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Population Growth in North Carolina: Implications on Coastal Wastewater Management

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Implications On Coastal Wastewater Management

by

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I. INTRODUCTION

The sustainability of North Carolina's coastal resources are threatened from environmental degradation. A decline in water quality has resulted, in part, from a lack of regional consensus on coastal wastewater management. Yet coastal population growth continues without the necessary infrastructure to support domestic wastewater treatment.

Ocean outfall is one alternative to the current use of on-site septic tanks and municipal discharge into coastal waters that has been considered for more than two decades. An ocean outfall option is attractive because it can divert pollution out of North Carolina's productive estuaries and sounds. By discharging treated wastewater effluent into the coastal ocean through a diffuser system, an outfall can also benefit from dynamic wave action and obtain higher dilution rates than in an estuary or sound.

However, any change in domestic sewage waste disposal has been thwarted by both public and state resistance. One primary concern is that the centralized treatment of wastewater, via an outfall, would accelerate coastal growth. This fear can be traced to the coupling of sewage and growth regulations, where coastal North Carolina has attempted to control population growth and density through septic tank siting requirements. Traditionally, the limit on coastal development in North Carolina has been the unsuitability of soils for septic tanks. The high financial burden on state and local levels has been another source of resistance contributing to the negative social perceptions surrounding an outfall.

This paper will attempt to address the feasibility of an ocean outfall in the state of North Carolina by summarizing results of earlier research, drawing expertise from current outfall projects, examining legal and financial obstacles, and evaluating progressive steps toward an integrated planning of coastal wastewater disposal. Integrated Coastal Management (ICM) is one framework through which North Carolina can better plan for and manage its wastes so it can achieve higher coastal environmental quality. The ICM methodology, proposed by the National Research Council, can enhance the selection and implementation of a wastewater management plan by minimizing human health and environmental risks. But in order to achieve integrated coastal management, the issue of population growth needs to be examined and addressed independently to properly assess its influence on wastewater management.

II. DEMOGRAPHIC TRENDS IN NORTH CAROLINA'S COASTAL MARGIN

Like many other coastal areas worldwide, North Carolina is experiencing intense coastal population growth, resulting in changes in historical land-use patterns (Chesson 1985, Environmental Protection Agency 1990, Gottovi 1993). Coastal growth has traditionally been concentrated in three counties: Dare, Carteret and New Hanover Counties (Fig. 1) (Copeland 1992). The average growth rate for North Carolina's twenty coastal counties during the 1980's was 19.2%, with Dare County (situated on the outer banks) exhibiting the highest growth rate during this same period at 70% (Howes 1993). Population growth rates over the last three decades reveal an even more dramatic rate of coastal population growth. Accordingly, the towns of Atlantic Beach and Emerald Isle in Carteret County experienced rates of 214% and 610%, respectively (Armingeon *et al.* 1989).

Of particular economic and environmental interest to North Carolina is the Albemarle-Pamlico estuarine region, the second largest estuarine complex in the United States, comprising nearly one-third of the state of North Carolina (Fig. 2). This region is currently growing at a rate exceeding 18,000 people per year (Environmental Protection Agency 1990). In the 1980's, a 70% increase in housing and a 184% increase in the number of marinas were indicative of this growth (Tschetter 1989). A compounding factor to the permanent residential growth of many coastal counties is the ongoing increase of the seasonal/recreational populations. This factor is often three to four times

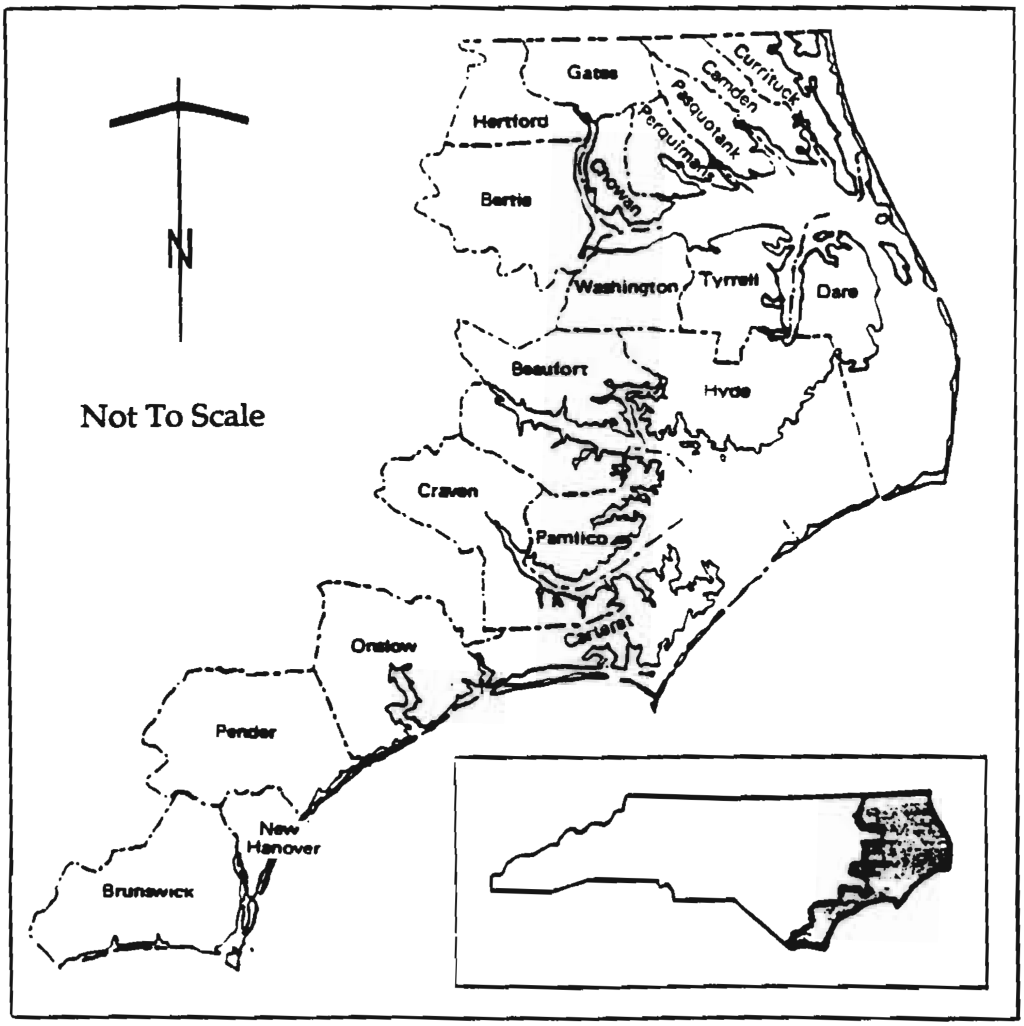

Figure 1. North Carolina's 20 coastal counties covered by the Coastal Area Management Act. Adapted from (North Carolina Department of Environment, Health and Natural Resources, Divison of Coastal Management, 1985, Figure 1.).

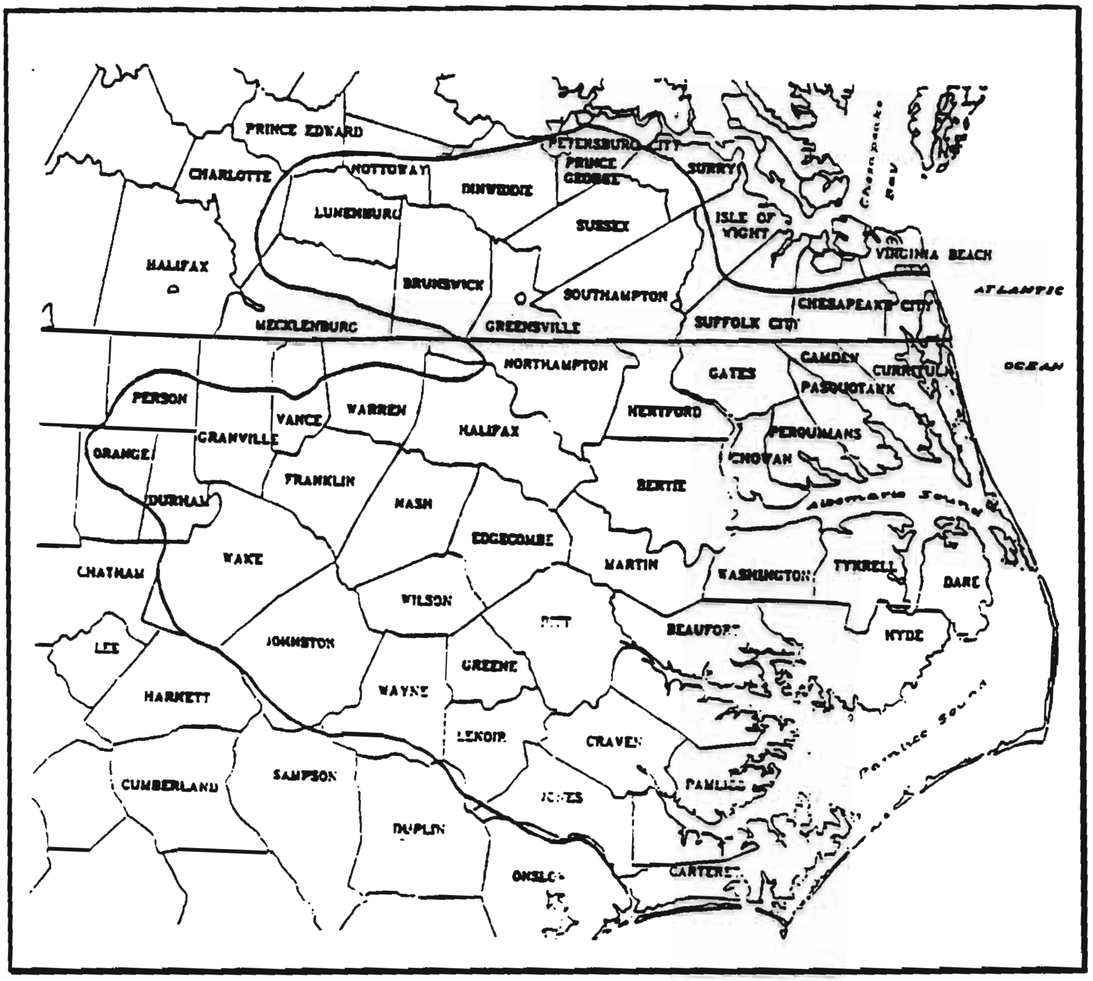

Figure 2. Albemarle-Pamlico Estuarine Study Area. Adapted from (Albemarle-Pamlico Estuarine Study, 1992, Figure I-1.).

