CARRYING CAPACITY ANALYSIS

NAGS HEAD, NORTH CAROLINA

DECEMBER 1984

The preparation of this document was financed in part through a grant provided by the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Ocean and Coastal Resources Management, National Oceanic and Atmospheric Administration.

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David J. Brower
Coastal Resources Collaborative, Ltd.
Chapel Hill, North Carolina

William E. Collins
Director of Planning & Development
Nags Head, North Carolina

C. Luther Propst
Coastal Resources Collaborative, Ltd.
Chapel Hill, North Carolina

Lee D. Einsweiler
Coastal Resources Collaborative, Ltd.
Chapel Hill, North Carolina

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INTRODUCTION

The purpose of a carrying capacity analysis is to determine the amount of development a given geographic area can absorb without significantly damaging the environment or endangering the public health, safety and welfare of the residents. Carrying capacity analysis is based on the assumption that the ability of the physical environment and the public infrastructure to absorb development is limited. Development which exceeds that limit will require the expenditure of public funds to avoid significant damage to the environment and/or harm to the public health, safety and welfare.

Carrying capacity analysis provides municipal officials with the opportunity to manage development to avoid exceeding carrying capacity thresholds and/or to budget for capital improvements to make it possible to exceed these carrying capacity thresholds without endangering the public health, safety and welfare.

Several factors affect the ability of a municipality to absorb development (i.e. the carrying capacity of a municipality). The relevance of each varies according to existing development and infrastructure, the institutional framework of the jurisdiction, the characteristics of the natural systems, for example soil conditions, flooding, watertable, etc.

This report analyzes four factors that are important to the capacity of Nags Head to absorb development: the availability of land for development, wastewater treatment and disposal, water supply and distribution, and hurricane evacuation.

Land availability is determined by measuring the amount of developable

land which has not yet been developed. The density of development is limited by waste water treatment regulations and by the zoning ordinance.

Wastewater treatment and disposal is a pressing concern in Nags Head and throughout coastal North Carolina. This threshold is probably the most important in determining the capacity of Nags Head to absorb development.

The Dare County Water System is the source of water for Nags Head and is beyond the direct control of the Town. The aquifer on Roanoke Island appears to have sufficient capacity to meet the needs of the system for the near future. The aquifer, however, does not have the capacity to serve all the growth that could occur in Dare County.

Hurricane evacuation is a regional concern. One cannot responsibly plan for evacuation by considering only one part of the region. It is important, however, to be aware of the parameters imposed by the need to evacuate a barrier island in the face of a hurricane.

This report indicates the approximate number of dwelling units that the Town of Nags Head can absorb before the reasonable capacity of each of these factors is exceeded.

LAND AVAILABILITY AND WASTEWATER TREATMENT

It is known that untreated or inadequately treated waste water can contaminate both groundwater supplies and surface waters, endangering public health and environmental quality. The primary factors that govern the overall acceptability of wastewater treatment and disposal with respect to protecting the public health and environmental quality include the following: 1) the method of wastewater treatment and disposal, 2) soil suitability for on-site wastewater disposal, 3) depth of the groundwater table, 4) proximity to surface waters, and 5) density of development.

It is possible to establish a relationship between development densities and the ability of the soils to absorb and treat wastewater using different wastewater treatment methods. It is, however, not possible to simplify the wastewater treatment and disposal problem enough to indicate precisely the density of development that will cause unacceptable contamination of the surficial or underlying aquifers and the adjacent surface waters.

The methods of treating wastewater that are usually considered to be feasible in Nags Head include the following: 1) on-site disposal using conventional septic systems, 2) on-site disposal using non-conventional septic systems, 3) package treatment plants with disposal by land application or by subsurface drainfields. A centralized sewage treatment system is not considered to be feasible.

Before discussing development capacity limitations due to wastewater treatment constraints, four subjects require elaboration: 1) the three methods of wastewater treatment and disposal that are feasible in Nags Head, 2) the existing wastewater treatment and disposal situation in Nags Head,

3) the limitations on septic tank use because of soil conditions, and 4) the state regulations governing density limitations on development using septic tanks.

1. Wastewater Treatment and Disposal Methods

A. On-Site Disposal Using Conventional Septic Systems

Currently the predominant method of wastewater disposal in Nags Head is by septic tank. A septic tank is basically a detention tank in which some of the solids settle out of the wastewater and undergo anaerobic digestion in the tank. The wastewater moves by gravity out of the tank to a system of tiles or pipes in subsurface trenches, the drainfield, where treatment by bacteria in the soil is followed by absorption of the wastewater by the soil.

A properly functioning system relies upon the soil to absorb and adequately treat all wastewater generated from a site. All soils, however, are not suitable for septic tanks as they may not allow wastewater to drain through the soil or they may allow wastewater to pass to the groundwater too quickly - hence without adequate treatment.

The advantages of disposal by septic systems are the use of natural aeration and filtration to treat wastewater close to the source of the wastewater, and their cost-effectiveness. The disadvantages and limitations of the use of septic systems are discussed later. Overdependence on septic systems for wastewater disposal on the Dare Beaches has been associated with degradation of water quality in Roanoke Sound, the closing of shellfish beds in the Sound, contamination of the surface aquifer on the Dare Beaches, and the possible contamination of the underlying water supply aquifer for the region.

B. On-Site Disposal Using Non-Conventional Systems

There are several on-site alternatives to conventional septic systems, including mound systems, low-pressure pipe systems, evapotranspiration beds, duplex drain fields, aerobic systems, land application, holding tanks, and no-flush toilets. These alternative systems may permit on-site disposal in areas where state regulations do not permit conventional systems and may improve treatment of effluent in areas where septic tanks are permitted but soil conditions or proximity to surface waters indicate that treatment by a conventional system will be inadequate. Development using alternative wastewater treatment systems is, however, likely to require larger minimum lot sizes than required for the use of a conventional system, due to the need to devote a large portion of the site to the wastewater disposal system.

For information on alternative wastewater treatment and disposal systems, contact EPA National Wastewater Flows Clearinghouse, West Virginia University, Morgantown, WV 26506, 800-624-8301. Two of the more promising technologies are low-pressure pipe systems and mound systems. Information on these systems is available in C. Cogger, B. Carlile, D. Osborne and E. Holland, May 1982, Design and Installation of Low-Pressure Pipe Waste Treatment Systems. UNC Sea Grant College Publication UNC-SG-82-03, and C. Cogger, B. Carlile, D. Osborne and E. Holland, August 1982, Design and Installation of Mound Systems for Waste Treatment. UNC Sea Grant College Publication UNC-SG-82-04. Alternative wastewater treatment systems are also discussed in the North Carolina Barrier Island Wastewater Management Environmental Impact Statement, June 1983.

C. Package Wastewater Treatment Facilities

Package wastewater treatment facilities are prefabricated units, which are smaller versions of conventional central wastewater treatment facilities. Package plants are commonly used to treat and dispose of wastewater from multi-unit condominium, motel, or townhouse projects. There are three primary methods of wastewater disposal used by package plants: land application by spray irrigation, subsurface disposal by drain fields, and land application by rotary distributors. Discharge into surface waters has been used but is no longer permitted for new facilities by state regulations. Disposal by spray irrigation is not often used in coastal areas because the method requires a large amount of land. Subsurface disposal uses nitrification lines similar to septic systems for the distribution of effluent beneath the ground surface. This method of disposal requires a smaller land area for a drainfield than is required for spray irrigation. Land application by rotary distributors is particularly advantageous on barrier islands where high percolation rates are common. It uses rotary distributors similar to those employed on conventional trickling filters to disperse effluent into a prepared circular bermed pit of sandy soil. This method of effluent discharge requires less land than other methods and is more easily operated and maintained.

There are many advantages to the use of package plants: relatively small acreage required for the actual plant, ease of installation, capability of modular expansion to increase capacity, and the potential for a private developer to lease or purchase capacity at a privately-owned facility. The disadvantages include: relatively high cost per unit especially for facilities with less than 10,000 gallons per day capacity

(capacity for approximately 20 to 30 dwelling units), difficulty in assuring that the facility meets design specifications, sensitivity to seasonal fluctuations in wastewater flows, and the need for careful supervision of the facility.

