MM - Denville

June 1976

Natural Resources Inventory

pg. 98

notes: expert report

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NATURAL RESOURCES INVENTORY

DENVILLE TOWNSHIP N. J.

ENVIRONMENTAL COMMISSION

JUNE 1976

DENVILLE ENVIRONMENTAL COMMISSION

Kensley Robert Thompson, Chairman

Kenneth Tarbox (to 5/76)	Gifford Boyce
Edward Kwiatkowsky	Dorothy Vanston Garcia
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DENVILLE TOWNSHIP ADMINISTRATION

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DENVILLE TOWNSHIP COUNCIL

Richard Mohr, President

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Willard Collins	Eugene Seroka

A NATURAL RESOURCE INVENTORY

FOR THE

TOWNSHIP

OF

DENVILLE

June 1976

Prepared By
Robert Catlin and Associates
City Planning Consultants, Denville, N. J.
Russell L. Montney, AIP, Principal in Charge
Walter C. Cramp, III, Environmental Consultant

Water Resources By Passaic River Coalition
Basking Ridge, N. J.

Habitats By Mark David London and Laurence H. Kaufman
Rockaway Township, N. J.

TOWNSHIP OF DENVILLE

ENVIRONMENTAL COMMISSION

NEW JERSEY 07834

To The Residents of Denville Township:

The Natural Resource Inventory (NRI) is another tool to be used in further promoting effective and enlightened land use planning for our community.

This Commission has sponsored and guided its preparation in an effort to provide data and information detailing the gifts that Nature has provided for our intelligent and continuing use.

This document is only the beginning and is based primarily upon existing documentation. It is our hope that, although it will provide some answers, it will also raise many questions and act as the catalyst to you, our fellow residents, to assist in its amendment and supplementation through field surveys and additional research.

Its use in assisting the formation of our community's new Master Plan by the Planning Board should also help serve to alert planners and interested citizens to potential problems which, in the past, could not have been readily identified. We view the NRI as an insurance policy that names the environment and posterity as beneficiaries.

Kensley Robert Thompson

Kensley Robert Thompson, Chairman

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INTRODUCTION

One of the major functions of the Denville Environmental Commission is to review and make factually based recommendations on proposed use of land in our community. A related function is to provide similar recommendations concerning existing land use. In order to most effectively perform these functions, the Commission must have factual data concerning the natural resources of the community. This document, our initial published Natural Resources Inventory (NRI), is intended to provide such factual data. The user should recognize that the information presented is basically gleaned from existing documentation which needs to be critically scrutinized in the light of field surveys and heretofore undiscovered documentation. Due to extremely limited financial resources available to the Commission, this latter effort, for the most part, must necessarily be accomplished by volunteer assistance from interested persons.

Our approach to preparing the NRI has been based upon the accompanying list of factors, which are arranged in order of a priority based on our judged needs of the community. Part A of the listing indicates those factors covered by this initial effort. Part B are those factors remaining to be researched and prepared for use.

PART A - FACTORS COVERED*

Priority

1. Hydrology
   - A. Ground Water
     - (1) Aquifer outcrop
     - (2) Geologic aquifer recharge
     - (3) Well location and gallons per minute (GPM)
     - (4) Flow of ground water
     - (5) Recharge areas outside municipality
     - (6) Quality of groundwater
   - B. Surface Water
     - (7) Surface water and direction of flow
     - (8) Low flow of streams - means 7 day/10 year recurrence interval
     - (9) Flood plains and marshes, swamps, bogs
     - (10) Depth to ground water (water table)
     - (11) Surface water quality, limnology, dissolved and suspended solids
     - (12) Watershed and subwatersheds (drainage units)
     - (13) Liquid waste and disposal systems

Priority

2. Geology
   A. Bedrock type and characteristics (structural type and age)
   B. Depth to bedrock and outcrop
   C. Unconsolidated materials and thickness
   D. Mineral resources (e.g. sand and gravel)
   E. Geologic cross sections
3. Soils
   A. Soil types, texture, stoniness, depth, hydrological types
   B. Shrink-swell potential
   C. Frost heave potential
   D. Erodability (K Factor) potential soil loss in cubic feet/year
   E. Percolation rates
   F. Surface runoff, permeability, perviousness
   G. Fertility (vegetative capability)
   H. P. H.
   I. Cation exchange capacity (nutrient absorption)
4. Vegetation
   A. Broad areas
   B. Fire hazard, history of wildfires (where applicable)
   C. Pollution affected types
   D. Vegetation of recreational and/or historic value (unique or scarce)
5. Wildlife
   A. Nuisance and hazardous species habitats
   B. Rare and beneficial species habitats
   C. Abundance and distribution within habitat/season

*Some factor elements shown above have not yet been included due to lack of adequate available documentation.

PART B - FACTORS TO BE COVERED IN THE FUTURE

6. Meteorology
   A. Air quality, static sources of air pollution
   B. Prevailing air currents (air sheds)
   C. Seasonal precipitation
   D. Topographic protection (wind)
   E. Soils wetness (atterberg limits)
   F. Maximum/minimum fluctuations in temperature
   G. Fog bound areas
7. Geography
   A. Physiographic region and/or subregions
   B. Slope, relief, elevation
8. Historic and Cultural Factors
   A. Existing land use

(1) Open space
(2) Pipelines
(3) Railroads
(4) Roads
(5) Recreation
(6) Urbanization
(7) Agriculture
(8) Waste treatment and disposal facilities (Sewage and solid)
(9) Environmental nuisances

B. Proposed land use (zoning, master plan)
C. Historic sites and areas
D. Possible or existing palenotological sites
E. Scenic qualities

As noted previously in reference to verification of accumulated data by field surveys and documentation research, volunteer assistance in preparing any of the above factor elements will be welcomed by the Commission permitting use of limited funds for researching and preparing other elements.

This document has been prepared with financial assistance from the State of New Jersey in the form of an Environmental Aid Grant with matching funds provided for in Denville Township's 1975 Budget. A substantial portion of the data presented has been jointly developed for Denville's Revised Master Plan, now in preparation, and this NRI through close cooperation with the Planning Board and their Consultant, Robert Catlin and Associates.

We wish to thank all of those Departments, Boards, Commissions and Committees of the Township of Denville for their assistance in providing requested data. We also recognize the part played by former members of this Commission in bringing the NRI to fruition. Mr. Kenneth Tarbox, now a resident of Alaska, must be singled out for his efforts and the unselfish use of his professional expertise as Co-Chairman of the NRI Committee up until May, 1976. Mr. Tarbox's Co-Chairman Mr. Gifford Boyce (now Chairman of the NRI Committee) must also be cited for his unstinting devotion to the task of giving birth to Denville's first NRI. We also acknowledge with sincere thanks the contributions made by the many Federal, State and County agencies cited throughout the report.

Although volunteer help was solicited and offers made by several Denville residents to assist in preparing the initial NRI, time and its concomittant lack of effective coordinative action precluded their use. We hope that now that the skeleton has been fleshed out and we have overcome many of our growing pains, these public-spirited persons will again offer their assistance to accomplish the many tasks yet remaining.

It bears repeating that this NRI is the record of our initial efforts to document data concerning the natural resources of our community. The preparation of a truly effective NRI, however, is a task that must continue for many years. Data from additional research and field surveys remain to be incorporated with the data contained herein. Amendments to data will also be necessitated from time to time based upon readjustments to the environment by man and nature. The goal we visualize for the future is a data bank of accurate environmental information which can be made easily and quickly available to administrators, legislators, planners, advisors and the interested public.

NATURAL RESOURCES INVENTORY

PAST CONSIDERATIONS

During the course of the assembly and preparation of the basic data for the 1962 Denville Township Master Plan, careful consideration was given to the physical characteristics of the environment based on information available at that time. This included the topography as it was shown by the U. S. Geological Survey Topography Maps from which excessive slopes were identified as well as surface drainage characteristics. Soil and internal drainage conditions were analyzed based on information available from the Engineering Soil Survey of New Jersey made in 1953. From this information, certain conclusions were drawn as to the limitations on development that were posed by the physical characteristics of the land in the Township.

DEVELOPING CONCERN FOR THE PHYSICAL ENVIRONMENT

In the ensuing years, a number of events have taken place which relate directly to further and more detailed consideration of the physical environment of the Township. Each of these events reflect a growing concern for environmental considerations and each has provided mechanisms for dealing more effectively with these environmental considerations.

These events include:

1. Aerial photography for the entire Township taken in April, 1969 from which detailed topography maps were prepared by photogrammetic methods at a contour interval of 2 feet.

2. The establishment of the Morris County Soil Conservation Services as a supportive arm to the Morris County Planning Board to review all proposed developments and provide recommendations with regard to soil conservation measures.

3. The publication in 1970 of Soil Survey Interpretations by the Morris

County Soil Conservation District together with soil maps for general use of all agencies dealing with land development.

4. The emergence of the environmental commissions at the municipal level of government first as an informal appointive body and then as a legislated formal commission with specific responsibilities.

In Denville, the Environmental Commission has developed a program for achieving a Natural Resources Inventory for the Township which has evolved concurrently with the Planning Board's initiative to prepare a Comprehensive Revision to the Master Plan. As a means of coordinating these parallel and supportive activities, the two agencies have and will continue to meet to avoid duplication of effort and provide a free exchange of information. By this means, both activities can continue concurrently.

With this background and based upon the more recent and detailed information of the environment available, the physical characteristics of Denville Township have been carefully reexamined in detail.

THE NATURAL ENVIRONMENT

The natural environment is a synthesis of the existing climatic processes such as erosion and sedimentation acting upon pre-existing natural land forms. These conditions are rarely ever stable but reflect a continual modification process by which surface relief is gradually altered. Every natural environment is a uniquely balanced system of dynamic processes associated with local meterology, hydrology, geology and vegetation.

Rational land planning requires an awareness of various aspects of the natural environment, particularly those which critically affect land development such as topography, surface drainage, water supply and erosion. The natural factors range from the critically obvious needs for water to the subtle role of vegetation in climate modulation. An adequate awareness of the environment should include both a knowledge of the more subtle ramifications of land alterations as well as the overt deterministic natural development limitations.

The Physical Characteristics Section of the Master Plan Report is a comprehensive review of environmental information gathered from numerous sources. The Report itself is divided into four Sections: Land Forms and Climatic Processes; Bedrock Geology; Geologic Soil Formations; and Comprehensive Development Factors. Land Forms and Climatic Processes briefly discusses the present land forms, their evolution and the contemporary climate with its associated environmental processes. In particular, the patterns of relief, erosion, sedimentation, flooding and drainage are reviewed along with the role of vegetation. Bedrock Geology is a review of bedrock conditions, usually underlying existing soil formations including the significance of fault zones and suitability of excavation and water yield. Geologic Soil Formations give specific information regarding soil conditions for a variety of soil types. Whereas there are 33 identifiable soil types, eight soil formations have been created based upon geologic origin to create a more workable soil grouping for planning purposes. The Comprehensive Development Factors is a review of the natural environment and land use impacts ranging from the critical determinants to the subtle climate modifications.

LAND FORMS AND CLIMATIC PROCESSES

The predominant natural land forms present in the northeastern United States reflect the Pleistocene Ice Ages and the presence of the most recent Wisconsin Glacier. The area affected by the glacier extends from Canada to central New Jersey. The extensive alteration of land relief patterns was due to glacial movement with its insipient scouring of pre-existing soil and rock formations along the axis of flow and deposition of transported glacial debris.

Prior to the Ice Ages, about 70 million years ago, (See Figure 1, Geologic Time Scale) northern New Jersey was eroded into a nearly level surface called the "Schooley" peneplain, probably during a sustained period of climatic aridity. Almost all pre-existing physiographic land forms were either truncated or buried under sediments to form the peneplain at an elevation of approximately 1,100 feet above sea level..

In the subsequent humid environment which has continued up to the present, this plateau surface has been dissected by the erosion of running water with the exception of the intermittent scouring of glacial movement during the Ice Ages.

FIGURE 1

GEOLOGIC TIME SCALE

Era	Period	Epoch	Duration in Millions of Years	Began Millions of Years Ago	Animals	Plants	Important Local Events
Cenozoic (recent life)	Quaternary	Recent Pleistocene	(Late archeologic and historic time) 1	 1	Mammals	Modern seed plants	The Wisconsin Ice Age Glacier The Evolution of Man
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	12 12 11 22 5	13 25 36 58 63			 The Schooley Peneplain Formed
Mesozoic (middle life)	Cretaceous Jurassic Triassic	(Early, Middle, or Late)	72 46 49	135 181 230	Reptiles and ammonites	Ancient seed plants	Age of Dinosaurs (tracks visible in Roseland, N.J.)
Paleozoic (dawn of life)	Permian Carboniferous: Pennsylvanian and Mississippian Devonian Silurian Ordovician Cambrian	(Early, Middle, or Late)	50 30 35 60 20 75 100	280 310 345 405 425 500 600	Amphibians Age of fishes Invertebrates	Spore-bearing plants Seaweeds	Appalachian Mountains Formed Sedimentary Bedrock Formed into Appalachian Geosyncline
Pre-Cambrian: Proterozoic and Archeozoic (before life)			900 (undetermined)	1,500	Indirect evidence of life		Pre-Cambrian Bedrock Formed

The primary effects of the Wisconsin Glacier in the last Ice Age include the scour and erosion of the pre-existing soil and bedrock, particularly in areas of high relief, the deposition of unsorted glacial debris either as till along the glacier path or a moraine at the terminus of the glacier, and the transportation and stratified deposition of glacial debris by melt water from the glacier as outwash and lake deposits. South of the Wisconsin terminal moraine, soil deposits from previous glacial episodes, referred to as old till, remained relatively undisturbed.

Following the Wisconsin glacial period, the climate reverted to a humid environment whereby new patterns of drainage, vegetation and soil formations evolved. Under humid conditions, much like today, where the average annual rainfall is 49 inches, well-formed drainage patterns developed. Typically, these patterns are dendritic or tree-like except as predisposed by manmade structural determinants and consist of small, intermittent streams and brooks that gather into larger perennial streams and rivers.

It should be noted that whereas arid environments tend to create extensive flat land form surfaces with mechanical erosion and intermittent orographic rainfall transportation, humid climates tend to dissect pre-existing land forms with chemical weathering and transportation in the form of solifluction (soil creep) or land slides with fluvial erosion confined to established drainageways. In addition, humid environments tend to produce "V" shaped valleys whereas glaciation produces "U" shaped valleys.

The existing land forms of northern New Jersey are predominantly glacial relicts and are presently being altered by the geomorphic processes associated with the contemporary humid climate. Similarly, the evolution of soils and drainage patterns of New Jersey reflect the effects of the present environment on both relict glacial deposits and pre-existing rock formations.

It is within this context that the geologic conditions of Denville, New Jersey can be reviewed.

Surface Relief

The most striking aspect of the natural environment is the surface relief conditions, as shown on the "Topography Map" of Denville. The relief patterns range from rugged, irregular, hilly terrain to rolling hills which are often flat-topped. There is a distinct tendency for ridgelines to be aligned along a northeasterly axis with the remnants of "U" shaped glacial valleys between them.

The surface relief is usually indicative of soil cover over bedrock. Areas of high relief or steep slope tend to have thin soils, whereas valley bottoms represent valleys buried with a variety of soil deposits, particularly thick on broad valley flats. This condition is due to the scouring of pre-existing rock by glacial movement, particularly in areas of high relief and the subsequent deposition of glacial debris in deep valley bottoms.

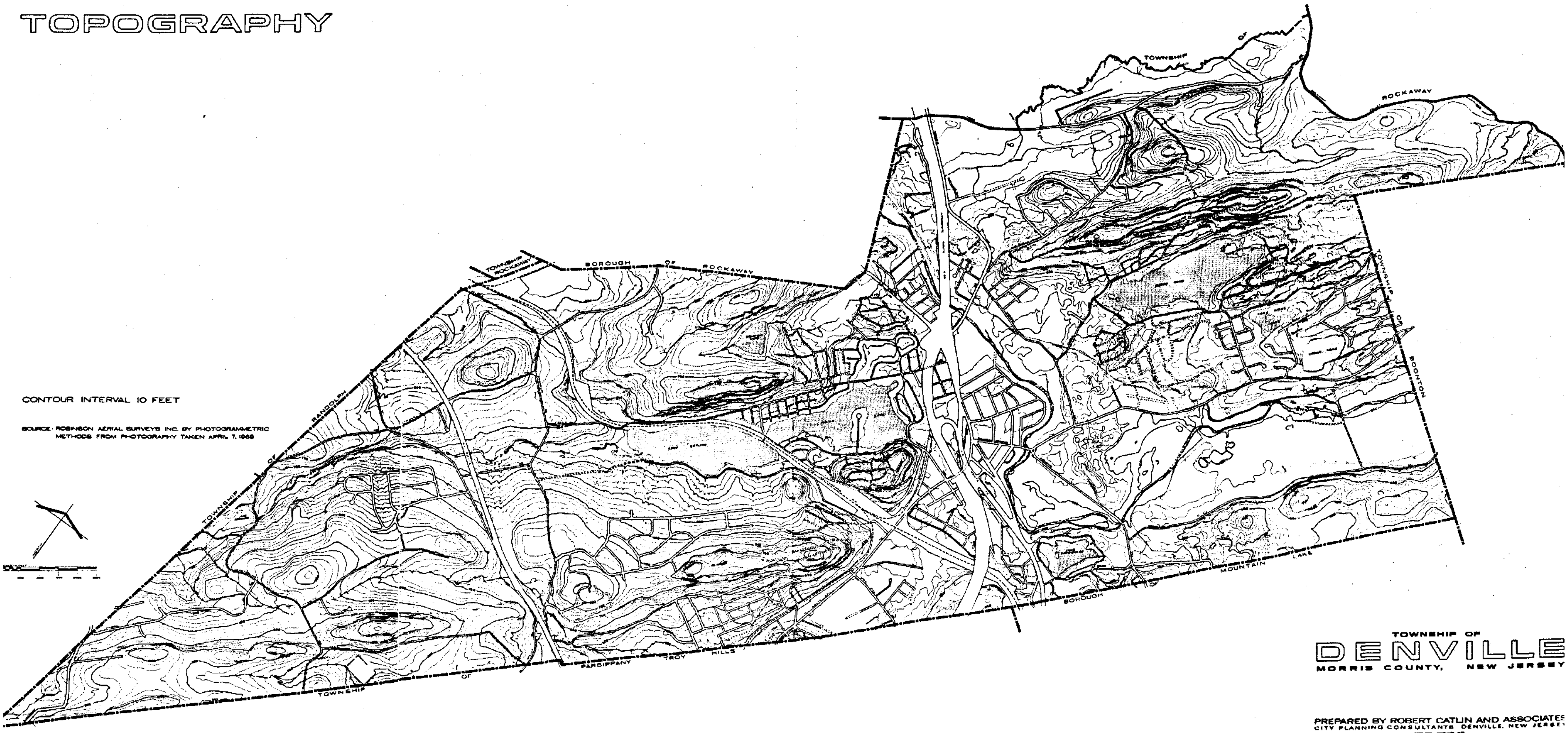
Topographic conditions in Denville indicate the highest relief south of the Wisconsin Terminal Moraine at approximately 1,000+ feet U.S.G.S. datum, whereas to the north, relief rarely exceeds 800 feet. This difference is probably associated with the longer exposure to glacial scouring north of the terminus of the glacier.

Surface and Soil Drainage

One of the predominant characteristics of a humid environment is the existence of well-defined surface drainage patterns. Rain, other than the minor portion that falls within drainage ways, falls upon vegetation and then to the ground where it is held in surface depressions, infiltrates into the soil or flows overland down slopes until it is intercepted by an established drainage course. The influx of water through soil pores to the ground water level is called infiltration. Soil and rock formations where water has infiltrated and been stored in voids are referred to as acquifers. Small brooks and streams tend to flow intermittently with seasonal rainfall whereas larger brooks, streams and rivers run perennially with waters that have been stored and then slowly released by soil and rock acquifers.

The "Surface Drainage Map" indicates the downslope direction of ground water flow as any path perpendicular to contour lines. Major drainageways and their divides have been delineated. As pointed out in 1962, the surface drainage as it is depicted on the "Surface Drainage Map" flows into a number of separate drainage basins. A substantial portion of the Township is drained by the Rockaway River and its tributaries in or near the Township including Den Brook, Beaver Brook and Mill Brook. Only surface drainage from the easterly