that of the permanent population (Tschetter 1989, Howes 1993). These trends suggest that the current demographic structuring will continue (Schubel 1993). The National Oceanic and Atmospheric Administration (NOAA) reported that the Southeast region of the U.S. will be the most rapidly growing area, in terms of coastal population, in the country in the next several decades (Schubel 1993).

III. ENVIRONMENTAL IMPACTS AND THEIR ECONOMIC IMPORTANCE

As a result of population pressures, environmental stress has been an issue. On a visit to the North Carolina coast, Walter Cronkite called the shoreline "a disaster zone" (Cronkite 1989). North Carolina's coastal water quality has degraded signifcantly in recent years (North Carolina Department of Environment, Health and Natural Resources (NCDEHNR) 1990, Albemarle-Pamlico Estuarine Study (APES) 1992, Howes 1993). Individual North Carolina estuaries have had as much as 41% of their acreages closed to shellfishing from 1970-1984 (McCullough 1984). Figure 3 shows shellfish bed closures in areas near the Barrier Islands during the 1980's (Terry 1993). By 1989, over 320,000 acres of shellfish beds were closed along the North Carolina coast (NCDEHNR 1990).

A contributing factor to the decline in coastal water quality is the discharge from river systems. Two of the largest river basins in North Carolina can only support 60% of their intended uses, although half of these are in danger of becoming support-threatened (NCDEHNR 1990). In terms of use of shellfishing acreage, three out of six major river systems had greater than 30% of their acreage closed (McCullough 1984).

Eutrophication, the result of increased organic input, and low dissolved oxygen levels have threatened the sustainability of fishery resources (APES 1992). Loading of nitrogens and phosphates in estuaries has increased nearly 70% over the past century (Paerl *et al.* 1990). Due to inadequate flushing rates and the tendency of nutrients to become trapped in-situ in sediment, most North Carolina estuaries have been classified as

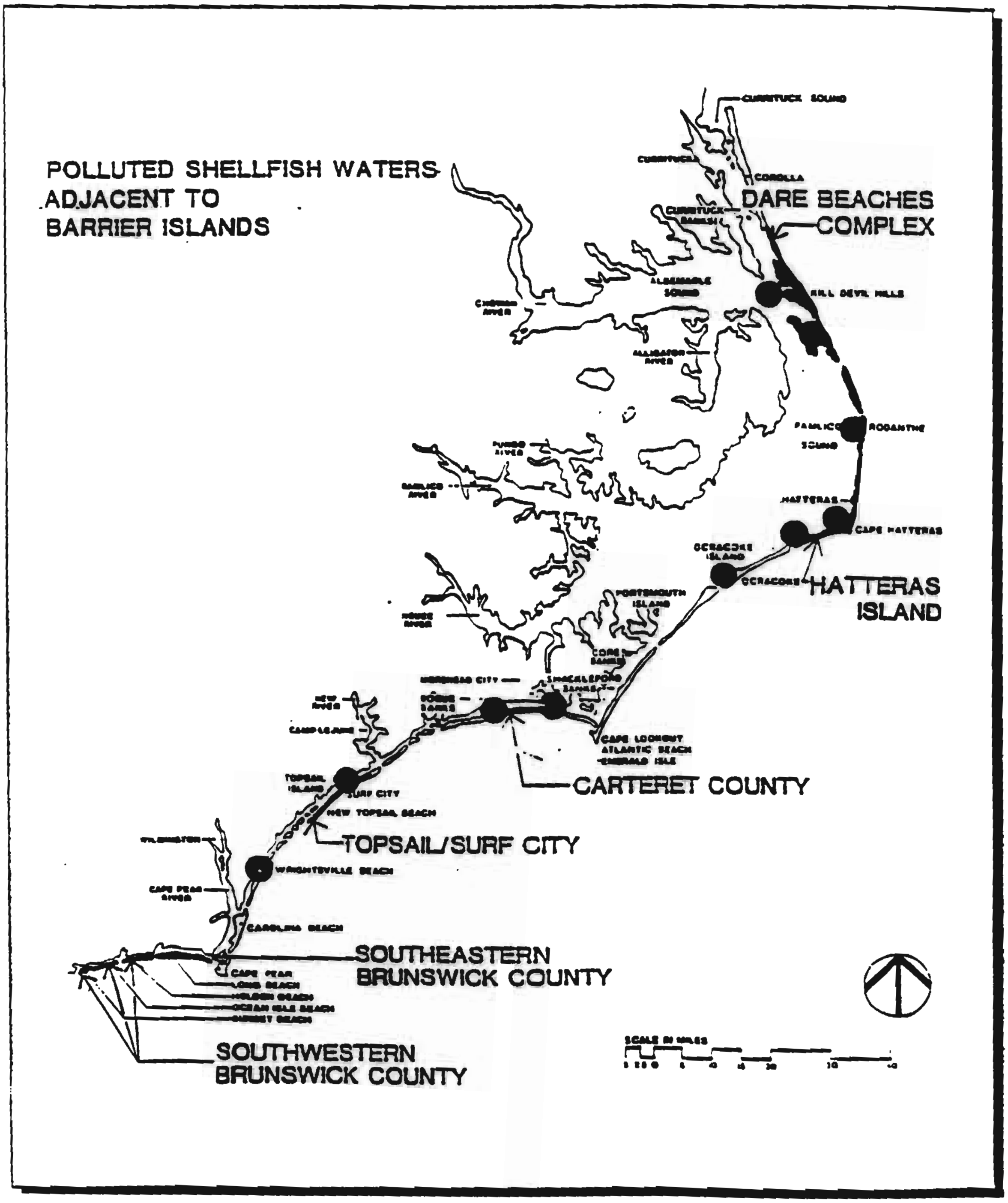

Figure 3. Shellfish bed closures adjacent to the Barrier Islands. Adapted from (Terry, 1993, Figure 8.).

Nutrient Sensitive Waters (NSW) (Howes 1993). Since 1984 the number of algal blooms, events caused by the overloading of estuaries with nutrients, has increased annually (APES 1992). The Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) reported that noticeable algal blooms were an early warning of the presence of domestic sewage (IMO *et al.* 1990). A severe bloom occurred along North Carolina's coast in 1987, when a red tide was responsible for a massive mortality of bay scallops (APES 1992). In 1991, a new, extremely toxic dinoflagellate was identified as the definitive cause for finfish and shellfish kills in the Neuse and Pamlico estuaries (APES 1992, Water Resources Research Institute of the University of North Carolina (WRRI-UNC) 1993). Low dissolved oxygen levels in estuaries, resulting from the decay of algal species, have resulted in large-scale fish kills (Environmental Protection Agency 1990).

Fish and shellfish diseases have also been prevalent. Blue crabs, menhaden and oysters have been found with lesions and sores (APES 1992). The causative diseases producing these lesions and sores can result in a range of effects, from producing unmarketable species to a host of human health risks, including fatality (APES 1992). In 1983, 23% of the hard clam samples taken were found contaminated with enteric viruses; which when consumed, are known to cause hepatitis and gastroenteritis (National Research Council *et al.* (NRC) 1993). In 1990, two of the diseases that have been responsible for the rapid decline in commercial oyster stocks, MSX and Dermocystidium, were observed in 30% and 70-80%, respectively, of the sites sampled (APES 1992). As a result, the Environmental Protection Agency (EPA) stated that 'human activities in the Albermarle-Pamlico Estuarine area may be exceeding the tolerance of the estuary to absorb their impacts' (EPA 1990).

A compounded result of environmental degradation is the stress on the local coastal economies. Many coastal communities depend on estuarine fisheries and tourism for their livelihood. Approximately 90% of the commercial fish and 60% of the recreational fish landed by weight in North Carolina were estuarine dependent (APES 1992). Fishing in Carteret County provided 45.2% of the state landings in 1973 while tourism accounted for nearly 40% of the total industry in Dare County (Nierstedt *et al.* 1980). In the mid-70's, New Hanover County had 86% of its saltwater acreage closed to shellfishing (North Carolina State University (NCSU) *et al.* 1979). A 1979 estimated value for revenue lost from closure of oyster and clam beds in New Hanover County was approximately $0.5 million (NCSU *et al.* 1979). The 1987 red tide resulted in a closure of shellfishing beds for five months, costing an estimated $5.5 million to the fishing industry and more than $150 million in losses to tourism and business (Gaddy 1988).

