99-071 —
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FINAL REPORT

Nonpoint Source Loadings and Phosphorus

Modeling for Mountain Lake

July 18, 2001

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This report was prepared with the aid of a grant from the New Jersey Department of Environmental Protection, Office of Intergovernmental Affairs, Environmental Services Program, matched by the Liberty Township Committee.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Aquatic Analysts, Inc. (AAI) of Middleville, New Jersey, was retained by Liberty Township to perform a stormwater assessment of Mountain Lake and its surrounding watershed located in Warren County, New Jersey. The purpose of this study was to develop a stormwater management plan to protect surface and ground water quality by reducing runoff and pollutant loadings from non point sources.

Water flowing over land during and following a rainstorm is called stormwater runoff. Stormwater runoff from urban, suburban and agricultural sources is one of the most significant water pollution problems in the United States. The porous and varied terrain of natural landscapes such as forests, wetlands and fields trap rainwater and snowmelt and allow it to filter slowly into the ground. Runoff reaches receiving waters gradually. Changes in local hydrology result when an undeveloped area changes to support urban land uses such as residential homes, commercial buildings, roads and parking lots. Impervious surfaces created by urban and residential activities prevent rainwater and snowmelt from following their natural course into the soil. By decreasing the amount of precipitation absorbed by the soil, these impervious surfaces increase the volume and velocity of water flowing over and off the land to receiving waters. This may lead to larger and more frequent flooding and increased erosion of stream banks. The quality of stormwater runoff is of vital concern when a waterbody is located nearby. Runoff can carry oil and gasoline from vehicles, pesticides and fertilizers, toxic metals, excess nutrients, sediments, pathogens (bacteria and viruses) and trash. Potential contaminants are washed into streams and lakes in sufficient concentrations to pollute the water quality of the receiving body of water.

Point source water pollution comes from a distinct location or point, such as a wastes from a municipal treatment plant or industry. Nonpoint source (NPS) pollution includes atmospheric deposition, eroding of streambanks, leaching landfills, leaking underground storage tanks, and runoff from construction sties, highways, cities and agricultural fields. NPS pollution contributes significantly to the degradation of water quality because it is diffuse and difficult to control.

The relationship between storm characteristics and water quality must be calculated before a stormwater management program can be developed. To determine the extent of stormwater runoff within a watershed, water quality or nutrient constituent load at different locations within the watershed are compared during storm event(s). As part of this stormwater assessment, Aqua-Link, Inc. was subcontracted by AAI to determine nonpoint source (NPS) pollutant loadings to the lake from its surrounding watershed. This study focused on those NPS pollutants which most commonly result in accelerated rates of lake eutrophication. The goal of this watershed NPS assessment was to identify those areas of the Mountain Lake watershed which contribute the highest loadings of nutrients and sediments to the lake on a mean annual basis. Therefore, Liberty Township may use this information to target high priority watershed areas with respect to the implementation of best management practices (BMPs).

STUDY AREA

Watershed Land Use Characteristics

Mountain Lake, a 122-acre natural lake system, is located in Liberty Township, Warren County, New Jersey (Figure 1). It has a mean depth of 17 feet and a maximum depth of 38 feet. Aquatic Analysts, Inc. identified five different stream monitoring stations or subwatersheds (No. 4, No. 6, No. 10, No. 11 and No. 29) throughout the Mountain Lake watershed (Table 1, Figure 2). The Mountain Lake watershed and its major subwatersheds were delineated using digital 7.5 minute topographic maps and ArcView GIS (Geographic Information System) software. Topographic maps were downloaded via the internet from the New Jersey Geographic Survey's (NJGS) website. In addition, digital 1995 land use, lake and stream coverages were obtained via the internet from the New Jersey Department of Environmental Protection's (NJDEP) website. Tabular attribute data for the 1995 land use coverage were exported and further analyzed using Microsoft Excel software (Appendix A). Using Excel software, NJDEP land use data were sorted by subwatersheds and then were recategorized into six different land use types. These six different land use types are as follows: agriculture, fields and parklands, forest, urban, wetlands and lakes (Appendix A). A summary of the land use data for the Mountain Lake watershed and its subwatersheds are presented in Appendix B.

Based upon the above analysis, the Mountain Lake watershed is approximately 3,101 acres (4.8 square miles) in area (Figure 1). The Mountain Lake watershed is defined as all lands that eventually drain into Mountain Lake plus the surface area of the lake. The surface area of Mountain Lake is 122 acres, therefore, 2,985 acres of land eventually drain into Mountain Lake. Of this 2,985 acres, forest and urban lands comprise 71.6 and 13.0 percent, respectively, of all land uses within the Mountain Lake watershed. Agriculture land uses and wetlands both represent 6.9 percent of all watershed land uses (Appendix B).

Lands that are adjacent to the lake, but do not fall within any of the major subwatersheds are defined as the "direct drainage." As noted in Table 1, the smallest and largest subwatersheds are subwatershed No. 11 and subwatershed No. 10, respectively.

Land use data for the entire Mountain Lake watershed and its major subwatersheds are shown in Figure 3. Land use data for the five major subwatersheds plus the direct drainage area are presented on a percentage basis in Table 2. As observed, the most dominant land use occurring in all five subwatersheds and the direct drainage area is forested lands. The highest level of urban land development occurs within the direct drainage area followed by subwatershed Nos. 10 and 11. For more information regarding the actual acreages for various land uses for each of the subwatersheds and the direct drainage area, refer to Appendix B.

METHODS AND RESULTS

Storm event sampling

During a storm event on May 19, 2000, discrete water samples were collected by volunteers trained by AAI at stream monitoring stations established in each of the five subwatersheds (Table 1; Figure 2). These samples were delivered to an E.P.A certified laboratory and the following nine variables were analyzed: total phosphorus (TP), ammonia (NH_3-N), nitrate (NO_3-N), nitrite (NO_2-N), total Kjeldahl nitrogen (TKN), total nitrogen (TN), total dissolved solids (TDS), total suspended solids (TSS) and fecal coliform (Table 3). At the time of sample collection, stream water depth and velocity data were also measured at all five monitoring stations. AAI determined instantaneous stream discharges using the collected stream water depth and velocity data for each subwatershed (Table 4).

Based upon the above stream data, total phosphorus, total nitrogen (sum of Kjeldahl nitrogen, nitrate nitrogen and nitrite nitrogen) and total suspended solids loadings for the five watersheds were estimated. These data were expressed on a daily or instantaneous (Table 5) and areal (Table 6) basis, and compared to one another. As shown in Table 5, the highest and lowest total phosphorus, total nitrogen and total suspended solids loadings were reported for subwatershed No. 10 and subwatershed No. 4, respectively. Subwatershed No. 10 was the largest contributor of both nutrients and sediments since this subwatershed comprises nearly 86.5 percent of total acreage of all five subwatersheds. Conversely, subwatershed No. 29, which is only 3.9 percent of the total subwatershed area, contributed nearly 16 percent of the total phosphorus loading to the lake. Calculated daily loadings for the May 19, 2000 storm event were also expressed as daily areal loadings as shown in Table 6. Based upon an areal basis, subwatershed No. 11 and subwatershed No. 6 contributed the highest and lowest quantities of phosphorus, nitrogen and suspended solids on a per hectare basis to the lake during the May 19 storm event.

Watershed Hydrologic Characteristics

The annual mean contributions of water to Mountain Lake via tributaries of the major subwatersheds and the direct drainage area were estimated using historical stream discharge data reported by the United States Geological Survey (USGS).

The USGS Gaging Station No. 01443900, which is located on Yards Creek near Blairstown, New Jersey, was selected to estimate the annual mean hydrologic loading to Mountain Lake. For this USGS Station, historical discharge data were obtained via the internet using the USGS NWIS-W Data Retrieval System. For the historical period of January 1, 1990 through September 30, 1998, the mean discharge at this station was determined to be 11.2 cfs (cubic feet per second). This mean discharge was then expressed on a cfsm (cubic feet per second per square mile) basis by dividing this value by its total drainage area. A summary of the above information is presented in Table 7.

Using the cfsm value shown in Table 7, the mean discharge was estimated for the entire watershed (excluding Mountain Lake) and each of its major subwatersheds and direct drainage area in the Mountain Lake watershed (refer to Appendix C). Based on the above, the estimated annual mean volume of water to Mountain Lake is 3.08×10^8 cubic feet.

NPS Pollutant Loading Estimates

Nonpoint source (NPS) pollutant loadings to Mountain Lake from its surrounding watershed were estimated using the unit area loading approach. In this approach, pollutant export coefficients compiled by Reckhow et al. (1980) and the U.S. Environmental Protection Agency (1980) were evaluated and the most applicable export coefficients for various watershed land uses were selected to estimate the **annual** loading of phosphorus, nitrogen, and suspended solids to Mountain Lake.

The selected export coefficients for total phosphorus, total nitrogen, and total suspended solids along with all loading calculations are presented in Appendix D. Based upon these calculations, total annual mean loadings of total phosphorus, total nitrogen and total suspended solids to Mountain Lake was estimated at 604 kg/yr, 5,484 kg/yr and 308, 349 kg/yr, respectively.

The estimated contributions for each of the subwatersheds and the direct drainage area with respect to the above total NPS loadings are presented in Table 8 (refer to Appendix E).

As shown in Table 8, subwatershed No. 10 contributes the highest nutrient (phosphorus and nitrogen) and suspended solids loadings to the lake. This should come as no surprise since subwatershed No. 10 is by far the largest drainage area within the entire watershed. The second highest contributor of nutrients and sediments is the direct drainage area. Although comprising only 7.4 percent of the entire watershed, the direct drainage area is the most urbanized watershed area as previously observed in Table 2. The lowest contributors of NPS pollution are subwatershed Nos. 4 and 11. As shown in Table 1, these two subwatersheds are the smallest in area when compared to the other remaining subwatersheds and the direct drainage area.