TOPOGRAPHY



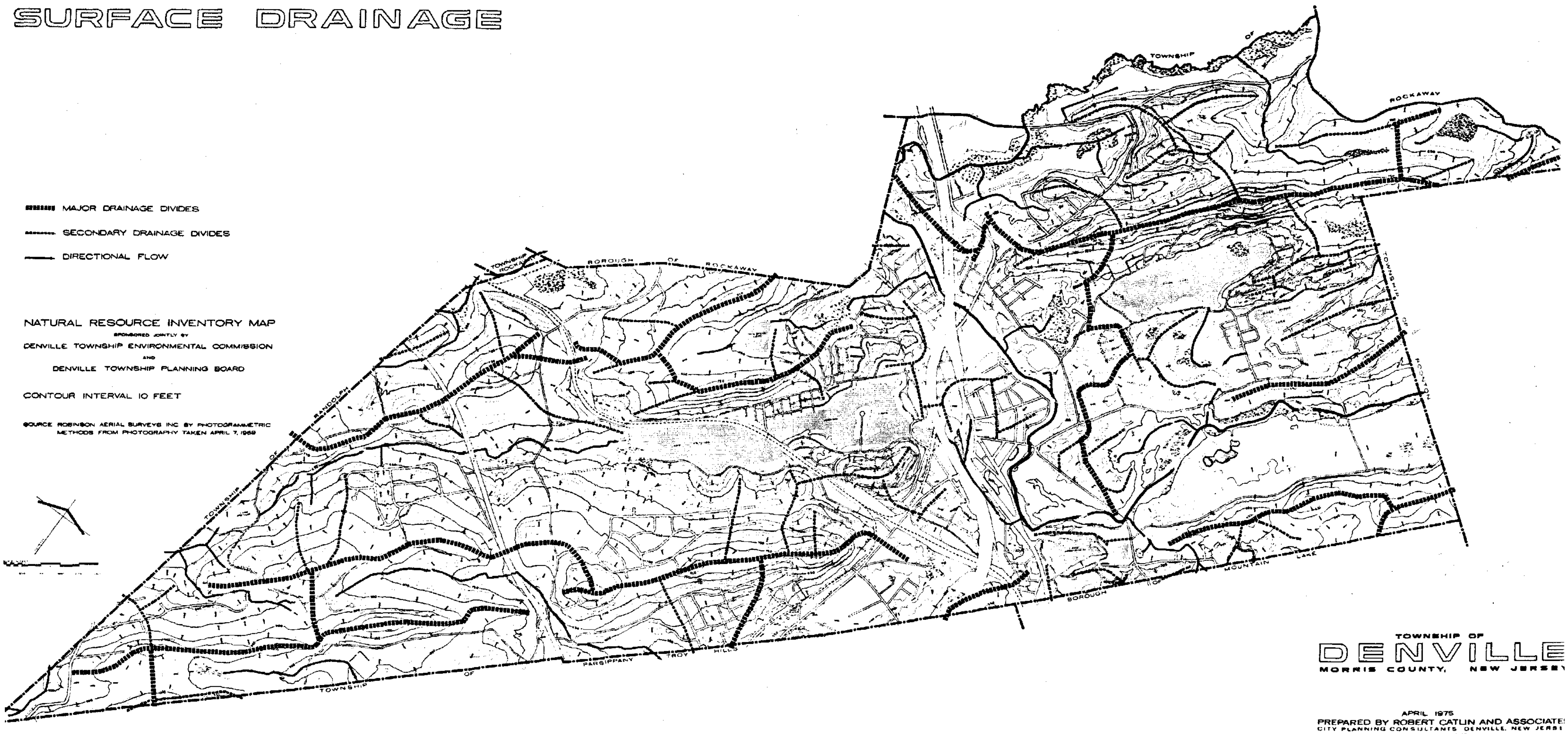
CONTOUR INTERVAL 10 FEET

SOURCE: ROBINSON AERIAL SURVEYS INC. BY PHOTOGRAMMETRIC METHODS FROM PHOTOGRAPHY TAKEN APRIL 7, 1969

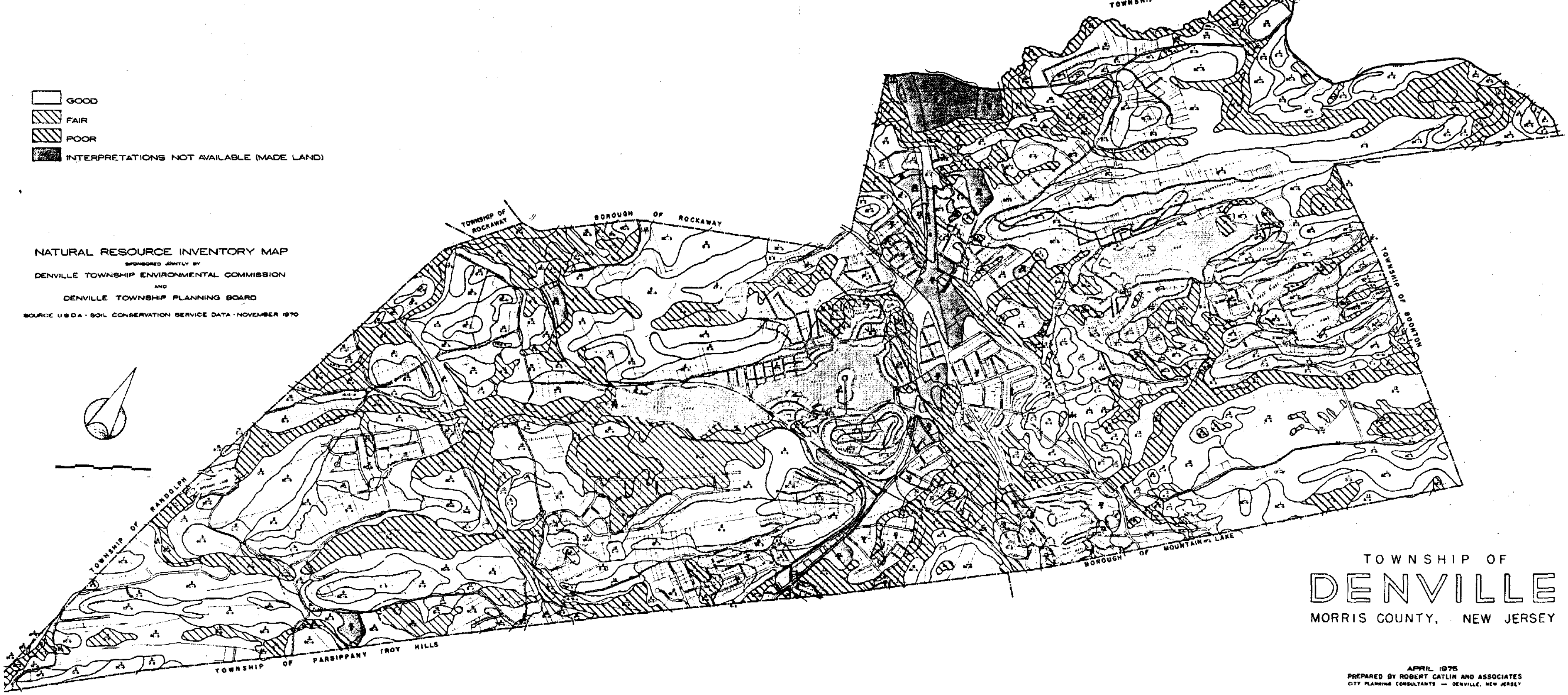
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY

PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS DENVILLE, NEW JERSEY

SURFACE DRAINAGE



SOIL DRAINAGE



portions of the Township leaves the Rockaway Watershed. The southeasterly section of the Township adjoining Route 10 goes into the Whippany Watershed via the Watnong Brook. Those areas in the northeast adjoining the Tourne County Park flow into Mountain Lakes and ultimately find their way to Troy Brook. Most of the drainage courses within the Township are well-defined by topography except for the flood plain areas in the central portion of the Township. Internal soil drainage patterns indicating wetness conditions and potential flooding hazards are shown on the "Soil Drainage Map." Those areas indicated as poor represent flood plains and floodways where water storage along the channel banks tend to predominate soil conditions with the effects of ponding and minimal erosion. Undelineated portions of the floodways and flood plains may be in evidence where the steepness of the stream precludes any lengthy interim stream flow storage or ponding or where manmade restrictions impede normal stream flow.

Depth to Water

The specific depth to water for any given location is rarely, if ever, constant but varies with topography, season, rainfall and local soil conditions. For the purposes of land use evaluation, the level of seasonal high water, as shown on the "Depth to Water Map," reflects the critical ranges of ground water restrictions for land development. Where the water table is sufficiently low and soil drainage good, organic matter is decomposed, principally by aerobic bacteria, whereas in areas of wetness or below the water table (in zone of saturation), organic matter tends to build up. The significant difference between these two zones is the ability of aerobic bacteria to break down organic wastes and the presence of oxygen to oxidize wastes to their simplest stable form. It is for this reason that subsurface sanitary disposal systems must be built well above the water table to allow for the aerobic decomposition and the oxidation of organic wastes to prevent ground water pollution. In terms of pollution control, once organisms and/or organic wastes enter the zone of saturation or a watercourse, the decomposition is relatively slow due to the limited bacterial action and lack of oxygen. The "Surface and Soil Drainage Map" and "Depth to Water Map," are of prime importance in assessing flood-prone areas and the study and control of water pollution and sediment control.

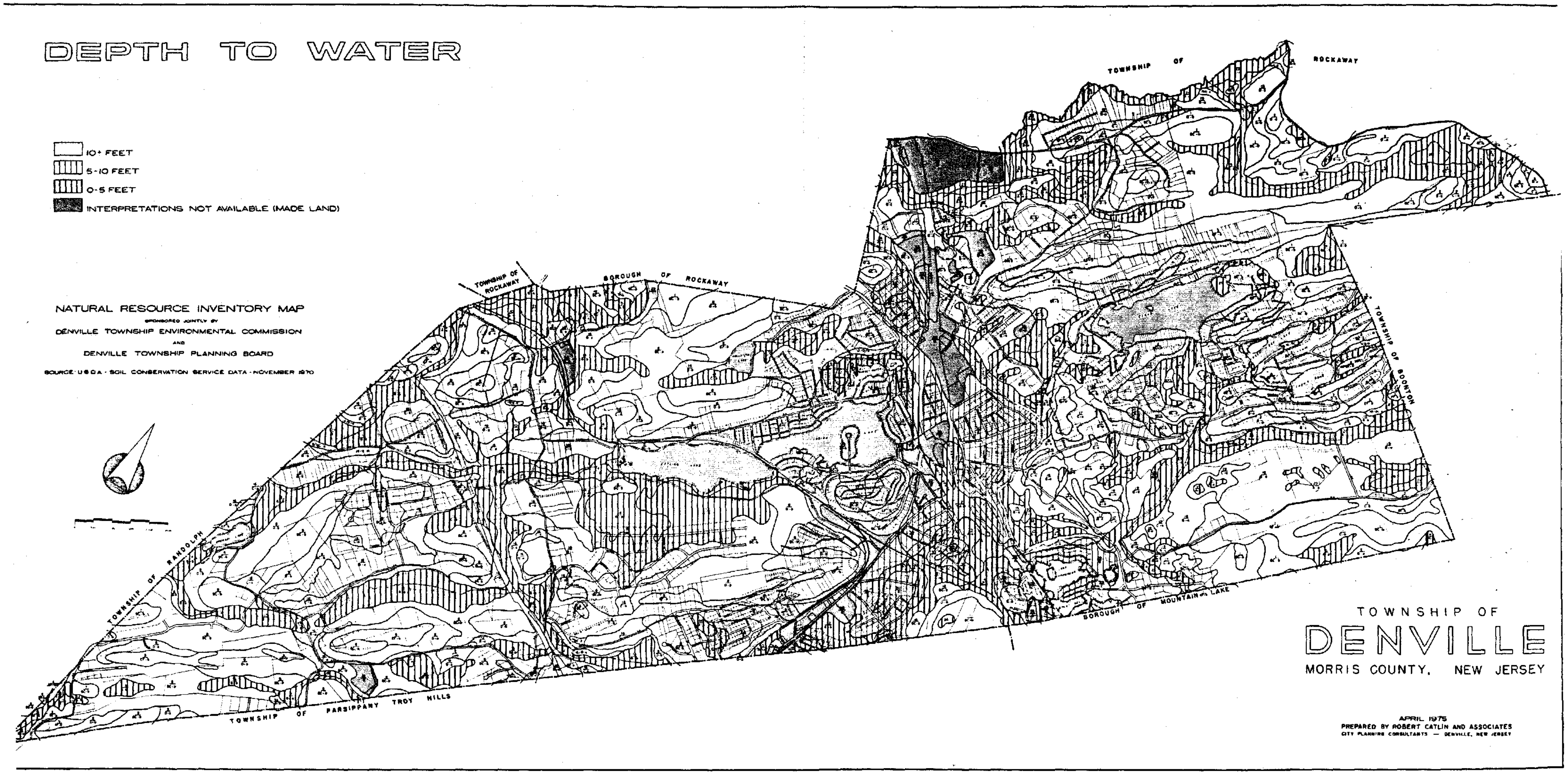
Vegetation

The intensive vegetation found in Denville is common to humid environments. Typically, rolling, stony hills are forested woodlands, the flat, well-drained areas are under cultivation and the wetlands have developed vegetation characteristics of swamplands. The role of dense vegetation found in humid climates is an important multi-faceted one, for vegetation is a prime factor in reducing erosion, mass soil movements, attenuating rainfall impact energy and associated storm water runoff, and modulating climatic wind, temperature and moisture conditions. The significance of natural, native vegetation as a human foodstuff is negligible as farming has taken on that role. Although man no longer relies upon natural vegetation for nourishment as he did during his evolution, key insights into modern pollution problems can be had by reviewing the basic cycle of plant nutrients and organic wastes. The organic cycle of vegetation growth and waste decomposition is briefly reviewed in the Nutrient Cycle Section of the Comprehensive Development Factors.

The foremost effect of vegetation is the reduction of erosion by the dissipation of raindrop impact energy. Raindrops striking on unvegetated surfaces can literally churn up the soil mixing large amounts of soil and water. In addition, vegetation retards the overland water runoff further limiting soil erosion and root structures inhibit mass soil movements down slope by acting as a cohesive soil binder.

Vegetation, particularly trees, impede air movements which correspondingly tend to stabilize the range of temperature extremes, both daily and seasonal, and ground moisture - humidity conditions. The reduction of air movement is particularly significant on upland hill slopes. One of the key aspects of climate modification in terms of maintaining surface temperature balances is evapotranspiration whereby plants release moisture into the air with a cooling effect. In effect, vegetation tends to form an insulating layer above the land surface stabilizing climatic extremes.

The problems of noise and air pollution associated with land development can be significantly diminished by vegetation which can significantly absorb noise, dust and a variety of chemical and gaseous pollutants. While the effects of vegetation are not directly deterministic, their beneficial role in the environment are too important to be overlooked or discounted. Above and beyond these reasons, is the natural aesthetic beauty of the environment which should not be taken for granted but preserved wherever possible.


DEPTH TO WATER
10+ FEET
5-10 FEET
0-5 FEET
INTERPRETATIONS NOT AVAILABLE (MADE LAND)
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE: U.S.D.A. - SOIL CONSERVATION SERVICE DATA - NOVEMBER 1970
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF BOONTON
BOROUGH OF MOUNTAIN LAKE
TOWNSHIP OF PARSIPPANY TROY HILLS
TOWNSHIP OF RANDOLPH
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
APRIL 1975
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

BEDROCK GEOLOGY

The approximate 12.8 square miles occupied by Denville Township in northeastern New Jersey is underlain by Pre-Cambrian gneisses as shown on the "Bedrock Geology Map." This very old crystalline bedrock is comprised of three formations: the white granitic Losee Gneiss; the gray granitic Byram Gneiss and the dark granular Pochuck Gneiss, however, due to the great variety and complexities of these Pre-Cambrian rocks, these formations have been considered as a single unit by the New Jersey State Bureau of Geology and Topography.

The most significant aspects of the bedrock geology are the depth to bedrock reflecting the thickness of the overlying soil, the surface resistance to excavation and the hydrologic characteristics for potable water supplies. The "Depth to Bedrock Map" indicates the relative thickness of soils overlying bedrock. Usually, bedrock is nearest to the surface in areas of high relief or steep slope where glacial scour was the most severe and deepest on flat valley bottoms. Whereas the crystalline rocks found in Denville are susceptible to the mechanical erosion of arid climates, weathering in a humid environment tends to be much slower. Since these rocks are resistant to glacial scour as well, relief tends to be relatively higher than that for other rock formations common to New Jersey. These rock formations are found closest to the surface in Denville along the higher ridges in the northern part of the Township including the Hillcrest Drive area as well as adjoining Cedar Lake, Rock Ridge Lake and Cooks Pond. Other areas are found along the ridges in the old till areas south of the terminal moraine. In addition, there are substantial areas in the southern portion of the Township where these rock formations are found at 6 to 10 feet below the surface.

The ease of excavation usually decreases with depth and may vary considerably with the extent and nature of fracture patterns. Bedrock fracturing may be extensive near the surface greatly facilitating excavation, however, the fracture zone is usually limited to the upper surface of the rock formation and diminishes beyond significance for water yields beyond a depth of 200 to 300 feet. As such, these bedrock acquifers tend to be thin with relatively low storage and transmissibility. Infiltration recharge is mainly accomplished by the downward percolation of ground water through the soil overburden. It should be noted that the filtration characteristics of Pre-Cambrian rocks are not nearly as goodas that of fine sand, silt and clay mixtures. Water yields for these rock formations average about 50 gpm (gallons per minute) but may exceed 100 gpm for wells in fractured rock associated with fault zones or when overlain by thick pervious deposits of sand or gravel mixtures. In general, water supplies developed from these crystalline rocks tend to be high in dissolved minerals. For a further discussion of the hydrology of Denville, refer to the Hydrologic Cycle Section of the Comprehensive Development Factors.

GEOLOGIC SOIL FORMATIONS

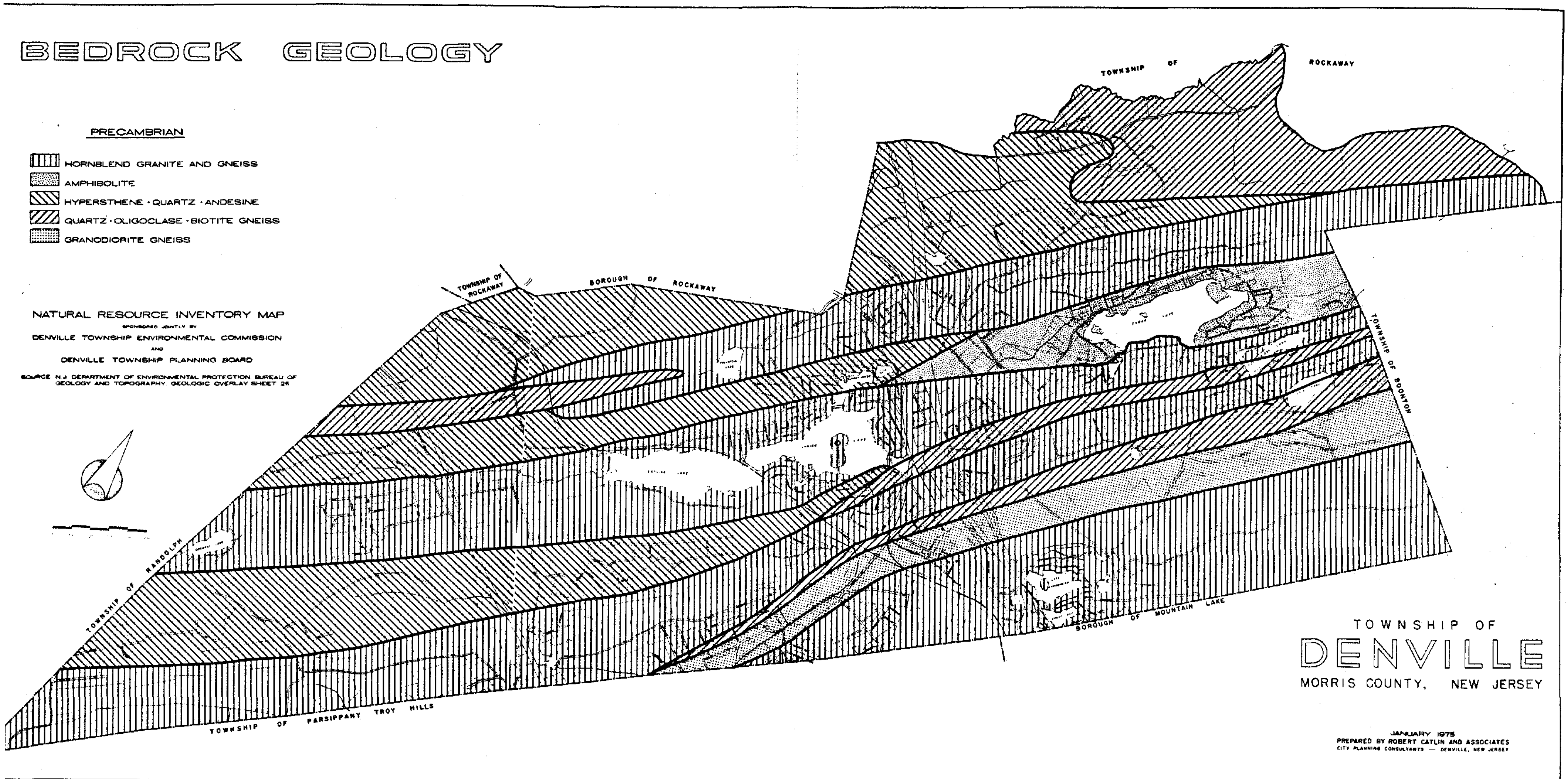
For the purpose of comprehensive municipal planning, the grouping of soils, based on the geologic origin is extremely useful. Soils of similar origin tend to exhibit a wide range of common site and soil characteristics useful for overall interpretations.

The geologic origin of soils in northern New Jersey are principally associated with the most recent Wisconsin Ice Age. The primary effects of the Wisconsin Glacier in the last Ice Age include the scour and erosion of the pre-existing soil and bedrock, particularly in areas of high relief, the deposition of unsorted glacial debris either "young granitic till" along the glacier path or a "terminal moraine" at the terminus of the glacier and the transportation and stratified deposition of glacial debris by melt water from the glacier as "outwash." South of the Wisconsin terminal moraine, soil deposits from previous glacial episodes, referred to as "old till mix," remained relatively undisturbed.

Following the Wisconsin glacial period, the formation of new humid drainage patterns evolved whereby materials were eroded, transported and redeposited as "alluvium" along watercourses. In conjunction with these new patterns, "organic muck" deposits were formed in low-lying areas of poor drainage.

Most recently, the impact of man and his technology has altered existing soil formations to varying degrees through excavation and fill for urban development and sand-gravel mining operations.

In general, the soil patterns of Denville, New Jersey are "bedrock controlled" whereby superficial glacial soils of varied gradation conform to topographic relief patterns indicative of the underlying bedrock. These soils vary in depth from a few feet with intermittent rock outcrops to over 100 feet.


BEDROCK GEOLOGY
PRECAMBRIAN
HORNBLEND GRANITE AND GNEISS
AMPHIBOLITE
HYPERSTHENE - QUARTZ - ANDESINE
QUARTZ - OLIGOCLASE - BIOTITE GNEISS
GRANODIORITE GNEISS
NATURAL RESOURCE INVENTORY MAP
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE N.J. DEPARTMENT OF ENVIRONMENTAL PROTECTION. BUREAU OF GEOLOGY AND TOPOGRAPHY. GEOLOGIC OVERLAY SHEET 26
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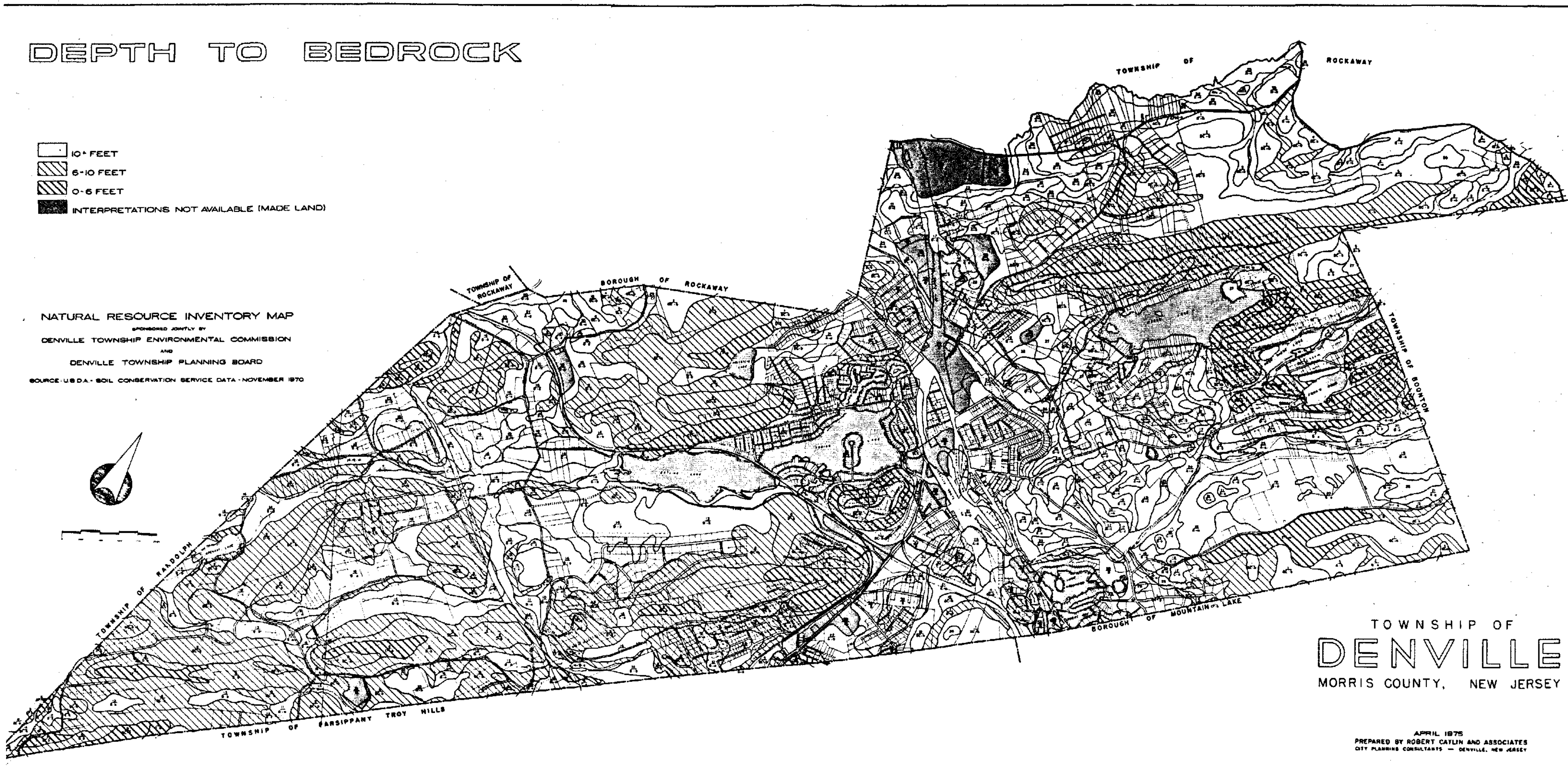
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PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

The glacial soil formations consist of unstratified till and sorted outwash overlying crystalline gneiss, bedrock. Other minor soil formations include post glacial alluvium and muck deposits. The permeability of these soils is moderate to good with the exception of surficial clay or muck deposits and soil formations having a "pan" or semi-permeable stratum. Generally, the ground water level follows the surface contour at a depth of several feet except for low-lying areas where it is shallower and on well-drained terraces where it is deeper.