IV. THE WASTEWATER DISPOSAL DEBATE

The North Carolina Department of Environmental Management (DEM) cited the failure of septic tanks, the most widely used method of household treatment of domestic waste, as a leading cause for the shellfish closures (APES 1992). In 1982, fifteen out of sixteen septic tanks were in violation of the thirty cm drainline rule separating the bottom of the tank from the fresh water aquifer, or groundwater supply (Augspurger 1989).

Contributing to coastal water quality degradation were the treatment plants that discharge wastewater effluent directly into surface waters, estuaries and sounds. Of the 39 municipal treatment plants in existence in some larger cities, twelve were shown to be in violation of their permits between 1987 and 1988 (Augspurger 1989). Package plants, i.e, treatment plants which serve more local communities such as hotels, condominiums and restaurants, that discharge directly into surface waters, were identified as commonly exceeding the EPA standard nitrogen and coliform levels (Augspurger 1989). Armingeon *et al.* (1989) reported that sewage treatment discharges were responsible for 60% of the total saltwater shellfish closures.

Despite the evidence, the disposal of domestic wastewater has plagued the state for two decades. Although numerous studies and meetings have been conducted to delineate and debate various disposal options, no decisions have been made, nor have any policies been developed by which coastal communities can take action.

Ocean outfall, the piped discharge of treated wastewater effluent, is one alternative for wastewater disposal that has received much attention. The concept of an ocean outfall was first introduced as a possible feasible solution for cleaning up the estuaries in the 1970's. This resulted in an "Ocean Outfall Wastewater Disposal Feasibility and Planning" report (NCSU *et al.* 1979). However, the idea of using an ocean outfall for domestic sewage in North Carolina was temporarily put aside only to emerge again fourteen years later. An Ocean Outfall Forum was held in April of 1993 to discuss the coastal impacts of ocean outfalls, highlighting technical, economic and population growth considerations. It is arguable that state and regional politics, as well as public perceptions, have stagnated any impetus for change and maintained the status quo. A major concern against the construction of an ocean outfall was the perception, by both public and state officials, that any form of centralized treatment of domestic sewage may result in an even greater rate of accelerated growth. Other perceptions included beliefs that an ocean outfall constitutes "ocean dumping;" that the regional IV EPA office in Atlanta would overrule any proposal for an outfall submitted by the state of North Carolina, based on requirements that land alternatives must be considered first; and that financial barriers are too high.

V. CURRENT STATE PRACTICE OF WASTEWATER DISPOSAL

North Carolina ranks first in the nation in use of the number of on-site septic systems (WRRI-UNC 1992). Fifty-eight% of individual households use septic tanks, compared to the national average of 25%. (WRRI-UNC 1992). Reasons for the failure of septic tanks include improper siting and maintenance, and unsuitability of North Carolina's coastal soils (APES 1992). The porous nature of the sandy soils, along with high water tables, limit the zones of aeration, therefore impacting the effectiveness of septic tanks. As a result, this situation threatens groundwater supplies and freshwater aquifers with contamination. North Carolina only enforces a thirty cm separation of the tank from the water table, although some other states have increased their regulation to as much as 60 to 120 cm (Augspurger 1989). State agencies, private consultants and the EPA have all found a variety of contaminants in groundwater in Dare, Carteret and Pender Counties (Armingeon *et al.* 1989, NCDEHNR 1991). The EPA found fecal coliform bacteria in 37% of the groundwater wells tested in Atlantic Beach, indicating the presence of sewage (Armingeon *et al.* 1989).

After three years of debate, North Carolina passed legislation in 1990 requiring stricter regulations for on-site wastewater treatment systems by amending its Rules for Sanitary Sewage Collection, Treatment and Disposal (Nichols *et al.* 1990). While new technologies have made the functioning of modified on-site systems more effective in poor soils, the amount of maintenance required is higher when compared with conventional systems (Nichols *et al.* 1990, WRRI-UNC 1992). These systems are also more expensive and can pose a financial hardship for individual owners in some rural communities in and along the coast (APES 1992).

In contrast to septic tanks, the failure of package treatment plants that serve a larger number of users was not due to improper design or placement, but rather an infrequent or nonexistent maintenance and the lack of technically trained and licensed operating personnel (Armingeon *et al.* 1989, Augspurger 1989).

Municipal, or public-owned treatment works (POTW's), are less common along the coast due to a lack of available construction funds. Of those that do exist, particularly in larger cities, many overload during periods of high rainfall. Many estuaries that receive POTW discharges are closed to shellfishing (Armingeon *et al.* 1989).

VI. ALTERNATIVES TO ON-SITE WASTEWATER DISPOSAL

Even if properly functioning, septic tanks still have the potential to pollute underground and inland waters (Nierstedt *et al.* 1980). Alternatives to on-site waste disposal and plants that discharge directly into surface waters include the use of landfills, deep well injection, abyssal ocean depths, incineration, land application and ocean outfalls. Source reduction, higher levels of treatment and recycling are additional options that can be overlaid on current practices, or used in conjunction with any of the alternatives.

Ocean dumping from ships and incineration at sea are now prohibited by U.S. law, or are in the process of being phased out, and hence are not considered viable alternatives. As in many states, space in landfills is running out. Since most of the sanitary landfills in North Carolina were built in the early 1970's and were unlined, possible leaching of toxic substances to groundwater sources is still a major concern (WRRI-UNC 1993). In a 1988 report to the governor's board, 13-20 of the 120 landfills in the state had less than a two-year capacity, with nearly 50 having less than a five-year capacity (Ad Hoc Committee on Waste Reduction 1989). Incineration on land is not desirable due to atmospheric pollution, potential for increased risk to human health, and higher costs due to a necessity for a large amount of wastes in order for incineration to be profitable (Gift *et al.* 1989, Buchholz 1993). In a comparison of options in New York

City, incineration was shown to have twenty times the risk to human helath of ocean disposal (Gift *et al.* 1989). Landfills and incineration further invoke the negative image of the NIMBY (not in my backyard) concept.

Some of the more technologically innovative ideas for disposal include subsurface waste injection and abyssal ocean disposal. However deep well injection of wastes into an aquifer near Wilmington, N.C. was not perceived as a successful means of waste disposal (Leenheer *et al.* 1976). Obstacles to success included leaks, the reactive nature of the waste with the aquifer and the slow degradation of waste in an underground environment (Leenheer *et al.* 1976). The conclusion from a three-year study on deep ocean disposal at the Woods Hole Oceanographic Institution (WHOI) was that "there was no compelling rush to develop a deep ocean option" and that "the waste management crisis can be dealt with feasibly and effectively in the coming years without resort to ocean dumping" (WHOI 1993). Several factors identified in deep ocean disposal were overcoming international legal obstacles, high internal costs to transport waste to remote sites, and opportunity costs of environmental uncertainty, or risk (WHOI 1993).

Source reduction, which can be used in conjunction with current practices or any of the alternatives, has received merit, particularly in regard to solid waste disposal. Unfortunately, sewage is one waste stream that cannot be reduced at the source (Parker and McIntyre 1988). By reducing the overall volume of sewage, water conservation can actually increase the concentration of pollutants (NRC *et al.* 1993). However, source control is good and warranted for toxic substances that may be in the waste stream.

Recycling, as a second means of reducing the overall volume of waste input, can, however, be incorporated into the design of a wastewater treatment system and deserves greater national attention than it has received. In Massachusetts, a closed-loop recycling plant reduced the amount of chemicals in its sludge by 97-100% (NRC *et al.* 1993). A zero sludge production facility in California was only 9% higher in total annual cost than a conventional facility (NRC *et al.* 1993). Unfortunately, for the most part, recycling of domestic waste is still in its infancy (Wheeler 1993).

The option of increasing treatment to reduce pollution is not always well founded either. Advanced levels of treatment, i.e., secondary or tertiary, are reported to achieve higher levels of water quality (Armingeon *et al.* 1989). However, while secondary treatment has been mandated legislatively to remove the biological oxygen demand, recent findings suggest that secondary treatment does little to improve water quality (NRC *et al.* 1993). Rather, secondary treatment may increase eutrophication by making nitrogen more mobile (Mearns 1993; NRC *et al.* 1993). Other findings report an increase in the concentration of dissolved forms of cadmium and zinc after the use of secondary treatment (Mearns 1993). The common practice of using chorination to disinfect wastewater effluent is also questionable because chlorine is highly toxic to some marine organisms (NRC *et al.* 1993).

Depending on the type, additional treatment can be up to five times more costly (NRC *et al.* 1993). A larger volume of residual by-product, specifically sludge, is produced as treatment is increased. Similar decision-making problems exist for sludge disposal, and because regulations are even stricter for its disposal due to its toxicity potential, sludge can be much more expensive to manage than the treated effluent (Champ *et al.* 1989). Factors associated with increased costs are environmental liability and the amount of energy and chemicals needed to treat the waste (Wheeler 1993).

