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TAYLOR CREEK HEADWATERS PROJECT

PHASE I REPORT; WATER QUALITY

by

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PREFACE

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ACKNOWLEDGEMENTS

Over the past 25 years the Taylor Creek watershed has been extensively studied and well documented by various state and federal agencies. It has been these studies along with the initial funding for the Taylor Creek Headwaters Project by the Coordinating Council for the Restoration of the Kissimme River Valley and Taylor Creek/Nubbin Slough Basin that have led to the development and implementation of best management practices (BMP's) throughout the basin.

Due to the considerable amounts of hydrologic and water quality data compiled over this period, material in this report will serve as a supplement for future analysis and provide additional baseline information preceding BMP implementation.

The authors wish to recognize the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, the IFAS Extension Service and most importantly the landowners in the Taylor Creek/Nubbin Slough Basin for their spirit and cooperation in the development and implementation of best management practices.

Special thanks go to Mr. Alan Goldstein and Mr. Fred Davis for their helpful critique of the draft report as well as to Elaine Rankin for her conscientious field efforts and graphic aid.

INTRODUCTION

Over the past two decades, the Taylor Creek/Nubbin Slough watershed (Figure 1) has evolved into a major agricultural area with emphasis on dairy farming. Due to the influx of dairy, beef cattle and citrus operations along this watershed, it has become a concern as to how these agricultural practices have affected the overall water quality of the basin and in turn, Lake Okeechobee. A recent study by Federico et al. (1981) concerning the eutrophication of Lake Okeechobee points out that the Taylor Creek/Nubbin Slough watershed (on an annual basis) contributes about 30% of the phosphorus and 5% of the nitrogen to the lake while contributing only 4% of the total water budget. This contribution of phosphorus is greater than that of any of the other tributaries that supply the lake, including the Kissimmee River. The nutrient enrichment of this watershed has been identified as a result of both agricultural point and non-point source pollution, primarily from dairy operations within the basin. Non-point sources are generally runoff from grazing pastures and dairy staging areas near milking barns, and the unrestricted access of cattle to the open channel and their tributary ditches. The animals utilize these watercourses for drinking and to alleviate heat stress. High nutrient concentrations (nitrogen and phosphorus) have been attributed to the discharge of feces and urine from dairy and beef cattle which have direct access and are predisposed to standing in and around these waterways. Because of the unspecific nature of non-point pollution, it becomes more difficult to control than point sources. Point sources generally occur due to improper maintenance of wastewater systems in and around dairy operations. These systems include lagoons, degraded drainage

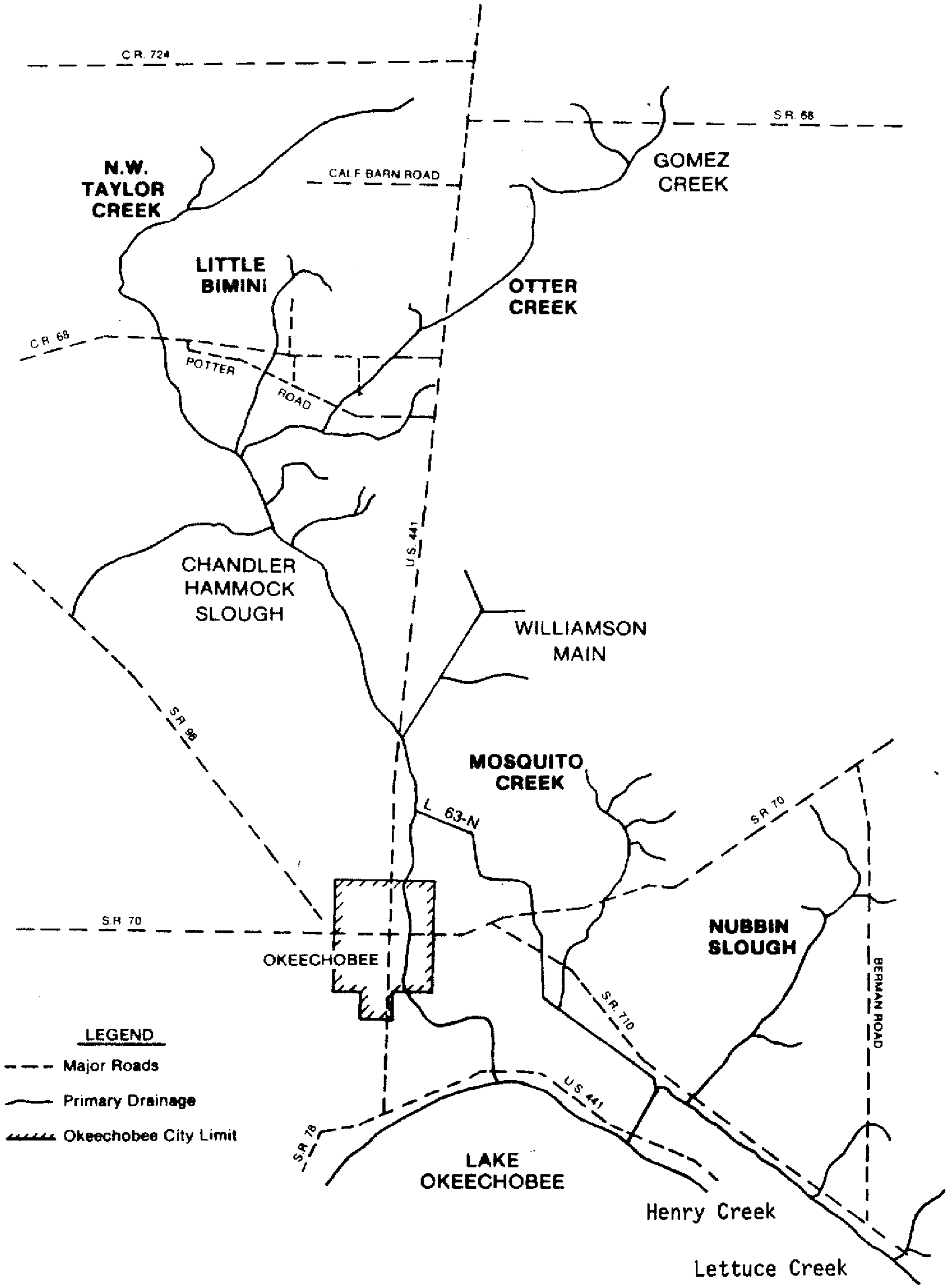

Figure 1. Taylor Creek/Nubbin Slough Watershed

ditches, and improperly functioning seepage fields due to high water tables in this area.

Early chemical and biological investigations on Lake Okeechobee by Joyner (1971), Davis and Marshall (1975), the report concerning the special project to prevent the eutrophication of Lake Okeechobee by MacGill et al. (1976), along with water quality studies within the Taylor Creek/Nubbin Slough basin by Allen et al. (1976), Stewart et al. (1978), and Federico (1977), have documented the need and provided the emphasis for the establishment of two programs designed to institute the use of best management practices (BMP's) aimed at alleviating the water quality problems of this area. These programs are: 1) The Taylor Creek Headwaters Program (TCHW) which provides 100% of the cost for landowners to install BMP's in the Taylor Creek headwaters area, and 2) a Federal Rural Clean Waters Program (RCWP) that provides 75% cost sharing with landowners to implement BMP's over the entire Taylor Creek/Nubbin Slough basin.

The initial TCHW and more recent RCWP programs are designed to address non-point pollution sources in order to evaluate the effectiveness of BMP's in alleviating high nitrogen and phosphorus loads. The incorporation of the following BMP's: 1) fencing, 2) watering facilities, 3) shade structures, 4) detention areas, and 5) water conservation practices will determine whether or not nutrient loads can be controlled and if so, what impact will this have on the water quality of the Taylor Creek/Nubbin Slough basin and in turn, Lake Okeechobee. BMP's suggested for installation and use in the RCWP and TCHW programs were introduced by the Coordinating Council for the Restoration of the Kissimmee River Valley and Taylor Creek/ Nubbin Slough Basin (KRVCC). Efficient wastewater utilization, fencing cows out of the open channels, and better herd rotation were suggested by Baldwin

(1975) in a report dealing with non-point source agricultural pollution as well as management alternatives for non-point pollution abatement in the Okeechobee-Kissimmee basin. The rationale behind these types of BMP's were adapted from standard SCS soil erosion practices that have been employed in agricultural pollution problem areas throughout the country. However, modifications of these practices were made in order to address the specific nutrient problems that plague south Florida (i.e., waste management, water conservation, and herd sizes).

HISTORICAL PERSPECTIVE

The Taylor Creek/Nubbin Slough watershed has been studied hydrologically since 1955. The initial investigations began from a formal arrangement between the U. S. Department of Agriculture's Agricultural Research Service (ARS), the Central & Southern Florida Flood Control District (presently the South Florida Water Management District), and the University of Florida Agricultural Experiment Station (FAES) to perform cooperative hydrologic research throughout the basin (Speir et al., 1969).

This watershed was selected for hydrologic research because: 1) it was a part of a larger area contained within the Central and Southern Florida Flood Control District; 2) there was a need by the Soil Conservation Service (SCS) and the Central & Southern Florida Flood Control District for hydrologic data from a natural watershed; and 3) the SCS had requested improvement works to enhance drainage and maintain water level control under Public Law 566 (Knisel et al., 1981).

From 1962 to 1968, Taylor Creek along with its major tributaries (N. W. Taylor Creek, Little Bimini, and Otter Creek) underwent development of extensive channelization as outlined in the "Work Plan for the Taylor Creek

Watershed" (Table 1). This plan was submitted in May 1959 by the SCS and funded under PL 566, providing landowners with watershed protection and flood control. By 1969, all construction and channel improvements were complete and operable, including three tainter-gate water management structures that were to be operated and maintained by the Okeechobee County Road Department (Knisel et al., 1981). Before the channelization effort, this area was inundated during the rainy season (June-September) with standing water. This presented severe drainage problems for many of the local landowners who had settled in the basin over the mid-fifties. The channel improvements and drainage systems outlined in the Taylor Creek work plan provided needed relief in that this watershed could now be easily drained and thus provide more useable land area for agricultural practices (i.e., dairy and beef cattle utilization) throughout the year. However, by solving drainage and flood relief problems, others were created. Storm hydrograph peaks occurred earlier and peak flow rates were higher after watershed channel and control structure treatments, and storm discharge receded more rapidly (Knisel et al., 1982; Yates et al., 1982). These drainage systems and channels now provided a direct route for nutrient discharge into the main waterways. Nutrients in the form of nitrogen (N) and phosphorus (P) that generally remained on the land long enough for uptake through plants, denitrification and return to the atmosphere (N) or soil adsorption (P) now had direct runoff routes through the primary and secondary drainage systems creating a water quality problem not only for Taylor Creek, but Lake Okeechobee as well.

This water quality problem became more evident in one of the early lake studies by Joyner (1971) which indicated that Lake Okeechobee was receiving considerable amounts of nutrient loads from its various

TABLE 1. Outlined Work Plan for the Taylor Creek Watershed[1] Presented by the Okeechobee Soil and Water Conservation District in May 1959[2].

I. LAND TREATMENT

A. WATERSHED PROTECTION

1. Pasture Planting, 3,268 hectares (8,073 acres)

2. Open Drains, 399.3 kilometers (248 miles)

3. Irrigation Pumping Plants (8)

B. FLOOD PREVENTION - DROP SPILLWAYS (33 pipe arch spillways)

II. STRUCTURAL MEASURES

A. CHANNEL IMPROVEMENTS, 48.1 kilometers (29.9 miles)

B. DROP SPILLWAYS

1. Twenty Single Purpose Drop Spillways for Grade Control

2. Six Drop Spillways for Water Management

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[1]This is a summary of the original work plan as presented by the Okeechobee Soil and Water Conservation District in 1959. Due to the agricultural growth (mainly dairy farming) within the project area between the time the work plan was completed and actual construction took place, several amendments or modifications to this plan were necessary to accommodate this agricultural growth. These amendments can be summarized as follows:

1. November 1961 - delete water management facilities from structure number 7 at the outlet of Williamson Ditch.
2. January 1962 - provide 0.3 km (0.2 miles) of channel improvement from the main channel up to drop spillway number 4 on Airport Ditch.
3. March 1963 -
   a. extend the main Otter Creek channel 4.7 km (2.9 miles)
   b. extend Wolf Slough channel 7.9 km (4.9 miles)
   c. add two grade stabilization structures
   d. relocate structure number 2
   e. eliminate four additional structures (10, 11, 12, and 18)
   f. delete 33 pipe drop spillways from land treatment for flood protection.

[2]A more detailed constructural as well as economic evaluation can be found in the "Work Plan for Taylor Creek, Okeechobee, Florida", May 1959. The amendment supplements are also included in this document.

tributaries. A follow-up study by Davis and Marshall (1975) indicated that the major contribution of P to Lake Okeechobee was coming from the Taylor Creek/Nubbin Slough area. These early reports provided evidence that the Taylor Creek/Nubbin Slough watershed was contributing to the nutrient enrichment of Lake Okeechobee. By 1972, the first water quality survey been performed in this watershed by the ARS. The objectives of this survey had by Allen et al. (1976) were: 1) to determine water quality of groundwater and open channel flows; 2) to estimate nutrient loads from the watershed and subwatersheds; 3) to relate water quality and nutrient loads to watershed hydrology and land use factors. Stewart et al. (1978) conducted a follow-up water quality survey that began in March 1974. In each of these two reports, water samples were measured for ortho phosphorus, nitrate-N, conductivity, and pH. Both studies indicated that high nutrient loads in the watershed were attributed to various agricultural practices such as cattle ranching, dairy farming, and citrus operations. Among these practices, dairy farming seemed to be the heaviest contributor of nutrients, mainly phosphorus. In addition, these studies pointed out that of the six tributaries or subwatersheds examined (N. W. Taylor Creek, Little Bimini, Otter Creek, Williamson Main Ditch, Mosquito Creek, Nubbin Slough), basin wide, Otter Creek was found to have the poorest water quality. This result is presumed to be due to the concentration of dairies (six) within this watershed.

Federico (1977) studied the relationship between landuse, rainfall, and runoff quality in the Taylor Creek/Nubbin Slough watershed. This study substantiated the earlier watershed investigations, finding that water quality problems were coming from agricultural practices and that Otter Creek was a major contributor to the overall nutrient enrichment of Taylor Creek/Nubbin Slough.

In summary, the following events led to the realization that development of best management practices (BMP's) was necessary in the Taylor Creek/Nubbin Slough watershed: 1) the primary channelization of the Taylor Creek watershed to allow a rapid discharge of water from agricultural land under PL 566 and secondary drainage ditches developed by private landowners; 2) early lake studies showing that significant contributions of phosphorus were coming from the Taylor Creek/Nubbin Slough watershed; 3) early water quality studies indicating that the source of the nutrients (subunits within the watershed) were from agricultural operations, mainly dairy farming.

In 1978, the KRVCC initiated the Taylor Creek Headwaters Project (TCHW) (Figure 2) in order to deal with the nutrient enrichment of the Taylor Creek/Nubbin Slough basin. This project was designed to determine the effectiveness of BMP's through a water quality monitoring program. The funding of this project was allocated by the KRVCC through appropriations from the Florida Legislature in June of 1978. These funds provide a 100% cost-sharing of state funds for landowners in the project area to implement BMP's. In June 1979, a technical advisory committee[1] implemented a water quality sampling effort which provided a base for designing a water quality monitoring program in the TCHW project area. This network contained 19 water quality monitoring stations, in addition to the existing 11 ARS monitoring stations already established throughout the Taylor Creek/Nubbin Slough watershed. These two sampling networks were designed to complement each other and to provide water quality information throughout the entire watershed.

[1]Technical Advisory Committee, composed of representatives of several State and Federal agencies selected by the Coordinating Council for the Restoration of the Kissimmee River Valley and the Taylor Creek/Nubbin Slough Basin (KRVCC)

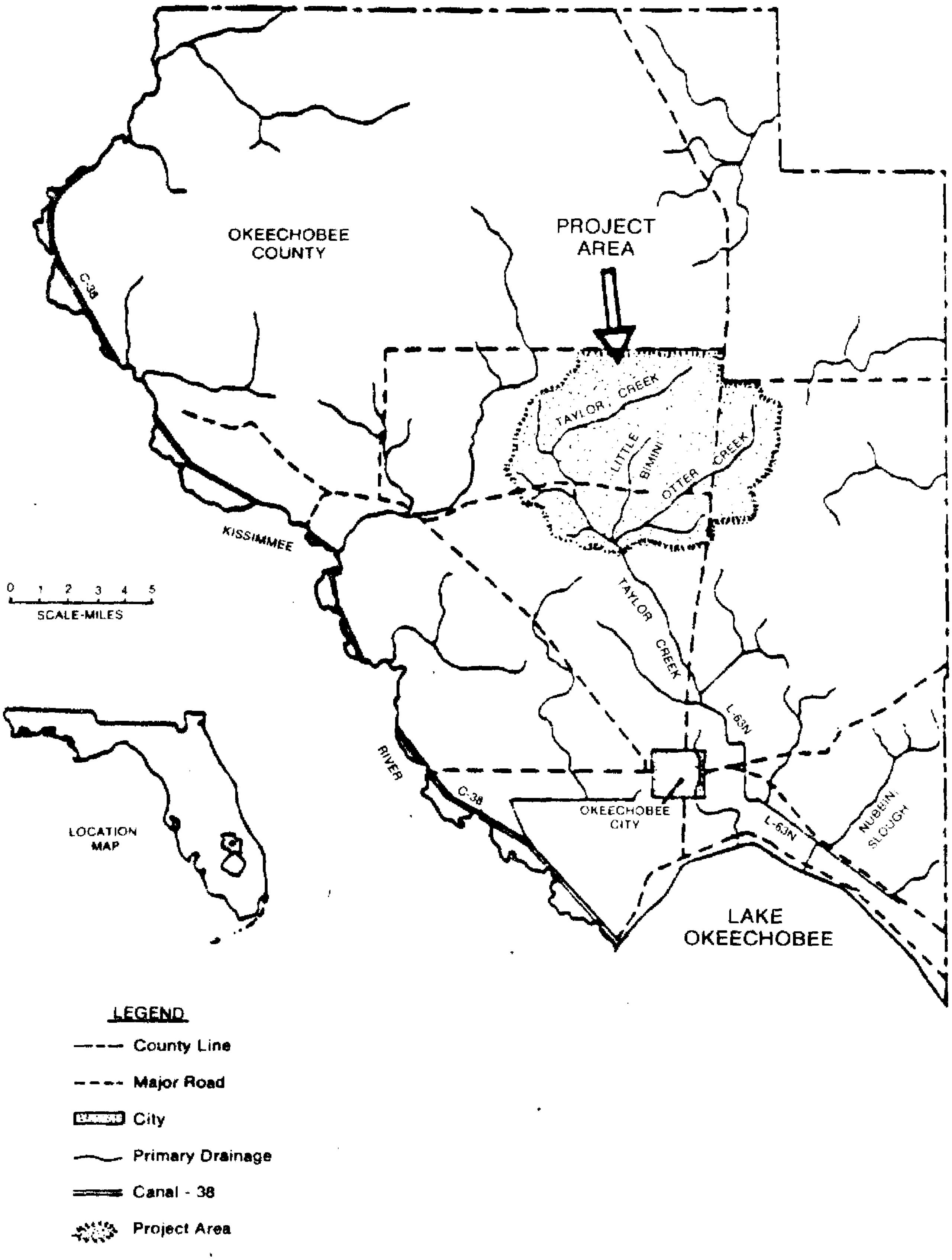


FIGURE 2. TAYLOR CREEK HEADWATERS PROJECT

In January of 1981, the KRVCC entered into a contractual agreement with the SFWMD that delegated the management and control of the TCHW project to the SFWMD. Simultaneously, the SFWMD entered into a contract with the Okeechobee Soil and Water Conservation District (SWCD) and the SCS for design, implementation, approval, and funding of BMP's in the TCHW project area. The initiation of the TCHW project was followed by the approval and funding of the Federal RCWP project application in July 1981 that was submitted by the Okeechobee County office of the USDA's Agricultural Stabilization and Conservation Service (ASCS). In addition to the efforts of the ASCS office, the KRVCC was also very active in the RCWP application procedure. This separate project expands the principal TCHW program, establishing a BMP implementation program throughout the entire Taylor Creek/Nubbin Slough watershed. The main goals of both projects are to establish BMP's that are designed to reduce nutrient loads to streams in the watershed, and in turn reduce loads entering the receiving body of water, Lake Okeechobee. Unlike the TCHW project where implementation of BMP's is 100% cost shared with landowners, the RCWP project will be a cooperative effort between landowners and the Federal government. This program will pay 75% of the total cost of BMP's while landowners will pay the remaining 25%.

Currently, the TCHW and RCWP projects are in the planning, designing, and implementation phases of BMP's throughout the watershed. Implementation of BMP's in the TCHW project area is not expected to be completed until 1983, while final implementation under the RCWP area may not be completed until 1986.

DESCRIPTION OF PROJECT AREA

WATERSHEDS

The Taylor Creek drainage basin lies within Okeechobee County, north of Lake Okeechobee. In 1973, the discharge from 271 km^2 (104.5 square miles) upper Taylor Creek watershed (W-2) was diverted into a new 14 km (9 miles) SFWMD canal, L-63N, that intercepted Nubbin Slough and other flows (Mosquito Creek, Lettuce Creek, Henry Creek) and emptied into Lake Okeechobee at gate structure S-191 (Figure 3). This diversion formed a new 488 km^2 (188 square miles) hydrologic unit, the Taylor Creek/Nubbin Slough watershed (TCNS) (Allen et al., 1982b).

Upper Taylor Creek (W-2) is located approximately 24 km (15 miles) north of Okeechobee City. This watershed has four main subwatersheds: Williamson Main (W-5), N. W. Taylor Creek (W-3), Little Bimini (W-LB), and Otter Creek (W-13). Table 2 provides a summary of land areas by subwatersheds along with the total land area of W-2, Nubbin Slough, the TCHW project, and the TCNS watershed (RCWP project area). This information will be referenced in the hydrology section of this report.

TOPOGRAPHY

The TCNS watershed is relatively flat with elevations ranging from 21 m (70 feet) msl at the northernmost portions to 6 m (20 feet) msl at Lake Okeechobee. This watershed rests over four main terraces (Wicomico, Phenholoway, Talbot, and Pamlico), each of which forms a step or change in elevation. These terraces lie on two main geologic formations in Okeechobee County, the Fort Thompson and Caloosahatchee (McCollum and Pendleton, 1971). The dominant soil association throughout the basin is the Myakka-Bassinger association (Figure 4). Other associations found are the Pomello-Paola, Immokalee-Pompano, and Pompano-Charlotte-Delray-

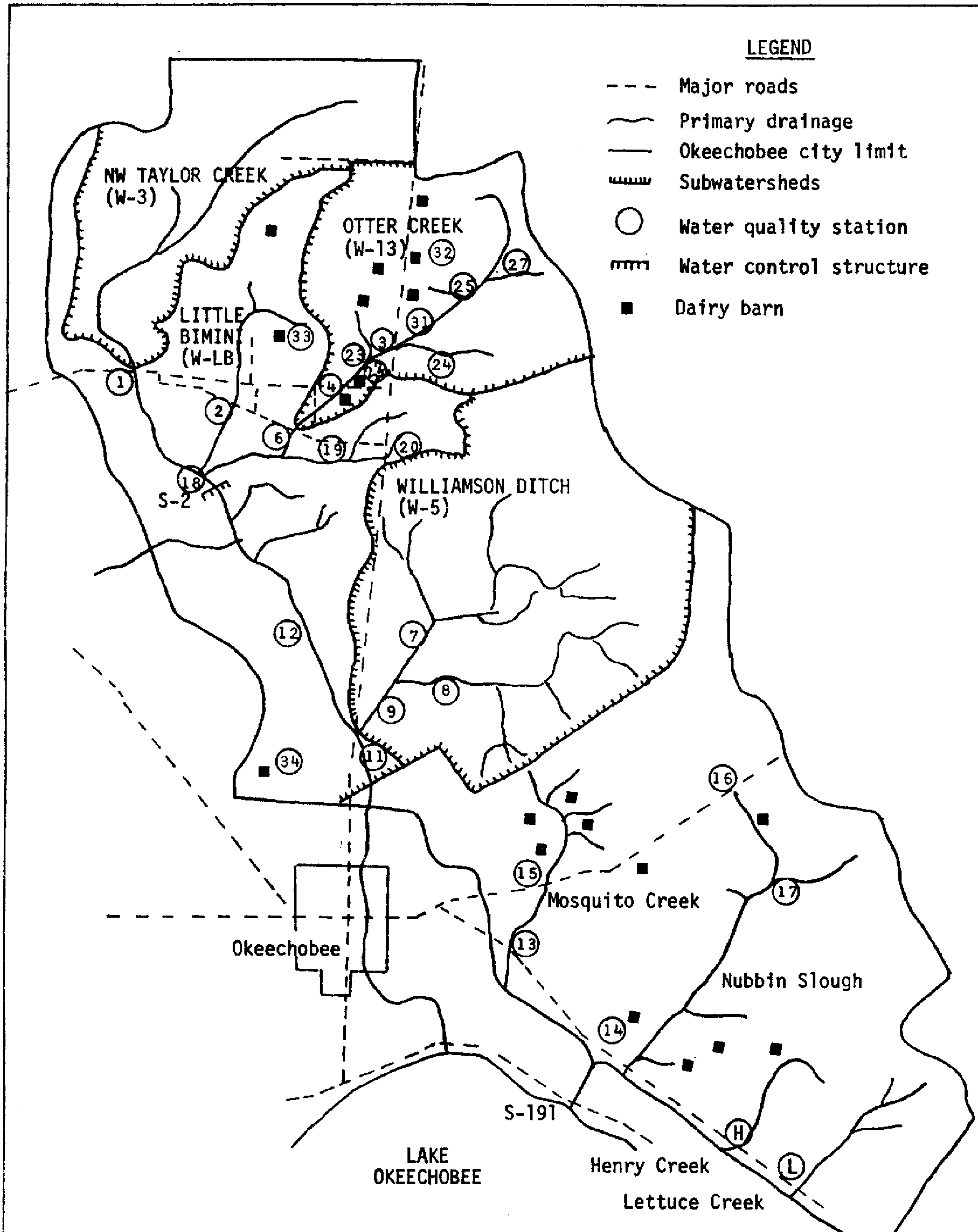


FIGURE 3. TAYLOR CREEK/NUBBIN SLOUGH WATERSHED

TABLE 2. Land areas for subwatersheds of W-2, total land area for W-2, Nubbin Slough, the TCHW Project and the entire TCNS watershed (RCWP), percent land area of W-2 and TCNS. (Most recent land areas from both ARS and SFWMD unpublished data)

Watershed	Acres	Mi^2	Km^2	Ha	W-2 Percent Land Area	TCNS Percent Land Area
W-2	66,866	104.5	270.6	27,060	100.0	55.5
W-5	21,026	32.8	85.1	8,509	31.4	17.5
W-RT[1]	11,031	17.3	44.6	4,465	16.6	9.2
W-3	12,203	19.1	49.4	4,938	18.3	10.1
W-13	7,127	11.1	28.8	2,884	10.6	5.9
W-LB	3,776	5.9	15.3	1,528	5.6	3.1
W-RH[2]	11,703	18.3	47.4	4,736	17.5	9.7
TCHW[3]	34,809	54.4	140.9	14,086	52.0	28.8
Nubbin Slough[4]	53,669	83.5	217.4	21,740		44.5
TCNS (RCWP)[5]	120,535	188.0	488.0	48,800		100.0

[1]W-RT is a remainder watershed below the TCHW Project. It is W-2 - (W-5 + TCHW).

[2]W-RH is a remainder watershed within TCHW. It is TCHW - (W-3 + W-13 + W-LB).

[3]TCHW is the Taylor Creek Headwaters Project area.

[4]Nubbin Slough represents the area draining into the L-63N canal below W-2. It is TCNS - W-2.

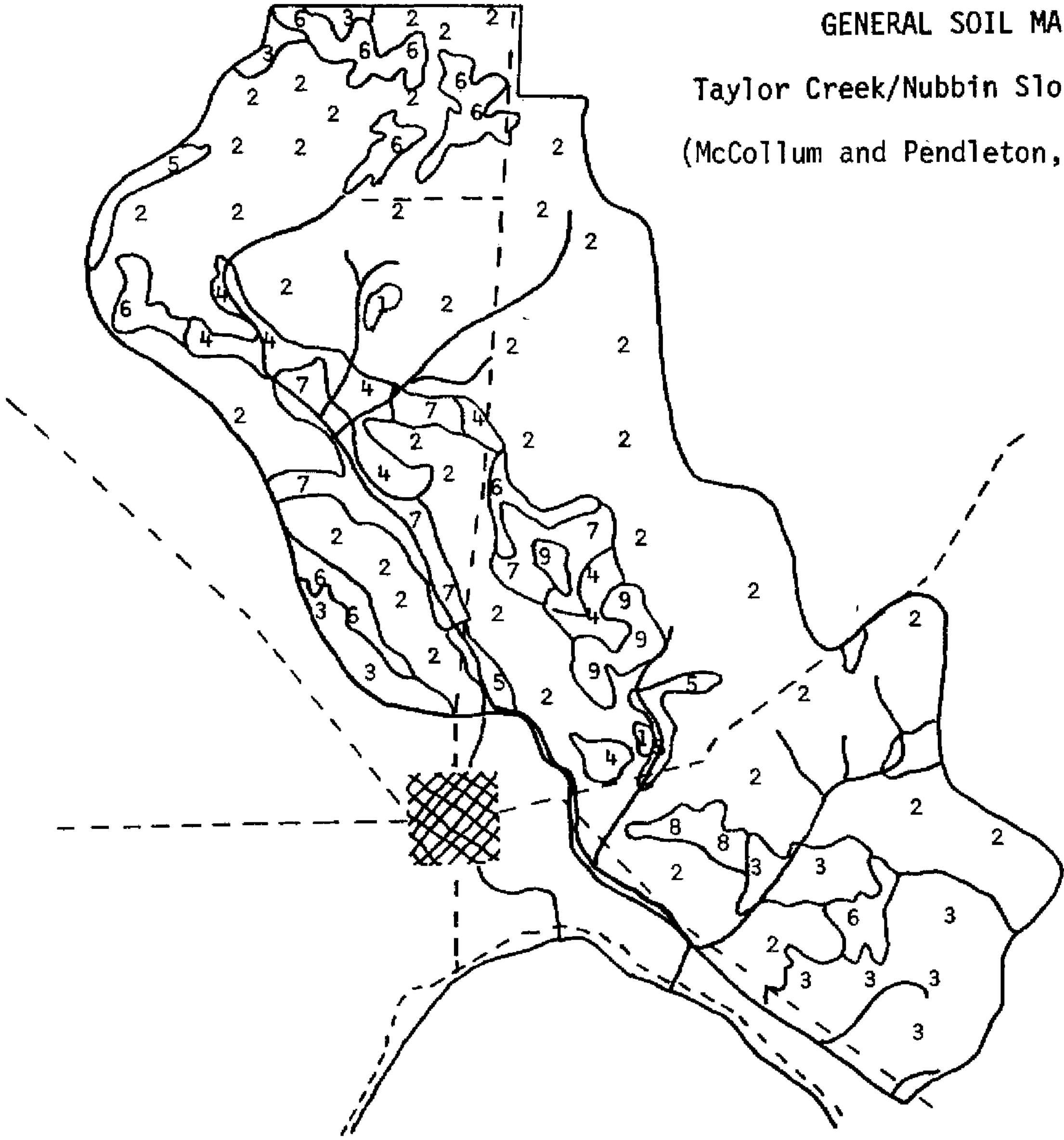
[5]TCNS is the entire Taylor Creek/Nubbin Slough watershed and represents the Rural Clean Waters Project area (RCWP).

FIGURE 4

GENERAL SOIL MAP

Taylor Creek/Nubbin Slough Basin

(McCollum and Pendleton, 1971)



Soil Associations

1 Pomello-Paola association
2 Myakka-Basinger association
3 Immokalee-Pompano association
4 Parkwood-Bradenton-Wabasso association
5 Placid-Pamlico-Delray association
6 Pompano-Charlotte-Delray-Immokalee association
7 Manatee-Delray-Okeelanta association
8 Felda-Wabasso association
9 Okeelanta-Delray-Pompano association

Immokalee. These all represent non-floodplain soils of the Phenholoway and Talbot terraces, and are poorly drained with the exception of the Pomello-Paola association which are moderately drained soils on low knolls and ridges. Associations found in low-lying areas and in the floodplains of the major streams are the Manatee-Delray-Okeelanta, Placid-Pamlico-Delray, and the Okeelanta-Delray-Pompano, all of which are very poorly drained organic soils. The Felda-Wabasso and Felda-Pompano-Parkwood represent a third class of soil associations that are poorly drained sandy soils lying in grassy sloughs and depressions. The most prevalent soils in the basin represented by the preceding associations are the Myakka and Immokalee soil types (McCollum and Pendleton, 1971).

Because the majority of the soil types in TCNS are poorly drained, localized flooding or waterlogging is common during a normal rainy season (June through September). The soils are generally sandy with a very small amount of clay-sized particles, low available water capacity when drained, high permeability in the surface layers, and low pH (4.5-5.5) (Allen et al., 1982).

LAND USE

As mentioned in the historical review, the upper Taylor Creek watershed (W-2) has been extensively ditched for pasture improvement (private land-owners) and open channel drainage (PL 566) providing for more rapid removal of surface water in an otherwise poorly drained area with high water tables. Figure 5 is an illustration of the TCHW project area and the extensive drainage within it. Because the soils have high infiltration rates, little surface runoff occurs until the soils become saturated during peak rainfall periods.

Land use in the TCNS watershed is generally improved pasture and

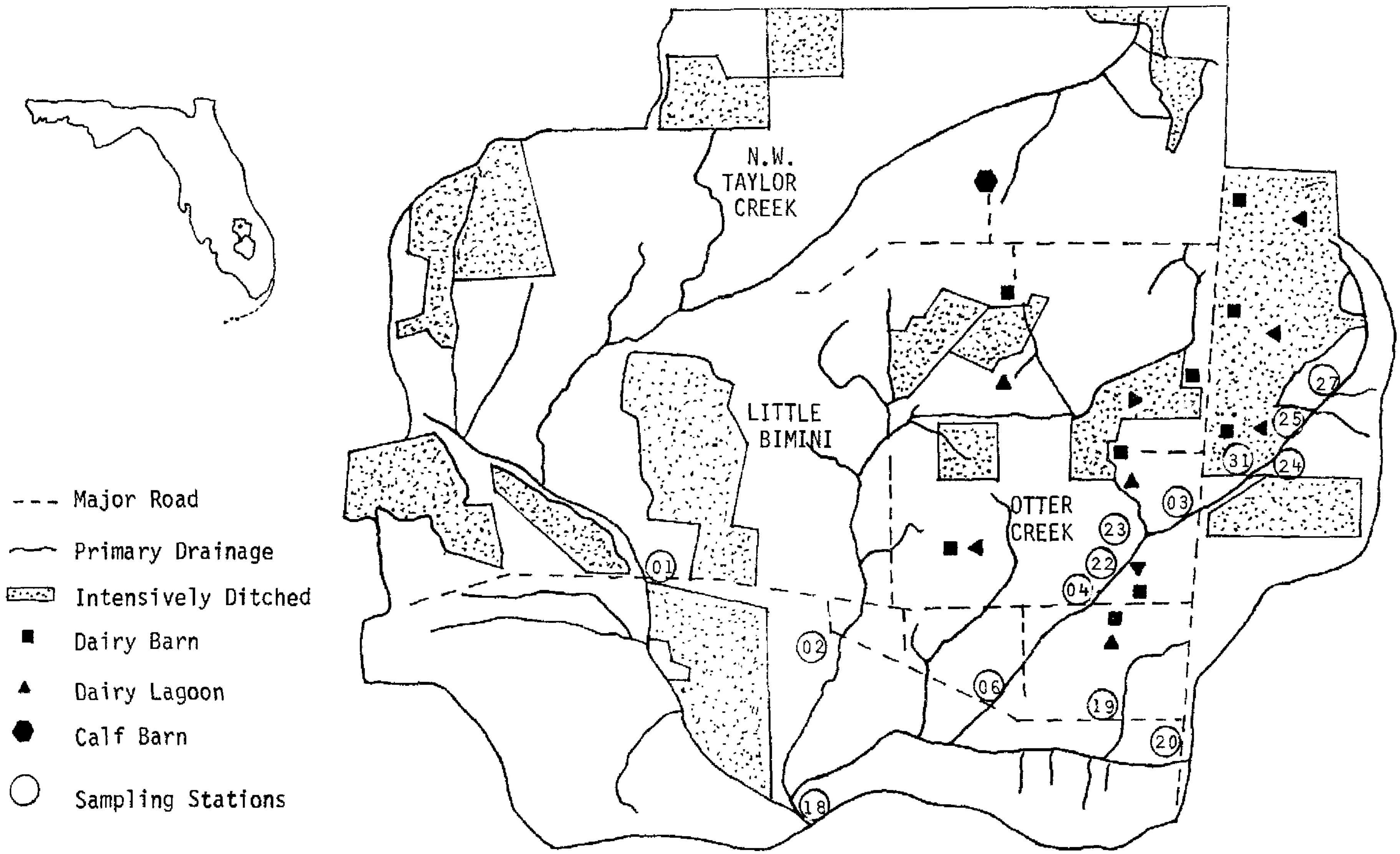


FIGURE 5. TAYLOR CREEK HEADWATERS PROJECT AREA

rangeland with scattered marshy cypress-type depressions. This early successional type habitat will support a wide variety of waterfowl, quail, turkey, deer, and wild hogs. Much of the pastureland varies from unimproved wire grass to improved productive domestic grass and clover pasture. The woodland areas vary from scattered pines to dense hammocks and swamps (U. S. Soil Conservation Service, 1959). Table 3 provides a breakdown of the land use patterns for upper Taylor Creek and Nubbin Slough for 1980, while Table 4 depicts changes in the land use patterns of upper Taylor Creek between 1959 and 1980.

As noted, TCNS supports several types of agricultural activities including beef cattle, dairy farming, and citrus (Tables 3 and 4). There are approximately 24 dairies operating in TCNS on 12,045 hectares (30,000 acres). These operations are milking more than 23,000 cows with an additional 5,000 animals on the dairies at any given time, mostly dry cows and springers. The majority of the dairies are concentrated in Otter Creek, Mosquito Creek, and Nubbin Slough. Approximately 19,838 hectares (49,000 acres; 56 farms) of the basin are used for beef production, grazing around 25,000 head. There are about 729 hectares (1,800 acres) of citrus grown in TCNS. Much of the citrus throughout the basin is found in the upper Taylor Creek watershed on one large holding (324 ha) at the confluence of N. W. Taylor Creek, Otter Creek, and Little Bimini. An additional 405 hectares (1,000 acres) are located in the Williamson Ditch watershed (Figure 3).

Short-term vegetable farming (watermelons and tomatoes) can also be found in TCNS. Vegetable growers generally lease tracks of land and install extensive drainage and irrigation systems. Soil-born diseases and nematodes usually invade these systems, so growers tend to move on to other areas after a year or two. This land is often converted into improved pasture by the rancher.

TABLE 3. 1980[1] land use for the Taylor Creek and Nubbin Slough watersheds.

Land Use	Upper Taylor Hectares	Upper Taylor Percentage[2]	Nubbin Slough Hectares	Nubbin Slough Percentage
Citrus	727	3%	3	-
Improved Pasture	18,768	69%	14,317	67%
Forest & Range	4,209	16%	6,625	30%
Urban	1,281	4%	258	1%
Miscellaneous	2,056	8%	337	2%

[1]SFWMD unpublished data.
[2]Percentages are based on total watershed areas for Upper Taylor Creek and Nubbin Slough of 27,041 and 21,540 hectares, respectively. Land areas were computed by SFWMD personnel.

TABLE 4. Land use in Upper Taylor Creek for specified years from 1959-1972.

Land Use	1959[1] Hectares	1959[1] %[3]	1960[1] Hectares	1960[1] %	1962[1] Hectares	1962[1] %	1964[2] Hectares	1964[2] %	1968[2] Hectares	1968[2] %	1972[2] Hectares	1972[2] %
Citrus	-	-	-	-	405	1%	511	2%	511	2%	1,023	4%
Improved Pasture	6,073	24%	6,680	26%	7,895	31%	8,695	34%	10,230	40%	12,020	47%
Forest & Range	15,789	62%	15,020	59%	13,428	53%	14,066	55%	12,276	48%	9,974	39%
Urban	-	-	-	-	-	-	-	-	-	-	-	-
Miscellaneous	3,712	14%	3,874	15%	3,846	15%	2,302	9%	2,557	10%	2,557	10%

[1]Based on land use data presented in Speir, Mills and Stephens (1969).
[2]Based on land use data presented in Knisel, et al. (1982).
[3]Percentages are based on a total watershed area in Upper Taylor Creek of 25,574 hectares as computed by USDA-ARS personnel.

Presently, over 95% of the project area is devoted to agricultural uses; however, some increasing urban development is present throughout the basin[1] (Table 4).

CLIMATE

The TCNS basin is a subtropical watershed with average maximum temperature at 32.5° C (90° F) in the summer and average minimum temperature at 18.5° C (65° F) in the winter. The average annual temperature is around 23° C (73° F). Average Thiessen-weighted rainfall is 118.36 cm (46.60 inches) based on a twenty-year period of record (1956-1976) for six ARS rain stations located in the W-2 watershed (Figure 6). Thiessen weights are given in the section on Hydrologic Monitoring. Sixty percent of the 118.36 cm occurs during the months of June through September. Because of the high water tables, seasonal groundwater fluctuations will generally correspond with fluctuations in rainfall (Knisel et al., 1982; Allen et al., 1982a; Speir et al., 1969). Table 5 presents quarterly rainfall amounts for upper Taylor Creek and subwatersheds from 1978-1981. This table clearly illustrates that 50 to 60 percent of the rainfall occurs during the third quarter of the year. Note that during 1980 and 1981, rainfall averages in W-2 were far below the 20-year rainfall average (118.36 cm). This becomes an important variable when dealing with water quality concentrations over this two-year period.

[1]General land use information was obtained from the Rural Clean Waters Project applications from Okeechobee County as presented by the Okeechobee Agricultural Stabilization and Conservation Service.

FIGURE 6. Thiessen Weighted Rainfall for Upper Taylor Creek 1956-1976
(unpublished ARS data)

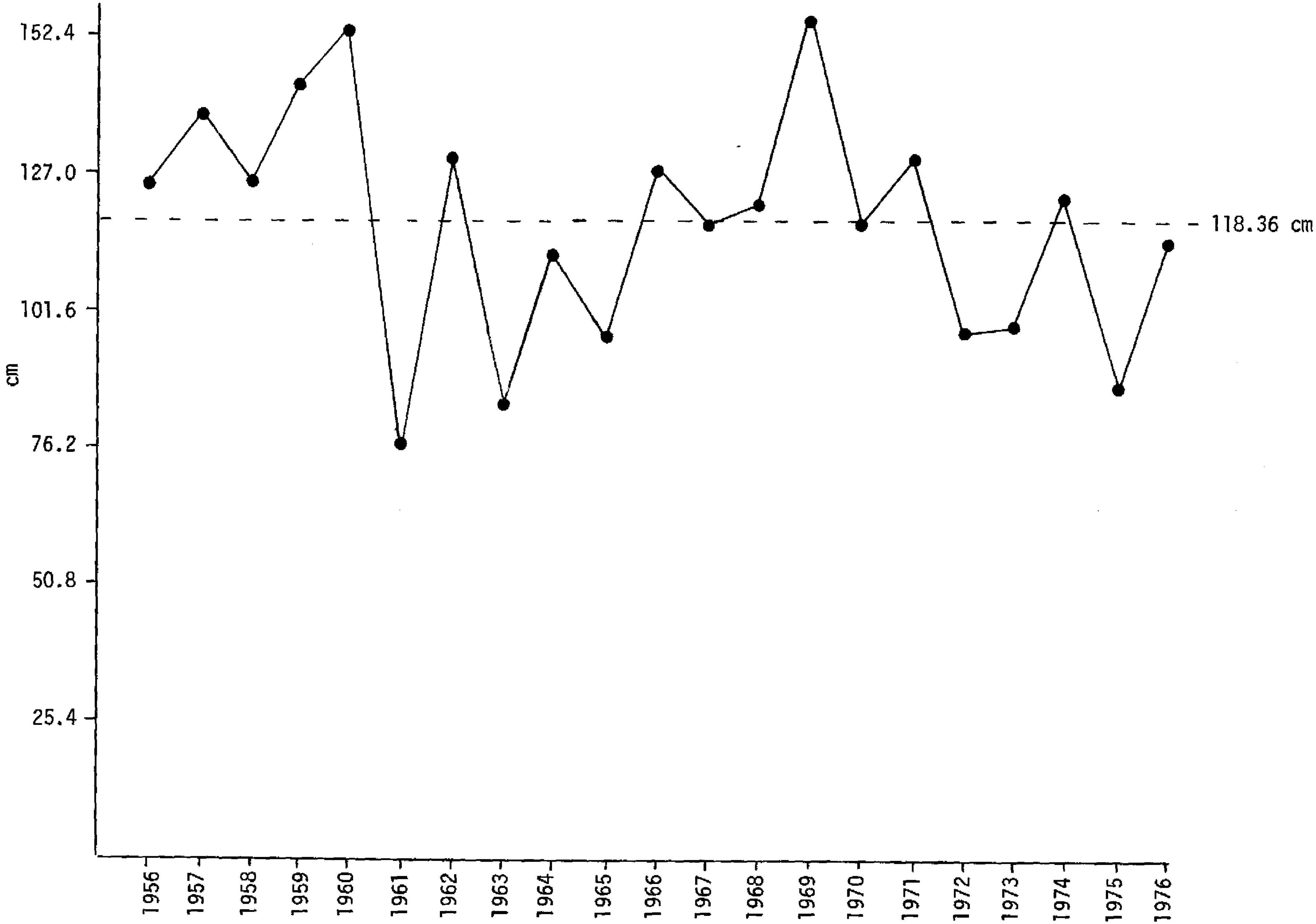


TABLE 5. Quarterly Thiessen Weighted Rainfall in Centimeters for the W-2 Watershed and Subwatersheds W-3, W-13, W-LB, and W-5 from 1978 to 1981. (unpublished ARS data)

YEAR	QUARTER	W-2	W-3	W-13	W-LB	W-5
1978	1	17.91	15.65	16.56	16.66	16.38
	2	30.05	37.31	38.05	25.88	36.65
	3	60.90	60.99	43.23	60.76	60.02
	4	19.23	21.59	15.37	22.96	18.72
		128.09	135.53	113.21	126.26	131.78
1979	1	20.37	16.43	21.29	25.15	15.24
	2	33.32	36.80	27.38	29.51	44.04
	3	76.61	82.19	84.71	83.44	66.78
	4	10.97	7.59	7.87	13.61	9.73
		141.27	143.03	141.25	151.71	135.79
1980	1	19.99	25.58	19.15	16.23	27.71
	2	21.97	32.56	30.53	15.67	22.73
	3	44.68	33.30	31.98	49.48	43.82
	4	15.11	13.89	9.86	12.93	16.10
		101.75	105.33	91.52	94.31	110.36
1981	1	9.68	13.18	9.91	10.39	8.41
	2	15.47	18.26	20.90	20.19	11.43
	3	54.53	55.25	57.76	50.88	55.63
	4	5.28	4.95	5.36	6.58	4.70
		84.96	91.64	93.93	88.04	80.16

IMPLEMENTATION OF PROJECT TO DATE

Various state and federal agencies are coordinating their efforts to provide maximum participation in both the TCHW and RCWP projects. These agencies and their responsibilities can be summarized as follows: 1) Agricultural Stabilization and Conservation provides contract coordination, issues funds, and acts as an intermediary for the Federal RCWP committee, local landowners, and other participating agencies; 2) SCS provides technical assistance, planning and designing water quality management plans for BMP implementation in both the RCWP and TCHW projects; 3) The County Extension Agency provides educational information to encourage total cooperation within both project areas; 4) SFWMD maintains a water quality monitoring program throughout the extent of both projects and provides state matching funds in the TCHW project to assure 100 percent cost-sharing to the landowners in this area; 5) Agricultural Research Service (ARS) provides hydrologic equipment and hydrologic data processing through the ARS-SFWMD cooperative research agreement of April 1, 1981.