In addition, the estimated annual mean NPS loadings were expressed on an areal basis. For each subwatershed and the direct drainage area, the NPS loadings were divided by the actual size of their drainage areas. By doing so, this allows for the subwatersheds and direct drainage area to be compared to one another on a per hectare (in English units, acre) basis. On a per hectare basis, the direct drainage area followed by subwatershed No. 10 contributed the highest NPS loadings of phosphorus, nitrogen and suspended solids. The lowest loadings were contributed by subwatershed No. 6 followed by subwatershed No. 29 (Appendix E).

The five subwatersheds and the direct drainage area were also ranked according to estimated nutrient and sediment loadings. Ranking was determined by assigning point values, ranging from 1 to 5 (lowest to highest), to the **total** and **areal** loadings for phosphorus, nitrogen and suspended solids. Next, the individual point values for phosphorus, nitrogen and suspended solids loadings were tallied for each of the subwatersheds and subsequently these total subwatershed scores were compared to one another (refer to Appendix E).

Based upon the total number of assigned points, the subwatersheds were ranked from lowest to highest with respect to estimated **total** nutrient and suspended solids loadings to the lake:

Subwatershed No. 4 < Subwatershed No. 11 < Subwatershed No. 29
< Subwatershed No. 6 < Direct Drainage < Subwatershed No. 10

Based upon the total number of assigned points, the subwatersheds were ranked from lowest to highest with respect to estimated **areal** nutrient and suspended solids loadings to the lake:

Subwatershed No. 6 < Subwatershed No. 29 < Subwatershed No. 4
< Subwatershed No. 11 < Subwatershed No. 10 < Direct Drainage

With exception of subwatershed No. 10, the overall rankings of the subwatersheds agree reasonably well. The low ranking of subwatershed No. 10 may be due to the fact that stream data were collected late during the storm hydrograph (receding limb of storm hydrograph). Under such circumstances, pollutant concentrations (nutrient and suspended solids) and stream discharge would be much lower than what typically occurs during peak stormflow conditions

Both the estimated total and areal load rankings support the conclusion that any water restoration initiatives should first commence within the direct drainage area and subwatershed No. 10. Subwatershed No. 6 should not be considered a priority for restoration since it is largely forested. In fact, this subwatershed contains the most forested lands when compared to all other subwatersheds. Overall on a total loading basis, subwatershed No. 6 out ranked subwatershed Nos. 4, 11 and 29 simply due to its greater size.

Phosphorus Modeling

Simply stated, the amount of phosphorus in the lake is a function of the amount of phosphorus flowing into the lake minus the amount of phosphorus flowing out of the lake minus the amount of phosphorus settling to the bottom of the lake. This simple input-output principle has been used to develop a large number of models to predict the in-lake phosphorus concentrations if the phosphorus input (loading) and the hydrology of the surrounding watershed are determined. The major difference between various phosphorus models is the methods in which the phosphorus sedimentation terms are determined. Since it is not practical to measure phosphorus sedimentation directly, it must be estimated empirically using morphometric and hydrologic characteristics for a given set of study lakes.

All lake phosphorus models are based on two assumptions. The first assumption is that a lake behaves as a continuously stirred reactor. In other words, the phosphorus concentrations in a lake are uniform throughout. Since this is seldom true in actual lake systems, it is necessary to sample a number of locations and different strata to estimate the true lake phosphorus content. The second assumption is that the lake is in a steady state condition which implies that in-lake phosphorus concentrations do not change over time. To address this last assumption, it is important to sample a lake at different times of the year to account for seasonal variations in phosphorus concentrations.

Most often these models are commonly used as a lake management tool to predict changes in lake water quality with changes in phosphorus loadings. The primary advantage of utilizing models in this matter is that lake managers have the ability to compare the current lake phosphorus concentration to the predicted concentrations by simply altering the phosphorus loadings to the lake.

As part of this investigation, models developed by Dillon and Rigler (1974), Vollenweider (1975, 1976), Reckhow et. al. (1980), and others were evaluated in order to determine the overall accuracy of the estimated annual mean loading of phosphorus to Mountain Lake. In general, phosphorus is the nutrient that is most often identified as the "limiting" nutrient in temperate Northeastern lake systems. Therefore, it is phosphorus that most likely controls the overall degree or level of eutrophication in Mountain Lake.

Numerous phosphorus models were evaluated for their applicability to Mountain Lake. The most critical stage in performing any modeling exercise is to select the most appropriate model. In general, empirical phosphorus models should not be applied outside the bounds of the data sets used to develop the model (Reckhow et. al., 1980). The following models were evaluated for their applicability to the lake: Vollenweider (1969), Kirchner and Dillon (1975), Chapra (1975), Larsen and Mercier (1975), Jones and Bauchman (1976), Reckhow (1977), Walker (1977), Canfield and Bauchman (1981), Prairie (1988), Prairie (1989), and others.

After reviewing over fifteen different models, the Reckhow Anoxic Model (Equation No. 1) was selected as a suitable model for the lake. Reckhow lists three known constraints for his anoxic model which are: 1) the in-lake phosphorus concentration should fall within the range of 0.017 and 0.610 mg/L as phosphorus; 2) the phosphorus influent concentration should fall within the range of 0.024 and 0.621 mg/L as phosphorus; and 3) the lake should undergo anoxia (low dissolved oxygen levels) during the summer months.

The three constraints of the above model were generally met as noted below. The 1999 mean total phosphorus concentration for the lake surface waters was reported as 0.055 mg/l as P (Aquatic Analysts, 2000). Based upon the estimated annual mean phosphorus loading (604 kg/yr), the estimated influent phosphorus concentration is 0.069 mg/l as P, which is very close to the upper limit reported by Reckhow. Lastly, the lake's hypolimnion does undergo anoxia during thermal stratification (Aquatic Analysts, 2000).

The Reckhow Anoxic Model is as follows:

$$TP = \frac{L}{[(0.17z) + 1.13(z/T)]} \qquad (1)$$

where,

TP = annual mean phosphorus concentration (g/m^3),

L = areal phosphorus loading ($g/m^2/yr$),

z = mean depth (m), and

T = mean hydraulic residence time (yr).

Input variables to this model were derived from information presented in this report and lake water quality data and bathymetric data reported by AAI (Appendix F).

Using the estimated annual mean phosphorus loading of 604 kg/yr (see NPS pollutant loading estimates section), the model predicts an in-lake phosphorus concentration of 0.059 mg/l as P. This value is in excellent agreement with the 1999 mean phosphorus concentration for surface waters, which was 0.055 mg/l as P, as reported by Aquatic Analysts (2000) and therefore corroborates the accuracy of the selected exported coefficients.

CONCLUSIONS AND RECOMMENDATIONS

The goal of a stormwater management plan is to eliminate pollutants from stormwater runoff prior to discharging to groundwater. AAI recommends the following better management practices (BMPs) to manage stormwater runoff:

1) Establish an infiltration system such as a retention basin created by excavation or berming, dry catchments, trenches and porous pavements. The catchments temporarily store stormwater where pollutants can settle or be filtered out by the soil. Retention slows the movement of water, causing the stormwater to drop some of its sediment load.

2) Identify and protect existing wetlands. Wetlands detain stormwater naturally, reducing downstream flooding. Wetlands trap sediment and filter nutrients from stormwater runoff.

3) Create artificial wetlands to detain stormwater and filter out pollutants from runoff to control nutrients and sediments.

4) Establish vegetated buffer strips of 15-30 feet on sites with sheet runoff, especially near parking lots or areas with impervious surfaces. A riparian buffer should be comprised of a mixture of trees, shrubs and grasses that naturally exist in an area. As runoff from adjacent lands flows through a buffer, pollutants and sediment are filtered and removed. Natural buffers that extend to the water's edge are effective in stabilizing lake banks and preventing erosion and preserving fish and wildlife habitat.

5) A community maintenance program should consists of the following: a) adopt and enforce erosion and sediment control ordinances for construction sites; b) regularly sweep streets and clean out catch basins; c) require yard wastes to be placed along the curb for pickup; and d) promote recycling and chemical (automotive fluids, paints, pesticides) disposal programs by establishing household hazardous waste clean-up events.

6) Educate lake residents to conserve water, minimize their use of fertilizers, pesticides and deicing materials, regularly maintain their septic systems, compost leaves and grass clippings, and dispose of used automotive oil, chemical substances and pet wastes properly.

Watershed best management practices (BMPs) for Mountain Lake should be implemented according to the priority ranking of the subwatersheds. In this study, major subwatersheds and the direct drainage area were ranked according to estimated areal nonpoint source (NPS) pollutant loadings to the lake. The lowest to highest estimated areal nutrient and suspended solids loadings to the lake area as follows:

Subwatershed No. 6 < Subwatershed No. 29 < Subwatershed No. 4

< Subwatershed No. 11 < Subwatershed No. 10 < Direct Drainage

Based upon this ranking, the lake association should first target BMPs within the direct drainage area and subwatersheds Nos. 11 and 4. These areas are immediately adjacent to the lake and contain land uses that contribute high nutrient and sediment loadings to the lake on a per acre (hectare in metric units) basis. Subwatershed No. 10 is very large and also contributes high nutrient and sediment loadings to the lake. In general, BMPs should first be targeted in close proximity to the lake and then proceed upstream. Subwatershed Nos. 29 and 6 contribute the lowest areal NPS loadings and should only be targeted after BMPs have been implemented in higher ranked subwatersheds.

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Table 1. Major Subwatersheds in the Mountain Lake Watershed.

Subwatershed/Other	Area acres	Area percent
No. 4	27.7	0.9
No. 6	218.5	7.3
No. 10	2,391.0	80.1
No. 11	16.9	0.6
No. 29	109.1	3.7
Direct Drainage	221.4	7.4
Total	2,984.6	100.0

Table 2. Percent Land Use Within the Mountain Lake Watershed.

