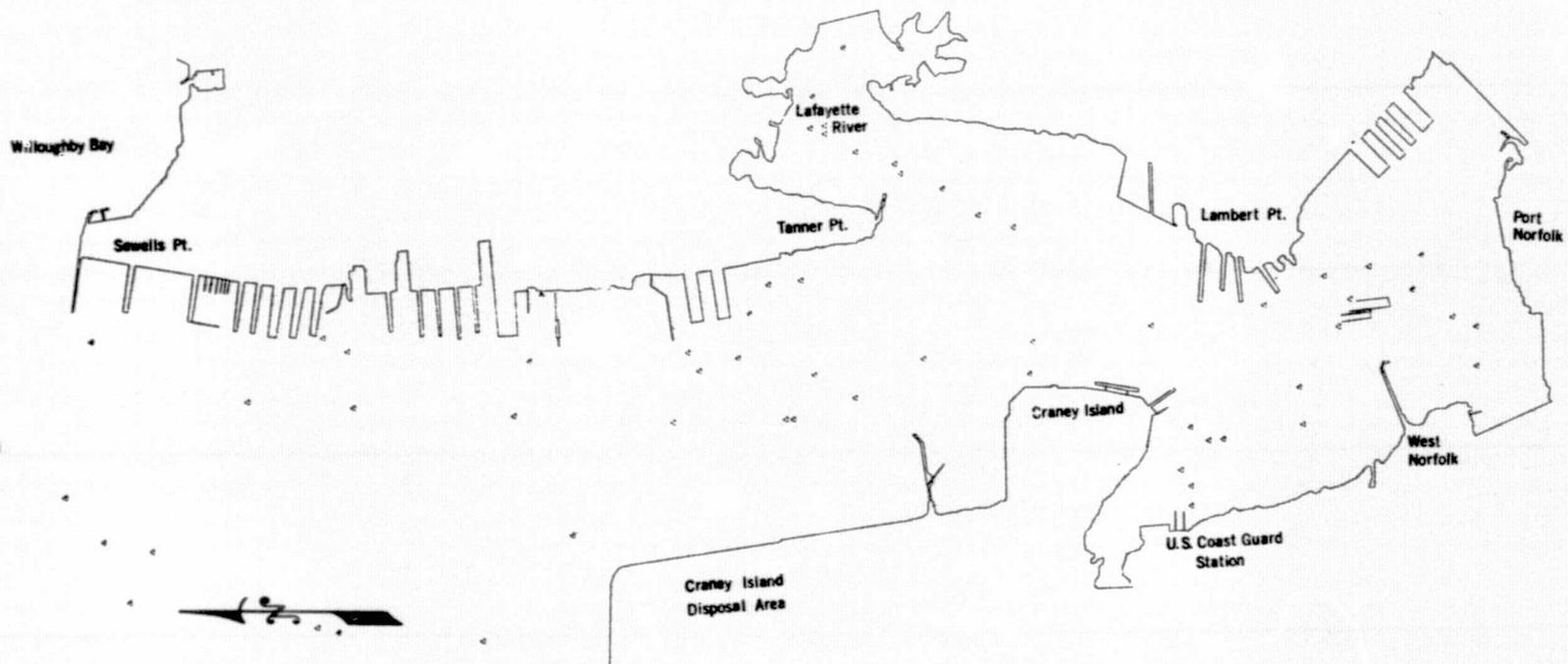
Use of Lagrangian Drifters to Produce Circulation Maps

The elements necessary to produce Lagrangian current maps for inclusion in an atlas consist of one or more field efforts, data reduction, and automated computer processing.

The field effort is conducted as in routine surface circulation studies, with three main elements: an aircraft equipped for nadir photography, a boat to deploy and monitor all markers, and good communications. The aircraft is the VIMS DeHavilland Beaver with a metric camera port which accommodates two Hasselblad 500 EL/M 70 mm format cameras with 50 mm Distagon wide angle lenses. The cameras are typically loaded with 70 frame magazines of Hi-Speed Ektachrome positive transparency film (resolving power of 60 lp/mm at a contrast 1000:1). The 70 mm cameras are driven by an intervalometer to insure 60% frame overlap, which provides for stereo viewing of uncut film and eliminates loss of data due to sun glint. A 22-foot Thunderbird twin outboard motor boat is used to deploy, remove, and identify markers as needed. As described in Gordon and Munday (1977), the markers are a new type of dye-emitting drifter with negligible wind drag. The key to a successful study is communications, which enable the aircraft personnel to direct the boat crew to drop locations, get positive identification on drifters, move drifters which have been driven out of the study area, and modify the time line of an experiment to suit wind and tide conditions. Public Safety Band radios are used which operate on a State controlled frequency. These are occasionally backed up with Citizens Band radios.

For data reduction, the photography is screened, markers identified, and frames chosen for measurement. A 1:24,000 U.S.G.S. topographic map

FIGURE 1. Elizabeth River, Hampton Roads, Virginia.  
Triangles indicate fixed buoys and channel  
markers.  
Scale 1:60,000



**Hampton  
Roads**

HHG1PLT4-H. GORDON-MV11  
ELIZABETH RIVER BASIN

is generally used as a base, and photography scaled and rectified on a Bausch and Lomb ZT4-H Zoom Transfer Scope. Buoy position is then transferred to the base map along with time from field notes and/or aircraft cassette tape recordings. Buoy position and time are then transferred to magnetic tape using a Numonics Graphics Calculator. The Numonics unit is also used to transfer shoreline information from the topographic map, and channel marker information from navigational charts. An example of such a map is shown in Figure 1 for the Elizabeth River basin.

Computer processing is performed on an IBM 370 facility with CALCOMP plot capability. The data, as stored on tape, can simply be plotted as a shoreline map and Lagrangian drifter tracks, with drifter positions indicated by a symbol at positions derived directly from the aerial photography. The problem with this representation is the lack of a common time base, and varying time interval between drifter positions. This can mistakenly be interpreted as current speed variation as the spacing of adjacent map symbols changes.

The simple solution is to linearly interpolate coordinates using the measurement data and the desired time. With linear interpolation, the new x-coordinate is

$$x' = x_1 + (x_2 - x_1) \times (t' - t_1) / (t_2 - t_1),$$

where  $t'$  is the desired time, and  $x_i$  and  $t_i$  are the measurement data. The  $y'$  coordinate is treated in analogous fashion. A more time-consuming procedure is to fit  $x$  versus  $t$  with a polynomial equation, and insert  $t'$  to obtain the desired  $x'$ . This procedure would smooth obvious irregularities in the Lagrangian trajectory, which might be presumed to be due to

noise or frontal shear. However, there does not appear to be any meaningful advantage in using more complicated procedures, despite their theoretical foundation and possibly higher accuracy, when the Atlas is to be constructed from empirical data and oriented to lay users. Complicated procedures would produce the undesirable result of substantially increasing the computational processing time.

Lagrangian data are also extrapolated beyond the measurement times as long as the extrapolation time is short. For small basin tidal currents, in the absence of nearby fronts, points are extrapolated as much as 15 minutes before the first and after the last points.

Wind direction and speed are vector averaged at three hour intervals from observations at the Norfolk Weather Bureau, and the resultant vector input to the computer program. Although winds in the local study area may be different, it is assumed that the wind driven component of surface circulation will be similar under similar wind conditions at any standard location. Also wind information is available from the Weather Service on a 24-hour basis, enhancing the real time utility of the map products. The computer program plots a scaled wind arrow with length proportional to one of three wind speed classes (0-9, 10-19, 20-29 knots) and direction pointing with the wind, and a north arrow on each Lagrangian map. An example of one of the maps is included as Figure 2. Drifter tracks are depicted by solid lines, overlain with circles to represent pseudo drifter position every 15 minutes from the interpolation routine. A special symbol near the beginning of each track is used to reference the data to predicted high or low tide at a standard tide station. Each fourth circle thereafter is blackened to highlight hourly intervals. Changes in the spacing of successive symbols can be directly interpreted as changes in tidal current speed.

FIGURE 2. Elizabeth River surface circulation.  
February 7, 1977.  
Ebb tide, wind NW 10-19 knots.

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ELIZABETH RIVER BASIN 020777 AM R



### The Surface Circulation Atlas

Conceptually, the Circulation Atlas is a readable compendium of Lagrangian circulation maps for different wind and tide conditions. The Atlas contains examples of the full range of empirically encountered flow field patterns in a single easily accessed document. It is oriented toward users among consulting engineering firms and governmental agencies. The Atlas is envisioned as a document providing a first look at current patterns and flow field trajectories. It will be available for use in the same manner as nautical charts and topographic maps.

### A Surface Circulation Atlas of the Elizabeth River

The first Surface Circulation Atlas of the Elizabeth River is partially complete using information from ten drifter releases over a period of seven days. The Atlas consists of eleven bound maps accessed through a condition matrix for tide phase, wind direction, and wind speed. Figure 3 includes the condition matrix as a part of the instruction sheet to the Atlas. The numbers in the matrix refer to individual indexed maps (e.g. Figure 2) in the Atlas which contain relevant surface circulation data for a particular wind and tide situation. Wind information is derived from the Norfolk Weather Service, and tides from published NOS predicted tide tables. This should not be misconstrued necessarily as local basin wind and tide, and is used only as a standard reference for locating the proper map. The assumption is that similar standard conditions produce like circulation patterns in a nearby estuary. There are many gaps in the matrix indicating the need for more experiments in different wind/tide conditions.