Recent studies in North Carolina have reviewed the wastewater disposal alternatives and concluded that the only two environmentally acceptable solutions for waste disposal along the coast were land application and ocean outfall (Nierstedt *et al.* 1980, Augspurger 1989). These options were environmentally acceptable because they remove the discharge of wastes out of the estuaries and sounds, the critical nursery and habitat grounds for fish and shellfish. The first of these aceptable solutions, land application, involves the application of treated effluent to soil, which acts as a natural filter to pollutants. Barriers to land application in the North Carolina coastal zone were summarized as limited availability and high costs associated with the purchase of coastal land, and unsuitability of soils (Nierstedt *et al.* 1980, Duke 1986, Armingeon *et al.* 1989, Augspurger 1989). Rapid Infiltration (RI) and Slow Rate (SR) are two types of land application that have been assessed. Rapid Infiltration systems are considerably less expensive, but result in a greater risk of pollution to groundwater, particularly in coastal soils. When the distance to the water table is minimal, Rapid Infiltration systems are likely to cause viral and bacterial contamination of groundwater (Armingeon *et al.* 1989). Therefore, Slow Rate systems are an environmentally sounder method of land application for North Carolina. However, a much larger amount of land is required for the Slow Rate system, along with an extensive sprinkler and irrigation system (Neirstedt *et al.* 1980, Duke 1986, Armingeon *et al.* 1989). As opposed to seven acres for a Rapid Infiltration system, a required estimate for a Slow Rate system was 200 acres (Nierstedt *et al.* 1980, Duke 1986). Since such a large tract would not be available on the barrier islands off North Carolina, this option would mean piping wastes as much as twenty miles to the mainland. Conclusions from one study were that Rapid Infiltration, for its jeopardy to groundwater, and Slow Rate, for using critical land, were not publicly acceptable (Nierstedt *et al.* 1980).

In a cost comparison, Duke (1986) estimated $2 million for either a Rapid Infiltration system or an ocean outfall, while a Slow Rate system would cost four times as much, or $8 million. Based on the cost effectiveness to coastal North Carolina, Nierstedt *et al.* (1980) advocated an ocean outfall for the disposal of wastewater on the barrier islands in Dare and Carteret Counties, and land application on the mainland of Carteret County.

VII. OCEAN OUTFALL

Technical, Environmental And Economic Concerns

Ocean outfall involves the discharge of treated effluent through a submarine pipe and diffuser system anywhere from 1- 11 km offshore. Ocean outfalls are not new in concept or practice, having been employed in the U.S. and Europe since the early 1900's. However, since the first major ocean outfall was constructed by the city of Los Angeles in 1906, technology has greatly increased the operational efficiency of ocean outfalls (Gunnerson 1988). Over time, outfalls have become longer to avert pollution away from the shoreline, are sited in more suitable locations, and configurations of diffusers are better developed to enhance waste dispersal (Huntington and Rumsey 1988). Coastal waters provide much greater dilution on a mass per mass basis than any other disposal medium (NRC *et al.* 1984, Huntington and Rumsey 1988). When compared to facilities that discharge wastes directly into rivers, streams and sounds, an outfall can increase the dilution 100-300 times and diminish hypoxia, eutrophication and accumulated suspended matter (Bascom 1989). The foremost advantage of using an ocean outfall is that the waste stream completely bypasses the estuaries and sounds.

Some drawbacks associated with ocean outfalls are that there is an insufficient level of understanding of the behavior and fate of pollutants and viruses in the saltwater environment (Pattinson and Jones 1988). One of the major arguments against ocean outfall is the potential for the long-term accumulation of toxic substances and heavy metals in bottom sediments (NCSU *et al.* 1979). Other effects include an increase in total biomass diversity and a decrease in species diversity, although these are not necessarily perceived as negative. Support exists that an increase in productivity can actually be beneficial (Parker and McIntyre 1988). It is contended that ocean disposal is more difficult to monitor than any land alternative. However, technology may change this practicality in the near future. New developments in benthic monitoring can assess rapidly changing bottom conditions and have proven cost-effective (Gerlinger *et al.* 1993).

In practice, ocean outfalls have received favorable results in Europe, Australia and the U.S. Nearly one half of the sewage in Scotland and one fourth of the sewage in England is discharged through outfalls (Cooper and Lack 1988). The United Kingdom has over 1000 outfalls serving 30% of its population (Whyte 1988). Due to its deep offshore water, Sydney, Australia has found outfalls to be beneficial, since it is now one of the best flushed coastal cities in Australia (Whyte 1988). In a 1987 conference organized by the Institute of Civil Engineers in London, it was stated that the "marine treatment of sewage utilizing long submarine outfalls and properly designed and located diffuser systems is the most effective way of minimizing the risk of harm of disease" (Snook 1988).

Southern California currently has among the least contaminated beaches in the world (Gunnerson 1988). As Southern California developed newer technologies, reduced point sources and extended the length of their outfalls, it became evident that environmental effects were sometimes quickly reversible (IMO *et al.* 1990). Beaches and shellfish grounds that were closed in the 1950's were reopened (Gunnerson 1988). Accordingly, there have been no documented cases of human illness by either bacteria or viruses from an outfall in California, and there have not been any adverse effects on fisheries, though more than 70% of the commercial fish landed in California are caught within fifty km of the three largest outfalls (Gunnerson 1988). In the 1950's and 60's, giant kelp beds were declining, but due to transplantation and a decrease in the source of input of suspended solids and DDT, the kelp beds have increased in abundance and diversity (Gunnerson 1988).

When considering the suitability of the regional applications of ocean outfall technology, the physical characteristics of North Carolina's nearshore environment have caused some skepticism of outfall efficiency in light of its wide shallow shelf and longshore currents. However, modelling using various diffuser configurations and "worst case" scenarios has demonstrated that adequate dilution can be hypothetically obtained (NCSU *et al.* 1979, NRC *et al.* 1993). In 1982, an engineering firm concluded that ocean outfall would "not adversely affect the marine environment or recreational activities in Dare County" (Duke 1986). North Carolina State University *et al.* (1979) concluded that an outfall using secondary treatment would not adversely affect fisheries or swimmers, previously closed shellfish areas could be reopened, and it was unlikely that benthic communities would be altered beyond the immediate vicinity of the pipe and diffuser.

Similarly, in a 1984 report issued by the National Research Council, ocean outfall is "definitely viable for the discharge of treated wastewater effluent from almost any U.S. city on the open coastline" (Duke 1986). Indeed, there are currently 37 outfalls in twelve states that discharge treated effluent into the coastal ocean on the east coast of the U.S. (NCDEHNR 1993). Additionally, all of Florida's ocean outfalls have shown durability under severe weather conditions by having survived a hurricane (Fergen 1993).

Although ocean outfalls are capital intensive projects and pose a major undertaking in terms of financial assistance, local cost comparisons with other alternatives reveal that ocean outfall is a cost-efficient method, even if the construction of extensive sewer systems over considerable distances is included in the estimate (Nierstedt *et al.* 1980, Duke 1986). In Europe, outfalls were the preferred disposal medium in most coastal areas and were shown to be financially efficient (Huntington and

Rumsey 1988, Pharoah 1988). In its executive summary, North Carolina State University *et al.* (1979) concluded that "ocean outfalls for treated effluent are technologically, economically and environmentally feasible."

Social and Political Concerns

Population growth

A major obstacle against change to the present wastewater disposal practice is that many coastal communities believe that an outfall, or for that matter, any centralized form of sewage treatment, will cause an even greater rate of population growth. Stated in the executive summary of the North Carolina State University *et al.* study (1979) is the statement that 'central sewer systems will increase land values, allow reduced lot size, stimulate growth and increase changes in population.' Although this statement was largely made to emphasize that local economies could be enhanced from an outfall, it has become a source of fear to the general public and concerned citizens who do not want their local surrounding environment spoiled by any further population pressure. The coupling of centralized wastewater treatment and population growth is evident in the remark "it is recognized that the town of Atlantic Beach has made the decision to accept huge density development and to build a central sewer system" (Duke 1986). The belief here is that centralized treatment facilitates growth.

Historically, growth and sewage regulations have been synonymous management issues in coastal North Carolina, especially in rural areas. Coastal North Carolina has attempted to manage growth and sewage through one set of regulations. Septic tank siting rules often serve as de facto zoning requirements (Nichols *et al.* 1990). The constraint on development is often the unsuitability of land for septic systems. If the limits are lifted via a centralized sewage treatment facility, coastal growth could proceed unchecked (Besse 1993, Howes 1993).

Virginia and New Jersey are two states that have been successful in separating these two issues, wastewater disposal and population growth. Donnie Wheeler, the Director of Water Quality, Hampton Roads Sanitation District, stated that "to use wastewater utilities, or any other utility, as a mechanism to control growth is, at best, short-sighted" (Wheeler 1993). In Virginia, planning of where growth and development are located is the responsibility of the local governments and planning boards through their land-use plans, and not the result of a wastewater treatment regulation. The regional authority, the Hampton Roads Sanitation District (HRSD), accepts these plans from the local governments and based on their population predictions, implements the construction of its infrastructure in phases. The municipalities own their sewer collection systems to the central facility and must carry the burden of their cost and maintenance. This process can serve as a check to the local land-use plans and help the local governments control their own growth. Each locality must also have a comprehensive infiltration and inflow program to hook up to the HRSD facility, which helps minimize and prevent overflows. The HRSD has received many awards by the EPA agency for the excellent operation of their treatment plants. Their integrated system includes one outfall that has been demonstrated to have "no statistically significant influence on the water quality in the outfall area" (Wheeler 1993).

