CRC

RECOMMENDED MEASURES TO MAINTAIN AND PROTECT THE QUALITIES OF SOUTH KINGSTOWN'S SALT POND REGION

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Prepared For

The South Kingstown Planning Board

by

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I. INTRODUCTION

A primary purpose of the four-year URI salt pond project is to provide south shore towns with an assessment of the widely recognized problems facing the salt ponds and practical recommendations for steps that can be taken to address, and in some cases to solve, these problems. For four years a team of researchers has investigated water quality degradation, water circulation and flushing, overfishing, sedimentation and nutrient cycling and related resource management problems to human activities on the ponds and adjoining lands. The Coastal Resources Center and the Principal Investigators have worked closely with the Town of South Kingstown throughout the project. This paper was requested by the Planning Board. Its purpose is to identify "critical resource areas" around the ponds that should be considered as priorities for preservation and protection to complement the aquifers and prime farmlands throughout the town being identified for protection by the Board.

Detailed information on groundwater around the ponds enables us to delinate the boundaries of the area from which freshwater and waterborne pollutants drain to the salt ponds. For all ponds groundwater is the primary source of freshwater. Thus for the purposes of this analysis and for the future management of the salt ponds, we define the inland reach of the groundwatersheds shown in Figure 1 as natural boundaries for the salt pond ecosystems. We refer to this area as the salt pond region. In South Kingstown this includes the entire groundwatersheds of Trustom, Cards and Potters Ponds and large segments of the Green Hill and Point Judith Ponds groundwatersheds with the exception of the Saugatucket Basin which drains into Point Judith Pond through the Saugatucket River. The region includes some 10,000 acres or 25 percent of the town's total land area.

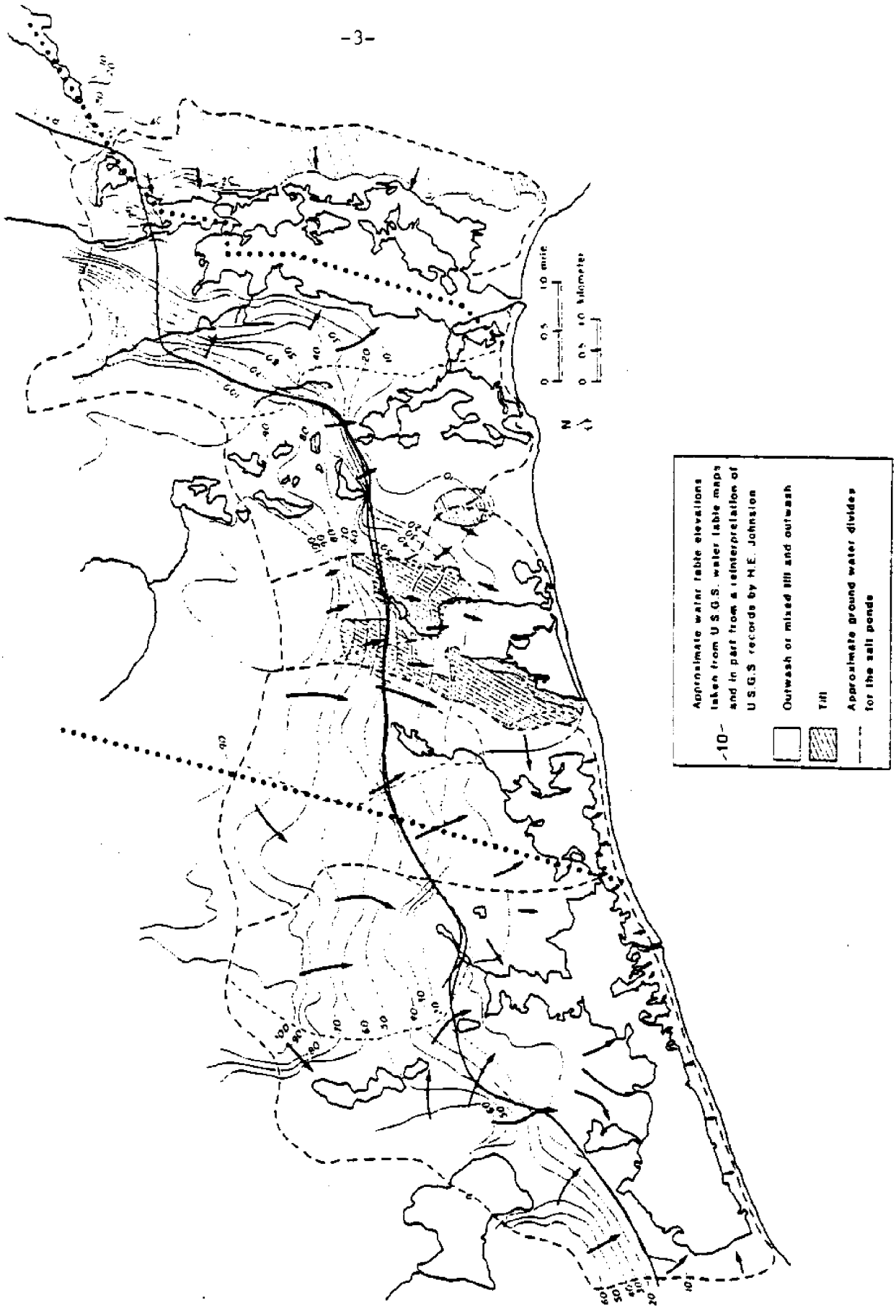
Extensive research on the salt ponds and our analysis of development leads us to the conclusion that all the major threats to the qualities of the salt ponds and the lands adjoining them may be traced to the rapidly expanding human population in the salt pond region. Present zoning would permit the number of houses in the region to increase from 3041 units in 1981 to a calculated 8500 units produced by adding together all the potentially developable lots under current zoning. If the number of housing units increases dramatically we foresee major losses in the scenic quality that gives the region much of its present value, spiralling pressures on the tax rate as a larger population demands more town services, the inability of increasingly large areas to provide potable drinking water and absorb wastes and further declines in the quality of salt pond waters. If South Kingstown is to avoid the consequences of such development--a process that may be seen in many coastal communities all along the east coast--it must take strong steps now to sharply reduce the ultimate size of the population in the region.

In this paper we identify the priority areas where reductions in the ultimate number of residential units in the salt pond region could be achieved by increasing the lot size in as yet sparsely developed areas. Two acre zoning is a base which, if applied uniformly over an entire groundwatershed, should keep nitrate concentrations below the 10 ppm

Figure 1. Approximate Groundwater Basins in the South Shore Region.

Source: John Grace and William E. Kelly, URI Department of Civil and Environmental Engineering, 1982.

Areas delineated by dashed lines are the recharge areas for groundwater in the salt pond region. The arrows indicate the general direction of groundwater flow within each groundwater basin. Dotted lines represent town boundaries.


0 0.5 10 mile
0 0.5 10 kilometer
N
Approximate water table elevations taken from U.S.G.S. water table maps and in part from a reinterpretation of U.S.G.S records by H.E. Johnston
Outwash or mixed till and outwash
Till
Approximate ground water divides for the salt ponds
-10-

public health limit. Two acre zoning, however, gives a slim safety margin and does nothing to preserve the scenic qualities of the region or relieve pressures on the tax rate. Several areas are already developed at much higher densities and further development, particularly in areas where public water is now available, is inevitable. It is essential, therefore, that the town recognize that down zoning is only a first step toward preserving the quality of the region and that such tools as the purchase or transfer of development rights must be vigorously applied if the scenic qualities of the region and health of the salt ponds are to be effectively protected. These and other measures to direct development away from critical areas into those amenable to further development and where public services already exist were discussed at Center workshops in the winter of 1980-1981. The town should also give a careful consideration to measures outlined in Appendix A that may be applied to reduce pollutants that flow into the salt ponds from areas that are already densely developed.

There is no doubt that many of the recommendations in this document will be hotly debated and will need refinement. All debate and evaluation, however, should be focussed on the objectives for the management of the salt pond region. We have based our selection of specific management initiatves on four principles.

1. To ensure that the resident population and physical alterations to the land within the salt pond region do not overtax the area's ability to produce sufficient supplies of drinking water, assimilate wastes and maintain good water quality in the salt ponds.
2. To enhance and preserve an aesthetically pleasing landscape, high real estate values and a diversity of activities that make the salt pond region a desirable place to live and visit.
3. To provide for densities and types of development that maintain a resident population of diverse economic standing and will not overburden the town with demands for municipal services.
4. To encourage businesses and activities that produce long-term benefits for the region by maintaining renewable resources.

Our recommendations are focused primarily on the first two objectives. These recommendations will demand forceful action that can only be taken if the citizens of South Kingstown unite in deciding that they wish to control their future. Determining how the land is used is a town prerogative and responsibility, exercised through zoning powers and by utilizing the many land management techniques that are available to town government. We recommend that the town coordinate its efforts to protect the quality and character of the salt pond region with those of neighboring towns and state agencies. The Coastal Resources Management Council is preparing a Special Area Management Plan for the salt ponds that will address use conflicts in the ponds, water pollution, public access, modifications to the shoreline and dredging. We urge the town to work with the Coastal Resources Management Council and the Department of Environmental Management to forge a well-integrated, mutually supportive management initiative.

II. THE PRINCIPAL PROBLEMS CAUSED BY CONTINUING DEVELOPMENT

Development Trends in the Salt Pond Region

During the past four decades the population of towns along Rhode Island's south shore has increased dramatically (Figure 2). Development has been most rapid in the narrow coastal plain between the salt ponds and the line of steep low hills north of Rte 1. Here develoment began slowly in the late 1800s as summer colonies were built in an otherwise rural and isolated region. By the 1950s highways provided easy access to industrial centers and residential subdivisions for year-round homes began to multiply. In South Kingstown farm land around summer colonies at Snug Harbor, Matunuck and Green Hill was platted and developed into subdivisions that have seen some of the most rapid development in the state during the past two decades. By 1980 South Kingstown's salt pond region, although only 25 percent of the town's land area, contained nearly 40 percent of the housing stock. Nearly all the houses are south of Route 1 where the density of houses is now nearly three times greater than in the town as a whole. In the last decade the building trend has been complemented by the conversion of former summer houses into year-round residences. In 1970, 74 percent of the houses south of Route 1 were seasonal but by 1980 the proportion had fallen to an estimated 26 percent, adding nearly 1,000 more year-round units to the nearly 840 new houses built in that decade. Thus the total number of houses south of Rte. 1 tripled during during the 1970's.

Despite all the recent building, the salt pond region today retains a predominately rural character. By 1981 only 26 percent of the land south of Rte 1 was developed for residential or commercial uses (Figure 3). Sixty percent of the developable land south of Rte. 1 and 80 percent of the developable land north of Rte. 1 was still woodland and fields. Current zoning (Figure 4) places a quarter of the salt pond region in residential use at a density of one house for each acre and sixty percent at one house for every two acres. This zoning provides for a potential tripling in the number of houses in the salt pond region from just over 3,000 in 1981 to nearly 8,500 at a calculated saturation that accounts for "grandfathered" lots (Table 1). Experience in other towns tells us that development will not attain a 100 percent saturation level. Many legally developable lots will not be built upon. Yet as the area becomes increasingly urban in character pressures will mount to change the zoning. If strong measures are not taken now we can expect to see that an expansion of public water lines and sewers already being discussed by town officials today. The difficulty in raising sufficient tax revenue to pay for these services will encourage the building of condominiums and town houses that could ultimately produce a resident population fully as large or larger than that derived from the theoretical 100 percent saturation under the current zoning.