FIGURE 3. Condition Matrix and instructions from prototype Elizabeth River Surface Circulation Atlas.

## ELIZABETH RIVER SURFACE CIRCULATION ATLAS

## CONDITION MATRIX

Instructions

The surface circulation maps in this atlas are keyed to wind data from the National Weather Service Office at Norfolk Regional Airport, and to NOAA Tide Tables for predicted high and low water at Sewells Point (Hampton Roads). The following steps are taken to locate the proper map:

- Using the NOAA Tide Tables, find the times of low and high tide at Hampton Roads closest to the time in question.
- Call the National Weather Service Office in Norfolk (853-0553) and request the current and previous (2 to 3 hours) wind velocities.
- Using the Condition Matrix, locate one of the sixteen squares appropriate for the tide phase and wind direction from steps 1 and 2. Within the square, locate the wind speed rectangle appropriate for the current wind speed (from step 2).
- The number(s) indicate the map number(s) which should contain the specific circulation data of interest. Turn to the indicated map(s).

On each map are surface buoy positions given every 15 minutes for various locations in the Elizabeth River Basin. The colored dot nearest the beginning of each track keys the data to low tide (blue dot) or high tide (red dot). The number opposite the colored dot refers to the number of hours after predicted high or low tide (no number indicates predicted high or low). Each full hour after a colored dot is depicted with a black dot for ease of interpretation. Wind speed and direction are indicated on each map with a scaled arrow (0-9 knots, short arrow; 10-19 knots, medium arrow; 20-29 knots, arrow same length as north arrow).

				WIND SPEED (kts)
				20-29
H		8	3	10-19
				0-9
				20-29
	N.E.S. 9	2.5	3.4	10-19
			6	0-9
				20-29
L	9			10-19
		7		0-9
				20-29
	10	8		10-19
		7		0-9
	NE	SE	SW	NW
	WIND DIRECTION			

EXAMPLE (HYPOTHETICAL)

Suppose surface circulation west of Tanner Point is desired at 1200 on a particular day. Consulting the NOAA Tide Tables reveals a predicted high tide at 0930 and a low tide at 1500. A call to the Norfolk weather bureau shows the winds to be 200° at 10 gusting to 15 knots. Checking the Condition Matrix for a tide phase between high and low, wind direction SW, and wind speed 10-19 knots reveals map numbers 2 and 5 are appropriate. Checking specific wind and tide data on both maps tends to favor map 2 with tide data beginning 2 to 2½ hours after high (1130-1200) and wind direction nearer 200°. Buoy tracks show a well-defined ebb flow.

The first version of the Elizabeth River Surface Circulation Atlas was delivered this spring to the U.S. Coast Guard, Fifth Coast Guard District, Portsmouth, Environmental Protection Branch. The document will be used to aid in the identification of oil spill sources, prediction of the movement of spilled oil, and formulation of clean-up plans. The Coast Guard is presently evaluating the Atlas for use on a day-to-day basis.

## QUANTICO CREEK/TOWN OF DUMFRIES

### FLOOD CONTROL DREDGING

#### The Problem

The town of Dumfries, Virginia is situated at the head of Quantico Creek which empties into the Potomac River. The headwaters of the creek adjacent to the town contain approximately 0.708 km<sup>2</sup> of freshwater marsh with abundant birds and animals. The town of Dumfries is subject to flooding at lower elevations during times of heavy rainfall. The town consequently applied for a permit to dredge through a portion of the marsh to establish a drainage channel, and to place spoil on the adjacent marsh. The permit application was submitted to the U.S. Army Corps of Engineers, and subsequently to the U.S. Fish and Wildlife Service (FWS) for comment. Since wetlands were involved, FWS requested an environmental evaluation from VIMS.

FWS at first suggested denial of the permit, but agreed to review this decision after an appeal from the Mayor of Dumfries. Although Dumfries furnished a set of engineering drawings with the application, these could not be overlain on any existing maps, and the agencies could not use the drawings to make an assessment of potential ecological impact on the marsh. FWS and VIMS thereupon decided to use remote sensing to make a current map of the area which could be used to analyze proposed changes (see Figure 4).

FIGURE 4. Quantico Creek and freshwater marsh, 1976.

Quantico Creek

Town of Dumfries



Virginia Institute of Marine Science  
Remote Sensing Section  
Gloucester Point, Virginia

100 m

### Methods

Quantico Creek was overflowed for mapping at scales of 1:24,000 and 1:9,000. The Zoom Transfer Scope was used to superimpose the engineering drawings for the proposed channel on photomosaics made by the VIMS Remote Sensing Section.

### Results

The photomosaic with superimposed engineering plans was used by VIMS and FWS in a joint analysis of the project. Recommendations for environmentally acceptable flood control measures were prepared. FWS has stated that the remote sensing allowed a "rapid determination of the extent of work necessary to accomplish the project purpose and the environmental features which would be altered or destroyed by various project alternatives." The major recommendation regarding the project, based largely on remote sensing in conjunction with field investigation, was that "the channelization as proposed extend no further downstream than 1,420 feet from the outfall of the sewage treatment plant" (see Oland, 1976 in Appendix; see also other letters in Appendix). This recommendation was made specifically to protect the freshwater marsh of 0.708 km<sup>2</sup>.

### Action

The recommendation was incorporated into a revised application, which was approved by FWS on March 18, 1977, and subsequently by the Army Corps of Engineers. The town of Dumfries has solicited bids for the dredging, and the bids will be opened June 28, 1977.

MARSH CHANGES FROM  
PAPERMILL CREEK HIGHWAY CONSTRUCTION DYKE

The Problem

During 1976 and 1977 a new highway was constructed from the Williamsburg Bypass, State Route 199, into the downtown Williamsburg business district. The highway was routed across the mouth of Papermill Creek, which has an area of 61,000 m<sup>2</sup>, more than one half comprised of tidal marsh. The highway construction permits from the Army Corps of Engineers, U.S. Coast Guard, state and local authorities took over one year to obtain. Despite opposition from the U.S. Fish and Wildlife Service, permission was given by the Army Corps to build the highway over the creek using a dyke (instead of an open pile structure), with the stipulation that a culvert be used to facilitate upland drainage and tidal flow. VIMS, asked to comment on the permits, expressed concern about inhibition of tidal flow, and suggested doubling the size of the culvert as the next best alternative to an open pile structure.

The Federal Highway Administration at this time was seeking proposals on the use of remote sensing in highway routing. It saw the opportunity at Papermill Creek for a benchmark case study to help formulate guidelines for future planning of highways over marsh/creek systems. A contract was signed between FHA and VIMS to monitor the dyke construction, the change of species composition of the marsh, the size of the marsh,

the tide heights above and below the dyke, and other effects which might alter the Papermill Creek environment. The U.S. Fish and Wildlife Service decided to participate in the monitoring of the biota.

#### Remote Sensing Methods

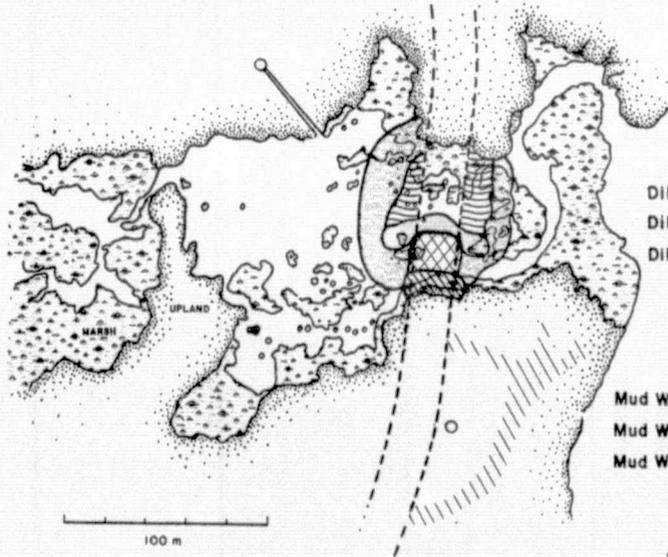
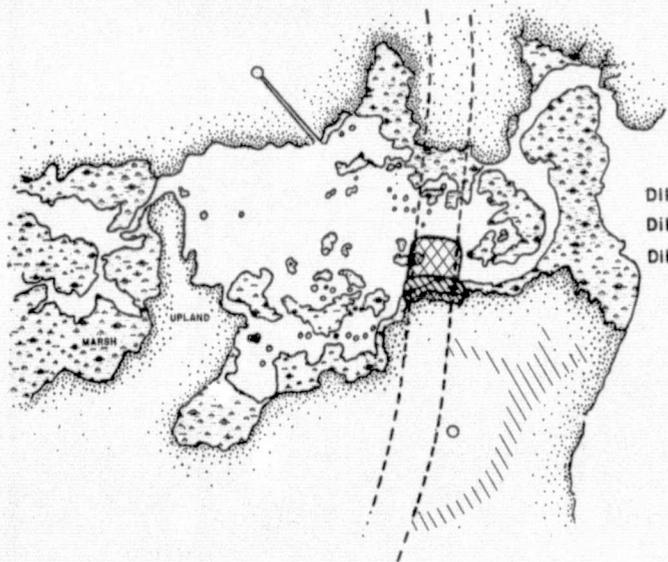
Periodic vertical aerial photography was chosen as the cheapest and best way to record immediate and long-term changes in the marsh and surrounding area. Photography was acquired with the 70 mm Hasselblad camera system in the VIMS Beaver aircraft. Color positive transparencies were used for mapping, and color negative transparencies were obtained to permit the making of color mosaics. A Bausch & Lomb ZT4-H Zoom Transfer Scope was used for making maps from the photographs. Areas were measured electronically with the Numonics graphics calculator.