Priorities under the original TCHW project were established by the SCS and the SFWMD. These were to: 1) begin planning and design work at the headwaters of each of the three subwatersheds (N. W. Taylor Creek, Little Bimini, Otter Creek); 2) implement BMP's on all dairies in the Otter Creek watershed; implement BMP's on all dairies in the Little Bimini watershed; 3) and finally, implement BMP's in the N. W. Taylor Creek watershed. The priorities established for the TCHW project were expanded under the new RCWP programs. The RCWP established the TCHW project area as number one priority, followed by the remainder of the dairies in TCNS, and the rest of the agricultural practices (beef cattle, citrus) in TCNS. These priorities will provide a framework for reviewing and implementing applications.

Landowners must visit the ASCS office to request or apply for an RCWP-TCHW water quality plan. Once applications for RCWP-TCHW are accepted, water quality work plans will be drawn up for a particular operation following the priorities guidelines established. The actual design and completion of a work plan follows a four-phase scheme: 1) Orientation - involves the initial contact with a landowner to describe the objectives of the project and request their cooperation; 2) Planning and Design - requires several on-site visits to the particular operation. These visits result in the creation of a planning map showing such things as existing fence lines, boundary lines, existing wells and watering facilities, along with proposed sites for BMP's (fencing, watering, shade, detention areas, and water conservation practices) installation. SCS engineers will use this map to develop a water quality management plan for the individual operation. Completion of the plan will enable engineers to determine approximate costs and identify areas for BMP implementation; 3) Landowner's Contracts - completion of the planning and design phase will initiate a final meeting with the landowner, the SCS, and other participating agencies (SFWMD, ASCS) and interested individuals to sign contracts of agreement for BMP implementation; 4) BMP Implementation - involves the actual construction of BMP's according to the prescribed management plan.

As noted earlier, BMP's to be used under the water quality management plans are fencing, watering, shade, detention, and water conservation practices. Sub-practices complementing these BMP's are dikes, land moothing, filter strips, and cattle crossings. The following provides a brief description of these prescribed BMP's. A more detailed description can be found in the U. S. Soil Conservation Service Standards and Specifications for the Okeechobee Field Office Technical Guide, Section 4 (Appendix 1).

1) Fencing - To exclude cattle from lounging in streambeds, alleviating any direct deposition of fecal materials.

2) Filter Strips - Vegetation strips such as pastures and grassed waterways. This will help control feedlot, dairy pasture, and storm runoff by providing natural nutrient sinks.

3) Land Smoothing - To remove shallow fill ditches, improve overland flow, surface drainage, and remove all land surface irregularities such as depressional areas that tend to pocket water.

4) Cattle Crossings - These will be constructed in areas where cattle has access to pasture land located on both sides of a creek or ditch, and access would be cut off if fences were established.

5) Shade Structures - To provide alternative shade areas for livestock in those areas where they have been fenced out of streams normally used for cooling.

6) Watering Facilities- Fencing cattle out of existing streams will eliminate a source of water. In this case, watering facilities (dug ponds, troughs) will be established for supplemental watering.

7) Detention Areas - These areas are constructed to detain and store storm event runoff, provide some degree of uptake and storage of nutrients, and provide a slow release of nutrients that are not taken up thus lessening the impact on receiving waters.

8) Dikes - Foundation constructed to prevent the overflow of agricultural wastewaters from detention areas and drainage ditches.

9) Water Conservation - Wash water recycling. This system was designed by the SCS District Conservationist for an initial test run at McArthur Farms, Inc. The system involves recycling water from the second stage (aerobic) lagoon system back to the barn for use in the cooling barn and

flush tanks. The rationale for this system is that: a) it provides for more efficient use of water by pumping it from the second stage lagoon for reuse rather than continued pumping of groundwater and subsequent discharge into adjacent seepage fields, and inturn, receiving waters; b) it provides a savings on electric power consumption by using smaller 15-horsepower pumps to move water from the second stage lagoon to the barn area and in turn decreases the use of existing 20-horsepower pumps for groundwater utilization. The success of this initial system will dictate whether or not similar systems will be proposed for other dairy operations (Appendix 1).

The present status regarding contractual agreements with landowners in the RCWP-TCHW programs can be categorized in the following manner: 1) signed contracts; 2) applied-for contracts; 3) not applied-for contracts (Figure 7). The TCHW-RCWP programs have approximately 81 landowners who qualify for the federal and state funds. As of July 1982, 32 landowners, representing 50 percent of the projects land area, have applied for contracts (management plans). Seven out of 20 of these landowners, located in the TCHW project area, have signed contracts and are undergoing BMP implementation at this time. Table 6 provides a breakdown of the current signed landowner agreements along with costs, acreages, and animal units. Table 7 provides a breakdown of BMP's contracted for implementation in the TCHW priority watershed (all the landowners listed in Table 7 have completed 3 phases of the 4-phase BMP implementation scheme and are currently involved in phase 4 BMP implementation). Appendix 2 provides a list of applicants for the TCHW-RCWP projects.

Completed BMP's throughout the priority one area (TCHW) are: 1) Otter Creek - The operation of an experimental recycling system began on 04/14/82

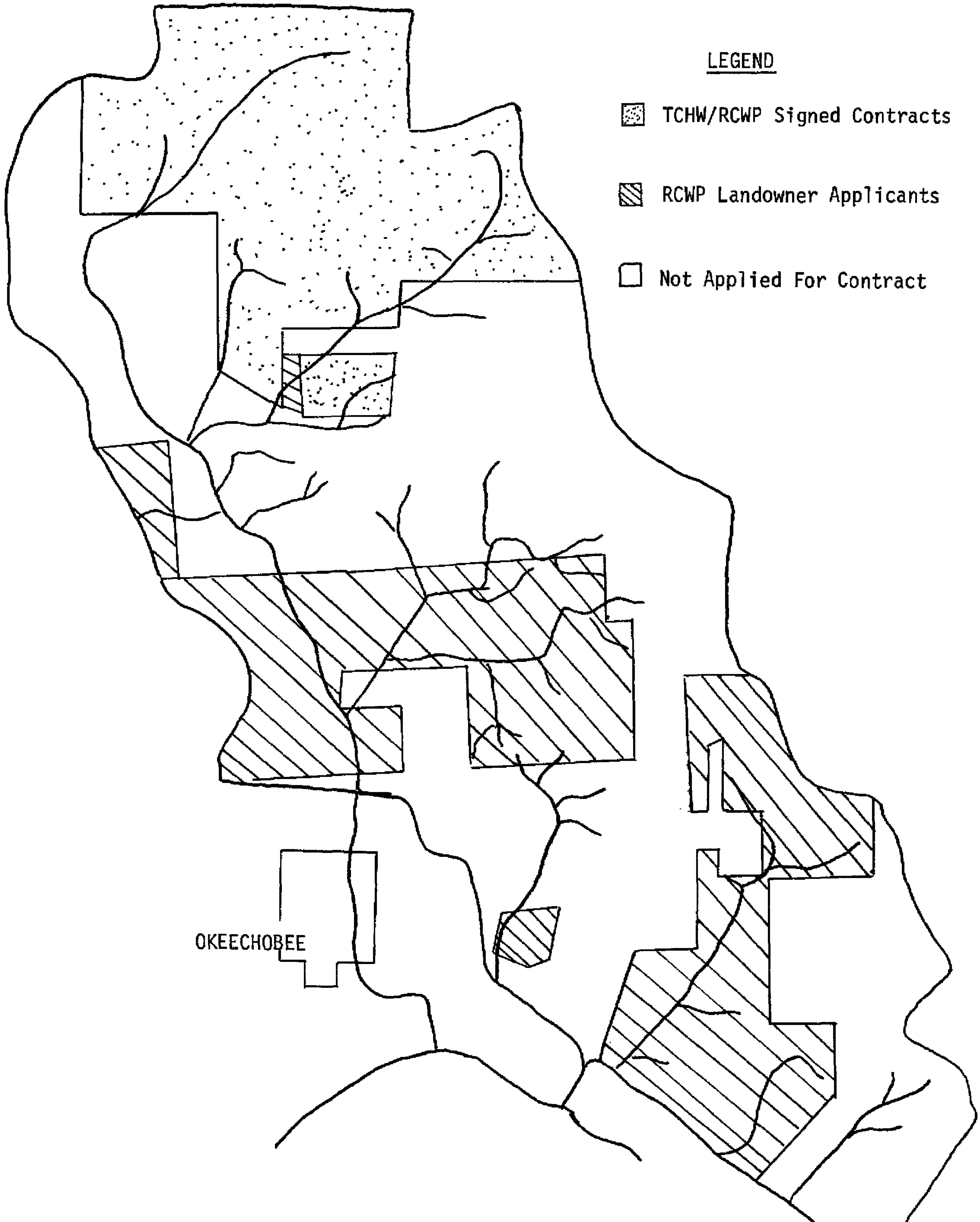


FIGURE 7. TCHW/RCWP CONTRACTUAL STATUS AS OF JULY 1982

TABLE 6. CURRENT SIGNED LANDOWNER AGREEMENTS, TOTAL LAND AREA, ANIMAL UNITS, BMP COSTS, COSTS PER AREA, AND COSTS PER ANIMAL UNIT WITHIN THE TCHW PROJECT AREA

WATERSHED	HECTARES	ANIMAL UNITS	BMP COSTS TCHW+RCWP	COST/HA	COST/ ANIMAL UNIT
OTTER CREEK					
McArthur	1,519	3,850	$ 99,570	$ 65.55	$ 25.86
H & W Rucks & Sons	462	800	54,679	118.35	68.35
Wilson Rucks	370	700	34,453	93.12	49.22
Monroe Arnold	24	50	395	16.46	7.90
Mildred Kirkland	52	300	16,578	318.81	55.26
Dr. Roger Davis	34	50	20,150	592.64	403.44
Sanford Gottlieb	44	50	22,522	511.86	450.44
	2,505	5,800	$248,347	$ 99.14[3]	$ 42.82[3]
LITTLE BIMINI					
McArthur	1,518	2,700	$ 42,311	$ 27.87	$ 15.67
H & W Rucks & Sons	407	800	31,761	78.04	39.70
	1,925	3,500	$ 74,072	$ 38.48	$ 21.16
N. W. TAYLOR CREEK					
McArthur	3,036	5,800	$ 47,194	$ 15.54	$ 8.14
TCHW PROJECT AREA	7,466	15,100	$369,613	$ 49.51	$ 24.48

[1]Dr. Roger Davis management plan drawn up; contracts pending signature.

[2]Sanford Gottlieb management plan drawn up; contracts pending signature.

[3]Based on total BMP costs per total contract area and total number of animal units for each watershed.

TABLE 7. BMP's UNDER CONTRACT, TOTAL HECTARES, AND TCHW-RCWP COSTS BREAKDOWN FOR EACH SUB-WATERSHED WITHIN THE TCHW PROJECT AREA

WATERSHED	HECTARES	BMP	QUANTITY	COSTS TCHW	RCWP
OTTER CREEK	2,505	Fencing[1]	19.37	$ 7,482	$ 22,451
		Shade	40	51,964	10,534
		Crossings	20	50,179	59,036
		Watering[2]	13	4,203	11,722
		Recycling	1	8,000	
		Detention	1	11,816	
		Miscellaneous[3]		10,345	615
			Subtotal------	$143,989	$104,358
LITTLE BIMINI	1,925	Fencing	24.47	$ 9,472	$ 28,412
		Shade	6	2,344	7,034
		Crossings	7	11,436	7,314
		Miscellaneous		8,060	
			Subtotal------	$ 31,312	$ 42,760
N. W. TAYLOR CREEK	3,036	Fencing	20.44	$ 7,938	$ 23,812
		Crossings	6	13,750	
		Watering	2	1,694	
			Subtotal------	$ 23,382	$ 23,812
TOTAL HECTARES--	7,466		TOTAL----------	$198,683	$170,930

[1]Fencing is based on total kilometers of fence.

[2]Watering facilities represent troughs or dug ponds, depending on landowner's request.

[3]Miscellaneous includes diversions, land smoothing, fill, and pipes needed to complement various BMP's.

at McArthur Barn #1. Some preliminary results of this system were obtained from Larry Sharpe, Okeechobee County District Conservationist of the SCS. The results are summarized as follows:

	Before	After	Savings
Total cubic meters used per day	1,022	225	797
KWH/year	50,574	43,800	6,774*
Runoff from animal waste system (m^3/year)	123,300**	None	To be determined by monitoring

*Savings due to 5 BMP less required over old system.
**Conservative estimate.

2) Little Bimini - Forty percent of the fencing (4.8 km or 3 miles) and 2 crossings have been completed at one of the three dairy barns in this watershed.

3) N. W. Taylor Creek - One stock watering pond has been installed outside of a calf-heifer operation.

There have been no signed contracts to date outside of the TCHW project area (Figure 7).

A water budget was computed for the second stage (aerobic) lagoon and the seepage disposal field based on the estimated groundwater pumpage before and after the installation of the barn washwater recycling system. For purposes of this discussion, it was assumed that water loss (evapotranspiration and seepage) before export from the first lagoon was negligible; therefore, total volume of groundwater pumped at the barn was exported to the second stage lagoon via the gravity flow system. The pumpage before and after was established to be 1,021.8 and 225.5 m^3 per day, respectively (10 and 2.2 acre inches per day, respectively, which is 304 and 67 acre feet per year, respectively). The area of the second stage lagoon is about 8.9 hectares (22 acres); therefore, the annual depth equivalent inputs of wastewater spread over the area of the lagoon would be about 419 cm (165 inches) and 93 cm (36.5 inches) for the before and after conditions, respectively. The area of the seepage disposal field is about 26.6 hectares (66 acres).

Pan evaporation averages 152.4 cm (60 inches) per year and watershed evapotranspiration averages 89-91 cm (35-36 inches) per year for Taylor Creek watershed (Allen et al., 1982a; Knisel et al., 1982; Yates et al., 1982). Although lake evaporation is somewhat less than 152.4 cm (60 inches) per year (Allen et al., 1982a; Federico et al., 1981), the lagoon evaporation was estimated to be 152.4 cm (60 inches) per year because of its large surface area to depth ratio. Since Allen et al. (1982a) showed that evapotranspiration averaged 104.1 cm (41 inches) per year in a wetter watershed (Monreve Ranch) and since it increased with increasing annual rainfall which increased the surface wetness for longer periods, the annual evapotranspiration from a wet seepage disposal field was estimated to be about 127 cm (50 inches) per year.

The simple water balance for both the lagoon and the seepage field is:

$$OP = P + IP - ET$$

where

OP = system output as runoff or seepage;

P = precipitation

IP = input of water (from barn wastewater for the second stage lagoon, and from the output of the second stage lagoon for the seepage disposal field);

ET = evapotranspiration (152.4 cm or 60 inches per year for the second stage lagoon, and 127.0 cm or 50 inches per year for the seepage disposal field).

It was assumed that no seepage to groundwater occurred.

Inputs and outputs were compared based on 1979 rainfall (141.25 cm or 56 inches) and 1981 rainfall (93.93 cm or 37 inches). The results are summarized:

System outputs before and after recycling for two annual rainfall amounts:

Rainfall (centimeters)	Before Recycling: 2nd Stage Lagoon (cubic meters)	Before Recycling: Seepage Field (cubic meters)	After Recycling: 2nd Stage Lagoon (cubic meters)	After Recycling: Seepage Field (cubic meters)
141.25	366,201	406,890	73,980	11,590
93.93	323,046	237,969	30,825	-85,077 *

*Negative value indicates the seepage field (theoretically) should have been able to evaporate 85,077 cubic meters of water inputs (69 acre feet) with no output.

These computations do not indicate whether the seepage field output would occur as direct runoff or as seepage losses to Otter Creek. During periods of heavy rainfall, it would likely be direct runoff.

Even during a dry year, these water balance calculations indicate that the seepage field would lose 237,969 m^3 (193 acre feet or 2.92 feet depth equivalent over 26.6 hectares) of liquid water either as runoff or seepage to Otter Creek. Although 1981 was extremely dry, direct runoff across the seepage field was observed during a rainy period in August 1981. Therefore, the water balance shows that the seepage field of 26.6 hectares will be overtaxed when 369,900 m^3 per year (300 acre feet/year) of wastewater are processed through the existing system.

With the proposed reduction in wastewater to about 82,611 m^3 per year (67 acre feet per year), the field disposal system should release much less water to Otter Creek, and a much higher proportion of output should occur as seepage through the soil rather than as direct runoff. This should result in less loading of N, P, and Cl to Otter Creek. Water quality data from Otter Creek show that the average concentrations of both P and N components were less in 1981, a dry year, than in 1979 or 1980.

Water budget computations for the second stage lagoon as well as the seepage disposal field before and after installation of the barnwash recycling system are presented in Appendix 3.

WATER QUALITY MONITORING (PRE BMP)

FRAMEWORK

In June of 1979, the KRVCC Technical Advisory Committee conducted a water quality grab sampling effort which provided a base for designing a long term water quality monitoring program for the TCHW project. Previous to this effort, the ARS had established an on-going water quality study throughout TCNS that began in 1972 with the collection of water quality samples at 15 sites (Allen et al., 1976). Six of the water quality stations used in this study were subsequently incorporated into the KRVCC network, forming the present TCHW monitoring network; the remaining water quality stations established by the ARS continue to be sampled as a part of the larger RCWP project in the TCNS basin.

The current TCHW-ARS monitoring network along with the original ARS network is presented in Table 8 (HLC stations are additional samples that were added to the monitoring network during 1981). TCHW stations 32, 33, and 34 were all added to the monitoring network in October 1981 to determine nutrient ratios of nitrogen, phosphorus, and potassium in several second stage dairy lagoons in the TCNS watershed (Figure 3).

Up until October 1, 1981, ARS collected all water quality samples and hydrologic data, but analyses of the water quality samples were performed by the SFWMD and hydrologic data analysis was conducted by ARS. At this time, the SFWMD took over all responsibilities for water quality and hydrologic data collection along with the continued analyses of al. TCHW-ARS water quality samples. ARS continues to support computer based hydrologic data reduction, storage, and analysis, as well as hydrologic interpretation and routine maintenance of hydrologic recorders.

TABLE 8. Period of Record, Location, and Number of Sampling Sites in the Taylor Creek/Nubbin Slough Watershed.

PERIOD OF RECORD	SITE #	SAMPLE LABEL	LOCATION
01/04/72 to Present	1	TCHW 01	N. W. Taylor Creek at HWY 68
03/19/74 to Present	2	TCHW 02	Little Bimini at Potter Road
01/04/72 to Present	3	TCHW 03	Otter Creek at S-13B & HWY 441
01/04/72 to Present	4	TCHW 04	Otter Creek at HWY 68
03/19/74 to 09/03/81	*5	TCHW 05	Otter Creek at Otter Creek Road
03/19/74 to Present	6	TCHW 06	Otter Creek at Potter Road
01/04/72 to Present	7	ARS 07	Williamson Main Ditch
01/04/72 to Present	8	ARS 08	Williamson East Lateral
01/04/72 to Present	9	ARS 09	Williamson Ditch at S-7
01/04/72 to Present	*10	ARS 10	Taylor Creek at HWY 441 (S-1)
03/19/74 to Present	11	ARS 11	Taylor Creek at Cemetery Road
01/04/72 to Present	12	ARS 12	Taylor Creek at Well Line B
03/19/74 to Present	13	ARS 13	Mosquito Creek at HWY 710
03/19/74 to Present	14	ARS 14	Nubbin Slough at HWY 710
03/19/74 to Present	15	ARS 15	Mosquito Creek at HWY 70
11/01/77 to Present	16	ARS 16	Nubbin Slough at HWY 70
11/01/77 to Present	17	ARS 17	Nubbin Slough at Berman Road
09/05/79 to Present	18	TCHW 18	Taylor Creek at S-2
09/05/79 to Present	19	TCHW 19	East Otter Creek at Potter Road
09/05/79 to Present	20	TCHW 20	East Otter Creek at HWY 441
09/05/79 to 09/03/81	*21	TCHW 21	Little Bimini at HWY 68
09/05/79 to 09/24/80	*22	TCHW 22	F & R Dairy Runoff
09/05/79 to Present	23	TCHW 23	Wilson Rucks Dairy Runoff
09/05/79 to Present	24	TCHW 24	Remsberg North Runoff
09/05/79 to Present	25	TCHW 25	McArthur #1 2nd Stage Lagoon Runoff
09/05/79 to 09/03/81	26	TCHW 26	Otter Creek at McArthur Farms
09/05/79 to Present	27	TCHW 27	McArthur Hayfield Runoff
09/05/79 to 09/03/81	*28	TCHW 28	Otter Creek Upstream
11/19/80 to Present	29	TCHW 29	Gomez Creek at N. HWY 68 West
11/19/80 to Present	30	TCHW 30	Gomez Creek at N. HWY 68 East
10/01/81 to Present	31	TCHW 31	McArthur Runoff at Otter Creek
10/28/81 to Present	32	TCHW 32	McArthur 2nd Stage Lagoon
10/28/81 to Present	33	TCHW 33	T. Rucks 2nd Stage Lagoon
10/28/81 to Present	34	TCHW 34	SEZ Dairy 2nd Stage Lagoon
06/11/81 to Present	24A	HLC 24	Henry Creek at HWY 710
06/11/81 to Present	25A	HLC 25	Lettuce Creek at HWY 710
03/01/76 to 09/31/81	**S-13	TCHW 508	Otter Creek at Potter Road
03/01/76 to 09/31/81	**S-13B	TCHW 509	Otter Creek at HWY 441

*Discontinued water quality sampling sites.

**These sites were selected for automatic samplers which are not in use at this time.

MATERIALS AND METHODS

There are presently 25 water quality samples collected biweekly throughout the TCNS watershed. Additionally, 2 water quality samples are collected, and three are collected at Gomez Creek from dairy lagoons monthly. A 150 ml filtered sample and a 250 ml unfiltered sample is collected at each water quality station. Samples are filtered using a Millipore filter holder housing a 47 mm Nuclepore polycarbonate membrane. Water samples are stored on ice in the field and transported to the SFWMD laboratory where they are refrigerated at 4° C until analysis. These samples are analyzed for chemical and physical parameters the week following collection. Chemical parameters measured are nitrogen species (nitrate, nitrite, ammonia, and total Kjeldahl nitrogen) and phosphorus species (ortho and total phosphorus). Physical parameters measured include pH, specific conductance, turbidity, and color. Lagoon samples are additionally analyzed for major cations calcium, manganese, sodium, and potassium. Laboratory methodology for water quality analysis can be found in Appendix 4.

OTTER CREEK

There are presently 5 dairies and a number of small beef cattle operations along Otter Creek. The most prevalent soil type in this area is Myakka fine sand which is a poorly drained soil (shallow profile, high water table with low relief) (McCollum and Pendleton, 1971), thus creating a need for the extensive drainage along Otter Creek. Water quality sample sites (12) can be broken down into several categories that best represent the various agricultural practices and their runoff water quality (Figure 8).

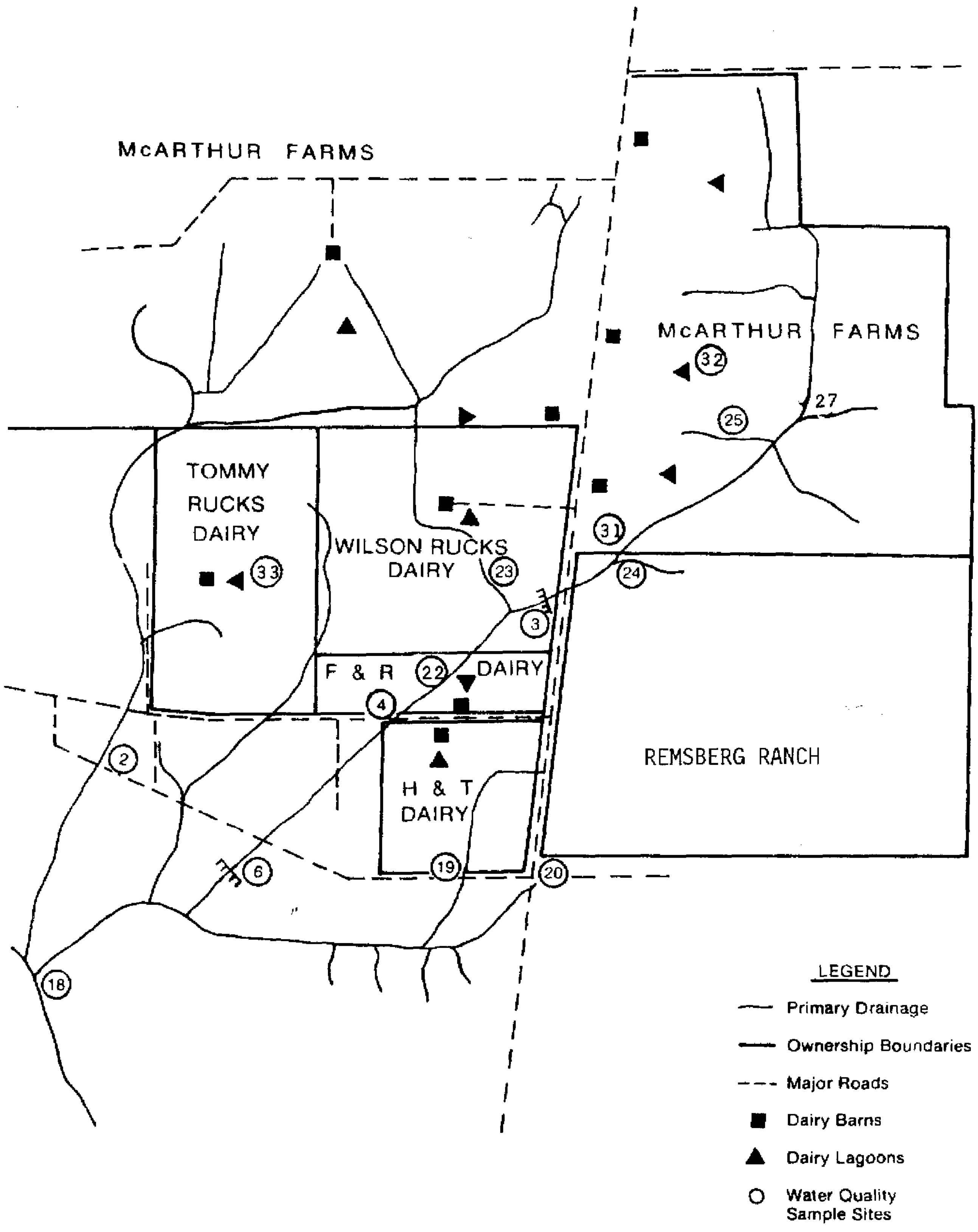


FIGURE 8. OTTER CREEK, LITTLE BIMINI DRAINAGE BASIN

These categories are: 1) open channel sites (03, 04, 06, 31[1]); 2) dairy runoff sites (19, 22, 23, 25); 3) beef cattle runoff sites (20, 24); 4) hayfield runoff site (27); 5) lagoon (aerobic) site (32[2]).

Site 03, located at SCS flow control structure S-13B that has been calibrated (Rice and Gwinn, 1981), represents drainage from the entire headwaters area of Otter Creek. This includes all drainage and runoff from McArthur Farms Barns 1, 2, and 3, McArthur's east hayfields, and the north drainage of Remsberg beef cattle operation. This site will be extremely important after BMP's have been installed at the McArthur operation. It will not only reflect changes (if any) in water quality data, but changes in nutrient loads from this area as well. Site 04, located about 1.61 km (1 mile) downstream from site 03, is an intermediate site used to monitor nutrient contributions between site 03 and site 06 further downstream. This site exhibited higher nitrogen and phosphorus concentrations (Tables 9 and 10) mainly because of its close proximity to several dairy outfalls (Figure 8). Site 06, the most extreme downstream sampling site in Otter Creek, reflects nutrient concentrations contributed by much of the Otter Creek watershed. There is another SCS flow control structure, S-13, also calibrated by Rice and Gwinn (1981), located about 91 meters (300 feet) downstream from site 06. Discharges from both S-13B (site 03) and S-13 (site 06) will be used along with water quality data to compute nutrient loads from this area. These data will be presented in the hydrology section. Tables 9 and 10 present annual means and ranges for the various chemical and physical analyses measured on the open channel sites in Otter Creek. Ortho and total phosphorus, as well as TKN, ammonia,

[1]Site 31 was added in October 1981. Because of its short period of record, data from this site will not be addressed in this report.

[2]Site 32 was added in October 1981. Some preliminary data will be discussed in this report.

TABLE 9. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Otter Creek for 1978 and 1979.

PARAMETERS[1]		1978			1979		
		03	04	06	03	04	06
O-PO4	$\bar{x}$	2.96	4.06	3.12	2.23	3.91	2.77
	min-max	0.35-4.20	2.77-7.31	2.13-4.35	0.90-3.91	2.14-8.82	2.06-3.83
T-PO4	$\bar{x}$	3.27	4.98	3.44	2.29	4.92	3.01
	min-max	0.49-4.61	3.55-9.83	2.26-4.96	0.98-3.91	2.48-16.23	2.06-4.18
TKN	$\bar{x}$	5.26	15.04	9.10	2.95	19.35	5.98
	min-max	0.83-8.83	5.87-44.91	5.26-4.96	1.05-6.93	2.84-231.24	2.47-10.32
NH4	$\bar{x}$	3.74	6.86	5.77	1.07	4.72	3.81
	min-max	0.18-7.38	4.06-13.42	3.58-14.80	0.04-4.44	0.49-14.64	0.47-8.24
NO2	$\bar{x}$	0.06	0.08	0.06	0.03	0.05	0.05
	min-max	0.004-0.14	0.01-0.15	0.01-0.15	0.01-0.08	0.02-0.11	0.01-0.21
NO3	$\bar{x}$	0.22	0.31	0.15	0.25	0.23	0.13
	min-max	0.004-0.93	0.01-0.98	0.004-0.68	0.004-1.52	0.02-1.15	0.004-0.65
TOTAL N	$\bar{x}$	5.53	12.47	9.31	3.20	19.62	6.15
	min-max	0.83-12.71	2.41-36.79	1.41-26.01	1.08-6.94	2.94-231.37	2.53-10.41
LAB COND (umhos/cm)	$\bar{x}$	454	496	417	377	427	356
	min-max	208-610	380-614	290-535	169-600	176-690	169-479
LAB pH	$\bar{x}$	6.84	6.91	6.86	6.81	6.95	6.91
	min-max	4.69-7.62	6.46-7.24	6.47-7.24	6.55-7.13	6.62-7.25	6.64-7.23
TURBIDITY[2] (NTU)	$\bar{x}$				2.30	11.20	5.60
	min-max				1.80-2.90	2.40-25.00	1.80-8.40
COLOR[2]	$\bar{x}$				190	239	201
	min-max				96-257	143-303	111-295
NO. SAMPLES		23	23	23	28	28	28

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity and color values for 1979 were derived from 10 samples collected between 09/05/79 & 12/10/79.

TABLE 10. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Otter Creek for 1980 and 1981.

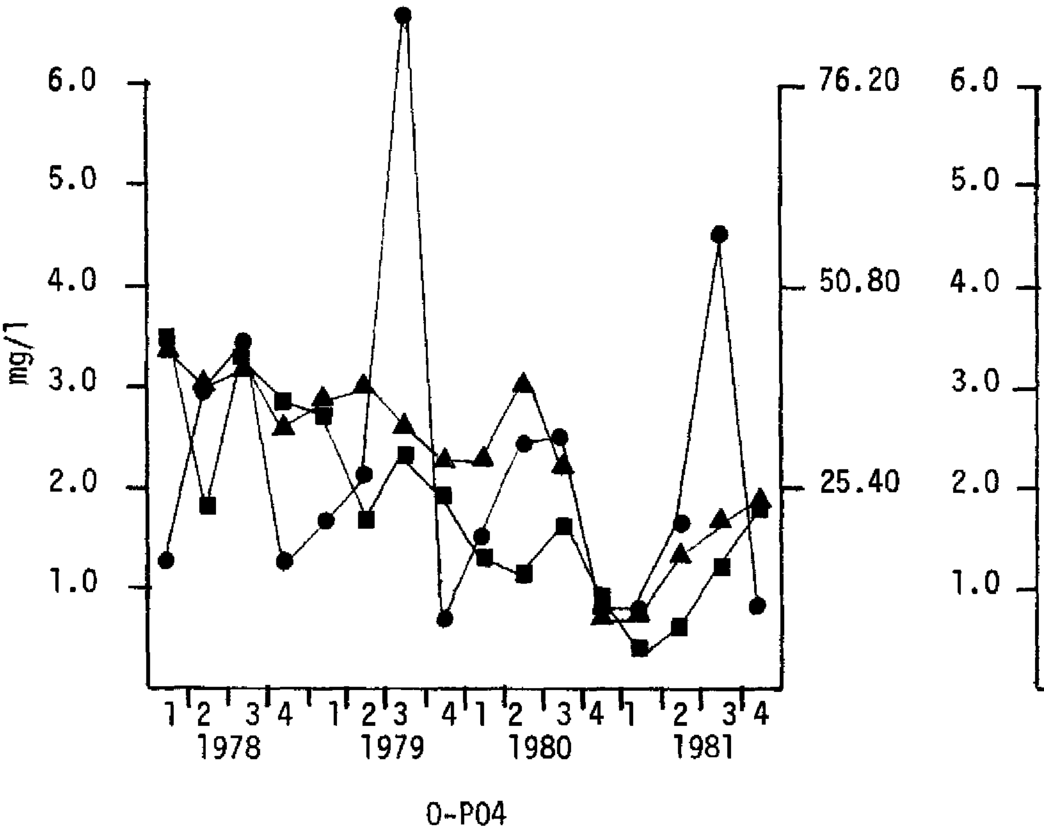
PARAMETERS[1]		1980			1981		
		03	04	06	03	04	06
O-PO4	x̄	1.26	3.19	2.16	0.99	2.06	1.45
	min-max	0.25-2.70	0.37-7.89	0.51-4.65	0.21-2.97	0.50-12.92	0.61-3.41
T-PO4	x̄	1.38	5.11	2.53	1.10	2.70	2.04
	min-max	0.28-3.08	0.50-17.67	0.49-5.86	0.23-2.96	0.59-21.01	0.63-11.79
TKN	x̄	2.14	20.49	7.82	2.09	13.21	4.90
	min-max	0.89-4.14	1.49-78.33	0.74-22.62	0.95-5.21	1.40-128.05	0.74-29.08
NH4	x̄	0.57	7.75	4.78	0.32	7.75	2.68
	min-max	0.04-2.75	0.02-37.43	0.04-14.05	0.01-2.41	0.07-88.27	0.03-19.81
NO2	x̄	0.01	0.04	0.02	0.02	0.06	0.04
	min-max	0.004-0.04	0.01-0.27	0.01-0.08	0.004-1.61	0.01-0.25	0.004-0.18
NO3	x̄	0.06	0.22	0.13	0.14	0.26	0.44
	min-max	0.004-0.37	0.01-0.65	0.01-0.65	0.004-1.61	0.01-1.22	0.01-1.72
TOTAL N	x̄	2.21	20.75	7.96	2.25	13.53	5.38
	min-max	0.91-4.16	2.09-78.45	1.12-22.84	0.98-5.23	1.64-128.54	1.16-30.84
LAB COND (umhos/cm)	x̄	416	497	392	451	509	367
	min-max	266-702	305-950	250-1140	240-910	263-1860	223-540
LAB pH	x̄	6.71	7.02	6.80	6.90	7.01	6.88
	min-max	6.48-7.00	6.81-7.43	6.57-7.35	6.47-7.49	6.63-7.50	6.63-7.23
TURBIDITY (NTU)	x̄	2.60	69.10	9.20	5.20	12.40	4.40
	min-max	0.60-8.00	0.50-500.00	1.50-40.00	0.30-36.00	0.30-100.00	1.20-23.50
COLOR	x̄	118	216	146	125	169	142
	min-max	52-320	83-656	62-340	53-283	69-384	54-308
NO. SAMPLES		23	23	23	26	24	23

[1]Chemical parameters are expressed in mg/l.

and nitrogen concentrations (NO_3, NO_x, and total nitrogen) were highest at site 04 during the 4-year period of record. This seems to indicate additional nutrient inputs between site 03 and site 06. Figures 9 and 10 present quarterly data for rainfall and selected nitrogen (N) and phosphorus (P) species for sites 03 and 06. Inorganic N and total N concentrations are highest at site 06, indicating additional N inputs downstream from site 03. This trend generally holds for P species as well; however, during 1978, there was only a a 5 percent increase in T-PO4 from site 03 downstream to site 06, while in 1979, 1980, and 1981, there was an average increase in T-PO4 downstream of 41 percent (Tables 9 and 10). The three open channel sites (03, 04, and 06), along with site 31 added in 1981, will help evaluate any changes in stream water quality when BMP's are installed.

Of the four dairy runoff sites, one site, 22, is no longer sampled due to access problems. These runoff areas are very important in analyzing the direct input of dairy drainage on the open channel of Otter Creek. Sites 19, 23, and 25 are all completely accessible to approximately 100 to 130 dairy cows a day. These drainage ways will eventually be fenced off, which will help to evaluate what effect fencing out cows has on water quality at these sites. Sites 19 and 23 represent direct natural tributary drainage into Otter Creek, and support similar numbers of dairy cows; however, nutrient concentrations monitored at each site differ greatly (Tables 11 and 12). It appears that dissimilarities in nutrient concentrations between these two sites can be attributed to the differences in soil types and runoff from an area with lower nutrient concentrations. Site 23 represents the soil type Myakka fine sand, which is a poorly drained soil with an organic pan at a depth of 61 cm (24 inches) with low hydraulic conductivity. Site 19 represents the Pomello soil type,

FIGURE 9. MEAN QUARTERLY O-PO4 AND T-PO4 CONCENTRATIONS AT TWO OPEN CHANNEL STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)



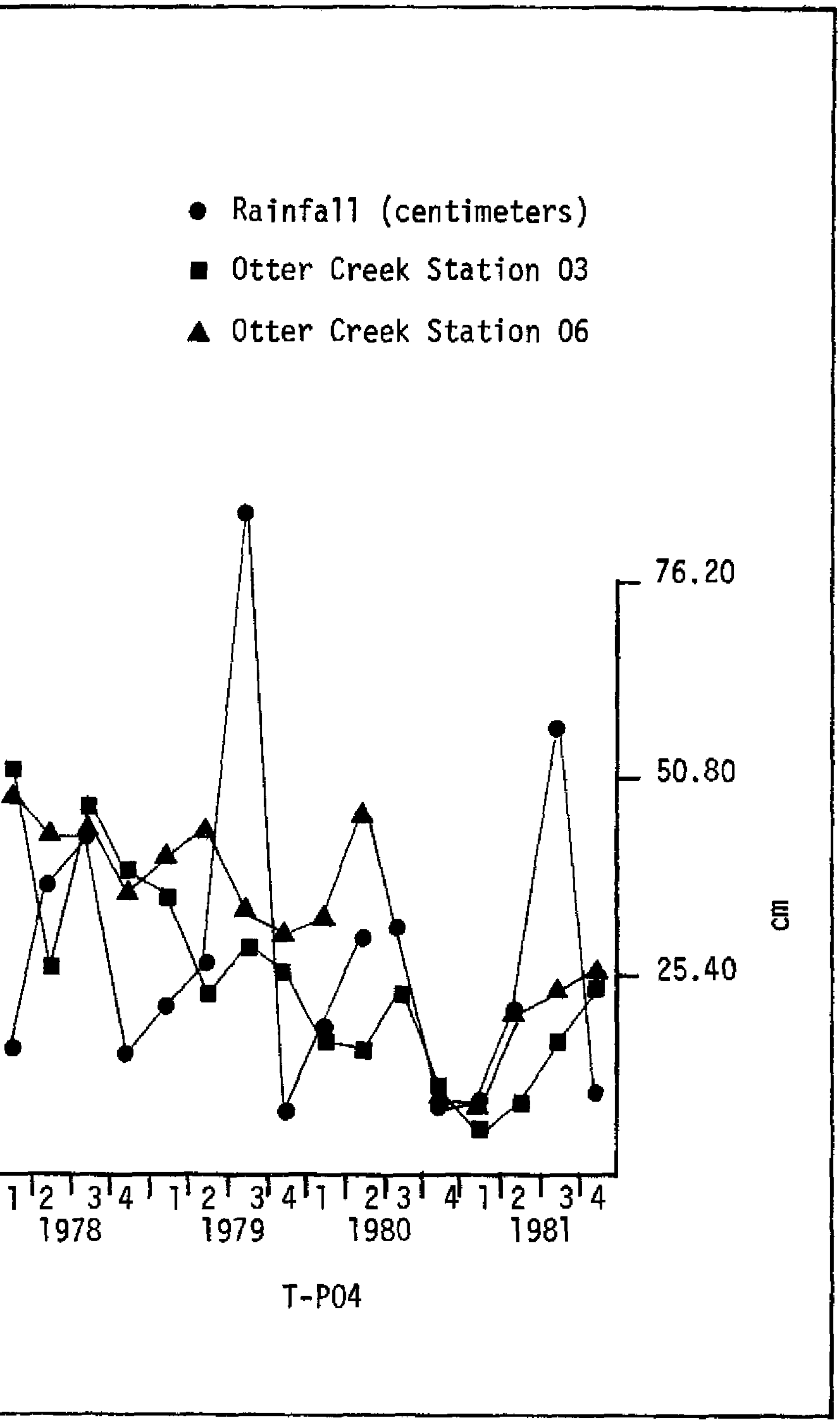

● Rainfall (centimeters)
■ Otter Creek Station 03
▲ Otter Creek Station 06
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1978
1979
1980
1981
T-P04

FIGURE 10. MEAN QUARTERLY INORGANIC NITROGEN AND TOTAL NITROGEN CONCENTRATIONS AT TWO OPEN CHANNEL STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)

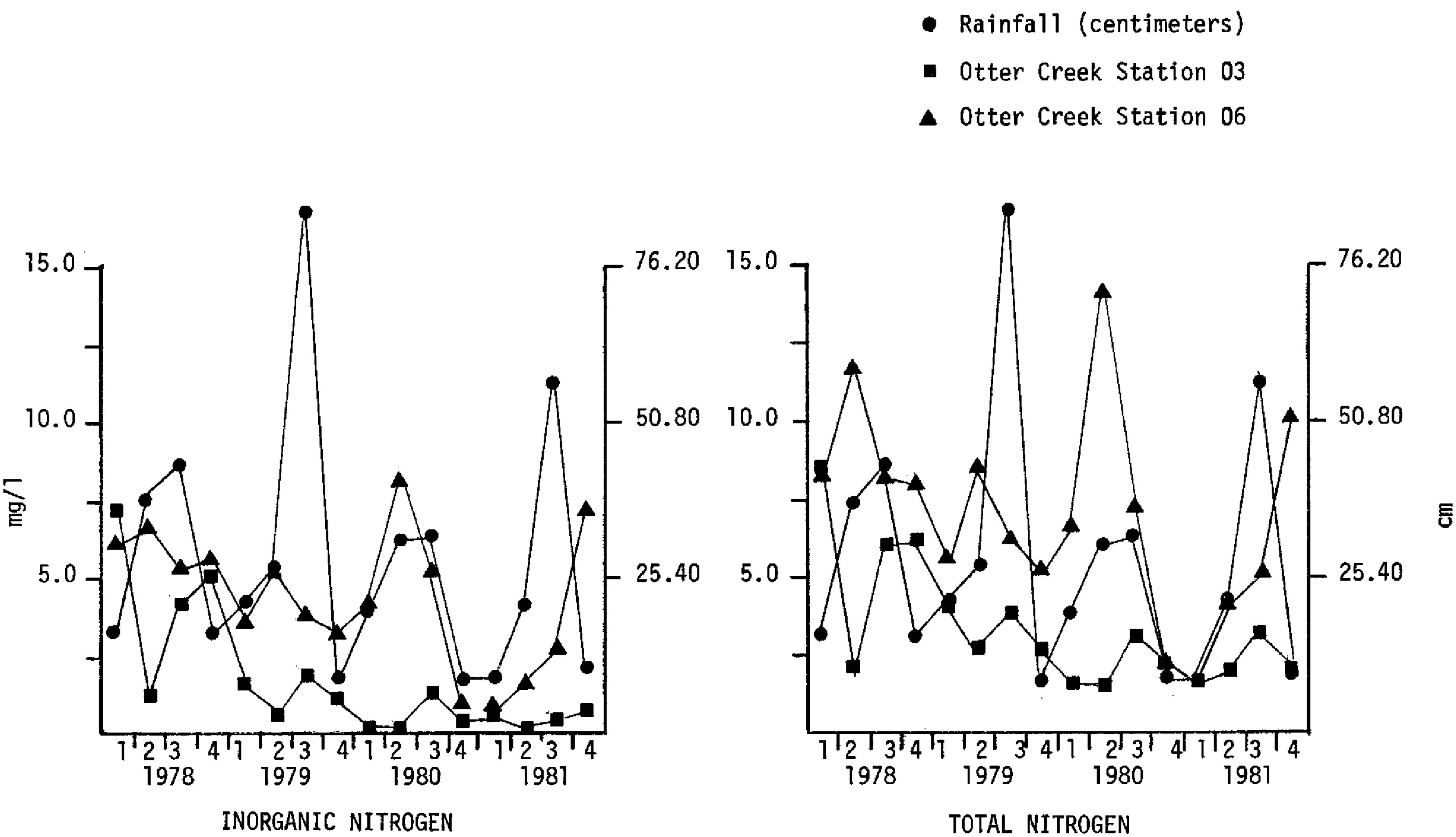


TABLE 11. Mean, Minimum, and Maximum Water Quality Values for Dairy Runoff Stations in Otter Creek September-December 1979

PARAMETERS[1]		25	23	22	19
O-PO4	$\bar{x}$	6.91	1.27	32.71	0.31
	min-max	3.10-10.90	0.21-3.48	21.63-62.00	0.01-1.00
T-PO4	$\bar{x}$	8.71	1.48	59.84	0.62
	min-max	6.49-11.25	0.31-3.63	25.89-109.31	0.84-1.09
TKN	$\bar{x}$	15.09	6.19	177.41	2.34
	min-max	6.32-42.97	3.64-8.47	16.20-348.38	1.05-5.89
NH4	$\bar{x}$	1.19	3.62	37.79	0.07
	min-max	0.19-2.30	0.55-4.74	2.29-63.27	0.01-0.21
NO2	$\bar{x}$	0.02	0.10	0.16	0.06
	min-max	0.01-0.04	0.02-0.28	0.02-0.73	0.004-0.01
NO3	$\bar{x}$	0.02	0.40	0.91	0.01
	min-max	0.004-0.05	0.01-1.07	0.004-0.70	0.01-0.03
TOTAL N	$\bar{x}$	15.13	6.65	178.20	2.36
	min-max	6.38-43.04	3.81-9.18	22.85-348.41	1.06-5.93
LAB COND (umhos/cm)	$\bar{x}$	542	310	1928	137
	min-max	360-882	155-367	998-2905	80-303
LAB pH	$\bar{x}$	7.25	6.34	7.13	6.37
	min-max	6.91-7.95	6.15-6.59	6.80-7.54	6.12-6.91
TURBIDITY (NTU)	$\bar{x}$	15.70	4.70	185.20	4.60
	min-max	4.80-49.00	2.50-18.00	40.00-435.00	3.20-7.40
COLOR	$\bar{x}$	242	196	1599	137
	min-max	96-331	147-263	425-4780	34-267
NO. SAMPLES		7	10	10	10

[1]Chemical parameters are expressed in mg/l.

