Section 5  Nitrates

5.0 INTRODUCTION

To what extent is nitrogen a potential or actual contaminant in Long Island's waters? This question presupposes two others: what are the major sources of nitrogen; and what is the fate of the nitrogen in the environment? Both questions are deceptively simple.

This section describes studies that have, in part, attempted to answer them. One of the aims of this section is to identify the more important uncertainties. This section presents methods and results that may be of value in managing nitrogen on Long Island.

The management of nitrogen appears to be essential to protect the region's drinking water supplies and the ecological balance of marine bays. Given current high levels of water consumption and use, the risks of degrading the water resources, whether it be the contamination of groundwater or the pollution of surface waters, are very high. Urban development and overuse of groundwater in Kings and Queens Counties have already caused contamination of the water supply on the western end of the Island.

The marine environs adjacent to the western end of Long Island have also been adversely affected, especially by sewage effluents and the dumping of sludge, provoking apprehension that the marine water resources of the whole of Long Island could decline in quality as Nassau and Suffolk also become further urbanized. Nitrogen is regarded as one of the key factors in that potential decline.

In this section, aspects of the nitrogen balance are briefly described; the development of the Island with respect to nitrogen is outlined; and the major sources and fate of nitrogen, as determined by recent studies, are discussed. The impact of nitrogen on the region's water resources is assessed. Finally, work undertaken at Cornell University, which is attempting to construct detailed nitrogen budgets for Nassau and Suffolk, is described and interpreted.

5.1 ASPECTS OF THE NITROGEN CYCLE

Since the early 1800's, man has known that nitrogen is a critical nutrient. Nitrogen is a component of all protoplasm, including, specifically, protein and nucleic acids. On the average, nitrogen constitutes more than fifteen percent of living organisms. Nitrogen is required by crops in amounts greater than any other nutrient. Requirements exceed 200 lbs/acre/year for some crops.

Nitrogen is also plentiful. In the atmosphere, it constitutes about 80 percent of the total volume. An even greater reservoir of nitrogen exists in primary rocks, where the quantity of nitrogen bound up is estimated to be 50 times greater than that in the atmosphere (Hutchinson, 1944). The nitrogen in rocks is held largely in a combined form, such as ammonium, and could, therefore, be utilized by living matter, were it accessible. Although the rate at which such nitrogen becomes biologically available is not known, it
is believed to have a relatively minor role in the nitrogen cycle, compared to atmospheric nitrogen.

Living matter depends primarily on the atmosphere as its source of nitrogen. However, dinitrogen, as the molecule N₂ is called, is inert because of the strength of the bond between the two nitrogen atoms. The conversion of dinitrogen into a nitrogenous form that is available for plants is performed by a specialized group of microbes. These include bacteria, many of which are symbiotic, and blue-green algae. In a process called fixation, the microbes are able to reduce N₂ to ammonium using a catalytic enzyme called nitrogenase. The ammonium nitrogen can then be incorporated into the principal biopsheric reservoirs in various forms of nitrogen: nitrite, nitrate, urea, protein and nucleic acids.

Organisms that fix dinitrogen play a highly critical role in the nitrogen cycle. In fact, nitrogen fixation is one of the major factors limiting life on earth. Although estimates are speculative, it is believed that nitrogen fixation in terrestrial and aquatic environments varies broadly from about 150 mg/m² to over 1000 mg/m².

Nitrogen is also fixed naturally by electrical storms, which dissociate nitrogen and oxygen molecules that recombine to form an oxide of nitrogen. This reacts with water vapor to produce nitric acid, which is carried in precipitation to the ground, where it becomes available for living organisms.

Since the industrial revolution, man has increasingly been unable to rely on natural fixation to satisfy his need for nitrogen. Until the early 1900’s, immediate sources of nitrogen were supplemented by inorganic nitrogen from mineral deposits (salt petre) and dried organic wastes of seabirds or bats.

Currently, about 95 percent of all the nitrogen applied as fertilizer in the U.S. is produced by artificial fixation. There are nearly 100 industrial complexes in the Nation capable of producing a total of about twenty million metric tons per year.

These figures demonstrate the potential augmentation of the amount of nitrogen entering the biosphere due to man’s activities. It is estimated that approximately 80 million metric tons of nitrogen are fixed synthetically every year, which is more than one-third of that fixed naturally. Some of the environmental consequences of this augmentation are readily evident, the accelerated enrichment of surface waters and contamination of groundwater being major examples.

An important characteristic of nitrogen is that, once in the biosphere, most nitrogenous compounds are easily transformed. Organic forms are readily decomposed by biochemical processes. Inorganic nitrogen is either soluble or volatile. Hence nitrogen does not accumulate in the biosphere in large deposits, as do sulphur or carbon. Doubtless, there is some long term biochemical enrichment of the lithosphere as a result of the formation of sedimentary rocks, with a corresponding loss from the atmosphere. However, this loss is partly offset by the release of nitrogen from primary rocks.

There is no evidence that there is a significant loss of nitrogen from the atmosphere in the long term because the process of biological denitrification returns an amount of nitrogen to the atmosphere commensurate with that which is fixed. Denitrification is brought about by certain bacteria that are able to grow in either the presence or absence of oxygen. If oxygen is absent, then denitrifying bacteria are able to reduce nitrate (NO₃⁻) to dinitrogen (N₂) or nitrous oxide (N₂O). These gaseous products eventually escape to the atmosphere and are temporarily lost to the biosphere.

The artificial augmentation of the flow of nitrogen in the environment has undoubtedly increased denitrification. Unfortunately, from the point of view of the nitrogen balance, denitrification is the most difficult component to quantify. Anaerobic conditions in the field may arise under diverse circumstances that may be transient; may occur at a multitude of micro sites; or may be general, and yet remain impractical to monitor. This difficulty has moved Cooke (1967) to assert that attempts to construct an even sheet are bound to fail, at least with respect to crops. It is an anomaly of the nitrogen cycle that nitrification, the bacterial oxidation of ammonia to nitrate, requires oxygen, whereas the reduction of nitrate to gaseous nitrogen requires its absence. There is no doubt, however, that many regional nitrogen computations reveal a large loss that may be as much as 50 percent of the total budget (Porter, 1975). In the absence of evidence that nitrogen is being stored in the biosphere, it appears reasonable to attribute the unaccounted nitrogen loss primarily to denitrification.

In summary, the life sustaining components of the natural nitrogen cycle depend on microbial fixation and denitrification. Over recent decades, however, man has disrupted this natural cycle by means of artificial fixation.

Excessive augmentation of the nitrogen cycle places ground and surface water at risk. This is due to the natural interaction of the nitrogen and water cycles. Flowing water is a primary agent in the transport of nitrogen compounds. In its nitrate form, nitrogen can be leached from the soil by water. Other organic and inorganic forms of nitrogen may be removed by water flowing over land. Man also uses water to carry off his wastes. The surface or groundwaters that eventually receive this nitrogen may be undesirably affected if, as a result, a drinking water supply is contaminated or an ecosystem is substantially altered.

Degradation of groundwater quality and enrichment of surface waters by nitrogen has occurred to a marked degree on Long Island. An assessment of the causes of such changes is the subject of this section.

5.2 HISTORICAL BACKGROUND TO THE PROBLEM OF NITROGEN ON LONG ISLAND

In a recent study of nitrogen isotope ratios of nitrate in Nassau and Suffolk Counties, Kreitler et al. (1978) concluded that the source of nitrate in the Magoty “is from a dominant agricultural source plus animal wastes.” If this conclusion is correct, it explains an apparent anomaly in levels of
nitrate in the groundwater in Nassau. For some time it has been apparent that older water in the Magathy aquifer had high levels of nitrogen which, in many areas, were higher than those found in the overlying Glacial aquifer. Since the water in the Magathy predated much of the urban development in the County, it was puzzling that newer water was of better quality, since the use of cesspools and septic tanks in the original developments were an obvious major source of nitrate-nitrogen.

An explanation of the anomaly could be that earlier agricultural activity had introduced significant amounts of nitrate to the groundwater. The history of farming on Long Island as a potential source of nitrogen is briefly discussed below.

Long Island has a history of intensive farming. The coincidence of fertile soils and a favorable climate with a ready market in New York City promoted a thriving agricultural industry on the Island. In the early nineteenth century, the enthusiasm of the farmers led to exhaustion of the soils. The land was rescued from premature retirement when it was discovered that fish made excellent fertilizers. The farmers organized fishing fleets to obtain sufficient quantities of fish. The fish were incorporated into the soil (i.e. one fish per hill of corn, a practice known to the Indians) or were broadcast on the surface (Talmage, 1977).

Extension of the Long Island Railroad throughout the Island also facilitated the use of organic fertilizers. The Railroad provided stable manure from New York City at 80 cents per wagon load, while at the same time, of course, making the city more accessible as a market. In the 1870's, according to Talmage, commercially prepared fertilizers became available and were widely used by the farmers.

The history of farming in the 20th century in Nassau and Suffolk may be noted from Table 5-1. According to the U.S. Census data almost 1/2 of the area in the two counties was in agricultural use at the beginning of the century. It may further be noted that the number of animals raised was significant. These livestock made their own contribution to the flow of nitrogen, in addition to that provided by imported manure.

Although it is accepted that the use of fertilizers has greatly increased during the last two decades, on Long Island the data suggest that fertilizers, both organic and inorganic, were generously applied earlier in this century. For example, in 1915, extension personnel were quoted by the Brooklyn Daily Eagle as saying "that farmers in almost every section of the Island have been driven to the excessive use of commercial fertilizer as a substitute for the barnyard variety, but it is a poor substitute, as it lacks the water-holding properties of the natural fertilizer, and it does not keep the ground loosened up for the inhalation of air." The "barnyard variety" referred to was dairy manure, which was in increasingly short supply on the Island. This was due to the imposition of strict health regulations governing the handling of milk, and dairy farmers, rather than accept the regulations, discontinued production.

In 1929, a survey of Long Island potato farms was conducted by the Department of Agricultural Economics, Cornell University. The annual average rate of commercial fertilizer application applied by the growers to their potato crops was found to be 100 pounds of nitrogen per acre. In addition, 61 farmers out of the 112 included in the study applied an average 7.7 tons of manure per acre as an additional source of nitrogen (Underwood, 1933). Underwood also reported that the costs of applying fertilizers in 1912, and 1929 were 33 and 23 percent, respectively, of the total cost of production. This compares to an estimated sixteen percent in 1976 (Snyder, 1977). Farming methods have greatly changed over the past seventy years, so the above cost figures must be viewed with caution. For example, pesticides now constitute a major cost, which was not the case early in this century. This notwithstanding, the data indicate that fertilizers have been a major factor in farming production for a considerable period. It may therefore be concluded, as suggested by Kreitler et al. (1978), that previously farmed lands were a possible major source of nitrogen to groundwater.

The potential significance of previous land use was probably obscured as Nassau County developed in the 1930's and 1940's, and as malfunctioning cesspools and septic tanks subsequently became a conspicuous cause of groundwater contamination. In 1949, for example, detection of nitrate contamination in shallow public supply wells in the Levittown area produced an awareness that led eventually to abandonment of the Upper Glacial aquifer in the County as a source of water supply (Nassau Department of Health, 1971). Since that time, many reports have indicated the potential hazards of domestic disposal systems in heavily populated areas of Long Island (Smith and Baier, 1969; Cohen et al., 1968; SCDEC, 1972; Perlmutter and Koch, 1972).

Apart from domestic wastewater, another potential source associated with urbanization that was identified by several reports is nitrogenous fertilizers applied to lawns (Holzhammer et al., 1970; Miller et al., 1974). It is now fully recognized that the cumulative effects of the many sources of nitrogen created by man must now be identified and controlled if the region's valuable water resources are to be preserved.

5.3 HUMAN WASTEWATER ON LONG ISLAND

5.3.1 Introduction

It is estimated that approximately 46 billion gallons of wastewater are produced annually in Nassau and Suffolk Counties. Of this flow, nearly 60 percent is treated by some type of on-site disposal system, such as septic tank systems. This percentage is comparatively high. In the entire United States, 29 percent of the population disposes of its waste through on-site disposal units. Nassau and Suffolk constitute two out of only four counties in the whole Nation with more than 100,000 domestic waste disposal systems (USEPA, 1977b). It follows that nitrogen from individual domestic disposal units is a main component in the region's nitrogen budget.
<table>
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<th>Total Acreage</th>
<th>Acreage in Farmland</th>
<th>Cropland Harvested (Acres)</th>
<th>Value of Land &amp; Bldgs. Per Acre</th>
<th>Total Cattle</th>
<th>Horses</th>
<th>Poultry (Other Poultry)</th>
<th>Ducks</th>
<th>Hogs</th>
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<td>1,142</td>
<td>196</td>
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<td>256</td>
<td>158</td>
<td>347</td>
<td>400</td>
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<td>4,268</td>
<td>8,570.13</td>
<td>343</td>
<td>29</td>
<td>5,091</td>
<td>101</td>
<td>101</td>
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<td>1964</td>
<td>5,855</td>
<td>3,512</td>
<td>6,850.11</td>
<td>193</td>
<td>29</td>
<td>129</td>
<td>101</td>
<td>101</td>
<td>400</td>
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<td>7,262.00</td>
<td>695</td>
<td>16,902.00</td>
<td>76</td>
<td>126</td>
<td>519</td>
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| Suffolk   |               |                     |                             |                                |              |        |                        |       |      |      |       |       |
| Year      |               |                     |                             |                                |              |        |                        |       |      |      |       |       |
| 1900      | 276,860       |                     | 180.65                      | 7,605                          | 5,870        | 247,526| 70,646                 | 11,637| 418  | 1,374| 67    |       |
| 1910      | 178,063       |                     | 180.65                      | 7,605                          | 5,870        | 247,526| 70,646                 | 11,637| 418  | 1,374| 67    |       |
| 1920      | 590,080       |                     | 180.65                      | 7,605                          | 5,870        | 247,526| 70,646                 | 11,637| 418  | 1,374| 67    |       |
| 1925      | 111,762       | 67,446              | 351.98                      | 5,732                          | 4,809        | 322,945| 3,305                  | 1,374| 67  |      |       |       |
| 1930      | 99,671        | 63,063              | 607.67                      | 3,614                          | 2,241        | 1,338,124| 119,005               | 2,548 | 48   | 435  | 26    |       |
| 1935      | 123,251       | 64,556              | 410.28                      | 5,325                          | 3,178        | 297,159| 489                    | 437  | 26  |      |       |       |
| 1940      | 500,080       | 119,061             | 66,526                      | 409.79                          | 5,006        | 1,711  | 348,949                | 712,853| 2,807| 469  | 410   |       |
| 1945      | 120,837       | 74,893              | 450.44                      | 4,808                          | 618          | 361,786| 129                    |       |      |      |       |       |
| 1950      | 123,000       | 68,880              | 587.37                      | 4,200                          | 500          | 388,300| 700                    |       |      |      |       |       |
| 1954      | 98,752        | 64,967              | 837.37                      | 4,218                          | 194          | 266,757| 4,800,822              | 1,661 | 428  |      |       |       |
| 1959      | 89,716        | 61,121              | 1,444.36                    | 3,197                          | 252          | 238,342| 8,000,000              | 1,956 |      |      |       |       |
| 1964      | 74,308        | 53,215              | 1,876.00                    | 2,443                          | 165,000      |       | 2,895                  |       |      |      |       |       |
| 1969      | 61,520        | 41,007              | 4,840.00                    | 959                            | 321          | 56,774 | 4,200,000              | 114   |      |      |       |       |

*CES estimate.
Source: U.S. Bureau of the Census.
5.3.2 Domestic or On-Site Disposal Systems

On-lot systems conventionally rely on two phases of treatment. In the primary phase, sedimentation occurs with some digestion and liquefaction of solid materials. On Long Island, septic tanks or cesspools are generally used to provide this treatment. In the secondary phase, treatment is provided by the soil in the so-called absorption field to which the cesspools, or tile drains, discharge. Purification occurs through the agency of the soil and soil organisms, which filter, break down and absorb most of the pollutants contained in the sewage. These processes, however, do not function effectively if the disposal system is overloaded. The U.S. Environmental Protection Agency, in its recent comprehensive review (1977a), noted that numerous studies have shown soil to be an extremely efficient purifying medium under properly managed conditions. Removal rates of potential disease organisms and viruses may be very high as described by Vaughn and Landry (1977). Heavy metals and complex organic substances are also effectively removed from percolating wastewater by the soil (USEPA, 1977a). A critical exception is the highly soluble inorganic compound: nitrate.

In assessing the potential role of on-site disposal systems, this study sought answers to specific questions:

1. What is the average daily flow of wastewater generated per person?
2. What is an average concentration of organic and inorganic nitrogen in
   a. the influent to the disposal system?
   b. the effluent from the disposal system?
   c. the percolate in the leaching area, i.e., what is the rate of attenuation
      in the concentration of nitrogen as it moves downward through
      the soil?
3. What are typical concentrations of nitrogen in groundwater immediately
   underlying the disposal systems?

A very large number of studies have considered wastewater flows and nitrogen loads to and from disposal systems, both on Long Island and elsewhere. There is substantial agreement between reported per capita flows, as can be seen from Table 5–2. The overall average is 44 gallons per person per day; the lowest value was reported in the Long Island Groundwater Pollution Study (NYSDH, 1969).

There is considerably more variability in reported nitrogen loadings. In addition, the strength of raw sewage is often not analyzed, or only inorganic nitrogen is measured. Such omissions render it almost impossible to assess the systems studied in terms of their effectiveness in treating nitrogen.

5.3.3 Holding Tanks

Concentrations of organic and inorganic nitrogen found in raw sewage prior to entry into disposal systems, and the corresponding strength of effluents, are shown in Tables 5–3 and 5–4, respectively. Although only three of the studies, (Hickey and Duncan, 1966; USEPA, 1977a; Andreoli, 1978) reported both influent and effluent concentrations, it appears that significant reductions in concentrations of nitrogen may occur in the septic tank or cesspool. The overall mean reduction for the three studies was sixteen percent (see Table 5–5). This reduction may be due in part to storage in the tank or gaseous losses. Early studies of the composition of gases produced by septic tanks indicated significant percentages of nitrogen (Fuller, 1912; Metcalf and Eddy, 1916). More recently, Hickey and Duncan (1966) obtained the results shown in Table 5–6.