2. Description of the Current Wastewater Treatment System in Nags Head

Two methods of wastewater treatment and disposal are commonly used in Nags Head: on-site disposal by conventional septic systems and package treatment facilities. There are five package plants which serve four multifamily residential projects and a nursing home. The capacity, mode of effluent disposal, and the status of these treatment facilities are described in Table 1. In addition to the 135 rooms at Elder Lodge Nursing Home, there are 295 dwelling units either completed or approved that are served by package treatment facilities.

All of the package plants except the facility at the Villas Condominiums utilize land application as the method of effluent disposal. The two methods of disposal most commonly used on barrier islands are those in use in Nags Head: subsurface application by drainfield and land application by rotary distributor.

The package plant at the Villas Condominiums installed some time ago discharges into Roanoke Sound but this is no longer permitted by state water quality regulations. The plant discharges into waters classified as SC waters -- suitable for fishing and other uses but closed to bathing and shellfishing for commercial purposes -- which would probably be classified as SA -- suitable for bathing and shellfishing for market purposes -- or SB -- suitable for bathing but not shellfishing for commercial purposes -- if not for this wastewater discharge.

The remainder of the wastewater generated in Nags Head is disposed of by conventional septic tanks. Currently (through May 1984) there are 3928 dwelling units completed or approved in Nags Head. Three thousand six hundred and

Table 1

EXISTING (AND PROPOSED) PACKAGE WASTEWATER TREATMENT

FACILITIES SERVING MULTI-UNIT HOUSING PROJECTS(1)

PROJECT/ DEVELOPMENT	TOTAL # UNITS	LOCATION	SIZING OF TREATMENT FACILITY (GPD)(2)	DEGREE OF TREATMENT	MODE OF EFFLUENT DISPOSAL	PROJECT STATUS
Armada Inn	105	Old Lighthouse Rd.	31,700 GPD	Tertiary	Subsurface Disposal	All units complete
Elder Lodge Nursing	135 Rooms	Health Center Dr.	20,000 GPD	Tertiary	Subsurface Disposal	All rooms complete
Dune Lantern	16	Virginia Dare Tr.	6,400 GPD	Tertiary	Tertiary Subsurface Disposal	All units complete
Nags Head Village	36	Ocean to Sound 14 mile post	Approved: 60,000 built 120,000 GPD	Tertiary	Rotary Distributors	18 units complete
			Permit (b) to construct (pending) Permit (a) to discharge additional 60,000 approved			18 additional units local have rec. all permits
Villas Condominiums	120	Villa Dunes Drive	60,000 GPD	Tertiary	Discharge into Roanoke Sound	All units complete

(1) Source: Based on data on file with Washington Regional Office, N.C. Division of Environmental Management, Washington, N.C.

(2) Some facilities are to be built in stages and, therefore, are sized to accommodate only a portion of ultimate flow.

thirty-three of these are served by septic tanks.

3. Limitations to Septic Tank Use

There are three primary limitations to the on-site disposal of wastewater in a barrier island setting such as Nags Head: soil suitability and type, depth to the water table, and proximity to surface waters. The first of these is soil suitability, or the ability of the soil to absorb and treat wastewater. The ability of the soil to absorb wastewater is largely a function of the texture of the soil material. The soil types found in Nags Head are described in Table 2. A cross-section of a typical portion of Nags Head is shown in Figure 1, which indicates the location of soil groupings and associated vegetation.

Table 2 lists the depth of the groundwater table usually associated with the soil types found in Nags Head. This is considered the most important factor affecting the suitability of a site for wastewater treatment and disposal since sufficient unsaturated soil is necessary below the drainfield in order to allow adequate treatment of the effluent before it reaches the groundwater. If the level of the groundwater table rises above the drainfield septic tank effluent can reach the surface of the ground, resulting in both public health concerns and aesthetic problems. The amount of unsaturated soil required for adequate treatment is between 1 foot and 4 feet, depending upon the permeability of the soil, in order to prevent contamination of the groundwater and nearby surface waters. The closer the system is to surface waters, the more likely is contamination of such waters.

It should be noted that there is a large difference between the amount of land considered severely limited or very severely limited for on-site

Table 2

Nags Head Septic Suitability of Soils

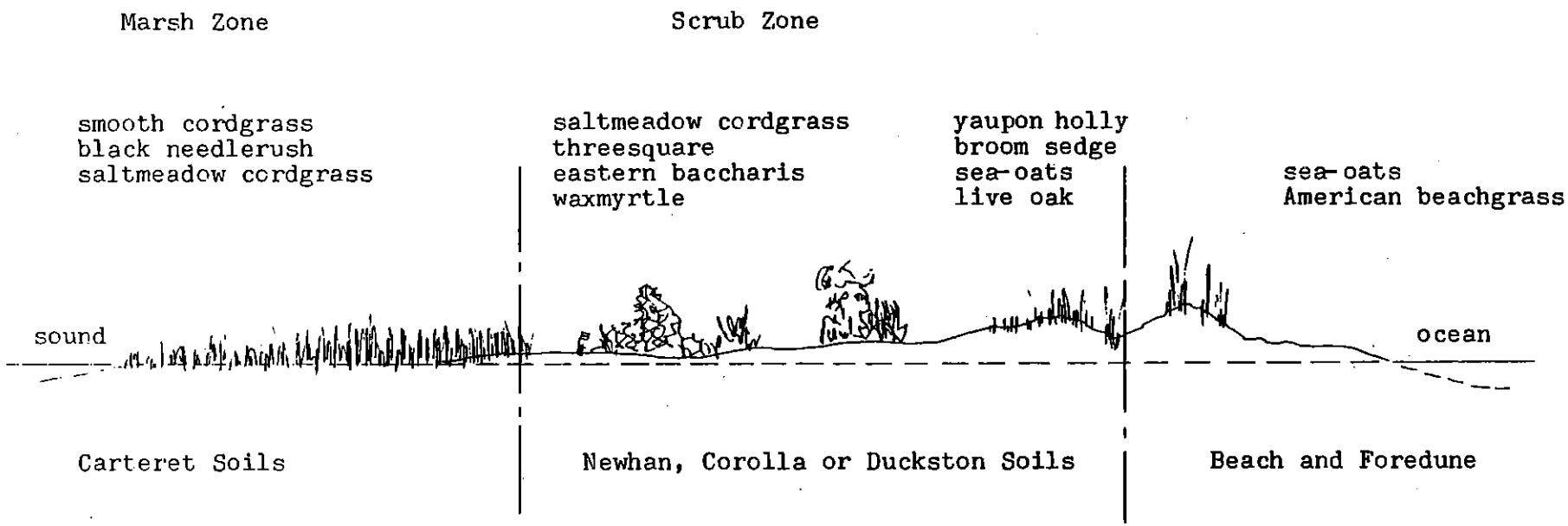
Soil Name	Soil Symbol	Suitability under State Regulations	Limitations to On-site Disposal, SCS criteria	Flooding	Depth to Seasonal High Water Table	Permeability (in/hr)
Beach Foredune Assn.	3	Suitable	Very Severe - flooding	frequent to rare	0.0 - 6.0'	Rapid, 6.3
Duneland	14	Suitable	Severe - blowing sand	none	6.0'	Very rapid, 20.0
Fripp Fine Sand	15	Suitable	Slight	rare, storm tides	6.0'	Rapid, 6.3
Newhan Fine Sand	21	Suitable	Slight	none	6.0'	Very Rapid, 20.0
Newhan Complexes	22-24	Suitable	Depends on soil mix	-	-	-
Corolla Fine Sand	7	Marginal	Very severe	rare to common	1.5 - 3.0'	Very Rapid, 20.0
Corolla Fine Sand, Forested	8	Marginal	Very severe	rare, storm tides	1.5 - 3.0'	Very Rapid, 20.0
Corolla - Duckston Complex	9	Unsuitable	Depends on soil mix	-	-	-
Hobonny Soils	11	Unsuitable	Severe - flooding	surface ponding	0.0 - 0.5'	Very Rapid, 20.0
Duckston Fine Sands	12	Unsuitable	Severe - wet	rare to common	0.0 - 2.0'	Very Rapid, 20.0
Duckston Fine Sands, Forested	13	Unsuitable	Severe - wet	rare to common	0.0 - 2.0'	Rapid, 6.3
Carteret Soils, High	18	Unsuitable	Very severe	monthly	1.0 - 3.0'	Rapid, 6.3
Carteret Soils	19	Unsuitable	Very severe	monthly	0.0 - 3.0'	Rapid, 6.3
Conaby Soils	26	Unsuitable	Very severe	surface	0.0	