Rapid development during the past three decades and the experience of towns up and down the coast show that we should expect that the pressures to build in South Kingstown's south shore region will continue and that the current land use controls will not prevent a wholesale change in the character of this area. The price of such development will be high and its impact on scenic quality, taxes, contaminated

Figure 2. Housing Density in the area south of Rte. 1 in the salt pond regions of South Kingstown, Narragansett, and Charlestown, 1940-1980.

Source: Town Tax Assessor's records 1980.

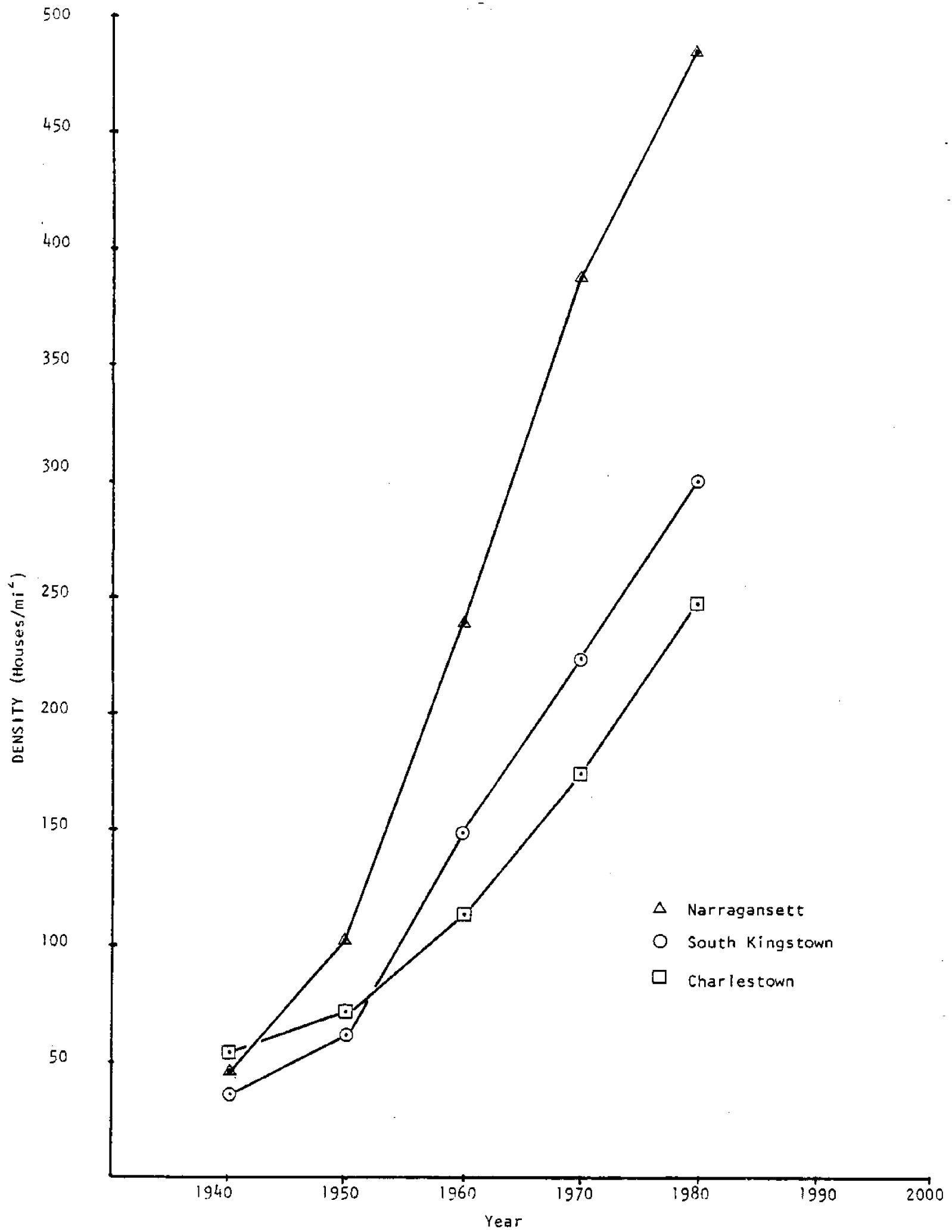

500
450
400
350
300
250
200
150
100
50
DENSITY (Houses/mi²)
1940
1950
1960
1970
1980
1990
2000
Year
Narragansett
South Kingstown
Charlestown

Figure 3. Percentages of Land Area in Generalized Land Use Categories in South Kingstown's Salt Pond Region, 1981.

Land use categories in the salt pond region were mapped on airphotos taken in April 1981 at a scale of 1:12,000. Land use categories are defined as follows:

- Open Land: forested and open lands not in active agricultural use, rural roads and miscellaneous uses not described below.

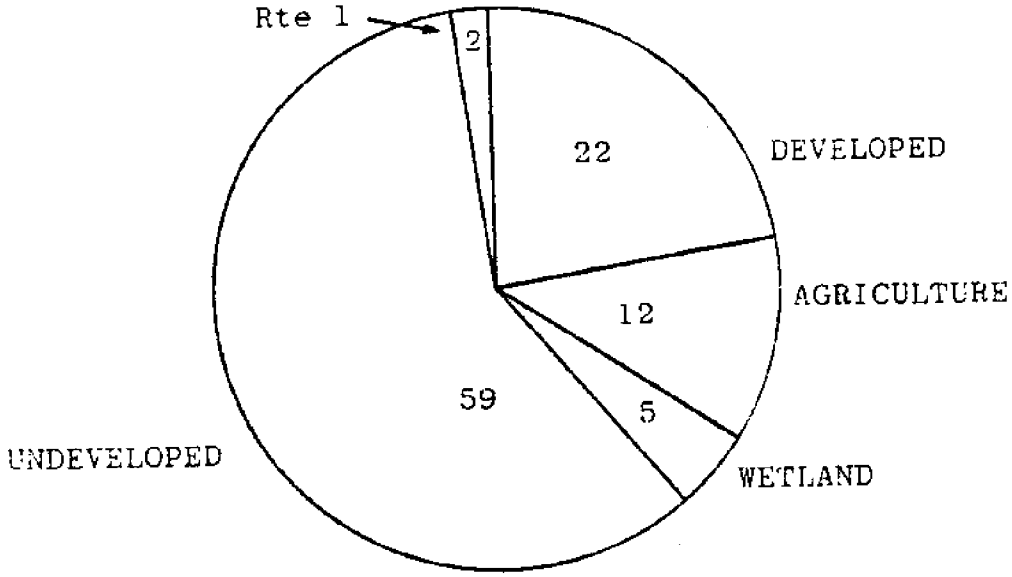
- Agriculture: fields in active production according to a U.S. Soil Conservation Service survey verified on-site in 1980.

- Wetlands: U.S. Department of Interior, National Wetlands Inventory 1980.

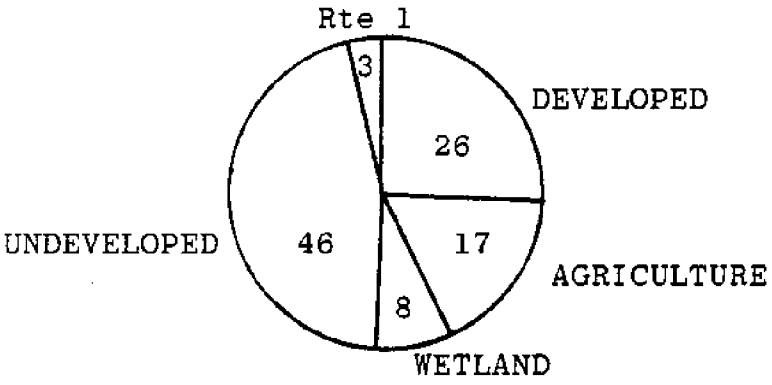
- Developed Lands: houses, lawns and sideyards, access roads, parking facilities, and undeveloped lots of less than 3 acres within otherwise developed areas; scattered dwellings in open areas were assigned 1 acre of developed land. No distinction was made between residential and commercial development.

LAND USE IN

SOUTH KINGSTOWN'S
SALT POND REGION



South of RTE 1



North of RTE 1

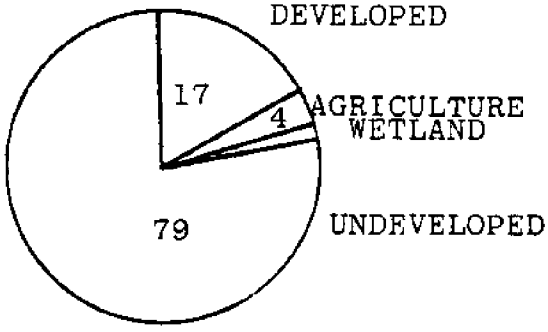


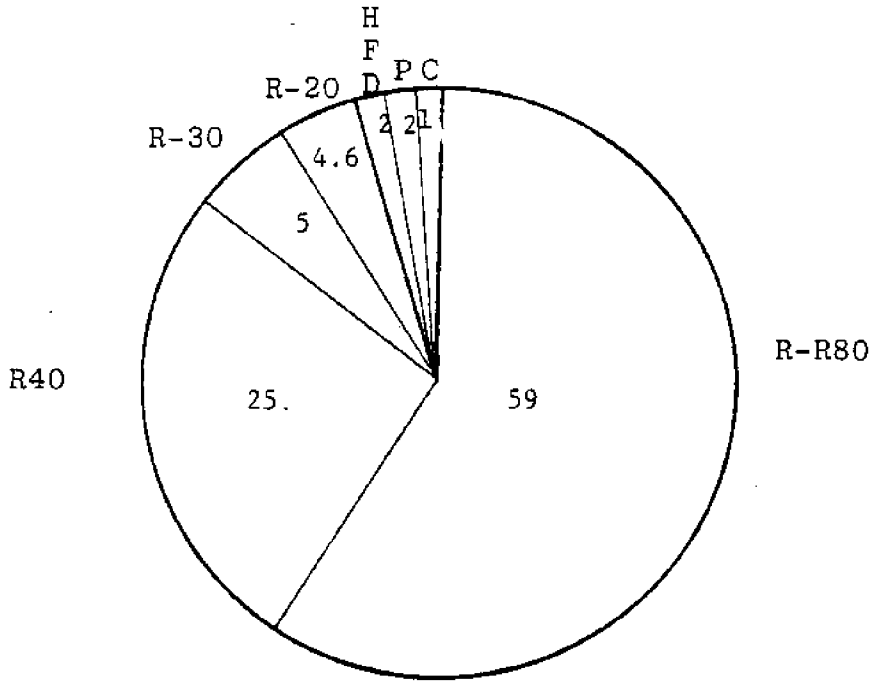
Figure 4. Percentages of Land Area in Generalized Zoning Classifications in the South Kingstown Salt Pond Region, 1981.

Source: Town of South Kingstown Zoning Ordinance, 1976. Official Zoning Map.