Papermill Creek has been aerially photographed six times thus far over a period of 10 months. Wetlands in the creek will be photographed and mapped during the summer of 1977 for the "final" before/after vegetation comparison.

#### Results

After three years in the planning and construction phase, the highway was opened to traffic in June, 1977. Most of the summer of 1976 was spent fabricating the concrete culvert. By August 11, 1976 the culvert was completed and the movement of dirt was begun to form an elevated dyke over the marsh/creek. The weight of the dyke material on the soft creek bottom displaced a large amount of mud from beneath the dyke in the form of a wave. Figure 5 graphically illustrates the growth of the mud wave

FIGURE 5. Papermill Creek mud wave development caused by highway/dyke construction.



from 250 m<sup>2</sup> on August 11, to 945 m<sup>2</sup> by August 27, to the present 3,140 m<sup>2</sup> as of March 8, 1977. The mud wave has caused the loss of marsh, and altered species composition in its vicinity. Mapping during the summer of 1977 will give the first quantitative indication of species change both in the vicinity of the mud wave and further up the creek. Careful attention will be paid to detect further spreading of the mud wave, and its possible effect on tidal flooding.

#### Action

The remote sensing mosaics, maps, and measurements were incorporated into a preliminary report to the Federal Highway Administration documenting the mud wave and other changes in Papermill Creek as a result of the dyke (Dawes, 1977). The FHA has one other similar study underway elsewhere in the United States. Results from both studies will be used in the formation of a set of guidelines concerning future highway construction over marshes.

DISPOSAL OF SPOIL FROM  
TANGIER ISLAND CHANNEL DREDGING

Tangier Island is a small island located near the Virginia, Maryland border in the center of the Chesapeake Bay, with an area of approximately 4 km<sup>2</sup>. The population on the island is small, and is commercially supported by a large crab industry, fishing, boating, and tourism. The island is dependent for fuel and supplies on boat deliveries from the Virginia mainland some 8 miles to the east. A problem, of recently serious proportions, is the filling by siltation of the main east and west entrance channels to the supply docks. During the winter of 1976-1977, the fuel boat was unable to reach the island, and fuel was delivered by barge on a temporary, emergency basis.

The agency responsible for maintaining navigable channels is the Army Corps of Engineers. However, due to the limited size of the island and the amount of marsh, disposal locations for dredge spoil are exceedingly hard to find. VIMS was approached by the Army Corps of Engineers to aid in the selection of suitable disposal sites for the spoil. A series of sites were identified involving the least ecological impact, consideration of the needs and wishes of the people of Tangier, and engineering feasibility. General photography from the VIMS Remote Sensing Library aided this site selection. In December 1976, the VIMS position was submitted in a report (VIMS, 1976), proposing three recommendations concerning five sites. Calculations in the interim by the Army

Corps suggested that the chosen prime sites may not contain all of the fill, and that agency, by letter, proposed additional overboard disposal without dike containment. In response to this it was necessary to determine which areas of the island were flooded, both tidal and non-tidal, before an amended recommendation could safely be made.

The VIMS Remote Sensing Section prepared a photomosaic of the island to help answer the disposal questions. Missions were flown in December 1976 at high and low tides with the VIMS Beaver aircraft. Photography was obtained with twin Hasselblad cameras loaded with panchromatic infrared film and color transparency film. The pan IR film, with its ability to record land and water at high contrast, was used to discriminate low areas subject to tidal flooding. The color film was used to determine land use of low-lying potential disposal areas.

After careful examination of the pan IR mosaics (see, for example, Figure 6) and color transparencies, and site visits, VIMS proposed to the Army Corps amendments and precautions to deal with excess spoil material (see Hargis, 1977 in the Appendix). Aerial photography was an essential ingredient in finding potential disposal locations, measuring their areas, and determining the impact on the surrounding physical and economic environment.

The Army Corps has selected two of the five areas and the dredging contract has been let.

FIGURE 6. Tangier Island panchromatic infrared mosaic at high tide, 1976.

# Tangier Island



Virginia Institute of Marine Science  
Gloucester Point, Virginia  
Remote Sensing Section

1000 m

## OWNERSHIP OF THE FISHERMAN ISLAND COMPLEX

### Background

On February 9, 1976, the Commonwealth of Virginia Senate passed Joint Resolution No. 57 (Commonwealth, 1976) which directed that an investigation be made by VIMS of the question of ownership of Adams Island. In the wording of the resolution,

". . . there is an island commonly known as Adams Island, located in Northampton County, directly east of lands known as the Isaacs or William Knight Shoals and near Fisherman's Island and . . . the United States Department of Interior, Fish and Wildlife Service has expressed interest in acquiring Adams Island for use as a wildlife refuge and in that connection has inquired regarding any legal interest or title the Commonwealth may have in the island; and whereas there is reason to believe the Commonwealth may have a legitimate basis for claiming title and ownership of Adams Island; and . . . the determination regarding the Commonwealth's interest, if any, in Adams Island is prerequisite to any negotiations with the United States regarding use of the island for a wildlife refuge . . . the Virginia Institute of Marine Science is directed to study the question of ownership of Adams Island in connection with and as a part of its current study of common lands . . .".

VIMS was directed to study the question of ownership and report its findings to the Attorney General by November 30, 1976. Pursuant to this directive, the legal department at VIMS prepared a report, An Investigation into the History and Ownership of Adams Island (Theberge, 1976).

In order to study the question of ownership it was necessary to define the physical history of the area, since "the islands, shoals, and sandbars (are) undergoing a continuous process of formation, accretion, erosion, submergence, reformation and migration leading to confusion over

ownership among federal, state, and private interests".

#### Earlier Study With Remote Sensing

The area's history had earlier been graphically traced in a Master of Arts thesis by Mr. Mark Boulé (Boulé, 1975). This work was performed with data consisting of historical maps and photographs. Boulé used a Bausch & Lomb ZT4-H Zoom Transfer Scope, with guidance and support of the Remote Sensing Section, to map geomorphological changes for Fisherman Island, Adams Island, and the Isaacs (island). In the historical photographic sequence, a 1974 9-inch format NASA transparency was the most recent. Figures 7 and 8 show changes from 1910-11 to 1927<sup>74</sup>.

Boulé found that the hydrodynamic processes operative in the area result in the offshore formation of shoals in a series of concentric bars which, as they become emergent above low water, migrate toward Fisherman Island and become welded to the southern shore of the island forming a sand spit. As each sand spit is reshaped by the waves and currents, it is driven inshore extending the southern beach and gradually moving westward to be replaced by another spit formed by the same process. Because Fisherman Island is the recipient of the southerly transport of sediment along the barrier islands of Virginia's Eastern Shore, the island as a whole is increasing in size.

#### New Study With Remote Sensing

In order to determine the most recent status of the island complex VIMS made new flights over the area with the Beaver aircraft, Hasselblad cameras, and color transparency film. Two flights were made, on 9 and

FIGURE 7: Fisherman Island complex in 1910-11 from C&GS chart.  
From Boule (1975).

FISHERMAN ISLAND, 1910-II

(from C & G S Chart H 3191)

