AN ASSESSMENT OF SEWER AND WATER SUPPLY ALTERNATIVES FOR PINELANDS GROWTH AREAS IN THE MULLICA RIVER BASIN, CAMDEN COUNTY

STATE OF NEW JERSEY · PINELANDS COMMISSION

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Prepared by the Staff of
the New Jersey Pinelands Commission

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NEW JERSEY PINELANDS COMMISSION
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INTRODUCTION

In February 1987, the Pinelands Commission received notice of the Camden County Municipal Utilities Authority's intention to propose a 208 water quality management plan for Chesilhurst Borough, Waterford Township, and Winslow Township, which was submitted to the Department of Environmental Protection for review and conceptual approval. The proposal recommended the transfer of existing and future sewage flows from Regional Growth Areas located in the three Atlantic Basin municipalities to the Delaware Basin. Information which was subsequently provided to the Commission by the Camden County Municipal Utilities Authority (CCMUA) indicated that the ultimate design flow for this interbasin transfer was 3.6 million gallons per day and 2.75 million gallons per day from the Mullica River Basin and Great Egg Harbor River Basin, respectively.

At the request of the Pinelands Commission staff, the CCMUA prepared an evaluation of the potential effects of the proposed interbasin transfers on local streamflows within the Atlantic Basin. This evaluation addressed water withdrawals under both existing conditions and projected, future conditions. After completing a preliminary review of the data provided by the CCMUA, Commission staff concluded that the interbasin transfer of flows to the Delaware River from the Mullica Basin would result in significant reductions in subbasin recharge. The Commission staff indicated that a more detailed hydrologic assessment of the proposed transfer would be required before the proposal could be given any further consideration.

In early May 1987, Commission staff initiated an assessment of sewer service alternatives for the lower Camden area. The CCMUA subsequently presented its formal plan which was prepared by Speitel Associates and entitled "Atlantic Basin Wastewater Management Plan Amendment (July 1987)." In November 1987, Pinelands Commission staff released a draft report (New Jersey Pinelands Commission, 1987) which summarized the preliminary results of its assessment. Comments on the draft report were received from several agencies. These comments are included in an appendix to the final report which is presented here.

This final report addresses several objectives. Current and future water supply and recharge patterns were estimated, wastewater discharge and water supply scenarios were developed, a basin-wide water quality inventory was completed, streamflows within each subbasin were estimated, the relative habitat quality and environmental sensitivity of each subbasin were compared, and the potential environmental impacts associated with altered streamflows and nutrient loading were assessed. Finally, recommendations on preferred alternatives, including growth management options, were developed.

STUDY AREA

The study area was limited to subbasins of the Mullica River Basin; portions of Camden County located within the Great Egg Harbor River Basin were not addressed (Figure 1). The following subbasins were studied:

A. Mullica River
   Mullica River headwaters
   Alquatka Branch*
   Wesickaman Creek*
   Mullica River and unnamed tributary (Lower Atsion)*

B. Sleeper Branch system
   Hays Mill Branch
   Wildcat Branch
   Cooper Branch
   Clark Branch
   Price Branch
   Gun Branch
   Sleeper Branch, upstream from Rt. 206
   Lower Sleeper Branch, downstream from Rt. 206*

C. Albertson Brook System
   Pump Branch
   Blue Anchor Brook
   Albertson Brook

D. Upper Great Swamp Branch, upstream from Rt. 206

E. Nescochague Creek*

* Secondary study basins; detailed land cover assessments were not completed for these areas. Water quality inventories were not conducted for Gun Branch, Alquatka Branch, or Wesickaman Creek.

The study area includes all of Chesilhurst Borough and Waterford Township, and portions of Winslow Township, Hammonton, Berlin Township, Berlin Borough, Shamong Township, and Evesham Township (Figure 2). Land cover, existing development, water supply, point and nonpoint pollution sources, streamflows and water quality in each of the primary study basins were inventoried. Buildout densities were estimated for all management areas in Chesilhurst Borough, Waterford Township, Winslow Township, Berlin Township, and Berlin Borough. Buildout densities represent the maximum development permitted under current zoning and within the constraints imposed by environmental features of the land.

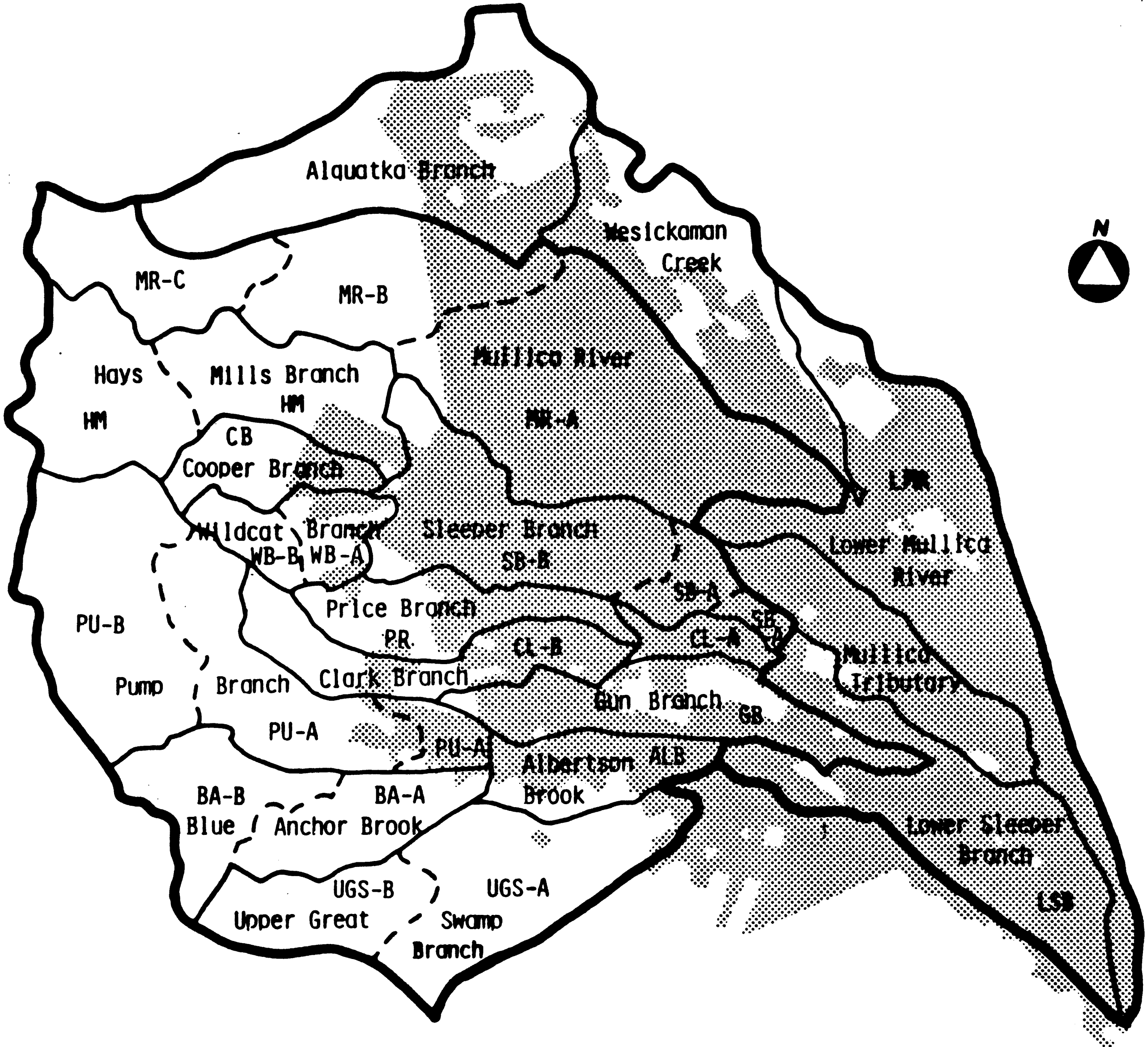

FIGURE 1. STUDY AREA BASINS SHOWING THE RELATIONSHIP OF WHARTON STATE FOREST (shaded area) TO INDIVIDUAL SUBBASINS

1" = 2 miles

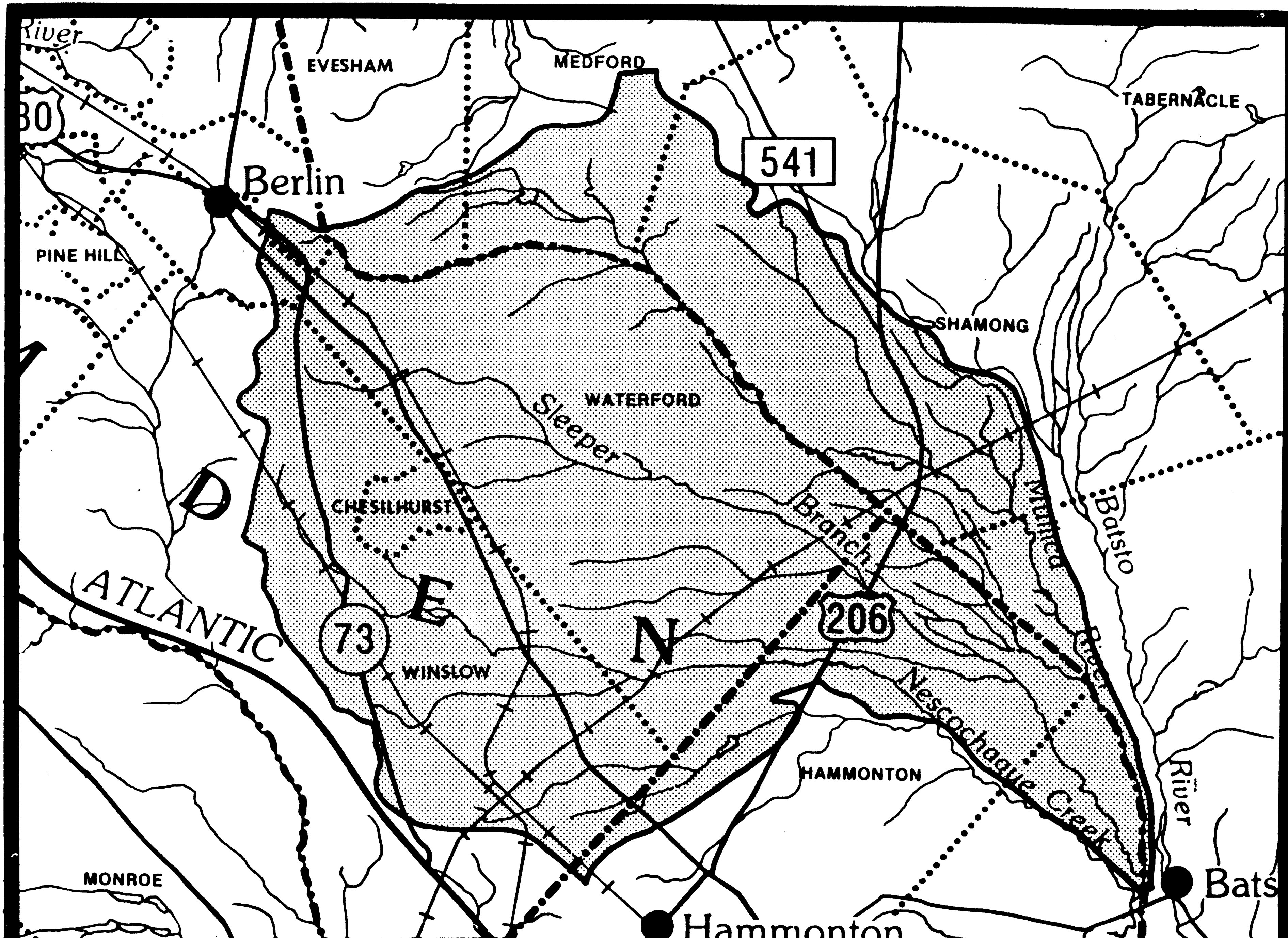

FIGURE 2. STUDY AREA BOUNDARY

EXISTING LAND USE AND LAND COVER

Several land use and land cover features were measured within each subbasin. These included soil drainage classes, the number of residential, commercial, industrial, and other units, developed land, agricultural land, and wetlands. The results of this inventory are presented in this section.

Developed and Agricultural Land

Both development unit density and developed land cover were measured. Development unit density was determined for each subbasin by counting units shown on the most current United States Geological Survey (USGS) 7.5 minute quadrangles (scale of 1:24,000). These data were updated using New Jersey Department of Environmental Protection (NJDEP) March 1986 photoquads (scale of 1:24,000). Non-residential units were identified from these sources when possible. Further classification was accomplished by using geographic tax record information to identify commercial, industrial, and other uses (churches, schools, municipal facilities). Comparisons with tax map data suggest that the unit count should be considered conservative.

Seventy percent of all residential units are found within the Hays Mill Branch, Pump Branch, and Mullica River B & C basins. The respective basin unit counts are 1440 (.30 units/acre, 195 units/sq mi), 1185 (.17 units/acre, 106 units/sq mi), and 1174 (.24 units/acre, 153 units/sq mi). The total units and densities in the mainstream sections of the Albertson Brook and Sleeper Branch systems and Gun Branch are very low. Total unit counts vary in the remaining basins from 160 units in Cooper Branch to 447 units in the Great Swamp Branch basin. Densities in these basins range from .08 units/acre (51 units/sq mi) in Clark Branch to .14 units/acre (91 units/sq mi) in Wildcat Branch. Existing unit counts are given in Table 1.

Developed land and agricultural land cover were mapped at a scale of 1:24,000 using NJDEP March 1986 photoquads. Mapped cover classes included developed land, non-forest land, field and row crop agriculture, and orchards. Selected areas were field checked. The acreage in each class was determined for each subbasin. These data are given in Table 2.

The mainstream segments of the Sleeper Branch system (SB-A and SB-B), Albertson Brook system (ALB), and Clark Branch (CL-A below the confluence of Clark Branch and Price Branch) and the lower reaches of the Mullica River (MR-A) are located within Wharton State Forest. They are among the least developed subbasin units studied. Agricultural land

TABLE 1. EXISTING UNIT COUNT-MULLICA RIVER BASIN

BASIN	SUBBASIN SIZE ACRES	RESIDENTIAL UNITS	COMMERCIAL UNITS	INDUSTRIAL UNITS	OTHER UNITS	RESIDENTIAL DENSITIES NO/ACRE	RESIDENTIAL DENSITIES NO/SQ MI
MULLICA RIVER (B+C)	4915	1174	63	3	76	0.24	153
SLEEPER BRANCH(A+B)	3974	25	0	0	0	0.01	4
HAYS MILLS BRANCH	4730	1440	88	4	6	0.30	195
COOPER BRANCH	1248	160	1	1	4	0.13	82
WILDCAT BRANCH	1440	204	15	0	3	0.14	91
PRICE BRANCH	1850	169	0	0	6	0.09	58
CLARK BRANCH	2707	216	1	0	16	0.08	51
GUN BRANCH	2822	17	0	0	0	0.01	4
BLUE ANCHOR BROOK	3360	425	1	2	1	0.13	81
PUMP BRANCH	7168	1185	34	1	22	0.17	106
ALBERTSON BK (MAIN)	1523	3	0	0	0	.00	1
GREAT SWAMP BRANCH	5165	447	20	2	2	0.09	55
GRAND TOTAL	40902	5465	223	13	136		

TABLE 2A. LAND COVER STATISTICS FOR THE MULLICA RIVER BASIN

SUBBASIN	TOT BASIN ACRES	WHARTON TRACT	PRIVATE LAND	DEVELOPED LAND	ROW/FIELD CROPS	ORCHARDS	NONFOREST	WETLANDS
		LAND COVER-PERCENT OF TOTAL BASIN AREA						
MULLICA-A	5952	95%	5%	1%	0%	0%	0%	8%
MULLICA-B	2854	30%	70%	18%	0%	11%	0%	38%
MULLICA-C	2061	0%	100%	45%	2%	1%	6%	9%
MULLICA-B+C	4915	17%	83%	29%	1%	7%	2%	26%
SLEEPER-A+B	3974	88%	12%	4%	2%	0%	0%	48%
HAYS MILL	4730	8%	92%	33%	6%	0%	1%	16%
WILDCAT-A	659	55%	45%	8%	21%	2%	6%	12%
WILDCAT-B	781	0%	100%	44%	11%	1%	2%	7%
WILDCAT TOTAL	1440	25%	75%	28%	16%	2%	4%	9%
COOPER BRANCH	1248	27%	73%	21%	6%	0%	3%	29%
GUN BRANCH	2822	89%	11%	1%	5%	10%	0%	61%
CLARK A	563	98%	2%	0%	0%	0%	0%	68%
CLARK B	2144	46%	54%	10%	14%	5%	4%	26%
CLARK TOTAL	2707	57%	43%	8%	11%	4%	3%	35%
PRICE BRANCH	1850	54%	46%	12%	17%	6%	2%	21%
PUMP-A	3200	20%	80%	18%	10%	5%	1%	10%
PUMP-B	3968	0%	100%	20%	10%	6%	1%	6%
PUMP TOTAL	7168	9%	91%	20%	10%	6%	1%	8%
BLUE ANCHOR-A	1734	2%	98%	18%	8%	17%	0%	9%
BLUE ANCHOR-B	1926	0%	100%	19%	14%	11%	1%	5%
BL ANCH TOTAL	3360	1%	99%	19%	11%	14%	1%	7%
ALBERTSON	1523	74%	26%	0%	16%	6%	0%	42%
UP GRT SWAMP-A	3354	6%	94%	9%	12%	32%	0%	14%
UP GRT SWAMP-B	1811	0%	100%	13%	9%	2%	3%	11%
UP GRT SWAMP TOTAL	5165	4%	96%	10%	11%	21%	1%	13%

TABLE 2B. LAND COVER STATISTICS FOR THE MULLICA RIVER BASIN. Refer to Wetlands and Transition Area section for definition of hydrologic sensitivity. HDW-hardwood swamp, PPL-pitch pine lowland, CEDAR-Atlantic white cedar swamp, WATER-lakes and ponds.