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<td>Organic</td>
<td>58</td>
<td>23</td>
<td>17</td>
<td>-</td>
<td>62</td>
<td>25</td>
</tr>
<tr>
<td>Ammonia</td>
<td>15</td>
<td>24</td>
<td>57</td>
<td>-</td>
<td>-</td>
<td>50</td>
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<tr>
<td>Total</td>
<td>73</td>
<td>47</td>
<td>73</td>
<td>62</td>
<td>75</td>
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</tr>
</tbody>
</table>

5.3.4 Absorption Fields

Complex processes govern the movement of nitrogen in absorption fields. Organic nitrogen and ammonia are readily retained by the soil (Walker et al., 1973; Andreoli et al., 1977). However, organic nitrogen is subject to mineralization, and the ammonia consequently produced, along with that already present, can be oxidized to nitrite and nitrate. Thus, in the long run, all the nitrogen, regardless of its initial form, may be subject to leaching as nitrate.
Walker et al. (1973) found that both organic and ammoniacal nitrogen were retained within centimeters of the crust formed in seepage beds, and that the levels of nitrate-nitrogen in the leachate were significantly less than the level of the total nitrogen originally entering the absorption field. Salvato (1955) found that the level of total nitrogen in a subsurface sand filter was 42 percent lower than that in the effluent from a septic tank. Finally, results from an experimental system reported by Andreoli et al. (1977) indicate that similar reductions of total nitrogen occurred in a field-scale experimental system on Long Island.

It should be noted that these results are not consistent with those obtained by the Long Island Groundwater Pollution Study (NYSDH, 1969), which investigated individual home installations. Great variability was observed, and in some cases very little reduction in nitrogen was found to occur.

Without detailed measurements, it is very difficult to interpret levels of nitrogen measured in groundwater underlying absorption fields. The dilution afforded by groundwater may produce an apparent attenuation in concentrations of nitrate-nitrogen that is misleading. For example, work reported by Viraraghavan and Warnock (1976) showed that levels of nitrate fell to background levels within 50 feet of the end of a tile field. This result is in contrast to those obtained by Walker et al. (1973), who demonstrated that concentrations of nitrate-nitrogen could exceed 10 mg/l at more than twice that distance.

In a study of eleven septic tank systems on sandy soils (Dudley and Stephenson, 1973), the average nitrate concentration in groundwater was about 15 mg/l. At none of the eleven sites were concentrations found to be greater than 10 mg/l at distances more than 50 feet downgradient from the absorption fields. These results are in agreement with those obtained by Preul (1966).

Such results indicate the difficulty of establishing the maximum number of disposal units that would not produce nitrate levels in excess of 10 mg/l over a broad area.
5.3.5 Discussion

For the purposes of this study, it was assumed that the daily average domestic wastewater flow was 40 gallons per person (Weston, 1976). As can be seen from Table 5—2, this flow rate is in close agreement with other studies.

Estimates of average levels of nitrogen in the influent to, and effluent from, on-site disposal systems are more difficult to achieve. Loadings of nitrogen per person are therefore not easily determined. Even greater uncertainties arise in assessing the fate of the nitrogen in the primary and secondary phases of on-site systems.

A summary of the levels of nitrogen and the percent removed by the primary treatment phase of the on-site systems is shown in Table 5—5. If the assumed average influent concentration is 61 mg/l of total nitrogen (based on the average of values from Hickey and Duncan, USEPA, and Andreoli, see Table 5—3), and the per capita flow is 40 gallons per day, then the corresponding annual load of nitrogen would be just over seven pounds. If Andreoli’s estimate of 75 mg/l total nitrogen for influents is used, then the annual per capita load is equal to just over nine pounds.

Andreoli also took detailed measurements of the leachate in the adsorption field. Over a twelve month period, the average concentration of total nitrogen at a four foot depth in the leaching field was 38.2 mg/l. This compared with the average influent concentration of 75 mg/l. Thus, an overall reduction of about 50 percent was observed. Although the data were less complete, measurements at a greater depth indicated that the levels of nitrogen continued to decrease and approached an overall reduction of 60 percent relative to the original strength of the sewage. This result is consistent with other studies, which have shown that average levels of nitrogen directly underlying on-site disposal systems that are functioning properly are rarely above 30 mg/l (Dudley and Stephenson, 1973).

Concentrations above 30 mg/l would appear to be atypical on Long Island even in high density residential areas that are unsewered (Perlmutter and Koch, 1972; Katz, 1978; USGS, 1976). Exceptions to this generalization might be expected where the disposal systems malfunction and the soil is heavily overloaded.

Exceptionally high concentrations of total nitrogen were observed during the Long Island Groundwater Pollution Study (NYSDH, 1969). At one of six sites studied, average concentrations of ammonia in the groundwater were as high as 75 mg/l. The disposal system on the site consisted of a septic tank and tile drains. Despite the 25 feet depth to groundwater, and the sand and gravel content of the soil, there was little nitrification or adsorption of ammonia.

The Long Island Groundwater Pollution Study did not include measurements of organic nitrogen, so it is not possible to determine what the total nitrogen loadings to the systems were. Also, measurements were taken of the septage in the tanks themselves, rather than of the influent or effluent, so the construction of a nitrogen balance from the data is impossible.

Despite the uncertainties regarding the data obtained from the Long Island Groundwater Pollution Study, it appears prudent to recognize that the levels of nitrogen measured were substantially higher than generally reported elsewhere. Therefore, for the purposes of this study, it was conservatively assumed that the average annual per capita nitrogen load in wastewater is ten pounds, which corresponds to an average nitrogen concentration of 82 mg/l in 40 gallons per day of raw sewage. It was further assumed, for initial calculations, that 50 percent of the nitrogen in the raw sewage will reach the groundwater.

Wastewater flows are also generated by institutional, commercial and industrial sources. The nitrogen in wastewater from these land uses can be estimated by using a standard sewage BOD to nitrogen ratio, and the sewage BOD loadings for various land use categories previously estimated by the NSRPB (1978).

In areas that are fully sewered, wastewater flows can be assumed to equal the sum of all the flows from all land uses. Where there is only partial sewerage, sewage flow figures can be divided between sewers and septic tanks according to the fraction of sewerage land.

Studies by the U.S. Geological Survey (Franke and McClamond, 1972) have indicated that about ten percent of the wastewater (and, therefore, ten percent of the nitrogen) transported in sewers leaks out to groundwater. Of the remaining 90 percent of the nitrogen load conveyed by sewers, some is discharged to groundwater after treatment; the remainder is discharged in the ocean after treatment, and the nitrogen it contains is lost.

5.4 NITROGEN FROM FERTILIZERS

5.4.1 Introduction

In assessing the potential impact of nitrogenous fertilizers on ground or surface waters, it is necessary to have reliable estimates of the quantities of fertilizers used and the fate of the nitrogen following application.

Rykbof (1973) undertook a survey of thirty-five Long Island sites in order to assess the effects of various fertilizer rates on turf. In their report of 1970, Holzmacher et al., estimated that households applied an average of 3 lbs. N/1000 sq. ft./year to their lawns.

The Suffolk County Department of Environmental Control also undertook a study of the Twelve Pines area, Medford, in 1974 (SCDEC, 1974). A total of 161 households were interviewed during the summer of 1974. As a result, the Department estimated that 9,600 pounds were applied to 21 acres of turf, corresponding to an annual application rate of 2.2 pounds of nitrogen per 1000 square feet.

5.4.2 208 Household Fertilizer Use Survey Methodology

During this study, extensive field surveys were carried out to quantify the use of fertilizers by major types of users: home owners, farmers, and insti-
tutions. Field work was also undertaken at representative sites throughout the Bi-county Region to monitor the movement and fate of nitrogen in the soil throughout the growing season.

A household survey was conducted using a questionnaire designed to elicit information regarding the quantity of nitrogenous fertilizers used, the extent of watering, the variety and quality of turf, and the method of disposing of grass clippings. A preliminary survey was made in Riverhead to test the questionnaire. Seven additional sites in Nassau and Suffolk were selected for the survey. In selecting the sites, particular attention was given to population density and to average household income.

The density of housing can affect the amount of fertilizer used, since density and the extent of impervious areas are directly related, and are inversely related to the area available for vegetation. Household income was considered because it was surmised that the degree of lawn care would be related to the level of income. Although there is doubtless some relation between income level and housing density, both should be considered, since some high density areas are occupied by high income households (e.g., central western Nassau).

Some consideration was also given to the topography and the age of existing development at potential survey sites, since these factors may also affect the care given to lawns and gardens. The age of a development may also affect the number of trees and size of those trees, which in turn affects the size of the lawn and variety of grass it contains. The maturity of the lawn is also important since well established lawns could behave differently in relation to fertilizer uptake than recently seeded lawns.

Seven areas were selected on the basis of the above considerations. The locations of the areas are shown in Figure 5-1. Within each area, the individual households to be surveyed were randomly selected. A sample size of sixty households was chosen based on information obtained during a SCDEC survey in the Twelve Pines area of Medford. From the Medford study results, the mean fertilizer use and standard deviation were estimated:

Mean = 1.52 lbs N/1000 sq. feet; Standard deviation = 1.4

A desirable sample size was then calculated using the argument of Snedecor and Cochran (1956). Using a permitted error of up to 25 percent of the mean, at the 95 percent level of confidence, the sample size required was as follows:

\[
\frac{n - 4 \text{ (standard deviation)}^2}{0.25 \text{ (mean)}^2} = 54
\]

Hence it was decided to administer 50 or more surveys per area. Two persons conducted the entire survey, and an effort was made to sustain uniformity in the way the questionnaires were administered. The Riverhead trial survey indicated that households at which responses could not be obtained on the initial visit should be replaced with alternate households. To avoid introducing a possible bias by making surveys only during working hours, the surveys were made from approximately 2:00 to 8:00 p.m.

In those cases where households used contract service for lawn and garden maintenance, the firm providing the service was questioned. Since the surveys were made during the summer, the results obtained had to be adjusted to provide estimates for the whole year. It is common practice to make

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**FIGURE 5-1** 208 Field Survey Areas: Household Fertilizer Use.
one or more fertilizer applications to turf in the fall, and indeed such applications are recommended. (See the publication: Cornell Recommendations for Turf.) A further questionnaire was mailed to all the houses visited in order to obtain additional information with which to adjust the estimates. As happens with many surveys conducted by mail, the response was poor. However, it was possible to estimate that about 50 percent more fertilizer was applied in the fall by the householders who used fertilizers. This conclusion is consistent with recommendations for fertilizer use on turf.

5.4.3 208 Household Fertilizer Use Survey Results

Use of fertilizer was characterized by extremes, i.e., was either non-existent or exceeded recommended rates. There are a variety of reasons why homeowners do not fertilize at all, among them being lack of income; the presence of a large number of trees on the property, and therefore little grass to fertilize or a deeply shaded lawn; or the fact that the residence is temporary housing, either a rental or seasonal occupancy. The behavior of a majority of homeowners represented one of these two extremes; only a minority followed the application instructions on the package. For this reason, care should be exercised in interpreting nitrogen application rates for an area. If 4 lbs N/1,000 ft.\(^2\) is applied to one lot and none to another, the average input will be 2 lbs/1,000 ft.\(^2\), which does not appear to be excessive. However, a large fraction of the fertilizer may leach through the soil on the first plot, while a much smaller amount would leach were two pounds applied to the entire area.

Some householders fertilize various parts of the yard differently. Sometimes the front lawn is fertilized and the back lawn is not. This gives validity to the idea that appearance and social value are important factors in maintaining a high quality lawn. Householders who kept their clippings often used them as a garden mulch or attempted to compost them along with other materials.

During the survey, an attempt was made to quantify the use of water for irrigating the lawns. Irrigation may induce higher rates of leaching of nitrogen than would otherwise occur. Initially, householders were requested to place a can on their lawns to catch the water, in an attempt to make crude estimates of the amount of water used. The results were erratic. Householders were then asked how frequently they watered. Although the information obtained does not permit good estimates to be made of the volumes of water applied, it does appear that some individuals apply water excessively.

The veracity of the responses to the questionnaire must also be considered. It was perceived that there was some unwillingness to respond to questions frankly, especially in the higher income areas of Nassau. Efforts were made to assure the respondents that responses would be kept confidential. Frequent explanations were made of the study being conducted and when requested, informative booklets were provided. However, quite a few householders appeared wary of the survey and some were very uncooperative. Where there was reserve in replying to questions, it appeared that respondents were inclined to give underestimates of their use of fertilizers. (A similar observation applies to pesticide use.)

Finally, time was the most limiting factor in this study. Although a large number of surveys were completed, the degree of confidence in extrapolating the results would have increased had more areas been surveyed. The Nassau-Suffolk Region is large and extremely diverse. Hence, the results of the survey must be accepted with caution. A summary of the results is given in Table 5-7.

<table>
<thead>
<tr>
<th>Survey Area</th>
<th>Number of Questionnaires Completed</th>
<th>1969 Average Family Income(^{1}) (Dollars)</th>
<th>Average Lot Size (square feet)</th>
<th>Fertilizer N Application lbs/1000 sq. ft.</th>
<th>Tons/acre turf/year(^{2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edgewood</td>
<td>60</td>
<td>8,662</td>
<td>5,000</td>
<td>1.74</td>
<td>0.0379</td>
</tr>
<tr>
<td>Southold</td>
<td>63</td>
<td>10,376</td>
<td>27,000</td>
<td>1.73</td>
<td>0.0377</td>
</tr>
<tr>
<td>Miller Place</td>
<td>50</td>
<td>10,673</td>
<td>29,000</td>
<td>1.70</td>
<td>0.0370</td>
</tr>
<tr>
<td>Medford</td>
<td>109</td>
<td>13,000(3)</td>
<td>13,000</td>
<td>2.19</td>
<td>0.0477</td>
</tr>
<tr>
<td>Huntington</td>
<td>52</td>
<td>14,713</td>
<td>15,000</td>
<td>3.32</td>
<td>0.0723</td>
</tr>
<tr>
<td>New Hyde Park</td>
<td>65</td>
<td>15,008</td>
<td>5,000</td>
<td>3.00</td>
<td>0.0653</td>
</tr>
<tr>
<td>Garden City</td>
<td>61</td>
<td>21,805</td>
<td>7,000</td>
<td>3.75</td>
<td>0.0817</td>
</tr>
</tbody>
</table>

\(^{1}\) Calculated from 1969 income data as reported in the 1970 Census of Population.

\(^{2}\) Based on CES Survey responses, multiplied by 1.5 to account fertilizer applied after survey was taken.

\(^{3}\) CES estimate for area surveyed.
As can be seen from Table 5–7, rates of fertilizer application by householders appear to be closely related to the level of household income. A graph showing the data and a line “fitted” to them by linear regression is depicted in Figure 5–2. The equation of the line accounts for about 85 percent of the variance.

\[
Y = 0.05 + 1.81 \times \text{FAMILY INCOME (IN THOUSANDS)}
\]

\[
R^2 = 0.92
\]

**FIGURE 5–2** Relationship Between 1969 Family Income and 1976 Turf Fertilizer Use.

The equation was used to estimate the total quantities of nitrogen applied in Nassau and Suffolk. The grid cells defined by the NSRPB were the units of computation used for the calculation. (See Section 5.6.2, Figure 5–12.) Unfortunately, income levels were not available for each cell. To make the estimation, grid cells were individually tabulated by listing the numbers of the 1970 census lying within their boundaries. The median family income for each tract for 1969 was obtained from the 1970 U.S. Census. An estimated average income level, for the households within each grid cell, was then estimated by computing the arithmetic mean of the median income levels of the tracts lying within the cell. (See Table 5–7.)

To complete the estimation for the entire region, it was necessary to calculate the total area of household lawns within each grid cell. During the survey, it was found to be impractical to use direct measurement in all areas in order to estimate the portion of the lots that were turfed. Direct measurements were made in a medium-density residential area. The average turfed area was found to comprise at least 40 percent of the entire lot. Table 5–8 presents estimates of turfed area based upon observations made during the survey, and the assumption that a specified fraction of the previous area of each lot is turfed.

Using the derived percentages of turfed areas, it is possible to calculate the total number of acres devoted to turf in each cell by multiplying the fractions corresponding to each category of residential area with the net acreage used for that category. Finally, by combining this result with an estimated rate of application related to income level, the total amount of nitrogenous fertilizer applied to residential lawns can be estimated. (See Section 5.7.1.)

**Table 5–8**

<table>
<thead>
<tr>
<th>NSRPB Residential Categories</th>
<th>% Impervious Area*</th>
<th>% of Area Turfed and Fertilized*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low density</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>0–1 Dwelling units/acre</td>
<td>35</td>
<td>39</td>
</tr>
<tr>
<td>2–4 Dwelling units/acre</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>5–10 Dwelling units/acre</td>
<td>55</td>
<td>36</td>
</tr>
<tr>
<td>High density</td>
<td>65</td>
<td>28</td>
</tr>
</tbody>
</table>

*Percentage of gross acre.

5.4.4 Use of Fertilizers on Turf Other Than Household Lawns

CES investigated the use of nitrogen on recreational and ornamental turf, such as golf courses, highways, playing fields and parks. A summary of the average annual rates of application is shown in Table 5–9.

Throughout 1976, extensive and intensive monitoring of nitrogen applied to turf was carried out. (See Figure 5–3 for monitoring locations.) A total of fourteen areas were sampled for soil nitrogen and soil water levels every two to three weeks. Samples were taken at several depths to determine profiles of nitrogen and water within and below the root zone. It was assumed that the greater part of the inorganic nitrogen detected below the root zone would eventually leach to groundwater. Some of the sites were subdivided and fertilized at different rates. Detailed measurements were made on a mature lawn at the Long Island Horticultural Research Station, where fertilizer and water were applied under controlled conditions. A listing of the basic data is available at the Suffolk County Cooperative Extension Service office in Riverhead.

Although sod farms were included in the survey, they more properly fall into the category of agricultural production, and were so regarded in this study. A key factor in normal turf culture is that it is not cropped in an agricultural sense. Although after cutting the grass the clippings may be re-
Table 5-9
ESTIMATED AVERAGE ANNUAL USE OF NITROGENOUS FERTILIZERS
APPLIED TO RECREATIONAL AND ORNAMENTAL TURF

<table>
<thead>
<tr>
<th>Use</th>
<th>Annual rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs N/1000 sq. ft.</td>
</tr>
<tr>
<td>Golf courses</td>
<td></td>
</tr>
<tr>
<td>Greens</td>
<td>7</td>
</tr>
<tr>
<td>Tees</td>
<td>5</td>
</tr>
<tr>
<td>Fairways</td>
<td>3</td>
</tr>
<tr>
<td>Weighted average*</td>
<td>3.5</td>
</tr>
<tr>
<td>Playing fields</td>
<td>3</td>
</tr>
<tr>
<td>Parks**</td>
<td>2</td>
</tr>
<tr>
<td>Highways</td>
<td>0–1</td>
</tr>
</tbody>
</table>

*Weighted according to relative areas based on County of Nassau golf courses:
Greens = 4.4%
Tees = 3.3%
Fairways = 92.3%

**As a rule only 10% of the turfed area in parks is fertilized.

moved, the nitrogen is not deliberately removed entirely as is normally the case with an agricultural crop. This is a key factor in the nitrogen balance for turf. A simplified representation of the nitrogen balance for turf is shown in Figure 5-4. Evidence suggests that under mature grass, soil organic nitrogen is in equilibrium with the soil, i.e., the curve representing organic nitrogen is asymptotic as shown in Figure 5-4. In this case, losses of nitrogen will approximately equal gains. Thus, on Long Island, if volatilization, denitrification and runoff are minimal, then virtually all the nitrogen in fertilizer supplied to mature grass will be leached. This may even be true if the grass is cropped and the clippings removed, because the clippings presumably remain in the area. There is, however, a possibility that there would be some volatilization of ammonia from the clippings, especially if they are composted, in which case the area may sustain an actual loss of nitrogen.