1927 NA Datum

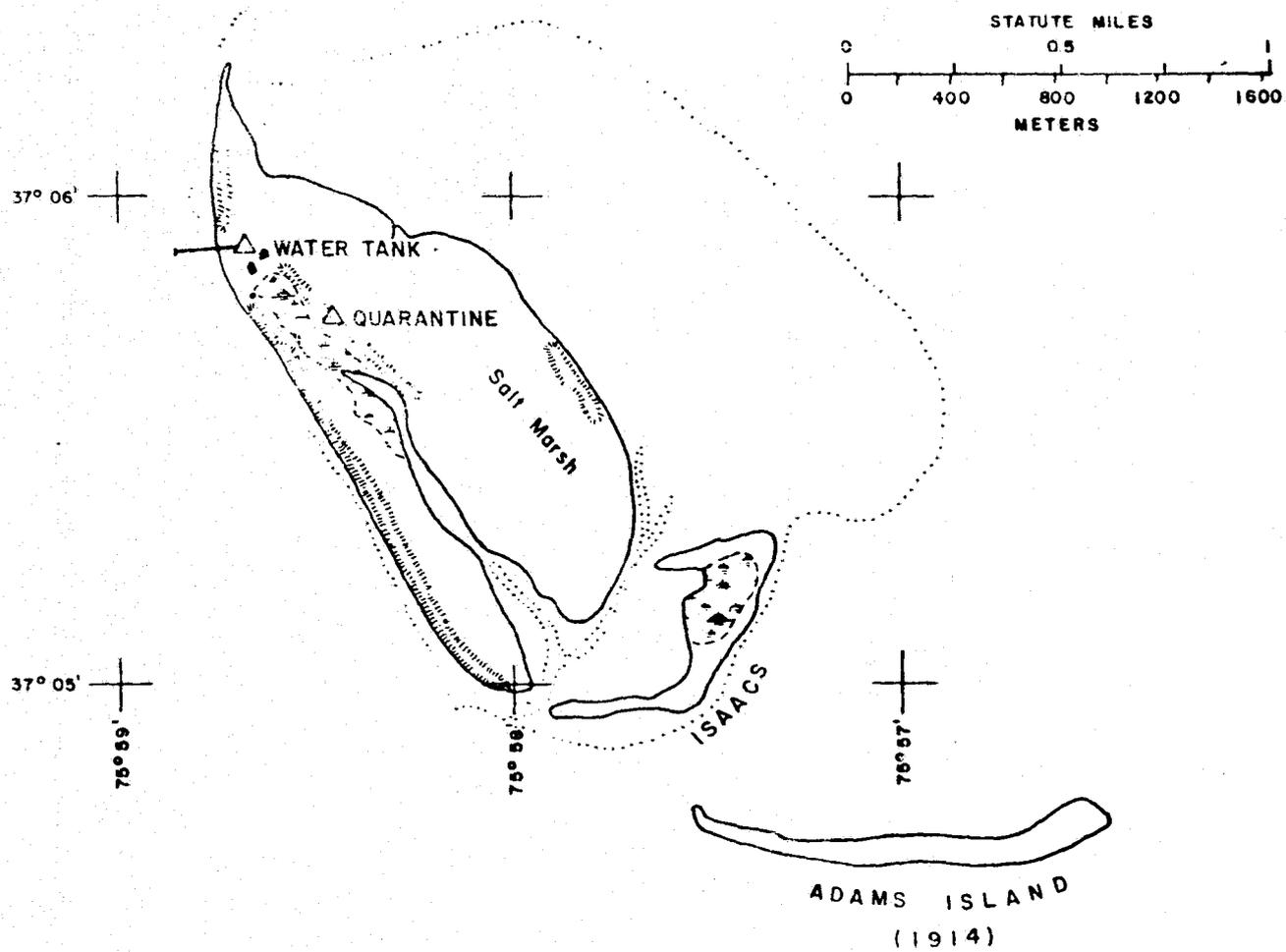
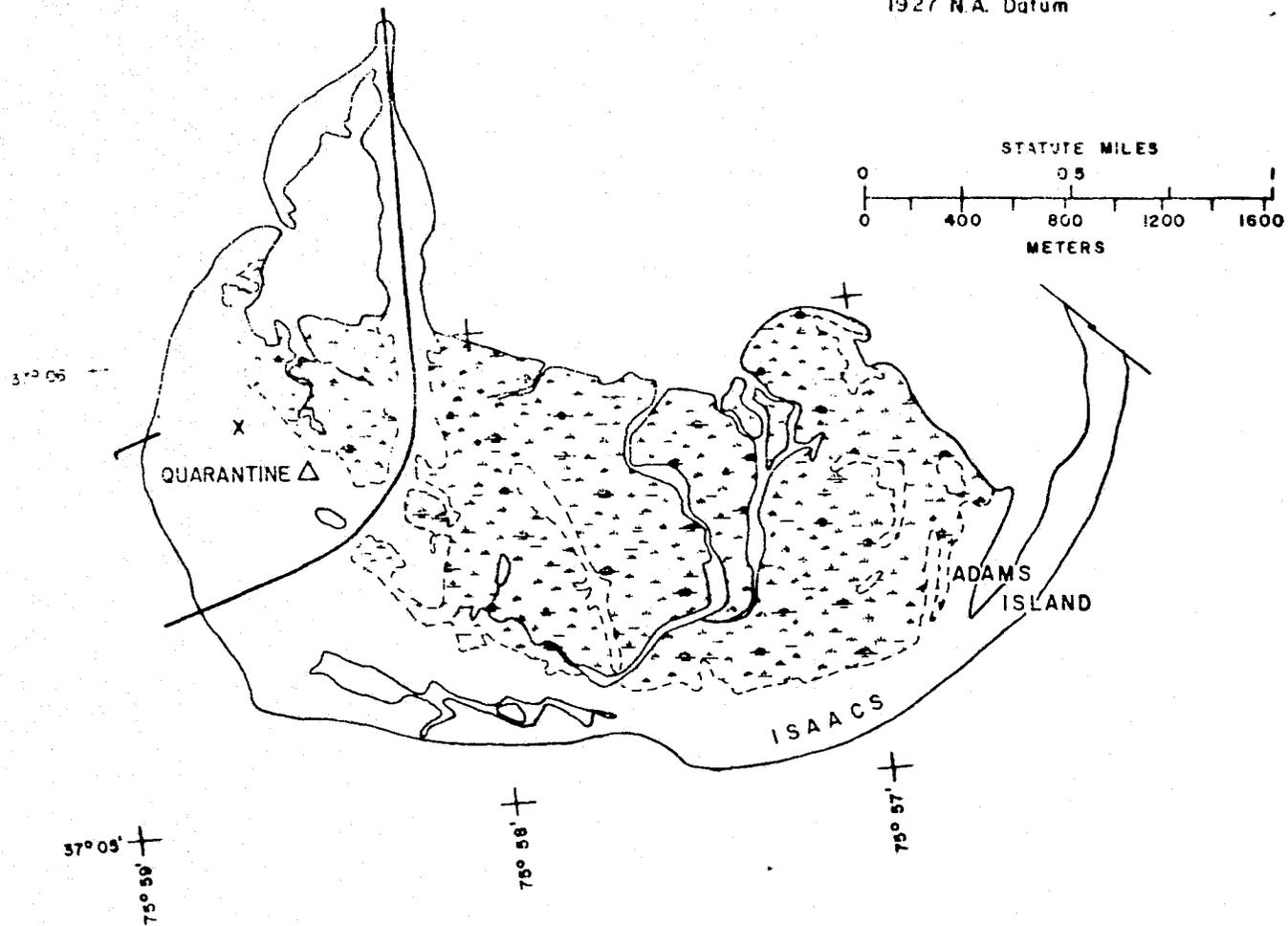


FIGURE 8: Fisherman Island complex in 1974 from NASA photograph.  
From Boulé (1975).

FISHERMAN ISLAND, 1974

(from NASA Photo 2443)

1927 N.A. Datum



30 August, 1976, coincident with predicted low and high tides. The film has been analyzed and interpreted in light of the legal question raised in the Senate Resolution.

### Results

Analysis has revealed two important facts:

1. The sand shoals moving across Smith Island Inlet (to the northeast of the Fisherman Island complex) to form the next spit on the eastern shore of Fisherman Island, are emergent and discrete at mean low water and
2. the shoals are not emergent at mean high water.

### The Legal Question

Any attempt to resolve the ownership of the islands of the Fisherman's Island complex must integrate the history and physical processes associated with these islands with the current status of law in Virginia relating to accretion and island formation.

The legal question concerning ownership of the island complex is based on common law and buttressed by an 1873 General Assembly Act, now section 62.1-1 of the Code of Virginia, which states that "the shore of the sea within the jurisdiction of this Commonwealth, and not conveyed by special grant or compact according to law shall continue and remain the property of the Commonwealth . . . and may be used as a common by all the people." By any reasonable definition, shoals and bars emergent as islands between low water and high water would be considered to be the shores of the sea and thus the subject of state ownership under this statute as well being the subject of state ownership under traditional common law principles

still applicable in Virginia today.

Once ownership is vested in the Commonwealth by virtue of common law and the Act of 1873, this ownership would continue, not disappear, upon merger of state owned property with privately held land. Such is also the case when privately held lands merge under similar circumstances.

Consequently, does there exist any land in the Fisherman Island complex over which the Commonwealth may claim ownership? The brief answer to the forgoing question is "yes". The Commonwealth may claim ownership of parcels originally vested, and it may have a potential claim in several other parcels of land north of the Isaacs and west of Adams Island and, also, parcels on the south, north and northwest sides of Fisherman Island.

#### The Importance of Remote Sensing

The general legal position advanced above is based on the general conclusion that the islands, shoals, and spits have either migrated from one place to another while remaining discrete, or submerged and reformed at different locations. This conclusion is based entirely on remote sensing analysis.

The following specific legal conclusions have been reached (Theberge, 1976, p. 23-24):

1. Due to remedial or curative statutes passed in 1932 and 1966 (sections 41.1-3 and 41.1-6 of the Code of Virginia) the grant of Adams Island is valid. It may be only valid, however, to high water as set out in the original grant and in accordance with common law and the Act of 1873 mandating that the ungranted shores of the sea shall continue and remain the property of the state.

2. It appears more likely than not that Adams Island migrated to its present position and, with exception of the area between high water and low water which may not have been included in the original grant, it also appears the Commonwealth in all probability has no proprietary interest in that part of Fisherman's Island identified as the remnants of the original Adams Island.

If the original island disappeared, however, the state would own what is now called Adams Island.

3. In view of sovereign ownership at common law and the Act of 1873, a strong argument exists for state ownership of the large sand spit extending from the eastern shore of the Fisherman's Island Complex. Since the spit represents the growing or accreting part of the island, the Commonwealth may desire to institute an action to claim ownership of the spit.
4. A group of three islands north of the Isaacs, west of Adams Island and east of Fisherman's Island has emerged above high water from the bed of the bay and title therein should be in the Commonwealth.