SUBBASIN	TOT BASIN ACRES	LAND COVER-PERCENT OF TOTAL BASIN AREA					
		HDW	PPL	CEDAR	WATER	BOG	TOT WET
MULLICA-A	5952	4%	4%	0%	0%	0%	8%
MULLICA-B	2854	17%	12%	7%	0%	2%	38%
MULLICA-C	2061	4%	3%	0%	2%	0%	9%
MULLICA-B+C	4915	12%	8%	4%	1%	1%	26%
SLEEPER-A+B	3974	20%	22%	1%	0%	5%	48%
HAYS MILL	4730	8%	6%	0%	1%	0%	16%
WILDCAT-A	659	7%	0%	0%	3%	2%	12%
WILDCAT-B	781	7%	0%	0%	0%	0%	7%
WILDCAT TOTAL	1440	7%	0%	0%	1%	1%	9%
COOPER BRANCH	1248	15%	13%	0%	0%	0%	29%
GUN BRANCH	2822	5%	46%	3%	0%	7%	61%
CLARK A	563	15%	33%	0%	0%	20%	68%
CLARK B	2144	6%	17%	2%	0%	2%	26%
CLARK TOTAL	2707	8%	20%	2%	0%	6%	35%
PRICE BRANCH	1850	9%	12%	0%	0%	0%	21%
PUMP-A	3200	8%	0%	2%	0%	0%	10%
PUMP-B	3968	5%	1%	0%	0%	1%	6%
PUMP TOTAL	7168	6%	0%	1%	0%	0%	8%
BLUE ANCHOR-A	1734	4%	1%	0%	3%	0%	9%
BLUE ANCHOR-B	1926	4%	0%	0%	0%	0%	5%
BL ANCH TOTAL	3360	4%	0%	0%	2%	0%	7%
ALBERTSON	1523	20%	11%	12%	0%	0%	42%
UP GRT SWAMP-A	3354	10%	3%	0%	1%	0%	14%
UP GRT SWAMP-B	1811	9%	1%	0%	2%	0%	11%
UP GRT SWAMP TOTAL	5165	10%	2%	0%	2%	0%	13%

is extensive only in the Albertson Brook basin, representing 22% of the basin area.

Developed land is most extensive in the upper reaches of the Mullica River (MR-C), comprising 45% of this subbasin. The lower subbasin (MR-B), is moderately developed (18%). Agricultural land coverage is low in MR-C (3%) and is moderate in MR-B (11%). Agricultural land in MR-B is totally comprised of blueberry fields.

The Sleeper Branch system includes Hays Mill Branch (HM), Wildcat Branch (WB-A and WB-B), Cooper Branch (CB), Clark Branch (CL), Price Branch (PR), and Gun Branch (GB). Developed land acreage is high in both Hays Mill Branch (33%) and Wildcat Branch (44%), while agricultural land cover is low to moderate. Developed land is concentrated in the upper reaches of both basins. The Waterford Township sewage treatment plant and spray field is located in the lower reaches of the Hays Mill Branch. The lower one third (33%) of the Hays Mill basin is within Wharton State Forest, while 25% of the Wildcat Branch basin (55% of WB-A) is within Wharton.

Cooper Branch is moderately developed (21%), and agricultural acreage is low (6%). As with Hays Mill Branch and Wildcat Branch, developed land is found mainly in the upper reaches of the basin. A portion of the Waterford Township STP spray field is located in this basin. The lower reaches of the basin, comprising about one quarter of the total basin area, extend into Wharton State Forest.

Price Branch is a tributary of Clark Branch. Clark Branch discharges into the Sleeper Branch at Parkdale. The upper reaches of Price Branch are moderately developed. Developed land comprises 12% of the total basin. Agricultural land is relatively extensive (23% of total land area) in the upper reaches of the watershed. More than half (54%) of the basin is within Wharton State Forest. Developed land in the portion of Clark Branch located above the confluence of Price Branch is low to moderate (10%). Agricultural development is moderate (19%). The lower half (46%) of this basin lies within Wharton State Forest. The mainstream of the Clark Branch (CL-A) lies totally within Wharton State Forest.

Gun Branch discharges to Sleeper Branch at a point located east of Route 206. This basin is almost entirely within the boundaries of Wharton State Forest. Only 1% of the land area is developed. Agricultural land comprises 15% of the basin with the majority of this acreage as blueberry fields.

Pump Branch and Blue Anchor Brook are part of the Albertson Brook system. Twenty percent of the Pump Branch basin is developed land, 16% is agricultural land, and 9% is within Wharton State Forest. Development and agriculture are evenly distributed within the lower (PU-A) and upper (PU-B) portions of the basin. Developed land in Blue Anchor Brook comprises 19% of the basin, while agricultural land represents 25% of the total area. As in Pump Branch, developed land and agricultural land is evenly distributed between the lower (BA-A) and upper (BA-B) portions of the basin. Only 1% of the basin lies within Wharton State Forest. The mainstream portion of the Albertson Brook located upstream from Route 206 is undeveloped, but 22% of this portion of the basin is cultivated.

Agriculture is the dominant land use in that portion of the Upper Great Swamp basin located west of Route 206, comprising 32% of the total land area. Most of the agricultural land is located in the lower basin (UGS-A). Forty-four percent of this subbasin is cultivated while only 11% of the upper basin (UGS-A) falls in this land use class. Thirteen percent and 9% of the upper basin and lower basin, respectively, is developed land. A small portion of the lower reaches (4%) is within Wharton State Forest.

EXISTING SEWER SERVICE

Existing sewer service areas in Winslow Township, Waterford Township, and Chesilhurst Borough are described in the Atlantic Basin Wastewater Management Plan Amendment (July 1987) prepared for the CCMUA by Speitel Associates. The existing sewage collection system services approximately 1,200 homes. The service area includes the Ivystone area of Winslow Township and the southwestern portion of Waterford Township, encompassing a square mile area. Sewage collected from these areas is conveyed to the Waterford Township MUA treatment plant.

The Waterford Township MUA sewage treatment plant design capacity is 0.75 mgd, but the present NJDEP permit limits the flow to 0.55 mgd until it can be demonstrated that the plant can meet required groundwater quality limits. The current flow rate is 0.26 mgd. The treated effluent from the plant is disposed of by spray irrigation at an adjacent 82.5 acre spray field located primarily in the Hays Mill Creek basin with a portion of the spray field in the Cooper Branch basin.

There is only one other sewage treatment plant in the study area. Wastewater from the Ancora Psychiatric Hospital facility in Winslow Township is treated on-site and disposed of by spray irrigation. The current flow rate is approximately 0.21 mgd. The spray field is located in the Blue Anchor Brook basin.

All other residential and commercial/industrial uses are serviced by on-site wastewater disposal systems. The majority of wastewater generated in the study area is disposed of on-site, resulting in both within-basin recharge and nutrient loading.

ESTIMATED BUILDOUT

Buildout within sewerable and unsewerable management zones was estimated for the entire study area. Sewerable areas were limited to Regional Growth Areas and Pinelands Villages. Projected residential and commercial/industrial development was estimated for each subbasin using a series of overlay maps showing watershed boundaries, developed land, upland soils, wetland soils, and municipal zoning.

Estimation of Maximum Residential Densities

Maximum future residential densities were estimated for Regional Growth Areas using the following method. First, undeveloped upland (non-wetland) acreage within each zone of a particular subbasin was determined. Land lost to streets was determined in relation to the allowable net density with Pinelands Development Credits (PDC). The sliding scale used is shown in the following chart:

Ranges of PDC Net Density (units/acre)			Undeveloped Upland Deduction for Streets (%)
0	to	.1	2
.1	to	.3	5
.3	to	1.0	8
1.0	to	2.0	12
2.0	to	4.0	20
4.0	to	+	25

The maximum number of units for each management zone was calculated in two ways: 1) PDC gross density x undeveloped acres and 2) PDC net density x undeveloped upland adjusted for streets. The lesser of the two values obtained was used to calculate maximum densities (maximum units/adjusted upland). These densities were further adjusted to account for potential realization.

This adjustment reflects the fact that a portion of the estimated buildout opportunities will not be utilized due to a variety of reasons including fragmented ownership patterns, isolated or poorly situated lots, development at less than maximum densities, etc. It was assumed here that where maximum densities are lower, a higher percentage of the potential may be realized.

Both high and low densities were determined using the following approach. If the maximum density is less than 4 units/acre, the low estimate =.75 x maximum number of units and the high estimate = .90 x maximum number of units. If the maximum density is greater than 4 units/acre, the high estimate = .85 x maximum number of units and the low estimate = .65 x the maximum number of units. With the exception of the use of PDCs, a similar approach was used to estimate buildout units in all other management zones.

Estimation of Commercial and Industrial Development

The following approach was used to estimate commercial and industrial development. Based on municipal zoning limits, the maximum square footage of commercial and industrial development was determined for the entire study area. Next, the ratio of existing jobs to population in Camden County was applied to future population values to estimate future employment. Future employment was translated to square feet of future commercial and industrial development. The square footage projection was then allocated among subbasins according to limits established by municipal zoning within each subbasin.

Buildout Results and Projected Water Supply Demands and Sewage Flows

The results detailing the analysis of buildout, projected water demands, and sewage flows are shown in Table 3. High and low estimates for residential units and commercial and industrial square footage are given for sewerable and nonsewerable areas. Further analysis of water demand and sewage flow are based primarily on the high values.

TABLE 3. FUTURE BUILDOUT ESTIMATES. High and low estimates are given for area population (POP), residential units (RES), and commercial and industrial square footage (C&I FTSQ).

Sub-basin	Sewer Service Cat	Total Area (Acres)	Undeveloped Total	Undeveloped Upland	Pop High Est	Pop Low Est	Res Units High Est	Res Units Low Est	C & I FtSq Allocated High Estimate	C & I FtSq Allocated Low Estimate
** Sewer Service Non-sewer										
ALBERTSON	Non-sewer	402	302	302	80	67	27	23	0	0
BL ANCH-A	Non-sewer	1530	932	756	1976	1608	671	546	0	0
BL ANCH-B	Non-sewer	938	926	853	318	265	108	90	0	0
CLARK BRN	Non-sewer	821	452	406	167	139	57	47	0	0
COOPER BR	Non-sewer	60	60	28	23	19	8	7	0	0
GUN BRANC	Non-sewer	87	102	73	27	23	9	8	0	0
HAYS ML-A	Non-sewer	24	3	3	2	2	1	1	0	0
HAYS ML-B	Non-sewer	1172	576	348	224	187	76	63	0	0
MULLICA-A	Non-sewer	210	112	112	93	77	32	26	0	0
MULLICA-B	Non-sewer	1498	449	296	222	185	75	63	15691	12899
MULLICA-C	Non-sewer	628	249	224	41	34	14	12	382404	314359
PRICE BRN	Non-sewer	651	423	396	112	93	38	32	0	0
PUMP BR-A	Non-sewer	1290	953	820	253	210	86	71	0	0
PUMP BR-B	Non-sewer	520	393	382	308	257	105	87	0	0
SLEEPER-B	Non-sewer	404	196	156	83	69	28	24	0	0
UP-G-SW-A	Non-sewer	2893	1562	1469	414	345	140	117	0	0
UP-G-SW-B	Non-sewer	1560	882	778	1058	869	359	295	0	0
WILDCAT-A	Non-sewer	175	126	117	92	77	31	26	0	0
WILDCAT-B	Non-sewer	40	18	18	15	12	5	4	0	0
** Subtotal **		14903	8716	7537	5509	4539	1871	1541	398095	327258

(Continues)

TABLE 3 CONTINUED. FUTURE BUILDOUT ESTIMATES. High and low estimates are given for area population (POP), residential units (RES), and commercial and industrial square footage (C&I FTSQ).

Sub-basin	Sewer Service Cat	Total Area (Acres)	Undeveloped Total	Undeveloped Upland	Pop High Est	Pop Low Est	Res Units High Est	Res Units Low Est	C & I FtSq Allocated High Estimate	C & I FtSq Allocated Low Estimate
** Sewer Service Sewer										
BL ANCH-A	Sewer	145	7	0	0	0	0	0	0	0
BL ANCH-B	Sewer	544	177	175	424	353	144	120	138316	113704
CLARK BRN	Sewer	275	152	152	606	505	206	172	20922	17199
COOPER BR	Sewer	809	536	359	617	514	210	175	653806	537468
HAYS ML-B	Sewer	2838	1329	1046	8228	6700	2794	2275	1410478	1159498
MULLICA-B	Sewer	239	44	33	241	196	82	67	0	0
MULLICA-C	Sewer	1054	335	305	1250	1017	424	345	444007	365000
PRICE BRN	Sewer	198	38	30	127	106	43	36	0	0
PUMP BR-A	Sewer	1146	464	427	3014	2481	1023	843	0	0
PUMP BR-B	Sewer	3629	2590	2400	13245	10914	4497	3706	189458	155746
UP-G-SW-A	Sewer	95	37	33	140	117	48	40	0	0
UP-G-SW-B	Sewer	115	84	84	356	297	121	101	0	0
WILDCAT-A	Sewer	114	76	76	348	290	118	98	0	0
WILDCAT-B	Sewer	596	175	153	656	547	223	186	221132	181783
** Subtotal **		11797	6044	5273	29253	24037	9933	8162	3078119	2530398
*** Total ***		26700	14760	12810	34762	28577	11804	9703	3476214	2857656

WATER QUALITY ASSESSMENT

The New Jersey Department of Environmental Protection, Division of Water Resources completed a basin-wide water quality sampling program for the Pinelands Commission. This program was conducted to enable the Pinelands Commission to: (1) assess the water quality of all subbasins within the Mullica River study area and (2) determine the relative sensitivity of each stream to changes in nutrient loading and groundwater recharge. Nineteen stations located along eleven streams were sampled for selected water quality parameters during the months of June, July and August, 1987. The location of sampling stations is shown in Figure 3. Parameters included water temperature, pH, specific conductivity, nitrogen (NO_2-N, NO_2+NO_3-N, NH_3-N, and total Kjeldahl-N), phosphorus (total phosphorus as P and Ortho-PO_4 as P), total suspended solids, total dissolved solids, and alkalinity. The results of the monitoring program are presented in Table 4.

Undisturbed Pinelands Streams

Undisturbed Pinelands streams are unusual because of the characteristically low pH and low nutrient values. When compared to streams in other parts of New Jersey and the United States, even degraded Pinelands streams display what is generally considered good water quality. Water quality for Pinelands streams must, therefore, be compared to Pinelands standards, that is, streams which display water quality that is characteristic of undisturbed Pinelands waters. McDonalds Branch in Lebanon State Forest and Oswego River (East Branch of the Wading River) in Penn State Forest provide such benchmarks.

Data collected by the United States Geological Survey and the New Jersey Department of Environmental Protection at stations located along these two streams during the summers of 1984 and 1985 are presented in Table 5. As can be seen from these data, pH values and nutrient concentrations are low. These representative data provide a reference point for assessing the relative water quality of the Mullica River tributaries.