Land Use	Subwatersheds/Direct Drainage					
	No. 4	No. 6	No. 10	No. 11	No. 29	Direct
Forest	93.1	96.6	68.7	82.8	87.5	67.8
Agriculture	0.0	0.0	8.4	0.0	0.4	2.1
Fields and Parkland	0.0	0.0	0.5	0.0	0.6	2.4
Urban	6.9	2.6	13.4	11.2	6.1	24.2
Wetlands	0.0	0.7	8.2	5.3	5.3	0.3
Lakes (not including Mountain Lake)	0.0	0.1	0.8	0.6	0.0	3.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Stream water quality data, May 19, 2000 storm event.

Subwatershed	TP	NH3-N	NO3-N	NO2-N	TKN	TN	TDS	TSS	Fecal coliform
No. 4	0.13	0.05	0.04	0.001	0.60	0.64	58.0	46.0	920
No. 6	0.08	0.07	0.05	0.001	0.40	0.45	94.0	43.0	330
No. 10	0.09	0.05	0.12	0.002	0.50	0.62	170.0	32.0	640
No. 11	0.34	0.26	0.25	0.006	2.90	3.16	130.0	110.0	2,100
No. 29	0.39	0.05	0.10	0.001	0.50	0.60	140.0	39.0	300

Note: a) All values are expressed as mg/L, except for fecal coliform reported as number of cells per 100 ml water;
b) TKN denotes total inorganic nitrogen and is the sum of nitrite, nitrate and ammonia nitrogen;
c) TN denotes total nitrogen and is the sum of Kjeldhal nitrogen and nitrite and nitrate nitrogen.

Table 4. Stream discharge data, May 19, 2001 storm event.

Subwatershed	Discharge (cfs)
No. 4	0.65
No. 6	1.58
No. 10	28.7
No. 11	0.39
No. 29	1.42

Table 5. Daily/instantaneous nutrient and sediment loadings, May 19, 2000 storm event.

		Load (Kg/d)		
Subwatershed	Area (ha)	Total phosphorus	Total nitrogen	Total suspended solids
No. 4	11.2 (1.0%)	0.21 (2.4%)	1.0 (2.0%)	73 (2.7%)
No. 6	88.4 (7.9%)	0.31 (3.6%)	1.7 (3.4%)	166 (6.1%)
No. 10	967.6 (86.5%)	6.32 (74.2%)	43.7 (84.7%)	2,247 (82.4%)
No. 11	6.8 (0.6%)	0.32 (3.8%)	3.0 (5.8%)	105 (3.8%)
No. 29	44.2 (3.9 %)	1.36 (15.9%)	2.1 (4.1%)	136 (5.0%)
Total	1,174 (100%)	8.52 (100%)	51.5 (100%)	2,727 (100%)

Table 6. Areal nutrient and sediment loadings, May 19, 2000 storm event.

		Areal load (Kg/ha/d)		
Subwatershed	Area (ha)	Total phosphorus	Total nitrogen	Total suspended solids
No. 4	11.2 (1.0%)	0.02	0.09	6
No. 6	88.4 (7.9%)	>0.00	0.02	2
No. 10	967.6 (86.5%)	0.01	0.05	2
No. 11	6.8 (0.6%)	0.05	0.44	15
No. 29	44.2 (3.9 %)	0.03	0.05	3

Table 7. Hydrologic Data for Yards Creek near Blairstown, NJ

USGS Station No.	Period of Record	Mean discharge (cfs)	Drainage area (square mile)	Mean discharge to drainage area ratio (cfsm)
1443900	January 1990 through September 1998	11.2	5.34	2.1

Source: USGS @ http://waterdata.usgs.gov

Table 8. Percent NPS loadings for major subwatersheds and direct drainage area.

Subwatershed/Other	Percent loading		
	Total phosphorus	Total nitrogen	Total suspended solids
No. 4	0.65	0.68	0.59
No. 6	4.07	4.87	3.52
No. 10	82.6	83.4	83.6
No. 11	0.46	0.44	0.43
No. 29	2.43	2.60	2.20
Direct drainage	9.80	8.02	9.64
Total	100.0	100.0	100.0