Similarly, New Jersey has established a regional sewage authority, the Cape May County Municipal Utilities Authority (CMCMUA), to open the state's previously closed back bay area to shellfishing. The Cape May County Planning Board calculated the projected population through the year 2020 for each of its municipalities and set a goal for maintaining reasonable growth, well below the highest possible density. The CMCMUA then sized their facilities accordingly and classified land areas as either sewerable or nonsewerable. But since municipal zoning was not controlled by the county planning board, the state developed a "Capacity Assurance Program" (CAP) to protect itself against higher levels of unforeseen future growth and municipalities that were not in compliance with the master plan. This enforcement tool insures that the total capacity of the facility is not prematurely exceeded. As in Virginia, the sewer collection system is owned by the local municipalities, with the state having the legal authority to review all sewer extensions for any building greater in size than a two-family dwelling (Norkis 1993).

There are two mechanisms through which the CAP program can limit growth. The first mechanism is that when a city reaches 80% of its total flow allocation and has not adopted a municipal development plan, CMCMUA turns down any additional sewer extension applications and future building permits are denied. The second way a city's growth is kept in check, is that when the average daily flow for two consecutive months is greater than the city's flow allocation, the CMCMUA issues a letter to the mayor, instituting a full building ban. The CAP program has achieved seven years of success and through the diversion of effluent to the ocean, has reopened 28,000 acres of shellfish grounds, with no known negative impacts to the ocean environment (Norkis 1993).

National Policy

It is necessary to separate media propaganda from the facts when faced with a controversial issue. There is a common perception that an ocean outfall constitutes "ocean dumping" and that it is morally wrong in principle to put sewage into the sea (Wakefield 1988, Kirkman 1993). This ideology has been politically enforced. Senator Muskie opposed ocean dumping because it was "selling a license to pollute" (Lahey 1989). Since 1970, it has become the policy of the U.S. to eliminate waste disposal in the marine environment (Erdheim 1985).

Ocean policy on disposal of wastes is divided on the type and the source of the wastestream. The Marine Pollution Research and Sanctuaries Act of 1972 regulates the discharge of waste seaward of the territorial sea baseline. Dissatisfied with the progress the EPA was making through its regulatory efforts, Congress rewrote the law and amended the act in 1977 as the Ocean Dumping Act (ODA) [33 U.S.C. 1401 et seq.] (Champ *et al.* 1989). The ODA prohibited the discharge of sewage sludge from vessels with a Dec. 31, 1981 termination date.

The discharge of treated wastewater effluent through a pipe is not legally considered ocean dumping (Duedall 1990). The Federal Water Pollution Control Act, amended as the Clean Water Act (CWA) [33 U.S.C. 1251 et seq.], regulates the discharge into waters landward of the territorial sea baseline and all discharge through pipelines (NRC *et al.* 1984). Pipelines on either side of the territorial sea baseline are regulated by the CWA. As is true of the ODA, the EPA is also the agency responsible for administering the regulatory policies of the CWA. The National Pollutant Discharge Elimination System (NPDES) is the discharge permitting program of the CWA that establishes effluent limits and monitoring and reporting guidelines (Davies 1988).

Section 403 of the CWA, known as the Ocean Discharge Program, requires that ocean outfalls satisfy two additional criteria over and above any other NPDES permit. These two conditions require that it must be demonstrated that the discharge will cause "no unreasonable degradation to the marine environment" and "no irreparable harm." The term "no irreparable harm" is based on the technical standard of suspended solids less than thirty mg/l. Secondary treatment of wastewater automatically satisfies this requirement. However, the "no unreasonable degradation" is subjective and highly controversial. No standard guidelines exist for this term (Leonard 1993).

Based on the direction of national policy, it was perceived that the amended "law and regulations clearly incorporate the use of land application techniques as a preferred method of achieving the clean water goals of the CWA" (Nierstedt *et al.* 1980). Unfortunately, the single- medium approach to federal regulation of waste management has often meant the transferring of pollution from one medium to another, typically the one with the least regulation (NRC *et al.* 1984, Champ *et al.* 1989). As ocean dumping declined from 1973-1979, land disposal became more popular and, subsequently, land disposal regulations increased (Erdheim 1985, Kitsos and Bondareff 1990). This in turn resulted in the 1977 Clean Water Act amendments and the relaxation of standards for the secondary treatment of ocean discharge (Sec 301). This appears to violate the original intention of the "no irreparable harm" condition of Section 403 (Nierstedt *et al.* 1980, Erdheim 1985, Wayland 1993).

In 1981, a federal court determined the EPA's interpretation of ODA to require a phase-out of the sewage sludge disposal to be illegal. The courts mandated that the ODA required a balancing of alternatives, and that the high cost of the land alternative in New York City was unreasonable (Leschine and Quinn 1989). The National Advisory Committee on the Ocean and Atmosphere (NACOA) subsequently issued a report in 1981 that waste disposal should involve a multimedia assessment, including the weighing of all costs associated with the different alternatives (Kamlet 1989). The ocean was clearly an "appropriate environment for the disposal of certain types of wastes when alternatives pose a greater risk to human health or the environment" (Kamlet 1989).

Still concerned with a national policy to protect the marine environment, Congress overturned the judicial decision in 1988 and instituted a ban on the dumping of sewage sludge, and industrial, medical and radioactive waste. The Ocean Dumping Ban Act [33 U.S.C. 1414] terminated dumping of sewage sludge by the new date Dec. 31, 1991, regardless of the unreasonable degradation criteria (Kitsos and Bondareff 1990). New York City was granted a waiver extending its time to come into compliance.

Hence, the national policy on ocean dumping has been highly subjective and contradictory at times. Ocean disposal terminology is confusing and has often been used equivocally with ocean dumping of sludge at sea from a platform. While dumping of sewage sludge from barges is called ocean dumping in the legislature, ocean outfall of wastewater effluent is called ocean discharge. However, both are types of ocean disposal, although they are regulated by two different laws. Nor is the discharge of treated wastewater effluent technically or legally equivalent to sewage sludge.

To emphasize, the Ocean Dumping Act applies only to sewage sludge and not the discharge of treated wastewater effluent. Although this paper is largely concerned with effluent discharge, it should be noted that any type of waste disposal still needs to address the elimination of the by-product of wastewater treatment, i.e., sewage sludge. Los Angeles, the only U.S. outfall permitted for the disposal of sewage sludge, has been ordered to terminate the disposal not because of any harmful effects, but because other means are available (NRC *et al.* 1993). Los Angeles will incinerate its wastes, despite the environmental consequences of increasing already critical air pollution (NRC *et al.* 1993). The U.S. laws governing sewage sludge disposal have been denoted as "not sensible" (Bascom 1989). Other countries in Europe have chosen to "control" disposal at sea, rather than prohibit it (Nauke 1989). Just as sludge is used to benefit agricultural land, it can create more productive coastal waters (Parker and McIntyre 1988, Bascom 1989).

State/Regional Policy

Similar to those on the national level, local politics have also been a deterrent to ocean disposal. State and regional policies have encouraged the current state practice of on-site wastewater treatment. Through the North Carolina general statues, state legislation has endorsed the use of on-site septic systems. Steve Steinbeck, North Carolina Division of Environment, Health and Natural Resources, has stated that it was by choice that North Carolina was the number one user of on-site septic systems (WRRI-UNC 1992). The state "views on- site systems as safe, efficient and permanent options for wastewater treatment and disposal" (WRRI-UNC 1992). In contrast, a centralized ocean outfall treatment facility has not been highly promoted by the state. Therefore, it may require a large consensus-building to change the current system.

The EPA Region IV has been, in the past, against centralized treatment because it promotes high-density development (Duke 1986). EPA stated that the evidence for septic tank-related pollution is poor and that runoff was a larger contributor (Duke 1986). The phasing out of EPA's Innovative and Alternative Technology Program in 1990 (NRC *et al.* 1993) was an action that would seem to favor maintaining the status quo. It was a common perception that EPA Region IV would not review a policy on an outfall made by the state, based on having available alternate options. This was refuted at the ocean outfall forum by Bob McGhee, EPA Region IV. He has stated that the only time alternatives must be addressed in an analysis is when the scientific conclusion of "no unreasonable degradation" cannot be made. If the state can demonstrate there are no unreasonable impacts from the outfall, then the state does not need to consider any alternatives in its decision-making (McGhee 1993).

The EPA vested the states with the permitting process within the CWA, although the regional EPA offices retain oversight authority. Currently, there are no state regulations prohibiting the construction of an ocean outfall for domestic waste. The North Carolina Environmental Management Commission (EMC) is responsible for establishing state guidelines. North Carolina's regulations mirror federal regulations and pose no stricter requirements to the construction of an outfall (Nierstedt *et al.* 1980). One ocean outfall is currently in operation in Southport, N.C. for the discharge of industrial waste effluent (Sauber 1993, NCDEHNR 1993). The one outfall demonstrates that it was possible to cut through the state and regional bureaucracy.

North Carolina's Coastal Area Management Act

One piece of state legislation that is of significant importance to the separation of the management of population growth from wastewater disposal siting requirements is the North Carolina Coastal Area Management Act [N.C.G.S. 113A-100]. Shortly after the federal Coastal Zone Management Act (CZMA) [16 U.S.C. 3501 et seq.] was passed in

1972, North Carolina was one of the states that took the forefront and legislated a state coastal management plan, the Coastal Area Management Act (CAMA), of 1974. North Carolina became one of the first states to institute comprehensive and mandatory local land-use planning in its coastal counties. The plan addressed many of the immediate concerns such as oceanfront development, beach access and land acquisition, and established Areas of Environmental Concern (AEC's). North Carolina organized a citizen's commission, the Coastal Resource Commission (CRC), to establish guidelines on development within the AEC's. Because of its success and effectiveness at that time, many other states sought to model many aspects in North Carolina's coastal plan (Owens 1985).

