

U.S. VIRGIN ISLANDS

ST. CROIX

**EAST END
AREA OF PARTICULAR CONCERN
(APC)**

A COMPREHENSIVE ANALYTIC STUDY

September 21, 1993

**VIRGIN ISLANDS DEPARTMENT of
PLANNING AND NATURAL RESOURCES**
Coastal Zone Management Program

Roy E. Adams
Commissioner

EAST END
AREA OF PARTICULAR CONCERN
(APC)

A COMPREHENSIVE ANALYTIC STUDY

V.I. DEPARTMENT OF PLANNING AND NATURAL RESOURCES
Coastal Zone Management Program

September 21, 1993

Draft Prepared By:
Island Resources Foundation
under Contract PC PNR-330-92

With assistance From:
The University of the
Virgin Islands

This publication is financed in part through a federal grant from the Office of Coastal Zone Management, NOAA under the provision of Section 305 of the Coastal Zone Management Act of 1972 (Public Law 92-583).

Copies of this document may be obtained from the Department of Planning and Natural Resources, (Coastal Zone Management Program), Nisky Center, Charlotte Amalie, St. Thomas, United States Virgin Islands 00802.

EAST END - ST. CROIX
AREA OF PARTICULAR CONCERN

COMPREHENSIVE ANALYTIC STUDY
TABLE OF CONTENTS

1.	INTRODUCTION	1
1.1	General	1
1.2	Relationship to Other Plans and Regulations	2
1.3	Historical Perspective	2
1.4	Other Classifications	3
2.	DESCRIPTION OF THE SITE	3
2.1	APC Boundary	3
2.2	Ownership Summary	3
2.3	Physical Environment	3
2.3.1	Climate	3
2.3.2	Geological Setting	3
2.3.3	Hydrological Setting	5
2.3.4	Coastal Environment	6
2.4	Biological Environment	6
2.4.1	Terrestrial	6
2.4.2	Marine	6
2.4.3	Endangered Species	9
2.5	Cultural Resources	9
2.5.1	Prehistoric	9
2.5.2	Historic	10
2.6	Built Environment	10
2.6.1	Roads and Ports	10
2.6.2	Water Systems	10
2.6.3	Wastewater Systems	10
2.6.4	Energy Systems	10
2.6.5	Solid Waste Disposal Systems	10
3.	RESOURCE USE, USE CONFLICTS, AND ADVERSE IMPACTS	11
3.1	Resource Use	11
3.2	Use Conflicts	11
3.3	Adverse Impacts	11
3.3.1	Water Quality	11
3.3.2	Air Quality	11
3.3.3	Noise	12
3.3.4	Impacts to Biological Resources	12
3.3.5	Impacts to Cultural Resources	12
4.	MANAGEMENT RECOMMENDATIONS	13
4.1	Policy Framework	13
4.2	Planning and Permitting	13
4.3	Legislative Change	15
4.4	Institutional Development	16
5.	CONCLUSION	16

LIST OF KEY ACRONYMS

Area of Particular Concern	APC
Base Flood Elevation	BFE
Biological Oxygen Demand	BOD
Coastal Barriers Resource System	CBRS
Coastal Zone Management Act	CZMA
Department of Housing, Parks, and Recreation	DHPR
Department of Planning and Natural Resources	DPNR
Department of Public Works	DPW
Division of Archaeology and Historic Preservation	DAHPR
Division of Coastal Zone Management	DCZM
Division of Environmental Protection	DEPD
Division of Fish and Wildlife	DFW
Environmental Assessment Report	EAR
Federal Emergency Management Agency	FEMA
Gallons Per Day	GPD
Mean High Water	MHW
Mean Low Water	MLW
Million Gallons Per Day	MGD
National Ambient Air Quality Standards	NAAQS
National Flood Insurance Program	NFIP
National Park Service	NPS
National Register of Historic Places	NRHP
Our Town Frederiksted	OTF
Sea Level Rise	SLR
Sewage Treatment Plant	STP
Significant Natural Area	SNA
Territorial Pollutant Discharge Elimination System	TPDES
Total Suspended Particulates	TSP
U.S. Army Corps of Engineers	USACOE
U.S. Environmental Protection Agency	USEPA
U.S. Fish and Wildlife Service	USFWS
U.S. Geological Survey	USGS
University of the Virgin Islands	UVI

LIST OF FIGURES

1. Location Map
2. APC Boundary Map
3. Ownership Summary Map
4. Average Rainfall Map
5. Soil Map
6. Marine Chart - Lang Bank
7. Marine Sanctuary Map
8. Land Use Map
9. Use Conflict Map/Resource Availability
10. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map

1. INTRODUCTION

1.1 General

East End, St. Croix is one of 18 Areas of Particular Concern (APC's) designated by the Planning Office in 1979 after public nominations and comment had been received (Figure 1). The East End St. Croix APC is located on the east end of St. Croix and includes East End, Jack, Isaac, and Cottongarden Bays; Kramer Park, Point Cudejarre, and Point Udall - the easternmost point in the United States of America.

The APC includes mountains, forests, beaches, and ocean cliffs, many areas which are of natural, cultural, geological, recreational, and scenic importance. Owing to the unusual combination of resources within the APC, the area has received other significant classifications as well. For example, sites within the APC have been nominated as Significant Natural Areas (SNA's).

On July 26th, 1991, the CZM Commission adopted the 18 APC's recommended in the Final Environmental Impact Statement (USDOC, 1979), which accompanies the Virgin Islands CZM Act. The Final Environmental Impact Statement notes "the importance of the entire coastal zone", but declares that "certain areas are of yet greater significance." It also establishes the criteria for the designation of Areas of Particular Concern which are as follows:

- Significant Natural Areas
- Culturally Important Areas
- Recreation Areas
- Prime Industrial or Commercial Areas
- Developed Areas
- Hazard Areas
- Mineral Resource Areas

In September of 1991, the Coastal Zone Management (CZM) Commission met and held public hearings on all three islands on the boundaries for all 18 APC's. The Commission met again on October 1, 1991 and, based upon public input and staff recommendations, approved the boundaries of the APC's.

APC management requires knowledge of an area's historical development and traditional uses, and an action-oriented plan for the area's future utilization. This Comprehensive Analytic Study and proposed management plan is intended to serve as an overall planning and management framework within which the various regulatory entities carry out their decision-making authorities.