TABLE 12. Annual Mean, Minimum, and Maximum Water Quality Values for Dairy Runoff Stations in Otter Creek for 1980 and 1981.

PARAMETERS[1]		1980				1981		
		25	23	22[2]	19	25	23	19
O-PO4	$\bar{x}$	3.87	1.14	11.53	0.08	4.01	2.57	0.07
	min-max	1.02-7.31	0.16-4.82	0.88-25.81	0.01-1.05	0.76-7.07	0.26-10.57	0.01-0.53
T-PO4	$\bar{x}$	10.14	3.46	54.68	0.41	4.85	4.56	0.26
	min-max	4.21-40.29	0.30-12.56	3.64-103.87	0.03-1.41	2.49-7.59	0.74-14.98	0.03-0.82
TKN	$\bar{x}$	22.75	32.21	246.41	3.06	4.94	26.78	1.92
	min-max	6.69-53.14	3.49-184.42	10.88-468.26	0.58-12.55	2.73-8.69	1.95-94.55	0.40-5.92
NH4	$\bar{x}$	1.45	6.82	30.74	0.05	0.63	14.11	0.05
	min-max	0.01-8.80	0.13-42.81	1.84-91.68	0.01-0.31	0.02-1.85	0.08-62.06	0.01-0.31
NO2	$\bar{x}$	0.02	0.04	0.02	0.01	0.03	0.03	0.01
	min-max	0.01-0.05	0.004-0.26	0.004-0.07	0.004-0.08	0.01-0.12	0.004-0.19	0.004-0.01
NO3	$\bar{x}$	0.06	0.15	0.01	0.18	0.01	0.10	0.02
	min-max	0.004-0.20	0.004-0.85	0.004-0.03	0.004-1.85	0.004-0.01	0.004-0.78	0.004-0.06
TOTAL N	$\bar{x}$	22.82	32.40	246.44	3.25	4.98	26.90	1.94
	min-max	6.79-53.39	4.39-184.80	10.89-468.28	0.59-12.61	2.75-8.71	1.98-94.57	0.45-5.92
LAB CONDUCTIVITY (umhos/cm)	$\bar{x}$	901	449	1751	179	817	600	237
	min-max	648-1200	314-1310	315-3050	90-980	160-1315	335-1395	89-1995
LAB pH	$\bar{x}$	7.73	6.63	7.08	6.23	7.60	6.97	6.66
	min-max	6.92-8.36	5.84-7.43	6.65-7.58	5.49-7.51	6.83-8.82	6.19-7.76	5.91-7.21
TURBIDITY (NTU)	$\bar{x}$	165.60	33.50	468.00	11.10	4.90	44.50	11.70
	min-max	7.70-1200.00	1.40-285.00	22.00-950.00	0.40-60.00	2.00-7.60	2.40-185.00	0.70-125.00
COLOR	$\bar{x}$	203	182	392	38	253	278	75
	min-max	83-319	84-378	107-1112	13-121	93-583	56-563	11-370
NO. SAMPLES		10	23	18	21	6	21	18

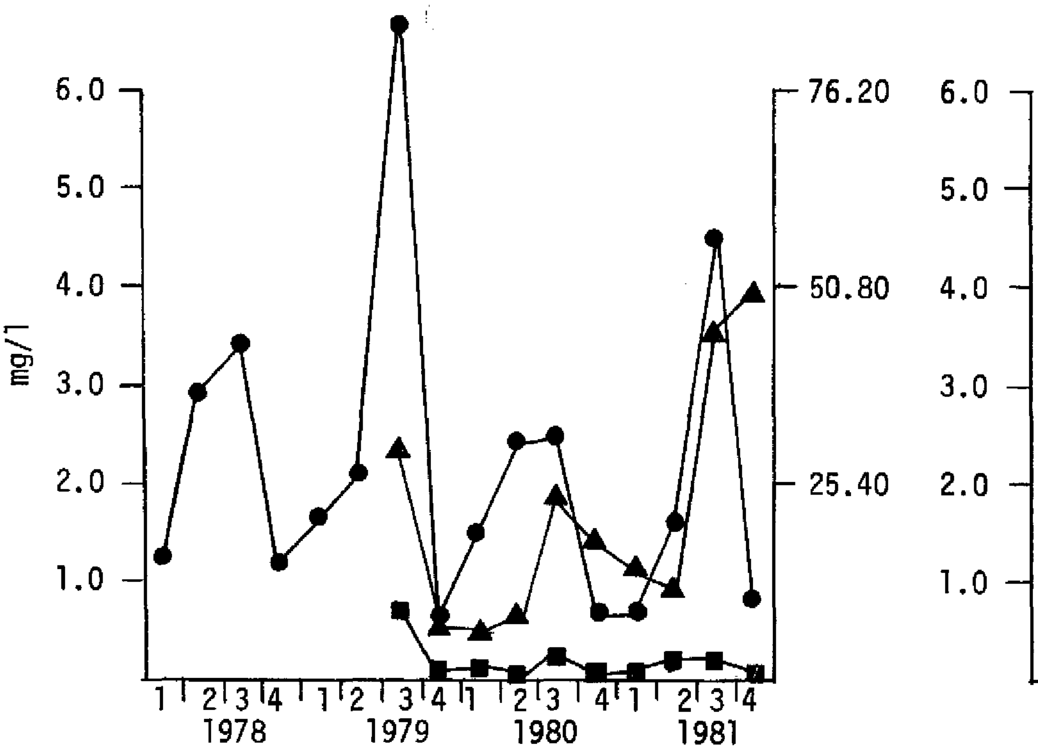
[1]Chemical parameters are expressed in mg/l.
[2]Period of record for Station 22 during 1980 is from 01/10/80 to 09/24/80

which is moderately well drained with the organic pan at 107 cm (42 inches) (McCollum and Pendleton, 1971; Allen et al., 1982). The greater depth of the organic pan at site 19 allows more percolation of water and nutrients into the soil profiles before they have a chance to run off, whereas at site 23, less percolation occurs because of the high organic pan and concomitant higher water tables allow more of the nutrients to run off into the open channel.

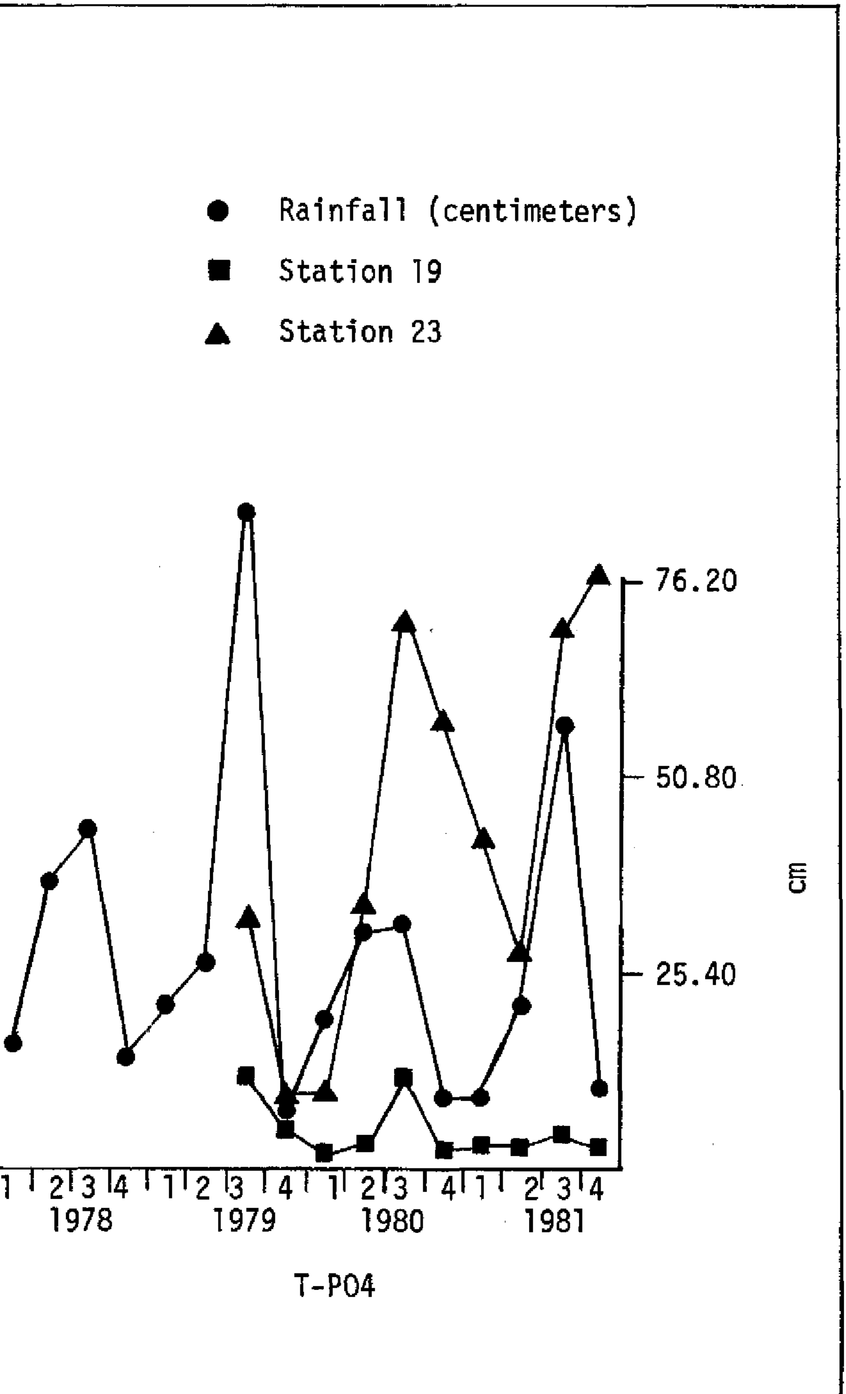
Beef cattle runoff upstream from site 19 can create a dilution effect by mixing downstream with dairy runoff. Figures 11 and 12 graphically depict the differences in N and P concentrations at sites 19 and 23. An interesting note here is that peaks in N and P correspond more with peaks in rainfall at these two runoff sites as compared to those exhibited at the open channel sites (Figures 9 and 10).

Site 25 monitors outfall into Otter Creek from a drainage system adjacent to a dairy seepage field and below a secondary (aerobic) lagoon. Fencing cows out of this system along with the enlargement of the secondary lagoon system and the creation of a washwater recycling system are BMP's that will be implemented to help improve water quality at this site. The reduction in wastewater of about 67 acre feet per year through the use of the washwater recycling system is expected to reduce the export of water to the seepage disposal field and thus release much less water to Otter Creek (see page 31). Tables 11 and 12 present annual nutrient concentrations for site 25. Nutrient concentrations at this site have been as hign as 53.4 mg/l total nitrogen and 40.3 mg/l total phosphorus. Any improvements in water quality coming from this system will help the overall water quality in the open channel. Comparing sites 23 and 25 (Tables 11 and 12), similar N and P concentrations are found in 1980 and 1981. The

FIGURE 11. MEAN QUARTERLY O-PO4 AND T-PO4 CONCENTRATIONS AT TWO DAIRY RUNOFF STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)

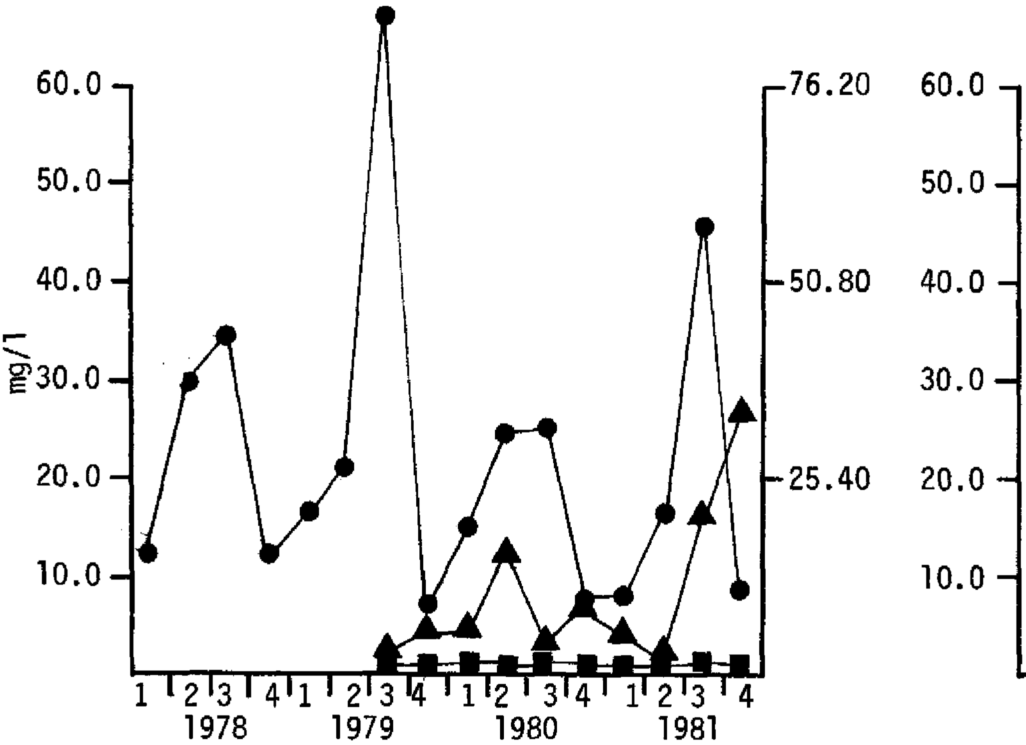


O-PO4

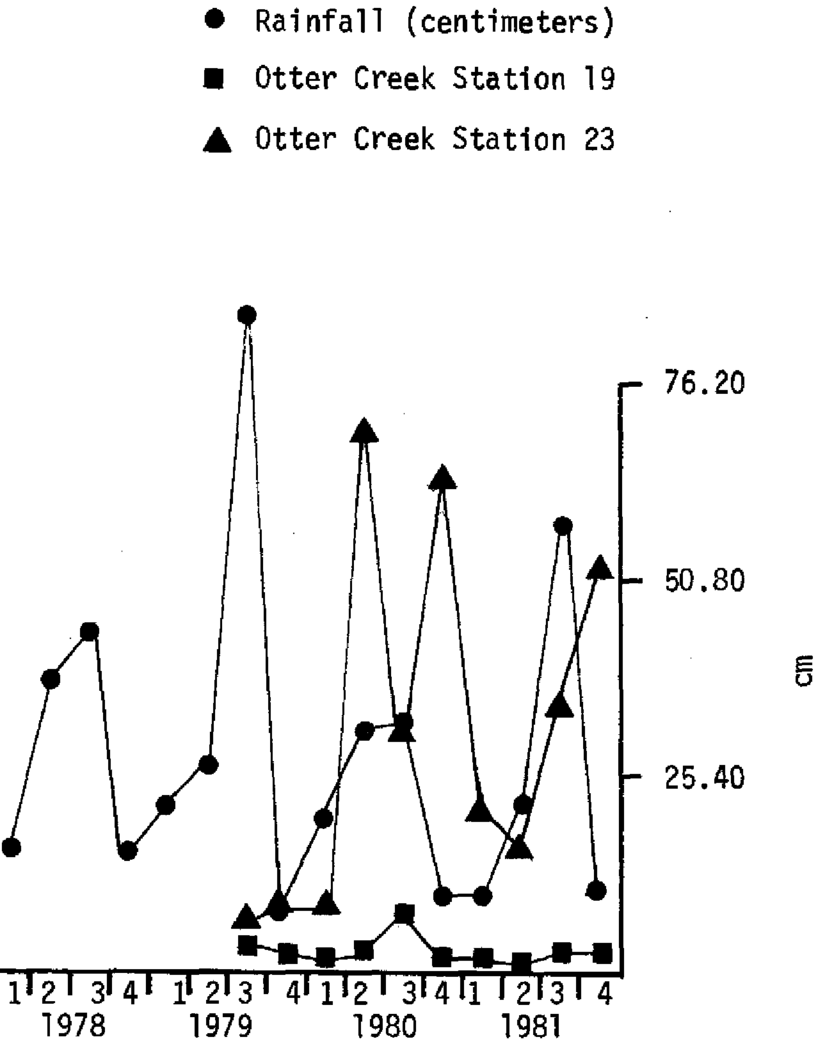


Rainfall (centimeters)
Station 19
Station 23
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1978
1979
1980
1981
T-PO4

FIGURE 12. MEAN QUARTERLY INORGANIC NITROGEN AND TOTAL NITROGEN CONCENTRATIONS AT TWO DAIRY RUNOFF STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)



INORGANIC NITROGEN



TOTAL NITROGEN

similarities here can also be attributed to similarities in land use practices (dairy farming) at both sites as well as the soil types, both representing Myakka fine sand.

Water quality sampling at site 22 was discontinued on September 24, 1980. However, during the sampling period of record, some interesting changes in water quality and land use occurred. Land use changes apparently have a direct effect on water quality. This site was located at the outfall of F & R Dairy. During the sampling period of record (September 1979 to September 1980), this site exhibited the highest total N and total P concentrations (468.3 mg/l N and 109.3 mg/l P) of any site in the entire TCNS watershed. These high nutrient concentrations were a direct result of point and non-point dairy pollution due to mismanagement of wastewater systems as well as cows from the operation having direct access to on-farm drainage systems and the open channel of Otter Creek. During the period when this dairy was operating, N and P concentrations at site 04 (directly downstream from the dairy) were about 80% higher and 270% higher, respectively, than upstream at site 03, directly above the dairy (Figure 8). In August 1980 when this dairy shut down, open channel concentrations on an average have shown a 58% decrease in total P and 60% decrease in total N (Allen et al., 1982). These decreases can be attributed to the elimination of cows from the waterways in and around the dairy as well as the shutdown of lagoon system and discontinued use of the seepage field. Figures 13 and 14 graphically show the on-site decreases in nutrient concentrations (N and P) after the dairy shutdown. Figure 15 graphically illustrates a decrease in specific conductivity after shutdown. High conductivity values present during operation of this dairy indicate the direct runoff of groundwater used in wash down and flush tanks in the everyday operation of this system.

FIGURE 13. PHOSPHORUS CONCENTRATIONS AT RUNOFF STATION 22 IN OTTER CREEK SEPTEMBER 1979 TO SEPTEMBER 1980

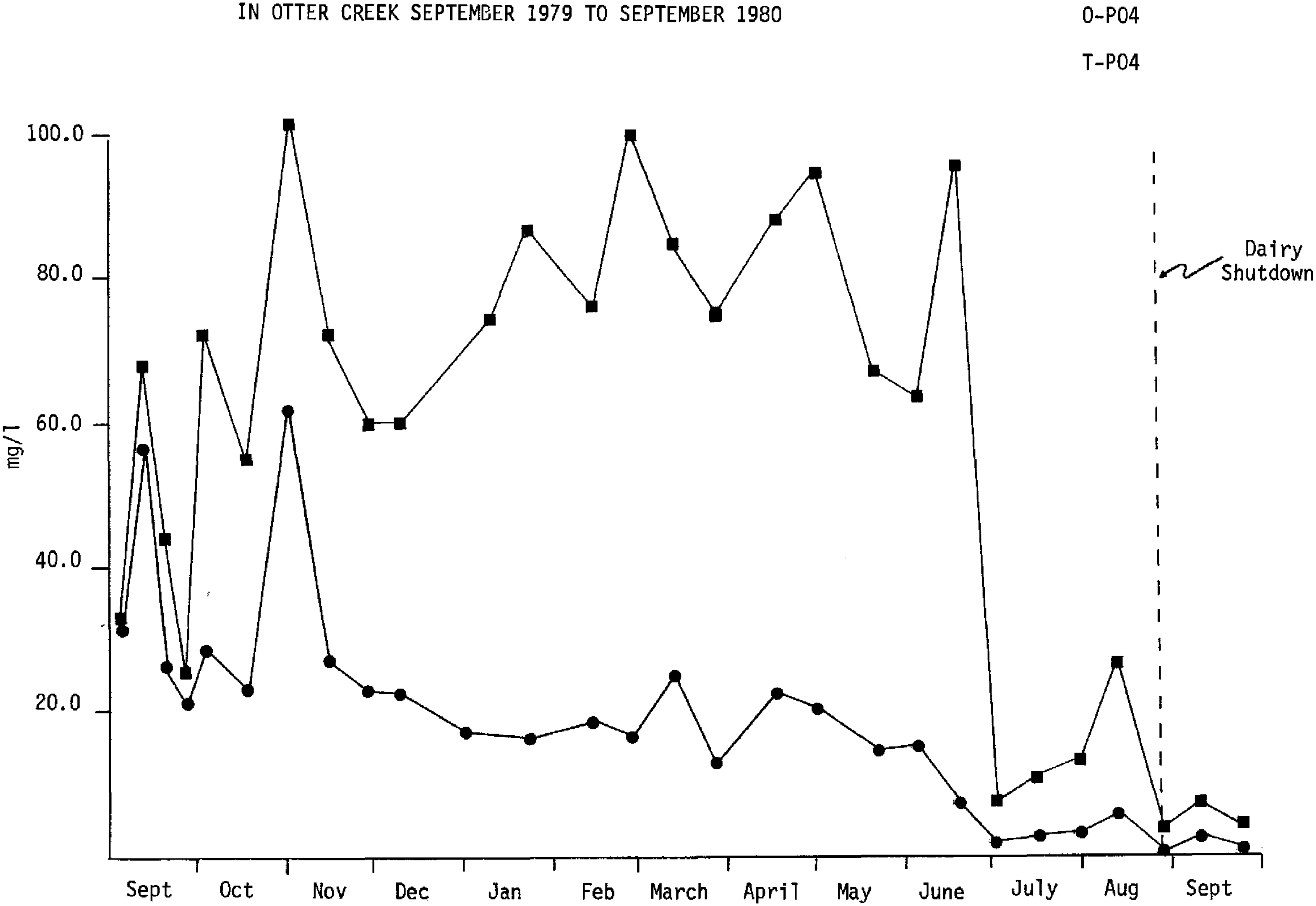


FIGURE 14. NITROGEN CONCENTRATIONS AT RUNOFF STATION 22 IN OTTER CREEK SEPTEMBER 1979 TO SEPTEMBER 1980

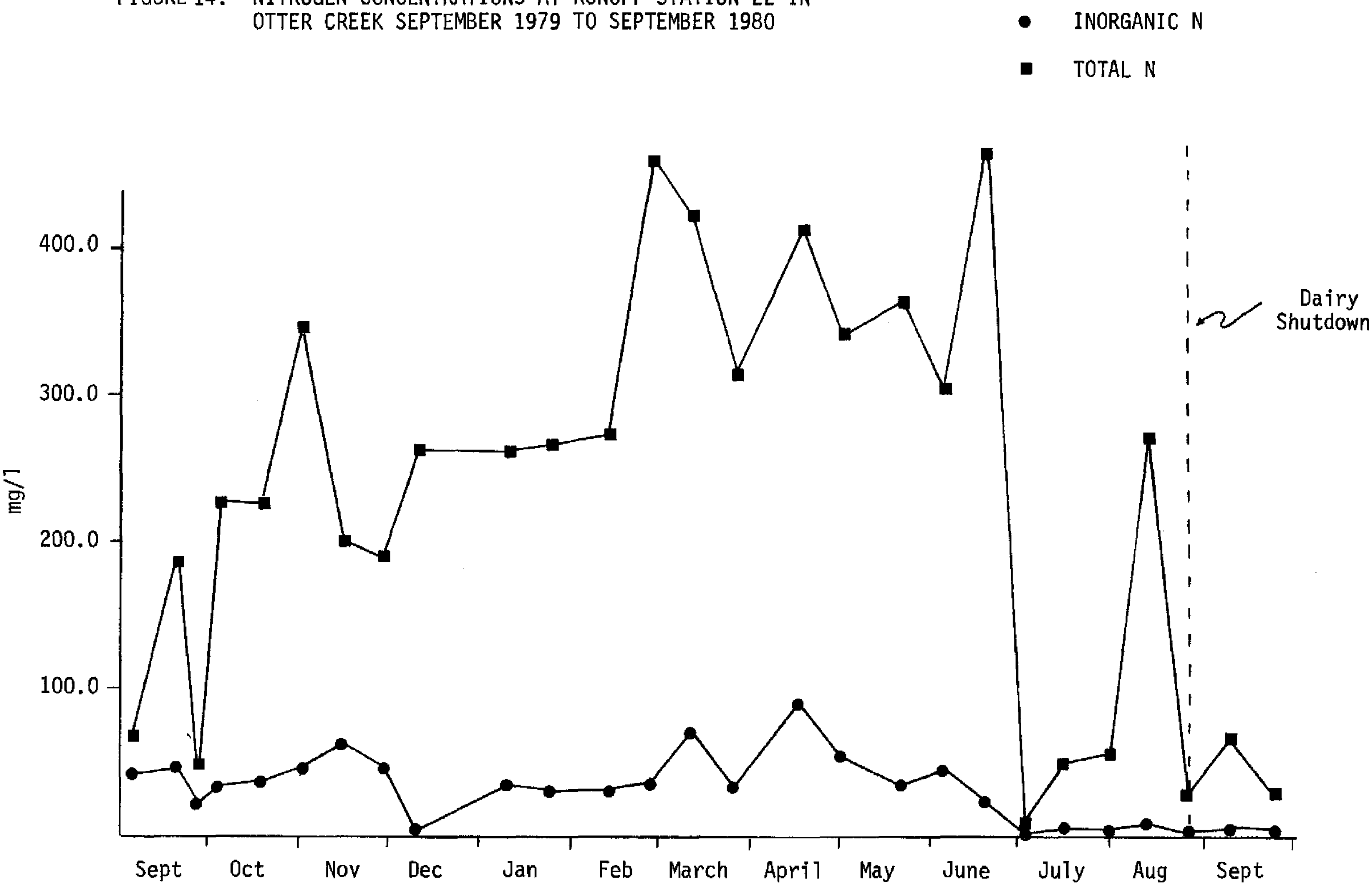
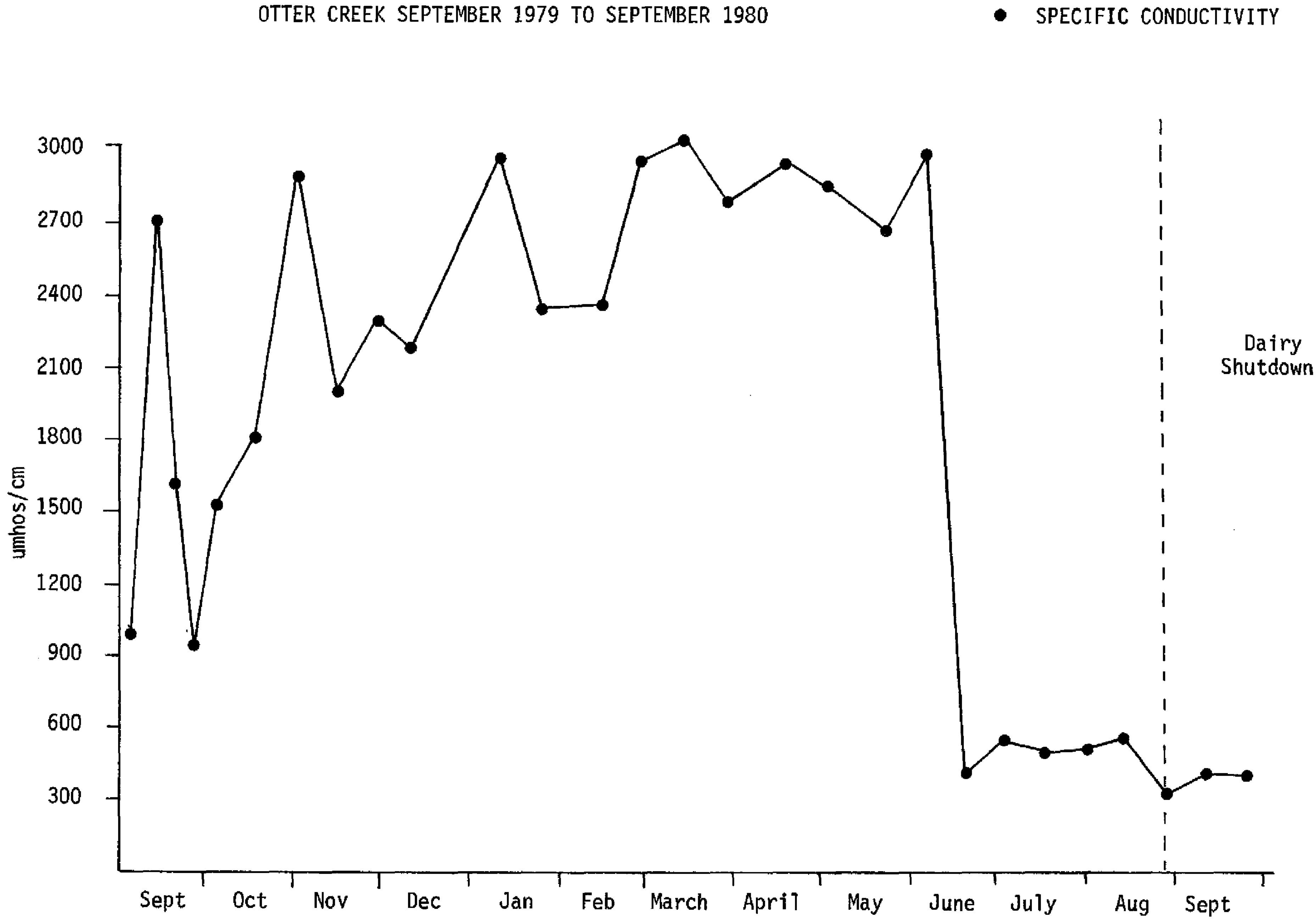


FIGURE 15. SPECIFIC CONDUCTIVITY AT RUNOFF STATION 22 IN OTTER CREEK SEPTEMBER 1979 TO SEPTEMBER 1980



A curious aspect of these data (Figures 13 through 15) is the sharp decrease in N, P, and specific conductivity values prior to the actual shutdown of this operation in August 1980. There are several hypotheses that can account for these decreases: 1) a gradual shutdown decreasing the herd size over this two month period; 2) limiting or discontinuing the use of flush tanks to clean barn and holding areas; 3) moving cows into the east pasture away from any drainage into the creek; 4) moving the cows away from the creek bed; 5) the lack of rainfall during this period, thus drying out the drainage systems around the creek and seepage fields. The latter would decrease runoff from these areas and decrease the nutrient export into the open channel. All of the above hypotheses have been substantiated by the SCS district conservationist and the area extension agent. Table 13 presents nutrient concentrations at sites 03 and 04 (1978-1981) located 0.8 km (0.5 miles) upstream and downstream, respectively, of F & R Dairy. Percent nutrient increases are given between these two sites to illustrate the effects that mismanagement of wastewater facilities and cattle lounging in the open channel have on downstream nutrient concentrations.

Table 14 presents annual means and ranges for the two beef cattle runoff sites (20 and 24) in Otter Creek. It appears that all parameter values at each of these sites are very similar in comparison, exhibiting low N and P concentrations. These lower concentration waters seem to help dilute downstream open channel concentrations in Otter Creek. Figures 16 and 17 illustrate the similarities of inorganic and total N and P concentrations at both sites. Quarterly peaks in P concentrations tend to correlate closely with peaks in rainfall. The predominant soil type at both sites is the Myakka fine sand (poorly drained); however, because the

TABLE 13. Effects of a Dairy-Intensive Area on Mean Annual Downstream Water Quality in the Otter Creek Watershed.

NUTRIENT[1]	STATION 03 Otter Creek at HWY 441 (upstream)	STATION 04 Otter Creek at S. R. 68 (downstream)	PERCENT INCREASE[2]
1978 JANUARY-DECEMBER			
TOTAL P	3.27	4.98	52%
ORTHO P	2.96	4.06	37%
TOTAL N	5.53	12.47	126%
TKN-NH4	1.52	8.11	435%
1979 JANUARY-DECEMBER			
TOTAL P	2.29	4.92	115%
ORTHO P	2.23	3.91	75%
TOTAL N	3.20	19.62	513%
TKN-NH4	1.88	14.97	696%
1980 JANUARY-DECEMBER			
TOTAL P	1.38	5.11	270%
ORTHO P	1.26	3.19	153%
TOTAL N	2.21	20.75	839%
TKN-NH4	1.57	14.16	801%
1981 JANUARY-OCTOBER			
TOTAL P	0.96	1.62	69%
ORTHO P	0.88	1.39	58%
TOTAL N	2.30	6.99	204%
TKN-NH4	1.74	3.70	113%

[1]Nutrient concentrations in mg/l.

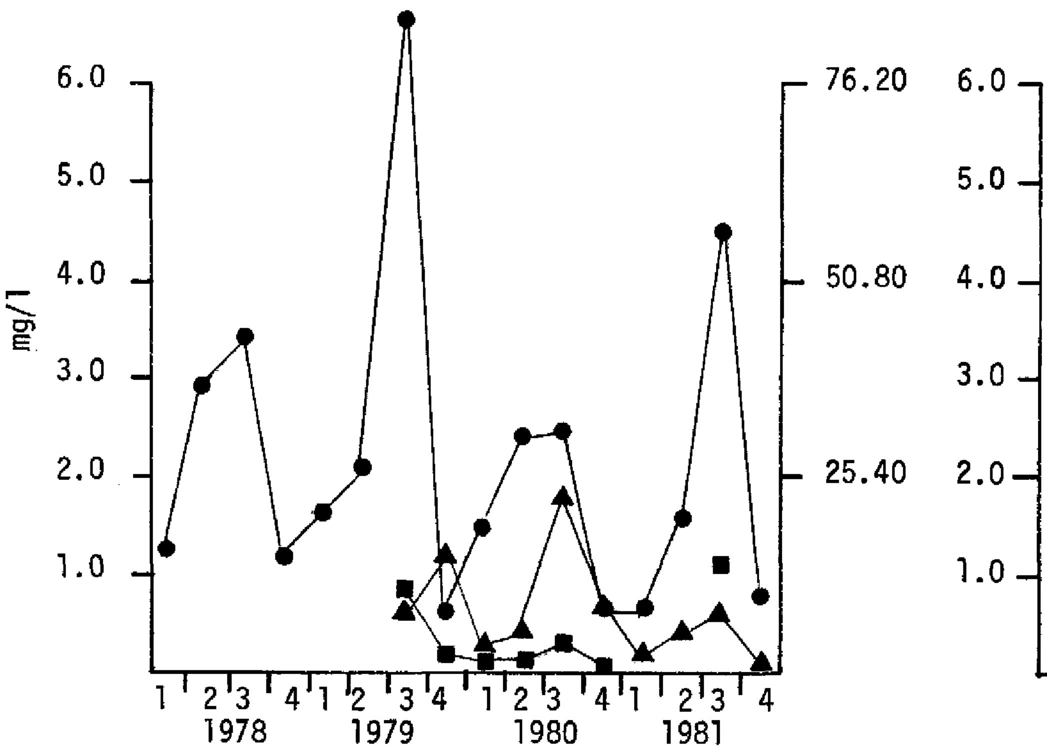
[2]Percent increase due primarily to cattle in streams and improper wastewater facilities.

TABLE 14. Annual Mean, Minimum, and Maximum Water Quality Values for Beef Cattle Runoff Stations (Improved Pasture) in Otter Creek from 1979 to 1981.

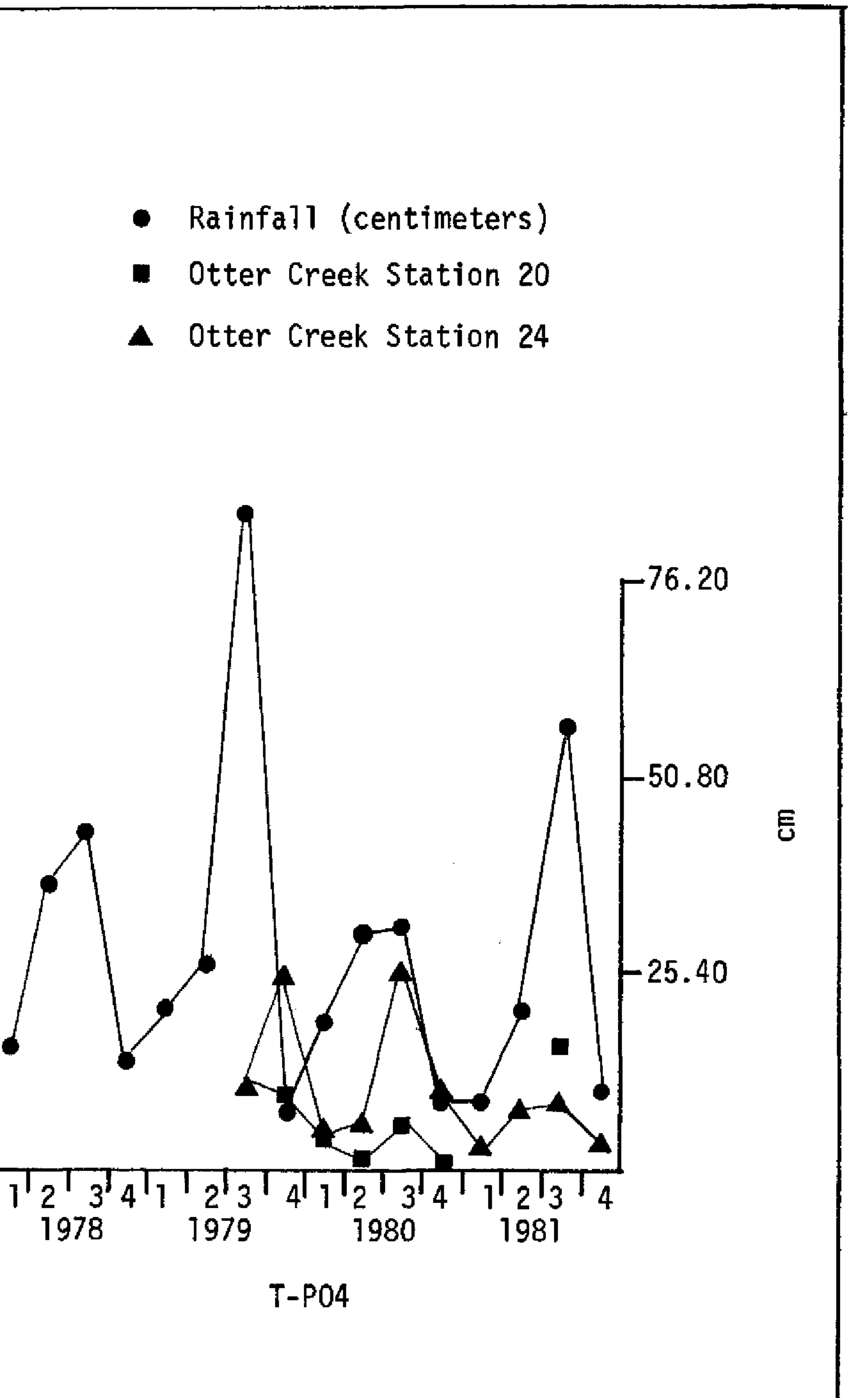
PARAMETERS[1]		1979[2] 20	1979[2] 24	1980 20	1980 24	1981 20	1981 24
O-PO4	$\bar{x}$	0.49	1.07	0.21	0.93	1.15	0.32
	min-max	0.04-1.01	0.36-1.77	0.02-1.04	0.01-2.81	1.04-1.27	0.02-0.94
T-PO4	$\bar{x}$	0.85	1.36	0.35	1.09	1.31	0.44
	min-max	0.20-2.68	0.01-4.18	0.08-1.28	0.06-3.36	1.17-1.46	0.07-1.12
TKN	$\bar{x}$	1.62	1.94	1.43	2.23	2.32	1.82
	min-max	0.93-2.05	1.54-2.38	0.86-1.91	0.94-4.66	2.26-2.37	1.00-3.97
NH4	$\bar{x}$	0.15	0.27	0.32	0.77	0.15	0.28
	min-max	0.02-0.46	0.01-0.74	0.01-1.07	0.01-5.04	0.06-0.24	0.01-3.40
NO2	$\bar{x}$	0.01	0.01	0.02	0.01	0.01	0.01
	min-max	0.01-0.01	0.01-0.02	0.004-0.07	0.004-0.02	0.01-0.01	0.004-0.01
NO3	$\bar{x}$	0.03	0.02	0.09	0.05	0.01	0.02
	min-max	0.004-0.07	0.004-0.05	0.01-0.35	0.004-0.02	0.004-0.02	0.004-0.10
TOTAL N	$\bar{x}$	1.65	1.96	1.53	2.29	2.34	1.84
	min-max	0.96-2.06	1.55-2.43	0.88-2.30	0.95-4.71	2.29-2.38	1.02-3.99
LAB COND (/cm)	$\bar{x}$	229	294	577	528	476	382
	min-max	117-422	199-404	346-1127	280-1485	392-560	200-650
LAB pH	$\bar{x}$	6.46	6.53	6.79	6.26	6.87	6.48
	min-max	6.18-6.85	6.09-6.90	6.40-7.17	4.59-6.88	6.78-6.95	5.21-7.22
TURBIDITY (NTU)	$\bar{x}$	2.80	2.70	7.00	2.40	1.00	2.90
	min-max	1.10-8.60	0.70-6.80	0.90-22.0	0.50-5.40	0.90-1.10	0.50-18.00
COLOR	$\bar{x}$	182	172	89	99	335	104
	min-max	46-266	101-231	25-233	20-325	307-362	43-271
NO. SAMPLES		10	10	9	22	2	21

[1]Chemical parameters are expressed in mg/l.
[2]Period of record for 1979 was from 09/15/79 to 12/10/79.

FIGURE 16. MEAN QUARTERLY O-PO4 AND T-PO4 CONCENTRATIONS FOR TWO IMPROVED PASTURE (BEEF CATTLE) RUNOFF STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)



O-PO4

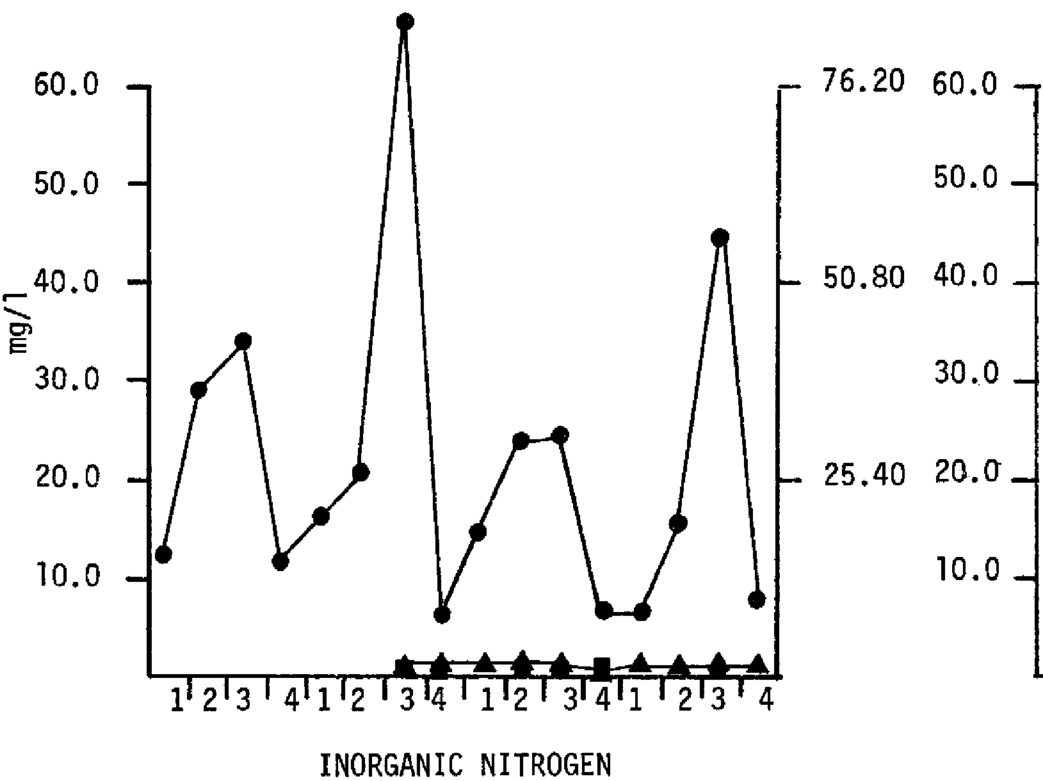


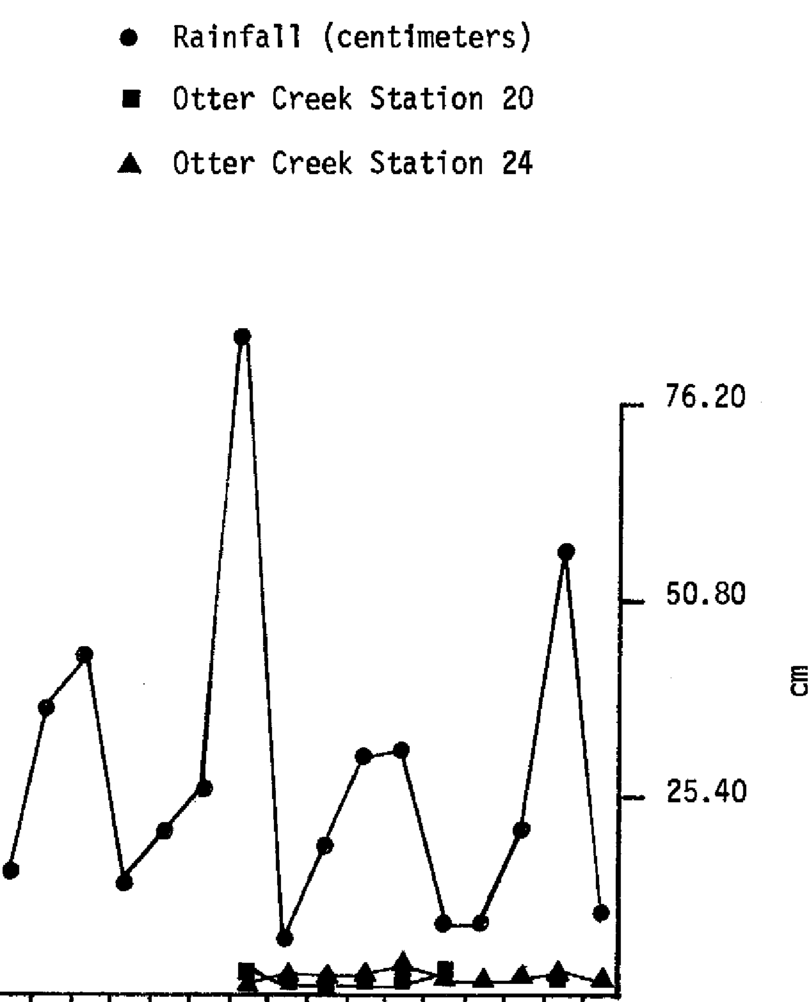
Rainfall (centimeters)
Otter Creek Station 20
Otter Creek Station 24
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1978
1979
1980
1981

T-P04

FIGURE 17.