Water Quality Inventory Results

Average dissolved oxygen concentrations recorded within the Mullica Basin are variable, but all are within the range observed for Pinelands streams. The lowest value (2.4 mg/l) was found at the Mullica River at Jackson Road. This may be attributed to the extensive wetland system which drains to the Mullica Basin at a point located just upstream from the sampling station. This suggestion is supported by the high total dissolved solids (TDS) and low pH observed at this

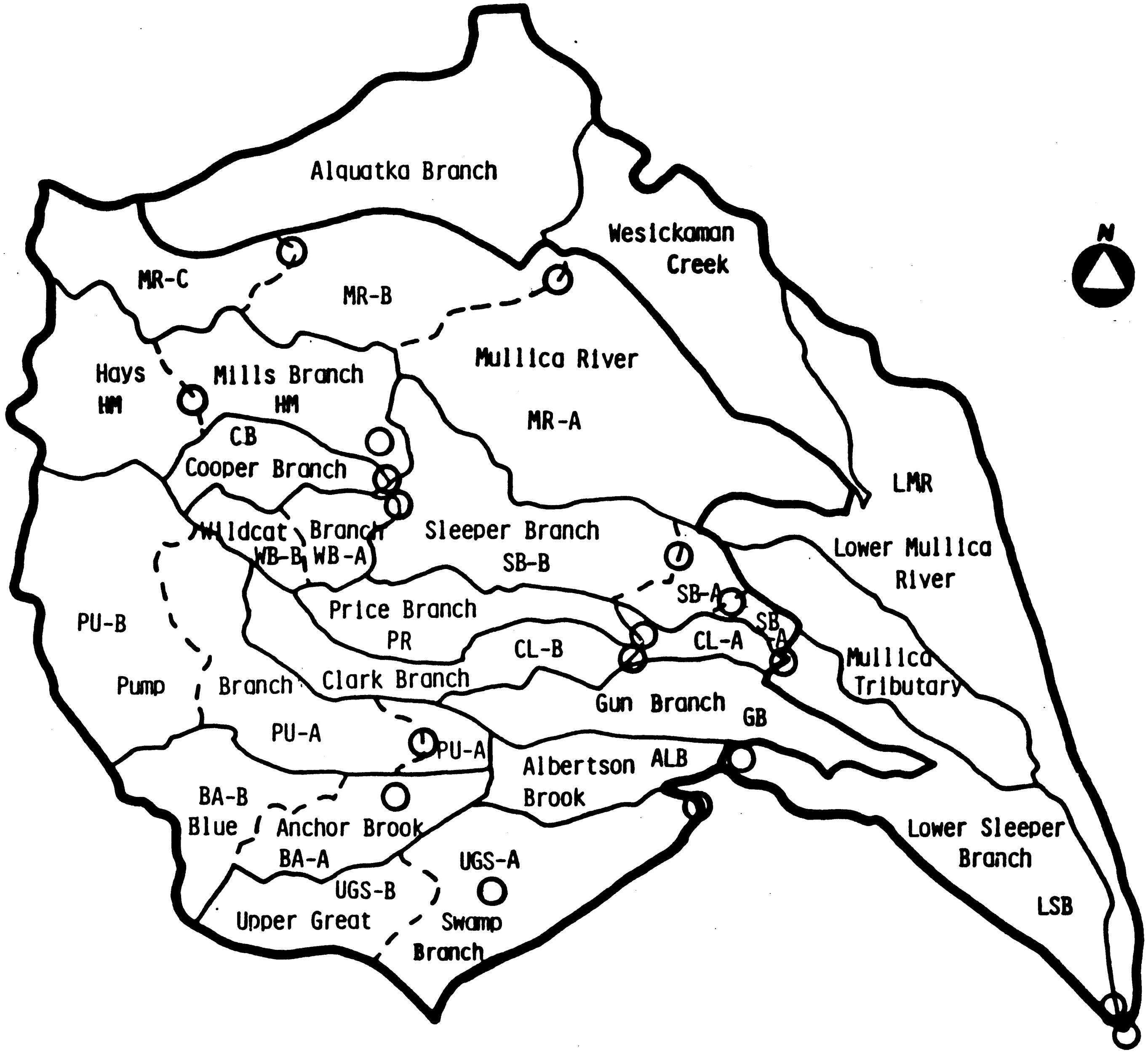

FIGURE 3. LOCATION OF WATER QUALITY MONITORING STATIONS

1" = 2 miles

TABLE 4. RESULTS OF MULLICA RIVER BASIN WATER QUALITY INVENTORY.

AVERAGE VALUES (N=3, JUNE, JULY AND AUGUST 1987)

STREAM	NH3-N mg/l	SD	TK-N mg/l	SD	NO2+NO3 mg/l	SD	TOT P mg/l	SD	ORTHO-P mg/l	SD	ALK mg/l
MULLICA RIVER	0.02	0.04	0.69	0.08	0.13	0.13	0.01	0.01	0.00	0.00	7.7
JACKSON-MEDFORD RD											
MULLICA RIVER	0.11	0.08	1.40	0.35	0.05	0.05	0.06	0.03	0.04	0.05	5.5
JACKSON RD											
MULLICA RIVER	0.08	0.09	0.94	0.09	0.15	0.04	0.48	0.78	0.02	0.02	2.3
PLEASANT MILLS											
SLEEPER BRANCH	0.05	0.05	0.63	0.10	0.62	0.07	.00	.00	.00	0.01	4.3
DIVERSION CHANNEL											
SLEEPER BRANCH	0.02	0.03	0.60	0.08	0.59	0.05	0.00	0.00	.00	0.01	3.7
PARKDALE											
SLEEPER BRANCH/	0.10	0.09	1.09	0.15	0.03	0.05	0.06	0.02	0.03	0.01	--
MULLICA CONFLUENCE											
HAYS MILL CK	0.05	0.05	0.74	0.07	0.94	0.01	0.02	0.01	.00	0.01	6.3
BELOW STP											
HAYS MILL CREEK	0.03	0.06	0.70	0.07	0.36	0.16	0.02	0.01	0.00	0.00	8.7
ABOVE STP											
COOPER BRANCH	0.08	0.09	0.73	0.15	0.22	0.09	.00	0.01	0.00	0.00	2.0
WILDCAT BRANCH	0.07	0.06	0.71	0.07	0.18	0.13	0.02	.00	0.00	0.00	7.0
PRICE BRANCH (N=2)	0.05	0.06	1.04	0.03	0.05	0.06	0.03	0.01	0.00	0.00	7.5
NO AUGUST SAMPLE											
CLARK BRANCH	0.03	0.06	0.78	0.20	0.02	0.03	0.01	0.02	.00	0.01	0.3
CONFLUENCE/PRICE											
CLARK BRANCH	0.05	0.06	0.83	0.09	0.00	0.00	0.01	0.01	.00	0.01	0.3
ALBERTSON	0.03	0.06	0.71	0.16	0.38	0.05	0.04	0.01	0.01	0.01	7.0
ABOVE PARADISE LK											
PUMP BRANCH	0.03	0.05	0.53	0.20	0.21	0.08	0.01	0.02	0.01	0.01	11.3
BLUE ANCHOR	0.02	0.03	1.58	0.55	0.02	0.03	0.10	0.02	0.02	0.02	11.3
GREAT SWAMP BR	0.32	0.23	1.11	0.06	0.15	0.13	0.08	0.04	0.01	0.02	15.3
WALKER RD											
GREAT SWAMP BR	0.05	0.09	0.65	0.15	2.58	0.63	0.02	0.02	0.01	0.01	7.0
MIDDLE RD											
NESCHOCHAQUE	0.02	0.03	0.68	0.16	0.31	0.04	0.05	0.03	0.01	0.01	4.7

TABLE 4 CONTINUED. RESULTS OF MULLICA RIVER BASIN WATER QUALITY INVENTORY

AVERAGE VALUES (N=3, JUNE, JULY AND AUGUST 1987)

STREAM	TEMP- °C	SD	SP COND m-mhoms	SD	D.O. mg/l	SD	MEDIAN pH	TSS mg/l	TDS mg/l
MULLICA RIVER JACKSON-MEDFORD RD	30.3	1.15	81.5	9.41	8.2	0.38	7.25	16.0	62.0
MULLICA RIVER JACKSON RD	23.0	2.29	59.5	15.02	2.4	0.78	4.84	59.7	185.3
MULLICA RIVER PLEASANT MILLS	23.5	1.73	39.9	0.59	7.2	0.35	6.40	12.7	80.3
SLEEPER BRANCH DIVERSION CHANNEL	19.7	0.46	45.7	5.34	7.5	0.36	6.35	3.0	42.3
SLEEPER BRANCH PARKDALE	20.2	1.04	41.4	11.75	7.7	0.44	6.02	5.0	46.7
SLEEPER BRANCH/ MULLICA CONFLUENCE	23.0	1.50	51.5	2.75	5.5	0.60	4.30	11.3	105.3
HAYS MILL CK BELOW STP	19.5	0.50	66.5	4.62	7.7	0.42	6.30	3.0	61.0
HAYS MILL CREEK ABOVE STP	28.2	0.29	75.2	4.23	7.4	0.52	7.00	3.0	54.0
COOPER BRANCH	22.8	0.29	37.2	2.76	4.6	1.01	4.75	8.3	34.0
WILDCAT BRANCH	27.2	0.76	49.2	0.70	6.1	0.10	7.03	1.3	31.0
PRICE BRANCH (N=2) NO AUGUST SAMPLE	13.3	11.56	58.8	2.76	3.6	1.24	5.56-5.83	4.0	76.5
CLARK BRANCH CONFLUENCE/PRICE	20.4	1.04	46.3	7.49	4.4	2.84	4.69	3.3	51.7
CLARK BRANCH	21.2	2.57	50.3	1.96	4.7	1.31	4.43-5.20	5.0	60.0
ALBERTSON ABOVE PARADISE LK	23.3	2.08	54.1	3.09	7.2	0.32	6.70	11.7	64.7
PUMP BRANCH	26.7	2.75	61.8	1.13	3.8	0.60	6.31	4.0	57.0
BLUE ANCHOR	30.3	1.61	59.8	8.95	10.2	1.15	9.11	19.0	63.7
GREAT SWAMP BR WALKER RD	29.5	2.18	101.3	9.76	8.0	1.80	6.87	15.0	82.3
GREAT SWAMP BR MIDDLE RD	20.8	1.15	105.9	10.73	6.4	0.79	6.24	6.3	73.7
NESCHOCHAQUE	22.2	1.89	53.1	2.29	7.4	0.26	6.46	7.7	73.0

TABLE 5. WATER QUALITY OF TWO UNDISTURBED PINELANDS STREAMS: McDonalds Branch in Lebanon State Forest and Oswego River in Penn State Forest.

STREAM	RANGE OF VALUES							
	SP COND umhos	D.O. mg/l	pH mg/l	NH3-N mg/l	TKN mg/l	NO2+NO3-N mg/l	TOT P mg/l	ORTHO-PO4 mg/l
MCDONALDS BRANCH 1984 (a)	39-62	1.7-7.0	4.0-4.4	<.010-.050	<.10-1.2	<.10	<.010	<.010
MCDONALDS BRANCH 1985 (b)	23-30	3.1-3.9	4.4-4.5	<.010-.010	<.10-.2	<.10-.12	<.010-.030	<.010
OSWEGO RIVER 1984 (c)	39-50	7.7-9.4	4.0-4.2	<.050-.130	.45-49	<.05	.030-.060	
OSWEGO RIVER 1985 (d)	36-37 (e)	8.0-8.9	3.8-5.0	.070-.160	.28-.37	<.05	<.020-.080	

(a) N=3: MAY, JUNE AND JULY SAMPLES
(b) N=3: JUNE, JULY AND AUGUST SAMPLES
(c) N=3: MAY, JULY AND AUGUST SAMPLES
(d) N=3: MAY, JULY AND AUGUST SAMPLES
(e) N=2: NO JULY SAMPLE
(f) N=2: NO JULY SAMPLE

station. The high mean TDS value reported for the Sleeper Branch at its confluence with the Mullica River may also be related to the extensive wetland systems located upstream from that station.

With the exception of the Mullica River at Pleasant Mills, total phosphorus and orthophosphate concentrations are relatively low in all streams. Low phosphorus concentrations are typical of both disturbed and undisturbed streams in the Pinelands, although the mechanisms responsible for maintaining these low levels are not clearly understood. One high total phosphorus value (1.38 mg/l) recorded in July is responsible for the high mean value reported for the Mullica River at Pleasantville; the June and August values (0.05 mg/l and 0.02 mg/l, respectively) are within the typically low range observed for this parameter.

The most obvious differences among the streams studied are the nitrite+nitrate-nitrogen concentrations (nitrite comprises a minor component of this parameter) and pH values. Nitrate-nitrogen and pH are the two water quality parameters which are generally most useful in distinguishing between disturbed and undisturbed streams.

Most of the streams sampled were characterized by relatively high median pH values. Only five stations displayed what can be considered typical Pinelands pH. The following ranking lists each stream station in order of increasing disturbance based on median pH.

UNDISTURBED STREAMS - pH

1. Sleeper Branch/Mullica River, 4.30
2. Clark Branch, 4.45-4.52
3. Clark Branch, mainstream, 4.69
4. Cooper Branch, 4.75
5. Mullica River, Jackson Rd, 4.84

DISTURBED STREAMS - pH

6. Price Branch, 5.56-5.83
7. Sleeper Branch, Parkdale, 6.02
8. Great Swamp, Middle Rd, 6.24
9. Hays Mill Creek, Tremont Ave, 6.30
10. Pump Branch, Rt 30, 6.31 (LAKE OUTLET)
11. Sleeper Branch, Diversion, 6.35
12. Mullica River, Pleasant Mills, 6.4
13. Nescochague, Pleasant Mills, 6.46
14. Albertson Brook, below Rt 206, 6.70
15. Great Swamp Branch, Walker Rd, 6.87 (LAKE OUTLET)
16. Hays Mills, Rt 30, 7.00 (LAKE OUTLET)
17. Wildcat Branch, 7.03 (LAKE OUTLET)

18. Mullica River, Medford-Jackson Rd, 7.25 (LAKE OUTLET)
19. Blue Anchor Brook, Rt 30, 9.11 (LAKE OUTLET)

A similar ranking can be developed using nitrite+nitrate-nitrogen as an indicator of disturbance. Only four streams displayed NO2+NO3-N concentrations which are typical of undisturbed streams. The remaining streams ranged from moderately disturbed to disturbed.

UNDISTURBED STREAMS - NO2+NO3-N Concentration (mg/l)

1. Clark Branch, 0.00
2. Clark Branch, mainstream 0.02
3. Blue Anchor, 0.02* (see narrative)
4. Sleeper Branch/Mullica River, 0.05
5. Price Branch, 0.05
6. Mullica River, Jackson Rd, 0.05

MODERATELY DISTURBED STREAMS - NO2+NO3-N Concentration (mg/l)

7. Mullica River, Jackson-Medford Rd, 0.13
8. Mullica River, Pleasant Mills, 0.15
9. Great Swamp, Walker Rd, 0.15
10. Wildcat Branch, 0.18
11. Pump Branch, 0.21
12. Cooper Branch, 0.22

DISTURBED STREAMS - NO2+NO3-N Concentration (mg/l)

13. Nescochague Creek, Pleasant Mills, 0.31
14. Hays Mill Creek, 0.36
15. Albertson Brook, 0.38
16. Sleeper Branch, Parkdale, 0.59
17. Sleeper Branch, Diversion, 0.62
18. Hays Mill Creek, Tremont Ave, 0.94
19. Great Swamp Branch, Middle Rd, 2.58

Sleeper Branch at its confluence with the Mullica River exhibits low pH and low nitrite+nitrate-nitrogen values. Clark Branch and Mullica River at Jackson Road show similar water quality characteristics. Although water quality in upstream reaches of both the Sleeper Branch and Mullica River reflect some degree of disturbance, the stations sampled receive flow from large, undisturbed drainage areas. The Sleeper Branch/Mullica confluence is located well within Wharton State Forest, and Alquatka Branch, a drainage comprised mainly of wetland and cranberry bog, represents more than half of the 10,752 acre basin which discharges to the Mullica River at Jackson Road station. The Mullica River at Medford-Jackson Road station is located upstream from the Jackson Road Station. Samples were taken at the outflow of a lake. There, the mean nitrite+nitrate-nitrogen concentration is somewhat elevated (0.13 mg/l) and the median pH (7.25) is quite high for a Pinelands stream. The elevated pH is probably related in some degree to biological activity in the lake. Such a high value would not be realized in an undisturbed Pinelands stream.

Although headwater areas of Clark Branch are moderately developed, a large area of Wharton State Forest lies upstream from the sampling stations at Burnt Mill Road and at Parkdale. Price Branch, which is a tributary of the mainstream of Clark Branch, displays nitrite+nitrate-nitrogen values that are characteristic of undisturbed streams, but pH values are elevated.

The mean nitrite+nitrate-nitrogen value given for Blue Anchor Brook at Rt 30 suggests that this stream is undisturbed. However, the median pH of this stream is the highest reported for all streams studied. The Blue Anchor Brook sampling station is located at the outflow of a lake. The low nitrite+nitrate-nitrogen levels may be due to high algal productivity during the summer months. This suggestion is supported by the high pH and total suspended solids levels and the highest mean dissolved oxygen and total kjeldahl nitrogen concentrations reported for all streams. Additionally, the water samples were green in color, a feature that is atypical of Pinelands streams. These factors are generally associated with high algal productivity, a characteristic that is more typical of disturbed Pinelands streams.

The Pump Branch and Blue Anchor Brook converge to form Albertson Brook. This stream was sampled downstream from Route 206 within Wharton State Forest. The mean nitrite+nitrate-nitrogen was 0.38 mg/l, while the median pH was 6.70. Both values are relatively high for Pinelands streams. Although no definite conclusions can be drawn, the observed degradation may be associated with agricultural activity within the basin.

The median pH value for Cooper Branch indicates that this stream is undisturbed, however, nitrite+nitrate-nitrogen values are moderately elevated. Both Pump Branch and Wildcat Branch have moderately elevated nitrite+nitrate-nitrogen levels, but pH values are typical of disturbed streams. The sampling stations for these two streams were located downstream from lakes, and the high pH values may be due in part to lake productivity.

Hays Mills Branch, Cooper Branch, and Wildcat Branch are three tributaries of the Sleeper Branch. The Sleeper Branch can be considered pristine at its confluence with the Mullica River, deep within the interior of Wharton State Forest. However, the upper reaches of this stream are disturbed. Two Sleeper Branch stations, located below the confluence of the three tributaries, were monitored. Both are within the borders of Wharton State Forest and are situated west of Route 206. Mean nitrite+nitrate-nitrogen values recorded at the diversion on Burnt House Road and at Parkdale were 0.62 and 0.59 mg/l, respectively, while respective median pH values were 6.35 and 6.02. These relatively degraded conditions are probably best associated with water discharging from Hays Mill Creek, the larger of the three Sleeper Branch tributaries.

Two stations were established along Hays Mill Creek. The first was located downstream from Atco Lake, on the eastern side of Route 30. The median pH was 7.0, while the mean nitrite+nitrate-nitrogen concentration was 0.36 mg/l. The second station is downstream from the Waterford Township STP and spray field. There, the median pH decreases to 6.30 (probably due to the distance from the lake), but the mean nitrite+nitrate-nitrogen concentration increases to 0.94 mg/l. Although no definite conclusion can be drawn, this three-fold increase in nitrite+nitrate-nitrogen could be associated with the STP discharge.