The APC planning effort recognizes that permit decision-making is most often reactive; that is, the decision to approve or disapprove a proposed development is made in response to a specific permit request and its content, rather than in response to previously established guidelines of what is or is not acceptable for the area. The goal of developing an APC management framework is to be able to make a priori decisions about the allowable extent to which an entire landscape unit may be modified. In other words, the planning goal is to raise the level of decision-making from the site-specific to that of natural landscape units and the maintenance of a wide array of interactive resource uses.

1.2 Relationship to Other Plans and Regulations

The East End, St. Croix APC was prepared under the authority of the Coastal Zone Management Commission. The Study and proposed plan is intended to serve as the overall planning and management framework within which the various planning and regulatory entities carry out their respective authorities. It is intended that the policy framework contained herein be incorporated into the policies and review criteria of those entities, including, but not limited to, the Department of

Planning and Natural Resources (DPNR), the Department of Housing, Parks and Recreation (DHPR), the Port Authority, the Water and Power Authority (WAPA), the Department of Public Works (DPW), the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the U.S. Army Corps of Engineers (USACOE), the U.S. Environmental Protection Agency (USEPA), and the Department of Property and Procurement. This Study and proposed plan will serve as a guide for future decisions concerning the area. Future development activity should be consistent with Study and proposed management plan.

The intent of this Study and proposed management plan is for all participating territorial and federal agencies to utilize the broad policy framework to guide planning and permit decisions with respect to their own authorities. For those agencies that issue permits or review and comment on permit applications, the Study and proposed plan does not eliminate the authority of those agencies, but increases the predictability and timeliness of the permitting process since many of the issues that must be addressed in a specific permit application are already addressed and mandated in the Plan.

The issues surrounding any proposed use or activity within the coastal environment are complex. A proposed use immediately outside the boundary of the APC planning area may result in significant adverse impacts on the APC and impair the goals of the APC management framework described herein. This Plan contains several different forms of guidance, all of which should be considered in evaluating impact on an APC. Both the individual property owner who is considering a specific proposal and the decision-maker who is evaluating the proposal should follow the guidance of this Plan.

1.3 Historical Perspective and Overview

Historic occupation of the East End was greatly influenced by climatological and geological factors. Settlement in East End Bay occurred during the early 1740's, with the agri-business originally devoted to cotton production. Pre-Danish maps do not record any settlement east of Cheney Bay, to the north, and Great Pond, to the south.

East End Quarter, where it was too dry for effective sugar cane growth, most of the cotton plantations were used for other more marketable products. By the time of the original Beck map of 1754, plantations were established in all but the north-west and east parts of the island, with a predominance of sugar cane plantations. The 1794 Oxholm map, which shows the island at the height of historic development for that period, indicates that the easternmost sugar mills were located at Coakley Bay on the northern shore, and at Great Pond and Cotton Grove on the southern shore. The map depicts a number of cotton plantations within the East End Zone, including, Cotton Garden and Teague Bay. (Aug. 1990: Baumgardt, Kenneth)

1.4 Other Classifications

As early as 1960, East End, St. Croix was identified as an area in need of special planning. The 1960 Department of the Interior (DOI) study for the Governor recommended East End to be a Nature Preserve. A decade later, East End was singled out as an Area for Preservation and Restoration (APR) and nominated as a Significant Natural Area (SNA) in the DCCA/Teytaud study of 1980. The following year it was identified as an important element in an early V.I. Territorial Park System plan (VITPS/Alexander, 1981).

The offshore waters surrounding the East End were proposed for candidacy as a National Marine Sanctuary site in 1982. The 1991 post Hurricane Hugo - Virgin Islands' Territorial Park System Planning Project (VITPSPP) (Island Resources Foundation (IRF), 1991), concurred with previous

management recommendations that the East End be preserved as a multi-purpose park within a proposed Territorial Park System. Additionally, IRF suggested including the adjacent marine platform and Lang Bank, the proposed Marine Sanctuary Site, with the East End Park in a combined area management scheme.

2. DESCRIPTION OF THE SITE

2.1 APC Boundary

The boundary for the East End St. Croix APC, established by the Coastal Zone Management Commission, is described as follows:

Beginning at Hughes Point on the shoreline, heading northwest for two thousand (2000) feet; then west for five hundred (500) ft; then northerly to the mid-point of Knight Bay (the boundary follows the western boundary of the East End Conservation, Recreation and Traditional Uses District as mapped on the Coastal Land and Water Use Plan); then due north to a point on the outer shelf edge or three mile limit (whichever is closer); then east along the outer shelf edge or three mile limit around Point Udall and south and west to a point south of Hughes Point; and then north to Hughes Point, the point of origin.

2.2 Ownership Summary

Although approximately 95% of the land of St. Croix is held by private owners, the Virgin Islands Government currently owns approximately 340 acres, almost 50% of the East End peninsula. This peninsula is an APC. The entire APC is zoned R1 under current zoning laws. Zoning designations are specified in the V.I. Code, Title 29, Chapter 3.

2.3 Physical Environment

2.3.1 Climate

Rainfall in the Virgin Islands generally increases with increasing elevation and exhibits a trend on each island of a dry-to-wet cline from east to west. St. Croix on the whole receives an average of about 45 inches of rain per year (Figure 4). February and March are normally the driest months, September and October the wettest, with most rainfall coming in brief showers. Heavy rainfall sometimes occurs during the passage of an easterly flowing tropical wave. Occasionally, these waves intensify into tropical depressions, tropical storms, or hurricanes. The climate of this APC is decidedly arid. At East End, the average annual rainfall is less than 30". Persistent salt-laden (Trade) winds from the east and relatively warm overall temperatures promote evaporation of soil moisture. Most of the rainfall does not occur until the air mass encounters the steeper hills to the west. The Virgin Islands experiences the eastern flow of the trade winds. At this latitude (about 18 degrees N), at sea level, the temperatures range from mid to high 70's at night to low to mid 90's in the heat of the day during the summers and low to mid 70's at night to mid to high 80's in the day, during the winter months.

2.3.2 Geological Setting

The underlying sedimentary rocks at East End were formed from volcanic debris deposited here in the late Cretaceous age (Justus, 1980). These rocks, of the Caledonian formation, are composed of alternating light gray layers of sandstones and conglomerates and blue-black layers of fossiliferous

mudstone or chert. According to Whetten (1968, in Multer & Gerhard, 1980) the Caledonia formation is at least 9,000 feet thick. Other significant geological features are wave-cut terraces at Cottongarden Point, Isaac Point and Cudejarre Point which show former relative sea levels, igneous intrusions at East and Cudejarre Points, and a fossil locality at Isaac Point. There are six major natural soil/land types found within the APC (USDA, 1970):

Volcanic Rock Land(Vr). This land type is made up of areas where volcanic rock outcrops cover 50 to 70 percent of the surface and is found on all three islands. It is restricted to wildlife habitat and aesthetic purposes. The very steep slopes, exposed rock, and shallow soil material preclude its use for commercial production of crops, forage, or trees and severely limit all engineering and recreational uses.