Remote sensing has been crucial to these conclusions. The data base included historical photography and recent photography (by NASA and VIMS), the data reduction consisted of standard mapping and zoom transfer techniques, and the data analysis involved photointerpretation for geomorphological change, vegetation classification, and tidal effects.

#### Action

The VIMS report (Theberge, 1976) was submitted November 30, 1976 to the Virginia Senate and Attorney General. The Attorney General will, in all likelihood, move to claim legal ownership of the lands in question in the courts, inasmuch as the Federal Government and private citizens are already involved in litigation over ownership of the same lands.

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APPENDIX A

ABSTRACTS OF MANUSCRIPTS SUBMITTED FOR PUBLICATION IN 1977

OUTFALL SITING WITH DYE-BUOY  
REMOTE SENSING OF COASTAL CIRCULATION

John C. Munday, Jr.  
Christopher S. Welch  
Hayden H. Gordon

Virginia Institute of Marine Science  
Gloucester Point, Virginia 23062

Submitted to

Photogrammetric Engineering and Remote Sensing

Abstract

A dye-buoy remote sensing technique has been applied to estuarine siting problems involving fine-scale circulation. Small hard cakes of sodium fluorescein and polyvinyl alcohol, in anchored buoys and low-windage current followers, dissolve to produce dye marks resolvable in 1:60,000 scale color and color infrared imagery. Lagrangian current vectors are determined from sequential photo coverage. Careful buoy placement reveals surface currents and submergence near fronts and convergence zones. Inexpensive and simple, the technique has been used in siting two sewage outfalls in Hampton Roads, Virginia. In case one, the outfall region during flood tide gathered floating materials in a convergence zone, which then acted as a secondary source during ebb; for better dispersion during ebb, the proposed outfall site was moved further offshore. In case two, flow during late flood was found to divide, with one half passing over shellfish beds; the proposed outfall site was consequently moved to keep effluent in the other half.

LAGRANGIAN DRIFTER DESIGN FOR THE  
DETERMINATION OF SURFACE CURRENTS BY REMOTE SENSING

Hayden H. Gordon and John C. Munday, Jr.

Remote Sensing Section  
Virginia Institute of Marine Science  
Gloucester Point, Virginia

Presented at the

Sixth Annual Remote Sensing of Earth Resources Conference

University of Tennessee Space Institute  
Tullahoma, Tennessee

March 29-31, 1977

Abstract

In estuaries, the interaction of wind, tidal current, and mixing of fresh and saline water produces a variable depth profile of current, with foam lines and convergence zones between water types. Careful measurement of surface currents via Lagrangian drifters requires a drifter design appropriate to both the depth of current to be measured and the tide and wind conditions of interest. The use of remote sensing to track drifters contributes additional constraints on drifter design. Several designs of biodegradable drifters which emit uranium dye plumes, resolvable in aerial imagery to 1:60,000 scale, were tested for wind drag in field conditions against data from calibrated current meters. A 20 cm-vaned wooden drifter and a window shade drifter set to 1.5 m depth had negligible wind drag in winds to 8 cm/sec. Prediction of oil slick trajectories using surface current data and a wind factor should be approached cautiously, as surface current data may be wind-contaminated, while the usual 3.5% wind factor is appropriate only for currents measured at depth.

PROGRESS TOWARD A CIRCULATION ATLAS  
FOR APPLICATION TO COASTAL WATER SITING PROBLEMS

John C. Munday, Jr. and Hayden H. Gordon

Remote Sensing Section  
Virginia Institute of Marine Science  
Gloucester Point, Virginia

Presented at the

Conference/Workshop on the Application  
of Remote Sensing to the Chesapeake Bay Region

Coolfont Conference Center  
Berkeley Spring, West Virginia

April 12-15, 1977

Abstract

Circulation data needed to resolve coastal siting problems can be assembled from historical hydrographic and remote sensing studies in the form of a Circulation Atlas. Empirical data are used instead of numerical model simulations in order to achieve fine resolution and include fronts and convergence zones. Eulerian and Lagrangian data are collected, transformed, and combined into trajectory maps and current vector maps as a function of tidal phase and wind vector. Initial Atlas development is centered on the Elizabeth River, Hampton Roads, Virginia.

WATER QUALITY ANALYSIS BY  
DIGITAL CHROMATICITY MAPPING OF LANDSAT DATA

T.T. Alföldi  
Canada Centre for Remote Sensing  
Ottawa, Ontario, Canada

and

John C. Munday, Jr.  
Virginia Institute of Marine Science  
Gloucester Point, Virginia, U.S.A.

Submitted March 15, 1977 to  
the Canadian Journal of Remote Sensing

Abstract

Digital chromaticity analysis of Landsat CCT data with the Image-100 system is a rapid and convenient method for investigating water quality. The chromaticity transformation involves ratio normalization by total radiance, which enhances and facilitates water colour monitoring and analysis. Effects of atmospheric and water surface reflection noise are suppressed by the chromaticity transformation, and the residual chromatic effects are easily perceived on a chromaticity diagram. Chromaticity loci have been defined for pure water, suspended solids, chlorophyll, bathymetry, dry vs. wet sand, snow, ice, air pollution, haze and clouds of variable thickness. A correlation coefficient of  $r = 0.96$  ( $p < 0.001$ ) has been obtained for multi-date sampling of suspended solids in the Minas Basin, Nova Scotia. A practical Landsat/Image 100 chromaticity analysis system for water quality monitoring at relatively low cost has now been developed.

PROGRESS TOWARD A  
LANDSAT WATER QUALITY MONITORING SYSTEM

Thomas T. Alföldi  
Applications Development  
Canada Centre for Remote Sensing  
Ottawa, Ontario

John C. Munday, Jr.  
Remote Sensing Section  
Virginia Institute of Marine Science  
Gloucester Point, Virginia

Presented at the  
4<sup>th</sup> Canadian Symposium on Remote Sensing

Quebec City  
Quebec, Canada

May 16-18, 1977

Abstract

The analysis of colour or "chromaticity" of Landsat scenes is providing a mechanism for the quantitative monitoring of water quality. Recent progress in the implementation of the chromaticity transform on the Image 100 now offers the speed and flexibility of this digital analysis system. Data extracted from over 40 Landsat images of Canada, the U.S. and Nigeria have defined the locus of chromaticities on a chromaticity diagram for a variety of water conditions. Discrete loci are identified for suspended sediment, chlorophyll and bathymetry. Moreover, contaminating shifts of these loci by sunglint, whitecaps, thin clouds, haze and air pollution may be detected on the diagram, and removed. Multidate suspended sediment sampling in the Minas Basin, Nova Scotia has produced correlation to Landsat data of  $r = 0.95$ , after atmospheric adjustment. The regression coefficients between the surface data and the satellite data are thereafter used with atmospheric adjustment to calibrate other satellite scenes with no surface sampling.

Chromaticity analysis matched with digital techniques is a fast, convenient and simple technique for the resource manager. Continuing development is aimed at an automated algorithm for a Landsat water quality index, to include correction for solar elevation effects, and system design for a wide area monitoring program including many water bodies.

LANDSAT TEST OF VOLUME REFLECTANCE  
MODELS FOR SUSPENDED SOLIDS MEASUREMENT

John C. Munday, Jr.  
Virginia Institute of Marine Science  
Gloucester Point, Virginia 23062

and

T.T. Alföldi  
Canada Centre for Remote Sensing  
Ottawa, Ontario, Canada

Abstract

Landsat radiance data were used to test mathematical models relating volume reflectance to suspended solids concentration. Digital CCT data for two Landsat passes over the Bay of Fundy, Nova Scotia were analyzed on a General Electric Co. Image 100 multispectral computing system. The two data sets separately and together were studied by individual bands and by chromaticity analysis. Results support the view that the relationship between Landsat radiance and suspended solids concentration is non-linear. The theoretical volume reflectance model developed by Gordon and co-workers is corroborated.

APPENDIX B

PHOTOGRAPHIC DISCRIMINATION OF "RED" WATER: SUMMARY

PHOTOGRAPHIC DISCRIMINATION  
OF "RED" WATER: SUMMARY

Introduction

The purpose of this study is to determine if there is a usable correlation between so-called "red" water and optical density as recorded on photographic film. The parameters used to describe "red" water include chlorophyll a concentration, cell count, spectrophotometry, and identification of major algal species. Aerial photography was obtained simultaneous with acquisition of field data on four days in August, 1976.

Field Methods

Two areas were chosen as field sampling areas, one near the mouth of the York River, Virginia, and the other approximately 25 kilometres upriver, near Clay Bank, and extending upriver toward the Purtan Island Marshes. Two boats were used in the field, a Thunderbird equipped to obtain profiles through the water column, and a smaller rubber boat whose main task was to obtain surface samples. Communications between the airplane and boats was via citizen band radios, which enabled the aerial observers to vector the boats into areas of "red" and "clear" water, where samples were taken for laboratory analysis. Sampling and aerial photography were obtained as close as possible to slack water viewed as a stable reference condition.

Water samples were analyzed for temperature (in situ), salinity, and chlorophyll a content. Some samples were analyzed using spectrophotometric methods, while others were analyzed for cell count and major algal species. Secchi depth measurements were taken at most stations; all values were less than 1.5 metres, indicating very turbid water.