Table 2 (Continued)

Nags Head Septic Suitability of Soils

Soil Name	Soil Symbol	Suitability under State Regulations	Limitations to On-site Disposal, SCS criteria	Flooding	Depth to Seasonal High Water Table	Permeability (in/hr)
Dredge Soils	10	Questionable		rare	3.0'	Rapid, 6.3
Madeland	17	Questionable	Severe	rare	3.0'	Rapid, 6.3

CHARACTERISTIC SOIL TYPES AND DOMINANT VEGETATION
CORE BANKS, NORTH CAROLINA



wastewater disposal systems according to the Soil Conservation Service criteria and the amount of land considered suitable for on-site wastewater disposal under existing state regulations. According to the SCS criteria, Newhan Fine Sand is the only soil type in Nags Head with slight limitations for septic tank use. All other soils in Nags Head are severely or very severely limited according to the SCS rating. Slight limitations indicate that soil properties are generally favorable or that minor limitations to the use of on-site septic systems can be easily overcome. The SCS criteria for rating soil suitability involves examination of properties that limit the absorption or treatment of effluent such as slope, susceptibility to flooding, depth to seasonal water table, and soil permeability.

The Soil Conservation Service criteria classifies the remainder of the soil types in Nags Head as having severe or very severe limitations for on-site wastewater treatment and disposal. A severe rating indicates that soil properties are unfavorable for septic system use and will require major and often expensive reclamation, usually including the addition of fill material, for proper system performance. A very severe rating is given to soil types so unsuitable for wastewater disposal that extreme alteration will be required for septic tank use.

The discrepancy between the SCS criteria and the state regulations exists because the state regulations -- unlike the Soil Conservation Service criteria -- do not address soil permeability as a factor in soil suitability for septic system use. State regulations allow on-site wastewater disposal in extremely porous soil where depth to water table is greater than 12 inches.

The soils on the Outer Banks are generally unsuitable for septic systems,

with the state regulations for septic tank use distinguishing between the varying degrees of unacceptability. A map comparing the soil types in Nags Head and current residential development indicates that the more suitable soils are currently developed and that future development is likely to take place on more severely limited soils.

4. State Regulations for the Use of Septic Tanks

State regulations govern the installation, location and use of septic tanks. (15 N.C.A.C. 2H, section .0300 et seq. and section .0400 et seq. and 10 N.C.A.C. 10A, section .1900 et seq.) The regulations which govern the density of development permitted with the use of septic tank systems are as follows: lots platted prior to July 1, 1977 may use on-site systems on parcels as small as 5000 square feet, which produces a density equivalent to approximately 8.7 units per acre; lots platted between July 1, 1977 and July 1, 1982 must be a minimum of 7500 square feet, a density equivalent of 5.8 units per acre; lots platted after July 1, 1982 must be a minimum of 15,000 square feet, or a density equivalent of 2.9 units per acre. These new regulations require a repair and replacement area of equal size to the septic system utilized, and a 50 percent increase in the absorption area requirements if beds instead of trenches are used. The new regulations also make it more difficult for property owners to obtain an exception to the minimum horizontal distance requirements for previously platted lots.

5. Nags Head Land Availability and Wastewater Treatment Carrying Capacity

This section of the report deals with the capacity of Nags Head to absorb development by using several scenarios of future development in

Nags Head.

Data concerning the maximum permissible densities of development served by septic systems indicate that the carrying capacity of the Town of Nags Head for septic tank treatment of wastewater without significant environmental deterioration and risk to public health may well have already been exceeded. (See 1980 Nags Head Land Use Plan Update, p. 65; Water Resources Research Institute, Wastewater Management in Coastal North Carolina, p. 2-10.) Thus all of the scenarios are based upon the assumption that future development will contain a mix of septic systems (since they are allowed) and package plants for wastewater treatment and disposal.

There are approximately 3928 dwelling units in Nags Head, of which approximately 3633 are served by septic systems. A study done by the Department of Environmental Management, The Impact of Septic Tanks on Shellfish Waters, indicates that the maximum density for septic tank use without contamination of surface waters may be one septic tank for between every four to seven acres. Septic tank densities of one tank every four acres, in soils commonly found in coastal North Carolina, were found to lead to contamination of nearby surface waters.

Nags Head contains approximately 4600 acres. There are currently about 3600 septic systems in the Town. The average septic system density over the acreage of the entire Town is therefore 1.2 systems per acre.

Approximately 850 acres in Nags Head are currently developed. There are approximately 3600 septic systems on these 850 acres. This produces an average density on developed acreage in Nags Head of 4.2 systems per acre.

According to the data derived from the Department of Environmental Management septic tank study the maximum density of septic tanks that does not result in water quality degradation is one tank for every four to seven acres. Based upon this the maximum number of septic tanks that Nags Head can sustain within the entire Town is between 661 and 1157 septic systems.

The projections in this report assume that no redevelopment of currently developed acreage at higher densities than currently exist will take place. In other words, existing development is left at existing densities and all growth is assumed to take place on currently undeveloped acreage. Maximum development projections will be higher if tracts in Nags Head undergo re-development at higher than existing densities.

There are 2621 undeveloped platted lots in the Town of Nags Head. Of these, 1883 are acceptable for development and connection to a conventional on-site septic system. Of the remaining 709 developed platted lots 127 are completely unbuildable due to CAMA and the federal wetlands protection program and the remaining 582 lots are unbuildable with conventional septic systems due to unsuitable soils. These 582 lots may be built upon, however, if alternative methods of wastewater treatment and disposal are used.

The total number of developed and undeveloped platted lots in Nags Head is 6520. Of these, the total potential number of dwelling units is 5811. An additional 582 dwelling units can be built, but located on lots considered unsuitable for the use of conventional septic systems. See Table 3.

In addition to these lots the Town contains land yet to be platted. The potential of unplatted parcels is measured under two scenarios: 1) assuming the use of conventional septic systems at a density of 15,000 square feet per dwelling unit; and 2) assuming package wastewater treatment facilities at the maximum density permitted by the Town zoning ordinance.

Table 3

Buildout Factors for Unimproved Platted Lots

District	Total Pl. Lots	Acceptable Pl. Lots *
R1	27	23
R2	1229	909
R3	70	63
CR	108	73
C2	959	625
SPD-20	199	190
TOTAL	2592	1883

* Acceptable based on marginal or suitable soils and location not in CAMA AEC.

Existing Dwelling Units (from 1980 Land Use Plan + bldg. permits to 1984)		3928 DU's
Unimproved Platted Lots		2592
Total potential buildout on pl. lots (on septic systems)		6520 DU's
Unacceptable platted lots		-709
wetland AEC lots	80	
ocean erodible AEC lots	47	
unsuitable soil lots	582	
Estimated Carrying Capacity (using septic systems on lots permitted by state regulations.)		5811 DU's

As shown in Table 4, there are 1526 acres in the Town of Nags Head which are unplatted, undeveloped, privately owned, and subject to development. This acreage does not include Jockey's Ridge State Park or property in the Nags Head woods owned by the Town or the Nature Conservancy. The Epstein tract already has an approved master plan allowing 1798 dwelling units and 900 motel rooms. The remaining unplatted, undeveloped acres, if platted with 15,000 square foot lots, would result in 1848 dwelling units served by septic systems.

If development on the unplatted and undeveloped parcels is served by package wastewater treatment facilities, the density of this development would be determined by the Nags Head zoning ordinance. One thousand, five hundred and twenty-six acres, including the Epstein tract, are available for development with the use of package facilities. At the permitted levels of density in the various zoning districts, 6576 dwelling units could be built on currently undeveloped parcels, plus 900 motel rooms approved on the Epstein tract.

There are 582 unimproved platted lots in Nags Head which cannot be developed with the use of a septic system due to unsuitable soils. These lots may however be developed with the use of alternative on-site wastewater treatment technology. The two most widely-used methods of on-site wastewater treatment on unsuitable soils are low-pressure pipe systems and mound systems. These systems require approximately one acre per dwelling unit for use.