Cramer stony clay loam, 12-40 percent slopes (CsE2). This soil type is found on the ridges and side slopes of dissected volcanic uplands in the eastern part of St. Croix. Most of the acreage is forest or brushy forest. Shallowness over rock, moderately steep slopes, stoniness, poor workability, and rapid runoff preclude cultivation. Limitations are severe for nonfarm purposes, as well as for industrial.

Cramer gravelly clay loam, 12-40 percent slopes (CrE). same as above statement.

Cramer stony clay loam, 40-60 percent slopes (CsF). This soil is on the side slopes of dissected volcanic uplands throughout the Virgin Islands. Steep slopes, shallowness over rock, rapid runoff, susceptibility to erosion and the large numbers of coarse fragments throughout the profile preclude cultivation and make it difficult to establish and maintain pasture. These limitations preclude nonfarm uses.

Isaac Series soils, 5-20 percent slopes (IvD). This soil occurs on side slopes and foot slopes of dissected volcanic uplands throughout the Virgin Islands. It has limitations for both farm and nonfarm uses.

Jaucus Sand, 0-5 percent slopes (JuB). This soil occurs as low, hummocky, sandy coastal areas on all three islands and on some small islands offshore. Severe conditions limit both farm and nonfarm uses.

San Anton Clay loam, 0-5 percent slopes (SaA). This soil type is found in the eastern portion of the APC boundary. It has favorable soil characteristics for both farm and nonfarm uses.

San Anton Clay loam, 5-12 percent slopes (SaA). same as above statement.

Historical seismicity in the USVI

As a result of convergence between the Caribbean and North American tectonic plates, the Virgin Islands are located in one of the most earthquake prone regions of the world. During the past 450 years, damage has occurred from earthquakes and associated tsunamis. Strong seismic shocks were recorded for the Virgin Islands in 1777, 1843, 1867, and 1918. Destructive tsunamis occurred in the U.S. Virgin Islands in 1867 and in 1918; the latter resulted in 116 deaths and economic losses estimated at \$4 million (in 1918 dollars) (USGS, 1984a). The 1867 tsunami was reported to have a wave height of 27-feet above sea level (Geoscience Associates 1984b).

Potential human and economic losses for a similar event occurring today would be several orders of magnitude higher. Scientists report high seismic potential for a major fault rupture in the Puerto Rico Trench north of Puerto Rico and the Virgin Islands (USGS, 1984a). The Virgin Islands are classified

as "Zone 4" for earthquake vulnerability, the highest damage zone and the same classification given to many parts of California (International Conference of Building Officials, 1988)

Studies prepared in 1984 estimated that an earthquake of MMVIII intensity (Modified Mercalli Scale) has a recurrence period of between 110 and 200 years for the St. Thomas/St. John area. The probability of such an earthquake occurring in the next twenty years is between 50 and 70 percent, and between 60 and 80 percent during the next 50 years (Geoscience Associates, 1984a and 1984b). The waterfront areas of Charlotte Amalie and Christiansted are especially vulnerable to impacts from earthquakes due to substantial construction on recently filled (reclaimed) land. It is these areas where liquefaction and ground settling are likely to be the greatest. Buildings constructed on loose alluvial or man-made fill soils along the waterfront majority of the waterfront area is built on reclaimed lands, with fill material deposited on top of an alluvial base (USVI Govt/DPNR 1992a).

2.3.3 Hydrological Setting

The EEN APC covers six complete watersheds ranging in size from about 30 acres to about 230 acres and the eastern halves of two watersheds which together, comprise about 85 acres of drainage area. Cottongarden Bay (the largest), Boiler Bay, and Lamb Bay watersheds are on the north side of the peninsula; East End Bay (the smallest), Isaac Bay and Jack Bay watersheds are on the south side. To the west, are the eastern slopes of the Grapetree Bay and Knight Bay watersheds.

Much of the land in the watersheds have slopes above 40 percent grade and much of the upper portions of the watersheds have slopes of nearly 60 percent grade. On these steep slopes, with the poor soil types (Cramer stoney clay loam), severe erosion would follow any disturbance of the ground cover.

There are no salt ponds to aid in sediment retention at the base of these slopes. On the lower, less sloped areas, mature vegetation, occasional littoral woodland, low rainfall, and relatively undisturbed beach berms have kept all but the occasional deluge from affecting the sensitive marine environment.

2.3.4 Coastal Environment

St. Croix does not experience significant tidal ranges or surface currents; maximum tidal ranges are on the order of one-foot. Tides are primarily diurnal, with only a slight secondary (semi-diurnal) tide cycle. Surface currents are driven by the North Equatorial Current, with its west-northwesterly flow; they tend to come more from the south during the summer months. Currents are generally less than 1.1 knots, but produce very complicated patterns of crossing sea and swell which can be observed on aerial photographs.

2.4 Biological Environment

2.4.1 Terrestrial

The East End APC is considered to be the largest open space area left on St. Croix and perhaps, excepting the Virgin Islands National Park on St. John, in the territory as a whole. In fact, one can drive to Point Udall overlook, get out of the vehicle and, except for the road to the east end, look

around in a 360 panorama and not see a man-made object. Based on this fact alone, preservation of the area for low-impact recreation, educational promotion and scientific study should be sought for the benefit of all people on St. Croix, not for just the few landowners of a new housing development.

2.4.2 Marine

Several factors and characteristics concerning the marine resources of the EEN APC have been identified by various researchers and are presented in the following extracts.

From: Chelsea, 1983, Preliminary candidate Marine Sanctuary Site Evaluation, East End St., Croix (Map, Figure 7):

1. A rich diversity of tropical marine organisms depend upon maintaining the integrity of the site.
2. Lang Bank has been identified as a Critical Area of high biological productivity.
3. The area has been an important site for scientific investigation of tropical marine habitats, and offers great potential as an interpretive center.
4. This area supports a small artisanal fishery.