MEAN QUARTERLY INORGANIC NITROGEN AND TOTAL NITROGEN CONCENTRATIONS AT TWO IMPROVED PASTURE (BEEF CATTLE) RUNOFF STATIONS IN OTTER CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE OTTER CREEK WATERSHED (W-13)





Rainfall (centimeters)
Otter Creek Station 20
Otter Creek Station 24
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
TOTAL NITROGEN

land use intensity is not as great on these beef cattle operations, we see more overland treatment of nutrients and thus lower N and P concentrations in runoff.

Site 27 is a hayfield runoff site draining into Otter Creek. This drainage area has no animal grazing pressure and represents relatively pristine water quality conditions compared to other areas in the watershed. Table 15 presents annual water quality values for hayfield runoff over a dominant soil type of Myakka fine sand. Total P concentrations have ranged from 0.27 mg/l to as high as 1.94 mg/l, while total N concentrations range from 1.15 mg/l to 2.43 mg/l. In comparison to the beef cattle and dairy runoff sites on Myakka fine sand, nutrient concentrations at the hayfield site reflect those exhibited from the less intensive beef cattle operations. However, another close comparison can be made between site 27 and the dairy runoff site, 19 (Pomello fine sand) where N and P concentrations (2.36 mg/l and 0.62 mg/l, respectively, in 1981) are similar to those at site 27. This helps strengthen conclusions by Allen et al. (1982) that an important factor that should be considered when selecting a dairy location is the soil type, whereby those soils that are more permeable and have deeper water tables tend to provide more efficient filtration and reduction of surface runoff.

In conclusion, overall nutrient concentrations in Otter Creek have declined since 1978. Decreases can be attributed to: 1) a decrease in annual rainfall (113 cm/yr in 1978 to 94 cm/yr in 1981) which helped deplete groundwater levels and dry out many drainage systems from beef and dairy operations; 2) the shutdown of F & R Dairy, improving downstream water quality in Otter Creek.

TABLE 15. Annual Mean, Minimum, and Maximum Water Quality Values for Hayfield Runoff (Station 27) into Otter Creek from 1979 to 1981.

	1979[4]		1980		1981	
	$\bar{x}$	min-max	$\bar{x}$	min-max	$\bar{x}$	min-max
CHEMICAL PARAMETERS[1]						
O-PO4	0.55	0.18-1.85	0.38		0.37	0.21-0.51
T-PO4	0.68	0.34-1.94	0.50		0.47	0.27-0.58
TKN	1.89	1.39-2.42	2.84		1.54	1.04-1.94
NH4	0.03	0.01-0.07	0.04		0.03	0.02-0.10
NO2	0.01	0.004-0.01	0.02		0.01	0.01-0.02
NO3	0.004	0.004-0.004	0.03		0.06	0.004-0.11
TOTAL N	1.89	1.39-2.43	2.89		1.61	1.15-1.95
PHYSICAL PARAMETERS						
LAB COND[2]	167	135-190	137		172	67-250
LAB pH	6.56	6.06-6.93	6.37		6.74	6.41-6.93
COLOR	241	183-302	551		200	141-226
TURBIDITY[3]	1.90	1.20-3.10	0.80		0.50	0.20-1.00
NO. SAMPLES		6		1		4

[1]Chemical parameters are expressed in mg/l.

[2]Lab conductivity is expressed in umhos/cm.

[3]Turbidity is expressed in NTU (nephelometric turbidity units).

[4]Period of record for 1979 was from 08/05/79 to 12/10/79.

The limited amount of rainfall that has occurred in this area since 1980 has created some unusual conditions. Groundwater levels have decreased to the point where short periods of heavy rainfall will not inundate drainage systems enough to create high flow conditions in the open channel. When these dry conditions exist during the summer months, cows do not congregate around drainage areas because of the lack of substantial water for cooling. Thus, decreasing the amount of runoff flow and eliminating the large number of cows from these systems decreased nutrient concentrations in the open channels. Because the major soil type in this area (Myakka fine sand) is poorly drained, when large amounts of rainfall occur, runoff from intensive dairy operations over these poorly drained soils tends to exhibit higher N and P concentrations than shown in areas with deeper water tables or less extensive land use practices.

LITTLE BIMINI

The number of dairy operations in the Little Bimini drainage basin increased from 2 barns (3,450 cows) in 1977 to 3 barns (4,550 cows) in 1978. The most dominant soil type is the Myakka fine sand with scattered areas of Pomello and Immokalee fine sand, the latter being somewhat more acidic than the Pomello and Myakka soil types.

There is one water quality sample site (02) in Little Bimini (Figure 8). This site is located in the open channel and ultimately receives discharge from all the dairies located in this subwatershed. Unlike Otter Creek, most of the outfall points of the dairies in the Little Bimini area flow through lengthy drainage systems before entering the main tributary. For this reason, dairy discharges and their associated nutrients entering Little Bimini are subject to a greater detention time, allowing for uptake through vegetation and sedimentation. As a result, mean nutrient concentrations (Table 16) are considerably lower than those found in Otter Creek. Table 16 presents mean annual nutrient concentrations at site 02, along with various physical parameters. An interesting note here is that nitrate concentrations are several times greater at Little Bimini than at Otter Creek or N. W. Taylor Creek (Figure 18). This may be attributed to: 1) nitrification, and 2) higher aerobic conditions that may exist in Little Bimini.

Data presented in Table 16 show a 69% decrease in total P and a 42% decrease in total N concentrations from 1978 to 1980. Decreases in annual nutrient concentrations can be attributed to: 1) decreases in annual rainfall, and 2) improvements in on-farm management practices (i.e., improvements in waste management facilities and paddock area runoff). Figures 19 and 20 graphically illustrate quarterly N and P concentrations from 1978 to 1981. Quarterly peaks in N as well as P concentrations correspond closely with peaks in rainfall. As with Otter Creek, much of the phosphorus found in Little Bimini is in the dissolved ($O\text{-}PO_4$) form (Figure 19); however, because of the higher nitrate concentrations in Little Bimini, inorganic nitrogen makes up a larger percentage of the total nitrogen constituent than is observed in Otter Creek and N. W. Taylor Creek (Figure 20).

In summary, nutrient concentrations in Little Bimini have decreased from 1978 to 1981. These decreases can generally be attributed to the decrease in rainfall amounts and the improvements of on-farm management practices at the dairies within this subwatershed. To date, McArthur Barn 4 (located in Little Bimini drainage) has completed approximately 40 percent of the fencing prescribed (4.8 km or 3 miles) by the SCS water quality plan, along with two cattle crossings.

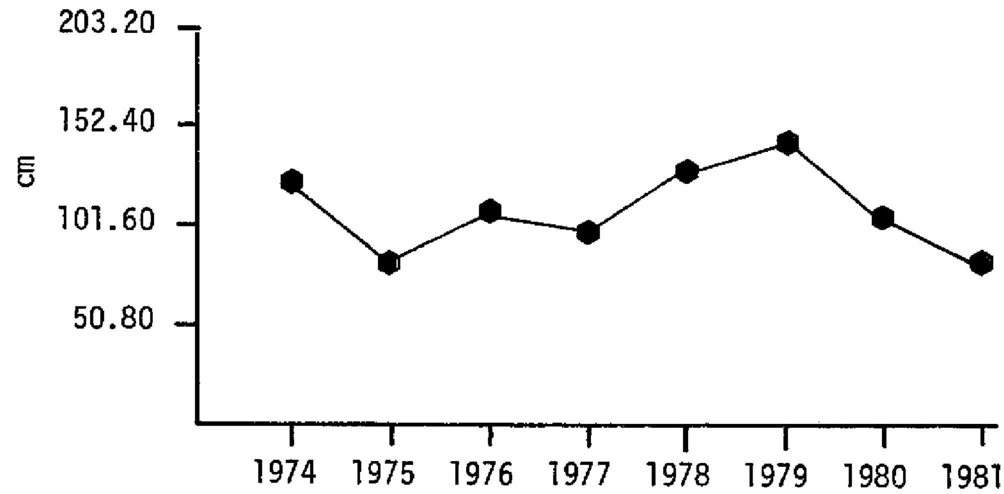
TABLE 16. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel of Little Bimini (Station 02) from 1978 to 1981

CHEMICAL PARAMETERS[1]	1978 $\bar{x}$	1978 min - max	1979 $\bar{x}$	1979 min - max	1980 $\bar{x}$	1980 min - max	1981 $\bar{x}$	1981 min - max
O-PO4	2.32	0.69-3.86	1.23	0.05-2.05	0.65	0.01-2.58	0.87	0.22-3.13
T-PO4	2.49	0.78-3.94	1.40	0.46-3.26	0.77	0.34-2.68	0.93	0.24-3.38
TKN	4.12	0.61-7.91	2.54	0.72-6.58	1.82	0.72-11.44	1.66	0.65-4.70
NH4	2.17	0.02-6.89	0.59	0.02-2.82	0.15	0.01-1.58	0.29	0.01-1.77
NO2	0.17	0.006-0.46	0.13	0.01-0.41	0.05	0.004-0.59	0.07	0.004-0.37
NO3	1.09	0.11-2.94	1.09	0.03-2.73	1.23	0.03-3.42	1.00	0.01-2.27
TOTAL N	5.38	1.09-9.25	3.76	0.80-7.19	3.12	0.95-11.52	2.73	0.74-5.50

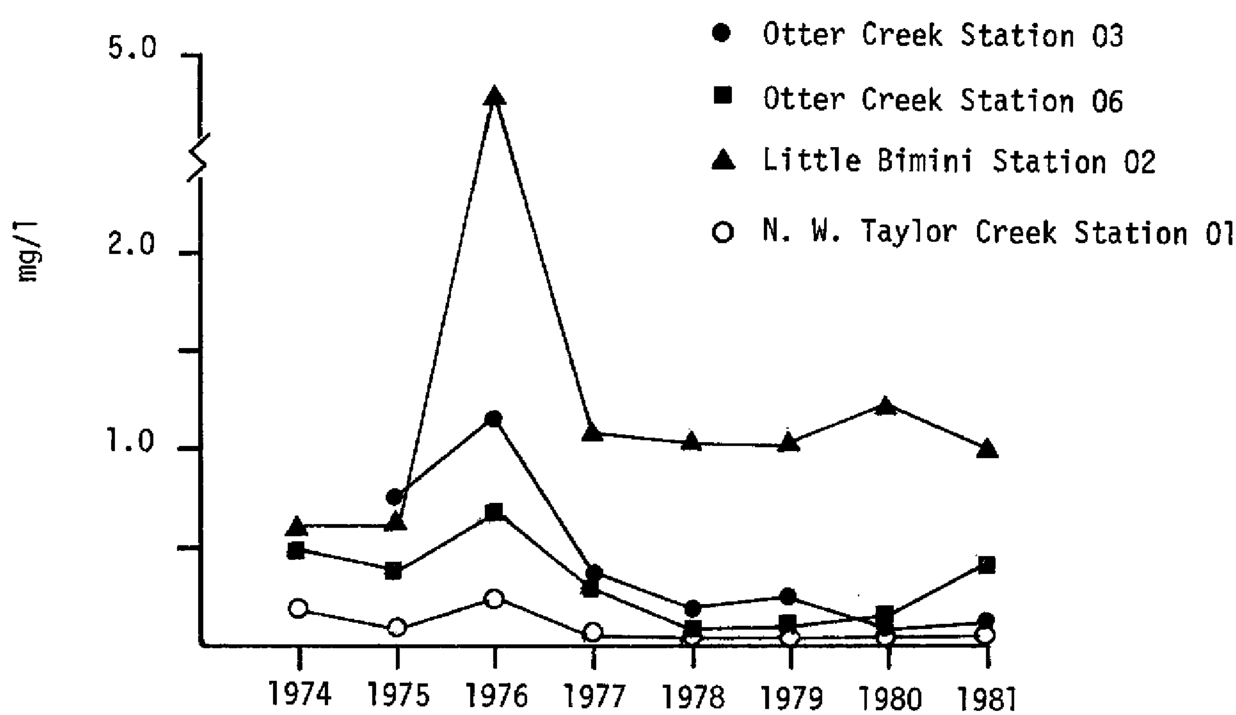
PHYSICAL PARAMETERS	1978 $\bar{x}$	1978 min - max	1979 $\bar{x}$	1979 min - max	1980 $\bar{x}$	1980 min - max	1981 $\bar{x}$	1981 min - max
LAB COND[2]	324	152-1282	229	141-381	250	102-420	280	129-384
LAB pH	6.97	6.67-7.39	6.95	6.61-7.69	6.99	6.15-7.22	7.22	6.86-7.80
COLOR			157[4]	93-225	97	65-241	124	48-376
TURBIDITY[3]			3.2[4]	2.1-4.7	2.8	1.0-6.9	1.6	0.3-2.6
NO. SAMPLES		23		28		23		24

[1]Chemical parameters are expressed in mg/l.
[2]Lab conductivity is expressed in umhos/cm.
[3]Turbidity is expressed in NTU (nephelometric turbidity units).
[4]Turbidity and color values for 1979 were derived from 10 samples collected between 9/5/79 & 12/10/79.

FIGURE 18. ANNUAL MEAN NITRATE NITROGEN CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TCHW PROJECT AREA AND TOTAL ANNUAL RAINFALL VALUES FOR THE UPPER TAYLOR CREEK WATERSHED (W-2)

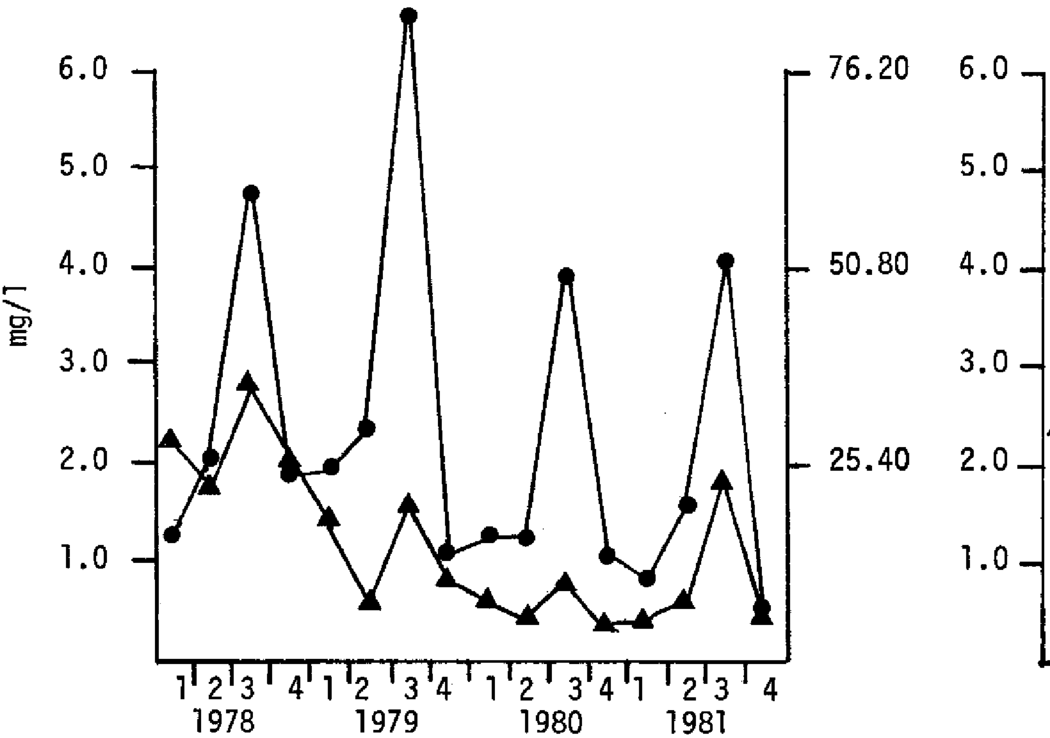


TOTAL ANNUAL RAINFALL

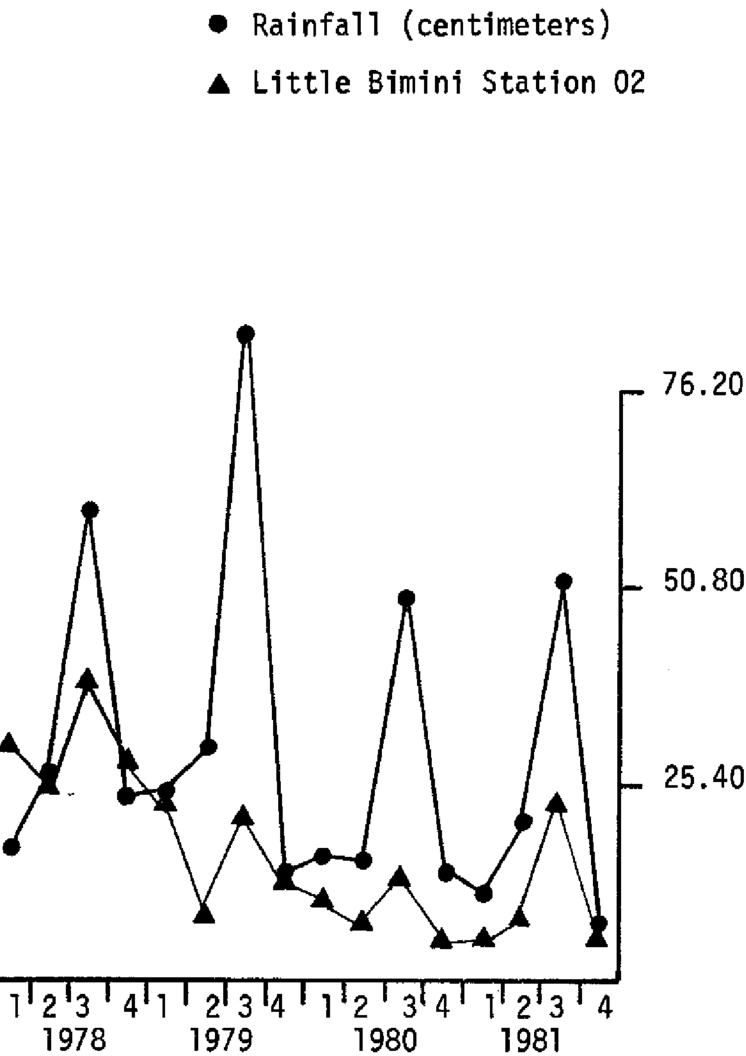


NO3

FIGURE 19. MEAN QUARTERLY O-PO4 AND T-PO4 CONCENTRATIONS AT THE OPEN CHANNEL STATION IN LITTLE BIMINI AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE LITTLE BIMINI WATERSHED (W-LB)



O-PO4



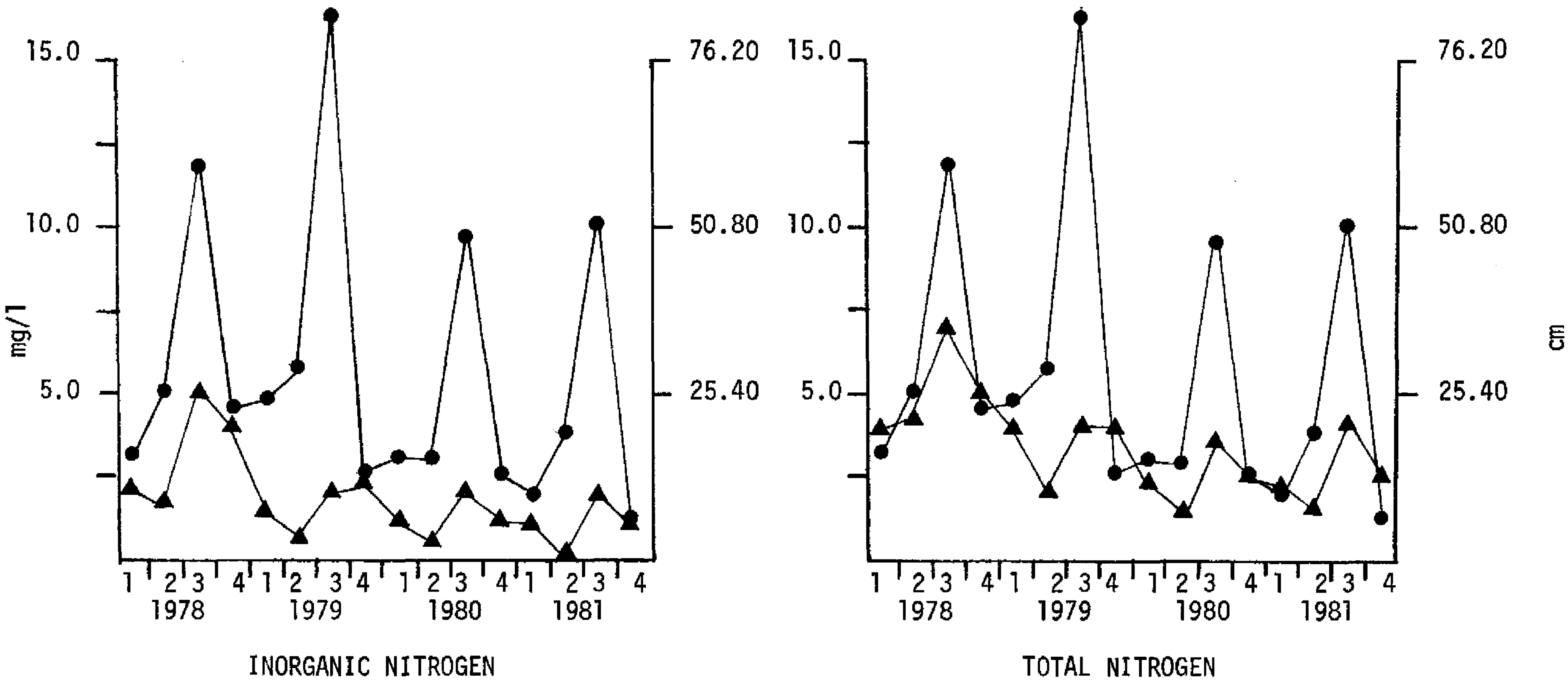
Rainfall (centimeters)
Little Bimini Station 02
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1978
1979
1980
1981

T-P04

FIGURE 20. MEAN QUARTERLY INORGANIC NITROGEN AND TOTAL NITROGEN CONCENTRATIONS AT THE OPEN CHANNEL STATION IN LITTLE BIMINI AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE LITTLE BIMINI WATERSHED (W-LB)

● Rainfall (centimeters)

▲ Little Bimini Station 02



N.W. TAYLOR CREEK

N. W. Taylor Creek has very little dairy activity associated with it. This subwatershed presently receives drainage from a 3,035 ha (7,500 acres) calf-heifer operation and approximately 1,903 ha (4,703 acres) of improved pasture for beef cattle. The dominant soils in the watershed are Immokalee and Myakka, both poorly drained and fairly acidic (pH 4.5-5.5).

There is one water quality site (01) in N. W. Taylor Creek which represents open channel flow (Figure 21). Nutrient concentrations at this site are generally lower than those exhibited in Little Bimini and Otter Creek. Figures 22 through 24 graphically depict comparisons of N and P concentrations from selected open channel sites in Otter Creek, Little Bimini, and N. W. Taylor Creek. Total N and P concentrations at N. W. Taylor Creek are not only lower, but exhibit least amount of annual fluctuation; whereby Otter Creek and Little Bimini show marked decreases in nutrient concentrations from 1978 through 1981. Table 17 presents annual means and ranges for various water quality parameters in N. W. Taylor Creek. The lower N and P concentrations can be attributed to less intensive agricultural land use in this basin. As mentioned, beef cattle and dairy farming are the predominant agricultural practices that site 01 monitors. In the northernmost section of the basin, there is a 5,800 head calf-heifer operation. Presently, these animals have direct access to N. W. Taylor Creek; however; there are 5.6 kilometers (3.5 miles) between this area and site 01, thus many of the nutrients are filtered through vegetative uptake and sedimentation; also, dilution occurs from waters of lower concentration coming from the downstream beef cattle operation. Further explanations of the low impact (agricultural nutrient enrichment) observed from the calf-heifer operation in N. W. Taylor Creek

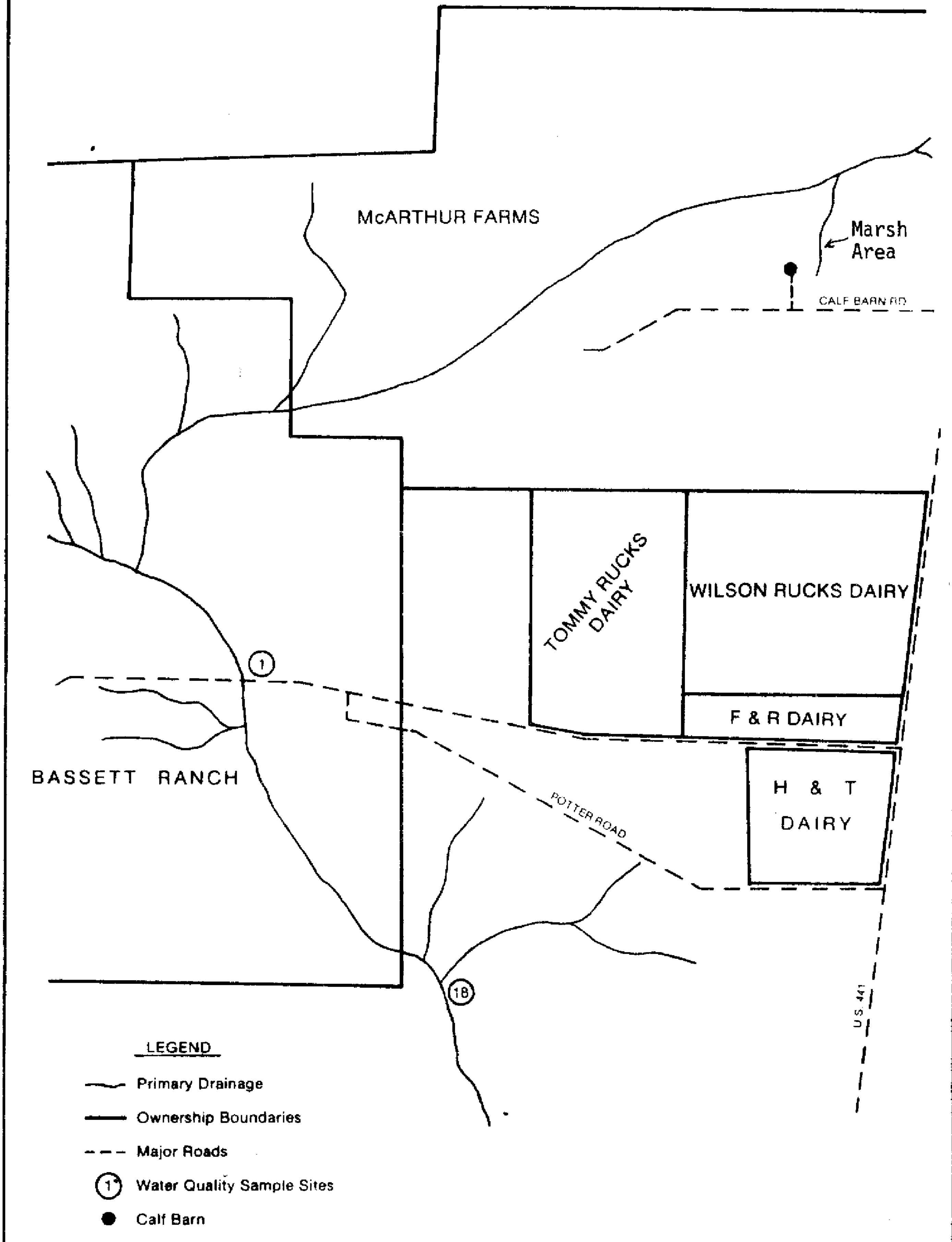


FIGURE 21. N. W. TAYLOR CREEK DRAINAGE SYSTEM

FIGURE 22. ANNUAL MEAN TOTAL NITROGEN CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TCHW PROJECT AREA AND TOTAL ANNUAL RAINFALL FOR THE UPPER TAYLOR CREEK WATERSHED (W-2)

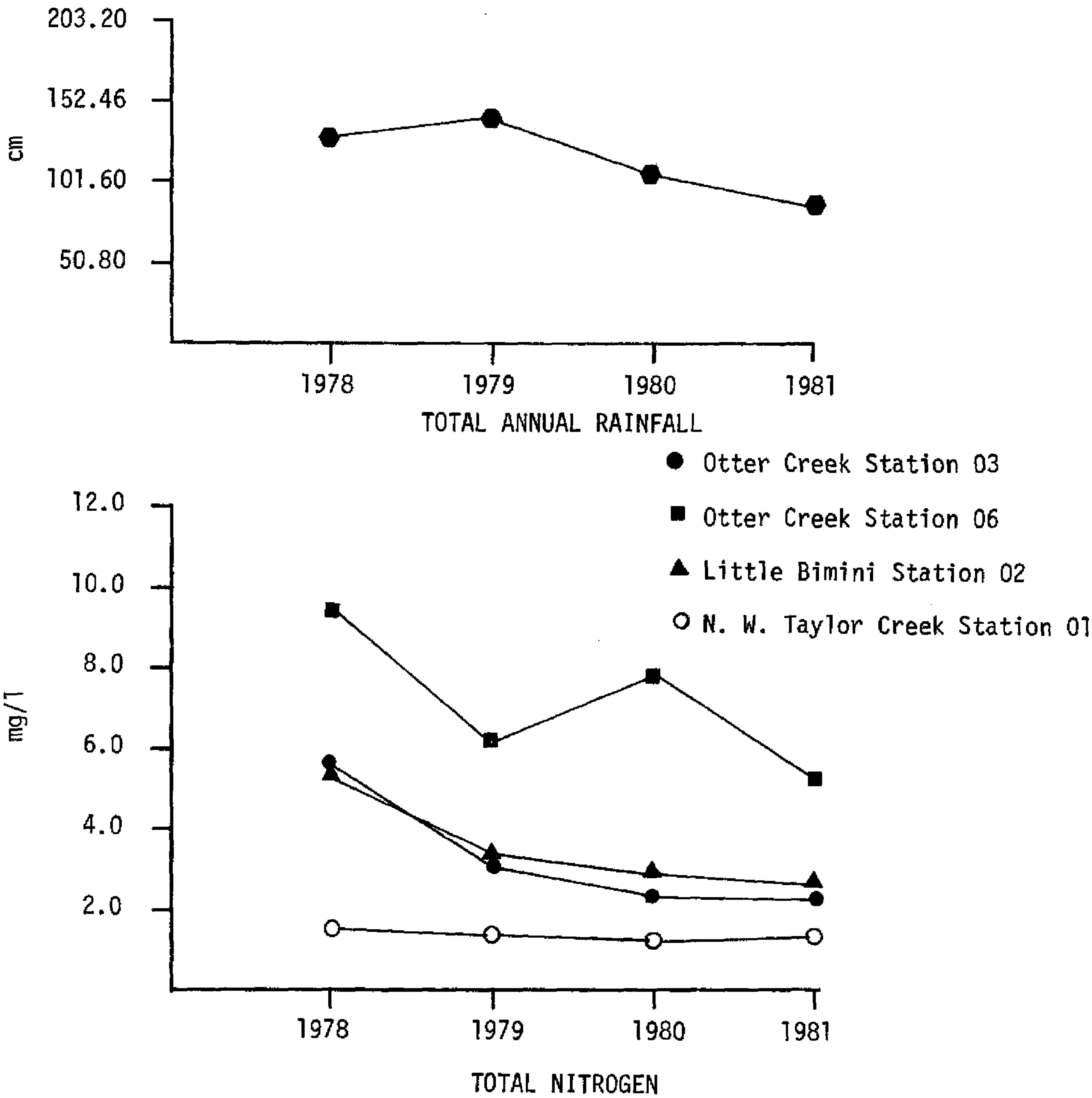
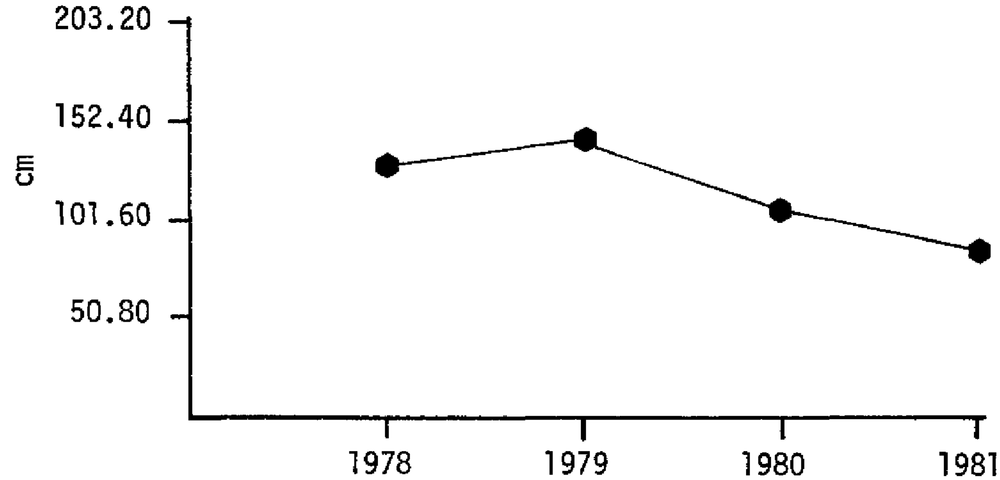
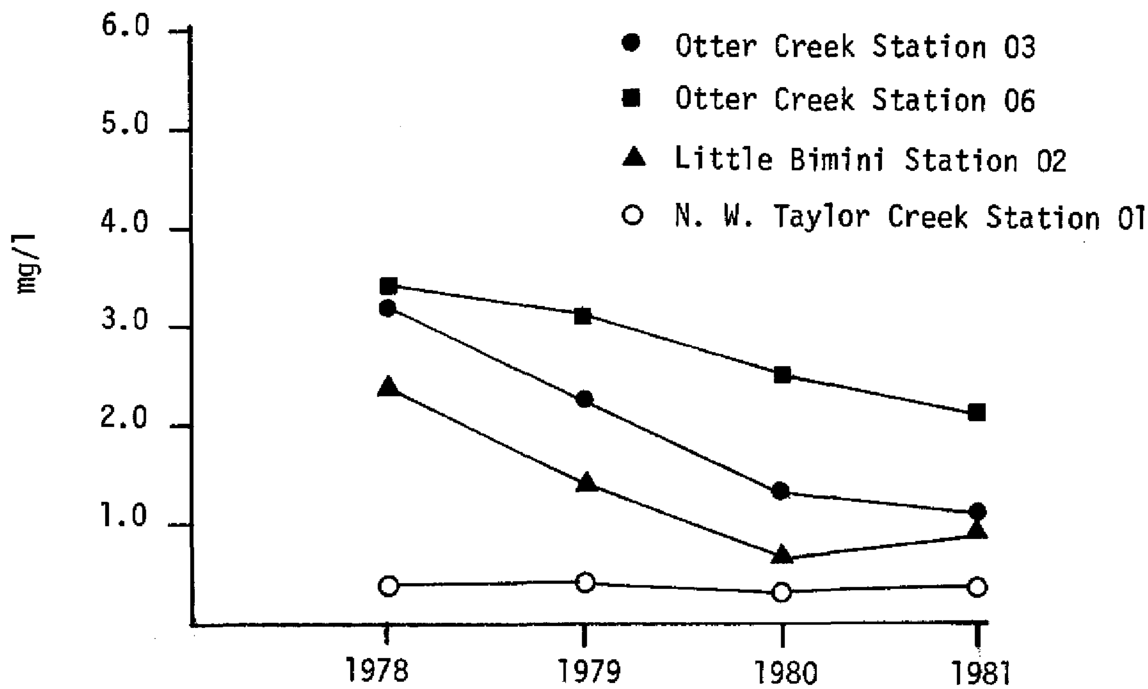


FIGURE 23. ANNUAL MEAN T-PO4 CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TCHW PROJECT AREA AND TOTAL ANNUAL RAINFALL FOR THE UPPER TAYLOR CREEK WATERSHED (W-2)



TOTAL ANNUAL RAINFALL



T-PO_4

FIGURE 24. ANNUAL MEAN O-PO4 CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TCHW PROJECT AREA AND TOTAL ANNUAL RAINFALL VALUES FOR THE UPPER TAYLOR CREEK WATERSHED (W-2)

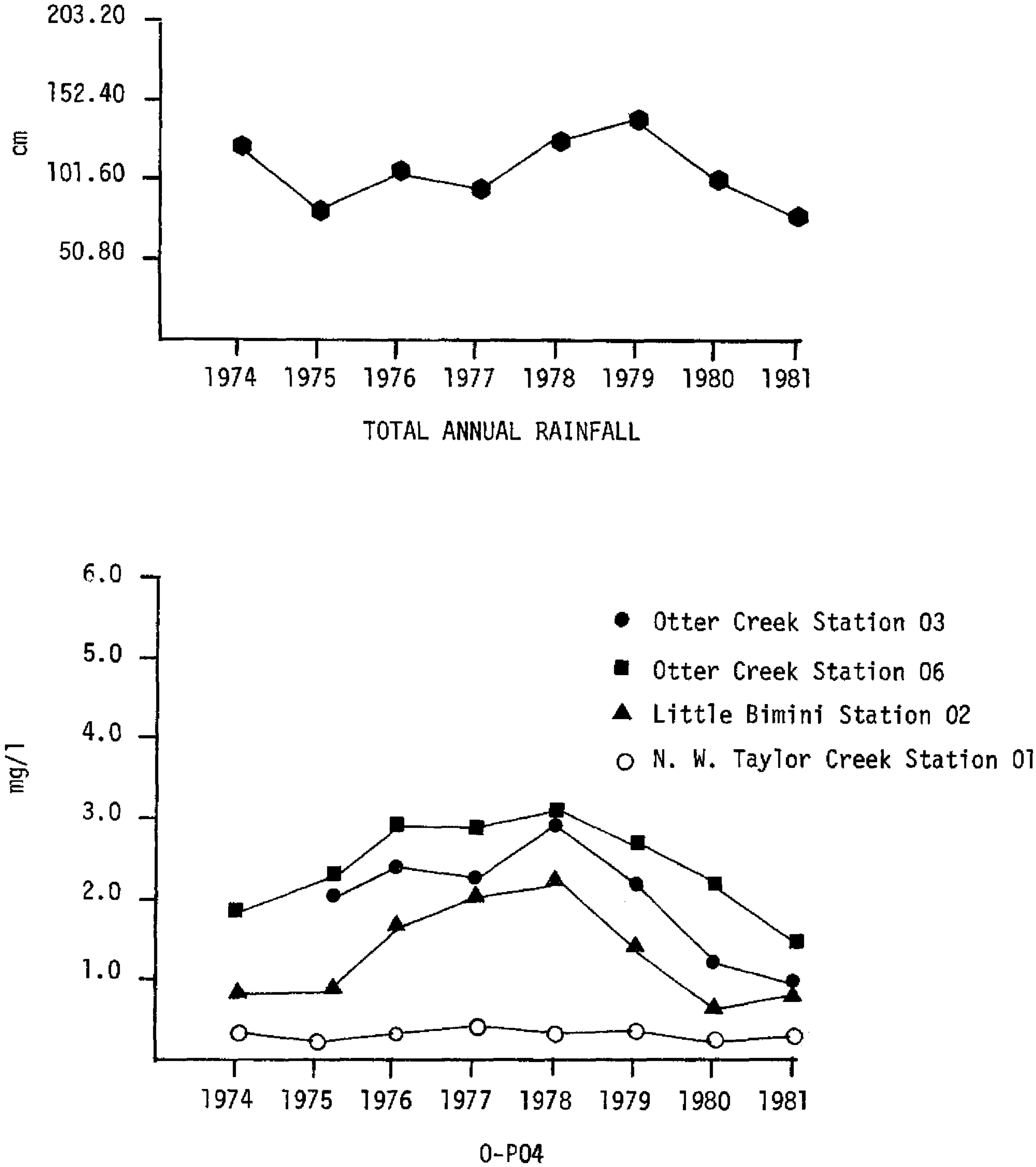


TABLE 17. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel of N. W. Taylor Creek (Station 01) from 1978 to 1981

CHEMICAL PARAMETERS[1]	1978 $\bar{x}$	1978 min - max	1979 $\bar{x}$	1979 min - max	1980 $\bar{x}$	1980 min - max	1981 $\bar{x}$	1981 min - max
O-PO4	0.37	0.12-0.74	0.35	0.12-0.81	0.29	0.07-0.77	0.32	0.03-1.15
T-PO4	0.43	0.19-0.89	0.42	0.15-0.78	0.34	0.09-0.84	0.38	0.06-1.31
TKN	1.68	0.74-2.44	1.62	0.99-4.47	1.12	0.45-2.08	1.18	0.29-2.85
NH4	0.06	0.02-0.50	0.04	0.01-0.11	0.04	0.01-0.36	0.04	0.01-0.18
NO2	0.01	0.004-0.02	0.01	0.006-0.02	0.01	0.004-0.03	0.01	0.004-0.10
NO3	0.06	0.004-0.29	0.07	0.004-0.38	0.06	0.004-0.15	0.07	0.004-0.31
TOTAL N	1.75	0.82-2.55	1.66	1.06-4.55	1.19	0.50-2.14	1.27	0.34-3.15
PHYSICAL PARAMETERS	**1978 $\bar{x}$**	**1978 min - max**	**1979 $\bar{x}$**	**1979 min - max**	**1980 $\bar{x}$**	**1980 min - max**	**1981 $\bar{x}$**	**1981 min - max**
LAB COND[2]	156	91-250	140	53-389	183	90-322	613	156-2100
LAB pH	6.87	6.21-7.51	6.76	6.21-7.20	6.84	6.15-7.26	7.13	6.83-7.53
COLOR			230[4]	113-330	115	38-302	132	29-529
TURBIDITY[3]			2.3[4]	1.3-3.7	2.2	0.4-4.6	1.3	0.2-6.0
NO. SAMPLES		23		28		23		25

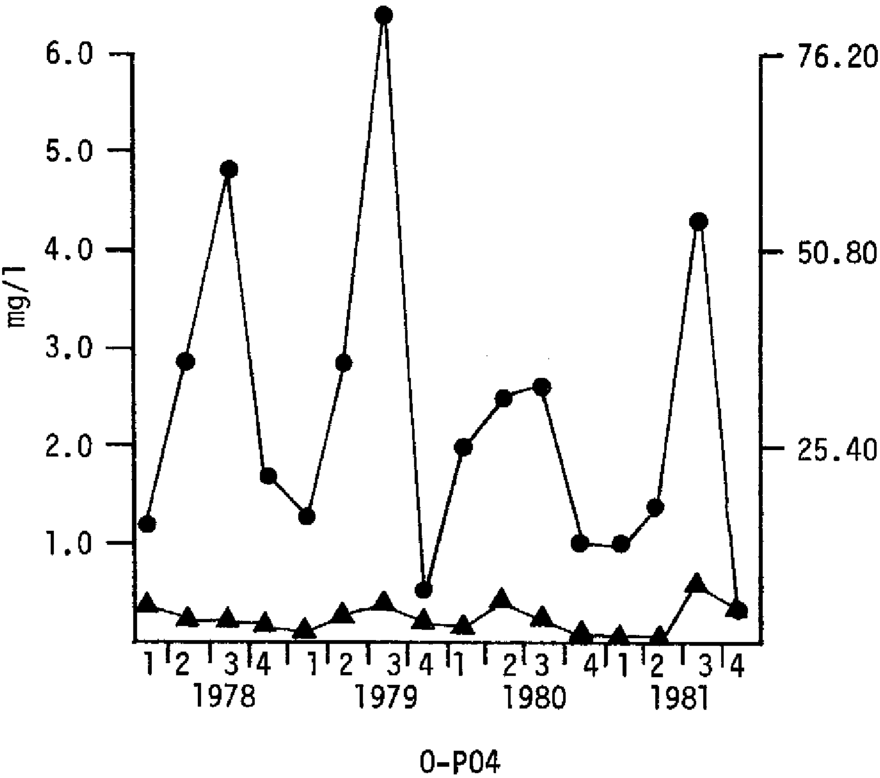
[1]Chemical parameters are expressed in mg/l.
[2]Lab conductivity is expressed in umhos/cm.
[3]Turbidity is expressed in NTU (nephelometric turbidity units).
[4]Turbidity and color values for 1979 were derived from 10 samples collected between 9/5/79 & 12/10/79.

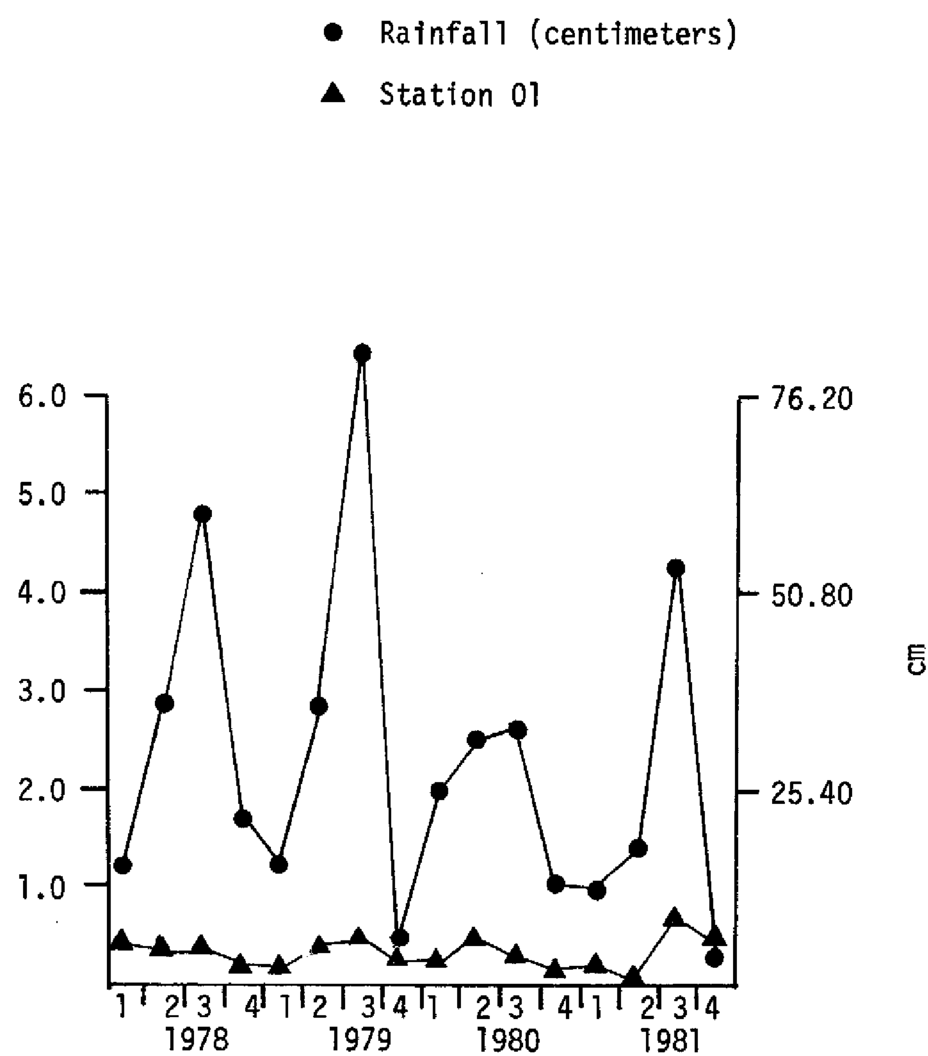
are: 1) discharge from the calf barn travels through a large marsh near Eagle Island before it goes into N. W. Taylor Creek; 2) less water is used at the calf barn, approximately 7.58 m^3 per day (2,000 gals/day), than the 1,136.36 m^3 per day (300,000 gals/day) used at each of the milking barns; 3) there is less ditching in the pastures surrounding this operation.