In summary, the total amount of development in Nags Head on currently platted lots, assuming no redevelopment at higher than existing densities, is 6520 dwelling units, not including development on the approved Master Plan for the Epstein tract. Three thousand, nine hundred and twenty-eight

Table 4

Buildout Factors for Unimproved Unplatted Parcels

District	Total Unimproved Acreage	Unsuitable Acreage *
R1	95.3	31.5
R2	237.6	25.6
R3	25.2	
CR	7.0	
C2	90.8	17.1
SPD-40	658.7	31.5
SPD-C	411.2	-
Total Acres	1525.8	105.7

Note: This total does not include publicly-owned land.
* Unsuitable soil on entire parcel.

District	Acreage	Density Permitted
R1	95.3	2.9 DU's/acre
R2	237.6	3.9 DU's/acre
R3	25.2	(8.0 DU;s on first acre,
CR	7.0	12.0 DU;s on all subsequent
C2	90.8	acres)
SPD-40	658.7	4.0 DU/acre
SPD-C	411.2	* as in master plan
Total Acres	1525.8	

Table 4 continued on next page.

Table 4 (cont.)

Buildout at Densities from State Health Regulations
(based on 15,000 sq. ft. lots for septic use)

District	Acreage	Buildout
R1	95.3	249 DU's
R2	237.6	620 DU's
R3	25.2	66 DU's
CR	7.0	18 DU's
C2	90.8	237 DU's
SPD-40	658.7	658 DU's
	Subtotal	1848
SPD-C (Epstein Tract)	411.2	1798 DU's
SPD-C	-	900 Motel Rooms
Total	1525.8	3646 DU's 900 Motel Rooms

Buildout at Maximum Permissible Densities
(as found in the Zoning Ordinance)

District	Acreage	Buildout
R1	95.3	249 DU's
R2	237.6	834 DU's
R3	25.2	272 DU's
CR	7.0	72 DU's
C2	90.8	980 DU's
SPD-40	658.7	2371 DU's
	Subtotal	4778
SPD-C (Epstein Tract)	411.2	1798 DU's
SPD-C	-	900 Motel Rooms
Total	1525.8	6576 DU's 900 Motel Rooms

NOTE: Acreage here not constrained by septic regulations.

of these already exist and 2592 are undeveloped lots. Approximately 709 of these lots face severe constraints to development, leaving a likely buildout between 5811 dwelling units and 6520 dwelling units.

Total buildout of the Epstein tract is 1798 dwelling units and 900 motel rooms. The total buildout on unplatted parcels other than the Epstein tract is between 1848 and 4778 dwelling units. The total amount of buildout, including the Epstein tract, on unplatted parcels is between 3646 dwelling units and 6576 dwelling units, plus 900 motel rooms.

The total buildout in Nags Head is therefore between 10,166 dwelling units and 13,096 dwelling units, plus the 900 motel rooms in the Epstein tract.

6. Building Activity Trends

The density of actual construction that has occurred in Nags Head since April 1980 has been higher than the density permitted by the zoning ordinance. This is due to development on lots which were platted when the zoning ordinance allowed smaller lots.

The actual "market" buildout trend over the past five years indicates that buildout is occurring at maximum permissible densities or greater. In none of the zoning districts in Nags Head is development proceeding at a density appreciably less than the density permitted by the zoning ordinance. See Table 5. The only significant differences between maximum permissible buildout under the zoning ordinance and market trends over the past five years are due to the development of grandfathered lots in previously platted parcels.

During the period between 1975 and 1979, there were 479 building starts in Nags Head according to the Land Use Plan Update. From April 1980 through May 1984, there were approximately 530 building starts. The development over

Table 5

Nags Head Building Activity Trends
(April 1, 1980 - May 23, 1984)

Zone	4/1/80 to 12/31/80	Calendar 81/82/83	1/1/84 to 5/23/84	Period Total	Acres	Density (Dwelling Units/acre)
R1	-	8SF	3SF	11SF	3.8*	2.9
R2	58SF	200SF	44SF	302SF	104.1*	2.9
	2D	17D	2D	21D	10.8*	3.9
R3	5SF	8SF	-	13SF	4.5*	2.9
CR	-	6SF	2SF	8SF	4.0	2.0
	1D	13D	1D	15D	11.1	2.7
	-	41MF	45MF	86MF	6.5	13.2
	-	69Motel	17Motel	86Motel	5.1	16.9
C2	25SF	61SF	9SF	95SF	16.3	5.8
	1D	1D	-	2D	0.7	5.7
	Other: Motel, retail, etc.				61.7	-
SPD	1SF	13SF	10SF	24SF	11.4	2.1
20&40	1Church	1Nsg Home			17.0	

SF = Single Family
D = Duplex
MF = Multifamily

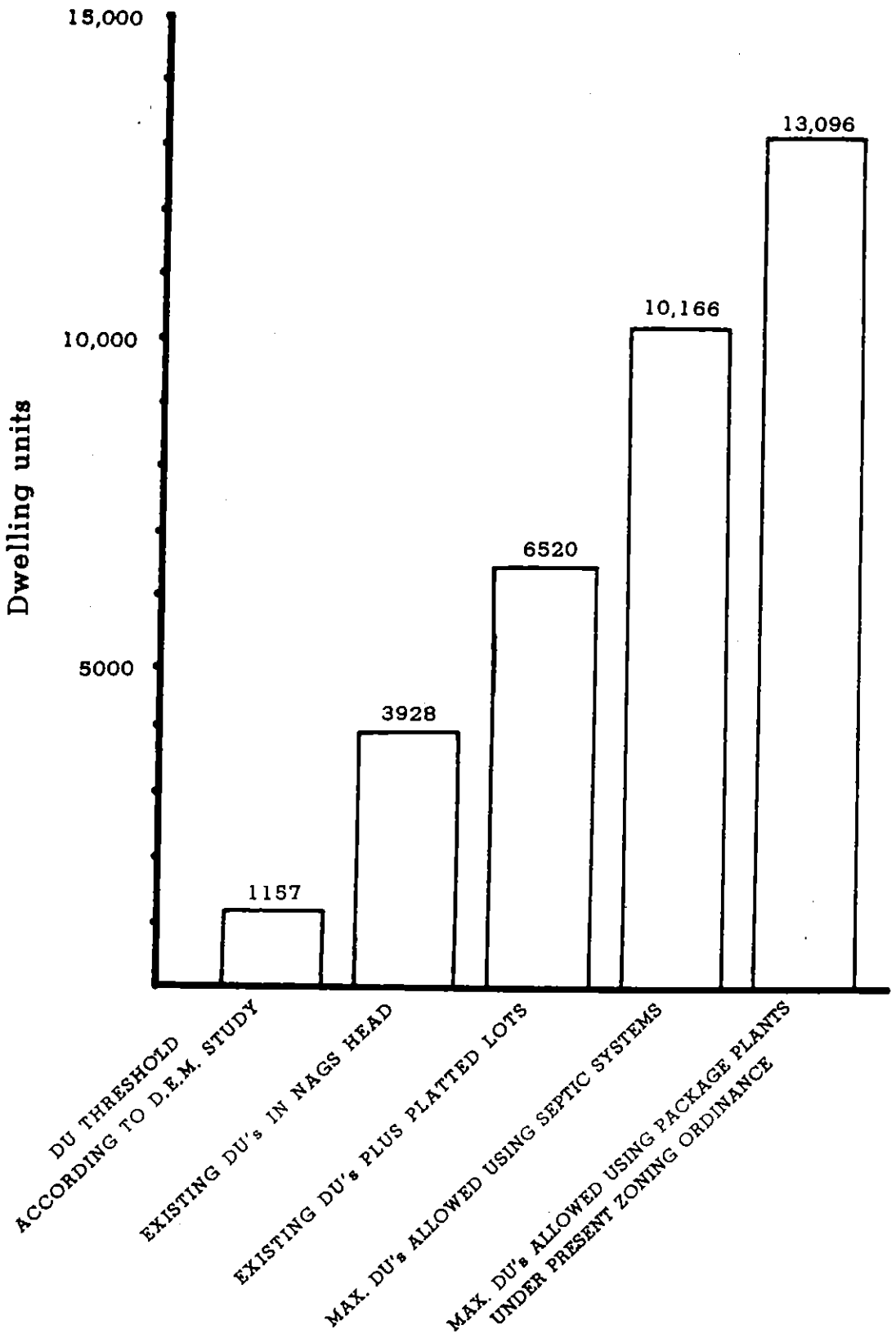
Table 5

Summary
Total New Construction, 4/1/80 through 5/23/84

453 Single Family DU's on	144.1 acres, or	3.1 DU's/acre
76 Duplex DU's on	22.6 acres, or	3.4 DU's/acre
86 Multi-family DU's on	6.5 acres, or	13.2 DU's/acre
Other	83.8 acres	
Total	257.0 acres	
Total Residential Acreage	173.2 acres	
Overall Residential Density	3.6 DU's/acre	
Building Starts, Single Family, 1975 - 1979 (1980 LUP)		479
Building Starts, Single Family, 4/80 - 5/84		529

the past five years has consumed approximately 50 acres per year. See Table 5. With approximately 1500 acres of undeveloped privately-owned land subject to development, and assuming a continuation of recent development rates (50 acres per year), Nags Head will reach full buildout in approximately 30 years.