The interpretation of many field studies is not straightforward, as can be seen from Figure 5-4. If the grass were immature, and the soil initially poor in organic nitrogen, there could be a net accumulation for an indefinite period. In such a case, the quantity of organic nitrogen being mineralized (D) will be less than the inorganic nitrogen being utilized by plants (B) and hence losses of nitrogen (E) will be less than gains (A) in the short run.

An investigation was made to determine the levels of losses of nitrogen due to volatilization that may be expected in freshly cut clippings. Replicated samples of grass clippings were taken and treated four ways, as indicated in Table 5-10. The highest average loss, which was only 12.8 percent, occurred
when freshly cut clippings were immediately dried in an oven. It does not, therefore, appear from these results that this gaseous loss of nitrogen from turf is likely to be significant.

As already indicated, the primary aim of the study was to measure the movement of inorganic nitrogen below the root zone. Such movement was found to occur on all plots, although to varying degrees. (See Figures 5–5 through 5–10.) As expected, the extent of downward movement of the nitrogen depended on soil conditions and the amount of nitrogen applied. The greatest losses occurred when nitrogen was applied immediately preceding irrigation or rainfall. For example, Figure 5–10 represents the measurements taken on mature turf at the Long Island Horticultural Research Station. The intent of the work was to determine the movement of nitrogen, after application, when the turf was irrigated following application.

The plots were ten feet by ten feet in area. Bulk densities, infiltration capacities, and field capacities were measured. In the first experiment, water was applied at the rate of one inch, twice a day for three days, following an application of 4 lbs. KNO$_3$ = N/1000 sq. ft. In the second experiment 2 lbs. of NaNO$_3$ = N/1000 sq. ft. was applied, and water was applied at the rate of one inch per day for seven days. As may be seen from the figure, the soil nitrogen profiles are very similar.

In addition to the intensive field experiments on turf already described, another experiment was conducted over a longer period of time. The intent of the experiment was to monitor the movement of inorganic nitrogen induced by rainfall and natural soil water percolation.

Eight plots, each measuring ten feet by ten feet, were marked out on good quality mature turf consisting of a mixture of bluegrass and fescue. Four treatments were applied to the plots: 0, 1, 2, and 3 lbs/1000 sq. ft. of ammonium nitrate-nitrogen. Two plots were utilized for each treatment.

Measurements for soil nitrogen were taken on October 4, 1976 at five equal depths, from zero to twenty inches. As can be seen from Figure 5–11, all the plots had similar initial background levels of inorganic nitrogen. Following the measurements, the fertilizer was applied. The data represent the averages of the results for each pair of replicates. A comparison of the

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% nitrogen in clippings after treatment</th>
<th>% reduction in nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original clippings</td>
<td>4.68</td>
<td>–</td>
</tr>
<tr>
<td>Oven dried immediately</td>
<td>4.08</td>
<td>12.8</td>
</tr>
<tr>
<td>Air dried after three days</td>
<td>4.25</td>
<td>8.8</td>
</tr>
</tbody>
</table>
graphs clearly shows the direct relation between the amounts of nitrogen applied and the levels actually observed. Movement of inorganic nitrogen down through the soil may be seen from the graphs, especially in the cases of the treatments involving higher rates of application. Measurements were taken every few days up until mid-December; a further set of measurements was made in mid-March. By that time, virtually all signs of the added inorganic nitrogen had disappeared from the soil profile.

5.4.5 The Impact of Turf Fertilization

Traditionally, studies of turf fertilization have been directed towards achieving the highest quality of turf. Only recently has there been considerable interest in the possible environmental effects of turf fertilization (Ricke and Ellis, 1974). In the past five years, several studies have explicitly examined the movement of nitrogen in the soil. English et al. (1974) found that both ammonia and nitrate-nitrogen were leached from soil columns seeded with creeping bentgrass. Losses of nitrogen in the columns were found to occur in all treatments studied, although to varying degrees. This conclusion was supported by subsequent work of Waddington et al. (1978) in which it was found that all but one fertilizer application of turfgrass produced higher levels of nitrogen in the soil.

Ricke and Ellis (1974) studied several treatments of nitrogen applied to ‘Merion’ Kentucky bluegrass. The authors concluded that the leaching of nitrate-nitrogen is greatest when (a) high annual rates of nitrogen are applied, (b) infrequent and heavy applications of soluble inorganic nitrogen are made, (c) irrigation or rainfall is heavy and (d) the soil is light and sandy. As has been noted on Long Island, virtually no nitrate-nitrogen was left in the top twenty inches of soil after the winter months.

Finally, Brown et al. (1977) obtained results similar to those above, i.e., losses of nitrogen and concentrations of nitrate in leachate were directly related to the amount of nitrogen and water applied. As in the case of the previous studies, the authors found that losses could be greatly reduced by irrigating at a rate commensurate with evapotranspiration, and by applying organic and slow release fertilizers. The authors concluded that, under careful management, losses of nitrogen from fertilized turf could be reduced to low levels.

There have also been several recent studies on Long Island. In 1973, Rykosta undertook a short term survey of thirty-five sites, including a variety of grass species, soil types and levels of fertilization. The sites included golf courses, institutions and household lawns in the Nassau-Suffolk Region. Each site was visited twice during the summer of 1973. Levels of inorganic nitrogen were determined from soil samples taken at three depths: 0–2, 2–9 and 9–16 inches. The results are summarized in Table 5–11. The table lists average levels of inorganic nitrogen measured in the top twenty inches of soil under turf at thirty-five sites. The turf at each site was fertilized at one of the four rates indicated in the table. Total nitrogen was not measured, so the

SUMMER INTENSIVE RUN
FERTILIZER APPLICATION = 4 lb KNO₃ − N/1000 sq. ft.

FALL INTENSIVE RUN
FERTILIZER APPLICATION = 2 lb NaNO₃−N/1000 sq. ft.

FIGURE 5-10  Total Inorganic Nitrogen Measured in the Top 20 Inches of Soil Under Mature Turf as a Function of the Amount of Water Applied.
Table 5-11

AVERAGE INORGANIC NITROGEN CONTENT OF TURFED SOILS
RANKED ACCORDING TO THE LEVEL OF NITROGEN APPLICATION*

<table>
<thead>
<tr>
<th>Soil Depth</th>
<th>Zero</th>
<th>Level of N application**</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–2&quot;</td>
<td>9.8</td>
<td>13.2</td>
<td>22.5</td>
<td>16.7</td>
</tr>
<tr>
<td>2–9&quot;</td>
<td>3.9</td>
<td>4.6</td>
<td>9.5</td>
<td>7.7</td>
</tr>
<tr>
<td>9–16&quot;</td>
<td>2.1</td>
<td>4.6</td>
<td>5.8</td>
<td>8.1</td>
</tr>
</tbody>
</table>

*ppm on a dry soil weight basis
**Definition of levels:
  Zero = No regular fertilization
  Low = About 2 lbs/1000 ft.
  Medium = About 2.5–4.5 lbs/1000 ft.
  High = More than 4.5 lbs/1000 ft.

Concentrations of inorganic nitrogen only serve as rough guides to the potential leaching of nitrogen associated with various levels of fertilization. As can be seen from the table, higher levels of inorganic nitrogen tend to be associated with higher application rates. It follows, therefore, that the higher Long Island turf roots rarely extend beyond nine inches into the soil; hence, soil inorganic nitrogen below nine inches is subject to leaching to groundwater.

Snow (1976) studied the effects of different rates of fertilizer applications on Kentucky bluegrasses. In particular, Snow attempted to account for the nitrogen applied by measuring the nitrogen recovered in clippings and the turf biomass. As a result of this work, Snow concluded “that large quantities of N may be leached from turfgrass areas.”

The Cooperative Extension Service has estimated that the total nitrogen load in fertilizer applied to all types of turf on Long Island is about 9,300 tons per year, of which approximately 5,600 tons per year may leach to groundwater. (See Section 5.7.1.)

5.4.6 Fertilizers Applied to Potatoes

About half the total cropland in Suffolk County is devoted to potato production. Thus, it was decided that this study should also be concerned with fertilizers applied to potatoes.

Potatoes require ample supply of nutrients, and, traditionally, large amounts have been supplied. Recent work completed by Meisinger (1976a), however, indicated convincingly that yields of potatoes could be sustained with applications of nitrogenous fertilizers as low as 150 lbs/acre. Normal applications were generally higher than this, and it is known that in some cases double that amount was applied annually. Surveys conducted by Rykbo (1976) indicated that average rates have now fallen, in part in response to the work done by Meisinger and the Cornell Horticultural Research Station. Rykbo concluded that average annual rates were about 220 pounds.

A detailed survey of eight representative farm operations was made for this study in cooperation with the Cornell University Cost Accounts Program. The average rate of application of nitrogen by the farmers, in 1976, was about 200 pounds, an estimate close to that obtained by Rykbo.

The staff of the Cornell Long Island Research Farm has been conducting research on the variations in yield obtained in response to different types of timing of application. A major part of the research work was funded by the Suffolk County Department of Environmental Control. Results indicated that equivalent yields could be obtained with less nitrogen fertilizer than the amounts used in current fertilizer programs (Meisinger, 1976a). It was found that split applications could provide fertilizer more effectively than a single application at the time of planting. Split applications decrease the total amount of fertilizer required, and also decrease the amount of fertilizer potentially available for leaching. In January 1975, the research farm commenced a project to test these results under commercial conditions.

Four commercial farmers agreed to participate in the study. On each of the farms, the field was divided in half; half to be fertilized according to the farmer’s current management practices, and half according to an experimental management program. Skimming wells were installed in each half field to monitor the groundwater nitrate-nitrogen concentrations. Yields were measured for comparative productivity. In 1976, monitoring wells were installed upgradient of the fields to determine background nitrogen levels.

The objectives of this part of the study were to determine the potential losses and gains of nitrate-nitrogen and ammonium-nitrogen within the soil under the potato crop. Core samples were taken every two weeks from March 1976 through December 1976, when preplanting, post harvest, and cover crop establishment and growth took place. A one inch diameter soil probe was used to extract samples to a twenty inch depth. The samples were divided into units of 0–12 inches and 12–20 inches. An assumption was made that the root zone was completely contained within the uppermost twelve inches. Therefore, any nitrates or ammonium measured in the 12–20 inch unit were assumed to be available for leaching into the groundwater. Each sample was taken two inches to either side of the seed through the fertilizer band.

Three random samples were taken from each half of the field, composited, placed in airtight containers, and stored at 35°F until chemical analyses were made. Storage time varied from zero to two weeks. The effects of the storage time were considered negligible.

The chemical analyses consisted of two measurements: gravimetric measurement and a micro-Kjeldahl steam distillation determination for nitrate-nitrogen and ammonium-nitrogen. Gravimetric measurements were made of twenty (20) gram samples of sifted soil. (The sifting process elimin-
ated gravels which would affect the gravimetric measurement.) The twenty gram samples were oven dried at 100°F for no less than twelve hours. The dried samples were reweighed, and the soil water content determined. Micro-Kjeldahl steam distillation required a preparation of potassium chloride (KCl) saturated soil samples. The twenty gram soil samples were extracted with 100 ml KCl. Magnesium oxide (MgO) and Devard’s alloy were used as reducing agents.

Well water samples were taken every two weeks by the staff of the Long Island Horticultural Research Station. These were also analyzed by micro-Kjeldahl steam distillation. Only nitrate-nitrogen (NO₃-N) was measured, since the concentration of ammonium-nitrogen (NH₄-N) was insignificant. The depth of the static water level was determined when the wells were installed. The depth indicated the potential time interval between the application of fertilizer and possible leaching through the soil profile to the groundwater. It was important to determine this relationship in order to derive a complete correlation between fertilizer management and the groundwater concentrations of nitrate-nitrogen.

Soil characteristics were determined for each of the demonstration potato farm sites. Soils were generally slightly acid, sandy loams, with low organic matter content and poor water holding capacities (high infiltration and permeability rates).

The results of the study showed low NO₃-N and NH₄-N concentrations in the early spring, prior to planting, indicating that the background soil nitrogen levels are low. Observed levels of nitrogen at various depths indicated a downward movement of the NO₃-N. The immediate and obvious response to fertilization application at planting was an increase in soil NO₃-N and NH₄-N concentrations. Leaching was apparent from the concentrations measured in the twelve to twenty inch layer, where it is unavailable to plant uptake. Decreasing concentrations in the surface layer for the two samples taken after fertilization were primarily due to plant uptake and/or leaching. Sidedressing applications increased nitrogen concentrations in the surface layer but did not tend to influence the subsurface layer. This suggests that the sidedress applications coincided with the times of high plant uptake requirements. Post harvest application of fertilizer for the winter cover crop of rye showed increased concentrations of NO₃-N in both the surface and subsurface layers. The observed absence of NH₄-N in subsoil layers indicated a tendency for the NH₄-N to leach.

The well water nitrate-nitrogen concentration data indicated several important points. During the first year, the well water samples from the experimental fertilizer management program fields registered higher NO₃-N concentrations than those from the current management program fields. This probably reflected antecedent management practices, and seemed to imply a considerable transit time between the surface and the groundwater. At each farm, current management program field well samples having greater NO₃-N concentrations than the experimental management program field well samples began to show up early in the second year (1976). This suggests that the experimental fertilizer management program may have been effective in reducing the NO₃-N concentrations leaching to the ground water. (For further details see reports of the Cornell Horticultural Research Station, L.I.)

The experimental management program consistently used 160 lbs/acre. The rate applied by the current management programs ranged between 190–270 lbs N/acre. The significance of this comparison is that the lower rates of fertilization were able to produce comparable yields. The premise of the experimental management program was that effective fertilizer applications must coincide with plant nutrient requirements. The peak of the nitrogen uptake occurs approximately six weeks after planting; therefore, the heaviest application should occur at this time. The experimental fertilization program applied 60 lbs N/acre at planting, and followed approximately six weeks later with a sidedress of 100 lbs N/acre.

Six weeks

The current fertilizer management programs apply the bulk of the fertilizer at planting, with a light sidedressing later in the season. If heavy rainfall occurs in the interval, and on Eastern Long Island this is more than likely, then the bulk of the fertilizer will be leached out of the root zone. Thus in the experimental fertilization program, the fertilizer is made more available to the plants and less susceptible to leaching to the groundwater.

The soil sampling program monitored nitrogen fertilizer movement during the potato season. A comparison of the fertilizer management programs indicates that there is approximately 40 to 70 percent more nitrogen available for leaching under the current management practices. The Long Island Horticultural Research Station calculated that, with efficient fertilizer management, 175 lbs N/acre/year would yield 125 lbs N in tubers/acre/year, and approximately 50 lbs N/year would be available for leaching. This leached nitrogen would produce a groundwater nitrate-nitrogen concentration of 10 mg/l if the annual recharge rate from precipitation is assumed to be 550 millimeters. This concentration is presently the maximum acceptable level for drinking water set by the USEPA. Therefore, it may be concluded that the previous rates of fertilization resulted in groundwater recharge concentrations that exceeded desired levels. Reductions in the rate of fertilization, in combination with the practice of timed fertilizer applications, have the potential to reduce nitrogen losses, while maintaining yields.

5.5 DOMESTIC ANIMALS AS A SOURCE OF NITROGEN

5.5.1 Dogs and Cats

As part of the 208 Program, the Soil Conservation Service (SCS) conducted a survey of households in five selected areas and found that “between 33% and 40% of the homeowners interviewed in the study of the sampled areas reported dog ownership” (Soil Conservation Service, 1977). The results of the survey were extrapolated to the whole Bi-county Region to produce an estimated total of between 300,000 and 360,000 (or 425,000 if stray are
included). This range corresponds closely to the estimate of 385,000 dogs, based on license data of the New York State Bureau of Dog Licensing. In order to avoid overestimating the canine nitrogen contribution, the following analysis uses a more conservative population estimate of 350,000.

From the same field survey, the Soil Conservation Service concluded that there are two cats to every three dogs in the region, or 233,000 in all. Assuming a human population of 2,736 million persons in the region, it follows that there is one cat to every twelve persons and one dog to every eight persons. Estimates of the total nitrogen load per dog per day were not readily available. For the purposes of the study, it was assumed that the nitrogen/BOD$_5$ ratio for humans could be applied to the animals. Hence:

\[
\text{Nitrogen load per dog} = 0.08 \text{ lb BOD}_5 \times 0.147 \text{ lb N/lb BOD}_5/\text{day} = 4.29 \text{ lb N/dog/year}
\]

Similarly, for cats, Loehr (1974) states that the BOD$_5$ load per cat per day is 0.06 lb. Therefore:

\[
\text{Nitrogen load per cat} = 0.06 \text{ lb BOD}_5 \times 0.147 \text{ lb N/lb BOD}_5/\text{day} = 3.22 \text{ lb N/cat/year}
\]

It is thereby possible to estimate the annual load of nitrogen from the pets per person as follows:

\[
\text{lb N from pets/person/year} = \frac{233,000 \text{ cats} \times 3.22 \text{ lb N/cat/year} + 350,000 \text{ dogs} \times 4.29 \text{ lb N/dog/year}}{2,736,000 \text{ persons}} = 0.82 \text{ lb N/person/year}
\]

A surprisingly large fraction of the nitrogen in freshly defecated matter is rapidly volatilized. In fact, data supports the hypothesis that approximately half the nitrogen in fresh animal waste is lost by volatilization as ammonia (Porter et al., 1975). For the purposes of this study, it was accordingly assumed that 50 percent of the nitrogen in pet waste would be lost in a gaseous form. It was also assumed that the remainder is deposited onto the soil surface, where it is available for removal by runoff or subsurface percolation. Thus, the actual nitrogen load from pets that may ultimately pollute ground and surface waters is equal to about 0.41 lb N/person/year.

5.5.2 Horses

It has been estimated by the Soil Conservation Service (SCS, 1977) that “there may be 30,000 or more horses in the bi-county planning area”. If it is assumed that the average nitrogen content in a horse’s daily waste is 0.3 pounds (Loehr, 1974) then the daily nitrogen loading from this source would be equivalent to over 300,000 persons, or about ten percent of the population. The magnitude of this equine source is therefore potentially highly significant.