In addition, recent man-made alterations have disturbed the pre-existing geological soil formation.

Geologic Soil Groups

Within the Township of Denville there are distinct soils which can be grouped by common factors such as geologic origin, mineral constituents and soil profile. These soil types can be further identified by local conditions of slope and erosion potential. The "Soil Reference Map," which has been prepared from the U.S.D.A. Soil Conservation Service Maps, includes 33 soils with local factors as shown in the accompanying Soil Index Charts. This map has limited usage except for special reference due to its complexity.

The "Surficial Geology Map" has reduced the number of soil types to eight groups based upon geologic origin and constituents. These geologic soil groups are:

Granitic Glacial Till (new)
Old Till Mix
Terminal Moraine
Glacial Outwash
Alluvium
Organic Muck Deposits
Urban Land
Made Land

Each of these basic groups has a common source and an implicit unique range of general characteristics associated with it.

For example, a "Glacial Till" soil is a well-graded mixture of gravel, sand and silt which is moderately permeable, well-drained with a varied depth to bedrock and ground water at depth of 2 feet or more. The above general range of information for a particular geologic soil gives a concise yet informative indicator of soil conditions within a given area.

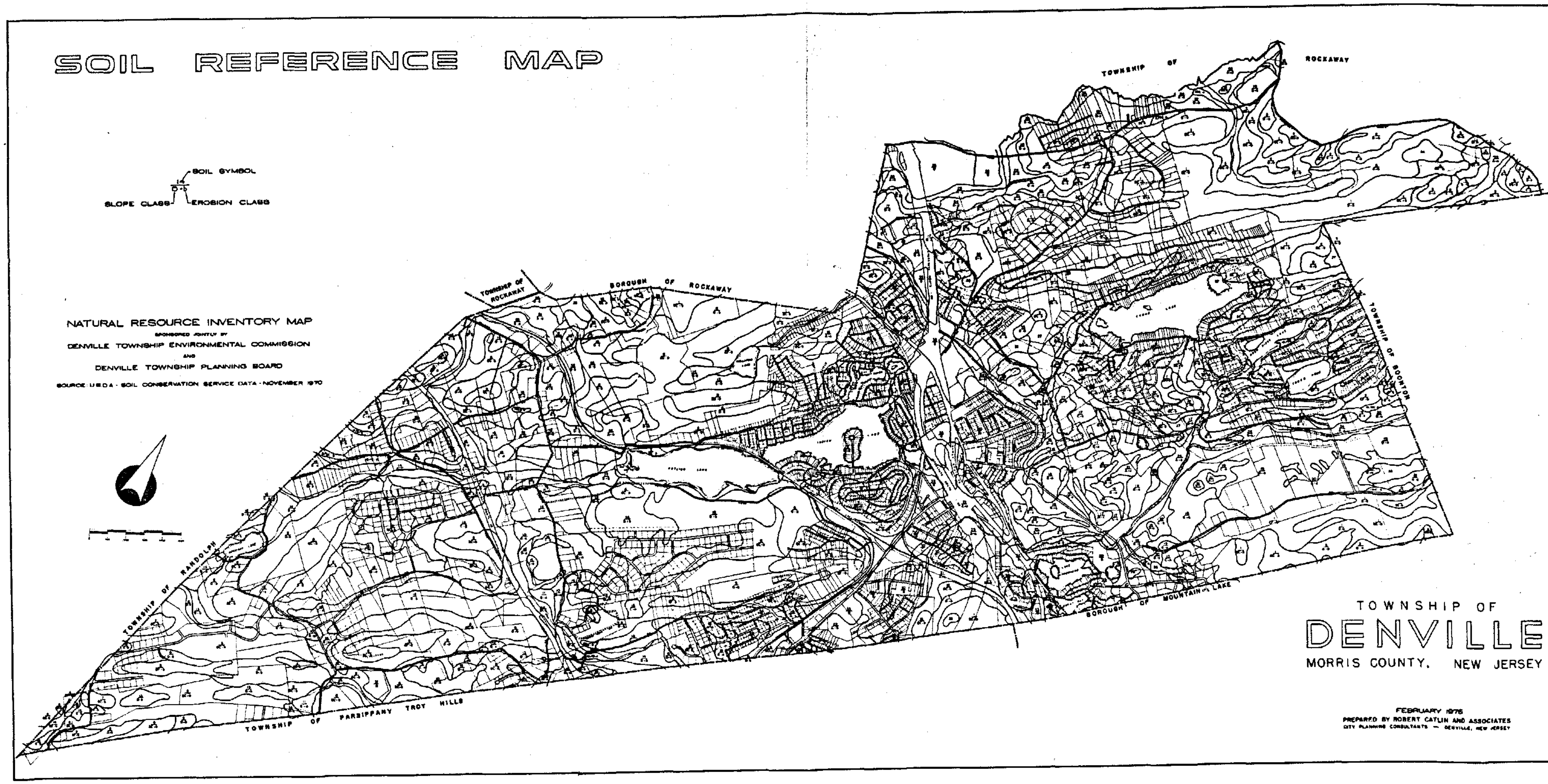
Granitic Glacial Till (New)

Glacial Till associated with the Wisconsin Glacier is composed of predominantly granitic gneiss and exhibits a wide range of conditions. Most notably, this soil type is a permeable mixture of very coarse gravel, sand and silt which tends to have a semi-permeable layer or pan at a depth of 2 or 3 feet restricting the overall permeability. Depth to bedrock exceeds ten (10) feet except in areas of high relief and along areas of increased slope. Drainage is good except in areas of low relief where occasional flooding and ponding may occur along natural drainage patterns due to high ground water. In addition, ground water may be ponded or perched in these low areas with seepage occurring in adjacent upslope vicinity.

Development Factors. The variety of conditions and their overall limitations are usually severe and occasionally moderate. The primary factor is poor internal drainage due to slow permeability across the pan with seepage or ponding depending upon the slope. Where encountered, the semi-impervious "pan" stratum may cause temporary shallow perched ground water or slight artisan ground-water conditions. These drainage conditions may adversely affect all forms of construction even with the accepted practices of intercept cutoff drains and drainage swales. The erosion potential increases with slope and soil erosion class is low. With regard to subsurface sanitary disposal, extreme care may be required to preclude the seepage of effluent, commonly referred to as "daylighting."

Old Till Mix

South of Wisconsin terminal moraine, older pre-Wisconsin soils exist relatively unaltered by the recent glaciation. Those soils are somewhat similar to the younger granitic till in composition, however, due to their age, they are more thoroughly weathered and tend to contain some clay which decreases with depth. These soils tend to have more well-developed soil horizons which


SOIL REFERENCE MAP
SOIL SYMBOL
SLOPE CLASS
EROSION CLASS
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE: U.S.D.A. - SOIL CONSERVATION SERVICE DATA - NOVEMBER 1970
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
BOROUGH OF MOUNTAIN LAKE
TOWNSHIP OF PARSIPPANY TROY HILLS
TOWNSHIP OF RANDOLPH
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
FEBRUARY 1976
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
APRIL, 1975

SOIL IDENTIFICATION			SOIL PROPERTIES						DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS			
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldgs. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
TILL YOUNG GRANITIC													
1 (2X19) (2019)	Gravel-Sand-Silt	B-b	3-8	10+	10+	Moderate slow, if with pan	High	---	Medium (0.10)	Severe	Severe	Severe	Severe
		BC-b	3-15	10+	10+	Moderate slow, if with pan	High	---	Medium (0.10)	Severe	Severe	Severe	Severe
		D-b	15-25	6-10	10+	Moderate slow, if with pan	High	---	High (0.10)	Severe	Severe	Severe	Severe
		EF-b	25+	0-6	40+	Moderate slow, if with pan	High	---	High (0.10)	Severe	Severe	Severe	Severe
2 (221N)	Gravel-Sand-Silt	B-a	3-8	10+	10+	Moderate above pan, slow over-all	High	---	Medium (0.20)	Slight	Moderate	Slight	Severe
		C-a	8-15	10+	10+	Moderate above pan, slow over-all	High	---	High (0.20)	Moderate	Moderate	Moderate	Severe
		D-b	15-25	6-10	10+	Moderate above pan, slow over-all	High	---	High (0.20)	Severe	Severe	Severe	Severe
3 (2X1R)	Gravel-Sand-Silt	BC-b	3-15	0-10+	10+	Moderate	High	---	Medium (0.20)	Moderate	Moderate	Moderate	Severe
		D-b	15-25	0-10+	10+	Moderate	High	---	High (0.20)	Severe	Severe	Severe	Severe
		EF-b	25+	0-10+	10+	Moderate	High	---	High (0.20)	Severe	Severe	Severe	Severe

SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
- continued -

SOIL IDENTIFICATION			SOIL PROPERTIES						DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS			
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldgs. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
4 (2X29) (222N)	Gravel-Sand-Silt	B-b	3-8	0-10+	10+	Moderate	High	---	Medium (0.20)	Moderate	Moderate	Moderate	Severe
		BC-b	3-15	0-10+	10+	Moderate	High	---	Medium (0.20)	Moderate	Moderate	Moderate	Severe
		D-a	15-25	0-10+	10+	Moderate	High	---	High (0.20)	Severe	Severe	Severe	Severe
		D-b	15-25	0-10+	10+	Moderate	High	---	High (0.20)	Severe	Severe	Severe	Severe
5 (2X39)	Sand-Silt	A-b	0-3	10+	0	Moderate above pan, slow over-all	High	Long ponding occasional flooding	Medium (0.20)	Severe	Severe	Severe	Severe
		B-a	3-8	10+	0	Moderate above pan, slow over-all	High	Long ponding occasional flooding	High (0.20)	Severe	Severe	Severe	Severe
		BC-b	3-15	10+	0	Moderate above pan, slow over-all	High	Long ponding occasional flooding	High (0.20)	Severe	Severe	Severe	Severe
6 (2X49)	Gravel-Sand-Silt	A-b	0-3	10+	0	Moderate above pan, slow over-all	Very High	Long ponding occasional flooding	Low (0-17)	Severe	Severe	Severe	Severe
TILL MIX. OLD													
7 (1017)	Gravel-Sand-Silt	BC-b	3-15	6-10	10+	Moderate to Rapid	Low Mod.	---	Med.-High (0.22)	Moderate	Severe	Moderate	Moderate

SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
- continued -

SOIL IDENTIFICATION			SOIL PROPERTIES							DEVELOPMENT CRITERIA LIMITATIONS			
						NATURAL DRAINAGE							
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldg. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
8 (101B)	Gravel-Sand-Silt	B-b	3-8	6-10	10+	Moderate to Rapid	Low	---	Medium (0.17)	Moderate	Severe	Moderate	Moderate
		BC-b	3-15	6-10	10+	Moderate to Rapid	Low	---	Medium (0.17)	Moderate	Severe	Moderate	Moderate
		D-b	15-25	6-10	10+	Rapid	Low	---	High (0.17)	Severe	Severe	Severe	Severe
		EF-b	25+	0-6	10+	Rapid	Low	---	High (0.17)	Severe	Severe	Severe	Severe
9 (101R)	Gravel & Sand (Silt)	BC-b	0-15	0-6	10+	Rapid	Low	---	Low (0.15)	Severe	Severe	Severe	Severe
		D-b	15-25	0-6	10+	Rapid	Low	---	Medium (0.15)	Severe	Severe	Severe	Severe
		EF-b	25+	0-6	10+	Rapid	Low	---	Medium (0.15)	Severe	Severe	Severe	Severe
10 (1427)	Sand-Silt-Clay	B-a	3-8	10+	2 Seepage	Slow Moderate Above pan	High	Brief ponding	Medium (0.26)	Severe	Moderate	Severe	Severe
		C-a	8-15	6-10	2-3 Seepage	Moderate Above pan, slow over-all	High	Seepage	High (0.26)	Severe	Moderate	Severe	Severe
11 (1X37)	Clayey Silt (Low P.I.)	B-a	3-8	10+	0	Slow	High	Brief ponding occasional flooding	Medium (0.32)	Severe	Severe	Severe	Severe
12 (1517)	Gravel-Sand-Silt or Clay	C-a/c	8-15	6-10	10	Moderate	Low	---	High (0.22)	Moderate	Moderate	Moderate	Moderate

SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
- continued -

SOIL IDENTIFICATION			SOIL PROPERTIES						DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS			
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldg. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
13 (1X29)	Sand-Silt-Clay	B-b	3-8	10+	2	Moderate to slow	Medium	Seepage	Medium (0.26)	Severe	Moderate	Moderate	Severe
		C-a/b	8-15	6-10	Seasonal seepage at 2 feet	Moderate to slow	Medium	Seepage	High (0.26)	Severe	Moderate	Severe	Severe
14 (1X39)	Silt-Clay (Low P.I.)	A-a	0-3	10+	0	Slow	V. High	Prolonged ponding Occ. flooding	Medium (0.32)	Severe	Severe	Severe	Severe
		B-b	3-8	10+	0-2	Slow	V. High	Brief ponding seepage	High (0.32)	Severe	Severe	Severe	Severe
		BC-b	3-15	10+	0-2	Slow	V. High	Brief ponding seepage	High (0.32)	Severe	Severe	Severe	Severe
		C-b	8-15	6-10	2	Slow	V. High	Seepage	High (0.32)	Severe	Severe	Severe	Severe
15 (1X41)	Silt-Clay (Low P.I.)	A-b	0-3	10+	0	Slow	High	Very Freq. Flooding Long ponding	Low (0.10)	Severe	Severe	Severe	Severe
16 (1317)	Gravel-Sand-Silty Caly	B-a/c	3-8	10+	10+	Moderate	Low	---	Medium (0.24)	Slight	Slight	Slight	Slight
		C-a/c	8-15	10+	10+	Moderate	Low	---	High (0.24)	Moderate	Moderate	Moderate	Moderate
		D-a/b/c	15-25	6-10	10+	Moderate	Low	---	High (0.24)	Severe	Severe	Severe	Severe

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DENVILLE TOWNSHIP, NEW JERSEY
- continued -

SOIL IDENTIFICATION			SOIL PROPERTIES							DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS				
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldg. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
MORAINE														
17 (201N)	Gravel-Sand-Silt Mixture	B-a	3-8	10+	10+	Moderate to Rapid	Moderate	---	Low (0.10)	Moderate	Moderate	Moderate	Moderate
		B-c	3-8	10+	10+	Moderate to Rapid	Moderate	---	Medium (0.10)	Slight	Moderate	Slight	Moderate
		C-a/c	8-15	10+	10+	Moderate to Rapid	Moderate	---	Medium (0.10)	Moderate	Moderate	Moderate	Moderate
OUTWASH														
18 (251N)	Gravel-Sand-Silt Mixture	BC-b	3-15	10+	10+	Rapid	Low	---	Medium (0.28)	Moderate	Slight	Moderate	Slight
19 (B21N)	Sand-Silt Mixture With Little Gravel	B-a/b	3-8	10+	10+	Rapid	Moderate	---	Medium (0.28)	Slight	Slight	Slight	Slight
		C-a/b	8-15	10+	10+	Rapid	Moderate	---	High (0.28)	Moderate	Moderate	Moderate	Moderate
20 (B225)	Sand-Silt	A-a	0-3	10+	2-3	Rapid	Moderate	Brief ponding	Low (0.20)	Moderate	Moderate	Slight	Moderate
		B-a	3-8	10+	2-3	Rapid	Moderate	Brief ponding	Medium (0.20)	Moderate	Moderate	Slight	Moderate
21 (B233)	Sand-Silt Mixture	A-a	0-3	10+	0	Rapid	V. High	Long ponding, Occasional Flooding	Low (0.17)	Severe	Severe	Severe	Severe
		B-b	3-8	10+	0	Rapid	High	Long ponding, Occasional Flooding	Low (0.17)	Severe	Severe	Severe	Severe
22 (B240)	Silty Sand with Little Gravel	A-a/b	0-3	10+	0	Rapid	Moderate	Long ponding	Low (0.17)	Severe	Severe	Severe	Severe

SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
-continued-

SOIL IDENTIFICATION			SOIL PROPERTIES						DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS			
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K-Factor)	Lt. Bldg. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
ALLUVIUM													
23 (0521)	Silty Sand	A-a	0-3	10+	0	Moderate	Moderate	Freq. flooding Brief ponding	Medium (0.28)	Severe	Severe	Severe	Severe
24 (0531)	Silty Sand	A-a	0-3	10+	0	Moderate	V. High	Freq. flooding Long ponding	Medium (0.28)	Severe	Severe	Severe	Severe
25 (0541)	Fine Sandy Silt	A-a	0-3	10+	0	Moderate	V. High	V. Freq. flooding Long Ponding	Medium (0.28)	Severe	Severe	Severe	Severe
ORGANIC MUCK													
26 (M34M) (M64M)	Organic Soil (Muck over sand)	-	Nearly Level	10+	0	----	Moderate	V. Freq. flooding Long ponding	Low (0.17)	Severe	Severe	Severe	Severe
27 (MC4M)	Organic Soil (Muck over silt)	-	Nearly Level	10+	0	----	Moderate	V. Freq. flooding Long ponding	Low (0.17)	Severe	Severe	Severe	Severe
URBAN LAND													
28 (U117)	Urban Land (20-80% disturbed Gravel-Sand-Silt/ clay)	B C	3-8 8-15	10+ 6-10	10 10	Moderate Moderate	Moderate Moderate	---- ----	Medium (0.22) High (0.22)	Slight Moderate	Slight Moderate	Slight Moderate	Slight Moderate

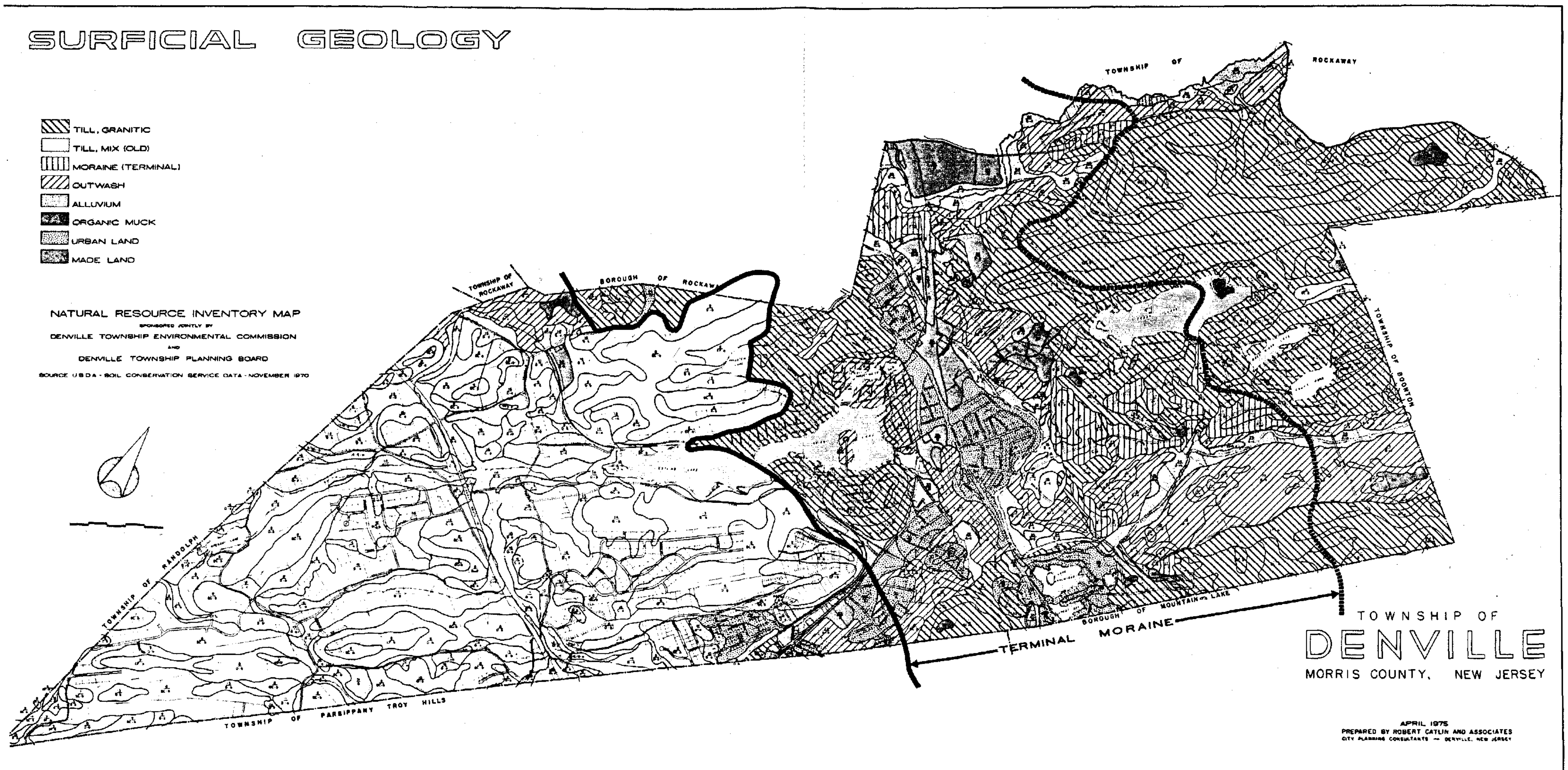
SOIL INDEX
DENVILLE TOWNSHIP, NEW JERSEY
- continued -

SOIL IDENTIFICATION			SOIL PROPERTIES						DEVELOPMENT CRITERIA				
						NATURAL DRAINAGE				LIMITATIONS			
Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %	Depth To Rock (Ft.)	Depth To Water (Ft.)	Permeability	Runoff Potential	Surface Water	Erosion Potential (K -Factor)	Lt. Bldg. W/O Bsmts.	Road Subgrade	Excavation For Bsmts. & Sewer Lines	Septic Effluent Disposal
29 (U21N)	Urban Land (20-80% Disturbed) (Gravel-Sand-Silt)	B	0-8	10+	6-10	Moderate to Rapid	Low	----	Low (0.17)	Moderate	Moderate	Moderate	Moderate
		C	8-15	10+	10+	Moderate to Rapid	Low	----	Medium (0.17)	Moderate	Moderate	Moderate	Moderate
30 (UBIN)	Urban Land (20-80% Disturbed) (Sand & Gravel)	B	0-8	10+	5+	Rapid	Low	----	Low (0.17)	Slight	Slight	Slight	Slight
		C	8-15	10+	5+	Rapid	Low	----	Low (0.17)	Moderate	Moderate	Moderate	Moderate

MADE LAND

Soil Unit (S.C.S.)	Description (U.S.C.S.)	SE Code	Slope %
31 (Z117)	Made Land Gravel-Sand-Silt (over 80% Disturbed)	B	3-8
32 (Z139) (Z23N)	Made Land Sand-Silt-Clay (over 80% Disturbed)	B	3-8
33 (Z219) (Z21N)	Made Land Gravel, Sand, Silt (over 80% Disturbed)	B	3-8
		BC	3-15
		C	8-15
		D	15-25

"The soils in these areas have been over 80% disturbed (excavated, stirred or filled). Since the original soil profile no longer exists no interpretations can be made. Each site requires investigation to determine its particular characteristics."