Nags Head Carrying Capacity Analysis



WATER SUPPLY AND DISTRIBUTION SYSTEM CAPACITY

The central issue with respect to water supply is at what level of development are capital improvements in the water supply, transmission, and distribution system required. Each component in the water supply system represents a fixed and limited capacity which must be increased when demand exceeds its capacity. Increased capacity in this case is a matter of increased capital expenditure.

1. Aquifer Capacity

The most important supply threshold is the capacity of the Roanoke Island aquifer. A recent report by Moore, Gardner and Associates for the County of Dare concluded that "it is evident that sufficient water supplies are available from the Roanoke Island Aquifer System to supply 15 mgd to the county water system." (p. 5-14). The report concludes that once the capacity of the Roanoke Island aquifer is exceeded, the most feasible source of supply is development of the aquifer on the mainland. Development of this water supply source would be costly, requiring the construction of a transmission main across Croatan Sound. The 15 mgd capacity of the Roanoke Island aquifer thus seems to be the most important water supply threshold. This threshold applies to water demand for the entire county population served by the regional water system which includes Nags Head, Kill Devil Hills, Kitty Hawk, Manteo and unincorporated portions of the county.

The Moore Gardner study also projects water demand for the Dare County Water Authority Service Area. They project the water demand for Nags Head in 2005 to be 6.1 mgd, and the water demand for the county system to be 15.49 mgd. (Moore Gardner, Table 4.2-1)

In 1983 Nags Head accounted for a demand of 1.5 mgd out of a total demand for 4.5 mgd for the entire system. This constitutes 33 percent of the total demand. In 2005 Nags Head is projected to account for a demand of 6.1 mgd out of a total demand for 15.49 mgd for the entire system. This will constitute approximately 40 percent of the total system demand.

These projections in the Moore Gardner Study are based upon continuation of the population and water demand trends that occurred between 1980 and 1984. Average annual growth between 1980 and 1984 was approximately 15 percent. (Moore Gardner, p. 4-1)

Based upon projected water demand at full buildout in Nags Head, the ultimate water demand created within the Town of Nags Head will be substantially less than the 6.1 mgd projected by Moore Gardner. Total water demand in Nags Head at full buildout -- under the conditions as explained in the land availability and wastewater section of this report -- will be between 4.43 mgd and 4.72 mgd. See Table 6.

Under existing development patterns, therefore, the portion of the total county water system demand created by Nags Head will allow the Roanoke Island aquifer to provide adequate quantities of water for the county without the need for development of a new aquifer on the mainland. If the share of the entire county supply devoted to Nags Head remains at 33 to 40 percent of the total county demand, then the total county demand will be between 11.1 mgd and 14.2 mgd. This level of demand is within the sustainable capacity of the Roanoke Island aquifer.

Table 6 indicates the computations performed to derive these projections.

In order to establish the relationship between the number of total dwelling units and the total potential water demand in Nags Head, the

demand for water generated by each additional dwelling unit must be determined. The 1980 Nags Head Land Use Plan Update and the 1984 Moore Gardner Water System Improvement Study provide data that establish the relationship between the total number of dwelling units and the demand for water. According to the Land Use Plan Update, average daily water use for residential users is 303.8 gallons per unit during the peak season, with that of motel rooms at 75 gallons per day. (p. 31) Actual motel room water use is closer to 300 gallons per room each day during the peak two months of the tourist season. (See Appendix A) Design capacity used by Dare County in sizing septic systems is 120 gallons per room each day.

Average non-housing water sales to restaurants, retail businesses, and so forth in 1980 was approximately 10 percent of the total water sales for the Town. In 1980, 94,900 gallons out of total sales of 949,000 gallons in a representative month were to non-housing commercial users.

The Land Use Plan Update provides a second method of projecting water demand. According to the Update, dwelling units along the beach area consume 110 gallons per day per bedroom. Dwelling units along the Bypass and toward the Sound consume 85 gallons per day per bedroom. One hundred gallons per day per bedroom seems a reasonable estimate of the total per day per bedroom water consumption. The Land Use Plan Update also contains data that indicates that the average number of bedrooms per dwelling unit in Nags Head is 3.2. (p. 27) As shown in Table 6, Projection 1 -- which assumes water demand of 300 gallons per day for dwelling units and 120 gallons per day for motel rooms (the standard used by the Dare County Health Department) -- indicates that projected water demand at full buildout

Table 6

Nags Head Water System

Total Potential Buildout on Platted Lots (DU's)	6520
Total Potential Buildout on Unimproved Parcels	6576
Additional Motel Rooms	900
Total Potential Dwelling Units at Full Buildout	13096
Additional Motel Rooms	900

Projection 1

- Assume 300 gal/DU/day
- Assume 10% of water used by commercial sector
- Assume 120 gal/unit/day in motels

Expected Residential Water Use	3,928,800 gal/day
Expected Motel Water Use	108,000 gal/day
Expected Commercial Water Use	392,880 gal/day
Total Water Use at Full Buildout	4,424,680 gal/day or 4.43 MGD

Projection 2

- Assume 100 gal/bedroom/day
- Assume 3.2 bedrooms/DU
- Assume 10% of water used by commercial sector
- Assume 120 gal/unit/day in motels

Expected Residential Water Use	4,190,720 gal/day
Expected Motel Water Use	108,000 gal/day
Expected Commercial Water Use	419,072 gal/day
Total Water Use at Full Buildout	4,717,792 gal/day or 4.72 MGD

is 4.43 mgd.

Projection 2, which assumes 100 gallons water demand per day per bedroom and assumes a continuation of the average number of bedrooms per dwelling unit at 3.2, indicates that projected water demand at full build-out is 4.72 mgd.

Both of these projections assume that water demand by commercial users remains at 10 percent of total demand. These projections also assume that the Nags Head zoning districts C-2 and C-R will continue the recent trend of developing with multi-family housing rather than hotel/motel development. Therefore the assumed densities within these zoning districts is approximately 12 units per acre, rather than approximately 24 units per acre which would be permitted with the construction of hotel or motel units.

If total potential water demand in Nags Head is limited to between 4.43 mgd and 4.72 mgd and the other areas within the Dare County Water Service Area limit their water demand to similar ratios of the total county water demand, the total demand on the Roanoke Island aquifer will peak at between 11.1 mgd and 14.2 mgd. This is based upon the demand created in Nags Head remaining between 33 percent and 40 percent of the total county demand.

2. Water Distribution System

There are three factors affecting the capacity of the Town of Nags Head to transport and distribute water to its residents following delivery to the Town by the Dare County Water System. These portions of the water delivery under the town's control include the following: 1) local pumping capacity, 2) storage tank capacity, and 3) capacity of the local water mains used for distribution.

The current capacity of the pumps which provide water for Nags Head is 2500 gallons per minute. During peak periods in the summer months, Nags Head consumes 1500 gallons per minute of this capacity. This results in 1000 gallons per minute excess capacity for use by future development. At current average use per dwelling unit, an additional 2600 dwelling units can be added to the system before additional pumping capacity is necessary. See Table 7. The units approved for the Epstein tract alone will consume this excess capacity. Consumption equivalency figures for other uses are in Appendix B.

