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Index of existing data sources for Chincoteague, Sinepuxent, Assawoman and Little Assawoman Bays : report to the Maryland Department of Natural Resources

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Index of Existing Data Sources for Chincoteague, Sinepuxent, Assawoman and Little Assawoman Bays

by

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Report to the Maryland Department of Natural Resources

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Acknowledgements

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ABSTRACT

Available data on the Chincoteague - Assawoman Bay system have been reviewed, indexed and summarized. Water quality data (including sources), other biological studies, hydrographic data, geological data and socio-economic studies are included.

I. Introduction

In order to project future water quality conditions, the existing conditions and future growth patterns must be known. This report is an attempt to document existing data sources relevant to the water quality in the Chincoteague/ Sinepuxent/Assawoman Bay system. Water quality data, point source pollution discharges, biological studies, hydrographic data, geological data, and socio-economic studies are included. This study plus others will eventually be used for undertaking waste load allocation for this area.

The Bay system is formed by the Delmarva Peninsula on the west and a barrier island complex to the east (Figure 1). The Bay system is about 45 miles long but rarely more than 5 miles wide. The water throughout the system is shallow and turbid. Ocean water enters the Bay system through two inlets, Ocean City Inlet and Chincoteague. Tidal circulation is weak, except near the inlets. Tide range is reduced substantially in the Bay system from a mean range of 3.4 feet at Ocean City Inlet and 2.6 feet at Chincoteague Inlet to less than 1.0 foot in Chincoteague Bay. Due to the small drainage area for the Bays freshwater inflow is relatively small.

Little synoptic water quality data are available throughout the Bay system although the State of Maryland has conducted some localized water quality surveys and does regularly monitor a few stations bimonthly. Some water

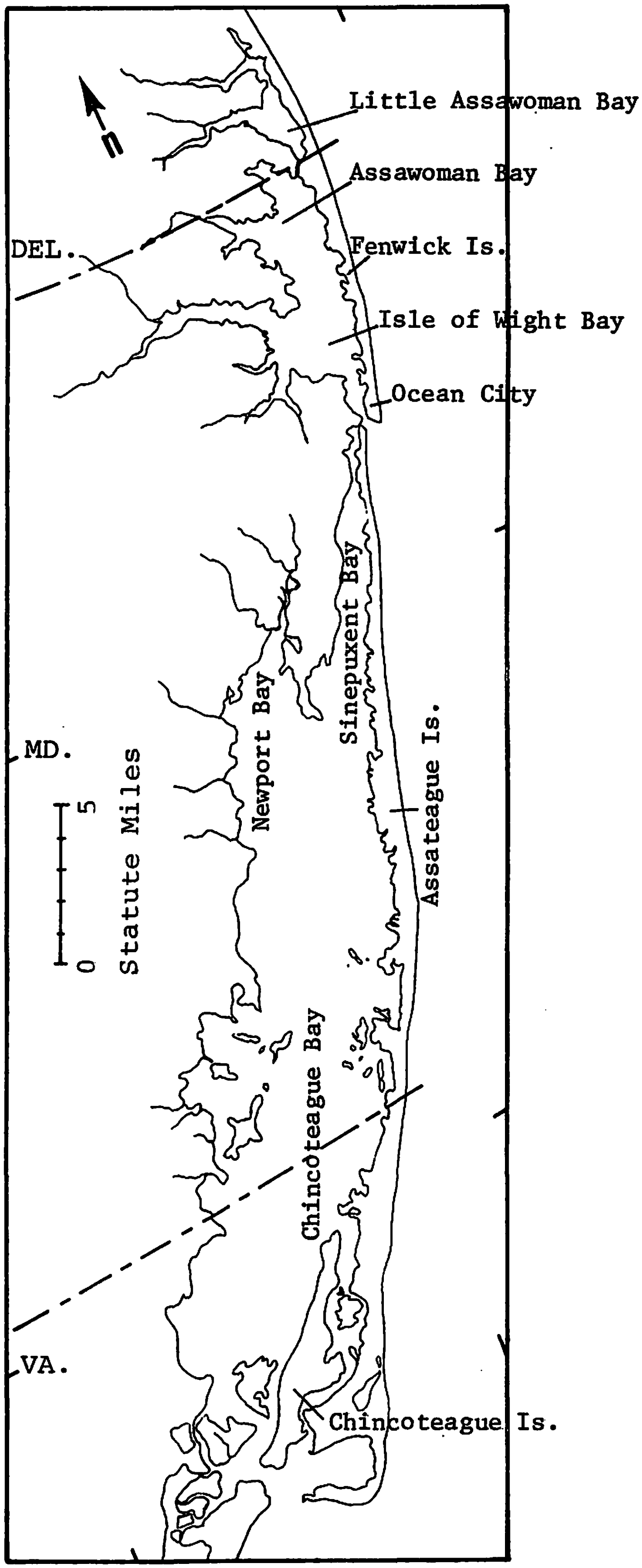


Figure 1. Map of study area.

quality degradation in several tributaries to the Bay system is noticeable although the overall water quality of the Bays is considered good.

Socio-economically, this rural area depends heavily on agriculture, fishing and tourism. This latter category has been responsible for rapid growth near Ocean City and the National Seashore. The complex of agriculture, processing plants for agricultural products, tourist facilities and permanent domiciles leads to a variety of point and non-point sources.

II. Water Quality Studies

A. Pollutional Sources

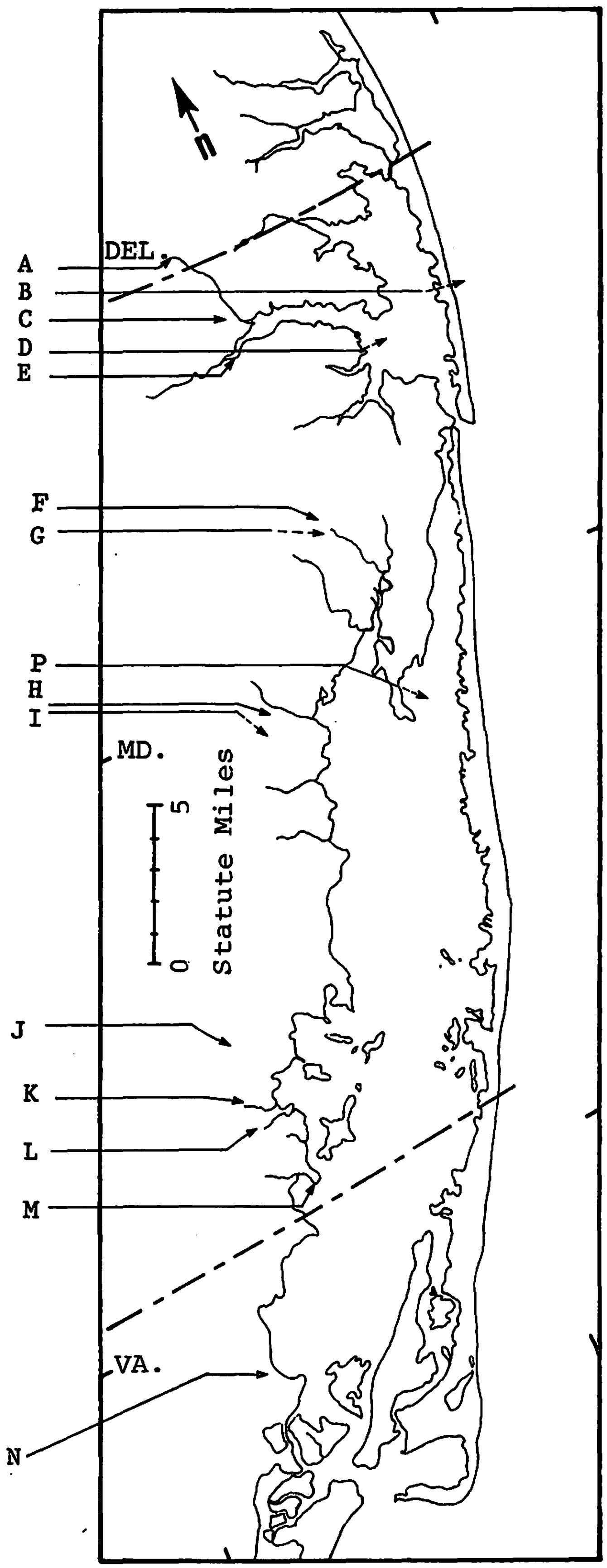
The drainage basin of Chincoteague and Assawoman Bays is relatively rural, but has significant recreational and commercial seafood processing activities. Therefore several categories of pollution sources need to be considered.

1. Point-Source Loadings

In Virginia, the only significant sewage treatment plant is at Wallops Station, with a flow of 120,000 gpd, almost entirely domestic. Two laundromats and two seafood processors on Chincoteague Island discharge untreated wastewater into Chincoteague Channel. Some public buildings in the town of Chincoteague remove their waste regularly by pumping and transport it to the Wallops plant. There are several Maryland treatment plants, and five in Delaware (one management, three private trailer parks and a condominium). Figure 2 shows the significant wastewater sources in the study area. Table 1 tabulates the industrial point sources in Maryland, including a notation as to which are in compliance with existing regulations and those which are not. (Md. Dept. of Natural Resources, 1974). Table 2 lists the effluent loadings of the municipal treatment plants in the study area.

2. Runoff (non-point sources)

The drainage basin of Chincoteague Bay is small, flat and relatively rural. Therefore runoff would be small



A. Selbyville STP
B. Ocean City STP
C. Bishop Processing Co.
D. Ocean Pines STP
E. Showell Poultry
F. Beatrice Food Inc.
F. Eastern Animal Food
F. Berlin Milling
F. Chesapeake Foods, Inc.
F. Ocean City Golf & Yacht Club
F. Sunshine Laundry
F. Powell Sand & Gravel
G. Berlin STP
H. Ralph Mason Canning Co.
I. Newark STP
J. Brimmer & Jones
J. Chincoteague Oyster
J. Leslie Webb & Co.
J. W. T. Onley
K. Golden Pride (P&L Poultry)
L. Berlin Milling
M. Greenback Canning
N. Wallops Station STP
P. Assateague National Seashore STP

Figure 2. Wastewater Sources in Study Area.

Table 1

Significant Industrial Point Sources in Maryland

Source	Location	Receiving Water	Existing Treatment
<u>In compliance with laws & regulations</u>			
Chesapeake Foods	Berlin	Kitts Branch	Biological stabilization
Eastern Animal Foods, Inc.	Berlin	Kitts Branch	Biological stabilization
P&L Poultry Processors, Inc.	Stockton	Pikes Creek	Biological stabilization
Ralph L. Mason Canning Co.	Newark	None	Land disposal (treatment facilities under design)
Ralston Purina	Berlin	Kitts Branch	Biological stabilization
Showell Poultry	Showell	Shingle Landing Prong	Biological stabilization
<u>Not in compliance</u>			
Milbourne Oyster	Stockton	Pikes Creek	Primary
Martin Fish	Ocean Pines	Isle of Wight Bay	None

Table 2

Municipal Waste Treatment Plants
in Chincoteague-Assawoman Watershed

Location	Receiving Stream	Avg. BOD/5 Loading (lb/day)
Wallops Station	Little Mosquito Creek	10
Berlin	Bottle Br.-Trappe Cr.	62.6
Newark	Marshall Creek	No discharge yet
Ocean City	Atlantic Ocean	2870
National Sea-shore Hdq.	Sinepuxent Bay	0.6
Ocean Pines	Isle of Wight Bay	11.2
Selbysville	Bunting's Branch	290*

* NPDES Limit

and would tend to seep into the ground locally before running off. The only significant population centers in the study are Chincoteague, Virginia and Ocean City, Maryland.