SURFICIAL GEOLOGY
TILL, GRANITIC
TILL, MIX (OLD)
MORAINE (TERMINAL)
OUTWASH
ALLUVIUM
ORGANIC MUCK
URBAN LAND
MADE LAND
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE U S D A - SOIL CONSERVATION SERVICE DATA - NOVEMBER 1970
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
TOWNSHIP OF RANDOLPH
TOWNSHIP OF PARSIPPANY TROY HILLS
BOROUGH OF MOUNTAIN LAKE
TERMINAL MORAINE
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
APRIL 1975
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

have formed an older gneissic till debris occasionally mixed with colluvium, residuum or alluvium.

Development Factors. The variety of conditions and their overall limitation tend to be severe and occasionally moderate. These soils are relatively well-drained except for low-lying areas and where semi-pervious "pan" stratum interfere with internal soil drainage. Depth to bedrock generally decreases and depth to water increases with slope. The erosion potential increases with slope and these may exhibit a slightly greater proclivity for landslides or slope failure along man-made cuts due to a higher clay content.

Terminal Moraine

At the terminus of the glacier, there is a conveyor-belt-like piling up or mounding of unstratified glacial debris referred to as the terminal moraine. A glacier is analogous to a very slow river that scours materials along its course and redeposits them in hollows or irregular mounds where the ice movement ends. These deposits are comprised of a wide variety of gravel, sand, silt and clay mixtures, usually many feet deep. The terminal moraine is usually thick, well-drained and exhibits a general axis perpendicular to glacial flow in contrast to other till deposits which reflect bedrock controlled relief parallel to glacial flow with either low-lying drainage problems or rockiness at higher elevations.

Development Factors. The development limitations for the terminal moraine are typically slight to moderate except for minor areas with slopes in excess of 15 per cent. These limitations are principally slope-associated problems, however, other than slope considerations, these soils have few, if any, restrictions.

Glacial Outwash

Glacial outwash consists of stratified silty sands and occasionally poorly-graded sand and gravel mixtures. These highly permeable deposits are associated with glacial melt water streams and typically many feet thick. Drainage conditions vary with topographic relief, drainage pattern and seasonal high ground water.

Development Factors. With the exception of slope limitations and severe restrictions in the poorly-drained, low-lying areas, the overall development limitations are slight to moderate. Both the erosion potential and class vary greatly depending upon local soil condition and gradation. These soils are generally acknowledged as ground water recharge areas due to their high permeability. Ground water quality may be detrimentally affected by the construction of subsurface sewage disposal systems in these areas due to their extreme perviousness and poor filtration, particularly in the coarser outwash. The minimum well sanitary system offset may be increased under the authority of the municipal health department or development restricted for the protection of acquifer recharge zones.

Organic Muck Deposits

In conjunction with the new drainage patterns during the post-glacial period, organic muck or swamp deposits formed in low-lying, poorly-drained areas. The thickness of these swamp deposits range from twelve (12) inches to over several feet and averages about two (2) feet. The underlying soils vary greatly including glacial till, stratified outwash and lakebed clays. Muck formations have a high water table, slow permeability, poor drainage, low erosion potential and poor bearing capacity.

Development Factors. Muck formations are indicative of poor drainage with severe construction limitations. Adjacent soil groups may serve as a rough indicator of sub-soil condition, however, the circumstances of poor drainage vary to the extent that no generalized interpretations can be made for development purposes.

Alluvium

Alluvial deposits are poorly-drained, permeable fine sandy silts that lie adjacent to streams on flood plains. These soils are flooded periodically following rainfall and tend to pond for several days. In addition, superficial muck may be encountered in conjunction with poor drainage conditions.

Development Factors. Alluvial soils have severe limitations for all aspects of development due to poor drainage, poor bearing strength and high ground water conditions. Both the erosion potential and class are medium.

Urban Land and Made Land

Within the last century, man's use of technology to alter land forms for construction material or site development has increased. The pattern of land alterations by man can be divided into two categories relating to the degree of disturbance.

Urban Land applies to areas where the soils are approximately 20 to 80 per cent disturbed by on-site excavation, fill or grading. Although the natural soil profile has been disturbed at the surface, the overall soil formation is still discernible and its characteristics applicable. It should be noted that Urban Land covers a wide range of materials and can best be interpreted for general purposes with regard to adjacent undisturbed soil formations. No overall characteristics or interpretations can be made.

Made Land relates to borrow and/or subsequent fill operations by which over 80 per cent of the natural soil profile has been disturbed. In such areas, only rough estimates of soil conditions can be made in reference to adjacent soil formations. Note that no generalized interpretations can be made due to the extreme degree of disturbance. These areas require detailed on-site investigations for the determination of actual soil characteristics.

COMPREHENSIVE DEVELOPMENT FACTORS

The natural environment of Denville is a uniquely complex balance of environmental processes and land forms. Any and all of man's activities, particularly land development, impinge upon these balanced cycles and result in a wide range of effects, many of which may be undesirable. These effects from land form alterations and modern technology range from discrete deterministic factors to almost intangible subtle climate modifications. The criticalness of any effect relates to the directness of man's dependent relationship upon the environment. For example, water is an easily identifiable determinant in that man takes his water directly from the environment. Any land use development that would significantly diminish water quality or quantity is a direct threat to man's existence. This direct relationship is what is meant as a deterministic factor. The majority of land alterations have semi-tangible environmental effects such as property damages, pollution or climate modification. It is the specific intent of this Section to delineate deterministic factors as well as potentially significant land use related environmental impacts.

Excessive Slope

The "Excessive Slope Map," a derivation of the "Topograhy Map," highlights several ranges of slope conditions and particularly the critically excessive slopes. The development limitations for increasing slopes include the necessity for massive cut and fill grading operations associated with maintaining maximum grades, and the problems of slope stability particularly where vegetation is removed and drainage patterns are altered. These restrictions become increasingly significant as grade slopes exceed 12 per cent. Areas delineated as in excess of 25 per cent are extremely susceptible to erosion, soil creep or gradual downslope movement and potential massive sliding.

The Erosion Cycle

Soil erosion is predicated on the two-fold action of water to mix soil particles with water to form a suspension and then to transport it down the land surface. This mixing of soil and water is in part due to the scour of water passing over soil, however, the primary agent of erosion is the percussion effect of raindrop impacts which can thoroughly churn up an exposed soil surface with water. In a humid environment, this effect is greatly offset where dense native vegetation exists. Plant foliage and roots act as both a cushion absorbing the impact of raindrops and an obstruction slowing overland runoff further inhibiting soil scour erosion. As such, erosion in a humid environment is principally confined to the exposed soil surfaces and in the drainageways.

The "Erosion Potential Map" refers to the tendency of a soil to erode based upon the physical characteristics of both the soil and site properties. In general, erosion potential, as defined by the U.S.D.A. - S.C.S., is low for 0-3 per cent slopes, medium for 3-8 per cent slopes, medium to high for 8-15 per cent slopes and high for those in excess of 15 per cent. Soil properties such as internal drainage, texture and structure may mitigate this tendency to a lesser extent. The two most critical factors are the vegetative ground cover and the slope conditions.

In terms of development limitations, erosion becomes potentially

EXCESSIVE SLOPES

PERCENT OF SLOPE

- 25% AND OVER
- 15% - 25%
- 8% - 15%
- 0% - 8%
- MARSHLANDS

NATURAL RESOURCE INVENTORY MAP

SPONSORED JOINTLY BY

DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION

AND

DENVILLE TOWNSHIP PLANNING BOARD

CONTOUR INTERVAL 10 FEET

SOURCE: ROBINSON AERIAL SURVEYS INC. BY PHOTOGRAMMETRIC METHODS FROM PHOTOGRAPHY TAKEN APRIL 7, 1969

TOWNSHIP OF

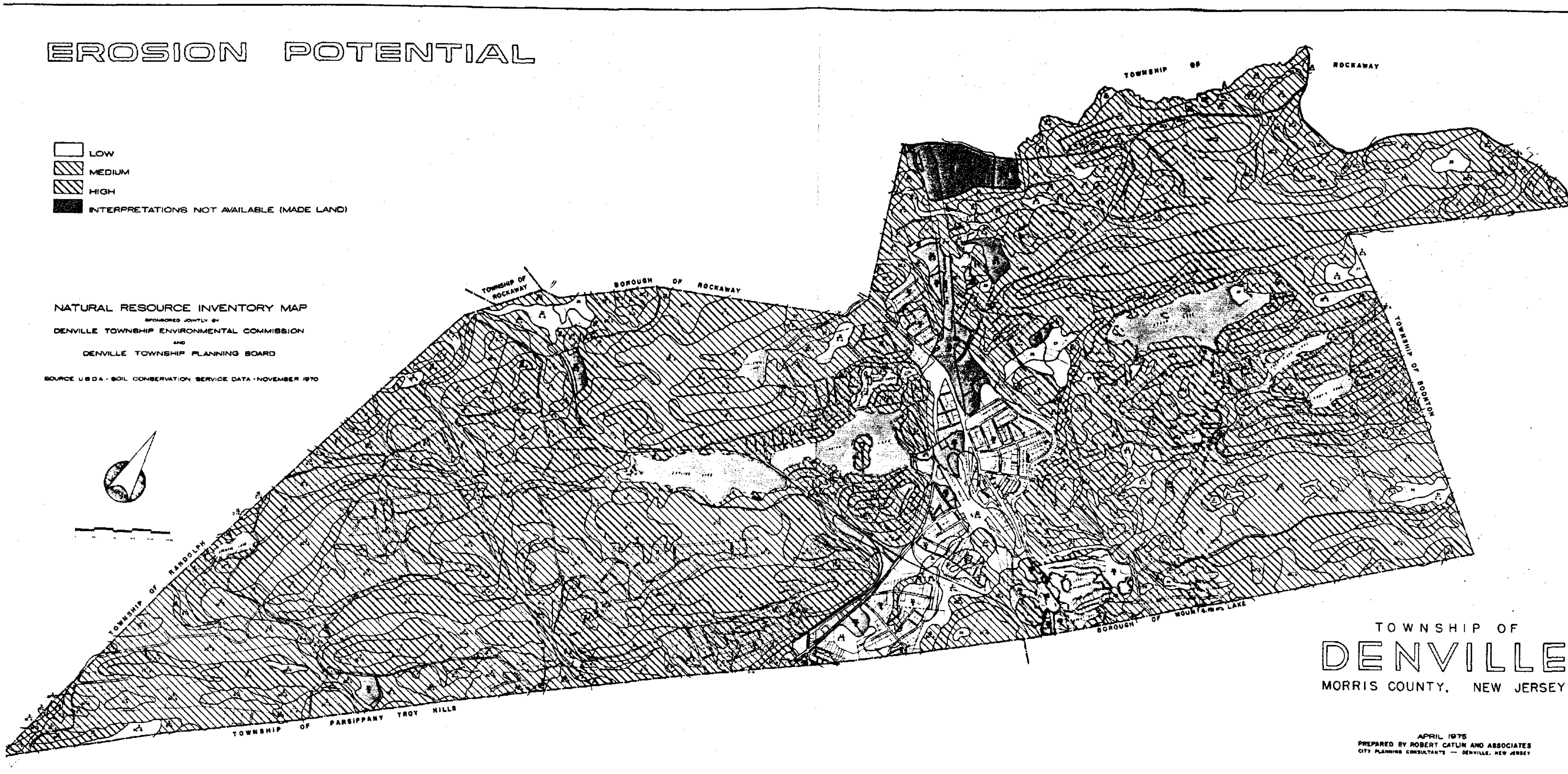
DENVILLE

MORRIS COUNTY, NEW JERSE

MARCH 1975

PREPARED BY ROBERT CATLIN AND ASSOCIATE

CITY PLANNING CONSULTANTS DENVILLE, NEW JERS


EROSION POTENTIAL
LOW
MEDIUM
HIGH
INTERPRETATIONS NOT AVAILABLE (MADE LAND)
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE U.S.D.A. - SOIL CONSERVATION SERVICE DATA - NOVEMBER 1970
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
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DENVILLE
MORRIS COUNTY, NEW JERSEY
APRIL 1975
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CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

significant for slopes in excess of 12 per cent particularly where vegetation is removed. Once erosion has transported sediment into watercourses, it is carried along in suspension until stream velocity and turbidity diminishes and sedimentation occurs, usually along the flood plains or relatively level areas of the river course.

Erosion is the continuing process of the environmental process of wearing down surface relief as hills. This gradual process is in balance with the local climate and geology for every natural setting. It should be noted that accelerated sediment production anticipated with land development in high erosion potential areas may overload the natural stream transport capacity and may result in additional extensive flooding with damage to the existing flora and fauna associated with watercourses.

The Hydrologic Cycle

The two most critical aspects of the hydrologic cycle are the availability of water for domestic, agricultural, commercial and industrial uses and the building constraints associated with drainageway flood plains. The basic hydrologic cycle consists of water which evaporates and rises from water bodies and is transported as water vapor over land where raindrops may form. Rain falling to earth is absorbed by plants and the soil, retained in surface depressions or flows overland downslope into drainage courses and then back to the ocean.

The Availability of Water

The availability of water is associated with either surface reservoirs or underground storage areas referred to as acquifers. Reservoirs are surface depressions where runoff water accumulates from streams usually with minimal filtering through soils. Since these bodies of water have little filtration and remain open to the atmosphere, they are very susceptible to sedimentation, pollution, temperature fluctuations and eutrophication or algae growths. Water supplies tend to be high in suspended solids and lower in dissolved minerals than well water.

Underground acquifers are the result of water infiltrating down into the pore spaces or voids in soil and rock where water is stored. Whereas, soil acquifers hold water in their sponge-like structure, bedrock acquifers consist of water held in and transmitted through fractured bedrock. The size, shape and percentage of voids or holes in soil and rock determine the rate of permeability, the ability to filter out pollutants and the acquifer storage capacity. Fine-grained soils, as clay and silt, very slowly filter and store large amounts of water, but their ability to transmit it is so small that they are considered essentially impervious. Coarser soil mixtures also store and transmit significant quantities of water with good to fair filtration except for uniform course sand or gravels.

Significant bedrock acquifers are mainly confined to the upper soil contact fracture zone which diminishes almost totally at the depth of over 200 - 300 feet and fractured rock associated with fault zones. Water in bedrock is stored and transmitted by open crevices that act as channels. Water transmission tends to be high but well water yield and storage tend to be low except where overlain by thick stratified glacial soils. In this regard, bedrock acquifers have substantially lower yields than thick coarse soil acquifers. Due to the poor filtration characteristics, the susceptibility of bedrock contamination for bedrock acquifers is higher than for soil acquifers where pollutants are not properly filtered.

Denville Township has all three sources of water; surface lakes water supplies, bedrock acquifers associated with the Pre-Cambrian gneisses and the soil acquifers consisting of Quaternary glacial deposits. Of these, the lakes are the most susceptible to pollution. The bedrock water availability is relatively low except as recharged by lakes and overlying soils and the soil acquifers have undermined boundaries and internal storage making their specific storage capacities and safe yields unknown. At present, Denville uses in excess of 1.65 mgd (million gallons per day), almost all of which is derived from Quaternary glacial soil deposits. The total safe yield from the soil acquifers is unknown but of prime importance in terms of a potential determinant for population growth limits and avoiding over pumping which may sufficiently draw down the water level to collapse the soil acquifer reducing storage and transmission.

It should be noted that the normal flow of ground water follows the contours of the ground surface downslope to streams and rivers in valley bottoms. At present, where wells are located adjacent to the river, pumping has probably reversed the flow such that the well is drawing water supplied by induced recharge from the river. As a result, the river water quality becomes of increasing importance. Polluted river water may be drawn into and filtered by the soil acquifer. Eventually, these contaminants, which may not readily decompose under anaerobic conditions, may reach the well site, may gradually contaminate the acquifer and eventually reach the well. Once the acquifer has been contaminated, the well site must be permanently abandoned and new water sources developed. This type of ground water acquifer contamination through induced recharge is well-evidenced in places such as Newark, New Jersey along the industrial section and should be carefully avoided to protect the availability of potable water.

Flooding

The portion of rainfall that is neither held in surface depressions nor absorbed by the soil becomes runoff consisting of overland flow and subsequently stream flow. The role of vegetation in retaining moisture and impeding overland flow is extremely significant. The net effect of vegetation is the attenuation of stream flow or reduction of storm water flood cresting. Once storm water runoff has entered an established watercourse, flows may exceed its normal banks into an area called the flood plain or floodway. In essence, the water on the flood plain is in storage and reflects the hydrologic conditions along the main channel. Obstructions to flow or low stream slopes tend to cause relatively larger and longer flooding.

Flood plains should be recognized as temporary reservoirs that should not be built in or developed. In terms of future planning, it should be noted that with the increased land development of any upstream watershed, storm water flooding along most rivers will increase in intensity and duration due to alteration of natural conditions.

Effects of Development

Land Development can be typified by three stages, rural, suburban and urban. As rural land, tracts are usually cleared where suitable for agriculture, small business or industry and residences. These areas have their own wells and rely on subsurface sanitary disposal systems. As a result, the water is pumped from the ground and locally recharged through a subsurface filter. In essence, rural areas alter only a small fraction of the land and most of the water that is diverted or withdrawn is recharged locally.

Suburban and urban development implies a shift to more extensive land development with central water supply and sewage treatment facilities. The land is stripped of vegetation and built upon, sodded or paved. Rain water infiltration is reduced resulting in increased storm water runoff with associated erosion, sedimentation and flooding. Ground water acquifers tend to be depleted by a combination of increased well water withdrawals, reduced infiltration and the diversion of waste water over long distances for treatment and discharge. As a result, stream flows tend to be more intermittent with higher flood crests during storm flows in the wet seasons and more pronounced dry spells of minimal flow. In general, water quality is significantly decreased with a marked increase of the biochemical oxygen demand (B.O.D.), dissolved solids and turbidity. The marked increase of soluble nitrates and phosphates associated with treated waste water effluent can significantly accelerate the normal eutrophication of lakes and streams particularly in dry spells where sewage plant discharges comprise a major portion of the stream flows.

The net effects of urbanization reflect a climate modification toward conditions analogous to that of a more arid environment. It is suggested that flood plains be recognized as natural reservoirs and development restricted to park and recreational development or natural preservation areas. It is also important that these areas and buffer zones along established drainageways be established to promote ground water recharge through the filtration, infiltration and attenuation of storm water runoff.

Sanitary Effluent Disposal

Subsurface sewage disposal systems, referred to as septic systems, are an important viable method of sewage disposal if and only when they are properly designed, installed and maintained. Considering that, in the United States, one home in four uses a sanitary system, the need to adequately understand their operation is essential. Many people feel that sanitary systems are temporary, only until sewers are made available. The fact of the matter is that subsurface disposal is a workable technique that can be designed as a permanent installation if soil and other conditions are acceptable.

There are three basic suitable conditions for subsurface disposal - soil permeability, depth to water and depth to bedrock or impervious formations. To begin with, the soil must be able to absorb and transmit water at a reasonable rate commensurate with domestic water consumption. Soil acts as a sponge-like filter whereby organic materials are absorbed or held until micro-bacterial action in the soil breaks them down. Extremely fine soils can not absorb sufficient water whereas course soil does not filter adequately to prevent pollution.

The term permeability refers to the rate at which water will move through a saturated soil. Although permeability is not the same as percolation, it nevertheless does provide a general indication of how well water will percolate in a given soil. Permeability in the Township has been rated on the "Soil Permeability Map" in terms of acceptable, unacceptable if pan present and unacceptable. These ratings are based on a combination of USDA-SCS data and State standards for percolation. In general, an acceptable rating corresponds to SCS ratings of rapid and moderate and wherein the properties of the soil should allow a maximum percolation rate of 40 minutes per inch.

Secondly, the infiltration of sewage must take place in the soil well above the water table in the presence of air where aerobic decomposition takes place, thoroughly breaking down organic wastes. Within the water table, decomposition is limited and certain organic solids may precipitate under anaerobic conditions contaminating ground water. It should be noted that even for a properly designed and installed system, some inorganic materials do not properly decompose, particularly synthetic detergents which have been known to contaminate ground water and pollute well water supplies.

Finally, the depth of the soil to bedrock must be sufficient to allow the filtration of sanitary effluent and the transmission of filtered effluent along with the natural flow of ground water. These three soil properties are indicated on the three maps, "Depth to Bedrock," "Depth to Water" and "Soil Permeability," and reflect the New Jersey State standards for individual sanitary disposal systems. Although these factors are primarily interrelated from the standpoint of suitability for sanitary effluent disposal, they also are associated with possible development limitations for building construction, roads and utility installations. The USDA - SCS rates the various soils in Denville as to the characteristics of these three factors.

To provide a comprehensive picture of the three soil properties discussed above, a "Composite Limitations Map" has been prepared showing depth to bedrock, depth to water table and soil permeability. Significant portions of the

Township are classified in the more severe categories for one or more of these soil properties, while an even greater area of the Township falls within the intermediate classifications indicating the need for concern as development takes place.