An additional concern with pumping capacity is the speed with which storage tanks serving the town can be refilled. As the towns consumption approaches its pumping capacity, less excess capacity is available to refill these tanks and the rate of refill therefore is slower.

Storage tank capacity in Nags Head is currently 300,000 gallons. An additional 500,000 gallon tank is expected to be completed this summer. This 800,000 gallon storage capacity could serve Nags Head water consumption from storage alone for approximately 9 hours at peak consumption (it should be noted however that peak consumption occurs infrequently and for relatively short periods of time). If the tanks were empty, over 13 hours would be required to refill them while serving regular demand, using the excess 1000 gallons per minute of pumping capacity currently available. As more water users are added to the system, this excess capacity diminishes, and the refill period becomes longer.

The capacity of the water distribution mains which serve individual neighborhoods in Nags Head is a critical threshold to the growth in these neighborhoods. When the size of a water main is inadequate for the volume of water demanded by its users, pressure loss results. This leads to user dissatisfaction and potential safety concerns. Relating the size of such

Table 7

Nags Head Water Distribution 1984

Pumping Capacity

Pumping Capacity of Dare County System (supply available to Nags Head)	2500 gal/min
Nags Head Peak Use	1500 gal/min
Excess Capacity for Future Use	1000 gal/min
Dwelling Units	3928 DU's
Peak Use	1500 gal/min
Average Use	0.382 gal/DU/min
Total Capacity Available	2500 gal/min
Average Use per Dwelling Unit	0.382 gal/DU/min
Total Dwelling Units Served at Capacity (capacity divided by average use)	6545 DU's

-- Note that this is pumping capacity only --

Total Additional Dwelling Units Possible Without Addint Pumping Capacity	2617 DU's

-- The amount of water used by other uses is shown in Appendix B --

Storage Tank Capacity

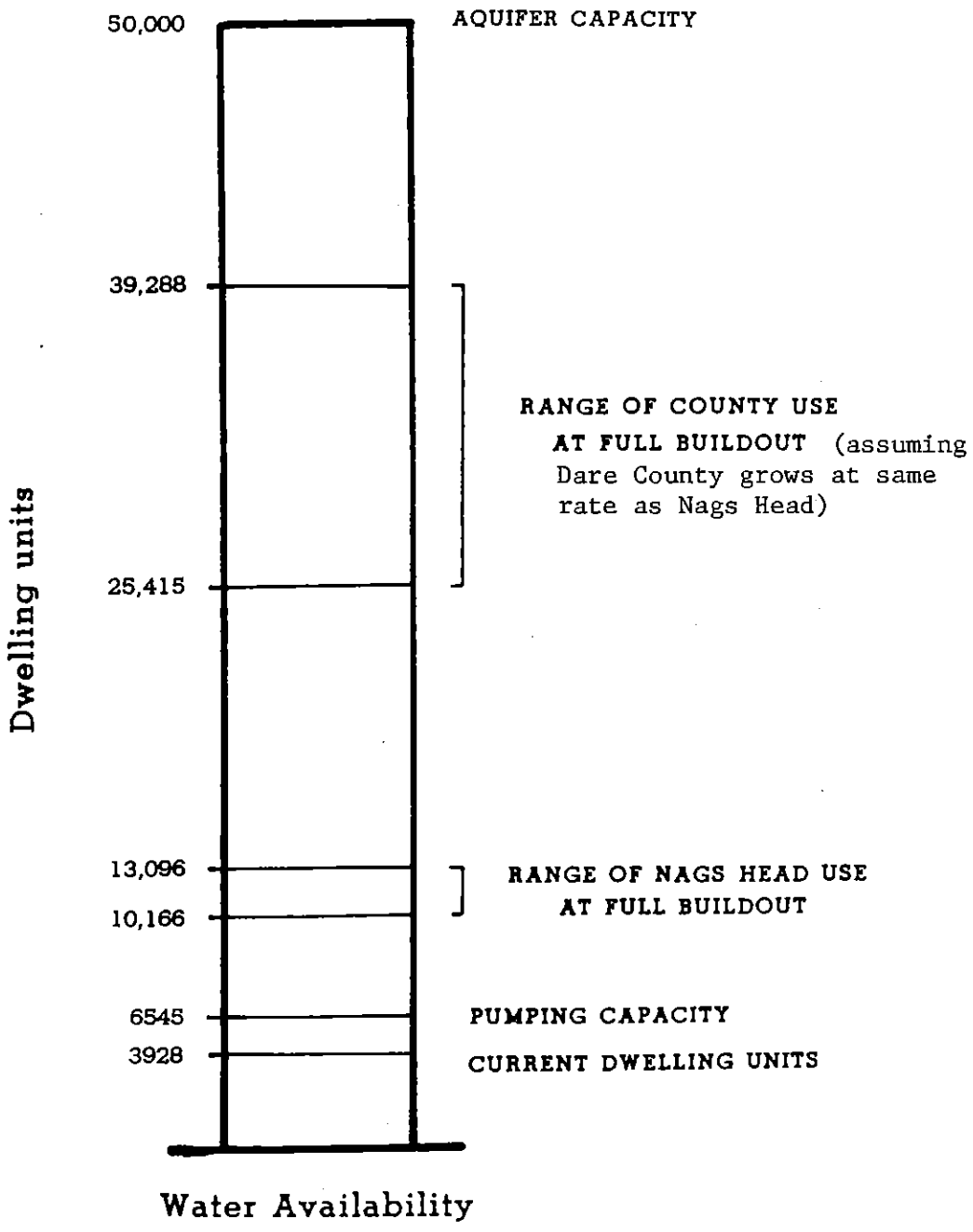
Capacity of Tanks	800,000 gallons
Consumption per Hour	90,000 gallons
Hours Available on Tank Service Alone	8.9 hours
Hours Required to Fill Tanks from Empty (while still serving at peak use)	13.3 hours

mains in newly developed areas to the potential total demand on the main is crucial to the future capacity of the main to provide water to all potential users.

Currently, 12-inch trunk lines carry water to the Town along the beach road and the bypass. These 12-inch lines feed a distribution network of 10-inch, 8-inch and 6-inch water lines, with much of the Town served by the 6-inch line. The number of dwelling units which can be connected to the 6-inch line is limited. As more units tap onto this system, velocity of the water in the mains must increase to provide the same level of service. This in turn increases the head loss, or loss of pressure due to friction in the pipes.

The Nags Head system currently operates at 58 to 62 p.s.i. The losses of pressure due to friction over distance can be severe. These basic problems are aggravated in south Nags Head because the primary service (8-inch main) is a dead end line, which makes it difficult to keep flow and pressure high enough. An engineering study to address allowable friction loss and determine adequacy of mains throughout the Town would help pinpoint current problem areas. If pressure falls low enough, the ability to fight fires using hydrants along the water line becomes inadequate, leading to safety concerns.

Nags Head Carrying Capacity Analysis



(Gallons/day converted to dwelling units)

HURRICANE EVACUATION CAPACITY

Hurricanes are a major threat in any coastal community. They are even more dangerous on a barrier island because of the unstable nature of the island's natural systems, the limited elevation of the island, and the limited number of transportation links to the mainland. In addition, there are usually not enough adequate shelters in beach communities to safely allow people to remain, therefore the majority of residents and visitors must evacuate.

The capacity of the bridges and causeways which connect the islands to the mainland present a threshold beyond which development results in safety concerns, since evacuation beyond this capacity cannot be assured. It is difficult to create an effective model of hurricane evacuation for Nags Head because the community is only one of many which rely on the same evacuation routes. Nags Head is one portion of a far larger area -- covering from the Currituck Banks to Ocracoke -- which responsible evacuation planning must treat as a single system.

The methodology used here is adopted from John R. Stone's Hurricane Emergency Planning: Estimating Evacuation Times for Non-Metropolitan Coastal Communities (UNC Sea Grant Publication, 1982). His process isolates the bottleneck in the evacuation system, and then calculates the time necessary to get all the evacuating vehicles through this bottleneck.