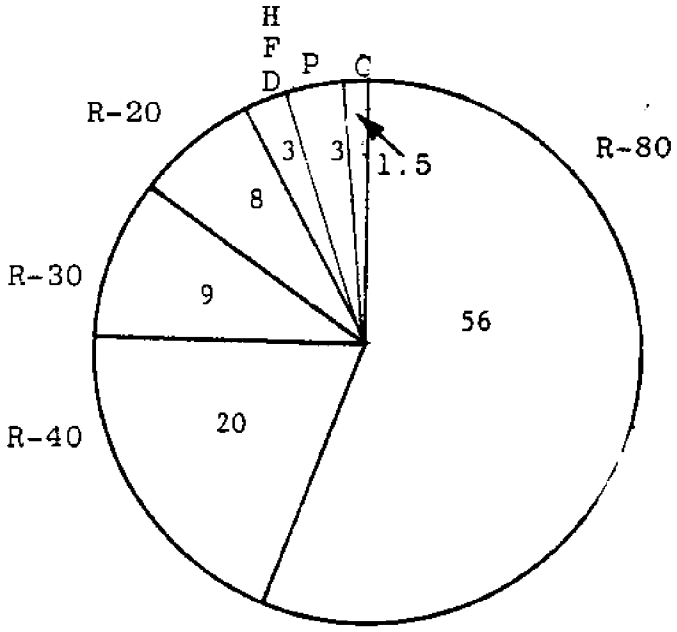
Key:

- R-R80 Rural Residential Zone 80,000 ft.^{2} minimum lot size
- R40 Residential Zone 40,000 ft.^{2} minimum lot size (includes R-40 and R-40A zones)
- R30 Residential zone, 30,000 ft.^{2} minimum lot size
- R20 Residential zone, 20,000 ft.^{2} minimum lot size
- HFD High flood danger zone
- P Public use zone
- C Commercial zone (includes C-2 and commercial waterfront zones)

ZONING
IN
SOUTH KINGSTOWN'S
SALT POND REGION



South of Rte 1



North of Rte 1

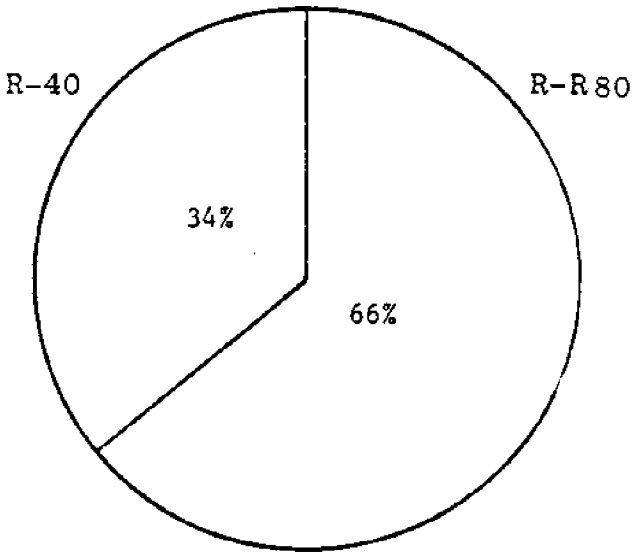


TABLE I
Projected Development in Salt Pond Watersheds in South Kingstown

Pond Watershed[1]	Houses[2] (1981)	Houses[3] (Zoned)	Groundwater[4] (1981) (mg NO_3-N/1)	Groundwater[5] (Zoned Capacity) (mg NO_3-N/1)
Green Hill Pond	937	2,574	2.0	5.5
Trustom Pond	80	246	2.1	2.8
Cards Pond	202	1,095	3.5	9.2
Potter Pond	755	1,902	0.6	1.5
Pt. Judith Pond	553	2,070	1.6	6.0

*Note: The present elevated nitrate concentrations in the groundwater of the Cards Pond watershed is probably due to agricultural practices.

[1] J. Grace, Civil Engineering, URI. 1981. Report for CRC. Groundwater Basins Calculated on the Basis of Extensive US Geological Survey Groundwater well Data for RI South Shore.

[2] C. Collins. 1981. House Counts from 1981 Aerial Photos.

[3] C. Collins. 1982. Projections of Development Allowed under Present Zoning for the Areas of South Kingstown within the Salt Pond Watersheds. The Estimate includes Grandfathered lots.

[4] S. Nixon and B. Nowicki . 1982. Average Annual Nitrate Concentrations in 68 Drinking Water Wells in the South Kingstown Portion of the Salt Pond Watersheds.

[5] Groundwater Nitrate Concentrations projected by Multiplying Present Concentrations by the Factor that Housing can Increase under Current Zoning. 10 mg NO_3-N/1 is the Public Health Limit for Drinking Water.

drinking water supplies and polluted salt ponds can all be reasonably predicted.

Loss of Scenic Quality

The importance of the south shore region to the town as a whole can hardly be overstated; miles of clean, accessible, sparsely developed ocean beaches, generally unpolluted coastal ponds rich in fish and shellfish and the feeling of being "in the country" provided by a mix of farmland, woodland, residential areas and open water. South Kingstown's coastal region in large part defines the character of the entire town and its future condition will profoundly influence all its residents. If development is accompanied by a fading of the natural and cultural amenities of South Kingstown's south shore region, it will no longer be as desirable an area in which to live or to visit. The old settlements,working farms, stone walls and open spaces toda stand out as landmarks in swaths of undeveloped land between dense ne ghborhoods. They are all to easily overwhelmed by the current patterns of residential development. As houses, roads and powerlines break up the natural contours and roadside views across fields to the coastal ponds, the distinction between the south shore and suburban communities elsewhere along the coast will disappear.

The beauty of the region is not only enjoyed by the fortunate few who live there. The region draws tourists from southern New England and beyond and this in turn provides jobs and income to the people of South Kingstown. The 1980 Regional Coastal Energy Impact Report[1] found that the number of tourist-related summer jobs along the south shore declines steeply as one moves inland. In 1979 for example, 64 percent of the seasonal jobs in south shore towns were related to tourism compared to 24 percent in inland towns. A recent survey conducted by Statewide Planning (1980) shows that the south shore attracts more than 70 percent of all the recreational trips taken by Rhode Island residents.[2] The attractiveness of the south shore region, therefore, benefits the town by providing a substantial number of jobs and income.

Increased Taxes

South Kingstown has the highest tax rate and annual budget among the south shore towns (Figure 5). Estimates of the net cost of each new unit of housing to the town in 1981 have been made by the Town Planning Department. The data shows that when the combined costs incurred by the occupants of the average single family home are subtracted from the average tax revenues generated by each housing unit, a net deficit of $925 is produced by each average single family home![3] At current rates of taxation, each single family dwelling unit, therefore, supports only about half its total cost to the town. The costs of suburban development are well known to planners across the country and the implications are dramatic. Continuing the current pattern of development will produce constant pressures to increase the tax rate and to make up the deficit with increased commercialization or the building of condominiums or town houses that can produce more tax revenue than isolated single family homes. A heavy tax burden on large lot owners will force many to sell off their holdings and this in turn will encourage further development.

Figure 5. Municipal Taxation and Expenditures in the South Shore Towns, 1980.

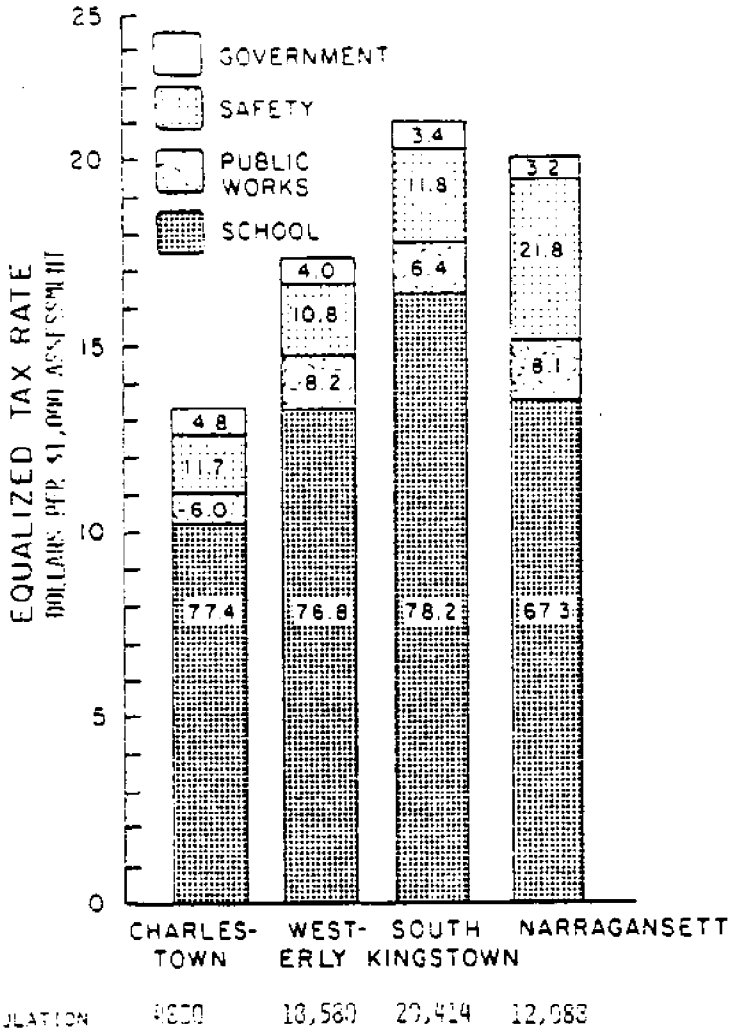
Source: R.I. Department of Community Affairs, Division of Tax Equalization.

1. Equalized property tax rates in the south shore towns and percentages of budget outlays 1980.

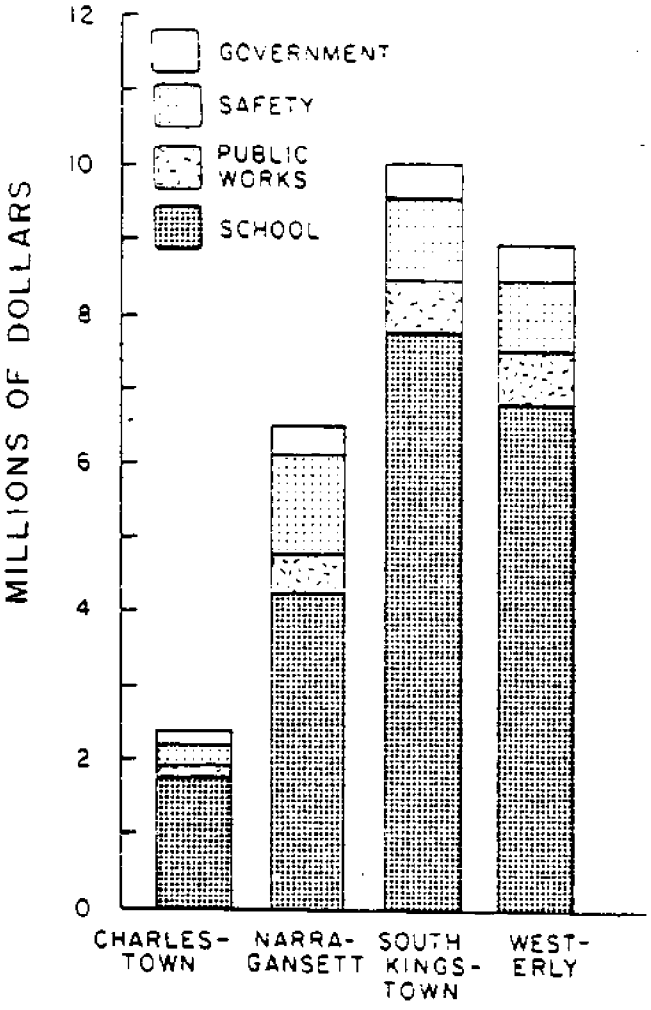
2. Budget outlays by category in the south shore towns, 1980.