[Extracts from]: The South St. Croix Reef: A Study of Reef Metabolism as related to Environmental Factors and Prepared for: DCCA

Prepared by: Walter H. Adey; Caroline S. Rogers; Robert s. Steneck; Norman H. Salesky [West Indies Laboratory, 1981]

The 4,000 year old eastern and southeastern bank barrier reef of St. Croix is one of the best developed reef systems in the tropical-Atlantic Caribbean area. With a length of 23 miles, it is the most extensive reef on the Puerto Rican-Virgin Islands shelf. Indeed, except for some American controlled Indo-Pacific islands, it is certainly the largest modern tropical reef structure on American territory. In spite of the explosive population growth on St. Croix in the last two decades, most of this reef system has remained largely unaffected by human activities. An industrial complex has been built at the southwestern end of the reef, and the northern section is heavily used for recreational purposes. However, the eleven mile section from Cotton-garden Point in the northeast around to Manchineel Bay in the southwest has remained essentially minimally impacted by the marine environment for the last 1,000 years.

In terms of the quality of life for an island population as well as shore protection, beach building and general recreational usage, this reef system is one of the most valuable natural assets possessed by the people of St. Croix. It is certainly the most important coastal resources. It has similar value to the many thousands of tourists that visit St. Croix each year, and of course has a more tangible value to the island in terms of the income brought by the visitors [sic]. While perhaps more modest, this reef system also has a considerable, but as yet unassessed, value in terms of the local commercial fishery for lobster, conch and fish.

The bank barrier reef of St. Croix is especially critical for three reasons: (1) much of it is still relatively untouched, and because many different sub-types of reef exist in this one complex, it can serve as a baseline reef for comparison with others throughout the Caribbean. Its maturity and diversity allow it to be major type for comparison with Indo-Pacific reefs; (2) it lies in American territory, where long-range protection and study are considerably more economically feasible than they might be for a similar reef on an independent island country; and (3) a marine laboratory, the West Indies Laboratory of Fairleigh Dickinson University with many of the facilities required for reef study, lies on the eastern end of St. Croix. (Marine Environments for the Virgin Islands technical supplement no.1)

[NB. The West Indies Laboratory was substantially damaged during Hurricane Hugo, September, 1989 and was closed. The insurance money received was used to help the financially troubled Fairleigh Dickinson University.

As discussed by Adey (1975, 1978) and Adey and Burke (1976), the eastern and southern bank barrier reef on St. Croix is 4-5000 years old.

The major transects from east to west are: off Isaac Bay, where a "young" reef breaking the surface in discontinuous fashion ranges from Cudejarre Point to Isaac Point; off Robin Bay where a strongly developed mature reef with a nearly continuous crest and a moderately deep reef flat blocks most of the shore from Rod Bay to Great Pond Bay; and off Halfpenny Bay where a continuous reef with a broad and shallow reef flat is developed.

As this study has further demonstrated, reef communities can be the most productive biological systems on the face of the earth. They are also among the most diverse and aesthetically interesting. The east and south bank barrier reef on St. Croix is one of the larger and better developed reefs in the Caribbean. In facing environmental and social problems, understanding how these biological/geological systems can be so productive and diverse must be among our top priorities.

The Virgin Islands Government should demonstrate to the Federal Government the importance of Federal fiscal support for land purchase and management to keep the south reef in a natural state for essential basic research as well as for controlled use by local and tourist populations.

The question of management of fully-developed reef systems is not one that has been properly addressed, nor can it be until the principal components of the system are sufficiently understood, a goal towards which this study is directed. Obviously, the surest approach to maintaining natural conditions is to prohibit all land and water use in the neighborhood of the reef. Since that approach is probably unattainable, we are led to the question that this study was designed to probe - what factors are most critical to reef function and how are human activities likely to affect those factors.

Reef systems are not static, and the basic patterns of geological change have been established for the major St. Croix reefs. The south shore reefs are particularly interesting in that all of the reef geological and ecological successional stages, young to old, are present. However, we can not expect all parts of the reef to remain in their present condition. St. Croix has not had a hurricane for some time. A major storm with its full impact on the south shore could accelerate a large part of the reef to the Halfpenny "old age" stage and render the reef less interesting for research or recreation. Nevertheless, this may be a century away, and it behooves us to preserve natural processes until that time.

Of particular interest is the role of grazers, fish and invertebrates, in maintaining algal turfs and a high level of productivity. We have not directly contributed to knowledge of grazer biomass, and dynamics and studies of grazer populations should be carried out. However, it seems very likely that overfishing of parrot fish and tangs could be crucial to these reefs in allowing colonization of larger algae. It might be that micrograzing invertebrates would only replace removed grazing fish, but predators are probably more effective in controlling micrograzer populations. In spite of the extremely high productivity of these reefs, it would seem that they are not characterized by significant export. Therefore general heavy fishing may never be feasible.

MONITORING

Prevention is preferable to monitoring, but the latter would probably always be necessary. We suggest stressing the following procedures to be carried out by two field technicians/wardens assigned full time to patrol and monitoring functions

- (a) continuous or monthly examination of community productivity at selected sites. Continuous monitoring by telemetry is probably possible and highly desirable, but the initial investment would be high.
- (b) legislation and patrol to maintain fishing, diving and boating at or near current levels on the reef itself. Public education on "how to behave" on or near a reef could probably be very effective. (Lagoonal or shelf fishing and recreational activities probably have little effect on the reef itself.)
- (c) develop a procedure for monitoring coral cover and spatial heterogeneity that is less time consuming and destructive than chain transects. Low level aerial photography carried out under calm conditions would seem to offer many possibilities.
- (d) biannual nutrient analyses (winter and summer) to determine that nutrients are remaining at a generally low level.

Intensive building or clearing of land along the watershed from Halfpenny Bay to East Point, especially of multi-unit dwellings or hotels would have great potential for damage to the reef system. While careful timing and control of run-off could probably greatly minimize damage during building, adequate control of a large population on this coast, relative to the reefs would likely be difficult.

2.4.3 Endangered Species

The U.S. Endangered Species Act defines "endangered species" to mean a species or subspecies that is in imminent danger of extinction throughout all or a significant portion of its range. "Threatened species" are those likely to become endangered in the foreseeable future unless current trends are reversed. Such species are protected by Federal Law; neither the whole animal or any products from it may be taken, sold, or possessed. Alteration of the habitat in which any of these species occurs may be, in certain cases, prohibited or constrained.

The V.I. Legislature has also passed endangered species legislation. Known as the Indigenous and Endangered Species Act of 1990, the bill (Act 5665), signed into law in December 1990, authorizes the Commissioner of the DPNR to promulgate a list of endangered and threatened species in the Virgin Islands. The V.I. Government, Department of Planning and Natural Resources, Division of Fish and Wildlife maintains a list of locally endangered or threatened species.