For Nags Head, the bottleneck is either the Highway 64 bridge and causeway to Roanoke Island, or the Highway 158 bridge to Currituck County. In calculating the capacity of both of these bridges, the major variables remain the same -- leading to an identical capacity for either bridge. This means that the difference in total evacuation capacity is related to travel

time to the bottleneck, as well as to the number of vehicles using that route during the evacuation.

For this capacity evaluation, all of the traffic generated south of the Nags Head - Kill Devil Hills line was sent over the Highway 64 bridge to Roanoke Island.

Four elements must be considered to determine the total evacuation time: bridge capacity, evacuation demand, travel time, and evacuation capacity. Each of these elements is described below, with the calculations which lead to total evacuation time. (See also Table 8)

1. Bridge Capacity

Capacity of the bridge and causeway system is based upon the maximum normal flow of traffic over the bridge. Five factors are then subtracted from this normal maximum to allow for the specific conditions during hurricane evacuation. These factors assume that the capacity will be reduced by blocked lanes, inclement weather, shoulder width and sight distance, oversize vehicles, and emergency vehicles. Each factor is discussed below:

Normal Flow - The Highway Capacity Manual describes normal flow for this type of road (the bridge and causeway) as 2000 vehicles per hour total in both lanes.

Blockage Factor - Fifteen percent of normal flow is lost due to stalled cars, fallen road signs, loose electric or phone lines, and so forth.

Weather Reduction Factor - Another 35 percent of the normal capacity is lost due to slippery roads, gale force winds, and heavy rains.

Lane/Clearance Factor - A further 23 percent reduction in capacity is due to limitations of the road itself such as lack of shoulder and limited

sight distances.

Oversize Vehicle Factor - One lane is closed for emergency vehicle use ten percent of the time.

After these five factors are subtracted from the normal flow capacity, the remaining total bridge capacity for hurricane evacuation is found to be 768 vehicles per hour.

2. Evacuation Demand

The number of vehicles which will be used to evacuate prior to a hurricane is calculated by using the number of dwelling units in Nags Head. Other vehicles which can be expected to arrive from Hatteras Island are also included. This does not include day tourists.

Evacuation demand is computed as follows:

Permanent and Tourist Residential Units - Data determining the number of dwelling units was taken from the 1980 Nags Head Land Use Plan and updated to the present using building permit information. There are 2238 tourist residential dwelling units (cottage courts and motels) and 1690 permanent residential dwelling units.

Vehicles Per Dwelling Unit - Estimates from the Highway Research Board's Highway Capacity Manual are: 1.6 vehicles per permanent dwelling unit, and 1.1 vehicles per tourist dwelling unit.

Early Evacuators - Fifteen percent of the population leaves before the order to evacuate is given.

Other Vehicles - Approximately 5000 vehicles can be expected to arrive from Hatteras Island according to the Hatteras Island Carrying Capacity Analysis (May 1984).

Total evacuation demand at peak occupancy is 9391 vehicles.

3. Travel Time

Travel time is the amount of time it would ordinarily take to drive from the furthest point in Nags Head to the bridge. The calculation is a simple division of maximum distance (15 miles) by average speed (35 MPH). Travel time for Nags Head is under one-half hour.

4. Evacuation Capacity

The bottleneck for Nags Head evacuees is clearly the bridge and causeway which link the island to Roanoke Island and the mainland. This section calculates the amount of time required to move the evacuating vehicles through this bottleneck. First, the period during which evacuation takes place is calculated, then the demand for evacuation during that period is examined to evaluate the bottleneck:

Warning Time - The National Weather Service can be counted on to provide no more than a 12-hour warning which is accurate to within approximately 50 miles of the landfall of the eye.

Hazard Cutoff Time - Roads are inundated or high winds prevent evacuation four hours before the landfall of the hurricane eye.

Evacuation Period - The amount of time during which evacuation may take place, i.e. 12-hour warning minus 4-hour hazard cutoff results in an 8-hour evacuation period.

Moving the total evacuation demand over the bridge and causeway takes over 12 hours; 9391 divided by 768. If fifteen percent of the vehicles leave before the order is given, this leaves over 1800 vehicles stranded on the island, after the 8-hour evacuation period. An additional 2.4 hours are

needed to evacuate these remaining vehicles. The total time necessary for full evacuation is almost 15 hours, even if 15 percent of the population leaves prior to the warning. If no significant number of vehicles leaves prior to the warning, over 16 hours are necessary for full evacuation.

An example given in Stone's manuscript asserts that only 400 to 500 vehicles per hour can pass over a two-lane bridge during hurricane evacuation conditions. This results in a scenario far worse than that resulting from the 768 vehicles per hour estimated in this analysis.

In addition, this evacuation model merely evacuates vehicles from Nags Head and Hatteras Island to Roanoke Island. On Roanoke Island, the vehicles from the barrier islands will be joined by vehicles from Manteo and Wanchese, further aggravating evacuation to the mainland.

Table 8

Nags Head Evacuation Analysis

BRIDGE CAPACITY			
Normal Flow	1000	veh/lane/hr	
Blockage Factor	0.85	(stalled cars, etc.)	
Weather Reduction Factor	0.65	(slick roads, etc.)	
Lane/Clearance Factor	0.77	(shoulder, sight distance)	
Oversize Vehicle Factor	0.95	(truck, trailer, RV)	
Emergency Vehicle Factor	0.90	(1 lane, 10% use)	
Total Bridge Capacity using two lanes		(veh/hr)	768
EVACUATION DEMAND			
Permanent Residential	1690	DU's	
Tourist Residential	2238	DU's	
Vehicles per Permanent DU	1.60		
Vehicles per Tourist DU	1.10		
Early Evacuators (%)	0.15		
Nags Head Vehicles			4391
Other Vehicles (areas outside Nags Head)			5000
Evacuation Demand at Peak Occupancy		(total vehicles)	9391
TRAVEL TIME			
Average Speed	35.00	MPH	
Maximum Distance	15.00	Miles	
Travel Time	0.43	Hours	
EVACUATION CAPACITY			
NSW Warning Time	12.00	Hours	
Hazard Cutoff Time	4.00	Hours	
Evacuation Period	8.00	Hours	

Table 8 continued on next page...

Table 8 (cont.)

Nags Head Evacuation Analysis

Vehicles Remaining Until Evacuation Order is Given	7982 Vehicles
Vehicles Which Can be Evacuated in 8 Hours Over the Bridge	6143 Vehicles
Vehicles Stranded on the Island	1839 Vehicles
Additional Hours Needed to Evacuate These Vehicles	2.40 Hours

TOTAL EVACUATION TIME (Time necessary before landfall of the eye, assuming that 15% leave early)

Hazard Cut-off Time	4.00 Hours
Evacuation Period	8.00 Hours
Travel Time	0.43 Hours
Add'l Hours Needed	2.40 Hours
Total	14.82 Hours

Time Necessary for Complete Evacuation (no vehicles leave before the order)	16.66 Hours

CONCLUSION

This report analyzes four primary factors that determine the capacity of the Town of Nags Head to absorb development: the availability of land for development, wastewater treatment and disposal, water supply and distribution and hurricane evacuation.

Land Availability and Wastewater Disposal

Land availability is determined by the amount of developable acreage in Nags Head which has not yet been developed and by the permissible development densities within the Town. Development densities are determined both by spetic tank regulations and by the Town zoning ordinance. The carrying capacity threshold resulting from land availability is closely related to the wastewater treatment carrying capacity threshold since the density of development in Nags Head is primarily restricted by wastewater treatment regulations which limit the density of development served by septic systems.

Soil conditions in Nags Head are generally unfavorable for the use of septic systems for wastewater disposal. Several studies indicate that existing regulations do not ensure against environmental degradation resulting from development with the use of septic systems at permitted densities. Widespread reliance on septic systems for wastewater disposal at permitted densities may lead to groundwater and surface water contamination due to the unfavorable nature of soils and the high water table found in much of Nags Head.

A North Carolina Division of Environmental Management study indicates that contamination of estuarine waters is to be expected when dense development with conventional septic systems occurs on unfavorable coastal soils.

The study found that the maximum density for septic tank use in the study area without water quality degradation in nearly estuarine waters is one septic tank for between every four to seven acres.