3. Sources of tax revenues in south shore towns in 1980-1981 tax year.

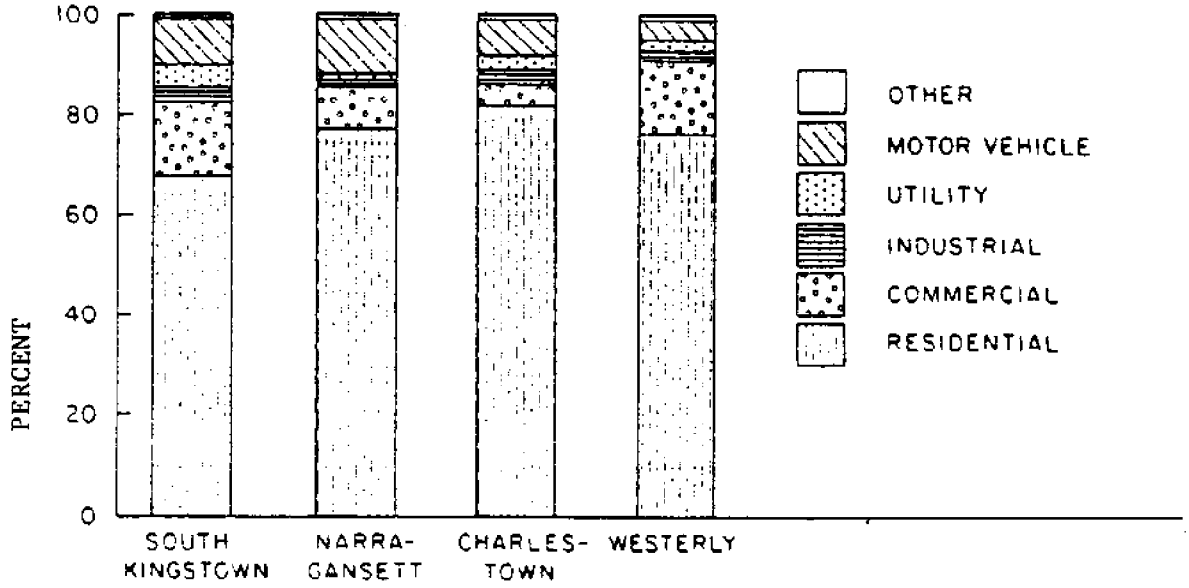
1


EQUALIZED TAX RATE
GOVERNMENT
SAFETY
PUBLIC WORKS
SCHOOL
25
20
15
10
5
0
4.8
11.7
6.0
77.4
4.0
10.8
8.2
76.8
3.4
11.8
6.4
78.2
3.2
21.8
8.1
67.3
CHARLES-TOWN
WEST-ERLY
SOUTH KINGSTOWN
NARRAGANSETT
POPULATION
9830
18,580
20,414
12,083

2


MILLIONS OF DOLLARS
GOVERNMENT
SAFETY
PUBLIC WORKS
SCHOOL
12
10
8
6
4
2
0
CHARLES-TOWN
NARRA-GANSETT
SOUTH KINGS-TOWN
WEST-ERLY

3


PERCENT
100
80
60
40
20
0
SOUTH KINGSTOWN
NARRA-GANSETT
CHARLES-TOWN
WESTERLY
OTHER
MOTOR VEHICLE
UTILITY
INDUSTRIAL
COMMERCIAL
RESIDENTIAL

The rapid transformation of the area south of Route 1 from an agricultural to a residential community has already placed several sizeable economic burdens on the town as a whole. Some $1.8 million were spent between 1968 and 1974 to provide public water to areas of Matunuck and Green Hill where closely packed houses had caused private wells to become contaminated. The burgeoning population made it necessary to build a new school in Matunuck in 1973 and a fire station in 1979. At the time, federal grants provided much of the funding, but present indications are that subsidies for future projects of this nature may be much less generous. As the population of the salt pond region continues to grow more services will have to be provided and fiscal burdens on the town will increase. This will generate constant pressure to increase the tax rate and allow even more development to help pay for expensive services. This "catch 22" spiral of development and demand for more public services is being played out in communities all along the east coast.

Contamination of Drinking Water

The burgeoning human population in the salt pond region is already overtaxing the natural abilities of the environment to supply potable drinking water and assimilate wastes. Let us first examine the problem of drinking water contamination. Within the groundwatersheds of the salt ponds rainwater seeps through porous soils to the watertable and flows slowly toward the ponds (Fig. 1). The excellent data on groundwater along the south shore permits us to estimate with some confidence the volumes of freshwater that are available and its direction of flow.[4] These data show that supplies should be adequate to supply individual wells even if the region attained our calculated 100 percent saturation development. The problem is how much of this water will be potable. The major threat is from elevated concentrations of nitrate that is derived principally from properly functioning septic systems and fertilizers. The federal standard for nitrate concentrations in drinking water is 10 milligrams of nitrate nitrogen per liter (mg/L NO_3-N) or 10 ppm.[5] Nitrate concentrations in drinking water higher than 10 ppm have been shown to cause methemoglobanemia or infant cyanosis, a condition where less oxygen is transported by the blood and the child suffers oxygen starvation that, in severe cases, can lead to death. No cases of infant cyanosis have been reported where concentrations are below 10 ppm. Contamination of groundwater with high nitrate concentrations is resulting from dense suburban development and causing severe problems for coastal communities with soils similar to ours on Long Island and in Delaware, New Jersey and North Carolina.[6] During the past two years Dr. Nixon's research team has analyzed the nitrate concentration in over 100 wells in South Kingstown's salt pond region (Figure 6). The results confirm theoretical calculation based on similar surveys elsewhere and show that in developed areas around the ponds, nitrate concentrations are at present 100 times higher than the background concentrations in undeveloped areas at the head of the watershed. On average, concentrations are 2.9 ppm, but in older densely developed communities, 5 ppm is common and some wells are above the federal limit of 10 ppm (Figure 7).[7]

Dr. Nixon's research and extensive work conducted elsewhere allow us to

estimate the sources of nitrate in the salt pond region (Table 2). The budget shows that suburban development is the primary producer of nitrate and that the inputs from onsite sewage disposal and lawn fertilizers, which are the two principal sources, will increase as development continues. The amount of nitrate that reaches groundwater from an average house depends on a number of factors that include the volume of sewage produced, the rate and type of microbial decomposition that takes place in the disposal systgem, depth to groundwater, the types of soils through which the leachate must flow and other factors. Despite all the variables, it is possible to extrapolate from present conditions and literature values to predict how much nitrate concentrations in the groundwater may be expected to increase as the human population grows. Such calculations for the South Kingstown salt pond region suggest that the volume of groundwater is sufficiently large to keep nitrate concentrations diluted below the 10 ppm limit if there is no more than one house for every two acres. Similar calculations led the R.I. 108 Water Quality Management Program to the same conclusion.[5] In several areas south of Rte. 1, however, housing is already four to six times more dense than this and further development appears to be inevitable.

Sewers are not the answer to the nitrate problem and the other pollutants released by large areas of dense development. The problems of nitrate pollution of drinking water supplies received great attention in Nassau County on Long Island where soils and salt ponds are similar to those along our south shore. In the 1950s aquifers became contaminated with high concentrations of nitrates. The county responded by drilling new deeper public wells and sewering large areas. The density of development increased since it was no longer limited by septic regulations. After the sewers were built nitrate contamination in groundwater did not decline as expected because of increased inputs from lawn fertilizers, domestic pet wastes, leaking sewer pipes and increased runoff due to the paving and roofing over of larger areas of the land. Some of the new deep wells also became contaminated and the condition of the salt ponds did not improve as had been hoped. Nassau's policy is now to strictly limit sewering only to those areas where existing development makes sewers an absolute necessity. In other areas the emphasis is on limiting the density of development and trying to maintain a reliance on onsite sewage disposal and individual wells.[88]

Data gathered by Dr. Nixon suggests that South Kingstown should be particularly concerned about nitrate concentrations in the watersheds of Green Hill and Cards Ponds. The town's wells for the South Shore Water System are just south of Factory Pond and draw from the Green Hill Pond watershed (see Figure 1). Much of the Factory Pond aquifer is already zoned for 2 acres yet projections of the number of houses that can still be built on the watershed at zoning capacity can be projected to bring groundwater nitrate levels in this area, where groundwater flow rates are high, from 2 ppm up to 5.5 ppm. It is a matter of judgment to decide how great a safety factor should be required for nitrates in a public water supply. Officials in Cortland County in rural New York decided they had to invest in expensive sewer installations because well water nitrate levels had been steadily increasing with suburban development and had reached 5 ppm.[9] Suffolk and Nassau Counties on Long Island underwent sewering and new wells when nitrate concentrations

Figure 6. Distribution of Groundwater Sampling Wells in the Salt Pond Regions of Charlestown, South Kingstown and Narragansett.

Source: Nixon, S. and B. Nowicki, 1982.

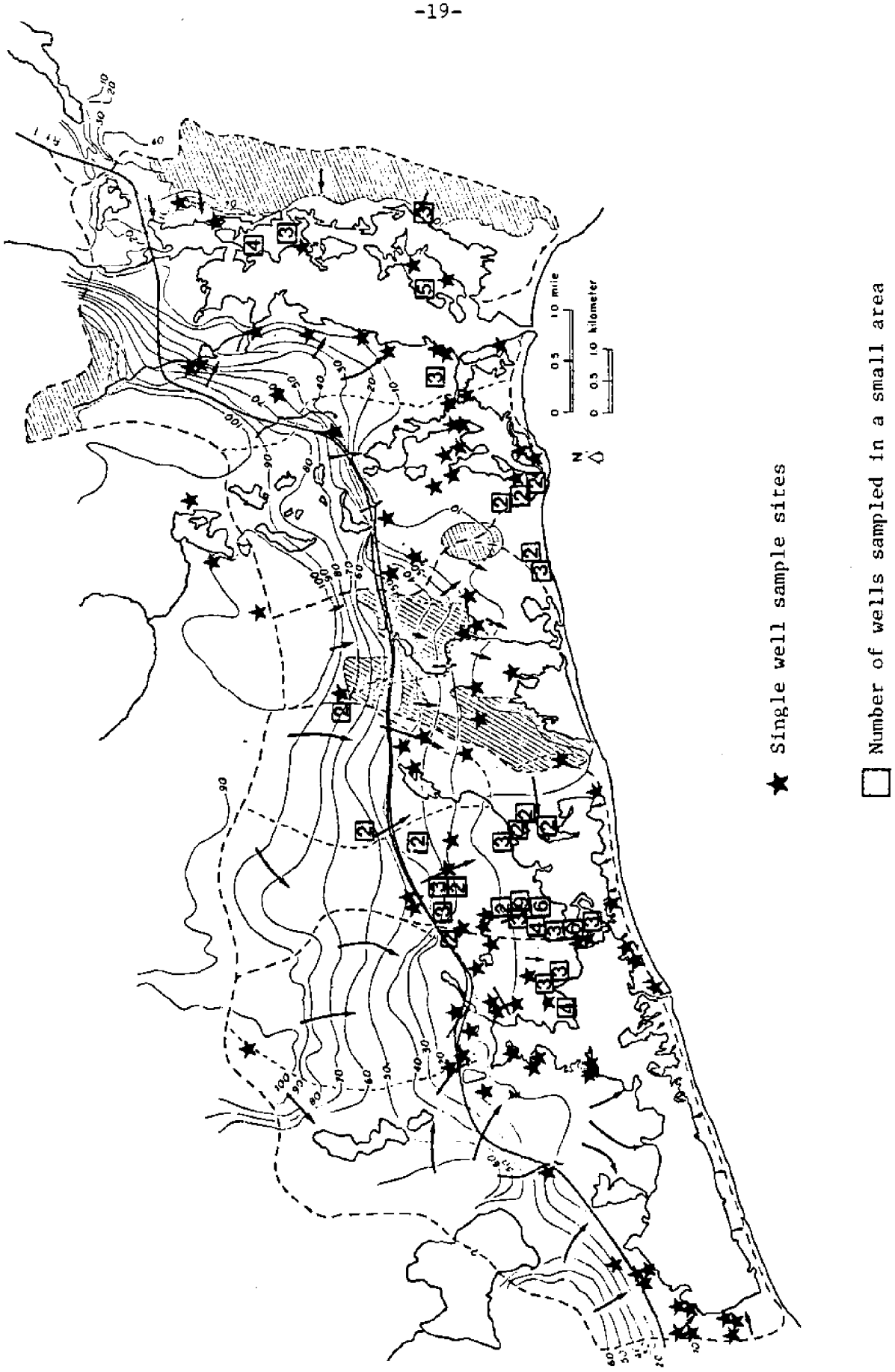

0 5 10 mile
0 5 10 kilometer
N
★ Single well sample sites
□ Number of wells sampled in a small area

Figure 7. Areas of Elevated Nitrate Concentrations in the Salt Pond Regions of Charlestown, South Kingstown, and Narragansett.