WATER RESOURCES

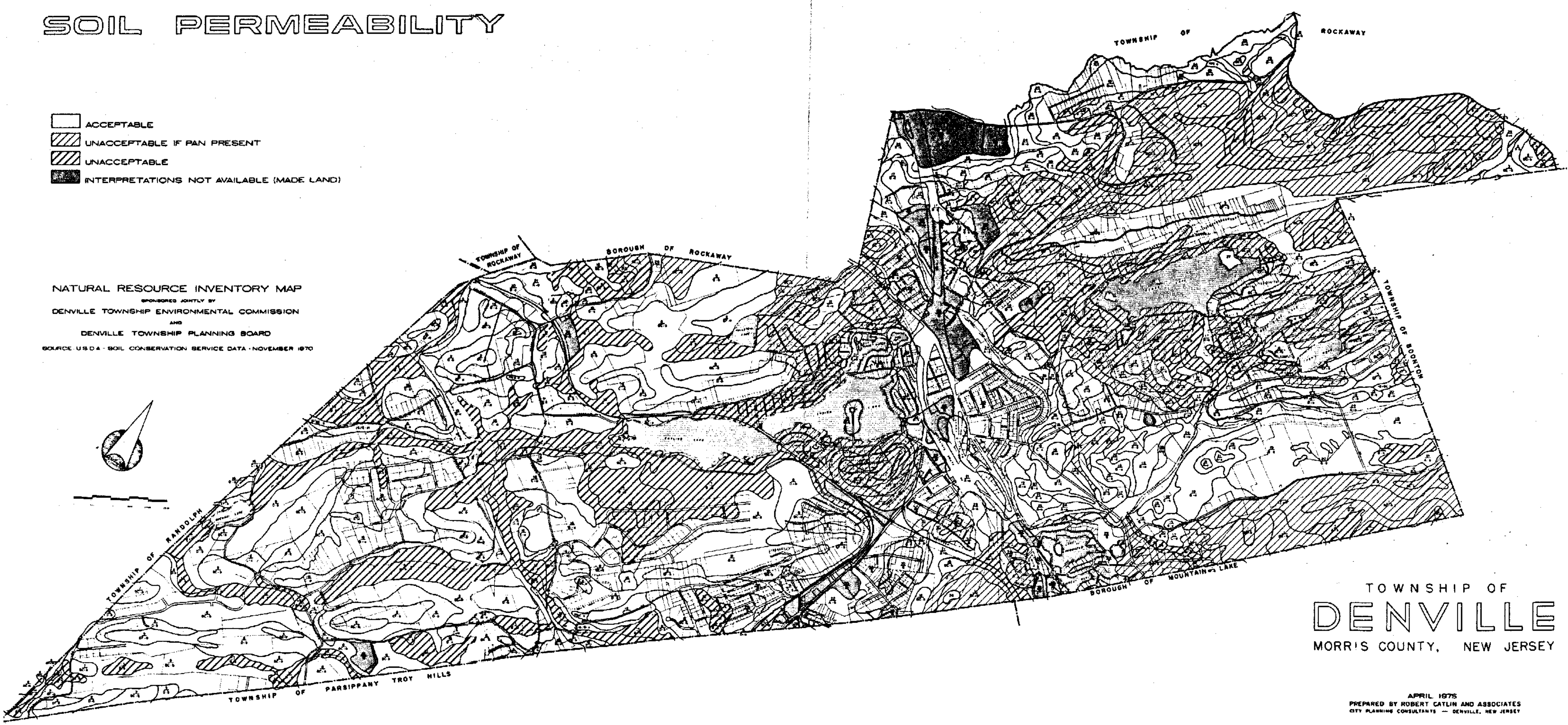
Because a natural resource inventory is important to the planning process, it is essential that the data be well developed and that the process remain continuous. The purpose for which the inventory is developed should be well understood by governmental officials and the public. The primary purpose of a natural resource inventory is the development of information for utilization in programs that will lead to the protection of resources for the highest and best purposes of the region.

At the present time, the Township of Denville has a water supply of superior standards as measured by the State of New Jersey and demonstrated in the tables found on Page 38. In order to protect and maintain this water quality, it is necessary for all portions of the planning process to recognize the water needs of the region.

The Federal Government has made significant progress in the development of laws which protect the waters of the United States, such as the Federal Water Pollution Control Act of 1965 and the subsequent amendments of 1972 known as P.L. 92:500. Section 101(a) in P.L. 92:500 sets forth the following goals:

> ".......restore and maintain the chemical, physical, and biological integrity of the Nation's water...it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985,.....it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983."

This law places responsibility on every governmental entity to review both the goals and strategies of this Act to determine their part in achieving the national goals.


SOIL PERMEABILITY
ACCEPTABLE
UNACCEPTABLE IF PAN PRESENT
UNACCEPTABLE
INTERPRETATIONS NOT AVAILABLE (MADE LAND)
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
SOURCE U.S.D.A. - SOIL CONSERVATION SERVICE DATA - NOVEMBER 1970
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
BOROUGH OF MOUNTAIN LAKE
TOWNSHIP OF PARSIPPANY TROY HILLS
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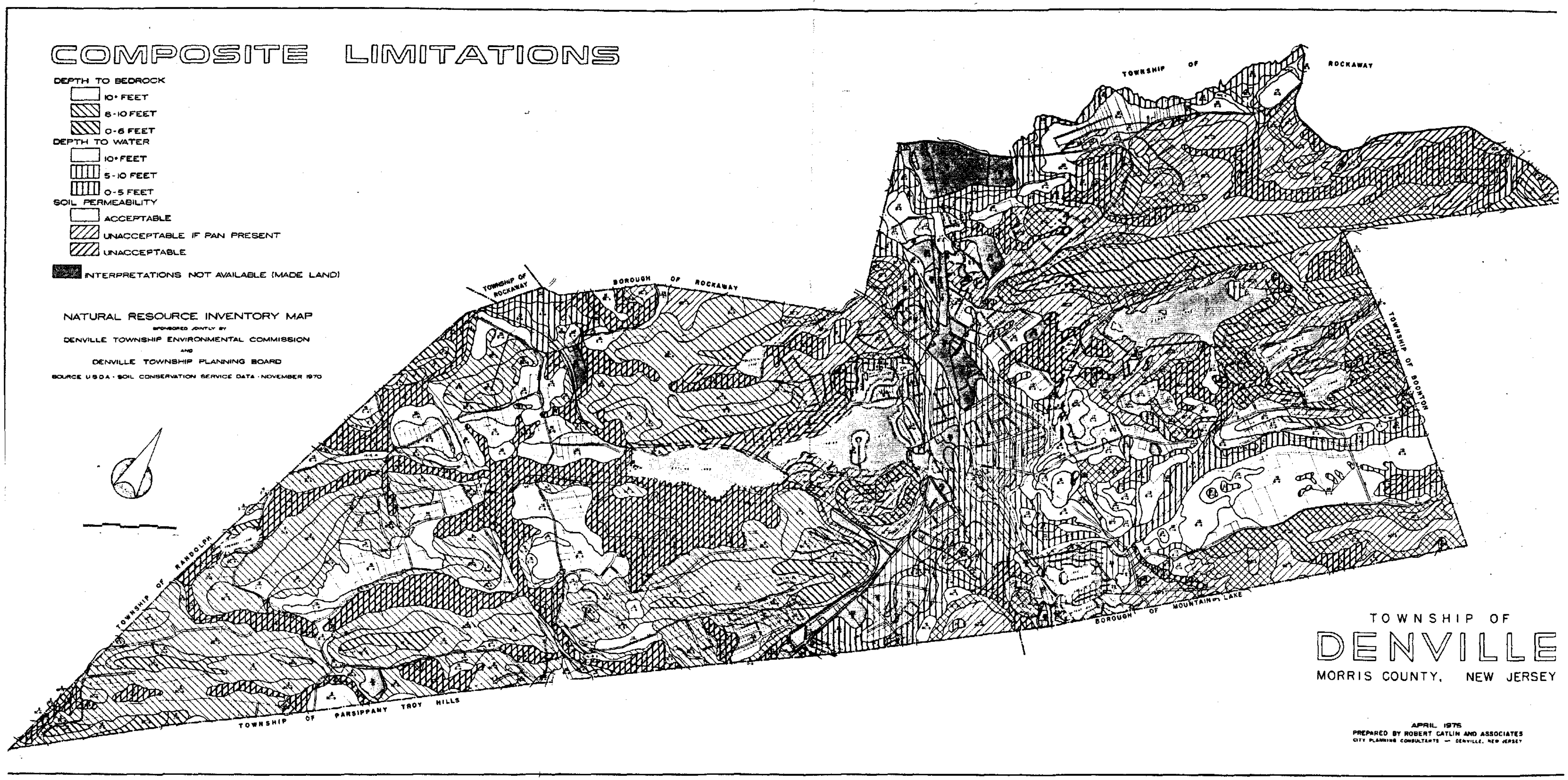
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
APRIL 1975
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY


COMPOSITE LIMITATIONS
DEPTH TO BEDROCK
10+ FEET
6-10 FEET
0-6 FEET
DEPTH TO WATER
10+ FEET
5-10 FEET
0-5 FEET
SOIL PERMEABILITY
ACCEPTABLE
UNACCEPTABLE IF PAN PRESENT
UNACCEPTABLE
INTERPRETATIONS NOT AVAILABLE (MADE LAND)
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The Federal Government has also placed additional emphasis on the protection of the water resources through the enactment of the Safe Drinking Water Act of 1974 (P.L. 93-523), which is a comprehensive effort to regulate uniformly and effectively the purity of drinking water throughout the Nation. Denville, therefore, must maintain its high water quality through land use regulations, which can still be implemented.

The State of New Jersey has begun to assume its responsibility for water resources management through the Flood Plain Control Act of 1972. The Act and its rules and regulations as formulated by the New Jersey Department of Environmental Protection was established to minimize losses and damages to public and private property owners caused by floods by limiting and restricting development within the flood plain, to enhance public health by minimizing pollution sources, and to protect wildlife and fisheries by preserving and enhancing the environment of the flood plain. This legislation recognizes that it is the State's role to assist in the development of regulations and procedures which provide both for protection of public health and safety and for a recognition of the multiple uses of flood plain lands as they relate to water resources. Under this law, all flood plains are to become delineated and each municipality must adopt regulations over their flood hazard lands. In so doing, it is important to recognize the threat of flooding and pollution toward potable water supply. The potential for flooding and pollution and the means to minimize those threats are important factors to be carefully considered in the planning process.

In 1975, the State of New Jersey took a further step by enacting a Soil Erosion Law based on the expertise and work of the U. S. Soil Conservation Service. Thus, we are beginning to have the tools made available which will enable communities to deal more effectively with water pollution and flooding problems through the planning process.

Within the last decade, government and planners have begun to recognize that the highest and best use of water is not as a carrier of waste but as a necessary resource for domestic, commercial, industrial, and recreational benefits. Denville's water resources provide it with many economic assets for a balanced environment. Thus, if the Township includes proper water resource management in its planning process, it has the potential for diversified maximum growth - in keeping options open for future redevelopment, dependent on the needs of the community, if its water resources are managed properly in concert with reasonable land use practices, it can provide for a balanced growth in harmony with the natural environment and for the benefit of the public good.

Watershed and Stream Flow

Denville is situated entirely within the Passaic River Basin. A major sub-basin of the Passaic in Denville is the Rockaway River, which along with its tributaries in Denville (Den Brook, Beaver Brook, Mill Brook, Peck Meadow Brook, and other lesser streams, See Watershed Map) drains all but the extreme eastern sections of the Township. This eastern section is drained by Watnong and Troy Brooks which are part of the Whippany system, another tributary of the Passaic.

Since the majority of Denville's concern is with the Rockaway Watershed and in light of the notable absence of stream data on the smaller brooks, data referring to the Rockaway River is presented but does not represent a complete picture of the water quality or flow characteristics of the smaller tributaries. It is recommended that Denville initiate a small stream monitoring system.

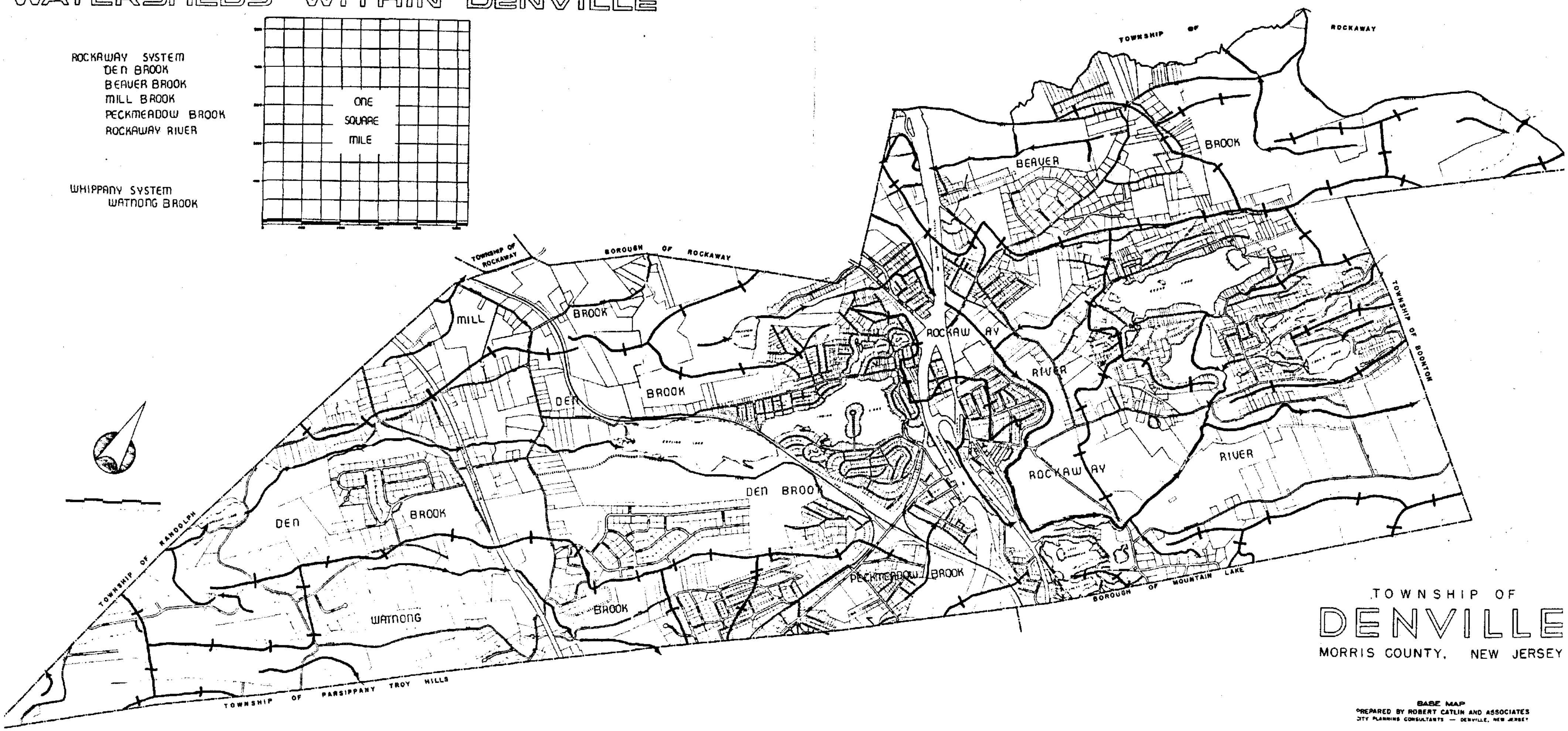
Precipitation is the prime source of stream flow. According to Anderson and Faust, 20 inches per year of precipitation is lost through evapotranspiration in the mountainous northwestern portion of the Passaic River Watershed, which is composed of the Rockaway River sub-basin, in which Denville is located.[1]

The mean annual floods of the Rockaway River between 1938 and 1971 was found to be 1760.8 cfs. The standard deviation of the peak annual flood was 690.7 cfs. An exceedence probability of 1 per cent or a so-called 100-year flood was found to be 4100 cfs. These peak annual flow data were measured at the U.S.G.S. Morris Avenue weir on the Rockaway in Boonton where the upstream drainage area is 116 square miles.

When these data are referred to the gauge on the upstream side of the Diamond Springs bridge, they must be modified by a ratio of 84 sq. mi./116 sq. mi. or 0.75 hence are 3/4 of the cited figures.

These data are given in the attached curve sheet No. 2 which shows that the 1 per cent exceedence or the 100-year probable recurrence interval is a peak flood of 4100 cfs. at the weir or 3200 cfs. at the Diamond Springs Bridge.

WATERSHEDS WITHIN DENVILLE



PASSAIC RIVER COALITION 2/76

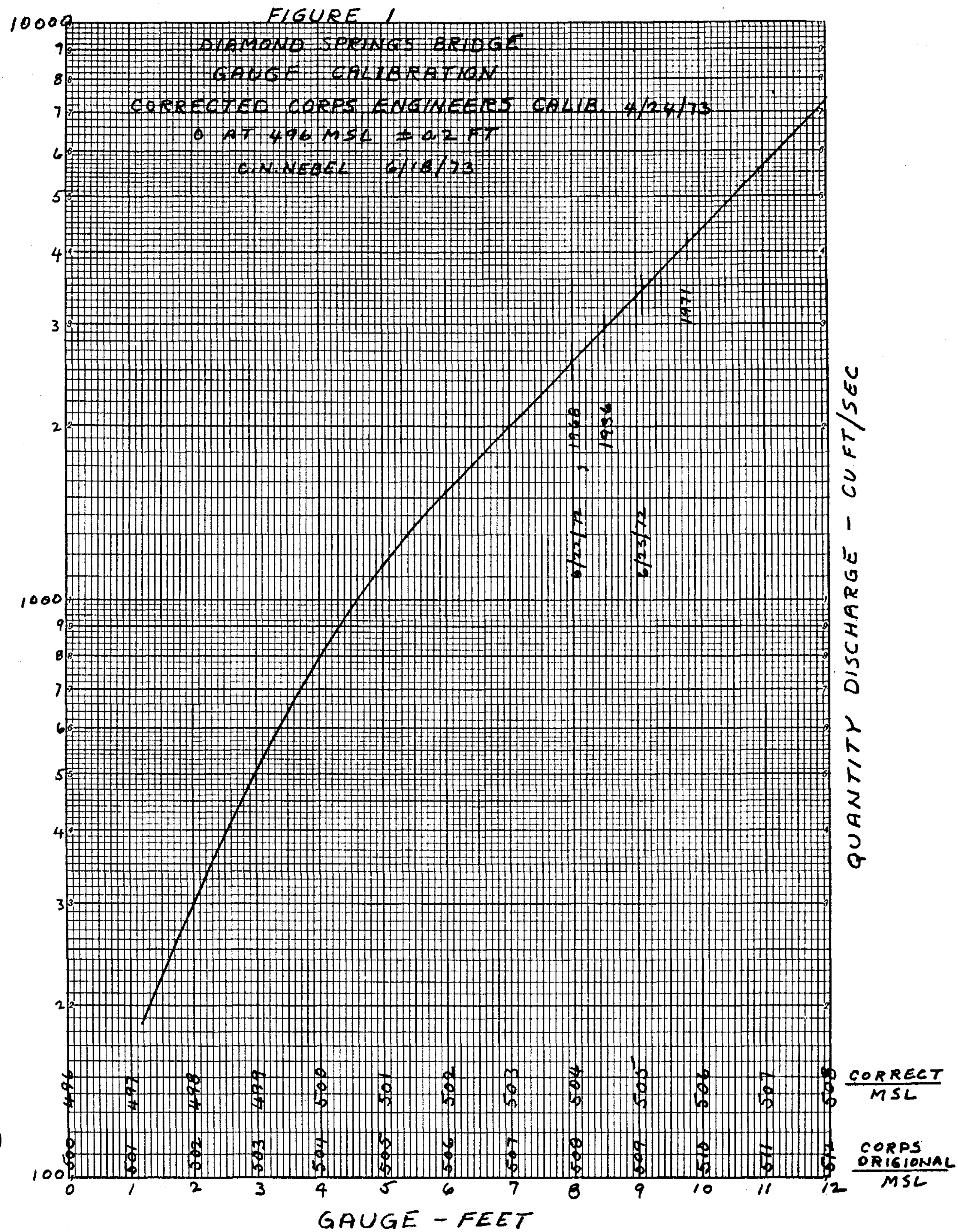
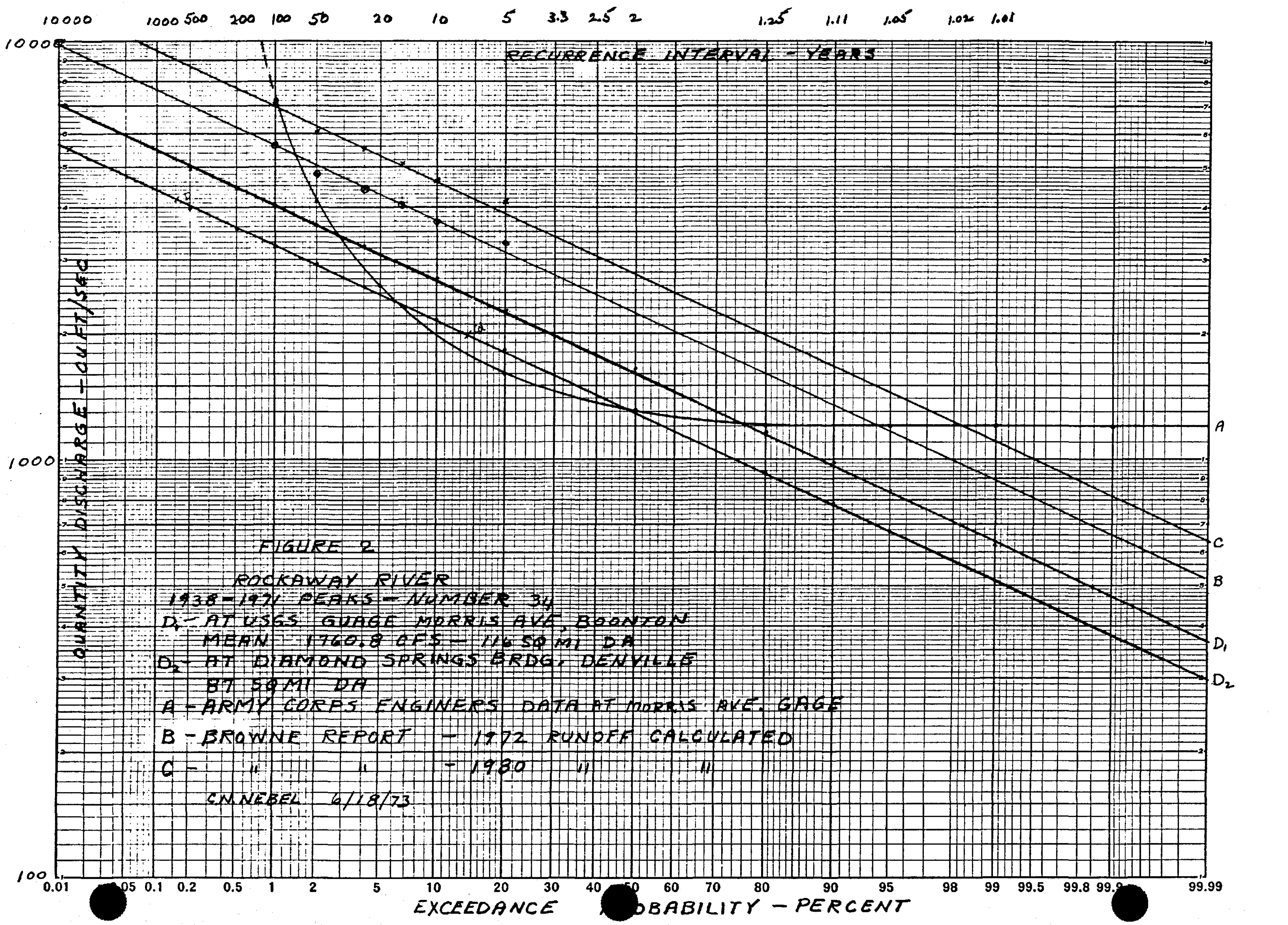


FIGURE 1
DIAMOND SPRINGS BRIDGE
GAUGE CALIBRATION
CORRECTED CORPS ENGINEERS CALIB. 4/24/73
0 AT 496 MSL ± 0.2 FT
C.N. NEBEL 6/18/73
10000
1000
100
1968
1956
1971
6/22/72
6/23/72
QUANTITY DISCHARGE - CU FT/SEC
496 497 498 499 500 501 502 503 504 505 506 507 508
CORRECT MSL
500 501 502 503 504 505 506 507 508 509 510 511 512
CORPS ORIGINAL MSL
0 1 2 3 4 5 6 7 8 9 10 11 12
GAUGE - FEET


RECURRENCE INTERVAL - YEARS
10000 1000 500 200 100 50 20 10 5 3.3 2.5 2 1.25 1.11 1.05 1.02 1.01
QUANTITY DISCHARGE - CU FT/SEC
10000
1000
100
EXCEEDANCE PROBABILITY - PERCENT
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.5 99.8 99.9 99.99
A
C
B
D1
D2
FIGURE 2
ROCKAWAY RIVER
1938-1971 PEAKS - NUMBER 34
D1 - AT USGS GUAGE MORRIS AVE, BOONTON
MEAN 1760.8 CFS - 116 SQ MI DA
D2 - AT DIAMOND SPRINGS BRDG. DENVILLE
87 SQ MI DA
A - ARMY CORPS ENGINEERS DATA AT MORRIS AVE. GAGE
B - BROWNE REPORT - 1972 RUNOFF CALCULATED
C - " " - 1980 " "
C.N. NEBEL 6/18/73

These data were supplied by Mr. S. J. Stanbowski of the Water Resources Division of the U. S. Department of the Interior. These data were calculated by the Log Pearson III flood frequency method using 34 annual peak flood samples including the 1971 Doria-flood data but not using the 1903 data which was measured at a point below the Boonton reservoir at an unspecified weir.