Another factor that may be conducive to the low nutrient concentrations in this watershed is that very little of this area has been disturbed by primary (PL 566) or secondary (private landowners) ditches, thus there is more overland treatment of nutrient runoff which provides a more effective natural filtration system or sink for available nutrients.

Figures 25 and 26 graphically illustrate quarterly N and P concentrations and rainfall from 1978 to 1981 at site 01; again, there is very little fluctuation throughout this period and there seems to be little influence from rainfall. By virtue of these more pristine conditions (in comparison with Otter Creek and Little Bimini), N. W. Taylor Creek provides a convenient standard by which to measure the degree of success (improving water quality) BMP implementation will have at Otter Creek and Little Bimini, as well as Mosquito Creek, Nubbin Slough, and Henry Creek.

FIGURE 25. MEAN QUARTERLY O-PO4 AND T-PO4 CONCENTRATIONS AT THE OPEN CHANNEL STATION IN N. W. TAYLOR CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE N. W. TAYLOR CREEK WATERSHED (W-3)

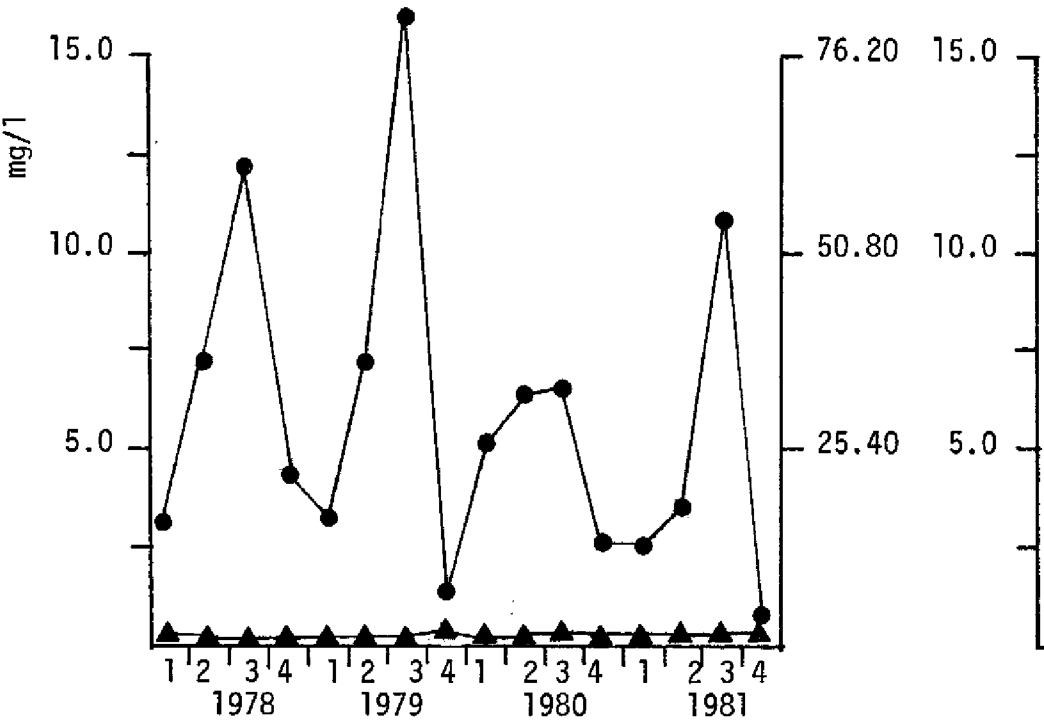




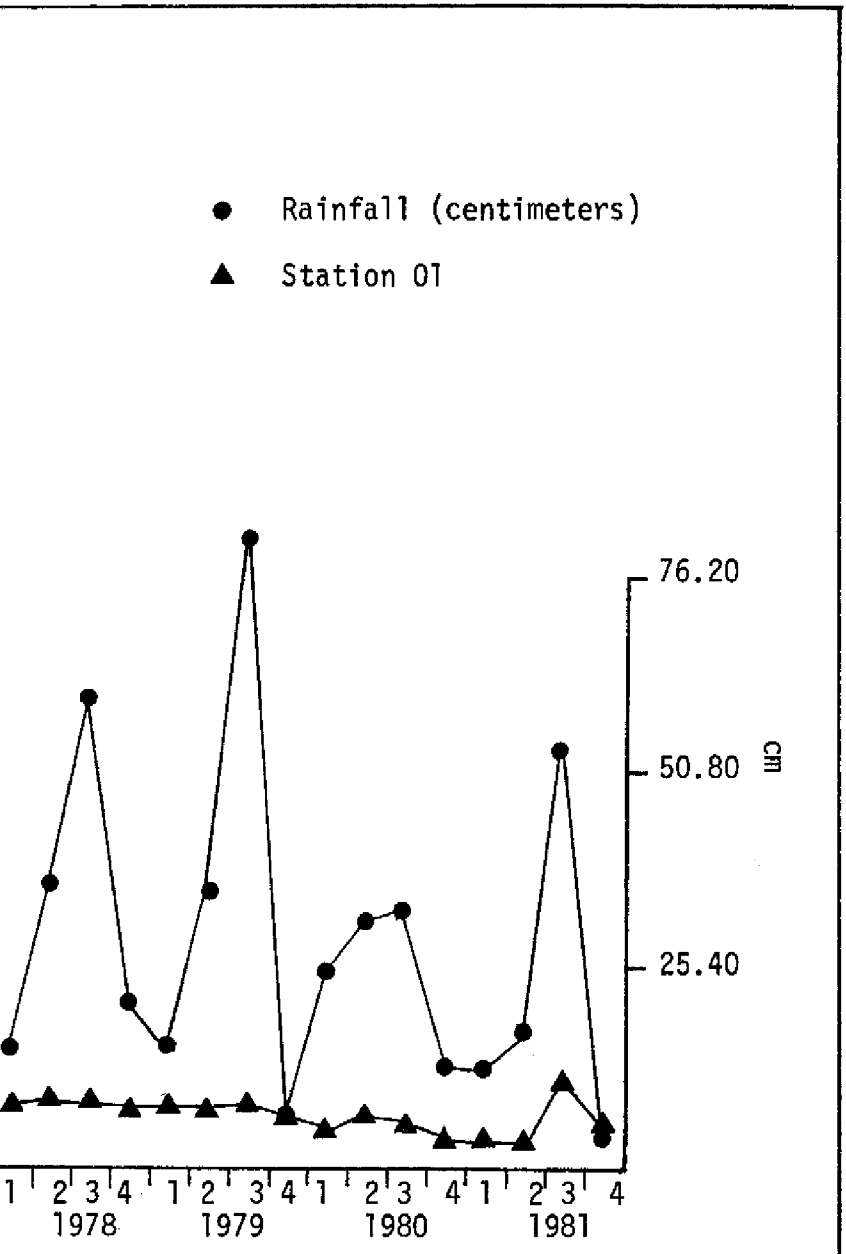
Rainfall (centimeters)
Station 01
6.0
5.0
4.0
3.0
2.0
1.0
76.20
50.80
25.40
cm
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
1978
1979
1980
1981

T-P04

FIGURE 26. MEAN QUARTERLY INORGANIC NITROGEN AND TOTAL NITROGEN CONCENTRATIONS AT THE OPEN CHANNEL STATION IN N. W. TAYLOR CREEK AND QUARTERLY THIESSEN WEIGHTED RAINFALL FOR THE N. W. TAYLOR CREEK WATERSHED (W-3)



INORGANIC NITROGEN



TOTAL NITROGEN

TAYLOR CREEK MAIN BRANCH

The main branch of Taylor Creek drains that area of the upper Taylor Creek watershed below the headwaters (Otter Creek, Little Bimini, and N. W. Taylor Creek), beginning at structure S-2 and terminating at the L-63N interceptor canal (Figure 3). The majority of land use is in cattle ranching (improved pasture) and citrus. This main branch extends approximately 14.4 km (9 miles) below the headwaters confluence (S-2) before entering into the L-63N interceptor canal to Nubbin Slough. Presently, there are three open channel monitoring sites (18, 12, 11) along this main channel. The dominant soil types surrounding this channel are the Manatee, Delray, and Okeelanta, outside of which lies Immokalee fine sand and scattered areas of Chobee fine sand. Manatee, Delray, and Okeelanta soils are typically poorly drained and are found in old or existing floodplains. Immokalee and Chobee soils are also poorly drained; these soil types lie outside of the floodplain. Chobee fine sand is generally associated with inland depressional areas (McCollum and Pendleton, 1971).

Annual water quality values for the open channel sites 18, 12, and 11 are presented in Tables 18 and 19. These sites (18, 12, 11) are located downstream from one another, respectively, with site 12 being approximately 7.2 km (4.5 miles) from both sites 18 and 11. N and P concentrations from 1979 to 1981 indicate progressive decreases from site 18 to site 11. In 1981, total P concentrations decreased 30% from site 18 to site 12, and another 21% from site 12 to site 11. Total N concentrations in 1981 decreased 53% from site 18 to site 12, and 10 percent from site 12 to site 11. These decreases from upstream to downstream suggest that Taylor Creek acts as a nutrient sink for upstream export as well as a source for dilution of upstream nutrients from lower concentrated waters downstream.

TABLE 18. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in the Main Branch of Taylor Creek for 1978 and 1979.

PARAMETERS[1]		1978		1979		
		12	11	18[3]	12	11
O-PO4	$\bar{x}$	1.11	0.87	1.06	0.98	0.74
	min-max	0.22-1.63	0.39-1.29	0.30-1.50	0.56-1.36	0.40-1.00
T-PO4	$\bar{x}$	1.44	0.98	1.35	1.08	0.85
	min-max	0.56-5.70	0.44-1.47	0.11-1.95	0.71-1.76	0.46-2.01
TKN	$\bar{x}$	1.94	1.86	2.75	1.91	1.69
	min-max	1.14-2.78	0.28-5.70	1.70-4.13	0.99-3.96	0.82-3.12
NH4	$\bar{x}$	0.30	0.14	0.77	0.20	0.11
	min-max	0.001-0.87	0.01-0.42	0.03-1.76	0.01-1.02	0.01-0.37
NO2	$\bar{x}$	0.07	0.04	0.07	0.04	0.02
	min-max	0.004-0.27	0.004-0.14	0.01-0.13	0.01-0.14	0.01-0.11
NO3	$\bar{x}$	0.41	0.29	0.56	0.35	0.23
	min-max	0.004-1.15	0.004-0.79	0.01-1.76	0.004-1.36	0.004-0.67
TOTAL N	$\bar{x}$	2.42	2.20	3.38	2.30	1.93
	min-max	1.15-3.46	0.61-5.70	1.79-5.03	1.00-4.77	0.91-3.71
LAB COND (µmhos/cm)	$\bar{x}$	341	575	210	293	567
	min-max	142-781	206-1650	88-366	85-980	97-1425
LAB pH	$\bar{x}$	7.09	7.07	7.07	7.04	7.09
	min-max	6.42-7.72	6.14-7.63	6.58-7.54	6.34-7.55	6.40-7.70
TURBIDITY[2] (NTU)	$\bar{x}$			4.00		
	min-max			2.10-7.00		
COLOR[2]	$\bar{x}$			190		
	min-max			97-282		
SAMPLES		25	25	8	28	28

[1] Chemical parameters are expressed in mg/l.

[2] Turbidity and color values for 1979 were based on 10 samples collected between 09/05/79 and 12/10/79.

[3] Water quality values for Station 18 in 1979 were based on 8 samples collected between 09/05/79 and 12/10/79.

TABLE 19. Annual Minimum and Maximum Water Quality Values for the Open Channel Stations in the Main Branch of Taylor Creek for 1980 and 1981.

PARAMETERS[1]		1980			1981		
		18	12	11	18	12	11
O-PO4	$\bar{x}$	1.29	0.75	0.69	0.87	0.57	0.46
	min-max	0.21-3.09	0.01-1.44	0.22-1.77	0.03-2.02	0.11-1.87	0.10-1.50
T-PO4	$\bar{x}$	1.48	0.89	0.75	0.94	0.66	0.52
	min-max	0.30-3.21	0.22-1.68	0.22-1.70	0.06-2.45	0.14-2.10	0.12-1.63
TKN	$\bar{x}$	3.56	1.80	1.60	3.27	1.64	1.47
	min-max	0.77-7.54	0.63-8.34	0.69-2.89	0.44-16.26	0.52-5.10	0.53-2.96
NH4	$\bar{x}$	1.85	0.15	0.18	1.64	0.10	0.08
	min-max	0.01-6.31	0.01-0.60	0.01-1.31	0.01-14.26	0.01-0.86	0.01-0.44
NO2	$\bar{x}$	0.10	0.03	0.02	0.06	0.02	0.02
	min-max	0.004-0.73	0.004-0.10	0.04-0.08	0.004-0.28	0.004-0.15	0.004-0.11
NO3	$\bar{x}$	0.42	0.28	0.19	0.66	0.21	0.19
	min-max	0.01-1.12	0.004-0.91	0.04-0.59	0.01-1.79	0.004-0.82	0.004-1.46
TOTAL N	$\bar{x}$	4.08	2.12	1.82	3.98	1.87	1.68
	min-max	1.17-8.70	0.69-8.35	0.73-3.14	0.45-17.93	0.53-5.11	0.54-3.33
LAB COND (umhos/cm)	$\bar{x}$	325	491	895	478	839	1320
	min-max	200-500	325-1160	420-1500	242-1850	331-2100	350-2650
LAB pH	$\bar{x}$	7.34	7.33	7.30	7.33	7.46	7.53
	min-max	6.68-8.65	6.99-7.93	6.78-7.73	6.77-9.11	7.01-7.81	6.93-8.14
TURBIDITY (NTU)	$\bar{x}$	5.20			3.70	1.90	1.50
	min-max	1.00-12.50			0.50-15.50	0.90-3.00	0.60-3.30
COLOR	$\bar{x}$	113			126	80	95
	min-max	33-265			29-350	36-216	34-242
NO. SAMPLES		21	23	22	21	26/9[2]	26/9[2]

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity and color values for 1981 stations 11 and 12 were based on 9 samples.

Station 18, located at the confluence of N. W. Taylor Creek, Little Bimini, and Otter Creek at structure S-2, presents a reference point at which to monitor nutrient export from the entire Taylor Creek headwaters, thus providing a check on the overall effectiveness of BMP's implemented throughout the TCHW project area. From site 18, there is continued nutrient reduction (denitrification, return to atmosphere (N), soil adsorption (P)) until ultimate discharge into the L-63N canal. Future nutrient decreases at site 18 should help substantially in decreasing the total nutrient export from upper Taylor Creek (W-2).

WILLIAMSON DITCH

Williamson Ditch is a man-made canal constructed prior to 1953 and improved for flood protection and water management under PL 566. This canal drains an area of approximately 85.1 km^2 (32.8 square miles) of agricultural land used primarily for beef cattle and citrus, ultimately discharging into the main branch of Taylor Creek directly above the L-63N interceptor canal. There are a variety of different soils found throughout this watershed, the major soils being Chobee, Manatee, and Okeelanta. These soils are all poorly drained, with high water tables.

Annual water quality values for the open channel sites 07, 08, and 09 on Williamson Ditch are presented in Tables 20 and 21. Because of the similarities in land use practices in the Williamson Ditch and N. W. Taylor Creek watersheds, similarities exist in N and P concentrations, with Williamson Ditch exhibiting low N (<2.50 mg/l) and P (<0.50 mg/l) mean annual concentrations. This watershed continues to exhibit high chloride concentrations (>1800 mg/l), as mentioned by Allen et al. (1976) and Stewart et al. (1978). One indicator for high chloride content in water is the specific conductivity. Tables 20 and 21 substantiate findings by Allen and Stewart presenting high conductivity values (as high as 5,250 umhos/cm) compared to those of N. W. Taylor Creek, Otter Creek, Little Bimini, as well as the other tributaries in TCNS (mean of about 500 umhos/cm). This area has approximately 405 ha (1000+ acres) of citrus, with a ditch system of irrigation. Water for irrigation is from artesian wells which are typically high in chloride throughout this area. Because chloride is a conservative ion, it is not subject to biochemical degradation; thus, downstream concentration reductions are due primarily from dilution by lower concentrated waters. Presently, these high chloride

TABLE 20. Annual Mean, Minimum, and Maximum Values for the Open Channel Stations in Williamson Ditch for 1978 and 1979.

PARAMETERS[1]		1978 07	1978 08	1978 09	1979 07	1979 08	1979 09
O-PO4	$\bar{x}$	0.12	0.63	0.33	0.16	0.41	0.26
	min-max	0.01-0.24	0.07-1.60	0.11-0.85	0.04-0.32	0.04-1.31	0.03-0.62
T-PO4	$\bar{x}$	0.16	0.79	0.54	0.21	0.47	0.34
	min-max	0.08-0.27	0.13-1.68	0.16-1.78	0.05-0.38	0.06-1.28	0.13-0.67
TKN	$\bar{x}$	1.67	2.27	2.72	1.70	1.97	2.29
	min-max	0.85-2.75	0.86-4.30	0.92-10.76	0.75-3.12	0.71-5.35	0.80-8.10
NH4	$\bar{x}$	0.04	0.18	0.69	0.11	0.14	0.39
	min-max	0.01-0.19	0.01-1.28	0.05-6.03	0.01-1.35	0.01-0.92	0.01-1.99
NO2	$\bar{x}$	0.01	0.02	0.02	0.01	0.02	0.01
	min-max	0.004-0.02	0.004-0.09	0.004-0.05	0.004-0.13	0.004-0.22	0.004-0.06
NO3	$\bar{x}$	0.02	0.16	0.09	0.07	0.03	0.10
	min-max	0.004-0.08	0.004-1.37	0.004-0.40	0.004-0.84	0.004-0.18	0.004-1.09
TOTAL N	$\bar{x}$	1.70	2.44	2.67	1.78	2.01	2.40
	min-max	0.95-2.81	1.06-4.31	0.93-10.84	0.78-3.90	0.72-5.38	0.86-8.12
LAB COND	$\bar{x}$	1372	1613	1126	1194	2297	1543
(umhos/cm)	min-max	324-3870	127-4450	221-2740	89-3065	160-5250	111-4077
LAB pH	$\bar{x}$	7.25	7.24	7.11	7.25	7.50	7.11
	min-max	6.54-7.82	6.11-7.77	6.05-7.92	6.26-7.82	6.42-8.96	6.30-8.01
NO. SAMPLES		25	23	25	28	28	28

[1]Chemical parameters are expressed in mg/l.

TABLE 21. Annual Mean, Minimum, and Maximum Values for the Open Channel Stations in Williamson Ditch:

PARAMETERS[1]		1980 07	1980 08	1980 09	1981 07	1981 08	1981 09
O-PO4	$\bar{x}$	0.15	0.41	0.27	0.12	0.33	0.23
	min-max	0.04-0.37	0.03-1.28	0.04-0.78	0.01-0.43	0.01-2.38	0.01-1.06
T-PO4	$\bar{x}$	0.28	0.49	0.41	0.18	0.40	0.37
	min-max	0.10-1.74	0.06-1.39	0.09-1.96	0.04-0.58	0.02-2.65	0.04-1.85
TKN	$\bar{x}$	1.60	2.06	2.09	1.35	1.86	1.76
	min-max	0.53-3.73	0.77-4.78	0.71-9.07	0.43-2.46	0.20-5.33	0.20-3.65
NH4	$\bar{x}$	0.15	0.35	0.29	0.05	0.28	0.26
	min-max	0.01-2.28	0.01-2.09	0.01-1.44	0.01-0.32	0.01-2.67	0.01-1.00
NO2	$\bar{x}$	0.01	0.01	0.02	0.01	0.01	0.02
	min-max	0.004-0.01	0.004-0.10	0.004-0.19	0.004-0.03	0.004-0.10	0.004-0.13
NO3	$\bar{x}$	0.10	0.04	0.08	0.05	0.05	0.06
	min-max	0.004-1.51	0.004-0.14	0.004-0.43	0.004-0.50	0.004-0.28	0.004-0.43
TOTAL N	$\bar{x}$	1.71	2.11	2.19	1.41	1.92	1.84
	min-max	0.59-5.27	0.79-4.81	0.73-9.16	0.44-2.51	0.24-5.43	0.23-3.80
LAB COND	$\bar{x}$	1475	2712	1714	2374	3723	2462
(umhos/cm)	min-max	395-2700	490-5000	245-5100	266-4450	265-5235	264-4710
LAB pH	$\bar{x}$	7.45	7.38	7.34	7.46	7.54	7.42
	min-max	7.19-7.85	7.06-7.79	7.09-7.58	6.73-7.92	6.86-8.32	6.88-7.74
TURBIDITY	$\bar{x}$				1.10	1.10	1.90
(NTU)	min-max				0.90-2.60	0.20-3.00	0.90-3.40
COLOR	$\bar{x}$				80	87	65
	min-max				32-188	31-304	29-155
NO. SAMPLES		23	23	23	26/9[2]	26/9[2]	26/9[2]

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity and color values for 1981 for stations 07, 08, 09 were based on 9 samples.

concentrations have not presented a water quality problem; however, if continued use increases, large volumes of artesian irrigation may over time degrade surface water quality in this area.

MOSQUITO CREEK

Mosquito Creek lies south of the upper Taylor Creek watershed and drains into the L-63N interceptor canal to Nubbin Slough. The hydrologic area for the Mosquito Creek watershed subunit has not been determined; however, USGS topography maps indicate that this watershed is similar in area to the N. W. Taylor Creek watershed. Mosquito Creek in the past has supported as many as 5 dairies (milking 1000+ cows each) belonging to Modern Dairy Farms, Inc. By 1981, the financial situation of this corporation forced the shutdown of 2 of the dairies. Presently, the amount of dairy activity taking place is limited due to a change of ownership which is taking place at this time. The dominant soil types in this area are the Immokalee fine sand, which borders the creek bed on both sides, along with scattered sections of Myakka and Pomello fine sand, the latter being more suited for dairy sites due to its better internal drainage capacity.

Tables 22 and 23 present water quality values for the open channel sites 15 and 13 in Mosquito Creek from 1978 through 1981 (Figure 3). As noted, dairy activity in this watershed has decreased during this period; however, N concentrations (NH_4, TKN, and total N) as well as P concentrations (ortho P and total P) exhibited minimal decreases from 1979 to 1981 (time period of dairy activity slowdown). The small decrease in N and P concentrations at both the upstream site (15) and downstream site (13) from 1979 to 1981 may be attributed to the decrease in rainfall as well as the subsequent slow down of dairy activities in the area. Interestingly enough, NO_3 concentrations showed, on an average, an increase (1978 through 1981) of 330% from the upstream site (15) to the downstream site (13). This large increase from site 15 downstream to site 13 may be

TABLE 22. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Mosquito Creek for 1978 and 1979.

		1978		1979	
PARAMETERS[1]		15	13	15	13
O-PO4	$\bar{x}$	2.70	2.72	3.23	3.52
	min-max	1.40-4.32	1.39-5.03	1.67-6.63	1.32-7.22
T-PO4	$\bar{x}$	2.82	2.76	3.31	3.60
	min-max	1.44-4.74	1.46-5.27	1.66-6.71	1.69-6.85
TKN	$\bar{x}$	5.84	4.38	11.89	8.67
	min-max	1.96-17.74	1.80-12.56	1.14-34.35	0.58-26.02
NH4	$\bar{x}$	3.71	2.32	9.36	6.39
	min-max	0.64-12.43	0.07-9.28	0.12-22.84	0.08-17.47
NO2	$\bar{x}$	0.03	0.21	0.02	0.13
	min-max	0.01-0.11	0.04-0.47	0.01-0.09	0.02-0.27
NO3	$\bar{x}$	0.35	1.43	0.32	1.41
	min-max	0.004-1.40	0.41-3.25	0.004-1.62	0.004-5.04
TOTAL N	$\bar{x}$	6.12	6.02	12.15	10.16
	min-max	2.97-17.76	2.60-15.59	1.15-34.36	0.59-27.31
LAB COND	$\bar{x}$	534	621	627	746
(umhos/cm)	min-max	230-801	315-1200	229-1130	175-1242
LAB pH	$\bar{x}$	7.04	7.17	7.00	7.24
	min-max	6.51-8.01	6.23-7.69	6.59-7.35	6.64-7.62
NO. SAMPLES		25	25	28	28

[1]Chemical parameters are expressed in mg/l.

TABLE 23. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Mosquito Creek for 1980 and 1981.

		1980		1981	
PARAMETERS[1]		15	13	15	13
O-PO4	$\bar{x}$	2.37	2.33	1.81	1.82
	min-max	0.09-11.05	1.27-5.05	0.58-7.11	0.01-4.38
T-PO4	$\bar{x}$	2.65	2.46	1.74	1.97
	min-max	0.15-14.36	1.33-4.93	0.60-3.38	1.09-4.18
TKN	$\bar{x}$	6.16	5.15	5.48	3.77
	min-max	0.96-15.70	1.64-10.93	1.26-17.04	1.22-8.31
NH4	$\bar{x}$	4.03	3.10	3.77	1.70
	min-max	0.01-8.74	0.10-8.05	0.04-10.39	0.01-6.02
NO2	$\bar{x}$	0.04	0.15	0.68	0.16
	min-max	0.004-0.10	0.01-0.43	0.01-0.17	0.01-0.54
NO3	$\bar{x}$	0.27	1.33	0.54	2.12
	min-max	0.004-1.00	0.38-4.92	0.004-1.94	0.14-4.02
TOTAL N	$\bar{x}$	6.47	6.63	6.09	5.89
	min-max	0.97-15.76	2.72-11.36	1.38-17.05	2.43-10.94
LAB COND (umhos/cm)	$\bar{x}$	642	804	752	762
	min-max	49-1160	523-1320	265-1300	340-1320
LAB pH	$\bar{x}$	6.88	7.25	7.05	7.38
	min-max	5.41-7.50	6.93-7.59	6.52-7.37	6.88-7.70
TURBIDITY[2] (NTU)	$\bar{x}$			1.30	1.00
	min-max			0.80-2.20	0.50-1.60
COLOR	$\bar{x}$			95	100
	min-max			54-278	55-282
NO. SAMPLES		22	22	25/9[2]	26/9[2]

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity and color values for 1981 were based on 9 samples.

attributed to the slow flow between the upstream and downstream sites which may contribute to nitrification. In comparison, NO_3 concentrations at Mosquito Creek site 13 are similar to those exhibited at site 2 on the Little Bimini watershed. From 1978 to 1981, NO_3 concentrations at site 13 have averaged 1.57 mg/l while concentrations at site 2 (Little Bimini) have averaged 1.10 mg/l. These similarities may be attributed to similar environmental conditions that exist in these two subwatersheds (i.e., stream flow, land use, soil types, rainfall, runoff).

NUBBIN SLOUGH

Nubbin Slough lies approximately 4.8 km (3 miles) southeast of Mosquito Creek and approximately 2.4 km (1.5 miles) north of S-191, the discharge point of the L-63N canal into Lake Okeechobee (Figure 3). The hydrologic area for the Nubbin Slough watershed subunit has not been determined; however, USGS topography maps indicate that Nubbin Slough is similar in area to the Williamson Ditch watershed. Since 1978, 3 dairy operations have been added in this watershed, the last operation being completed in 1982, bringing the total number of dairies to 5 that are presently located along Nubbin Slough. The dominant soil types throughout the Nubbin Slough watershed are the Immokalee and Myakka fine sands, which as noted earlier, are poorly drained and not conducive to dairy wastewater management. There are a few scattered areas of Pomello fine sand; however, they are not as large as those seen in the Otter Creek and Little Bimini watersheds and therefore offer little help for drainage considering the intensity of dairy farming throughout Nubbin Slough.

There are two open channel water quality sites (14 and 17) in Nubbin Slough. Site 14 is located downstream at the outfall into the L-63N canal. Above this site lie the 5 dairy operations, 3 of which are less than 1.61 km (1 mile) from the outfall point. Site 17 is approximately 9.7 km (6 miles) upstream of site 14 and above any major dairy input (Figure 3). (Posey Dairy, located upstream from site 17 and outside the TCNS watershed, has ditch interconnections that will drain through site 17 when pastures become inundated. However, detention time in these ditches as well as the marsh area below them have provided substantial nutrient treatment).

Tables 24 and 25 present annual water quality values for the open channel sites in Nubbin Slough from 1978 to 1981. Total P concentrations

TABLE 24. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Nubbin Slough for 1978 and 1979.

PARAMETERS[1]		1978		1979	
		14	17	14	17
O-PO4	$\bar{x}$	1.44	0.15	1.31	0.26
	min-max	0.68-2.39	0.06-0.36	0.70-2.92	0.03-0.84
T-PO4	$\bar{x}$	1.61	0.20	1.82	0.31
	min-max	0.77-3.00	0.08-0.46	0.84-6.08	0.07-0.93
TKN	$\bar{x}$	4.55	1.82	6.33	1.56
	min-max	1.98-9.29	0.61-8.09	2.09-23.43	0.45-5.91
NH4	$\bar{x}$	2.14	0.04	2.10	0.04
	min-max	0.45-6.45	0.01-0.25	0.19-7.66	0.01-0.30
NO2	$\bar{x}$	0.06	0.01	0.03	0.01
	min-max	0.01-0.13	0.004-0.01	0.004-0.14	0.004-0.02
NO3	$\bar{x}$	0.21	0.02	0.17	0.004
	min-max	0.004-0.72	0.004-0.28	0.004-0.90	0.004-0.01
TOTAL N	$\bar{x}$	4.82	1.85	6.53	1.57
	min-max	2.32-9.29	0.62-8.10	2.43-23.45	0.46-5.92
LAB COND	$\bar{x}$	426	100	340	69
(umhos/cm)	min-max	164-1200	58-630	100-590	50-92
LAB pH	$\bar{x}$	6.84	5.53	6.70	5.45
	min-max	6.27-7.23	4.28-7.17	6.32-7.10	5.02-6.49
NO SAMPLES		23	20	28	24

[1]Chemical parameters are expressed in mg/l.

TABLE 25. Annual Mean, Minimum, and Maximum Water Quality Values for the Open Channel Stations in Nubbin Slough

PARAMETERS[1]		1980 14	1980 17	1981 14	1981 17
O-PO4	$\bar{x}$	1.76	0.12	2.44	0.34
	min-max	0.95-3.66	0.04-0.36	0.49-5.85	0.04-0.89
T-PO4	$\bar{x}$	2.32	0.20	3.15	0.45
	min-max	0.53-5.36	0.07-0.74	1.28-8.69	0.07-1.17
TKN	$\bar{x}$	8.19	1.36	11.63	3.26
	min-max	2.14-20.67	0.49-3.38	1.60-52.04	5.98-25.41
NH4	$\bar{x}$	4.11	0.04	4.75	0.37
	min-max	0.48-13.47	0.02-0.16	0.59-17.38	0.02-2.31
NO2	$\bar{x}$	0.05	0.01	0.06	0.02
	min-max	0.01-0.14	0.004-0.01	0.004-0.48	0.004-0.04
NO3	$\bar{x}$	0.28	0.02	0.26	0.01
	min-max	0.01-1.10	0.004-0.21	0.004-1.55	0.004-0.01
TOTAL N	$\bar{x}$	8.52	1.41	11.96	3.27
	min-max	2.62-20.85	0.76-3.42	3.11-52.06	0.60-25.42
LAB COND	$\bar{x}$	398	101	554	136
(umhos/cm)	min-max	210-620	47-820	132-980	51-620
LAB pH	$\bar{x}$	6.76	5.34	6.94	5.99
	min-max	6.48-7.06	5.02-6.71	6.58-7.48	5.46-6.67
TURBIDITY[2]	$\bar{x}$			9.50	6.90
(NTU)	min-max			1.50-25.00	1.20-23.00
COLOR	$\bar{x}$			206	168
	min-max			102-340	76-261
NO. SAMPLES		23	20	26/9[2]	16/8[2]

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity and color values for 1981 were based on 9 samples at Station 14 and 8 samples at Station 17.

at site 14 have increased 49% from 1978 to 1981. NH_4-N has increased 55%, and total N concentrations have increased 60% over this same period. At site 17, all N and P species in 1978 were on the same order as those found in the Williamson Ditch area and the N. W. Taylor Creek area. These concentrations have also increased substantially over the last four years (89% NH_4-N, 43% total N, and 56% T-PO_4). The increases observed at site 14 can be attributed to the direct discharge of dairy wastewater into Nubbin Slough from at least one of the 5 dairies in this watershed[1]. Another dairy in this area, located directly upstream and adjacent to the previously mentioned operation, has a field ditch that ties directly into Nubbin Slough. On-site observations of this ditch on 03/24/82 indicated that the water passing through it, as well as the organics within it, were visually similar to water observed at site 14. A preliminary water quality sample from this ditch taken on 07/29/82 showed the total P concentration to be in excess of 2.0 mg/l and the total N concentration in excess of 12.0 mg/l.

Another interesting event has occurred at site 17. As mentioned, water quality at this site has been comparable to other areas of the watershed exhibiting low nutrient concentrations (1.85 mg/l total N and 0.20 mg/l total P). Recently, there has also been a trend toward increasing N and P concentrations (3.27 mg/l total N and 0.45 mg/l total P). The evolution of higher nutrient concentrations at this site can be attributed to the recent introduction of dairy heifers directly upstream of the sampling site as first witnessed on 10/02/81. Since then, these animals periodically have access to this portion of Nubbin Slough. Because the majority of the data at this site indicates relatively pristine conditions, we may be witnessing firsthand the gradual transformation of a somewhat

[1]Personal communication with Okeechobee SCS office.

undisturbed portion of a watershed into a nutrient exporting area typical of the more dairy-intensive areas. Because dairy activities are still limited above site 17, concentrations continue to be considerably lower than those observed at site 14 which drains areas of greater dairy activity. Two other reasons that may contribute to the lower N and P concentrations at site 17 are: 1) the size of the marsh area just above the sampling site; 2) the highly organic soil type (Pamlico muck) throughout the marsh which may be providing additional P uptake. Table 26 presents the effects of a dairy-intensive area on downstream water quality by comparing increases in nutrient concentrations from site 17 to site 14.

As mentioned, N and P concentrations coming from this watershed have increased to the point whereby Nubbin Slough exhibits the poorest water quality of any of the other watersheds, including Mosquito Creek and Otter Creek (in earlier comparative studies, Otter Creek showed the poorest water quality (Allen et al., 1976; Federico, 1977; Stewart et al., 1978)). Figures 27 and 28 graphically depict annual N and P trends at the outfalls of Otter Creek, Mosquito Creek, and Nubbin Slough. These figures substantiate conclusions as to the deterioration of this watershed. The alarming note here is that Nubbin Slough is so close to the outfall at S-191 and Lake Okeechobee (2.4 km). It would seem that cleaning up water quality in this area through RCWP will have the most immediate impact on Lake Okeechobee by substantially decreasing nutrient loads at S-191.

An additional beef cattle runoff site (16) is located above Nubbin Slough to the north (Figure 3). Because this site has been dry (non-flowing) 95 percent of the time throughout the last 3 years, data at site 16 will not be included in this report.

TABLE 26. Effects of a Dairy-Intensive Area on Mean Annual Downstream Water Quality in the Nubbin Slough Watershed.

NUTRIENT[1]	STATION 17 Nubbin Slough at Berman Rd. (upstream)	STATION 14 Nubbin Slough at HWY 710 (downstream)	PERCENT INCREASE[2]
1978 JANUARY-DECEMBER			
T-P04	0.20	1.61	705%
0-P04	0.15	1.43	853%
TKN	1.82	4.55	150%
NH4	0.04	2.14	5,250%
NOx	0.02	0.27	1,250%
CONDUCTIVITY (umhos/cm)	100	426	326%
1979 JANUARY-DECEMBER			
T-P04	0.31	1.82	487%
0-P04	0.26	1.31	404%
TKN	1.56	6.33	306%
NH4	0.04	2.10	5,150%
NOx	0.01	0.20	1,900%
CONDUCTIVITY (umhos/cm)	69	340	393%
1980 JANUARY-DECEMBER			
T-P04	0.19	2.37	1,147%
0-P04	0.11	1.79	1,527%
TKN	1.56	8.40	438%
NH4	0.04	4.24	10,500%
NOx	0.03	0.31	933%
CONDUCTIVITY (umhos/cm)	101	404	300%

[1]Nutrient concentrations in mg/l.

[2]Percent increase may be due to improper wastewater facilities and direct discharge of wastewater into the main watercourse.

FIGURE 27. ANNUAL MEAN O-PO4 AND T-PO4 CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TAYLOR CREEK/NUBBIN SLOUGH WATERSHED

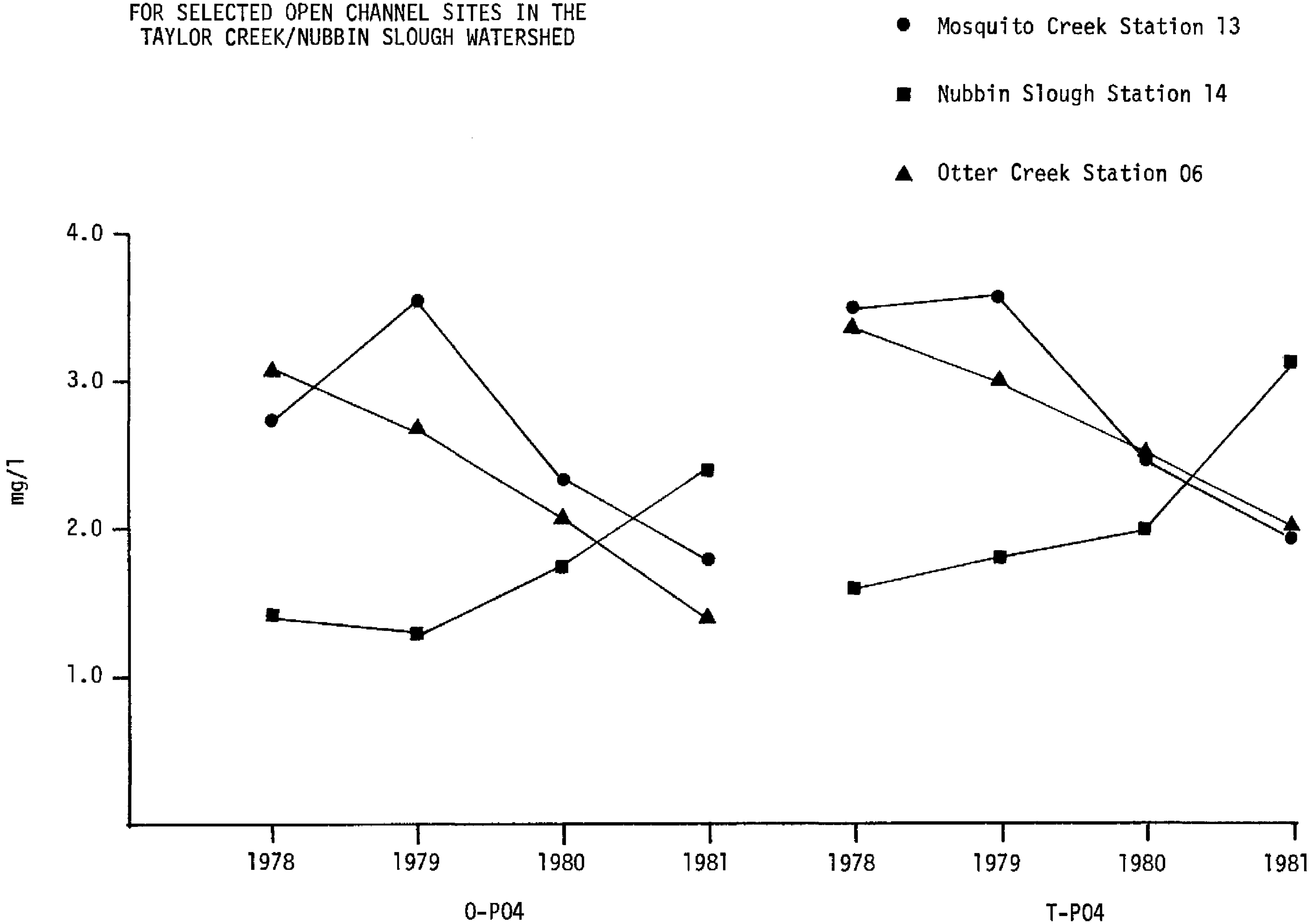
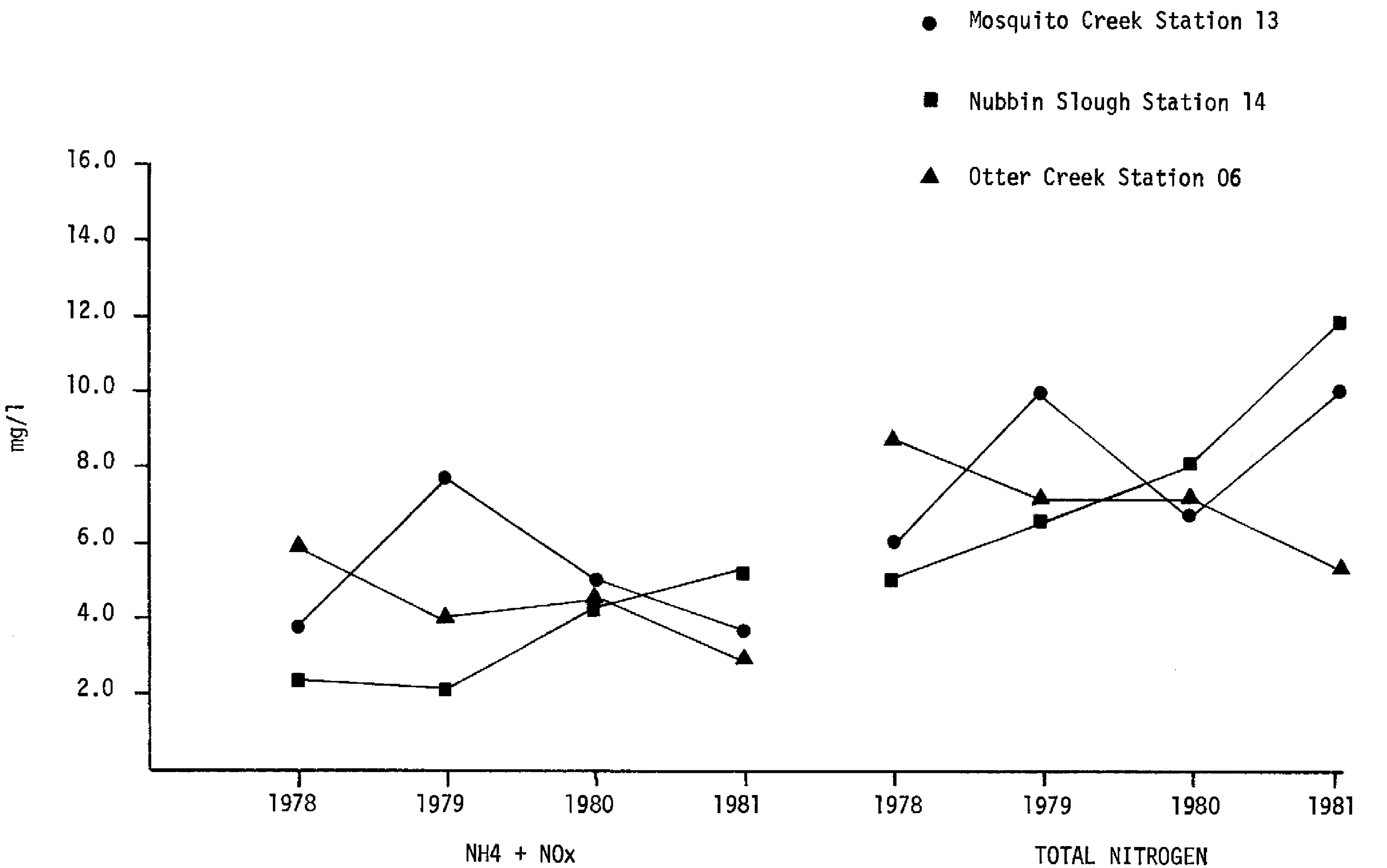


FIGURE 28. ANNUAL MEAN INORGANIC AND TOTAL NITROGEN CONCENTRATIONS FOR SELECTED OPEN CHANNEL SITES IN THE TAYLOR CREEK/NUBBIN SLOUGH WATERSHED



HENRY AND LETTUCE CREEKS

Henry and Lettuce Creeks lie at the southernmost portion of the TCNS watershed (Figure 3). USGS topography maps indicate that the hydrologic area of Henry Creek is similar to that of Otter Creek (2,884 ha) while Lettuce Creek is more similar in size to Williamson Ditch (8,509 ha). The dominant soil types within these two watersheds are Immokalee and Myakka fine sands, the latter being more predominant around Henry Creek. These soil types indicate that these areas are also poorly drained and have high water tables. There is one dairy located in each of these watersheds; however, the location of the dairy in Henry Creek is much closer to the channel (approximately 1.61 km) than the dairy in Lettuce Creek, which is located at the southernmost perimeter of the watershed about 8 km (5 miles) from the creek.

Water quality sampling at both of these creeks began on 06/11/81. Preliminary water quality analysis for N and P species indicate that Henry Creek has higher N and P concentrations than at Lettuce Creek; however, because Lettuce Creek is a larger watershed (a visual inspection indicates that the volume of water coming from this watershed is much greater than that coming from Henry Creek), nutrient loads may be greater at Lettuce Creek. From 06/11/81 to 12/24/81, there have been 14 water quality samples taken at each of these tributaries along their outfall to the L-63N canal. Preliminary data show selected mean N and P concentrations at Henry Creek to be: 1) 1.23 mg/l O-PO_4; 2) 1.54 mg/l T-PO_4; 3) 5.89 mg/l total N; 4) 2.15 mg/l NH_4-N. Selected N and P concentrations in Lettuce Creek are: 1) 0.15 mg/l O-PO_4; 2) 0.22 mg/l T-PO_4; 3) 1.76 mg/l total N; 4) 0.22 mg/l NH_4-N. As noted, concentrations at Lettuce Creek are substantially lower; this can be attributed to more overland treatment of dairy runoff due to the greater distance of the dairy from the creek.

Because these two watersheds are classified as low priorities for RCWP funds, actual contracts and BMP implementation are not anticipated until management plans are completed for the higher priority farms.

S-191 AT NUBBIN SLOUGH

S-191 represents the outfall to the entire Taylor Creek/Nubbin Slough watershed (Figure 3). Water quality at this point is important in analyzing nutrient contributions from TCNS, and to help evaluate its impact on Lake Okeechobee. Table 27 presents annual means and ranges for water quality values at S-191 from 1978 to 1981. Total P concentrations in general fluctuated very little with a four-year average of 1.02 mg/l and an average standard deviation of 0.20. N concentrations, however, increased 30%, the greatest fraction in the form of organic nitrogen which increased 26% over this period. The increases in organic N at S-191 can be a result of the increased deterioration of water quality that is being observed at Nubbin Slough only 2.4 km (1.5 miles) upstream. The overall total N increases observed at S-191 also correlate well with Figure 28, which shows the gradual increase of total N concentrations at Nubbin Slough from 1978 to 1981 (60% increase). Mosquito Creek, where N concentrations are generally as high or higher than Otter Creek and Nubbin Slough (Figure 28), could be another factor influencing increased N concentrations at S-191.