Source: Nixon, S. and B. Nowicki, 1982.

Background levels at the head of the watersheds are 0.01 mg/l NO_3-N.

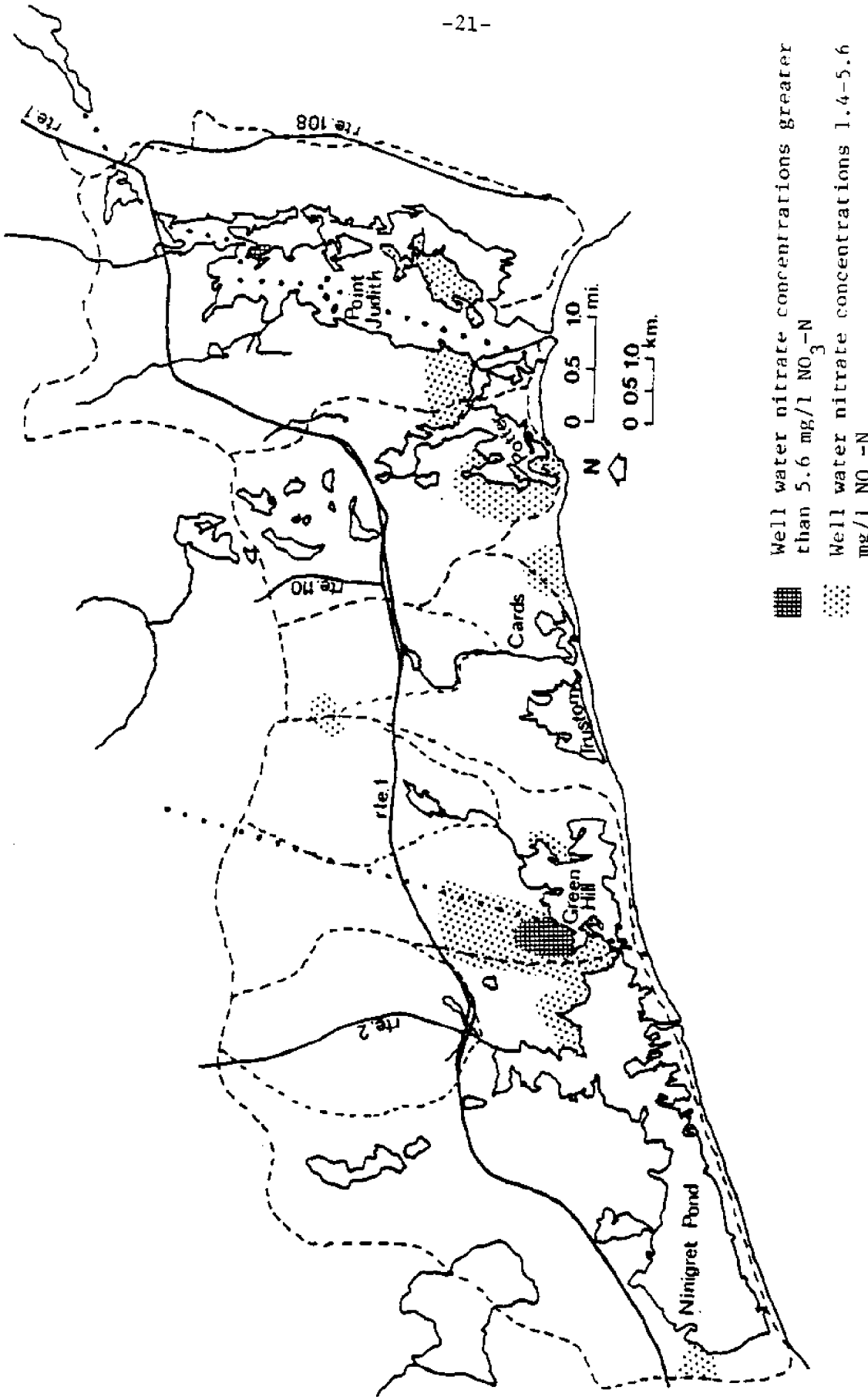

Rte 1
Rte 108
Point Judith
Rte 110
Cards
Rte 1
Green Hill
Rte 2
Ninigret Pond
0 5 10 mi.
0 05 10 km.
N
Well water nitrate concentrations greater than 5.6 mg/l NO_3-N
Well water nitrate concentrations 1.4-5.6 mg/l NO_3-N

Table 2 Estimated inputs of dissolved inorganic nitrogen to the coastal lagoons and salt ponds of the study area; units are pounds of nitrogen per year and lbs./acre/year.[1]

	Direct Rainfall	Streams & Rivers	Storm Runoff	Ground-water	Total
Point Judith	6790	16000	810	58,765	82,365
lbs/acre/y					54
Potter	1420	~0	140	27,740	29,300
lbs/acre/y					89
Cards	180	570	150	4,015	4 915
lbs/acre/y					114
Trustom	680	~0	70	6,205	6,955
lbs/acre/y					43
Green Hill	1860	2460	250	29,200	33,770
lbs/acre/y					78
Charlestown	7400	2800	310	61,685	72,195
lbs/acre/y					42

[1]Nixon, S.W., B.N. Furnas, R. Chinman, S. Grainger, S. Hefferman. 1982. Nutrient inputs to Rhode Island coastal lagoons and salt ponds. Final report to statewide planning. 24 pp.

approached 8 ppm.[8] In order to safeguard the south shore water supply for the future, it would be prudent for South Kingstown to change zoning over the recharge area of the town well aquifer to a lot size larger than 2 acres. Reducing the density of development and mitigating pollution loads from runoff and waste disposal in this area should also prevent further deterioration in the water quality in Green Hill Pond. The groundwater that feeds Factory Pond Brook supplies 55 percent of the freshwater that flows into Green Hill Pond.[4] Maintaining the volume and quality of freshwater flow to the pond is critically important in preserving the pond's circulation and the estuarine characteristics that are vital to the spawning and nursery value of the pond for fish and shellfish.

It is evident from Table 1 that the groundwater in the Cards Pond watershed is also in jeopardy. The concentrations present today can probably be attributed to agriculture but if the area is transformed into residential use at the present zoned density of one house per acre, we project that nitrate concentrations could become unacceptably high. This area should therefore be rezoned at a lower density.

Pollution of the Salt Ponds

Groundwater is the principal source of freshwater to all the ponds. When groundwater is enriched with nitrates plant growth in the ponds is stimulated and this can lead to eutrophication. In large densely developed areas less rainwater is absorbed into the ground than on undisturbed open land and pollutants carried by surface runoff into the salt ponds and their tributaries may be expected to become an important problem.

It is very difficult to trace the behavior and impacts of a single substance, such as nitrate, in a salt pond. We do know, however, that nitrogen is a limiting nutrient and therefore a primary determinant of the amount of plant growth in the salt ponds. As nitrate becomes available in greater amounts, plant growth is stimulated. More vegetation, particularly in the form of floating mats and stringy green algae, is in itself undesirable, and the problem becomes more serious when the bacteria that breakdown decaying plant matter consume the available oxygen in the water. Thus, overfertilized (eutrophic) waters are characterized by high concentrations of nutrients, low oxygen, turbidity, and if sufficiently severe are toxic to fish and shellfish. In the summer, poorly flushed areas periodically show the symptoms of severe eutrophication and turbid waters thick with algae predominate in restricted coves of most of the salt ponds. Field experiments in Ninigret Pond have demonstrated that additions to salt pond waters of very low levels of nitrate do indeed cause dramatic blooms of nuisance algae.[10]

Once nitrate enters groundwater in the salt pond region it travels slowly towards the ponds. Setback regulations around the salt ponds do no more than delay the time it takes for nitrate to reach the ponds and are not effective in reducing the ultimate impact of too large a resident population. Dr. Nixon's experiments with local soils show that a 100 foot setback for a septic system may be expected to delay nutrients from reaching a pond by only three years.[7] After that time

some 80 percent of the nitrogen and 9 percent of the phosphorous released by a septic system may be expected to begin flowing into the pond. Nitrates can be controlled only by preventing them from entering the groundwater by adding denitrification units to individual septic systems, or by building public sewers, or by limiting the population in the watershed. Since sewage is only one source of nitrate from densely developed areas, the best measure is to control the total number of housing units in the watersheds of each pond.

Bacterial contamination of the salt ponds is already a result of development. The summer concentrations of total and fecal coliform bacteria exceed the upper limit permitted in waters that are open to shellfishing in portions of three or the five salt ponds in South Kingstown (See Figure 8). Coliform levels are also high in Trustom Pond but this is a result of the dense waterfowl populations. According to a survey conducted in the ponds in 1980 by the Nixon research team, fecal coliforms exceeded shellfishing levels in Green Hill Pond during the summer but not the winter. Levels of fecal coliforms in eastern Green Hill Pond were exceptionally high, exceeding recreational bathing limits during the summer. Conditions have apparently been deteriorating over the last several years. Surveys conducted by R.I. Department of Health in the summer of 1959[11] and by Marine Research Inc. in 1974[12] showed coliform concentrations in these ponds that were well below shellfishing standards. The summer highs observed in 1980 correspond to the seasonal increase in residential population and recreational use of the pond. In Cards Pond median total and fecal coliform concentrations exceeded shellfishery and bathing standards during the summer and much of the fall, at times when the pond is heavily used as a swimming area by children. For many years the town has dug a temporary breachway between Cards Pond and the ocean twice a year or as requested by town residents. Dr. Nixon recommended in 1981 that the town open the breach more frequently during the summer to flush out the polluted water. Median coliform concentrations in Potter Pond did not exceed shellfishing levels in 1980.

Water quality conditions have improved in Point Judith Pond since the installation of the sewage treatment system in the 1970s. In 1980 only the upper pond exceeded shellfishing standards, a marked reduction since a Department of Health survey in 1979. The present source of the bacterial contamination in upper Pond Judith Pond and Green Hill Pond may be attributed to runoff from densely developed areas and antiquated on-site sewage treatment systems. Modern septic systems standards were adopted in the state in 1969 by which time 80 percent of the present houses around Point Judith and Potter Ponds and 60 percent around Charlestown and Green Hill had already been built. Even where modern septic systems are in place, an average system has a life expectancy of only 30 years and failures are not uncommon where water tables are high year round or seasonally.[13] Here again reducing the density of development is the most effective way to reduce the loadings of nitrate and bacteria to the salt ponds.

III. AREAS OF CRITICAL CONCERN FOR THE SALT PONDS

There are three areas in South Kingstown of critical concern in which development should be reduced and further development carefully planned

in order to protect water quality in the salt ponds.