The mean nitrite+nitrate-nitrogen value reported for Great Swamp Branch at Walker Road is moderately high (0.15 mg/l), and the median pH (6.87) suggests degraded water quality conditions. Like other lake outflow monitoring stations, the high pH value may reflect the effect of biological conditions in the lake. The highest mean NH_3-N concentration in this study was reported for this station. This may be related to wastewater disposal lagoons located upgradient from the sampling station. These lagoons were used until recently for the disposal of wastewaters containing ammonium sulfate.

The highest nitrogen values measured during this study were found at a downstream Great Swamp Branch station, located at Middle Road directly downstream from Route 206. The mean nitrite+nitrate-nitrogen value was 2.58 mg/l which represents extremely degraded conditions. The median pH was 6.24. The high nitrogen values may be related to the extensive agricultural activity occurring between the Walker Road and Middle Road stations.

The Mullica River and Nescochague Creek (above its confluence with the Mullica River) were monitored at Pleasant Mills near Batsto. These two rivers represents the two major streams sampled in this study. Mean nitrite+ nitrate-nitrogen (0.31 mg/l) and the median pH value (6.46) reported for the Nescochague Creek were high. Although the mainstream of this river is within Wharton State Forest, its major tributaries include Albertson Brook, Great Swamp Branch, and several smaller tributaries draining the Hammonton area. The degraded conditions found in these tributaries is, therefore, reflected in Nescochague Creek.

Moderately elevated nitrite+nitrate-nitrogen values were also recorded at the Mullica River at Pleasant Mills (mean=0.15 mg/l), along with high pH (median=6.4). The discharge from Nescochague Creek may be partially responsible for these elevated levels.

WETLANDS AND TRANSITIONAL AREAS

Wetland habitats are especially sensitive to changes in water levels and water quality. These habitats are generally associated with soils exhibiting a seasonally high depth to the water table of between 0-1.5 ft from the land surface. Transitional habitats occur in the area between wetlands and uplands, occupying a continuum ranging from hydric to xeric conditions. The water table along this gradient ranges in depth from 1.5-5 ft from the land surface. The roots of plants found in the transition may be in direct contact with the water table; consequently these communities may also be affected by changes in water level.

An estimate of the area of wetland and transitional habitats in the study area can provide a measure of the relative sensitivity of each basin to hydrologic impacts, especially changes in water table level associated with water supply development. Using 1:24,000 scale soil maps, the acreage of wetland (0-1.5 ft), transitional (1.5-5 ft), and upland (greater than 5 ft) soils was determined for each basin. The acreage of pitch pine lowland, hardwood swamp, cedar swamp, bog, and open water was determined from Pinelands Commission vegetation maps. The results obtained are presented as percent of total basin area in Table 2.

Three direct measures of hydrologic sensitivity are given in Table 2: 1) wetland soils; 2) transitional soils; and 3) wetland vegetation type. The fourth column provides an average measure of hydrologic sensitivity which combines the effect of the three measured variables. This percentage represents the mean of wetland soils, wetland plus transitional soils, and wetlands vegetation percent cover values. These values have been placed in four percent cover classes, 0-15%, 16-25%, 26-50%, and 51-100%, representing increasing relative hydrologic sensitivity.

Class I (most sensitive, 51-100%): Clark Branch A, Gun Branch, Sleeper Branch A+B, Mullica B

Class II: Cooper Branch, Albertson, Clark A+B, Mullica B+C, Clark B, Upper Great Swamp A

Class III: Upper Great Swamp A+B, Price Branch, Upper Great Swamp B, Hays Mill Branch

Class IV (least sensitive, 0-15%): Pump A, Wildcat Branch A, Mullica River C, Blue Anchor Brook A, Pump Branch A+B, Blue Anchor Brook A+B, Wildcat Branch A+B, Blue Anchor Brook B, Wildcat Branch B, Pump Branch B

THREATENED AND ENDANGERED SPECIES

Information on the occurrence of threatened and endangered plant and animal species in the study area was obtained from the New Jersey Natural Heritage Program. The complete data set and a description of the precision assigned to each species occurrence can be obtained from the Pinelands Commission upon request.

Occurrence data are summarized in Table 6. No attempt was made to weight the data using geographic precision criteria or to rank species. The number of occurrences for both the entire period of record and for recent (since 1970) records are given for each species. Fifteen plant species and four animal species designated as endangered by the Pinelands Commission have been reported as occurring within the study area. All but one of the plant species-Pickerings morning glory (Brewaria pickeringii)-are found in wetland or transitional habitats. Pine Barrens treefrog (Hyla andersonii) and tiger salamander (Ambystoma tigrinum) are dependent on wetlands for breeding.

As can be seen in Table 6, the majority of the records predate 1970. Only historical records exist for four plant species, Cleistes divaricata, Coreopsis rosea, Helonias bullata, and Platantherea integra. The one tiger salamander record dates from 1900. Historical records are important because they indicate that a species may still occur within an area. Many old stations have been reconfirmed. Recent records, however, provide more conclusive evidence on the present distribution of a species.

Endangered species have been reported from all subbasins within the study area with the exception of Wildcat Branch. For the period of record, the greatest number of species and species occurrences have been reported from the Lower Mullica River, Nescochague Creek, and Lower Sleeper Branch. The total number of species and species occurrences in the remaining basins ranges from two to eight and from two to ten, respectively.

Recent endangered plant occurrences have been reported from only eleven subbasin units. These are, in order of importance (ranked according to the number of species and species occurrences): Lower Mullica River; Sleeper Branch (upper), Clark Branch-A; Mullica River-A=Lower Sleeper Branch=Gun Branch=Clark Branch-B; Nescochague Creek; Pump Branch-A=Upper Great Swamp-A=Upper Great Swamp-B.

Pine Barrens treefrog have recently been reported from eight subbasins: Mullica River-A; Lower Mullica River; Sleeper Branch (upper); Lower Sleeper Branch; Clark Branch-A; Albertson Brook; Upper Great Swamp-B; and Nescochague Creek.

TABLE 6. THREATENED AND ENDANGERED SPECIES OF THE MULLICA RIVER BASIN (SOURCE: NJ NATURAL HERITAGE PROGRAM, TRENTON, NJ). The total number of period of record occurrences (T) for all species is given for each subbasin along with the total number of occurences (R) for the period 1970-1987. Subbasin symbols are keyed to Figure 1.

SPECIES	SUBBASIN																			
	LM-R		MR-A		MR-B		MR-C		SLB		LSB		HM		CB		GB		WB	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
PLANTS																				
BREWARIA PICKERINGII VAR. CAESARIENSE	3	1									2	0								
CALAMOVILFA BREVIPILIS	4	2			1	0	1	0	1	1	2	0					1	1		
CAREX BARRATTII	5	5	1	1									2	0	1	0	1	0		
CLEISTES DIVARICATA	2	0																		
COREOPSIS ROSEA													1	0						
EUPATORIUM RESINOSUM	6	1							1	1	2	0	1	0	1	0	1	0		
GENTIANA AUTUMNALIS	5	2							1	1	2	0	1	0			1	1		
HELONIAS BULLATA	1	0			1	0	2	0					1	0						
JUNCUS CAESARIENSIS	8	5	1	1							1	0	1	0	1	0				
MUHLENBERGIA TORREYANA	9	6							2	2	3	1					1	1		
NARTHECIUM AMERICANUM	10	6									3	1								
PLATANTHERA INTEGRA	1	0									1	0								
RHYNCOSPORA KNIESKERNII	4	1	2	0					1	0	2	0					1	0		
SCHWALBEA AMERICANA	1	0	1	0					1	0			1	0			1	0		
SCIRPUS LONGII	5	1	1	1	1	0			1	1	1	1					1	0		
ANIMALS																				
HYLA ANDERSONII	2	2	2	2					2	2	3	3								
PITUOPHIS MELANOLEUCUS	5	5	2	2					1	1	1	1	2	1						
MELANERPES ERYTHROCEPHALUS	1	1									1	1								
AMBYSTOMA TIGRINUM																				
SUMMARY																				
TOTAL NO PLANT SPECIES	14	10	5	3	3	0	2	0	7	5	10	3	7	0	3	0	8	3	0	0
TOTAL PLANT OCCURRENCES	64	30	6	3	3	0	3	0	8	6	19	3	8	0	3	0	8	3	0	0
TOTAL NO ANIMAL SPECIES	3	3	2	2	0	0	0	0	2	2	3	3	1	1	0	0	0	0	0	0
TOTAL ANIMAL OCCURRENCES	8	8	4	4	0	0	0	0	3	3	5	5	2	1	0	0	0	0	0	0

TABLE 6 CONTINUED. THREATENED AND ENDANGERED SPECIES OF THE MULLICA RIVER BASIN (SOURCE: NJ NATURAL HERITAGE PROGRAM, TRENTON, NJ). The total number of period of record occurrences (T) for all species is given for each subbasin along with the total number of occurences (R) for the period 1970-1987. Subbasin symbols are keyed to Figure 1.

SPECIES	SUBBASIN																					
	PR		CL-B		CL-A		PU-A		PU-B		BA-A		BA-B		ALB		UGS-A		UGS-B		MESC	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
PLANTS																						
BREWARIA PICKERINGII VAR. CAESARIENSE																					3	0
CALAMOVILFA BREVIPILIS			1	1	1	1															1	0
CAREX BARRATTII	1	0	2	0	1	0	2	0	2	0	1	0	1	0	2	0	1	0	2	1	1	0
CLEISTES DIVARICATA																						
COREOPSIS ROSEA									1	0												
EUPATORIUM RESINOSUM	1	0	2	0	1	1	3	1			1	0	1	0	1	0	1	0			3	0
GENTIANA AUTUMNALIS			1	1	1	1											1	1			4	1
HELONIAS BULLATA							2	0	1	0												
JUNCUS CAESARIENSIS																					1	0
MUHLENBERGIA TORREYANA			2	1	1	1	1	0			1	0	1	0							2	0
NARTHECIUM AMERICANUM																					1	0
PLATANTHERA INTEGRA																					1	0
RHYNCOSPORA KNIESKERNII					1	0															2	0
SCHWALBEA AMERICANA			1	0	1	0			1	0	1	0					2	0	1	0		
SCIRPUS LONGII			1	0	1	1									1	0	1	0	2	0	10	1
ANIMALS																						
HYLA ANDERSONII					1	1									2	2			2	2	3	3
PITUOPHIS MELANOLEUCUS					1	1			1	0												
MELANERPES ERYTHROCEPHALUS																					1	1
AMBYSTOMA TIGRINUM																					1	0
SUMMARY																						
TOTAL NO PLANT SPECIES	2	0	7	3	8	5	4	1	4	0	4	0	3	0	3	0	5	1	3	1	11	2
TOTAL PLANT OCCURRENCES	2	0	10	3	8	5	8	1	5	0	4	0	3	0	4	0	6	1	5	1	29	2
TOTAL NO ANIMAL SPECIES	0	0	0	0	2	2	0	0	1	0	0	0	0	0	1	1	0	0	1	1	3	2
TOTAL ANIMAL OCCURRENCES	0	0	0	0	2	2	0	0	1	0	0	0	0	0	2	2	0	0	2	2	4	4

ESTIMATES OF STREAM FLOW CHARACTERISTICS

Estimates of stream flow characteristics in the study area are necessary in order to develop water budgets for each subbasin. The water budgets permit an assessment of alternative water supply and sewage treatment and disposal scenarios on streamflow characteristics.

Definitions

The following terms and their definitions are used in this section to describe streamflow characteristics:

AVERAGE ANNUAL FLOW:	The average of all mean daily discharges, in cubic feet per second (CFS).
7-DAY, 2 YEAR LOW FLOW:	The minimum 7-day average flow occurring with a recurrence interval of 2 years, in CFS.
7-DAY, 10 YEAR LOW FLOW:	The minimum 7-day average flow occurring with a recurrence interval of 10 years, in CFS.

Available Data

The approach employed to estimate streamflow characteristics used existing data as much as possible. The stream locations under consideration in the study area fall into three categories of existing streamflow data availability:

1. streams with continuous gaging stations
2. partial record stations
3. ungaged stream locations

The only continuous gaging station in the study area is located at the Mullica River near Batsto (U.S.G.S. Station 01409400). Low-flow characteristics for this station have been estimated by statistical analysis of a continuous 16-year period of record which were published by the U.S. Geological Survey (Gillespie and Schopp, 1982). Data for three other continuous gaging stations located outside the study area were useful in estimating flow within the study area using methods described below. These stations are Batsto River at Batsto (01409500), Great Egg Harbor River at Folsom (01411000), and Oswego River at Harrisville (01410000).

Ten partial record stations are located within the study area. A number of instantaneous measurements have been made by the U.S. Geological Survey at these locations under base-flow conditions over the course of several years. The U.S. Geological Survey published low-flow characteristics for these stations based on data collected through the late 1970's (Gillespie and Schopp, 1982). Additional streamflow measurements have been made at partial record stations. All these data are on computer file at the U.S.G.S.

Flow in the remaining locations under consideration has not been measured by the U.S.G.S. Zimmer (1979) measured flow at some otherwise ungaged locations within the study area. The New Jersey Department of Environmental Protection, Bureau of Monitoring Management, measured flow at selected ungaged locations at the request of the Pinelands Commission on three occasions during the summer of 1987. Locations for which flow characteristics are estimated are shown in Figure 4.

Continuous Gaging Station

Low-flow characteristics for the Mullica River near Batsto have been previously determined by the U.S.G.S. using a computer program which analyzed an entire continuous flow record of sixteen years. Annual minimum average flows of various durations were selected, and a log-Pearson Type III probability distribution was fit to describe the frequency of "non-exceedance" of these flows (the probability that a given flow would not be exceeded during a seven-day period of a given year). The resulting low-flow frequency curve was used to estimate various low-flow characteristics, including the 7-day, 2-year low flow and the 7-day, 10 year low flow (Gillespie and Schopp, 1982). Average annual flow was determined from the average of daily average flow values for the period of record. Among the stream locations under consideration in the study area, the estimates of flow characteristics for this station are the most reliable, owing to the relatively large amount of available flow data.

Partial Record Stations

Published low-flow characteristics for the ten partial record stations under consideration were estimated using data collected through the late 1970's. To obtain the best possible estimates of flow characteristics, the estimates were updated, using a similar methodology, by incorporating additional data collected by the U.S. Geological Survey through September, 1986. The staff of the New Jersey District of the U.S. Geological Survey provided advice and arranged for repeated runs of the regression computer program.

The methodology used takes advantage of both the large amount of data collected at continuous gaging stations near

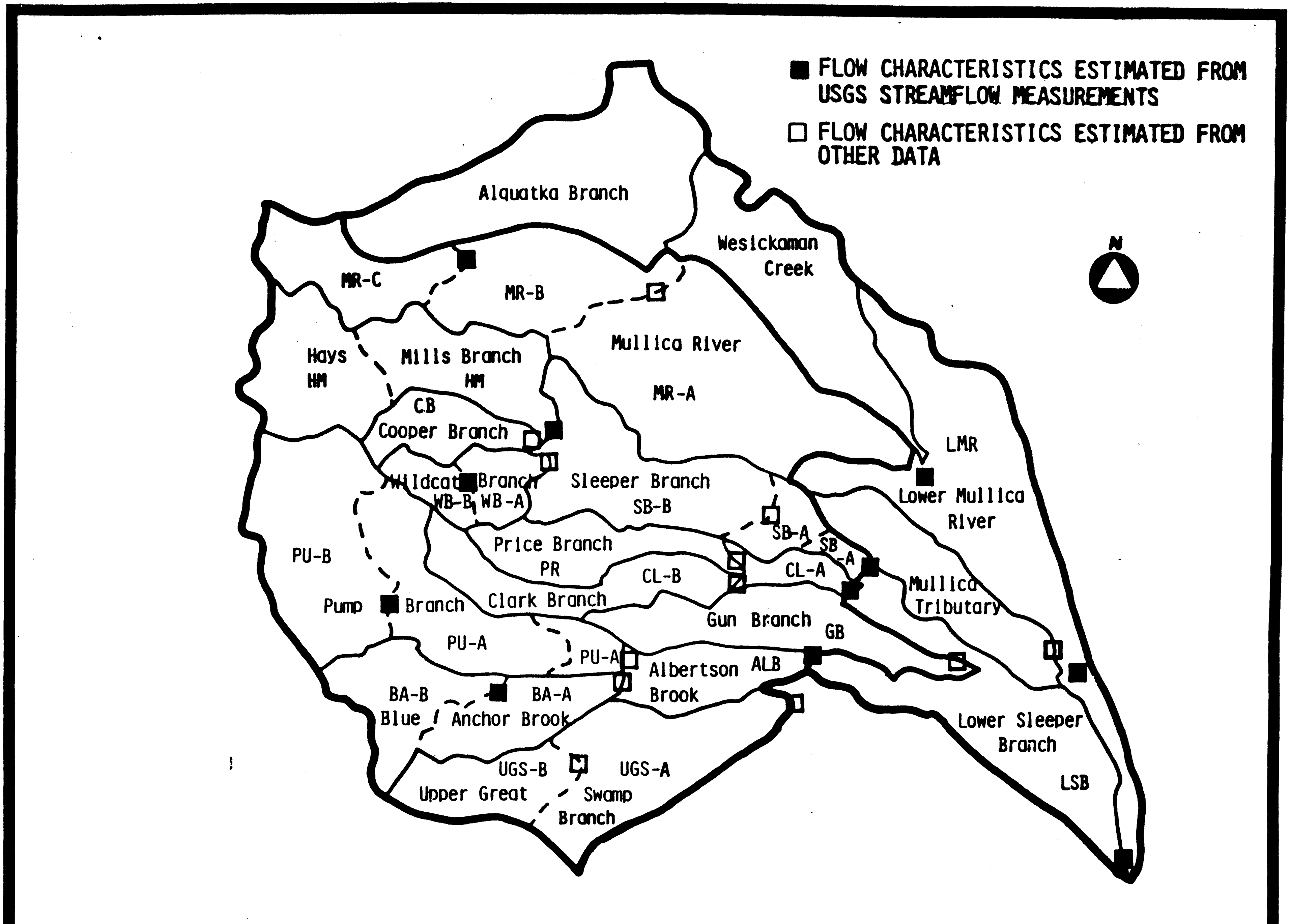

FIGURE 4. LOCATION OF STREAM FLOW ESTIMATION POINTS

1" = 2 miles

the study area and the smaller amount of data for partial record stations within the study area. An underlying premise is that there is a relationship between flow of streams and concurrent flow of continuously gaged streams near the study area. The assumed form of this relationship is expressed as

$$Y = A\ (X)^{B}$$

where

Y = discharge at the partial record station (CFS)
X = concurrent discharge at a continuous gaging station (CFS)
A = y - intercept of the regression line, and
B = slope of the regression line.