3. Sanitary Landfills

Chincoteague Island has two sanitary landfills and a promiscuous dump. The landfills are located on well-drained land having a high percolation rate. Maryland localities have five dumps or landfills but are moving toward the establishment of two sanitary landfill sites. The currently existing dumps within the Chincoteague Assawoman Drainage Basin are:

a. Ocean City - Lewis Road
b. Berlin - Flower Street
c. Girdletree - Byrd Hill Road

Because of the nature of these dumps, no estimate is available of present input. These sites are presently being operated after the manner of landfills, with a covering of dirt being regularly applied over the fresh solid waste.

4. Watercraft Discharges

It is difficult to estimate the magnitude of wastes from boats, especially pleasure craft. However, boat traffic in this region is considerable. There are several marinas on both the Virginia and Maryland shores, concentrated mainly around Ocean City inlet and Chincoteague Channel. In addition both Maryland and Virginia maintain public boat ramps. Besides the obvious effect of coliform count, small craft emit engine exhaust underwater, spill fuel and oil, exude toxic metals from anti-fouling paint, and erode banks with their wake and resuspend sediments with their propeller wash.

B. Water Quality Data

1. Summary of Sources

There is no great quantity of available data for the Chincoteague Bay system. Maryland has regularly monitored its portion of the eastern shore bay system since about 1969. In addition there have been a number of special studies, some unpublished, of problem areas. These studies have been thorough, including benthic and aquatic macroflora and macrofauna as well as nutrients, chlorophyll, plankton and dissolved oxygen. A tabulation is contained in Table 3. Their findings have been summarized by Allison (1974).

The Virginia Water Control Board and Bureau of Shellfish Sanitation have only sampled occasionally for specific purposes, such as testing the coliform levels over shellfish grounds. The National Marine Fishery Service (N.M.F.S.) conducted a surf clam study in 1973 which included salinity and temperature measurements over the beds. However, the study area was along the seacoast rather than in the Bay. N.M.F.S. also monitored salinity and temperature daily at its Franklin City laboratory from 1958 to 1968. The Federal Water Pollution Control Agency sampled salinity, temperature and turbidity on one occasion at a number of sites near Chincoteague Inlet. Table 4 summarizes the available water quality data.

Table 3

Studies of Water Quality Problem Areas

Date	Stream	Agency	Investigator	Reference
1961	Trappe Creek	Md. Water Pollution Control Commission	R. J. Rubelman	Survey Report 61-6-TC
1964	Buntings Branch	Md. Water Pollution Control Commission	R. J. Rubelman	Survey Report 63-9-BB
1966	Marshall Creek	Md. Dept. of Water Resources	C. R. DeRose	
1969	Kitts Branch, Trappe Creek	Md. Dept. of Water Resources	R. V. Creter	Report No. One
1972	Sinepuxent Bay Snug Harbor	Md. Water Resources Administration	Allison & Butler	
1973	Mystic Harbor	WAPORA, Inc.	P. DeWitt	Proj. I-34 Final Report
1973	Isle of Wight	Md. Water Resources Administration	J. Allison	
1974	St. Martin River & Vicinity	Md. Marine Utilities, Inc.	Normander Associates, Inc.	Assessment of Ocean Pines Facility, Sept. '74.

Table 4

Sources of Water Quality Data

Source of Data	Variables Observed	Inclusive Dates	No. Stations	Sampling Scheme	Frequency	Remarks
C.B.I.	temp., salinity, DO, turbidity	1943-1953		various studies	irregular	various reports - see McGary, Sieling in references.
C.B.I.	nutrient, sediment, heavy metals	1975	unspecified	unspecified	unspecified	Ocean outfall efficiency study at Ocean City
Delaware Water Resources Div.	DO, BOD, coliform, ammonia, TKN, organic N, phosphates	continuing	1	surface	approx. 3/yr; irregular scheduling	
FWPCA, Middle Atlantic Region	salinity, pH, DO, suspended solids	July 14,'67	5	surface	once	"Water Quality Survey of the Eastern Shore Chesapeake Bay, Wicomico River, Pocomoke River, Nanticoke River, Marshall Creek, Bunting Branch and Chincoteague Bay" Summer 1967 Data Report.
Marine Sciences Consortium, Inc.	various projects	continuing	unspecified	unspecified	unspecified	student research
Md. Dept. of Water Resources	DO, BOD, coliform, turbidity	1967-present	varying	tributary or streams	as needed	special studies of water quality problem areas

Table 4 (cont'd)

Source of Data	Variables Observed	Inclusive Dates	No. Stations	Sampling Scheme	Frequency	Remarks
Maryland Water Resources Admin.	temp., pH, DO, salinity, organic N, ammonia, nitrate, nitrite, total P, organic P, TOC, chlorophyll "a", total iron, coliform, fecal coliform, turbidity	1973;1974	16 + tributaries	surface	once or twice/year	
Maryland Water Resources Admin.	nutrients, chlorophyll, salinity, temp.,DO	continuing	5	surface	6/year	primary network stations
NMFS	temp., salinity	1958-1968	1	surface	daily	daily monitoring at Franklin City Lab.
Va. Bureau of Shellfish Sanitation	coliform, fecal coliform, fecal strep	continuing		surface	monthly	sampling of waters over oyster grounds
Virginia State Water Control Board	temp., pH, alkalinity, DO, BOD's, total solids, suspended solids, hardness, COD, coliform, ammonia, nitrite, nitrate	1966 thru present	variable	surface	occasional	infrequent samples to study special problems

2. Important Results

The most critical parameters concerning water quality for this system are dissolved oxygen, coliform and fecal coliform bacteria as well as chlorophyll concentration. The following summary of expected values and extremes is based on several of the previously mentioned sources.

a. Dissolved Oxygen

Dissolved oxygen concentration in the open bays infrequently falls below six parts per million and almost never falls below five parts per million due to the shallowness of the systen and good vertical mixing. However, dissolved oxygen concentrations in the small streams emptying into the Bay are frequently quite low. Figure 3 (from Allison, 1974) summarizes the problem areas. This figure and the following ones for coliform and chlorophyll are for a critical low-flow period.

b. Coliform

Concentrations of coliform bacteria in the open bays are normally less than 30 per 100 ml (most probable number) and fecal coliform concentration is normally less than 20. However, the tributaries usually have coliform counts greater than 1000 and fecal coliform counts greater than 100. Individual measurements have been as high as 90 thousand and 9 thousand respectively. Figures 4 & 5 (from Allison, 1974) summarize the problem areas. High coliform concentrations in tributaries to the Bay system from point sources have caused

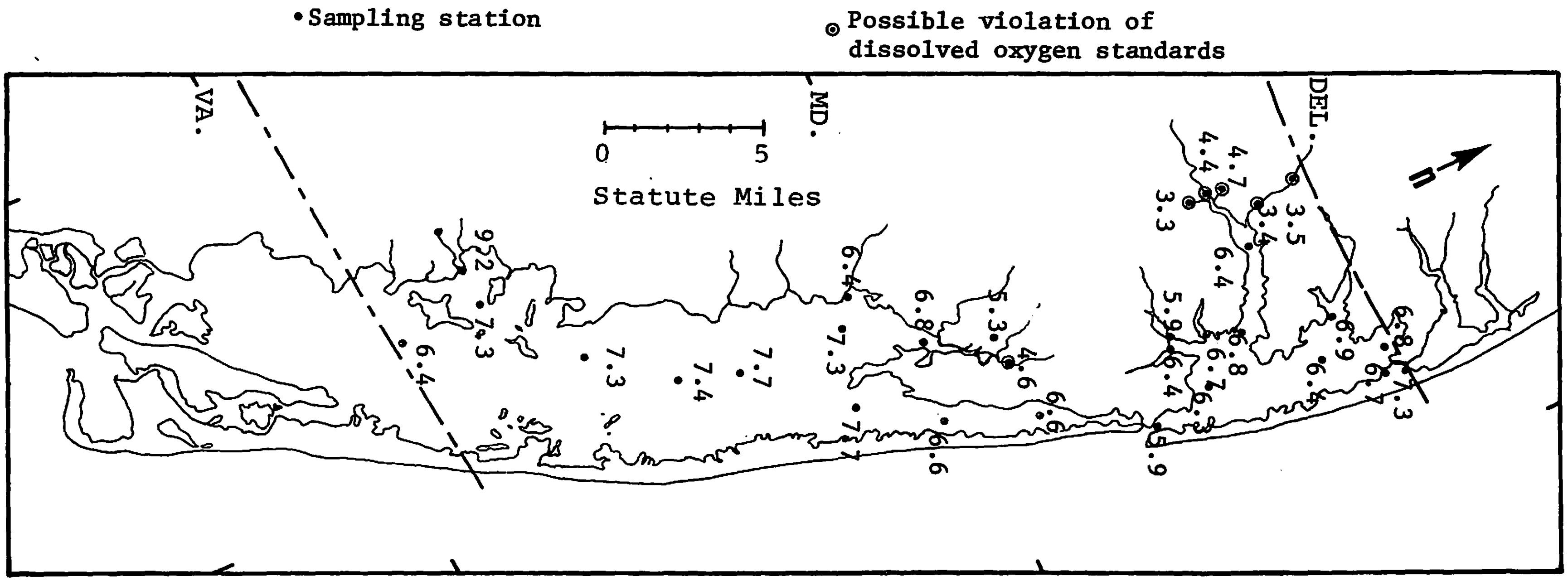


Figure 3. Observed dissolved oxygen in Maryland study area.