In 1985 many states, including Georgia, Maine, New Jersey, Rhode Island, Vermont and Washington, addressed the next set of critical issues facing the coastal zone, particularly growth management (Owens 1993). However, North Carolina was not one of these states (Owens 1993). While it was mandated that all twenty coastal communities form land-use plans, implementation of them was voluntary (Owens 1993). The state's regulatory powers were limited to the area within the AEC's, delineating only 3% of the total area in the twenty coastal counties, a narrow band only 75 feet wide (Shaw 1992, Besse 1993). All areas outside the AEC's fall within local regulatory jurisdiction. Since zoning is frequently met with high local resistance, many areas outside the AEC's are not properly zoned, or regulated (Besse 1993). There are currently no erosion rates or setback regulations in place to control the development of the 4000 miles of waterfront land in the sounds (Shaw 1992). The CRC has had a policy of not interfering with the local autonomy of the plans, and provides no state oversight, coordination or guidance (Besse 1993). Therefore, current local land-use plans may not be adequate to manage growth (Besse 1993, Owens 1993).

In 1992, an assessment of the North Carolina coastal management plan by the Federal Office of the Ocean and Coastal Resource Management (OCRM) and the North Carolina Division of Coastal Management (DCM) identified that four of the eight areas specified by Congress in the 1990 amendments of the Coastal Zone Management Act (CZMA) were priority areas for North Carolina (NCDEHNR, DCM, Final Assessment 1992). A draft strategy recommended that two of these, cumulative and secondary impacts (i.e., growth and development) and Special Area Management Planning (SAMP), be incorporated into the local land-use plans when they are updated in 1994 (NCDEHNR, DCM, Draft Strategy 1992).

Public Education

Public perception is strongly influenced by the media and coastal politics. National and state policies, through the help of the media, can often sway what becomes a critical issue. Concerns give way to new concerns. Specifically, what previously had been a preoccupation over coastal beach pollution has given way to a preoccupation with toxic contamination of air and groundwater (Leschine and Quinn 1989). Indeed, contamination of groundwater supples has received increasing local focus in North Carolina. However, the issues surrounding this end result, wastewater disposal and population growth, have clearly not been defined (Armingeon *et al.* 1989).

A 1989 survey reflected that Carteret County residents believed that there were development problems within the county, but not within their respective towns. The majority of residents noted that population growth was occurring in the county but not locally. Additionally, the majority observed that waste disposal methods were inadequate in the county but not in their locality. Armingeon *et al.* (1989) reported that misinformation and a lack of education led to the failure by the voters to endorse a county-wide sewer and water project bond referendum in 1987.

New Hanover is one county that has recently converted to a centralized sewer system. Increased taxes, growth and a still existent pollution problem have all led to negative connotations regarding centralized systems (Gottovi 1993, Hayes and Sisson 1993). However, fundamental principles underlie the reasons for these effects. These include the facts that the central facility discharges directly into nearby surface waters and that the issue of growth management is only now being addressed (Gottovi 1993, Hayes and Sisson 1993).

Public participation is vital to the success of creating effective policies (NRC *et al.* 1993). However, the regional and national concern for ocean disposal and the local public concern for land disposal (Huetteman *et al.* 1989) has been a source of conflict and restrained any effective state policy on waste management. Fear of growth and a general lack of public understanding on the issues must be overcome through education to bridge the gaps between competing objectives.

Financing

Even though ocean outfall has been acclaimed as the most cost-effective method of wastewater disposal, financing an outfall may be beyond the current capacity of many localities. This can lead to a complete rejection of all possible combinations of alternatives and maintain the present system of wastewater disposal.

A variety of estimates exist on the total cost to construct an outfall in North Carolina, although actual costs are site specific. Duke (1986) reported that a small one to two millions of gallons a day (MGD) outfall located one to two miles offshore would cost minimally $2 million in Atlantic Beach, Carteret County. Brown and Caldwell (1982) reported an estimated $5.6-8.9 million for a 1.1 mile long, ten MGD outfall in Dare County. Figures are even higher when sewer systems, which transport the waste to the central facility, are included into the total cost estimate. Nierstedt *et al.* (1980) estimated

$28-31 million for a 2.1 mile long 6.4 MGD outfall in Dare County and $39-43 million for a 2.2 mile long 6.9-8.9 MGD outfall in Carteret County. Both figures include sewer systems.

In practice, Virginia spent $13.75 million to construct an outfall in 1983, while New Jersey estimated the cost to build one outfall was $7 million (Norkis 1993, Wheeler 1993). New Jersey's total facility, comprising three outfalls and four regional plants, cost $368 million (Norkis 1993). However, this is not relatively overwhelming if compared to the $270 million it cost New Hanover County to build their one centralized sewer plant which discharges into surface waters (Hayes and Sisson 1993). Improper planning and addressing growth after the construction of the facility were criticized as two reasons responsible for the inflation of New Hanover's initial cost estimate of $60 million (Hayes and Sisson 1993). Experts emphasized that if a facility is properly planned before construction starts, the savings can be considerable (NRC *et al.* 1993).

External costs must also be included in the costs of constructing an outfall. Regulatory costs are one additional external expense. For North Carolina to meet the requirements of Section 403 of the CWA, it is estimated that it will cost $1.2 million (Leonard 1993). This figure includes site specific evaluations, benthic surveys, public workshops, fees for meeting rooms and a technical advisory committee.

Since 1976, the federal government has shifted the responsibility of financing water projects to state and local governments, with local governments getting the largest share of the expenses. Local governments have often contributed nearly twice as much as the state (Snyder *et al.* 1984). The EPA, the largest funder of the Section 201 wastewater treatment grant program, reached its peak level of funding in 1976 (Snyder *et al.* 1984). Before 1976, the federal government could be expected to finance as much as 75% of the cost of construction. By 1984, the contribution from the federal government had diminished to between 40-55% (Snyder *et al.* 1984). In 1990, federal construction grants program were terminated and replaced with the Revolving Loan Program, administered by the states. Through this program, federal money is loaned to states that provide bonds to local communities to help build wastewater treatment plants. While revolving funds eliminate the need to go back to the legislature year after year, the name implies that they could be self-supporting. It is estimated that more than 80% of the cost to build a wastewater treatment facility falls on the local taxpayers (NRC *et al.* 1993).

As the local responsibility of financing increases, it becomes necessary to secure other methods of financing. The use of economic incentives provides various alternatives, including: taxes, subsidies, user fees and effluent fees, to name a few. User charges have been met with much success, and unlike taxes and subsidies, have encouraged conservation and efficiency and are socially more acceptable. User fees can also be transferred to seasonal and recreational populations. User fees can cover the entire cost of owning and operating a wastewater treatment facility (Snyder *et al.* 1984). However, as of 1984, most municipalities were not charging rates high enough to cover the operating and maintenance costs of their water service utilities (Snyder *et al.* 1984).

Except for the EPA 201 funding that provided about 50% of the initial cost of construction, Virginia has been able to fully support all capital operations and reserve costs through user fees. The reserve fund supports future new construction. The average household pays $15 every two months to the HRSD authority who provides the service (Wheeler 1993).

New Jersey uses a unique rate-setting formula to transfer the costs to their summer population. Fixed charges (75% of the total), which include the costs of construction, are billed over a ninety-day period in the summer. The variable costs (25%) are distributed over the year. The municipalities are billed on the actual flow delivered to the central facility and in this way can seek to minimize future rate hikes in local costs by controlling growth (Norkis 1993).

VIII. INTEGRATED COASTAL MANAGEMENT

It is now estimated that 85% of municipal effluent is discharged directly into national bays and estuaries, causing increased continental stress to our coastal environment (NRC *et al.* 1993). Coastal water quality and groundwater pollution have received a large amount of national attention. This clean water ideology has been prevalent in regional initiatives such as the Coastal Ocean Program, National Estuary Program and Coastal America. As point source control of pollution has improved through legislative efforts and federal regulations, it has become evident that the solution to coastal environmental problems must incorporate nonpoint source control of pollution as well (NRC *et al.* 1993). Recently, under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990, Congress has mandated that all coastal states develop Coastal Nonpoint Pollution Control Programs to ensure the protection and restoration of the quality of it's coastal waters (EPA 1993, NOAA and EPA 1993). To adequately control nonpoint sources of pollution, the program emphasizes a joint partnership between coastal zone management and water quality agencies, integrating federal, state and local authorities (EPA 1993, NOAA and EPA 1993).

Most of these clean water initiatives incorporate basinwide or watershed approaches to water quality management and are now common worldwide. Two emerging concerns that have become increasingly critical to the basinwide approach to controlling combined sources of pollution are wastewater and stormwater management. Indeed, wastewater management is now the third largest business in the U.S. (Champ *et al.* 1989).

In its report, the National Research Council *et al.* (1993), at the direction of Congress and the EPA, has advocated Integrated Coastal Management (ICM) as the best method of "Managing Wastewater in Coastal Urban Areas," the title of its book. ICM is not a new concept. It has been proposed by NACOA in 1981, the UN Conference on Environment and Development in Rio de Janeiro in 1992 and the World Bank (NRC *et al.* 1993). Although much of the North Carolina coastal zone is more rural than urban, the goals of ICM and its three part iterative process can have direct application in the selection and implementation of a wastewater management plan for coastal North Carolina.