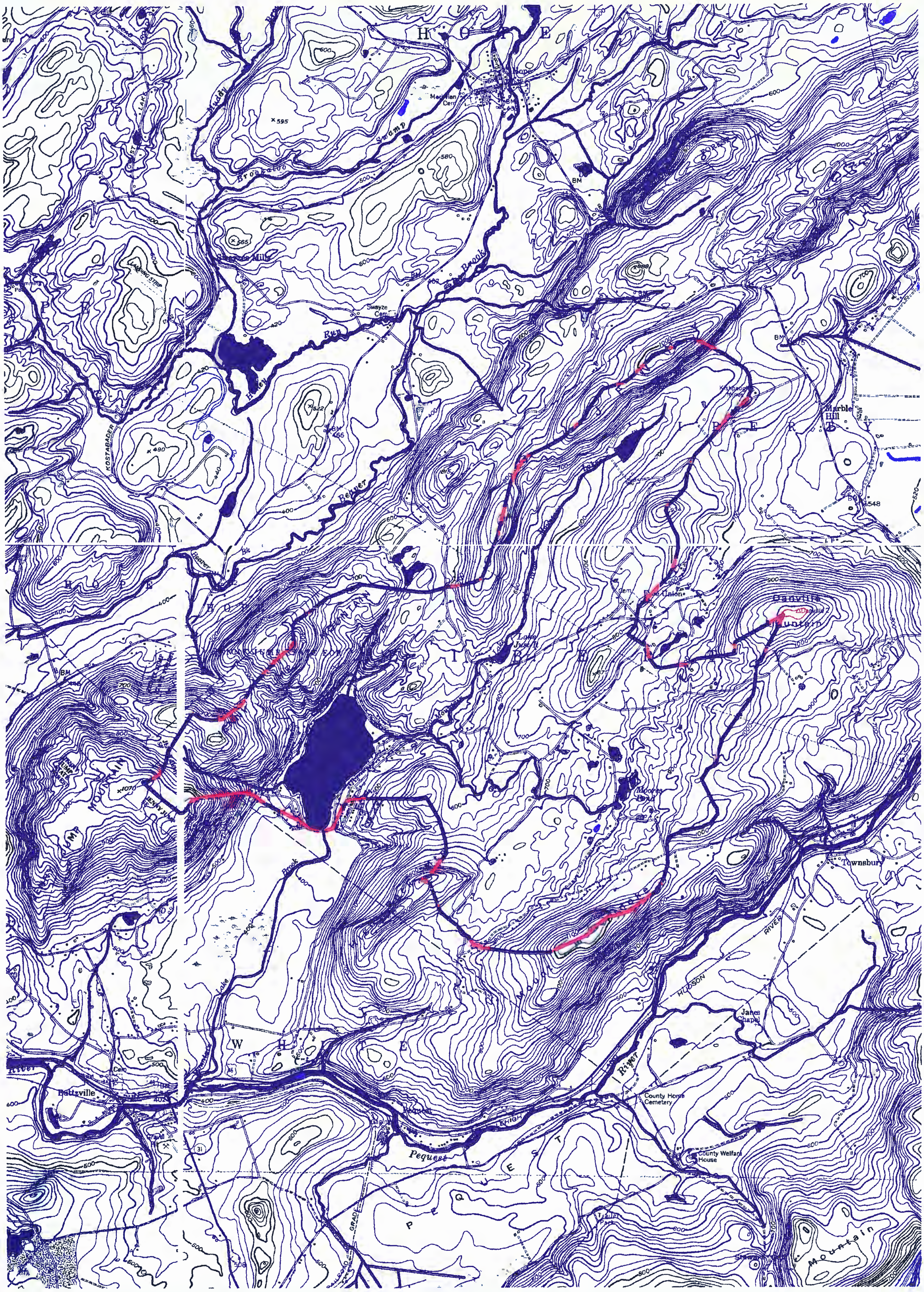

Figure 1: Mountain Lake Watershed

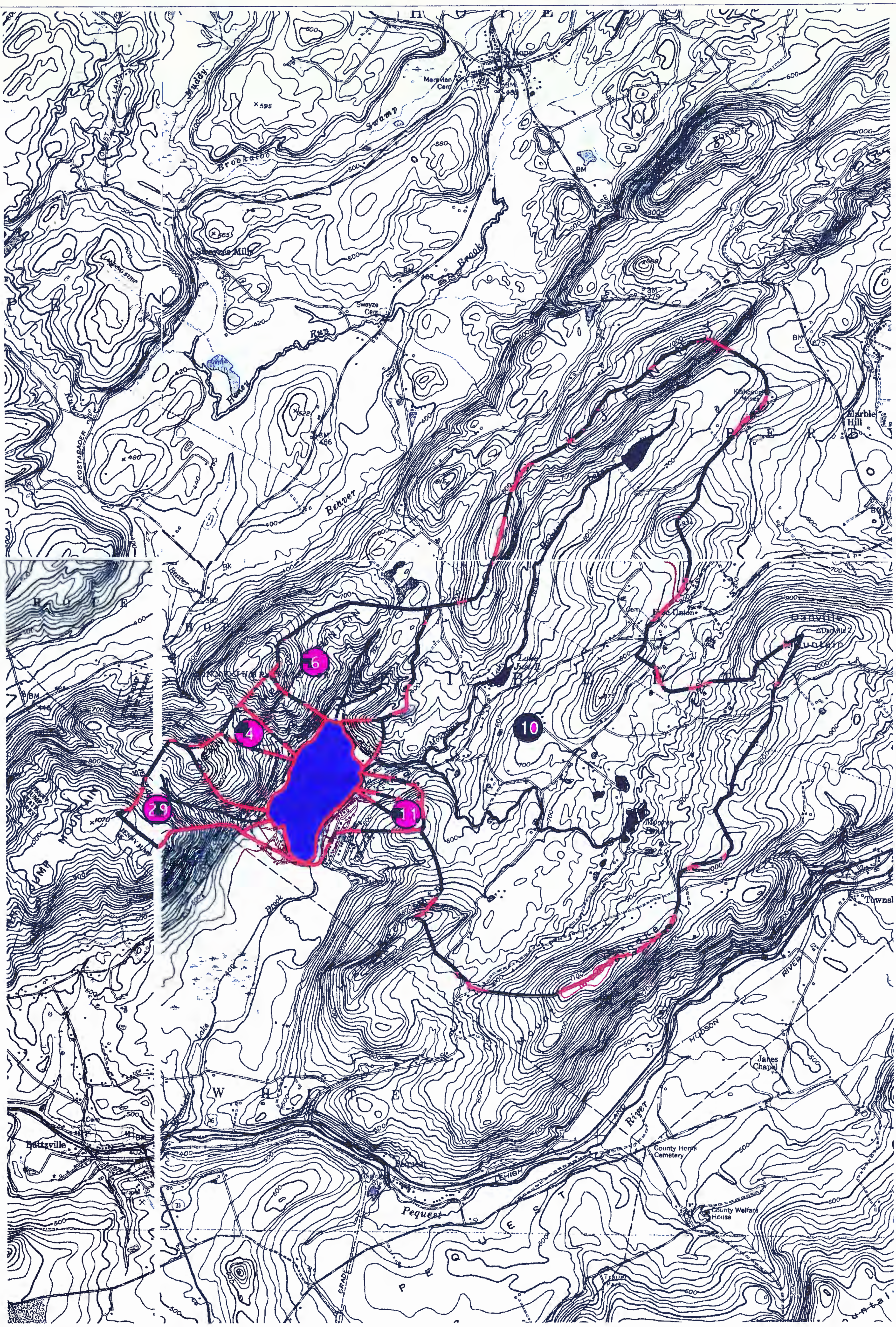

Figure .2: Subwatersheds of Mountain Lake Watershed

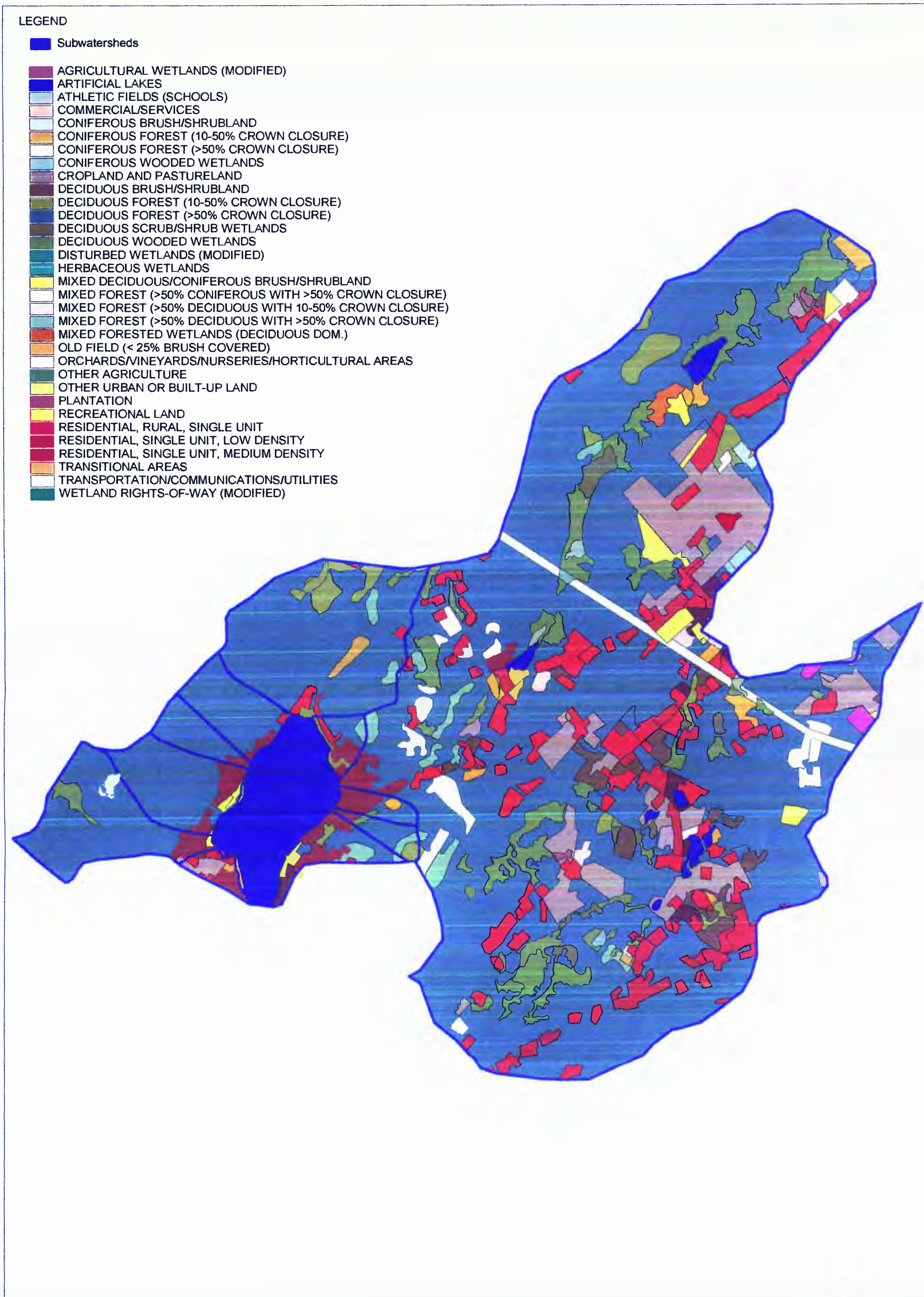

Figure 3: Land Uses in Mountain Lake Watershed

APPENDIX A

NJDEP 1995 Land Use Data

Mountain Lake
Project No. 1020-02

NJ DEP 1995 Land Use/Coverage Data

Drainage Area	LU95	Adjusted Land Uses	TYPE95	ACRES	HECTARES	Subtotal Acres
10	2140	Agriculture	WETLANDS	1.3	0.526	201.0
10	2140	Agriculture	WETLANDS	1.1	0.429	
10	2100	Agriculture	AGRICULTURE	2.2	0.872	
10	2100	Agriculture	AGRICULTURE	0.0	0.001	
10	2100	Agriculture	AGRICULTURE	4.4	1.795	
10	2100	Agriculture	AGRICULTURE	79.8	32.287	
10	2100	Agriculture	AGRICULTURE	4.9	1.983	
10	2100	Agriculture	AGRICULTURE	4.0	1.630	
10	2100	Agriculture	AGRICULTURE	0.6	0.242	
10	2100	Agriculture	AGRICULTURE	13.1	5.291	
10	2100	Agriculture	AGRICULTURE	0.7	0.284	
10	2100	Agriculture	AGRICULTURE	2.5	1.004	
10	2100	Agriculture	AGRICULTURE	0.8	0.343	
10	2100	Agriculture	AGRICULTURE	3.7	1.505	
10	2100	Agriculture	AGRICULTURE	9.3	3.756	
10	2100	Agriculture	AGRICULTURE	2.2	0.875	
10	2100	Agriculture	AGRICULTURE	3.1	1.236	
10	2100	Agriculture	AGRICULTURE	5.8	2.365	
10	2100	Agriculture	AGRICULTURE	8.2	3.335	
10	2100	Agriculture	AGRICULTURE	4.2	1.711	
10	2100	Agriculture	AGRICULTURE	19.1	7.722	
10	2100	Agriculture	AGRICULTURE	9.3	3.774	
10	2100	Agriculture	AGRICULTURE	9.9	3.999	
10	2100	Agriculture	AGRICULTURE	1.0	0.407	
10	2100	Agriculture	AGRICULTURE	1.1	0.462	
10	2200	Agriculture	AGRICULTURE	1.8	0.741	
10	2200	Agriculture	AGRICULTURE	0.1	0.021	
10	2200	Agriculture	AGRICULTURE	3.9	1.586	
10	2400	Agriculture	AGRICULTURE	2.9	1.173	
10	1804	Fields/Parkland	URBAN	2.7	1.079	11.3
10	1804	Fields/Parkland	URBAN	0.9	0.358	
10	1800	Fields/Parkland	URBAN	5.7	2.302	
10	1800	Fields/Parkland	URBAN	2.0	0.818	
10	4430	Forest	FOREST	3.1	1.237	1,642.0
10	4430	Forest	FOREST	0.3	0.104	
10	4220	Forest	FOREST	9.1	3.680	
10	4420	Forest	FOREST	1.1	0.429	
10	4420	Forest	FOREST	0.2	0.087	
10	4420	Forest	FOREST	1.4	0.572	
10	4420	Forest	FOREST	1.5	0.590	
10	4420	Forest	FOREST	0.4	0.147	
10	4420	Forest	FOREST	0.4	0.173	
10	4420	Forest	FOREST	1.2	0.471	
10	4420	Forest	FOREST	5.0	2.017	
10	4420	Forest	FOREST	1.4	0.574	
10	4420	Forest	FOREST	7.2	2.921	
10	4420	Forest	FOREST	2.9	1.171	