The regression line used was the "structural line" referred to by Riggs (1968) and described by Gillespie and Schopp (1982). The regression analyses were performed for each partial record station and matched with each of four continuous gaging index stations (Mullica River, Batsto River, Great Egg Harbor River, and Oswego River). The dates of all partial record measurements were checked to determine whether concurrent flow conditions at index stations could be considered base-flow. Those dates on which the flow at the four index stations was judged not to represent base-flow conditions were excluded from the analysis. The four correlated values of each flow characteristic were averaged to obtain the final estimate.

Ungaged Locations

For the eleven ungaged locations, flow characteristics were estimated using methods which take advantage of data other than stream flow data. A regionalization method was used to estimate flow characteristics from ungaged drainage areas. The staff of the New Jersey District of the U.S. Geological Survey again provided advice and arranged for runs of the regression computer program.

The method used involved regressing a given flow characteristic of 112 New Jersey Coastal Plain streams against drainage area. The assumed relationship is expressed as

$$Y = C\ (A)^{B}$$

where

Y = characteristic flow at an ungaged location, CFS
A = drainage area, square miles
C = y - intercept of the regression line, constant, and
B = slope of the regression line.

Regression runs were repeated for the average flow (Q Avg.), the 7-day, 2-year low flow, Q (7-2), and the 7-day, 10-year average flow, Q (7-10). The resulting predictive equations are the following:

$$Q\ avg = 0.941\ A^{1.15}$$

$$Q\ (7\text{-}2) = 0.120\ A^{1.36}$$

$$Q\ (7\text{-}10) = 0.102\ A^{1.25}$$

Four ungaged locations are situated downstream from partial record stations for which flow was estimated using the correlation method described earlier. Rather than using the above regression equations, a better estimate of flow characteristics could be obtained by using an upstream flow characteristic as a point to describe an adjusted linear relationship between a flow characteristic and drainage area. The general form of the equations used for these locations was:

$$Q_2 = Q_1 \quad (A2/A1)^B$$

where

Q_2 = estimated characteristic flow at ungaged location, in CFS
Q_1 = characteristic flow at upstream partial record station, in CFS
A2 = drainage area of ungaged location, square miles
A1 = drainage area of upstream partial record station, square miles
B = slope of regression line from regional equation for particular flow characteristic.

This method assumes a log-linear relationship with the same slope as the corresponding regional equation, but provides an improved y-intercept. Thus, it provides an improved estimate.

The data collected by DEP and Zimmer at certain locations were compared with the flow characteristics estimated using the methods described above. DEP measurements were collected on summer dates on which index station flow was consistently between the average flow and the 7-day, 2-year low flow, which is typical of summertime flow conditions. The measured flows did not indicate any errors in estimated flow characteristics except for Price Branch and Clark Branch. DEP reported zero flow at both the Price Branch and Clark Branch locations on August 17, 1987. Estimated low-flow characteristics for these streams were low values, (<1 cfs) yet they were above zero. On August 17, 1987 the flow of the Great Egg Harbor River at Folsom was 47 CFS, which is between the annual average and the 7-day, 2-year low flow for that location. While it is possible that both Price Branch and Clark Branch had ceased flowing only for a short time, the flow condition of the Great Egg Harbor River at Folsom indicates that it is more likely that the 7-day, 2-year low flow and 7-day, 10-year low flow of both of these streams is zero. The streams are thus considered intermittent.

Results and Discussion

Estimated existing flow characteristics and the method of estimation for each stream location are listed in Table 7.

Estimated existing annual average flow ranged from 0.75 CFS for Wildcat Branch below WB-B to 119 CFS for the Mullica River near Batsto. Existing 7-day, 2-year low flow ranged from zero CFS for Clark Branch below CB-B and Price Branch below PB, to 30 CFS for the Mullica River near Batsto. Existing 7-day, 10-year low flows ranged from zero CFS for Clark Branch below CB-B and Price Branch below PB, to 15 CFS for the Mullica River near Batsto.

Those flow characteristics estimated by methods 1 and 2 on Table 7 are expected to be more accurate than those estimated by the other methods.

TABLE 7. STREAMFLOW CHARACTERISTICS AND METHODS FOR ESTIMATION OF FLOW. Refer to Figure 4 for key to streamflow locations. 7QS - 7 day, 2 year low flow, 7Q10 - 7 day, 10 year low flow.

STREAMFLOW LOCATION	AVG FLOW (CFS)	7Q2 (CFS)	7Q10 (CFS)	METHOD
MR-C	7.87	0.46	0.17	2
MR-B	24.14	5.57	3.47	4
MR-A	59.13	14.18	8.42	2
MULLICA TRIB	27.03	5.17	2.90	2
LMR	119.00	30.00	15.00	1
HAYES MILL	17.15	6.45	4.47	3
COOPER BRANCH	2.03	0.30	0.24	4
WB-B	0.75	0.04	0.01	2
WB-A	1.84	0.12	0.03	3
SB-B	25.80	6.02	3.73	4
SB-A	5.01	0.74	0.38	2
LSB	9.53	1.61	0.85	2
PB	3.19	* 0.00	* 0.00	4
CB-B	3.78	* 0.00	* 0.00	4
CB-A	24.88	8.18	5.48	2
GB	5.18	0.90	0.65	4
PU-B	7.02	1.31	0.72	2
PU-A	13.86	2.93	1.51	3
BU-B	2.88	0.40	0.19	2
BU-A	6.03	0.96	0.42	3
ALB	33.28	13.70	9.88	2
UGS-B	3.11	0.49	0.37	4
UGS-A	10.39	2.05	1.39	4

KEY TO THE METHODS OF FLOW ESTIMATION:

1 = CONTINUOUS GAGING STATION
PUBLISHED VALUE BASED ON 16-YR PERIOD OF RECORD

2 = PARTIAL-RECORD STATION
AVERAGE OF VALUES ESTIMATED FROM CORRELATIONS WITH FOUR INDEX STATIONS

3 = UNGAGED LOCATION
AREA-RATIO METHOD; ASSUMED RELATIONSHIP Q2 = Q1(A2/A1)EXP(B)

4 = UNGAGED LOCATION
REGIONAL REGRESSION METHOD; CALCULATED FROM Q = C(A)EXP(B)

* BASED ON ZERO DISCHARGE OBSERVED BY DEP BUREAU OF MONITORING MANAGEMENT, AUGUST, 1987

HYDROLOGIC BUDGET AND NUTRIENT LOADING

The hydrologic budget and nutrient loading analyses were completed to assess the environmental impacts of alternative wastewater disposal and water supply scenarios. The assessment approach was designed to include the following three features:

1. the capability to assess changes in both in-stream inorganic nitrogen concentrations and flow characteristics resulting from changes in land use and wastewater disposal;

2. flexibility to consider a number of wastewater management scenarios as well as additional factors or other information which may need to be incorporated through the course of model development; and

3. simplicity in concept and execution.

The Mass-Balance Model

A mass-balance model was chosen as the best way to address the three features described above. An ideal model can precisely account for all processes and stresses acting on a system and can make exact predictions without error. Such models, however, are rarely, if ever, possible. Therefore, it is to be expected that even a good model will only approximately predict the response of a system to changes in stress. The scope and accuracy of predictions will be a function of:

1) the detail of the model in space and time;

2) the accuracy and completeness of the data used to develop the model; and, most importantly

3) the representativeness of the conceptual framework used to develop the model.

As the amount of data available for this project was in itself expected to significantly limit both the scope and the accuracy of predicted impacts, there would have been little to be gained by attempting to develop a complex and detailed model of the hydrology and water quality in the study area. Instead, a simple mass-balance approach for both water and nitrogen was considered appropriate. The most general form of a mass-balance model is the simple mathematical statement:

(SUM OF INPUTS) = (SUM OF OUTPUTS) + (CHANGES IN STORAGE)

If the changes in storage are nil, then the equation becomes simply:

(SUM OF INPUTS) = (SUM OF OUTPUTS)

If all inputs and outputs could be accounted for and accurately estimated, then both sides of the equation would balance. However, as this will never be the case, another term is needed to represent the net unaccounted sources or sinks in the equation for a balance to be represented. The new equation becomes:

(SUM OF INPUTS) = (SUM OF OUTPUTS) +
(NET UNACCOUNTED SOURCES/SINKS)

Simplifying Assumptions

The modeling approach used the following underlying, simplifying assumptions:

1. annual average conditions of both the present and future are assumed to approximate a steady state in terms of water and nitrogen budgets (changes in storage of water and nitrogen are essentially zero);

2. net unaccounted water and nitrogen sources or sinks are assumed to remain constant in the future and equal in the present; and

3. groundwater divides coincide approximately with drainage divides.

These simplifying assumptions allow for a rational accounting of the inflow and outflow of water and nitrogen within each of the study area subbasins. If the major existing inflows and outflows of water and nitrogen can be quantified and reconciled in a mathematical statement of balance which reflects a presumed steady state, then the effect of future changes in any of the budget components can be shown in a new statement of balance reflecting an anticipated new steady state. However, the accuracy of predicted impacts relies heavily on a number of specific assumptions in addition to the general assumptions described above. The following discussion addresses the limitations imposed by the three general assumptions noted above.

The data used to construct the model indicate that average annual conditions can readily be estimated. The amount of nitrogen or water in storage at the times of data collection, however, is rarely known or easily estimated. Therefore, if storage can be assumed to be constant in the time frame of the model, the modeling effort is simplified considerably. If the assumption of zero change in storage of average annual conditions deviates from reality, however, then the statements of balance for existing or future conditions would be substantially in error. For example, if unknown nitrogen sinks (i.e. ammonia adsorption onto soil particles) have been storing nitrogen within a watershed for some time at a significant rate, then measured outflows (stream load) would indicate better water quality than might occur at a later date if the capacity of the sink is reached. Nitrogen, then, which would previously have been stored, would instead bypass the sink and becomes entrained in stream water. If this were the case, an existing stream might be considered pristine and protected from degradation under existing conditions, when in fact it might suffer degradation in the future without additional anthropogenic stress.

The assumption that the net unaccounted sources or sinks remain at the same rate in the future as in the present is necessary because the effect that new stresses would have on the net unaccounted source or sink rates cannot be quantified. If this assumption deviates significantly from reality, then predictions may not be realistic. For example, if the pH of a stream is raised as a result of a change in land use, ammonia volatilization, a specific process beyond the scope of this study, may increase substantially. In such case, future nitrogen concentrations might be over-predicted as a result of changes in the "unknown" component of a nitrogen budget.

The assumption that drainage divides and groundwater divides coincide is necessary because insufficient groundwater level data are available to fully delineate groundwater divides. If groundwater divides are significantly different from drainage divides, then groundwater and nitrogen in groundwater may flow to streams other than those expected. This would result in less accurate predictions of flow and in-stream nitrogen concentrations.

Water Budget

The development of two distinct but related models was attempted for this environmental assessment. One is a water budget and the other is a nitrogen budget. The water budget consists of inputs and outputs. Inputs are defined as any water which enters into a particular section of a watershed by any of the following means:

1) on the surface of the ground, vegetation or surface waters;

2) in streamflow entering the subbasin; and

3) in wastewater discharges.

Outputs are defined as any water which leaves a particular section of a watershed by any of the following means:

1) from the surface of the ground, vegetation or surface waters;

2) in streamflow leaving the subbasin; and

3) from wells screened within the Kirkwood or Cohansey aquifers within the watershed section.

Each means of input and output include a number of components. Every specific component of water input and output cannot be realistically identified or quantified. However, a number of contributing components which could be measured or estimated were identified as potentially significant within the study area. They are listed below, along with a discussion of how they were measured or estimated.

Inputs

1. Precipitation

The National Climatic Data Center in Asheville, North Carolina publishes monthly and annual summaries of precipitation for various stations in New Jersey. The Hammonton station is located about 2 miles to the south of the study area and was assumed to be representative. Average annual and monthly precipitation were obtained from the 1985 annual summary which addresses the entire period of record for the Hammonton station.

2. Septic System Recharge

Recharge from septic systems was assumed to be 100% of the wastewater generated by a given user. That is, it was assumed that no additional evapotranspiration from leach fields occurs as a result of the wastewater discharge. This assumption was also incorporated in studies by the U.S. Geological Survey on the hydrologic effects of sewering on Long Island (Thomas E. Reilly, personal communication).

Residential sewage flows were based on the following assumptions: 1) there are 3.1 persons per household; 2) 75 gallons of wastewater are generated per capita per day; 3) 95% occupancy rate. Flows were estimated for existing residential development and for projected residential development. Existing commercial, industrial, and other nonresidential uses were assigned the same flow rates as households. Projected commercial/industrial water consumption was based on the employment to square footage relationship. This translated into .15 gallons/day/square foot. These estimates were made for each municipality and all management areas within every subbasin studied.

3. Wastewater Treatment Plant Discharges

Existing flows discharged at the Waterford sewage treatment plant and Ancora State Psychiatric Hospital sewage treatment plant were obtained from the 1987 CCMUA report previously cited and NJPDES reports, respectively. Future flows were estimated using the approach previously described for septic system recharge.

4. Gross Agricultural Water Application

Gross agricultural water application was defined as the total amount of water, in inches per year, supplemental to rainfall, which is applied to crops. Two approaches were considered in estimating this water input. The first was to compile and total all reported agricultural water withdrawals for each subbasin, thus making the assumption that all water withdrawn for agricultural uses was in fact applied for irrigation. Agricultural water withdrawals were obtained for reporting owners of wells with capacities of at least 100,000 GPD from records of the U.S. Geological Survey and the Department of Environmental Protection, Bureau of Water Allocation.

The other approach was to estimate crop needs and irrigation efficiency using information from the literature along with acreage figures for agricultural lands within each watershed section. The method used for these estimates is described in Doorenbos and Pruitt (1975). Two categories of crops were considered, 1) orchard crops and 2) vegetable and field crops. The withdrawals reported within each watershed section were compared with the total gross water application estimates based on crop needs and acreage. Reported withdrawals were consistently lower than calculated estimates, indicating that either 1) reported withdrawals are underestimated, or 2) calculated gross water applications are over-estimated.

Because of the likelihood that the withdrawals from a number of small capacity wells used for agricultural activities are not reported, calculated gross water application based on crop needs and acreage were used.

5. Streamflow

Average annual streamflow upstream from each subbasin was estimated. The methods used were explained earlier.

Outputs

1. Evapotranspiration

a. Agricultural Lands

Evapotranspiration from agricultural lands during the growing seasons was assumed to be equal to crop needs. Growing season evapotranspiration was estimated using the Blaney-Criddle method as adapted by Doorenbos and Pruitt (1975). As in estimating gross water applications, orchards were distinguished from vegetable and field crops.

Non-growing season evapotranspiration was estimated using the method of Thornthwaite and Mather (1957) as programmed for microcomputer by Hughes and others (1985).

b. Spray Irrigation of Wastewater

Evapotranspiration from a spray field within a forested area (e.g. the Waterford plant) was estimated using the method of Thornthwaite and Mather (1957) as programmed for microcomputer by Hughes and others (1985).

c. Other Surfaces

Evapotranspiration from lands other than those described above was estimated using the method of Thornthwaite and Mather (1957) as programmed for microcomputer by Hughes and others (1985).

2. Streamflow

Average annual streamflow downstream from each watershed section was estimated. The methods used were explained earlier.

3. Irrigation Losses

Irrigation losses occur as a result of the vaporization of irrigation water which is sprayed under pressure. Therefore, the amount of water available to meet crop needs is less than the gross water applied. The rate of irrigation loss is estimated as the product of gross water application (estimated as described above) and irrigation efficiency. The value of 75% irrigation efficiency has been estimated for New Jersey (Rutgers University, no date).

4. Public Water Well Withdrawals

No existing public water supply wells are located within the study area and screened within the Kirkwood or Cohansey aquifers.

5. Private Residential Water Well Withdrawals

Residential water withdrawals were based on the following assumptions: 1) 3.1 persons per household; 2) 90 gallons were used per capita per day; 3) 95% occupancy rate. Withdrawals were estimated for existing residential development and for projected residential development. Existing commercial, industrial, and other nonresidential uses were assigned the same withdrawal rates as households. Projected commercial/industrial development water consumption was based on the employment to square footage relationship. This translated into .18 gallons/day/square foot. These estimates were made for each municipality and all management areas within every subbasin studied.

6. Private Commercial and Industrial Water Well Withdrawals

Existing and future commercial and industrial water supply well withdrawals were based on estimates described earlier.