The objectives of ICM are "to restore and maintain the ecological integrity of coastal ecosystems" and "to maintain important human values and uses associated with those resources." The three parts of ICM are dynamic planning, selection and implementation, and research and monitoring. The procedure involves cross-media considerations, the regional integration of multiple sources (reflecting the basinwide approach), environmental-based standards (as opposed to technical-based), growth management, economic incentives, public involvement and education, risk taking and perhaps, setbacks. ICM means that there is not one solution to wastewater management, but rather management is site specific and incorporates characteristics of individual waterbodies. Wastewater management should be planned, iterative and incremented in stages to allow feedback into the system. ICM also emphasizes that wastewater and stormwater programs should be designed in conjunction with one another. Cities that have combined storm and sanitary sewers are more cost-efficient than those with separate systems (NRC *et al.* 1993).

Selecting the best strategy for the disposal of wastewater is an arduous task. Decision-making can be streamlined by establishing clear goals, assessing risks and then developing management alternatives for reducing the risks (NRC *et al.* 1993). Identifying alternatives, quantifying outcomes, and evaluating and weighing the variety of outcomes is meant to be iterative (Wolfe 1989). Rarely are decisions made once through. The Chesapeake Bay Program went through three iterations of just the initial goal-setting process of establishing a 40% reduction in nutrient loading (NRC *et al.* 1993).

North Carolina's Efforts at ICM

The National Research Council *et al.* (1993) advocated the following immediate steps as signals of progress toward ICM: the development of a National Estuary Program, establishment of a regional water resource agency, integration of growth management and land-use plans, public involvement and building a scientific and technical information base.

North Carolina has been one of the first states to implement the basinwide approach to resource management. There are seventeen basinwide water quality management plans in place (WRRI-UNC 1993). The Albemarle-Pamlico Estuarine Study is part of the National Estuary Program that has produced a Comprehensive Conservation Management Plan. The CCMP targets nonpoint sources and agricultural runoff. North Carolina has instituted the Agricultural Cost Share Program and a nutrient and pollutant trading program that is a national experiment aimed at reducing agricultural nonpoint source pollution (APES 1992).

Although North Carolina has not followed suit like some other states (California, Florida, Maine, New Jersey, Virginia) and established a regional water and sewer authority, several key legal and financial elements are in place to proceed with the establishment of such an authority. North Carolina statues provide numerous options for a variety of organizations to provide water and sewer service (Snyder *et al.* 1984). North Carolina also has one of the most envied bond assessment programs in the nation (Snyder *et al.* 1984). Through the establishment of Local Government Commissions, bonds can be issued directly by the local commissions at lower interest rates and avoid costly state auditing and oversight programs (Snyder *et al.* 1984). A recent increase in state financial support for wastewater management is evident in the passing of two pieces of legislature: the passing of the Clean Water Bond in North Carolina in November 1993 that will provide $145 million in grants and loans to local governments for wastewater collection and treatment facilities and water projects, and the reauthorization of the 1993 federal Clean Water Act that will authorize $2.5 billion in State Revolving Funds in 1995 to be increased $500 million annually until the year 2000.

The establishment of a regional authority can bring cities and counties together to achieve a common goal. A regional authority, because of its autonomy and regulatory power, can overcome the pressures by local developers, something that the single city governments are usually unable to do (Snyder *et al.* 1984). At the end of 1993, nine local governments addressed Governor Hunt to encourage the integration of stormwater runoff with sanitary waste disposal, perhaps seen as a first step toward establishing regional collaboration.

If local land-use plans are updated in 1994 to include population growth and development, as is currently planned in the Division of Coastal Management's Draft Strategy (NCDEHNR, DCM 1992), North Carolina will have achieved a major step at integrated growth management. However, CAMA must also be strengthened to provide oversight and guidance when updating the local plans, and be broadened to include areas outside the AEC's.

North Carolina has had a strong history of public involvement and education through the Sea Grant Program. Scientific and technical expertise abound in North Carolina in its many universities, colleges and research institutes. However, some false public perceptions about wastewater disposal, ocean outfalls, and population growth are indicative that more work needs to be done in this area. Together with the Sea Grant Program, universities can help to more clearly define ocean disposal terminology, the options involved and alternative management strategies.

Coastal North Carolina has yet to pass through the planning stage before it can select and implement a waste management disposal alternative, i.e., an ocean outfall. The first order priority is to establish concise goals. Simply stating the goal of cleaning up North Carolina's estuaries is not concise enough (NRC *et al.* 1993). Secondly, although alternatives have been looked at, there is a lack of any comprehensive risk assessment, and total benefit/cost studies that incorporate external costs have not yet been performed. Risk assessments and natural resource damage assessments can reduce competing objectives and enhance the decision-making process.

IX. CONCLUSION

The current practice of wastewater treatment discharge, directly or indirectly, into estuaries and sounds in coastal North Carolina seems to contradict the aims of many clean water initiatives. Ocean outfall is one viable strategy that can get the discharge out of the bays and estuaries to achieve more productive results. Ocean outfall has received effective results worldwide. It's popularity does not in and of itself preclude any other alternatives but one recipe for success it to find something that works and model it (Robbins 1986). "Is there anyone so wise as to learn by the experience of another" (Voltaire).

Research has demonstrated that an ocean outfall is a technically, environmentally and economically feasible solution for coastal North Carolina. Although public resistance and cost have been two primary deterrents, both of these obstacles can be overcome, if properly planned for. By increasing efforts at public education, North Carolina can build a consensus and promote a better understanding of the issues surrounding wastewater treatment and population growth. Through education, the technical and legal difference between ocean dumping and effluent discharge can be facilitated. As Virginia and New Jersey have successfully demonstrated, user fees can transfer a large share of the cost of financing an outfall to the seasonal population.

Planners must keep in mind that the solution to North Carolina's waste disposal problems is not clearcut. Ocean outfall, as is true of any alternative, will involve implications and trade-offs. Relocating the waste stream from the estuary to the coastal ocean may still continue to put overall stress on the environment, as will population pressure. Although the sustainability of estuarine fishery resources will improve, an outfall may transfer long-term problems to other jurisdictions. The issue of appropriate technology, i.e., the degree of sewage treatment, must also be considered in the decision to build a centralized wastewater treatment facility.

The decision-making process will be an arduous task and will involve time, risk taking and setbacks. Integrated Coastal Management is one framework that can help to minimize conflict and competing objectives between social groups. North Carolina has made some important steps toward an integrated management of its coastal resources. But in order to reach a definitive decision, the process mandates necessary steps such as establishing clear goals and using risk assessment. Natural resource damage assessments can be a critical tool for change. Ultimately, coastal North Carolina's strategy for wastewater management will rely on five factors: engineering feasibility and reliance, health effects, environmental acceptance, social acceptance and cost (Gift *et al.* 1989).

Whatever North Carolina's final strategy is , wastewater disposal and population growth cannot be controlled through one management requirement. Septic tanks, or the unsuitablility of soils, need not be the limit on growth and development in North Carolina. Successful results can be obtained by managing population growth first through land-use plans, then integrating each locality's growth plans into the construction of a centralized wastewater disposal facility. This paper recommends that North Carolina revamp state policies by broadening CAMA to include territory outside the AEC's, address growth management by requiring implementation of local land-use plans, provide the Coastal Resource Commission with oversight authority, provide suitable infrastructure and institutional arrangements for the establishment of a regional authority, and include public participation at all levels of the planning process.

Coastal North Carolina must stop debating the issues and start taking active steps towards problem resolution by planning for its future. It is not necessary to wait for a scientific conclusion regarding appropriate technologies. Because it is iterative, ICM can be incremented in stages. It allows for flexibility, new inputs and feedback over time. This paper believes that domestic wastewater, via an ocean outfall, can be managed successfully through the ICM framework to create a higher level of environmental quality in North Carolina. As Governor Hunt so boldly said, "the economic resource here is the environment" (Hunt 1993). It is time to protect it.

X. LITERATURE CITED

Ad Hoc Committee on Waste Reduction. 1989. Waste reduction in North Carolina: a report and recommendations to the governor's waste management board. 46 p.

Albemarle-Pamlico Estuarine Study. 1992. The first public draft of the comprehensive conservation management plan of the Albemarle-Pamlico Estuarine Study. North Carolina Department of Environment, Health and Natural Resources, unpagin.

Armingeon, N., M. Gausling, J. Hebert, M. Mahon, J. Nowell, J. Ple and A. Romano. 1989. Wastewater disposal in Carteret County: public opinions and alternatives. School of Forestry and Environmental Studies, Duke Marine Laboratory, Duke University, unpub. rep., 72 p.

Augspurger, T.P. 1989. Assessment of coastal North Carolina domestic wastewater disposal alternatives. Division of Coastal Management, North Carolina Department of Environment, Health and Natural Resources, 43 p.

Bascom, W.T. 1989. Disposal of sewage sludge via ocean outfalls. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Besse, D. 1993. Reflections on effective coastal growth management and centralized wastewater treatment. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Brown and Caldwell. 1982. Final report: preliminary design and marine survey for ocean outfall, Dare County, North Carolina. Brown and Caldwell Consulting Engineers, Atlanta, Ga.

Buchholz, R.A. 1993. Principles of environmental management: the greening of business. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Champ, M.A., M.A. Conti and P.K. Park. 1989. Multimedia risk assessment and ocean waste management. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Chesson, Jr., J.P. 1985. Succeeding at coastal management. In: Striking a balance: reflections on ten years of managing the North Carolina coast. Division of Coastal Management, North Carolina Department of Natural Resources and Community Development, 43 p.