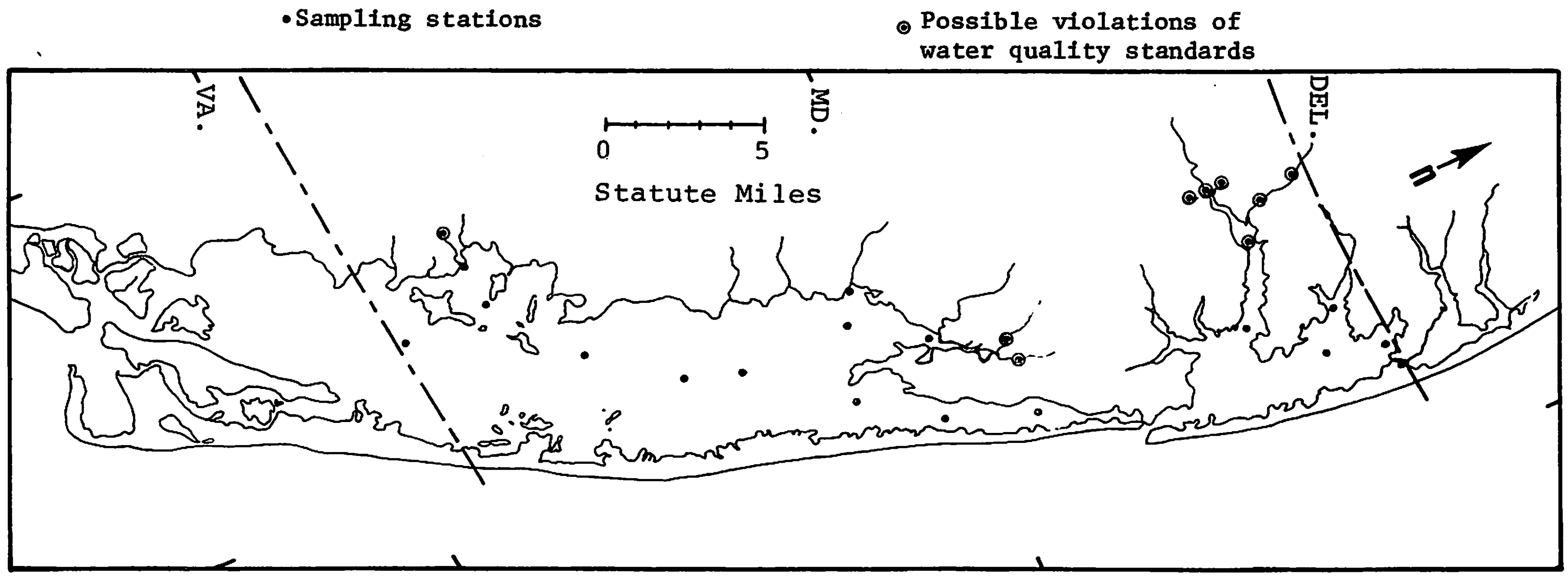


Figure 4. Observed coliform bacteria in Maryland study area.

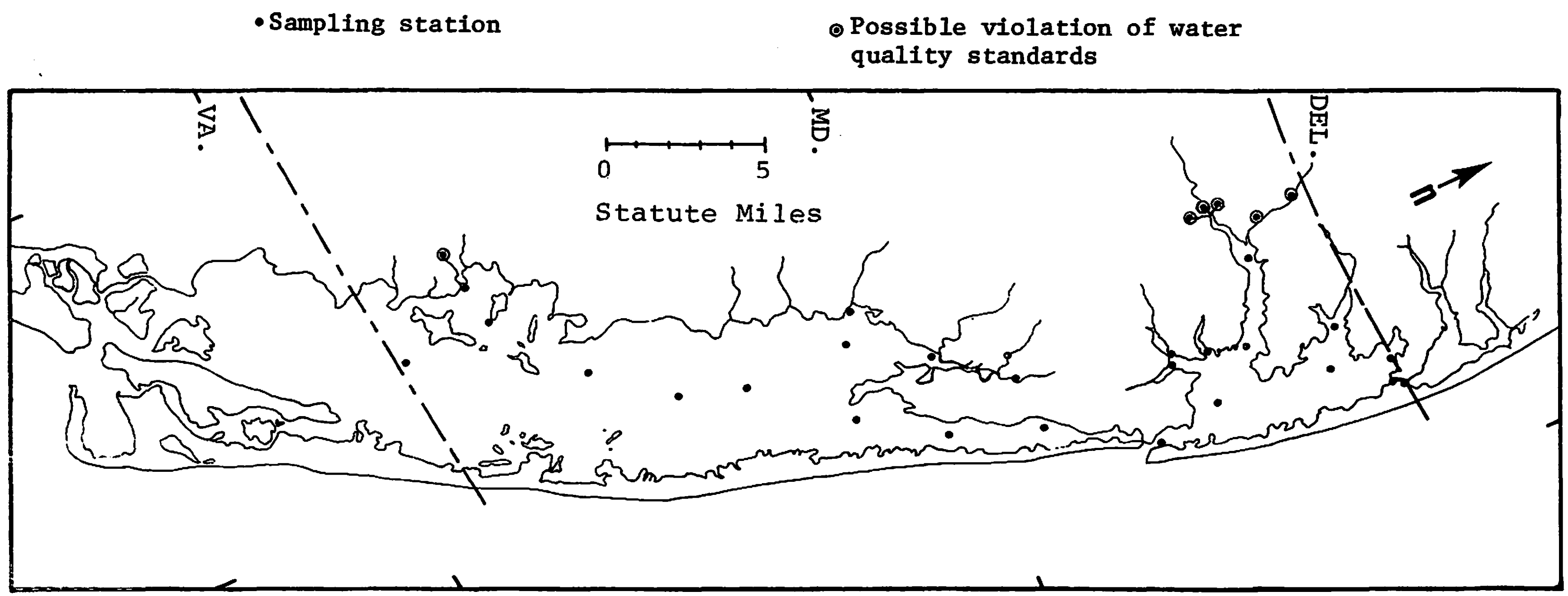


Figure 5. Observed fecal coliform in Maryland study area.

bacteriological standards to be exceeded in Newport Bay (Allison, 1974) and led to the condemnation of some shellfish grounds adjacent to Chincoteague Island (Virginia Water Control Board, 1971).

c. Chlorophyll

Chlorophyll "a" concentration in the open bays often exceeds 50 micrograms per liter (the generally accepted level for a bloom condition) but seldom reaches 100 micrograms per liter. Concentrations in the tributaries are frequently between 100 and 500. On one occasion a chlorophyll "a" concentration of 1170 micrograms per liter was observed upstream of the mouth of Pikes Creek, in Johnson Bay. Figure 6 (from Allison, 1974) summarizes the observation points.

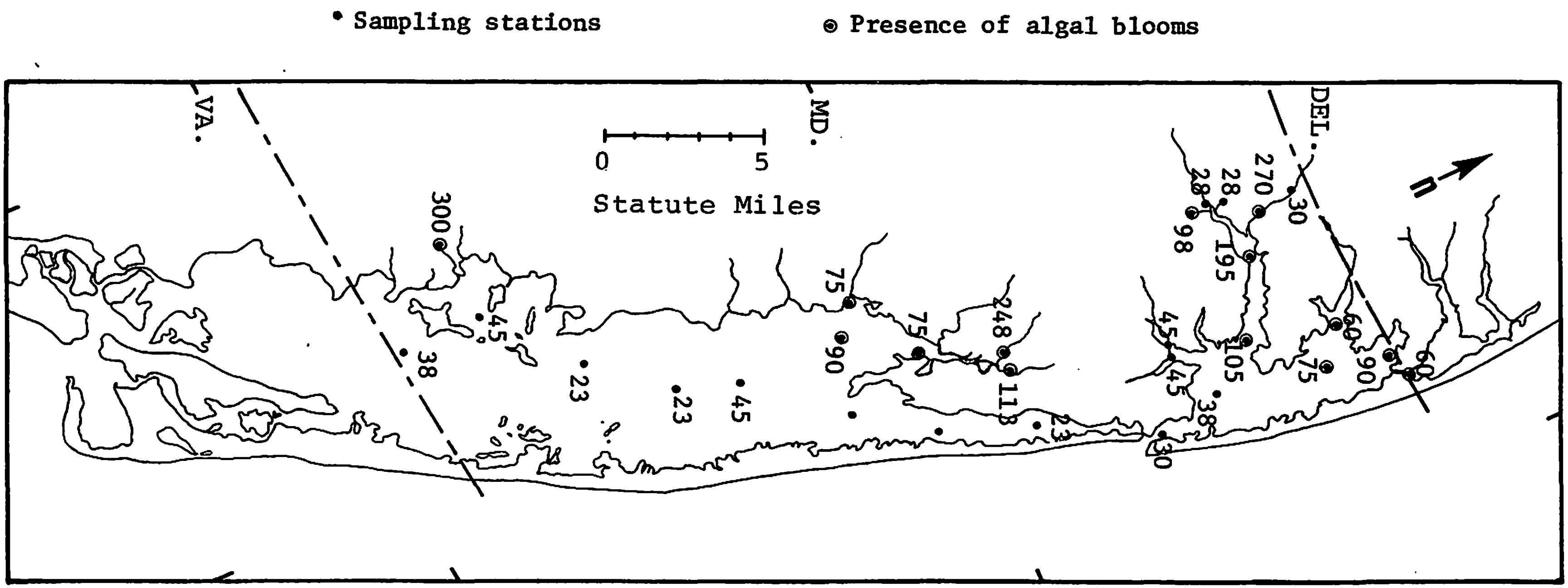


Figure 6. Observed chlorophyll "a" in Maryland study area.

III. Important Physical Parameters

A. Hydrographic Variables

Elevated water temperature influences water quality by increasing the metabolic rates of the bio-chemical processes that occur in a natural body of water and by depressing the saturation concentration of dissolved oxygen. Dissolved oxygen saturation also decreases with increased salinity. Tidal currents are important for dispersing pollutants and for generating the turbulent overturning needed to aerate the water column.

1. Temperature

Chesapeake Bay Institute (CBI) has gathered some temperature and salinity data over the years. The most important part of these data have been summarized by McGary & Sieling (1953). A number of water quality studies have also measured temperature and salinity, as shown in Table 2.

The bays in the study area are shallow (average depth <6 ft) and susceptible to rapid spring and summer warming and also rapid fall and winter cooling. Consequently, at points, water temperature will exceed $30^{\circ}C$. Normally the minimum water temperature will be about $3^{\circ}C$, but isolated instances of $0^{\circ}C$ have occurred. Chincoteague Bay is connected to the ocean at both ends. Owing to its shallowness, it is found to be warmer in the center than near either inlet in the summer, and to be coldest in the center in the winter. Data from Assawoman Bay indicate a temperature range from 6^{o}C to 27^{o}C but these data are sparse and so do not reflect the true range.

2. Salinity

The range of salinity in the bays is rather narrow, since they have such a small drainage area which minimizes freshwater inflow and discharge directly into the ocean. Averaged over the whole of Chincoteague Bay (Pritchard, 1960), salinity ranges from 26.5 ppt to 31.5 ppt. Isolated measurements have been as high as 33 ppt and as low as 25 ppt. Salinity in the center of Chincoteague Bay is lower than ocean salinity during spring runoff and on the average salinities throughout the Bay are lower during spring than the rest of the year. During late summer and early fall, salinities, on the average throughout the Bay system, are greatest with salinities near mid-Bay higher than ocean salinities due to the combined effects of evaporation and low runoff. No significant vertical salinity gradient was noted at any time of the year.

3. Tides and Tidal Currents

The only significant source of tide height and tidal current data for the study area is the National Ocean Survey, which publishes the _Tide Tables_ and _Tidal Current Tables_ (U.S. Dept. of Commerce, 1975). The construction of these tables entails the placement of temporary gauges at field locations in order to make a comparison with a reference station. Temporary tide gauges are installed for half a lunar month; temporary current meters for at least a hundred hours. The tabulated tidal characteristics for stations in the study area are shown in Table 5. The Tidal Current Tables list no locations within the study area.