Net Ground Water Flow

A notable component of the hydrologic budget which is not included in this analysis is net ground water flow into or out of subbasins. It was not possible to estimate this component due to insufficient knowledge of the ground water flow system in the study area. For this reason it was assumed that the net ground water flow into or out of each subbasin was zero.

Nitrogen Budget

An attempt was made to quantify a balance between nitrogen inputs and outputs in each subbasin. This approach is described below, followed by a discussion of an alternative approach taken because data limitations prevented the development of a mass balance budget.

Nitrogen inputs were defined as any nitrogen entering a watershed section by any or all of the following means:

1) in streamflow entering a subbasin;

2) in sewage discharges (STP and septic system); and/or

3) in agricultural runoff.

The only nitrogen output that could be quantified was stream load. Other processes of nitrogen output, such as volatilization and denitrification, could not be estimated. These were considered negligible.

Each of these general means of input and output include a number of components. Every specific component of nitrogen input and output cannot be realistically identified or quantified. However, a number of contributing components which could be measured or estimated were identified as potentially significant within the study area. They are listed below, along with a discussion of how they were measured or estimated.

Inputs

1. Septic System Discharges

   Nitrogen in domestic wastewater was assumed to be 11.2 grams per capita per day, as published by the EPA (1980). It was assumed that all nitrogen in septic discharges is converted to inorganic nitrogen. It was also assumed that, at steady state, the rate at which nitrogen from septic systems is discharged to the soil equals the rate at which it is entrained in stream flow.

2. Sewage Treatment Plant Discharges

   The nitrogen remaining in pre-treated wastewater was considered. The average nitrogen load is estimated as the product of the average effluent nitrogen concentration and the average flow.

3. Agricultural Losses

The amount of nitrogen applied to agricultural lands was assumed to be 140 lb-N/acre/year for orchards and 100 lb-N/acre/year for vegetable and field crops (from Pinelands Commission, 1980). Of the nitrogen in fertilizer applied to crops, any in excess of that required by the crop can be expected to be lost by leaching to ground water or through surface runoff. In consideration of the soil types predominating the agricultural lands within the study area, the percentage lost was assumed to be 10% (from Brown, 1980).

4. Stream Load

The average existing nitrogen load of a stream entering a subbasin was estimated as the product of average flow of the stream and the average nitrogen concentration of the stream. The average future nitrogen load of a stream entering a subbasin was estimated as the sum of future nitrogen inputs and unaccounted nitrogen of the upstream subbasin. The average future nitrogen concentration of a stream entering a subbasin was estimated as the estimated average future nitrogen load of the stream divided by the estimated average future stream flow of the stream.

Outputs

1. Stream Load

The average existing nitrogen load of a stream leaving a subbasin was estimated as the product of average flow of the stream and the average nitrogen concentration of the stream. The average future nitrogen load of a stream leaving a subbasin was estimated as the difference between future nitrogen inputs and unaccounted nitrogen.

The average future nitrogen concentration of a stream leaving a subbasin was calculated as the estimated future nitrogen load of the stream divided by the estimated average future stream flow of the stream. However, due to the inadequacy of the database, estimated nitrogen inputs did not come close to balancing estimated nitrogen outputs, and the amount of unaccounted nitrogen was unacceptably high. Consequently, any predictions of future nitrogen concentrations would have been highly unreliable. For this reason, the nitrogen mass balance approach was replaced by a different approach which considers only those nitrogen inputs which can be estimated. The sum of these inputs is termed "potential nitrogen loading."

Potential Nitrogen Loading

The potential nitrogen loading is defined as the total of all estimated anthropogenic nitrogen sources released within the subbasin area and within the drainage areas of all upstream subbasins flowing to the subbasin, expressed as pounds of nitrogen per day per square mile of total drainage area. The sources include all of those described above for the nitrogen budget, with the exception of stream load. This potential loading term is considered an appropriate measure that can be used to compare the relative stress acting on different subbasins. Existing and future potential nitrogen loadings were thus compared for the assessment of future impacts of development and wastewater disposal alternatives.

SUMMARY OF EXISTING CONDITIONS IN THE MULLICA RIVER BASIN

Hydrologic Budgets

The components of the hydrologic budgets described earlier were estimated for the existing annual average conditions in each subbasin. These components are summarized in Tables 8 and 9. The "net unknown" amount indicates how much water is not accounted for in the budget. The higher net unknowns can be explained using additional information on the surface hydrology of the study area. The large negative net unknowns for Sleeper Branch subbasins SB-A and LSB are probably indicative of unaccounted outflow. Large positive unknowns for the Mullica Tributary, Clark Branch (CL-A) and Lower Mullica River (LMR) are probably indicative of unaccounted inflow. Topographic maps and field experience indicate that Sleeper Branch loses water in surface diversions to these three streams, which would partially explain the large unknowns in their respective budgets. The components of the hydrologic budget for the other subbasin are probably estimated with reasonable accuracy.

Potential Nitrogen Loadings

The existing potential nitrogen loadings for the stream locations under consideration are listed at the bottom of Tables 8 and 9. These loading estimates provide a means of comparison of relative stress in that the loadings were calculated as pounds per day per square mile of drainage area. Drainage areas were reported by Velnich (1984). The loadings ranged from zero for the Mullica River tributary to 18.6 lb/day/square mile for Hays Mill Creek. The high value for Hays Mill Creek is attributed to the Waterford MUA treatment plant discharge and the several hundred dwelling units currently utilizing on-site wastewater disposal.

TABLE 8. HYDROLOGIC BUDGET SUMMARY AND POTENTIAL NITROGEN LOADING.
Refer to Figure 1 for key to subbasins.

	MR-C	MR-B	MR-A	MULLICA TRIB	LMR	HAYES MILL	CB	WB-B	WB-A	SB-B	SB-A	LSB	
INFLOWS													
PRECIPITATION	6.86	28.95	34.75	8.74	27.72	15.75	4.16	2.20	4.80	11.19	0.85	13.58	MGD
SEPTIC RECHARGE	0.11	0.07	0.00	0.00	0.00	0.17	0.04	0.04	0.01	0.01	0.00	0.00	MGD
STP DISCHARGES	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	MGD
IRRIGATION	0.03	0.11	0.01	0.00	0.00	0.11	0.03	0.04	0.06	0.02	0.00	0.00	MGD
UPSTREAM INFLOW	0.00	5.09	15.60	0.00	55.68	0.00	0.00	0.00	0.48	13.59	16.67	22.67	MGD
TOTAL IN	7.01	34.22	50.36	8.74	83.40	16.29	4.22	2.27	5.35	24.81	17.52	36.25	MGD
OUTFLOWS													
AVG STREAMFLOW	5.09	15.60	38.21	17.47	76.91	11.08	1.31	0.48	1.19	16.67	3.24	6.16	MGD
GENERAL ET	3.32	14.04	17.43	4.39	13.93	7.29	1.97	0.94	2.15	5.51	0.43	6.82	MGD
ORCHARD ET	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.00	0.00	MGD
VEG AND FIELD ET	0.11	0.63	0.03	0.00	0.00	0.61	0.15	0.18	0.29	0.14	0.00	0.00	MGD
IRRIGATION LOSSES	0.01	0.03	0.00	0.00	0.00	0.03	0.01	0.01	0.02	0.01	0.00	0.00	MGD
SPRAY FIELD ET	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	MGD
PUB WITHDRAWALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	MGD
PVT RES WITHDRAWAL	0.23	0.08	0.00	0.00	0.00	0.33	0.04	0.04	0.01	0.01	0.00	0.00	MGD
AGRIC WITHDRAWALS	0.03	0.11	0.01	0.00	0.00	0.11	0.03	0.04	0.06	0.02	0.00	0.00	MGD
PVT C&I WITHDRAWAL	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	MGD
TOTAL OUT	8.87	30.49	55.69	21.86	90.83	19.64	3.51	1.72	3.76	22.36	3.67	12.98	MGD
NET UNKNOWN	1.86	-3.73	5.33	13.12	7.43	3.36	-0.71	-0.55	-1.60	-2.45	-13.86	-23.27	MGD
POTENTIAL NITROGEN LOADING IN LB/DAY/SQ MI	12.50	4.20	2.20	0.00	1.50	18.60	7.10	14.90	10.40	9.80	9.60	4.80	

TABLE 9. HYDROLOGIC BUDGET SUMMARY AND POTENTIAL NITROGEN LOADING.
Refer to Figure 1 for key to subbasins.

	PR	CL-B	CL-A	GB	PU-B	PU-A	BA-B	BA-A	ALB	UGS-B	UGS-A	
INFLOWS												
PRECIPITATION	6.16	7.14	1.88	9.40	13.22	10.66	6.42	5.78	5.07	6.03	11.24	MGD
SEPTIC RECHARGE	0.04	0.05	0.00	0.00	0.16	0.12	0.05	0.04	0.00	0.04	0.06	MGD
STP DISCHARGES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	MGD
IRRIGATION	0.18	0.17	0.00	0.11	0.29	0.23	0.23	0.23	0.15	0.08	0.80	MGD
UPSTREAM INFLOW	0.00	0.00	4.50	0.00	0.00	4.54	0.00	1.86	12.85	0.00	2.01	MGD
TOTAL IN	6.38	7.36	6.38	9.51	13.67	15.54	6.70	8.12	18.07	6.16	14.11	MGD
OUTFLOWS												
AVG STREAMFLOW	2.06	2.44	16.08	3.35	4.54	8.96	1.86	3.89	21.51	2.01	6.71	MGD
GENERAL ET	2.39	2.92	0.94	4.23	5.59	4.64	2.42	2.19	1.99	2.69	3.19	MGD
ORCHARD ET	0.28	0.24	0.00	0.00	0.61	0.72	0.53	0.72	0.23	0.09	2.65	MGD
VEG AND FIELD ET	0.64	0.63	0.00	0.61	0.79	0.28	0.55	0.28	0.50	0.34	0.82	MGD
IRRIGATION LOSSES	0.05	0.04	0.00	0.03	0.07	0.06	0.06	0.06	0.04	0.02	0.20	MGD
SPRAY FIELD ET	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	MGD
PUB WITHDRAWALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	MGD
PVT RES WITHDRAWALS	0.05	0.06	0.00	0.00	0.18	0.14	0.06	0.05	0.00	0.05	0.07	MGD
AGRIC WITHDRAWALS	0.18	0.17	0.00	0.11	0.29	0.23	0.23	0.23	0.15	0.08	0.80	MGD
PVT C&I WITHDRAWALS	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.04	0.01	MGD
TOTAL OUT	5.64	6.50	17.02	8.33	12.08	15.03	5.72	7.42	24.41	5.33	14.45	MGD
NET UNKNOWN	-0.74	-0.86	10.64	-1.18	-1.59	-0.52	-0.98	-0.70	6.34	-0.83	0.34	MGD
POTENTIAL NITROGEN LOADING IN LB/DAY/SQ MI	8.70	8.30	7.50	2.10	11.50	11.10	10.70	13.30	9.30	7.10	11.50	

WATER SUPPLY AND SEWAGE DISPOSAL ALTERNATIVES

With the exception of Hays Mill Branch, where water quality reflects the increased nitrogen loading associated with the Waterford Township sewage treatment plant, water quality degradation in the study area is primarily a response to residential, commercial/industrial, and agricultural land uses established prior to the implementation of the Comprehensive Management Plan. Development that has occurred since that time has probably contributed to the degradation of the ground and surface water resources, however, the percentage increase in development over pre-CMP levels is small.

Impacts Associated with Agricultural Activities

Agricultural activities (fertilization and liming) have and probably continue to contribute significantly to surface water degradation in the study area. Mitigation of this impact would require either a reduction in the acreage of farmed land or a substantial change in agricultural practices, alternatives which are beyond the scope of Pinelands regulations.

Impacts Associated with Development

Nutrient loadings associated with existing unsewered development can be reduced through sewering, treatment, and disposal of wastewater either within the Mullica Basin or, as suggested by the CCMUA, in the Delaware Basin. Both disposal strategies are complicated by the associated interbasin transfers of water which can affect stream flows and water table levels within the affected basins. Although a within Mullica River basin alternative would prevent the transfer of water from the watershed, it does not solve the problem of subbasin to subbasin transfers (e.g. Pump Branch to Hays Mill Branch). The nutrient loading and water transfer issues are made more critical when future, projected development is considered.

Preserving the Ecological Integrity of Wharton State Forest

All the streams studied flow to Wharton State Forest. Within the study area, the Wharton boundary also represents the boundary of the Preservation Area. The results of the water quality inventory indicate that development and agricultural activities in the headwaters areas of the Mullica Basin are impacting the water resources of Wharton State Forest and the Preservation Area. The impact varies among streams; it is most severe in the Great Swamp Branch. Designation of the headwater regions of the Mullica River as a high growth area has created a significant land use/environmental protection confict: how can additional development be permitted in this region without further affecting the ecological integrity of Wharton State Forest?

In developing and exploring alternatives to meet the sewering needs of the lower Camden County growth projections, the primary concern was preserving the integrity of Wharton State Forest. In absolute terms, this requires that no further degradation of either the quality or quantity of water flowing into Wharton occur. Since nondegradation can only be accomplished if no additional development is permitted, this goal is, for practical purposes, unachievable. The approach chosen was developed within the context of the Comprehensive Management Plan.

All future water supply and sewage treatment and disposal scenarios developed were based on the land management classifications for Camden County assigned in the Comprehensive Management Plan. Water supply and effluent disposal scenarios attempt to accommodate Regional Growth level densities while minimizing within subbasin water quality and quantity impacts and within Wharton water quality and quantity impacts. The second objective is primary.

Ranking of Subbasins

Study area streams were grouped in four stream systems: 1) Mullica River; 2) Sleeper Branch; 3) Albertson Brook; and 4) Great Swamp Branch. Both the Albertson Branch and Upper Great Swamp Branch join the Nescochague Creek southeast of Route 206. These systems were subjectively ranked based on their relationship to Wharton State Forest, existing water quality, hydrologic sensitivity, land use patterns, and other intrinsic natural resource features described in this report. The relative degree of water resource impacts (streamflow reduction and nitrogen loading) allowed in these systems under various scenarios was based on this ranking.

Data collected in this assessment suggests that the overall intrinsic natural resource value of the upper headwaters of the Mullica River (MRC) is low. It is, however, an ecological component of the only state designated wild river in New Jersey-the Lower Atsion. It also contributes flow to Atsion Lake, an important state recreation and swimming area.

The Sleeper Branch system represents a significant portion of Wharton State Forest. The entire mainstream of the Sleeper Branch and portions of all its headwater basins lie within Wharton State Forest; in fact, it occupies a central position in the Mullica River basin. The basin displays contrasting features associated with the character of its tributaries. The environmental quality of Wildcat Branch and Hays Mill Branch reflect the intensity of land use within these basins, while Clark Branch is less disturbed. Deep within Wharton, the Sleeper Branch displays excellent Pinelands water quality, and is known to support typical Pinelands, acid water aquatic communities.

As previously indicated, degradation of Sleeper Branch west of Route 206 is associated primarily with low quality water flowing from Hays Mill Branch, a feature that is probably related in large part to the disposal of treated sewage effluent at the Waterford Township STP. Reducing the impact of the STP would contribute substantially to the improvement of the Hays Mill Branch, and consequently, the Sleeper Branch system.

Because of its relationship to Wharton State Forest, the inherent values of a number of its tributaries, and the potential for enhancing the existing water quality of the system, the Sleeper Branch basin has been ranked along with the Mullica River as a primary target for protection.

In comparison to the Mullica River and Sleeper Branch systems, the Albertson Brook and Great Swamp Branch basins must be considered to be of lesser quality. Pump Branch and Blue Anchor Brook basins, the two basins which comprise the Albertson Brook system, are almost entirely outside the boundaries of Wharton, as is Great Swamp Branch. All are disturbed upon entering Wharton State Forest. Both Albertson Brook and Upper Great Swamp are tributaries of Nescochague Creek. As previously noted, the Nescochague also receives drainage from the Hammonton area, and is somewhat disturbed at its confluence with the Mullica River. Although the water supply and effluent disposal scenarios were developed and evaluated with the overall goal of minimizing hydrologic impacts to all the subbasins within the study area, the Albertson Brook and Great Swamp systems were judged to be secondary to the Mullica River and Sleeper Branch systems.

Water Supply and Sewage Flow Scenarios

A total of sixteen water supply and sewage flow scenarios were evaluated. These are summarized in Table 10. The scenarios fall into two categories. The first category includes those which assume that the projected buildout in areas designated for growth will demand 3.9 mgd in water supply and that 3.3 mgd in sewage will be generated. The second category addresses a reduced sewage flow of 2.6 mgd accomplished by downzoning. As described in the sections on hydrologic budget and nutrient loading, other inputs and outputs (private wells, septic systems, agricultural activities) occurring throughout the study area are also considered.