Several federally listed rare or endangered species are found within the East End St. Croix APC. Those found are:

- Brown Pelican
- Green Turtle
- Hawksbill Turtle
- Leatherback Turtle
- Least Tern

Several endangered species of whales have been reported off the coast of St. Croix (USACOE, 1990). These include the Sei whale (*Balaenoptera borealis*), the Finback whale (*Balaenoptera phyalus*), the Humpback whale (*Megaptera novaeangliae*), and the Sperm whale (*Physeter catadon*).

2.5 Cultural Resources

2.5.1 Prehistoric

A prehistoric site is known near Cramer's park. There was little or no access to the eastern portion of the area when early archaeological work was done. There are several likely locations for prehistoric sites, primarily in East End and Jack and Isaac Bays but no recent studies have been done (Ehle and Gore, 1989).

2.5.2 Historic

A survey done on behalf of a proposed development in Estate Longpoint-Cottongarden (Figueredo, 1988), which is just outside the APC, found records for a portion of Estate Longpoint-Cottongarden that indicate that it was a cotton plantation in the late 1700's, becoming pasture after 1800.

2.6 Built Environment

This area is mostly unimproved. There are a few residential buildings with a large satellite receiving dish.

2.6.1 Roads and Ports

East of Kramer Park the roads are unimproved. Access to this area is by way of Long Point to Jack's Bay via a dirt road. Access from Grapetree Bay is presently being disputed. (There is no direct access).

2.6.2 Water Systems

For residents of this area, cisterns are the main water source. Since this area is usually very dry, the water source is supplemented by private water haulers.

2.6.3 Wastewater Systems

Because of the mixture of soils found in this area, volcanic rock land, Cramer stoney clay loam, Cramer gravelly clay loam, Isaac series soils, Jaucus sand, and San Anton clay loam, farm or nonfarm use of individual cisterns or sewage tanks and drainfields are not recommended.

2.6.4 Energy Systems

Power for St. Croix is generated at the Richmond power plant on the western outskirts of Christiansted. Power outages are common. A new 22 MW power plant is planned to start construction during 1993 at the Southshore Industrial Area. WAPA is awaiting EPA permits. The new power plant is badly needed, as WAPA has projected an average 50 days/year of insufficient power supply given current supply/demand rates. In 1991, St. Croix experienced 304 hours, or 12.5 days, of insufficient supply (Daily News, 12 July 1992). The two large industries, HOVIC and VIALCO, operate independent power systems for their operations.

2.6.5 Solid Waste Disposal Systems

St. Croix's only municipal solid waste landfill is located on the central southshore, at Estate Anguilla

within the Southshore Industrial APC. Residents are responsible for disposing of solid waste in large roadside dumpsters, which are transported to the landfill by a private contractor. Businesses are required to provide for their own solid waste removal.

3. RESOURCE USE, USE CONFLICTS, AND ADVERSE IMPACTS

3.1 Resource Use

The following list identifies the known and interpreted land and water uses of the East End Area of Particular Concern as indicated on the Land Use Map. Land use was interpreted from aerial photography and groundtruthed for accuracy. The classification system, based on the Teytaud/U.S. Geological Survey (TUSGS) land use/land cover classification system (DDCA-DCZM, 1981), is hierarchical, with three levels of categories, increasing in specificity from level I (e.g., 100 series [the most general] -Urban or Built-up Land) to level II (e.g., 110 series - Residential) to level III (e.g., 111 - Single unit, low density [less than 2 DUPA], the most detailed:

1. recreational: (171 beaches and shore, 177 community recreational);
2. fishing grounds/marine sanctuaries (#s???)
3. institutional: (165 military installation, 166 scientific station);
4. open land : (192 inactive land);
5. scrub/brush land: (321, dwarf coastal scrub);
6. woodland: (421 woodland with cactus); 424 mixed woodland and brush);
7. habitat for endangered species.
8. bays (541 open bays);
9. transportation (146 navigable waterways, 147 auto parking (for Cramer Park and at East End Scenic Vista);
10. open marine waters (550 nearshore);
11. marine bottom communities (561 marine grass beds, 562 coral reefs, 563 unvegetated sand);
12. barren land (710 beaches and 703 exposed rocky shorelines);
13. residential: (111 low density);
14. agriculture: 251 inactive agricultural lands);

3.2 Use Conflicts

There are no use conflicts within the APC.

3.3 Adverse Impacts

3.3.1 Water Quality

The water quality in the APC is excellent.

3.3.2 Air Quality

Legally, there are no "non-attainment areas" in the Territory with respect to compliance with National Ambient Air Quality Standards (NAAQS).

Title V of the federal Clean Act (CAA) requires all states and territories to submit a federally enforceable operating permits program to control air pollution to EPA by November 15, 1993. As a result, many small businesses will soon be required to monitor and control their emissions of pollutants and apply for operating permits. The National Ambient Air Quality Standards will be the standards by which permittees must comply. Realizing that many small businesses have neither the technical expertise or the financial resources to comply with the act, EPA requires that the Virgin Islands adopt a small business assistance program to assist businesses in complying with the act.

3.3.3 Noise

There is no noise pollution within the APC.

3.3.4 Impacts to Biological Resources

There is presently no known negative biological impact to the APC, however, there has been persistent efforts to subdivide and develop this area. Development in this APC must be continuously scrutinized to avoid detrimental impact on the biological resources of the APC.

3.3.5 Impacts to Cultural Resources

The construction of the new National Radio Astronomy Observatory (NRAO) dish during the winter and spring of 1990-91, on a 4 - acre parcel of government land at Estate Longpoint and Cotton Garden was contested by CaribBank Financial Group on the grounds that the dish created visual pollution of the area and that it is inappropriate for coastline development (VI Daily News, 04/28/90). CaribBank is planning a 300 - acre, 157-home subdivision near the antenna site and felt that the dish was not amenable with a housing development. It seems as though the two groups reached an out-of-court settlement.

The 100 foot tall dish, the easternmost part of an interconnected ten-station Very Long Baseline Array (VLBA) antenna dish chain which spans the US from St. Croix to Hawaii, is designed to receive real-time radio signals from space. Scientists hope to relate the signals to hypotheses about the origins of the universe.

Existing recreational facilities in the EEN APC are limited to the beach and campground area at Kramer Park, several rough access roads to the east end beaches and a few primitive trails leading from the overlook at Point Udall. The Kramer Park site has a good beach, picnic tables and a large open field often used as a campground on holiday weekends. Rest rooms and changing houses are at the park sites but the food and beverage concession area that existed at the site was damaged during Hurricane Hugo in September, 1989, and has not been rebuilt.