McGary and Sieling (1953) studied the tidal currents and tide heights in Chincoteague Bay. The same pattern of tide ranges as shown in Table 5 was observed, namely much greater in the inlets than in mid-bay. Tidal current measurements were done by stopwatch timing of surface floaters. The tidal currents were found to be quite weak, on the order of 0.3 knots (0.5 fps) or less.

Pritchard (1960) analyzed the tidal dynamics of Chincoteague Bay using these tidal data. Using CBI salinity data (McGary & Sieling, 1953; Sieling, 1956) he constructed a rough flushing model of the bay.

Harleman and Lee (1969) produced a dynamic model of the tides in Chincoteague Bay but did not study transport processes. The results of their model showed about a 6.5 hour lag in time of high and low water from both inlets to mid-Bay near Ricks Point. In mid-Bay the tide range was dramatically reduced and the mean water surface was higher than at the inlets. Predicted maximum tidal currents ranged from approximately 1.0 fps at the inlets to 0.1 fps near mid-Bay.

Table 5

Tide Table Data for Chincoteague Bay and Assawoman Bay

Place	Position		Relative Time Difference				Ranges	
	Lat.	Long.	High Water (hrs. & min.)		Low Water (hrs. & min.)		Mean (ft)	Spring (ft)
Ocean City (outer coast)	38 20	75 05	−0	28	−0	30	3.4	4.1
Ocean City (Isle of Wight Bay)	38 20	75 05	−0	14	−0	25	2.7	2.7
Assateague Beach, Toms Cove	37 52	75 22	+0	16	+0	16	3.6	4.4
Chincoteague Point	37 54	75 25	+0	05	+0	11	2.6	3.1
Bogues Bay, Chincoteague Inlet	37 53	75 30	+0	38	+0	57	3.0	3.6
Wishart Point, Bogues Bay	37 53	75 30	+0	20	+0	42	2.6	3.1
Chincoteague Channel	37 56	75 23	+0	40	+0	47	1.7	2.1
Piney Island, Assateague Channel	37 56	75 21	+1	05	+1	13	2.1	2.5
Greenbackville	38 00	75 23	+2	19	+2	48	0.6	0.7
George Island Landing	38 02	75 22	+2	53	+3	02	0.6	0.7
Assacorkin Is.	38 04	75 19	+3	33	+3	42	0.4	0.5
Public Landing	38 09	75 17	+4	58	+5	27	0.4	0.5

from: Dept. of Commerce, 1975a

A dye study was performed in Sinepuxent Bay (Hall, 1970) to study the flushing characteristics of a proposed outfall site for a treatment plant to be located on Assateague Island. Unfortunately, the batch release was made at an intermediate tidal stage, rather than at slack before flood or slack before ebb. Thus the release represents neither a "best case" nor a "worst case" and the deduced travel times are open to question.

Another unpublished dye release was made into Isle of Wight Bay during the Ocean City diffuser outfall experiment (Carter, et al., 1966). This study showed poor flushing characteristics including not only prolonged retention in Isle of Wight Bay but transport northward into Assawoman Bay (J. Allison, pers. comm.).

4. Climatological Data

The bays in the study area are shallow with weak circulation. Consequently wind stirring could be an important mechanism for transport and mixing. Additionally, solar heating is important as explained in the sections on salinity and temperature. Weather observations for this region are rather sparse.

The National Weather Service maintains several observation posts in the study area. For the most part, these consist of non-recording instruments. Table 6 shows the locations of stations in or near the study area, together with the types of data available from them (U.S. Dept. of Commerce 1974a, 1974b). Table 7 summarizes the

Table 6 . Weather Observation Stations in or near the Study Area

Station	State	Recording or Non-Recording	Parameters
Wallops Is. WSO	Va.	both	precipitation, temperature, wind speed & direction, atmospheric pressure, sunshine, sky cover
Assateague State Park	Md.	non-recording	temperature & precipitation
Snow Hill	Md.	non-recording	temperature & precipitation

Table 7

Normal Average Air Temperature in
on Near Study Area

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
* Assateague State Park	35.1	37.2	43.5	52.4	61.4	70.1	74.6	75.4	71.4	60.6	49.2	42.6	56.0
** Snow Hill	37.6	38.1	44.6	54.4	63.8	72.0	76.3	74.8	68.9	58.7	48.3	38.5	56.3
** Wallops Island WSO	36.2	37.3	43.9	54.1	63.3	71.4	76.2	75.2	69.9	60.2	49.4	38.8	56.3

** Based on period 1941-1970

* Based on period 1969-1974

normal monthly average air temperature at these stations. Table 8 summarizes the precipitation data. More detailed data are available for Wallops Island, Virginia, for which NWS publishes a monthly Local Climatological Data - Wallops Island. This publication tabulates, by three-hour intervals, the following:

sky cover
ceiling
visibility
weather, if any
temperature (dry & wet bulb)
dew point
relative humidity
wind direction & speed

Mather (1969) has constructed isopleths of mean annual precipitation for Delmarva Peninsula based on 1949-1965 data (figure 7). While the pattern of isopleths seems reasonable, a number of alternative patterns could be drawn from the same data.

5. Offshore Studies

While the inlets can generally be expected to remove potential pollutants from the bay system, the reverse process is a matter for at least some concern. In the nearby waters, CBI did a dye study for an ocean diffuser outfall at Ocean City, Md. (Carter, et al., 1966). It was concluded that the dye dispersed rapidly and was effectively reflected at a distance of 200 ft. offshore in those instances in which the dye was transported shoreward. CBI is currently engaged in a study of the efficiency of this outfall diffuser.

Farther offshore, the drift bottle experiments of Norcross (1967) show a prevailing onshore drift of surface

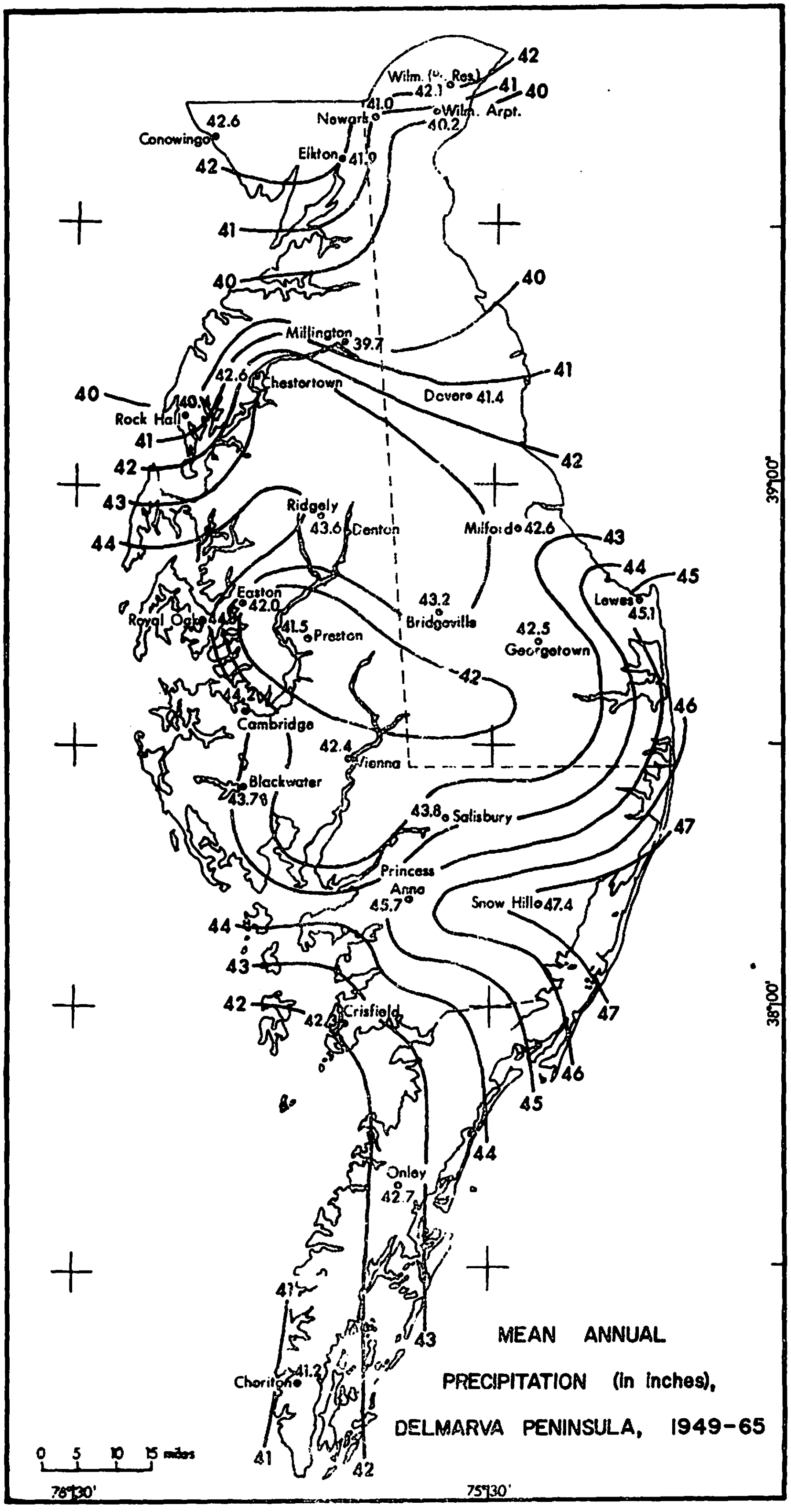


Figure 7. Mean annual precipitation for Delmarva Peninsula.

Table 8

Normal Average Total Monthly Precipitation in or Near Study Area

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Ann.
*Assateague State Park	3.03	3.61	3.14	3.27	4.08	3.12	5.38	4.29	2.11	2.95	2.71	3.56	41.25
**Snow Hill	3.60	3.62	4.69	3.35	3.43	3.85	4.37	5.01	3.82	3.65	3.56	3.69	46.64
**Wallops Island WSO	3.11	3.52	4.22	3.09	3.36	3.46	3.90	3.71	3.23	2.84	3.04	3.28	40.76

* Based on period 1969-1974

** Based on period 1941-1970

drifters along this section of coastline. This characteristic is more a matter of concern for the exposed shoreline than for the embayed waters.

IV. Biological Studies and Inventories

Biological investigations are as varied as the biota in the lagoonal system and the surrounding watershed. Table 9 summarizes the studies performed in recent history. Generally, studies center on various aspects of commercial species, such as their range, ecology, population or susceptibility to predation. The most important commercial species are oysters, hard clams, surf clams, blue crabs and various species of finfish. Figure 8 (from Allison, 1974) shows the blue crab, clam and oyster grounds in Maryland. Figure 9 (from Leber & Lippson, 1970) shows the relative abundance of blue crab and mud crab in Chincoteague Bay.

Few of the investigations were concerned with water quality as an environmental factor. The most notable exception is the work of Sieling (1959; 1960a). The ecological investigations by the Maryland Water Resources Administration have been summarized in the section dealing with water quality.

All three states partaking in the study area inventoried their wetlands as to extent and vegetation type. This was done for Maryland (Metzgar, 1973) and Delaware (Garvin & Wheller, 1972) by means of remote sensing and in Virginia (Wass & Wright, 1969) by a combination of remote sensing and study of existing maps.