In developing the scenarios, rapid infiltration was chosen as the method used to dispose of treated effluent

TABLE 10. WATER SUPPLY AND SEWAGE FLOW SCENARIOS

SCENARIO	WATER SUPPLY SOURCE	LOCATION OF SEWAGE DISPOSAL FACILITIES AND FLOWS (MGD)
S-0	LOCAL WELLS IN ALL SUBBASINS	3.3 MGD CAMDEN REGIONAL FACILITIES
S-1	LOCAL WELLS IN ALL SUBBASINS	1.0 MGD PU-B SUBBASIN
		1.0 MGD UGS-A SUBBASIN
		1.3 MGD CAMDEN REGIONAL FACILITIES
S-2	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN UGS-A SERVING HM SUBBASIN	1.0 MGD IN UGS-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES
S-3	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN UGS-A SERVING HM SUBBASIN	1.0 MGD IN UGS-A SUBBASIN
		1.0 MGD IN BA-A SUBBASIN
S-4	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN UGS-A SERVING HM SUBBASIN	0.5 MGD IN UGS-A SUBBASIN
		0.5 MGD IN BA-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES
S-5	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN UGS-A SERVING HM SUBBASIN	1.0 MGD IN BA-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES
S-6	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	3.3 MGD CAMDEN REGIONAL FACILITIES
	1.0 MGD WELL IN UGS-A SERVING HM SUBBASIN	
S-7	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN PU-B SERVING HM SUBBASIN	1.0 MGD IN UGS-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES
S-8	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN PU-B SERVING HM SUBBASIN	1.0 MGD IN UGS-A SUBBASIN
		1.0 MGD IN BA-A SUBBASIN
S-9	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN PU-B SERVING HM SUBBASIN	0.5 MGD IN UGS-A SUBBASIN
		0.5 MGD IN BA-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES
S-10	LOCAL WELLS IN ALL BUT HAYS MILL SUBBASIN	1.4 MGD IN PU-B SUBBASIN
	1.0 MGD WELL IN PU-B SERVING HM SUBBASIN	1.0 MGD IN BA-A SUBBASIN
		0.9 MGD CAMDEN REGIONAL FACILITIES

TABLE 10. CONTINUED. WATER SUPPLY AND SEWAGE FLOW SCENARIOS

SCENARIO	WATER SUPPLY SOURCE	LOCATION OF SEWAGE DISPOSAL
S-11	LOCAL WELLS IN ALL BUT SLEEPER BRANCH AND MULLICA RIVER SUBBASINS 1.2 MGD WELL IN UGS-A SERVING SLEEPER BRANCH AND MULLICA RIVER SUBBASINS	1.4 MGD IN PU-B SUBBASIN 1.2 MGD CAMDEN REGIONAL FACILITIES
S-12	LOCAL WELLS IN ALL BUT SLEEPER BRANCH AND MULLICA RIVER SUBBASINS 1.2 MGD WELL IN UGS-B SERVING SLEEPER BRANCH AND MULLICA RIVER SUBBASINS	1.4 MGD IN PU-B SUBBASIN 1.2 MGD CAMDEN REGIONAL FACILITIES
S-13	LOCAL WELLS IN ALL BUT SLEEPER BRANCH AND MULLICA RIVER SUBBASINS 1.2 MGD WELL IN PU-A SERVING SLEEPER BRANCH AND MULLICA RIVER SUBBASINS	1.4 MGD IN PU-B SUBBASIN 1.2 MGD CAMDEN REGIONAL FACILITIES
S-14	LOCAL WELLS IN ALL BUT SLEEPER BRANCH AND MULLICA RIVER SUBBASINS 1.2 MGD WELL IN PU-B SERVING SLEEPER BRANCH AND MULLICA RIVER SUBBASINS	1.4 MGD IN PU-B SUBBASIN 1.2 MGD CAMDEN REGIONAL FACILITIES
S-15	LOCAL WELLS IN ALL SUBBASINS	1.4 MGD IN PU-B 1.9 MGD CAMDEN REGIONAL FACILITIES

A 43% REDUCTION IN SEWAGE FLOWS HAS BEEN APPLIED TO SELECTED SUBBASINS IN THE SLEEPER BRANCH AND MULLICA RIVER SYSTEMS within the Mullica Basin. Nitrate-nitrogen concentration of the effluent was assumed to be 2 mg/l. Rapid infiltration involves the use of basins with highly permeable bottoms through which effluent is allowed to percolate to ground water. Application rates are higher than for spray irrigation, so that land area requirements are smaller. Nitrogen removal is negligible during rapid infiltration discharge, so that in order for the discharge to meet the ground water nitrate-nitrogen standard, the effluent total nitrogen must be no greater than 2 mg/l, unless additional land area is designated for dilution and the basin is designed and situated to maximize the effect of dilution. The land area needed for an effluent containing more than 2 mg/l nitrate-nitrogen must be determined on a site specific basis. A minimum of 10 feet between the bottom of the basin and the seasonally high water table elevation is required, and a minimum of four feet is required between the bottom of the basin and the top of the resultant mounded water table. These requirements are limiting factors in sizing of basins.

Assuming a maximum permitted application rate of 0.34 gallons per day per square foot, which appears to be a likely rate considering soils within the study area, the minimum infiltration basin acreage requirement would be about 60 acres per MGD. Permitted application rates for rapid infiltration basins were determined using NJDEP's long term acceptance rate methodology.

Using land cover maps (developed land, forest land, non-forest land, and agricultural land), aerial photographs, and soils maps, all undeveloped land with a seasonal high water table greater than five feet from the surface was identified. Sufficient acreage meeting the depth to seasonal high water table criterion was found in Pump Branch B basin, Blue Anchor A basin, and Upper Great Swamp A basin. The general location of these sites is shown in Figure 5.

Changes in average streamflow, 7-day, 2-year minimum streamflow, and nitrogen loading per unit drainage area, given as percent increases from current levels, were calculated for each scenario. The results of this analysis are given in Table 11. Only streams which showed significant reduction in streamflow are presented in this table.

1. Delaware Basin Scenario

The first scenario, S-0, assumes that water demand in each subbasin is satisfied by local, within subbasin wells, and that 3.3 mgd in sewage is transferred to the Delaware Basin for disposal. Transfer of flows to the Delaware River assumes that capacity exists at the Camden County Municipal Utilities Authority sewage treatment plant.

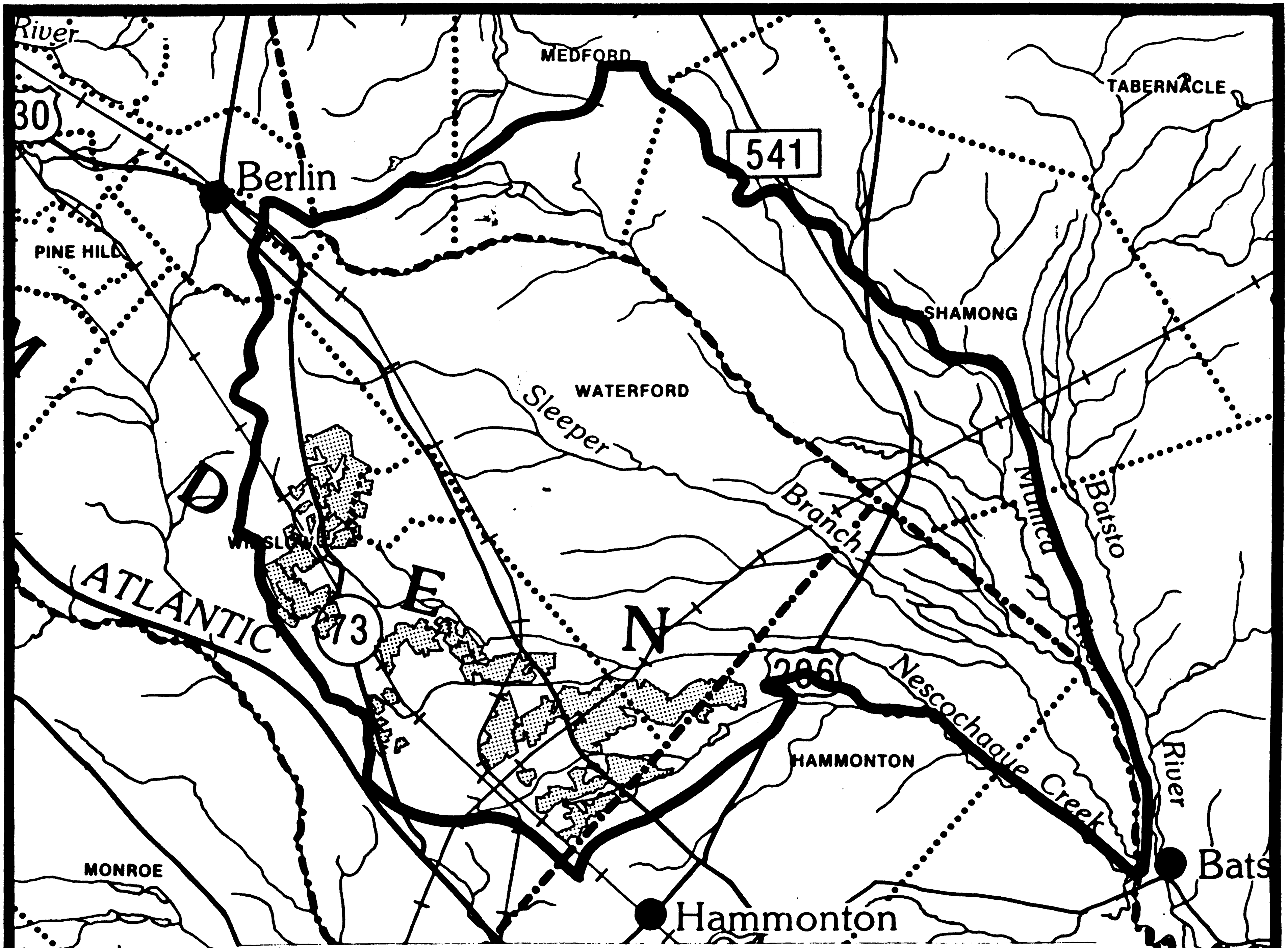

FIGURE 5. POTENTIAL SITES FOR LAND APPLICATION OF WASTEWATER

TABLE 11. PERCENT CHANGES IN AVERAGE STREAMFLOW, LOW FLOW AND NITROGEN LOADING FOR EACH SCENARIO DESCRIBED IN TABLE 10.

Change in Average Streamflow (%)

SUBBASIN	S-0	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Mullica MR-C	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	2	1	1	2	-5
Hays Mill	-11	-11	-2	-2	-2	-2	-2	-2	-2	-2	-2	1	1	1	1	-11
Cooper	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-2	-2	-2	3	-13
Wildcat Branch WB-B	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	2	2	2	7	-23
Wildcat Branch WB-A	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	2	2	2	4	-10
Sleeper Branch SB-B	-9	-9	-3	-3	-3	-3	-3	-3	-3	-3	-3	1	1	1	1	-9
Pump Branch PU-B	-21	1	9	9	9	9	-21	-13	-13	-13	-13	9	9	9	-18	9
Pump Branch PU-A	-14	-3	1	1	1	1	-14	-10	-10	-10	-10	1	1	-12	-12	1
Blue Anchor Branch BA-B	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
Blue Anchor Branch BA-A	-2	-2	-2	23	10	23	-2	-2	23	10	23	-2	-2	-2	-2	-2
Albertson Brook ALB	-6	-2	0	5	2	5	-6	-4	0	-2	0	0	0	-6	-6	0
Upper Great Swamp UGS-B	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-64	-2	-2	-2
Upper Great Swamp USG-A	-1	14	-1	-1	-8	-16	-16	14	14	6	-1	-19	-19	-1	-1	-1

Change in 7-Day, 2-Year Low Flow Streamflow (%)

SUBBASIN	S-0	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Mullica MR-C	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	36	36	36	36	-80
Hays Mill	-30	-30	-4	-4	-4	-4	-4	-4	-4	-4	-4	3	3	3	3	-30
Cooper	-91	-91	-91	-91	-91	-91	-91	-91	-91	-91	-91	-13	-13	-13	22	-91
Wildcat Branch WB-B	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	31	31	31	127	-100
Wildcat Branch WB-A	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	-100	38	38	38	71	-100
Sleeper Branch SB-B	-38	-38	-12	-12	-12	-12	-12	-12	-12	-12	-12	3	3	3	5	-38
Pump Branch PU-B	-100	4	51	51	51	51	-100	-67	-67	-67	-67	51	51	51	-95	61
Pump Branch PU-A	-67	-15	7	7	7	7	-67	-46	-46	-46	-46	7	7	-59	-59	7
Blue Anchor Branch BA-B	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23	-23
Blue Anchor Branch BA-A	-14	-14	-14	146	65	146	-14	-14	146	65	146	-14	-14	-14	-14	-14
Albertson Brook ALB	-15	-4	0	12	6	12	-15	-11	0	-5	0	0	0	-14	-14	0
Upper Great Swamp UGS-B	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-100	-15	-15	-15
Upper Great Swamp USG-A	-5	70	-5	-5	-43	-80	-80	70	70	33	-5	-98	-98	-5	-5	-5

Change in Nitrogen Loading Per Unit Drainage Area (%)

SUBBASIN	S-0	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Mullica MR-C	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Hays Mill	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67	-67
Cooper	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95	-95
Wildcat Branch WB-B	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88	-88
Wildcat Branch WB-A	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53	-53
Sleeper Branch SB-B	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65
Pump Branch PU-B	-89	-65	-56	-56	-56	-56	-89	-56	-56	-56	-56	-56	-56	-56	-56	-56
Pump Branch PU-A	-64	-50	-45	-45	-45	-45	-64	-45	-45	-45	-45	-45	-45	-45	-45	-45
Blue Anchor Branch BA-B	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
Blue Anchor Branch BA-A	75	75	75	96	86	96	75	75	96	86	96	75	75	75	75	75
Albertson Brook ALB	-16	-7	-3	6	2	6	-16	-3	6	2	6	-3	-3	-3	-3	-3
Upper Great Swamp UGS-B	131	131	131	131	131	131	131	131	131	131	131	131	131	131	131	131
Upper Great Swamp USG-A	39	57	57	57	48	39	39	57	57	48	39	39	39	39	39	39

2. Buildout Scenarios

Scenarios S-1 through S-10 accommodate the sewage flows generated by maximum buildout. They all have one feature in common: the water demands of the Hays Mill Creek subbasin are satisfied by supplies from other basins, thereby reducing stream flow impacts in this stream and the Sleeper Branch. The scenarios mostly involve the placement of regional water supply wells and sewage disposal in the Albertson Brook and Upper Great Swamp Branch systems, and the transfer of "surplus" sewage flows to the Delaware Basin. Scenario S-15 relies on local wells with a 1.4 mgd disposal facility in PU-B. The remaining 1.9 mgd is transferred to the Delaware River basin.

3. Downzoning Scenarios

In these scenarios (S-11 through S-14), sewage flow is reduced to 2.6 mgd, and growth areas in the Mullica River system and the Sleeper Branch system (rather than just the Hays Mill Branch subbasin) are treated as water supply receivers. Water supply is derived from either the Upper Great Swamp Branch subbasin or the Pump Branch subbasin, and sewage flows are transferred to the Delaware Basin and the Pump Branch subbasin.

4. Comparison of Scenarios

The interbasin transfer occurring in the Delaware River Basin scenario (S-0) results in across the board reductions in stream flow for those streams listed in Table 11. This alternative maximizes streamflow reductions within the Mullica River Basin. With a few exceptions (Mullica River C, Blue Anchor Brook, and Upper Great Swamp Branch), this transfer also results in a decrease in stream loading. This is due to the removal of existing loads (existing septic systems and the Waterford Township STP discharge). Similar decreases are noted under other scenarios in the majority of the other basins. The increased nutrient loading in several other stream locations is due to future, non-growth area development served by on-site wastewater disposal systems. The results obtained from all other scenarios should be compared to this maximum-transfer scenario.

a. Streamflows

Like the Delaware River Basin scenario, S-1 relies on local wells distributed throughout the study area. However, 2.0 mgd of sewage is treated within the Mullica River Basin (Pump Branch A and

Upper Great Swamp Branch B). The remaining 1.3 mgd is transferred to the Delaware Basin. The increase in recharge within these basins is reflected in Pump Branch and Upper Great Swamp Branch A streamflows.

With the exception of flow in Hays Mill Branch and Sleeper Branch, stream flows in the Sleeper Branch system streams are the same under scenarios S-2 through S-10 as they are in the first two alternatives. A similar situation exists for the Mullica River. Stream flows in the Albertson Brook and Upper Great Swamp systems vary according to scenario. With the exception of a lower flow in Upper Great Swamp A under scenarios S-5 and S-6, flows in these systems are higher or equal to those resulting from S-0 and S-1.

Under scenarios S-11 through S-14, stream flows in the Mullica River and all Sleeper Branch system streams are higher than those in alternatives S-0 and S-1. Average stream flows in the other systems are also higher with the exception of lower flows in Upper Great Swamp Branch in S-12. A reduction in 7-day, 2-year low flows does occur in Upper Great Swamp Branch A, Upper Great Swamp A and B, Pump Branch A, and Pump Branch A and B under S-11, S-12, S-13, and S-14, respectively.

Each of the sixteen scenarios was ranked according to change in average stream flows. Both decreases and increases from existing flow conditions were evaluated. Although increases were ranked higher than decreases, excessively high increases reduced the status of a scenario. The results of this ranking are shown below. This ranking was then checked against changes in 7-day, 2-year low flows. Scenarios with low flows below those reported for S-0 are highlighted with asterisks (*).

LEAST CHANGE: S11*, S13, S14, S12*, S2, S4, S3,

S5, S10, S9, S8, S7, S1, S15, S6, S0: GREATEST CHANGE

b. Nitrogen Loading

Nitrogen loading in the Mullica River and Sleeper Branch systems remain the same through all scenarios. Pump Branch loads are variable compared to S-0. All scenarios result in greater Pump Branch loads (14%-19% higher in Pump Branch A and 24%-33% higher in Pump Branch B); however, all loads are reduced from baseline estimates. In all scenarios, Blue Anchor Branch A increases are equal to or somewhat greater than the S-0 increase in nitrogen loading (Blue Anchor A increases are 11%-21% higher than S-0 increases). Blue Anchor B loadings remain the same in all scenarios (+24%). With one exception, Albertson Brook loads increase above S-0. The majority of these increases are still below baseline levels.