10	4420	Forest	FOREST	1.0	0.416
10	4420	Forest	FOREST	0.0	0.000
10	4420	Forest	FOREST	1.3	0.546
10	4420	Forest	FOREST	1.3	0.520
10	4420	Forest	FOREST	5.0	2.042
10	4420	Forest	FOREST	3.0	1.200
10	4420	Forest	FOREST	3.1	1.272
10	4420	Forest	FOREST	1.8	0.715
10	4420	Forest	FOREST	0.9	0.370
10	4420	Forest	FOREST	5.5	2.224
10	4120	Forest	FOREST	3.1	1.249
10	4120	Forest	FOREST	401.7	162.582
10	4120	Forest	FOREST	0.2	0.077
10	4120	Forest	FOREST	0.2	0.084
10	4120	Forest	FOREST	5.9	2.402
10	4120	Forest	FOREST	3.4	1.356
10	4120	Forest	FOREST	2.1	0.841
10	4120	Forest	FOREST	2.2	0.891
10	4120	Forest	FOREST	0.0	0.003
10	4120	Forest	FOREST	0.8	0.316
10	4120	Forest	FOREST	48.0	19.442
10	4120	Forest	FOREST	750.4	303.694
10	4120	Forest	FOREST	0.1	0.053
10	4120	Forest	FOREST	172.3	69.732
10	4120	Forest	FOREST	1.1	0.454
10	4120	Forest	FOREST	0.9	0.381
10	4120	Forest	FOREST	2.0	0.790
10	4120	Forest	FOREST	2.1	0.855
10	4120	Forest	FOREST	3.1	1.245
10	4120	Forest	FOREST	12.6	5.118
10	4120	Forest	FOREST	0.4	0.171
10	4120	Forest	FOREST	0.8	0.308
10	4120	Forest	FOREST	2.2	0.888
10	4120	Forest	FOREST	1.4	0.580
10	4120	Forest	FOREST	5.9	2.374
10	4120	Forest	FOREST	1.3	0.532
10	4120	Forest	FOREST	2.3	0.950
10	4110	Forest	FOREST	1.7	0.700
10	4110	Forest	FOREST	13.1	5.284
10	4110	Forest	FOREST	6.2	2.491
10	4110	Forest	FOREST	2.0	0.811
10	4110	Forest	FOREST	0.6	0.257
10	4110	Forest	FOREST	1.6	0.643
10	4110	Forest	FOREST	3.1	1.256
10	4110	Forest	FOREST	0.1	0.045
10	4110	Forest	FOREST	2.4	0.987
10	4110	Forest	FOREST	0.5	0.195
10	4110	Forest	FOREST	2.5	0.999
10	4440	Forest	FOREST	2.5	1.009
10	4440	Forest	FOREST	3.7	1.506
10	4440	Forest	FOREST	1.7	0.706
10	4440	Forest	FOREST	8.7	3.537

10	4440	Forest	FOREST	0.7	0.280	
10	4440	Forest	FOREST	3.8	1.536	
10	4440	Forest	FOREST	0.2	0.076	
10	4312	Forest	FOREST	3.5	1.401	
10	4312	Forest	FOREST	1.2	0.476	
10	4312	Forest	FOREST	1.1	0.426	
10	4312	Forest	FOREST	1.9	0.767	
10	4312	Forest	FOREST	1.1	0.446	
10	4312	Forest	FOREST	3.1	1.267	
10	4312	Forest	FOREST	2.2	0.887	
10	4312	Forest	FOREST	4.4	1.777	
10	4312	Forest	FOREST	4.1	1.652	
10	4312	Forest	FOREST	5.0	2.009	
10	4322	Forest	FOREST	2.4	0.964	
10	4322	Forest	FOREST	2.1	0.842	
10	4322	Forest	FOREST	0.2	0.078	
10	4322	Forest	FOREST	4.5	1.828	
10	4322	Forest	FOREST	3.3	1.330	
10	4322	Forest	FOREST	2.2	0.900	
10	4322	Forest	FOREST	1.3	0.516	
10	4322	Forest	FOREST	0.7	0.283	
10	4322	Forest	FOREST	0.0	0.003	
10	4322	Forest	FOREST	6.3	2.531	
10	4322	Forest	FOREST	2.7	1.100	
10	4321	Forest	FOREST	2.3	0.946	
10	4321	Forest	FOREST	0.8	0.335	
10	4321	Forest	FOREST	2.6	1.055	
10	4321	Forest	FOREST	2.4	0.957	
10	4410	Forest	FOREST	6.1	2.469	
10	4410	Forest	FOREST	2.7	1.101	
10	4410	Forest	FOREST	1.3	0.526	
10	4410	Forest	FOREST	1.8	0.732	
10	4410	Forest	FOREST	0.3	0.122	
10	4410	Forest	FOREST	1.8	0.713	
10	4410	Forest	FOREST	0.7	0.273	
10	4410	Forest	FOREST	1.3	0.507	
10	4410	Forest	FOREST	4.7	1.882	
10	4410	Forest	FOREST	1.7	0.685	
10	4410	Forest	FOREST	0.0	0.004	
10	4410	Forest	FOREST	1.0	0.386	
10	4410	Forest	FOREST	0.7	0.290	
10	4410	Forest	FOREST	0.2	0.066	
10	4230	Forest	FOREST	5.3	2.145	
10	4230	Forest	FOREST	1.5	0.613	
10	4230	Forest	FOREST	1.2	0.473	
10	4230	Forest	FOREST	2.1	0.869	
10	4230	Forest	FOREST	3.5	1.435	
10	4230	Forest	FOREST	1.2	0.488	
10	4230	Forest	FOREST	1.8	0.740	
10	5300	Lake	WATER	8.0	3.237	20.1
10	5300	Lake	WATER	3.4	1.360	
10	5300	Lake	WATER	0.1	0.047	

10	5300	Lake	WATER	1.7	0.672	
10	5300	Lake	WATER	1.0	0.419	
10	5300	Lake	WATER	1.3	0.509	
10	5300	Lake	WATER	4.0	1.619	
10	5300	Lake	WATER	0.6	0.238	
10	1200	Urban, Commercial	URBAN	1.7	0.681	319.4
10	1200	Urban, Commercial	URBAN	0.2	0.095	
10	7500	Urban, Construction	BARREN LAND	0.0	0.019	
10	7500	Urban, Construction	BARREN LAND	0.1	0.036	
10	7500	Urban, Construction	BARREN LAND	0.3	0.109	
10	7500	Urban, Construction	BARREN LAND	0.8	0.331	
10	7500	Urban, Construction	BARREN LAND	0.2	0.086	
10	1700	Urban, Other	URBAN	2.4	0.962	
10	1700	Urban, Other	URBAN	3.2	1.291	
10	1700	Urban, Other	URBAN	0.0	0.001	
10	1700	Urban, Other	URBAN	0.0	0.013	
10	1700	Urban, Other	URBAN	0.2	0.075	
10	1700	Urban, Other	URBAN	0.6	0.255	
10	1700	Urban, Other	URBAN	0.3	0.119	
10	1700	Urban, Other	URBAN	1.1	0.443	
10	1700	Urban, Other	URBAN	3.6	1.470	
10	1700	Urban, Other	URBAN	1.0	0.395	
10	1700	Urban, Other	URBAN	2.9	1.161	
10	1700	Urban, Other	URBAN	0.4	0.145	
10	1130	Urban, Resid Low Density	URBAN	1.6	0.636	
10	1130	Urban, Resid Low Density	URBAN	2.3	0.939	
10	1130	Urban, Resid Low Density	URBAN	5.2	2.108	
10	1130	Urban, Resid Low Density	URBAN	1.7	0.694	
10	1130	Urban, Resid Low Density	URBAN	3.9	1.588	
10	1130	Urban, Resid Low Density	URBAN	1.4	0.566	
10	1130	Urban, Resid Low Density	URBAN	2.5	0.993	
10	1130	Urban, Resid Low Density	URBAN	2.2	0.884	
10	1130	Urban, Resid Low Density	URBAN	2.3	0.928	
10	1130	Urban, Resid Low Density	URBAN	0.1	0.021	
10	1130	Urban, Resid Low Density	URBAN	1.2	0.489	
10	1130	Urban, Resid Low Density	URBAN	6.0	2.431	
10	1130	Urban, Resid Low Density	URBAN	4.2	1.693	
10	1130	Urban, Resid Low Density	URBAN	2.1	0.830	
10	1130	Urban, Resid Low Density	URBAN	0.4	0.174	
10	1130	Urban, Resid Low Density	URBAN	0.3	0.112	
10	1130	Urban, Resid Low Density	URBAN	4.0	1.602	
10	1130	Urban, Resid Low Density	URBAN	0.7	0.282	
10	1130	Urban, Resid Low Density	URBAN	0.9	0.377	
10	1130	Urban, Resid Low Density	URBAN	3.1	1.258	
10	1130	Urban, Resid Low Density	URBAN	1.2	0.476	
10	1130	Urban, Resid Low Density	URBAN	9.0	3.632	
10	1130	Urban, Resid Low Density	URBAN	0.7	0.297	
10	1130	Urban, Resid Low Density	URBAN	1.8	0.717	
10	1130	Urban, Resid Low Density	URBAN	2.0	0.826	
10	1130	Urban, Resid Low Density	URBAN	2.6	1.069	
10	1130	Urban, Resid Low Density	URBAN	0.3	0.137	
10	1120	Urban, Resid Med Density	URBAN	3.9	1.578	