The estimate of 30,000 horses, which has had wide circulation, appears to have originated in a were article, printed

in the Brooklyn, Queens and Long Island section of the New York Times, Sunday, July 28, 1974. In the article, the president of the Nassau-Suffolk Horseman’s Association claimed that despite the decline of Long Island as a horse center, “it is estimated that some 30,000 horses still remain on the Island”. The president did not indicate what fraction of this number applied to Nassau and Suffolk County, nor does other data apparently support the estimate.

In 1973, a SCS Survey of veterinarians identified 4,000 horses located in concentrations of ten or more animals. Since most horses are stabled in groups, this figure may account for a major portion of the horses, exclusive of race horses, in the Nassau-Suffolk Region.

It may be noted that in the 1974 Census of Agriculture, 34 farms were listed for Suffolk County as containing 321 horses. Even prior to the universal adoption of motor tractors on and off the farm, less than 15,000 farm and domestic horses and mules were reported for both Nassau and Suffolk Counties (1920 census).

It may further be noted that a significant part of the feed ‘or the region’s horses may be provided by the region itself, especially those animals which are pastured. Thus, the net addition to the region’s nitrogen economy would be correspondingly reduced. To pasture the 4,000 horses enumerated by the Soil Conservation Service would take about 1,000 acres. It is not known how much land is devoted to pasture in the Bi-county Region, although that on farms is negligible.

Finally, according to the SCS (1977), about 2,000 race horses may be housed in the region during the racing season. However, since the waste they produce is shipped daily to mushroom farms in Pennsylvania, these animals may be virtually ignored in the region’s nitrogen budget.

In summary, two conclusions are apparent. The total number of horses, and their distribution in the region are unknown, and their net contribution to the region’s nitrogen budget cannot be quantified. However, it would appear there are probably substantially fewer animals than the 30,000 that have been estimated. With existing data, it appears that the 5,000 non-racehorses is a reasonable estimate, and that these regionally would not represent a significant input to the nitrogen budget.

5.6 ASSESSMENT OF NITROGEN SOURCE EFFECTS ON GROUNDWATER QUALITY

5.6.1 Introduction

Several recent studies have examined groundwater data from Long Island in an attempt to gain a greater understanding of the main causes of contamination. Sulam and Ku (1977) examined long term records of groundwater quality in an unsewered area of southeast Nassau County, and concluded that the maximum concentration of contaminants had occurred during the most recent period, “when the effluents from thousands of cesspools and septic tanks were being discharged”. The authors also concluded that
fertilizers used before and during urbanization may have contributed large quantities of contaminants to the groundwater.

Katz (1978) made a very comprehensive study of data obtained from the southern half of Nassau County over the last twenty-five years, which showed that an improvement in the quality of groundwater with respect to nitrogen had occurred in the sewered part of the study area; improvement had also occurred in the unsewered area, but to a lesser degree. In another study of water samples from shallow wells, Katz (1978) examined short term variations in quality, and concluded that the fluctuation in quality appeared to be related to variations in non-point source pollution inputs. A preliminary analysis of trends in data from individual wells in Nassau County was made in an attempt to correlate urbanization and the extension of sewer service with groundwater quality. Unfortunately, the analysis failed to reveal a clear trend (see below).

Groundwater quality depends upon many factors, some of which may be markedly intermittent. For example, variations in the levels of inorganic nitrogen reaching groundwater may be governed by seasonal or meteorological factors, as suggested by Katz. Therefore, to adequately estimate an average concentration for a given year, a representative set of observations must be made. One observation per month appears to be a minimum number required. Analyses for annual trends will be misleading if good estimates of annual mean concentrations are lacking. Furthermore, a period of several years must be covered by the observations. When such factors as long term cyclical patterns in the weather are taken into account, a minimum period of at least ten years is needed. Since no wells in Nassau County have a sufficient number of observations within each year, or a continuous observation record lasting at least a decade, the trend analyses undertaken by Katz and others were inconclusive.

5.6.2 Soil Conservation Service Analysis

The SCS was able to overcome some of the problems discussed in the previous section by grouping observations from different wells located in the same vicinity and aquifer. An example of such a grouping is shown in Tables 5–12 and 5–13. Wells screened in the Upper Glacial aquifer in Nassau County were grouped according to the NSRBP land use grid cells. (See Figure 5–12.)

The median concentrations of wells in each cell, as estimated by the USGS, were averaged over the period 1972 to 1976. All grid cells that were entirely sewered, or those that were without sewers, and for which observations were available, are listed in Table 5–12 and 5–13, respectively. The corresponding estimated population densities which were derived by dividing the estimated 1975 population in each grid cell by the number of acres of land (usually 1,440) in each grid cell, are also shown. As can be seen, there appear to be significantly lower nitrate-nitrogen concentrations in the sewered areas. The overall unweighted average population density in the sewered area is 12.7 persons per acre, with a corresponding average nitrate-nitrogen concentration of 4.5 mg/l. This compares with a lower overall population density of 5.8 persons per acre in the unsewered area, and a higher average median concentration of 5.8 mg/l. It should be noted that this comparison must be accepted with caution, since the histories of the areas within the two sets of grid cells differ.

After examination, the estimated average of the medians for two of the grid cells in Table 5–13, grid cells 81 and 123, were considered to be unreliable. Grid cell 81 is located in Bayville, on the North Shore of Nassau County. Measurements were available from only one well, which was screened

<table>
<thead>
<tr>
<th>Grid Cell No.</th>
<th>Persons/Gross Acre</th>
<th>Average Median* (mg/l)</th>
</tr>
</thead>
<tbody>
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<td>6.4</td>
<td>5.6</td>
</tr>
<tr>
<td>19</td>
<td>12.2</td>
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<td>4.4</td>
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<td>13.7</td>
<td>1.4</td>
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<tr>
<td>31</td>
<td>11.8</td>
<td>7.2</td>
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<td>33</td>
<td>14.1</td>
<td>3.9</td>
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<td>5.8</td>
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<td>43</td>
<td>10.2</td>
<td>6.8</td>
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<td>11.0</td>
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<td>4.9</td>
</tr>
<tr>
<td>159</td>
<td>11.2</td>
<td>9.4</td>
</tr>
</tbody>
</table>

*Medians based on observations made during 1972–76 from 49 wells.

Source: USGS Open-file report 76–845

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at about 160 feet. Therefore, data from grid cell 81 were omitted from further analyses. Grid cell 123, which is in Levittown, had the largest number of wells and observations. Land use within grid cell 123 is primarily residential, with a population density of 10.5 persons per gross acre. Despite the uniformity of land use, concentrations of nitrate-nitrogen varied from less than 1 mg/l to about 16 mg/l (see Table 5–14), and the range is even larger if the individual observations, rather than the averages, are considered.

Table 5–14 shows that long term averages can be misleading, since after 1965, samples were no longer collected from the two wells with the highest average concentrations. Abandoning wells producing poor quality water and replacing them with new wells is a common procedure. As a result, aggregate long term averages of well data may be biased in that they tend to understate pollutant concentrations.

A linear regression analysis was made relating population densities to the average of the median concentrations in the other grid cells. The result is shown in Figure 5–13. The relation obtained was based on observations over the period 1972–1976 for all wells, with the two exceptions noted, located in the Upper Glacial aquifer in unserved areas (see Table 5–13). Another analysis was performed independently using observations from wells that were carefully selected according to location and depth (Weston, 1977). Although this analysis mainly considered southeast Nassau County, the results obtained were very similar.

The variability of nitrate-nitrogen concentrations measured at public water supply wells makes it difficult to interpret these data in relation to the drinking water standard of 10 mg NO₃⁻/l (applicable to water at the tap). An average (mean) value of 10 mg/l at the wellhead implies that the measured nitrate-nitrogen concentrations will exceed this level an unspecified percentage of the time. In order to assess the health implications of wellhead nitrate-nitrogen concentrations, the relationship between mean nitrate values and the percentage of measurements violating the 10 mg/l standard must be determined. An evaluation of this relationship for Nassau County wells was made by Porter (1977).

Porter's statistical analysis required the calculation of 90th, 80th, 70th, 60th, and 50th percentile values (the nitrogen concentration values below which the various percentages of measured concentrations occurred). Wells were grouped according to NSRPA land use grid cells so that the calculation of 90th percentile values, which requires at least 30 well measurements, could be made. A total of seventeen Nassau County grid cells, with a combined total of 865 observations from 54 wells, were utilized by Porter (see Table 5—15). Linear regression analyses were made for each set of percentile values and associated means in each grid cell (see Figure 5—14).

Figure 5—14 indicates the relationship between the average (mean) con-
Table 5–13

POPULATION DENSITIES AND THE AVERAGE OF THE MEDIAN
NITRATE-NITROGEN CONCENTRATIONS IN WATER FROM WELLS
SCREENED IN THE UPPER GLACIAL AQUIFER IN AREAS WITHOUT SEWERS

<table>
<thead>
<tr>
<th>Grid Cell No.</th>
<th>Persons/Gross Acre</th>
<th>Average Median* (Mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>55</td>
<td>3.3</td>
<td>6.6</td>
</tr>
<tr>
<td>65</td>
<td>0.9</td>
<td>1.9</td>
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<tr>
<td>71</td>
<td>1.5</td>
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<td>81</td>
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<tr>
<td>82</td>
<td>4.2</td>
<td>3.1</td>
</tr>
<tr>
<td>84</td>
<td>0.7</td>
<td>1.5</td>
</tr>
<tr>
<td>104</td>
<td>4.4</td>
<td>2.3</td>
</tr>
<tr>
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<td>120</td>
<td>6.3</td>
<td>9.8</td>
</tr>
<tr>
<td>123</td>
<td>11.9</td>
<td>2.3**</td>
</tr>
<tr>
<td>133</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>140</td>
<td>12.8</td>
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<td>8.4</td>
</tr>
<tr>
<td>174</td>
<td>8.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Overall Average</td>
<td>5.8</td>
<td>5.8</td>
</tr>
</tbody>
</table>

*Medians based on observations made during 1972–76 from 27 wells.
**This estimate appears to be highly biased. See text for discussion.
Source: USGS Open file report 76–845.

The concentration of nitrate-nitrogen measured at a particular well and the percentage of the measurements for that well that will be less than a specified concentration (in particular, the 10mg NO3-N/l concentration used as the standard for drinking water). For example, if the average value of nitrate measurements for a well is 6mg/l, then 90% of the measurements from that well will be less than 10 mg/l (or conversely, 10% of the measurements will be greater than 10 mg/l). Similarly, if the average value of nitrate measurements is 7.1 mg/l, then only 80% of the measurements will be less than 10 mg/l (see Table 5–15).

Figure 5–14 can also be used to determine the average (mean) concentration of nitrate-nitrogen measured at a well that would correspond to a specified percentage of compliance with the 10 mg/l drinking water standard (or some other standard). For example, if it is desired that 90% of the samples from a well have concentrations below 10 mg/l (i.e., meet the drink-

ing water standard 90% of the time), then the average (mean) concentration for water from the well would have to be less than or equal to 6 mg/l. Similarly, if compliance with the 10 mg/l standard is desired for only 50% of the samples (i.e., 50% of the time), then the average concentration in the well water could be as high as 10.3 mg/l (see Table 5-16).

The relationships between population density and groundwater nitrate-nitrogen concentrations (see Figure 5-13), and between groundwater nitrate-nitrogen concentrations and the percentage of violations of the drinking water standard (see Figure 5-14) can be compared to relate population density to percent violations (see Table 5-16). The statistical analysis relating population densities to variation in groundwater concentrations, as specified by percentage violation of the standard, is justified as a planning tool in the absence of reasonably convenient alternatives. The following three reservations should be noted:

1. The analysis is more empirical than statistical.
2. It would be an error to interpret the analysis as demonstrating a relation between population density, per se, and groundwater quality. Population density, as a statistical variable, is correlated with many other variables, including highways, animals, and lawns (Weston, 1977). Cross correlations between such variables have been discussed by Haith (1975).
3. The groundwater data used for the analysis itself may be misleading. On purely theoretical grounds, the concentrations of nitrate-nitrogen appear too low. When all the sources of nitrogen associated with human settlements are considered, it appears remarkable that a population of ten persons per acre, with all the associated sources of nitrogen, would correspond to an average concentration of about 8 mg/l of nitrogen in the underlying groundwater. At normally assumed values of recharge (about twenty inches per year) a concentration of 8 mg/l would result from a per capita loading of about four pounds of nitrogen per year. Such a value is remarkably low, since the quantity of original nitrogen associated with an individual is close to four times that value.

That the observed groundwater concentrations are frequently unexpectedly low has been remarked by others. This may also be seen when the gross estimates of the nitrogen loads originating from the major sources are tabulated (see Section 5.7).

From a management standpoint, it is important to recognize the limitations in relying exclusively on existing groundwater data to guide management decisions. Since sources of groundwater contamination are subject to management, rather than the groundwater itself, it appears prudent, when deriving management policies, to quantify the actual sources themselves.

5.7 NITROGEN BUDGET FOR NASSAU AND SUFFOLK COUNTIES

5.7.1 Nitrogen Budget Formulation

In order to construct a comprehensive nitrogen budget for Nassau and Suffolk Counties, a computer program was developed at Cornell University that considers the relationships shown schematically in Figure 5-15. Computations were made for areas defined by the NSRPB land use grid cells (see Figure 5-12). The hydrological computations required for the program were based on the Bi-county Regional Water Budget Model described by Baskin (1977). By using the water budget model in combination with the nitrogen balance calculated for each grid cell, it was possible to estimate nitrogen loads in surface runoff to marine waters, and the loads and corresponding concentrations of inorganic nitrogen that leach to groundwater.
Table 5–15

SUMMARY OF WELL DATA USED TO DERIVE MEAN PERCENTILE RELATIONSHIPS

<table>
<thead>
<tr>
<th>Grid Cell No.</th>
<th>Number Wells</th>
<th>Number Observ.</th>
<th>Median</th>
<th>Average</th>
<th>Standard Deviat.</th>
<th>90%</th>
<th>80%</th>
<th>Percentiles 70%</th>
<th>60%</th>
<th>50%</th>
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<tr>
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<td>8.9</td>
<td>8.4</td>
<td>7.6</td>
<td>7.2</td>
<td>6.7</td>
</tr>
<tr>
<td>77</td>
<td>4</td>
<td>37</td>
<td>4.4</td>
<td>4.8</td>
<td>2.0</td>
<td>8.7</td>
<td>6.2</td>
<td>5.5</td>
<td>4.7</td>
<td>4.4</td>
</tr>
<tr>
<td>82</td>
<td>2</td>
<td>53</td>
<td>4.5</td>
<td>8.2</td>
<td>6.5</td>
<td>16.9</td>
<td>15.2</td>
<td>13.3</td>
<td>8.9</td>
<td>4.5</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>63</td>
<td>1.8</td>
<td>1.7</td>
<td>0.5</td>
<td>2.4</td>
<td>2.1</td>
<td>1.9</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>123</td>
<td>11</td>
<td>130</td>
<td>2.7</td>
<td>5.0</td>
<td>5.3</td>
<td>13.9</td>
<td>9.7</td>
<td>7.3</td>
<td>4.8</td>
<td>2.7</td>
</tr>
<tr>
<td>141</td>
<td>3</td>
<td>38</td>
<td>15.0</td>
<td>13.7</td>
<td>7.1</td>
<td>23.1</td>
<td>20.0</td>
<td>19.0</td>
<td>18.0</td>
<td>14.5</td>
</tr>
<tr>
<td>142</td>
<td>3</td>
<td>31</td>
<td>8.7</td>
<td>8.1</td>
<td>4.7</td>
<td>14.2</td>
<td>11.0</td>
<td>10.0</td>
<td>9.0</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Table 5–16

RELATIONSHIP BETWEEN PERCENT VIOLATIONS OF THE 10 mg/l STANDARD FOR DRINKING WATER, MEAN GROUNDWATER NITRATE CONCENTRATIONS AND POPULATION DENSITIES

<table>
<thead>
<tr>
<th>Percent violations</th>
<th>mean concentrations mg/l</th>
<th>population densities persons/gross acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>6.0</td>
<td>6.7</td>
</tr>
<tr>
<td>20%</td>
<td>7.1</td>
<td>8.6</td>
</tr>
<tr>
<td>30%</td>
<td>7.9</td>
<td>9.8</td>
</tr>
<tr>
<td>40%</td>
<td>8.7</td>
<td>11.2</td>
</tr>
<tr>
<td>50%</td>
<td>10.3</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Figure 5–16 shows the computed range of average inorganic nitrogen concentrations in percolating water in unsaturated soil for Nassau and Suffolk Counties. Table 5–17 lists the estimates of gross nitrogen loadings to the marine bays. For comparison, the estimates made by Tetra Tech (NISRPB, 1978) are included. Agreement between the two sets of results is reasonable for the North Shore bays and Peconic River, but less so for the South Shore bays. It should be noted that the methods of estimation used are different. Tetra Tech's estimates were largely based on the field measurements made during the 208 Program. The Cornell estimates are derived from water and nitrogen budgets.

A nitrogen budget for the region is presented in Table 5–18. As shown in the table, the estimated annual load of nitrogen carried down to groundwater by regional recharge is over 16,000 tons. This nitrogen is primarily in the nitrate form, and about 30 percent of it originates from human wastes discharged to the ground. The 16,000 tons that appears in the groundwater is only about 50 percent of the original load. Runoff accounts for very little of
FIGURE 5–15  Macromodel of Nitrogen Leaching.

The difference, and it is believed that denitrification in the soil is a major factor. A very large portion of the nitrogen input to the Long Island system is believed to escape to the atmosphere in the gaseous form.

The figures given in Table 5–18 represent gross averages for the entire Bi-county Region. It must be recognized that a great deal of variability will be encountered under specific conditions. Also, the relative average magnitudes of the various components will change from locality to locality within the region. Table 5–19 shows gross estimates of nitrogen produced in a residential area with medium density housing (three houses per acre). A comparison with the estimates in Table 5–18 shows that the relative magnitudes of the loads from the various sources for medium density residential land use differ from those for the region as a whole. The original total load of nitrogen for the acre would produce a concentration of inorganic nitrogen of about 30 mg/l, if it all leached. On the basis of work done during the 208 program, it has been estimated that additions in nitrogen levels during, or prior to, leaching to groundwater, would produce an actual concentration closer to 15 mg/l. This compares with 10 mg/l that would be predicted by empirical relations based on groundwater data presented in Section 5.6.