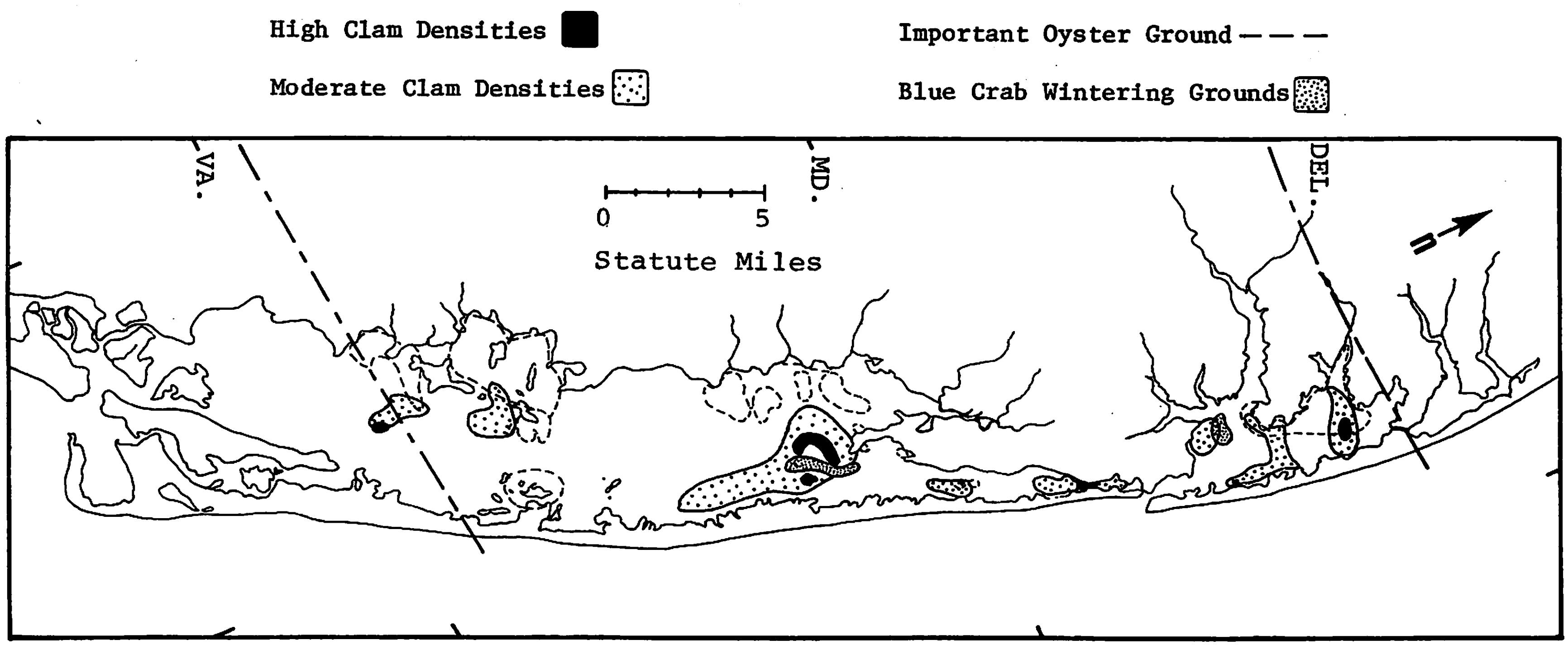


Figure 8. Blue crab, clam and oyster grounds in Maryland study area.

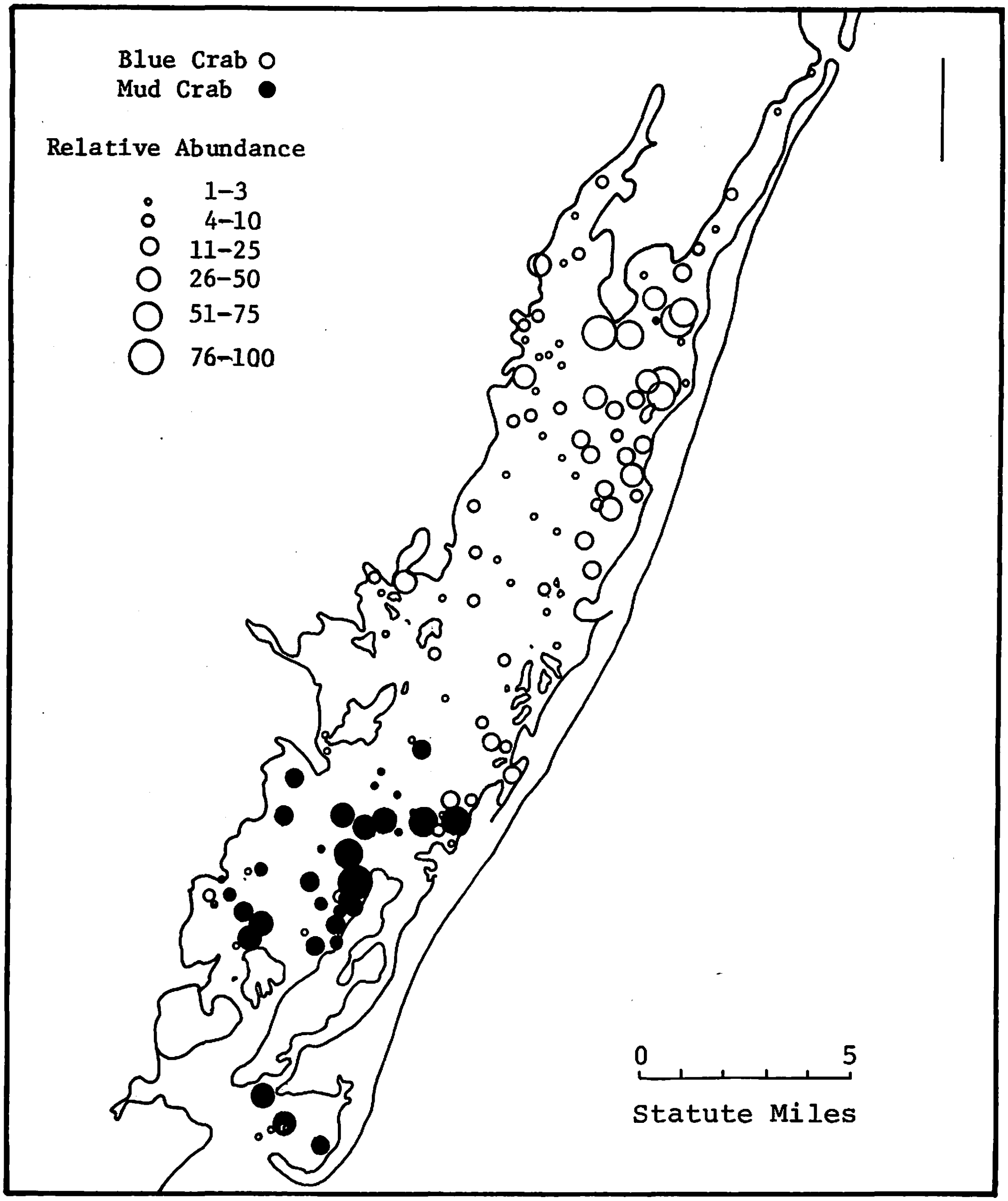


Figure 9. Relative abundance of blue crab and mud crab in Chincoteague Bay.

Table 9. Biological Studies in Eastern Shore Lagoonal System

Institution	Organism or Communities	Aspect Considered	Geographical Area	Inclusive Dates	Investigators	Reference
C.B.I.	commercial species	ecology	Chincoteague Bay, Assawoman Bay	1952-1954	Sieling, F. & J.W. McGary	Proc. Nat. Shellfisheries Assoc. Vol.43, 1952; Vol. 45, 1954
Duke Univ.	hard clam	environmental influences	Chincoteague & Assawoman Bays	1953	Wells, H.G.	Ecology, Vol.38, No. 1, Jan. '57
Icthyological Associates, Inc.	least brook lamprey	occurrence & range	Sussex County, Delaware	1973-1974	Rhode, F.C., et al.	Ches. Science Vol.15, No. 3, Sept. '74
Md. Dept. of Natural Resources	blue crab	management	Chincoteague Bay, Md.	1973	Campbell, D.W. P. J. Duket	Commercial Fisheries News, Vol.8, No. 2, Mar., 1975
Md. Dept. of Natural Resources	hard clams	seed clam planting	Chincoteague Bay, Md.	1972	Casey, J.F.	Commercial Fisheries News, Vol.5, No.6, Nov. 1972
Md. Dept. of Natural Resources	benthic flora & fauna	species composition & abundance	Chincoteague & Assawoman Bays	1959-1961	Stotts, V.F.	unpublished report, 1966 (Md. Prog. W-30-R-14, Job No. 4)
Md. Nat. Res. Inst.	submerged vegetation	primary productivity	Chincoteague Bay	1970	Anderson, R.R.	"Assateague Ecological Studies"
Md. Nat. Res. Inst.	phytoplankton	primary productivity	Chincoteague Bay	1970	Boynton, W.	"
Md. Nat. Res. Inst.	blue crab	migration	Chincoteague & Assawoman Bays	1953-1954	Cargo, D.G.	Jo. Mar. Res. Vol. 16, No. 3, Oct. 1958

Table 9 (contd)

Institution	Organism or Communities	Aspect Considered	Geographical Area	Inclusive Dates	Investigators	Reference
Md. Nat. Res. Inst.	benthos	quantitative survey	Chincoteague & Sinepuxent Bays	1969	Drobeck, K.S., et al.	"Assateague Ecological Studies"
Md. Nat. Res. Inst.	sika deci	ocurrence	Assateague Island	1962	Flyger, V. & N. W. Davis	Ches. Sci., Vol. 5, No. 4, Dec. 1964
Md. Nat. Res. Inst.	oysters	mariculture	Chincoteague Bay, Md.	1967-	Hidu, H. et al.	N.R.I. Spec. Report No. 2, CBL Ref. 67-78
Md. Nat. Res. Inst.	salt marshes	primary productivity	Chincoteague Bay, Md.	1970	Keefe, C. W. Boynton	"Assateague Ecological Studies"
Md. Nat. Res. Inst.	crustaceans	identification, correlation in physical parameters	Chincoteague & Sinepuxent Bays	1969	Leber, K.M. III, & R. L. Lippson	"
Md. Nat. Res. Inst.	mud crab	ocurrence	Chincoteague Bay	1956-1960	Schwartz, F.J.	Ches. Sci. Vol. 1, No. 3-4, Dec. '60.
Md. Nat. Res. Inst.	finfish	quantitative species composition	Chincoteague & Sinepuxent Bays	1959	Schwartz, F.J.	American Midland Naturalist, Vol. 65, No. 2, Apr. 1961
Md. Nat. Res. Inst.	sea squirt	abundance & ecology	Sinepuxent & Chincoteague Bays	1959-1960	Schwartz, F.J.	Ches. Sci. Vol. 1, No. 3-4, Dec. 1960
Md. Nat. Res. Inst.	finfish	ocurrence	Isle of Wight Bay, Assawoman Bay	1959-1963	Schwartz, F.J.	Ches. Sci. Vol. 5, No. 4, Dec. 1964