#### Photographic Methods

Imagery was obtained at altitudes varying from 600 m to 1500 m. A Hasselblad EL/M with a 50 mm Distagon lens was used to obtain 70 mm vertical imagery using Kodak 5257 High Speed Ektachrome (ASA-160). This film was used for density measurements. Imagery in 35 mm format was obtained using a Nikon F2. It consisted of oblique photographs taken to locate the sampling boat with reference to known land features.

Optical density measurements were taken with a Brumac transmission densitometer using a 1 mm blackened aperture in the red, green, and blue bands. Measurements were taken at boat sampling points and were also taken in other areas of obvious "red" and "clear" water in order to determine what density differences exist between the two.

#### Results and Interpretation

Means and standard deviations were calculated for the red and clear water points. On each emulsion band taken singly, the difference in the means is not significant at  $P < .15$  using a t-test to compare the means. Therefore, red water cannot be identified in the data by analysis of densities from emulsion bands taken singly. However, when data from the three emulsion layers are lumped, the means from red and clear water are

different, significant at the  $P < 0.10$  level using the t-test. (The red and clear water means were 1.465 and 1.600, yielding a difference of 0.135, while the standard estimate of the difference is 0.099, a ratio of 1.36.)

In some frames, what was identified as red water by aerial observers imaged black or purple on the positive transparencies. This effect was visible only on those days when turbidity was very high. A measurement of density differences for these black or purple image points reveals variations between "clear" and "black" water on the order of 0.1 optical density units. The largest difference between the black and clear water is in the red band, with the black water (*i.e.*, "red water") having the higher density (less light transmitted thru the film). This is not the expected result as algae should have increased the reflection (lower densities) in the red band (see Clarke *et al.*, 1970; Bukata *et al.*, 1974; and Suits, 1973). The explanation of this finding may lie in the fact that sediment has a generally flat spectral reflectance, and very high sediment loads would be expected to produce the maximum reflectance possible. We hypothesize that in the "black" water areas, algal absorption reduced the reflectance from the maximum reflectance caused by suspended sediment.

In summary, red water can sometimes be discriminated from clear water in any one frame. Consequently, boundaries of red water in the York River can sometimes be mapped using aerial photography with High-Speed Ektachrome film. With respect to quantitative measurements, density readings over several frames have not been adequately investigated, but it appears that

conclusions drawn from density measurements are unreliable without further technical refinement. Thus, algal concentrations cannot, at present, be determined using this technique.

#### Biological Identification

A biological analysis of the water samples collected during the August, 1976 study reveals that the red water bloom was primarily a bloom of Gymnodinium splendens, along with several other dinoflagellates.

APPENDIX C  
LETTERS AND REPORTS INVOLVING USERS

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MAY 17 1976

District Engineer  
Baltimore District, Corps of Engineers  
Post Office Box 1715  
Baltimore, Maryland 21203

Dear Sir:

The U. S. Fish and Wildlife Service has revised WABOP-7/4 (Dumfries, Town of) 76-145, Public Notice No. 118, dated 3 March 1976. The applicant has requested a permit to dredge 97,700 cubic yards of material from Quantico Creek, at Dumfries, Prince William County, Virginia. The proposed spoil area is landward of the proposed dike adjacent to the channel. This letter constitutes the report of the Service and the Department of the Interior on the application, submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U. S. C. 661 et seq.).

An on-site inspection of the project area, May 11, 1976, revealed that a portion of the upstream project area has been previously channelized and is presently confined by dikes on both sides. The proposed downstream project area is a freshwater marsh vegetated with arrow-arum (Peltandra virginica), spatterdock (Najas lutra), saltmarsh bullrush (Scirpus robustus) and several other wetland species including American lotus (Nelumbo lutea). American lotus is rarely found in this area of Virginia. Wildlife utilization of the project area is evidenced by beaver cuttings, raccoon tracks, muskrat runs and numerous wading birds observed feeding on the marshes. Conversations with fishermen at the project area reveal a limited run of herring occurred in Quantico Creek this year. The area is heavily fished for carp, catfish and sunfishes by sport fishermen.

Implementation of this project, as proposed, would result in the direct loss of marsh and shallow bottom habitat by dredging, dike construction and spoil disposal. In addition, the proposed dikes would impound marsh areas or alter drainage patterns such that their productive capabilities would significantly change. These wetlands provide the habitat necessary

Discussed  
changes with  
Phil Au  
5/13

AEV SOUTHERN AREA OFFICE

AEV SOUTHERN AREA OFFICE



# Incorporated Town of Dumfries

CHARTERED 1749  
DUMFRIES, VIRGINIA 22026

TELEPHONE 22-1100  
6/3/76  
AEV

June 3, 1976

Department of the Interior  
Fish and Wildlife Service  
Post Office & Courthouse Building  
Boston, Massachusetts 02109

Attention: Acting Regional Director

Gentlemen:

The Dumfries Town Council on behalf of it's citizens are most concerned with the unfavorable stand the U. S. Fish and Wildlife Service has taken concerning dredging of Quantico Creek.

Flooding in the town has been a long-time problem for it's citizens and is continually getting worse. We would be most appreciative if we could meet with the service biologist from the Annapolis Field Office, at their convenience, to discuss this urgent problem and hopefully reach a mutual solution for dredging Quantico Creek.

Sincerely yours,

*Paul B. Clary*  
Paul B. Clary  
Mayor, Town of Dumfries

cc: Department of the Army

Regional Director, AEV, Boston, MA

June 23, 1976

Supervisor, ES, SAO

Mayor of Dumfries

We have contacted Mr. Clary and scheduled a meeting June 29. Jim Oland will represent this office.

Philip B. Aus

DIVISION OF ECOLOGICAL SERVICES  
1825B Virginia Street  
Annapolis, Maryland 21401

July 12, 1976

District Engineer  
Baltimore District, Corps of Engineers  
Post Office Box 1715  
Baltimore, MD 21203

ATTN: HAB-P-7/4 (Dumfries, Town of)  
76-145, Public Notice #116

Dear Sir:

In response to the June 3, 1976 request from Mayor Gary of Dumfries, Virginia, representatives of the U. S. Fish and Wildlife Service met on-site with town representatives June 29, 1976. The purpose of this meeting was to review the situation of Dumfries with the goal of finding an environmentally acceptable solution to the flooding problems.

Site inspection revealed that the major problems occur at the aerial sewer line crossing and the area just down stream of this crossing. Existing conditions at the sewer line crossing are such that the water level of Quantico Creek is nearly touching the base of the pipe. Large quantities of debris have collected upstream of this pipe and its support piles. The debris would act as a dam during high runoff periods. Just below the sewer line crossing, the creek divides into several small streams running through a low wooded area. These streams flow into the tidal marshes of Quantico Creek.

Removal of the damming effect of the aerial sewer line and establishment of a free flow from the upstream area to the tidal portion of the creek should provide the desired flood control benefits without unnecessary environmental degradation. This Service, therefore, recommends that the project plans be modified to provide that:

1. blockage of the stream by the aerial sewer line and its support piles is eliminated, and
2. the channelization as proposed extend no further downstream than 1,426 feet from the outfall of the sewage treatment plant.

REPRODUCIBILITY OF THE  
ORIGINAL PAGE IS POOR

umber one above could be accomplished by elevating the line above flood level or placing it under the streambed.

Please advise this office of any further action regarding this project.

Sincerely yours.

**Ralph C. Pisapia**

Ralph C. Pisapia  
Acting Supervisor  
Southern Area Office

cc AEV, Boston, MA  
DIR, Annapolis, MD  
EPA, Philadelphia, PA  
EMFS, Oxford, MD  
EMFS, Gloucester, MA  
Town of Dumfries, Dumfries, VA

SAG/BLAND/LEACHMAN/PISAPIA:jf1:7-12-76  
31410-1120-430

UNITED STATES GOVERNMENT

# Memorandum

TO : Hayden Gordon, VIMS, Gloucester Point, VA

DATE: August 3, 1976

FROM : Jim Oland, FWS, Annapolis, MD

SUBJECT: Use of Remote Sensing for Project Evaluation at Town of Dumfries, on  
Quantico Creek, Virginia

Enclosed are pertinent correspondence from our files regarding the subject project. Our initial field evaluation determined that the proposed project would result in the loss of an undetermined quantity of marsh and alteration of drainage patterns. Thus, our recommendation for permit denial was based on unquantifiable environmental degradation. Subsequent to issuing our recommendation for denial, we met with the Town representatives and obtained copies of their engineering drawings.

Prior to formulating recommendations for an "acceptable" project, we viewed the aerial photography and engineering overlays of the project area at VIMS. The use of this photography allowed us to make a rapid determination of the extent of work necessary to accomplish the project purpose and the environmental features which would be altered or destroyed by various project alternatives. Recommendation number two in our letter dated July 12, 1976 was based largely on the information gained from the aerial photography in conjunction with field investigation.

Final resolution of the situation at Dumfries has not yet been made. If additional alternatives are proposed by the town, we would expect to utilize the remote sensing at VIMS for further analysis of potential environmental impact. In addition, we expect to find the remote sensing information at VIMS beneficial in our evaluation of other proposed and future projects.