The variability in the relative magnitudes of major nitrogen sources—domestic waste (population), fertilizers, precipitation, domestic pets—as a function of population density, is shown in Figure 5–17. The estimates depicted in the figure were derived from the nitrogen budget applied to unserved areas (the grid cells listed in Table 5–13) with various land use mixes and household income levels (see Sections 5.4 and 5.6). Clearly, the variation in potential nitrogen loads from area to area is an important consideration when developing wastewater management policies for specific areas.
5.7.2 Summary and Conclusions

The amount of nitrogen released into the Long Island environment by major sources of nitrogen was estimated. The estimation was made utilizing field data for fertilizer obtained during the period of the study, and a review of the literature on other sources.

Extensive and intensive monitoring of nitrogen was also performed to determine the downward movement of nitrogen from fertilizer through the upper soil profiles under different conditions. This, combined with other data obtained during the recent 208 Study, provided a comprehensive means of estimating the transport of nitrogen, from its sources, down to groundwater and overland to surface waters.

A computer program was constructed to provide a convenient means of identifying water and nitrogen budgets for each of the grid cells defined by the Nassau-Suffolk Regional Planning Board. Components in the budgets were related to land use characteristics.

The following conclusions were reached:

1. The major sources of nitrogen are human waste and fertilizers, which annually contribute approximately 14,000 and 13,000 tons, respectively.

2. Available data indicates that there are large (e.g., 50%) reductions of nitrogen in on-site disposal systems, although variations in removal capability may vary significantly.

3. Available data indicates that most of the nitrogen applied to turf is lost to ground and surface waters, except in those cases where clippings are removed and taken to landfills.

4. It is estimated that about 75 percent of nitrogen applied to agricultural crops such as potatoes is removed by the crop.
Table 5–18
SUMMARY OF GROSS ESTIMATES OF SOURCES AND FATE
OF NITROGEN IN THE BI-COUNTY REGION
(based on 1975 and 1976 data)

<table>
<thead>
<tr>
<th>Source</th>
<th>Initial Nitrogen Load (tons/yr)</th>
<th>Load to Groundwater (tons/yr)</th>
<th>Comment on Sink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-site systems</td>
<td>8,500</td>
<td>4,300</td>
<td>(Denitrification, etc.)</td>
</tr>
<tr>
<td>Sewers &amp; sewage treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewer leakage</td>
<td>500</td>
<td>200</td>
<td>(Denitrification, etc.)</td>
</tr>
<tr>
<td>Effluent discharge to ground</td>
<td>200</td>
<td>100</td>
<td>(Denitrification, etc.)</td>
</tr>
<tr>
<td>Effluent discharge to marine bays</td>
<td>4,200</td>
<td>–</td>
<td>(Discharge to sea)</td>
</tr>
<tr>
<td>Sub-total</td>
<td>13,400</td>
<td>4,600</td>
<td></td>
</tr>
<tr>
<td>Fertilizers and Animals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm (Incl. sod farms)</td>
<td>4,000</td>
<td>1,000</td>
<td>(Crop removal)</td>
</tr>
<tr>
<td>Turf (Incl. households, golf courses, etc.)</td>
<td>9,300</td>
<td>5,600</td>
<td>(Volatilization &amp; Denit.)</td>
</tr>
<tr>
<td>Animals (primarily dogs &amp; cats)</td>
<td>1,600</td>
<td>800</td>
<td>(Volatilization &amp; Denit.)</td>
</tr>
<tr>
<td>Ducks</td>
<td>600</td>
<td>300</td>
<td>(Volatilization &amp; Denit.)</td>
</tr>
<tr>
<td>Sub-total</td>
<td>15,500</td>
<td>7,700</td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td>4,000</td>
<td>3,700</td>
<td>(By difference from totals)</td>
</tr>
<tr>
<td>Total</td>
<td>32,900</td>
<td>16,000*</td>
<td>(Totals estimated by water/nitrogen model)</td>
</tr>
</tbody>
</table>

*Assuming an annual recharge of about 500 billion gallons, the resulting concentrations in the leachate equals about 6.8 mg/l.

Table 5–19
ESTIMATED ANNUAL LOADS ORIGINATING ON AN ACRE
OF RESIDENTIAL LAND WITH THREE HOUSES

<table>
<thead>
<tr>
<th>Source</th>
<th>Lbs. of Nitrogen Load</th>
<th>Approx. load to Groundwater</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Persons</td>
<td>100</td>
<td>50</td>
<td>(10 lbs. N/person)</td>
</tr>
<tr>
<td>15,000 sq. ft. turf</td>
<td>45</td>
<td>25</td>
<td>(average household income $16,000)</td>
</tr>
<tr>
<td>Pets</td>
<td>10</td>
<td>5</td>
<td>(0.82 lbs/person approx.)</td>
</tr>
<tr>
<td>Precipitation</td>
<td>10</td>
<td>6</td>
<td>(1 mg/l)</td>
</tr>
</tbody>
</table>

FIGURE 5–17 Relationships Between Population Density and Nitrogen Loadings to Groundwater from Major Pollution Sources.
BIBLIOGRAPHY


Schmitz, N. Lawns. Circular 143. State College, Pennsylvania: The Pennsylvania State College School of Agriculture and Experiment Station, Division of Agriculture Extension, 1931.


6.0 INTRODUCTION

Two water quality objectives defined by Public Law 92–500 are the elimination of the discharge of pollutants into navigable waters by 1985, and achievement, by 1983, of interim goals, which provide for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water. Achieving these goals requires meeting the criteria for “fishable and swimable water.” The New York State Environmental Conservation Law calls for the promulgation of rules and regulations setting limits for total and fecal coliform bacteria, dissolved oxygen, copper, zinc, total dissolved solids and other parameters.

Other goals not specifically defined under the law but also of great importance are the reduction of sediment, the control of nitrogen and phosphorus, and the prevention of salt water intrusion into surface and groundwaters.

Inasmuch as animal wastes appear to contribute to the pollution of the Nassau-Suffolk surface and groundwaters, they must be considered in water quality management planning.

The purpose of this section is to define and identify the non-point sources of pollution that are caused by animal wastes in the bi-county area and to recommend appropriate actions.

Animal population, waste characteristics, waste impact and control are discussed in detail. General recommendations and specific recommendations for waste control are included.

Nassau and Suffolk are suburban counties, with a 1977 population of approximately 2.8 million. Although Suffolk leads all counties in the State in dollar income from farming, it has few farm animals other than commercial market ducks. However, the bi-county area has many pets, recreation horses, and wild animals. Except for market ducks, animal populations are generally widely scattered and dispersed, with few concentrations.

Estimates of manure production per animal or per 1,000 pounds of live weight vary widely as do the estimates for each component of manure. These factors vary as a function of animal species, breed, age, sex, type of feed, climate, and measurement methods. Table 6–1, which is based on average values, indicates the relative importance of different animal wastes in the bi-county region. Table 6–2 shows the daily production and composition of livestock manure (feces and urine).

The values in Table 6–1 represent only the solids portion of animal manure. The liquid portion, although not represented, also contains BOD, nitrogen and other components. The daily per animal values for BOD shown in Table 6–1 were calculated from pounds of BOD per day per 1,000 pounds of live weight, using average weights of 125 pounds for humans, 1,000 pounds for horses, four pounds for ducks, 1,350 pounds for cattle, 4.5 pounds for poultry, and 150 pounds for swine. The daily per animal value for dogs was derived from Table 6–5 and other sources. Wild ducks (not included
### Table 6-1

**SUGGESTED HUMAN AND ANIMAL WASTE PRODUCTION VALUES FOR BIOCHEMICAL OXYGEN DEMAND (BOD) AND BACTERIOLOGICAL CONTENT**

<table>
<thead>
<tr>
<th>Biotype</th>
<th>Nassau-Suffolk Population (Numbers)</th>
<th>Single Animal (Grams)</th>
<th>Total Population (Pounds)</th>
<th>BOD per Animal Per Day (Pounds)</th>
<th>Human BOD Equiv.</th>
<th>Daily Total Human BOD Equivalent</th>
<th>Total Animal BOD Load (% Human)</th>
<th>Coliform</th>
<th>Fecal Streptococci</th>
<th>FC/FS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>2,735,637</td>
<td>150</td>
<td>903,000</td>
<td>0.17</td>
<td>1.00</td>
<td>2,735,637</td>
<td>100.0</td>
<td>NA</td>
<td>13.30</td>
<td>3.0</td>
</tr>
<tr>
<td>Dog</td>
<td>425,000</td>
<td>227</td>
<td>212,500</td>
<td>0.13</td>
<td>0.76</td>
<td>323,000</td>
<td>11.81</td>
<td>18.0</td>
<td>18.00</td>
<td>7.300</td>
</tr>
<tr>
<td>Horse</td>
<td>30,000</td>
<td>16,100</td>
<td>1,063,875</td>
<td>1.40</td>
<td>8.24</td>
<td>247,200</td>
<td>9.04</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Duck</td>
<td>750,000</td>
<td>336</td>
<td>400,000**</td>
<td>0.02</td>
<td>0.12</td>
<td>90,000</td>
<td>3.29</td>
<td>NA</td>
<td>32.70</td>
<td>53.6</td>
</tr>
<tr>
<td>Cattle</td>
<td>1,825</td>
<td>26,300</td>
<td>105,721</td>
<td>1.89</td>
<td>11.12</td>
<td>20,294</td>
<td>0.74</td>
<td>NA</td>
<td>0.23</td>
<td>1.3</td>
</tr>
<tr>
<td>Chicken</td>
<td>121,200</td>
<td>182</td>
<td>48,587</td>
<td>0.02</td>
<td>0.12</td>
<td>14,544</td>
<td>0.53</td>
<td>NA</td>
<td>1.30</td>
<td>3.4</td>
</tr>
<tr>
<td>Swine</td>
<td>635</td>
<td>2,700</td>
<td>3,776</td>
<td>0.34</td>
<td>0.20</td>
<td>1,270</td>
<td>0.05</td>
<td>NA</td>
<td>3.30</td>
<td>84.0</td>
</tr>
</tbody>
</table>

*Fecal Coliform-Fecal Streptococci ratio

**Total volume of waste from market ducks adjusted for probable age distribution and does not include wild or semi-wild population.


in this table, are about one pound lighter than market ducks. Information regarding cats, turkeys, wild geese and other animals was not available. However, geese can be roughly estimated at 4.5 times the duck figures (H.W. Oneth, November 30, 1976).

Coliform bacteria are a major component of urban and rural stormwater runoff and have been a factor responsible for the closure of portions of Great South Bay to shellfishing. Table 6-3 shows the total coliform and fecal coliform counts in stormwater runoff from four typical Long Island areas. Stormwater samples were collected by the Soil Conservation Service (SCS) staff during the spring, summer and fall of 1976 and analyzed by New York State Department of Environmental Conservation.

The values in Table 6-3 indicate that the suburban and agricultural areas contribute similar amounts of total coliform bacteria. High total coliform counts are expected from agricultural areas, since normal soil coliform bacteria, *Aerobacter aerogenes*, are included as part of the total coliform count. They also indicate that agricultural watersheds contribute markedly fewer fecal coliform bacteria. Since the urban areas studied have sanitary sewers, it is logical to assume the probable source of their high fecal coliform counts is animal. Dogs were inventoried in approximately 35 percent of the households. The Baldwin site watershed drains directly into Baldwin Bay.
### Table 6-2

**DAILY PRODUCTION AND COMPOSITION OF LIVESTOCK MANURE (FECES AND URINE)**

(Upper figure is average; lower figures represent the range given in literature)

(Dashes indicate data not available or entry not appropriate)

<table>
<thead>
<tr>
<th></th>
<th>Dairy Cattle</th>
<th>Beef Cattle</th>
<th>Feeder Swine</th>
<th>Breeder Swine</th>
<th>Poultry 1/1000 lb live weight</th>
<th>Sheep</th>
<th>Horses</th>
<th>Catfish</th>
<th>People</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manure</strong></td>
<td>85</td>
<td>62</td>
<td>69</td>
<td>50</td>
<td>53</td>
<td>36</td>
<td>50</td>
<td>31.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>72–90</td>
<td>41–68</td>
<td>50–90</td>
<td>32–67</td>
<td>30–40</td>
<td>40–60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Solids</strong></td>
<td>9.3</td>
<td>8.9</td>
<td>7.2</td>
<td>4.3</td>
<td>13.9</td>
<td>2/4</td>
<td>9.5</td>
<td>17.5</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>6.8–13.5</td>
<td>6.0–11.1</td>
<td>6.0–9.0</td>
<td>9.0–17.4</td>
<td>2/13–31</td>
<td>8.4–10.7</td>
<td>2.8–3.5</td>
<td>2.4–4.4</td>
<td></td>
</tr>
<tr>
<td><strong>Volatile Solids</strong></td>
<td>6.9</td>
<td>6.9</td>
<td>5.7</td>
<td>3.2</td>
<td>10.8</td>
<td>2/14.5</td>
<td>8.0</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>5.7–7.9</td>
<td>4.8–8.2</td>
<td>4.0–7.0</td>
<td>8.0–12.9</td>
<td>2/8–17.5</td>
<td>6.0–8.1</td>
<td></td>
<td>1.1–2.6</td>
<td></td>
</tr>
<tr>
<td><strong>BOD₅</strong></td>
<td>1.4</td>
<td>1.5</td>
<td>2.3</td>
<td>1.3</td>
<td>3.4</td>
<td>5.1</td>
<td>0.8</td>
<td>1.4</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>0.8–1.8</td>
<td>1.0–1.8</td>
<td>2.0–2.8</td>
<td>1.5–5.5</td>
<td>4.1–7.6</td>
<td>0.7–0.9</td>
<td>1.1–4.9</td>
<td>0.6–2.10</td>
<td></td>
</tr>
<tr>
<td><strong>COD</strong></td>
<td>8.4</td>
<td>7.9</td>
<td>5.9</td>
<td>5.2</td>
<td>12.5</td>
<td>–</td>
<td>10.0</td>
<td>–</td>
<td>3.12</td>
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<tr>
<td></td>
<td>4.2–13.3</td>
<td>6.6–9.0</td>
<td>4.7–7.1</td>
<td>9.5–15.8</td>
<td>7.5–12.0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Total Nitrogen as N</strong></td>
<td>0.37</td>
<td>0.43</td>
<td>0.45</td>
<td>–</td>
<td>0.86</td>
<td>1.42</td>
<td>0.40</td>
<td>0.30</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>0.29–0.51</td>
<td>0.30–0.58</td>
<td>0.20–0.70</td>
<td>0.46–1.50</td>
<td>1.17–1.62</td>
<td>0.34–0.45</td>
<td>0.7–2.5</td>
<td>0.14–0.26</td>
<td></td>
</tr>
<tr>
<td><strong>Total Phosphorus as P</strong></td>
<td>0.069</td>
<td>0.090</td>
<td>0.17</td>
<td>–</td>
<td>0.40</td>
<td>0.62</td>
<td>0.075</td>
<td>0.12</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0.026–0.100</td>
<td>0.023–0.170</td>
<td>0.09–0.27</td>
<td>0.20–0.75</td>
<td>0.4–0.9</td>
<td>0.040–0.120</td>
<td>0.24–0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total potassium as K</strong></td>
<td>0.20</td>
<td>0.23</td>
<td>0.26</td>
<td>–</td>
<td>0.35</td>
<td>0.9</td>
<td>0.32</td>
<td>0.25</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>0.08–0.35</td>
<td>0.11–0.38</td>
<td>0.10–0.60</td>
<td>0.12–0.50</td>
<td>0.6–1.2</td>
<td>0.24–0.40</td>
<td>0.7–2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although there are built-up areas on Long Island that do not shed storm runoff to any surface waters, the densest population centers are located in watersheds that discharge directly to the marine edge and to inland lakes and ponds. These watersheds share similar topography and soil characteristics. Highways and local roads are mostly depressed below the ground level and serve as the principal drainage channels for runoff water. Hempstead, Babylon, Islip, and portions of Brookhaven and Southampton towns all drain into Great South Bay and its tributaries.

The residents in the Great South Bay watersheds use garden sprays and fertilizers, and pet populations are apparent. Some residents were observed dumping dog waste and oil into storm sewer inlets. When questioned, most people demonstrated little awareness of the environmental impact of these
practices.

In the past thirty years the introduction of the recharge basin, a form of large excavated pit vertical drain, has provided for storm water discharges from most new subdivisions in Suffolk County and many in Nassau. An evaluation of the impact of waste carried into these recharge basins and its possible effect on groundwaters is not included as a part of this report.

Dogs and semi-wild ducks were found to be major sources of non-point pollution in the bi-county area. Market, ducks, horses, cattle, wild ducks and geese may be major sources of pollution locally, but vary widely in both volume and characteristics of the waste material.

Other sources of non-point pollution such as deer, seagulls, and miscellaneous wildlife were not considered because adequate waste information was not available.

6.1 ANIMAL POPULATIONS

Agricultural animals in the bi-county region are generally found in small groups and in widely scattered locations. There are an estimated 500 dairy cows and 1,300 other cattle and calves; 121,000 chickens; 26,000 turkeys; and up to 750,000 market ducks. Sheep number 120; swine, 635; and horses on agricultural units, 550 (U.S. Department of Commerce, 1976). The recreational horse population is estimated at 30,000 and the dog population, at 425,000.

6.1.1 Cats

Cats outnumber all domestic animals except dogs. In the course of homeowner interviews in selected study areas in the two counties, it was found that there were about 2/3 as many cats as dogs. If this ratio is valid, the bi-county area contains an estimated 285,000 cats. Neither the existing literature nor the SCS interviews gave any indication that cat fecal waste poses a surface water pollution problem.

6.1.2 Dogs

Dogs are generally found in high concentrations in suburban and vacation-recreation areas. Nassau and Suffolk Counties follow this pattern, encountering problems of overpopulation and limited dog controls. The actual number of dogs in Nassau-Suffolk can only be estimated, because a reliable census count has not been compiled.

The following paragraphs discuss some of the common estimating methods and the results obtained when they are applied to the bi-county area.

The New York State Department of Agriculture and Markets licensed 135,143 dogs in Nassau in 1975 and 121,795 dogs in Suffolk. The two counties alone account for almost 25 percent of the total New York State dog registration. The number of dogs licensed in the bi-county area can be assumed to be considerably short of the actual total number of dogs for several reasons: first, only dogs over six months of age are licensed; second, owners caught with unlicensed dogs are usually required to obtain a dog license without penalty (newer dog owners questioned perceived not licensing their dog as a reasonable gamble); third, the present basis for dog licensing, i.e., the dog census, taken by local municipalities to identify those homes having dogs, is conducted in a way that does not best serve the purpose of dog licensing controls. Dog owners may not be at home or they may not report their dogs completely. The per dog fee paid to enumerators for taking the census is too small to generate a vigorous search for even a majority of the dog owners. A total of 287,951 dogs were enumerated in the bi-county area in 1976.

According to New York State Bureau of Dog Licensing, less than two thirds of all dogs are actually licensed (Kehrer, 1976). Applying this ratio to the license figures results in an estimate of 385,000 dogs. If the same ratio is applied to the 1976 enumeration figures, the estimate is 462,000.