Table 9 (cont'd)

Institution	Organism or Communities	Aspect Considered	Geographical Area	Inclusive Dates	Investigators	Reference
Md. Nat. Res. Inst.	oyster	ecology	Chincoteague & Assawoman Bays	1951-1955	Sieling, F.W.	Proc, Nat. Shellfisheries Assoc. Vol. 46, 1955
					Sieling, F.W. & J. W. McGary	Proc. Nat. Shellfisheries Assoc, 1952.
Md. Nat. Res. Inst.	oyster	suspended cultch	Chincoteague Bay, Md.	1956 -	Sieling, F.W.	Maryland Tidewater News, Vol. 12, No. 10, March 1956
Md. Nat. Res. Inst.	southern drill	range extension	Chincoteague Bay	1955-1960	Sieling, F.W.	Ches. Sci. Vol. 1, No. 3-4, Dec. 1960
Md. Nat. Res. Inst.	finfish	quantitative species composition	Chincoteague & Sinepuxent Bays	1970	Wiley, M.L., J.P. Chandler, R. Hartman	"Assateague Ecological Studies"
N.M.F.S. Oxford, Md.	oysters	infection by <u>Minchinia</u>	Chincoteague Bay, Va.	1963-1966	Couch & Rosenfield	Proc. National Shellfisheries Assoc. Vol. 58, June 1968
N.M.F.S. Oxford, Md.	oyster drill	sexual dimorphism	Chincoteague Bay	1958-1959	Griffith & Castagna	Ches. Sci., Vol. 3, No. 3, Sept. '62.
N.M.F.S. Oxford, Md.	surf clams	management	Maryland Seacoast	1973	Ropes, J.	Commercial Fisheries News, Vol. 7, No. 5, Sept. 1974.
N.M.F.S. Oxford, Md.	marine amoebae	taxonomy	Chincoteague Bay, Va.		T. Sawyer	Trans. Amer. Micros Soc. Vol. 94, No. 1, pp. 71-92, 1975

Table 9 (cont'd)

Institution	Organism or Communities	Aspect Considered	Geographical Area	Inclusive Dates	Investigators	Reference
University of Delaware	wetlands	mapping	Delaware Marshes	1973	Klemas, et al.	University of Delaware, 1973
U.S. Fish. & WS	mammals	ocurrence	Assateague Island	1956-1959	Paradiso, J.L. & C.O. Handley, Jr.	Ches. Sci. Vol. 6, No. 3, Sept. 1965
VIMS	boring sponge	distribution	Public Landing, Md.	1959-1961	Hopkins, S.H.	Ches. Sci. Vol. 3, No. 2, June, 1962.
VIMS	sub-benthic fauna	species composition & diversity	Assateague Island	October 31, 1964	Mackiernan, G.W.	Student field trip, manuscript report
VIMS	oyster drill	pesticide effects on	Chincoteague Bay, Va.	1963	Wood, L. & B.A. Roberts	Proc. Nat. Shellfisheries Assoc. Vol. 54, 1963.

V. Geological Data

A. Bottom Sediments

Evidence suggests that the lagoonal system was formed within the last 15,000 years as rising sea level inundated the Coast (Johnson, 1973). In the process a line of sand dunes became isolated from the mainland and formed a barrier island. The barrier island is dynamic, with ocean breakthrough occurring frequently but closing up again within a few years, except in the case of Ocean City Inlet, which has been jettied to maintain its present configuration. Sediments in the enclosed bays tend to be recent (Stout, 1953; Newman & Rasnack, 1965). The sediment is mainly quartz sand with some mud (Wells & Erickson, 1937). In the eastern portions of the bays the bottom tends to be hard and sandy. These sediments are supplied by wind transport and storm overwash of sand from the barrier island (Bartherger & Biggs, 1970). Toward the mainland, on the other hand, the bottom tends to consist of muds from the alongshore wetlands. Figure 10 shows this distribution for Chincoteague Bay. Along the western side of Chincoteague Bay, former oyster beds have been covered with two to six inches of soft deposit (Sieling, 1960).

B. Surface Water Resources

There have been three temporary stream gauging sites in the study area (Cushing, et al., 1973). These

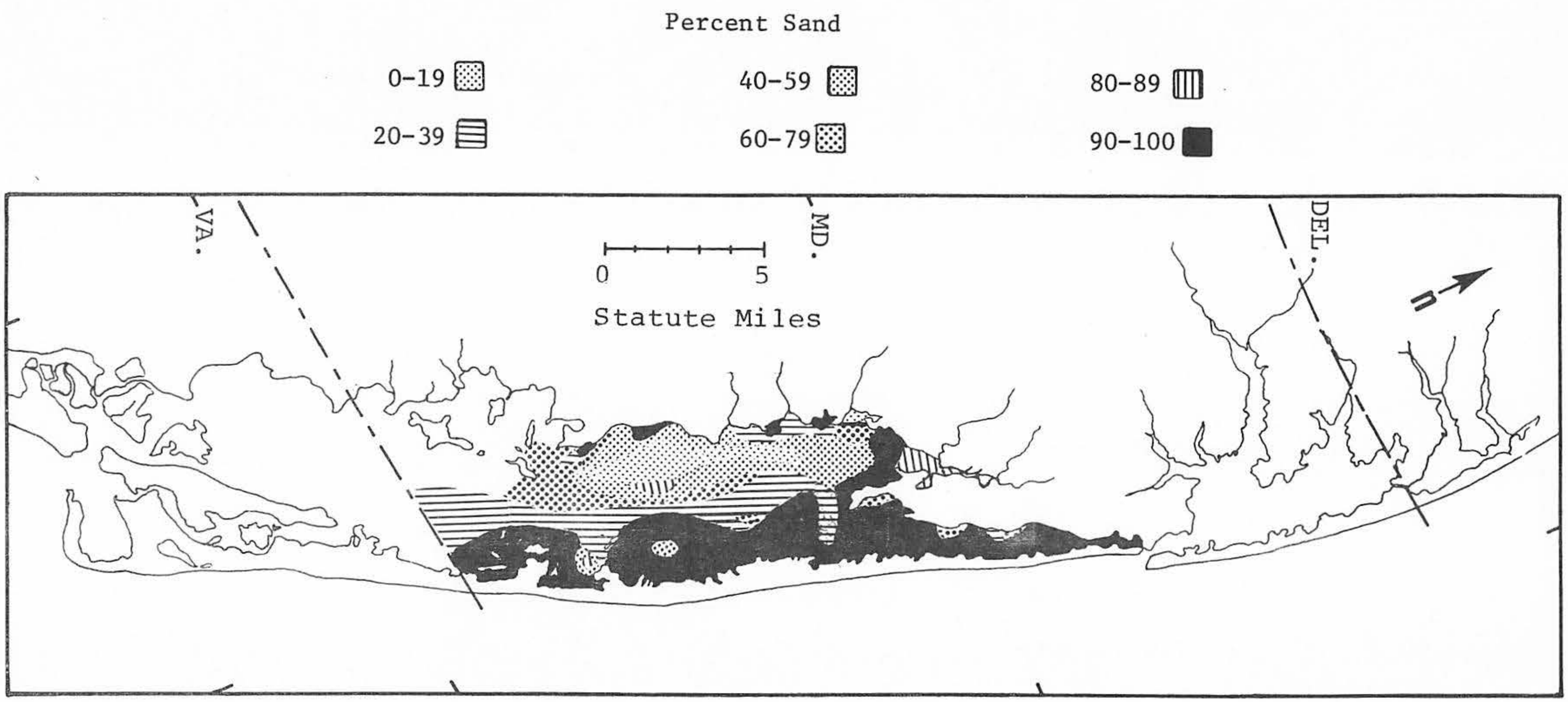


Figure 10. Distribution of sediment in Chincoteague Bay based on percentage of sand.

stations were manned during low-flow periods to augment geographic coverage for low-flow statistics. The characteristics of the three sites are similar to those of the permanent station on the Stockley Branch of the Indian River. The locations and characteristics of the temporary gauging stations and the comparison stations are shown in Table 10 (Cushing, op. cit., p. 14). A fuller low flow frequency - duration table for Stockley Branch is shown in Table 11. High flow characteristics are given in Table 12.

Mather (1969) has computed runoff (Figure 11) for Delmarva peninsula based on precipitation records and calculated evapotranspiration and aquifer recharge. His results are from calculations rather than primary data.

C. Groundwater Resources

Several aquifers underlie the study area but only the three uppermost aquifers are judged able to supply large quantities of fresh water without danger of salt water contamination. These are the Pocomoke, Manokin and Quaternary aquifers (Cushing, 1973). Table 13 summarizes aquifer data. The three aquifers can be thought of as a single unit because of their extensive inter-connections, particularly in the northern part of the study area.

The Manokin aquifer is more than 150 feet thick, extending downward from a depth of about 200 feet under the study area. In places the aquifer is partially filled with salt water, so that salt water intrusion is a danger at the