Continued water quality monitoring at S-191 will provide valuable data when analyzing overall effects of BMP installation on water quality throughout the entire TCNS watershed.

TABLE 27. Annual Mean, Minimum, and Maximum Water Quality Values at S-191/Nubbin Slough from 1978 to 1981.

	1978		1979		1980		1981[4]	
CHEMICAL PARAMETERS[1]	$\bar{x}$	min-max	$\bar{x}$	min-max	$\bar{x}$	min-max	$\bar{x}$	min-max
T-PO4	1.10	0.78-1.38	1.00	0.65-1.52	0.99	0.63-1.30	0.98	0.16-1.22
O-PO4	0.99	0.42-1.31	0.79	0.17-1.36	0.88	0.26-1.16	0.93	0.80-1.07
TKN	2.07	1.17-3.97	2.46	1.43-3.72	2.72	1.48-4.01	2.78	1.46-3.64
NH4-N	0.22	0.03-0.56	0.31	0.01-1.26	0.38	0.02-1.64	0.26	0.01-1.46
NO2-N	0.07	0.01-0.15	0.05	0.004-1.54	0.08	0.03-0.51	0.07	0.004-0.24
NO3-N	0.51	0.07-1.62	0.57	0.004-0.12	0.53	0.004-1.54	0.96	0.004-1.63
TOTAL N	2.65	1.78-4.24	3.09	1.43-3.72	3.33	1.74-4.34	3.80	2.06-4.80
PHYSICAL PARAMETERS								
pH	6.74	6.10-7.20	6.72	6.20-7.16	6.96	6.55-7.64	7.67	7.23-8.49
COLOR	217	26-313	192	118-400	171	100-300	104	70-142
TURBIDITY[2]	2.30	0.80-6.70	2.20	0.70-6.50	1.60	0.60-4.50	2.10	1.10-3.60
NUMBER OF SAMPLES[3]	29		29		24		12	

[1]Chemical parameters are expressed in mg/l.
[2]Turbidity is expressed in NTU (nephelometric turbidity units).
[3]Number of samples are based on an average number of samples over all parameters during the given period of record.
[4]Period of record for 1981 is from 01/14/81 to 05/19/81.

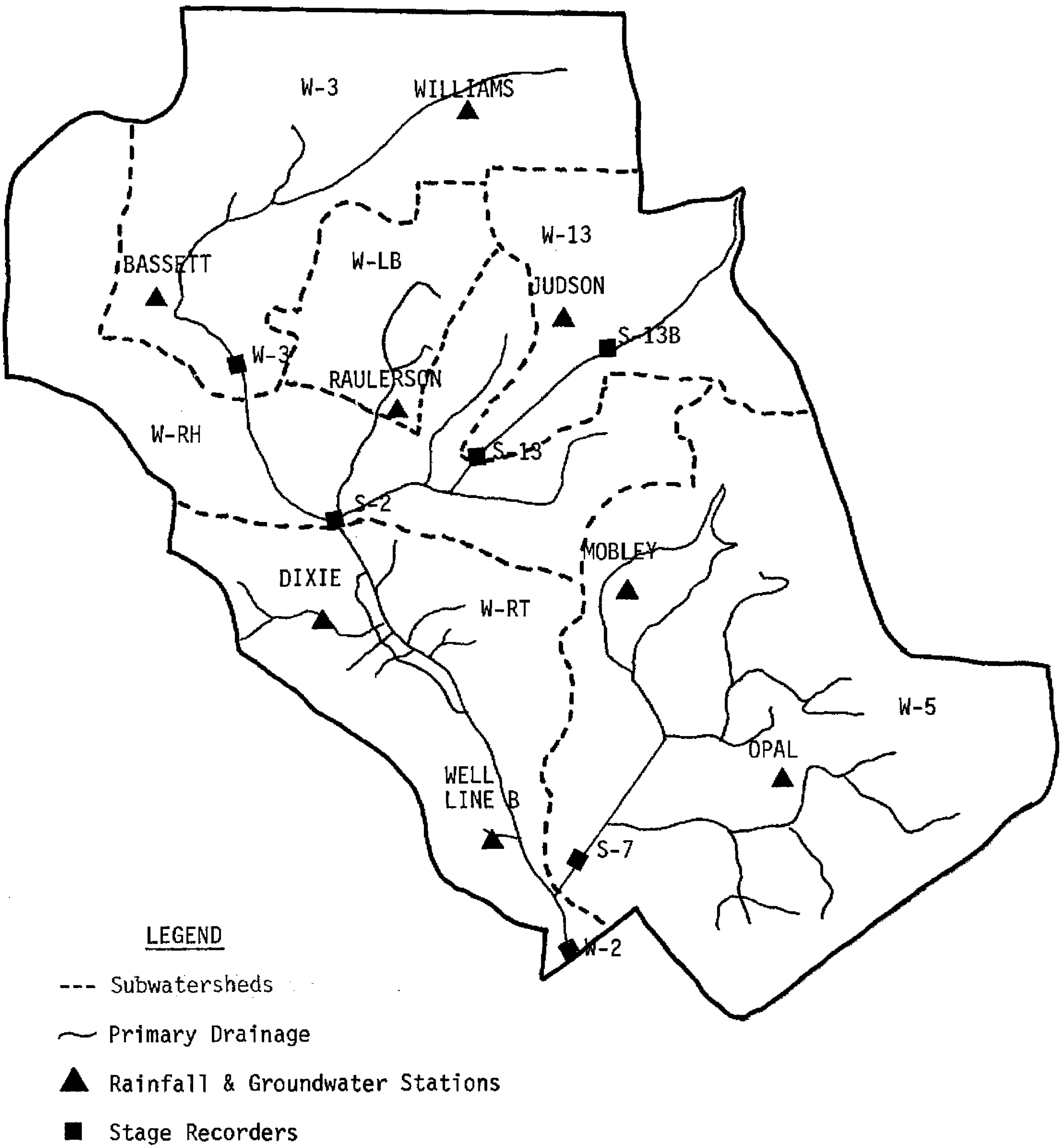
HYDROLOGIC MONITORING

FRAMEWORK

To date, all of the hydrologic monitoring within the TCNS watershed has occurred in upper Taylor Creek with the exception of the gauging station at S-191 where discharge and nutrient loads represent the total volume of water and mass of nutrients that enter Lake Okeechobee from this watershed (Figure 3).

The upper Taylor Creek watershed (W-2) can be divided into six small subwatersheds (Figure 29): N. W. Taylor Creek (W-3); Little Bimini (W-LB); Otter Creek (W-13); a remainder watershed in the headwaters (W-RH); a remainder watershed in the tailwaters (W-RT); Williamson Ditch (W-5). Of the six subwatersheds, three (W-3, W-13, and W-5) are gauged as well as the entire W-2. These gauged watersheds provide average daily discharge data which with biweekly water quality data can be used to compute nutrient loads. Methodology used to calculate nutrient loads was to multiply average daily discharges (m^3/sec) over a particular time period (interval), with corresponding nutrient concentrations. Water quality samples are collected biweekly; therefore, two chemistry data points between a given interval were averaged to give an estimated concentration for the interval. This average concentration was used with average daily discharges to compute nutrient loads. Nutrient loads are reported in kilograms and megagrams (10^3 kilogram = 1 megagram = 1 metric ton). This technique was used by Federico et al. (1981) and described by Schieder et al. (1978). The average daily discharge data was obtained from three operating ARS discharge recording stations (S-13B, S-13, and S-2) and three U. S. Geological Survey discharge recording stations (W-2, W-3, S-7) in the upper Taylor Creek watershed (W-2) (Figure 29). The W-LB, W-RH, and W-RT

FIGURE 29. UPPER TAYLOR CREEK WATERSHED W-2



subwatersheds are all ungauged; therefore, data associated with these areas are derived values. For example, the area of W-RH was arrived at by subtracting the combined areas of W-3, W-13, and W-LB (the area of W-LB was known) from the total area of the headwaters (that area north of S-2 in Figure 29). This can be formulated as follows: areas of (headwaters) - (W-3 + W-13 + W-LB) = W-RH. The area of W-RT was arrived at by subtracting the combined areas of the headwaters and W-5 from the total area of W-2. This can be formulated as follows: areas of (W-2) - (headwaters + W-5) = W-RT.

Nutrient loads and discharges for W-LB, W-RH, and W-RT were derived by assuming that each of these ungauged subwatersheds had similar geographical and land use patterns as one of the gauged watersheds. It was found through the use of aerial photographs and USGS topography maps that W-RH was similar in size and land use to W-3. The W-RT was similar in size and land use to W-5. Because W-LB had a known area as well as calculated Thiessen-weighted area rainfall percentages, discharge calculations were best derived from the total Thiessen-weighted rainfall, total discharge, and total land area of W-2 (with the exception of 1980, where discharge data from W-2 was incomplete); therefore, the discharge for W-LB was derived from W-13, and the discharges from W-2 were derived from W-5 using areas, Thiessen percentages, and known discharges from W-13 and W-5. Calculations for the remainder watersheds can be summarized as follows:

1) W-RH

a) x = discharge

$$\frac{\text{area of W-3}}{\text{discharge W-3}} = \frac{\text{area of W-RH}}{x}$$

b) y = kg of nutrients

$$\frac{\text{area of W-3}}{\text{kg of nutrients W-3}} = \frac{\text{area of W-RH}}{y}$$

2) W-RT

a) x = discharge

$$\frac{\text{area of W-5}}{\text{discharge of W-5}} = \frac{\text{area of W-RT}}{x}$$

b) y = kg of nutrients

$$\frac{\text{area of W-5}}{\text{kg of nutrients W-5}} = \frac{\text{area of W-RT}}{y}$$

Because there were known nutrient quantities in W-LB, discharges were the only derived values. Once the discharges were obtained, normal calculations followed to get nutrient loads. Discharge calculations for W-LB are summarized as follows:

$$\frac{\overline{R}\ \text{W-LB}}{\overline{R}\ \text{W-2}} \times \frac{A\ \text{W-LB}}{A\ \text{W-2}} \times \text{CMS W-2} = \text{CMS W-LB}$$

where:

$\overline{R}$ = Thiessen-weighted rainfall

A = Area of watershed

CMS = Discharge in cubic meters per second.

In 1980, this same equation was used to calculate discharge for W-LB, with the exception of W-13 being the gauged watershed.

Rainfall and groundwater values in W-2 are obtained from a network of eight rainfall and groundwater recorders situated throughout the watershed (Figure 29). These recorders (Williams, Bassett, Judson, Raulerson, Mobley, Opal, Dixie, and Well Line B) provide Thiessen-weighted rainfall for each of the four major subwatersheds (W-3, W-13, W-LB, and W-5) as well as the W-2 watershed. Table 28 provides a breakdown of the subwatersheds and their assigned Thiessen percentages by station. Table 5 provides quarterly Thiessen-weighted rainfall for each of the major subwatersheds,

TABLE 28. Thiessen Percentages by Station for W-2 and Subwatersheds W-5, W-3, W-13, and W-LB.

WATERSHED	RAINFALL STATION	THIESSEN %
W-2	Williams	11.92
	Bassett	12.26
	Raulerson	11.32
	Judson	14.68
	Dixie	7.66
	Mobley	13.32
	Opal	19.13
	Well Line B	9.71
W-3	Williams	55.22
	Bassett	39.31
	Raulerson	5.47
W-5	Judson	2.61
	Mobley	28.23
	Opal	61.12
	Well Line B	8.03
W-13	Williams	3.53
	Raulerson	2.11
	Judson	94.36
W-LB	Williams	27.00
	Raulerson	46.00
	Judson	27.00

and W-2 from 1978 to 1981. A complete analysis of the hydrology and the hydrogeology of W-2 over the past decade, along with the ramifications of the PL 566 project on upper Taylor Creek (W-2) is presented in the "Hydrology and Hydrogeology of the Upper Taylor Creek Watershed, Okeechobee County, Florida" by Knisel et al. (1982). A summary of these analyses was given by Yates et al. (1982).

UPPER TAYLOR CREEK (W-2)

W-2 represents approximately 55.5 percent of the total land area of TCNS (Table 2). In order to more clearly evaluate the nutrient contribution from W-2, one must look at its subwatersheds as well. Tables 29 through 31 present annual discharges for W-2 and its subwatersheds, along with nutrient loads per unit land area and net gains or losses of nutrients throughout the watershed. During 1979, annual rainfall amounts totaled 101.8 cm (40.1 inches) (Table 5). This year also exhibited the highest ratios of nutrient loads per unit land area (8.97 kg total N/ha and 4.53 kg total P/ha) in the W-2. During 1979, there was also an observed net gain of P (more P was released than that measured at inflow points upstream). This net gain could possibly be attributed to conservative estimates of nutrient loads coming from the ungauged portions of W-2 (W-RH, W-RT, and W-LB). In 1978, the percentage of the total N and P load at S-191 from the W-2 were 29.4 and 30.0 percent, respectively. In 1979, the N and P percentages at W-2 were 33.0 and 46.4 percent, respectively. Percentages of N and P values through the third quarter of 1980 at W-2 were 14.4 and 23.4 percent, respectively. These percentages seem to indicate that the majority of the nutrient loads from TCNS are coming from inflows below W-2 (L-63N canal); however, a closer inspection (Figures 30 and 31) of quarterly nutrient loads from W-2, S-191, and the TCHW area shows that during the third quarters of 1978 and 1979, over 60 percent of the total N loads in TCNS were from the W-2. Figure 31 shows that during the third quarter of 1979 (Hurricane David), over 50 percent of the total P loads in TCNS were from W-2. One explanation for these substantial differences between yearly and quarterly N and P loads is that during drought periods when ground-water levels decrease, flow conditions in the open channel decrease also.

1978

TABLE 29. ANNUAL DISCHARGE AND NUTRIENT LOADS FROM THE TAYLOR CREEK WATERSHED, NUTRIENT LOAD PER UNIT LAND AREA AND NET GAIN OR LOSS OF NUTRIENTS WITHIN THE WATERSHED

Watershed		W-2	W-5	[1]RT	W-3	W-13	W-LB	[2]RH	Net Gain or Net Loss
Area (mi^2)		104.5	32.8	17.3	19.1	11.1	5.9	18.3	
Hectares		27,060	8,509	4,465	4,938	2,884	1,528	4,736	
% Land Area		100.0	31.4	16.6	18.3	10.6	5.6	17.5	
Nutrient Loads									
O-PO4	Kg	47,567	10,723	5,656	7,024	15,936	9,767	6,730	-8,269
T-PO4	Kg	54,288	15,032	7,928	8,499	17,457	10,466	8,143	-13,237
NOx+NH4	Kg	27,914	11,653	6,146	2,145	28,624	17,110	2,055	-39,819
TKN	Kg	111,096	74,550	40,178	33,321	41,787	19,621	31,925	-130,286
Total N	Kg	127,614	78,493	41,400	34,246	43,082	24,110	32,812	-126,529
Discharge (cms-days)		699	296	156	220	57	41	211	-282
Nutrient Load/Land Area									
O-PO4	Kg/ha	1.75	1.26	1.27	1.42	5.52	6.39	1.42	-15.53
T-PO4	Kg/ha	2.01	1.77	1.78	1.72	6.05	6.85	1.72	-17.88
NOx+NH4	Kg/ha	1.03	1.36	1.38	0.43	9.93	11.20	0.43	-23.70
TKN	Kg/ha	4.11	8.76	9.00	6.74	14.49	12.84	6.74	-54.46
Total N	Kg/ha	4.72	9.22	9.27	6.94	14.94	15.78	6.93	-58.36
Discharge (cms-days/ha)		0.03	0.03	0.03	0.04	0.02	0.03	0.04	-.16

[1]RT = Remainder watershed in the tailwaters of Taylor Creek [2]RH = Remainder watershed in the headwaters of Taylor Creek

1979

TABLE 30. ANNUAL DISCHARGE AND NUTRIENT LOADS FROM THE TAYLOR CREEK WATERSHED, NUTRIENT LOAD PER UNIT LAND AREA AND NET GAIN OR LOSS OF NUTRIENTS WITHIN THE WATERSHED

Watershed		W-2	W-5	[1]RT	W-3	W-13	W-LB	[2]RH	Net Gain or Net Loss
Area (mi^2)		104.5	32.8	17.3	19.1	11.1	5.9	18.3	
Hectares		27,060	8,509	4,465	4,938	2,884	1,528	4,736	
% Land Area		100.0	31.4	16.6	18.3	10.6	5.6	17.5	
Nutrient Loads									
O-PO4	Kg	99,954	11,448	6,038	14,918	22,410	13,581	14,293	+17,266
T-PO4	Kg	122,664	14,173	7,475	17,419	24,622	14,852	16,689	+27,434
NOx+NH4	Kg	30,146	11,731	6,187	2,763	25,287	12,405	2,647	-30,874
TKN	Kg	237,079	72,245	38,105	52,525	44,634	21,281	50,325	-42,036
Total N	Kg	242,675	74,047	39,055	53,746	46,175	25,563	51,495	-47,406
Discharge (cms-days)		1,472	351	185	390	94	87	374	-9
Nutrient Load/Land Area									
O-PO4	Kg/ha	3.69	1.35	1.35	3.02	7.77	8.89	3.02	-21.71
T-PO4	Kg/ha	4.53	1.67	1.67	3.53	8.54	9.72	3.52	-24.12
NOx+NH4	Kg/ha	1.11	1.37	1.39	0.56	8.77	8.12	0.56	-19.66
TKN	Kg/ha	8.76	8.49	8.54	10.64	15.48	13.93	10.62	-58.94
Total N	Kg/ha	8.97	8.70	8.75	10.88	16.01	16.73	10.87	-62.97
Discharge (cms-days/ha)		0.05	0.04	0.04	0.08	0.03	0.06	0.08	0.28

[1]RT=Remainder watershed in the tailwater of Taylor Creek [2]RH=Remainder watershed in the headwaters of Taylor Creek

1980

TABLE 31. ANNUAL DISCHARGE AND NUTRIENT LOADS FROM THE TAYLOR CREEK WATERSHED, NUTRIENT LOAD PER UNIT LAND AREA AND NET GAIN OR LOSS OF NUTRIENTS WITHIN THE WATERSHED

Watershed		W-2	W-5	[1]RT	W-3	W-13	W-LB	[2]RH	Net Gain or Net Loss
Area (mi^2)		104.5	32.8	17.3	19.1	11.1	5.9	18.3	
Hectares		27,060	8,509	4,465	4,938	2,884	1,528	4,736	
% Land Area		100.0	31.4	16.6	18.3	10.6	5.6	17.5	
Nutrient Loads									
O-PO4	Kg	14,160	2,372	1,251	1,128	7,179	1,247	1,081	-98
T-PO4	Kg	15,338	3,429	1,809	1,302	8,227	1,517	1,247	-2,193
NOx+NH4	Kg	8,523	3,689	1,946	429	15,809	3,472	411	17,233
TKN	Kg	33,169	15,480	8,165	3,922	23,932	5,161	3,758	-27,249
Total N	Kg	37,518	16,187	8,538	4,183	24,414	9,677	4,008	-29,489
Discharge (cms/days)		224	77	41	32	38	22	31	-17
Nutrient Load/Land Area									
O-PO4	Kg/ha	0.52	0.28	0.28	0.23	2.49	0.82	0.23	-3.52
T-PO4	Kg/ha	0.58	0.40	0.41	0.26	2.85	0.99	0.26	-4.21
NOx-NH4	Kg/ha	0.31	0.43	0.44	0.09	5.48	2.27	0.09	-6.94
TKN	Kg/ha	1.07	1.82	1.83	0.79	8.30	3.38	0.79	-13.57
Total N	Kg/ha	1.39	1.90	1.91	0.85	8.47	6.33	0.85	-14.45
Discharge (cm/days/ha)		0.008	0.009	0.009	0.006	0.01	0.01	0.007	-0.04

[1]RT=Remainder watershed in the tailwaters of Taylor Creek [2]RH=Remainder watershed in the headwaters of Taylor Creek

FIGURE 30. QUARTERLY TOTAL NITROGEN LOADS FOR TAYLOR CREEK/NUBBIN SLOUGH AT S-191, UPPER TAYLOR CREEK (W-2) AND THE TAYLOR CREEK HEADWATERS AREA

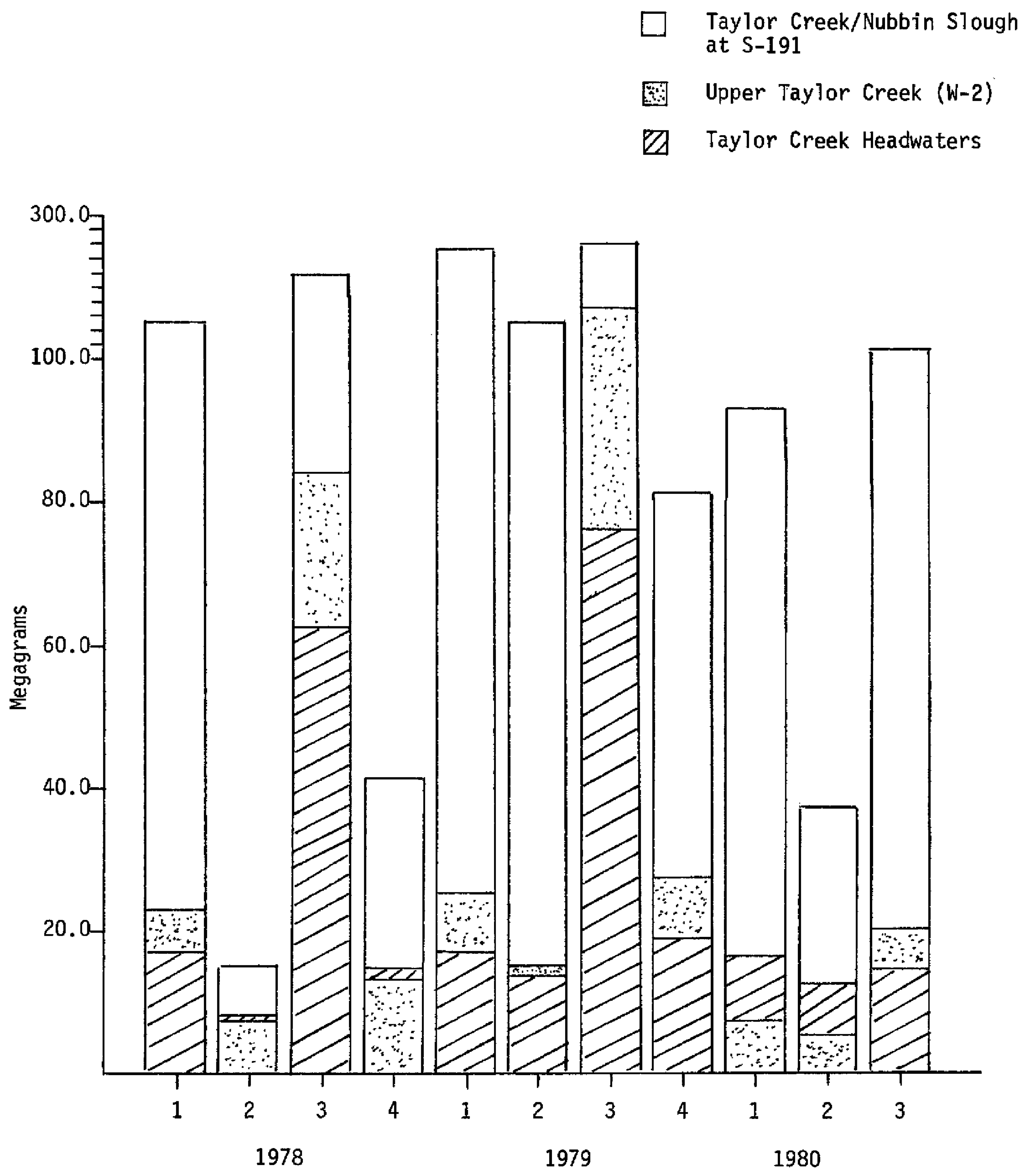
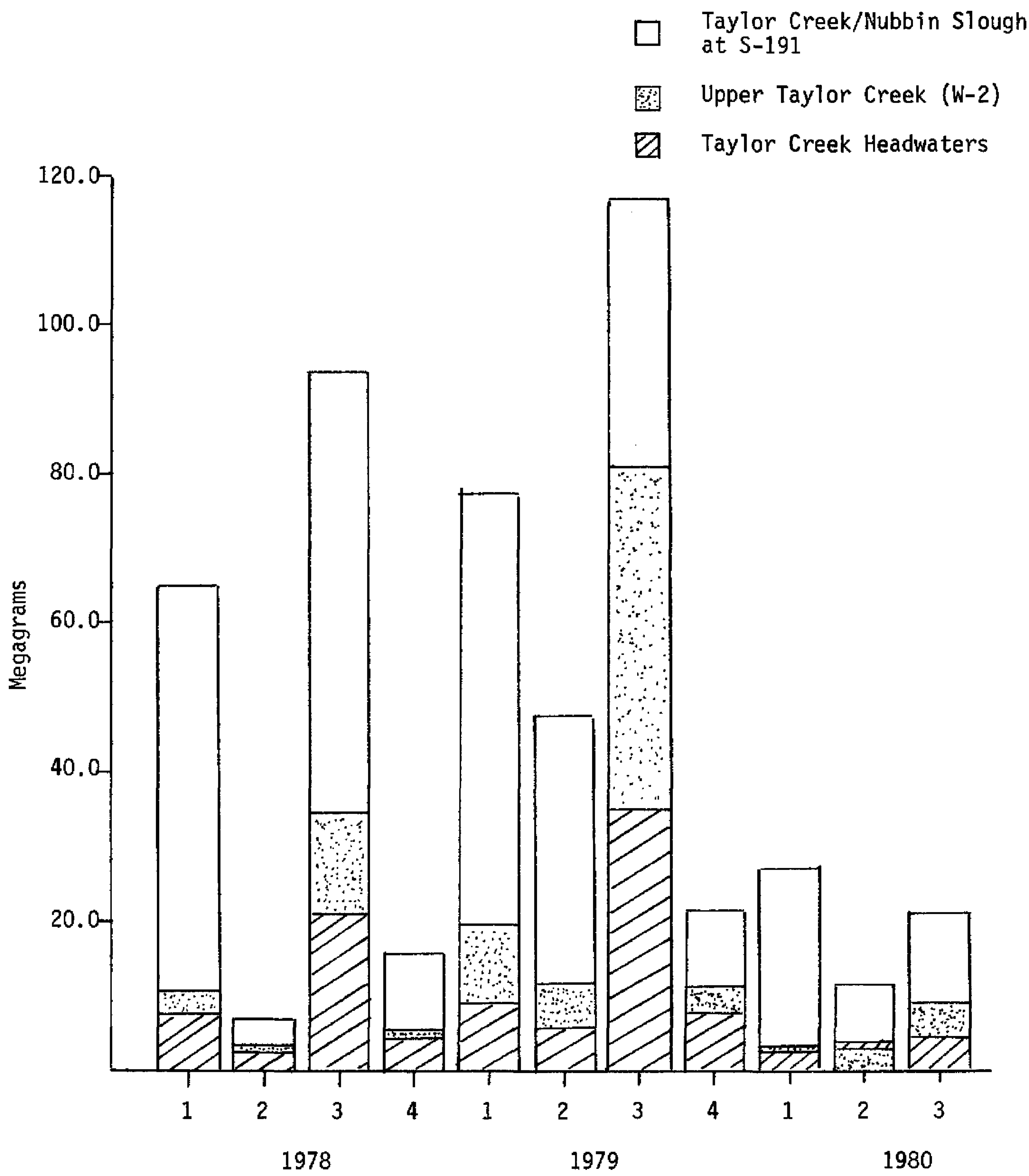


FIGURE 31. QUARTERLY T-PO4 LOADS FOR TAYLOR CREEK/NUBBIN SLOUGH AT S-191, UPPER TAYLOR CREEK (W-2) AND THE TAYLOR CREEK HEADWATERS AREA



The low-flow conditions throughout the W-2 creates more detention time for nutrients within this watershed, providing more time for W-2 to act as a nutrient sink. During 1978 and 1979 (Tables 29 and 31), there were substantial losses of total N and P loads than shown in 1979 (Table 30), the year characterized by having the greatest discharge. In fact, O-PO4 and T-PO4 showed net gains in nutrients at W-2 (+17,266 and +27,434 kilograms, respectively) during 1979. Allen et al. (1982), in a recent publication on evapotranspiration, rainfall, and water yield, showed a specific case where it took a series of rainfall events that totalled more than 25.4 cm (10 inches) to restore soil water conditions and raise the water table to the surface when tables were low in W-2 (i.e., 180 cm or 6 feet). When water tables are that low, most of the rainfall infiltrates with very little runoff and streamflow untill the groundwater levels rise to near the surface. Rainfall events thereafter result in large amounts of runoff and streamflow. This somewhat substantiates some of our findings regarding the amount of nutrient transport out of the W-2, and illustrates under what hydrologic conditions high N and P exports from this watershed are generally expected.

Annual discharges at W-2 (Tables 29 through 31) represent the volume of water being exported out of the W-2 watershed during a given year (discharge is presented in cms-days, an average daily flow rate summed over a year). Because a portion of the W-2 watershed is ungauged (i.e. Little Bimini, and the Remainder watersheds) the sum total of the discharges of the subwatersheds in W-2 does not equal the total annual discharge at W-2. The combined discharges of the subwatersheds have in effect (1978, 1979 and 1980) been greater than the total discharge at W-2. Several reasons for this are: 1) lateral seepage; 2) evapotranspiration losses and 3) utilization of open channel water for irrigation. Tables 29 through 31 show a net loss in discharge of 282, 9, and 17 cms-days for

1978, 1979 and 1980 respectively; however these losses seem to be rather insignificant (except for 1978) when looking at the total water budget for W-2. In fact because discharge at several of the ungauged watersheds were calculated experimentally the sum total of the discharges from the subwatersheds were closer than expected to the total discharge at W-2.

Another important note when examining the water budget for W-2 is that rating curves do not provide an accurate measure of discharge at the W-2 gauging site under extremely low flow conditions as witnessed in 1980. For this reason (as noted earlier in the text) discharges from W-2 during 1980 were weighted based on areas, Thiessen percentages and known discharges from W-5. In addition under extreme low flow conditions discharge at S-191 into Lake Okeechobee is negligible, thus creating a semi-static state from S-191 upstream to S-2. Under these conditions water in Taylor Creek has actually been observed flowing north (upstream) instead of south toward the lake. Discharges from the individual subwatersheds during low flow may actually exceed the total discharge measured at W-2. When this occurs the discharge at W-2 will be less than the sum of the discharges of the subwatersheds thus showing a net loss in total discharge exported from W-2.

OTTER CREEK (W-13)

The Otter Creek watershed (W-13) represents 10.6 percent of the land area of W-2 and 5.9 percent of the entire TCNS land area (Table 2). W-13 has two gauging sites, S-13B and S-13, located upstream and downstream, respectively (Figure 29). The upstream site was established to monitor discharge of runoff from beef cattle, dairy, and hayfield operations. The downstream site (S-13) monitors discharge of runoff from S-13B along with an area extensively used for dairying located downstream of S-13B and upstream of S-13. Figures 32 through 35 depict quarterly inorganic and total N and P loads as well as quarterly discharge values at S-13B and S-13.

With the exception of the fourth quarter of 1980, where the discharge at S-13B was less than 50 percent of the total discharge of S-13, flow at S-13B generally represents greater than 50 percent of the total flow of the W-13 watershed (Figures 32 through 35). Comparing total N and P loads at S-13B and S-13, higher N and P loads are more indicative of S-13, the downstream site. This can generally be attributed to the greater intensity of dairy farming below S-13B. However, in quarters 1 and 3 during 1979, both ortho and total P loads at S-13B represented over 50 percent of the total load at S-13. In general, S-13B seems to contribute the greatest amount of flow while the area below S-13B contributes the higher N and P loads.

Looking at the discharge and water quality input from the seepage disposal field at McArthur Barn #1 (upstream of S-13B) annual nutrient loads can be estimated under the limitations of the following assumptions. First, it was assumed that the seepage field water balance could estimate annual runoff and seepage discharge. Second, it was assumed that one can multiply average annual nutrient concentrations by annual estimated discharge from the seepage field to compute estimated annual loads.

FIGURE 32. OTTER CREEK WATERSHED

Quarterly Discharge and Total Nitrogen Loads at S-13 and S-13B

1978 - 1980

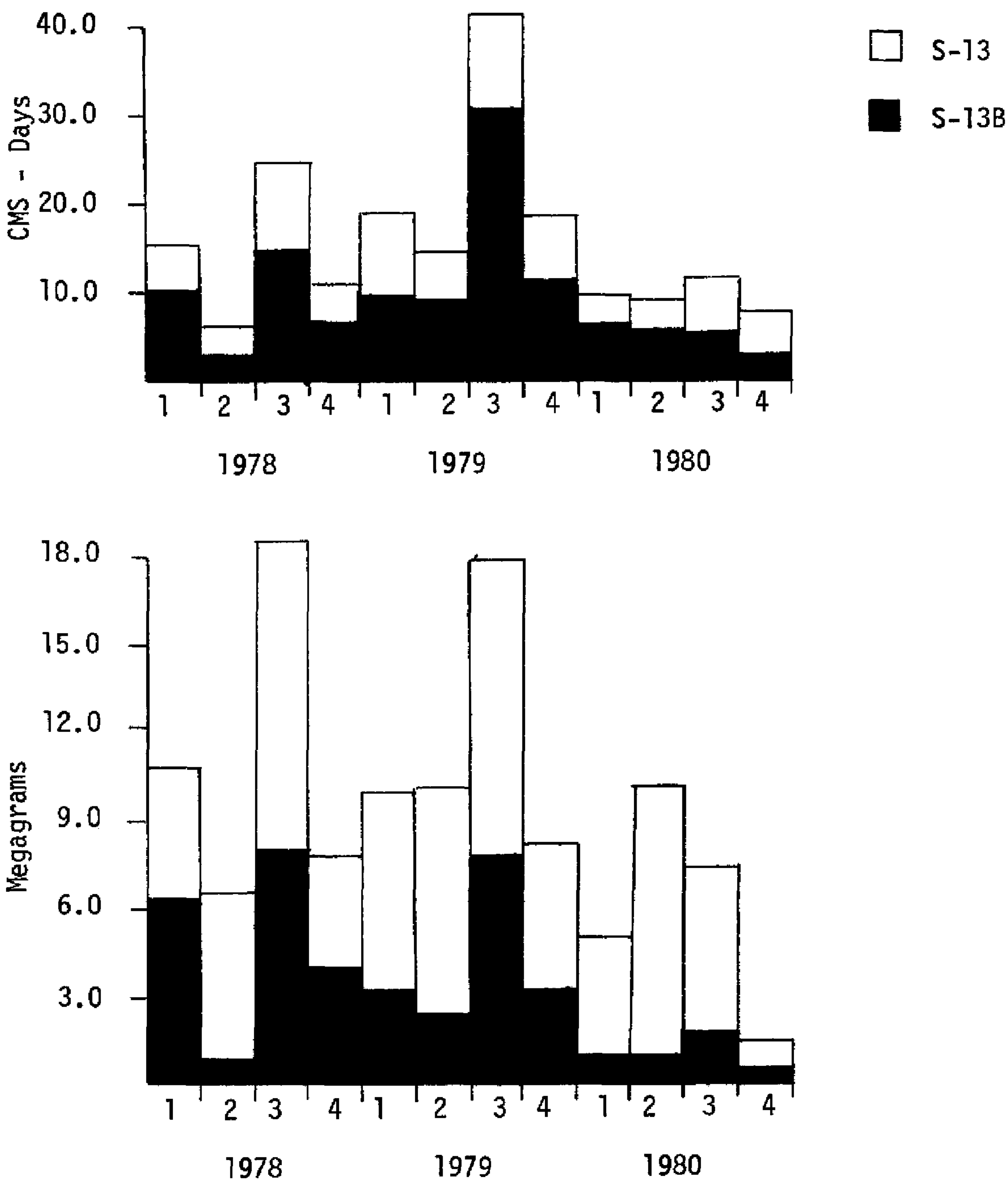
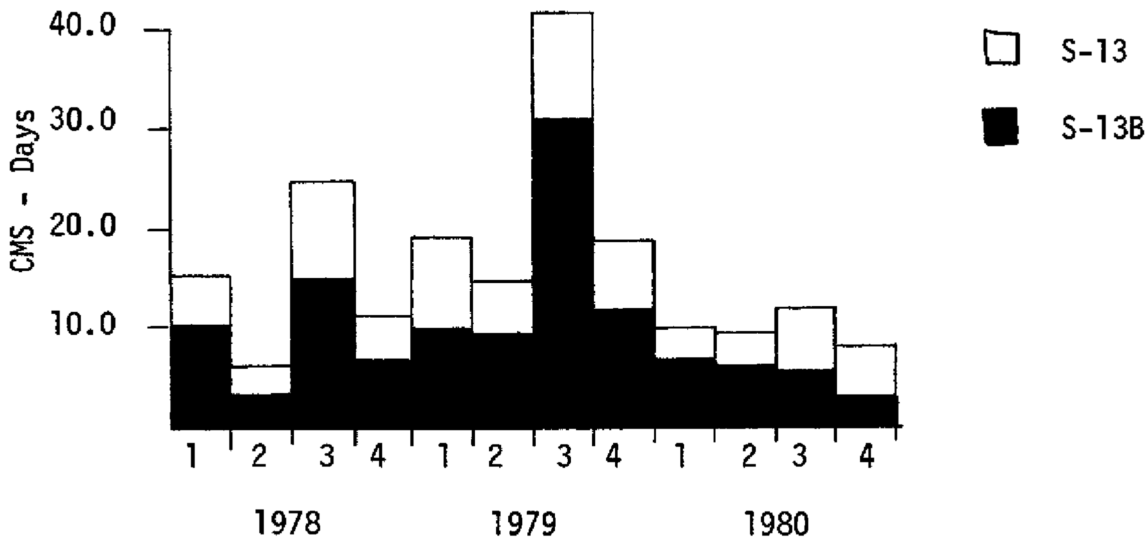


FIGURE 33. OTTER CREEK WATERSHED

Quarterly Discharge and Inorganic Nitrogen Loads at S-13 and S-13B

1978 - 1980



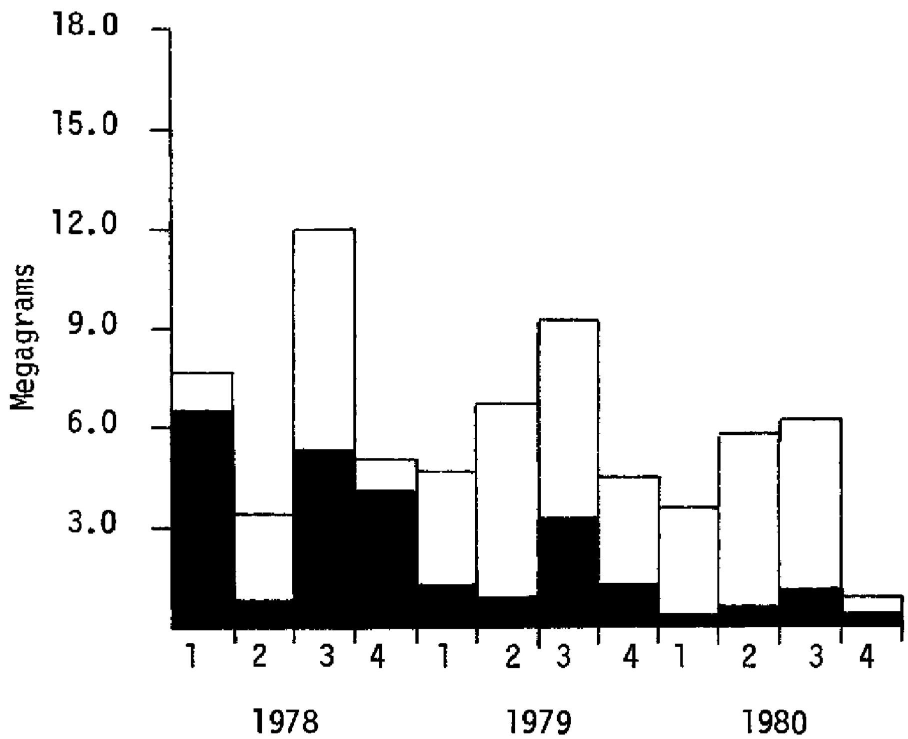


FIGURE 34. OTTER CREEK WATERSHED

Quarterly Discharge and Total Phosphorus Loads at S-13 and S-13B

1978 - 1980

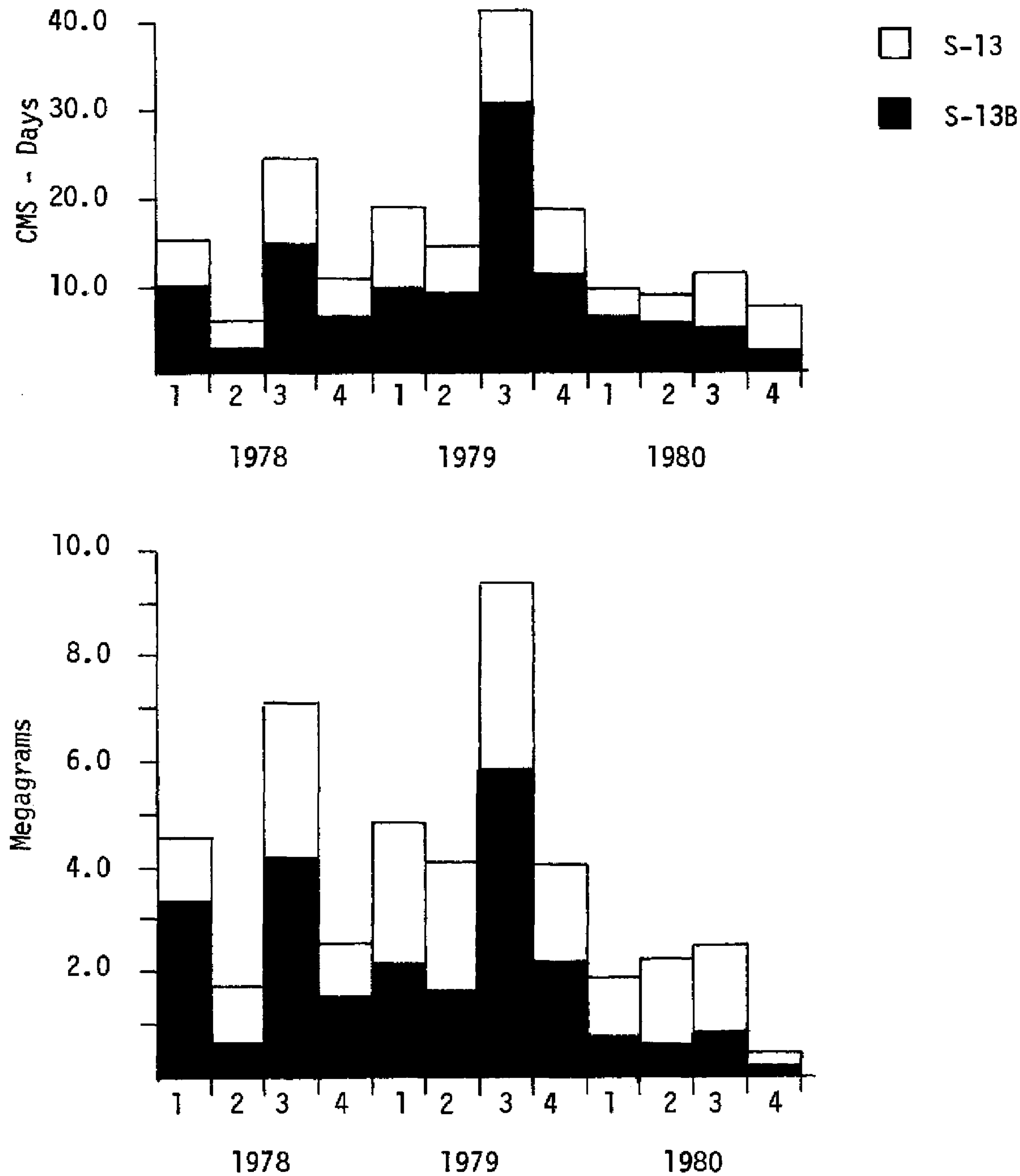
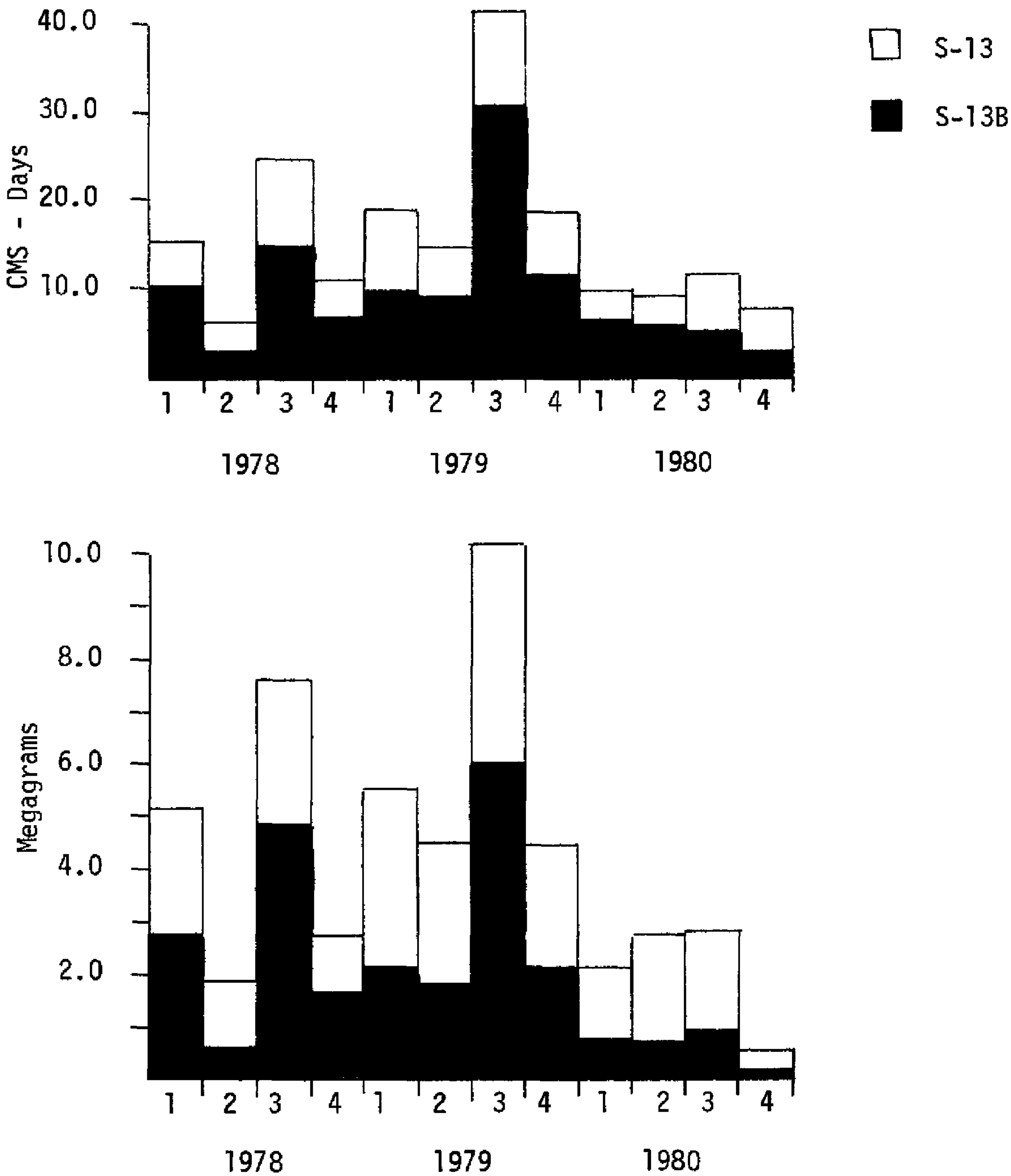


FIGURE 35. OTTER CREEK WATERSHED

Quarterly Discharge and Ortho Phosphorus Loads at S-13 and S-13B

1978 - 1980



For 1979, the estimated annual discharge of 330 acre-feet converts to 407×10^6 liters. The average water quality parameter concentrations were taken from Table 11. Loads and loads per unit land area are included in Table 30. For 1980, the estimated annual discharge of 182 acre-feet converts to 224.5×10^6 liters, and loads included in Table 31 were computed from average concentrations in Table 12.