The dog population can also be estimated using interview material from the detailed study of watershed areas. Between 33 and 40 percent of the homeowners interviewed in the study of five sampled areas reported dog ownership. Among dog owners, one in five, or 20 percent reported more than
one animal. If it is assumed that ownership patterns in the sampled areas are representative of those in the Island as a whole, and that the Nassau-Suffolk Regional Planning Board estimate of a total of 750,000 households is correct, then the bi-county dog population comprises between 300,000 and 360,000 animals.

Still another method of estimating dog populations was used by Beck (A. Beck, 1973). He suggests that human population numbers can be used as a basis for predicting number of dogs. A ratio of 7:1 for urban and 5:1 for suburban areas should be used. On the basis of Beck’s ratios, the estimated 2,738,000 bi-county residents could be expected to own between 400,000 and 470,000 dogs. Dr. R.W. Johnson (1975) estimated that in 1975, in Nassau County alone, there were approximately 350,000 dogs.

The canine population is increasing rapidly. In fact, the dog population on Long Island and in the nation is expanding more rapidly than the human population. Anvik (1974) estimates that the nationwide rate is 4.5 percent per year. Djarassi, et al (1973), estimated that 2,000 to 3,000 dogs and cats are born hourly in the United States. Others have suggested that hourly birth rates may be as high as 10,000.

The number of stray dogs in an area has a strong effect on the growth rate of the canine population. Strays are defined as any dogs running loose, whether licensed or not. Dogs released temporarily by their owners are technically stray dogs.

This impact of strays is discussed further, and in detail in The Ecology of Stray Dogs: A Study of Free Running Urban Animals by A. Beck (1973). Hummer (1975) reports that a single fertile stray female dog can generate more than 400 additional female dogs in five years under ideal conditions. Strays are more common in the more densely populated suburban areas, probably due to a greater availability of food.

Table 6—4 provides recent dog license and enumeration figures, which may be used to estimate dog populations in Long Island municipal subdivisions.

In summary, the dog population of the bi-county area is between 300,000 and 500,000. For purposes of this report, 425,000 has been selected as the most likely number. Canine numbers are increasing at an estimated rate of over four percent per year. Stray dogs play a major role in these increases.

### 6.1.3 Wildfowl

Certain wildfowl population figures are available from the New York State Department of Environmental Conservation Mid-winter Aerial Wildfowl Census. For the Long Island area in January 1975, diving ducks numbered 56,200; other ducks, 17,100; geese, 4,800; Brant, 24,000; swans, 700; and Mergansers, 6,700. In 1976 total counts declined slightly, while in 1977, the numbers of wildfowl enumerated returned to 1975 levels.

### Table 6—4

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hempstead</td>
<td>59,995</td>
<td>50,682</td>
<td>Atlantic Beach</td>
<td>482</td>
<td>223</td>
</tr>
<tr>
<td>North Hempstead</td>
<td>21,957</td>
<td>22,573</td>
<td>Bayville</td>
<td>613</td>
<td>813</td>
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<tr>
<td>Oyster Bay</td>
<td>30,525</td>
<td>29,048</td>
<td>Bellrose</td>
<td>128</td>
<td>130</td>
</tr>
<tr>
<td>Cities</td>
<td></td>
<td></td>
<td>Cedarhurst</td>
<td>553</td>
<td>535</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Centre Island</td>
<td>113</td>
<td>117</td>
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<td></td>
<td></td>
<td></td>
<td>Floral Park</td>
<td>1,829</td>
<td>1,522</td>
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<td>Glen Cove</td>
<td>2,418</td>
<td>2,064</td>
<td>Laurel Hollow</td>
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<td>325</td>
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<tr>
<td>Long Beach</td>
<td>1,953</td>
<td>1,874</td>
<td>Freeport</td>
<td>3,916</td>
<td>3,336</td>
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<tr>
<td>Town</td>
<td></td>
<td></td>
<td>Garden City</td>
<td>2,002</td>
<td>2,332</td>
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<tr>
<td>Babylon</td>
<td>27,515</td>
<td>21,564</td>
<td>Hempstead</td>
<td>3,260</td>
<td>2,593</td>
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<tr>
<td>Brookhaven</td>
<td>35,324</td>
<td>26,372</td>
<td>Hewlett Bay Park</td>
<td>84</td>
<td>79</td>
</tr>
<tr>
<td>East Hampton</td>
<td>1,683</td>
<td>2,302</td>
<td>Hewlett Neck</td>
<td>71</td>
<td>64</td>
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<tr>
<td>Huntington</td>
<td>18,175</td>
<td>24,687</td>
<td>Lynbrook</td>
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<tr>
<td>Islip</td>
<td>39,811</td>
<td>23,206</td>
<td>Malverne</td>
<td>1,021</td>
<td>1,005</td>
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<tr>
<td>Riverhead</td>
<td>2,674</td>
<td>2,824</td>
<td>Massapequa Park</td>
<td>3,075</td>
<td>2,727</td>
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<tr>
<td>Shelter Island</td>
<td>378</td>
<td>1,597</td>
<td>Mill Neck</td>
<td>291</td>
<td>269</td>
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<tr>
<td>Smithtown</td>
<td>12,633</td>
<td>11,894</td>
<td>Old Brookville</td>
<td>336</td>
<td>300</td>
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<tr>
<td>Southampton</td>
<td>2,747</td>
<td>3,066</td>
<td>Oyster Bay Cove</td>
<td>436</td>
<td>439</td>
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<tr>
<td></td>
<td>6,500</td>
<td>4,283</td>
<td>Rockville Centre</td>
<td>2,124</td>
<td>2,238</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sea Cliff</td>
<td>896</td>
<td>807</td>
</tr>
</tbody>
</table>

### Table 6—4

<table>
<thead>
<tr>
<th>Village</th>
<th>Enumerated 1974</th>
<th>Licensed 1974</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Rockaway</td>
<td>1,535</td>
<td>1,153</td>
</tr>
<tr>
<td>Farmingdale</td>
<td>640</td>
<td>621</td>
</tr>
<tr>
<td>Hewlett Harbor</td>
<td>206</td>
<td>197</td>
</tr>
<tr>
<td>Island Park</td>
<td>526</td>
<td>524</td>
</tr>
</tbody>
</table>

**Total Enumerations 287,951**

**Total Licensed 256,938**

227
The Federation of New York State Bird Clubs (1976) reports about 6,500 wintering Canada and snow geese. If it is assumed that a typical goose (Oneth, 1976) is four to five times the weight of a duck and has similar waste characteristics, it can be estimated that 100 geese produce 330 pounds of manure in a 24-hour period. This means that the total average wintering goose population produces 21,450 pounds of manure daily. Much of this is discharged directly into surface waters or adjacent to them.

Canada geese located on ponds along Merrick Road and the Sunrise Highway in Nassau County are changing their migration habits and are becoming year round residents, according to Dr. R.W. Johnson (1975). This change, which may be the result of feeding by man, sharply increases the waste loading from geese on these ponds. The greenskeeper at the Lake Success Golf Course reports fairway grass heavily damaged by the droppings of Canada geese living on and near the lake. Crop farmers in the Mecox Bay area report that certain farm fields are heavily manured by geese in fall and winter. Geese are attracted to the fields by the winter cover crops. Some of these fields shed storm runoff to Mecox Bay.

6.1.4 Semi-wild Ducks

White Pekin ducks that have been released, abandoned, or have escaped, and their descendants that are produced from interbreeding between the White Pekins and wild ducks are sometimes called "Indian Runners". These semi-wild ducks also include crosses between Indian Runners and wild ducks. The first and second generation cross breeds are too heavy bodied, 4.3 pounds and up, to sustain prolonged flight. They usually have a light tan appearance, pinto coloration, and large white patches on the neck, breast and tail. The male Indian Runner-Mallard cross usually has a black head; the female cross is without the distinctive black mask on the beak.

An accurate count of the semi-wild ducks on Long Island's inland ponds is not available. White Pekin ducks have been observed in the bi-county area on many ponds including Hook Pond in East Hampton, Wethamton Sanctuary, Barry Road Pond, Wading River Pond, Blydenburgh Park Pond, Argyle Lake, Stony Brook Mill Pond, Setauket Mill Pond, Cowen's Lake and the Peconic River. (See map at the end of this section).

The origin of the semi-wild duck population is largely related to the practice of giving baby ducklings to children at Easter. Park employees interviewed reported noticeable increases in the white duck populations within two months after Easter. An inventory of semi-wild duck populations on fresh surface waters in Nassau is currently being conducted by the Nassau Heath Department (Natural Resources Defense Council, Inc., 1975). Inventory data was not available at this writing. John Renkavinsky, Fish and Wildlife Division, New York State Department of Environmental Conservation, estimated the inland pond wild duck population for Nassau-Suffolk at 18,000 (Renkavinsky, 1976).

A count of the semi-wild duck population is essential to help educate the public as to the need for the control of pet duck sales and the release of pet ducks. The Federation of New York Bird Clubs and/or other organizations might include such a count when they make their next annual bird count effort.

6.1.5 Horses

The Nassau-Suffolk Horsemen's Association, Inc. estimates that there are approximately 30,000 horses in the bi-county area. However, the Association officials, concerned about regulations, have been reluctant to locate or identify horse concentrations. Prior to 1973, the Cooperative Extension Service office at Riverhead attempted to locate horse owners in order to control an outbreak of equine encephalitis.

Response was limited and counts have since been lost. In 1973 the Riverhead staff of the SCS, in attempting to locate concentrations of horses of ten or more animals, contacted most of the large animal veterinarians within the bi-county area. Good cooperation was received. Only 4,000 horses were located in concentrations of ten or more animals.

The 1974 United States Census of Agriculture (1976), lists 60 farms having nearly 600 horses and the telephone book lists 25 commercial riding stables in Nassau County and about 50 in Suffolk. Two racetracks, Belmont and Roosevelt Raceway, house about 2,000 horses in season and half that number when the racing season is closed. Veterinarians report local areas in both counties—Muttontown, Brookville, East Patchogue, Oakdale, and Sayville among them—where the number of horse owning residents is well above the Nassau-Suffolk average. Horseback riding is a popular family activity in the bi-county area. The presence of more than 75 commercial riding stables and of many private clubs and horse farms indicates a prominent future for the Long Island riding horse.

In summary, there may be 30,000 or more horses in the bi-county planning area, and probably less than 5,000 are housed in concentrations of ten or more. Approximately 25,000 horses are owned and housed in singles, pairs or small numbers, as a widely dispersed population of large animals. The dispersion of the horse population suggests that there may be many small non-point equine waste pollution sources affecting Long Island surface waters.

6.2 ANIMAL WASTE CHARACTERISTICS

Waste composition varies with animal age, breed, sex, and feed (Moore, 1970). For example, ducks produce about twice the daily volume of waste of humans, but more than five times the fecal coliform bacteria and more than 36 times the fecal streptococci. Tables 6-1 and 6-2 provide additional details regarding this variability. The following paragraphs describe the waste characteristics of dogs, semi-wild ducks and horses:
6.2.1 Dog Waste

The volume or weight of waste generated by a dog population can vary according to size, age, diet, and level of activity. Johnson (1975), concludes that an average Nassau County dog will produce a half-pound of feces and 3/4 quart of urine daily. Kramer (1971), estimates that 500,000 New York City dogs produce 110,000 pounds of waste on a dry basis each day. The half-pound of waste per dog per day value is regarded as conservative by veterinarians (Oneth, 1976).

A study in Saskatoon, Saskatchewan Canada (Anvik, Hyne and Rahaman, 1974), estimated that the city’s 13,200 dogs produced 7,260 pounds of solid waste per day. It also estimated that 29,300 pounds of dog solid waste were on the streets of Saskatoon on March 30, 1973. A detailed study of a sample area of twenty of the city’s 1,400 blocks provided the basis for these figures. Beck has reported that a large dog will produce 50 percent more waste than the average sized dog under similar conditions (Beck, 1973). Using 425,300 as the most probable number of dogs for the bi-county area, the SCS estimates that the total daily yield of dog waste amounts to about 106 tons of feces and 80,000 gallons of urine. This would amount to approximately 38,700 tons and 29 million gallons annually.

More documentation of the composition of dog waste is needed in view of its impact on Long Island surface waters. Generally dog wastes are high in nitrogen and are a source of coliform bacteria. The results of laboratory analyses of three collections in the Chicago area are shown in Table 6–5.

<table>
<thead>
<tr>
<th>Item</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Soluble, mg/100 ml</td>
<td>16.5</td>
<td>20.2</td>
<td>178.3</td>
</tr>
<tr>
<td>Volatile Water Soluble, mg/100 ml</td>
<td>10.3</td>
<td>15.9</td>
<td>145.8</td>
</tr>
<tr>
<td>BOD₅, mg/l</td>
<td>78</td>
<td>377.3</td>
<td>300</td>
</tr>
<tr>
<td>COD*</td>
<td>200.7</td>
<td>552</td>
<td>720</td>
</tr>
<tr>
<td>Coliform, MPN/g</td>
<td>16,090</td>
<td>16,090</td>
<td>1,400,000</td>
</tr>
</tbody>
</table>

*Source does not provide dimension, assumed to be mg/l.
Source: American Public Works Association; Water Pollution Aspects of Urban Runoff; USDI; Federal Water Pollution Control Administration; Washington, D.C.; January 1969.

6.2.2 Duck Waste

Certain specific kinds of ducks, other than commercial ducks and wild ducks cause pollution of surface waters on Long Island. They are the semi-wild White Pekin ducks and their descendants that do not migrate.

The amount and characteristics of waste produced by semi-wild ducks is similar to that produced by White Pekin ducks. Variations are due to differences in feeding, activity and age (Moore, 1970). Domestic farm reared ducks are known to be heavy feeders. During the first seven weeks of their lives they can consume 21 pounds of concentrated feed. Young semi-wild ducks can be expected to consume even larger volumes of food, since the food they eat is not concentrated.

Best estimates indicate that 100 semi-wild ducks on a typical park pond can produce 74 pounds of duck manure per day or 13.5 tons per year (Geldreich, 1969 and Wadleigh, 1969). A group of 100 semi-wild ducks would contribute about 207 pounds of nitrogen, 90 pounds of phosphorus, and 130 pounds of potash to such a pond each year. Each duck adds eleven billion fecal coliform bacteria to its watery environment each day.

Table 6–6, which shows the average amounts of the major nutrients contained in the daily waste per 1,000 pounds live weight of humans, ducks, and chickens, facilitates comparison of the nutrient loadings attributable to each of these sources.

<table>
<thead>
<tr>
<th>Nutrient (lbs.)</th>
<th>Man</th>
<th>Ducks</th>
<th>Chickens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen as N</td>
<td>0.20</td>
<td>1.42</td>
<td>0.86</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.024</td>
<td>0.62</td>
<td>0.40</td>
</tr>
<tr>
<td>Total K</td>
<td>0.064</td>
<td>0.9</td>
<td>0.35</td>
</tr>
</tbody>
</table>


Duck waste is a concentrated pollutant. Table 6–7 confirms that bacteria and nutrient levels of White Pekin duck waste are especially high in coliform and nitrogen and exceed those of humans and chickens.

6.2.3 Horse Waste

An average horse produces eight to eleven tons of feces and urine per year (SCS), or, stated somewhat differently, a 1,000 pound horse will average 0.9 cubic feet of waste per day of which 65 percent will be water (Parr, 1974). Given the estimated 30,000 horses kept in the Nassau-Suffolk area, the expected daily waste production would be between 660 and 900 tons. Yearly horse waste figures probably total 300,000 tons, exclusive of bedding straw, chips or hay. By comparison, a human population of 2,700,000 people produces an estimated human waste total of 1,725,000 tons yearly.
Table 6-7
ESTIMATED PER CAPITA CONTRIBUTION OF INDICATOR MICROORGANISMS

<table>
<thead>
<tr>
<th>Animal</th>
<th>Daily Production</th>
<th>Ratio FC/FS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fecal Coliform, (Million)</td>
<td>Fecal Strept, (Million)</td>
</tr>
<tr>
<td>Man</td>
<td>2,000</td>
<td>450</td>
</tr>
<tr>
<td>Ducks</td>
<td>11,000</td>
<td>18,000</td>
</tr>
<tr>
<td>Chickens</td>
<td>240</td>
<td>620</td>
</tr>
</tbody>
</table>

As indicated in Table 6-8, horse waste is relatively low in five day biochemical oxygen demand (BOD₅) and higher in phosphorus than most other animal wastes.

Table 6-8
AVERAGE COMPOSITION OF ANIMAL MANURES
lbs/day/1,000 lbs. of live weight

<table>
<thead>
<tr>
<th></th>
<th>Horses</th>
<th>Ducks</th>
<th>Poultry</th>
<th>Cows</th>
<th>People</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD₅</td>
<td>1.4</td>
<td>5.1</td>
<td>3.4</td>
<td>1.4</td>
<td>1.36</td>
</tr>
<tr>
<td>N-Nitrogen</td>
<td>0.30</td>
<td>1.42</td>
<td>0.86</td>
<td>0.37</td>
<td>0.20</td>
</tr>
<tr>
<td>P-Phosphorus</td>
<td>0.12</td>
<td>0.62</td>
<td>0.40</td>
<td>0.069</td>
<td>0.024</td>
</tr>
<tr>
<td>K-Potassium</td>
<td>0.25</td>
<td>0.9</td>
<td>0.35</td>
<td>0.20</td>
<td>0.064</td>
</tr>
</tbody>
</table>


Horse feces generally contain a higher percent of undigested nutrients than that present in human wastes. The waste from a single horse contains eleven times the BOD of an average human. The 30,000 horses in the bi-county area produce waste having the equivalent BOD₅ of 330,000 people.

6.3 ANIMAL WASTE IMPACT

In any animal waste management planning and control program, careful attention must be paid to the extreme variability in both volume and characteristics of the animal waste in question. The following paragraphs discuss actual and potential impact of wastes from dogs, ducks, and horses in the bi-county area.

Burge (1974), in his consideration of health hazards associated with animal waste, concludes that the incorporation of manures into farm fields lowers the impact of animal wastes on the environment and provides a sound and reasonable disposition of animal waste. Feces deposited on grassy soil areas are reduced by sunlight and air, and are less likely to be washed away by storm water. Soluble pollutants and bacteria are more likely to be washed into the topsoil layer where pollutants are consumed, impounded and recycled.