The East End area overall has been subject to numerous scientific surveys done by students at the former West Indies Lab. Although the reef systems are excellent in quality and condition, not much takes place in the area, mostly due to the difficult access to many of the sites. Several dive shop operators take guided dive tours to locations at Lang Bank, and the tour operators are careful to use moorings rather than anchors to limit reef damage.

4. MANAGEMENT RECOMMENDATIONS

4.1 Policy Framework

Establishing a comprehensive policy framework to guide decision-making for improvements and future development of East End, St. Croix APC is a crucial process to be undertaken if the blight of

similar APC's elsewhere is to be avoided. Private citizens, elected leaders, citizen action groups, other community groups, and the business community must all participate in the planning and goal-setting process, and reach consensus on the best strategy to pursue to ensure that the East End develop with vitality and sound planning.

4.2 Planning and Permitting

The East End APC is currently zoned as PR-1.

Since the late 1980's, DPNR/Comprehensive Planning staff have worked to prepare a Comprehensive Land and Water Use Plan that will re-designate all land and water in the Territory as one of ten(10) new designations, known as "Intensity Districts". The purpose of the proposed Comprehensive Plan is to allow the territorial Government to begin providing public services and facilities concurrent with the demand for those services and facilities; that is, to ensure that the provision of public services and facilities occurs at the proper level and at the proper timing during the course of development. The overarching goal of the proposed Comprehensive Plan is to ensure that the quality-of-life for island residents is maximized by guiding the location and type of future growth through the provision of public facilities. DPNR/Comprehensive Planning is currently working to finalize the proposed Comprehensive Plan, including preparation of maps.

Due to potential for adverse impacts to marine resources in the event of sediment runoff, all permitted development should be required to strictly follow Best Management Practices (BMP's) for nonpoint source pollution control. Nonpoint source pollution is a significant contributor to the overall degradation of nearshore environments in the Virgin Islands (Tetra Tech, 1991). Although the islands have no perennial streams or rivers, episodic events of intense rainfall deliver pulses of fresh water laden with sediments, nutrients, organic matter, and potentially toxic chemicals to nearshore receiving waters. Control of nonpoint source pollution may have significant positive effects on pristine and otherwise valuable marine habitat. DPNR/CZM is currently working to assess the enforceability of existing regulations with respect to control of nonpoint source pollution.

Permitted development should be required to maintain an adequate distance from critical landscape features (such as guts, salt ponds, beaches, etc.). The setback distance (or buffer zone) should be determined through consideration of slope, aspect, vegetative cover, and other relevant factors. DPNR/CZM has drafted specific regulations as it pertains to steep slope development and is awaiting passage by the legislature.

Natural Hazards Mitigation

There is a need in the Territory for an effective coastal storm hazard mitigation policy and plan. The siting of facilities along the coast increases a cumulative threat potential with respect to three types of coastal storm impacts: (1) threats to public health, safety, and welfare; (2) costs to tax payers for disaster relief and protection; and (3) losses of irreplaceable natural resources (Godschalk, et al., 1989). Compounding the potential for catastrophic losses due to coastal storms is the possibility of significant sea level rise (SLR) in the decades ahead.

While average SLR over the last century has been less than one-foot (10-15cm), an increase in that much or more (10-20cm) is projected by 2025, and of between 1.5 and 6.5 feet (50-200cm) by the year 2100. Using an average of 1 meter of shoreline erosions per cm of SLR, the resulting average by 2025 would be 33 to 66 feet (10-20 meters) [Godschalk,et al., 1989].

There are generally three strategies that may be adopted to mitigate coastal storm hazards and SLR impacts. First, the natural coastline can be "hardened" by using designed protective structures, such as bulkheads, revetments, gabions, etc.. Second, facilities and structures built in high hazard areas can also be hardened through the use of stricter building standards to achieve increased wind and/or flooding resistance. These strategies often require resorting to and preparing for evacuation of people during a storm event, with its incumbent risk to human life.

Third, and a better approach, coastal development can be directed or redirected away from high hazard areas through the use of shoreline setback standards and/or re-zoning of high hazard areas to achieve simultaneous risk reduction and other objectives such as open space preservation or wildlife management.

This so-called "development management" strategy, is generally the most cost-effective option. As with the use of stricter building codes, increased costs associated with the alteration of land use patterns to reduce the exposure of people and property to storm damage are offset by long-term savings (from less damage) and reduced insurance rates. It is always (politically) easier to add a hazard mitigation section to an existing plan, regulation, or program than it is to adopt a totally new set of tools. In fact, there is no better time than today to prepare for the next storm, by introducing legislation that will require the use of new guidelines for decision-making during the next re-building effort.

A coastal storm hazard mitigation policy and regulations should be developed for the Territory on a site-specific basis. A "development management" alternative to hazard mitigation is recommended, and will require that implementing legislation be enacted soon in preparation for the next disaster. Future public and private developments should be directed away from high hazard areas. Redevelopment policies should be considered for existing shoreline development to minimize potential losses, and to establish a reconstruction plan prior to its need.

As seen above, earthquake potential in the Territory is relatively high. While most of the APC is on lands with negligible slope, other lands immediately east and north of Frederiksted have considerable slopes. Where landfilled areas are to be used for construction, logic suggests that certain compaction standards be adhered to and a certified engineer report required for all major facilities.

Appropriate attention should be given the design for major facilities, especially those which will house large assemblies of people, so that threats from seismic activity are absolutely minimized.

Flooding mitigation will be an ongoing concern for new developments in many locations in the APC and its watersheds. As mentioned above, FEMA/NFIP A-Zone and V-Zone floodplains exist throughout the area.

Strict adherence to National Flood Insurance Program policies and regulations is recommended, and new developments restricted where the hydrology and flooding potential of an area may adversely affect important wildlife habitat or other natural features. Channelization for flood control should be avoided wherever possible, and new developments directed away from floodplain hazard areas. Cumulative impacts from the increased use of non-porous surface materials should be assessed, and guidelines established for the use of "grassphalt" and other porous surface materials on access roads, parking lots, and other suitable areas. These measures will be of

increasing relevance for the contributory watersheds of La Grange Gut, in order to minimize flood potential at the Gut's lower reaches. Regular maintenance of all drainage systems, and an assessment of proper sizing of culverts, should be integral to a program of stormwater management for the APC.

Water

Due to the fairly undeveloped status of the East End, the water quality remains more or less unpolluted. However, actions to develop the area could lead to widespread water pollution as is found elsewhere on St. Croix.