Under these assumptions, Table 30 shows that the loads per unit land area for all nutrient components (except $NO_x + NH_4$) from the seepage field was about 15 times the average load per unit land area from watershed W-13 (Otter Creek). Likewise, the total nutrient loads from the seepage field were almost 15% of the loads from W-13 (Otter Creek), with discharge being about 5% of W-13 discharge.

In 1980, the computations of nutrient loads per unit land area indicated that the seepage field values were 20 to 30 times as large as for the whole W-13 watershed. About 20% of the nutrients appeared to be coming from the seepage field, with discharge being about 6.8% of the W-13 discharge (Table 31).

If these assumptions and computations are reasonably correct, it appears that barn waste water can contribute a significant part of watershed nutrient loads when disposed over a limited field area. The computations of the annual discharge and nutrient loads from the seepage disposal field are presented in Appendix 5.

BMP's implemented in the dairy areas above S-13B (i.e., washwater recovery system and fencing in the area of the seepage disposal field at McArthur Barn #1) should not only decrease nutrient concentrations but discharge as well. The shutdown of F&R Dairy, along with decreasing rainfall and groundwater levels has helped decrease flow and loads from the area above S-13. Additional fencing on another dairy unit upstream of S-13 should aid in further decreasing nutrient loads in this area (see Tables 6 and 7 for BMP information).

Tables 29 through 31 summarize annual nutrient loads in W-13. The loading rates of N and P per unit land area for W-13 from 1978 to 1980 are substantially greater than those observed for the overall W-2. Interestingly enough, the loading rates at W-13 were slightly less than those observed at the W-LB in 1978 and 1979.

Figures 36 through 38 compare quarterly discharge, total P and total N loads at W-2 (upper Taylor Creek), W-13 (Otter Creek), W-LB (Little Bimini), and W-3 (N. W. Taylor Creek) from 1978 to 1980. With the exception of the third quarter in 1979, W-13 has exhibited the highest total P loads of any of the subwatersheds in the TCHW project area; however, the W-3 exhibits the highest discharges (Figure 36). In the second quarter of 1980, W-13 actually had higher total P loads than those measured for the entire W-2. With the exception of the third quarter of 1978 and the third quarter of 1979, W-13 also exhibited the highest total N loads in the TCHW project area. In addition, total N loads during the first and second quarters of 1980 exceeded the total N loads at W-2 (Figure 38). These high N and P loads at W-13 from 1978 to 1979 clearly illustrate the impact intensive dairy farming has on a watershed (see Tables 29 through 31 which present kilograms of nutrients per land area).

FIGURE 36. QUARTERLY DISCHARGES FROM UPPER TAYLOR CREEK W-2 AND THREE SUBUNITS W-3, W-13, AND W-LB FROM 1978 to 1980

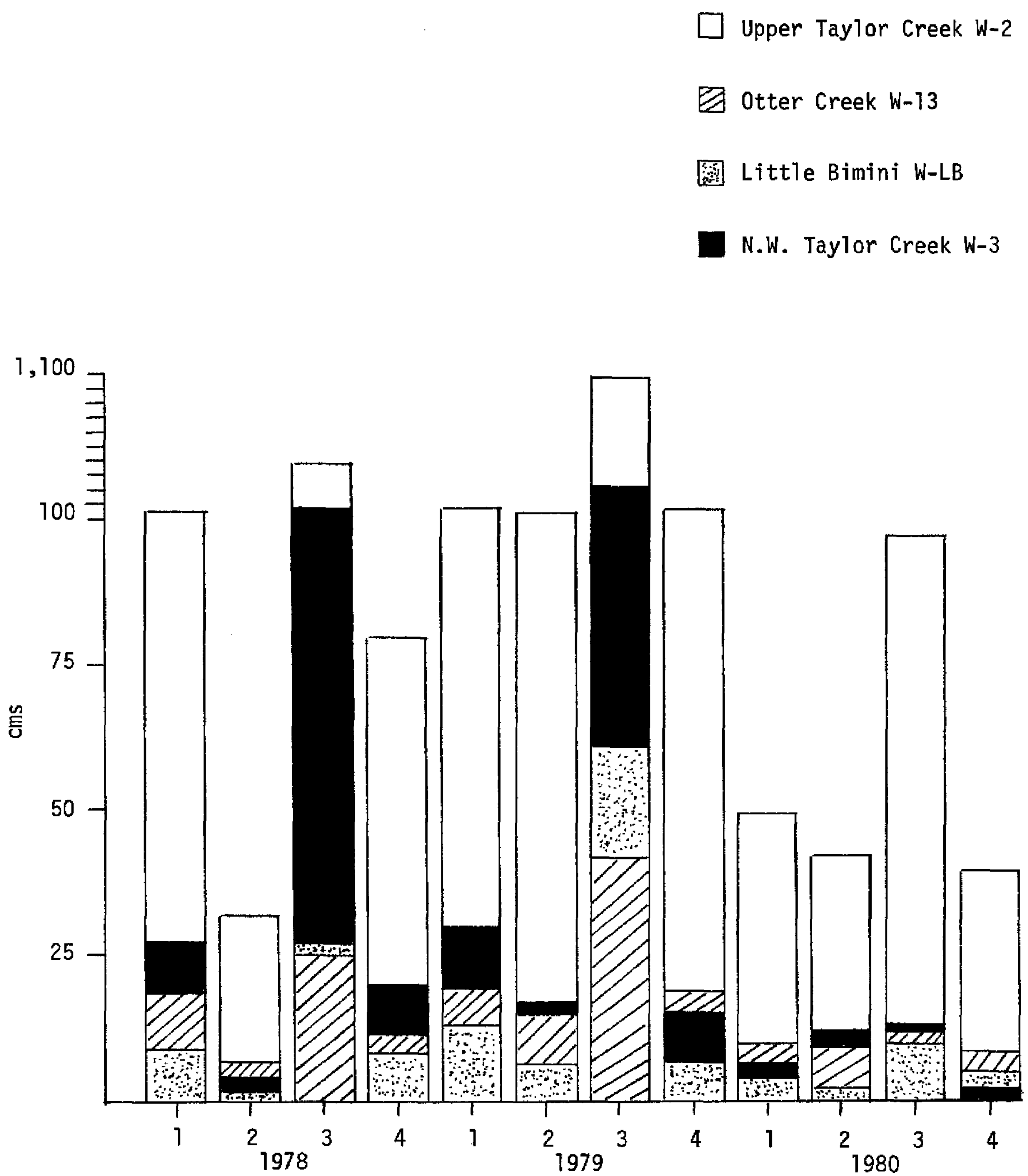


FIGURE 37. QUARTERLY T-PO4 LOADS FOR UPPER TAYLOR CREEK W-2 AND THREE SUBUNITS W-13, W-LB, AND W-3 FROM 1978 to 1980

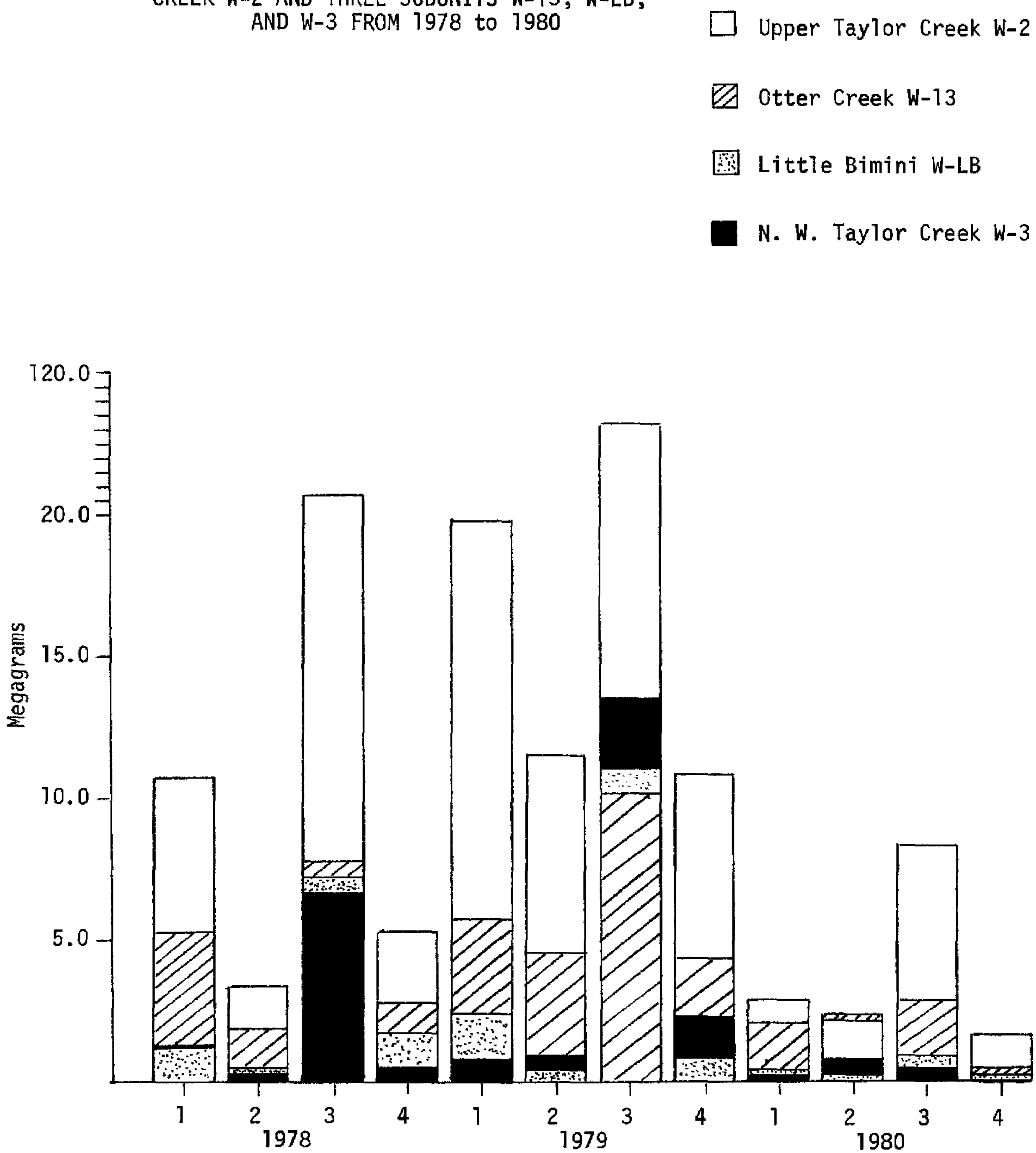
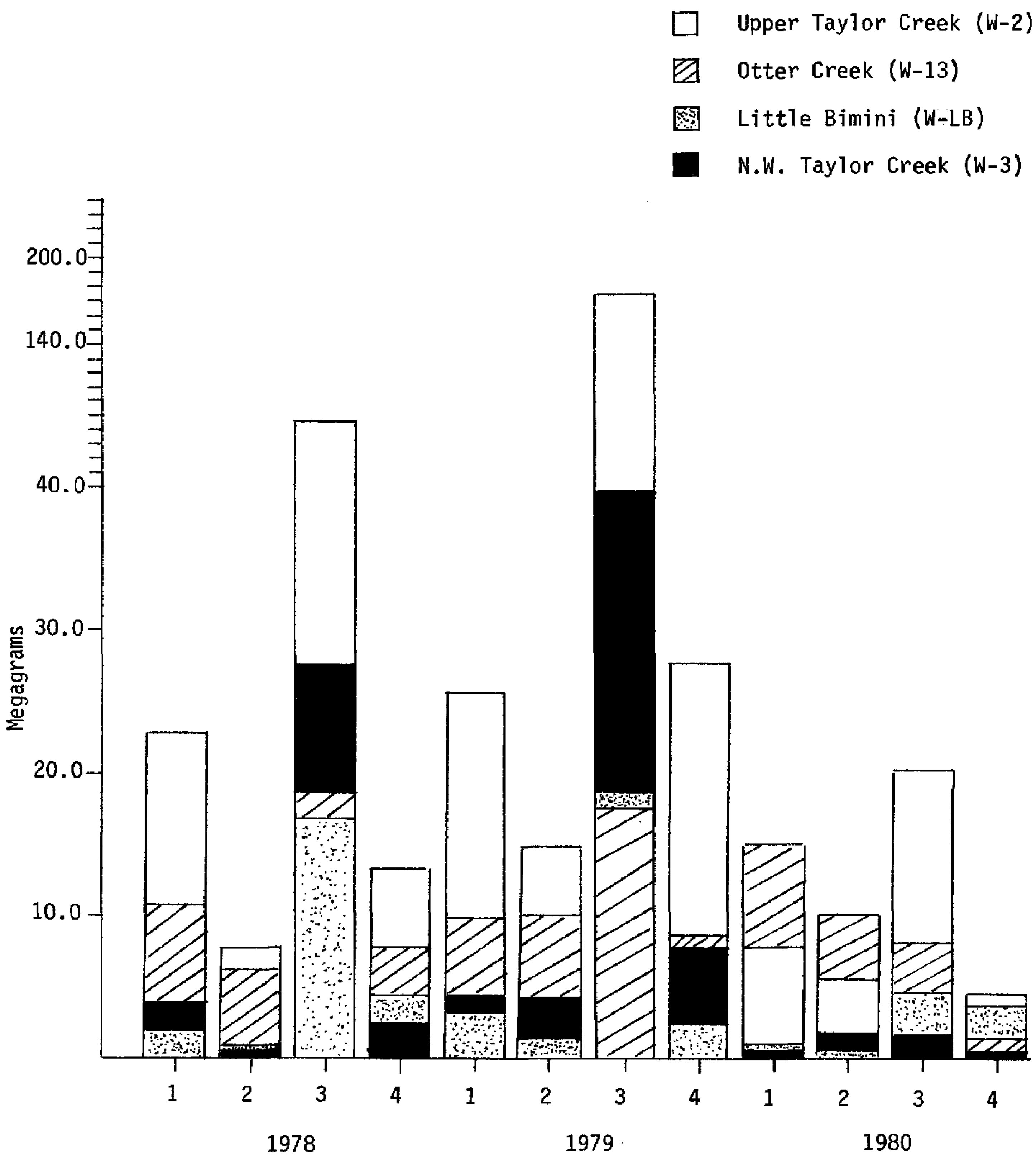


FIGURE 38. QUARTERLY TOTAL NITROGEN LOADS FOR UPPER TAYLOR CREEK (W-2) AND THREE SUBUNITS W-13, W-LB, AND W-3 FROM 1978 TO 1980



LITTLE BIMINI (W-LB)

The Little Bimini watershed (W-LB) represents 5.6 percent of the land area of W-2 and 3.1 percent of the entire TCNS land area (Table 2). As noted earlier, the W-LB is an ungauged watershed whereby discharge from this watershed is derived using ratios of land area and rainfall from similar gauged watersheds.

Tables 29 through 31 present annual loading data for W-2 and its subwatersheds. In 1978 and 1979, W-LB contributed the greatest amount of ortho and total P per unit of land area than any of the other watersheds. In 1980, total P loads per unit land area were 0.99 kg/ha as compared to 6.85 kg/ha and 9.72 kg/ha in 1978 and 1979, respectively. Ritter and Allen (1982) suggest that the decrease in N as well as P loads coming out of W-LB in 1980 can generally be attributed to two variables: 1) the decrease in rainfall from 1978 to 1980 (126.3 cm to 94.3 cm, respectively); 2) the improvements in the wastewater and paddock drainage systems at one of the upstream dairy sites in W-LB. Because of the abnormal low rainfall conditions that have existed from October 1979 to December 1980 throughout the W-2, it is difficult to substantiate the later conclusion. Looking closely at Figure 38, during the fourth quarter of 1980 total N loads at W-LB represented about 90 percent of the N loads in the entire W-2. This can be somewhat misleading because W-LB generally has a higher inorganic N fraction (NO_3-N) than the other subwatersheds; whereas, the greatest contributions of N loads throughout the W-2 generally come from the organic N fraction. It is felt that the condition that existed in the fourth quarter of 1980 was due to the low flow conditions which decrease the organic N load from the other subwatersheds and because the inorganic fractions in these areas have never been substantial (except for NH_4-N which generally volatilizes before it gets very far downstream), the higher NO_3-N loads at W-LB create a higher total N load.

Additional installations of BMP's at several dairy farms within this subwatershed should in the near future help to determine the effectiveness of these BMP's in further decreasing N and P loads from W-LB.

N. W. TAYLOR CREEK (W-3)

The N. W. Taylor Creek watershed (W-3) represents 18.3 percent of the land area of W-2 and 10.1 percent of the entire TCNS land area (Table 2). Even though discharges from W-3 are high (at times over 30 percent of the discharge at W-2), N and P loads per unit land area remain low (Tables 29 through 31). Figure 36 shows that during high discharge periods, W-3 contributes a significant percentage of the discharge at W-2. Interestingly enough, during quarter 3, 1978, and quarter 3, 1979, total N loads were highest at W-3 and total P loads were highest also during quarter 3, 1979. This is generally attributed to the high volumes of water that are generated from this watershed during peak rainfall periods (60.9 cm, quarter 3, 1978; 76.6 cm, quarter 3, 1979). The heavy rainfall during these periods probably helped flush nutrients generated from a 5,800 head calf-heifer operation located at the top of the watershed. Generally, these nutrients have greater detention times before they move downstream; however, when water tables are high, heavy rains inundate these subwatersheds, passing nutrients more rapidly. None the less, W-3 will be used as a comparison with which to base success or failure of BMP's in clearing up water quality problems throughout TCNS.

WILLIAMSON DITCH (W-5)

The Williamson Ditch watershed (W-5) represents 31.4 percent of the land area of W-2 and 17.5 percent of the entire TCNS land area (Table 2). As noted in the water quality section, land use for W-5 is generally beef cattle and citrus. Nutrient loads in the past have been low from watersheds with less intensive agricultural land use practices (as compared to dairy farming). Total P loads per unit land area (1.28 kg/ha) on an average are lower than those exhibited at W-3 (1.84 kg/ha); however, total N loads per unit land area were about the same (6.61 kg/ha W-5 and 6.22 kg/ha W-3). Tables 29 through 31 present loading data for W-5 in comparison to the other subwatersheds.

Because similarities do exist between land use practices, area, nutrient loads, and discharges between W-5 and W-3, the W-5 can also be used comparatively to evaluate the relative success of BMP's on improving stream and runoff water quality.

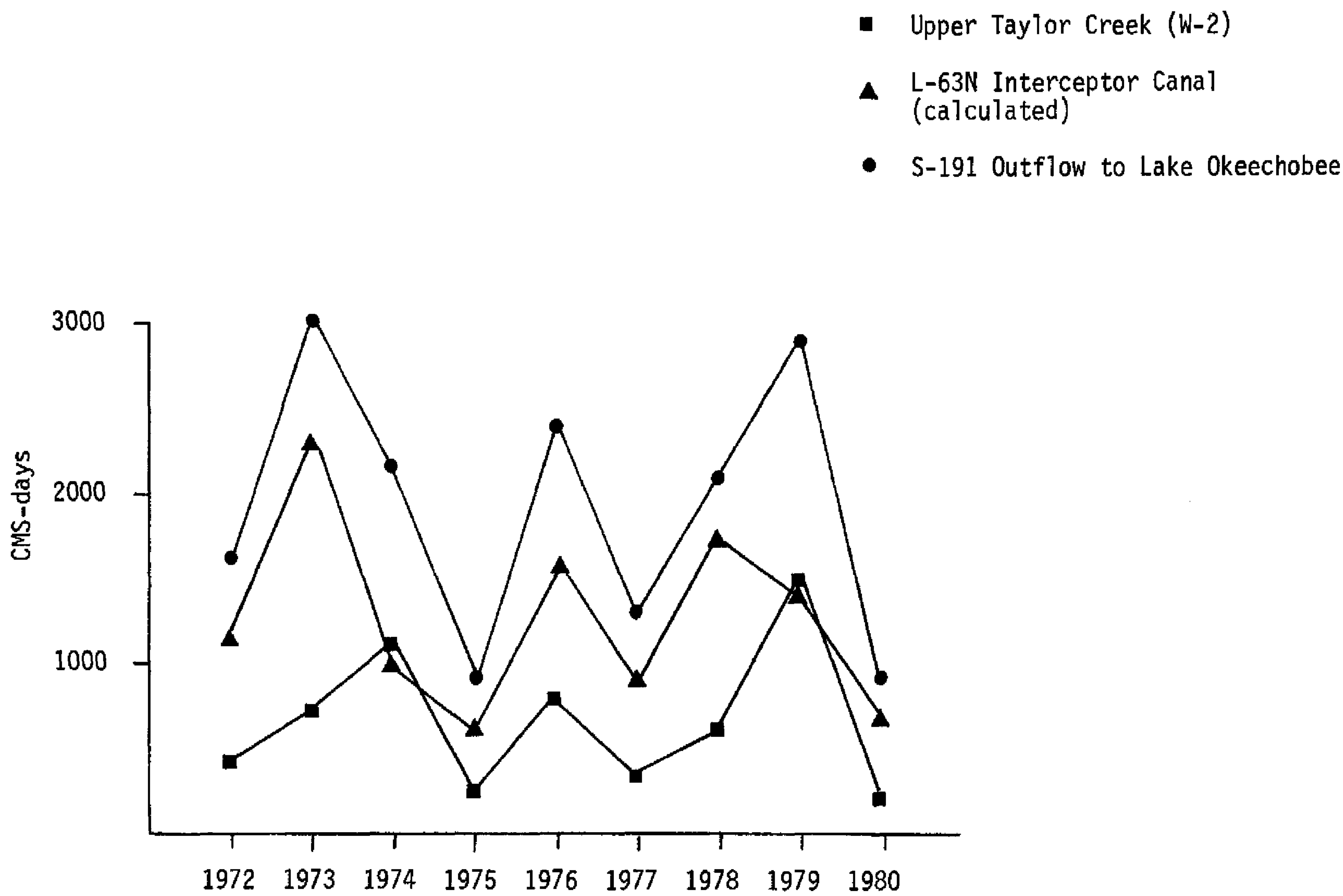
W-RH AND W-RT

As noted earlier, there is a considerable portion of the W-2 watershed that is ungauged, making up remainder watersheds (Figure 29). In total, these two remainder watersheds (W-RH and W-RT) make up 34.1 percent of the W-2 and 18.9 percent of the entire TCNS land area. Discharge and loading calculations, as well as land use practices within these watersheds, indicate that contributions of N and P loads as well as loads per unit land area are similar to W-3 and W-5 (Figures 29 through 31). Based on this, it can be assumed that nutrient contributions from these watersheds will continue to model those coming from watersheds with less intensive agricultural activities.

S-191 AT NUBBIN SLOUGH

Outflow at S-191 represents the total discharge and loads coming from TCNS. Discharge from the L-63N canal, which drains Mosquito Creek, Nubbin Slough, Henry Creek, and Lettuce Creek, can, at best, be calculated by subtracting the discharge from W-2 from the discharge at S-191. A summary of discharges at these 3 areas is presented in Figure 39. With

FIGURE 39. SUMMARY OF TOTAL ANNUAL DISCHARGES IN THE TAYLOR CREEK/NUBBIN SLOUGH WATERSHED



the exception of 1974 and 1975, the L-63N canal drainage contributes a greater percentage of the total discharge at S-191.

Presently, there is no accurate way of assessing nutrient loads at the subwatersheds within the L-63N canal system. Plans have been developed for installation of stage recorders at the outflow points of these subwatersheds by the end of 1982. These recorders will provide needed discharge and loading data to help evaluate BMP installation for the RCWP programs. As noted in the water quality section, a water quality monitoring program has been established in these subwatersheds.

Figures 30 and 31 present a comparison of annual total N and total P loads at S-191, upper Taylor Creek (W-2), and the Taylor Creek headwaters. With the exception of quarters 2 and 4 in 1978, and quarters 2 and 4 in 1980, S-191 has exported over 100 megragrams of nitrogen per quarter (1 megagram = 1 metric ton) from 1978 to 1980. During 1978 (quarters 1 and 3) and 1979 (quarters 1, 2, and 3), S-191 has exported over 50 megagrams of phosphorus to Lake Okeechobee. The export of total N and total P per unit land area at S-191 (Taylor Creek/Nubbin Slough) (Table 2) falls between the nutrient load per unit land area of the W-2 and W-13 watersheds (Tables 29 through 31). Total N loads per unit land area per year for 1978 and 1979 were 8.9 kg/ha and 14.0 kg/ha, respectively. During 1980, only three quarters are presented showing a ratio of total N to unit land area of 4.9 kg/ha. Total P loads for 1978 and 1979 were 3.7 kg/ha and 5.4 kg/ha, respectively. Total loads for 3 quarters during 1980 were 1.1 kg/ha.

FUTURE PROGRAM DIRECTION

STATUS AND TIME FRAME OF POST-BMP ANALYSIS

Presently, 100 percent of the dairies in the TCHW project area are under contract for BMP implementation. McArthur Farms, Inc., the first dairy operation to sign a contract, has started implementing BMP's; however, weather conditions will dictate how quickly all prescribed BMP's for this operation, as well as the others in the project area, will be completed. If this area undergoes a normal wet season of 76.2 cm (30 inches) June-September, then completion of all BMP's in the TCHW area could extend on into the later portion of 1983.

SCS engineers are now working on RCWP project areas that are outside the TCHW project area. Final completion of BMP's in these areas could be around 1985 or 1986, depending on weather conditions.

MINI-STUDIES

Gomez Creek

Collection of 2 water quality samples (sites 29 and 30) began on November 19, 1980, at Gomez Creek, located about 6.4 km (4 miles) east of the upper TCHW project boundaries (Figure 40). These sites were added by the ARS to collect baseline water quality data in the event proposals to divert water from the TCHW project area (mainly from W-13) into Gomez Creek and then northeast into an existing slough were carried out. Currently, this proposal has been ruled out in preference to other management techniques in W-13. This baseline data, however, offers some interesting analyses regarding a relatively undisturbed system with little agricultural runoff.

The dominant soil types in this system are the Myakka, Immokalee, and Pomello fine sands; the latter as mentioned having a deeper water

FIGURE 40. UPPER TAYLOR CREEK WATERSHED W-2 AND GOMEZ CREEK

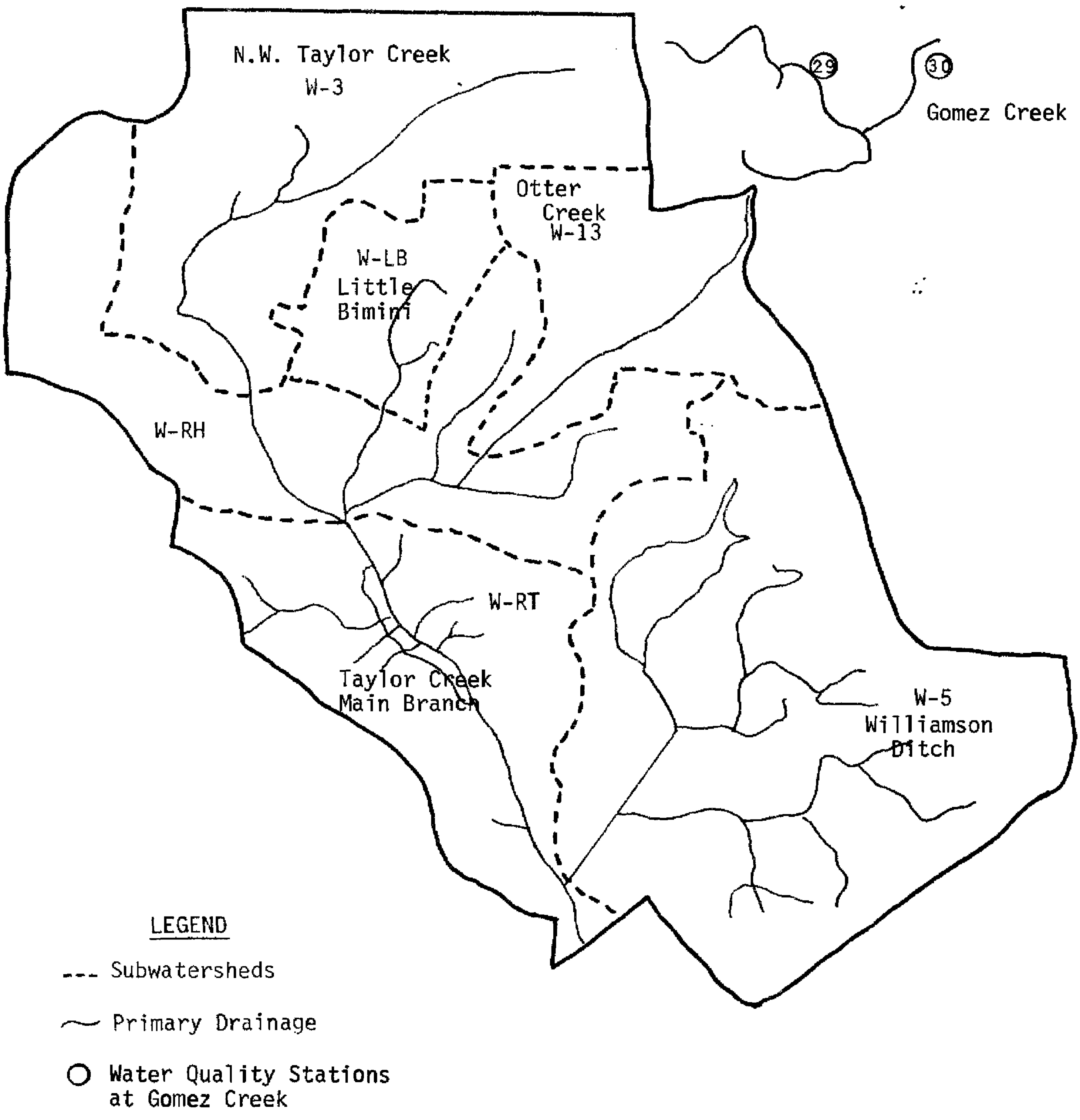


table. Part of the Gomez Creek watercourse is a slough without a well defined channel. The dominant soil types in the slough are a combination of Pamlico and Placid soils that are nearly level soils, poorly drained with a fairly high organic matter content (McCollum and Pendleton, 1971). Table 32 presents water quality data for 1981 at sites 29 and 30 in Gomez Creek. There is some dairy input between site 29 and site 30 (upstream and downstream, respectively); thus, N and P concentrations are higher at site 30. Even though total N and P concentrations (2.51 mg/l N and 1.78 mg/l P) are higher in Gomez Creek downstream of the dairy input, they are lower than in the channelized areas of Otter Creek. It could be that the nutrients entering Gomez Creek may be getting additional treatment from this relatively undisturbed (i.e., not channelized) slough system. A higher organic content in the soils of this area may provide soil adsorption of P, which may be contributing to the lower P concentrations here. These two sites will continue to be monitored to identify long term trends (if any) within this system. Because there is also some dairy runoff entering Gomez Creek, and water quality values are relatively low, this station may also provide an additional standard with which to evaluate BMP implementation throughout TCNS.

PHOSPHORUS IN SEDIMENTS

A major concern regarding implementation of BMP's throughout TCNS has been whether or not there will be a lag period between installation of BMP's and an observed change in water quality. This question may be best addressed by demonstrating whether or not the streambed sediments throughout the watershed have P retention capabilities. Blue (1970) in laboratory experiments involving Leon fine sand (similar to Myakka and Immokalee soils in Okeechobee County) showed that the P retention

TABLE 32. Annual Mean, Minimum, and Maximum Values for the Open Channel Stations in Gomez Creek for 1981.

	STATION 29		STATION 30	
CHEMICAL PARAMETERS[1]	$\bar{x}$	min-max	$\bar{x}$	min-max
O-PO4	0.15	0.01-0.37	1.66	0.61-2.66
T-PO4	0.20	0.04-0.50	1.78	0.55-3.27
TKN	1.25	0.58-2.37	2.23	0.35-9.60
NH4	0.10	0.01-0.48	0.15	0.01-0.75
NO2	0.005	0.004-0.01	0.03	0.004-0.25
NO3	0.03	0.004-0.33	0.25	0.004-0.69
TOTAL N	1.29	0.58-2.42	2.51	0.36-9.89
PHYSICAL PARAMETERS				
LAB CONDUCTIVITY[2]	134	89-220	307	187-475
LAB pH	6.32	5.88-6.74	6.98	6.48-7.33
COLOR	137	57-383	149	60-382
TURBIDITY[3]	1.50	0.30-3.50	1.40	0.30-3.70
NUMBER OF SAMPLES	23		24	

[1] Chemical parameters are expressed in mg/l.

[2] Lab conductivity is expressed in OMHOS/cm.

[3] Turbidity is expressed in NTU (nephelometric turbidity units).

capabilities of this soil in the first 60 cm was very low. Burton et al. (1975) concluded that sediments of the Kissimmee River-Lake Okeechobee watershed have limited soil sorption capacity for phosphates. It was found, however, that sediments did act as a source of nutrients when overlying water concentrations were low. Fiskell and Mansell (1974) studied P retention capabilities of Oldsmar fine sand (similar to the Bassinger and Wabasso soils in Okeechobee County) under different types of tillage (soil profile mixing). With 200 mg/l P/g soil, it was found that P sorption in the surface tillage treatment (unmixed profile) was generally low except for longer retention times (i.e., 24 hours); however, when this condition did exist, only 7 percent of the 200 mg/l P/g soil was sorbed in the A horizon (0-15 cm). Selim et al. (1974) determined the effects of water flow velocity and the degree of soil water saturation on the movement of P through undisturbed cores of A_1, A_2, and B_{2h} horizons of Oldsmar fine sand. It was found that P adsorption was greater in soils with high organic content, high silt, clay, and high in extractable Fe and Al. With decreased water flow rates through the column (decreasing water velocities), increased P contact time in the soil allowed more P adsorption. These types of studies will help reach a better understanding of the P retention and ultimate leaching capabilities of the soils in the TCNS watershed. Ultimately, a program will be designed to help answer some important questions regarding the amounts of P in the streambed sediments and whether or not the sediment will act as a source of P when overlying water concentrations decrease.

In a preliminary survey, soil samples were collected at seven streambed sites in the TCHW project area (Figure 41 and Table 33). Samples consisted of a six-inch soil core and were analyzed for total

FIGURE 41. TCHW PROJECT AREA AND SOIL SAMPLE LOCATIONS

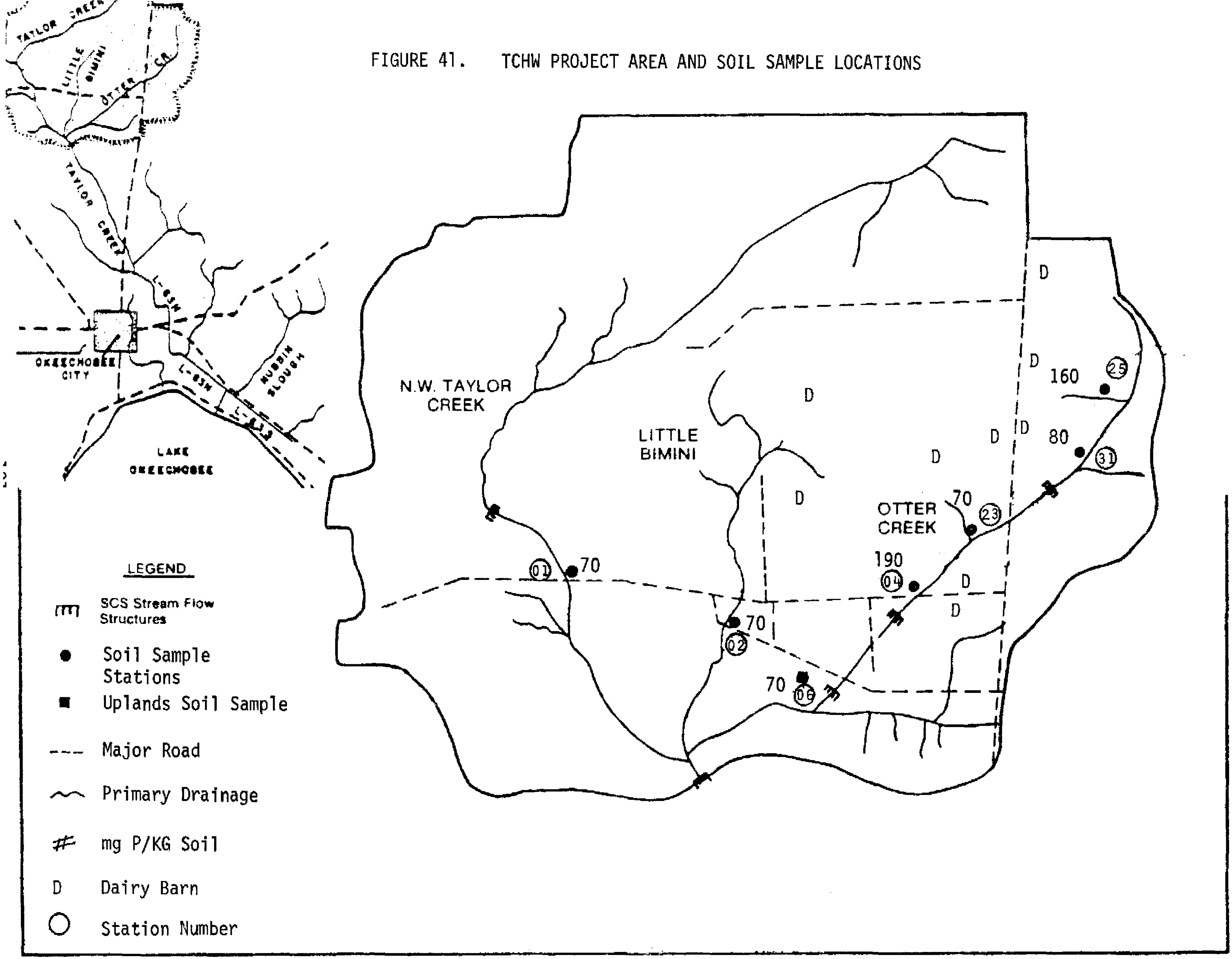


TABLE 33. Description of Soil Sample Locations

Station 25	Drainage ditch into Otter Creek adjacent to dairy seepage field.
Station 31	Otter Creek open channel draining three dairy barns with 1000+ head of dairy cows each.
Station 23	Tributary draining into Otter Creek, cooling area for approximately 130 dairy cows. This tributary also receives some seepage from the primary and secondary lagoon systems of one dairy operation.
Station 04	Otter Creek open channel; seems to act as a sediment trap for the 5 dairies located upstream. This station is directly downstream of old F & R Dairy.
Station 06	Represents an upland soil sample adjacent to Otter Creek. This station is on a semi-improved beef cattle pasture.
Station 02	Little Bimini open channel, draining three dairies with a total of 3,000+ head of dairy cows. This station is located at least 2 miles from the nearest dairy operation.
Station 01	N. W. Taylor Creek open channel, draining primarily improved pasture (beef cattle) with limited dairy activity (calf heifer operation) in the headwaters.

phosphate and TKN. Phosphate analysis was performed on samples solubilized by Kjeldhal digestion using the automated ascorbic acid method with a Technicon AutoAnalyzer. Samples for nitrogen analysis were digested to ammonia and analyzed with a Technicon AutoAnalyzer. All Kjeldhal digestions were performed on a BD-20 block digester. Sample values were expressed in percent dry weight of the soil, which indicates soil moisture is not being taken into account.

Figure 41 depicts the initial sampling sites along with P values translated to mg P/kg soil. The highest values, 190 mg P/kg soil (site 04) and 160 mg P/kg soil (site 25), are from areas with more extensive dairy activity or a higher organic buildup within the streambed. These values were much lower than values obtained in the Chandler Slough study (Federico et al., 1978). P values in the marsh areas of Chandler Slough were as high as 310 mg P/kg soil, 340 mg P/kg soil in the creek bed, and 130 mg P/kg soil in the upland area. It was concluded that these higher P values were in the top 15 cm (6 inches) of the soil. It was also noted that the P content per square meter was higher in the inorganic soils than in the organic soils.

A more detailed analysis of P in sediments within the TCNS watershed can be pursued in order to better understand and possibly evaluate nutrient contributions from sediments.

SUMMARY AND CONCLUSIONS

(FINDINGS OF THE PRE-BMP STUDY)

1) High N and P concentrations in Little Bimini, Otter Creek, Mosquito Creek, Nubbin Slough, and Henry Creek can be directly related to the density of dairies and dairy animals within these subwatersheds.

2) High chloride concentrations reflected by high specific conductivity values (>5,000 umhos/cm) continue to exist in the Williamson Ditch (W-5) subwatershed. These high conductivity values are the result of the use of artesian wells to irrigate the citrus in this area.

3) Decreases in rainfall, runoff, and groundwater levels have resulted in decreased N and P concentrations throughout the watershed from 1978 to 1981.

4) N and P concentrations along Otter Creek before and after the dairy (located adjacent to Otter Creek) shutdown illustrate the impact that an improperly maintained dairy and animal wastewater management system can have on stream water quality.

5) Some early improvements in on-farm management practices (i.e., more efficient use of wastewater runoff facilities, fencing cows out of paddock area drainage, and routine maintenance of existing lagoon systems) along Little Bimini, Mosquito Creek, and Otter Creek seem to have some positive impacts on improving downstream water quality.

6) From 1978 to 1981, total N and total P concentrations at Nubbin Slough (outflow, site 14) have increased 148% and 96%, respectively. These increases can be attributed to the improper utilization of wastewater facilities and the continued access of cows to the open channel at several of the dairies in this subwatershed.

7) The percentage of nutrient loads from the TCHW and W-2 areas that contribute to the total load at S-191 is greatly dependent on rainfall and groundwater conditions. When water tables are high and soil moisture conditions are replenished, upper Taylor Creek (W-2) contributes over 50 percent of the N and P loads at S-191.

8) N and P loads at S-13, the outfall to the Otter Creek watershed (W-13), have decreased over 50 percent from 1978 to 1980. These decreases can be attributed to the shutdown of F & R Dairy and the decreasing runoff conditions that evolved over this period.

9) In 1978 and 1979, Little Bimini exhibited the highest ortho P (6.39 kg/ha and 8.89 kg/ha, respectively) and total P (6.85 kg/ha and 9.72 kg/ha, respectively) loads per unit land area in the TCHW project area.

10) Decreases in N and P loads at Little Bimini in 1980 can generally be attributed to the drought conditions that existed; however, on-farm management practices (improvement in wastewater drainage facilities and fencing cows out of paddock drainage ditches) may have helped decrease loads as well.

11) The Taylor Creek channel between site 18 and site 11 of the W-2 will act as a nutrient sink under drought conditions, with N and P loads being reduced from upstream totals.

12) Total N loads and total P loads per unit land area at S-191 for 1978 (8.9 kg/ha and 3.7 kg/ha, respectively) and 1979 (14.0 kg/ha and 5.4 kg/ha, respectively) are representative to those subwatersheds within Taylor Creek/Nubbin Slough that are associated with intensive dairy farming activities.

13) The predominant soil type throughout the Taylor Creek/Nubbin Slough basin is the Myakka fine sand, a poorly drained soil associated with a high water table. Because of the extreme flood hazard of this soil and its inability to effectively assimilate nutrients, this soil type, along with the other poorly drained soils of this basin, are not conducive to nutrient uptake desirable for areas with intensive dairy activity.

14) The Pomello soil type is associated with a deeper water table and is fairly well drained. Soils of this nature are more conducive to the assimilation of nutrients and are therefore more desirable for location of intensive agricultural activities such as dairy farming.

SUMMARY

(BMP GOALS AND EXPECTED RESULTS)

1) The TCHW and RCWP projects are designed to determine the extent of the effects of BMP's (fencing, watering, shade, detention, and water conservation practices) on alleviating high nutrient loads coming from the Taylor Creek/Nubbin Slough basin.

2) The TCHW project will absorb 100 percent of the BMP implementation costs for landowners participating in the project area. The RCWP project will pay up to 75 percent of the BMP installation costs up to $50,000 for approved practices, while the landowners will pay the additional 25 percent.

3) Presently, 50 percent of the land area, as well as 100 percent of the dairies in TCNS are signed up for water quality management plans under the joint TCHW/RCWP programs. All of the dairies in the TCHW project area have signed contracts and are beginning BMP implementation.

4) The wash water recycling system began operating on 04/14/82. Early results show a savings of 797 m^3 (210,240 gallons) of water a day. This translates into 292,221 m^3/year (237 acre feet/year).

5) BMP's installed above S-13B (i.e., fencing, wash water recycling system) should decrease N and P loads as well as discharge in this area.

6) More efficient utilization and management of dairy wastewater systems and the implementation of BMP's in the Nubbin Slough subwatershed should have a positive impact on stream water quality as well as downstream water quality at S-191.

7) Mini-studies, such as Gomez Creek and analysis of phosphorus in streambed sediments, will provide additional tools with which to analyze the effectiveness of BMP's.

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APPENDIX 1

SCS STANDARDS AND SPECIFICATIONS

APPENDIX 1

Work Unit Technical Guide
All Florida
Section IV-C
October 1971

STANDARDS AND SPECIFICATIONS
for
FENCING
(Code 382)

Definition - Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people. (Does not include electric or other temporary fences.)

Purpose - To (1) exclude livestock or big game from areas that should be protected from grazing; (2) confine livestock or big game on an area, or prevent trespass; (3) subdivide grazing land to permit use of grazing systems; (4) protect new seedlings and plantings from grazing; and (5) regulate access to areas by people.

Where Applicable - On any area where livestock or big game control or exclusion is needed, or where access to people is to be regulated.

SPECIFICATIONS

General Specifications - Fences will be located and constructed to effectively control, exclude, or regulate use on an area for the purpose intended.

I. REGULAR FENCES

A. Wire - Fences will be constructed of at least three but preferably four wires, either barbed or smooth, or of woven and at least two wires of either barbed or smooth wire; total height of fence to top wire to be not less than 44 inches. Barbed and smooth wire shall be 12-1/2 gage double strand or equivalent in strength. Woven wire shall be at least 32 inches high, have 11 gage or larger top and bottom strands, 14-1/2 gage or larger intermediate and stay wires, and stay wires spaced not more than 12 inches on center. All wire should be new galvanized material. New 15½ gauge Gaucho wire may be used in lieu of wire types described above.

When splicing of wire is necessary, the "Western Union" splice should be used. This splice is made by overlapping the ends of each wire and wrapping each wire 5 times around the other wire. The use of a fence splicing tool will facilitate this operation and result in a neat job.

B. Staples - Stamples shall be of 9 gage hard wire, and should be 1-1/2 inches long for soft woods and 1 inch long for hardwood posts. The staples should be driven diagonally with the wood grain to avoid splitting, Space should be left between the staple and the post to permit movement of the wire.