The measurement of the 1903 flood peak flow of 7550 cfs. at the above point with an upstream drainage area of 119 sq. mi. gives a flow of 7340 cfs. at the U.S. G. S. Morris Avenue weir. This information was furnished by Mr. Clark Giluan, Supervising Engineer, Flood Plains Management Section of the Department of Environmental Protection.

The Corp of Engineers mistakenly attributed the 1903 peak flood of 7350 cfs. to the Diamond Springs Bridge. Their data curve is incorrect in shape and is questionable. This data was taken from their "Reconnaissance Report for the Rockaway River at the Township of Denville," dated 13 January 1972. The data in curves B and C were extracted from the Browne Report entitled, "Volume One, Rockaway River System; Drainage Study, Morris County, N. J." The calibration of the upstream gauge at the Diamond Springs Bridge is given in curve sheet No. 1.

It can be seen that there is a variance in these probability frequency distributions. This data is used to determine the mean annual flood from which the floodway and the flood hazard flood designs are determined. The Department of Environmental Protection is going to resolve the data and choose a 100-year flood design from which to calculate the floodway and flood hazard delineations to be used in the Flood Plain Ordinance. These delineations are not scheduled to be completed before the end of 1977.

Water quality data relating to the Rockaway River taken upstream from the dam on the Boonton Reservoir indicated the following chemical analysis:[2]

Chemical Analysis - milligrams/liter	Minimum	Maximum
Silica	2.2	12
Iron	.04	1.5
Calcium	9.0	24
Magnesium	3.2	12
Sodium	4.0	11
Potassium	.5	3.0
Sulfate	17	32
Chloride	6.1	24
Floride	.0	.4
Dissolved solids (residue at 180 C)	75	149

The 1972 Study of the Upper Passaic Basin by Anderson and Faust, water quality evaluation, utilized the standard measure for expressing the extent of river pollution as dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), coliform count, turbidity, dissolved solids and heavy metals. There is no normal DO level; the count varies with temperature, river flow, and chemical composition.

The State of New Jersey Rules and Regulations Establishing Surface Water Quality Criteria defines a dissolved oxygen content for "trout maintenance streams - daily average not less than 6.0 mg/1. Not less than 5.0 mg/1 at any time."[3] The Anderson and Faust study which is the most recent evaluation does not provide an example of average DO. It, however, states: "Lower percentages of oxygen-saturation values at Pine Brook and Two Bridges are related, of course, to the inflow of high-oxygen-demanding water from the Rockaway-Whippany River system......A downward trend is observed on the Rockaway River .....Oxygen saturation levels at the Rockaway River sampling site average 60 per cent."[4] As oxygen content declines, and the water's assimilative capacity diminishes, the process of "anerobic decay" sets in. This is undesirable and P.L. 92-500 has established water quality goals which should not only bring attention to this fact but should bring all the waters in the United States to fishing and swimming quality, which can be achieved in the Rockaway Valley. The Anderson and Faust study concluded that higher amounts of trace elements than are normally found in New Jersey exist in all of the Passaic River Basin. They show the following for the Rockaway River above the reservoir at Boonton.[4]

Trace Element	Maximum	Minimum
Aluminum	410	7
Barium	28	14
Boron	100	27
Copper	7.0	2.0
Lithium	3.0	.40
Nickel	7.0	2.0
Strontium	70	23
Chromium	7.0	not measurable
Lead	5.0	" "
Molybdenum	2.0	" "
Rubidium	4.0	" "
Titanium	15	" "
Vanadium	2	" "

The Passaic Valley Water Commission maintains a water quality monitoring station on the Rockaway at the Boonton Reservoir. In the warmer months, (April through September), dissolved oxygen readings of 2 ppm or less were common in 1972. During the cooler parts of the year the dissolved oxygen levels are usually sufficient, reaching ultimate levels of 9 ppm and averaging 5 ppm in most of the upper basin.

The remaining pollution is attributed to a variety of sources which are generally called "non-point sources." The major non-point sources in Denville are runoff of silt and sediment from areas of loose landfill and/or unprotected soil near excavation sites. Leachate from malfunctioning septic systems also contribute to the problem.

Industrial pollution is another source. In Denville there are no known discharges into the Rockaway system according to the U. S. Environmental Protection Agency, Region II, under the permit system of P.L. 92-500.

Runoff

Surface runoff, interflow, groundwater flow and channel precipitation influence the rate of discharge.

Runoff, the method by which the water may either infiltrate into the soil or accumulate and flow from an area, depends on the intensity and duration of rainfall, its distribution on the basin, the direction of the storm movement, the type of precipitation and the type of storm. When the intensity of the rainfall is greater than the soil infiltration or permeability potential, surface runoff occurs. This does not happen, however, until the assimilative capacities of the natural environment are filled.

Denville, which still contains excellent open space and forested areas, can illustrate the value of controlled runoff in development. Runoff and erodability are great in areas where groundcover has been destroyed. It is, therefore, essential to maintain the hardwood forest cover within the Township, which has the greatest retention capacity especially in those areas where there are excessive slopes. (See map on Excessive Slopes)

Due to the steep slope topography, the utilization of retention or detention ponds is limited. Thus with additional development, increased flow into the brooks and rivers within the Township will become more noticeable. Excessive runoff and siltation are becoming more evident in Denville and have a negative effect on the water quality of Den Brook and Lake Openaki, (the problem originating at Shongum Lake).

A regional responsibility with the total watershed or the sub-watersheds being evaluated therefore exists since the loss of prime water quality may result from land use practices elsewhere.

Since Denville's lakes are part of its major natural resource base and an important asset to the community at large, measures should be enacted to control soil erosion (such as the regulation of unnecessary tree and groundcover removal). In addition, lake or pond maintenance programs should be developed and implemented to assure the continuation of good water quality. Depending on ownership of the ponds and their effect on the water quality of the receiving streams, the Township should formulate an ordinance which outlines the responsibilities of these basins by both the private and public sectors. The Health Department may develop and implement a monitoring syste, which would provide the Township with the data base necessary to pursue and develop an equitable lake and pond maintenance program. Consultation on such a project and ordinance could be obtained from the Soil Conservation Service.

Another factor which has great meaning to Denville is: the greater the runoff, the greater the flood potential as seen in the value of the runoff coefficient which is used to calculate peak flow of a river. In flat, residential areas where 30 per cent of the area is impervious, the runoff coefficient is 0.40; in moderately steep areas, where 50 per cent of the area is impervious, the coefficient jumps to 0.65, and in moderately steep built-up areas with 70 per cent of the area impervious, the coefficient is 0.80.[5]

Flooding

Flooding is a recognized water resource problem in Denville. The Corps of Army Engineers has analyzed the situation in Denville as follows:

"The flood plain area in Denville, New Jersey consists of a broad, flat area of approximately 550 acres on the right bank of the Rockaway River. The developed portion of the flood plain consists of approximately 110 owner-occupied residential structures and 40 commercial and industrial structures. The commercial development varies from local service and sales-oriented shops to major sub-regional shops. The total development occupies above 175 acres. Many of the industrial plants provide employment to residents of the surrounding areas. The flood plain area also contains a regional high school."[6] The regional high school referred to actually is the River View School.

The Army Corps of Engineers has recommended a plan which they claim will protect the study area against the recurrence of a 105-year frequency flood on the Rockaway River and Den Brook. The plan would consist of levees, flood walls, closure structures and miscellaneous interior drainage facilities. According to a reevaluation computed by the Corps in August, 1975, the average annual benefits that accrue as a result of the proposed plan under existing conditions of development are estimated at $330,000. The estimated annual charges, including operation, maintenance and major replacement, are $363,000, for a resulting benefit-cost ratio of 0.91.[6]

The total reevaluation for future benefits to existing and future development have not been fully computed by the Corps. In addition, Morris County is presently reviewing the many aspects of the total Flood Control program for the Passaic River Basin, as the Corps will apply for General Design Memorandum through the Omnibus bill in 1976.

In September, 1972, Gilbert Associates, Inc., Engineers and Consultants, Reading, Pa., completed a "Flood Control Study." They proposed two alternate plans. Each plan recommends the raising of homes and filling of low areas in specified areas, the raising of Pocono Road to Saint Clairs Hospital, the installation of flap gates on storm sewers, installation of sump pumps in basements, installation of appropriate drainage structures, dredging of Rockaway River at Diamond Spring Road and Jersey City sewer trunk crossing, and the demolition of Jersey City sewer trunk structure to be replaced by an underground conduit.

Infiltration

Special attention must be paid to the process of infiltration, for it is through the study of the infiltration rate that the amount of runoff can be calculated. This result can then be applied to future design problems.

The rate of infiltration depends on many factors, including precipitation intensity and type; the condition of the soil surface, the density type and stand of vegetation; the temperature and chemical composition of the water; and the physical properties of the soil (porosity grain and pore size, moisture content, etc.).

Denville is located in the New Jersey Highlands region. The major portion of the topography of Denville was determined by the last glaciation, which has set the criteria for how and where infiltration takes place.

Groundwater occurs in both consolidated and unconsolidated formations, which may contain aquifers if sufficiently porous and permeable. Groundwater of high quality is available throughout a large portion of Morris County due to the less densely packed surface deposits (soil, rock, glacial till) of the Quaternary period.[7] Denville extracts its water from these deposits which consist of clay, sand, silt, gravel and boulders using five wells.

The openings in which the water occurs fall into two general categories: the openings between individual particles as in sand and gravel, (the original interstices); and the crevice joints or fractures in the harder bedrock below (the secondary interstices).

The porosity of a formation is that part of its volume which consists of openings or pores, where the water is stored. Porosity is an index of how much water can be stored in an aquifer but not of its ability to yield water. The yield rate of an aquifer is a function of pore size and interconnection. Therefore, an aquifer can be defined as any formation that has sufficient porosity and water-yielding ability to permit the removal of water at a dependable, reasonably useful rate.

Basically the Quaternary rocks in Denville are glacial in origin with a large part of the Township (approximately 50%) covered by the newer glaciation of the Wisconsin Terminal moraine. It is from these stratified drift deposits which form a substantial groundwater reservoir from which Morris County derives 77% of its water. (the figure in Denville is nearly 100%)

The Terminal or End Moraine from which the water is obtained was formed at the outermost edge of the Wisconsin Glacier. This stratified drift deposit of the Quaternary rocks form the mineral framework for the most highly developed groundwater reservoir in Morris County. If this aquifer is to continue to yield substantial quantities of water, precautions must be taken to protect direct or indirect impacts toward its natural functions.

The unconfined drift deposits are related and closely associated with the present day alignment of the surface drainage network of the Rockaway River. According to Gill and Vecchioli[8], these are the most extensively developed deposits in Morris County. The unconfined aquifers are recharged directly from precipitation on the outcrop area of the stratified drift. (See map - Groundwater Geology)

It is critical to recognize that since Denville's main wells are located on the banks of the Rockaway River that a reverse gradient could exist. When pumping takes place, the water in the river may pull down into the aquifer and eventually be pumped into the water supply, as happens in Dover and Wharton. Therefore, as development occurs in the future (either in Denville or upstream), the water quality of the Rockaway River will possibly determine the quality of the aquifer in that general area. For example, if the quality of the Rockaway River declines, so may that of the wells, and since future growth will also depend on some of the yield from these wells for water supply, it clearly demonstrates the need to structure any growth and development within a concern for water quality and the maintenance of this aquifer's utilization.

Efficient aquifer recharge is best accomplished through the natural system provided the river water quality remains high.

According to Gill and Vecchioli, 1,649,000 gallons daily are used in Denville from the Quaternary deposits and only 1,000 gallons daily come from the Precambrian aquifer (St. Francis Health Resort use). Since most of Denville is overlain with Quaternary deposits, there is potential for further ground water development; yet the extent of this supply has not been fully explored and should be, since water availability becomes one of the limiting factors for future plans for development.

According to the Water Department of Denville, at present, during summer peaks the consumption is 2 mgd leaving no reserve storage capacity. However, a new water tank with a storage capacity of 1.5 mg is under construction on Hertz Way to provide additional storage capacity.

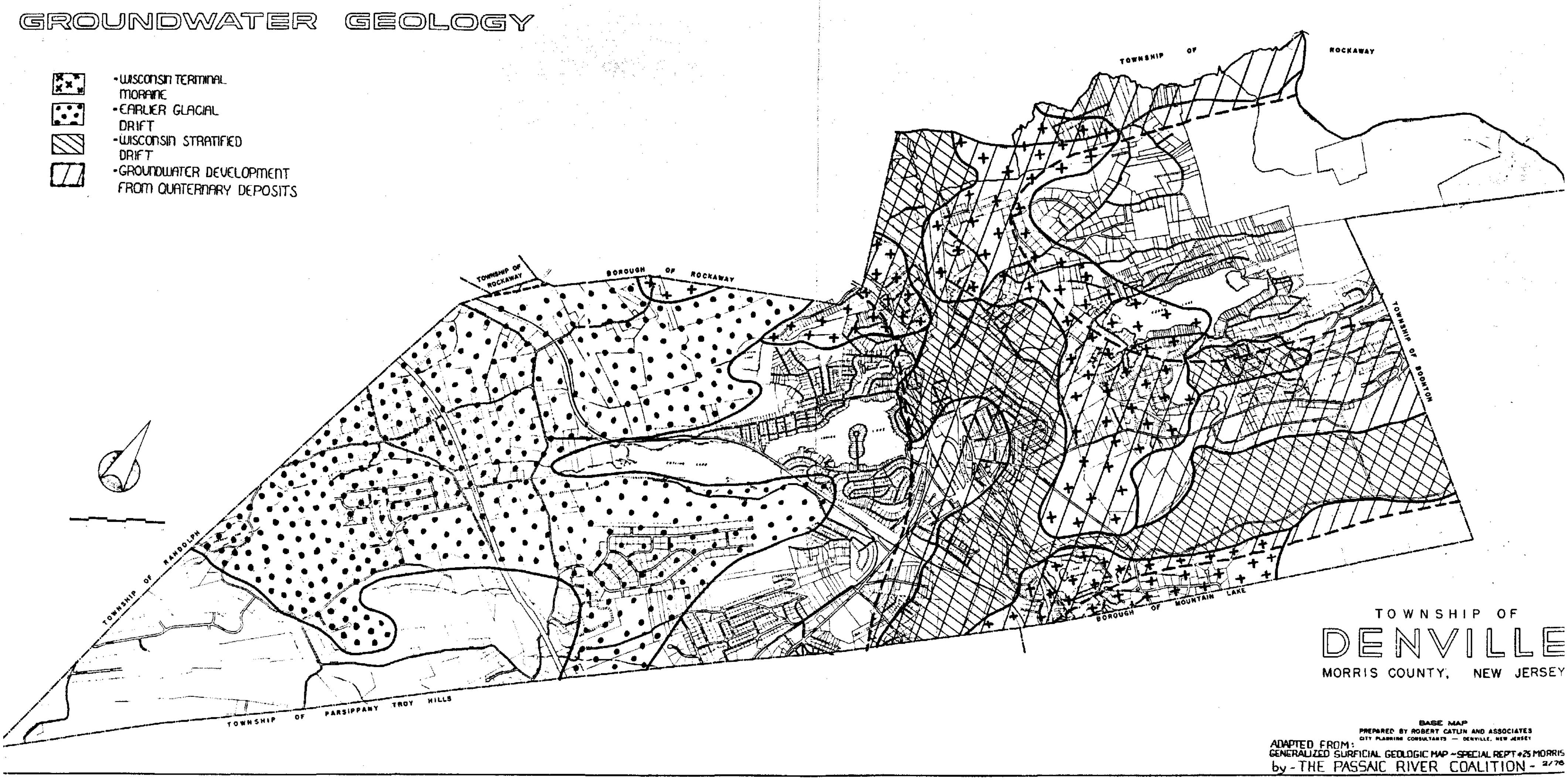
The upland areas to the north of Denville are on the whole expected to produce only small to moderate additional supplies so that it is important that Denville and the municipalities surrounding it not overextend themselves, since the water resources in the remaining upland areas are very limited and a regional need will become more apparent.

Recharge

Since the ground water in the confined or artesion areas is recharged in part from the fracture network in the adjacent bedrock, the water entering the bedrock is derived from precipitation on the upland recharge areas of which Denville is a major part. This means that the highland municipalities form the recharge network for those municipalities at lower elevations in the region. Care should be taken to protect such recharge areas or additional stress will be placed on the region with regard to water quality and quantity.

Availability of Ground Water

By knowing the extent of the sand and gravel body in the river valley or in the glacial outwash terrain, an evaluation of the availability of ground water can be made. Sandy areas can represent shallow unconfined aquifers, while areas of high permeability are apparent as having high recharge potential.


GROUNDWATER GEOLOGY
- WISCONSIN TERMINAL MORAINE
- EARLIER GLACIAL DRIFT
- WISCONSIN STRATIFIED DRIFT
- GROUNDWATER DEVELOPMENT FROM QUATERNARY DEPOSITS
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF BOONTON
BOROUGH OF MOUNTAIN LAKE
TOWNSHIP OF PARSIPPANY TROY HILLS
TOWNSHIP OF RANDOLPH
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
BASE MAP
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY
ADAPTED FROM:
GENERALIZED SURFICIAL GEOLOGIC MAP ~ SPECIAL REPT #25 MORRIS
by - THE PASSAIC RIVER COALITION - 2/76

(See Aquifer Recharge Potential Map by PRC) Ground water flow is almost invariably at right angles to the topographic contours. Understanding this interchange is crucial to the system.

Ground water as part of the hydrologic cycle is subject to continuous movement - the rate of which depends on the formations involved and the hydraulic gradient which the steep topography imposes on the area. Thus, there are regions of recharge where percolating water from rainfall or surface bodies of water moves into the ground water system; regions of discharge where water is lost from the ground water system to surface stream flow or evapotranspiration; and areas of ground water transmission.

This flow system does not recognize man-made political origin boundaries within. Denville is part of the Rockaway watershed, 90% and Whippany watershed, 10%. To date no comprehensive study has been made of the flow of the ground water resources of the region. However, the State of New Jersey recognizes that the need exists, as it has placed a priority of number 5 on "Ground Water Quality Management." However, in their April, 1976 "Objectives and Level of Detail of Future Water Quality Management Planning In New Jersey" document, the State has not yet applied a dollar value toward the implementation of such a study.[9] According to Gray, several methods of field techniques are available to study ground water movement (tracers, geochemical analysis). However, it is generally agreed that, <u>in principle,</u> water tends to degrade in quality as it moves toward the discharge area.[10] Whether this holds true in the Rockaway Valley must yet be determined. In glacial regions water flowing through till shows an increase in calcium and magnesium. This results in hard water. (hard water - characterized by the presence of substances, alkaline earths, which prevent lathering with soap)

The municipal responsibility toward the safe yield of the basin should be based on the natural basin yield (according to Freeze in 1966) [11] at least during the initial stages of development. For Denville, the natural basin yield (discharge) is approximately 4,883 gpm.

Because of the recurring questions of adequate water supply sources in New Jersey, a continuous appraisal of the yield and quality of ground water sources should be made as development proceeds to guard against a depletion of water resources under all conditions, including of course, drought.

Study of a ground water basin is made to define the ground water system in terms of the potential for development. Interpretations of the aquifer, its characteristics and recharge potential can be made based on the following criteria; the topography, in-flow/out-flow estimates based on precipitation and surface flow, and the geology. The State of New Jersey is presently considering the correlation of this type of data.

Water Supply

The wells listed in the Morris County Report on Ground Water are as follows:

	Peak Yield	Guarantee Yield	Year Drilled
1. N. J. Power & Light	225 gpm		1955
2. Advance Pressure Casting	78 gpm		1959
3. St. Francis	80 gpm		1927
4. Boro of Mountain Lakes	600 gpm		1928
5. Boro of Mountain Lakes	560 gpm		1958
6. No. 1 Denville Municipal Well	406 gpm	350 gpm	1947
7. No. 2 Denville Municipal Well*	760 gpm	700 gpm	1947
8. No. 3 Denville Municipal Well*	614 gpm	700 gpm	1931
9. No. 4 Denville Municipal Well	542 gpm	350 gpm	1946
10. No. 5 Denville Municipal Well	1,018 gpm	1,000 gpm	1961
Total	4,883 gpm	3,100 gpm	

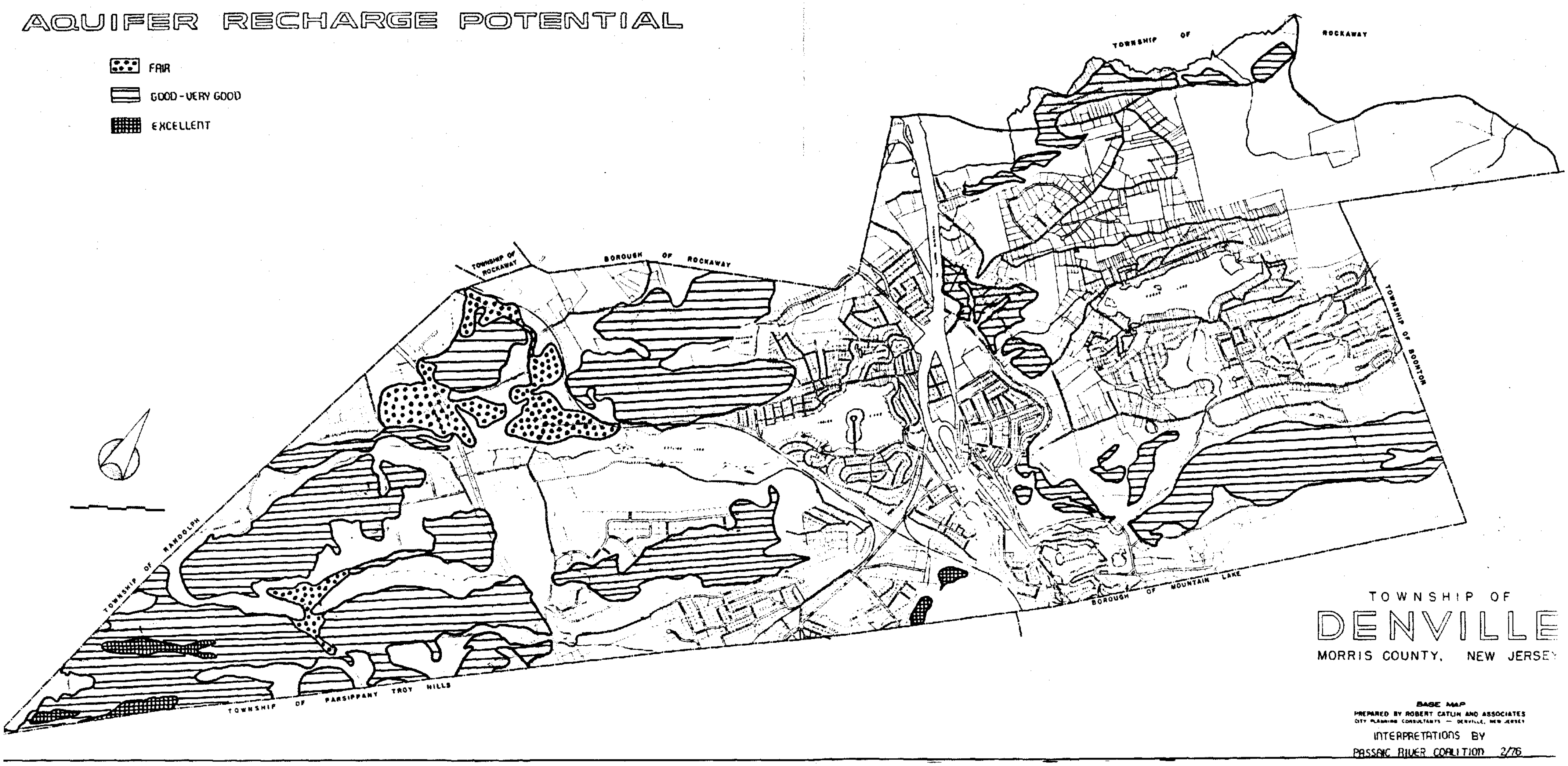
Total - Denville Municipal Wells - 3,340 gpm 3,100 gpm

Part of Denville's water supply system in addition to the 5 wells includes 8 tanks for gravity flow as follows:

	Capacity	Elevation
1. Tank at foot of Horizon Drive	0.5 mg	1,013
2. Tank off Franklin Road	0.5 mg	790
3. Tank above Holstein Lake	0.2 mg	865
4. Elevated tank south of Ford Road	**	**
5. Tank on Hillcrest Road	0.25 mg	713
6. Tank between Hillcrest and Baird Drive	0.5 mg	790
7. Summer Tank at Terminus of Hillcrest Road	10,000 g	na
8. New tank on Hertz Way	1.5 mg	na
Total	3.460 mg	

* Located in Randolph Township

** Belongs to Reaction Motors and is stagnant


AQUIFER RECHARGE POTENTIAL
FAIR
GOOD - VERY GOOD
EXCELLENT
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
TOWNSHIP OF RANDOLPH
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MORRIS COUNTY, NEW JERSEY
BASE MAP
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INTERPRETATIONS BY
PASSAIC RIVER COALITION 2/76

In 1975, the Denville Water Department recorded a total annual consumption of 733,476,000 gallons which resulted in an average daily consumption of 2,009,500 gallons.