Recent studies indicate that if proper management is followed, manures can be applied to land on a year-round basis to achieve a lowered environmental impact. Young and Mutchler (1976), report that less than three percent of the total nitrogen and four percent of orthophosphate in manure ran off of manured, sloping land during the winter when it was fall plowed preceding the application. This contrasted with sixteen to twenty percent of total nitrogen and orthophosphate in the runoff from similarly treated grassland. It is concluded that level, or nearly level, fall plowed cropland can effectively retain animal manures that are applied to frozen ground if such procedure is necessary to control or reduce pollution from animal waste accumulations over winter. At other times spreading and plowdown or soil injection of animal waste slurry is appropriate for land application of animal wastes.

6.3.1 Dog Waste Impact

Dr. P. M. Schantz (1976), of the Center for Disease Control, Atlanta, Georgia, has stated that there is “a potentially important public health problem as a result of the increasing numbers of stray dogs in urban areas...” Marron et al. (1974), found that at least thirteen diseases are transmitted to man by parasites in dog feces, including salmonellosis, tuberculosis, toxoplasmosis and visceral larval migrans.

Beck and others (Beck, 1973; Burge, 1974; and Johnson, 1975) have commented extensively on the problem of dog feces in public areas as it relates to pollution and health. Dogs assimilate only 30 to 50 percent of their food, providing food for rats in their excrement. Dogs are attracted to beaches and parks by the food scraps.

Dog urine causes cankers and other damage to trees and thus increases landscape maintenance or replacement costs (Hummer, 1975).

In 1973, James Redman (1973), Aquatic Biologist for New York State Department of Environmental Conservation (NYSDEC) at Stony Brook, reported that, “Storm water runoff has been directly responsible for most of the recent closures of shellfish growing areas. Results of these (urban land runoff) sample examinations demonstrated conclusively that this (runoff) material transports large numbers of organisms. Methods should be developed for diverting urban runoff from estuarine waters.”

Redman analyzed a number of street runoff water samples for fecal coliform and fecal streptococci. Microbiologists generally agree that the fecal coliform content of human waste will be more than two times the fecal streptococci content. In animal waste, it is usually the reverse. A majority of Redman’s samples showed the fecal strep to be more numerous, supporting the contention that animals are the major source of the fecal colii in storm runoff.
The example of a single southeastern Nassau village lends further credence to Redman's findings. Residents of Massapequa Park have 2,727 licensed dogs. Application of the previously described estimation techniques indicates that the total dog population comprises 4,090 animals producing some 373 tons of solid animal waste annually. This village sheds or diverts most of its storm drainage water to South Oyster Bay. Using the Saskatoon, Canada figures cited above (Anvik, Hynie and Rahaman, 1974), an estimated 9,000 pounds of solid dog waste is present at any particular time on the streets of such a village. Much of this will be flushed into the Bay by the next major rainstorm.

6.3.2 Duck Waste Impact

The duck waste impact includes pollution from domestic duck farm operations, from the White Pekin duck that has been released or abandoned, and from the wild duck population.

6.3.2.1 Duck Farm Operations. Major changes in duck farm operations are now taking place. Discharges of treated wastewater have decreased from more than 5,000,000 gallons per day in 1972 to less than one-third of that amount in 1976. Storm runoff which formerly flowed through the farms is now largely contained or will be by mid-year. A few farms have already eliminated wastewater discharges completely. Solid waste consists of sludge from treatment lagoons, scrapings from pens, and straw and manure cleaned from buildings. Building manure is taken or given to gardeners or spread on crop fields. The sandy pen scrapings are frequently used as fill within the closed system. Some farmers cover rather than scrape. Lagoon sludge is removed and trucked away by cesspool cleanout firms. The SCS believes that this sludge should be applied to agricultural land as a valuable soil amendment. However, specialized manure handling equipment is needed.

In the United States as a whole, land application of duck wastes, including partially treated duck process waste water, has been considered the generally appropriate and available method for waste disposal for the duck industry. However, on Long Island fewer than five farms have sufficient land for such a procedure. Only about half the duck farms are so located that nearby vacant land, which could be combined with owned land to provide sufficient acreage for irrigation of the waste water, is available for sale or lease.

If correct management is followed, animal waste can be disposed of by applications on a year-round basis without adverse impact on ground or surface waters. (Graber, 1974; Moore, 1970; Purr, 1974; SCS, 1975; Wadleigh, '68; Young and Mutchler, 1976; and Burge, 1974). Because of variations in soil, slope and waste characteristics, adjacent land use, and other factors, each application site requires planning on an individual basis. Conservation plans, as prepared for farm operators by the SCS working through the Suffolk County Soil and Water Conservation District, can include such planning.

The SCS classifies soils by "hydrologic groups". Knowledge of these groupings can provide guidance for proper management of irrigation waste water. Soils in Group "A" are moderately rapidly permeable sands, have limited internal surface area, limited absorption capacity and base exchange capacity. Soils in Group "B" have 30 to 80 percent fines, are moderately slowly permeable and have greater runoff potential than the "A" soils. Soils in groups "C" and "D" are not common and are of little significance on Long Island. Although "B" group soils are present in the bi-county area, they are not usually found on or near existing duck farms, an important factor in planning waste application rates.

A combination of waste water management measures is probably the best approach to the achievement of zero discharge that is available to duck farmers today. These measures should include the treatment and recycling of wastewater in periods of no precipitation, and irrigation of wastewater on managed hayfields after storms. To accomplish this, water use flows must be cut to the minimum during and after periods of rainfall. Adequate storm water holding ponds or holding areas should be developed. Continued operation of present treatment systems would be necessary, but without discharges to receiving waters. In most cases irrigation equipment and land would have to be added.

Another option for waste water disposal involves the use of the marsh-pond waste treatment system, pioneered by Maxwell Small of Brookhaven Laboratory and the Town of Brookhaven. Approximately sixteen of the present duck farms do have sufficient land for such a facility. Marsh-pond treatment is designed to produce a high quality effluent appropriate for high rate land application.

An additional as and yet unattractive alternative for duck farmers is duck production without waste water. So far, this has been tried without economic success, making this option uncompetitive and unsuitable at the present time. The nationally renowned Duck Research Laboratory at Eastport would be the logical institution to undertake further research on the question.

Relocation of duck farms to interior areas of Long Island has been suggested. However, studies to determine the impacts of such a relocation on the movement of nitrogen and other pollutants through the soil are needed before relocation can be endorsed.

If the completely dry operation concept were to become fully and economically feasible, relocation, if it were still necessary, would then become more realistic. Such an operation requires continuous housing, which has been particularly unsuccessful with the "breeder" ducks that produce the eggs for starting new ducklings every seven weeks.

6.3.2.2 Semi-wild Ducks. The White Pekin pet duck that has been released or abandoned onto a public pond is dependent on feeding by humans for survival. It is common to see parents bring their children to feed these ducks at local ponds. Unable to fly in search of food, the semi-wild duck
becomes an aggressive beggar, making the act of feeding more rewarding for children. Such feeding sustains high duck populations, promotes growth, and indirectly, pollutes the pond. The Nature Conservancy recognizes that the feeding of wildlife creates this kind of problem and prohibits feeding at its sites on Long Island. Artificial feeding also alters the eating and migrating habits of wild ducks that visit the pond.

Ducks have an aquatic orientation and their waste is deposited directly into or near surface waters. Ponds, especially in residential areas, are under particular stress. Extraneous inflows such as those from urban storm runoff are often rich in nutrients that stress the ecosystem. Any unnecessary duck waste can further upset a pond’s nutrient balance and can be responsible for production of excessive algae and weeds and the presence of high coliform counts.

Numerous diseases are communicated to animals and man via waters contaminated with duck wastes. These duck related diseases include the following: Salmonella, Psittacosis or Ornithosis, Type A Influenza, Yobal Virus, Eastern Equine Encephalitis (E.E.E.), Schisosomiasis (Swimmer’s Itch) and New Castle Disease. All but Eastern Equine Encephalitis can be passed to humans through waste contaminated water (Burger and Maher, 1977).

Swimming at Hempstead Harbor beaches was recently jeopardized because of high levels of coliform (8,000–10,000 MPN/100ml) at the outfall of Roslyn Park Pond. The large duck population, over 500 birds on the pond, was deemed responsible for the high coliform counts. In addition to chlorinating the pond outflow, the town officials transplanted ducks from this pond to other town ponds. The population of “Indian Runners”, sustained in large measure by hand feeding, had grown so rapidly that, in effect, a pollution problem was transplanted along with the ducks. The present resident duck population at Roslyn Park Pond is now estimated to include over 100 White Pekins.

6.3.2.3 Wild Ducks. The wild duck populations of Long Island are a cherished part of our wildlife heritage. Much of the general public is unsympathetic toward the duck hunter, insisting on strong enforcement of federal and state laws that limit duck hunting. These same protective attitudes toward ducks reinforce the concept of feeding semi-wild ducks on inland ponds.

To a degree, wild ducks pollute bays and ponds. Brandvold, et al. (1976), in their study of the influence of wild ducks and waterfowl on surface waters, concluded that large migrating populations increase the available nitrogen and phosphorus compound and cause increased oxygen demand.

6.3.3 Horse Impact

Although it is comparatively easy to prove that there are a large number of horses producing vast quantities of waste that constitute a serious threat to Long Island surface waters, it is not possible to criticize the average horse owner for waste mismanagement. The relatively few known concentrations of waste are managed relatively well, with most stable waste stored away from storm runoff wash, and most accumulations faithfully picked up by gardeners, farmers or trash collectors.

At Belmont and Roosevelt Raceways, stables are cleaned daily and a large amount of straw is used to absorb waste liquids. The waste is stored in bins, one for every 26 horses, and these are emptied twice each week. The manure is loaded on trucks and shipped daily to mushroom farms in Pennsylvania.

Commercial riding stables usually stockpile manure out of sight behind buildings and provide some rainfall runoff protection. Some owners lime the manure or use a fly repellent. The waste is given to gardeners, nurserymen or farmers. The demand seems to exist this far round. No large piles were observed at the stables visited.

There have been isolated instances of complaints about commercial stables and stable owners expressed concern over their neighbors’ past complaints to the local health department. Such complaints had been followed by a visit from the health inspector, who provided guidelines for cleaning up the nuisance.

Most local governments issue a general business license to commercial stables. The license evidently has no connection with waste management or complaints. However, some riding stable owners expressed concern that the license might be used to limit their activities in the future.

During this study, horses were observed in a variety of locations—garages, backyards, woodlands, near ponds in residential settings. In isolated cases runoff from small paved surfaces having horse waste was seen draining into surface waters. The field staff only occasionally observed situations where storm runoff washed horse waste onto the drainage ways of neighboring properties.

Manure applied to nearly level to gently rolling grasslands at the rate of ten to 30 tons of dry waste per acre per year presents little or no hazard from nitrate runoff or leaching. Applications in excess of 30 tons per year can result in potentially harmful nitrate leaching (Parr, 1974).

6.4 ANIMAL WASTE CONTROLS

The Federal Water Pollution Control Act, 1972 Amendments, (PL 92-500) and subsequent EPA guidelines and standards as published specify those animal feeding operations that are subject to permit regulations:

"Only an animal feeding operation defined as concentrated animal feeding operations is subject to the permit requirements. Such an operation occurs where: (1) more than 1,000 animal units are confined and there is a discharge of pollutants more frequently than that resulting from a 25-year, 24-hour storm event; (2) more than 300 and less than 1,000 animal units are confined and there is a discharge of pollutants into navigable waters more frequently than that resulting from a 25-year, 24-hour storm event through a man-made device or directly into
navigate, water flowing through a feedlot; (3) there are 300 animal units or less confined and the Director of the State Program, after an on-site inspection, determines that pollutants are discharged into navigable waters through a man-made device or directly into navigable waters flowing through a feedlot.” (Final NPDES regulations from the March 18, 1976 Federal Register on concentrated animal feeding operations.)

The New York State Sanitary Code classifies animal wastes as both offensive material and sewage when the animal wastes are water borne. Section 17-0105, Article 17, of the State Environmental Conservation Law, defines sewage as the “water-carried human or animal wastes from residences, buildings, industrial establishments or other places together with such ground water infiltration and surface water as may be present...” This section of the law together with related health rules and regulations provides a limited basis for the control of animal waste pollution by designated state and local agencies. However, the definition of “sewage” does not specify a lower limit of animal waste concentrations. Street runoff carrying dog waste components may be “sewage” under the law.

California, Iowa, Maine, Nebraska and Ohio, states with substantial animal husbandry, have passed laws or rules and regulations controlling disposal of farm animal wastes and have developed guidelines for land disposal and/or irrigation of liquid manures. However, no state laws were found to deal with wastes from dispersed animal populations.

The California State Water Resources Control Board has issued guidelines for the disposal of animal wastes to protect water quality and prevent other problems. Storm water management devices must be designed to accommodate the flow from a 10-year frequency, 24-hour storm. Storm runoff must not flow through manure storage areas on farms or other animal enterprises.

Iowa considers land application of animal wastes the primary means of disposal. The Water Quality Commission has formulated a policy giving recommended application rates and time of application. It includes a procedure to be used on land near watercourses that are subject to ten year frequency flooding.

Maine has developed guidelines for animal waste disposal, which, although they do not have the effect of law, are cited as references in municipal ordinances. Conformance with the guidelines is required as a condition of approval for large farm development. The guidelines specify time and rates of application of waste and of waste spreading with regard to water courses or water supply sources. Soils and slopes receive special attention. Conditions for manure piling and lagoon liquid manure disposal by irrigation are covered. Commercial fertilizer relationships are suggested.

Nebraska has rules and regulations primarily addressing animal waste disposal from point sources with no consideration for waste from pastures or rangeland. Rule No. 20 of “Rules and Regulations Pertaining to Livestock Waste Control” focuses on proper storage and disposal concentrations of animal waste to prevent water and land pollution. It includes a prohibition of manure spreading on frozen ground, and, therefore, represents a degree of animal waste control that reduces non-point source pollution.

Ohio’s sediment and animal waste control law provides for implementation of non-point source control through soil and water conservation districts and locally prepared conservation plans (Unger, 1976). A Livestock Waste Management Guide has been prepared to assist an owner in the selection of a waste handling system. It deals primarily with cattle and swine, but some mention is made of horses. Specific mention is made of rainfall runoff. The value of manure as a source of plant nutrients, i.e., as fertilizer, is stressed.

Present New York State and local health regulations that permit the control of offensive material provide that upon receipt of a complaint, a health department representative may investigate and cause a hearing to be held relative to a “nuisance”, and may subsequently require the abatement of such nuisance.

Except for the 28 duck farms, Suffolk and Nassau counties have fewer than twenty commercial livestock or animal husbandry farm operations. Very few abut surface waters. Accumulated animal wastes are managed in accordance with present controls. These controls appear to be sufficient to prevent serious or repeated animal waste pollution from livestock farm operations in the bi-county area. The following paragraphs describe existing and proposed controls affecting dogs, ducks and horses.

6.4.1 Dog Controls

The first New York State Dog Control Law was enacted in 1917. This law, which superseded local laws that were considered ineffective, was a licensing law intended to protect domestic animals from dogs and to create a fund to compensate the animal owners for damages caused by dogs (Kehrer, 1975 and Renkavinsky, 1976). The 1929 revision to the New York State Dog Control Law included authority to impose restrictions on the keeping and running of dogs at large. Dogs are the only animals required to have a license in New York State.

In 1973, the New York State Department of Agriculture and Markets proposed a revision of the 1929 dog licensing law to achieve more effective dog population control. Many of the suggested changes were strongly opposed by dog owners during a series of emotion-filled public hearings. Notwithstanding their apparent unpopularity, the same law change proposals have merit today. The 1973 proposed law included the following provisions, none of which were enacted (Kehrer, 1975):

1. Substantial increases in fees for fertile dogs, with moderate fees for sterilized dogs.
2. Ear tattoos for identification (as now used with cattle).
3. Electronic data processing for licenses and enumeration, to be sup-
plemented by the existing animal control officers, who would also register new dogs.

4. Provision to allow withholding of dog control funds from any municipality failing to adequately control and enumerate their dogs.

The shortcomings of the present law are revealed in part, by the above proposals for change. Local units of government are supposed to hire dog enumerators to canvas an area and to list all dogs. Dog census takers are paid 50 cents per dog counted. Dog owners may not be contacted, or may not acknowledge all their dogs, or the census taker may lose interest when not enough dogs are found per hour of work.

The Dog Control Laws enacted recently on Long Island deal primarily with the nuisance of dog waste on streets and lawns, and usually require dog waste clean up. Dog waste related complaints are common. Nassau County Health Department reported 550 animal waste related complaints during 1975, and an expenditure of $32,000.00 in salaries to service them (Cooperative Extension Service of Suffolk County, 1975).

Local leash laws are designed to prevent dogs from running loose, causing damage or a nuisance, or threatening the public. All towns and villages in Nassau and Suffolk counties except the Town of East Hampton reported having a leash law. East Hampton and Southampton Towns ban dogs from beaches and Hempstead Village, Valley Stream, and Roslyn exclude dogs from parks.

Dog curb laws may have a negative effect on the environment. East Hills and Rockville Centre have dog curbing laws requiring that owners walking dogs allow their pets to defecate only at or near the street curb. In theory, the waste will then be swept up by street cleaning operations. In fact, animal waste in or near the road is easily flushed into the storm drainage system by rainstorm runoff. The drainage system empties into bays and estuaries, recharge basins, etc.

Dog cleanup laws, discussed subsequently, are one alternative to simple curbing ordinances. Other alternatives found in literature searched included dog toilets, or grassed areas near apartment buildings (probably would become offensive); punitive license fees, including a WCBS editorial suggestion of $1.00 per pound of body weight; waste areas at parks, authority for dog wardens to shoot free roaming dogs on sight; authority to require neutering of captured dogs before being returned to a claiming owner; etc. It was concluded that none of the above had sufficient merit and/or appeal to receive popular support.

Residents of Eastern Suffolk County are concerned about summer vacationers who often acquire dogs and then leave them behind upon their return “to the city”. It was frequently suggested that dogs belonging to temporary residents be required to have an ear tattoo and be registered.

Dog controls are a highly emotional subject, as evidenced at numerous public hearings on dog laws. Strong leadership at the county and regional level may be necessary to bring about significant improvements in dog waste management.

6.4.2 Duck Controls

Duck farm animal waste disposal is regulated by Federal and State laws. Under those laws, duck farms are required to achieve zero discharge of wastewater to any receiving surface waters by 1983. A majority of the present Long Island duck farmers now plan to meet this requirement.

Wild duck population numbers are affected to a degree by Federal and State regulation of hunting. The Federal law sets hunting seasons, bag limits and areas where lead shot may not be used. State and local laws may further specify areas where hunting is prohibited or limit hunting in other ways. The overall effect is to protect and stabilize migratory waterfowl populations. Long Island tidal wetlands have been classified as “The most important coastal waterfowl area in the North Atlantic States” (Natural Resources Defense Council, Inc., 1975).