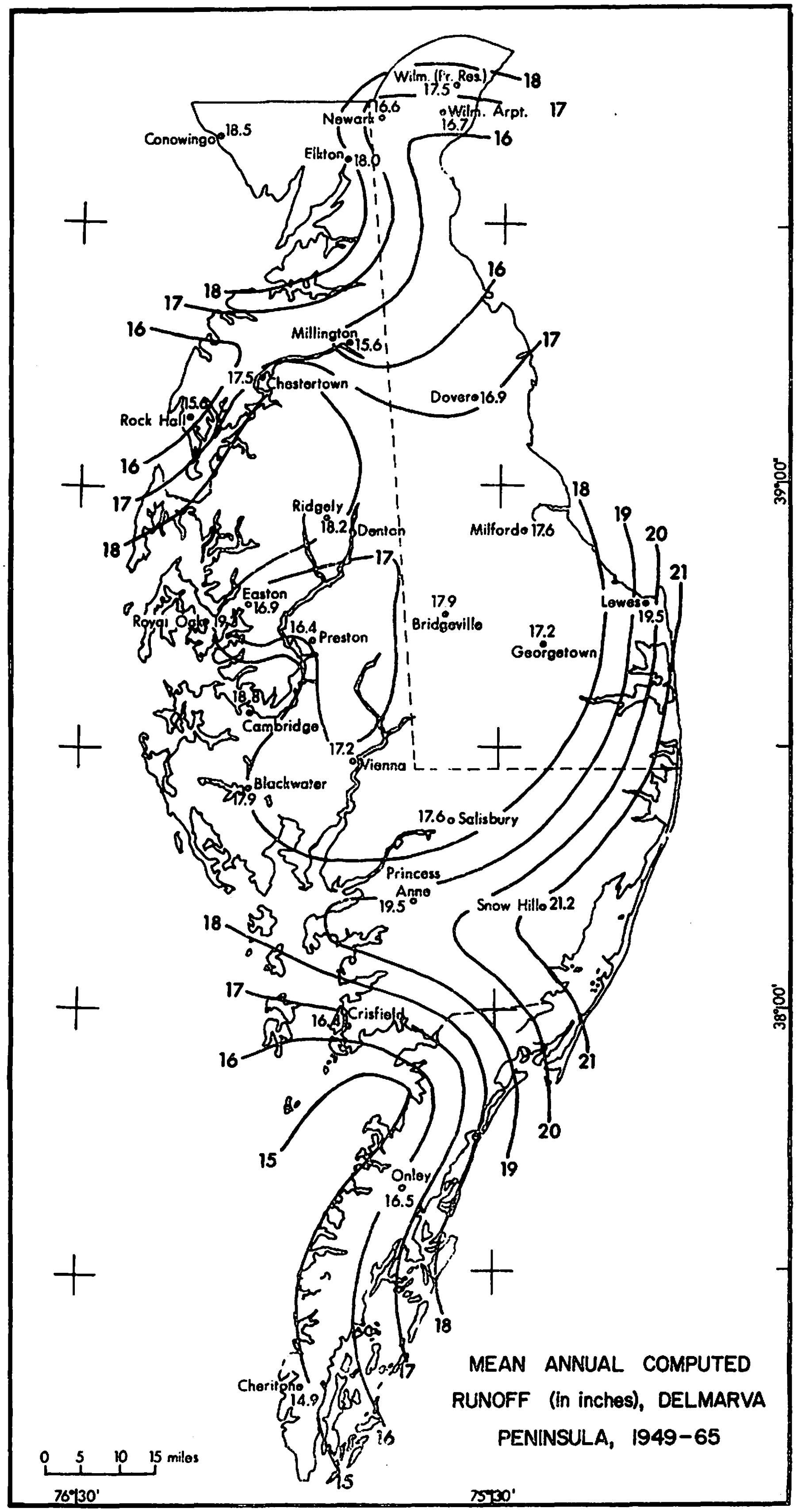


Figure 11. Mean annual computed runoff for Delmarva Peninsula.

Table 10

Stream Flow Gauging Station Relevant to Study Area

Stream	Branch	Type	Latitude	Longitude	Drainage Area (sq.mi.)	Period of Record	Average Discharge (cfs)	annual low flow (cfs/sq.mi.) for 7 consecutive days and for indicated recurrence interval		
								2 yr.	10 yr.	20 yr.
Indian River	Stockley Branch	daily record	38°38'19"	75°20'31"	5.24	1943-1967	6.95	.31	.11	.08
Dirickson Creek	Bearhole Ditch	Miscl.	38°28'17"	75°09'22"	6.2	1968-1971	---	.11	.02	---
St. Martins River	Middle Branch	Miscl.	38°24'02"	75°12'45"	3.7	1968-1971	---	0	---	---
St.Martin River	Birch Branch	Miscl.	38°24'33"	75°12'48"	6.5	1968-1971	---	.03	.02	---

Table 11

Magnitude & Frequency of Annual Low Flow at Stockley Branch Gaging Station

Period (Consecutive Days)	Annual Low Flow, in Cubic Feet Per Second for Indicated Recurrence Interval, in Years			
	2	5	10	20
7	1.6	.9	.6	.4
14	1.8	1.0	.7	.5
30	1.9	1.1	.8	.6
60	2.2	1.3	1.0	.8
90	2.3	1.4	1.1	.9
120	2.6	1.7	1.4	1.1

Table 12

Magnitude and Frequency of Annual High Flows at Stockley Branch Gauging Station

	Discharge in Cubic Feet Per Second for Indicated Recurrence Intervals, in Years				
	2 yrs.	5 yrs.	10 yrs.	25 yrs.	50 yrs.
Peak Flow	55	80	98	122	142
Daily Flow	41	64	82	106	126

Table 13

Summary of Aquifer Data

Aquifer	Areal Extent (sq.mi.)	Area of Use (sq.mi.)	Area of Potential Use (sq.mi.)	Estimated Perennial Yield (mgd)	Estimated Withdrawals 1970 (mgd)
Manokin	3500	1200	2300	*	6
Pocomoke	2150	1600	550	*	6
Quaternary	5950	5950	0	1040	61

* Included with Quaternary aquifer

Nanticoke River and in a small area of Delaware adjoining Delaware Bay. In the study area, however, the aquifer seems capable of producing a plentiful supply of potable water. Near Ocean City the water contains less than 2.0 milliequivalents per liter of calcium and less than 4.0 milliequivalents per liter of carbonate and bicarbonate.

This area of use of this aquifer covers the study area north from Sinepuxent Bay and also the Virginia portion of Chincoteague Bay, but not the Maryland portion of Chincoteague Bay.

The Pocomoke aquifer is nearer to the surface than the Manokin. It is more than 100 feet deep and 50 to 100 feet thick beneath the study area. It is used over the study area with the exception of southern Assateague Island, where is considered to be not of potential use. Ocean City depends on this aquifer for large quantities of good quality water (Pellenbarg & Biggs, 1970). Sussex County, Delaware expects the Pocomoke and Manokin aquifers to yield adequate water supplies to meet future needs through the year 2000 (Sussex County, 1975) for the County's South Coastal Zone, which includes the Delaware portion of the study area. They note, however, that iron removal may be necessary. While salinity intrusion is not a problem in the study area, a test well on Assateague Island yielded water with a carbonate & bicarbonate concentration of about 5.4 milliequivalents per liter and a sodium and potassium concentration of about 5.2 milliequivalents per liter.

The entire Quaternary aquifer (i.e. the local ground water table) is considered liable to salt water intrusion and so is not relied on directly for large supplies of fresh water. It is considered reliable for vacation cottage supplies in isolated areas. This aquifer also recharges the deeper aquifers to some extent at the points of contact between aquifers.

VI. Planning Studies

A. Socio-Economic Profile

The study area is predominately rural, with population density less than 100 per square mile. (see Table 14). Net migration of the region is negative. All three counties have a greater percentage of people over 65 than their respective states (U.S. Bureau of the Census, 1973) suggesting that there is an outmigration among young working people which not quite counter balances an influx of retirees (Accomack-Northampton Planning District Commission, 1973). Another indication of the high incedence of those over 65 is the high death rate in these counties as compared to their respective states.

Educational levels are lower in these counties than in their respective states. Median years of school completed is at least a year lower than each respective state. Fewer than half the over-25 population in Sussex County has graduated from high school; in Worcester and Accomack Counties fewer than one third have graduated from high school.

Sussex County is somewhat more industrialized than the other two counties in the study area and actually has a lower unemployment rate than its respective state. Worcester County has the strongest orientation toward employment in services, probably because of the tourism in Ocean City & nearby. Virginia and Maryland as a whole have a substantial amount of employment in Government, compared to the Eastern

Table 14

Census Data for Study Area

Population, 1970

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Total	3,922,399	24,442	4,648,494	29,004	548,101	80,353
Per square mile	397	51	117	61	277	85
Net migration	12.4	-5.5	3.6	-9.4	8.5	-1.4
Percent urban	76.6	14.6	63.1	-	72.1	14.2
Percent Negro	18	33	18	37	14	20
Age (%):						
Under 5	8.8	8.1	8.4	7.2	8.9	8.5
18+	64.7	65.2	65.7	67.8	64.0	65.3
65+	7.7	12.9	7.9	15.5	8.0	11.1
Median	27.3	31.9	27.0	35.0	26.9	29.8
Foreign Stock (%)	11.6	2.5	5.4	1.2	11.7	3.8
Birth rate (per 1000) (1968)	17.9	17.6	18.0	16.4	18.4	19.7
Death rate (per 1000) (1969)	8.4	12.0	8.5	15.0	8.8	11.6

Source: Bureau of the Census, U. S. Department of Commerce. 1973b. County and City Data Book 1972. U.S.G.P.O., Washington, D. C.

Table 14 (cont'd) Education

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Persons 25 years and older:						
Total	2,082,549	14,039	2,446,082	17,337	287,395	44,739
Median years of school completed	12.1	10.2	11.7	9.5	12.1	11.1
% less than 5th grade	4.5	10.5	7.7	14.8	3.7	5.9
% completed high school	52.3	32.3	47.8	30.7	54.6	43.0
% completed 4-year college	13.9	5.6	12.3	4.6	13.1	6.8
Persons 3-34 years old enrolled in school:						
Kindergarten and elementary	737,363	4,383	824,557	4,597	105,366	14,296
High School	275,083	1,909	310,132	1,650	39,336	5,233
% Negro in elementary and high school	21.0	39.9	22.0	51.8	16.5	24.6
% in private elementary and high schools	12.8	.8	6.8	2.4	12.8	1.2
No. in college	131,019	131	132,659	146	17,001	805

Source: Bureau of the Census, U. S. Department of Commerce. 1973b. County and City Data Book 1972. U.S.G.P.O., Washington, D. C.

Table 14 (cont'd) Labor Force

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Total	1,590,094	9,916	1,766,740	11,220	225,644	33,709
Unemployed (%)	3.2	3.2	3.0	6.3	3.8	2.8
Employed (Total)	1,538,766	9,597	1,714,250	10,513	210,927	32,569
Industry (%):						
Manufacturing	19.5	22.3	22.4	23.7	29.7	30.2
Wholesale & Retail	19.2	18.1	18.0	21.2	19.2	18.3
Services	7.4	12.6	7.9	7.6	8.0	6.3
Educational Services	8.0	4.3	7.8	4.4	8.4	6.8
Construction	6.6	9.9	7.4	8.3	7.6	9.0
Government	25.7	12.6	23.5	14.8	15.3	15.3
White Collar						
Professional & Managerial	27.7	18.0	24.6	16.9	26.4	18.1
Sales & Clerical	28.2	16.8	24.4	14.3	24.6	18.3
Craftsmen & Foremen	13.7	15.1	14.3	12.5	14.6	15.8
% Working outside county of residence	36.7	18.1	39.9	20.7	10.8	13.2

Source: Bureau of the Census, U. S. Department of Commerce. 1973b. County and City Data Book 1972. U.S.G.P.O., Washington, D. C.

Table 14 (Cont'd) Income

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Families:						
Total	974,143	6,274	1,162,256	7,686	136,915	20,953
% with female head	11.4	11.9	11.1	13.1	10.7	11.0
% Families with income:						
less than $3,000	7.1	15.8	11.0	23.5	7.5	11.9
$3,000 - 4,999	7.1	15.6	11.0	19.6	8.0	12.8
$5,000 - 6,999	9.8	15.6	13.4	17.5	11.1	15.6
$10,000 - 14,999	28.2	20.2	23.9	12.9	29.1	24.7
$15,000 - 24,000	21.8	8.8	15.2	5.7	17.1	10.0
more than $25,000	6.8	3.3	4.5	1.1	5.2	2.2
Median Family Income:						
All families (total dollars)	11,057	7,386	9,044	5,670	10,209	8,257
White families ($)	11,629	8,521	9,762	6,735	10,732	8,775
Negro families ($)	7,696	5,204	5,740	4,013	6,399	5,731
Families below:						
Low income level	7.7	17.3	12.4	25.2	8.3	12.6
125% of low income level	10.9	25.0	17.2	34.1	11.7	17.4

Source: Bureau of the Census, U. S. Department of Commerce. 1973b. County and City Data Book 1972. U.S.G.P.O., Washington, D. C.