4.3 Legislative Change

There is no V.I. law regarding the use of jet skis which are generally incompatible with other watersports activities. Although they are considered to be motor vessels, there are no standards (noise, speed, etc.) by which they operate, and no provisions in the law to consider the needs and safety of other water users, including swimmers and various aquatic or wildlife species.

The Division of Archaeology and Historic preservation is currently working on an Antiquities Legislation Bill that will be submitted to the Legislature for approval. This Bill will address the requirements for archaeological work any where in the Territory.

The Antiquities Legislation Bill will ostensibly bring greater clarification to the question of overlapping jurisdictions on historic protection matters, and will generally strengthen the overall authority and mandate of the Historic Preservation Commission (HPC). While such development is good, lawmakers should not lose sight of the long-term institutional and legal framework needed to bring about a comprehensive, coordinated, streamlined permitting system.

5. CONCLUSION

The East End is one of the few natural area on St. Croix that remains virtually undeveloped. The St. Croix Community and the V.I. Government should continue to work together in order to maintain the integrity of the site and its adjacent land and waters. The APC boundary should be seen as a *necessary* "buffer zone" within which development should be strictly controlled.

The V.I. Government should begin now to identify sources of funds to either acquire land or obtain conservation easements in this critically sensitive area. Such a fund-raising effort should be multi-faceted and creative, employing a variety of mechanisms that will encourage landowners in the area and the general public at large to participate.

The ecological integrity of the East End will rest on the ability of the Government to insure effective control over watershed development. Sound land use planning and site-specific mitigation practices must be utilized through the watershed if downstream effects are to be minimized. Technical expertise in planning and resource management is needed, including, but not limited to watershed/nonpoint source pollution control, wildlife habitat management, water use planning and the management of aquatic habitat.

A long-term vision of the importance of bio-diversity conservation is needed. DPNR is mandated, by law, to effectively carry out this function.

REFERENCES CITED

- Adey, Walter, Rogers, C., Steneck, R., Salesky, N., 1981. The south St. Croix reef: A study of reef metabolism as related to environmental factors and an assessment of environmental management. West Indies Laboratory, St. Croix, for the Department of Conservation and Cultural Affairs.
- Alexander, J., Sr. May, 1981. Virgin Islands Park System (Draft). Department of Conservation and Cultural Affairs.
- Anderson, J.R., et al., 1976. A land use and land cover classification system for use with remote sensor data. U.S. Geological Survey Professional Paper 964.
- CaribBank Financial Group, L.P., June 21, 1991. Response of the applicant to comments raised at the June 5, 1991 public hearing on the Jack's Bay Project. prepared by Bioimpact, Inc, Sive, Paget & Roesel, P.C. and Edward D. Stone, Jr. & Associates, 2 Volumes.
- Chelsea International Corporation, 1982. Preliminary Candidate Marine Sanctuary Site Evaluation (C-3), East End St. Croix, U.S. Virgin Islands, for: NOAA.
- Daley, Christopher B., 1991. Support ebbs for waterfront building, in: The Washington Post, November 26, 1991.
- DeGraaf, Joan (DPNR), 1989. SNA resource protection and management issues pre- and post-Hurricane Hugo.
- Department of Conservation and Cultural Affairs, 1975. Report on water quality, Virgin Islands United States of America, 1970-1975. See especially Appendix D, "Water Quality Standards for Coastal Waters of the Virgin Islands."
- Department of Conservation and Cultural Affairs, 1982. A Report on the Environmental Quality and Documented Physical and Biological Conditions of Bays to be included in the Proposed Coastal Water Use Policies. Office of natural Resources management, DCCA.
- Department of Conservation and Cultural Affairs, 1982. A Report on the Environmental Quality and Documented Physical and Biological Conditions of Bays to be included in the Proposed Coastal Water Use Policies. Office of Natural Resources Management, DCCA.
- Department of Conservation and Cultural Affairs, Division of Natural Resources Management, 1975. Environmental reconnaissance surveys of selected bays. Government of the Virgin Islands of the United States.
- Department of Conservation and Cultural Affairs, n.d. Preliminary recommendations for the water and shoreline use plan.
- Department of Planning and Natural Resources, 1989. An Environmental Management Policy Initiative for the East End Area of Particular Concern Division of Coastal Zone Management,

Department of Conservation and Cultural Affairs, Government of the Virgin Islands of the United States, May 1981. A Virgin Islands land use/land cover classification system (based on the U.S. geological survey and state of Florida classification systems).

Ehle, C and Gore A., 1989. An Environmental management Policy Initiative for the East End Area of Particular Concern.

Ewel, J.J. and Whitmore, J.L., 1973. The Ecological Life Zones of Puerto Rico and the U.S. Virgin Islands, Forest Service Research Paper ITF-18, Institute of Tropical Forestry, Rio Piedras, Puerto Rico.

Federal Emergency Management Agency, Revised March 18, 1987. National Flood Insurance Program, Flood Insurance Rate Map, U.S. Virgin Islands, Community-Panel Number 780000 0070 C.

Federal Emergency Management Agency, Revised March 18, 1987. National Flood Insurance Program, Flood Insurance Rate Map, U.S. Virgin Islands, Community-Panel Number 780000 0090 C

Forman, Richard T.T., 1974. An Introduction to the Ecosystems and Plants on St. Croix, US Virgin Islands, in: Multer, H.G. and Gerhard, L.C., 1974, Geology-Ecology of St. Croix, USVI

Gosselink, James G., et al., 1990. Landscape Conservation in a Forested Wetland Watershed, Can we manage cumulative impacts?, in: Bioscience Vol. 40 No. 8, pp 588 - 600

Government of the United States, 1972. Coastal Zone Management Act of 1972, PL 92-583, October 27, 1972. Bureau of National Affairs, Inc., Washington, D.C. 20037.

Government of the Virgin Islands of the United States, Department of Conservation and Cultural Affairs, n.d. A report on the environmental quality and documented physical and biological conditions of bays to be included in the proposed coastal water use policies.

Government of the Virgin Islands, 1971. Open Shorelines Act No. 3063.

Government of the Virgin Islands, 1979. Proposed rules and regulations for the Virgin Islands (Chapter 21) Coastal Zone Management Program, St. Thomas.

Government of the Virgin Islands, March 18, 1991. Rules and regulations for the Virgin Islands (Title 12, Chapter 21) Coastal Zone Management.

Government of the Virgin Islands, n.d. Federal Coastal Zone Management Regulations.