10	1120	Urban, Resid Med Density	URBAN	10.6	4.290
10	1120	Urban, Resid Med Density	URBAN	0.3	0.134
10	1140	Urban, Resid Rural	URBAN	2.7	1.092
10	1140	Urban, Resid Rural	URBAN	1.0	0.420
10	1140	Urban, Resid Rural	URBAN	0.8	0.331
10	1140	Urban, Resid Rural	URBAN	2.0	0.811
10	1140	Urban, Resid Rural	URBAN	0.2	0.064
10	1140	Urban, Resid Rural	URBAN	0.9	0.351
10	1140	Urban, Resid Rural	URBAN	9.7	3.910
10	1140	Urban, Resid Rural	URBAN	1.4	0.553
10	1140	Urban, Resid Rural	URBAN	0.0	0.004
10	1140	Urban, Resid Rural	URBAN	7.3	2.937
10	1140	Urban, Resid Rural	URBAN	2.3	0.915
10	1140	Urban, Resid Rural	URBAN	6.1	2.472
10	1140	Urban, Resid Rural	URBAN	2.8	1.126
10	1140	Urban, Resid Rural	URBAN	2.4	0.983
10	1140	Urban, Resid Rural	URBAN	0.0	0.001
10	1140	Urban, Resid Rural	URBAN	0.4	0.176
10	1140	Urban, Resid Rural	URBAN	0.8	0.317
10	1140	Urban, Resid Rural	URBAN	0.9	0.373
10	1140	Urban, Resid Rural	URBAN	1.9	0.772
10	1140	Urban, Resid Rural	URBAN	0.5	0.220
10	1140	Urban, Resid Rural	URBAN	1.9	0.784
10	1140	Urban, Resid Rural	URBAN	0.6	0.226
10	1140	Urban, Resid Rural	URBAN	1.0	0.404
10	1140	Urban, Resid Rural	URBAN	1.1	0.458
10	1140	Urban, Resid Rural	URBAN	1.9	0.758
10	1140	Urban, Resid Rural	URBAN	2.1	0.857
10	1140	Urban, Resid Rural	URBAN	0.4	0.143
10	1140	Urban, Resid Rural	URBAN	1.4	0.577
10	1140	Urban, Resid Rural	URBAN	1.0	0.415
10	1140	Urban, Resid Rural	URBAN	0.1	0.028
10	1140	Urban, Resid Rural	URBAN	10.2	4.114
10	1140	Urban, Resid Rural	URBAN	1.8	0.720
10	1140	Urban, Resid Rural	URBAN	1.0	0.418
10	1140	Urban, Resid Rural	URBAN	1.3	0.533
10	1140	Urban, Resid Rural	URBAN	2.0	0.819
10	1140	Urban, Resid Rural	URBAN	1.1	0.449
10	1140	Urban, Resid Rural	URBAN	0.4	0.147
10	1140	Urban, Resid Rural	URBAN	0.5	0.222
10	1140	Urban, Resid Rural	URBAN	1.9	0.772
10	1140	Urban, Resid Rural	URBAN	0.6	0.238
10	1140	Urban, Resid Rural	URBAN	0.3	0.113
10	1140	Urban, Resid Rural	URBAN	0.0	0.010
10	1140	Urban, Resid Rural	URBAN	0.9	0.351
10	1140	Urban, Resid Rural	URBAN	0.3	0.107
10	1140	Urban, Resid Rural	URBAN	0.8	0.309
10	1140	Urban, Resid Rural	URBAN	0.4	0.172
10	1140	Urban, Resid Rural	URBAN	1.4	0.551
10	1140	Urban, Resid Rural	URBAN	0.1	0.026
10	1140	Urban, Resid Rural	URBAN	1.2	0.483
10	1140	Urban, Resid Rural	URBAN	1.7	0.674

10	1140	Urban, Resid Rural	URBAN	3.6	1.465
10	1140	Urban, Resid Rural	URBAN	3.6	1.438
10	1140	Urban, Resid Rural	URBAN	1.0	0.404
10	1140	Urban, Resid Rural	URBAN	1.6	0.629
10	1140	Urban, Resid Rural	URBAN	3.2	1.283
10	1140	Urban, Resid Rural	URBAN	5.7	2.299
10	1140	Urban, Resid Rural	URBAN	1.3	0.546
10	1140	Urban, Resid Rural	URBAN	1.0	0.406
10	1140	Urban, Resid Rural	URBAN	6.6	2.684
10	1140	Urban, Resid Rural	URBAN	3.1	1.239
10	1140	Urban, Resid Rural	URBAN	0.9	0.347
10	1140	Urban, Resid Rural	URBAN	1.0	0.424
10	1140	Urban, Resid Rural	URBAN	1.0	0.408
10	1140	Urban, Resid Rural	URBAN	2.1	0.861
10	1140	Urban, Resid Rural	URBAN	1.1	0.428
10	1140	Urban, Resid Rural	URBAN	0.7	0.278
10	1140	Urban, Resid Rural	URBAN	1.0	0.405
10	1140	Urban, Resid Rural	URBAN	0.3	0.126
10	1140	Urban, Resid Rural	URBAN	3.0	1.208
10	1140	Urban, Resid Rural	URBAN	0.2	0.066
10	1140	Urban, Resid Rural	URBAN	3.8	1.539
10	1140	Urban, Resid Rural	URBAN	1.8	0.730
10	1140	Urban, Resid Rural	URBAN	3.4	1.367
10	1140	Urban, Resid Rural	URBAN	3.6	1.452
10	1140	Urban, Resid Rural	URBAN	1.4	0.582
10	1140	Urban, Resid Rural	URBAN	1.5	0.616
10	1140	Urban, Resid Rural	URBAN	1.6	0.636
10	1140	Urban, Resid Rural	URBAN	1.1	0.459
10	1140	Urban, Resid Rural	URBAN	3.2	1.311
10	1140	Urban, Resid Rural	URBAN	2.7	1.108
10	1140	Urban, Resid Rural	URBAN	1.1	0.452
10	1140	Urban, Resid Rural	URBAN	2.3	0.925
10	1140	Urban, Resid Rural	URBAN	2.3	0.949
10	1140	Urban, Resid Rural	URBAN	1.0	0.418
10	1140	Urban, Resid Rural	URBAN	0.1	0.027
10	1140	Urban, Resid Rural	URBAN	2.2	0.906
10	1140	Urban, Resid Rural	URBAN	1.1	0.433
10	1140	Urban, Resid Rural	URBAN	1.1	0.433
10	1140	Urban, Resid Rural	URBAN	0.2	0.064
10	1140	Urban, Resid Rural	URBAN	7.1	2.883
10	1140	Urban, Resid Rural	URBAN	0.2	0.073
10	1140	Urban, Resid Rural	URBAN	0.3	0.101
10	1140	Urban, Resid Rural	URBAN	0.6	0.258
10	1140	Urban, Resid Rural	URBAN	5.4	2.174
10	1140	Urban, Resid Rural	URBAN	1.3	0.532
10	1140	Urban, Resid Rural	URBAN	0.3	0.111
10	1140	Urban, Resid Rural	URBAN	0.6	0.234
10	1140	Urban, Resid Rural	URBAN	0.6	0.237
10	1140	Urban, Resid Rural	URBAN	2.1	0.839
10	1140	Urban, Resid Rural	URBAN	2.2	0.886
10	1140	Urban, Resid Rural	URBAN	1.3	0.514
10	1140	Urban, Resid Rural	URBAN	0.3	0.130

10	1140	Urban, Resid Rural	URBAN	0.7	0.297	
10	1140	Urban, Resid Rural	URBAN	0.1	0.029	
10	1140	Urban, Resid Rural	URBAN	1.1	0.437	
10	1140	Urban, Resid Rural	URBAN	0.4	0.175	
10	1140	Urban, Resid Rural	URBAN	1.0	0.415	
10	1140	Urban, Resid Rural	URBAN	1.5	0.587	
10	1140	Urban, Resid Rural	URBAN	0.6	0.249	
10	1140	Urban, Resid Rural	URBAN	1.3	0.513	
10	1140	Urban, Resid Rural	URBAN	1.1	0.453	
10	1140	Urban, Resid Rural	URBAN	1.3	0.515	
10	1140	Urban, Resid Rural	URBAN	2.0	0.819	
10	1400	Urban, Transportation	URBAN	5.5	2.208	
10	1400	Urban, Transportation	URBAN	13.9	5.622	
10	1400	Urban, Transportation	URBAN	8.1	3.286	
10	6220	Wetlands	WETLANDS	1.4	0.559	197.2
10	6231	Wetlands	WETLANDS	0.8	0.338	
10	6231	Wetlands	WETLANDS	8.2	3.339	
10	6231	Wetlands	WETLANDS	1.1	0.430	
10	6231	Wetlands	WETLANDS	1.7	0.684	
10	6231	Wetlands	WETLANDS	1.9	0.781	
10	6231	Wetlands	WETLANDS	0.8	0.338	
10	6231	Wetlands	WETLANDS	2.1	0.846	
10	6231	Wetlands	WETLANDS	2.6	1.067	
10	6210	Wetlands	WETLANDS	21.1	8.528	
10	6210	Wetlands	WETLANDS	18.2	7.376	
10	6210	Wetlands	WETLANDS	5.2	2.089	
10	6210	Wetlands	WETLANDS	4.8	1.944	
10	6210	Wetlands	WETLANDS	12.9	5.214	
10	6210	Wetlands	WETLANDS	8.2	3.319	
10	6210	Wetlands	WETLANDS	0.0	0.001	
10	6210	Wetlands	WETLANDS	2.4	0.968	
10	6210	Wetlands	WETLANDS	0.8	0.324	
10	6210	Wetlands	WETLANDS	1.9	0.775	
10	6210	Wetlands	WETLANDS	3.2	1.305	
10	6210	Wetlands	WETLANDS	3.7	1.490	
10	6210	Wetlands	WETLANDS	7.8	3.166	
10	6210	Wetlands	WETLANDS	0.0	0.015	
10	6210	Wetlands	WETLANDS	0.8	0.340	
10	6210	Wetlands	WETLANDS	0.7	0.303	
10	6210	Wetlands	WETLANDS	2.0	0.799	
10	6210	Wetlands	WETLANDS	1.2	0.476	
10	6210	Wetlands	WETLANDS	1.4	0.572	
10	6210	Wetlands	WETLANDS	2.6	1.042	
10	6210	Wetlands	WETLANDS	2.7	1.094	
10	6210	Wetlands	WETLANDS	2.0	0.825	
10	6210	Wetlands	WETLANDS	0.6	0.261	
10	6210	Wetlands	WETLANDS	20.6	8.327	
10	6210	Wetlands	WETLANDS	0.6	0.239	
10	6210	Wetlands	WETLANDS	1.1	0.464	
10	6210	Wetlands	WETLANDS	1.1	0.444	
10	6210	Wetlands	WETLANDS	0.9	0.350	
10	6210	Wetlands	WETLANDS	2.7	1.074	