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, GAINESVILLE, FLORIDA
SCS-FORT WORTH, TEX. 1971

C. Posts

1. Line Posts

Wooden - Untreated posts of such species as cypress; and pine posts treated with a creosote coal-tar solution, or pentachlorophenol, with not less than six pounds retention percubic foot, in accordance with Federal Specification TT-W-571c, are acceptable.

Size - Length must be sufficient to provide for the construction of at least a 44-inch-high fence, permit stapling of the top wire without splitting, and to be set solidly in the ground a minimum depth of 2 feet in deep soils or 18 inches in rocky soil; top diameter commercial size 3 inches or larger.

Spacing.- Maximum interval 20 feet if no stays are used between posts, or not to exceed 30 feet if stays are used between posts at intervals not to exceed 10 feet.

Steel -Standard "tee" or "U" section steel posts weighing not less than 1.33 pounds per foot of length, exclusive of anchor plate, may be used in lieu of wooden line posts. Length shall be same as for wooden posts. Steel posts shall be rolled from high carbon steel and shall have a protective coating. The coating may be either galvanizing by the hot dip process or painting in accordance with Commercial Standard 184 with one or more coats of high grade, weather resistant steel paint, or enamel applied and baked. Steel posts shall be studded, embossed, or punched for the attachment of wire to the posts. Wire shall be attached to the posts by wrapping with number 16 gage galvanized wire or by use of manufacturer's special designed clips.

2. Corner, Gate and Brace Posts

Wooden - Same species as above.

Size - Length sufficient to provide for the construction of at least a 44-inch-high fence, and permit setting at least 36 inches in the ground; top diameter commercial size 6 inches or larger.

Bracing - Required at all corners, gates, and at all definite angles in the line fence. Braces must be the equivalent of a commercial size 4" diameter top line post of the above species with minimum length of 6.0 feet notched into the top one-half of the brace post and post being braced, installed not less than 3 feet above ground line. A tension member composed of 2 complete loops of number 9 gage smooth wire or 2 complete loops of number 12-1/2 gage double strand barbed or smooth wire shall extend from a point approximately 6 inches below the top of the brace post to ground level of the post being braced into the ground to a "deadman". Use of a "deadman" may be omitted when the stretch of fence is 300 feet or less. The brace wire shall be twisted to secure the brace and provide needed rigidity.

II. SUSPENSION FENCES

A. Dimensions and quality of all materials used, fence heights, and fence construction shall be in accordance with the requirements set forth in SPECIFICATIONS for REGULAR FENCES except as noted in the following items.

B. Bracing shall be required at all corners, gates, definite angles in the line as specified in SPECIFICATIONS for REGULAR FENCES and at prescribed spacing in straight line sections of the fence as described below. All corner, gate, brace and pull posts shall be 8 feet long and with an 8-inch-diameter top, and imbedded in the ground at least 3-1/2 feet. Suspension fences shall not be constructed on a curve; directional changes in the line shall be by definite angles properly braced.

C. In straight sections of a suspension fence, anchor or pull posts braced according to SPECIFICATIONS for REGULAR FENCES shall be spaced at intervals not to exceed 1,320 feet. Any straight section of fence more than one-half mile long shall have a minimum of two (2) line anchor or pull post assemblies. The pull post assemblies should be equally spaced along straight sections.

D. Line posts shall be spaced not more than 100 feet apart with a minus 20-foot variable allowed to compensate for difficult terrain. (In such cases, an 80- to 100-foot spacing for that particular interval would be permissible.)

E. Galvanized twisted wire stays shall be spaced approximately 15 feet apart in the line.

F. All stays should swing free of the ground to permit the fence to sway when contacted by animals.

G. When wooden line posts are used, they shall have a minimum top diameter of 4 inches (commercial size). Any suitable fastener showing good workmanship and allowing the wire to freely contract and expand may be used to secure the wire to the post. An example of an acceptable fastener is a 1½" staple secured diagonally but not tight against the wire.

H. Suspension fences should be constructed with approximately a three-inch sag in the wire between posts 100 feet apart, 1½ inch sag between posts 50 feet apart, to permit maximum sway of the fence. Temperature changes that might affect this degree of sag should be considered. (Fence wire will tighten in cold weather and become slack in hot weather.)

VARIATIONS

Variations from the above materials and installation specifications may be approved by the responsible technician provided he determines that such variations will result in an installation that will meet or exceed one installed in accordance with the above specifications.

Approved:

Area Conservationist	Date
Field Specialist - Range	Date

PRACTICE STANDARDS AND SPECIFICATIONS

Filter Strip -393

Definition: A vegetated strip such as a pasture, grassed waterway, and terrace channel of a perennial grass.

Purpose: To control feedlot, dairy and storm runoff by providing a vegetated area in which settling, dilution, absorption of pollutants and infiltration can occur.

Where Applicable: At field edges, adjacent to cattle holding areas, dairy barns and feedlots.

SPECIFICATIONS

1. Length - The filter should have a minimum length of 300 feet or a minimum contact time of two hours.

2. Filter Area - Use the following formulas to determine the filter area and dimensions:

$$\text{Filter Area (Ac)} = \frac{\text{Volume Runoff from Problem Area (Acre inches)}}{2.7 \text{ (inches hour)}}$$

3. Filter Width - Use a minimum length of 300 feet. The filter length times its width is equal to its area.

$$300 \text{ ft} \times \text{width} = \text{Square feet of filter area}$$

$$\text{Width} = \frac{\text{Square ft. of filter area}}{300}$$

4. Water Spreading - Spread runoff from the problem area over the vegetated strips as much as possible. Use of spreader ditches or similar practices may be needed.

5. Plant Suitability - Any of the grasses and legumes suitable for pasture planting can be used that furnish suitable cover. Refer to the Technical Standard for Pasture Planting (512) for a list of these plants, seeding rates and dates for planting.

6. Soil Preparation - Prepare soil according to good cultural practices, establishing a good seedbed to destroy or reduce competition from undesirable vegetation and provide a smooth and firm seedbed.

7. Fertilizing and Liming - At the time of establishment, fertilize and lime in accordance to specifications in the Technical Standard for Pasture Planting (512). Fertilize and lime established vegetative field strips in accordance with the Technical Standard for Pasture Management.

Filter Strip (acre)

Definition

A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff.

Purpose

To remove sediment and other pollutants from runoff by filtration, infiltration, absorption, adsorption, decomposition, and volatilization, thereby reducing pollution and protecting the environment.

Conditions where practice applies

This practice applies: (1) on cropland at the lower edge of fields or on fields adjacent to streams, ponds, and lakes; (2) in areas requiring filter strips as part of a waste management system to treat polluted runoff or waste water; (3) in wooded areas where filter strips are needed as part of a harvesting system to reduce delivery of sediment into waterways.

Planning considerations

Evaluate slopes and soil material, vegetative species, time of year for proper establishment of vegetation, necessity for irrigation, visual aspects, fire hazards, and other special needs.

The concentrated flow must be minimized and needed repairs made immediately to reestablish sheet flow.

The need for facilities to outlet into streams or channels shall be considered.

If filter strips are to be used in treating waste water or polluted runoff from concentrated livestock areas, the following must be considered:

1. Facilities (basin or channel) to remove settleable solids before directing the flow through the filter strip.
2. Good drainage to insure satisfactory performance.
3. A flat filter strip in the cross section to insure uniform distribution of flow.
4. Provisions for preventing continuous or daily discharge of liquid waste unless the area is adequate for infiltrating all daily applied effluent.
5. Enough rest periods to reestablish an aerobic soil profile.
6. An adequate filter area and length of flow to provide the desired treatment. A serpentine or switchback channel can be used to provide greater length of flow.
7. Provisions for excluding roof water and unpolluted surface runoff.
8. Slopes less than 5 percent are more effective; steeper slopes require a greater area and length of flow.
9. Provisions for mowing and removing undesirable vegetation to maintain the effectiveness of the filter area.
10. The need for gated pipe or sprinklers to distribute flow uniformly across the top of the filter strip.

Plans and specifications

Plans and specifications for filter strips shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Filter Strip Specifications

Engineering specifications

All trees, stumps, brush, rocks, and similar materials that can interfere with installing the filter strip shall be removed. The materials shall be disposed of in a manner that is consistent with standards for maintaining and improving the quality of the environment and with proper functioning of the filter strip.

The filter strip shall be shaped to the grade and dimensions shown on the plan or as staked in the field. If necessary, topsoil shall be stockpiled and spread to the required grade and thickness. Excess spoil shall be disposed of in areas where it does not interfere with the required flow characteristics of the filter strip.

Vegetative specifications guide

Specify methods of seedbed preparation; adapted plants; planting dates and rates of seeding or sprigging; need for mulching, use of a stablizing crop, or mechanical means of stabilizing; and fertilizer and soil amendment requirements. Specify requirements for maintenace.

Land Smoothing (acre)

Definition

Removing irregularities on the land surface by use of special equipment.

Scope

This practice applies to operations classed as rough grading. Ordinarily, this does not require a complete grid survey. It does not apply to the "floating" done as a regular maintenance practice on irrigated land or the "planning" done as the final step in drainage land grading (462) or in irrigation land leveling (464).

Purpose

Improve surface drainage, provide for more effective use of precipitation, obtain uniform planting depths, provide for more uniform cultivation, improve equipment operation and efficiency, and improve terrace alinement and facilitate contour cultivation.

Conditions where practice applies

This practice applies on areas where depressions, mounds, old terraces, turn rows, and other surface irregularities interfere with the application of needed soil and water conservation and management practices.

It is limited to areas having adequate soil depth.

Design criteria

The extent of rough grading required and tolerances of the finished smoothing job shall be in keeping with the requirements of the planned cropping system.

Plans and specifications

Plans and specifications for land smoothing shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Land Smoothing Specifications 1/

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The land to be smoothed shall be cleared of vegetative matter and trash.

Irregularities that are not likely to be removed by three passes of a land plane or a land leveler shall be rough graded to a more uniform topography before starting the overall smoothing operation.

The ground surface should be plowed or disked prior to smoothing.

At least three passes of a land plane or leveler shall be made in different directions over the land to be smoothed, consisting of one pass along each diagonal and the last pass generally in the direction of cultivation or irrigation.

1/ See Supplement (attached).

SUPPLEMENT

Specifications

LAND SMOOTHING (acre)

Checking for Completion

Land smoothing shall be checked for completion in accordance with applicable procedures outlined in EFM, Florida Supplement, Chapter 14, "Standard Format and Notekeeping Procedures for Land Smoothing."

LIVESTOCK SHADE STRUCTURE

DEFINITION

A portable, metal frame structure with a mesh fabric to provide shade for livestock.

SCOPE

This standard applies to areas where shade is not available for livestock. This standard covers the minimum design criteria, material requirements and installation requirements. It does not apply to permanent structures.

PURPOSE

To provide alternate shade areas for livestock, where needed, to protect surface waters from pollution and to protect the livestock from excessive heat.

CONDITIONS WHERE THE PRACTICE APPLIES

Applicable where animal productivity and well being is adversely affected because of heat generated by sunshine and the lack of shade. It is also used to provide alternate shade areas so that livestock can be excluded from existing shade area on streambanks or depressions that if used would result in pollution of surface waters. Used as such, it may be a needed component in an animal waste management system. It can be utilized to provide shade in a pasture used for rotational grazing or in a holding area for dairy, beef, or swine operations.

PLANNING AND DESIGN CONSIDERATIONS

Orientation. It is desirable for the area to be kept dry, the longest axis should be oriented in a north to south direction. This will permit a greater amount of sunshine to affect the total shaded area. If the animals are to be confined under the structure, then an east to west orientation would be desirable. For structures that are to be regularly moved, an east-west orientation of the long axis is desirable.

Protection. The top of the structure should be relatively flat so that strong winds will have minimum effect on the structure. A 1.0 foot pitch for the top of the structure is permissible to provide faster rain runoff from the roof. Tie-down of the structure at the four corners is recommended.

Size. For dairy and beef animals, 30 to 50 square feet of space should be allowed for each mature animal with the structure having a height of 10 to 12 feet. For swine 15 to 20 square feet of space should be allowed for each mature animal with a minimum height of 7.0 feet.

Location. The structure should be a minimum of 50 feet from any type structure that could be an obstruction to the circulation of air.

SERVICE LIFE

A well constructed and maintained structure should last 10 years. It is necessary to maintain the tension on the fabric in order for it to realize its life expectancy. Maintenance coatings may be required on the structural steel to provide the expected life.

MATERIALS

Structural Members. The structural members shall be constructed of 2" minimum diameter steel pipe for all main structural members, and shall meet or exceed ASTM A-120 for Schedule 40 pipe. The skid pipes shall be galvanized or otherwise protected with a suitable protective paint coating, including a primer coat and two or more final coatings. In some installations, it may be desirable to provide this protection to all pipes. An exception to the use of the above pipe requirements would be the use of good used steel pipe having a wall thickness greater than 0.25". The corners of the roof frame shall be braced with No. 8 rebar or 2" minimum steel pipe. The brace plates are to be constructed of a minimum 0.25" flat plate steel conforming to ASTM A-36. All welding shall be continuous and shall conform to the code for welding in Building Construction, American Welding Society, AWS D1.0-63 for the type of weld used. The weld shall be suitable for the steel and the intended service.

Fabric. Mesh shade fabric shall be suitably constructed of high-quality materials and shall be certified by the manufacturer to be suitable for this use. The mesh fabric shall provide 70 to 80 percent shade.

Polypropylene fabric or similar materials that are highly resistant to outdoor exposure are acceptable cover material and shall meet or exceed the following:

PROPERTIES	REQUIREMENTS	TEST METHOD
*Tensile Strength, lbs.	175x110	ASTM D-1682
*Burst Strength, PSI	300	ASTM D-751
*UV Resistance Strength Retention,%	80 after 1200 hours of exposure	Federal Test Method Standard No. 191, Method 5804
Shade Level, %	73 77 80	ASTM D-1494
Weight, OZ/YD^2	4.2 4.4 4.6	ASTM D-1910

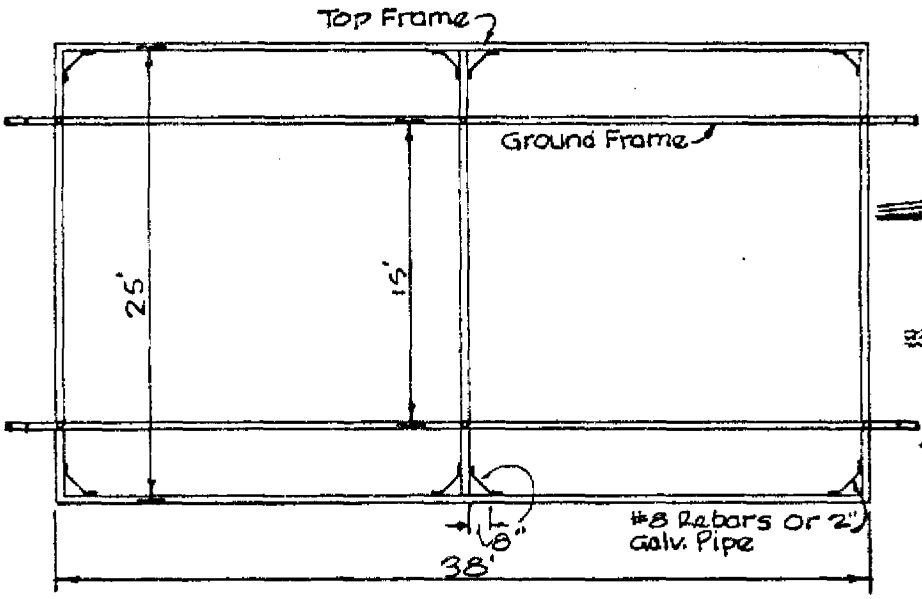
*Requirements listed are for a 73% shade level. A higher shade level would exceed these figures.

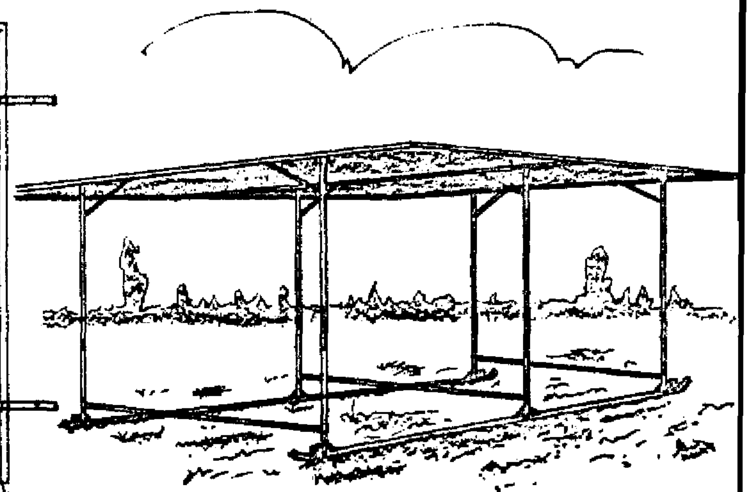
STRUCTURAL DETAILS

Typical sketch and structural considerations. The structure is to be constructed in accordance with sketch for structural details and/or in accordance with specifications supplied by the manufacturer. Minor variations in dimensions of the structure as shown on the sketch are allowed to accommodate standard materials. Dimension variations of over 10% that could affect the structure stability are acceptable provided the manufacturer or installer certifies the structural strength as being adequate. Bracing shall be as indicated. Instead of field welding, it is permissible for shop fabrication to be performed for easy field assembly. All such fabrication shall permit assembly of structure to have strength equal to the following sketch.

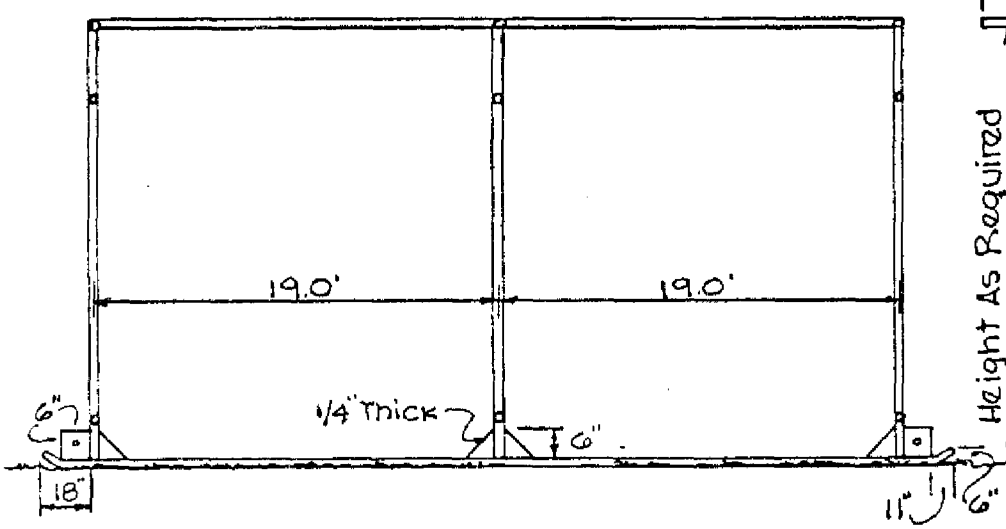
All such fabricated members shall be joined by no less than two 0.5" machine bolts with connecting members being no less than double pipe thickness or 3/8" steel plate. Plan for such fabrication will need to be approved by an SCS engineer. The fabric shall be adequately secured to the structural steel members so as to provide adequate and even tension on the fabric in accordance with the manufacturer's recommendations.

STRUCTURAL DETAILS

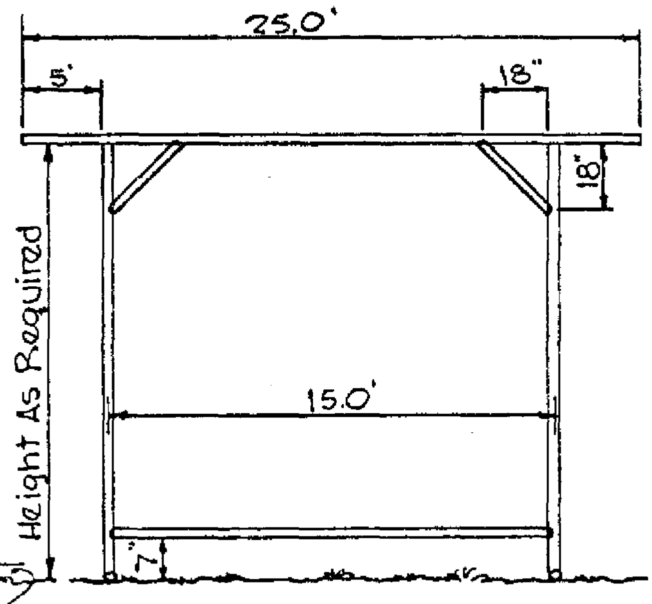




TOP VIEW



FRONT VIEW



SIDE VIEW

PLANS AND SPECIFICATIONS

Plans and specifications for installing livestock shade structures shall be developed in accordance with this standard.

Dike (ft)

Definition

An embankment constructed of earth or other suitable materials to protect land against overflow or inundation.

Scope

This standard applies to dikes used to protect land and property, including dikes for floodways and wildlife improvement.

Dikes are divided into the following classes:

Class I dikes are used to protect improved areas where inundation, erosion and scour, or sediment and debris may cause high property damage or loss of life.

Class II dikes are used to protect agricultural lands of medium to high capability; improvements are generally limited to farmsteads and allied farm facilities.

Class III dikes are used to protect agricultural lands of relatively low capability or improvements of relatively low value. These dikes are limited to low heads of water.

Purpose

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

Conditions where practice applies

The land and other improvements to be protected must be suitable for the intended use.

Class I dikes are constructed on sites where:

1. There is a possibility of loss of life if dike failure occurs.
2. High-value land or improvements are to be protected.
3. Unusual or complex site conditions require special construction procedures to insure satisfactory installation.
4. A dike is designed to withstand more than 12 ft of water above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas.

Class II dikes are constructed in highly developed and productive agricultural areas.

Class III dikes are usually built on sites where the spoil from excavated drainage channels is available. Class III dikes shall be used only on sites where:

1. The maximum design water stage against the dike is:

	ft
Mineral soils	6
Organic soils	4

(Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

2. Damages likely to occur from dike failure are minimal.

Design criteria—all dikes

In locating dikes, careful considerations shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

Protection. A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with recommendations in local technical guides.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

Maintenance. All dikes must be adequately maintained to the required shape and height. Erosion-controlling vegetation shall be established on dikes as required by climatic conditions and the need for protection against wave action. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the enbankment. Provisions for maintenance access must be provided.

Design criteria—Class I dikes

Location. Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height. The design height of a dike shall be the design high water depth plus 2 ft of freeboard, or 1 ft of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.
2. If dike failure is unlikely to result in loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year-frequency flood, whichever is greater.
3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.
4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall be not less than 5 percent.

Interior drainage. If inflow from the area to be protected by the dike may result in loss of life or extensive high-value property damage, provisions shall be included in the plans to provide protection against a 10-day, 100-year-frequency inflow hydrograph, plus an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever is greater.

Embankment and foundation. The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 ft for embankment heights of 15 ft or less and 12 ft for heights more than 15 ft. If maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall be not less than 1 ft above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If pervious foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 ft in width, shall be left in the ditches at intervals not greater than 400 ft to form a series of unconnected basins.

For dikes having a design water depth of more than 5 ft, the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design water line with the water side of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside toe of a dike than a distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and conduits. Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with antiseep collars.

All conduits through a dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Design criteria—Class II dikes

Design water stage. The maximum design water stage permitted is 12 ft above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 ft, the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height. The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 ft or freeboard of 1 ft plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus an allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior drainage. Provisions must be made for adequate drainage for the area to be protected by the dike.

Cross section. The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design water height	Minimum top width	Steepest side slope
ft	*ft*	
0–6	6	1–1/2:1
6–12	8	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Design water height	Minimum top width	Steepest side slope
ft	*ft*	
0–6	8	2:1
6–12	10	2–1/2:1

Side slopes of 3 horizontal to 1 vertical on waterside and 2:1 on landside may be used instead of 2–1/2:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be not less than 10 ft if a maintenance road is planned on top the dike. "Turnarounds" or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate.

Foundation cutoff. A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and borrow pits. Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft	10 ft
More than 6 ft	15 ft

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 ft, the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and conduits. The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with antiseep collars.

All conduits through the dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains. Drains shall be used where necessary to insure safety of dikes and shall be located on the land side, have a graded sandgravel filter, and be designed and installed in accordance with Soil Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside toe of a dike than a distance 3 times design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sandgravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Design criteria—Class III dikes

The design criteria shall be on site conditions for mineral or organic soils as applicable.

Top width. Minimum top width is 4 ft.

Side slopes. Minimum side slope is 1:1.

Freeboard. The minimum freeboard is 1 ft plus wave height. The constructed height shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

Foundation cutoff. A cutoff shall be installed if necessary to insure dike stability.

Plans and specifications 1/

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

1/ See Supplement (attached)

SUPPLEMENT

Specifications

DIKE (ft)

Specifications shall be in keeping with the preceding standard, shall describe the essential requirements for proper installation of the dike, and shall include consideration of the following items:

Class I Dikes

Foundation Preparation
The foundation area shall be cleared of all trees, stumps, roots, brush,boulders, sod and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil which is high in organic matter shall be removed. The surface of the foundation shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankments. The necessary compaction shall be obtained by using equipment adapted to site conditions. The trench shall be kept free of standing water during backfill operations. Material from the cutoff trench may be placed within the dike section if suitable.

Conduit Installation
All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction
The material placed in the fill shall be free of all sod, roots, frozen soil, stones over 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used. The construction equipment shall be operated over the area of each layer in a way that will result in the required compaction. Special equipment shall be used when the required compaction cannot be obtained without it.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture of gradation from the surrounding material. Where it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

Class II Dikes

Foundation Preparation

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod and debris. All channel banks and sharp breaks shall be sloped no steeper than 1:1. Topsoil which is high in organic matter shall be removed. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankment. The necessary degree of compaction shall be obtained by using equipment adapted to site conditions. The trench shall be kept free of standing water, if feasible, during backfill operations. The material from cutoff trench may be placed within the dike section if suitable.

Conduit Installation

All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction

The embankment material may be obtained from a selected borrow area or from a channel. In the construction of borrow trenches on the water side of the dike, an unexcavated plug at least 25 feet wide shall be left at intervals not to exceed 1320 feet.

The fill material shall be free of organic matter and other objectionable material. Placing and spreading of fill shall begin on the lowest part of the working area and continue in horizontal layers of approximate uniform thickness, preferably 6 inches thick but not more than 18 inches thick, depending on the equipment used. Where the borrow yields materials of varying texture and gradation, the more impervious material shall be placed toward the water side of the dike. The construction equipment shall be operated over the area of each layer in a manner to break up large clods and obtain compaction.

Fill material shall be moist but not too wet for equipment operations and shaping. Water shall be added to the fill material where it is too dry to permit compaction.

Dumped fill, where used, shall be placed in layers or deposited in a manner suitable to the equipment used and the material excavated. Shaping shall be done so as to break up lumps and clods of earth. Excessively wet material shall be placed to permit free drainage and shaped after it has drained. When the fill slumps due to wetness, the dike shall be constructed in stages.

Class III Dikes

Foundation Preparation

The foundation area shall be cleared of all stumps, trees, brush, roots, organic matter and debris. Top soil of high organic content shall be removed or thoroughly scarified before the placement of the embankment material. All channels or deep depressions to be crossed by the dike shall be shaped with side slopes no steeper than 1:1 to insure an adequate bond. Such channels or depressions shall then be backfilled with suitable embankment materials.

Conduit Installation

Conduits through the dike shall have straight alignment and shall be placed on a firm foundation. Suitable backfill material shall be placed around the conduits in thoroughly compacted layers.

Embankment Construction

The embankment material shall be of suitable quality and may be taken from borrow trenches parallel to the embankment. Such trenches, if on the water side of the dike, shall be interrupted by leaving unexcavated plugs at intervals not to exceed 1320 feet when required for protection against erosive velocities.

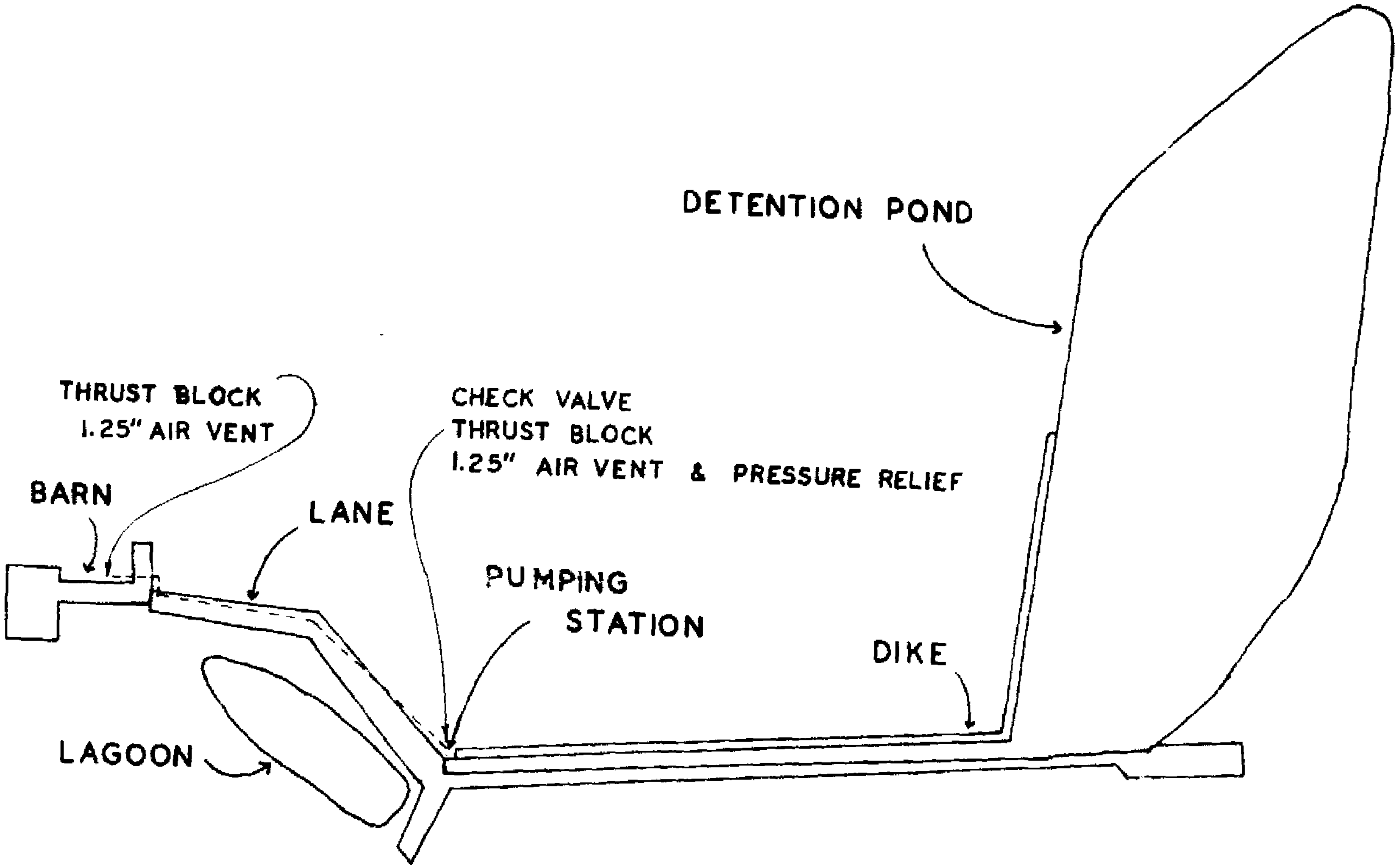
The fill shall be placed in layers or deposited in such a manner as to prevent lamination or voids. Shaping shall be done so as to break up any large lumps or clods of earth. Excessively wet material shall be placed to permit free drainage prior to shaping to the design section.

The final cross section shall be smooth and uniform.

Earth fill around conduits through the dike shall be adequately compacted to prevent piping.

Permanent and temporary pumping stations shall be so located and installed as to insure stability of the pump site and dike.

Wash water recovery system as designed by Larry Sharpe SCS District Conservationist, Okeechobee County.



LOCATION SKETCH

SPECIFICATIONS

PIPE — 6" PVC, SCHEDULE 40

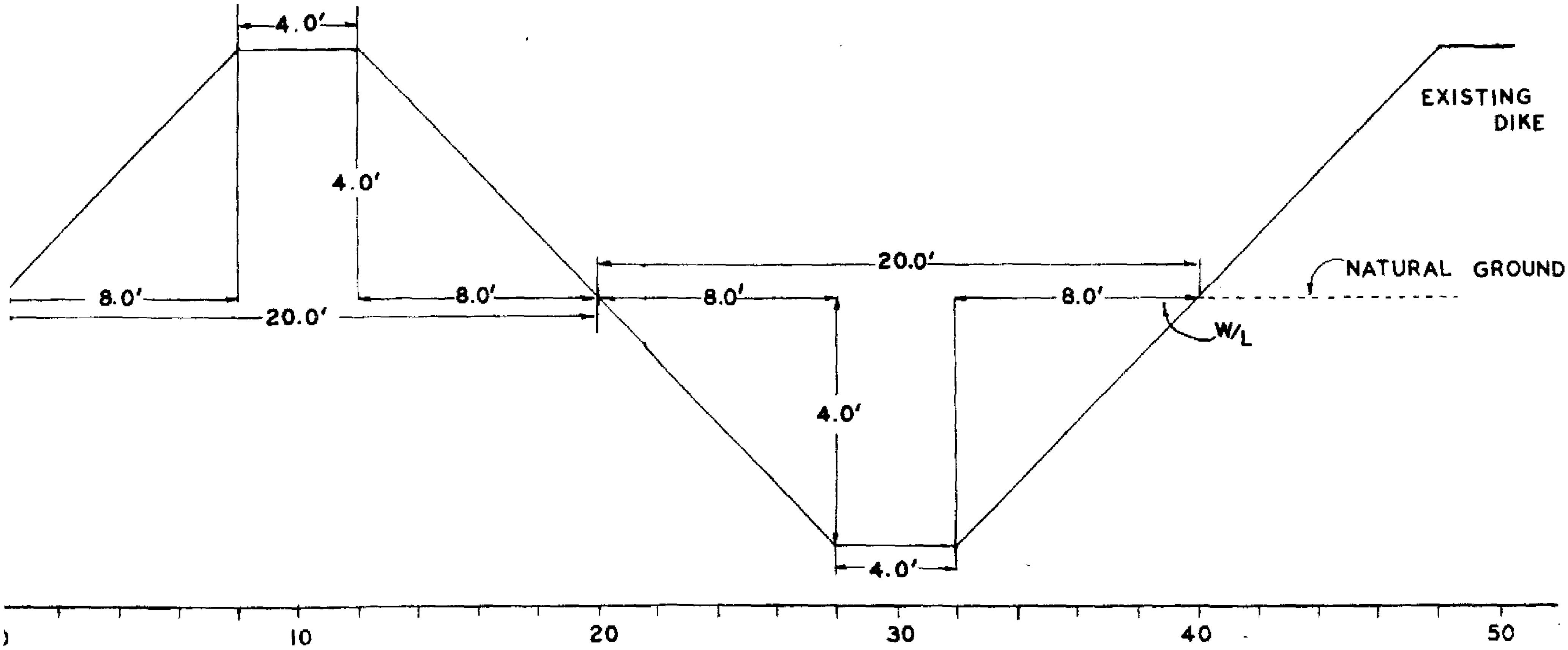
THRUST BLOCK — 1.7 SQ. FT. REQUIRED

PIPE COVER — 30" MINIMUM

PUMP REQUIREMENTS — 270 GPM at 115 TDH

FILTER MIN. 300 GPM w/#10 MESH SCREEN

wash water recovery cont.



TYPICAL CROSS-SECTION

1.25

APPENDIX 2

TCHW/RCWP LANDOWNERS IN PARTICIPATION

APPENDIX 2

RCWP/TCHW APPLICANTS
(July 1982)

	Applicant[1]	Program	Signed Contract
1.	Clarence Arnold	RCWP	No
2.	Gloria and Marvin Arnold	RCWP	No
3.	Monroe Arnold	RCWP/TCHW	Yes
4.	Louis T. Cox, Jr.	RCWP	No
5.	Frank D. Cunningham	RCWP	No
6.	D. R. Daniel	RCWP	No
7.	Davie Dairy, Inc.	RCWP	No
8.	Roger Davis	RCWP	Yes
9.	Enrico Dairy Farm, Inc.	RCWP	No
10.	Sanford Gottlieb	RCWP/TCHW	Yes
11.	Freeman Hales	RCWP	No
12.	Harvey Cattle Co.	RCWP	No
13.	Betty Louise Hazellief	RCWP/TCHW	No
14.	Nathaniel Hazellief	RCWP/TCHW	No
15.	Gilbert H. James	RCWP	No
16.	Roger L. Jones	RCWP	No
17.	Mildred B. Kirkland	RCWP/TCHW	Yes
18.	James Lashley	RCWP	No
19.	Emma Lawrence	RCWP	No
20.	McArthur Farms, Inc.	RCWP/TCHW	Yes
21.	Murphy White Dairy, Inc.	RCWP	No
22.	Newcomer Dairy, Inc.	RCWP	No
23.	New Palm Dairy, Inc.	RCWP	No
24.	Posey Dairy, Inc.	RCWP	No
25.	Red Top Dairy	RCWP	No
26.	Rofra Corporation	RCWP	No
27.	H. W. Rucks and Sons	RCWP/TCHW	Yes
28.	Wilson Rucks Dairy	RCWP/TCHW	Yes
29.	SEZ Dairy	RCWP	No
30.	L. B. Starnes	RCWP	No
31.	Haynes Williams	RCWP	No
32.	Williamson Cattle Co.	RCWP	No

[1]Number of applicants reoresent 50 percent of the TCNS land area.
List up to date as of July 1982.

APPENDIX 3

WATER BUDGETS FOR SECOND LAGOON AND SEEPAGE DISPOSAL FIELD AT MCARTHUR BARN #1

APPENDIX 3

Computation of area of Second-Stage Lagoon and Seepage Disposal Field at McArthur Barn #1.

Map Source: Mark Hurd

Map Scale: 1:24,000

Test of Map Scale: 7000 ft measured 89 mm

(7000 ft x 304.8 mm/ft)/89 mm = 23,973.

Map scale is accurate.

Second Stage Lagoon dimensions:

Length	∿	18 mm	= 0.180 m
Width	∿	8.5 mm	= 0.085 m
Area	∿	153 mm^2	0.0153 m^2

Scale = $24{,}000^2 = 5.76 \times 10^8$

$0.0153\ m^2 \times 5.76 \times 10^8 = 8{,}812{,}800\ m^2$

= 8.8128 hectares

x 2.471 acres/hectare = 22 acres

Seepage Disposal Field dimensions:

Estimated length x width of the irregular field is

21 mm x 22 mm = 462 mm^2

= 0.0462 m^2

$\times 5.76 \times 10^8 = 26.6112 \times 10^6\ m^2$

= 26.6112 hectares

x 2.471 acres/hectare

= 66 acres

Input/Output Water Balance for Second-stage lagoon and seepage disposal field (Annual Basis), before and after recycle system.

Assume:

--Total Water input		
Before: 269,760 gal/day	= 10 ac-in/day	= 1,021,818 liters/day
After: 59,520 gal/day	= 2.2 ac-in/day	= 225,455 liters/day
--Area 2nd Stage Lagoon	= 22 Acres	= 8.8 ha
--Area Seepage disposal field	= 66 Acres	= 26.7 ha
--Pan Evaporation (15-yr ave.)	= 60 in/yr	= 152.4 cm/yr
(further assume that second stage lagoon evaporation is the same as pan, and that the saturated seepage disposal field is 50 in/yr)		
--Rainfall		
e.g., 1979	= 56 in/yr	= 141.25 cm/yr
e.g., 1981	= 33 in/yr	= 93.93 cm/yr
--No deep seepage to deep groundwater		

Water Balance

OP = P + IP - ET

OP = system output as runoff or seepage

P = precipitation

IP = input of water (from first-stage lagoon → second-stage lagoon, or from second stage lagoon → disposal field)

ET = evapotranspiration

CASE I. Before Recycling System

A. 1979 Rainfall 141.25 cm (56 inches)

1. Second Stage Lagoon

OP = P + IP - ET

= 56 + 166 - 60

= 162 inches = 3564 acre inches = 297 acre feet

= 0.410 cfs = 1.16×10^{-2} cms averaged over year

2. Seepage Disposal Field

OP = P + IP - ET

= 56 + 54 - 50

= 60 inches = 3960 acre inches = 330 acre feet

= 0.456 cfs = 1.29×10^{-2} cms

About 330 acre feet would be the expected output per year. Part of this would occur as direct surface runoff from the seepage disposal field during wet periods, and part would occur as seepage drainage to Otter Creek.

B. 1981 Rainfall 93.93 cm (37 inches)

1. Second Stage Lagoon

OP = P + IP - ET

= 37 + 166 - 60

= 143 inches = 3146 acre inches = 262 acre feet

= 0.362 cfs = 1.02×10^{-2} cms

2. Seepage Disposal Field

OP = P + IP - ET

= 37 + 48 - 50

= 35 inches = 2310 acre inches = 193 acre feet

= 0.251 cfs = 7.10×10^{-3} cms

With lower rainfall, expected output from seepage field would be reduced tremendously. However, surface runoff output was observed during August 1981 during heavy rainfall events in a very dry year.

CASE II. After Recycling System

A. 1979 Rainfall 141.25 cm (56 inches)

1. Second Stage Lagoon

OP = P + IP - ET

= 56 + 36.5 - 60

= 32.5 inches = 715 acre inches = 59.6 acre feet

= 0.082 cfs = 2.3 x 10^{-3} cms averaged over year

2. Seepage Disposal Field

OP = P + IP - ET

= 56 + 11 - 50

= 17 inches = 1122 acre inches = 93.5 acre feet

= 0.129 cfs = 3.65 x 10^{-3} cms

Reducing groundwater pumpage and using recycled barn wash water reduced liquid water losses from the seepage field by 236 acre feet.

B. 1981 Rainfall 93.93 cm (37 inches)

1. Second Stage Lagoon

OP = P + IP - ET

= 37 + 36.5 - 60

= 13.5 inches = 297 acre inches = 25 acre feet

= 0.035 cfs = 1.0 x 10^{-3} cms

2. Seepage Disposal Field

OP = P + IP - ET

= 33 + 45 - 50

= -12.5 - -825 acre inches = -69 acre feet

= -0.095 cfs = -2.7 x 10^{-3} cms

With recycling of barn wash water, and low rainfall, seepage field output may be reduced to almost nil.

Water output computed from Second Stage Lagoon and Seepage Disposal Field, before and after recycling, for two rainfall conditions.

Year (Rain)	BEFORE		AFTER	
	2nd-Stage Lagoon	Seepage Field	2nd-Stage Lagoon	Seepage Field
1979(141.25cm)	297[1/]	330	60	94
1981(93.93 cm)	262	193	25	-69 [2/]

1/ Units: Acre feet per year

2/ The negative value suggests that more input to the seepage field could have been applied without significant runoff

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The above computations are based on assumption of a continuous smooth cycle of rainfall. In actual conditions, heavy rainfall events will cause output pulses of runoff, and dry periods may reduce surface wetness and reduce evapotranspiration.

APPENDIX 4

ANALYTICAL METHODS

ANALYTICAL METHODS USED FOR DETERMINATION OF WATER CHEMISTRY

AUTOANALYZER II

Determination	Method	Range	Sensitivity
Ammonia	Colorimetric, automated, Berthelot reaction Technicon AA II Method 154-71W EPA Method 350.1	0.0 - 2.0 mg/l	0.04 mg/l 2.0% of full scale
Nitrite	Colorimetric, automated diazotization with sulfanilamide which couples with N-l-napthylethylenediamine dyhdrochloride Technicon AA II Method 161-71W EPA Method 353.2	0.0 - 0.20 mg/l	0.004 mg/l 2.0% of full scale
Nitrate	Same as nitrite with cadmium reduction column Technicon AA II Method 100-70W EPA Method 353.2	0.0 - 0.20 mg/l	0.004 mg/l 2.0% of full scale
Total Kjeldahl	Colorimetric, semi-automated block digestion with H_2SO_4 Technicon AA II Method 334-74 EPA Method 351.2	0.0 - 10.0 mg/l	0.20 mg/l 2.0% of full scale
Ortho Phosphate	Colorimetric, automated, phosphomolybdenum blue complex with ascorbic acid reduction Technicon AA II Method 55-171W EPA Method 365.1	0.0 - 2.0 mg/l	0.04 mg/l 2.0% of full scale
Total Phosphate	Same as ortho phosphate with a persulfate digestion Technicon AA II Method 55-171W EPA Method 365.1	0.0 - 2.0 mg/l	0.04 mg/l 2.0% of full scale

ANALYTICAL METHODS USED FOR DETERMINATION OF WATER CHEMISTRY

PHYSICAL PARAMETERS

Determination	Method	Range	Sensivity
pH	Electrometric EPA Method 150.1	0 - 14 pH	0.01 pH
Color	Spectrophotometric comparison to platinum-cobalt standard solutions Standard Method 204A, 15th Ed., p. 61, 1980 EPA Method 110.2	0 - 500 mg/l	1.0 mg/l
Specific Conductance	Electrometric Standard Method 205, 15th Ed., p. 71, 1980 EPA Method 120.1	0 - 1.5 x 10^6 umhos/cm	0.1 umhos/cm
Turbidity	Nephelometric Standard Method 214A, 15th Ed., p. 132, 1980 EPA Method 180.1	0-1,000 NTU	2% of full scale

APPENDIX 5

COMPUTATIONS OF ANNUAL DISCHARGE AND NUTRIENT LOADS FROM THE SEEPAGE DISPOSAL FIELD AT MCARTHUR BARN #1

APPENDIX 5

Computation of Annual discharge and nutrient loads from McArthur Barn #1 Seepage Disposal Field

Assume that the annual loads can be computed by multiplying the average annual nutrient concentration by the annual total discharge.

Conversion of acre-ft to liters

1979:

330 acre-ft x 43,560 ft^2/acre = 14.37 x 10^6 ft^3

= 407,049 m^3

= 407 x 10^6 liters

Nutrient	Conc.	Load	Load/Land Area
	(mg/l)	(kg)	(kg/ha)
$O\text{-}PO_4$	6.91	2813	105
$T\text{-}PO_4$	8.71	3545	133
$NO_x + NH_4$	1.21	493	18
TKN	15.09	6142	230
Tot. N	15.13	6159	231
Discharge	$\sim 10^6$	$4.711 \frac{m^3 \cdot days}{sec}$	$0.176 \frac{m^3 \cdot days/ha}{sec}$

1980:

182 acre-ft x 43,560 ft^2/acre = 7.928 x 10^6 ft^3

= 224,494 m^3

= 224.5 x 10^6 liters

(cont. on next page)

Nutrient	Conc.	Load	Load/Land Area
	(mg/l)	(kg)	(kg/ha)
$O\text{-}PO_4$	3.87	869	33
$T\text{-}PO_4$	10.14	2479	93
$NO_x + NH_4$	1.51	339	13
TKN	22.75	5107	191
Tot. N	22.83	5125	192
Discharge	$\sim 10^6$	$2.598 \frac{m^3 \cdot days}{sec}$	$0.0973 \frac{m^3 \cdot days/ha}{sec}$