Semi-wild ducks are not specifically controlled or protected by law. The State law, authorizing towns and municipalities to establish dog catchers as peace officers with certain police powers, is not clear as to whether such persons can enter properties to capture and remove semi-wild ducks. Property owners can, under this law, have the town or municipality receive and impound the ducks which an owner removes from his property.

The Soil Conservation Service has found no law or section of a law that can be construed to support the contention that semi-wild ducks are a public nuisance. However, Article 26, Section 354 and Article 25B, Section 35 of the Agriculture and Markets Law do address aspects of the problem. The first, which attempts to discourage the sale of baby ducks for pets, states that, “No person shall sell, offer for sale, barter or give away live baby chicks, ducklings or other fowl under two (2) months of age in any quantity less than six” (Berman, 1970). In attempting to solve the problem of domestic ducks polluting local ponds, these laws may have complicated the issue by encouraging larger purchases. The second, which applies to dogs and other animals as well as ducks, states that: “The owner . . . of an animal, who abandons such animal . . . is guilty of a misdemeanor, punishable by imprisonment of not more than one year or by a fine of not more than $500 or both.”

6.4.3 Horse Controls

The present primary document for statewide control of horse waste is the New York State Public Health Law, which cites animal wastes as sewage when they are water borne, whether carried by storm runoff or baseflow seepage, and as a public nuisance when the waste is offensive to neighboring property owners. Upon complaint, a health department representative may investigate, cause a hearing to be held relative to the nuisance, and require the abatement of the problem.

Zoning ordinances are often used to control the keeping of horses and, indirectly, the related problems. In the more densely populated areas in western Nassau County, such ordinances frequently prohibit the stabling of horses or limit such activities to a few selected locations.

Babylon Village and others require a special permit. In Smithtown,
where larger lots are more common, one horse may be kept on half an acre and up to three horses on one acre of land. Southold and Brookhaven allow no more than two horses on one acre of land. The Islip Town Board recently passed an ordinance prohibiting keeping a horse on less than half an acre of ground. or more than two horses on each additional half an acre. Horse owners must provide stables with no less than 50 square feet of space, covered containers for manure, rodent-proof feed storage places and at least 400 square feet of outside corral space "enclosed by a suitable fence" ten feet from the property line. A $5.00 two-year license for each horse is required.

Methods for handling waste disposal are specified in Smithtown, Brookhaven and Islip ordinances. Closed waterproof containers away from property lines are required for manure storage. Huntington requires tertiary treatment of wastewater at dairies and commercial stables, unless served by the municipal sewage system; but has no regulation for horse manure disposal from private residences.

Outside the New York area, the Ogden, Utah and Greenwich, Connecticut codes prohibit the housing of horses or other large farm type animals or their waste, within 75 feet of a public street, drain or body of water.

6.4.4 General Recommendations

Recommendation I: Require that each landowner having concentrations of animals that exceed those stated in the table below, have a soil and water conservation plan.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Maximum Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equine</td>
<td>2</td>
</tr>
<tr>
<td>Beef Cattle</td>
<td>3</td>
</tr>
<tr>
<td>Dairy Cows</td>
<td>2</td>
</tr>
<tr>
<td>Turkeys</td>
<td>160</td>
</tr>
<tr>
<td>Chickens</td>
<td>500</td>
</tr>
<tr>
<td>Hogs</td>
<td>14</td>
</tr>
<tr>
<td>Ducks</td>
<td>400</td>
</tr>
<tr>
<td>Sheep</td>
<td>24</td>
</tr>
<tr>
<td>Dogs</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 6-9

MAXIMUM ANIMALS PER ACRE OF OPEN LAND WITHOUT A CONSERVATION PLAN

or any combination of animals exceeding 2,000 lbs. of body weight.


Under present State law, almost every agricultural producer must obtain a soil and water conservation plan by January 1, 1980. An amendment to the Soil and Water Conservation Districts Law, Chapter 441, of the Laws of New York 1975, directed the New York State Soil and Water Conservation Committee to define the lower limits of animal concentrations for concentrated agricultural operations. Table 6-9 above, quotes the figures that were adopted for all animals except dogs. This item has been added in response to local needs. The above recommendation will extend coverage to non-agricultural animals whose owners maintain high concentrations of animals per acre.

Chapter 441 describes a soil and water conservation plan as a "document containing proposals for the conservation of soil and water resources, and which provides an orderly method for landowners and occupiers to follow in limiting soil erosion and reducing the amount of pollutants entering into the waters or on the lands of the State of New York".

Soil and Water Conservation Plans are prepared for any requesting landowner or operator, by the local Soil and Water Conservation District. There is no charge for the services, which are subject to the limits of staff availability. Districts will determine priorities. Plans must meet USDA, SCS Conservation Planning Standards. Plans may be prepared by others as long as they are reviewed and approved by the District.

Conservation Districts historically give high priority to plan requests that result from animal waste problems. Health officers investigating an animal waste problem can refer property owners directly to the local Conservation District for such a plan. Implementation and installation of planned pollution control practices are the responsibility of the landowner or operator.

The amendment to the Soil and Water Conservation Districts Law cited above makes no provision for plan implementation and enforcement. Enforcement of provisions of the Conservation Plan should be by those local agencies now charged with regulating animal waste nuisance abatement. These agencies include the State DEC, the county health departments, environmental control agencies and town conservation agencies.

Recommendation II: Request the USDA Agricultural Research Service and/or others to conduct research to establish safe and effective methods and rates for land application of duck waste water on Long Island soils.

Research needs to include the following:
1. Investigation of the efficiency of marsh-pond duck waste water treatment in obtaining a high quality effluent for land application.
2. Monitoring of nitrogen movement and denitrification near duck pens.
3. Investigation of methods to enhance the economic feasibility of continuous housing of breeder ducks.
6.4.5 Dog Recommendations

Recommendation I: Repeal ordinances that require the curbing of dogs in order to reduce dog waste pollution.

Curb your dog ordinances, specifying that the curb area of a street is the proper place for dogs to defecate, have a negative effect on the environment in most watersheds. These laws encourage dog defecation and urination on or near impervious street surfaces. Part or all of such curbed dog animal waste is usually flushed into the storm water collection system to pollute nearby receiving surface waters.

Albert C. Jensen, of the Division of Marine and Coastal Resources, New York State Department of Environmental Conservation, writes: “We believe that a major source of the coliform bacteria in street runoff is the faces of dogs and other animals. An informal survey of the Great South Bay watershed indicated a population of 80,000 to 100,000 dogs...approximately ten tons of dog feces per day impacting the ecosystem of the bay.” (Jensen, 1973).

Dog curbing laws may not withstand court appeal. For example, an Essex County, New Jersey court decided that a local dog curb law is “unreasonable, arbitrary, and dangerous” (Knapp, 1972). The Essex (N. J.) County Court held, in October 1971, that,

“a New Jersey ordinance requiring a dog owner to remove excrement and dispose of it in a sanitary manner constitutes proper exercise of police power, but portion of the ordinance requiring the dog owner to curb the dog in the street is invalid, since it exposes the owner and dogs unnecessarily to the dangers of vehicular traffic.”

The decision reads, in part:

“There was a time when dog owners loved their animals as pets, but today we find that such large dogs are being employed extensively for security purposes as well, because of the alarming increase in crimes of violence. The tons of solid waste and urination that are daily deposited by dogs have undeniably fouled our streets, our walks and parks to the extent that it has become well-nigh intolerable, threatening the health and safety of our citizens.”

“Persons stepping into dog feces on sidewalks or in street while crossing, or when entering or alighting from automobiles, can easily carry it on their shoes, and thence into their homes. Infants crawling about a rug or floor upon which such animal feces have been deposited may ingest them, since young children, especially babies, are known to be constantly placing their fingers into their mouths. Following a heavy rainfall, dog feces are known to find their way into sewers, along with other litter and debris.”

The laws governing municipalities for N. J. hold that,

“The right to the possession of dogs in a municipal corporation is subject to the limitation that such possession must not interfere with the health, security, and comfort of the other inhabitants of the corporation.”

The use of the street-curb area for the deposit of dog waste can be further evaluated by comparing the rainfall runoff coefficients for lawns with those for pavement. Solid wastes are not easily flushed from sod areas by storm flows. During a three and one-half inch rainfall (two-year frequency, 24 hours storm) typical Long Island lawns shed only one-seventh (1/7) the runoff water as paved areas of equal size.

Recommendation II: Prepare a dog cleanup model ordinance for inclusion in the 208 Plan recommendations and urge the adoption of this ordinance by municipalities having an average density in excess of 100 residences per square mile (or other appropriate ratio).

Such a model ordinance should contain clauses that would accomplish the following:

1. Prohibit owners from permitting dogs to defecate on roads, sidewalks, parking lots, play areas, parks or other places where people congregate, unless there is prompt cleanup and removal of feces.

2. Prohibit the free roaming of dogs, with or without license and collar, except as expressly permitted by the landowner involved.

3. Call for the sanitary disposal of feces collected during cleanup.

The model ordinance should provide penalties for failure to comply, but make it clear that the dog owner's property is exempt from the cleanup requirement. It must provide some guidance for disposal of the cleaned material, such as public or commercial trash collection or shallow pit composting. However, the emphasis of the ordinance should be on dog control and the cleanup of solid waste from impervious surfaces that shed storm runoff to a public storm drainage system.

The primary objective of such an ordinance is the development of constructive public attitudes toward the control of dog waste in public places. If serious attempts at enforcement are to be considered, then such an ordinance will benefit from a "presumptive evidence" clause, wherein the person walking a dog shall be presumed to have no intention of cleaning up after the dog if he or she fails to carry appropriate clean up equipment.

The Soil Conservation Service feels that the clauses outlined above can adequately meet the needs of a community for managing dog waste in public places. However, local residents may desire additional clauses in the law to control dog damage to residential lawns and other property.

Several villages on Long Island have passed dog waste clean up laws. Malverne was the first, followed by Freeport, Great Neck, Hempstead, Valley Stream, Westbury, the Town of Smithtown, Rockville Centre, Great Neck Estates and Ocean Beach. Stewart Manor also has a cat ordinance. In Malverne in the last five years, between 175 and 200 summonses have been
issued, bringing fines as high as $25. The ordinance permits fines up to $250. Valley Stream passed its dog waste pickup ordinance a year ago, hired a part-time person to enforce it, and has issued summonses. Complaints have diminished since enforcement began.

Probably two-thirds of dog owners "put the dog out" to defecate at least part of the time. Data gathered in the five study areas for this report showed that only 40 percent of the owners said they leashed and walked their dogs.

Recommendation III: Revise dog licensing procedures under the NYS Agriculture and Markets Law, as follows:
1. Provide that first and second dog-related offenses may be handled administratively, without court proceedings.
2. Provide that local units of government be allowed to increase dog licensing fees: (a) to cover their dog-related expense and (b) to discourage fertile dog ownership.
3. Provide a record of dog-related offenses.

Administrative rather than judicial proceedings are needed to handle summonses related to dog control. Court calendars are crowded, especially in larger jurisdictions. Dog defecation cases are usually given low priority. Some law enforcement officers interviewed reasoned that dog-related offenses were not of much importance, since they were seldom given court hearing time. If an unlicensed dog is picked up, but returned upon purchase of the standard dog license, there may be no incentive to relicense the dog the following year. Under an administrative procedure, a set fine for failure to license dogs could be imposed. Automated, computerized dog licensing is needed to keep track of dog owner offenses effectively, thereby making it possible to increase penalties for repeat offenders. Such a record is a key element in dog control law enforcement and a major factor in dog waste management.

In 1971 the Town of Islip licensed 22,135 dogs and obtained $42,276 in license fees. Townwide dog control expense that year came to $296,000. For Babylon, the figures were 20,185 dogs licensed, $39,186 in fee income, and $75,000 in dog control costs.

An increase in fee differentials between sterilized and fertile dogs of either sex can help to reduce the number of unwanted dogs. Present fees, set in 1929, are $2.35 for a male or spayed female and $5.35 for an unspayed female. In 1929, spaying a bitch cost little more than the license fee differential, and that difference was sufficient to provide a large incentive for spaying. Today, dog neutering costs range from $30 to $80.

Recommendation IV: Fund a continuing public information program through the appropriate county environmental control agency to make dog owners more aware of their responsibilities.

Dog owners need frequent reminders that dog waste in streets pollutes; pet abandonment is a crime; their dog's waste in public places is their responsibility; failure to license a dog is wrong; and clean up is the law in some communities. The proposed public information program should extend to schools and other organizations.

Interviews of dog owners, conducted in the five study watersheds generally indicated that few if any dog owners had any idea that dog waste is a substantial source of storm runoff water pollution. More than 50 percent of the owners interviewed admitted they routinely released their pets; that they were not aware that a released dog was technically a stray dog; and that their action was, therefore, illegal in municipalities with leash laws.

Recommendation V: Provide partial funding for dog neutering programs in critical watershed areas; use increased license fees for fertile dogs to help defray costs. (The latter part of this recommendation would depend on the adoption of Recommendation III)

Anvik (Anvik, Hyne and Rahman, 1974) reports dog and cat populations are expanding more rapidly than the human population, due largely to the numbers of stray animals. The Town of Brookhaven has already proposed the funding of a neutering program in their capital budget. The Town of Islip is preparing to set up a subsidized program of pet sterilization. Nassau County is also considering proposals for pet sterilization. "Critical Watershed Areas" are those municipalities with high density land areas (e.g., more than 100 homes per square mile) shedding storm runoff to shellfish or recreation-use waters.

The probable dog population of the bi-county area is 425,000 animals. A sizable percentage of these dogs are not sterilized. It is probably too costly to subsidize an area-wide dog sterilization service. Therefore, a base map should be developed showing major land areas that contain critical watersheds. Dog owner residents of these critical watersheds should have first priority on available funding.

Whether or not to fund the sterilization of male dogs can be debated. It is doubtful that reducing by one-half the number of fertile males in an area would actually reduce dog pregnancies. The probability would always exist that a small but effective number of fertile males would be attracted to the female in heat. However, the public educational value of both male and female dog sterilization is recognized. Public support for controlling dog numbers is thought to be needed for any effective dog waste management program. Islip Town representatives, knowledgeable about their own neutering program, and leaders from other communities with dog neutering programs strongly support sterilization of both sexes, primarily for the educational value.

During our interviews with local officials, we learned that veterinarians have objected to continuous employment at dog sterilization clinics, preferring to work at more mixed activities. The cost of establishing these clinics was also considered objectionable.

Suggestions were received from interviewees urging the financing of dog neutering clinics through a local tax on pet food. It was also proposed
that animal shelters be required to offer only sterilized pets for adoption and that a limit be set on the number of unsterilized dogs per household. This section neither supports nor opposes these ideas.

6.4.6 Duck Recommendations

Recommendation I: Eliminate White Pekin ducks and their derivatives from inland ponds that are not part of a farm operation.

Alternatives for implementing this recommendation are as follows:
1. Generate legislation at the county and/or municipality level authorizing and directing dog wardens, park employees and law enforcement officers to remove White Pekin ducks and their derivatives from publicly controlled reaches of inland bodies of water.
2. Provide a bounty for the delivery to local animal pounds of White Pekin ducks and their derivatives that have been removed from non-farm inland freshwaters.

In support of this recommendation, it should be recognized that the introduced White Pekin duck stimulates artificial feeding, attracts wild ducks, is non-migratory, is a heavy coliform and nitrogen polluter, spreads avian diseases, and may destroy shoreline vegetation, causing shore erosion.

The Soil Conservation Service concludes that if the White Pekin duck and its descendants are effectively eliminated from public inland water bodies, the feeding of wild ducks, while not desirable, is not sufficiently harmful to surface water quality to warrant prohibition of such feeding.

Recommendation II: Prohibit the sale of White Pekin ducks as pets within the bi-county area.

Generate a penalty law against retail sales of ducks for pet keeping purposes.

In view of the nature of the proposed measures, it may be necessary to conduct a public information program to avoid adverse public attitudes toward White Pekin duck elimination.

6.4.7 Horse Recommendations

Recommendation I: Prepare a model ordinance for local use providing a limitation on the number of horses per acre on residential land and specifying the management of and disposal of certain horse wastes.

The following clauses should be included in order to insure adequate waste management:
1. Not less than one-half acre of open unpaved land shall be provided for a single horse or other equine livestock; not less than one-fourth acre of open unpaved land shall be provided for each additional horse.
2. Each premises having less than one-half acre of open, unpaved land per horse shall have and meet the provisions of an animal waste management plan, approved by (agency to be specified) or be in violation.
3. Animal waste, including manure and soiled bedding shall be kept in weatherproof containers at least 50 feet from adjoining property lines.

4. Paved or otherwise unvegetated or bare soil areas used as horse yards, paddocks, pastures, or similar shall be graded or controlled so that no storm runoff water from one-year frequency rainstorms falling on such areas, shall flow from the horse owner's property to other public or private lands.

Recommendation II: Where Horse Recommendation I is not implemented, authorize the county health departments to require the preparation and implementation of a conservation plan covering animal waste management whenever necessary to abate a horse waste related nuisance.

The plan should be prepared by a professional conservationist or the equal and reviewed by the SWCD for each horse waste related complaint involving (1) animal waste sewage flowing off the property, or (2) failure to properly store horse waste.

6.5 CONCLUSION

Nassau and Suffolk Counties are suburban residential counties having a 1977 population of approximately 2.8 million persons. The densest population centers are generally located in watersheds that discharge directly onto the marine edge and to inland lakes and ponds. Highways and local roads are usually depressed below the natural ground level and serve as principal drainage channels for runoff water. Recharge basins provide storage for storm water discharges for most new subdivisions in Suffolk County and many in Nassau.

Dogs and semi-wild White Pekin ducks were found to be unregulated sources of non-point animal waste pollution. Urban runoff containing dog waste and other animal waste is responsible for most of the recent closures of shellfish growing areas. An information program and new laws are recommended to control dog waste disposal. Semi-wild White Pekin ducks and their descendants are also serious sources of pollution in many ponds and lakes. Diseases are communicated to animals and man via waters contaminated by duck wastes. New laws and public awareness concerning the problem are needed to control these wastes.

Market duck waste has been a pollution hazard in the past and is now regulated by Federal and State laws. Under these laws duck farmers are required to achieve very limited discharges of wastewater by July 1, 1977, and zero discharge to any receiving surface waters by 1983.

Zoning ordinances in some municipalities are used to control horses and, indirectly, the waste related problems. However, there are many small non-point horse waste pollution sources affecting surface waters. These may require control.

Under present state law agriculture producers must develop a plan to reduce sediment and related animal waste pollution by January 1, 1980. This plan is developed with the assistance of the Nassau and Suffolk County Soil and Water Conservation Districts. It is recommended that the present law be amended to require non-agricultural animal owners, who have high concentrations of animals per acre, to develop a plan, with Soil Conservation District assistance, for the control of animal waste.
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