Copeland, B.J. 1992. Personal communication. Director, University of North Carolina Sea Grant College Program.

Cooper, V.A. and T.J. Lack. 1988. Monitoring for environmental impact. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Cronkite, W. 1989. In: G. Lawson. Trouble waters. Hadnot Creek Pub. Co., Swansboro, N.C.

Davies, T.T. 1988. Legislation and future developments in the marine disposal of sewage and sludge in the USA. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Duedall, I.W. 1990. A brief history of ocean disposal. Oceanus 33(2):29-38.

Duke, C.S. 1986. Sewage treatment options for Atlantic Beach, North Carolina. Institute of Policy Sciences and Public Affairs, Duke University, unpublished master's memo, 51 p.

Environmental Protection Agency. 1990. Progress in the National Estuary Program. Report to Congress, 44 p.

Environmental Protection Agency, Office of Water. 1993. Guidance specifying management measures for sources of nonpoint pollution in coastal waters. Issued under the authority of Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990, Washington, D.C.

Erdheim, E. 1985. United States marine waste disposal policy. In: B.H. Ketchum, J.M. Capuzzo, W.V. Burt, I.W. Duedall, P.K. Park, D.R. Kester (eds.). Nearshore waste disposal, Vol. 6, wastes in the ocean. John Wiley and Sons, N.Y.

Fergen, R.E. 1993. Construction of ocean outfalls and diffuser systems. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Gaddy, C. 1988. Troubled waters. WRAL-TV5, Capital Broadcasting Co., Inc.

Gerlinger, T., G. Robertson and D. Maurer. 1993. Rapid response benthic monitoring of a Southern California ocean outfall. Sea Technology 34(10):23-28.

Gift, J.J., H. Plugge, W.J. Rue, B.L. Rubin, J.A. Fava, S.E. Storms, D.A. Segar and E. Stamman. 1989. Incineration versus ocean disposal of sewage sludge: a multimedia assessment of New York City management options. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Gottovi, K. 1993. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Gunnerson, C.G., ed. 1988. Integrated resource recovery wastewater management for coastal cities: the ocean disposal option. World Bank Technical Paper, #77, the World Bank, Washington, D.C., 396 p.

Hayes, D. and W. Sisson. 1993. Land use planning and coastal growth due to centralized wastewater treatment: New Hanover case study. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Howes, J. 1993. North Carolina, coastal wastewater and growth. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Huetteman, T.J., D.E. Levin, R.F. Lorang and R.X. Wells. 1989. Ocean versus land-based sewage sludge disposal alternatives for Nassau County. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Hunt, Jr., J.B. 1993. Keynote address. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Huntington, R. and P.B. Rumsey. 1988. Marine treatment, disposal and performance of sewage outfall- UK practice. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP. 1990. Joint group of experts on the scientific aspects of marine pollution (GESAMP): the state of the marine environment. Rep. Stud. GESAMP No. 39, 114 p.

Kamlet, K.S. 1989. Ocean dumping regulation: issues and approaches. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Kirkman, D.A. 1993. Ocean outfalls and coastal economics. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Kitsos, T.R. and J.M. Bondareff. 1990. Congress and waste disposal at sea. Oceanus 33(2):23-28.

Lahey, W.L. 1989. Pricing mechanisms for ocean waste disposal: a viable regulatory tool. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Leenheer, J.A., R.L. Malcolm and W.R. White. 1976. Physical, chemical and biological aspects of subsurface organic waste injection near Wilmington, N.C. U.S. Dept of Interior, Geological Survey Prof Paper 987.

Leonard, J.N. 1993. Technical considerations of ocean outfalls- Clean Water Act 403(c): status and cost for ocean discharges. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Leschine, T.M. and R.J. Quinn. 1989. Decision analysis as an aid to future waste management decisions. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

McCullough, M. 1984. North Carolina coastal water quality trends 1970-1984. Division of Coastal Management, North Carolina Department of Environment, Health and Natural Resources, 12 p.

McGhee, R.F. 1993. Introduction to day two of the forum. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Mearns, A.J. 1993. 'Appropriate' technologies for marine pollution control. Sea Technology 34(10):31-37.

National Oceanic and Atmospheric Administration and Environmental Protection Agency. 1993. Coastal nonpoint pollution control program: program development and approval guidance. Washington, D.C.

National Research Council, Committee on Ocean Waste Transportation, Marine Board, Commission on Engineering and Technical Systems. 1984. Ocean disposal systems for sewage sludge and effluent. National Academy Press, Washington, D.C.

National Research Council, Committee on Wastewater Management for Coastal Urban Areas, Water Science and Technology Board, Commission on Engineering and Technical Systems. 1993. Managing wastewater in coastal urban areas. National Academy Press, Washington, D.C.

Nauke, M.K. 1989. Obligations of contracting parties to the London Dumping Convention. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Nichols, R.C., J.M. Duffin, and J.M. McCarthy. 1990. Evaluation of state environmental management and resource protection programs in the Albemarle-Pamlico region. Research Triangle Institute, Center for Environmental Systems, APES project no. 90-02, 165 p.

Nierstedt, R.J., D.A. Okun, C.R. O'Melia, J.K. Sherwani, M.S. Heath, W.J. Wicker and L.D. King. 1980. Wastewater management in coastal North Carolina. Water Resources Research Institute of the University of North Carolina, rep. no. 165.

Norkis, C.M. 1993. The ocean outfall experience of Cape May, New Jersey: development, history, design and construction. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

North Carolina Department of Environment, Health and Natural Resources, Division of Coastal Management 1985. A guide to protecting coastal resources through the CAMA permit program, 68 p.

North Carolina Department of Environment, Health and Natural Resources, Division of Coastal Management. 1992. Draft strategy for achieving enhancements to the North Carolina Coastal Management Program. Section 309 CZMA, 22 p.

North Carolina Department of Environment, Health and Natural Resources, Division of Coastal Management. 1992. Final assessment of the North Carolina Coastal Management Program. Section 309 CZMA, 55 p.

North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management. 1990. Water quality progress in North Carolina, 1988-1989 305(b) rep.

North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management. 1993. Ocean outfall discharges on the east coast of the United States. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

North Carolina Department of Environment, Health and Natural Resources, Division of Water Resources. 1991. Currituck County outer banks water supply study. 88 p.

North Carolina State University, East Carolina University, and University of North Carolina at Chapel Hill. 1979. Ocean outfall wastewater disposal feasibility and planning. Final rep., prepared for Coastal Plains Regional Commission and N.C. Dept. of Admin., 430 p.

Owens, D.W. 1985. Coastal management in North Carolina. American Planning Association:322-329.

Owens, D.W. 1993. Growth management: alternatives, innovations and land use planning. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Paerl, H.W., M.A. Mallin, J. Rudek, and P.W. Bates. 1990. The potential for eutrophication and nuisance algal blooms in the Albemarle-Pamlico estuary. APES project no. 90-15, 54 p.

Parker, M.M. and A.D. McIntyre. 1988. Sewage sludge disposal at sea- options and management. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Pattinson, C. and R. Jones. 1988. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Pharoah, D.F.H. 1988. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Robbins, A. 1986. Unlimited power. Ballantine Books, New York.

Sauber, J. 1993. Personal communication. North Carolina Division of Environmental Management.

Schubel, J.R. 1993. Understanding the environmental impacts of secondary growth. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Shaw, R. 1992. Personal communication. North Carolina Division of Coastal Management.

Snook, W.G.G. 1988. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Snyder, T., D. Whittington and D. Hillstrom. 1984. Financing water projects in North Carolina: the state role. Water Resources Research Institute of the University of North Carolina, rep. no. 220, 62 p.

Terry, C. 1993. Wastewater options: North Carolina Barrier Islands Study 1982. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Tschetter, P.D. 1989. Characterization of baseline demographic trends in the year-round and recreational populations in the Albemarle-Pamlico Estuarine Study area. APES project no. 89-03, 93 p.

Wakefield, J.A. 1988. Coastal pollution-aesthetics and/or health. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Water Resources Research Institute of the University of North Carolina. 1992. Water Resources Research Institute News. North Carolina State University, no. 278, Nov/Dec.

Water Resources Research Institute of the University of North Carolina. 1993. Water Resources Research Institute News. North Carolina State University, no. 283, Sept/Oct.

Wayland, III, R.H. 1993. Federal perspectives and policies. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Wheeler, D. 1993. The ocean outfall experience at Hampton Roads, Virginia: history, design an construction. In: K. Swetlow (ed.). Proceedings of the North Carolina Ocean Outfall Forum. Sponsored by Neuse River Council of Governments and North Carolina Department of Environment, Health and Natural Resources, Atlantic Beach, North Carolina.

Whyte, M.W. 1988. Marine disposal of sewage and sludge- Australian practice. In: Marine treatment of sewage and sludge. Proceedings of the Conference Organized by the Institution of Civil Engineering and held in Brighton on 29-30 April 1987, Thomas Telford, London.

Wolfe, D.A. 1989. A decision-analytic approach for development of optimal waste management strategies. In: M.A. Champ and P.K. Park (eds.). Oceanic processes in marine pollution, Vol. 3, marine waste management: science and policy, Robert E. Krieger Pub. Co., Malabar, Florida.

Woods Hole Oceanographic Institution, Marine Policy Center. 1993. Optimal strategies for waste management: economic perspectives on the ocean option. White paper, 10 p.