  
Jim Oland

Enclosure



5010-110

*Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan*

Comments of  
VIRGINIA INSTITUTE OF MARINE SCIENCE  
on the  
Disposal of Spoil  
from

Tangier Island Channel Dredging

December 9, 1976

The spoil disposal problem from maintenance dredging of the east and west approach channel to Tangier Island must be viewed as a long-term as well as an immediate problem. In addition, the problem must be considered in the light of the existing severe erosion problem on the western shore of the island and the need for solutions to the problems of sewage treatment and disposal as well as solid waste disposal. Finally, we must be mindful of the unique cultural and physiographic characteristics of Tangier Island and the fact that the people of Tangier need suitable living and work space.

Up to the present time, dredge spoil disposal for the two channel projects has been on marshes adjacent to the channels. The principal spoil site, East Point Marsh, is under private ownership and no longer available. Those on the island to the north (North Tangier) are owned by the county and remain available.

Based upon the above considerations, the information available to us concerning the proposed disposal sites, the characteristics of the material to be dredged and disposed of and the engineering requirements of the containment areas, we offer the following analysis of the options and recommendations concerning disposal of the materials to be dredged from the East Channel.

The possible disposal sites which have been considered by the various agencies to one degree or another are:

1.) Overboard disposal in Tangier Sound.

Although this disposal route was approved by EPA, the Virginia Marine Resources Commission objected due to their concern that it would impact the oyster replenishment program. VIMS itself prefers, as a matter of policy, that spoil be used as constructively as possible and that it not be placed overboard within Chesapeake Bay except where such disposal is the most feasible option--preferably the only option.

2.) Previous disposal sites on the north island of Tangier. These sites remain as an open option for the Corps.

3.) Sites 1, 2, 3, 4 and 5 on the south island of Tangier (see Figure 1).

a.) Site 1 - This site is located behind the new seawall at the south end of the runway. Present plans call for using this site for disposal of material dredged ( 40,000 cu. yds.) from the West approach channel.

b.) Site 2 - This site is located on the western side of the runway. The extent of the site has not been specified in detail, but it could be as large as 17 to 20 acres depending on design and material volumes. The total marsh area west of the runway is about 43 acres. Utilization of this site is preferred by the Town of Tangier since it is here that they plan development of outdoor recreational facilities and the foundation for a proposed (but yet to be approved) sewage treatment plant. The generalized site desired by the town for the recreational field is shown shaded in blue in Figure 1.

Tangier Island Comments

Page 4

December 9, 1976

- c.) Site 3 - This site is located between the runway and West Ridge and it is about 18 acres in area.
- d.) Site 4 - This site, unspecified in area, is between the West and Main Ridges.
- e.) Site 5 - This site was examined early by the Corps but removed from consideration due to its small size and marginal efficiency when using hydraulic dredging. This marsh now serves as the landfill site (western edge) for solid waste disposal.

We shall narrow our attention to Sites 2, 3, 4 and 5 since overboard disposal has been rejected by VMRC and Site 1 is allocated for spoil from the West Channel. The sites on the north island are uncontested and remain open to the Corps should a site with constructive utilization of spoil be unattainable.

- 1.) Site 2 - The natural erosion rate of the west shore of Tangier Island is about 20 feet per year. The attached aerial photograph (Figure 2) shows the projected shoreline positions for 10, 20, and 30 years in the future. It is apparent that erosion prevention measures will be necessary within the next ten years if the runway is to continue in

operation. It is also apparent that all of the viable marsh at Site 2 will be lost via shoreline retreat in 20 years if erosion is not checked.

The marsh grasses of Site 2 are varied. The undisturbed portion north of the wind "sock" (about 16 acres) is much more valuable than that to the south of the wind "sock" from the viewpoint of productivity. At the present time, the marshes here have good tidal communication which results in uninhibited export of marsh grass detritus.

2.) Site 3 - This area is a poorly drained, stagnant marsh with very few biological values. The poor drainage is due to the existence of the runway which means the only tidal communication is via a very small drain parallel to the south end of the runway. Tidal flooding occurs only during extreme tides. Unless extraordinary measures are taken to preserve the limited existing drainage, it is likely that Site 3 will become totally isolated from tidal exchange due to the spoil disposal and engineering activities at Site 1.

3.) Site 4 - In spite of the fact that this area has been used for solid waste disposal by individuals, it remains a productive marsh site with good tidal

communication. Earlier in the island's history, ditches were cut to the houses of Main Ridge so that fuel and supplies could be delivered. These channels are still serviceable for small boat storage and passage.

- 4.) Site 5 - This area is a mixed species community composed of the grasses found in the southern and northern areas of Site 2. As previously mentioned the western bank is used as a site for solid waste disposal. The total area is about 4.5 acres which is surrounded on three sides by higher land which is formed mainly by dredge spoil.

To summarize the biological evaluation, we consider Site 3 to be the least valuable from the point of view of biological productivity and contribution to the overall ecosystem and the southern portion of Site 2 and Site 5 to be middle ranked. The undisturbed northern portion of Site 2 and Site 4 are the highest ranked of the sites.

From the long-term point of view, we would designate Site 3, Site 5, and Site 2 as spoil disposal areas. This suggestion is based on the position that as long as marsh is being used as disposal sites, every effort should be made to make constructive use of the spoil. The rationale for designating Site 3 is that

December 9, 1976

it is now a compromised site and it is likely to be further compromised by the disposal at Site 1.

Site 2 however, about 45 acres in extent (of which 6 acres are spoil), should not have any large scale disposal until the rampant shoreline erosion has been stopped or until a positive plan for protection has been approved with funding identified.

Since protection of the western face of the west ridge is of paramount importance, it is a matter of considerable urgency since reliable predictions are that a major part of West Ridge, including many of the public and private improvements thereon as well as the wetlands, will be marked away in successive steps over the next 20 or 30 years (see Figure 2). The recommendations of the Task Force Report for a stone seawall should be followed. The rationale for the use of Site 2, and the qualifier concerning erosion protection, is as follows:

- 1.) Although the sewage treatment plant site has not yet been approved, the suggested site is the most reasonable with respect to economic and environmental considerations. Placement at that site would involve the loss of at least 5 acres of marsh. Protection of the shoreline must be included in this plan. Approximately 1,200 feet of protection would be required for the treatment plant. The layout is shown in Figure 1.

We note that the plan for the treatment plant (Tangier Island, Step 1 Study, Project No. 68-0774 SR by Shore Engineering, Melfa) includes provision of 400 ft. of shoreline protection.

- 2.) At the present rate of erosion, the runway will be lost within ten years unless the new seawall section at the end of the runway is extended by 1,400 feet to the north (Figures 1 and 2).
- 3.) Since the steps required in 1 and 2 would sever tidal communication to the marsh south of the wind "sock" the biological vitality and values would be lost in any event. Subsequent filling of this marsh acreage would be justified in terms of enhancing the integrity of the seawall as well as to prevent stagnant conditions.
- 4.) The shoreline protection which will be required in a) and b) would entail riprapping 2,600 feet of the 4,400 feet of shore north of the existing seawall. In order to prevent flanking at the north end of the riprap required for the treatment plant, sound engineering design would call for

completion of the seawall to the entrance of the west channel.

Given the unique circumstances of Tangier Island, we feel that filling of the zone north of the wind "sock" (about 16 acres) subsequent to installation of adequate shoreline protection as presented by the Task Force referred to above would be justified (after filling the area to the south of the wind "sock").

The reason we cannot endorse large scale disposal of dredge material on Site 2 prior to shoreline stabilization is that without such stabilization the material will be refluxed to the marine environment as the shoreline retreats. Much of the eroded material would simply recycle back into the Tangier channels and harbor. This is due to the fact that the material in the east channel is composed of about 40 to 50 percent silt/clay and most of the sand fraction is fine sand (as opposed to coarse). In our opinion, the addition of this type of material to Site 2 would not make a significant contribution to the inhibition of the erosion rate.

On November 16th, members of the VIMS review team met with representatives of the Norfolk Corps of Engineers to discuss and review the factors of the case. They advise us that about 125,000 cubic yards of material will be removed from the channel. As previously indicated their rather sparse information on grain size characteristics indicates that 40 to 50

percent of the material is in the silt/clay range and that most of the sand fraction is fine sand. In their preliminary evaluation of Site 3, the Corps determined that 17 acres would be required with a dike height of 8 feet or greater and a fill elevation of 6 feet above ground level. The Corps has expressed concern about the consequences of dike failure (if filled to the 6-foot elevation) since the fill elevation would then be several feet higher than the West Ridge and a few feet higher than the runway.

The dredged material would be introduced at the north end with the fluids spillway on the south end. In the normal settling, the sand fraction would remain, for the most part, near the discharge with the silts settling away from the discharge. The town administration expressed concern about the drainage in the area since the Ridge would be at a lower elevation. However, the Corps advises that they would have drainage around the periphery of the dike.

At that meeting, the possibility of using both Sites 3 and portions of Site 2 were discussed with a view toward the most constructive use of the spoil while minimizing the impact on the marshes. The Corps indicates that this approach would permit using a lower dike elevation at Site 3 (dike height of about 6 feet with fill elevation to 4 feet above ground level). The areal requirement at Site 2 would then be about 5 acres. Moreover, they indicate that it would be possible to install a

Y in the discharge system so that when relatively clean sand was encountered, it could be shunted to Site 2. This would emplace the higher quality (and more readily usable) material at Site 2.