The Green Hill Pond Watershed:

The lands around Green Hill Pond are some of the most densely developed in the salt pond region. The pond itself is poorly flushed and it shows many signs of deteriorating water quality. Bacterial contamination, as discussed above, appears to be increasing. The concentraton of nitrate in groundwater around the pond is amongst the highest in the south shore region and residents complain of turbid waters and bad odors. If the large lot zoning recommended for the Factory Brook aquifer is adopted much of the remaining open space in the Green Hill watershed will be protected. We recommend that the small area of open land outside the Factory Brook aquifer along the eastern boundary of the watershed also be included within a down-zoned area. These steps and adoption of appropriate measures to reduce pollution sources within already developed areas outlined in Appendix A may forestall further deterioration and might even bring some improvement.

Lands Adjoining the Northwest Shore of Point Judith Pond:

Extensive research on Point Judith Pond shows that the pond may be divided into two distinct segments along a line below Plato and Ram Islands.[14] South of this line the pond is relatively well flushed, the bottom is predominately clean sand and the water is visably clearer than to the north. North of the islands water movements are more restricted and the abundant eggs and larvae of several species of fish and shellfish that are seasonally found in this area are not easily flushed out to sea but stay in the pond where conditions are favorable for their development.[15] These circulation characteristics are probably the principal reason why the area between the Narrows and the islands is the best spawning and nursery habitat in the pond. Many years ago this area contained the most productive oyster beds and Smelt Brook was used by anadromous fish.[16] Unfortunately the patterns of water circulation that conserve eggs and larvae will also prevent pollutants from being flushed out of the pond. At present, the lands that abut this important area are undeveloped. We recommend that future building here should be kept at as low a density as possible (Figure 9).

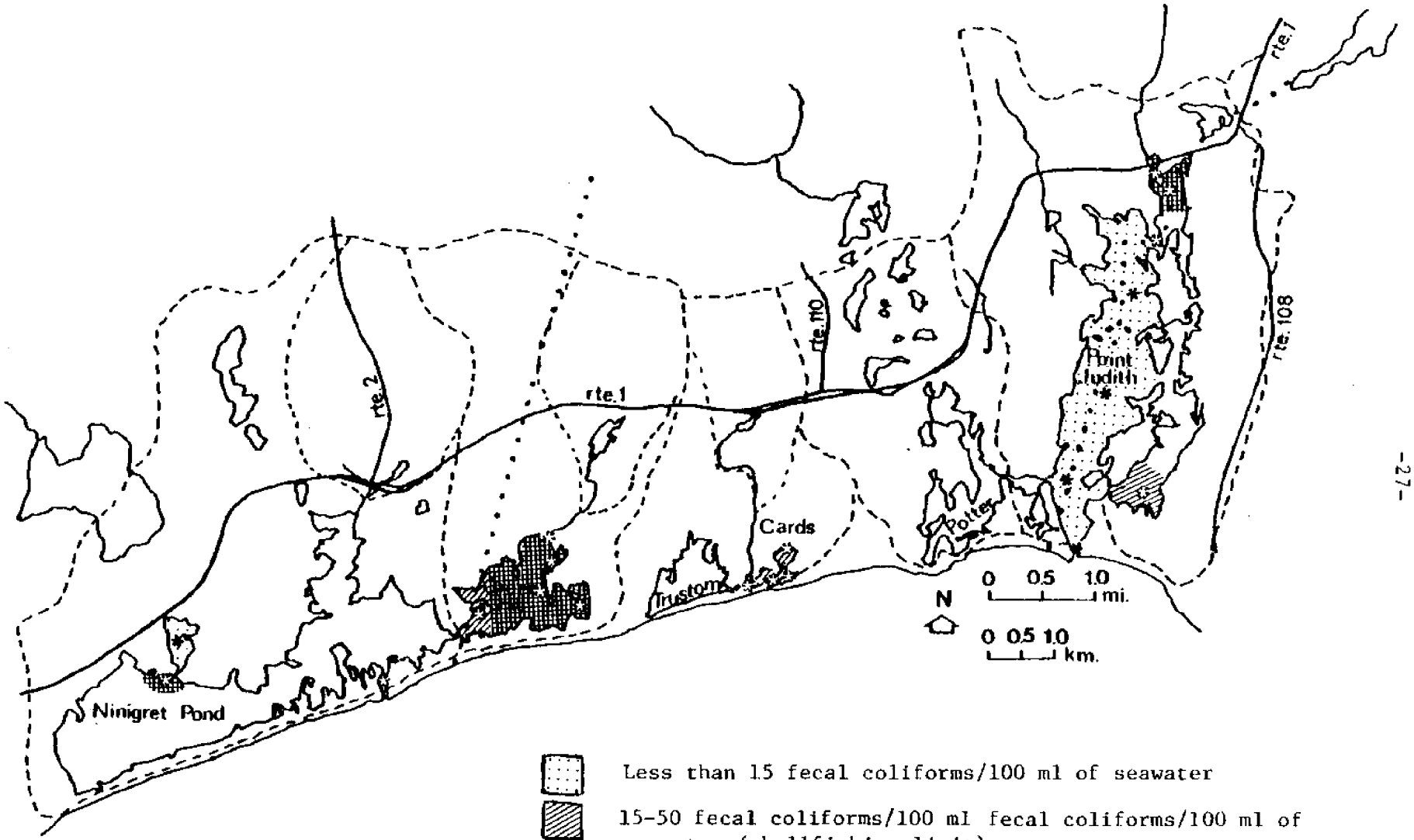
Northern Potter Pond:

Like Green Hill Pond and upper Point Judith Pond, Potters Pond is poorly flushed. Exchange with the ocean is through a small inlet that flows under Succotash Road into lower Point Judith Pond. Lands around the southern half of Potters are densly developed and water quality in this area is poor. During the summer the waters are eutrophic, vegetation rots along the shores and the bottom is a soft organic ooze low in oxygen and unsuitable for most shellfish. The lands around the upper pond, however, are at present sparsely developed and water quality in the upper pond is good and supports many species of fish and shellfish. If development around the area became dense enough to elevate the nitrate concentration in groundwater and cause contaminated runoff to enter the pond we expect that water quality in the pond would decline rapidly. The lands around upper Potter Pond are also particularly beautiful and steeped in the heritage of the salt pond region. The

Figure 8. Fecal coliform bacteria concentrations in the salt ponds 1980-1981.

Source: S. Nixon, B. Furnas, R. Chinman, S. Grainger, and S. Heffernan. 1982. Nutrient Inputs to Rhode Island Coastal Lagoons and Salt Ponds. Final Report to R.I. Statewide Planning. 24 pp.

The concentrations depicted for Green Hill Pond and Cards Pond are for summer, 1981 and the levels in Upper Pt. Judith Pond are year round. At these times, these three areas exceed the Rhode Island water quality standards for shellfishing and for recreational bathing in which median fecal coliform levels should not exceed 15 per 100 ml and 50 per 100 ml of seawater respectively.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Less than 15 fecal coliforms/100 ml of seawater
15-50 fecal coliforms/100 ml fecal coliforms/100 ml of seawater (shellfishing limit)
Greater than 50 fecal coliforms/100 ml of saltwater (bathing limit)
sampling stations

remains of a prehistoric encampment and several indian settlements make the area of great interest to archeologists. Great House at the head of the pond is a historic landmark and stonewalls still stand across the mouths of several coves that were once used as "pots" in which fish seined from the pond were stored during the 1700s and 1800s. The great beauty of this area is another reason for preserving it. We recommend that the area shown on Figure 9 also be zoned at a very low density.

IV. RECOMMENDATIONS

Measures to Reduce the Amount of Development in the Existing Sparsely Developed Areas of the Salt Pond Watersheds

Several areas south of Rte. 1 are already developed at densities much greater than the one house for two acres necessary to maintain the quality of drinking water and the town has already had to provide public water to some communities. Two thirds of South Kingstown's salt pond region, however, is sparsely developed and it is not too late to preserve the high scenic quality of the land, prevent further deteriorations in salt pond water quality and avoid a spiraling demand on town services and consequent pressures to increase taxes. If the consequences of over-development are to be avoided the town must drastically reduce the potential number of residential units in the salt pond region by energetically pursuing a course of action that includes all the following components:

- The total loadings of nitrate and other pollutants to the recharge area for public water supply wells near Factory Brook must be kept as low as possible. If the small number of additional residential units that could be permitted in this area are clustered, the cluster should be as far north of Rte. 1 as possible to assure that nitrate inputs are well diluted before groundwater reaches the town well. Sparsely developed lands adjacent to salt pond areas that will be particularly sensitive to elevated nitrate levels in the groundwater and contaminated runoff, are identified in Figure 9. These areas also have particularly high scenic values and should therefore be considered as the priorities for inclusion in the "Critical Resource Area" designation being considered by the town. Here the number of houses should be kept as low as possible and further development should be clustered. Small properly designed clusters need not produce contaminated runoff, will preserve expanses of open land and will be less costly to build and service than a similar number of widely dispersed houses. Efforts to conserve open space should be focused on the flat cleared lands south of Rte. 1 where buildings are most visable and valuable agricultural lands provide the town with an important and all too easily destroyed resource.
- It must be recognized that public water and sewers encourage dense development. The town should therefore limit these services to those areas where development is already too dense to provide potable drinking water and absorb wastes. All other areas should be zoned at a minimum density of two acres for residential unit.
- Efforts to preserve open space and cluster futher development

will be greatly facilitated if the town adopts innovative land management techniques such as those discussed at Coastal Resources Center Workshops during the winter of 1981-1982 that are briefly outlined in Appendix A. Techniques including tax relief and the purchase and transfer of development rights will promote proper land use while reconciling private property rights with public interests in community quality of life, municipal finances and natural resources preservation.

Measures to Mitigate the Pollution of Drinking Water Supplies and Salt Ponds from Existing Densely Developed Areas

The principal threat to groundwater quality is at present the nitrate produced primarily by propery functioning on-site sewage disposal systems and fertilizers. As the salt pond region becomes more densely developed, surface runoff will become an increasingly significant source of a variety of pollutants including organic matter and bacteria. A 100 ft. buffer of undisturbed naturally occurring vegetation should be required along salt pond and their tributaries for all new developments. Buffers will help prevent pollutants from reaching the ponds and will help retain scenic values.