If one figures the guaranteed gpm of the Township's 5 wells and computes a 24-hour total, it yields approximately 4.5 million gallons. The average resident may use up to 100 gallons in the same period.[12] When one considers these preceding figures in terms of the residential or commercial growth they may support, other factors must be evaluated. A reserve water supply must be set aside to assure fire protection and future growth must be planned to preserve the aquifer recharge areas so as to obtain maximum yield.

Maximum flexibility in the planning process can be maintained only through stewardship of these aquifer recharge areas. If the Township's water supply is not maintained, land use changes in the next quarter century may not be possible.

At present, it can be said that Denville has a reasonable growth potential in terms of its water supply.

Chemical Analysis

The quality of the ground water which is pumped into the public supply network is found in the analytical data collected yearly by the New Jersey Department of Environmental Protection. The most recent test was taken on April 24, 1975 at the Sunoco Gas station at West Main and Legion Place.

Bacteriological Analyses:

Coliform Organisms	0	Chlorine Residual	.1 ppm

Physical-Chemical Analyses.

	State Standard	Denville #10217
Color	10	0
Odor	III	0
Turbidity	5	0
pH		7.4
Alkalinity to pH 4		132
Nitrate as NO_3	30	6.6 ppm
Chloride	250	7 ppm
Total Dis. Solids	500	254 ppm
ABS/LAS	0.5	neg ppm
Total hardness	150	160 ppm
Total Iron	0.3	0.2 ppm
Manganese	0.05	neg ppm
Sodium	50	6 ppm
Sulphate	250	21 ppm
Fluoride	1.5	neg ppm

Land Use Influences

Land use practices modify either the infiltration rate or the area of the moisture storage potential. Dense vegetal cover protects soil from the impact of rainfall thus preventing compaction caused by the inwash of soil particles which seals the earth's surface. When soils with little vegetative cover increase runoff from storm rainfall, the recharge areas lose their effectiveness.

Sediment by definition is any fragmental material transported by, suspended in, or deposited by such natural agents as water. Sedimentation within the Township has a very marked effect on the overall water quality in the lakes as well as the streams. Another important factor is the mineral and nutrient matter contained in Denville's surface water, which is due to the runoff of fertilizers into the lakes, resulting in eutrophic growth.

Certain measures have been taken in the past to arrest this process chemically with copper sulfate, but the possible overtreatment and residual effects had deleterious effects on the aquatic biology of the lakes. The use of copper sulfate has since been outlawed. This makes it apparent that the solution lies in preventive rather than remedial efforts.

Sedimentation occurs when falling raindrops break down large soil clumps into single grains, which may be thrown upward by the energy of the drops and then carried in solution by the overland flow and the force of water. As they flow toward the channel they may loosen additional particles. In those portions of the Township where the erodability is greatest (see Soil Erosion Potential Map), the incoming particles and force of the water cause severe gully or channel erosion. This action is quite evident at almost all the new developments within the Township and causes serious problems not only in the surface waters but in the storm sewer network which carries some of the runoff from these developments.

"Land use is one element of the hydrologic landscape which can be deliberately manipulated to create water resource characteristics beneficial to society.[10] Therefore, it is important to assess the value of new development not only in terms of increased ratables but also by the stress it may cause on the natural hydrologic system. The diseconomy is easily seen when an area is developed and runoff increases, imposing problems on another portion of the municipality. Studies regarding the specific increase in runoff from development differ in determining the rate but all agree there is a substantial increase. One such study concludes that "if 20% of an area is paved or roofed and 50% drained by storm sewers it will experience flooding five times as often."[13] Another study indicates that when a hillside is cleared for construction, the increase in sediment washing off the slope can range from 500 to 1,000%.[14] The impact from such development is almost always felt by flooding downstream or downslope from the development (urbanization).

Waste Disposal

Denville is a member municipality of the Rockaway Valley Regional Sewer Authority. The existing trunk lines were constructed in the 1920's and have become obsolete. Because of a building ban imposed in 1968, the RVRSA has been formed and been evaluating methods for waste water management for the member municipalities. These efforts have been ongoing and many problems have had to be solved -- many dealing with administrative and jurisdictional questions.

Less than 50% of the Township is presently sewered; the rest of the residents are using subsurface disposal or septic systems. Due to the nature of the seasonally high water table in many geologic areas of Denville, disposal by septic systems becomes impractical.

According to the RVRSA Pollution Control Report, the final design has been completed for collection systems to service three additional sections of Denville, Cedar Lake, Rock Ridge Lake and Lake Arrowhead. However, these systems may not be constructed until the regional interceptor line and treatment plant are constructed.

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HABITATS

Denville Township may be divided into five (5) major habitat types:

1. Wetlands (marshes, bogs and swamps.
2. Mesic upland wooded habitat.
3. Open land.
4. Urban/residential.
5. Lakes and streams.

In the following discussion, types 1 through 4 are considered to be terrestrial, and type 5 is aquatic.

The geographic location of these five habitats in Denville are presented on the habitat map. The classification is based on

1. An aerial photograph of Denville (Raytheon, 1969)

2. Four USGS topographic sheets: Mendham, Morristown, Dover and Boonton.

3. The surface drainage map of Denville (Catlin, 1975)

The classification is subjective and should be at least partially verified by field investigations.

The vegetation of each of the non-urban terrestrial habitats (Table 2) dominates Denville's landscape and is discussed below. Many organisms are likely to live in several of the habitats. Because of this organism, data is presented in tabular format rather than in text. Mammals, snakes, amphibians and birds that are either known to occur or likely to occur in Denville are listed in Tables 3, 4, 5 and 6, respectively. Indications of habitat and seasonal abundance are included in several tables.

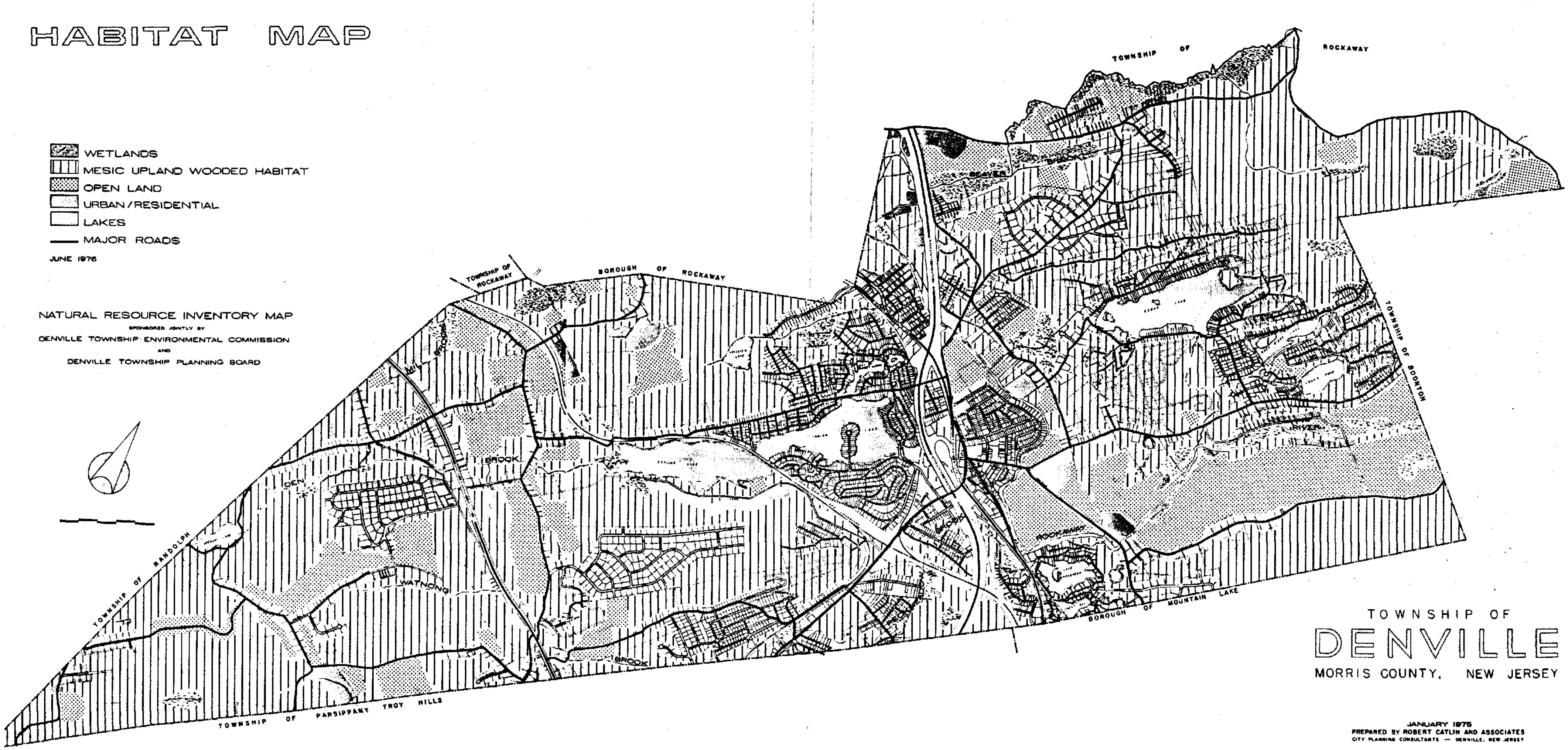
HABITAT MAP
WETLANDS
MESIC UPLAND WOODED HABITAT
OPEN LAND
URBAN / RESIDENTIAL
LAKES
MAJOR ROADS
JUNE 1976
NATURAL RESOURCE INVENTORY MAP
SPONSORED JOINTLY BY
DENVILLE TOWNSHIP ENVIRONMENTAL COMMISSION
AND
DENVILLE TOWNSHIP PLANNING BOARD
TOWNSHIP OF ROCKAWAY
BOROUGH OF ROCKAWAY
TOWNSHIP OF ROCKAWAY
TOWNSHIP OF BOONTON
BOROUGH OF MOUNTAIN LAKE
TOWNSHIP OF PARSIPPANY TROY HILLS
TOWNSHIP OF RANDOLPH
DEN
BROOK
WATNONG
BROOK
BEAVER
BROOK
ROCKAWAY
RIVER
TOWNSHIP OF
DENVILLE
MORRIS COUNTY, NEW JERSEY
JANUARY 1975
PREPARED BY ROBERT CATLIN AND ASSOCIATES
CITY PLANNING CONSULTANTS — DENVILLE, NEW JERSEY

TABLE 1

TERRESTRIAL HABITATS LIKELY TO OCCUR IN DENVILLE

A. Fresh water marshes

B. Bogs

C. Swamps and floodplains

D. Mesic uplands

E. Steep slopes and ridges

F. Rock outcroppings

Terrestrial habitats occurring in the Highlands Section of New Jersey (Robichaud and Buell, 1973)

TABLE 2

Characteristic vegetation expected to occur in selected terrestrial habitats of Denville, New Jersey (adapted from Robichaud & Buell, 1973)

Common Name	Scientific Name	HABITAT: Marsh	Bog	Swamp & Floodplain	Mesic Upland
Herbs					
Arrow-arum	(Peltandra virginica)	x			
Arrowhead	(Sagittaria latifolia)	x			
Blue flag	(Iris versicolor)	x			
Bulrush	(Scirpus spp.)	x			
Bur reed	(Sparganium)	x			
Cattail	(Typha)	x			
Ferns			o	+	*
Grasses	(Gramineae)			+	*
Hairgrass	(Deschampsia flexuosa)				*
Marsh fern	(Dryopteris thelypteris)	x	o		
Mosses	(Bryophyta)			+	*
Pitcher Plant	(Sarracenia purpurea)		o		
Sedges	(Cyperaceae)	x	o	+	
Skunk cabbage	(Symplocarpus foetidus)	x	o	+	
Sphagnum	(Sphagnum)		o		
Spike rush	(Eleocharis spp.)	x			
Sundews	(Drosera spp.)		o		
Swamp Loosestrife	(Decodon verticillatus)		o		
Swamp milkweed	(Asclepias)	x	o	+	*
Touch-me-not	(Impatiens spp.)	x			
Waterdock	(Rumex verticillatus)	x			
Wild Sarsaparilla	(Aralia nudicaulis)				*

TABLE 2 (continued)

Common Name	Scientific Name	HABITAT: Marsh	Bog	Swamp & Floodplain	Mesic Upland
Wintergreen	(Gautheria procumbrens)			+	*
Shrubs					
Alder	(Alnus)			+	
Blueberry	(Vaccinium sp)		o		
Bog rosemary	(Andromeda glaucophylla)		o		
Buttonbush	(Cephalanthus occidentalis)			+	
Cranberry	(Vaccinium macrocarpon)		o		
Huckleberry	(Gaylussacia)		o		
Labrador tea	(Ledum groenlandicum)		o		
Laurel	(Kalmia)		o		
Leatherleaf	(Chamaedaphne calyculata)		o		
Spicebush	(Lindera benzoin)			+	*
Wild azalea	(Rhododendron Nudiflorum)				*
Swamp azalea	(Rhododendron vicosum)		o		
Viburnum	(viburnum)				*
Willow	(salix spp)			+	
Witch hazel	(Hamamelis virginiana)			+	
Trees					
Ash	(Fraxinus spp)			+	*
Basswood	(Tilia americana)			+	
Beech	(Fagus grandifolia)				*
Blackgum	(Nyssa sylvatica)		o	+	
Black Oak	(Quercus velutina)				*
Black Spruce	(Picea mariana)		o		
Chestnut Oak	(Quercus prinus)				*
Dogwood	(Cornus florida)				*

TABLE 2 (continued)

Common Name	Scientific Name	HABITAT Marsh	Bog	Swamp Floodplain	Mesic Upland
Elm	(Ulmus spp)			+	
Hemlock	(Tsuga canadensis)		o		
Hickory	(carya spp)				*
Hop hornbeam	(Ostrya virginiana)				*
Ironwood	(Carpinus caroliniana)				*
Larch	(Larix laricina)		o		
Pin Oak	(Quercus palustris)			+	
Red Maple	(Acer rubrum)		o	+	*
Red Oak	(Quercus rubra)				*
Sassafras	(Sassafras albidum)				*
Scarlet Oak	(Quercus coccinea)				*
Southern white cedar	(Chamaecyparis thyoides)		o	+	
Sugar maple	(Acer saccharum)				*
Tulip tree	(Liriodendron tulipifera)				*
White Oak	(Quercus alba)			+	*
White pine	(Pincus strobus)		o		
Yellow birch	(betula lutea)		o		

TABLE 3

MAMMALS OF THE DENVILLE REGION OF MORRIS COUNTY, NEW JERSEY

Common Name	Scientific Name	Distribution	Usual Habitats: Forest Land	Usual Habitats: Open Land	Usual Habitats: Wet Lands
Opossum	Didelphis virginiana	common	X	X	
Masked shrew	Sorex cinereus	occasional	X	X	X
Smokey shrew	Sorex fumeus	occasional	X		
Short-tailed shrew	Hlaring breviczuda	common	X	X	X
Least shrew	Cryptotis parva	occasional		X	
Eastern mole	Scalopus aquatious	common	X	X	X
Star-nose mole	Condylura cristata	occasional	X	X	X
Little brown bat	Myotis lucifugus	occasional	-	-	- (1)
Bat	Myotis Keeni	occasional	-	-	-
Bat	Myotis sodalis	occasional	-	-	-
Bat	Myotis leibii	occasional	-	-	-
Silver-haired bat	Lasionycteris noctivagans	occasional	-	-	-
Bat	Pipistrellus subflavus	occasional	-	-	-
Big brown bat	Eptesicus fuscus	occasional	-	-	-
Red bat	Lasiurus borealus	occasional	-	-	-
Hoary bat	Lasiurus cinereus	occasional	-	-	-
Cottontail	Sylvilagus floridanus	common		X	X
Mountain cottontail	Sylvilagus transitionalis	occasional	-	-	-
Chipmonk	Tamias striatus	common	X	X	
Woodchuck	Marmota monax	common	X	X	
Gray Squirrel	Sciurus carolinensis	common	X		
Red Squirrel	Tamiasciurus hudsonicus	occasional	X		
Flying squirrel	Glaucomys udans	common	X		
Beaver	Castor canadensis	occasional			X
White-footed mouse	Peromyscus leucopus	common	X	X	
Wood rat	Neotoma floridana	occasional	-	-	-
Red-backed vole	Clethrionomys gapperi	occasional	X		
Meadow vole	Microtus pennsylvanicus	common		X	X
Woodland vole	Microtus pinetorum	occasional	X		
Muskrat	Ondatra zibethicus	common		X	X
Bog lemming	Synaptomys copperi	occasional	-	-	-
Jumping mouse	Zapus hudsonius	occasional		X	X
Woodland jumpingmouse	Napaeozapus insignis	occasional	X		
Porcupine	Erethizon dorsatium	may be extinct	-	-	-
Red fox	vulpes fulva	common	X	X	X

Common Name	Scientific Name	Distribution	Usual Habitats: Forest Land	Open Land	Wet Lands
Gray fox	Urocyon cinereaorgenteus	common	X	X	
Black bear	Ursus americanus	may be extinct	-	-	-
Raccoon	Procyon lotor	common	X		X
Long-tailed weasel	Mustela frenata	occasional	X	X	X
Mink	Mustela vison	occasional	X		X
Skunk	Mephitis mephitis	common	X	X	
Otter	Lutra canadensis	occasional	-	-	-
Bobcat	Lynx rufus	may be extinct	-	-	-
White-tailed deer	Odocoileus virginianus	common	X		
Human	Homo saplens	common	X	X	X
House mouse	Mus musculus	common	-	-	-
Barn/Brown rat	Rattus norvegieus	common	-	-	-
Roof/black rat	Rattus rattus	occasional	-	-	-

(1) No data available.

Source: Person communication with Karl Anderson, Naturalist at New Jersey Audubon Society. Franklin Lakes, New Jersey 07417

Usual habitats based on Roberts & Early (1952)

TABLE 4

SNAKES OF THE DENVILLE AND HIGHLANDS REGION OF MORRIS COUNTY, NEW JERSEY

Common Name	Scientific Name	Distribution
Eastern garter snake	Thamnophis sirtalis	common in variety of habitats
Eastern milk snake	Lampropeltis trizngulum	occasional
Eastern ribbon snake	Thamnophis sauritus	mod. common near water
Eastern worm snake	Carphopis amoenus	occasional, burrowing species
Hog-nosed snake	Heterodon platyrhinos	mod. common in sandy areas
Northern black racer or Blacksnake	Coluber constrictor	mod. common in dry woods
Northern brown snake or DeKay's snake	Storeria dekayi	very common, but secretive
Northern copperhead (1)	Agkistrodon contortrix mokesen	occasional in rocky upland woods
Northern ring-necked snake	Diadophus punctatus edwardii	mod. common in moist woods
Northern water snake	Natrix sipedon	common in and near water
Pilot black snake or Black rat snake	Elaphe obsoleta	occasional in rocky woods
Red-bellied snake	storeria occipitomaculata	occasional in woods and bogs
Smooth green snake	Opheodrys vernalis	occasional in upland meadows
Timber rattlesnake (1)	Crotalus horridus horridus	very rare in rocky uplands

(1) Venomous, but not aggressive

Source: Person communication with Karl Anderson, Naturalist at New Jersey Audubon Society, Franklin Lakes, New Jersey 07417. Modified from Highlands Audubon Society - Nature Bulletin No. 3 - Snakes of the Highlands Region.