Table 14 (Cont'd) Housing

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Housing, Year-Round Units:						
Total Number	1,234,680	8,962	1,484,952	11,409	174,990	29,307
% change, 1960-70	35.1	12.7	29.1	1.1	27.1	22.0
Median number of rooms	5.5	5.5	5.2	5.1	5.7	5.4
% in one-unit structures	68.8	83.6	74.7	91.3	75.5	83.2
% in structures built in 1960 or later	30.4	17.5	31.5	14.3	29.9	24.4
% in structures built prior to 1960	46.4	68.6	45.9	71.7	45.0	56.7
Housing, Occupied Units:						
Total Number	1,174,727	7,873	1,390,635	9,713	164,804	25,662
Average number of persons/unit	3.3	3.1	3.3	2.9	3.3	3.1
% Owner-Occupied	58.8	66.1	62.1	69.6	68.0	71.8
Median value of owner occupied, single-family units ($)	18,847	11,686	17,366	6,865	17,275	14,117
Median gross rent, renter-occupied ($)	127	79	116	57	113	84
% lacking some or all plumbing	3.7	19.6	11.6	36.0	4.1	13.7
% with 1.01 or more persons/room	6.3	9.3	7.7	9.0	5.5	7.8

Table 14 (Cont'd) Housing (Cont'd)

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
Housing, Occupied Units (Cont'd)						
Negro-occupied Units:						
Total Number	182,040	2,088	218,300	2,851	20,555	4,179
Owner-Occupied(%)	37.7	47.5	51.6	50.8	49.5	50.1
Lacking some or all plumbing	9.3	53.8	29.2	76.3	17.2	52.7
With more than 1.01 persons/room (%)	15.5	22.3	20.5	20.4	16.7	26.3

Source: Bureau of the Census, U. S. Department of Commerce. 1973b. County and City Data Book 1972. U.S.G.P.O., Washington, D. C.

Table 14 (Cont'd) Retail, Service and Wholesale Trade

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
RETAIL ESTABLISHMENTS						
Number	N.A.	406	N.A.	371	N.A.	917
Sales for all establishments by kind of business (%):						
Food stores	23.2	22.2	23.7	27.7	21.1	26.4
Automotive Dealers	17.8	14.0	19.1	10.8	18.1	16.7
General Merchandise	16.5	5.1	15.1	6.9	18.5	4.1
Eating & drinking places	7.6	12.2	5.8	5.1	6.4	6.3
Gas & service stations	6.9	9.1	7.7	9.6	6.3	6.9
Furniture, home furnishings & equipment	4.1	5.9	4.6	4.0	5.0	3.7
Building materials, hardware & farm equipment dealers	3.6	11.9	5.0	8.4	4.3	7.9
Apparel & Accessories	5.1	3.5	5.0	3.9	5.0	6.7
Drug stores & proprietary stores	4.2	2.7	4.1	2.8	2.8	2.3

Table 14 (Cont'd) Retail, Service and Wholesale Trade (Cont'd)

	Maryland	Worcester County	Virginia	Accomack County	Delaware	Sussex County
SERVICE ESTABLISHMENTS						
Number	N.A.	325	N.A.	177	N.A.	497
Receipts of all establishments (%):						
Hotels, motels, camps	6.0	51.2	16.1	**	10.2	19.4
Auto repair & services	18.6	5.4	13.2	**	16.6	10.2
Amusements & recreation	11.5	27.3	9.0	**	23.0	*
WHOLESALE TRADE						
Number of establishments	N.A.	41	N.A.	64	N.A.	109

N.A., not applicable

* , withheld to avoid disclosure
** , data not available

Shore counties. Probably the figures for the states are biased by the heavy concentration of federal employees in the Washington, D. C. suburbs.

The income in the study area is considerably below the states as a whole, both among whites & negroes. More than half of the housing units being used were built prior to 1960, i.e. ten years before the 1970 census. Sussex County increased its housing units 22% between 1960 & 1970, but Worcester County added only 13% and Accomack County added only 1%. The figures do not include recreational units. A substantial percentage of the housing units lack some or all plumbing (36% in Accomack County).

While the data on several establishments are incomplete, they indicate a heavy dependence on tourism in this area. Ocean City, Md. and Assateague National Seashore attract summer residents and day visitors from Baltimore, Washington, D. C. and even farther away. The waters are well suited for boating and fishing. There are six wildlife areas listed in Table 15.

The economy of the area also depends heavily on seafood and farming, both of which tend to produce seasonal employment patterns. In recent years, commercial fishing has declined and agriculture has become less labor-intensive (Burrell, et al., 1972). Industry is unwilling to locate in the southern part of the area for a combination of reasons (Chappuie, et al., 1971b) including high shipping cost, low labor skills available and absence of natural resources.

Table 15

List of Wildlife Refuges in the Study Area

Name	County	Location
Assawoman Wildlife Area	Sussex	on Little Assawoman Bay
E. A. Vaughan Wildlife Mgmt. Area	Worcester	NE of Snow Hill, off Rt. 12
Sinepuxent Bay Wildlife Mgmt. Area	Worcester	Sinepuxent Bay
Pocomoke State Forest	Worcester	N. of Snow Hill off Rt. 12
Chincoteague National Wildlife Refuge	Accomack	Assateague Island
Saxis Waterfowl Mgmt. Area	Accomack	on Rt. 698 near Saxis

B. Recreational Planning

The earliest recreational studies of this area are concerned with the proposal to establish and ultimate establishment of a national seashore (U.S. Dept. of Interior, 1963; U.S. Bureau of Outdoor Recreation, 1963; U.S. National Park Service, 1965). The history of the project has been summarized in a report by the Maryland Joint Executive - Legislative Committee on Assateague Island (1972).

A preliminary study has been made of the feasibility of establishing a wilderness area on Assateague (Lynch, et al., 1974). The proposed site would include 6500 acres straddling the Va.-Md. border and would thus effectively cut the island in half. This wilderness area would be added to a number of wildlife refuges already existing in the study area (see Table 15).

The Corps of Engineers (1968) has recommended the building of an inland waterway from Roosevelt Inlet, Del. to Cape Charles, Va., by way of Indian River Inlet & Assawoman & Chincoteague Bays, thereby linking together two existing projects near Ocean City and Chincoteague Island. The report studies the costs and benefits and deduces a favorable ratio, based on commercial and recreational traffic. This project has been funded by Congress, but a review is in progress (U.S. Army Corps of Engineers, 1973).

A study was made of the recreation - tourism potential of Virginia's eastern shore by Spindletop Research

(Chappuie, 1971a). According to this report, visitation to Assateague National Seashore exceeded one million in 1970 and is expected to more than double by 1980.

A study was made of the environmental effects of boating in Chincoteague Bay (Roy Mann, 1974). This study enumerated the multiple ways in which boating could affect the environment and recommended a sort of zoning system whereby waterways were classified according to carrying capacity. It also recommended a monitoring system for ascertaining situations where capacity is approached. The report also recommended further research to establish more quantitatively the environmental effects of boating.

C. Population & Resource Planning

Each of the three counties containing a part of the study area has made its plan concerning future growth and future facility requirements for such items as water supply, sewers, schools and roads.

Sussex County in Delaware (1975) has issued a preliminary land use study for its South Coastal Zone, which includes the drainage area of Little Assawoman Bay and the southern part of the drainage basin of Indian River Bay. It thus includes the Delaware portion of the study area. The most interesting points relevant to this study are:

1. Ground water from the Pocomoke and Manokin aquifers should be sufficient to serve the expected growth to the year 2000, but that in some places treatment to remove iron

will be required.

2. Sussex County as a whole was expected to grow at a rate of 1.0% to 1.2% through the year 2000. However, summer population is expected to grow much faster.

3. A sewage treatment plant has been built 1.5 miles west of South Bethany, but not yet put on line. Removal rate will be 90% and capacity will be 3 mgd. The plant will serve projected summer needs through the year 1984. The interim receiving stream will be the Assawoman Canal, but the ultimate solution will be an ocean outfall or spray irrigation, depending on relative cost-effectiveness.

A special Governor's Task Force prepared for the State of Delaware (1972) a report on the Coastal Zone. This report was concerned with the possible impact on the coastal zone caused by development of offshore oil resources and by mushrooming demand for recreational areas. The report recommended that zoning regulations be put in force well in advance of development, in order to better control management.

Morton Hoffman & Co. (1973) have projected the population growth of Worcester County under a variety of development alternatives and fixed assumptions. The development alternatives have to do with the degree of regulation that will be imposed and the extent to which waterfront development will be permitted. The fixed assumptions are:

1. rapid development will continue in Ocean City with few governmental constraints;

2. Additional sewerage facilities must be built in West Ocean City, i.e. mainland west of Ocean City.

3. Growth in and around Assateague Island will occur as specified by the Governors Joint Executive - Legislative Committee (1972).

A comprehensive master plan for Worcester County was published in 1965 (J. Tarrant). This plan worked out plans, based on projected needs and county objectives, for land use, major highways, recreation areas, schools and community facilities. For meeting anticipated water and sewer needs, the following moves were suggested:

1. expansion of public sewer systems at Berlin, Snow Hill and Pocomoke City;

2. development of sewer systems in the areas of West Ocean City, Sinepuxent Neck and Public Landing;

3. replacement of the existing public dumps with a small number of sanitary landfill sites.

A revised master plan created by Urban Pathfinders, Inc. is presently in the draft stage, undergoing revision to accomodate citizen input. It is expected to be presented to the County Commissioners in the near future for their consideration and possible adoption.

The Maryland Department of State Planning (1974b) has developed a system of land use classification based on remote sensing imagery. A map of existing land use patterns in Worcester County has been prepared. Similar systems and maps have been prepared for geology, aquifers and minerals and soil types (1974a).

A land use plan has been formulated for Virginia's Eastern Shore (Accomack-Northampton Planning District Commission, 1973). This body has no legislative power, and so the report is advisory. According to this report the population of Chincoteague Island (though not necessarily the town of Chincoteague) is expected to increase 20% in the next 20 years in response to the demand of burgeoning tourist visitation. At the time of writing (1973) there were 270 motels and cottage rooms and 1480 campsites.

There have also been a number of reports on the problem of maintaining and expanding the economic base of this area (Kenyon, et al., 1973; Chappuie, 1971b). Industrial growth is hampered by lack of natural resources and shortage of labor skills and by remoteness from markets. Agriculture is somewhat hampered by inefficient methods.

A regional water quality management plan has been worked out for Northern Accomack County. (Shore Engineering Inc., 1974). According to this study, the town of Chincoteague has already reached a population equivalent of over 10,000 (several times the permanent population) when commercial, industrial and recreational facilities are included. The projected waste load in twenty years was expected to be 1.5 mgd. A regional treatment plant was proposed for northern Accomack County. This plant would treat up to 3.0 mgd with 95-97% removal of BOD and phosphorus. The plant would be located just north of Wallops

Station and would discharge into Mosquito Creek. On Chincoteague Island, there would be a system of pumped sewers which would cover most of the island, and would converge on a 12" main to go across the causeway to the mainland.

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