In areas where development is already too dense for groundwater to dilute nitrate loadings, new houses should be required to meet low nitrate discharge standards. Methods for achieving low-nitrate discharges are described in Appendix A and include:

- composting or incinerating toilets
- on-site denitrification of domestic sewage
- collection and treatment of sewage at a municipal or small-scale "package" treatment plant
- a requirement that the lawn areas of each new dwelling unit does not exceed 2000 square feet
- a septic tank management program
- a buffer zone of undisturbed natural occurring vegetation between houses and the salt ponds or their tributaries

The pollutants carried by runoff are best handled through measures that minimize direct discharges to waterbodies and encourage infiltration of runoff into the ground. Techniques described in Appendix A that should be incorporated where appropriate into zoning ordinances include:

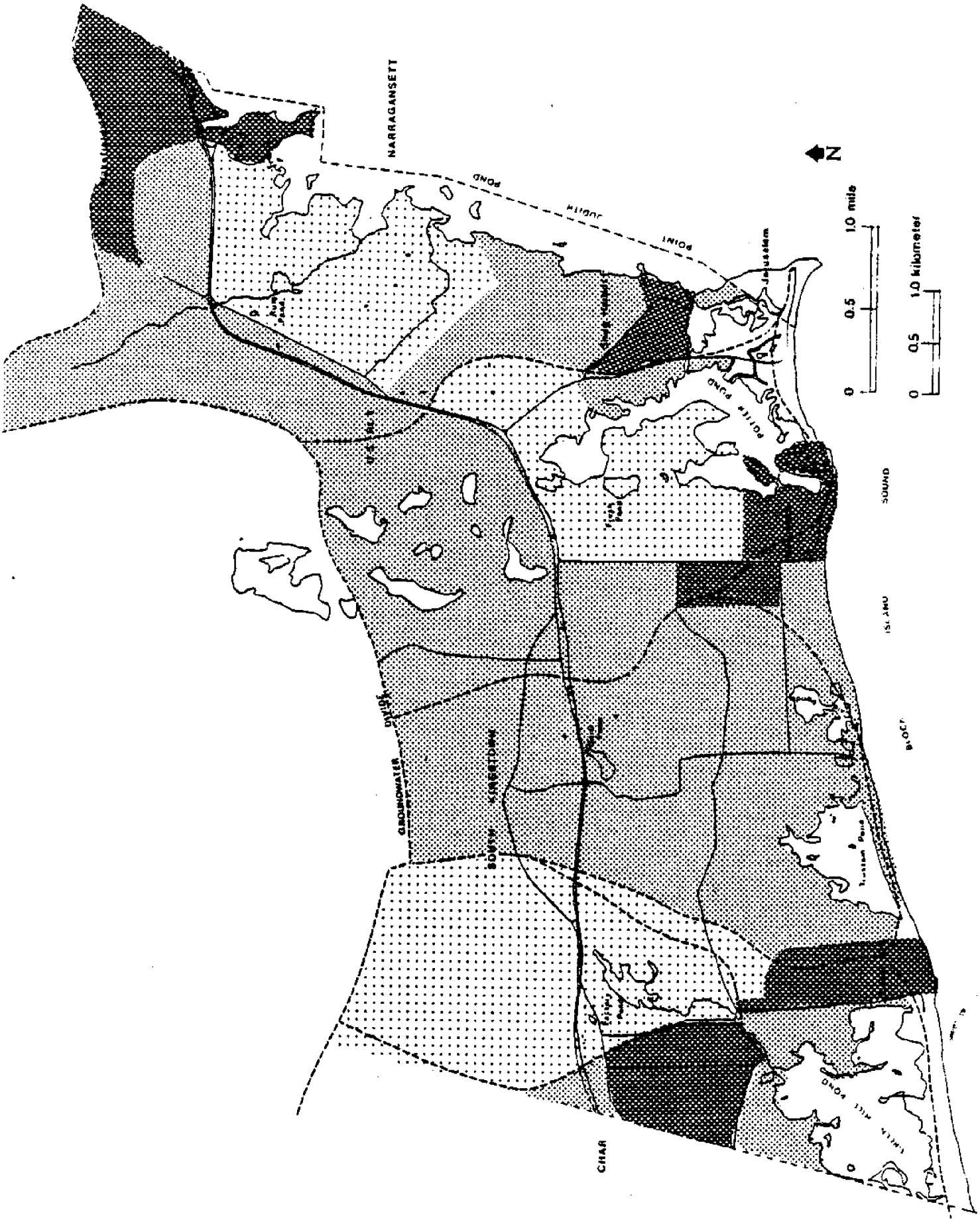
- elimination of existing point discharges to the ponds from Rte. 1 by using vegetated swales and catchment basins
- buffer strips of natural vegetation around all waterbodies and wetlands
- adoption of a stormwater runoff control ordinance for subdivisions
- use of permeable pavements and other structural measures that encourge the dispersion of runoff

Figure 9. Recommended Priority Areas for Protection in South Kingstown's Salt Pond Region.

 : Critical resource areas recommended for maximum protection; lots should be as large as possible and more than 2 acres.

 Important groundwatershed and rural resource areas, a minimum of two acre lots.

 : Densely developed areas where pollution mitigation is essential.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runoff. Studies of pollutants in runoff from grid pavements indicated they were reduced to less than 2 percent of the quantity carried by runoff from a concrete slab. Filtration through the grid pavement and underlying soils removed significant amounts of the pollutants tested, with the exception of nitrate.

Permeable gravel or porous pavement should be required for all driveways and parking lots within 200 ft. of the salt ponds and tributaries. Paved roads should not slope directly down to the shoreline. Permeable pavement should be encouraged elsewhere in the pond's drainage basins.

Other Structural Techniques: Other structural techniques which should be encouraged include:

a. Dutch drains consist of gravel filled ditches with an optional drainage pipe in base. They can be used to collect runoff from roofs without gutters and as dividing strips to collect sheet flow from areas of impermeable pavements. Runoff from small storms can be retained entirely within the drain. In large storms, the drain can reduce peak flow rates. Infiltration to groundwater is increased in either case.
b. Terraces and runoff spreaders are earth formations which intercept runoff and decrease erosion. A terrace is an embankment constructed across the slope which directs runoff around the slope rather than down it. A level spreader is a channel which disperses runoff over an undisturbed, vegetated area. These techniques are most effective on rolling topography with well-drained soils.
c. Seepage pits consist of shallow holes backfilled with stone or gravel. They receive runoff and aid infiltration and are effective in well-drained soils.
d. Recharge basins are pits designed to receive runoff and maintain natural recharge by infiltration through the bottom and sides of the basin. They are particularly effective in aquifer recharge areas. Experience on Long Island has shown that little maintenance is necessary in porous glacial soils.
e. Tile fields and seepage ditches or perforated corrugated steel pipe can be used to distribute runoff through the subsoil. Sediment removal is necessary to avoid clogging of the system.
f. Seepage beds are large areas of unpaved open space or porous pavement which allow stormwater to spread out and soak in after a storm. They can be used as parking lots or recreational areas.

Techniques for Preserving Open Space and Directing Future Development: Land use techniques should be pursued that will promote proper land use while reconciling the private rights to development with the public interests in community quality of life, municipal finances and natural resources preservation. These innovations include the purchase and transfer of development rights. The legal concept underlying TDR and PDR is that "title to real estate is not a unitary or monolithic right, but a bundle of individual rights," each one of which may be separated from the rest and transferred to someone else leaving the original owner with all other rights of ownership. Under a PDR system, the town would purchase the development rights of a parcel of land from its owner, leaving the remainder of the rights untouched including

those to buy and sell, and to enjoy and to use the land for other purposes. The costs of acquisition of these rights should be lower than outright purchase. Areas most suitable for PDR include those critical areas which should remain undeveloped but are not priority areas for public access. Taking PDR a step further, TDR systems allow for the purchase of development rights in priority conservation areas and transfer them to parcels where increased density is consistent with town goals. Transfer "sending" areas and "receiving" areas would be chosen according to their resource values and development capacities and incorporated in a town zoning system. TDR programs may be instituted either on a mandatory or voluntary basis. Under a mandatory system critical areas would be zoned as "sending" areas. Landowners in the area would not be permitted to develop their land but would be issued development coupons which would be required of anyone wishing to build in a receiving area. Coupons could be used by the landowner or bought by developers. Voluntary systems would allow willing buyers and sellers to transfer development rights. Someone wishing to obtain a higher density than allowed by current zoning could purchase development rights from landowners in cricital areas.

The town should also consider preferential tax assessments for priority areas of open space and the aquisition of conservation easements.

e. Ensure upgrading and containued maintenance of all systems by a pre-sale inspection for all houses. Failed or substandard systems should become an encumbrance on the deed of the property. Require or replacement within one year of purchase.

Measures to Control Pollution from Runoff

Surface runoff from areas of dense residential development and roads contains pathogens, nitrates, heavy metals, hydrocarbons, sediments and other pollutants that can have a major impact on such small, poorly flushed waterbodies as the salt ponds. The volume of runoff that flows from an area is proportional to the percentage of impermeable surface. The most effective way to minimize the effects of the contaminants contained in runoff on the salt ponds and tributaries is to forestall continuing development in as yet undeveloped areas and to eliminate existing direct flows.

Direct Flows: The major existing source of direct flows from storm drains to the salt ponds is Route 1 which discharges into Point Judith, Potter and Factory Ponds. There are also several storm drains that flow from town roads directly into lower Potter Pond and upper Point Judith Pond. The towns should urge the Department of Transportation to redesign culverts and storm sewers as they renovate and upgrade Rte. 1. The towns should incorporate sections into subdivision regulations prohibiting direct drainage into surface waterbodies.

Natural Vegetation Buffer Strips: Buffer strips of natural vegetation can be effective in reducing runoff and removing contaminants. This measure requires no construction or additional expenditures on the part of the homeowner or developer. A 100-foot buffer zone of natural vegetation around the perimeter of the salt ponds, tributary streams and wetlands should be incorporated into subdivision regulations. The towns should consider granting conservation easements on such buffer strips.

Stormwater Runoff Control Ordinance: The towns should adopt special regulations that would apply to subdivisions and commercial developments in the salt pond region. This would ideally require that runoff from developments will not exceed predevelopment levels, thus preventing downstream flooding, limiting contamination from pollutants in runoff and maintaining groundwater supplies. In addition, the ordinance should require practices which minimize erosion and sedimentation during construction.

Permeable Pavement: The towns should encourage the use of structural devices which aid infiltration and slow runoff and amend the building code to promote such devices. Porous pavements allow for infiltration and groundwater recharge and reduce the need for storm sewers. Porous asphalt laid over a base of crushed stone is suitable for roads and parking lots but require regular cleaning if it is to function properly. Modular paving is available in a variety of lattice, block and brick designs. Concrete grid pavements are used extensively in Europe. With a properly designed subbase, they can support heavy vehicle traffic and are suitable for parking lots, driveways, and emergency vehicle roads. Concrete grid pavements can virtually eliminate

should perhaps be made, however, for the Short Point-Billington Cove area on upper Pt. Judith Pond). Two options are available which remove nitrogen and do not divert groundwater supplies. Forest land application of wastewater following primary treatment can effectively reduce nitrogen and also produce a harvestable crop. Land for this type of treatment is available north of Rte. 1. Another alternative is traditional sewage treatment with tertiary treatment to remove nitrogen followed by subsurface infiltration of the treated waters to recharge groundwater.

A third option for collection and treatment are package sewage treatment plants. Plants are prefabricated and available in a range of sizes suitable for subdivisions and small towns. Tertiary treatment modules are available to remove nitrate. To avoid diversion of groundwater flows to an offshore outfall, effluent should be discharged through subsurface infiltration to groundwater.

The groundwater investigations undertaken by this project show that there are small areas along the south shore that discharge groundwater directly offshore rather than into the salt ponds. These areas are close to dense developments at Matunuck Point, Blackberry Hill, Roy Carpenter's Beach, and Green Hill and might be suitable for small communal leaching systems that would channel the leachate into the ocean rather than the salt ponds.

Lawns: The size and distribution of lawns can be influenced by town ordinances. Subdivision and zoning regulations should encourage small lawns and the preservation of trees and natural vegetation. A guideline of no more than 2000 square feet of lawn per house should be applied to new developments in densely developed areas where nitrate concentrations in groundwater are already elevated.