TABLE 5

AMPHIBIANS OF THE DENVILLE REGION OF MORRIS COUNTY, NEW JERSEY

Common Name	Scientific Name	Distribution
American toad	Bufo terrestris americanus	common
Fowler's toad	Bufo woodhousei fowleri	common in sandy habitats
Northern spring peeper	Hyla crusifera	common in woodlands
Eastern gray treefrog	Hyla versicolor	common in woodlands
Bullfrog	Rana Catesbeizna	common in larger bodies of water
Green frog	Rana clamitans v. melanota	common
Eastern wood frog	Rana sylvatica	common in woodlands
Pickerel frog	Rana palustris	common in cool running streams
Spotted salamander	Ambystoma maculatum	common
Red-spotted newt	Diemictylus viridescens	common in shallow pools
Northern Dusky salamander	Desmognathus fuscus	common in and near running streams
Red-backed salamander	Plethodon cinereus	common in woodlands
Northern red salamander	Pseudotriton ruber	common in upland areas
Northern Two-lined salamander	Eurycea bislineata	common in running streams

Source: New Jersey Nature News, New Jersey Audubon Society 3-63

TABLE 6

BIRDS WHICH ARE KNOWN TO APPEAR IN DENVILLE, NEW JERSEY

Name	Occurrence	Seasonality
Common Loon	R	M
Pied-billed Grebe	U	M
Great Blue Heron	U	S
Green Heron	U	S
Egret Great	H	SR
Black-crowned Night Heron	U	SR
Least Bittern	H	S
American Bittern	H	S
Mute Swan	C	PR
Whistling Swan	R	M
Canada Goose	C	PR
Snow Goose	R	M
Mallard	AB	PR
Black Duck	U	WR
Gadwall	H	WR
Pintail	H	WR
Green-winged Teal	H	M
Blue-winged Teal	H	SR
Shoveler	H	M
Wood Duck	R	SR
Ring-necked Duck	R	M
Canvasback	R	M
Lesser Scaup	X	-
Common Goldeneye	X	-
Bufflehead	X	-
Ruddy Duck	H	M
Hooded Merganser	H	M
Common Merganser	H	M
Turkey Vulture	C	S
Goshawk	H	M
Sharp-shinned Hawk	U	M
Cooper's Hawk	R	M
Red-tailed Hawk	C	PR
Red-shouldered Hawk	R	M
Broad-winged Hawk	U	SR
Rough-legged Hawk	H	WR
Golden Eagle	H	M
Bald Eagle	H	M
Marsh Hawk	H	M
Osprey	U	M
Peregrine Falcon	H	M
Pigeon Hawk	H	M
Sparrow Hawk	C	PR
Ruffed Grouse	U	PR
Bobwhite	H	PR
Ring-necked Pheasant	H	PR
Virginia Rail	H	SR
Sora	H	SR

Name	Occurrence	Seasonality
Common Gallinule	H	SR
American Coot	H	WR
Semipalmated Plover	H	M
Killdeer	U	SR
American Woodcock	U	SR
Common Snipe	U	SR
Spotted Sandpiper	H	SR
Solitary Sandpiper	H	M
Greater Yellowlegs	H	M
Lesser Yellowlegs	H	M
Iceland Gull	H	WR
Herring Gull	C	WR
Ring-billed Gull	AB	WR
Black-headed Gull	x	-
Rock Dove	AB	PR
Mourning Dove	AB	PR
Yellow-billed Cuckoo	R	SR
Black-billed Cuckoo	H	SP
Barn Owl	H	PR
Screech Owl	AB	PR
Great Horned Owl	U	PR
Barred Owl	H	PR
Long-eared Owl	H	WR
Short-eared Owl	x	-
Saw-whet Owl	H	WR
Common Nighthawk	C	M
Chimney Swift	C	M
Ruby-throated Hummingbird	C	M
Belted Kingfisher	C	PR
Flicker, Common	AB	SR
Pileated Woodpecker	C	PR
Red-bellied Woodpecker	U	PR
Red-headed Woodpecker	H	SR
Yellow-bellied Sapsucker	U	M
Hairy Woodpecker	C	PR
Downy Woodpecker	C	PR
Eastern Kingbird	C	SR
Great Crested Flycatcher	C	SP
Eastern Phoebe	C	SR
Yellow-bellied Flycatcher	R	M
Flycatcher Willow	H	SR
Flycatcher Akler	H	M
Least Flycatcher	H	SR
Eastern Wood Pewee	U	SR
Olive-sided Flycatcher	R	M
Horned Lark	H	WR
Tree Swallow	C	SR
Bank Swallow	U	SR
Rough-winged Swallow	U	SR
Barn Swallow	C	SR

Name	Occurrence	Seasonality
Purple Martin	U	SP
Blue Jay	AB	PR
Common Crow	AB	PR
Fish Crow	U	M
Black-capped Chickadee	AB	PR
Boreal Chickadee	I	WR
Tufted Titmouse	AB	PR
White-breasted Nuthatch	C	PR
Red-breasted Nuthatch	U	WR
Brown Creeper	U	PR
House Wren	C	SR
Winter Wren	U	M
Carolina Wren	C	PR
Long-billed Marsh Wren	H	SR
Mockingbird	C	PR
Catbird	C	SR
Brown Thrasher	C	SR
Robin	AB	SR
Wood Thrush	AB	SR
Hermit Thrush	C	M
Swainson's Thrush	C	M
Gray-cheeked Thrush	U	M
Veery	C	SR
Eastern Bluebird	H	SR
Blue-gray Gnatcatcher	U	SR
Golden-crowned Kinglet	U	M
Ruby-crowned Kinglet	C	M
Water Pipit	H	M
Cedar Waxwing	U	SR
Starling	AB	PR
White-eyed Vireo	U	SR
Yellow-throated Vireo	H	SR
Solitary Vireo	U	M
Red-eyed Vireo	C	SR
Philadelphia Vireo	R	M
Warbling Vireo	U	SR
Black & White Warbler	C	SR
Worm-eating Warbler	U	SR
Golden-winged Warbler	H	SR
Blue-winged Warbler	U	SR
Tennessee Warbler	C	M
Orange-crowned Warbler	H	M
Nashville Warbler	C	M
Parula Warbler	U	M
Yellow Warbler	AB	SR
Magnolia Warbler	C	M
Cape May Warbler	C	M
Black-throated Blue Warbler	C	M
Warbler Yellow rumped	C	M

Name	Occurrence	Seasonality
Black-throated Green Warbler	C	M
Cerulean Warbler	H	SR
Blackburnian Warbler	U	M
Chestnut-sided Warbler	C	SR
Bay-breasted Warbler	C	M
Blackpoll Warbler	C	M
Pine Warbler	H	M
Prairie Warbler	H	SR
Palm Warbler	C	M
Ovenbird	C	SR
Northern Waterthrush	H	M
Louisiana Waterthrush	H	SR
Connecticut Warbler	R	M
Mourning Warbler	R	M
Yellowthroat	C	SR
Yellow-breasted Chat	H	SR
Hooded Warbler	U	M
Wilson's Warbler	U	M
Canada Warbler	C	SR
American Redstart	C	SR
House Sparrow	AB	PR
Bobolink	H	M
Eastern Meadowlark	H	SR
Red-Winged Blackbird	C	SR
Baltimore Oriole	C	SR
Rusty Blackbird	U	M
Common Grackle	AB	SR
Brown-headed Cowbird	C	SR
Scarlet Tanager	C	SR
Cardinal	AB	PR
Rose-breasted Grosbeak	C	SR
Indigo Bunting	U	SR
Evening Grosbeak	I	WR
Purple Finch	C	WR
House Finch	AB	PR
Pine Grosbeak	H	WR
Common Redpoll	I	WR
Pine Siskin	I	WR
American Goldfinch	C	PR
Red Crossbill	I	WR
White-winged Crossbill	I	WR
Rufous-sided Towhee	C	SR
Savannah Sparrow	H	M
Dark-eyed Junco	C	WR
Tree Sparrow	C	WR
Chipping Sparrow	C	SR
Clay-colored Sparrow	H	M
Field Sparrow	C	PR
White-crowned Sparrow	U	M
White-throated Sparrow	AB	WR
Fox Sparrow	U	M
Lincoln's Sparrow	H	M
Swamp Sparrow	U	SR
Song Sparrow	C	PR
Snow Bunting	H	M
Black headed Grasback	AC	WR

Name	Occurrence	Seasonality
Purple Martin	U	SP
Blue Jay	AB	PR
Common Crow	AB	PR
Fish Crow	U	M
Black-capped Chickadee	AB	PR
Boreal Chickadee	I	WR
Tufted Titmouse	AB	PR
White-breasted Nuthatch	C	PR
Red-breasted Nuthatch	U	WR
Brown Creeper	U	PR
House Wren	C	SR
Winter Wren	U	M
Carolina Wren	C	PR
Long-billed Marsh Wren	H	SR
Mockingbird	C	PR
Catbird	C	SR
Brown Thrasher	C	SR
Robin	AB	SR
Wood Thrush	AB	SR
Hermit Thrush	C	M
Swainson's Thrush	C	M
Gray-cheeked Thrush	U	M
Veery	C	SR
Eastern Bluebird	H	SR
Blue-gray Gnatcatcher	U	SR
Golden-crowned Kinglet	U	M
Ruby-crowned Kinglet	C	M
Water Pipit	H	M
Cedar Waxwing	U	SR
Starling	AB	PR
White-eyed Vireo	U	SR
Yellow-throated Vireo	H	SR
Solitary Vireo	U	M
Red-eyed Vireo	C	SR
Philadelphia Vireo	R	M
Warbling Vireo	U	SR
Black & White Warbler	C	SR
Worm-eating Warbler	U	SR
Golden-winged Warbler	H	SR
Blue-winged Warbler	U	SR
Tennessee Warbler	C	M
Orange-crowned Warbler	H	M
Nashville Warbler	C	M
Parula Warbler	U	M
Yellow Warbler	AB	SR
Magnolia Warbler	C	M
Cape May Warbler	C	M
Black-throated Blue Warbler	C	M
Warbler Yellow rumped	C	M

Name	Occurrence	Seasonality
Black-throated Green Warbler	C	M
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Blackpoll Warbler	C	M
Pine Warbler	H	M
Prairie Warbler	H	SR
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Louisiana Waterthrush	H	SR
Connecticut Warbler	R	M
Mourning Warbler	R	M
Yellowthroat	C	SR
Yellow-breasted Chat	H	SR
Hooded Warbler	U	M
Wilson's Warbler	U	M
Canada Warbler	C	SR
American Redstart	C	SR
House Sparrow	AB	PR
Bobolink	H	M
Eastern Meadowlark	H	SR
Red-Winged Blackbird	C	SR
Baltimore Oriole	C	SR
Rusty Blackbird	U	M
Common Grackle	AB	SR
Brown-headed Cowbird	C	SR
Scarlet Tanager	C	SR
Cardinal	AB	PR
Rose-breasted Grosbeak	C	SR
Indigo Bunting	U	SR
Evening Grosbeak	I	WR
Purple Finch	C	WR
House Finch	AB	PR
Pine Grosbeak	H	WR
Common Redpoll	I	WR
Pine Siskin	I	WR
American Goldfinch	C	PR
Red Crossbill	I	WR
White-winged Crossbill	I	WR
Rufous-sided Towhee	C	SR
Savannah Sparrow	H	M
Dark-eyed Junco	C	WR
Tree Sparrow	C	WR
Chipping Sparrow	C	SR
Clay-colored Sparrow	H	M
Field Sparrow	C	PR
White-crowned Sparrow	U	M
White-throated Sparrow	AB	WR
Fox Sparrow	U	M
Lincoln's Sparrow	H	M
Swamp Sparrow	U	SR
Song Sparrow	C	PR
Snow Bunting	H	M
Black headed Grasback	AC	WR

Occurrence:

AB Abundant - hard to miss in season.

C Common - easy to find almost any day in season.

U Uncommon - probably can be found on most days in season.

R Rare - probably can't be found on a given day, even in season.

AC Accidental - does not regularly occur in our area.

I Irruptive - occurs only during years of invasions.

H Hypothetical - has probably occurred in our region, but I have no record of it.

x Occurs - sighted locally

Seasonality:

PR Permanent resident - some individuals present all year.

WR Winter resident - in our area during this season only (under normal circumstances)

SR Summer resident - probably breeds in our area.

M Migrant - is in our area only during spring and fall.

\- Unknown

Source: Michael R. Hannisian, 211 Franklin Road, Denville, New Jersey 07834

Wetlands

Denville's wetlands form a small percentage of total Township acreage. Because of the general importance of these wetlands (marshes, bogs and swamps), this acreage is critical to the Denville environment.

Undeveloped floodplains provide important protection against flood damage and erosion from lands upstream. Protection is based on a delicate balance that exists between the stream channel and flow and the floodplain. All streams, including the Rockaway River, rise above their banks with varying frequency, often in the spring and fall. The intensity of flooding, however, may be moderated by floodplain vegetation. The floodplain absorbs much excess water when left in its natural state. Unfortunately, most floodplains have been altered by man's activities.

Wetlands, in general, serve as flood storage areas by withholding water and gradually releasing it into streams that drain the wetlands. In locations where temporary water storage areas have been reduced because of the cutting of floodplain forests or the filling in of wetlands, flooding hazards are increased.

Wetland areas, furthermore, serve as a source for groundwater replenishment (aquifer recharge). Some water that floods lowland areas may be lost to the air by evaporation and plant transpiration, but much water is absorbed into the ground enhancing ground water supplies.

Wetland vegetation through its physiological activity absorbs nutrients from the water which helps to maintain water quality. Whether the source of the nutrients is septic or agricultural runoff, both surface water and ground water may become polluted if wetland vegetation can no longer absorb all of the nutrients.

Each of the wetland types has a characteristic appearance which is determined by the dominant plant species. Fresh water marshes look like grassy fields as they have many grass-like herbaceous plants and lack trees. Bogs and swamps do have trees, but their characteristic vegetation differs from each other. Trees that occur in bogs are typically conifers, while swamp trees are usually deciduous. Dominant herbs and shrubs are also different in each habitat (Table 2).

Fresh water marshes are found along the edges of Denville's lakes, ponds, streams, and wherever depressions in the land are flooded regularly and have high water tables. The vegetation of Denville marshes is likely to be similar to that in the Troy Meadows of Morris County. Cattails and reed grass predominate with various rushes, sedges, ferns and other herbs (Table 2).

Bog habitats are likely to occur in Denville in areas that are not flooded as regularly as marshes. Bogs are acidic and low in fertility. Organic matter, known as peat, accumulates in the substrate because acid conditions are not good for microbial decomposition.

These conditions favor the growth of sphagnum moss and a characteristic plant assemblage (Table 2). Sphagnum and sedges dominate in the zones nearest the water. Many acid - tolerant shrubs are also characteristic of bogs including leatherleaf, cranberry, blueberry, huckleberry and labrador tea. Several trees are also typical of northern New Jersey bogs: red maple, black spruce and larch.

Swamps and floodplains form the third type of wet lowland found in Denville. Although swamps and floodplains have different origins, comparable moisture conditions produce their similar plant communities. Like in bogs, standing water is present for part of the year. Unlike bogs, however, drainage is better, and waters do not become acidic. Peat does not accumulate, and the plant communities are different.

The vegetation of wetter swamps differs from drier swamps. Wetter sites contain thickets of shrubs; the most abundant in northern New Jersey are button bush, alder and willow; less abundant are swamp azalea, winterberry, viburnum, spicebush and others.

The drier swamps are more forested. Red maple and yellow birch are particularly characteristic. In addition, ash, basswood, tulip trees and black gum occur less abundantly. Herbs such as skunk cabbage, cinnamon fern and various sedges and mosses live on swamp forest floors. Four additional tree species occur in better drained portions of floodplains including willow, river birch, sycamore and box elder.

Mesic Upland Wooded Habitat

The forested area of Denville Township and all of the forested areas of the eastern half of the United States lie within the very broad category of natural vegetation known as the Eastern Deciduous forest. Within this broad category, there are nine forest regions. Denville and the entire Highlands physiographic region of New Jersey are within the Mixed Oak forest region.[1] In Denville, the Mixed Oak forest occupies the mesic upland plant habitat which is the predominant habitat. The upland habitat contrasts with the previously described wetlands by lacking standing water although retaining a good supply of soil moisture.

The Mixed Oak forest of Denville helps prevent land erosion and loss of soil nutrients. Forest vegetation, moreover, increases water infiltration rate permitting ground water storage. Together these help reduce the impact of flood-producing rainstorms.

Forests are important for several other reasons. (e.g. they may affect climate; a group of trees will greatly reduce the effect of wind. They also cool the air: trees and shrubs may greatly reduce noise pollution. Robichaud and Buell (1973) report that each 100 feet of woodland vegetation absorbs about 6 to 8 decibels of sound intensity. Along major highways, such a reduction may greatly ameliorate noisy conditions).

Three oak species (red, white and black oaks) dominate Denville's Mixed Oak forest. Other less abundant trees include: chestnut oak, scarlet oak, hickory, red maple, ash, tulip tree, beech, sweet birch, and black gum. All of the above form the forest overstory with mature heights ranging from 60 to 100 feet.

An understory layer of smaller trees (30 - 40 feet) exists in the Mixed Oak forest. Dogwood is the most abundant; other species include hop hornbeam, sassafras and ironwood. In addition, viburnum and spicebush are the important shrubs.

Open Lands

The open land habitat of Denville includes agricultural land, pasture, old fields and mowed fields (in schools and parks). Most of these represent former mesic forested land that has been cleared by man at some time in the past. If left alone, the land undergoes a gradual vegetative succession, which begins with various annual herbs (ragweed, foxtail grass, etc.), followed by perennial herbs (aster, goldenrod and little bluestem grass). Following the herbs, woody species such as red cedar, sassafras, and red maple become dominant in the fields. Eventually shade tolerant trees of the Mixed Oak forest emerge as dominants.

Many stages of succession are likely to be found in Denville. Farmed lands and mowed fields have planted or natural annuals and perennials. Various abandoned and old fields have had later successional stages.

Urban/Residential

The classification Urban/Residential habitat is very coarse, with this habitat being the predominant land use pattern. In a given area, it is very possible that many of the areas indicated as being of this type are of mixed habitats and contain a small percentage of open land as well as forested areas, wetlands and water areas.

Urban/residential habitats in Denville include commercial and industrial areas, major roads, railroads and high and low density residential areas.

Much of the vegetation of this habitat is planted; and is not native.

Aquatic Habitat

Within Denville Township the important aquatic habitat types include several man-made lakes, many miles of small streams and a reach of the Rockaway River. The lakes are an important focal point for community development and recreation (boating, fishing and bathing). The streams provide needed water to the lakes and are a source of organisms for the lakes and river. They also are of limited recreational value for fishing. The Rockaway River provides bathing and fishing within the Township.

The lakes of the Township provide an important habitat. Geologically they are very young, but the effects of man's activities along their shorelines has accelerated their aging. They were for the most part constructed in the late 1800's and early 1900's and follow the contours of the valley slopes which they occupy. Rapid development has accelerated the deposition and accumulation of debris on their bottoms.

The largest lake found within the Township is Cedar Lake (99 acres), while the smallest of the lakes surveyed is Rock Ridge[2] (11 acres). Cedar Lake is also the deepest lake of those surveyed (27 feet). Water quality of the lakes surveyed is considered to be good in most swimming areas, although

TABLE 7

SELECTED INFORMATION ON SEVERAL LAKES AND THE ROCKAWAY RIVER
DENVILLE TOWNSHIP, MORRIS COUNTY, NEW JERSEY

	Lakes					Rockaway
	Arrowhead	Cedar	Estling	Indian	Rock Ridge	River
Date Created	1927	1895	1894	1924	1907	-
Area (acres)	19.7	99	74	93	11	-
Mean Depth (feet)	7.5	14	4.5	5	6	-
Maximum Depth (feet)	17	27	15	15	12	-
Construction	Dam	Dam	Dam	Dam	Dam	-
Presently being stocked?	No	Yes	No	Yes	Yes	Yes
Monthly Mean Coliform Density						
June '75 Mean (Number of Samples)	43(1)	217(4)	-	219(8)	190(4)	2400(1)
Minimum-Maximum	-	75-460	-	23-1100	430240	-
July '75 Mean (Number of Samples)	93(1)	154(4)	-	380(8)	119(4)	1210(5)
Minimum-Maximum	-	43-240	-	43-2400	23-240	200-1500
August '75 (Number of Samples)	1300(2)	273(4)	-	129(8)	22(4)	1630(5)
Minimum-Maximum	1100-1500	23-460	-	23-240	23-93	750-3900

locally high coliform[3] densities have been observed in some lakes outside of bathing areas. Coliforms are utilized as an indicator of a potential health hazard caused by introduction of sewage into surface waters. Potential sources of sewage include inadequate or poorly designed septic and sewer systems.

Streams within the Township provide a major habitat for smaller aquatic organisms, primarily fish, insect larvae and amphibians and reptiles. There are over 15 miles of streams in the Township excluding the Rockaway River. Flow on many of the streams is controlled by the dam facilities associated with the lakes. The longest streams within the Township are Beaver Brook and Den Brook. Some of the smaller streams have only intermittent flow, while others have permanent flow.

The Rockaway River originates in the northwestern corner of Morris County. As previously discussed in the Water Resources section, the mean annual floods of the Rockaway River between 1938 and 1971 at the U.S.G.S. Morris Avenue weir in Boonton was 1760.8 cfs with a peak flood of 4100 cfs. The peak flood at the Diamond Spring Bridge in Denville was determined to be 3200 cfs. during this period.

To the general public fishes are probably the most important component of aquatic life found in the Township and cause thousands of dollars to exchange hands yearly. Most adult fish occurring in Denville are remarkably tolerant of changing environmental conditions. Breeding of fishes, however, is fairly well restricted by habitat preferences and human interference. Stocking of several lakes provides certain game species (e.g. trout) which would otherwise not be present in the lakes.

Correspondence with various members of five lake associations indicated good fishing with the following species being important in the lakes:

Pickerel	Large mouth bass
Pumpkin Seed	Small mouth bass
Bluegill	Rainbow trout
Yellow Perch	Brown trout
Black Crappie	Other sunfish

The Rockaway River also provides recreational fishing within the Township. In 1974, the State of New Jersey stocked catchable size trout (7 inches) in the Rockaway River between Milton and Boonton:

Rainbow trout (17,910)   Brown trout (5,410)

In the summer of 1969, the New Jersey Department of Environmental Protection sampled the Rockaway River by electoshocking. The species captured are reported in Table 8.

Habitat Footnote References

1. Mixed Oak forest region has been offered by Robichaud and Buell (1973) as an alternate name to the Oak-Chestnut forest region because man's interference with natural succession and the Chestnut Blight Fungus have so drastically changed the composition of this forest region.

2. Cook's Pond (approximately 9 acres) is smaller than Rock Ridge Lake but was not included in the survey as its owners could not be contacted.

3. A bacterial indicator of water quality.

Habitat References

1. Roberts, H. A. and Early, R.C. 1952
Mammal survey of southeastern Pennsylvania. Pennsylvania Game Commission, Harrisburg. 70 pp.

2. Robert Catlin & Associates, 1975. Surface drainage map of Denville.

3. U.S.G.S. topographic sheets Mendham, Morristown, Dover and Boonton.

4. Raytheon, Inc. 1969 Aerial photograph of Denville.

5. Robichaud, B. and Buell, M. 1973. Vegetation of New Jersey. Rutgers University Press, New Brunswick, N.J. 340 pp.

TABLE 8

FISH CAPTURED BY ELECTRO-SHOCKING ROCKAWAY RIVER

Location	Roxbury Township (1)		Boonton Township (2)	
Date	8/27/69		7/17/69	
Bottom Type	Rock & Gravel		Rock & Gravel	
Depth of River (feet)	2-3		2-3	
Width of River (feet)	10-12		23-25	
Species Captured	No.	Wt.(lb)	No.	Wt.(lb)
Small mouth Bass	-	-	2	0.6
Large mouth Bass	1	0.4	1	0.1
Rock Bass	16	2.5	18	4.6
Blue Gill	7	0.6	6	0.5
Pumpkinseed	-	-	20	3.5
Redbreast Sunfish	21	5.0	63	18.0
White Sucker	15	4.6	-	-
Fall Fish	7	0.5	-	-
Yellow Perch	-	-	5	1.0
Common Shiner	33	0.4	-	-
Golden Shiner	-	-	1	0.2
Cutlip minnow	16	0.3	-	-
Stone Cat	8	0.4	-	-
Long nose Pace	21	0.2	-	-
	145	14.9	116	28.5

(1) off Route 80
(2) off Route 287

Information Sources for Habitat Element

New Jersey Department of Environmental Protection
Division of Fish, Game and Shellfisheries

Denville Township Board of Health

Mr. James Prior, Cedar Lake
Mr. Allen Livingston, Estling Lake
Mr. Lewis Filman, Lake Arrowhead
Mr. Mike Carmel, Rock Ridge Lake

Ms. Wendy Vogt, Morris Museum of Arts and Sciences

Ms. Norma O'Hare, Denville Free Public Library

Mr. Karl Anderson, New Jersey Audubon Society

Mr. K. Robert Thompson, Denville
Ms. Lorraine Caruso, Denville
Mr. Glenn Mahler, Parsippany
Mr. Mike Hannisian, Denville
Mr. Charles Fisher, Denville

Mr. D. JacAngelo, New Jersey Fish Laboratory, Lebanon, New Jersey