10	6210	Wetlands	WETLANDS	0.8	0.331	
10	6210	Wetlands	WETLANDS	1.9	0.761	
10	6210	Wetlands	WETLANDS	5.5	2.226	
10	6210	Wetlands	WETLANDS	0.6	0.245	
10	6210	Wetlands	WETLANDS	0.5	0.202	
10	6210	Wetlands	WETLANDS	9.9	4.003	
10	6210	Wetlands	WETLANDS	0.4	0.173	
10	6210	Wetlands	WETLANDS	0.6	0.261	
10	6210	Wetlands	WETLANDS	8.9	3.621	
10	6210	Wetlands	WETLANDS	0.0	0.010	
10	6210	Wetlands	WETLANDS	2.2	0.904	
10	6210	Wetlands	WETLANDS	1.5	0.619	
10	7430	Wetlands	WETLANDS	0.4	0.167	
10	6240	Wetlands	WETLANDS	2.2	0.909	
10	6240	Wetlands	WETLANDS	1.4	0.555	
10	6240	Wetlands	WETLANDS	1.2	0.501	
10	6251	Wetlands	WETLANDS	6.1	2.477	
10	1461	Wetlands	WETLANDS	1.3	0.524	
						2,391.0
11	4120	Forest	FOREST	9.3	3.758	14.0
11	4110	Forest	FOREST	2.5	1.024	
11	4322	Forest	FOREST	2.2	0.887	
11	5300	Lake	WATER	0.1	0.033	0.1
11	1120	Urban, Resid Med Density	URBAN	1.9	0.770	1.9
11	1120	Urban, Resid Med Density	URBAN	0.0	0.017	
11	6210	Wetlands	WETLANDS	0.9	0.370	0.9
						16.9
29	2100	Agriculture	AGRICULTURE	0.4	0.180	0.4
29	1800	Fields/Parkland	URBAN	0.7	0.271	0.7
29	4120	Forest	FOREST	95.5	38.665	95.5
29	1130	Urban, Resid Low Density	URBAN	0.4	0.157	6.7
29	1120	Urban, Resid Med Density	URBAN	6.1	2.453	
29	1140	Urban, Resid Rural	URBAN	0.2	0.090	
29	6210	Wetlands	WETLANDS	5.8	2.366	5.8
						109.1
4	4120	Forest	FOREST	25.8	10.446	25.8
4	5300	Lake	WATER	0.0	0.002	0.0
4	1120	Urban, Resid Med Density	URBAN	1.9	0.763	1.9
						27.7
6	4210	Forest	FOREST	4.9	1.963	211.0
6	4420	Forest	FOREST	0.1	0.060	
6	4120	Forest	FOREST	182.5	73.838	
6	4110	Forest	FOREST	8.2	3.331	
6	4110	Forest	FOREST	2.7	1.101	
6	4110	Forest	FOREST	4.3	1.729	
6	4110	Forest	FOREST	0.2	0.083	
6	4110	Forest	FOREST	1.1	0.438	
6	4110	Forest	FOREST	1.2	0.485	

6	4322	Forest	FOREST	0.1	0.052	
6	4322	Forest	FOREST	3.1	1.274	
6	4322	Forest	FOREST	2.5	1.014	
6	4322	Forest	FOREST	0.1	0.027	
6	5300	Lake	WATER	0.3	0.141	0.3
6	1130	Urban, Resid Low Density	URBAN	1.1	0.441	5.7
6	1130	Urban, Resid Low Density	URBAN	0.0	0.004	
6	1140	Urban, Resid Rural	URBAN	0.3	0.111	
6	1140	Urban, Resid Rural	URBAN	1.0	0.401	
6	1140	Urban, Resid Rural	URBAN	0.0	0.000	
6	1140	Urban, Resid Rural	URBAN	0.2	0.097	
6	1140	Urban, Resid Rural	URBAN	3.1	1.235	
6	6210	Wetlands	WETLANDS	0.1	0.043	1.5
6	6210	Wetlands	WETLANDS	1.4	0.581	
						218.5

DRAINAGE	2100	Agriculture	AGRICULTURE	4.7	1.904	4.7
DRAINAGE	1800	Fields/Parkland	URBAN	1.4	0.561	5.3
DRAINAGE	1800	Fields/Parkland	URBAN	1.4	0.575	
DRAINAGE	1800	Fields/Parkland	URBAN	0.2	0.079	
DRAINAGE	1800	Fields/Parkland	URBAN	2.3	0.938	
DRAINAGE	4120	Forest	FOREST	47.1	19.073	150.0
DRAINAGE	4120	Forest	FOREST	63.3	25.634	
DRAINAGE	4120	Forest	FOREST	9.8	3.984	
DRAINAGE	4120	Forest	FOREST	7.3	2.941	
DRAINAGE	4120	Forest	FOREST	7.3	2.952	
DRAINAGE	4120	Forest	FOREST	1.2	0.488	
DRAINAGE	4110	Forest	FOREST	2.5	0.995	
DRAINAGE	4110	Forest	FOREST	1.7	0.677	
DRAINAGE	4110	Forest	FOREST	0.0	0.001	
DRAINAGE	4110	Forest	FOREST	0.1	0.053	
DRAINAGE	4110	Forest	FOREST	0.0	0.002	
DRAINAGE	4322	Forest	FOREST	1.8	0.740	
DRAINAGE	4322	Forest	FOREST	0.8	0.325	
DRAINAGE	4322	Forest	FOREST	4.5	1.828	
DRAINAGE	4410	Forest	FOREST	1.4	0.556	
DRAINAGE	4410	Forest	FOREST	1.2	0.472	
DRAINAGE	5300	Lake	WATER	0.1	0.049	7.1
DRAINAGE	5300	Lake	WATER	0.0	0.006	
DRAINAGE	5300	Lake	WATER	4.1	1.667	
DRAINAGE	5300	Lake	WATER	1.0	0.404	
DRAINAGE	5300	Lake	WATER	1.9	0.750	
DRAINAGE	1700	Urban, Other	URBAN	3.9	1.583	53.6
DRAINAGE	1130	Urban, Resid Low Density	URBAN	2.0	0.804	
DRAINAGE	1130	Urban, Resid Low Density	URBAN	0.9	0.376	
DRAINAGE	1130	Urban, Resid Low Density	URBAN	1.9	0.763	
DRAINAGE	1130	Urban, Resid Low Density	URBAN	0.4	0.148	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	3.0	1.213	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	7.2	2.933	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	10.7	4.328	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	7.7	3.115	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	5.5	2.241	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	0.0	0.003	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	2.9	1.168	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	0.5	0.204	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	0.5	0.220	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	0.1	0.037	
DRAINAGE	1120	Urban, Resid Med Density	URBAN	0.6	0.245	

DRAINAGE	1120	Urban, Resid Med Density	URBAN	4.4	1.770	
DRAINAGE	1140	Urban, Resid Rural	URBAN	0.0	0.001	
DRAINAGE	1140	Urban, Resid Rural	URBAN	0.8	0.326	
DRAINAGE	1140	Urban, Resid Rural	URBAN	0.6	0.245	
DRAINAGE	6210	Wetlands	WETLANDS	0.1	0.050	0.7
DRAINAGE	6210	Wetlands	WETLANDS	0.6	0.230	
						221.4
		Total Land Area w/o Mountain Lake		**2,985**		**2,985**

APPENDIX B

Summarized NJDEP 1995 Land Use Data

Appendix B. Landuse/Coverage Per Drainage Areas.

	Subwatershed Acreages (ac)							
Landuse	4	6	11	10	29	Direct	Subtotal	% Subtotal
Forest	25.8	211.0	14.0	1,642.0	95.5	150.0	2,138.3	71.6
Agriculture	0.0	0.0	0.0	201.0	0.4	4.7	206.1	6.9
Fields/Parkland	0.0	0.0	0.0	11.3	0.7	5.3	17.3	0.6
Urban	1.9	5.7	1.9	319.4	6.7	53.6	389.2	13.0
Wetlands	0.0	1.5	0.9	197.2	5.8	0.7	206.1	6.9
Lakes	0.0	0.3	0.1	20.1	0.0	7.1	27.6	0.9
Subtotal	27.7	218.5	16.9	2,391.0	109.1	221.4		
Total	2,984.6						2,984.6	100.0
% Subtotal	0.9	7.3	0.6	80.1	3.7	7.4		
% Total	100.0							

Appendix B: Landuse/Coverage Per Drainage Areas (cont'd).

	Subwatershed Acreage (ha)							
Landuse	4	6	11	10	29	Direct	Subtotal	% Subtotal
Forest	10.4	85.4	5.7	664.5	38.6	60.7	865.4	71.6
Agriculture	0.0	0.0	0.0	81.3	0.2	1.9	83.4	6.9
Fields/Parkland	0.0	0.0	0.0	4.6	0.3	2.1	7.0	0.6
Urban	0.8	2.3	0.8	129.3	2.7	21.7	157.5	13.0
Wetlands	0.0	0.6	0.4	79.8	2.3	0.3	83.4	6.9
Lakes	0.0	0.1	0.0	8.1	0.0	2.9	11.2	0.9
Subtotal	11.2	88.4	6.8	967.6	44.2	89.6		
Total	1,207.9						1,207.9	100.0
% Subtotal	0.9	7.3	0.6	80.1	3.7	7.4		
% Total	100.0							

Appendix B: Landuse/Coverage Per Drainage Areas (cont'd).