It should be noted that the Corps of Engineers had not performed detailed engineering studies of any of the sites on the south island of Tangier and that their estimates of the volumes removed are based upon surveys of April 1976. Presumably more complete information will be available after designation of the spoil sites.

Moreover, there are formal restrictions on penetration of runway air space by the FAA which must be considered. These restrictions (subject to waiver) for Tangier are as follows:

- 1.) No obstacles may penetrate the plane coincident with that of the runway elevation (6.4 feet above MLW) for a distance of 212 feet on either side of the runway and within 200 feet at the north end of the runway. This boundary is shown in red in Figure 1.
- 2.) At the limit of the above boundary no obstacles may penetrate the plane inclined at a slope of 1 in 7 extending to a height of 150 feet. Thus, at a distance of 14 feet from the aforementioned boundary (in red) a dike 2 feet higher

than the runway would be permitted; at a distance of 28 feet a dike 4 feet higher than the runway would be permitted.

Inspection of Figure 1 shows that more than one-half of Site 3 falls within the restricted zone as does most of the area desired by the town for the recreational facility.

With the above as background we offer the following recommendations for the immediate disposal problem:

#### Recommendation I

We recommend that temporary waivers be requested from the FAA to permit the penetration of temporary earth dikes higher than the runway elevation. Conversations with the Corps indicates a 90-day waiver would probably suffice for construction, filling and initial dewatering following which the dike elevations could be graded to conformity with the regulations. If waiver can be secured then our recommendation is that:

- A.) That Site 3 be utilized as the principal site with any limitations imposed by the Virginia Airport Authority. Part of this should include an engineering evaluation of the effect of possible lateral displacement of the marsh substrate due to

overburden pressure and consequent movements of the foundations of the runway and the homes on West Ridge. Existing boring logs from the Airport Authority indicate the marsh horizon is only several feet thick and that it contains appreciable fine sand. Under these conditions, we do not expect the problem to be severe, but it must be explicitly examined.

In the course of filling this area, the northern end of the site would contain the sand fractions and would be the earliest usable acreage in this site. In passing, it might be noted that this area should also be evaluated by the town for its recreational facility.

- B.) That portions of Site 2 be used for disposal of the remainder of the material (Figure 1) utilizing a Y shunt to permit the use of the higher quality material. To the extent possible, the existing spoil areas on the north and immediate west of the runway should be increased in elevation. The fill should not extend beyond the zone marked in Figure 1 which will preserve the present tidal communication in the system. The delineated configuration will supply the area estimated by

the Corps. Approximately one-half of the area has already been disturbed by previous spoil activities.

As noted earlier, the above combination would require dike elevations in Site 3 which would penetrate above the runway elevation by 2 to 3 feet. The ground elevation of Site 3 is about 2 feet (MLW). Thus a 6 to 7 ft. dike added to that would penetrate the runway elevation (6.4 ft., MLW) by 2 to 3 feet.

#### Recommendation II

The Corps of Engineers has advised us that Site 3 would not be a suitable site for disposal if a FAA waiver cannot be obtained. They explain that this is due to the fact that the resulting containment volume would be so small that they would not achieve adequate settling of the finer grained materials. If the appropriate waiver cannot be obtained we recommend the following course of action provided a positive plan for protection of the entire south island western shoreline is approved with construction scheduled within 3 to 5 years after spoil disposal:

- A.) Use approximately 16 acres of Site 2. The boundaries shown in Figure 1 include about 16 acres with a fringe of undisturbed marsh which is allocated as a buffer so that the spoil will not be refluxed

into the marine environment prior to stabilization of the shoreline.

Although this plan would supply fill for the sewage treatment plant site we suggest that verification be obtained from engineers familiar with such plants that this fill is suitable for the purpose. If it is not, then filling in this location should be deferred and the spoil from the pending dredging should be placed on the north island sites behind suitable dikes.

B.) A request should be made to the Corps of Engineers to reconsider Site 5 as a disposal site for emplacement of the sandy spoil. If this site could be used then the town could transfer the material, when dry, to the area desired for the recreational facility.

C.) The remainder of the material should be placed in the sites on the north island, suitably diked.

#### Recommendation III

If a FAA waiver cannot be obtained to permit the plan of Recommendation I and no positive plan can be developed for shoreline stabilization (Recommendation II) we then recommend:

- A.) That the Corps of Engineers be requested to reconsider Site 5 as a disposal site for emplacement of the sandy spoil so that the town could transfer the material, when dry, to the area desired for the recreational facility.
- B.) That the remainder of the dredged material be emplaced on the previously used sites on the north island behind suitable dikes.

Our proposed solutions will, in our opinions, permit the constructive use of the spoil in this unique situation while avoiding unnecessary destruction of the marshes or refluxing the dredged material to the marine environment.



# COMMONWEALTH of VIRGINIA

## Virginia Institute of Marine Science

Gloucester Point, Virginia 23062

March 2, 1977

WILLIAM J. HARGIS, JR.  
DIRECTOR

Phone: (804) 642-2111

Mr. Zane M. Goodwin  
Chief, Engineering Division  
Department of the Army  
Norfolk District, Corps of Engineers  
803 Front Street  
Norfolk, Virginia 23510

Dear Mr. Goodwin:

I am writing in response to your letter of 10 February 1977 regarding the proposed dredging of the east channel to Tangier Sound in which the Corps proposal for employing a contingency overboard disposal site is presented. We concur with Mr. S. M. Rogers of the VMRC that upland disposal of all the material is favored. As you recall from our report, the Institute, as a matter of policy, is opposed to overboard disposal except as a last resort.

It is distressing to note that, at this late date, there is now concern about the suitability of the on-site material for levee construction at the upland sites near the airport (site designation 1 and 2 in your letter). You state in your letter that if adequate levees cannot be constructed or if their height is restricted by airport regulations, you propose to employ some "limited" overboard disposal in order to complete the dredging. I presume you mean thereby that such restrictions, either suitability of material or airspace requirements, would mean reducing the elevation of the levees with the consequent requirement for additional spoil area.

In the light of the uncertainty of the suitability of the on-site material adjacent to the airport for levee construction, we offer the following recommendations which are consistent with those contained in our report dated 9 December 1976 and with the needs and wishes of the residents of Tangier as we understand them.

- 1) If, because of engineering restrictions or airspace restrictions, the levee heights at the

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sites adjacent to the airport (sites 1 and 2) must be reduced and more spoil area is needed, then we recommend enlarging site 2 to the south parallel to the runway to accommodate the additional needs for area. We would also recommend use of our site 5 for this purpose; with appropriate levees, of course. The cautions and conditions noted in our request of 9 December 1976 should be attended to.

- 2) If your further evaluation indicates that sites 1 and 2 cannot be used at all due to the unsuitability of the material for levees, then we recommend that the previously used spoil areas on the north island group be utilized with suitable diking.
- 3) If the north island sites, suitably diked, do not offer sufficient area for disposal, or if that alternative is not available, then we would reluctantly acquiesce to the use of your overboard site designated number 3 if the following efforts for containment are utilized:
  - a. If this does not provide enough space to receive the excess spoil, then the small gut connecting Toms Gut and Oyster Creek Gut should be sealed with a dike so as to prevent possible deposition of silts and clays at the mouth of that gut where crab peeler pens are located.
  - b. A sediment curtain should be placed across the northern end of the cul de sac to minimize loss of sediment from the area.

We recommend no further consideration of site 4, as there is no natural containment, and the exposure to wave action in Tangier Sound would result in resuspension of the dredge spoil materials.

We wish to reiterate that we see no good reason at this point to justify overboard disposal which will cover productive shallow and adjacent shoreline areas. If additional volume is needed, should your site 1 and 2 be insufficient because of restrictions (of any sort) on levee construction, site 2 can be enlarged southward. If this is not possible, but sites 1 and 2 can be used for part of it, a diked upland area on one of the previously used north islands should be used. If site 1 and 2 cannot be used at all we recommend upland disposal on the north

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island group - with dikes of course. Only if these are not possible at all would we not object to overboard disposal in site 3, with appropriate precautions.

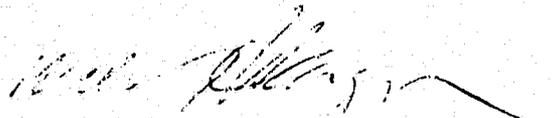
It must be especially noted again that the north islands have all been used for spoil disposal in the past! It would be difficult to understand at this point why they cannot be so used again. Unless we misunderstand the situation we see little economic reason why the north island site or sites cannot be used in preference to overboard disposal in site 3. The distance is the same and precautions are necessary in either case.

Furthermore, overboard disposal will destroy presently unaltered natural shorelines and bottoms. Also sediments will be washed into adjacent areas eventually even with the use of sediment curtains. The impact from diked upland disposal on the north islands would be much smaller.

We appreciate your calling on us for our scientific opinions and recommendations on this project and are pleased to render them.

We would respectfully urge that the project go forward according to the original recommendations as it is extremely important to the people of Tangier and Accomac County.

Sincerely yours,



William J. Hargis, Jr.  
Director

WJHJr:trw

cc: Dr. Robert Byrne  
Mr. Thomas Barnard