A Septic Tank Management Program

The town should establish septic tank management programs with the goal of upgrading substandard systems and improving maintenance. While minimum standards for the installation of on-site disposal units are enforced by the state, the towns can do much to safeguard public health by ensuring that septic systems function properly and that backups, clogging and bacterial contamination are avoided. Septic tank maintenance and upgrading will not solve the nitrate problem, but will help check the flow of other contaminants into groundwater and the salt ponds. A management program would ideally consist of several components. Some could be incorporated into existing town programs, while others would require state enabling legislation and/or a system of user fees. The elements of a program could be as follows:

a. Establish an education and information program on the importance of a properly maintained system. The town could offer a septic tank cleaning rebate, and publicize the program to encourage pumping.
b. Require homeowners to eliminate known violations such as effluent pipes that are connected to storm sewers. Investigate areas with high coliform concentrations such as Green Hill Pond for direct sewage flows and old cesspool systems.
c. Issue permits for on-site disposal systems with the requirement that the owner show proof of inspection or pumping every three years.
d. Require septage haulers to maintain records of pumpouts, septic tank failures and their probable cause. Such records could be used to pinpoint areas of chronic failure.

APPENDIX A

Techniques for Achieving a Low Nitrate Discharge

To protect the quality of groundwater, a low-nitrogen effluent should be required of all new houses built in areas dependent on private wells where lot sizes are too small (less than 2 acres) to assure that the septic effluent will be sufficiently diluted to keep the nitrogen concentration below 10 mg/l NO_3-N. Low nitrogen discharge standards may also be applied to areas abutting poorly flushed portions of the salt ponds that already show signs of eutrophication. On-site sewage disposal alternatives which do not remove nitrogen (such as mounds, aerobic tanks and electro-osmosis) only expand the areas which may be developed and therefore increase the total nitrate loadings to the drainage basin. Techniques of disposal that may achieve a low nitrate discharge include:

Compost Toilet or Incinerating Toilet: Properly operating systems present no public health dangers. They produce ash or a soil-like compost free of pathogens and nearly all the nitrogen is vented to the atmosphere as a gas. Maintenance of compost systems involves checking liquid levels, adding bulking agents and removing approximately half a bushel of compost each year. These systems are approved by DEM where soil and groundwater heights meet the criteria for a subsurface sewage disposal system that could be built if the composting systems were to fail. Composting systems are used in conjunction with a reduced leachfield which handles the "gray water" produced by sinks, washing machines and baths.

On-site Denitrification: Waste treatment and water recycling systems are currently available on a scale suitable for multi-unit housing, shopping centers, office buildings, and manufacturing plants. Systems suitable for individual homes are being developed. A denitrification unit converts nitrate to nitrogen gas which is released to the atmosphere. A residential unit is being tested which removes approximately 70 percent of the nitrate from household effluent using a buried 1,300 gallon concrete treatment unit, a sump pump and absorption field. The system is designed to treat 300 gallons per day. Production units will be available in 1982 and are estimated at $8,000 per unit and would cost some $400 per year in electricity to operate.[11]

Traditional septic tanks with an added denitrification process are being tested on Long Island and at the University of Connecticut. The Long Island unit consists of a standard septic tank and leachfield with an impermeable pan beneath it. Methanol is pumped into the pan to stimulate denitrification. The Connecticut unit uses "gray water" to denitrify "black water" and requires three tanks, a sand filter and a leachfield. Both systems are being designed for minimum upkeep and cost. Denitrification systems have not been approved by the R.I. Department of Environmental Management.

Collect and Treat: Construction of a traditional sewage collection system and treatment plant would effectively remove nitrogen and effluent from the watershed. This option, however, is extremely expensive and is potentially destructive to pond ecology. We strongly recommend that South Kingstown not expand the regional sewer system into the salt pond region (an exception

Figure 10. Existing Zoning on South Kingstown's Salt Pond Region

Source: South Kingstown Zoning Ordinance, Official Zoning Map, 1976.

Key:


-R-R 80 Rural Residential 80,000 ft^2 (2 acre) zoning


-R-40, R40A Residential 40,000 ft^2 (1 acre) zoning


-R-30 Residential 30,000 ft^2 (3/4 acre) zoning


-R-20 Residential 20,000 ft^2 (1/2 acre) zoning


-Commercial C-2 and Commercial Waterfront Zoning

Public

HFD High Flood Danger Zone (restricted use area)

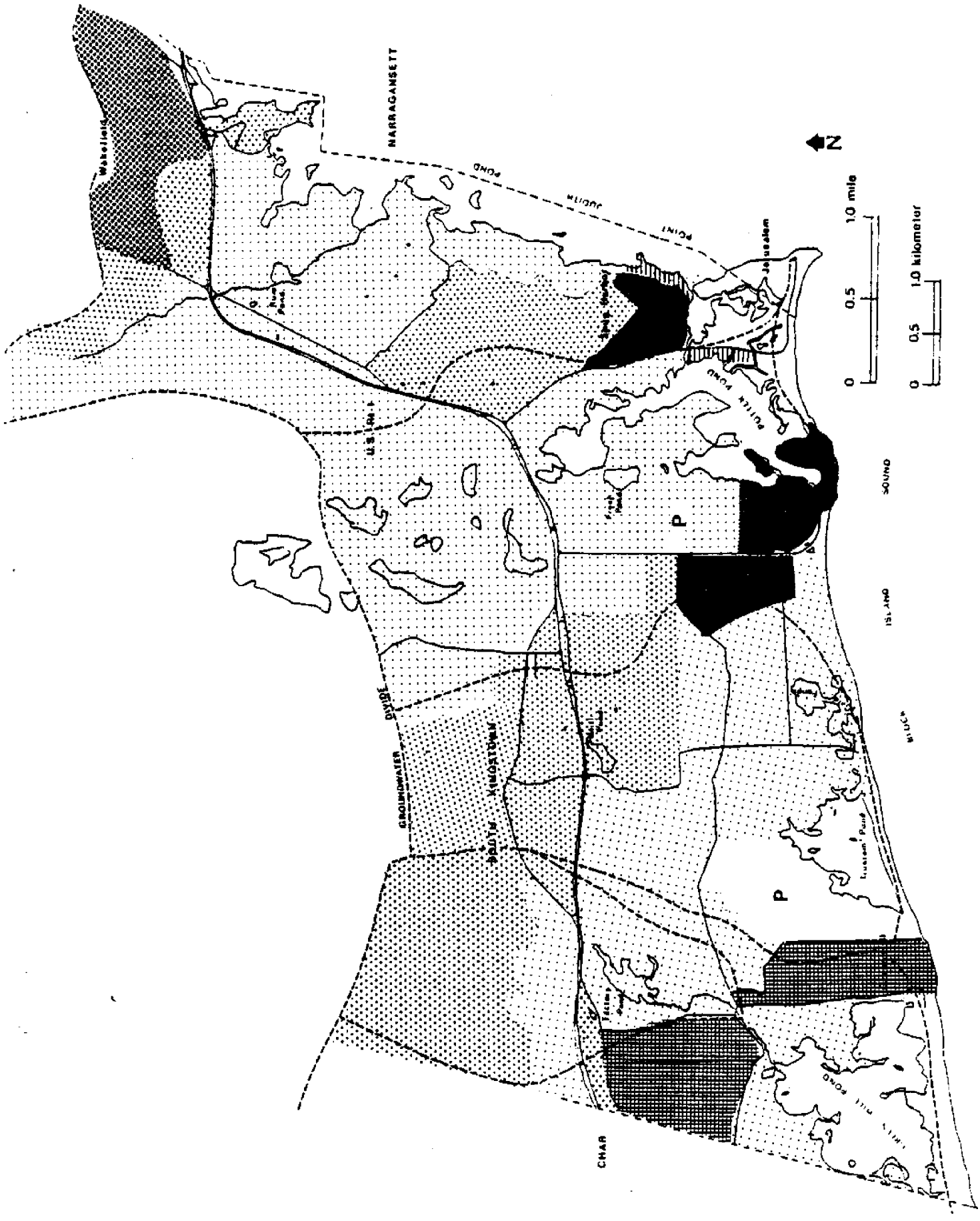
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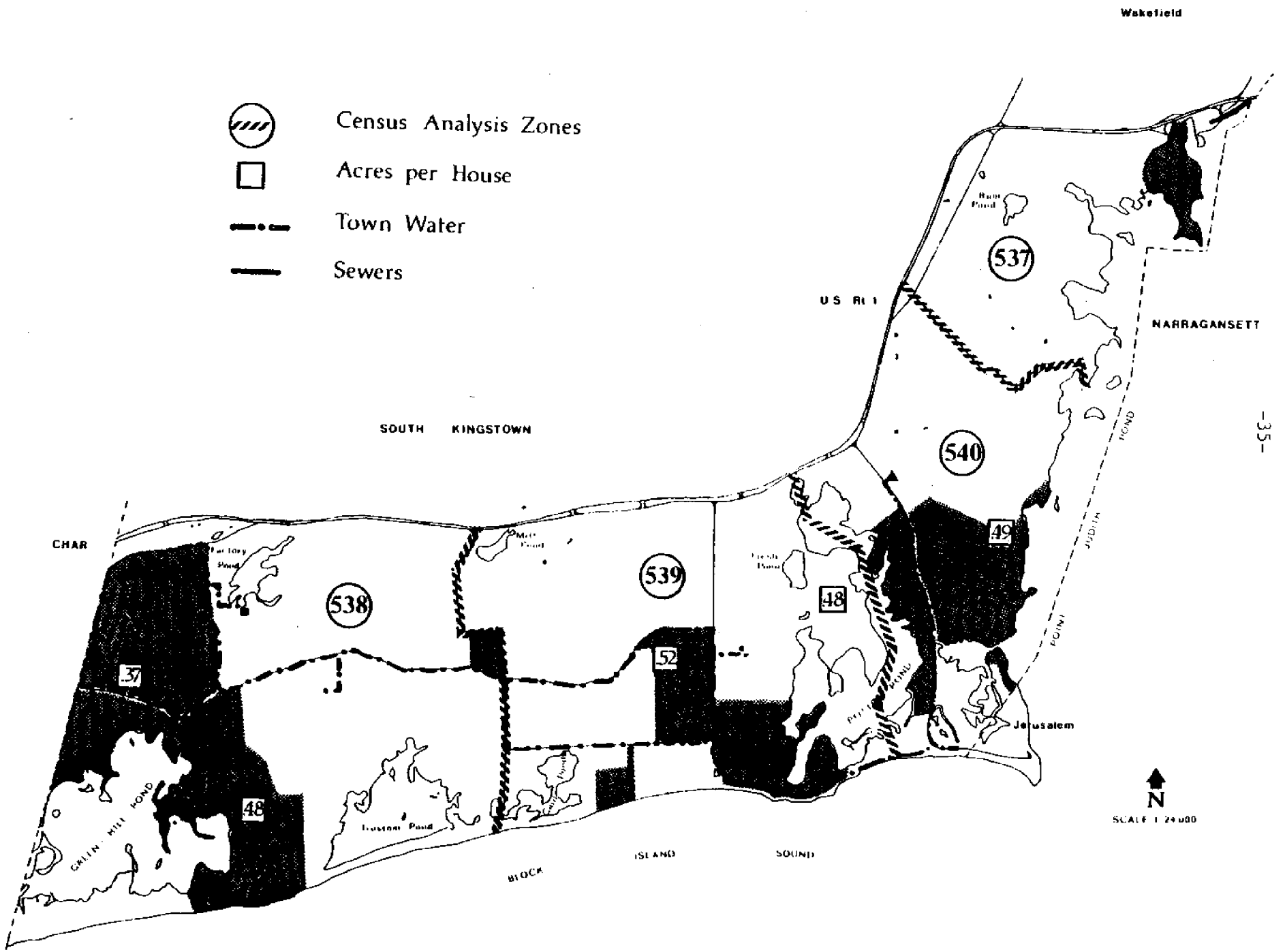
Figure 11. Existing Public Water and Sewer Lines in the Salt Pond Region of South Kingstown.


Census Analysis Zones
Acres per House
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GREEN HILL POND
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