	Subwatershed Acreage (%)					
Landuse	4	6	11	10	29	Direct
Forest	93.1	96.6	82.8	68.7	87.5	67.8
Agriculture	0.0	0.0	0.0	8.4	0.4	2.1
Fields/Parkland	0.0	0.0	0.0	0.5	0.6	2.4
Urban	6.9	2.6	11.2	13.4	6.1	24.2
Wetlands	0.0	0.7	5.3	8.2	5.3	0.3
Lakes	0.0	0.1	0.6	0.8	0.0	3.2
Subtotal	100.0	100.0	100.0	100.0	100.0	100.0

Source: NJDEP 1995 land use/coverage data

APPENDIX C

Estimated Hydrology for Subwatersheds

and Direct Drainage

Appendix C. Hydrologic Budgets: Major Subwatersheds and Direct Drainage

Drainage Area	Area (ac)	Area (ha)	Area (mi)	Area (%)	Mean cfsm*	Calc. annual mean cfs	Calc. annual Q(ft3/yr)	(%)
Site 4	28	11.2	0.04	0.9	2.1	0.09	2,897,370	0.9
Site 6	219	89.4	0.34	7.3	2.1	0.72	22,661,573	7.3
Site 10	2,391	967.6	3.74	80.1	2.1	7.85	247,414,703	80.1
Site 11	17	6.8	0.03	0.6	2.1	0.06	1,759,118	0.6
Site 29	109	44.2	0.17	3.7	2.1	0.36	11,279,048	3.7
Direct drainage	221	89.6	0.35	7.4	2.1	0.73	22,868,528	7.4
Total	2,985	1,207.9	4.7	100.0			308,880,338	100.0

Note: (*) cfsm based upon mean daily Q values for nearby USGS Gaging Station:
Yards Creek near Blairstown, NJ (01443900).

APPENDIX D

Nonpoint Source Loading Calculations

Appendix D. Loading calculations.

Landuse	Export coefficients (kg/ha/yr) TP	TN	TSS
Forest	0.23	2.86	100
Agriculture	1.13	16.5	750
Fields/Parkland	0.60	8.50	250
Urban	1.91	9.97	1,000
Wetlands	0.00	0.00	0
Lakes	0.00	0.00	0
Total			

Summary of calculations:

ID	Loading (kg/yr) TP	TN	TSS	Area (ha)
4	3.9	37.5	1,813	11.2
6	24.6	267.2	10,846	88.4
11	2.8	23.9	1,335	6.8
10	498.7	4,572.7	257,861	967.6
29	14.7	142.7	6,769	44.2
Direct	59.2	439.6	29,725	89.6
	603.8	5,483.5	308,349	1,207.9

Landuse	Area(ha) 4	Export coefficients(kg/ha/yr) TP	TN	TSS	Loading (kg/yr) TP	TN	TSS
Forest	10.4	0.23	2.86	100	2.46	29.9	1,044
Agriculture	0.0	1.13	16.5	750	0.00	0.0	0
Fields/Parkland	0.0	0.06	8.50	250	0.00	0.0	0
Urban	0.8	1.91	9.97	1,000	1.47	7.7	769
Wetlands	0.0	0.00	0.00	0	0.00	0.0	0
Lakes	0.0	0.00	0.00	0	0.00	0.0	0
Total	11.2				3.93	37.5	1,813.0

Appendix D. Loading calculations (cont'd).

Landuse	Area(ha) 6	Export coefficients(kg/ha/yr) TP	TN	TSS	Loading (kg/yr) TP	TN	TSS
Forest	85.4	0.23	2.86	100	20.1	244.2	8,539
Agriculture	0.0	1.13	16.5	750	0.00	0.0	0
Fields/Parkland	0.0	0.60	8.50	250	0.00	0.0	0
Urban	2.3	1.91	9.97	1,000	4.41	23.0	2,307
Wetlands	0.6	0.00	0.00	0	0.00	0.0	0
Lakes	0.1	0.00	0.00	0	0.00	0.0	0
Total	88.4				24.5	267.2	10,845.8

Landuse	Area(ha) 11	Export coefficients(kg/ha/yr) TP	TN	TSS	Loading (kg/yr) TP	TN	TSS
Forest	5.7	0.23	2.86	100	1.34	16.2	567
Agriculture	0.0	1.13	16.5	750	0.00	0.0	0
Fields/Parkland	0.0	0.60	8.50	250	0.00	0.0	0
Urban	0.8	1.91	9.97	1,000	1.47	7.7	769
Wetlands	0.4	0.00	0.00	0	0.00	0.0	0
Lakes	0.0	0.00	0.00	0	0.00	0.0	0
Total	6.8				2.81	23.9	1,335.5

Appendix D. Loading calculations (cont'd).

Landuse	Area(ha) 10	Export coefficients(kg/ha/yr) TP	TN	TSS	Loading (kg/yr) TP	TN	TSS
Forest	664.5	0.23	2.86	100	156.8	1900.5	66,451
Agriculture	81.3	1.13	16.5	750	92.2	1344.6	61,008
Fields/Parkland	4.6	0.60	8.50	250	2.74	38.9	1,143
Urban	129.3	1.91	9.97	1,000	246.9	1288.7	129,259
Wetlands	79.8	0.00	0.00	0	0.00	0.0	0
Lakes	8.1	0.00	0.00	0	0.00	0.0	0
Total	967.6				498.7	4,572.7	257,861.2

Landuse	Area(ha) 29	Export coefficients(kg/ha/yr) TP	TN	TSS	Loading (kg/yr) TP	TN	TSS
Forest	38.6	0.23	2.86	100	9.12	110.5	3,865
Agriculture	0.2	1.13	16.5	750	0.81	2.7	121
Fields/Parkland	0.3	0.60	8.50	250	0.17	2.4	71
Urban	2.7	1.91	9.97	1,000	5.18	27.0	2,711
Wetlands	2.3	0.00	0.00	0	0.00	0.0	0
Lakes	0.0	0.00	0.00	0	0.00	0.0	0
Total	44.2				14.6	142.7	6,768.5

Appendix D. Loading calculations (cont'd).

	Area(ha)	Export coefficients(kg/ha/yr)			Loading (kg/yr)		
Landuse	Direct	TP	TN	TSS	TP	TN	TSS
Forest	60.7	0.23	2.86	100	14.3	173.6	6,070
Agriculture	1.9	1.13	16.5	750	2.16	31.4	1,427
Fields/Parkland	2.1	0.60	8.50	250	1.29	18.2	536
Urban	21.7	1.91	9.97	1,000	41.4	216.3	21,692
Wetlands	0.3	0.00	0.00	0	0.00	0.0	0
Lakes	2.9	0.00	0.00	0	0.00	0.0	0
Total	89.6				59.2	439.6	29,724.8

Source: NJDEP 1995 Land use/coverage data

APPENDIX E

Ranking of Subwatersheds and

Direct Drainage Area

Appendix E. Ranking of drainage area loadings.

Drainage area	Area (ha)	Loading (kg/yr) TP	TN	TSS	Loading (%) TP	TN	TSS	Assigned point values TP	TN	TSS	Sum	Overall rank
4	11.2	3.93	37.5	1,813	0.65	0.68	0.59	1	2	1	4	1
6	88.4	24.5	267.2	10,846	4.07	4.87	3.52	4	4	4	12	4
11	6.8	2.81	23.9	1,335	0.46	0.44	0.43	2	1	2	5	2
10	967.6	498.7	4572.7	257,861	82.6	83.4	83.6	6	6	6	18	6
29	44.2	14.6	142.7	6,769	2.43	2.60	2.20	3	3	3	9	3
Direct	89.6	59.2	439.6	29,725	9.80	8.02	9.64	5	5	5	15	5
Total	1,207.9	603.8	5483.5	308,349	100.0	100.0	100.0	21	21	21		

Ranking of drainage area with streams:

Drainage area	Overall rank
4	1
6	4
11	2
10	5
29	3

Appendix E. Ranking of drainage area loadings (cont'd).

Drainage area	Area (ha)	Calculated areal loading (kg/ha/yr) TP	TN	TSS	Assigned point values TP	TN	TSS	Sum	Overall rank
4	11.2	0.35	3.35	161.7	3	3	3	9	3
6	88.4	0.28	3.02	122.6	1	1	1	3	1
11	6.8	0.41	3.49	195.2	4	4	4	12	4
10	967.6	0.52	4.73	266.5	5	5	5	15	5
29	44.2	0.33	3.23	153.3	2	2	2	6	2
Direct	89.6	0.66	4.91	331.7	6	6	6	18	6
Total	1,207.9				21	21	21		

Ranking of drainage areas with streams:

Drainage area	Overall rank
4	3
6	1
11	4
10	5
29	2

APPENDIX F

Phosphorus Modeling Results

Appendix F. Phosphorus modeling.

INPUT PARAMETERS

	ft^2		m^2
LAKE SURFACE AREA		5,052,960	469435.345
	ft^3		m^3
LAKE VOLUME		85,900,320	2432422.181
	ft^3		m^3
ANNUAL WATER INFLOW (Q)		308,880,338	8746502.755
	kg		g
P LOAD		604	604000

CALCULATED PARAMETERS

	yr	
RESIDENCE TIME (T)	0.278102259781909	
	1/yr	
FLUSHING RATE (RHO)	3.59579961983844	
	m	
MEAN DEPTH (z)	5.18159147429406	
	g/m^2 yr	
AEREAL P LOAD (L)	1.28665215867386	
	g/m^3	
MEAN ANNUAL INFLOW P CONC.	0.0690561721539852	=LOAD/Q
MEAN ANNUAL INFLOW P CONC (TPi)	0.0690561721539852	=(L*T)/Z
	m/yr	
AREAL WATER LOAD (Qs)	18.6319646534247	= Q/Ao

Predicted In-Lake TP Concentration Using Various Lake Models