Loadings in Upper Great Swamp Branch B remain the same through all scenarios; there is a 131% increase above existing conditions. The response of Upper Great Swamp A is variable; compared to S-0 (+39%), increases range from 0%-18%.

SUMMARY OF SCENARIOS AND RECOMMENDATIONS

A total of sixteen scenarios has been presented here. All assume that water supplies will be obtained from the Kirkwood-Cohansey Aquifer. They represent only a sampling of all possible scenarios that can be developed. They do, however, contribute to the development of a strategy to accommodate development densities projected in the Pinelands while minimizing quality and water quantity impacts.

A strategy which relies on the interbasin transfer of all sewage flows from the Mullica River basin to the Delaware River basin has the greatest impact on the flow of streams entering Wharton State Forest. Within basin discharge of treated effluent does increase nutrient loads in receiving basins, but this impact can be directed towards streams which have less relative (compared to other subbasins in the Mullica River basin) resource value.

The approach which minimizes overall impacts to the Mullica River basin includes:

1. a reduction in sewage flows generated within Pinelands growth areas (maximum of 2.6 mgd accomplished through downzoning);

2. preservation of streamflows in the Sleeper Branch system and the Mullica River basin by supplying water to these basins from regional wells located in the Pump Branch and/or Upper Great Swamp Branch;

3. transferring sewage generated in the Sleeper Branch system and the Mullica River basin out of these basins;

4. recharging sewage flows in the Pump Branch and/or Upper Great Swamp in an amount comparable to within subbasin water demands;

5. transferring remaining flows to the Delaware River basin for disposal; and

6. development of a regional water supply master plan in concert with 208 management plans.

The last point is a critical one. In the absence of a coordinated water supply and sewage disposal plan, water balances within the affected subbasins cannot be achieved. The implementation of any of these alternatives must be accompanied by a comprehensive monitoring program to assess associated short-term and long-term impacts on the water resources of the Mullica River basin.

REFERENCES

Brown, K.W., and Associates, 1980. An Assessment of the Impacts of Septic Leach Fields, Home Lawn Fertilization, and Agricultural Activities on Ground Water Quality, K.W. Brown and Associates, Route 5, Box 877, College Station, Texas.

Camden County Municipal Utilities Authority, 1986. Chesilhurst Borough, Waterford Township and Winslow Township: Wastewater Management Plans. CCMUA, Camden, NJ.

Doorenbos, J. and W.O. Pruitt, 1975. Guidelines for Predicting Crop Water Requirements, Food and Agriculture Organization of the United Nations, Rome, Italy.

Gillespie, B.D., and R.D. Schopp, 1982. Low-Flow Characteristics and Flow Duration of New Jersey Streams, U.S. Geological Survey Open-File Report 81-1110, U.S. Geological Survey, Trenton, NJ.

Hughes, H., B. Snowden, and S. Pacenca, 1985. Thornthwaite and Mather's Climatic Budget Method: An Implementation Using LOTUS 1-2-3 (TM) Spreadsheet Program (DRAFT), Center for Environmental Research, Cornell University, Ithaca, NY.

New Jersey Agricultural Experiment Station, No Date. Sprinkler Irrigation in New Jersey, New Jersey Agricultural Experiment Station, College of Agriculture and Environmental Science, Rutgers - The State University, New Brunswick, NJ.

New Jersey Pinelands Commission, 1980. Comprehensive Management Plan for the Pinelands National Reserve (National Parks and Recreation Act, 1978) and Pinelands Area (New Jersey Pinelands Protection Act, 1979). Pinelands Commission, New Lisbon, NJ.

New Jersey Pinelands Commission, 1987. An Assessment of Sewer and Water Supply Alternatives for Pinelands Growth Areas in the Mullica River Basin, Camden County. Draft Report, Pinelands Commission, New Lisbon, NJ.

Riggs, H.C., 1968. Some Statistical Tools in Hydrology: U.S. Geological Survey Techniques of Water Resources Investigations, Book 4, Chapter A1.

Thornthwaite, C.W., and J.R. Mather, 1957. Instructions and Tables for Computing Potential Evapotranspiration and Water Balance. Drexel Institute of Technology Publications in Climatology, Vol. 10, No. 3.

United States Environmental Protection Agency, 1975. Process Design Manual for Nitrogen Control.

United States Environmental Protection Agency, 1980. Design Manual, Onsite Wastewater Treatment and Disposal Systems, EPA-6251/1-80-012, USEPA, Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

United State Environmental Protection Agency, 1981. Process Design Manual for Land Application of Municipal Wastewater, USEPA, Center for Environmental Research Information, Cincinnati, Ohio.

United States Environmental Protection Agency, 1984. Process Design Manual for Land Application of Municipal Wastewater, Supplement on Rapid Infiltration and Overland Flow, EPA Center for Environmental Research Information, Cincinnati, Ohio.

Velnich, A.J., 1984. Drainage Areas in New Jersey: Atlantic Coastal Basins, South Amboy to Cape May, U.S. Geological Survey Open-File Report 84-150, U.S. Geological Survey, Trenton, NJ.

Zimmer, B.J., 1979. Nitrogen Dynamics in the Surface Waters of the New Jersey Pine Barrens, Ph.D. Thesis, Rutgers - The State University, New Brunswick, NJ.

The Pinelands Commission
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M E M O R A N D U M

DATE: June 8, 1988

TO: Members of the Commission

FROM: Terrence D. Moore
Executive Director

SUBJECT: Sewer and Water Supply Policies for Regional Growth Areas in the Mullica River Basin, Camden County

Enclosed for your review is our staff's final report entitled "An Assessment of Sewer and Water Supply Alternatives for Pinelands Growth Areas in the Mullica River Basin, Camden County". As you will recall, a draft of this technical report was released for comment in November, 1987.

Background

Although the report itself presents a more detailed historical perspective, the assessment is an outgrowth of various plans outlined by Camden County and the municipalities of Winslow, Chesilhurst, and Waterford to provide sewer service to designated growth areas within the Mullica River Basin. The report seeks to analyze various alternatives to determine relative impacts and to develop recommendations which the Commission may wish to consider in an effort to address major environmental issues of concern.

Need for Commission Action

Although the technical report itself requires no action on the part of the Commission, there is a need for the Commission to consider what, if any, policies are appropriate in order to establish a framework within which sewer and water supply planning can be based.

The need for a comprehensive Commission policy becomes evident when one considers three long standing objectives of the Commission which, in this particular case, conflict with each other.

- o Regional Growth Areas have been identified in various portions of the Pinelands as a means to accommodate growth influences without destroying the essential character of the Pinelands. Portions of Chesilhurst, Waterford and Winslow have been identified as Growth Areas and can not reach their development potential without central sewer service.

- o To protect water quality, stringent discharge standards have been established. Even with these standards in place, the discharge of large amounts of treated sewer effluent can substantially increase the total loading of pollutants in important basins. For this reason and others, the Camden County Municipal Utilities Authority initially proposed that wastewater be transferred out of the Mullica Basin for treatment at its Camden facility.

- o To maintain water balances, the Commission has worked to minimize transfers of ground and surface water from the Pinelands. Although treatment and disposal of the sewer effluent within the Pinelands would address this, pollutant loading would increase and the hydrology of individual subbasins within the Mullica could be affected.

<u>Recommended Policy</u>

As the report indicates, an alternative has been identified which addresses, in large part, each of these competing objectives. That alternative is one which:

- o Continues to recognize the growth areas of Chesilhurst, Waterford and Winslow but requires that future development potential be reduced to lessen the stress on the area's water resources.

- o Minimizes environmental impacts through the strategic location of water supply wells and by transferring a portion, but not all, of the wastewater out of the Mullica Basin for treatment and disposal.

Specific Issues to be Addressed

1) Monitoring Potential Impacts. The report utilizes several different methodologies to estimate potential impacts. Although no better methodologies are available, a question exists as to whether the impacts may ultimately prove to be overstated or understated. In order to continually evaluate the policies to be established, a program to monitor actual impacts is advisable. From a policy standpoint, the paramount question is who should be responsible for designing and implementing the monitoring program.

2) Future Sewer and Water Demands. The report estimates that a total demand for sewer collection and treatment in the growth areas may amount to 3.3 mgd once they are "fully" developed. Of this, 2.6 mgd would be attributable to future development. Total water supply demand is estimated to be 3.9 mgd, of which 3.1 mgd would be to service future development.

   The report concludes that these total demands will overly stress the system and should be reduced to 2.6 mgd in total sewer flow (of which 1.9 mgd is for future development) and 3.1 mgd total water demand (of which 2.3 mgd is for future development).

   Although precise projections of future demands is speculative, it does seem clear that existing land use policies will eventually lead to higher demands and greater ecological impacts than are considered prudent. The primary question facing the Commission is whether steps should be taken now to change land use policies to avoid the potential for overdevelopment, even though total demands will not be reached for several decades.

3) Water Supply. From a hydrologic standpoint, certain subbasins have been found to be more critical than others. Even with reduced demand, the report concludes that sewering plans must be coupled with sound and comprehensive water supply planning.

   The questions facing the Commission are whether a comprehensive water supply plan should be developed now, by whom, and how its development and implementation should be related to sewer plans.

4) Sewering Plans. Although the assessment has shown that an approach which combines in-basin and out-of-basin treatment and disposal is preferable, a major question exists as to how the approach should be implemented.

Since the estimated flows will not be reached for decades and a monitoring program might indicate a need to revise the approach in the meantime, what steps should be taken in the short term to address what is acknowledged as a long term issue?

Recommendations

Based upon my analysis of the report and recent correspondence received from the Camden County Municipal Utilities Authority and the Waterford Township Municipal Utilities Authority (copies attached), I believe that the Commission should adopt a comprehensive set of policies to address the long term issues raised in the report. These policies should establish a framework now to deal with the long term land use, water supply, and wastewater treatment issues. However, I recommend that the Commission also recognize that implementation of these policies should be staged over time and that, with a comprehensive monitoring program in place, better data can be obtained which may lead to a refinement and re-examination of those policies in the future.

My specific recommendations follow:

1) Monitoring: The Commission should require that a long term monitoring program be instituted as part of any sewer or water supply project. It is likely that a sewering proposal will be the first capital project to be considered; thus, the development and approval of a program to monitor water quality and hydrologic impacts within the study area should be a pre-condition for Commission approval of such a proposal. In practical terms, the Camden County Municipal Utilities Authority (CCMUA) would assume responsibility for developing and implementing the monitoring program.

2) Future Sewer and Water Demands: The Commission should move to reduce future development potential within the three primary growth areas (Winslow, Waterford, and Chesilhurst). This should be accomplished by reducing the densities permitted in municipal zoning ordinances. Since precise development projections from an analysis of zoning schemes is an inexact science, I recommend that the Commission establish an immediate goal of reducing future growth area zone capacities by an

average of 25%. Our staff would then monitor development trends in comparison to these revised zoning standards to determine if further adjustments are necessary in the future.

3) Water Supply: A comprehensive water supply plan for the region must be developed. The plan must either avoid the Cohansey aquifer as a water supply source or, if the Cohansey is used, site a supply system in the Pump Branch subbasin. The plan must also address water distribution systems and identify how the entire system should be constructed and operated.

The Camden County Municipal Utilities Authority should be responsible for development of the plan. Completion of the plan within one year should be a condition imposed upon the Commission's approval of a sewering project.

4) Sewer Service: The Commission should approve a wastewater management plan for the region which:

- expressly limits the transfer of effluent from the Mullica River Basin to 1.2 mgd.

- proposes to treat and dispose of any effluent flows above 1.2 mdg within the Basin. Future siting of a suitable disposal area should be limited to the Pump Branch subbasin.

- acknowledges the Camden County Municipal Utilities Authority's role in water monitoring and water supply planning.

Once the wastewater management plan is completed, the Commission could approve the construction of an interceptor to transfer up to 1.2 mgd of effluent from the Mullica Basin to the CCMUA treatment facility in the Delaware Basin. Approval of the interceptor would be subject to various construction safeguards and conditions to prevent additional sewer flows without the expressed approval of the Commission. Treatment of the excess effluent within the basin would be viewed as the second stage of implementation and can be re-examined based upon the results of the monitoring program.

We will be drafting a resolution for consideration at your July 8 meeting. In the meantime, I am also providing copies of the report and my recommendations to those parties which have been directly involved in this issue.

TDM/JCS/km/P3D

Attachments

cc: Mr. Engelbert, Camden County Municipal Utilities Authority
Mr. Aldo Cevallos, Camden County Municipal Utilities Authority
Mayor Edward J. Cuneo, Jr., Winslow Township
Mayor Charles J. Arsenault, Waterford Township
Mayor Edward Wanzer, Chesilhurst Borough
Mr. Greg Boyle, Waterford Township Municipal Utilities Authority
Mr. Gregory Marshall, Department of Environmental Protection
Mr. Barry Chalofsky, Department of Environmental Protection
Ms. Barbara Ann Kurtz, Department of Environmental Protection
Mr. Robert Schopp, United States Geological Survey
Mr. Michael Ontko, Delaware Valley Regional Planning Commission
Mr. Gerald Hansler, Delaware River Basin Commission
Mr. Al Churchill, Churchill Associates

RESOLUTION OF THE NEW JERSEY PINELANDS COMMISSION

No. PC4-88-65 Date of Introduction 7/8/88

Title

RESOLUTION Setting Forth Pinelands Commission Policies for Sewer and Water Supply Planning Within the Mullica River Basin, Camden County

Commissioner Hogan presents the following Resolution:

WHEREAS, a technical analysis of wastewater treatment and water supply alternatives for the Mullica River Basin, Camden County was undertaken by the Pinelands Commission staff in May, 1987; and

WHEREAS, a draft technical report was distributed for review and comment in November, 1987; and

WHEREAS, a final technical report was issued in May, 1988; and

WHEREAS, the Pinelands Comprehensive Management Plan designates portions of Waterford and Winslow Townships and all of Chesilhurst Borough as Regional Growth Areas; and

WHEREAS, Regional Growth Area designations contemplate centralized wastewater treatment as a means to accommodate the wastewater generated by the anticipated development; and

WHEREAS, careful planning for centralized wastewater treatment is necessary if such development is to be accommodated in a manner which does not significantly affect important ecological resources; and

WHEREAS, the technical report concludes that, if the future levels of development within the Regional Growth Areas are reduced and a sound water supply program is instituted, central sewer service can be provided to these Regional Growth Areas; and

WHEREAS, the Executive Director has submitted a memorandum dated June 8, 1988 wherein the Commission is encouraged to adopt a set of policies to establish a framework upon which sound and comprehensive sewer and water supply planning can be based; and

WHEREAS, the Commission has determined that the technical report and the Executive Director's recommendations establish such a framework.

NOW, THEREFORE BE IT RESOLVED that the Pinelands Commission hereby adopts the following policies with respect to wastewater treatment and water supply planning for the Mullica River Basin, Camden County:

1. Future zone capacities within the Regional Growth Areas of Winslow, Waterford, and Chesilhurst which are located within the Mullica River Basin must be reduced by twenty-five percent, such reduction to be accomplished by each municipality through adoption of amendments to its zoning ordinance.

2. A comprehensive water supply and distribution plan for these Regional Growth Areas be developed by the Camden County Municipal Utilities Authority and such plan must provide that any central water supply system which

relies upon the Cohansey formation be located within the Pump Branch subbasin in a manner that minimizes stream flow reductions within the basin.

3. A wastewater management plan be developed by the Camden County Municipal Utilities Authority which proposes to manage a total of 2.6 mgd of effluent, of which 1.4 mgd shall be slated for disposal within the Pump Branch subbasin. Said plan shall recognize the need to develop and implement a sound and comprehensive water supply and distribution plan, and recognize the need for a long term stream monitoring program to provide detailed data on stream flows and water quality.

4. An application for the development of interceptor facilities to transfer up to 1.2 mgd of effluent for treatment and disposal outside of the Mullica River Basin can, subject to Comprehensive Management Plan development standards, be considered for approval as the first phase of implementing the comprehensive wastewater management plan. Such application shall not be considered for approval, however, until the Executive Director has approved an independent, comprehensive long term stream monitoring program which the Camden County Municipal Utilities Authority will implement, unless the Camden County Municipal Utilities Authority has expressly committed itself to the development of a water supply and distribution plan no later than one year following approval of such application, and unless such application includes adequate design and construction measures to prevent the transfer of wastewater from the Mullica River Basin over and above 1.2 mgd without the expressed approval of the Commission.

BE IT FURTHER RESOLVED that the Executive Director is authorized to cooperate with the Camden County Municipal Utilities Authority, the Townships of Waterford and Winslow, the Borough of Chesilhurst, the Department of Environmental Protection, and any other agency to implement these policies and to undertake such long term staff projects as are necessary to monitor development trends and analyze environmental impacts in the Mullica Basin.

Record of Commission Votes

Commissioners	AYE	NAY	NP	ABS	Commissioners	AYE	NAY	NP	ABS	Commissioners	AYE	NAY	NP	ABS
Ashmun	X				Coleman	X				Lefke	X			
Auerbach S	X				Darlington					McFadden	X			
Avery	X				Hogan	X				Norcross	X			
Brown			X		Hyres			X		Snyder	X			
Chavooshian	X				Lee			X		Sullivan	X			

Adopted at a meeting of the Pinelands Commission Date: July 8, 1988

Executive Director

Chairman