Government of the Virgin Islands, Virgin Islands Planning Office, Coastal Zone Management Program, 1977. Marine environments of the Virgin Islands technical supplement no. 1.

Government of the Virgin Islands. n.d. Guidelines for the development of a long range comprehensive plan for the United States Virgin Islands.

- Holloway, Marguerite, 1991. High and dry, in: *Scientific American*, December 1991, Volume 265, Number 6, pg 16.
- Hubbard, D, ed., 1989. Terrestrial and marine geology of St. Croix, U.S. Virgin Islands. Special publication number 8, West Indies Laboratory, St. Croix, 213 pp. (See individual papers especially Bruce, et al., [above] and Harry Roberts, p.99.)
- Hubbard, Dennis K., et al., 1981. The production, transportation, and deposition of carbonate sediments on the insular shelf of St. Croix, U.S. Virgin Islands. West Indies Laboratory, Fairleigh Dickinson University, Contribution Number 76.
- Island Resources Foundation, 1991. Virgin Islands Territorial Park System Planning Project and Hurricane Hugo Coastal Resources Damage and Recovery Assessment.
- McKinzie, William E., Scott, Bob F., Rivera, Luis H., 1965. Soils and their interpretations for various uses. Soil Conservation Service, U.S. Department of Agriculture, Virgin Islands Government, St. Croix, Virgin Islands.
- Millemann, Beth, Time, Tide and Federal Insurers, How a Government Plan Has Helped Ruin America's Shores, in: *The Washington Post*, August 4, 1991
- Moore, Donald R., 1969. Report on the mollusca collected on St. Croix. Special project #3, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, U.S. Virgin Islands.
- Multer, G. and Gerhard, L., 1974. Geology-ecology St. Croix, U.S.V.I. Special publication No.5, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, 312 pp.
- Multer, H. Gray, 1974. Summary of the Holocene geology of the Great Pond Area, Southeast St. Croix, in: Multer, H.G. and Gerhard, L.C., 1974, Geology-ecology St. Croix, U.S.V.I.
- Multer, H. Gray, and Gerhard, Lee C., 1974. Guidebook to the geology and ecology of some marine and terrestrial environments, St. Croix, U.S. Virgin Islands. Special publication no. 5, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, U.S.V.I.
- National Oceanic and Atmospheric Administration Office of Coastal Zone Management Sanctuary Programs Division, 1983, National Marine Sanctuary Site Evaluations, Recommendations and Final Reports, prepared by Chelsea International Corporation.
- Nichols, M. and Kuo, A., et al., April 1979. Virgin Island Bays: Modeling of water quality and pollution susceptibility, Technical Report 3.
- Ogden, John C., et al., 1972. An Ecological Study of Tague Bay Reef, St. Croix, U.S. Virgin Islands, special Publication in Marine Biology Number 1, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, U.S. Virgin Islands.
- Rogers, C., et al., 1984. Comprehensive report on ambient water quality monitoring St. Croix, St Thomas, and St. John, 1973-1983.

- Schouten, Fredreka, July 27, 1991. CZM Commission selects 18 areas for special care (about the 18 APC's). In: Virgin Islands Daily News.
- Soil Conservation Service, USDA, 1970. Soil Survey, Virgin Islands of the United States
- Strategic Planning Group, 1991. United States Virgin Islands Comprehensive Land and Water Use Plan, Executive Summary, prepared for: Department of Planning and Natural Resources, Government of the United States Virgin Islands.
- Teytaud, A, March 18, 1989. Suggested methods for SNA field evaluation and priority ranking. Virgin Islands Conservation Society, Inc.
- Teytaud, A., May, 1981. A Virgin Islands land use/land cover classification system. Division of Coastal Zone Management, DPNR.
- Teytaud, A., n.d. A framework for environmental planning and management in the Virgin Islands coastal zone.
- Teytaud, A.R., 1980. Draft Guidance Plan for the St. Croix Coral Reef System Area of Particular Concern, Department of Conservation and Cultural Affairs.
- Teytaud, A.R., July, 1981. Development on Steep Slopes: Recommendations for Development Suitability, Erosion Control, and Septic Tank Systems in the U.S. Virgin Islands, DCZM Technical Circular #3. Division of Coastal Zone Management, DCCA.
- Teytaud, A.R., July, 1981. Notes and Procedures for Mangrove Revegetation Projects, DCZM Technical Circular #2. Division of Coastal Zone Management, DCCA.
- Treadway, Tyler, July 19, 1991. CZM rejects subdivision on St. Croix. (about Carib bank's plan to subdivide 301 acres into 163 homesites at Jacks' and Isaac's Bays.) In Virgin Island Daily News.
- U.S. Department of Commerce, 1979. Jan. The Virgin Islands Coastal Management Program and Final Environmental Impact Statement. "Chapter Six, Areas of Particular Concern". NOAA.
- U.S. Department of Commerce, 1980. Improving your waterfront: a practical guide. NOAA, Washington, D.C.
- U.S. Department of Commerce, April 1990. Coastal management solutions to nonpoint source water pollution. NOAA, National Ocean Service, Office of Ocean and Coastal Resource Management.
- U.S. Department of Commerce, Jan 1979. The Virgin Islands coastal management program and final environmental impact statement. "Chapter Six, Areas of Particular Concern". NOAA.

- U.S. Department of Commerce, June 7, 1983. National Marine Sanctuary Site Evaluations - Recommendations and Final Reports, prepared by Chelsea International Corporation for NOAA, Office of Ocean and Coastal Resource Management. (Relevant to East End, St. Croix and southeast St. Thomas waters.)
- U.S. Department of Interior, National Park Service, 1960. Park and recreational area plan - Virgin Islands, A Report on the Recreational Resources.
- U.S. EPA 1990. EPA Region II Caribbean distinctive habitats module.
- U.S. EPA, April, 1990. Coastal management solutions to nonpoint source water pollution. U.S. Dept of Commerce Technical Assistance Bulletin # 102.
- U.S. EPA, edited by Titus, James G., 1987. Greenhouse Effect, Sea Level Rise and Coastal Wetlands.
- U.S. EPA, May, 1991. Proposed guidance specifying management measures for sources of nonpoint pollution in coastal waters.
- United States Department of the Interior/National Park Service, 1983. General Management Plan, Development Concept Plan, Environmental Assessment, Buck Island Reef National Monument/United States Virgin Islands.
- Virgin Islands CZMP Staff, 1991. Areas of Particular Concern (Descriptions, July 18). Dept Planning and Natural Resources.