This density contrasts sharply with an average density of septic systems on developed acreage in Nags Head of 4.2 systems per acre. The Town already far exceeds the capacity of the soils to treat wastewater through on-site septic systems without presenting a threat to environmental quality and a risk to the public health.

The Development projections in this report assume that all growth takes place on currently undeveloped acreage and undeveloped lots, and that no redevelopment of currently developed acreage at higher densities than currently exist takes place. Undeveloped platted lots in existing subdivisions are treated as having the potential for one dwelling unit.

The total amount of buildout in Nags Head on currently platted lots, assuming no redevelopment at higher densities, is 6520 dwelling units, not including development of the approved Master Plan for the Epstein tract. Three thousand, nine hundred and twenty-eight of these dwelling units already exist and 2592 are undeveloped lots. Approximately 709 of these lots face severe regulatory constraints to development; 127 are completely unbuildable due to CAMA and wetlands protection regulations, while the remaining 582 lots are unbuildable with conventional on-site septic systems due to unsuitable soil conditions. These 582 lots may be developed using alternative methods of wastewater disposal. This produces a likely buildout between 5811 dwelling units and 6520 dwelling units on

already platted lots.

Total buildout of the Epstein tract, according to the approved Master Plan, is 1798 dwelling units and 900 motel rooms.

The total potential buildout of unplatted parcels is measured under two scenarios: first, assuming a density of 15,000 square feet per dwelling unit - the maximum density permitted with the use of septic systems on newly platted lots; and second, assuming the maximum density permitted by the Town zoning ordinance with use of package wastewater treatment as necessary.

With the use of septic systems, the total buildout on unplatted parcels other than the Epstein tract is 1848 dwelling units. With the use of package plants, potential buildout is 4778 dwelling units, plus development on the Epstein tract.

The total buildout on unplatted parcels other than the Epstein tract is between 1848 and 4778 dwelling units. The total amount of buildout, including the Epstein tract, on unplatted parcels is between a low figure of 3646 dwelling units and a high figure of 6576 dwelling units, plus 900 motel rooms.

The total buildout in Nags Head is therefore between 10,166 dwelling units and 13,096 dwelling units, plus 900 motel rooms.

Actual buildout in Nags Head since 1980 appears to be occurring at the maximum permissible buildout or greater. Greater densities are due to the construction of dwelling units on lots grandfathered at higher densities in previously platted parcels.

Water Supply and Distribution

The central issue with respect to water supply carrying capacity is

the level of development at which capital improvements in the water supply and distribution system are required. Increased water supply capacity is a function of increased capital expenditure. The most important supply threshold in Nags Head is the capacity of the Roanoke Island aquifer, which is thought to have a capacity of approximately 15 mgd.

Based upon projected water demand in Nags Head at full buildout, the ultimate water demand within the Town, under the conditions outlined earlier, will be between 4.43 mgd and 7.72 mgd. This indicates that with a continuation of existing development patterns, the Roanoke Island aquifer can provide adequate quantities of water for the county without the need for development of a new aquifer. If the share of county-wide demand generated by Nags Head remains constant, (that is if Nags Head and the rest of the county grow in the same proportion) demand for the entire county will at full buildout, be between 11.1 mgd and 14.2 mgd. This level of demand is within the 15.0 mgd sustainable capacity of the Roanoke Island aquifer.

There are additional concerns related to the distribution network in the Town, however these are more susceptible to traditional engineering analysis.

Hurricane Evacuation

The capacity to evacuate the Town of Nags Head in the event of a hurricane presents a carrying capacity threshold beyond which continued development results in safety concerns, since evacuation of vehicles beyond this capacity cannot be assured. It is difficult to create an effective model of hurricane evacuation for a community such as Nags Head since the evacuation of Nags Head is only one component of a larger evacuation system which covers from the Currituck Outer Banks to Hatteras Island.

The bottleneck in the evacuation of Nags Head is the bridge and causeway

connecting Nags Head to Roanoke Island. Not including day tourists on the Outer Banks and assuming that Kill Devil Hills and points north evacuate over the U.S. 158 bridge, total evacuation demand for the Roanoke Island bridge and causeway is 9391 vehicles. Based upon John R. Stone's methodology, the total bridge capacity for hurricane evacuation is 768 vehicles per hour.

The National Weather Service provides no more than a 12-hour warning before landfall of a hurricane. Roads can be expected to be inundated or high winds prevent travel four hours before landfall. A 12-hour warning minus a 4-hour hazard cut-off leaves an effective evacuation period of 8 hours.

The total evacuation demand requires over 12 hours to cross off the Outer Banks onto Roanoke Island (9391 vehicles divided by 768 vehicles per hour). Over 1800 vehicles may be stranded on the island due to inability to evacuate. These projections assume that 15 percent of the residents and visitors on the island leave before an evacuation order is given. If none leave prior to the evacuation order, over 16 hours will be needed for full evacuation. As Nags Head and the other beach communities continue to grow the problem is only going to get worse.

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APPENDIX A

Water Demand

Restaurant Water Use

The state design standard used for restaurant wastewater treatment facilities is 40 gallons per seat. The information below is taken from the water bills for the period 10/82 through 9/83. The 12-month average is the water use from this period divided by 365 days, further divided by the number of seats as shown on the building permit. The 2-month peak is taken from the highest meter reading period divided by 60 days, further divided by the number of seats.

NAME	12-MONTH AVERAGE	2-MONTH PEAK
Tale of The Whale	17.1 gal/seat	44.6 gal/seat
Munde's	12.1	26.3
By George	14.3	27.2
Dunes	17.9	46.9
Owens	24.2	42.0
Sam & Omies	44.2	67.4
RV's	21.8	44.8

Looking at the figures above, it is clear that five of the seven restaurants listed are using more than the design standards for their septic system for the entire 2-month peak period. The daily fluctuation in the operation of these restaurants might raise the peak consumption per seat far beyond the state design capacity. Closer examination of smaller time increments would be needed to determine this.

APPENDIX A (cont.)

Hotel and Motel Water Use

The state design standard used for hotel/motel wastewater treatment facilities is 75 gallons per room each day. The design standard used by Dare County is 120 gallons per room each day.

NAME	12-MONTH AVERAGE	2-MONTH PEAK
Colonial Inn	92 gal/room/day	232 gal/room/day
Cabana East	181	358
Silver Sands	39 (closed 4 months)	135
Armada*	114	193
Islander	87	203
Beachcomber	131	315
Owen's	141	323
Sea Oatel	111	412

Some of the hotel/motel's listed above exceed the county design standard even when averaging over the entire year. During the peak two months, many of these facilities are two and three times above the county design capacity for this septic system.

*Has attached Restaurant.

APPENDIX B

WASTEWATER DESIGN FLOWS

NORTH CAROLINA ADMINISTRATIVE CODE REQUIREMENTS
EQUATED WITH DWELLING UNITS*

(Example: A barber shop with three chairs equals one dwelling unit)

Barber Shop	100 gal/chair	.33 DU per chair
Beauty Shop	125 gal/chair	.42 DU per chair
Bowling Alleys	50 gal/lane	.16 DU per lane
Construction Camp	50 gal/person	.16 DU per person
Campground	150 gal/campsite	.50 DU per campsite
Churches	5 gal/member	.016 DU per member
Factories per shift (exclusive of industrial wastes)	25 gal/person	.083 DU per person
Laundry self-service	500 gal/machine	1.67 DU per machine
Motel/Hotel	75 gal/room	.25 DU per room
with cooking facilities	125 gal/room	.42 DU per room
Resort	200 gal/room	.66 DU per room
Offices per shift	25 gal/person	.083 DU per person
Nursing/Rest Homes with laundry	150 gal/bed	.50 DU per bed
without laundry	75 gal/bed	.25 DU per bed
Residential Care Facility	75 gal/bed	.25 DU per bed
Restaurants	40 gal/seat	.13 DU per seat
Service Stations	250 gal/toilet or urinal	.83 DU per toilet or urinal
Stores	250 gal/toilet or urinal	.83 DU per toilet or urinal
with food service	add 40 gal/seat	
Swimming Pools and Bathhouses	10 gal/person	.033 DU per person
Theaters and Auditoriums	3 gal/seat	.01 DU per seat
Travel Trailer Parks	150 gal/space	.50 DU per space

*based on 300 gal/DU/day